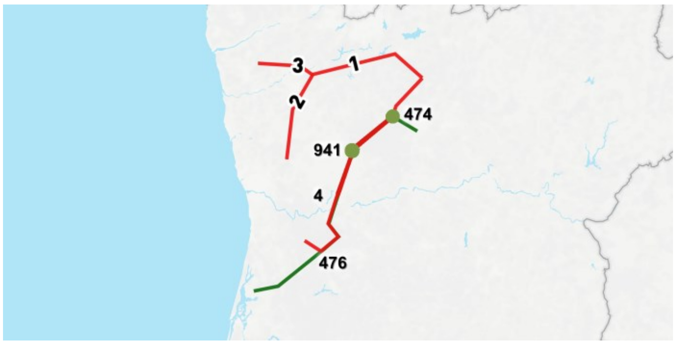
## Project 1 - RES in north of Portugal

The main objective of this project consists in introducing the network reinforcements that are needed to allow the connection of new RES generation (hydro with pumping and also wind) that is foreseen in the north of Portugal (a part of it already under construction), where the RES potential is high. The project includes a set of new 400 kV OHL that will form a new axis between P. Lima-Pedralva-V. Minho-R. Pena-Fridão-Feira. A new 400 kV OHL Pedralva-Sobrado (PCI 2.16.1) is also included in this cluster, in order to ensure the maintenance of the NTC values between PT and ES that were available prior to the connection of these new power plants.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal boundary in Portugal (north) |
| PCI label | PCI 2.16.1 and 2.16.3 |
| Promoted by | REN |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1 | Line V.Minho-Pedralva 1 and 2 | 33% | V.Minho (PT) | Pedralva (PT) | Commissioned | 2015 | Investment on time | The first circuit was commissioned in 2014, the second in 2015. |
| 2 | New 67km double Pedralva (PT) - Sobrado (PT) 400kV | 20% | Pedralva (PT) | Sobrado (PT) | Permitting | 2022 | Rescheduled | Due to the expected delay of the connection of new RES generation in North of Portugal, the commissioning date of this investment item was rescheduled |
| 3 | Double circuit Pedralva - Ponte de Lima 400kV | 14% | Pedralva (PT) | Ponte de Lima (PT) | Under Construction | 2016 | Delayed | In the first stage the line will be conected between Pedralva and Vila Nova de Famalicão (previously Vila do Conde). New substation of Ponte de Lima (previously Viana do Castelo) will be commissioned in 2018 |
| 4 | 400kV OHL V.Minho (PT) -Ribeira de Pena (PT) - Fridão (PT) - Feira (PT) | 21% | V.Minho (by Ribeira de Pena and Fridão) | Feira (by Ribeira de Pena and Fridão) | Permitting | 2021 | Rescheduled | Due to the expected delay of the connection of new hydro power plants, the commissioning date of this investment item was rescheduled. |
| 474 | New substation in Rib. Pena. | 21% | Ribeira de Pena (PT) | | Permitting | 2020 | Rescheduled | Due to the expected delay of the connection of new hydro power plants, the commissioning date of this investment item was rescheduled. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 476 | New 400+220kV double circuit OHL Vila Pouca Aguiar - (Rib. Pena) - Carrapatelo - Estarreja. | 12% | V. P. Aguiar (by Carrapatelo) | Estarreja (by Carrapatelo) | Permitting | 2020 | Rescheduled | Due to the expected delay of the connection of new RES generation in Portugal, the commissioning date of this investment item was rescheduled |
| 941 | Fridão | 21% | Fridão | | Permitting | 2022 | Rescheduled | Due to the expected delay of the connection of new hydro power plants, the commissioning date of this investment item was rescheduled |

## Additional Information

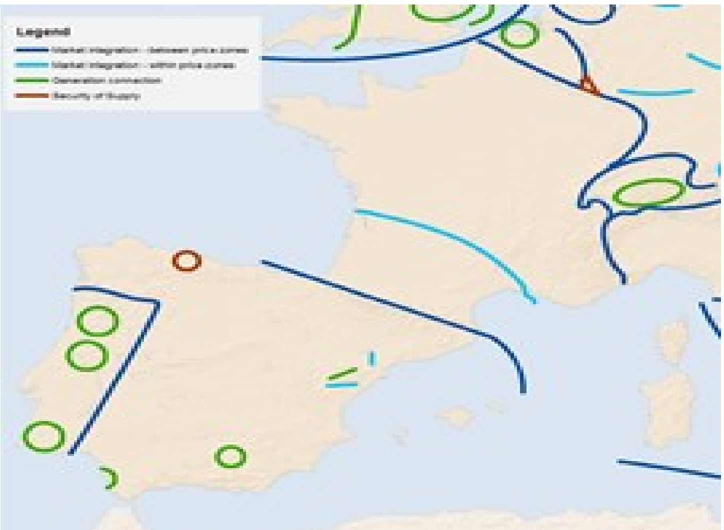
Portuguese National Development Plan
http://www.erse.pt/pt/consultaspublicas/consultas/Documents/53_Proposta%20PDIRT-E_2015/PDIRT%202016-2025%20-%20Junho%202015%20-%20Relat%C3%B3rio.pdf
PCI page – link to EC platform:
http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html
Clustering:
This project includes a set of new 400 kV OHL that will form a new axis between P. Lima-Pedralva-V. Minho-R. Pena-Fridão-Feira, ensuring the network capacity to evacuate the new amounts of generation, taking also into consideration the n-1 security criteria. The new substations of R. Pena and Fridão are also considered in this axis for direct connection of generation.
A new line between Pedralva and Sobrado is also included in this cluster, in order to ensure the maintenance of the NTC values between PT and ES that were available prior to the connection of the new generation.

## Investment needs

This project integrates new amounts of hydro power plants in the northern region of Portugal and at same time creates better conditions to evacuate wind power that is already in operation and also new wind farms with authorization for connection. These new amounts of power will increase the flows in the region, and it is expected that the new flows could reach 3500 MW in the future, which must be evacuated to the littoral strip and south of Portugal, where the major consumption areas are located, through three new 400 kV independent routes as the existing network supported in the 150 kV and 220 kV is not adequate. Part of these flows will interfere and accumulate with the already existent flows entering in Portugal through the international interconnections with Spain on the north, namely the 400 kV Cartelle (ES)-Alto Lindoso (PT)-Riba d'Ave (PT)-Recarei (PT).
This project includes a set of new 400 kV OHL that will form a new axis between P. Lima-Pedralva-V. Minho-R. Pena-Fridão-Feira, ensuring the network capacity to evacuate the new amounts of generation, while taking into consideration the n-1 security criteria. The new substations of R. Pena and Fridão are also included in this axis for the direct connection of the new power plants. Part of this 400 kV axis will be constructed as a double line (400 kV + 220 kV), in order to reinforce the existing 220 kV network between V. Pouca de Aguiar-Carrapatelo-Estarreja.
A new OHL between the already in service substation of Pedralva and the future of Sobrado (PCI 2.16.1 Internal line between Pedralva and Sobrado) is also included in this cluster, in order to ensure the maintenance of the NTC values

between PT and ES that were available prior to the connection of these new power plants (with more than 2400 MW of installed power). In fact, due to the location of these new hydro power plants (near the PT-ES border) as well as the location of their network connection points (near existing interconnection axis between Minho (PT) and Galiza (ES)) it was identified that additional congestions may occur in some situations due to the new production. These congestions would lead to a reduction in the NTC values between Portugal and Spain not compatible with the needs of the Iberian Market and the Internal Energy Market (IEM).

The GTC is common to all Visions, so the comparison among SEW/GTC ratios depends only from the SEW values. The SEW of the project reflects the benefit of integrating new generation (RES) that will replace more expensive generation (fossil fuel based generation).




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | outside-inside: 2500 |
| | inside-outside: 3100 |
| Delta GTC contribution (2030) [MW] | outside-inside: 2900 |
| | inside-outside: 4200 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 200 ±14.5 |

| | |
|---|---|
| Cost explanation | Uncertainty regarding total length of lines, extra costs due to safety, environmental or legal requirements imposed during permit grating process.<br>Cost same magnitude as in TYNDP2014.<br>Only CAPEX. |
| S1 | Negligible or less than 15km |
| S2 | 15-25km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | 30 ±10 | 40 ±10 | 130 ±20 | 180 ±30 |
| B3 RES integration (GWh/yr) | 410 ±80 | 410 ±80 | 410 ±80 | 1580 ±320 | 2090 ±420 |
| B4 Losses (GWh/yr) | 25 ±25 | 0 ±25 | 0 ±25 | 75 ±25 | 75 ±25 |
| B4 Losses (Meuros/yr) | 1 ±1 | 0 ±1 | 0 ±1 | 4 ±2 | 5 ±2 |
| B5 CO2 Emissions (kT/year) | -200 ±30 | -200 ±100 | -200 ±100 | -600 ±100 | -700 ±100 |

Savings in variable generation costs (SEW) and reduction on CO2 emissions are caused by the integration of new RES generation in the system replacing fossil fuel based generation. Therefore the highest values are reached in the scenarios with higher RES integration.

There is an increase of losses in the scenarios where RES integration is very high. The location of this new generation is further from the load centres and this new renewable generation is replacing conventional generation located closer the load centres.

Regarding the S1 (protected areas) and S2 (urbanised areas) indicators, the definitive routes of the projects are still to be determined, but they will always be selected taking the objective of minimizing impact.

## Project 2 - RES in center of Portugal

The main objective of this project consists in introducing the network reinforcements that are needed to allow the connection of new RES generation (hydro with pumping and wind) that is foreseen for the center area of Portugal, where RES potential is high. This project includes new 400 kV OHL that will form two new 400 kV axes: one linking Paraimo/Batalha-Penela-Seia substations, at the west side of Serra da Estrela, and the other connecting the Fundão and Falagueira substations, at the east side of Serra da Estrela. New substations for direct connection of the new power plants are also included.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal boundary in Portugal (center) |
| PCI label | |
| Promoted by | REN |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 8 | New single circuit 400kV OHL Seia-Penela (108km). | 70% | Seia | Penela | Permitting | 2020 | Rescheduled | Due to the expected delay of the connection of new hydro power plant, the commissioning date of this investment item was rescheduled |
| 9 | New double circuit OHL Fundão (PT) -'Castelo Branco zone' (PT)-Falagueira(PT) | 30% | Fundão (PT) | Falagueira (PT) | Design | 2017 | Investment on time | Project on time |
| 478 | New double circuit 400kV OHL (15km) to connect Penela substation to Paraimo-Batalha line. | 70% | Penela (PT) | Paraimo / Batalha (PT) | Permitting | 2019 | Rescheduled | Due to the expected delay of the connection of new hydro power plant, the commissioning date of this investment item was rescheduled |
| 481 | Expansion of the existing Penela substation to include 400kV facilities. | 70% | Penela (PT) | | Permitting | 2019 | Rescheduled | Due to the expected delay of the connection of new hydro power plant, the commissioning date of this investment item was rescheduled |
| 484 | New 400/220kV substation in Fundão. | 30% | Fundão (PT) | | Design | 2017 | Investment on time | Project on time |

### Additional Information

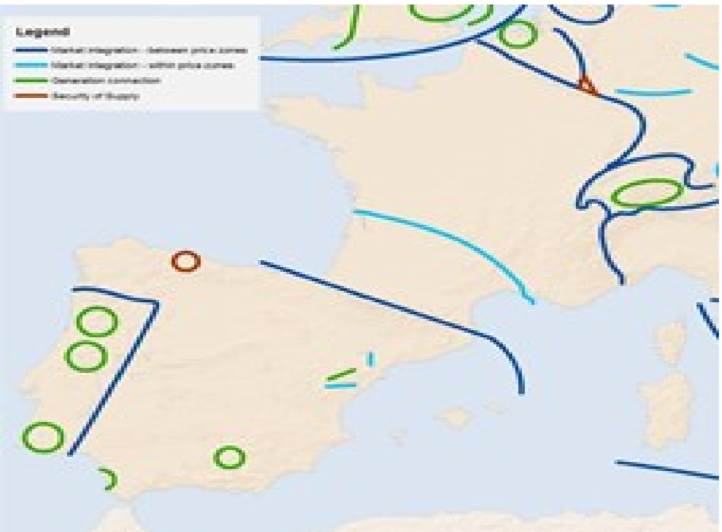
Portuguese National Development Plan
http://www.erse.pt/pt/consultaspublicas/consultas/Documents/53_Proposta%20PDIRT-E_2015/PDIRT%202016-2025%20-%20Junho%202015%20-%20Relat%C3%B3rio.pdf
Clustering:
This project includes new 400 kV OHL that will form two new 400 kV axes: one linking Paraimo/Batalha-Penela-Seia substations and the other connecting the Fundão and Falagueira substations. New substations for direct connection of the new power plants are also included. In a subsequent step, these two 400 kV axis will be interconnected through an OHL between Fundão-Guarda-Seia, reinforcing capacity and ensuring n-1 security in case of a failure. In TYNDP 2014 and TYNDP 2016 this 400 kV link Fundão-Guarda-Seia wasn't included in this cluster, with the other two axes, just because its commissioning date didn't fulfil the CBA 1.0 5 years rule for clustering projects, although this axis is relevant to full achieve the main objective of the project.

In April 2016 the Portuguese government with the project promoters agreement cancelled the construction of two new hydro power plants that are considered in this project: Girabolhos and Alvito, totalizing 589 MW with pumping. Considering that when this decision was taken the TYNDP studies were already concluded the project is listed in this TYNDP edition considering these two hydro power plants. In future TYNDP editions this project will be reviewed and updated in accordance.

## Investment needs

This project integrates new hydro power plants (some of them with pumping) and provides better conditions to evacuate already existent wind generation and also increases network capacity to integrate new wind generation in the inner central region of Portugal (the wind target in this region surmounts more than 2000 MW). The existing network based in the 150 kV and 220 kV is no more sufficient to integrate these new amounts of power, and a new 400 kV axis will be launched in this region, in two major routes: one to the littoral strip, involving Penela, Paraimo and Batalha substatinos, and another by the interior, establishing a connection with the Falagueira substation, where there is an interconnection with Spain (Falagueira-Cedillo).
This project includes some new 400 kV OHL forming two new 400 kV axes: one linking Paraimo/Batalha-Penela-Seia substations and the other connecting the Fundão and Falagueira substations. New Fundão substation for direct connection of new power plants is also included.
In a subsequent stage, these two 400 kV axis will be interconnected through a 400 kV OHL to be built firstly between Fundão and Guarda and afterwards between Guarda and Seia, reinforcing the capacity and ensuring n-1 security in case of a failure. This 400 kV link Fundão-Guarda-Seia wasn't included in this cluster (wich already contained the other two axes), as its foreseen commissioning date didn't fulfil the 5 years CBA rule for clustering projects, although this axis is relevant to full achieve the main objectives of the project.

The GTC is common to all Visions, so the comparison among SEW/GTC ratios depends only from the SEW values. The SEW of the project reflects the benefit of integrating new generation (RES) that will replace more expensive generation (fossil fuel based generation).



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | downstream-upstream: - |
| | upstream-downstream: 1100 |
| Delta GTC contribution (2030) [MW] | downstream-upstream: - |
| | upstream-downstream: 1700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 106 ±6.9 |
| Cost explanation | Uncertainty regarding total lenght of lines, extra costs due to safety, environmental or legal requirements imposed during permit grating process.<br>Cost same magnitude as in TYNDP2014.<br>Only CAPEX. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

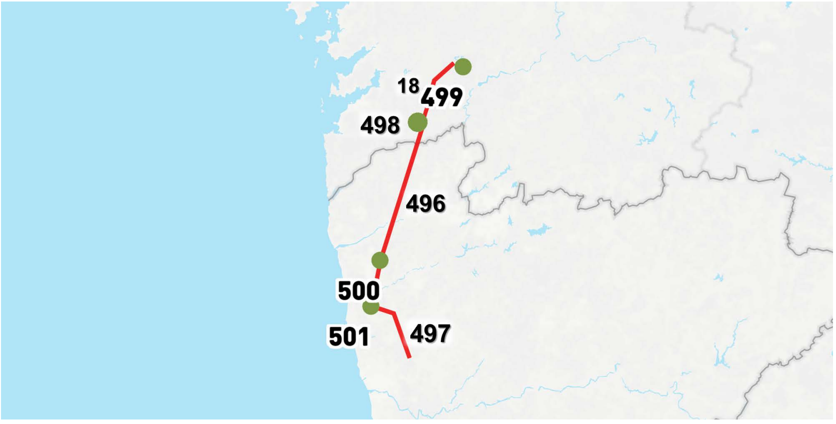
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 30 ±10 | 40 ±10 | 130 ±20 | 240 ±40 |
| B3 RES integration (GWh/yr) | 440 ±80 | 450 ±90 | 450 ±90 | 1680 ±340 | 2740 ±550 |
| B4 Losses (GWh/yr) | -25 ±25 | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | -300 ±50 | -200 ±100 | -200 ±100 | -700 ±100 | -1000 ±200 |

Savings in variable generation costs (SEW) and reduction on CO2 emissions are caused by the integration of new RES generation in the system replacing fossil fuel based generation. Therefore the highest values are reached in the scenarios with higher RES integration.
There is a reduction of losses in all scenarios because this project allows the connection of new generation near the load centres.
Regarding the S1 (protected areas) and S2 (urbanised areas) indicators, the definitive routes of the projects are still to be determined, but they will always be selected taking the objective of minimizing impact.

## Project 4 - Interconnection Portugal-Spain

In order to reach a complete operational Iberian Electricity Market (MIBEL), and strengthening the Internal Energy Market (IEM), the increase of the interconnection between Spain and Portugal is needed.A new OHL 400kV interconnection between Fontefría (Spain) and Ponte de Lima (Portugal). Internal reinforcements complement the cross border section, such as the axis in Spain between Fontefría and Beariz and in Portugal between Ponte de Lima (previously Viana do Castelo), Vila Nova de Famalicão (previously Vila doConde) and Vermoim/Recarei.This project was included in the 2013 and 2015 PCI list (PCI 2.17).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Portugal - Spain |
| PCI label | 2.17 |
| Promoted by | REE;REN |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 18 | New northern interconnection. New double circuit 400kV OHL between Beariz (ES) - Fontefria (ES). | 100% | Beariz (ES) | Fontefria (ES) | Permitting | 2017 | Delayed | The delay of this investment is affected by the explanation in the investment 496. Also, environmental problems lead to re-routing. |
| 496 | Interconnection 400kV Fontefría (ES) - Ponte de Lima (PT) - Vila Nova de Famalicão (PT). | 100% | Fontefría (ES) | Vila Nova de Famalicão (PT) (By Ponte de Lima) | Permitting | 2018 | Delayed | Due to local opposition in the border area REN had to withdraw the Portuguese section of the interconnection of the ongoing EIA process to maintain the schedule of other investments included in the EIA needed for connecting new hydro in Cávado |
| 497 | New double circuit 400kV OHL between Vila Nova de Famalicão (PT) - Recarei/Vermoim (PT). | 100% | Vila Nova de Famalicão (PT) | Recarei/Vermoim (PT) | Commissioned | 2015 | Investment on time | Line commissioned |
| 498 | New northern interconnection. New 400kV substation Fontefria (ES), previously O Covelo. | 100% | Fontefria (ES) | | Permitting | 2017 | Delayed | The delay of this investment is affected by the explanation in the investment 496. Also, environmental problems lead to re-routing |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 499 | New northern interconnection. New 400kV substation Beariz (ES), previously Boboras | 100% | Beariz (ES) | | Permitting | 2017 | Delayed | The delay of this investment is affected by the explanation in the investment 496. Also, environmental problems lead to re-routing |
| 500 | New 400/150kV substation Ponte de Lima (PT), previously V. Castelo. | 100% | Ponte de Lima (PT) | | Permitting | 2018 | Delayed | Substation renamed to Ponte de Lima. See Investment 496. |
| 501 | New 400kV substation Vila Nova de Famalicão (PT), previously Vila do Conde. | 100% | Vila Nova de Famalicão (PT) | | Commissioned | 2015 | Investment on time | Substation commissioned. |

## Additional Information

Clustering: the project consists on a set of investments in the same transport corridor, based on a 400 kV OHL axis linking the substations of Beariz and Fontefría, in Spain, with P. Lima-V. N. Famalicão-Recarei/Vermoim, in Portugal. These reinforcements are all needed (as they are in series) to achieve the main objectives of the project: reinforcement of the interconnection capacity between Portugal and Spain having in mind the MIBEL targets agreed by the Portuguese and Spanish governments and also to allow Portugal to achieve the 10% interconnection ratio defined by the EC, both contributing for the IEM.

Project website

http://www.ree.es/es/actividades/gestor-de-la-red-y-transportista/proyectos-de-interes-comun-europeos-pic ;

http://www.ren.pt/pt-PT/o_que_fazemos/projetos_interesse_2015/

*PCI page – link to EC platform*

http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

Other links:

*Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

*Portuguese National Development Plan*

http://www.erse.pt/pt/consultaspublicas/consultas/Documents/53_Proposta%20PDIRT-E_2015/PDIRT%202016-2025%20-%20Junho%202015%20-%20Relat%C3%B3rio.pdf

*Inter-Governmental agreement (Madrid Declaration)*

https://ec.europa.eu/energy/sites/ener/files/documents/Madrid%20declaration.pdf

*Constitution of the High Level Group on Interconnections for South West Europe*

The High Level Group is responsible to prepare a plan to implement the Madrid Declaration and ensure regular monitoring of progress of the projects and provide adequate technical assistance to the Member states. The group will deal with both gas and electricity infrastructure.

http://europa.eu/rapid/press-release_IP-15-5187_en.htm

XXII Portuguese-Spanish Summit (main conclusions)

Main conclusions from the XXII Portuguese-Spanish summit where both governments agreed to continue working on the definition and routes for two new interconnection in order to reach a interconnection capacity of 3000 MW by 2010 between both countries.

http://www.erse.pt/pt/mibel/construcaoedesenvolvimento/Documents/CONCLUS%C3%95ES%20CIMEIRA_BADAJOZ_2006.pdf

## Investment needs

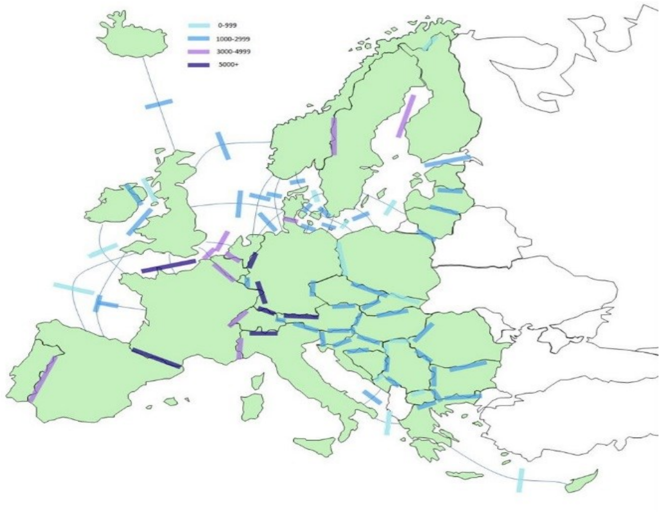
In 2006 the Spanish and Portuguese governments set the goal to reach 3000 MW of exchange capacity in the ES-PT border (in both directions) in order to reach a complete operational Iberian Electricity Market (MIBEL). It has been identified the need to have, in 2010, two new interconnections, one in the south and another in the north

In 2014 the new Southern interconnection Puebla de Guzmán (ES) – Tavira (PT) entered into full operation, reinforcing the capacity, mainly in the direction from Portugal to Spain, and reducing the congestion level in around 6%.

However, the Spain to Portugal direction still needs to overcome existing (and future) restrictions in the northern part of the border. In fact according to the market studies performed in TYNDP framework it is expected that this direction will be the most used in the following decade. Although the congestion rate in the Spain to Portugal direction in 2014 was low (4%), without this new project it can increase up to 17%-53% in 2030 (depending on the scenario), while with the new project the congestions are limited to 3%-9% in 2030 (depending on the scenario).

The Declaration of Madrid of the Energy Interconnection Links Summit among the Governments of France, Spain and Portugal, the EC and the EIB, highlights the urgency of implementing the already planned interconnections Portugal-Spain and Spain-France and conduct further investigations aiming at developing electrical interconnection projects in order to reach 8 GW capacity for the France-Spain border in order to meet the ambitious deadline of achieving the interconnection objective by 2020.

The GTC is common to all Visions, so a comparison between the ratio SEW/GTC only depends from the SEW values. The SEW reflects the benefit of a higher market integration provided by the increase of the interconnection capacity allowing a better optimization of the generation mix. For a GTC increase of 1 GW the ratio SEW/GTC is in the range 7 to 48 M€/GW/year (depending on the scenario).




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | PT-ES: [700 ; 1000] |
| | ES-PT: [1300 ; 1900] |
| Delta GTC contribution (2030) [MW] | PT-ES: [700 ; 1000] |
| | ES-PT: [1300 ; 1900] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 128 ±12.8 |
| Cost explanation | Uncertainty includes total length of lines, extra costs due to safety,<br>and environmental or legal requirements imposed during permit grating process.<br>The cost magnitude of the project (CAPEX cost) is of the same magnitude as in previous TYNDP. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 40 ±10 | 60 ±10 | 10 ±10 | 70 ±10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±10 | 150 ±20 | 50 ±20 | 430 ±140 |
| B4 Losses (GWh/yr) | 25 ±25 | 75 ±25 | 100 ±25 | 75 ±25 | 100 ±25 |
| B4 Losses (Meuros/yr) | 1 ±1 | 4 ±1 | 4 ±2 | 4 ±2 | 6 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±60 | 500 ±100 | 300 ±100 | ±100 | -300 ±100 |

In the Cost Benefit Analysis it was used the GTC increase upper limit (PT->ES 1000MW; ES->PT 1900 MW)

Savings in variable generation costs (SEW) in 2020 EP, 2030 V1and 2030 V2 are caused mainly by a decrease of CCGTs in Portugal compensated by an increase of coal in Spain and Central Europe (In 2020 EP, 2030 V1 and 2030 V2 generation from coal is cheaper than from gas due to the fairly low CO2 prices). This situation results in a global increase of CO2 emissions as the CO2 emission factor is higher for coal when compared with gas..

In 2030 V3 and V4 the SEW benefits are caused by a decrease of CCGTs in Portugal compensated by an increase of less expensive technologies like nuclear and renewables. This situation results in a global decrease of CO2 emissions. In every scenario Portugal continues to be a net importer and Iberian Peninsula (mainly Spain) reduces spillage.

In addition, SEW in 2020 is lower than in 2030 due to less potential for optimization of unit commitment, and less gas to be substituted by coal  and is higher is the 2030 top-down visions, especially in V4 which imply higher efficiency of a European common approach for optimizing the location of RES versus national and independent approaches of RES policies.

The project does not contribute to avoid ENS at national level (as scenarios, according to ENTSO-E assumptions,are build to fulfil adequacy requirements) nor at local level in the area of the connection points. However a higher meshing in Iberian Peninsula would improve the overall system security and its robustness from the dynamic point of view.

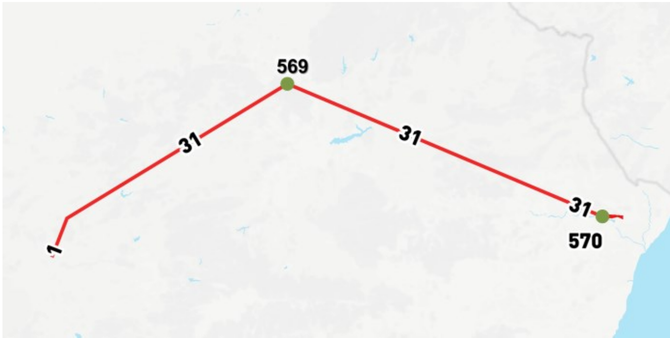
The project’s SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.54 | 1.18 | 0.48 | 2.08 |
| Standard deviation marginal cost difference in the reference case  [€/MWh] | 3.65 | 6.23 | 5.31 | 11.39 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 4.96 | 8.37 | 4.10 | 8.92 |

## Project 13 - Baza project

This Project includes a new double circuit Caparacena-Baza-La Ribina 400 kV OHL, in Spain with two new 400 kV substations in Baza and La Ribina.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Internal boundary in the south of Spain |
| PCI label | |
| Promoted by | REE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 31 | New double circuit Caparacena-Baza-La Ribina 400kV OHL. | 100% | Caparacena (ES) | La Ribina (ES) | Under Consideration | 2025 | Investment on time | Investment rescheduled due to, and in accordance with, delayed development of new power plant, as considered in the Master Plan 2020 in progress |
| 569 | New 400kV substation in Baza | 100% | Baza (ES) | | Under Consideration | 2025 | Investment on time | Investment rescheduled due to, and in accordance with, delayed development of new power plant, as considered in the Master Plan 2020 in progress |
| 570 | New 400kV substation in La Ribina (will be also connected to Carril-Litoral 400kV line ). | 100% | La Ribina (ES) | | Under Consideration | 2025 | Investment on time | Investment rescheduled due to, and in accordance with, delayed development of new power plant, as considered in the Master Plan 2020 in progress |

### Additional Information

Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

Clustering: the project consists of a new substation (Baza) and 2 double circuits that connect this new substation to the existing network (Baza-Caparacena and Baza La RIbina), as only one would not allow evacuation of generation in case of contingency or solving constraints in the parallel axis. La Ribina is a new subestion required to connect to the existing axis

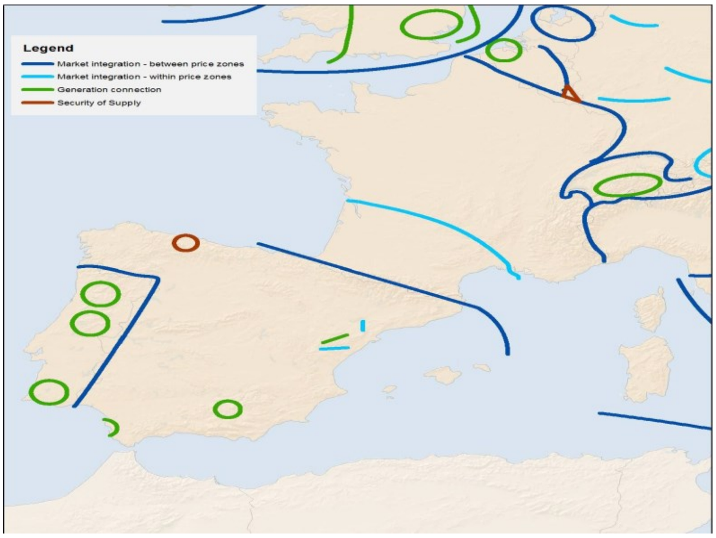
Litoral-Rocamora with the lowest impact in the territory. All the investments are in series so a lack of any of them do not allow to get the full GTC increase of the project.

## Investment needs

There is a need to integrate an important contingent of wind and solar generation, both at transmission and distribution level in an area of Jaen where the transmission network is very weak. Around 350 MW of wind and 100 MW of thermosolar are considered in Vision 1 in the Baza 400kV substation, and around 450 MW , 125 MW of thermosolar and 550 MW of photovoltaics are considered in Vision4.

Moreover, a new pumping hydropower plant with pumping storage could be expected in this area, as considered in previous TYNDP, although it is not considered in this TYNDP according to last information available.

On the other hand, certain congestions are detected in the existing single circuit Litoral- Tabernas- Hueneja-Caparacena 400 kV, between Almeria and Granada, so a new project will also allow reduce congestion in this east-west flows.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | ROW-Baza: [2200 ; 3100] |

| | |
|---|---|
| | Baza-ROW: [1900 ; 2300] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 113 ±11.3 |
| Cost explanation | Value (CAPEX cost) updated according to last Spanish investment standard costs |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 60 ±10 | 80 ±10 | 90 ±10 | 110 ±20 |
| B3 RES integration (GWh/yr) | N/A | 1090 ±220 | 1300 ±260 | 1460 ±290 | 1580 ±320 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -500 ±100 | -500 ±100 | -600 ±100 | -600 ±100 |

Savings in variable generation costs (SEW) are caused mainly by the integration of new RES generation in the system and solution of certain constraints in parallel network that allow to use most efficient generation. Therefore higher values are in the scenarios with higher RES considered.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 16 - Biscay Gulf

The project consist of  370 km HVDC-VSC link (2 bipoles of 1000 MW each) mainly subsea in the Biscay Gulf, between Gatica (Basque Counrty, ES) and Cubnezais (Nouvelle Aquitaine, FR). Included in the Madrid Declaration, this project aims at improving the interconnection between Iberia and mainland Europe, allowing for higher integration of RES in Iberia, especially solar and helping Spain to come closer to he 10% interconnection ratio objective.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Spain - France |
| PCI label | 2.7 |
| Promoted by | REE;RTE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 38 | New HVDC interconnection in the western part of the border via DC subsea cable in the Biscay Gulf. | 100% | Gatica (ES) | Cubnezais (FR) | Planning | 2025 | Rescheduled | There is a common political will to speed up the project, but more detailed technical studies showed the need to reschedule the project till 2025 due to manufacturing and installation needs adjustment. Specifically there will be a partial operation of the link before 2025 as the first bipole will be in service in 2024. |

### Additional Information

**Project website**

http://www.ree.es/es/actividades/gestor-de-la-red-y-transportista/proyectos-de-interes-comun-europeos-pic ;

*PCI page – link to EC platform* http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

**Other links**

*Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

*French National Development Plan* http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

*Inter-Governmental agreement (Madrid Declaration)*
https://ec.europa.eu/energy/sites/ener/files/documents/Madrid%20declaration.pdf

*Constitution of the High Level Group on Interconnections for South West Europe*

http://europa.eu/rapid/press-release_IP-15-5187_en.htm

## Investment needs

One of the main concerns in South Western Europe is the low interconnection capacity FR-ES, too low to enable the Iberian Peninsula to fully participate in the internal electricity market, and the Spanish interconnection ratio far from the 10% objective. In 2014, congestion in the FR-ES border was 71% with an average price-spread of around 17€/MWh. In 2015 the new Eastern Interconnection was commissioned after more than 30 years. However it is considered not enough, neither in the short nor long term.

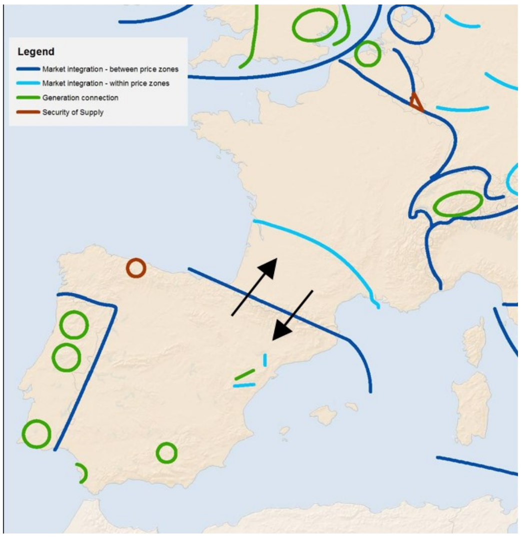
Biscay Gulf project would be the next one in the FR-ES border to increase the exchange capacity, if we except the PST in Arkale that will allow to take full benefit from the Eastern interconnection. This alternative came up as the preferential strategy after deep technical and environmental prefeasibility studies across the whole French-Spanish border.

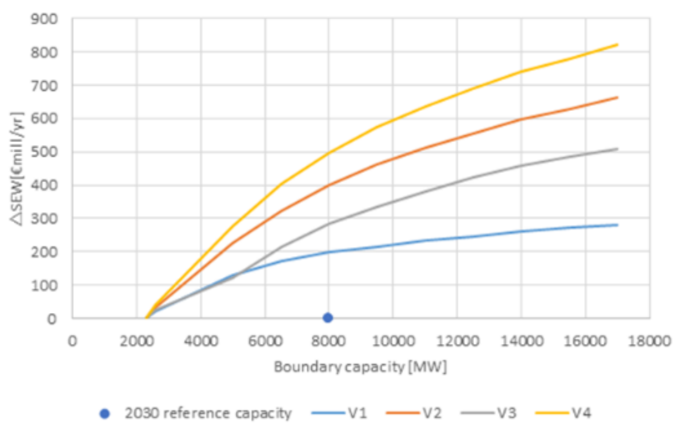
In fact, this PCI project has also the label of an e-Highway PCI, showing it is fully in-line with long term needs.

The curves in the right show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases (beyond 5 GW, boundary capacity is supposed to increase simultaneously by homothetical steps, 1/3 MIBEL-GB, 1/3 MIBEL-FR, 1/3 MIBEL-IT). So no assessment per project are behind these values. This study should be considered as an aditional analysis with respect to the CBA assessment analysis.

In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 (where RES optimization has been carried out) in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.

Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Mid-Term and Long Term projects on the French-Spanish border were assessed according to their maturity and expected commissioning dates taking into account the following order; PST in Arkale (project 184), Biscay Gulf (Project 16), Navarra-Landes (Project 276), Aragon-Atlantic Pyrenees (Project 270)
The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

The project 's SEW accounts for savings in generation fuel and operating costs. When connecting an "electrical peninsula" the project also enables saving in generation capacity. These avoided investments in generation represent at least 40 M€/year of additional economic benefits (this figure appearing conservative compared to similar assessments in the literature.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | FR-ES: 2200 |
| | ES-FR: 2600 |
| Delta GTC contribution (2030) [MW] | FR-ES: 2200 |
| | ES-FR: 2600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1750 ±150 |
| Cost explanation | Only CAPEX is considered. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 200 ±30 | 120 ±20 | 150 ±20 | 120 ±30 | 240 ±30 |
| B3 RES integration (GWh/yr) | 40 ±40 | 460 ±200 | 960 ±190 | 700 ±250 | 1000 ±140 |
| B4 Losses (GWh/yr) | 700 ±100 | 800 ±100 | 1200 ±400 | 750 ±100 | 1200 ±200 |
| B4 Losses (Meuros/yr) | 30 ±5 | 40 ±10 | 55 ±20 | 35 ±10 | 55±20 |
| B5 CO2 Emissions (kT/year) | 2400 ±500 | 800 ±400 | ±100 | -1000 ±200 | -2300 ±200 |

The project increases flows in both directions but specially imports of the Iberian Peninsula in 2020 and 2030 V1 and exports in 2030 V3 and V4.

Savings in variable generation costs (SEW) in 2020 and 2030 V1 are caused by a decrease of gas generation in the Iberian Peninsula compensated by an increase of coal generation in Germany and Central Europe. SEW value in 2020 is higher as there is more coal than in 2030 V1. This situation results in a global increase of CO2 emissions. In 2030 V3 and

V4 the SEW is caused mainly by a decrease of CCGTs in Central Europe replaced by nuclear and RES in the region. This situation results in a global decrease of CO2 emissions. In addition, SEW is higher in the V4 top-down vision, which imply higher efficiency of a European common approach for optimizing the location of RES versus national and independent approaches of RES policies, resulting in high amount of additional RES in Iberia, mainly solar.

The project does neither show contribution to avoid ENS at national level (as scenarios are built to fulfil adequacy requirements) nor at local level in the area of the connection points. However an increased transfer capacity between Iberia and the rest of Europe would improve the system security and its robustness from the dynamic point of view.

The project also contributes to the stability of the system and helps for a full-integrated European internal energy market. No evaluation of these additional benefits is available as they are difficult to quantify and monetize.

Losses increase in all the scenarios as the project allows higher long transit power flows on long distances in order to supply the demand with the cheapest generation throughout western Europe. The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round and European-wide computation. The assessment of losses shows a very high sensitivity to assumptions regarding the detailed location of dispatched generation and requires further investigation, in order to reduce the high (up to 30 to 50%) uncertainty on the quantification of the variation of the losses on the AC network. The losses on the HVDC itself can however be rather accurately computed and account for about 250 to 350 GWh per year, depending on the visions. Last, the monetisation of losses has been performed on an hourly basis resulting in a lower amount for the annual costs of losses (compared to the methodology with average value), due to lower marginal costs in the exporting country where losses are assumed to be sourced.

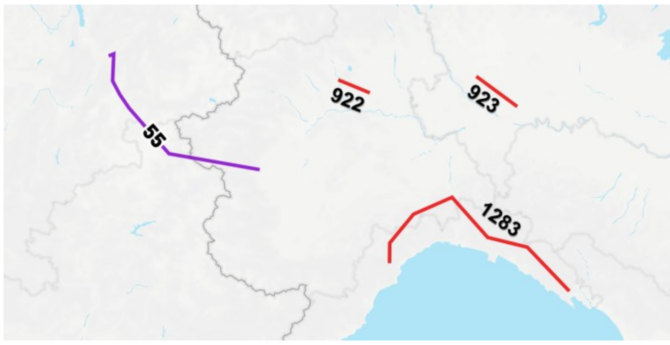
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.61 | 3.67 | 4.24 | 5.80 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 6.35 | 9.91 | 15.13 | 16.55 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 15.07 | 10.58 | 9.91 | 13.75 |

The project reduces the congestion rate in a range from 13 to 23% in 2030, depending on the scenario. After the commissioning of the project the congestions are limited to 36-48%. Moreover the project increases the interconnection ratio of Spain in 1-2% in 2030, depending on the scenario.

## Project 21 - Italy-France

The Project comprises a new 320 kV HVDC interconnection between France and Italy. The new HVDC link will connect the substations of Piossasco and Grande Ile mainly along motorway infrastructures and the Fréjus tunnel. The project includes as well the removing of limitations on existing 380 kV internal Italian lines. The removing of limitation is necessary to take full advantage of the increase of interconnection capacity provided by the cross-border line.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | France - Italy |
| PCI label | 2.5.1 |
| Promoted by | RTE;TERNA |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 55 | "Savoie - Piémont" Project :New 190km HVDC (VSC) interconnection FR-IT via underground cable with two convertor stations, mainly along motorway infrastructures and in the new gallery of the Fréjus tunnel. | 100% | Grande Ile (FR) | Piossasco (IT) | Under Construction | 2019 | Investment on time | Works in progress. |
| 922 | Removing limitations on the existing 380 kV Rondissone-Trino | 30% | Rondissone (IT) | Trino (IT) | Planning | 2019 | Investment on time | - |
| 923 | Removing limitations on the existing 380 kV Lacchiarella-Chignolo Po | 30% | Lacchiarella(IT) | Chignolo Po(IT) | Planning | 2019 | Investment on time | - |
| 1283 | Removing limitations on the existing 380 kV Vado-Vignole | 30% | Vado(IT) | Vignole(IT) | Planning | 2019 | Investment on time | |

## Additional Information

Link to Project page on RTE website

http://www.rte-france.com/fr/projet/savoie-piemont-190-km-de-solidarite-europeenne-entre-chambery-et-turin

Link to last release of the French National Development Plan

http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

Link to the last release of the Italian National Development Plan

http://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/pianidisviluppo.aspx

Link to EC Transparency Platform

http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

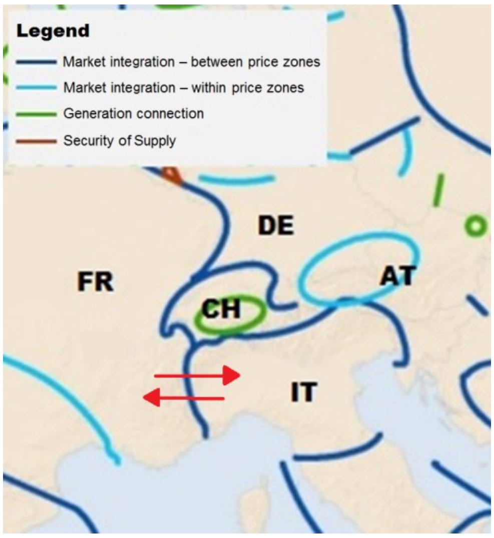
## Investment needs

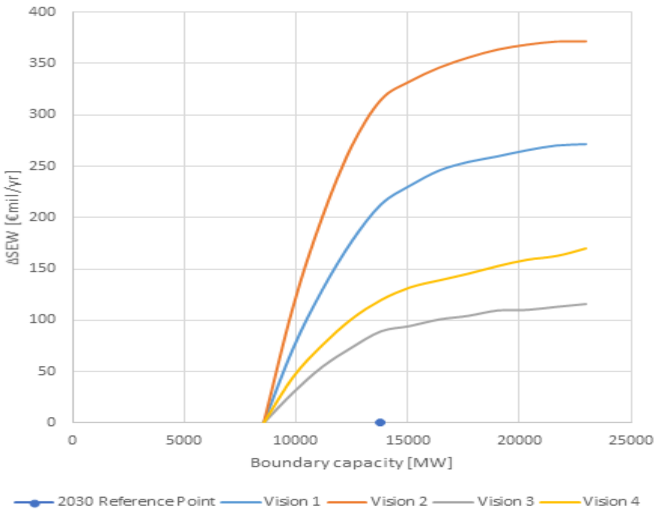
Historically, the main driver for grid development on the Northern Italian borders is the integration of the Italian peninsular system, with predominant gas generation, into the main European system where prices are ususally lower.

The project aims at increasing the capacity of the Italian northern border to improve access on the Italian peninsula to the European electricity market; it also increases possible mutual support of both countries and favours RES integration in high RES scenarios.

Therefore this border, and more in general the Italian Northern boundary, is mainly used in import direction towards Italy. TYNDP2016 market simulations have shown that in the future, the behaviour above described will be confirmed in the "low CO2 scenario", but in low load hours the flows could be observed in the opposite directions. This phenomena begin relevant in the high RES scenarios, triggered by the development of solar generation in Italy, which benefits from one of the biggest potentials in Europe. According to the results the interconnection hereby described lead the system to a more efficient use of the generation in EU, in low RES scenarios (V1 and V2), and a better integration of Italian renewable generation in the opposite frameworks (V3 and V4).

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for Vision2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-FR : 1000 |
| | FR - IT: 1200 |
| Delta GTC contribution (2030) [MW] | IT-FR : 1000 |
| | FR - IT: 1200 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1300 ±65 |
| Cost explanation | The cost value includes only CAPEX cost. The main investment is the HVDC line. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 90 ±10 | 40 ±20 | 90 ±30 | 30 ±10 | 40 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 50 ±40 | 90 ±80 |
| B4 Losses (GWh/yr) | 225 ±25 | 225 ±25 | 375 ±37 | 250 ±25 | 125 ±25 |
| B4 Losses (Meuros/yr) | 9 ±1 | 12 ±1 | 17 ±2 | 14 ±2 | 8 ±2 |
| B5 CO2 Emissions (kT/year) | 1600 ±120 | 800 ±400 | 1100 ±300 | -300 ±100 | -400 ±200 |

As all projects on the northern Italian border, this project was assessed via the Multiple TOOT/PINT approach according to their maturity and expected commissioning date, taking into account the capacity increases confirmed by the grid studies.

CBA results show a stable benefit for all visions, except for EP2020 and Vision 2 where it is higher, due to the fact that coal is before gas in the merit order, which increases the Italian imports. As for many projects in TYNDP, the project decreases CO2 emissions only in high RES scenarios (Visions 3 and 4), as for the other visions with low CO2 prices, increasing exchanges favour coal generation that is cheaper but more emitting than gas generation. Some benefit in terms of RES integration (especially solar energy in Italy) can be captured only in high RES scenarios.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.86 | 1.71 | 1.11 | 2.34 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.90 | 5.71 | 7.18 | 10.72 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.64 | 16.99 | 4.06 | 6.01 |

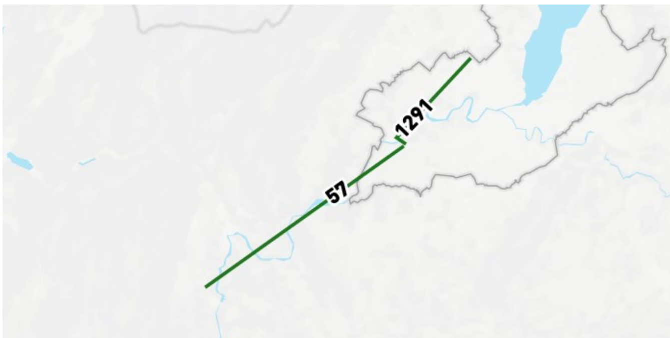
The above table shows that the prices convergence is quite good in the reference case (taking into account the planned projects) in all scenarios. Nevertheless the standard deviation of price differential remains significant in the visions with high RES; in this respect, projects on this border provide market players with additional hedging against prices volatility. They also increase the flexibility of the Italian system to cope with operational issues like accomodating the high generation ramping rates inherent to systems with high RES penetration. All these additional benefits are not captured in the SEW.

## Project 22 - Lake Geneva West

The project consists of uprating the existing 225-kV double circuit overhead line Genissiat- (FR) - Verbois (CH) - Foretaille (CH) in order to increase its capacity.

Génissiat - Verbois will be implemented first and provide increased interconnection capacity; in a second stage, Verbois - Foretaille will improve the security of supply of Geneva area.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | France - Switzerland |
| PCI label | |
| Promoted by | RTE;SWISSGRID |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 57 | Reinforcement of the interconnection in the area of Geneva's lake. | 100% | Genissiat (FR) | Verbois (CH) | Planning | 2018 | Rescheduled | Feasibility studies showed the works are lighter and could be achieved earlier than initially thought. |
| 1291 | reinforcement of the existing 220 kV double line | 20-30% | Foretaille (CH) | Verbois (CH) | Design & Permitting | 2023 | New Investment | Investment Foretaille - Verbois 1. Improves the security of supply in the area of Geneva 2. Ensures that the CH-FR GTC can be further increased once the investment Génissiat-Verbois has been realised |

### Additional Information

*Link to the French National Development Plan:*

http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

*Link to the Swiss Strategic Grid 2025:*

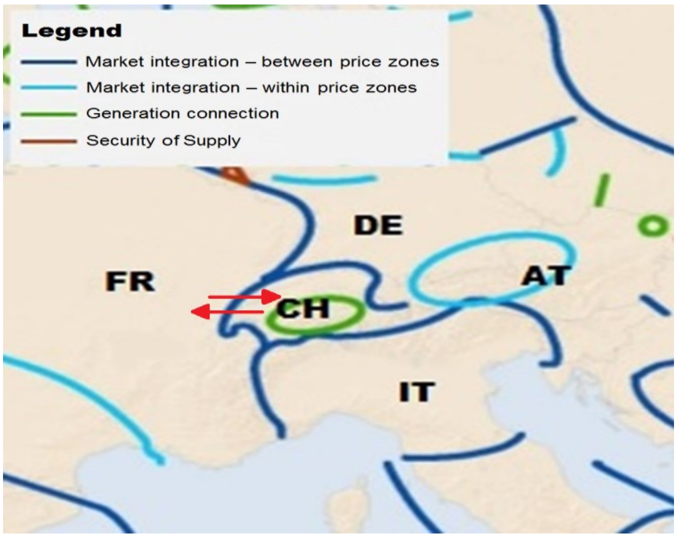
https://www.swissgrid.ch/swissgrid/en/home/grid/grid_expansion.html

## Investment needs

The upgrade of Genissiat-Verbois 225kV double-circuit line is the first step for increasing the capacity on the France - Switzerland border by optimizing the existing grid. Project 253 (Upstream reinforcement in France to increase FR-CH capacity) and project 199 (Lake Geneva South) may follow at a later stage.

The benefits of this project are mainly linked with the increase of exchanges from France to Switzerland, as the natural flows when Switzerland imports are concentrated in the Western part of the Geneva Lake due to higher demand north of the Lake.

Analyses on this border showed that the benefit SEW provided by a standard 1 GW capacity increase is around 10M€ in all 2030 visions except in Vision 4 where it is higher.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | FR-CH: 500 |
| | CH-FR: 0 |
| Delta GTC contribution (2030) [MW] | FR-CH: 550 |
| | CH-FR: 100 |
| Capex Costs 2015 (M€) | 60 ±12 |

| | |
|---|---|
| Source: Project Promoter | |
| Cost explanation | The cost value includes only CAPEX cost.<br><br>Cost on the French side is around 3 M€ (upgrade of the ampacity of the Genissiat Verbois 225 kV lines). |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | 20 ±10 |
| B4 Losses (GWh/yr) | 0 ±25 | 50 ±25 | 100 ±25 | 25 ±25 | 100 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 2 ±2 | 4 ±2 | 1 ±2 | 6 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | ±100 | ±100 | -100 ±0 |

The SEW provided by this project remains quite stable for all visions, except for Vision 4 where it is higher, linked to a higher amount of integrated RES.

Regarding CO2 emissions and losses, the impact of the project can be considered as neutral.

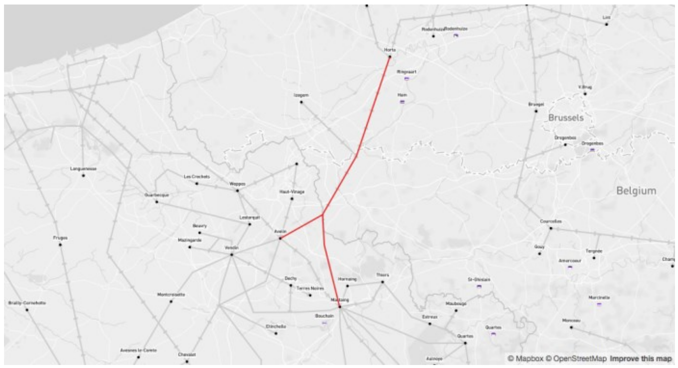
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.43 | 1.07 | 0.81 | 1.96 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.77 | 4.58 | 6.21 | 10.10 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.29 | 7.85 | 2.35 | 3.96 |

The above table shows that the prices convergence is quite good in the reference case (taking into account the planned projects) in all scenarios. The portfolio of projects on this border helps reducing the gap between market prices significantly, especally in V1 and V2.

## Project 23 - France-Belgium  Phase 1

The project consists in the reconductoring of the existing 80km double-circuit 400kV AC cross-border line between Lille(Avelin/Mastaing, FR) - Avelgem (BE) - Zomergem (Horta, BE) with High Temperature Low Sag conductors to double its capacity.  The project aims at ensuring reliable grid operation to cope with more volatile south-north flows, and at increasing the interconnection capacity between France & Belgium to sustain an adequate level of market integration.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | France - Belgium |
| PCI label | |
| Promoted by | ELIA;RTE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 60 | Replacement of the current conductors on the axis Avelin/Mastaing - Avelgem - Horta with high performance conductors (HTLS = High Temperature Low Sag) | 100% | Avelin/Mastaing (FR) | Horta (BE) | Design | 2022 | Rescheduled | Detailed feasibility studies showed the works could be achieved by 2022, earlier than initially planned, assuming acquisition of all necessary permits as planned. |

### Additional Information

The project is integrated in RTE's 2015 National Development Plan: http://www.rte-france.com/fr/actualite/preparer-le-systeme-electrique-de-demain-apres-consultation-publique-rte-publie-son-schema

The project is integrated in Elia's National Development Plan 2015-2025: http://www.elia.be/fr/grid-data/grid-development/plans-d-investissements/federal-development-plan-2015-2025

### Investment needs

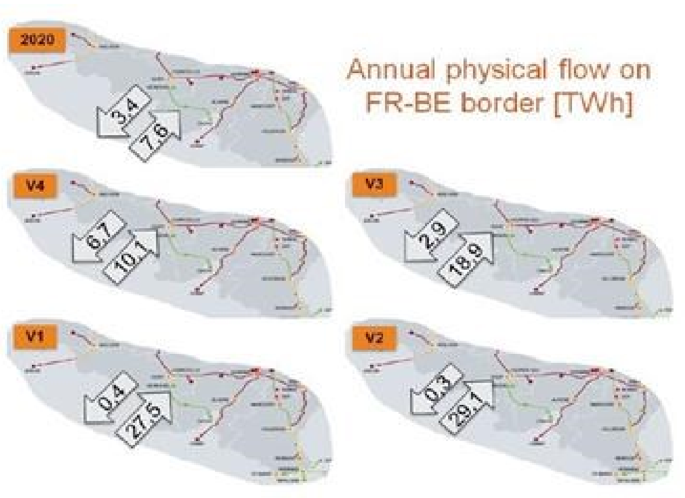
The main driver is relieving congestion on the French-Belgium border resulting from higher bulk power flows within the CWE area, transporting energy through and to Belgium.

Increasing the interconnection capacity between France and Belgium creates synergies between the export position of France in favorable meteorological conditions and the import position of Belgium in "coal before gas" market conditions, with higher flows from south (France) to north (Belgium) appearing more frequently on the French-Belgium border.

In the visions 3 & 4 characterized by increased RES integration and "gas before coal" market conditions, the bulk power flows are more volatile and induce both high south-north as well as north-south flows on the French-Belgium border.

This project notably increases the transmission capacity between France and Belgium, evaluated as an 1 GW increase. In addition, projects under study 173 & 280 show signals of complementary effects, assuming a total transmission capacity increase of 2 GW.

TYNDP analyses showed that a 1-GW capacity increase on this border provides an additional SEW of about 20-40 M€ depending on the vision.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | FR-BE: [800 ; 1200] |
| | BE-FR: [800 ; 1200] |

| | |
|---|---|
| Delta GTC contribution (2030) [MW] | FR-BE: [600 ; 1000] |
| | BE-FR: [600 ; 1000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 140 ±20 |
| Cost explanation | Cost represents currently expected total project investment cost. Uncertainty range is related to procurement/construction cost uncertainties. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | 20 ±10 | 20 ±10 | 30 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±20 | <10 | 500 ±140 | 190 ±20 |
| B4 Losses (GWh/yr) | 200 ±50 | 200 ±50 | 200 ±50 | 150 ±50 | 150 ±50 |
| B4 Losses (Meuros/yr) | 8 ±2 | 10 ±3 | 9 ±3 | 9 ±3 | 10 ±3 |
| B5 CO2 Emissions (kT/year) | 100 ±30 | 200 ±200 | 100 ±300 | -100 ±100 | -200 ±100 |

The GTC is assessed taking into account remedial actions on the Aubange–Moulaine 225kV axis, and is slightly lower in 2030 than 2020 given the evolution in how the bulk power flows spread out across the different branches of the FR-BE border.

The SEW increase is relatively stable across the different visions, emphasizing the structural benefit of relieving congestion on the French-Belgium border. The higher RES integration benefits in Visions 3 and 4 relate to the nature of these scenarios. With regards to CO2 emissions, the project can be considered to have a neutral effect.

In all scenarios the project sustains higher bulk power flows and consequently higher losses through the AC grid.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.62 | 1.05 | 2.31 | 1.45 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.36 | 4.64 | 10.48 | 8.08 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 17.81 | 16.19 | 1.00 | 0.66 |

## Project 24 - Belgian North Border: BRABO I

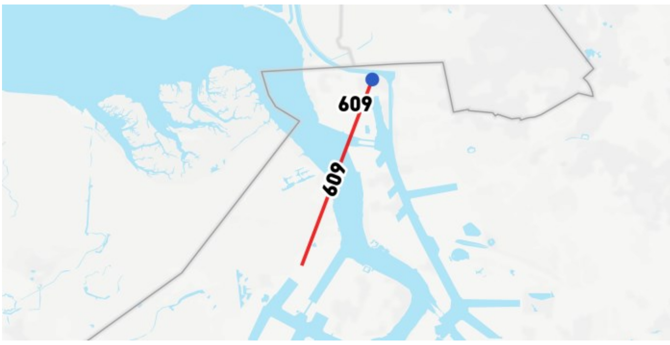
Installation of an additional PST in Zandvliet, the 4th on the Belgian North Border, combined with the upgrade of the 150kV AC line Doel-Zandvliet to a 380kV line

Classification: Mid-term Project

Boundary: Belgium (Antwerp area) - Netherlands

PCI label:

Promoted by: ELIA




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 609 | Installation of an additional PST in Zandvliet (BE) combined with the upgrade of the 150kV AC line Doel (BE) - Zandvliet (BE) to a 380kV line. | 100% | Zandvliet (BE) | | Under Construction | 2016 | Investment on time | Progressed as planned. |

### Additional Information

This project is integrated in Elia's National Development Plan 2015-2025: http://www.elia.be/nl/grid-data/grid-development/investeringsplannen/federal-development-plan-2015-2025

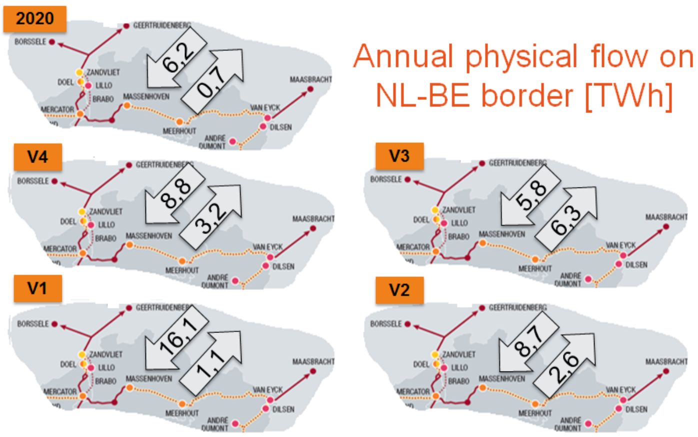
Additional information can be found back on the project's dedicated website: http://www.elia.be/nl/projecten/netprojecten/brabo

### Investment needs

.The development of the Belgian North Border is driven by a congruation of factors: facilitate market integration and security-of-supply by increasing the interconnection capacity between Belgium & Netherlands, secure the supply of electricity around the Antwerp harbour area in light of the increasing industrial demand, and develop capacity for the potential integration of new production units.

Increasing integration of wind in the northern part of Germany results into higher and more volatile bulk power flows that can be exported from Germany in favorable meteorological conditions, through the Netherlands and into/through Belgium. This creates congestions on the Belgian North Border, especially in winter conditions with large North-South oriented flows in the CWE region. The Belgian North Border has to be reinforced to alleviate these congestions which would otherwise limit the potential for market exchanges within the CWE zone.

This project # 24 constitutes the first phase of the BRABO project (phases II & III are listed as project # 297). The BRABO project aims - amongst others - at increasing the interconnection capacity between Belgium and the Netherland with 1000 MW. This increase can be obtained in the direction from NL to BE via project 24 for as long as the production at substation Doel does not surpass 2 GW. In the direction from BE to NL the 1000 MW increase can be obtained after the realization of the substation Rilland (NL) (part of project #103) by TenneT.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE-NL: 1000 |
| | NL-BE: 1000 |
| Delta GTC contribution (2030) [MW] | BE-NL: [700 ; 1000] |
| | NL-BE: [700 ; 1000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 30 ±5 |
| Cost explanation | The provided cost represents the currently expected total investment cost. |

| | |
|---|---|
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 10 ±10 | 10 ±10 | <10 | 20 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 10 ±20 | 200 ±60 | 120 ±50 |
| B4 Losses (GWh/yr) | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 200 ±30 | 200 ±100 | ±100 | ±100 | ±100 |

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

The slight difference in GTC increase between 2020 and 2030 is related to the different production park setting (planned nuclear phase out in Belgium by 2025).

The increase in SEW is ~10 M€ in coal before gas scenarios (2020, 2030V1, 2030V2) and ~20 M€ in the gas before coal scenarios (2030V3, 2030V4). The higher RES integration benefit in the 2030 V3 & V4 scenario's is related to the nature of these scenario's containing more RES in the production mix. With respect to the CO2 impact, there is a very minor increase in the coal before gas scenarios due to the replacement of gas by coal, and a neutral effect in the gas before coal scenarios.

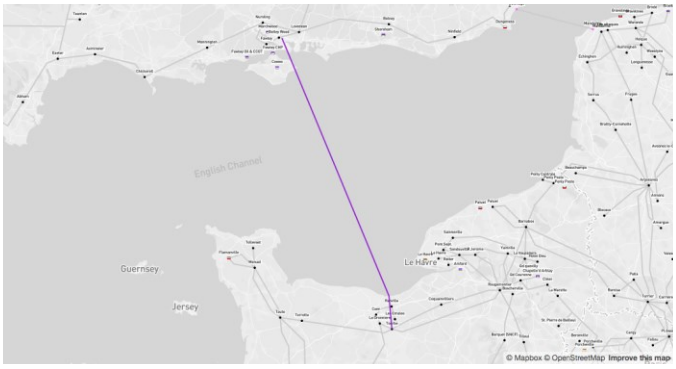
The effect on the losses is estimated to be neutral. At one hand the project enables higher bulk power to be transported. On the other hand the project increases the flow regulation capability of the Belgian North Border and lowers the impedance between Zandvliet and Doel substations.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.52 | 0.13 | 0.88 | 0.60 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.08 | 1.49 | 6.41 | 5.06 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.65 | 2.66 | 4.08 | 3.78 |

# Project 25 - IFA2

IFA2 is a new HVDC VSC subsea interconnector that will develop between Tourbe in France (area of Caen) and Chilling in Great Britain (area of Southampton). It has been selected as PCI 1.7.2 in the NSOG corridor on 14/10/13.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | France - Great Britain |
| PCI label | 1.7.2 |
| Promoted by | NGIHL;RTE |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 62 | New subsea HVDC link between the UK and France. Capacity is still to be determined. (Possibly 1000MW) | 100% | Tourbe (FR) | Chilling (GB) | Permitting | 2020 | Investment on time | On the French side, the Ministry of Energy aknowledged the notification of the investment on 08/04/14. |

## Additional Information

More information related to the project can be found on IFA2 project website. Added to general project statements, specific information are given for both sides of the Channel (Public consultation, phases of the project...).

The project is also part of both French and British National Development Plans.

In addition IFA2 project has been confirmed on 27 January 2016 as Project of Common Interest in the priority corridor Northern Seas Offshore Grid (NSOG), included in cluster 1.7 (Commission Delegated Regulation 2016/89 of 18 November 2015).

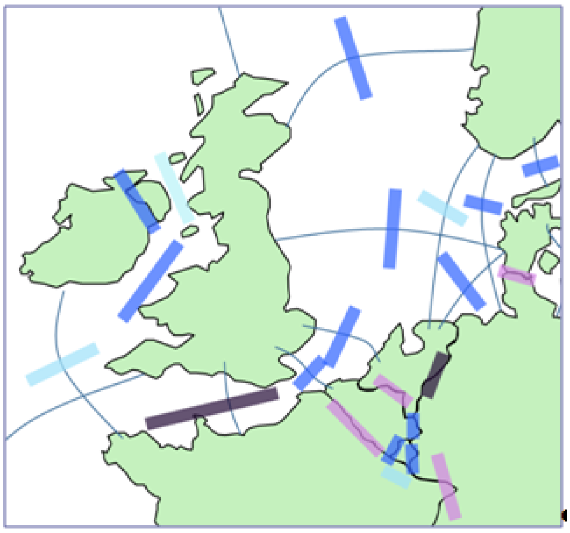
## Investment needs

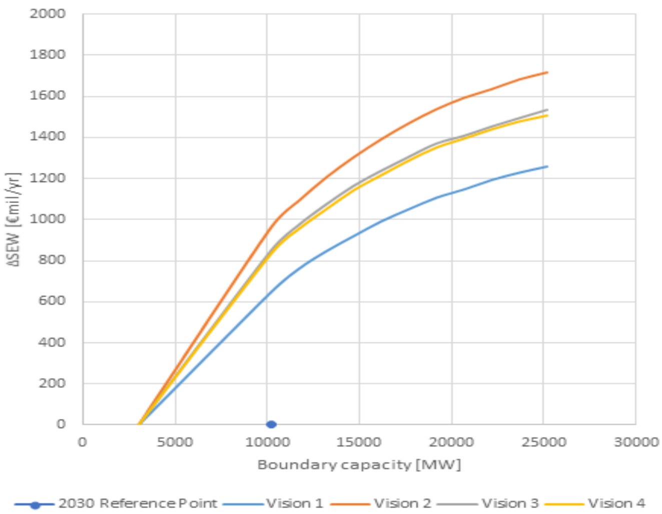
The TYNDP2016 High RES scenario market analysis, performed in the Common Planning Studies phase, has shown a market-based target capacity between France and Great Britain of more than 5GW. The objective of IFA2 project is to increase the interconnection capacity between Great Britain and continent, and to integrate more RES generation, especially wind generation in Great Britain.

Chosen connection points on both French and British transmission grid allow a safe operation for both studied time horizons 2020 and 2030. The full capacity (1000MW) can be used without leading to unmanageable critical system failure.

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between Great Britain and the continent . On the SEW/GTC graph we can see that even starting from a 2030 capacity of about 10GW between Great Britain and the continental and Nordics areas, extra capacity still allows savings on the boundary.

IFA2 project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between Great Britain and the continent.






## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | GB-FR: 1000 |
| | FR-GB: 1000 |
| Delta GTC contribution (2030) [MW] | GB-FR: 1000 |
| | FR-GB: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 685 ±145 |
| Cost explanation | Compared to TYNDP2014, and thanks to most recent bilateral cost evaluations performed by promoters, the estimated cost and the uncertainty range do not change. Only CAPEX is considered here. |
| S1 | 15-50km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 90 ±20 | 60 ±10 | 100 ±10 | 90 ±20 | 80 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 740 ±200 | 910 ±280 | 520 ±150 |
| B4 Losses (GWh/yr) | -300 ±30 | 0 ±25 | 350 ±35 | 650 ±65 | 650 ±65 |
| B4 Losses (Meuros/yr) | -14 ±2 | 0 ±1 | 16 ±2 | 39 ±4 | 43 ±5 |
| B5 CO2 Emissions (kT/year) | 1600 ±230 | 1000 ±200 | 400 ±300 | -600 ±200 | -600 ±200 |

The Social Economic Welfare of the project is promising and close to 80-100M€ / year in all visions and time horizon, except in Vision 1 2030 where it is 60M€/year.

In 2020, the project decreases the overall losses. This is mainly due to the high flows from France to Great Britain. This energy is directly brought by the project to the south of Great Britain, close to the high demanding area of Greater London. Then the AC losses are highly reduced in Great Britain (less need to bring power from the north of the country to the south).

In 2030, even considering the unavoidable losses through the HVDC itself, the impact of the project on the overall losses is neutral in Vision 1. In vision 2 the flows are more balanced between the two countries, so the losses increase. In vision 3 and 4, France is mainly importing from Great Britain, and this energy has to reach high demanding areas in France (e.g Greater Paris area) but also in all Europe, which explain that the losses are higher.

Ofgem has published an initial project assesmnet of the Cap and Floor regime for the projects FAB Link, IFA2 VIking Link and Greenlink. This document states that the revenues from the capacity market, for this project in particular could be around 21 millions pounds annually.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.92 | 7.80 | 8.25 | 7.26 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.72 | 13.56 | 19.68 | 18.44 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.60 | 13.49 | 10.67 | 11.29 |

# Project 26 - Austria - Italy

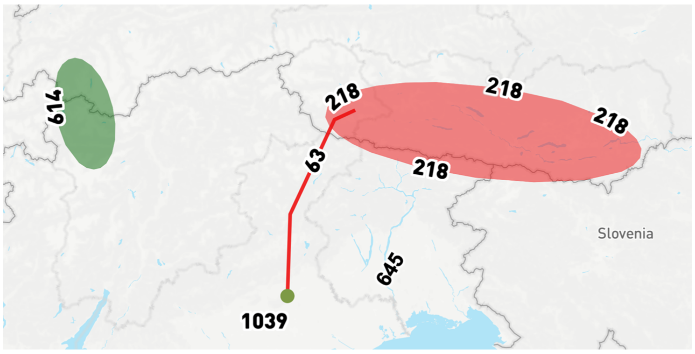
Reinforcement of the interconnection between Italy and Austria via two new crossborder links at 380 kV and 220 kV and closure of the 380-kV-Security Ring in Austria.

Classification Long-term Project

Boundary Austria - Italy

PCI label 3.2.1 (Lienz - Veneto region) and
3.2.2 (Lienz - Obersielach)

Promoted by APG;TERNA




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 63 | Reconstruction of the existing 220kV-interconnection line as 380kV-line on an optimized route | 70-80% | Lienz (AT) | Veneto region (IT) | Planning | 2024 | Rescheduled | Planning in progress coordinatedly between TERNA and APG |
| 218 | New 380kV OHL connecting the substations Lienz (AT) and Obersielach (AT) | 20-30% | Obersielach (AT) | Lienz (AT) | Planning | 2024 | Rescheduled | Tests and gaining of experience for novel technical solution in progress. |
| 614 | New 220kV interconnector between the substations Nauders (AT) and Glorenza (IT) | 20-30% | Nauders (AT) | Glorenza (IT) | Design | 2020 | Delayed | Common planning progress between Terna and APG ongoing. |
| 1039 | New 380/220/132 kV substation | 100% | Volpago (IT) | | Planning | 2022 | Investment on time | - |

## Additional Information

With the decision C(2013) 7520, the Terna and APG application for TEN-E programm (TEN-E 319/12) for "network and feasability study for a new alternate current extra high voltage Interconnection" has been approved, the goal of the study is to analyse the possibility to increase the cross border capacity through removing the existing limitation on the 220 kV existing line as well. The TEN-E programm will identify the temporal steps of the project implementation.

The PCI 3.2.2 / investment 218 is part of the Austrian 380-kV ring and therefore a major basis for a secure and efficient connection of existing generation and demand areas as well as a prerequisite for further connection of hydro storage power plants in the western/southern part of Austria as well as for realisation of further powerful interconnectors.

Looking at the investment 218 itself without the context of the project 26, the increase of transmission capacity is not only given on the AT-IT border. Due to the fact, that this investment is the key for closing the important 380-kV-ring in Austria, an capacity increase on regional level and for wide area transports is achieved. Therefore additional benefits in terms of GTC increases on other borders than “AT-IT” are existent but were not in the scope of the assessment of project 26 within the TYNDP. These benefits on other borders have to be respected for assessment according to Regulation 347 Annex IV.1. In sum the increases on all borders e.g. together with Germany or Slovenia are higher than 500 MW.

Link to last release of the Italian  National Development Plan 2016

http://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/pianidisviluppo.aspx

Link to last release of the Austrian National Development Plan:

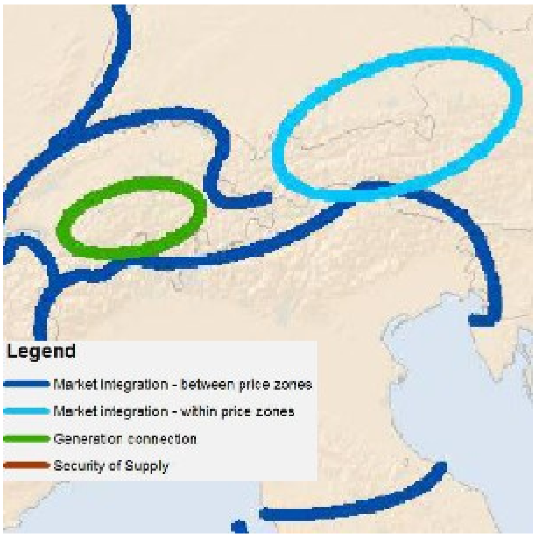
http://www.apg.at/en/grid/grid%20expansion/Netzentwicklungsplan

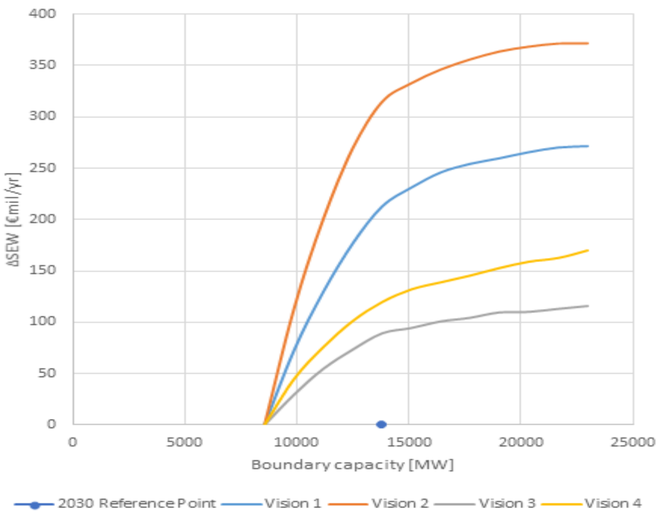
## Investment needs

Historically, the main driver for grid development on the Northern Italian borders is the integration of the Italian peninsular system, with predominant gas generation, into the main European system where prices are ususally lower. Therefore this border, and more in general the Italian Northern boundary, is mainly used in import direction towards Italy. Nevertheless, according to the TYNDP2016 market simulations this behaviour above described could change in low load hours, especially in "high RES scenario", where the flows could be in the opposite directions.

This  interconnection, therefore, will allow to increase the efficient use of EU generation in low CO2 price scenario, by the possibility to cover the Italian demand through the cheaper power plants located in North-East Europe, while, in high CO2 price scenario, it will allow to improve the integration of Italian RES generation to the rest of EU system, by the use of pumping storage capacity located in Austria.

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for V2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.
The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IT-AT: 1000 |
| | AT-IT: 1100 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 715 ±100 |
| Cost explanation | The estimated costs include:<br><br>Item 63 (Lienz – Veneto Region)<br>Item 218 (Lienz – Obersielach)<br>Item 614 (Nauders – Glorenza and internal reinforcements)<br>Item 1039 (S/E Volpago) |
| S1 | Negligible or less than 15km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| **Scenario specific CBA indicators** | **EP2020** | **Vision 1** | **Vision 2** | **Vision 3** | **Vision 4** |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 30 ±10 | 30 ±20 | 20 ±20 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 70 ±60 | 30 ±20 |
| B4 Losses (GWh/yr) | N/A | 75 ±25 | 75 ±25 | -425 ±42 | -150 ±25 |
| B4 Losses (Meuros/yr) | N/A | 4 ±1 | 3 ±2 | -26 ±3 | -10 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | 600 ±200 | 400 ±200 | -100 ±100 | -300 ±100 |

The project has been assessed according to multiple TOOT approach on the Italian Northern Border.

In the CBA results, only the GTC increase on the common border AT-IT is calculated. It is important to mention, that especially for the Austrian internal investment 218, also the GTC on other Austrian borders is possitively influenced due to the fact that internal congestions are relieved.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| **Complementary information about the border on which the project is located** | **Vision 1** | **Vision 2** | **Vision 3** | **Vision 4** |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.43 | 1.14 | 1.42 | 0.91 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.97 | 4.50 | 8.33 | 5.85 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 11.00 | 13.20 | 2.11 | 2.01 |

*Comment on the security of supply:* The security of supply (SoS) indicator is to be understood in the way it is defined within the Cost Benefit Analysis methodology which focuses merely on the connection of partly isolated grid areas. In general in rather meshed parts of the transmission grids other aspects are more significant for the security of supply (e.g. n-1-margin, cascade effects, etc.) and therefore the project benefit indicator on SoS according to the CBA methodology underestimates the real value of the project. The considered project is vital for the Austrian SoS. It comprises an important part of the Austrian 380-kV-Security Ring, enforces the east-west connection in Carinthia and improves the connection to distribution grids.

## Project 28 - Italy-Montenegro

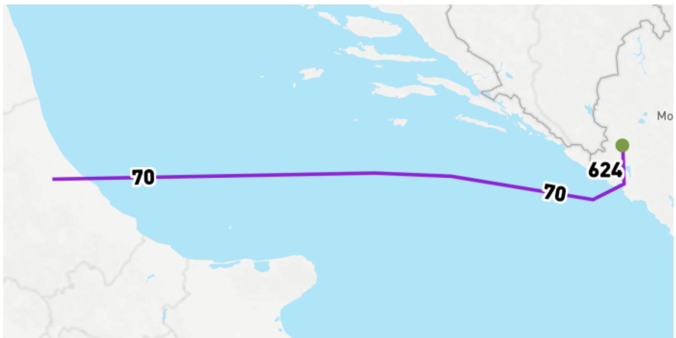
The Italy-Montenegro interconnection project includes a new HVDC subsea cable between Villanova (Italy) and Lastva (Montenegro) and the DC converter stations.The HVDC link between Italy and Balkansis correlated with the Transbalkan Corridor (projects 146 and 227) and the Mid Continental East Corridor (project 144).

Classification Mid-term Project

Boundary Italy - Montenegro

PCI label 3.19.1

Promoted by CGES;TERNA




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 70 | New 1200MW HVDC interconnection line between Italy and Montenegro | 100% | Villanova (IT) | Lastva (ME) | Under Construction | 2019 | Investment on time | Works in progress. |
| 624 | 400 kV AC substation for connection of the HVDC Montenegro - Italy and supply of coastal network in Montenegro | 100% | Lastva (ME) | | Under Construction | 2016 | Rescheduled | The commissioning date has been updated to be coherent with the new schedule of the activities also considering that the construction phase of the substation started in mid 2014 |

### Additional Information

PCI information:

https://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/progettidiinteressecomune.aspx

Link to the last release of the Italian National Development Plan:

http://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/pianidisviluppo.aspx

## Investment needs

The project will allow to have a link between the Italian peninsula and the South East Europe in order to help the most efficient use of generation capacity located in Eastern countries; to enable possible mutual support of Italian and Balkan power systems and to contribute the RES integration, as the solar generation in Italy, in the European interconnected system by improving cross border exchanges.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | ME-IT : 1200 |
| | IT - ME: 1200 |
| Delta GTC contribution (2030) [MW] | ME-IT : 1200 |
| | IT - ME: 1200 |
| Capex Costs 2015 (m€) | 1246 ±65 |

| | |
|---|---|
| Source: Project Promoter | |
| Cost explanation | The estimated costs include:<br>Item 70 (New 1200MW HVDC interconnection line between Italy and Montenegro)<br>Item 624 (SS 400/110 kV Lastva) |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 130 ±20 | 140 ±50 | 150 ±50 | 140 ±40 | 60 ±40 |
| B3 RES integration (GWh/yr) | 50 ±10 | <10 | <10 | 1650 ±400 | 350 ±190 |
| B4 Losses (GWh/yr) | 325 ±25 | 400 ±40 | 400 ±40 | 125 ±25 | -50 ±25 |
| B4 Losses (Meuros/yr) | 14 ±1 | 21 ±3 | 18 ±2 | 7 ±2 | -4 ±2 |
| B5 CO2 Emissions (kT/year) | 1400 ±170 | 2800 ±1600 | 1400 ±500 | -600 ±500 | -600 ±200 |

The project has been assessed according to the TOOT approach in both market and network analysis.

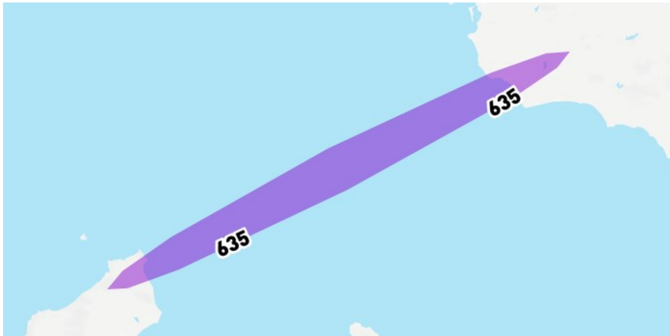
The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.79 | 6.88 | 10.05 | 5.23 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 10.48 | 9.48 | 23.07 | 16.51 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.41 | 18.77 | 5.08 | 3.79 |

## Project 29 - Italy-Tunisia

The project consists in a new interconnection between Tunisia and Sicily to be realized through an HVDC submarine cable. The realization of the project is supported by the Italian and Tunisian Governments to increase the interconnection capacity of the Euro-Mediterranean system. Moreover, the project will contribute to reduce, under specific conditions, present and future limitations to the power exchanges on the northern Italian border, with France, Switzerland, Austria and Slovenia, and therefore it will allow to significantly increase the transmission capacity and its exploitation by at least 500 MW on that boundary.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Italy - Tunisia |
| PCI label | |
| Promoted by | TERNA |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 635 | New interconnection between Italy and Tunisia -new DC submarine cable | 100% | Sicily Area (IT) | Tunisia node | Planning | 2022 | Investment on time | - |

## Additional Information

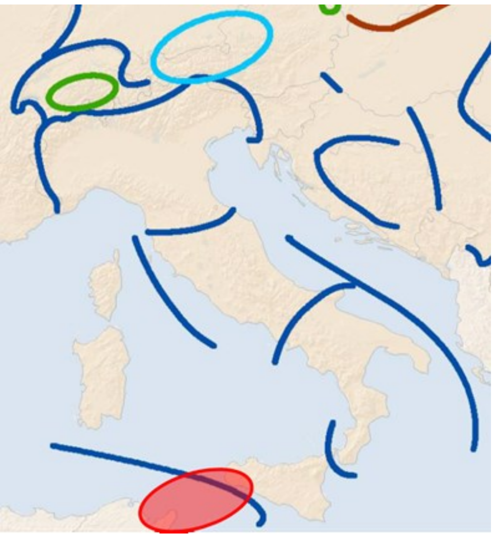
Link to the last release of the Italian National Development Plan

http://www.terna.it/en-gb/sistemaelettrico/pianodisviluppodellarete.aspx

## Investment needs

The project hereby described will allow to improve, significantly, the interconnection of the EU system with the North Africa countries in order to guarantee the possibility, in the short-mid term, to cover the African countries demand by the generation surplus of EU countries, especially in unbalanced load conditions; and in the long term, to import the large scale RES generation under development.
The project will allow also to increase the operational flexibility of both systems.

The analysis performed has showd a general high SEW for the project, especially in the high RES scenarios.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | TU-IT: 600 |
| | IT-TU: 600 |
| Delta GTC contribution (2030) [MW] | TU-IT: 600 |
| | IT-TU: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 600 ±90 |
| Cost explanation | The project cost could be significantly affected by the design solution adopted as well as eventual reinforcments required within both Italian and Tunisian grids. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 190 ±30 | 100 ±20 | 120 ±20 | 170 ±30 | 130 ±20 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 890 ±180 | 260 ±50 |
| B4 Losses (GWh/yr) | 175 ±25 | 200 ±25 | 175 ±25 | 175 ±25 | 175 ±25 |
| B4 Losses (Meuros/yr) | 7 ±1 | 10 ±2 | 8 ±1 | 10 ±2 | 11 ±2 |
| B5 CO2 Emissions (kT/year) | 700 ±100 | ±100 | 300 ±100 | -800 ±100 | -700 ±100 |

Regarding the GTC indicator: in addition to the GTC made available on the border Italy - Tunisia, the project will contribute to reduce, under specific conditions, balancing problems causing limitations to the transmission capacity and to power exchanges on the northern Italian border. In this respect, based on the results of the performed studies, the project will make possible to increase the transmission capacity and its exploitation by at least 500 MW on the norther border with France, Switzerland, Austria and Slovenia.

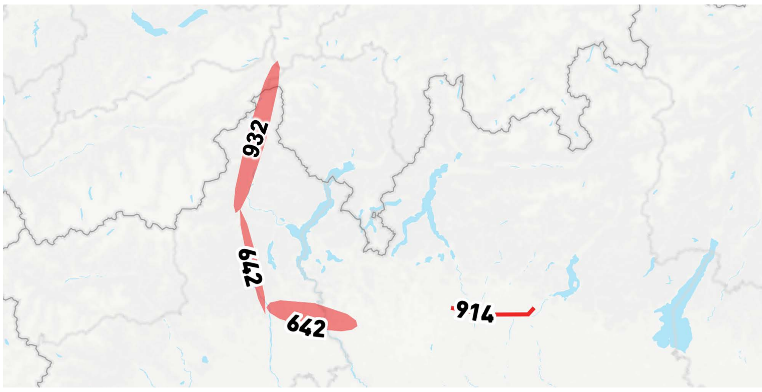
The power system of Northern Africa has been modelled using confidential data provided by STEG (Tunisian Company of Electricity and Gas) after the definition of TYNDP 2016 scenarios.
The Tunisian power system has been implemented on ENTSO-e models and used for CBA; the approach is coherent with criteria used for all projects present in the TYNDP 2016.

The mentioned benefits will be achieved according to different future scenarios.

## Project 31 - Italy-Switzerland

o The project consists of a new 400 kV line San Giacomo-Pallanzeno, conversion from AC to DC of the 220 kV line between S. Giacomo and Milan area, including the realization of two newAC/DC converter stations and to the 220 kV to 400 kV substation upgrade. Additional internal lines in Italy and in Switzerland are required to get the full advantage from the interconnection capacity provided by the cross-border line.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Switzerland - Italy |
| PCI label | PCI 2.15.1 |
| Promoted by | SWISSGRID;TERNA |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 642 | Interconnection IT-CH;S. Giacomo project | 100% | Airolo (CH) | Pallanzeno(IT)-Baggio(IT) | Design & Permitting | 2022 | Investment on time | progressed as planned |
| 914 | Upgrade to 380 kV of existing 220 kV | 100% | Cassano (IT) | Chiari (IT) | Design & Permitting | 2022 | Investment on time | progressed as planned |
| 932 | new 400 kV section in Magenta substation | 100% | Magenta(IT) | | Design & Permitting | 2020 | Investment on time | progressed as planned |

### Additional Information

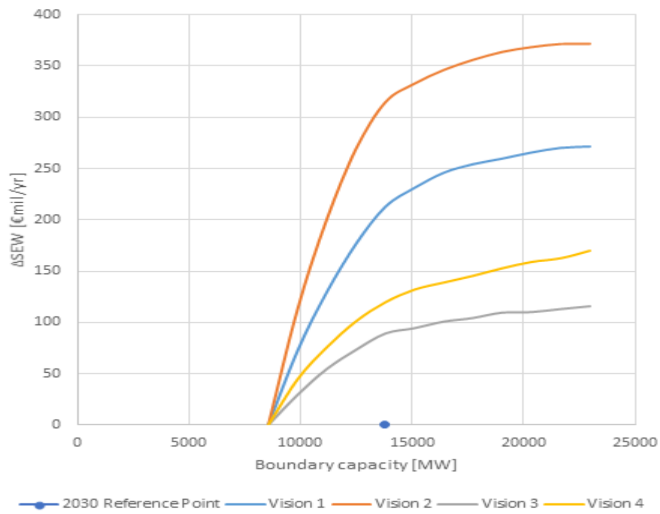
PCI information:
https://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/progettidiinteressecomune.aspx

### Investment needs

Historically, the main driver for grid development on the Northern Italian borders is the integration of the Italian peninsular system, with predominant gas generation, into the main European system where prices are ususally lower. Therefore this border, and more in general the Italian Northern boundary, is mainly used in import direction towards Italy. Netherless, according to the TYNDP2016 market simulations this behaviour above described could change in low load hours, especially in "high RES scenario", where the flows could be in the opposite directions.

This interconnection, therefore, will allow to increase the efficient use of EU generation in low CO2 price scenario, by the possibility to cover the italian demand through the cheaper power plants located in North-West Europe, while, in high CO2 price scenario, it will allow to improve the integration of Italian RES generation to the rest of EU system, by the use of pumping storage capacity located in Switzerland.

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for Vision2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-CH: 600 |
| | CH-IT: [1000 ; 1100] |
| Delta GTC contribution (2030) [MW] | IT-CH: 750 |
| | CH-IT: 750 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 995 ±100 |
| Cost explanation | The estimated costs include:<br>Item 642 Pallanzeno(IT)-Baggio(IT)-Airolo (CH) 910 M€<br>Item 914 Cassano (IT) - Chiari (IT) 60 M€ |

| | |
|---|---|
| | Item 932 Magenta substation 25 M€ |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 40 ±< 10 | 10 ±10 | 30 ±20 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | 30 ±20 |
| B4 Losses (GWh/yr) | 50 ±25 | -25 ±25 | -25 ±25 | 25 ±25 | 25 ±25 |
| B4 Losses (Meuros/yr) | 2 ±1 | -2 ±2 | -1 ±1 | 1 ±2 | 1 ±2 |
| B5 CO2 Emissions (kT/year) | 1000 ±70 | 300 ±100 | 400 ±300 | ±100 | -300 ±100 |

As all projects on the northern Italian borders, this project was assessed via the Multiple TOOT/PINT aproach according to their maturity and expected commissioning date, taking into account the capacity increases confirmed by the grid studies.

The approach used for assessing benefits for that project is the multiple TOOT, as adopted for all projects on the Italian northern border. The multiple TOOT approach method tends to yield greater benefits for projects commissioned first.

In other terms, if some project expected to be built before the commissioning of Project 31 turned out to be built later its commissioning, it would lead to an increase of benefits provided by Project 31.

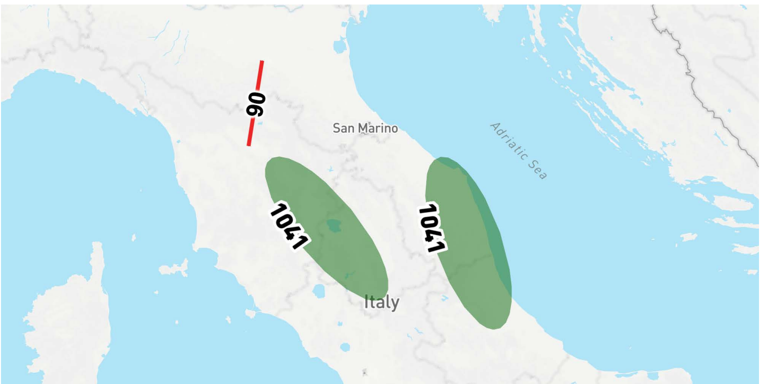
The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.46 | 0.67 | 0.38 | 0.59 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.89 | 3.56 | 4.20 | 4.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.55 | 9.18 | 1.81 | 2.12 |

## Project 33 - Central Northern Italy

The project consists in the strengthening of interconnection between the northern and the central part of Italy. It will involve the upgrading of existing 220 kV over-head line to 400 kV between Colunga and Calenzano substations as well as the removing of limitations on the existing 220 kV network in Central Italy.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Italy Center- Italy South |
| PCI label | |
| Promoted by | TERNA |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 90 | Voltage upgrade of the existing 80km Calenzano-Colunga 220kV OHL to 400kV, providing in and out connection to the existing 220/150kV substation of S. Benedetto del Querceto (which already complies with 400kV standards). | 100% | Calenzano (IT) | Colunga (IT) | Design & Permitting | 2022 | Delayed | delay in the permitting process (EIA) |
| 1041 | Removing limitations on existing 220 kV grid | 100% | Villanova (IT) | S. Barbara (IT) | Planning | 2022 | Delayed | Additional technical studies on-going. |

### Additional Information

Link to the last release of the Italian National Development Plan

http://www.terna.it/en-gb/sistemaelettrico/pianodisviluppodellarete.aspx

### Investment needs

In Italy, the day ahead energy market is split in 6 different bidding zones due to internal congestions on the south to north axis and between the main Islands and the Italian peninsula. The project contributes to overcome internal boundaries which affect power exchanges within price zones and market structure. Furthermore, the project favors the integration of RES generation installed in central part of Italy especially, wind and solar power plants.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT North-IT Center : 600 |
| | IT Center - IT North: 400 |
| Delta GTC contribution (2030) [MW] | IT North-IT Center : 600 |
| | IT Center - IT North: 400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 300 ±30 |
| Cost explanation | The estimated cost includes items 90 (Colunga-Calenzano) and 1041 (Villanova - S. Barbara). |
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 110 ±20 | 90 ±10 | 120 ±20 | 220 ±30 | 190 ±30 |
| B3 RES integration (GWh/yr) | 1280 ±260 | 1270 ±250 | 1270 ±250 | 1960 ±390 | 1440 ±290 |
| B4 Losses (GWh/yr) | -75 ±25 | -100 ±25 | -100 ±25 | -100 ±25 | -100 ±25 |
| B4 Losses (Meuros/yr) | -4 ±1 | -6 ±2 | -5 ±2 | -6 ±2 | -7 ±2 |
| B5 CO2 Emissions (kT/year) | -2200 ±300 | -700 ±100 | -400 ±100 | -1100 ±200 | -900 ±100 |

The project has been assessed according to the TOOT approach in both market and network analysis.

The mentioned benefits will be achieved according to different future scenarios.

## Project 35 - CZ Southwest-east corridor

A corridor of internal 400 kV overhead lines inside the Czech Republic connecting existing 420 kV substations between Prestice, Kocin, Mirovka and Cebin in the southwest-east direction. The project consists of buidling a new AC 400 kV overhead line which connects 420 kV substations Kocin and Mirovka with double circuit line of about 120.5 km lenght and a capacity of 2x1730 MVA, building of a 400 kV overhead lines that involves changing of a 400 kV existing single-ciruit line to double-circuit line with a capacity of 2x1730 MVA between Kocin-Prestice and Mirovka-Cebin. The upgrading of the existing 420 kV substation Kocin is also a part of the project.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Czech - Germany |
| PCI label | 3.11.3; 3.11.4; 3.11.5 |
| Promoted by | CEPS |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 311 | Upgrade of 400/110kV substation | 100% | Kocin (CZ) | | Design & Permitting | 2024 | Investment on time | Investment evolution as indicated in previous TYNDP. |
| 313 | New double 400kV OHL | 100% | Kocin (CZ) | Mirovka (CZ) | Design & Permitting | 2024 | Investment on time | Investment evolution as indicated in previous TYNDP |
| 315 | New 400kV OHL | 100% | Kocin (CZ) | Prestice (CZ) | Design & Permitting | 2028 | Investment on time | Investment evolution as indicated in previous TYNDP. |
| 316 | New 400kV OHL | 20% | Mirovka (CZ) | Cebin (CZ) | Design & Permitting | 2029 | Rescheduled | Changes on the generation side (in relation to other types of generation) |

### Additional Information

Information about PCI can be found on the CEPS website:

PCI 3.11.3: http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/projekty-spolecneho-zajmu/Stranky/Vnitrostátní-vedení-Přeštice-Kočín-PCI-3.11.3.aspx

PCI 3.11.4: http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/projekty-spolecneho-zajmu/Stranky/Vnitrostátní-vedení-Kočín-Mírovka-PCI-3.11.4.aspx

PCI 3.11.5: http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/projekty-spolecneho-zajmu/Stranky/Vnitrostátní-vedení-Kočín-Mírovka-PCI-3.11.5.aspx

EC transparency platform also provides information about these PCI:
3.11.3: https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_11_3_en.pdf

3.11.4: https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_11_4_en.pdf

3.11.5: https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_11_5_en.pdf

## Investment needs

Part of the corridor North-South electricity interconnections in central Eastern and South Eastern Europe aiming at facilation of the power flow in the north-south-west-east direction, reducing of infrastructure vulnerability in the southwest-east direction in the Czech grid, ensuring the security of supply in the southern regions and provision of additional transmission capacity for connection of potential power generation capacities in the southern part of the Czech republic

Separate market based capacity increase has not been evaluated, due to the fact that the investigation which is relevant to the market based capacity increase was considered for Polish synchronous profile PL-DE/CZ/SK. This boundary (CZ-DE) that relates to the Project 35, 177 and 200 is mostly stressed by unscheduled flows caused by volatile production of RES. This fact can be explored when investigating the dependency that describes the higher benefit of each GW when considering higher prices of CO2 emissions and higher RES installed capacity

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-CZ: 500 |
| | CZ-DE: 950 |
| Delta GTC contribution (2030) [MW] | DE-CZ: 500 |
| | CZ-DE: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 518 ±104 |
| Cost explanation | As preparation of the investment items continues, route and technology (e.g. type of towers) are detailed specified to reflect different technical, safety, environmental and legal requirements imposed from different permit grating processes (e.g. EIA, land and construction permit) which usually as a result |

| | |
|---|---|
| | affects cost estimation of the investment which were previously given. The difference in currency exchange rate was also taken into consideration.<br><br>The cost value includes only CAPEX cost. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 0 ±0 | 20 ±10 | 20 ±0 | 40 ±0 | 50 ±10 |
| B3 RES integration (GWh/yr) | 0 ±0 | 240 ±10 | 230 ±10 | 540 ±40 | 390 ±80 |
| B4 Losses (GWh/yr) | N/A | -625 ±62 | -125 ±25 | -25 ±25 | -50 ±25 |
| B4 Losses (Meuros/yr) | N/A | -34 ±4 | -6 ±1 | -2 ±2 | -4 ±2 |
| B5 CO2 Emissions (kT/year) | 0 ±0 | -100 ±100 | -100 ±100 | -200 ±0 | -500 ±100 |

Project 35 is 100% dependent on the Project 200, these 2 projects have been evaluated by CBA methodology simultaneously together and it resulted into having same CBA results. Evaluation of benefits in this way stems from the topology, when projects are predominately in series connection and GTC increase and other benefits can only reached by when all these related projects are realized. CBA results according to the common methodology indicates that there are generally decreasing benefits in losses from Vision 1 to Vision 4 with minimum benefit in Vision 3 (high RES), on the other hand increasing benefits from Vision 1 to Vision 4 in CO2. No indicators for horizon 2020 because of the expected commissioning dates

Project 35 together with project 200 brings additional benefits not covered by common CBA methodology, which are mostly linked to the security of supply and system flexibility. These projects will help to eliminate overloads in N-1 situation in case high of parallel flows across Czech power grid caused by power flow transits from northern part of the Europe to southern or east-south Europe and therefore facilitate RES integration.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.55 | 0.51 | 3.42 | 4.78 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.06 | 2.74 | 12.85 | 14.47 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 4.13 | 4.77 | 6.65 | 7.78 |

The transmission capacity of the 220 kV grid in the western and southern part of the Czech grid has already exhausted which in some operation cases cause violation of the security criteria N - 1. It is also planned that the operation of the 220 kV will be decommissioned step-by-step between 2019 - 2040, so reinforcement brough by the project not only eliminates the congestion in this part of the grid but also replaces the 220 kV grid to be decommisioned.

## Project 36 - Kriegers Flak CGS

The Combined Grid Solution (CGS) is a new AC offshore connection between Denmark and Germany with back-to-back stations in Germany. The project is a combined grid connection of the offshore wind farms Kriegers Flak, Baltic 1, 2 and an interconnection between both countries

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Denmark-East - Germany |
| PCI label | PCI 4.1 |
| Promoted by | 50HERTZ;Energinet.dk |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 141 | The Kriegers Flak Combined Grid Solution is the new offshore connection between Denmark and Germany used for both grid connection of offshore wind farms Kriegers Flak and interconnection. | 100% | Ishøj / Bjæverskov (DK) | Bentwisch (DE) | Under Construction | 2018 | Investment on time | New design due to result of first tendering process, where the offers exceeded expected prices by far. Second tendering process and construction is ongoing |

### Additional Information

This is the world's first combined solution of offshore wind connection AND interconnection of countries in one integrated solution. The project increases thus security of supply for offshore wind power plants and provides new transmission capacity for trading electricity in an integrated infrastructure as well. The usage of cable capacity is optimised, thereby increasing the project's socio-economic value.

Project Website:

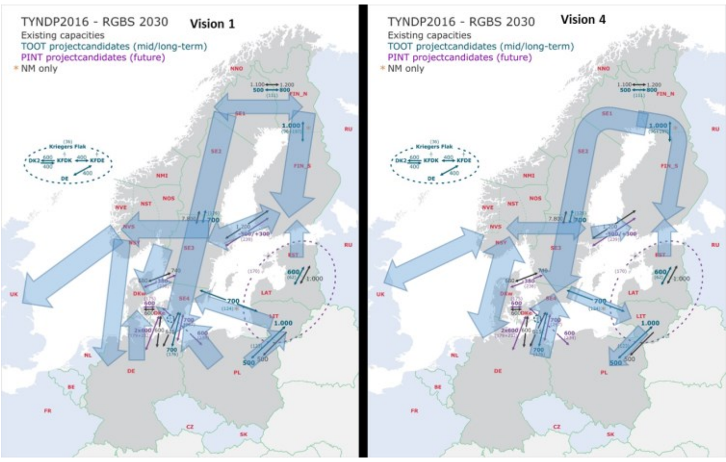
http://energinet.dk/EN/ANLAEG-OG-PROJEKTER/Anlaegsprojekter-el/Forbindelse-til-Tyskland-Kriegers-Flak-CGS/Sider/default.aspx

http://www.50hertz.com/en/Grid-Extension/Projects-of-Common-Interest-PCI

## Investment needs

The project helps linking the Nordic and Central European powersystems in hours of low wind, enabeling access to the nordic hydro power. The power flows in the region tends, except in vision 4, to be from the nordics towards central Europe which the interconnector will support.

This is the world's first combined solution of offshore wind connection AND interconnection of countries in one integrated solution. The project increases thus security of supply for offshore wind power plants and provides new transmission capacity for trading electricity in an integrated infrastructure as well. The usage of cable capacity is optimised, thereby increasing the project's socio-economic value.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DKE-DE: 400 |
| | DE-DKE: 150 |
| Delta GTC contribution (2030) [MW] | DKE-DE: 150 |
| | DE-DKE: 150 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 350 ±50 |

| | |
|---|---|
| Cost explanation | The uncertainty covers general project related risks, particularily related to the construction phase of the project. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 10 ±10 | 40 ±10 |
| B4 Losses (GWh/yr) | 50 ±25 | 0 ±25 | 25 ±25 | 25 ±25 | 25 ±25 |
| B4 Losses (Meuros/yr) | 2 ±1 | 0 ±1 | 1 ±1 | 1 ±2 | 1 ±2 |
| B5 CO2 Emissions (kT/year) | -200 ±50 | -200 ±100 | -200 ±100 | ±100 | ±100 |

The project is assessed without the wind farm connection, as it is assumed this will be done regardless of whether a conncetion between DK and DE is a part of the project. The project is assessed with the TOOT methodology which will give a lower bound of the value of a interconnector. The socio economic value of the interconnector is in all visions assessed to be less than €10m per year while the project helps reduce the curtailment of RES a little. With regards to the CO2 emission the project is more or less neutral, only in vision 2 resulting in a reduction of emissions while it in the other visions has an impact of less than 100kT per year.

KF CGS is a hybrid project and also connects offshore wind beside its function as an interconnection. In contrast to other wind-connecting projects in the TYNDP, the benefits of wind generation have not been considered for TYNDP-SEW calculations for KF CGS.

In simulations, it was treated as an interconnector only – but considering less capacity than physically available, as the rest is used by the wind. Simulations setup was following the CBA rules and thus more pessimistic than the project actually is.

KF CGS is a medium term project – a major part of the benefit is caused by its early implementation.

KF CGS is an innovative project – this is not valued by TYNDP categories. KF CGS includes a new designed controller which translates the new bilateral joint regulatory model into action, also outbalancing uncertainty / variations of wind power production. The controller solves both technical and economic issues and defines the amount of electric power to be sent in each direction (prioritizing wind or trade depending on wind level, optimizing losses etc.)

KF CGS would not be built without EEPR grants.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.73 | 4.07 | 4.19 | 3.39 |

| | | | | |
|---|---|---|---|---|
| Standard deviation marginal cost difference in the reference case  [€/MWh] | 4.02 | 11.08 | 14.79 | 13.26 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.92 | 8.57 | 11.80 | 9.05 |

## Project 37 - Norway - Germany, NordLink

NordLink: a new HVDC connection between Southern Norway and Northern Germany.Estimated subsea cable length: 514km. Capacity: 1400 MW.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Germany - Norway |
| PCI label | 1.8 |
| Promoted by | STATNETT;TENNET-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 142 | Nord.Link; a new HVDC connection between Southern Norway and Northern Germany. Estimated subsea cable length; 514km. Capacity; 1400 MW. | 100% | Tonstad (NO) | Wilster (DE) | Under Construction | 2020 | Investment on time | Agreement between the two TSOs on commissioning date. |
| 406 | Voltage uprating of existing 300 kV line Sauda/Saurdal - Lyse - Tonstad - Feda - 1&2, Feda - Kristiansand; Sauda-Samnanger in long term. Voltage upgrading of existing single circuit 400kV OHL Tonstad-Solhom-Arendal. Reactive power devices in 400kV substat | 100% | (Southern part of Norway) (NO) | (Southern part of Norway)(NO) | Under Construction | 2020 | Delayed | Revised progress due to less flexible system operations in a running system (voltage upgrade of existing lines). Commissioning date expected 2019-2021. |

### Additional Information

Project Website;

http://www.statnett.no/en/Projects/NORDLINK/

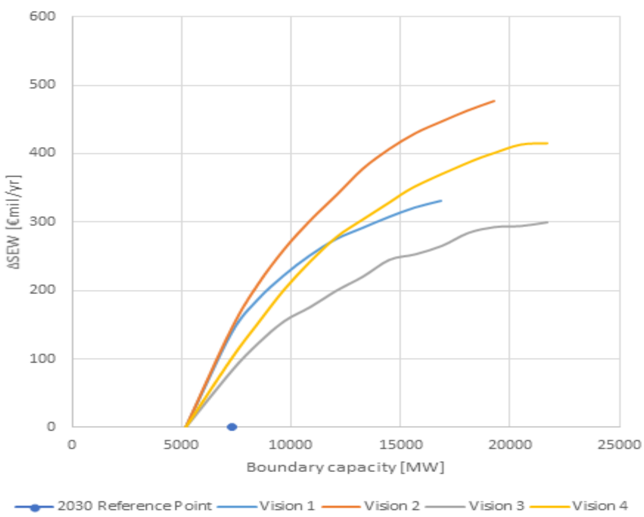
## Investment needs

A 514 km long subsea interconnector between Norway and Germany is planned to be realized in 2020. The main driver for the project is to integrate the hydro-based Norwegian system with the thermal/nuclear/wind-based Continental system. The interconnector will improve security of supply both in Norway in dry years and in Germany/Continental Europe in periods with negative power balance (low wind, high demand etc.). Additional the interconnector will be positive both for the European market integration, for facilitating renewable energy and also for preparing for a power system with lower CO2-emission. The interconnector is planned to be a 525 kV 1400 MW HVDC subsea interconnector between southern Norway (Tonstad) and northern Germany (Wilster).

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between the Nordics and the Continental system. In the SEW/GTC-curve we can see that the increase from todays capacity to the 2030-level is having a large SEW-value for all the scenarios. This is also one of the reason for the NordLink between Norway and Germany being realised. At the same time there is a need for having attention to the assumptions of TYNDP 2016. Bringing CO2, oil , gas, coal-prices down to 2016-level will influence the SEW-values of projects like NordLink in a negative direction, i.e. the SEW values would be smaller than the ones identified for 2030. The CO2 price assumptions for 2030 are higher than the ones seen today. Bigger CO2 prices create larger marginal cost price differences between the different generation technologies

Having a look at SEW/GTC-values of the different Visions indicates that the energy-balance of the different Visions both for the Nordics and Continental countries are the main driver for price differences and hence SEW-values. Eg. the Nordic surplus is very high in Vision 2, which gives a high price difference and hence high SEW/GTC-values.

NordLink will increase the capacity between the Nordics and the Continent by 1400 MW.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-NO: 1400 |
| | NO-DE: 1400 |
| Delta GTC contribution (2030) [MW] | DE-NO: 1400 |
| | NO-DE: 1400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1850 |
| Cost explanation | |
| S1 | 50-100km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 110 ±20 | 100 ±10 | 100 ±20 | 120 ±10 | 70 ±10 |
| B3 RES integration (GWh/yr) | 100 ±20 | 220 ±170 | <10 | 890 ±180 | 350 ±70 |
| B4 Losses (GWh/yr) | 350 ±35 | 350 ±35 | 350 ±35 | 350 ±35 | 350 ±35 |
| B4 Losses (Meuros/yr) | 15 ±1 | 19 ±2 | 16 ±2 | 21 ±2 | 23 ±3 |
| B5 CO2 Emissions (kT/year) | -400 ±80 | ±100 | -500 ±500 | -700 ±100 | -100 ±800 |

The pan-European analysis only take into account one average hydrological year. Studies by the Norwegian TSO Statnett shows that an important driver for the benefit of Norwegian interconnectors is the increased potential for power export from Norway during periods of excessive inflow. The benefit arises both from reducing the risk for hydropower curtailment and from avoiding price collapse in Norway during wet summers. The benefit is non-linear, which means that simulating over one average year is not equal to taking the average over several hydrological years. Internal studies indicates that SEW-values might double if also taking into account wet and dry years. This means that the benefit indicators calculated in the pan-European analysis probably are underestimated.

Also the benefit of RES and CO2 (increased RES, decreased CO2) are expected to be under-estimated. Especially in wet years the RES-values will be much higher, this as the interconnectors helps exporting RES/hydro instead of having hydro-curtailment (water running directly to the sea). This also leads to decreased CO2-emissions if taking wet/dry years into account.

Summarized the CBA-indicators for projects going to Norway for SEW, RES and CO2 are supposed to be underestimated in the pan-European models.

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

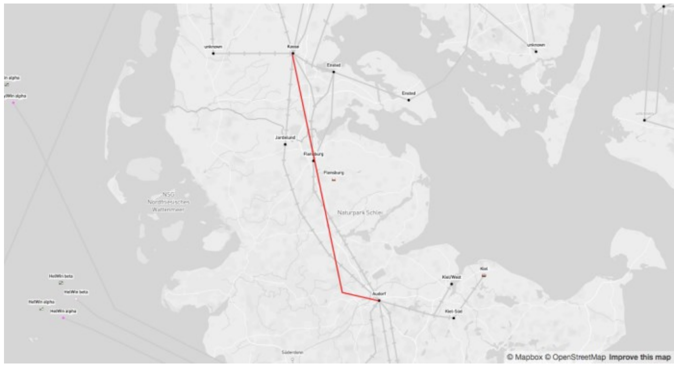
The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 18.46 | 10.75 | 10.88 | 8.11 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 14.53 | 17.74 | 23.13 | 18.56 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | -0.21 | 11.27 | 18.22 | 13.63 |

## Project 39 - DKW-DE, step 3

This project is the third phase in the Danish-German agreement to upgrade the transfer capacity between Denmark West and Germany. The third-phase project consists of a new double circuit 400 kV line from Kassoe (Denmark) to Audorf (Germany). It mainly follows the trace of an existing 220 kV line, which will be substituted by the higher voltage line. The project is labelled by the EC as project of common interest (PCI 1.4.1).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Denmark-West - Germany |
| PCI label | 1.4.1 |
| Promoted by | Energinet.dk;TENNET-DE |



### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 144 | Step 3 in the Danish-German agreement to upgrade the Jutland-DE transfer capacity. It consists of a new 400kV route in Denmark and In Germany new 400kV line mainly in the trace of a existing 220kV line. | 100% | Audorf (DE) | Kassö (DK) | Permitting | 2020 | Investment on time | step forward from planning to permitting |

### Additional Information

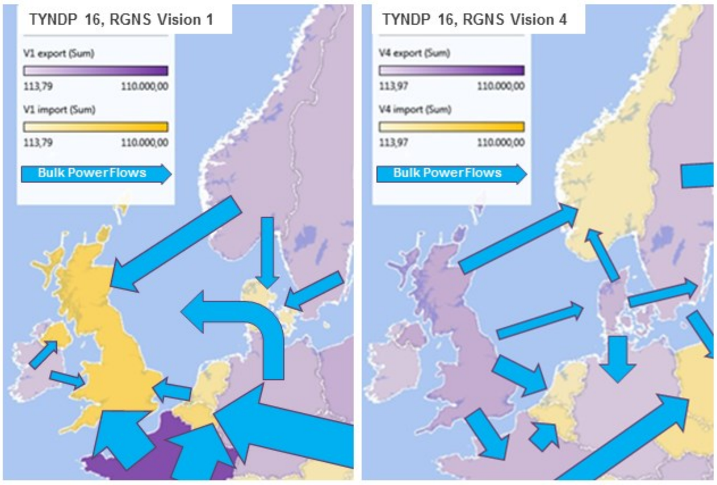
Project websites:
http://energinet.dk/DA/ANLAEG-OG-PROJEKTER/Anlaegsprojekter-el/Udbygning-af-elforbindelse-Sydoestjylland-Tyskland/Sider/default.aspx
http://www.kassoe-audorf.eu/

http://www.tennet.eu/de/unser-netz/onshore-projekte-deutschland/audorf-flensburg/

### Investment needs

Main bulk flow direction in this local area (DE North, DK West) is along the North-South axis (main direction depending on the Vision). Project contributes to bearing these flows. RES integration (mainly wind energy, both on- and offshore) in this local area keeps on increasing, thus the grid infrastructure needs to be upgraded respectively.

The project promoter states "*Project estimations show that the project significantly improves the SoS of the region (esp. DKW and Northern DE).*"




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DKW-DE: 720 |
| | DE-DKW: 1000 |
| Delta GTC contribution (2030) [MW] | DKW-DE: 720 |
| | DE-DKW: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 500 ±100 |
| Cost explanation | Undiscounted CAPEX at time of delivering at investment level. |
| S1 | 15-50km |
| S2 | 15-25km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | <10 | 20 ±10 | 10 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 20 ±30 | 120 ±70 | 130 ±50 |
| B4 Losses (GWh/yr) | 50 ±25 | 50 ±25 | 25 ±25 | 25 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 2 ±1 | 2 ±2 | 1 ±1 | 1 ±2 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | -200 ±100 | -200 ±100 | ±100 |

The TYNDP16 indicators (SEW, RES, CO2) are less optimistic compared to the TYNDP14 indicators, which can be explained by the changed scenarios. Since the TYNDP14 edition scenarios have further developed with major movements of RES between countries and differences in demand development.

The project is closely linked to project 251 (PCI 1.4.1 and 1.4.2), as these projects are serially directly connected and thus and complementing each other.

Therefore also the benefits should be considered as strongly being related to each other.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.48 | 2.49 | 2.99 | 1.91 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.09 | 8.66 | 12.68 | 10.41 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.87 | 10.40 | 13.06 | 9.92 |

In each Vision there is a price differential between DK and its neighbours, causing bilateral exchanges or transit flows, which proceed through the Northern German grid.

The project releases congestions in the underlying distribution grid.

## Project 40 - Luxembourg-Belgium Interco

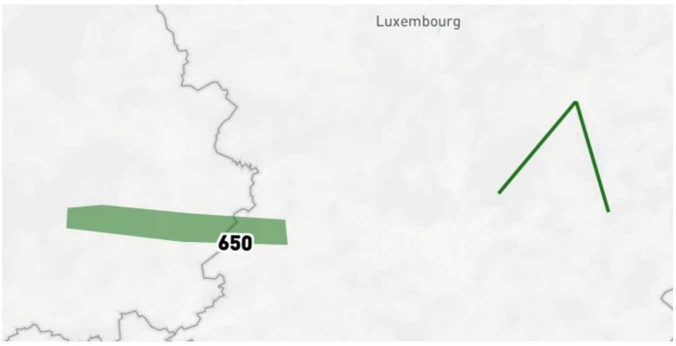
The project envisions the realization of an interconnection between Luxembourg and Belgium allowing to increase the transfer capability between LU, DE and BE and contributing to the security of supply. In a first step a phase-shift transformer is integrated at Schifflange (LU) and the Luxembourg network is being reinforced by creating a loop around Luxembourg city, including substations for in feed in lower voltage levels, hereby enabling the existing line Aubange (BE) - Schifflange (LU) to figure as interconnector. Note that the PST (investment item #446 of previous TYNDP) is technically commissioned in 2016.On a longer-term perspective, the reference solution for the further development of transfer capacity in the area consists of two AC cables between Aubange (BE) & Bascharage (LU). The identification of complementary reinforcements is subject to further studies.

Classification  Mid-term project

Boundary  Luxembourg - Belgium

PCI label  2.3.2

Promoted by  CREOS; ELIA; AMPRION




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 447 | New 20km 225kV double-circuit line with 1000 MVA capacity including substations | 100% | Heisdorf (LU) | Berchem (LU) | Under Construction | 2017 | Investment on time | Substation Blooren is under construction, line section Heisdorf Blooren is under construction |
| 650 | Additional 220 kV interconnection between substation Bascharage (CREOS-LU) and substation Aubange (ELIA-BE) is envisioned via a 16km double circuit underground cable with a total capacity of ~1000 MVA. | 55% | Bascharage (LU) | Aubange (BE) | Under Consideration | 2022 | Rescheduled | Robustness of the envisioned reference solution towards the long-term perspective of the energy transition is subject of ongoing studies. |

### Additional Information

Project website:

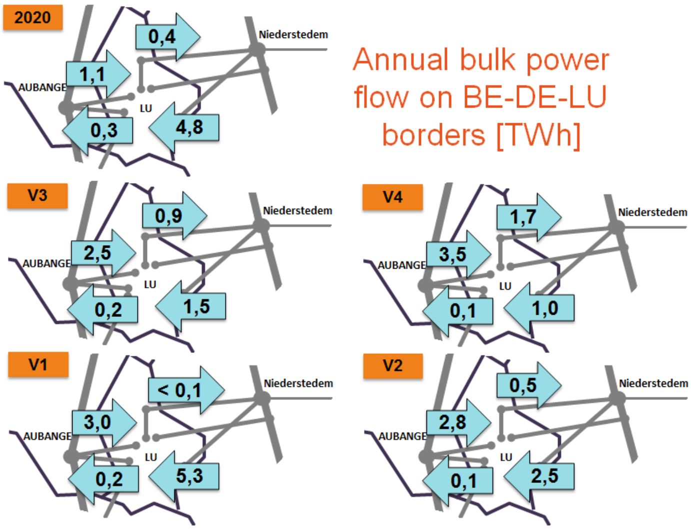
http://www.creos-net.lu/creos-luxembourg/infrastructure/interconnector-bedelux.html

http://www.elia.be/en/projects/grid-projects/Interconnector-BeDeLux

## Investment needs

The interconnection between Luxembourg and Belgium is mainly triggered by Luxembourgish security of supply considerations. Besides this, the new interconnection contributes to the European electricity market integration by developing transport capacity between the Belgian bidding zone and the DE/AT/LU bidding zone.

After the implementation of the first interconnection phase and the finalisation of the internal reinforcement around Luxembourg City put in operation Q1 2017 a grid transfer capacity of GTC of 400 MW is achieved. The project consisting of two additional cables between substation Bascharage (LU) and Aubange (BE) would deliver an additional grid transfer capacity of 500 MW. The final capacity on the Belgian - Luxembourgish border would amount to 900 MW in total. This is subject to further studies, and identification of potentially complementary reinforcements to sustain the resulting bulk power flows across the DE-LU-BE 220 kV grid.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE-LU: 900 |
| | LU-BE: 900 |
| Delta GTC contribution (2030) [MW] | BE-LU: 900 |

| | |
|---|---|
| | LU-BE: 900 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 140 ±35 |
| Cost explanation | The reported cost is the currently expected total investment cost.Uncertainty range reflect uncertainties in design/routing of the cable and any eventual procurement/realization uncertainties.The new loop around Luxembourg city including substations for in feed in lower voltage commissioned in 2017 (investment item 447) is mainly an internal grid reinforcement. In addition the loop facilitates the developed cross-border capacity in direction DELUBE by lifting congestion on internal lines. The costs of the internal grid reinforcement project counts for 80-90 M€ of the reported investment cost. Given it is not exclusively related to the development of the interconnector it is provided for information only. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 10 ±10 | 20 ±10 | 10 ±10 | 10 ±10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 170 ±60 | 100 ±30 |
| B4 Losses (GWh/yr) | -25 ±25 | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±50 | 400 ±100 | 200 ±100 | ±100 | ±100 |

The reported GTC increase reflects the complementary role of the internal grid reinforcement in Luxemburg with both phases of the development of the interconnecter BE-LUX (phase 1: PST Schifflange, phase 2: two additional cables).

The market integration effect results in a SEW increase aroud 10 to 20 M€. The RES integration effect is limited. With respect to the CO2 impact there is a slight increase in CO2 in the coal before gas scenarios (2020, 2030 V1, 2030 V2) related to substation of gas-fired production by cheaper coal-fired production, and a neutral effect in the 2030 V3 & V4 scenarios.

The effect of developing the 220kV grid on the global losses in the CWE area is negligable.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.49 | 0.54 | 1.22 | 0.86 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 5.10 | 3.02 | 7.92 | 6.28 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 13.65 | 12.41 | 6.55 | 7.85 |

## Project 42 - OWP TenneT Northsea part 1

Connection of offshore wind parks in the North Sea to Germany. Consisting of subsea AC and DC cables. The OWP will help to reach the European goal of CO2 reduction and RES integration

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | North-South |
| PCI label | |
| Promoted by | TENNET-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 160 | New AC-cable connection. | 100% | Offshore-Wind park Nordergründe (DE) | Inhausen (DE) | Under Construction | 2016 | Investment on time | on time relative to TYNDP14 |
| 163 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster HelWin1 (DE) | Büttel (DE) | Commissioned | 2014 | Investment on time | in operation |
| 164 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster SylWin1 (DE) | Büttel (DE) | Commissioned | 2015 | Investment on time | in operation |
| 165 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster DolWin1 (DE) | Dörpen/West (DE) | Commissioned | 2015 | Delayed | due to the project |
| 166 | New AC-cable connection | 100% | Offshore Wind park Riffgat (DE) | Emden /Borßum(DE) | Commissioned | 2014 | Investment on time | in operation |
| 167 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster BorWin2 (DE) | Diele (DE) | Commissioned | 2015 | Investment on time | in operation |
| 654 | New HVDC transmission system consisting of offshore | 100% | Cluster DolWin2 (DE) | Dörpen/West (DE) | Under Construction | 2016 | Delayed | due to the project |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | platform, cable and converters. | | | | | | | | |
| 655 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster DolWin3 (DE) | Dörpen/West (DE) | Under Construction | 2017 | Investment on time | on time |
| 657 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster HelWin2 | Büttel (DE) | Commissioned | 2015 | Investment on time | on time |

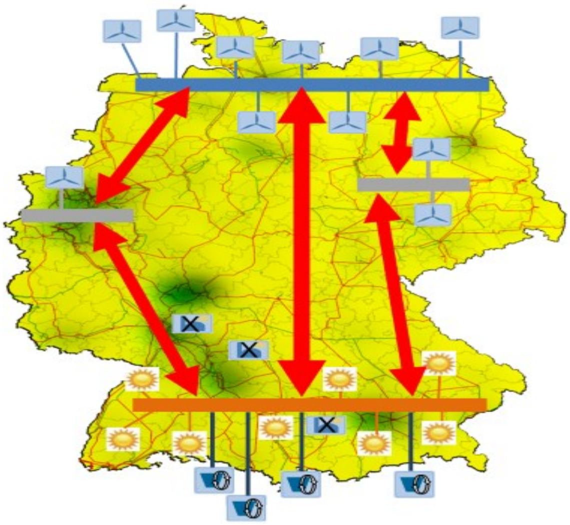
## Additional Information

Information on offshore projects within the northern sea promoted by TenneT TSO GmbH (http://www.tennet.eu/de/netz-und-projekte/offshore-projekte.html) in German

## Investment needs

Germany is planning to build a big amount of offshore wind power plants in the North- and Baltic Sea. The OWP will help to reach the European goal of $CO_2$ reduction and RES integration. These offshore infrastructure projects in the North- and Baltic Seas areas, will deliver benefits for the regional society by pooling generation portfolios, integrating markets, lowering $CO_2$ emissions, facilitating the integration of renewables (both onshore as well as offshore) and ensuring sufficient system resilience.

The development of off-shore wind farms in the North of Germany induces needs for undersea connections to these wind farms as well as reinforcements of the grid capacity from North to South. According to German law, these grid connections have to be constructed and operated by the TSO.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the project 191, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

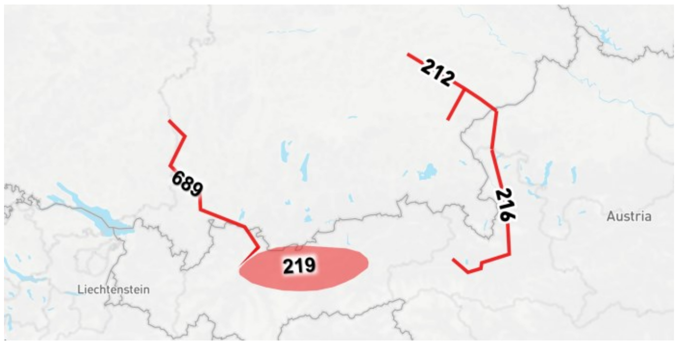
| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern: 5750 |
| | DE intern: 5750 |
| Delta GTC contribution (2030) [MW] | DE intern: 5750 |
| | DE intern: 5750 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 7000 ±1000 |
| Cost explanation | |
| S1 | More than 100km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 670 ±140 | 1220 ±90 | 1060 ±80 | 1350 ±70 | 1520 ±90 |
| B3 RES integration (GWh/yr) | 15550 ±3110 | 20640 ±10 | 20650 ±20 | 19200 ±150 | 20180 ±70 |
| B4 Losses (GWh/yr) | 550 ±55 | 925 ±92 | 1000 ±100 | 1300 ±130 | 1825 ±182 |
| B4 Losses (Meuros/yr) | 23 ±3 | 50 ±5 | 46 ±5 | 77 ±8 | 122 ±13 |
| B5 CO2 Emissions (kT/year) | -12200 ±1830 | -11700 ±200 | -15800 ±2000 | -7300 ±1000 | -8400 ±1300 |

## Project 47 - Austria - Germany

This project reinforces the interconnection capacity between Austria and Germany. The national investments comprised are a precondition to achieve the full benefit of the cross border investments and are vital for the Austrian security of supply (e.g. part of the Austrian 380-kV-Security Ring). It supports the interaction of RES in Northern Europe (mainly in Germany) and in the eastern part of Austria with the pump storages in the Austrian Alps and therewith facilitates their utilisation.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Germany - Austria |
| PCI label | 3.1.1(Investment 212),<br>3.1.2(Inv.216) and 2.1(Inv. 219) |
| Promoted by | AMPRION;APG;TENNET-DE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 212 | New 380kV double circuit OHL Isar/Altheim - St. Peter including new 380kV switchgears Altheim, Pirach, Simbach and St. Peter. | 75-85% | Isar (DE) | St. Peter (AT) | Permitting | 2020 | Delayed | Delayed due to long permitting process |
| 216 | New internal double circuit 380kV-line connecting the substations Salzburg and Tauern (replacement of existing 220kV-lines on optimized routes). | 55-65% | St. Peter (AT) | Tauern (AT) | Permitting | 2021 | Delayed | Significant delays in the authorisation process (EIA). |
| 219 | Upgrade of the existing 220kV-line Westtirol - Zell-Ziller and erection of additional 220/380kV-Transformers. Line length: 105km. | 20-30% | Westtirol (AT) | Zell-Ziller (AT) | Planning | 2022 | Rescheduled | Tests and gaining of experience for novel technical solution in progress |
| 689 | Upgrade of an existing overhead line to 380 kV (Length: approx. 114 km), extension of existing and errection of new 380 kV substations | 20-30% | Vöhringen (DE) | Westtirol (AT) | Planning | 2020 | Investment on time | |

## Additional Information

Detailed information to Investment 212 / PCI 3.1.1 can be found under: http://www.apg.at/en/projects/Deutschlandleitung

Detailed information to Investment 216 / PCI 3.1.2 can be found under: http://www.apg.at/en/projects/380-kV-salzburg-line

http://www.netzentwicklungsplan.de/en (German network development plan in German)

Second PCI-List

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

## Investment needs

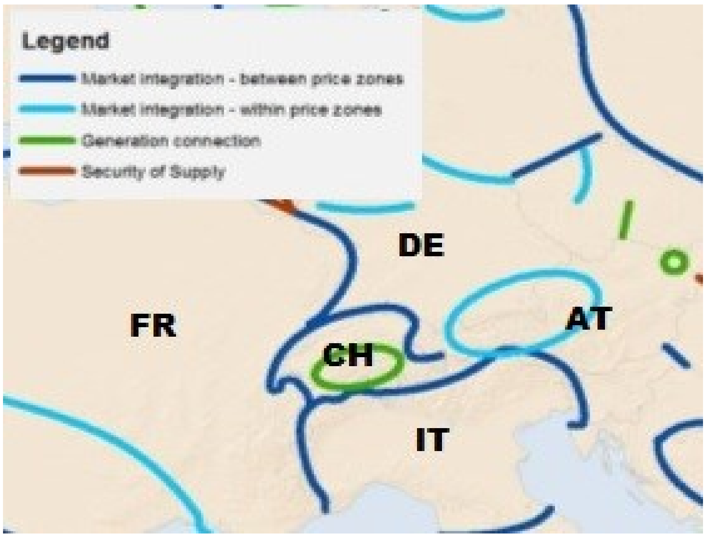
The project consists of four investments which together ensure a homogenous distribution of the reinforcement benefits on the Austrian – German border and the transmission of RES from Northern Europe (mainly in Germany) to the DE-AT border and it's adequate connection of the hydro storage power plants in the west of Austria.

The PCI 3.1.1 / investment 212 ensures the transmission of high RES amounts mainly coming from the northern parts of Germany to the DE-AT border and therefore helps to strengthen the connection capacity at the DE-AT border to ensure the connection to the hydro power plants in Austria. The permitting process on Austrian side of the project is already completed. The coordinated start of the construction phase is planned as soon as the permitting process in Germany is completed.

The PCI 3.1.2 / investment 216 is part of the Austrian 380-kV ring and therefore a major basis for a secure and efficient connection of existing generation and demand areas as well as a prerequisite for further connection of hydro storage power plants in the west/south part of Austria as well as for realization of further powerful interconnectors. The permitting process is currently ongoing in the second level of juristiction.

PCI 3.1.1 and 3.1.2 are complemented by investment items 689 "Vöhringen (DE) – Westtirol (AT)" and 219 "Westtirol – Zell/Ziller". These projects will also increase the cross-border transmission capacity between Germany and Austria. Compared to a separate assessment of these projects, additional benefits of the common cluster can be identified.

For this border, no specific capacity analysis has been done in TYNDP16. According to the CBA results of the latest project on this border (P198), the benefit SEW provided by a standard 1 GW capacity increase can be assessed between 20M€ and 50M€  in the 2030 visions except in Vision 2 where it is lower.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed in the 2030 Visions with a triple TOOT step compared to the projects 187 and 198 , which are commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-AT: 2900 |
| | AT-DE: 2900 |
| Delta GTC contribution (2030) [MW] | DE-AT: 2900 |
| | AT-DE: 2900 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1250 ±250 |
| Cost explanation | The project gains remarkable SEW values in all visions.<br><br>This is especially visible in the green Visions 3 and 4, since this project enables the exchange of the RES generated energy with the flexible pump storages in the alps. |
| S1 | 15-50km |
| S2 | 15-25km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 80 ±10 | 80 ±20 | 90 ±70 | 210 ±60 | 180 ±70 |
| B3 RES integration (GWh/yr) | 10 ±< 10 | 60 ±10 | 20 ±10 | 2030 ±260 | 1210 ±220 |
| B4 Losses (GWh/yr) | -25 ±25 | 320 ±100 | 75 ±25 | 350 ±35 | 515 ±35 |
| B4 Losses (Meuros/yr) | -2 ±2 | 17 ±6 | 3 ±2 | 21 ±2 | 34 ±3 |
| B5 CO2 Emissions (kT/year) | 1100 ±160 | 1100 ±100 | 600 ±300 | -900 ±700 | -1200 ±200 |

Costs based on standard costs for OHL taken from German Grid Development Plan

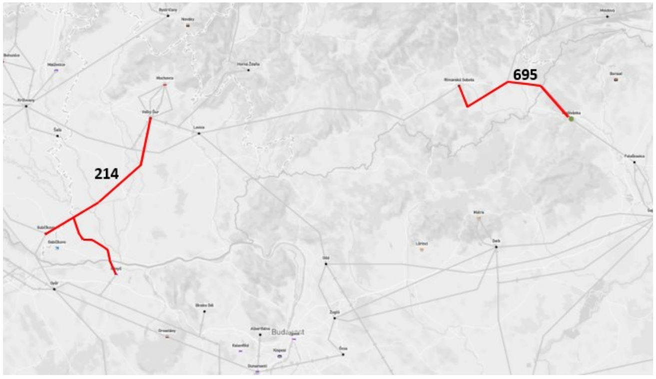
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.29 | 0.13 | 2.23 | 1.85 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.26 | 1.29 | 10.38 | 9.64 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 5.14 | 4.40 | 6.82 | 7.09 |

*Comment on the security of supply:* The security of supply (SoS) indicator is to be understood in the way it is defined within the Cost Benefit Analysis methodology which focuses merely on the connection of partly isolated grid areas. In general in rather meshed parts of the transmission grids other aspects are more significant for the security of supply (e.g. n-1-margin, cascade effects, etc.) and therefore the project benefit indicator on SoS according to the CBA methodology underestimates the real value of the project. The considered project is vital for the Austrian SoS. It comprise an important part of the Austrian 380-kV-Security Ring, enforces the east-west connection in Tyrol and improves the connection to distribution grids.

## Project 48 - New SK-HU intercon. - phase 1

This project will increase the transfer capacity between Slovak and Hungarian transmission systems, improve security and reliability of operation both transmission systems and support North - South RES power flows in CCE region. Main investments of this project are double circuit AC OHL 400 kV from new Gabcikovo (Slovakia) substation to Gönyű (Hungary) substation, with one circuit connected to the Veľký Ďur (Slovakia) substation and double circuit AC OHL (preliminary armed only with one circuit on Hungarian side) 400 kV from Rimavska Sobota (Slovakia) substation to Sajóivánka (Hungary) substation.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Slovakia - Hungary |
| PCI label | 3.16 and 3.17 |
| Promoted by | MAVIR;SEPS |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 214 | New 2x400 kV interconnection between SK and HU | 50-60% | Gabčíkovo (SK) | Gőnyü (HU) | Planning | 2019 | Delayed | The approval of the Contract of Construction for each PCI in the project between the two promoters has been in delay compared to the original schedule. The project promoters agreed jointly in November 2015 to set a new feasible commissioning date, which will also figure in the Contract. |
| 695 | Ercetion of the new 2x400kV interconnection between SK and HU. | 40-50% | Rimavská Sobota (SK) | Sajóivánka (HU) | Planning | 2019 | Delayed | The approval of the Contract of Construction for each PCI in the project between the two promoters has been in delay compared to the original schedule. The project promoters agreed jointly in November 2015 to set a new feasible commissioning date, which will also figure in the Contract. |
| 696 | 2x70 Mvar shunt reactors in station Sajóivánka | 100% | Sajóivánka (HU) | | Planning | 2019 | Delayed | The approval of the Contract of Construction for each PCI in the project between the two promoters has been in delay compared to the original schedule. The project promoters agreed jointly in November 2015 to |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | set a new feasible commissioning date, which will also figure in the Contract. |
| 697 | Second 400/120 kV transformer in station Sajóivánka | 100% | Sajóivánka (HU) | Planning | 2019 | Delayed | The approval of the Contract of Construction for each PCI in the project between the two promoters has been in delay compared to the original schedule. The project promoters agreed jointly in November 2015 to set a new feasible commissioning date, which will also figure in the Contract. |

## Additional Information

Project PCI website:

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_16_1_en.pdf

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_16_2_en.pdf

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_16_3_en.pdf

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_17_en.pdf

Slovak website for the PCI projects 3.16 and 3.17:

http://www.economy.gov.sk/3161-medzistatne-vedenie-medzi-stanicami-gabcikovo--sk--a-g/144266s

http://www.economy.gov.sk/3162-vnutrostatne-vedenie-medzi-stanicami-velky-dur--sk--a-gabcikovo--sk--/144272s

http://www.economy.gov.sk/317-2x400kv-vedenie-est-rimavska-sobota-/144273s

Hungarian website for the PCI projects 3.16 and 3.17:

http://www.mavir.hu/web/mavir/pci-jeloltek

http://www.mavir.hu/web/mavir-en/eu-projects-of-common-interest-to-be-implemented-by-mavir

2nd PCI list: https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

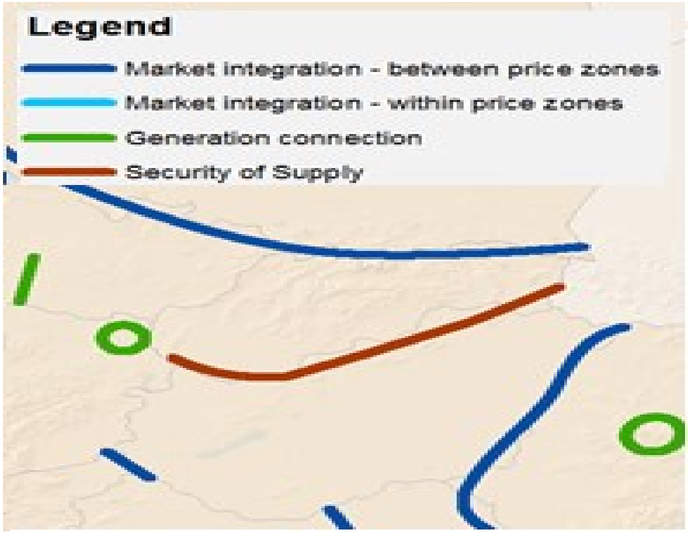
Slovak TYNDP document: http://www.sepsas.sk/seps/Dokumenty/ProgRozvoj/2015/04/DPR_PS_2015_2024_en.pdf

Hungarian National Development Plan (only in Hungarian): http://www.mavir.hu/documents/10258/15454/HFT_2015.pdf

## Investment needs

**Main drivers of the project:**

- improving the secure and reliable operation of the SK and HU transmission systems, especially on the SK-HU and SK-UA profiles which are heavy loaded during the significant time of the year due to the high transit flows through the Slovak transmission system,
- increasing the transmission capacity of the SK-HU profile which is the part of the "4M MC" market coupling, where sufficient transmission capacity on the coupled cross-border profiles is the main assumption to have a secure and efficiently functioning common market.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | HU-SK: 200 |
| | SK-HU: 1550 |
| Delta GTC contribution (2030) [MW] | HU-SK: 950 |
| | SK-HU: 2400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 82 ±8.2 |

| | |
|---|---|
| Cost explanation | The costs of the project include only CAPEX and are in 2015 price levels, when the estimation of the project investment cost have been done. The value of the costs provided includes implementation phase costs (studies, permissions, etc.), construction costs of the lines and the costs for the substations extensions. All possible factors that can influence the investment costs value are considered in the "uncertainty range". |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 10 ±10 | 10 ±10 |
| B4 Losses (GWh/yr) | -25 ±25 | 50 ±25 | -725 ±315 | -105 ±25 | -125 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 2 ±2 | -34 ±15 | -7 ±2 | -9 ±2 |
| B5 CO2 Emissions (kT/year) | -200 ±50 | ±100 | ±100 | ±100 | ±100 |

The project's SEW accounts for savings in generation fuel and operating costs. The project could also enable savings by avoided investment in generation capacity, in particular for projects connecting “electric peninsulas”. This aspect has not been included in the CBA methodology.

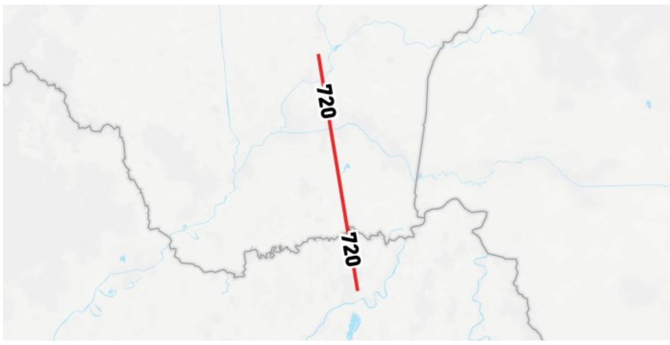
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.37 | 0.18 | 0.65 | 0.30 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.55 | 1.44 | 5.53 | 3.77 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 6.64 | 5.81 | 1.02 | 0.30 |

Project 48 improves secure and reliable operation of the both transmission systems (SK and HU) and contributes to a transmission capacity increase on this highly used crosss-border SK-HU profile, which is part of the "4M MC" Market Coupling Zone. Therefore it helps to decrease the difference of the electricity market prices between SK and HU.

## Project 54 - New SK-HU intercon. - phase 2

This project will increase the transfer capacity between Slovak and Hungarian transmission systems, improve security and reliability of operation both transmission systems and support North - South RES power flows in CCE region. Realization of this project is tightly connected to the negotiations between Slovak and Ukrainian TSOs regarding future operation of the existing Slovak interconnection with Ukraine. Main and only investment of this project is double circuit AC OHL 400 kV from Velke Kapusany (Slovakia) substation to Kisvárda region (Hungary).

| | |
|---|---|
| Classification | Future Project |
| Boundary | Slovakia - Hungary |
| PCI label | 3.18 |
| Promoted by | MAVIR;SEPS |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 720 | Erection of new 2x400kV line between SK and HU. | 100% | Veľké Kapušany (SK) | Kisvárda area (HU) | Under Consideration | 2029 | Rescheduled | Investment is dependant on the future operation of the SK-UA existing cross-border line, which has been prolongued till around 2030 based on the diagnostics. |

### Additional Information

2nd PCI list: https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

Slovak website of the PCI project 3.18:

http://www.economy.gov.sk/3181-medzistatne-vedenie-medzi-stanicami-velke-kapusany--sk--a-oblast-kisvarda--hu-/144274s

Hungarian website of the PCI project 3.18:

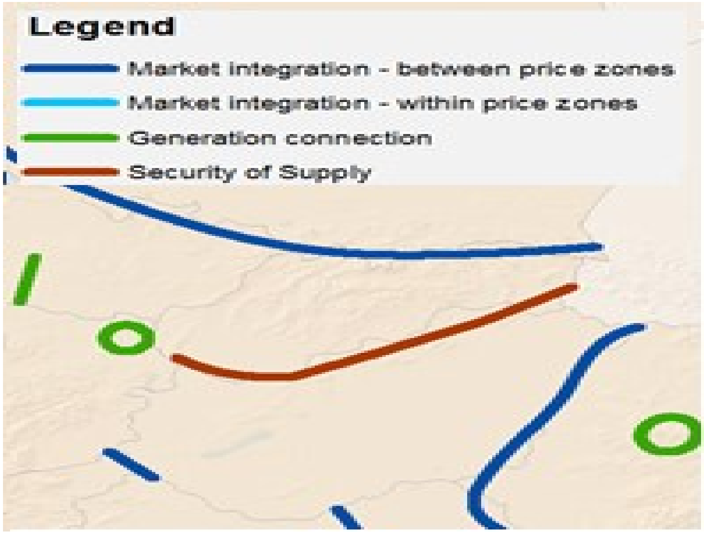
http://www.mavir.hu/web/mavir/pci-jeloltek

http://www.mavir.hu/web/mavir-en/eu-projects-of-common-interest-to-be-implemented-by-mavir

## Investment needs

**Main drivers of the project:**

- improving the secure and reliable operation of the SK and HU transmission systems, especially on the SK-HU and SK-UA profiles which are heavy loaded during the significant time of the year due to the high transit flows through Slovak transmission system,
- increasing the transmission capacity of the SK-HU profile which is the part of the "4M MC" market coupling, where sufficient transmission capacity on the coupled cross-border profiles is the main assumption to have secure and efficiently functioning common market.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | HU-SK: 300 |
| | SK-HU: 250 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 63 ±6.3 |

| | |
|---|---|
| Cost explanation | The costs of the project include only CAPEX and are in 2015 price levels, when the estimation of the project investment cost have been done. The value of the costs provided includes implementation phase costs (studies, permissions, etc.), construction costs of the lines and the costs for the substations extensions. All possible factors that can influence the investment costs value are considered in the "uncertainty range". |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

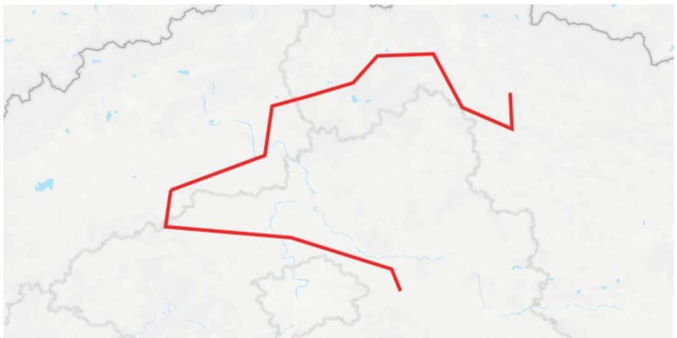
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

The GTC of the Project 54 is lower in comparison with the past TYNDP2014 due to methodology and assumption changes (PINT method was used for assessment instead of the previous double TOOT method). In comparison with GTC values of the Project 48, what is the project of 4 400 kV OHL on the SK-HU boundary to be commissioned earlier as Project 54 is planned, the results are lower, due to the fact that will be commissioned after 48 and there is no place for other possible beneficial GTC increase. Project 54 would be primarily built to maintain secure and reliable operation of the Slovak and Hungarian power systems after the possible decommissioning of the 400 kV cross-border OHL Veľké Kapušany - Mukachevo between Slovakia and Ukraine. Not all indicators are assessed, as this project is a Future one, with high level of commissioning uncertainty which is strongly dependent on the Slovak - Ukrainian interconnection situation as stated above in description of main drivers of the project

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.37 | 0.18 | 0.65 | 0.30 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.55 | 1.44 | 5.53 | 3.77 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 6.64 | 5.81 | 1.02 | 0.30 |

## Project 55 - CZ West-East corridor

The project consists of reinforcements of three 400 kV AC overhead internal lines located in the nothern-western part of the Czech Republic in the west-eastern direction of power flows between existing 400 kV substations Vyskov, Cechy Stred, Babylon and Bezdecin. The individual reinforcement of the above lines will be achieved by changing the existing single-circuit line to double-circuit line with transmission capacity of 2x1730 MVA.



Classification Mid-term Project

Boundary West-East

PCI label N/A - the project is not in the PCI list

Promoted by CEPS

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 302 | New 400kV OHL | 59% | Vyskov (CZ) | Cechy stred (CZ) | Under Constructi on | 2016 | Investment on time | Progress as indicated in TYNDP 2014 |
| 303 | New 400kV OHL | 21% | Babylon (CZ) | Bezdecin (CZ) | Design & Permitting | 2018 | Investment on time | Progress as indicated in TYNDP 2014 |
| 304 | New 400kV OHL | 44% | Babylon (CZ) | Vyskov (CZ) | Design & Permitting | 2019 | Ahead of time | Rescheduling due to construction phases harmonization of several investments |

### Additional Information

Information about all three investment items under this project is available on the national 10-year development plan which can be found under this link:

http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/Documents/Rozvoj%20PS/Pl%c3%a1n%20rozvoje%20p%c5%99enosov%c3%a9%20soustavy%20%c4%8cesk%c3%a9%20republiky%202016%20-%202025_final.pdf

## Investment needs

The project will facilitate power evacuation from the existing and new generation capacities (CCGT and Lignite) which are located in the high concentareted power generation capacities in the north-western part of the Czech grid in the west-east direction of the power flow. Further, the project will prevent the non-fulfillment of the operational security criteria of the Czech power system; will substantially increase the interoperability and flexibility of the system in the Czech Republic in the north-western part of the system and ensure the security of supply in all those regions whose energy supply depend on these lines including the central part where the Capital city is located. Enhancement of the market flows in the northern-western direction is another driver for this project.

Capacity Analysis has not evaluated a boundary related to this project, because its main driver is mostly related to the evacuation of flexible thermal generation, which contributes to the European balancing market, or when there is low RES production in other parts of the region (e.g. dry years like 2015) etc. There is a constant contribution to the capacity applying the common CBA, thus capacity analysis will not bring any further need to explore more capacity on this boundary.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | outside: 650 |
| Delta GTC contribution (2030) [MW] | outside: 0 |
| | outside: 100 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 265±53 |
| Cost explanation | As preparation of the investment items continues, route and technology(e.g. type of towers) are detailed specified to reflect differenttechnical, safety, environmental and legal requirements imposed fromdifferent permit grating processes (e.g. EIA, land and constructionpermit) which usually as a result affects cost estimation of theinvestment which were previously given. The difference in currencyexchange rate was also taken into consideration.<br><br>The cost value includes only CAPEX cost. |

| | |
|---|---|
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| **Scenario specific CBA indicators** | **EP2020** | **Vision 1** | **Vision 2** | **Vision 3** | **Vision 4** |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 0 ±25 | -25 ±25 | -25 ±25 | -50 ±25 | -50 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | -2 ±2 | -1 ±1 | -3 ±2 | -4 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | ±100 | ±100 | -100 ±100 |

Due to the development of the CBA methodology the contribution of this project to GTC changed compared to that in the TYNDP 2014 and due to the changing in ENSTO-E Visions in comparison of 2020 and 2030 there is some evolution of GTC. On top of benefits in the context of the CBA methodology, there are other regional benefits; one of these benefits is the connection of flexible generation enabled by the project that contributes to the regional balancing market.

Project 55 benefits besides of those covered by CBA indicators there are other additional benefits related to security of supply in the central Bohemia. This project represents the first phase to enable the connection of new 400 kV substation called “Praha – Sever” important to supply the capital city of Prague. The new 400 kV substation together with this project will considerably increase the security of supply of the capital city.

One (doubling the circuit of the existing OHL 400 kV with a capacity of 2x2500 A) of the three investment items under this project has been successfully completed and commissioned at the end of 2015. This reinforcement has enabled to reduce the limitation of power generation evacuation from the area which had to be imposed in some grid situations. The completion of the whole project is also seen as replacement of the part of the 220 kV grid which is planned to decommissioned in the near future.

## Project 62 - Estonia-Latvia 3rd IC

Project nr 62 is a planned third 330 kV interconnection between Estonia and Latvia. The project consists of 3 investments of which nr 386 is the main inter-area investment, AC 330 kV OHL between Kilingi-Nõmme substation in Estonia and RigaCHP2 substation in Latvia. The Estonia-Latvia third interconnection associated investments are nr 735 AC 330 kV OHL Harku-Lihula-Sindi in Estonian and nr 1062 RigaCHP2-RigaHPP in Latvia. Both investments are relevant for capacity increase between Estonia and Latvia by 600 MW. The project also helps to improve SoS and contributes to RES increase in the Baltics western coastal areas. The project is also a precondition for construction of off-shore wind parks in Estonia and Latvia. The Estonia-Latvia third interconnection is the significant project for all the Baltic region, because it will increase competition for electricity market in Baltic States and between Baltic States and Nordic countries. It will provide reliable transmission network corridor will improve interoperability between Baltic states. In addition after commissioning the projects forming the Baltic Energy Interconnection Plan the reinforced Baltic States transmission system and its connections to Nordic and Central Europe can also serve as an alternative route for exporting Nordic surplus to the Central European power system.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Estonia - Latvia |
| PCI label | The second PCI list No. 4.2 |
| Promoted by | AST;ELERING |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 386 | Estonia-Latvia third interconnection | 100% | Kilingi-Nomme (EE) | R-TEC2 (LV) | Design & Permitting | 2020 | Investment on time | Electricty market integration, Security of Supply, RES connection to the transmission network. |
| 735 | New double circuit Harku-Sindi 330/110 kV OHL. | 100% | Harku (EE) | Sindi (EE) | Design & Permitting | 2020 | Investment on time | Planning phase finsished in 2016 |
| 1062 | Investment increases transmission capacity within Baltic States | 100% | RigaCHP2 | RigaHPP | Under Consideration | 2020 | New Investment | -Security of Supply, Capacity increase through Baltic States by 600 MW |

### Additional Information

Project website:

http://elering.ee/general-information/

http://www.ast.lv/eng/transmission_network/latvian_estonian_3rd_interconnection/

PCI link:

https://ec.europa.eu/energy/sites/ener/files/documents/pci_4_2_1_en.pdf

https://ec.europa.eu/energy/sites/ener/files/documents/pci_4_2_2_en.pdf

National development plans:

http://elering.ee/varustuskindluse-aruanded/

http://www.ast.lv/eng/par_ast/public_reports/development_plan_of_transmission_power_system/

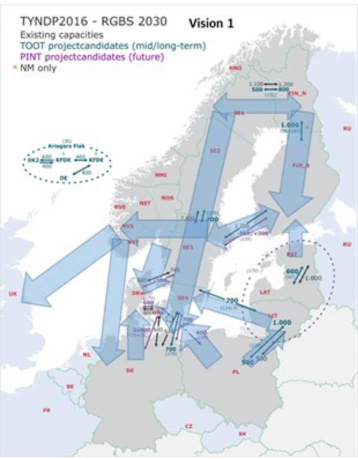
## Investment needs

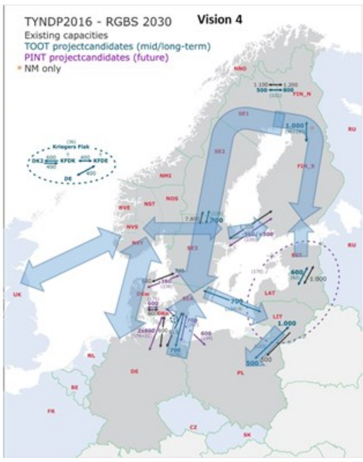
Estonia-Latvia 3rd interconnection with all its investments is an important project being a backbone for the Baltic synchronization enabling to strenghten north-south transmissioon network between Estonia and Latvia.

The investments are relevant for capacity increase between Estonia and Latvia by 600 MW. The project also helps to improve SoS and contributes to RES increase in the Baltics western coastal areas. The project is also a precondition for construction of off-shore wind parks in Estonia and Latvia. The Estonia-Latvia third interconnection is the significant project for all the Baltic region, because it will increase competition for electricity market in Baltic States and between Baltic States and Nordic countries. It will provide reliable transmission network corridor will improve interoperability between Baltic states. In addition after commissioning the projects forming the Baltic Energy Interconnection Plan the reinforced Baltic States transmission system and its connections to Nordic and Central Europe can also serve as an alternative route for exporting Nordic surplus to the Central European power system.

Baltic states country balances and main power flows in Vision 1. Biggest flows on Estonia-Latvia order are foreseen in case of Vision 1.  For VIsion 1 the limiting branches that cause bottlenecks between Estonia-Latvia are two existing interonnecting overhead lines (Tartu-Valmiera and Tsirguliina-Valmiera).

The project does not directly influence the TYNDP-defined main-boundary of the region.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | LV-EE: 500 |
| | EE-LV: 500 |
| Delta GTC contribution (2030) [MW] | LV-EE: 600 |
| | EE-LV: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 176 ±28 |
| Cost explanation | Uncertainty  costs arerelated to the changing prices of tehcnology (e.g pole types are not decided jet) and uncertainty of material cost.<br><br>Project cost is devided between two investments of the cluster. First is Kilingi-Nõmme - Riia overhead line and the second is Harku-Sindi overhead line.<br><br>Project cost is in correlation with line lenght.<br><br>Estimated life cycle OPEX is around 9 MEuros. |
| S1 | More than 100km |
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 20 ±10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 10 ±10 | <10 |
| B4 Losses (GWh/yr) | -25 ±25 | 150 ±25 | 175 ±25 | 25 ±25 | 25 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 8 ±1 | 8 ±1 | 1 ±2 | 1 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | 200 ±100 | 200 ±100 | ±100 | ±100 |

Currently the EE-LV cross-border is the weakest cross-section in Baltic States, which makes the price difference between Estonia and Latvia/Lithuania, and there around 67% of time in 2015 the capacity was fully utilised. Currently there is congestion for which elimination we are planning a new interconnector between Latvia and Estonia. In the TYNDP 2016 all projects are assessed in the normal case when in operation is current grid plus planned interconnectors. In this case the SEW benefit from project realisation for Baltic Sea region is low, because generation developments in all Baltic States countries decrease the overall SEW benefit and in some Visions the NPP in Visaginas gives opposite power flows. Secondly according to Estonian TSO maintenance plan they are planning to repair existing two interconnectors between Latvia and Estonia when 3rd EE-LV interconnector will be in place, what means that after commissioning of 3rd EE-LV interconector the cross-border capacity will remain the same as today for around 5 years from 2020-2025 (taking into account unexpected delays). The 3rd EE-LV interconnector is relevant in all scenarios for Baltic States desynchronisation from Russian IPS/UPS power system (project in PCI2 list called Various aspects of the integration of the Baltic States' electricity network into the continental European network, including their synchronous operation (generic project) and in the TYNDP 2016 called Baltic Synchro with CE) pointed out in all studies performed so far. The 3rd EE-LV interconnector main idea is to **increase or ensure the same level as today SoS within Baltic States, eliminate price difference between Estonia and Latvia.** The overall SEW benefit looking at figures is seconder thing regarding to TYNDP 2016 study.

B6: This project strongly affects the ability to have maintenance on existing lines at all, even in normal regime. New 330 kV lines in Estonia and on EE-LV border will provide the ability to have maintenance on other existing EE-LV 330 kV interconnectors and allows to survive relevant N-1 contingencies. Currently there are two 330kV lines connecting Estonia and Latvia which are partially constructed on the same corridor and the lines are connected to one substation in Latvia. Without the new Estonian internal and interconnectors EE-LV 330 kV lines in many contingency cases can lead to existing 330 kV lines overloading. The new lines help to prevent voltage collapses in case of high power exchange in several contingency cases. The problematic voltage collapse areas are existing 330 kV interconnector area and internal Estonian South-West area.

B7: The project is necessary and beneficial for several scenarios and future developments. The project is necessary to implement already in today's conditions as there are often bottleneck hours on Estonia-Latvia border, limiting the market exchange. 3rd interconnector is necessary also to improve several technical conditions – Internal SoS, Steady state stability improvement, voltage stability improvement in internal regions and on existing EE-LV border, etc. The balancing capacity is strongly improving after EE-LV 3rd interconnector commissioning and additional balancing service can be provided by existing power plants and via HVDC interconnectors.

SoS: Improves import capabilities and strengthens supply network for main load centres in Estonia and Latvia.

SEW: the highest results compared to TYNDP 2014 are changed from Vision 2 to Vision 1. The reason for this is the change in assumptions of scenarios. This resulted in the highest flows on the Estonia-Latvian cross-section in Vision 1 for the TYNDP2016.

Losses: In scenarios where the project resulted in higher flows through the Baltic system due to bottleneck removal the consequences were also higher losses. In other scenarios the effect was negligible.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.09 | 0.06 | 0.02 | 0.02 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 1.02 | 0.60 | 0.01 | 0.00 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.09 | 0.74 | 0.04 | 0.07 |

## Project 69 - East Anglia Cluster

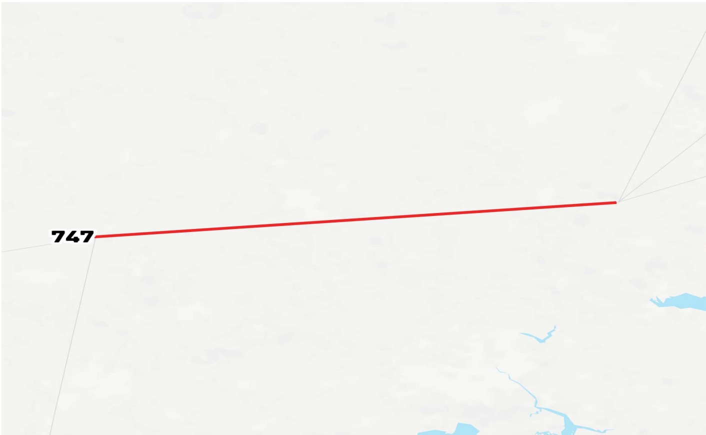
This investment is internal to the NGET TSO. This group of investments are in response to an expected growth in offshore wind and nuclear generation in and around the area at stake and is located north and east to London.

Classification Future Project

Boundary inside-downstream

PCI label

Promoted by NGT




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 747 | New 400kV double circuit | 100% | Bramford (GB) | Twinstead (GB) | Design & Permitting | 2023 | Delayed | Delay in project requirement due to generation going back. |

### Additional Information

The work on this wider reinforcement project was stopped following the signal from System Operator in November 2013, as published in ETYS 2013 report.

The ETO business won't restart this project until the go signal is received from the System Operator, under annual Network Options Assessment.

### Investment needs

This project would alleviate constraints in the East Anglia area; the coastline and waters around East Anglia are attractive for the connection of offshore wind projects, including the large East Anglia Round 3 offshore zone that lies directly to the east. The existing nuclear generation site at Sizewell is one of the approved sites selected for new nuclear generation development.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB Internal: 1950 |
| | GB Internal: 1950 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 360 ±10 |
| Cost explanation | |
| S1 | NA |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

The alleviation of congestion permits better useage of renewable and nuclear generation in the area; this leads to the modest Welfare and CO2 benefits seen.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 71 - COBRA cable

'The project is an interconnection between Endrup (Denmark) and Eemshaven (The Netherlands). The project consists of a 320 kV DC subsea cable and related substations on both ends, 320-350 km apart, applying VSC DC technology. The project is supported by the European Energy Programme for Recovery (EEPR) and is labelled by the EC as project of common interest (PCI 1.5).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Denmark-West - Netherlands |
| PCI label | 1.5 |
| Promoted by | Energinet.dk;TENNET-NL |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 427 | COBRA; New single circuit HVDC connection between Jutland and the Netherlands via 350km subsea cable; the DC voltage will be 320kV and the capacity 700MW. | 100% | Endrup (DK) | Eemshaven (NL) | Under Construction | 2019 | Investment on time | Permits in place, main contracts signed, construction started. |

### Additional Information

Project analysis shows that the project improves the SoS of the region (esp. DKW and Dutch System), due to the choice of technology, which facilitates to support system stability.

Project websites:
http://www.energinet.dk/EN/ANLAEG-OG-PROJEKTER/Anlaegsprojekter-el/Kabel-til-Holland-COBRA/Sider/Kabel-til-Holland-COBRA.aspx

http://www.tennet.eu/nl/ons-hoogspanningsnet/internationale-verbindingen/cobracable

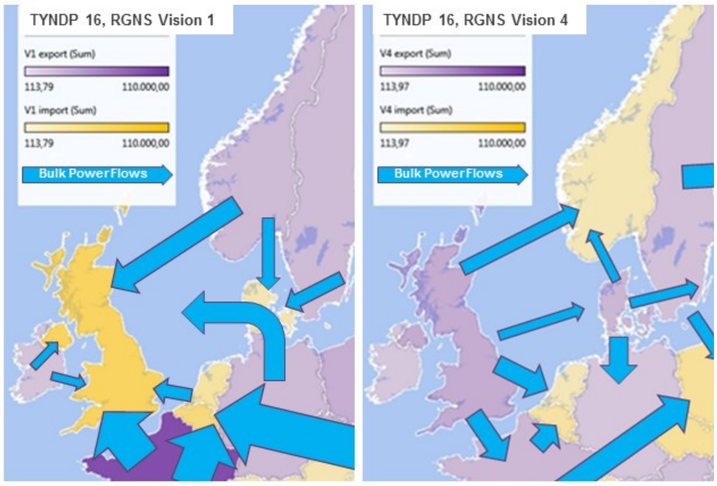
The Investment Decision has already been taken based on joint analysis, considering more detailed studies and other scenarios than used in the TYNDP. The project is currently under construction.

## Investment needs

The main bulk flow direction in this region is along the North-South axis and West-East axis as well. According to the TYNDP analysis, the net flow direction for this project is from DKW to NL, the amount of it depending on the Vision. Especially in the green Visions the hourly flows and directions can vary a lot due to transporting variable RES, which cause higher overall flows in both directions.

Overall RES integration (mainly wind energy, both on- and offshore) in this local area keeps on increasing, thus the grid infrastructure needs to be upgraded respectively. The project bypasses a congested onshore grid area and contributes to release bottlenecks.

The technology used facilitates significant improvement of the security of supply of the countries involved. Active and reactive power can be controlled independently; meaning that the project can significantly contribute to ensure voltage stability .




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | NL-DKW: 700 |
| | DKW-NL: 700 |
| Delta GTC contribution (2030) [MW] | NL-DKW: 700 |
| | DKW-NL: 700 |

| | |
|---|---|
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 620 ±60 |
| Cost explanation | undiscounted total at time of delivery. Capex only. project is one investment. No change compared to TYNDP14. |
| S1 | 50-100km |
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | 10 ±10 | 20 ±10 | 10 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 160 ±100 | 150 ±50 |
| B4 Losses (GWh/yr) | 200 ±25 | 200 ±25 | 250 ±25 | 225 ±25 | 225 ±25 |
| B4 Losses (Meuros/yr) | 8 ±1 | 10 ±2 | 11 ±2 | 13 ±2 | 15 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±30 | 300 ±100 | ±100 | -200 ±100 | ±100 |

The TYNDP16 indicators (SEW, RES, CO2) are less optimistic compared to the TYNDP14 indicators, which can be explained by the changed scenarios since the TYNDP14 edition. For the new scenarios RES installations had been rearranged between countries, especially in the RGNS region. Additionally differences in demand development account for changed regional flows.

This explains why the values for the CO2 indicator changed from saving CO2 in the 2014 edition to increasing CO2 in the 2016 edition (Vision 1); resp. less CO2 savings (Vision 4).

COBRA I is a medium term project. A major part of its benefit are caused by its early implementation. It is an innovative project, using new technology, which implies higher risks – this is not valued by TYNDP categories.

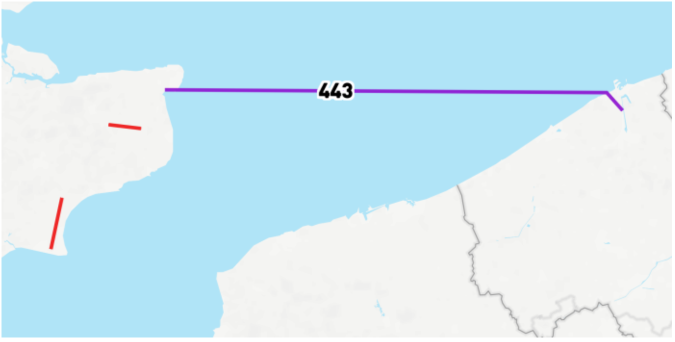
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.15 | 2.82 | 3.30 | 2.16 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.60 | 9.00 | 13.28 | 10.94 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.88 | 19.76 | 15.54 | 13.48 |

In each Vision there is a price differential between DK and the NL and a difference in average of marginal costs, causing power exchanges. The project bypasses a congested Northern German grid, facilitating exchange of RES (=wind) energy to where it is needed. In general the wind is less correlated compared to correlation between DKW and DE.

## Project 74 - Thames Estuary Cluster (NEMO)

This project envisions the realization of NEMO – the first interconnector between Great Britain and Belgium – as a 1 GW HVDC link of ~140km with technical commissioning by 2018 and operation in 2019, including a number of onshore UK reinforcements to facilitate this and other potential interconnector connections within the Thames Estuary region.The NEMO interconnector is promoted by NGIHL and Elia. The reinforcements to the internal GB network are the responsibility of NGET.NEMO aims to enhance market integration, facilitate the penetration of renewable energy sources in the energy mix and to contribute to security of supply since providing import capacity in a context of decommissioning of power plants.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Belgium - Great Britain |
| PCI label | 1.1 |
| Promoted by | ELIA; NGIHL; NGET |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 443 | New DC sea link of 1000 MW over a distance of around 140 km between Richborough (GB) and Gezelle (BE). | 100% | Richborough (GB) | Gezelle (BE) | Under Construction | 2019 | Investment on time | Final Investment Decision has been taken and confirms the target date of technical commissioning end 2018 with commercial operation in 2019. |
| 449 | New 400kV double circuit OHL and new 400kV substation in Richborough | 100% | Richborough (GB) | Canterbury (GB) | Design & Permitting | 2018 | Investment on time | Investment on time |
| 450 | Reconductor Sellindge - Dungeness | 40% | Sellindge (GB) | Dungeness (GB) | Under Construction | 2016 | Delayed | Delayed by one year due to interconnector progresion. |

### Additional Information

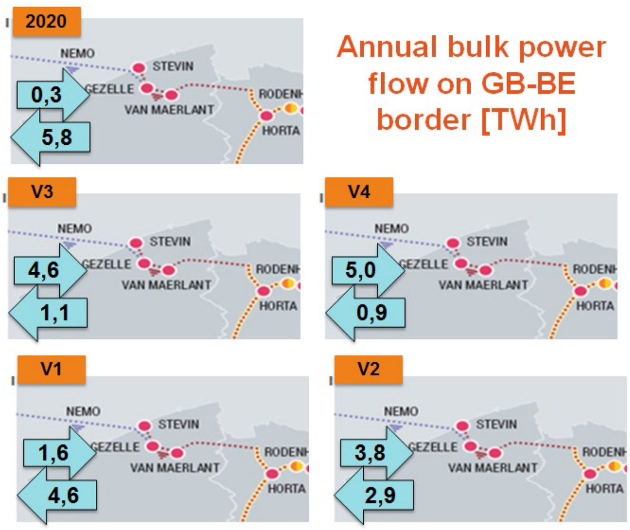
The project is integrated in Elia's National Development Plan 2015-2025: http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

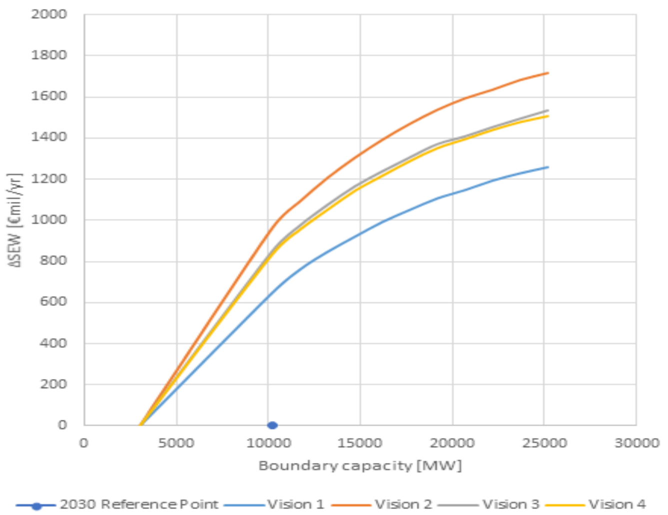
There is also a dedicated project website: http://www.nemo-link.com/

## Investment needs

The project contributes to further integration of the UK and Central European power systems, which are characterized by different production mix structures and subsequent wholesale market price deltas. In the scenarios 2020 & 2030 V1 the main direction of the bulk power flow is from Central Europe to UK given that on average the price is cheaper in Central Europe. In the scenario 2030 V2 a significant higher share of renewables in the UK induces also flows in the direction from UK to Central Europe. A higher share of renewables combined with a merit order switch to 'gas before coal' results in flows mainly going from UK to Central Europe in the 2030 V3 & V4 scenarios.

NEMO as the first UK-BE link contributes with 1 GW in achieving the target capacity on the UK - Central Europe boundary. The potential for further integration between UK and Belgium is captured via project # 121.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE-GB: 1000 |
| | GB-BE: 1000 |
| Delta GTC contribution (2030) [MW] | BE-GB: 1000 |
| | GB-BE: 1000 |

| | |
|---|---|
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 800 ±100 |
| Cost explanation | The presented cost reflects the currently expected total investment cost.The cost of the NEMO interconnector itself (PCI label 1.1.1) is in the 600-700 M€ range. New technology is involved, resulting in higher uncertainties regarding project Investment Cost.The remainder of the cost is attributed to the internal NGET reinforcements. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 90 ±20 | 40 ±10 | 90 ±10 | 80 ±10 | 80 ±20 |
| B3 RES integration (GWh/yr) | <10 | <10 | 740 ±210 | 720 ±210 | 530 ±170 |
| B4 Losses (GWh/yr) | 0 ±25 | -300 ±30 | -320 ±30 | -100 ±25 | 120 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | -17 ±2 | -15 ±2 | -6 ±2 | 8 ±2 |
| B5 CO2 Emissions (kT/year) | 1600 ±250 | 800 ±100 | 200 ±300 | -500 ±100 | -600 ±100 |

The 1000 MW link between UK and Belgium creates a significant increase in SEW across the different scenarios. From 2020 to 2030 the reduction in nuclear & coal/lignite capacity in the CWE region reduces the price spread, hence a lower welfare figure in 2030 V1 compared to 2020, which is counterbalanced by an increase in renewables in Visions 2, 3 and 4. With respect to the CO2 emissions, the increase in the 2020, 2030 V1, 2030V2 scenarios is related to the substituation effect of gas being replaced by coal, whilst the decrease in the 2030 V3 & 2030 V4 scenarios is related to gas & renewables replacing coal.

The losses figures represent the effect of the losses generated in the DC link itself combined with the effect of the resulting bulk power flows in both the UK as well as the CWE power systems. The DC losses in the link itself mount to 120-150 GWh/year.

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.31 | 7.72 | 7.00 | 7.00 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.20 | 13.64 | 18.42 | 18.08 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 3.13 | 9.60 | 10.63 | 11.50 |

## Project 75 - STEVIN & Modular Offshore Grid

This project facilitates the integration of up to 2.3 GW offshore capacity into the Belgian grid via the modular development of an offshore hub (MOG), and the extension of the 380kV backbone to the coastal area (STEVIN) via the construction of a new 50km double-circuit 380 kV corridor between Zomergem and Zeebrugge (partially undergrounded) enabling 3000 MVA transport capacity. The STEVIN project also facilitates the integration of the NEMO interconnector between Belgium and Great-Britain.The Modular Offshore Grid aims at centralizing the offshore wind of four offshore future wind farms in Belgium in an offshore hub and transporting it via 220 kV AC cables to the new substation Stevin at Zeebrugge. The modular aspect relates to the different phases in which this offshore infrastructure is envisioned to be developed, in line with the roadmap of the offshore wind farm developers. Note that this is subject of on-going investigations and alignment with the concerned offshore wind farm developers and competent authorities. Furthermore, the modular approach leaves the possibility to continue the development as per the long term potential of offshore development in the North Sea

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Belgium (offshore - inland) |
| PCI label | |
| Promoted by | ELIA |

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 444 | The STEVIN project extends the 380 kV backbone from the substation Horta (Zomergem) to a new substation Stevin at Zeebrugge with a 50km double-circuit 380kV link, partially undergrouded over a distance of ~10 km. | 100% | Horta (BE - Zomergem) | Stevin (BE - Zeebrugge) | Under Construction | 2017 | Investment on time | State Council procedures no longer pending due to agreements reached with involved stakeholders. Construction phase initiated. |
| 752 | The Modular Offshore Grid envisions the modular creation of the offshore infrastructure for the integration of the wind farms of four offshore wind farms in the Belgian part of the North Sea. The offshore infrastructure consists of an offshore hub to centralize the production from these offshore wind farms, and then transport it via 220 kV subsea AC cables to the onshore | 33% | Offshore platform(s) | Stevin (Zeebrugge) | Permitting | 2019 | Rescheduled | 2019 refers to 1st step in modular construction of an offshore hub. Subject of ongoing alignment with wind farm developers and competent authorities. MOG is presented here into the extent that it would be considered as regulated infrastructure. |

| | |
|---|---|
| | substation Stevin at Zeebrugge. |

## Additional Information

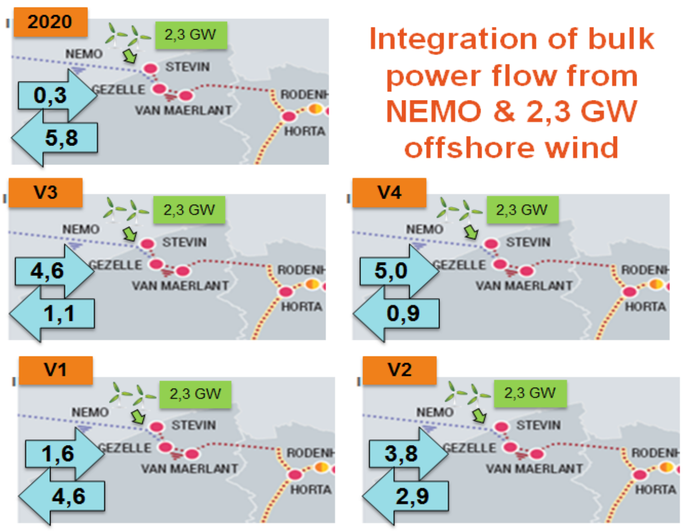
The project is integrated in Elia's National Development Plan 2015-2025: http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

Detailed information on the STEVIN investment can be found back at the following dedicated website: http://www.stevin.be/

## Investment needs

Integration of offshore wind in the Northern Seas is one of the key objectives of the concerned region. This project delivers an important piece of the solution by enabling the integration of up to 2,3 GW of offshore wind in Belgium, as well as the integration of the 1 GW NEMO interconnector between the UK and Belgium.

Furthermore, the transport capacity that the STEVIN investment creates is important for the development of industrial activities in the coastal area in terms of securing the supply of energy as well as the integration of onshore RES given the saturation on lower voltage levels.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

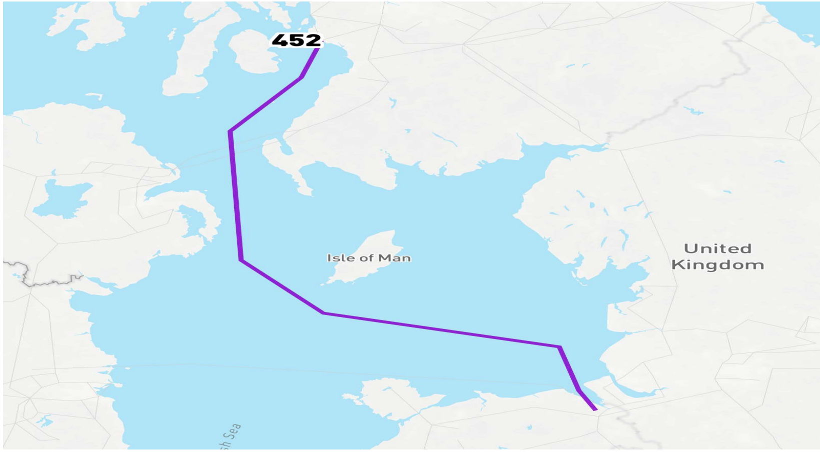
| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE-BEcoast: 3000 |
| | BEcoast-BE: 3000 |
| Delta GTC contribution (2030) [MW] | BE-BEcoast: 3000 |
| | BEcoast-BE: 3000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 670 ±100 |
| Cost explanation | Cost represents the currently expected total project investment cost.<br>Uncertainty range related to procurement/construction cost uncertainties. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 320 ±50 | 430 ±40 | 360 ±20 | 420 ±20 | 480 ±40 |
| B3 RES integration (GWh/yr) | 7070 ±1420 | 7100 ±40 | 7080 ±10 | 6260 ±190 | 6920 ±80 |
| B4 Losses (GWh/yr) | 120 ±25 | 570 ±50 | 570 ±50 | 250 ±25 | 250 ±25 |
| B4 Losses (Meuros/yr) | 5 ±1 | 30 ±3 | 26 ±3 | 14 ±2 | 16 ±2 |
| B5 CO2 Emissions (kT/year) | -800 ±5130 | -3800 ±200 | -4800 ±200 | -2200 ±100 | -2300 ±100 |

The project generates a significant SEW increase and CO2 savings directly related to the integration of 6-7 TWh of offshore energy in Belgium on annual basis. The transportation of this energy to the load centers where it is consumed implies an increase in system losses.

## Project 77 - Anglo-Scottish -1

Western link is a new 2.4GW (short-term rating) submarine HVDC cable route from Deeside to Hunterston with associated AC network reinforcement works on both ends. It is recommended to proceed in the Network Options Assessment, including a fast de-load scheme.




Classification Future Project

Boundary North-South

PCI label

Promoted by NGT; SPT

## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 452 | New 2000MW HVDC Link on the West Coast of the UK | 100% | Hunterston (GB) | Deeside (GB) | Under Construction | 2017 | Delayed | Delayed due to complexity in construction and other issues |

## Investment needs

The project alleviates North - South power flow congestion in the UK and facilitate the connection of RES and the connection of the remote Scottish Islands.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB Internal: 2400 |
| | GB Internal: 2400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1220 |
| Cost explanation | NB This does not include onshore reinforcement works carried out by SPT at this stage. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

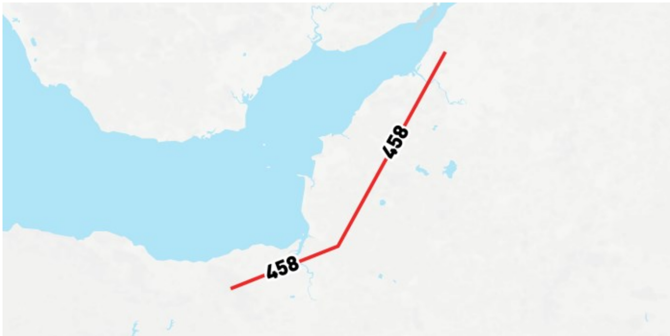
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 70 ±10 | 40 ±10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 100 ±100 | 400 ±100 | ±100 | 200 ±100 |

The project has the highest benefits in vision 2 due to the forecasted increase in Wind generation. Wind generators typically locate in Scotland and the Western link will contribute to transmitting the electricity to the demand centre in the which is mainly in the South of the country. In vision 4 installation of renewable generation is high as is the storage capability. Therefore, the significance of the HVDC is lower due to the smart grid and smart metering innovative which smooth's the peak demand.
As the project is treated as a GB internal transmission network having no interconnection with the Continent, B4 indicator (impact on losses) was not assessed.

## Project 78 - South West Cluster

A new 400kV transmission route between Hinkley Point and Seabank

| | |
|---|---|
| Classification | Future Project |
| Boundary | West-East |
| PCI label | |
| Promoted by | NGT |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 458 | New Hinkley Point - Bridgwater - Seabank 60km double circuit 400kV OHL | 100% | Hinkley Point (GB) | Seabank (GB) | Design & Permitting | 2022 | Rescheduled | Based on current the generation connection dates the investment has been rescheduled. |

## Investment needs

The new Hinkley Point – Seabank double circuits aims to strengthen the connection of south west area with central area in GB by increasing network capability, and transport the electricity generated by new Hinkley Point C nuclear, renewable generations and interconnectors in the south west region.

Project needed for renewables off of the South West peninsula, the replanting of Hinkley Point nuclear power station and further CCGT at Seabank.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB Internal: 4150 |
| | GB Internal: 4150 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 814 |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 1380 ±210 | 1040 ±160 | 750 ±110 | 1370 ±210 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 3600 ±500 | 3000 ±500 | 2400 ±400 | 4900 ±700 |

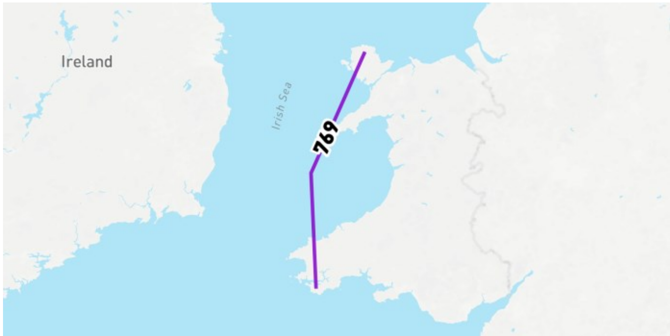
The project has very large benefit, as it is key for connection of future nuclear- thus without the project, a large volume of constraint costs are paid to curtail this, hence the large values seen across the scenarios.

As the project is treated as a GB internal transmission network having no interconnection with the Continent, B4 indicator (impact on losses) was not assessed.

## Project 79 - Wales Cluster

A new subsea HVDC circuit rated at 2-2.5GW connecting from Wylfa/Irish Sea to Pembroke. The reinforcement work includes ex-tending both Wylfa and Pembroke 400kV substations

| | |
|---|---|
| Classification | Future Project |
| Boundary | West-East |
| PCI label | |
| Promoted by | NGT |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 769 | New HVDC bipolar interconnection with possible offshore connection points at the Irish Sea offshore wind farms. | 100% | Wylfa (GB) | Pembroke (GB) | Under Consideration | 2024 | Delayed | Delayed due to anticipated changes in the local generation background. |

### Additional Information

As a TO the Wylfa-Pembroke link remains an investment option for providing future capacity in Wales should it be needed. At the moment development of this project is not actively progressing as there is not believed to be a need for delivery at this time. This approach is in line with the NOA recommendations.

### Investment needs

Reinforcement of the internal grid to facilitate the integration of nuclear plant and RES.

### Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB Internal: 2000 |
| | GB Internal: 2000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1180 |
| Cost explanation | |
| S1 | 50-100km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 630 ±90 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 20000 ±3000 | -300 ±100 | -100 ±100 | 53700 ±8100 |

The variability of forecast generation in Wales means the project has very low benefit against two futures.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 81 - North South Interconnector

A new 400 kV interconnector between Woodland in Ireland and Turleenan in Northern Ireland.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Ireland - Northern Ireland |
| PCI label | 2.13.1 |
| Promoted by | EIRGRID;SONI |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 462 | A new 400 kV interconnector between Northern Ireland and Ireland. | 100% | Woodland (IE) | Turleenan (NI) | | | Delayed | Further studies required before re-submission for planning consents |

### Additional Information

Project website:

http://www.eirgridgroup.com/the-grid/projects/north-south/the-project/

PCI page:

https://ec.europa.eu/energy/sites/ener/files/documents/pci_2_13_1_en.pdf

This circuit will establish a second interconnector between Ireland and Northern Ireland, effectively eliminating the ongoing risk of system separation, thus allowing an increased transfer capacity. The project is being supported through the consents processes in both jurisdictions by SONI and EirGrid. Upon receipt of consents the project will be implimented by the respecting transmission asset owners with an expected completion date of Q4 2019.

## Investment needs

The promotor states;

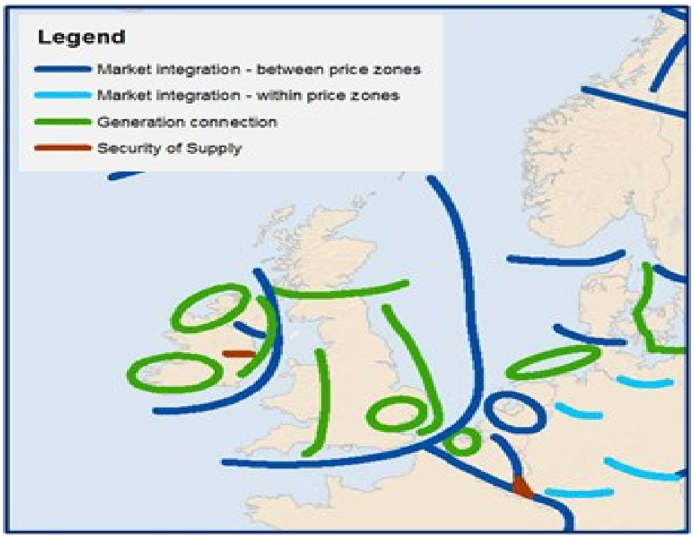
"*The transmission network needs to be reinforced to:*

*(1) Support lower energy costs for the island of Ireland by ensuring the efficient functioning of the Single Electricity Market (SEM);*

*(2) Allow shared generation capacity on the island and therefore ensure security of supply;*

*(3) Assist in meeting the governments' renewable energy targets by facilitating the integration of renewable generation; and*

*(4) Accommodate the long-term security of supply needs of the north-east of Ireland."*




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IE-NI: 800 |
| | NI-IE: 800 |
| Delta GTC contribution (2030) [MW] | IE-NI: 800 |
| | NI-IE: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 286 |
| Cost explanation | The uncertainty range in costs for the project is €277m to €329m. The estimated cost refers to the investment cost only; |

| | |
|---|---|
| | the cost uncertainty range relates to procurement and construction cost uncertainties. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | 20 ±10 | 20 ±10 | 30 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | 120 ±30 | 90 ±30 | 50 ±10 | 260 ±60 | 200 ±40 |
| B4 Losses (GWh/yr) | -25 ±25 | -25 ±25 | -25 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | -2 ±2 | -1 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | -200 ±30 | ±100 | ±100 | -200 ±100 | -300 ±100 |

The project promoter states

*"The proposed second North-South interconnector is a critical and strategically urgent transmission reinforcement. A comprehensive and detailed analysis has been undertaken by EirGrid and SONI, examining a range of power system indicators such as generation adequacy and security of supply, network security, and the costs of producing electricity for the years 2020 and 2030. These studies encompass a range of scenarios and sensitivities using current forecasts for demand, generation portfolio and fuel prices. A range of electricity production cost (Socio Economic Welfare) and security of supply benefit savings can be attributed to the construction of the second North-South interconnector with combined annual electricity production cost and security of supply savings of the order of €20m per annum in 2020 rising to between €40m - €60m per annum from 2030. The modelling approach undertaken by Eirgrid and SONI uses similar input data and assumptions to the TYNDP process, however it employs a more detailed modelling methodology than that used in the TYNDP assessments.*

*In contrast to the TYNDP 16 asessments, the production cost / socio economic welfare analysis employed by EirGrid and SONI considers the cost impacts of reductions in system stability must run unit requirements brought about by the construction of the new interconnector. The analysis also considers the cost impacts of other operational rules like limits on the amount of non synchronous generation, and operating reserve requirements.*

*The security of supply analysis considers a detailed analysis of the predicted generation portfolio and demand forecasts in the Single Electricity Market (SEM) over a range of scenarios and assumptions, and utilises the methodology and tools endorsed by the energy regulators to assess the capacity payment pot size in the SEM. This approach results in an estimate that the additional security of supply benefit from the second North-South interconnector is at least 240 MW on an enduring basis. This benefit was monetised by using the cost of a new peaking generator from the SEM Committee Decision Paper on the capacity requirement and annual capacity payment sum for 2015. The resultant enduring security of supply saving is of the order of €19m.*

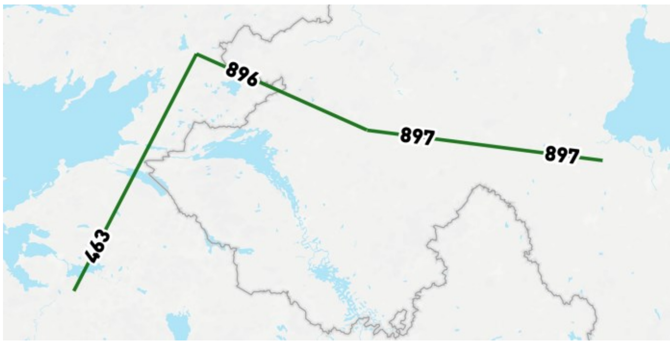
*The combined savings for the project are assessed over two time horizons, 2020 and 2030 which correspond with the time horizons assessed under TYNDP 2016. There are two scenarios considered in each time horizon. In 2030, key input data such as demand, installed capacity of generation portfolio and fuel prices are the same as those used in the TYNDP 16 assesssments and both visions 1&3 are assessed. In 2020 the Expected progress scenario is assessed as the base case with a further low fuel price scenario also being assessed. The low fuel price scenario assesses the production cost savings using lower fuel prices than those assumed for the EP2020 scenario in TYNDP 2016. In all studies, a detailed representation of the generation portfolio is used."*

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.02 | 0.01 | 0.02 | 0.01 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 0.38 | 0.00 | 0.87 | 0.17 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.51 | 2.64 | 3.06 | 4.04 |

## Project 82 - RIDP I

The infrastructure development is required to facilitate connection of renewable generation in the North and West of the Island. It will further integrate the Ireland and Northern Ireland transmission systems and provide capacity for substantial demand growth in the area.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Ireland - Northern Ireland |
| PCI label | 2.13.2 |
| Promoted by | EIRGRID;SONI |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 463 | A new EHV link from Sranangh to South Donegal | 100% | Sranangh (IE) | New substation in South Donegal (IE) | | | Investment on time | The preferred scheme has been selected since the last TYNDP; this is one of the elements of the preferred scheme. |
| 896 | A new 275 kV cross border link from South Donegal to Omagh South | 100% | South Donegal (IE) | Omagh South (NI) | | | New Investment | Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study. |
| 897 | A new 275 kV line from Omagh South to Turleenan | 100% | Omagh South | Turleenan | | | New Investment | Investment 82.463 of the previous TYNDP described the as then undefined scheme that was the subject of a joint study between NIE and EirGrid. That study has since been completed. This investment is one of a number emerging from the study. |

### Additional Information

Project website:

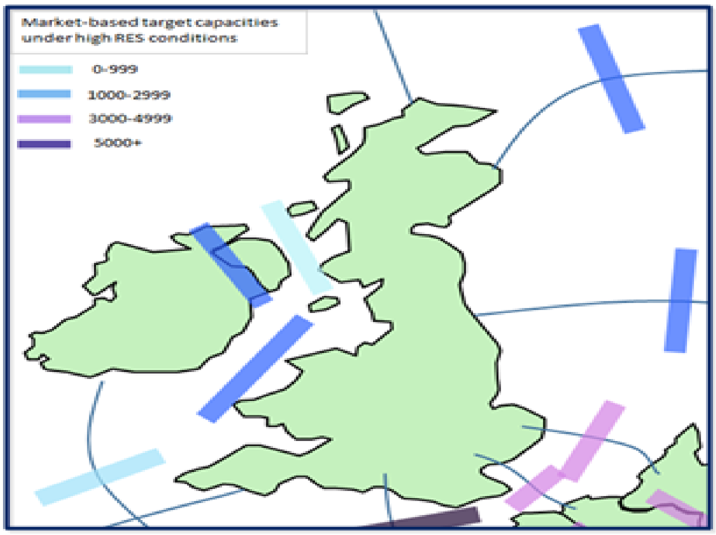
http://www.eirgridgroup.com/how-the-grid-works/ridp/

PCI page:

https://ec.europa.eu/energy/sites/ener/files/documents/pci_2_13_2_en.pdf

## Investment needs

This project is required to facilitate the increasing renewable generation in the North West of the island of Ireland. The existing transmission network in the region is relatively weak, consisting of mainly 110 kV infrastructure. This project enables the future RES in both jurisdictions to access the existing 220 kV in Ireland and the 275 kV network in Northern Ireland. It contributes to the target capacity of interconnection between Northern Ireland and Ireland.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-NI: 550 |
| | NI-IE: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 412 |

| | |
|---|---|
| Cost explanation | The uncertainty range in costs for the project is €371m to €618m.<br><br>The uncertainty range reflects a range of -10% to +50% on the central estimate. The level of variation, at 50%, reflects the fact that the central cost estimate is based primarly on overhead line development and the variation is to allow for the potential for underground cable to be required. The costs now detailed reflect a more considered assessment of the scope of construction, compared to the lower costs presented in TYNDP 2014. Whilst the project comprises three elements, only an aggregated cost for all three components has been documented. OPEX costs for this project have not been calculated. They will be very dependent on the detailed scope of the work that proceeds. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 30 ±10 | 20 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | N/A | 570 ±40 | 510 ±30 | 200 ±100 | 480 ±50 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -200 ±100 | -300 ±100 | -200 ±100 | -400 ±300 |

This project enables significant quantities of renewable generation to be securely connected to the Ireland and Northern Ireland transmisison systems, resulting in large reductions in generation curtailment and CO2 emissions.

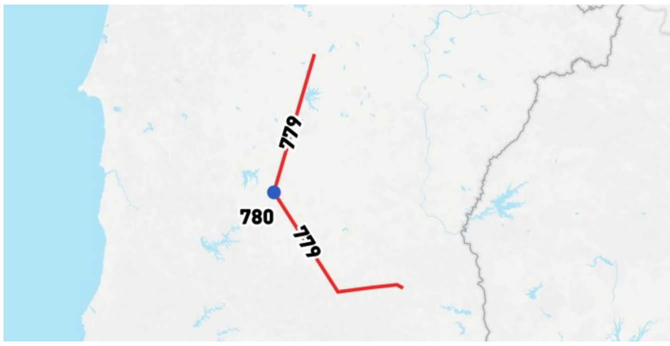
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.02 | 0.01 | 0.02 | 0.01 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 0.38 | 0.00 | 0.87 | 0.17 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.51 | 2.64 | 3.06 | 4.04 |

## Project 85 - Integration of RES in Alentejo

The main objective of this project consists in introducing the network reinforcements that are needed to allow the connection of new RES generation (mostly solar but also some wind) that is foreseen for the south region of Portugal, where the solar potential is considerably high. The project includes two new 400 kV OHL that will constitute a new axis between F. Alentejo-Ourique-Tavira substations. It is also included the expansion of the Ourique substation to include the 400 kV voltage level.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Internal boundary in Portugal (Alentejo) |
| PCI label | |
| Promoted by | REN |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 779 | New 107 km double-circuit 400+150 kV OHL F. Alentejo-Ourique-Tavira. | 100% | F. Alentejo (by Ourique) | Tavira (by Ourique) | Planning | 2025 | Investment on time | Project on time |
| 780 | Extension of existing Ourique substation to include 400 kV facilities. | 100% | Ourique (PT) | | Planning | 2024 | Investment on time | Project on time |

### Additional Information

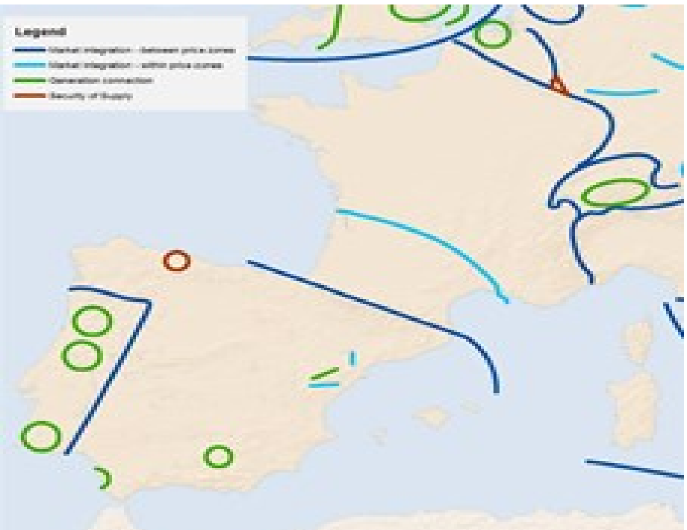
Portuguese National Development Plan:
http://www.erse.pt/pt/consultaspublicas/consultas/Documents/53_Proposta%20PDIRT-E_2015/PDIRT%202016-2025%20-%20Junho%202015%20-%20Relat%C3%B3rio.pdf
Clustering: the project consists of a new axis connecting Ferreira do Alentejo and Tavira substations, with an intermediate substation (Ourique) that will need to be expand to include the 400 kV voltage level. All investments are in series so a lack of any of them will not allow to get the full GTC increase of the project.

## Investment needs

This project integrates new amounts of solar (and also some wind) generation in the south regions of Portugal. The existing network at 150 kV is not sufficient to integrate the expected new significant amounts of power and a new 400 kV axis should be launched in this region, establishing a connection between the two southern interconnections between Portugal and Spain: the Ferreira do Alentejo-Alqueva (PT) to Brovales (ES), and the Tavira (PT) to Puebla de Guzmán

(ES). This axis will also close a 400 kV ring in the southern part of Portugal that will guarantee the network integration of the new RES and at the same time the load growth in the region (Algarve is one of the regions that presents the biggest growth rate in Portugal), in a safe and quality manner.
This project includes a new 400 kV axis between the two already in service F. Alentejo and Tavira substations, together with the expansion of Ourique substation to introduce the 400 kV voltage level, where new generation will be connected directly. The new axis F. Alentejo-Ourique-Tavira, constitutes a new transport corridor that increases network capacity and also ensures n-1 security in case of a failure.

The GTC is common to all Visions, so the comparison among SEW/GTC ratios depends only from the SEW values. The SEW of the project reflects the benefit of integrating new generation (RES) that will replace more expensive generation (fossil fuel based generation).



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | outide-inside: - |
| | inside-outide: 1400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 70.3 ±7 |

| | |
|---|---|
| Cost explanation | Uncertainty regarding total length of lines, extra costs due to safety, environmental or legal requirements imposed during permit grating process.<br>Cost same magnitude as in TYNDP2014.<br>Only CAPEX |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

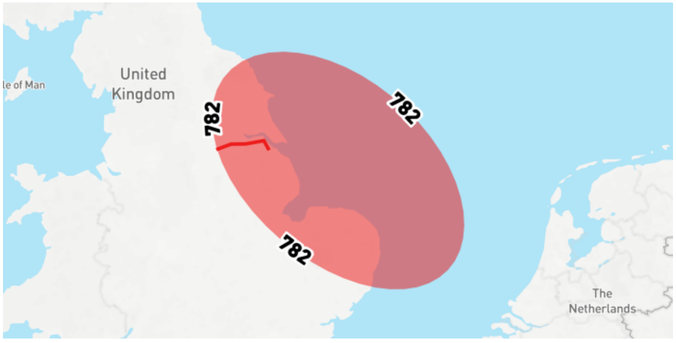
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | 120 ±20 | 40 ±10 | 240 ±40 |
| B3 RES integration (GWh/yr) | N/A | 290 ±60 | 1340 ±270 | 490 ±100 | 2750 ±550 |
| B4 Losses (GWh/yr) | N/A | 0 ±25 | 0 ±25 | 0 ±25 | 75 ±25 |
| B4 Losses (Meuros/yr) | N/A | 0 ±1 | 0 ±1 | 0 ±1 | 5 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | -100 ±100 | -500 ±100 | -200 ±100 | -1000 ±200 |

Savings in variable generation costs (SEW) and reduction on $CO_2$ emissions are caused by the integration of new RES generation in the system replacing fossil fuel based generation. Therefore the highest values are reached in the scenarios with higher RES integration.
There is an increase of losses in the scenarios where RES integration is very high. The location of this new generation is further from the load centres and this new renewable generation is replacing conventional generation located closer the load centres.
Regarding the S1 (protected areas) and S2 (urbanised areas) indicators, the definitive routes of the projects are still to be determined, but they will always be selected taking the objective of minimizing impact.

## Project 86 - East Coast Cluster

A very high level indication of the works required for GB East Coast. In detail the projects will consist of multiple offshore HVDC and AC circuits and connecting platforms joining to multiple onshore connection points with their own reinforcement requirements.

Classification Future Project




Boundary East-West

PCI label

Promoted by NGT

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 781 | East Coast Integrated Offshore Transmission | 100% | Under Consideration (GB) | Under Consideration (GB) | Under Consideration | 2026 | Delayed | Rescheduled due to changes in the generation timescales. |
| 782 | Connection of Triton Knoll, Doggerbank & Hornsea GB Wind Farms and all associated works | 100% | Under Consideration (GB) | Under Consideration (GB) | Under Consideration | 2026 | Delayed | Rescheduled due to changes in the generation timescales. |

### Additional Information

To reduce costs and meeting CO2 emission obligations, this project constructs the generation enabling works for a number of offshore wind power generation as well as new gas fired power plants.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB Internal: n/a |
| | GB Internal: n/a |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 3500 ±100 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | 50 ±10 | 70 ±10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

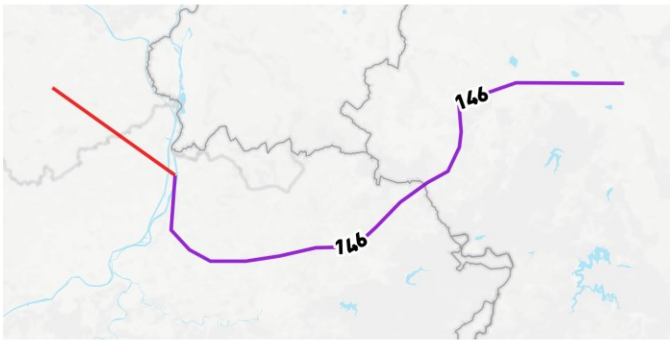
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

Vision 1 and 4 have less development of new RES generation therefore less offshore wind farms are forecasted in this scenario. As a result, there will be a lower level of generation of the East coast therefore driving less economic requirement for the reinforcements.

## Project 92 - ALEGrO

This project realizes the first interconnection between Belgium (Lixhe) and Germany (Oberzier) as a 94 km HVDC link with a bidirectional rated power of approximately 1.000 MW capacity, incl. internal reinforcements in the AC grid in Belgium. The direct coupling of the Belgian and German markets contributes to the completion of the internal energy market and to securing the adequacy (security-of-supply) of Belgium.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Belgium - Germany |
| PCI label | 2.2 |
| Promoted by | AMPRION;ELIA |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 146 | Underground HVDC connection (cable + 2 convertor stations) between Germany and Belgium | 100% | Area of Oberzier - Aachen/Düren (DE) | Area of Lixhe - Liège (BE) | Permitting | 2020 | Delayed | The expected commissioning date of 2020 is based on the hypothesis of acquiring all necessary permits as planned. |
| 1045 | Reinforcements in the Belgian AC grid in the Lixhe-Herderen area to - amongst others - accommodate the integration of ALEGrO interconnector.<br><br>The reinforcements consist of<br>i) installation of a second 380 kV circuit on the existing 380 kV overhead line Lixhe-Herderen (2017). This second circuit will be realized with high performance conductors (HTLS)<br>ii) construction of a 380 kV substation in Lixhe including two 380/220 kV transformers (2017) and one 380/150 kV transformer (2019). | 100% | Lixhe | Herderen | Under Construction | 2017 | Investment on time | Progressed as planned. |

## Additional Information

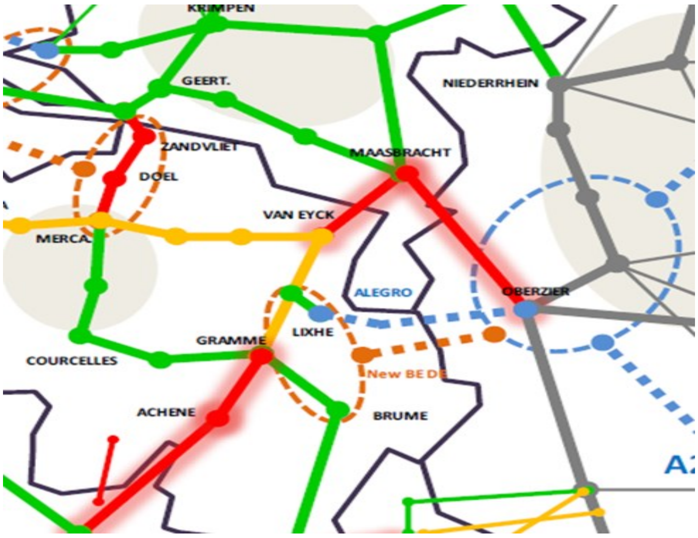
The project is integrated in Elia's National Development Plan 2015-2025: http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

Dedicated project websites: http://netzausbau.amprion.net/projekte/alegro-deutschland-belgien and http://www.elia.be/nl/projecten/netprojecten/alegro/alegro-content

## Investment needs

The transition of the energy mix in Belgium and Germany is characterized by a planned nuclear phase out and an ambitious target for the integration of RES. This generates a corresponding need to develop transmission capacity between the Belgian and German power systems, enabling to secure the adequacy (security-of-supply) in Belgium as well as the utilization of the cheapest available energy across the border.

ALEGrO as the first DE-BE link contributes with 1 GW to the development of interconnection capacity on the BE-DE border. The potential for further development of interconnection capacity between Germany and Belgium is captured via project # 225.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-BE: 1000 |
| | BE-DE: 1000 |
| Delta GTC contribution (2030) [MW] | DE-BE: 1000 |
| | BE-DE: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 560 ±35 |
| Cost explanation | The presented cost represents the currently expected total project investment cost. The cost related to the ALEGrO investment (PCI 2.2.1) is in the 490-550 M€ range. Uncertainty range covers for the fact that finally incurred cost may differ due to the following reasons: results of procurement/tendering processes may differ from expected costs; changes in technical project specifications compared to current planning.<br><br>The cost related to internal AC reinforcements in Belgium (PCI 2.2.2 & PCI 2.2.3) is in the 35-45 M€ range. Uncertainty range related to procurement / construction cost uncertainties. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±20 | 30 ±10 | 20 ±10 | 20 ±10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±10 | <10 | 270 ±150 | 150 ±40 |
| B4 Losses (GWh/yr) | -40 ±25 | 250 ±50 | 350 ±50 | 100 ±50 | 75 ±25 |
| B4 Losses (Meuros/yr) | -2 ±1 | 13 ±3 | 16 ±2 | 6 ±3 | 5 ±2 |
| B5 CO2 Emissions (kT/year) | 600 ±100 | 600 ±100 | 300 ±200 | -100 ±100 | ±100 |

Highest SEW values in the coal before gas scenarios 2020, 2030V1 & 2030 V2 due to replacement of significant amounts of gas-fired production in Belgium with cheaper production, such as coal-fired production, from Germany. In 2030V3 & 2030 V4 the evolution in the production park is combined with a merit order switch between gas and coal, leading gas-fired production setting the price during most of the year and consequently a smaller potential for price convergence. The substitution effect of gas-coal is reflected in the CO2 impact indicator.

A full picture of the project benefits - highest around 2025 given planned nuclear phase out in Belgium and the related contribution of ALEGrO to ensure adequacy and security-of-supply in Belgium - has been assessed in complement to the TYNDP works. The combination of the benefits highlights the societal value of the ALEGrO project.

The losses figures represent the effect of the losses generated in the DC link itself combined with the effect of the resulting bulk power flows in the CWE power system. The DC losses in the link itself mount to 100-170 GWh/year depending on the scenario.

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.50 | 0.55 | 1.22 | 0.88 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 5.10 | 3.02 | 7.92 | 6.34 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 13.64 | 12.40 | 6.55 | 7.83 |

## Project 94 - GerPol Improvements

Upgrade of the existing 220 kV double interconnection line between Krajnik and Vierraden to 400 kV double line in the same direction together with installation of Phase Shifting Transformers on two existing interconnection lines (Krajnik-Vierraden by 50Hertz Transmission GmbH in Vierraden and Mikułowa-Hagenverder by PSE S.A. in Mikułowa) on the PL/DE border including an upgrade of substations Vierraden, Krajnik and Mikułowa.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Poland - Germany |
| PCI label | 3.15 |
| Promoted by | 50Hertz; PSE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 139 | Upgrade of existing 220 kV line Vierraden-Krajnik to double circuit 400 kV OHL. | 100% | Vierraden (DE) | Krajnik (PL) | Under Construction | 2018 | Delayed | Finalization of the investment in due date (2017) was not possible because of permit granting reasons (regarding building of the “Uckermark” line) on 50Hertz side. Therefore the schedule for switching off of the existing 220 kV line to 400 kV has been changed. The interconnector will be temporally disconnected until 2018 in order to perform necessary works in the substations Krajnik and Vierraden. In 2018 first two PST in Vierraden will be installed and the line will be connected on 400 kV through a 220/400 kV transformer. The project is planned to operate in final shape (4 PSTs in SS Vierraden and the 2x400 kV interconnector) by 2020, depending on the permit granting process for the “Uckermark” line. |
| 796 | New 400/220 kV switchyard in Krajnik | 100% | Krajnik (PL) | | Design & Permitting | 2020 | Rescheduled | The commissioning date was adjusted to optimize the planning and development of transmission system. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 799 | New PST in Mikułowa | 100% | Mikułowa (PL) | Commissioned | 2016 | Delayed | The PSTs in Mikułowa substation have been constructed in 2015. In first half of 2016 test and trials have been performed. The delay accured due to technical difficulties during starting phase. |
| 992 | Installation of new PSTs in Vierraden | 100% | Vierraden | Design & Permitting | 2018 | Delayed | The 380 kV commissioning will be possible after finalization of the new connecting OHL from Vierraden to Neuenhagen (near Berlin) to replace the current 220 kV network and form a new 380 kV grid. |

## Additional Information

Link to PSE S.A. Development Plan where this project is included: http://www.pse.pl/index.php?modul=10&gid=402

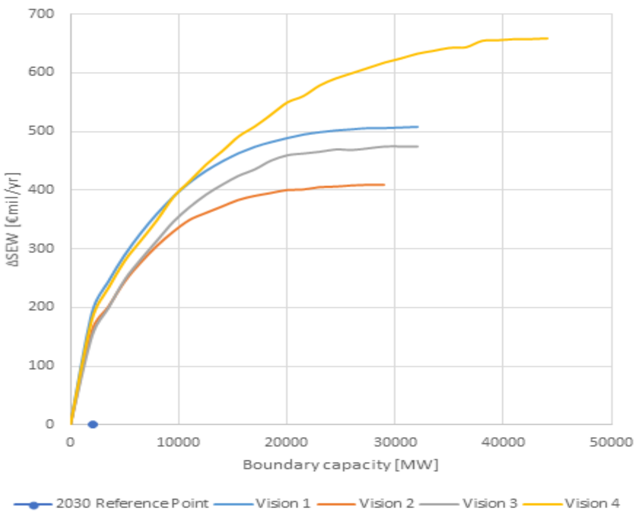
2nd PCI list: https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

Description of PCI projects on PSE website: http://www.pse.pl/index.php?dzid=256&did=2063

## Investment needs

This Project contribute to the following:
• decreasing of unscheduled flow from Germany to Poland, Poland to Czech Republic and Poland to Slovakia by increasing of controllability on entire synchronous profile;
• enhancement of market capacity on Polish synchronous profile - PL/DE as well as PL-CZ/SK border in case of both import and export. The project provides additional capacity (NTC – Net TransferCapability) of 500 MW in terms of import and 1500 MW export; greater level of safety and reliability of operation of the transmission network in Poland due to enhanced control of power flow.

The analyses show that high dependency of prices in Poland are strictly relevant with CO2-prices. Self-sufficiency of Poland allow sustain on high level the security of supply at the expense of high energy prices. The emissions are dependent on the visions, where low CO2-prices leads to increased coal-fired production hence increased emissions. Implementation in Poland high efficiency coal technology allow decrease level of emissions significantly.
Making the balance between societal welfare gain and infrastructure investment costs for increasing levels of interconnection, the optimal level of interconnection ranges from 2,5 GW to 4,5 GW. Compared to the present and planned investments this shows a potential for further projects.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the project 230, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-PL: 2000 |
| | PL-DE: 1000 |
| Delta GTC contribution (2030) [MW] | DE-PL: 500 |
| | PL-DE: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 85 |
| Cost explanation | 85 MEUR - Cost of the project on PL side |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 130 ±20 | 190 ±10 | 140 ±20 | 70 ±10 | 70 ±10 |
| B3 RES integration (GWh/yr) | 10 ±< 10 | 10 ±10 | 10 ±10 | 350 ±70 | 170 ±10 |
| B4 Losses (GWh/yr) | 475 ±47 | 1025 ±102 | -75 ±25 | -150 ±25 | 350 ±35 |
| B4 Losses (Meuros/yr) | 20 ±2 | 55 ±6 | -4 ±2 | -9 ±2 | 23 ±3 |
| B5 CO2 Emissions (kT/year) | -400 ±50 | 2000 ±100 | 500 ±100 | -1700 ±300 | -1400 ±200 |

Detailed TYNDP project CBAs show that average SEW contributions per project in the perimeter of this boundary range from 40 to 82MEuro/year. This corresponds to about 95 MEuro/year per additional GW of transfer capacity.

The difference between values for 2020 and 2030 is due to different grid structure and generation mix in calculation models in 2020 and 2030.

## Project 96 - Keminmaa-Pyhänselkä

The project is 400 kV overhead line in North Finland. Integration of new RES generation at Bothnian bay and increased transmisison capacity demand. Will help utilizing the Swedis/Finnish cross border capacity.

Classification Long-term Project

Boundary Finland North-South

PCI label

Promoted by FINGRID


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 801 | Integration of new generation + increased transmission capacity demand. | 100% | Keminmaa (FI) | Pyhänselkä (FI) | Planning | 2024 | Investment on time | Investment progresses as planned, rescheduled slightly since last TYNDP due to expected development on the drivers behind the investment. |

### Additional Information

The project consist of 400 kV overhead line, series compensation of the line and substation extensions at the terminal substations.

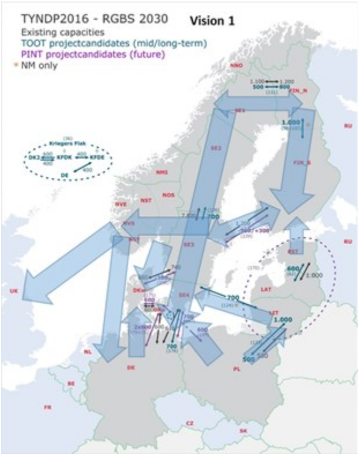
Fingrid has published a national development plan in 2015. The investment plan presents a detailed look of the projects. The plan is available in Finnish:

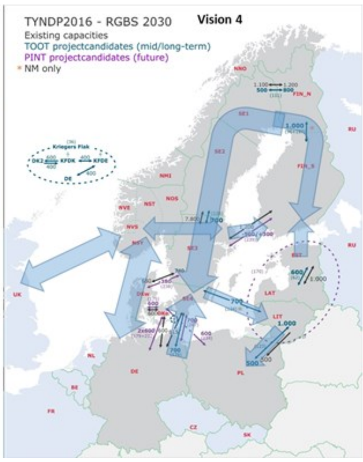
http://www.fingrid.fi/fi/asiakkaat/asiakasliitteet/Kehittämissuunnitelma/Kantaverkon_kehittämissuunnitelma%202015%20-%202025.pdf

### Investment needs

This project is needed for the 3 rd AC Finland-Sweden north connection (project 111) and it also allows to connect more renewables in North Finland. The reinforcement is needed to facilitate the power flows mainly from Sweden and North Finland towards South Finland.

The project do not influence the TYNDP-defined main-boundary of the region however the project is needed to connect the project 111 that adds another 500 – 800 MW capacity between Sweden and Finland.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | -: 900 |
| | -: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 50 ±5 |
| Cost explanation | Early cost estimation. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | -25 ±25 | -25 ±25 | -50 ±25 | -75 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | -2 ±2 | -2 ±1 | -5 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

The project SEW benefits are delivered by the 3 rd AC Finland-Sweden north connection (project 111).

## Project 103 - Reinforcements Ring NL

The project reinforces the Dutch grid to accommodate new conventional and renewable generation, to handle regional flow patterns and to facilitate the cross-border capacity increase with neighbouring countries. The project investments are spanning overall from 2019 to 2027.


| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Netherlands - Germany; Netherlands - Belgium |
| PCI label | |
| Promoted by | TENNET-NL |

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 438 | New 175-200km AC overhead line with capacity of 2x2650 MVA of 380kV. | 100% | Eemshaven (NL) | Diemen (NL) | Design & Permitting | 2020 | Investment on time | Changes in plans of thermal plants at Eemshaven offers the opportunity to phase the grid expansions. The a first phase consists of a new 380 kV connection between Eemshaven-Oudeschip and Vierverlaten and the upgrade the circuits form Diemen-Lelystad-Ens. The second phase is a future project and consists of a new 380 kV connection between Vierverlaten and Ens. The second phase of the project expected after 2030. |
| 439 | New 100-130km double-circuit 380kV OHL with 2x2650 MVA capacity. | 100% | Borssele (NL) | Tilburg (NL) | Design & Permitting | 2025 | Delayed | With a 380 kV substation at Rilland, the Zuid-West 380 kV project can be taken into service in two parts. The first part consists of the Borssele - Rilland line including substation Rilland (2020) and the second part consist of the Rilland – Tilburg line (2025). |
| 440 | New 380 kV double-circuit mixed project (OHL+ underground | 100% | Maasvlakte (NL) | Beverwijk (NL) | Under Construction | 2019 | Investment on time | The part from Maasvlakte to Bleiswijk has been commisssioned. Phase 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | cable) including approximately 20km of underground cable for 2650 MVA. The cable sections are a pilot project. The total length of cable at 380kV is frozen until more experience is gained. | | | | | | | between Bleiswijk and Beverwijk wll be commissioned in 2019. |
| 441 | Upgrade of the capacity of the existing 300km double circuit 380kV OHL to reach a capacity of 2x2650 MVA. | 100% | Zwolle (NL) | Maasbracht (NL) | Planning | 2030 | Investment on time | Upgrade of the capacity of the existing 300km double circuit 380kV OHL to reach a capacity of 2x2650 MVA along the Dutch Central ring (Hengelo-Zwolle-Ens Diemen-Krimpen-Geertruidenberg-Eindhoven-Maasbracht); First phase (Ens-Zwolle) 2025; last phase 2030 |
| 442 | Upgrade of the capacity of the existing 150km double circuit 380kV OHL to reach a capacity of 2x2650 MVA | 100% | Krimpen aan de IJssel (NL) | Maasbracht (NL) | Design | -2027 | Investment on time | Upgrade of Krimpen-Geertruidenberg is expected in 2023, Geertruidenberg-Maasbracht completed in 2027. |

## Additional Information

All investements in this project are related to the upgrade of the main 380 kV ring structure in the Netherlands. There are three new connections (Randstad380, NoordWest380, and ZuidWest380) included to create additional ring structures. The other investments forsee an upgrade of the existing ring structure to 4 kA.

## Investment needs

The reinforcements NoordWest380 (to Eemshaven) and ZuidWest380 (to Borssele) are needed to facilitate the bulk (renewable) generation in these areas. Bulk power flows from mainly north to south and east to west, cause overloads in the existing 380kV ring. Further reinforcement is therefore needed to faciitate these flows and also to increase the GTC's between the Germany and the Netherlands, and between Belgium and the Netherlands.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NL-DE: n/a |
| | DE-NL: 2900 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 2500±500 |
| Cost explanation | Based on estimations of National Investment Plan 2015. |
| S1 | More than 100km |
| S2 | More than 50km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 10 ±10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 10 ±20 | 80 ±80 | 40 ±20 |
| B4 Losses (GWh/yr) | N/A | -350 ±35 | -350 ±35 | -400 ±40 | -375 ±37 |
| B4 Losses (Meuros/yr) | N/A | -19 ±2 | -17 ±2 | -24 ±3 | -26 ±3 |
| B5 CO2 Emissions (kT/year) | 300 ±50 | 300 ±100 | 200 ±100 | ±100 | ±100 |

The project will better facilitate Bulk Power flows from East to West and vice versa, resulting in integration of more renewable resources, especially offshore wind in the Netherland and wind energy in Northern Germany.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.98 | 0.42 | 0.35 | 0.28 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.08 | 2.64 | 4.31 | 3.63 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 12.23 | 9.93 | 3.06 | 4.31 |

## Project 107 - Celtic Interconnector

Celtic Interconnector will be the first interconnection between Ireland and France. A survey of the route of the HVDC (VSC) link with 700 MW capacity has been done from the southern coast of Ireland to La Martyre (Finistère) in France.

PCI 1.6 - The project was selected as PCI 1.6 in the NSOG corridor on 14/10/13 and this status was re-afformed on 18/11/15.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | France - Ireland |
| PCI label | PCI label 1.6 |
| Promoted by | EIRGRID;RTE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 810 | A new HVDC subsea connection between Ireland and France | 100% | West Wexford or East Cork (IE) | La Martyre (FR) | Under Consideration | 2026 | Rescheduled | The project is now starting the Initial Design and Pre-consultation Phase Feasibility Study resulted in minor commissioning postponement. |

### Additional Information

More information can be found on the Project Website

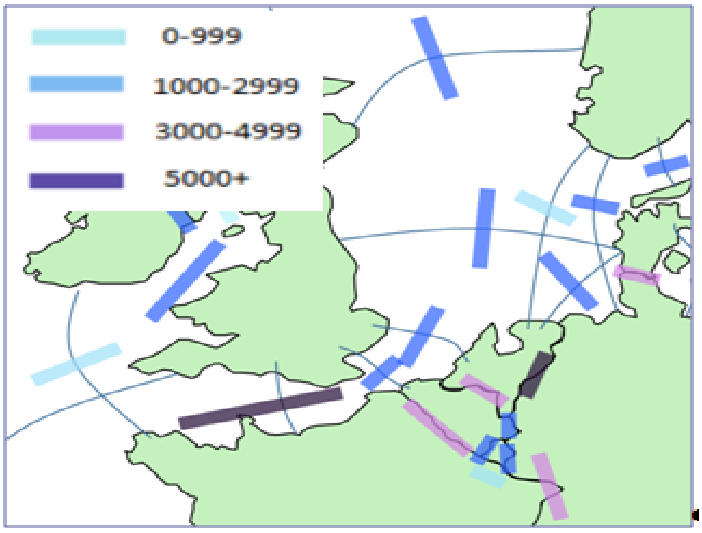
The project is also part of both RTE and Eirgrid National Development plans.

In addition the CELTIC project has been confirmed on 27 January 2016 as a Project of Common Interest in the priority corridor Northern Seas Offshore Grid (NSOG), 1.6 (Commission Delegated Regulation 2016/89 of 18 November 2015)

### Investment needs

This HVDC link will connect the Irish island system with the peninsula of Brittany, allowing mutual support between these two areas. The full capacity (700MW) can be used without leading to unmanageable critical system failure on both sides. The Irish system stability will also benefit from this HVDC link, especially for frequency control. The project would help to cover the market based target capacity evaluated to a maximum of 1GW

The CELTIC project will be the first link between Irish and mainland European electricity transmission systems. It gives an interesting alternative to projects between Great Britain and Continental grid.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-FR: 700 |
| | FR-IE: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 920 ±150 |
| Cost explanation | Only CAPEX is considered here. |
| S1 | NA |
| S2 | NA |

| | |
|---|---|
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 80 ±20 | 70 ±10 | 80 ±10 | 100 ±20 | 90 ±10 |
| B3 RES integration (GWh/yr) | 490 ±100 | 580 ±140 | 610 ±150 | 1340 ±180 | 950 ±200 |
| B4 Losses (GWh/yr) | N/A | 550 ±55 | 625 ±62 | 700 ±70 | 700 ±70 |
| B4 Losses (Meuros/yr) | N/A | 30 ±3 | 29 ±3 | 42 ±4 | 47 ±5 |
| B5 CO2 Emissions (kT/year) | 800 ±100 | 300 ±200 | 400 ±400 | -600 ±100 | -500 ±200 |

The loss figures presented in the table above are calculated using the common TYNDP methodology. Due to the necessity of the TYNDP to model the Pan-European network, it is not possible to pro-vide the same level of refinement that a project by project assess-ment can.  As a result, the TYNDP methodology allows flows to occur across borders even when there is a very low price difference. While this is appropriate for a meshed AC system (e.g. continental Eu-rope), it is quite likely that market flows across HVDC interconnect-ors will take into account losses on the interconnector itself, pre-venting uneconomical flows from taking place.

Based on a more refined project assessment, an appropriate wheel-ing charge (reflecting losses on the interconnector and therefore a more accurate monetization) would lead to a reduction in the mone-tized value of losses by 30-60% with negligible impact on the SEW.

Analyses for the 4 TYNDP 2030 visions show that a standard 1 GW capacity increase on this border provides a SEW benefit of about **€100-145M€, depending on the vision**.

The project's SEW accounts for saving in generation fuel and operat-ing costs. The project could also enable savings by avoiding invest-ment in generation capacity, in particular for projects connecting electric peninsulas. This aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 8.76 | 8.46 | 13.26 | 9.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.12 | 13.81 | 25.45 | 21.63 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 14.38 | 15.04 | 10.10 | 12.68 |

Additional capacity between France and Ireland will reduce energy price differential between the two countries. It will also allow to increase RES integration, especially wind generation to be connected on the Irish system, and then offering a direct connection to the continental market.

# Project 110 - Norway-Great Britain North Sea Link

North Sea Link, 1400 MW and 720 km long interconnector between Norway and England.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Great Britain Norway |
| PCI label | 1.10 |
| Promoted by | NGIHL;STATNETT |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 424 | A new 1400MW HVDC bipolar installation connecting Western Norway and Great Britain via 720km subsea cable. | 100% | Kvilldal (NO) | Blythe (GB) | Under Construction | 2021 | Investment on time | On time |

## Additional Information

www.nsn-link.com;
www.statnett.no;
www.NationalGrid.com

PCI 1.10.
*There is only one PCI between UK and Norway, however two potential projects (110 and 190)*.

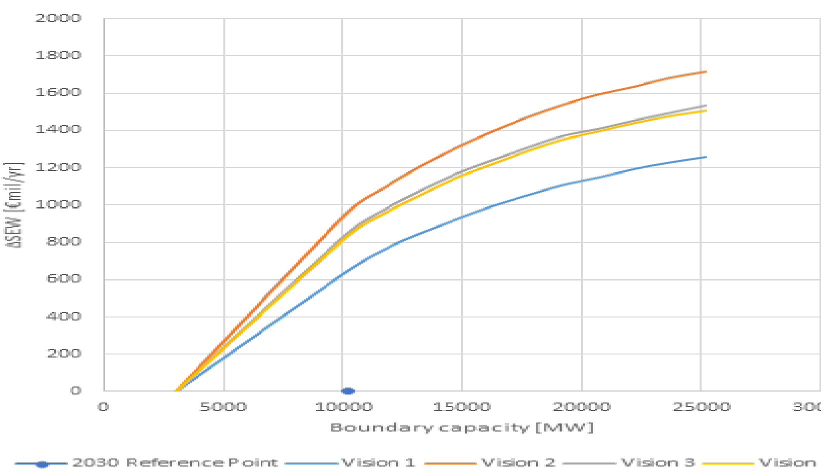
## Investment needs

A 720 km long subsea interconnector between Norway and England is planned to be realized in 2021. When realized it will be the world's longest cable. The main driver for the project is to integrate the hydro-based Norwegian system with the thermal/nuclear/wind-based British system. The interconnector will improve security of supply both in Norway in dry years and in Great Britain in periods with negative power balance (low wind, high demand etc.). Additional the interconnector will be positive both for the European market integration, for facilitating renewable energy and also for preparing for a power system with lower CO2-emission. The interconnector is planned to be a 500 kV 1400 MW HVDC subsea interconnector between western Norway (Kvilldal) and eastern England (Blyth).

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between the Nordics and Great Britain. In the SEW/GTC-curve we can see that the increase from todays capacity to the 2030-level is having a large SEW-value for all the scenarios. This is also one of the reason for the North Sea Link between Norway and Great Britain being realised. At the same time there is a need for having attention to the assumptions of TYNDP 2016. Bringing CO2, oil, gas, coal-prices down to 2016-level will influence the SEW-values of projects like North Sea Link in a negative direction,  i.e. the SEW values would be smaller than the ones identified for 2030. The CO2 price assumptions for 2030 are higher than the ones seen today. Bigger CO2 prices create larger marginal cost price differences between the different generation technologies.

Having a look at SEW/GTC-values of the different Visions indicates that the energy-balance of the different Visions both for the Nordics and Great Britain are the main driver for price differences and hence SEW-values. Eg. the Nordic surplus is very high in Vision 2, which gives a high pricediffernmce and hence high SEW/GTC-values.

North Sea Link will increase the capacity between the Nordics and the Great Britain by 1400 MW.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | NO-GB: 1400 |
| | GB-NO: 1400 |
| Delta GTC contribution (2030) [MW] | NO-GB: 1400 |
| | GB-NO: 1400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1850 |

| | |
|---|---|
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 190 ±30 | 140 ±10 | 190 ±10 | 170 ±30 | 140 ±10 |
| B3 RES integration (GWh/yr) | 90 ±20 | 150 ±150 | 850 ±60 | 840 ±170 | 870 ±390 |
| B4 Losses (GWh/yr) | 875 ±87 | 475 ±47 | 275 ±27 | 275 ±27 | 475 ±105 |
| B4 Losses (Meuros/yr) | 37 ±4 | 25 ±3 | 12 ±2 | 16 ±2 | 32 ±7 |
| B5 CO2 Emissions (kT/year) | 2200 ±350 | 1500 ±400 | 700 ±300 | -900 ±300 | -900 ±600 |

The pan-European analysis only take into account one average hydrological year. Studies by the Norwegian TSO Statnett shows that an important driver for the benefit of Norwegian interconnectors is the increased potential for power export from Norway during periods of excessive inflow. The benefit arises both from reducing the risk for hydropower curtailment and from avoiding price collapse in Norway during wet summers. The benefit is non-linear, which means that simulating over one average year is not equal to taking the average over several hydrological years. Internal studies indicates that SEW-values might double if also taking into account wet and dry years. This means that the benefit indicators calculated in the pan-European analysis probably are underestimated.

Also the benefit of RES and CO2 (increased RES, decreased CO2) are expected to be under-estimated. Especially in wet years the RES-values will be much higher, this as the interconnectors helps exporting RES/hydro instead of having hydro-curtailment (water running directly to the sea). This also leads to decreased CO2-emissions if taking wet/dry years into account.

Summarized the CBA-indicators for projects going to Norway for SEW, RES and CO2 are supposed to be underestimated in the pan-European models.

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 22.55 | 13.64 | 13.11 | 11.69 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.66 | 18.45 | 24.55 | 21.62 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 9.28 | 18.63 | 21.88 | 18.17 |

## Project 111 - 3rd AC Finland-Sweden north

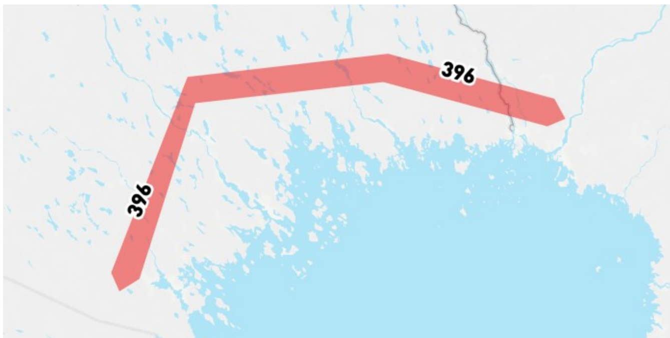
Third AC 400 kV overhead line interconnector between Finland north and Sweden SE1. Strengthening the AC connection between Finland and Sweden is necessary due to new wind power generation, larger conventional units and decomissioning of the existing 220 kV interconnector.

Classification Long-term Project

Boundary Finland - Sweden

PCI label

Promoted by FINGRID;SVK




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 396 | Third single circuit 400kV AC OHL between Sweden and Finland | 100% | Finland North (FI) | Sweden bidding area SE1/SE2 | Under Consideration | 2025 | Investment on time | |

### Additional Information

*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realize under the stated time period. The plan is available in Swedish through the following link:*

http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

Fingrid has published a national development plan in 2015. The investment plan presents a detailed look of the projects. The plan is available in Finnish:
http://www.fingrid.fi/fi/asiakkaat/asiakasliitteet/Kehittämissuunnitelma/Kantaverkon_kehittämissuunnitelma%202015%20-%202025.pdf

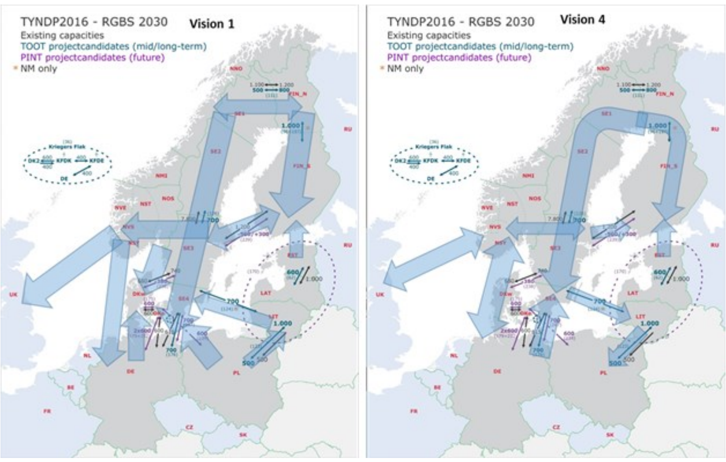
Fingrid and Svenska kraftnät has in November 2016 published a joint cross-border capacity study which is available through the following link:
http://www.fingrid.fi/en/news/announcements/Pages/Cross-border-capacity-upgrade-between-Finland-and-Sweden.aspx
http://www.fingrid.fi/fi/verkkohankkeet/voimajohtoliitteet/Cross-border%20capacity%20study%20btw%20Finland%20and%20Sweden.pdf

## Investment needs

This project will decrease the bottleneck between Sweden and Finland and increase the security of supply in Finland. Evaluation of the need for interconnection capacity between Sweden and Finland was also made by Svenska kraftnät and Fingrid in a separate bilateral study published in November 2016 (http://www.fingrid.fi/fi/verkkohankkeet/voimajohtoliitteet/Cross-border%20capacity%20study%20btw%20Finland%20and%20Sweden.pdf).

The project do not influence the TYNDP-defined main-boundary of the region however the project candidate adds another 500 – 800 MW capacity between Sweden and Finland where there are several drivers for additional capacity increase such as:

- North-South transmission of surplus and wind power from the Northern Scandinavia
- System adequacy
- Increased flexibility and market integration in different weather years
- Reduced dependency of Finland on Non-ENTSO-e member countries




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | SE1-FI: 500 |
| | FI-SE1: 800 |
| Delta GTC contribution (2030) [MW] | SE1-FI: 500 |

| | |
|---|---|
| | FI-SE1: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 130 ±15 |
| Cost explanation | Early cost estimation. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 50 ±25 | -25 ±25 | -50 ±25 | -85 ±45 | -120 ±70 |
| B4 Losses (Meuros/yr) | 2 ±1 | -2 ±2 | -2 ±1 | -5 ±3 | -8 ±5 |
| B5 CO2 Emissions (kT/year) | ±100 | -100 ±100 | ±100 | ±100 | -200 ±100 |

Cost Benefit analysis in TYNDP 2016 does not take into account different hydrological years, but instead an average hydro year is used. Interconnectors in the Nordic countries give higher SEW benefits in extreme weather years.

Project 96 (Keminmaa-Pyhänselkä) in Finland has to be realized to achieve the planned GTC increase.

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.14 | 0.14 | 1.73 | 4.03 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 1.66 | 1.55 | 9.37 | 12.30 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.01 | 1.51 | 6.64 | 12.37 |

## Project 113 - Doetinchem - Niederrhein

This new AC 400-kV double circuit overhead line will interconnect The Netherlands and Germany (Rhine-Ruhr area). Upon realization of the project there will be four double circuit interconnections between The Netherlands and Germany. The project will increase the cross border capacity and will facilitate the further integration of the European Energy market especially in Central West Europe. The new line will also increase the security of the transmission capacity.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Netherlands - Germany |
| PCI label | 2.12 |
| Promoted by | AMPRION;TENNET-NL |

## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 145 | New 400 kV line double circuit DE-NL interconnection line (Length: approx. 57 km) | 100% | Niederrhein (DE) | Doetinchem (NL) | Under Construction | 2017 | Investment on time | New 400kV line double circuit DE-NL interconnection line, to facilitate the market. |

## Additional Information

More detailed information on the project can be find here (in German):

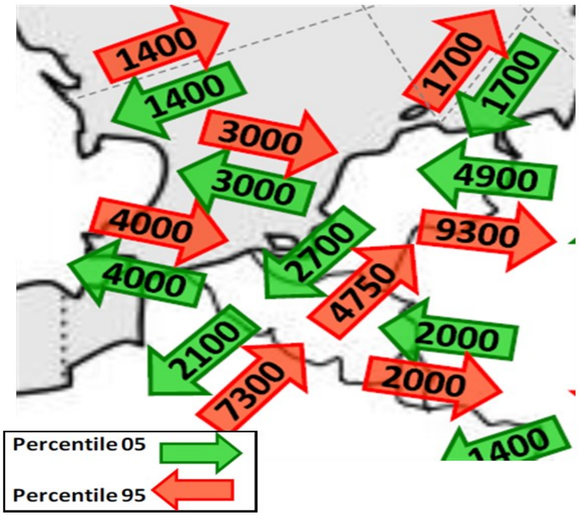
http://netzausbau.amprion.net/projekte/wesel-niederlande/projektbeschreibung

And here (in English):

http://www.tennet.eu/our-grid/onshore-projects-netherlands/doetinchem-wesel-380-kv/

## Investment needs

The North Sea Region is characterised by a significant increase in RES generation (especially offshore wind). The grid has to be developed in order to support these new exchange possibilities, facilitating the access to the most economic energy mix, while minimizing grid congestions. High flows in both directions West-East and North-South are expected. The project strengthens the European single market especially in the CWE-Region. It also increases the number of interconnectors between The Netherlands and Germany and therefore the security of supply.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | NL-DE: [1100 ; 1200] |
| | DE-NL: [1100 ; 1500] |
| Delta GTC contribution (2030) [MW] | NL-DE: n/a |
| | DE-NL: (1500 ; 1800] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 220 ±30 |
| Cost explanation | |
| S1 | 15-50km |
| S2 | 25-50km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 50 ±40 | 30 ±10 | 20 ±10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | 30 ±20 | <10 | 40 ±40 | 100 ±40 |
| B4 Losses (GWh/yr) | -125 ±25 | -275 ±175 | 30 ±130 | 0 ±25 | -25 ±25 |
| B4 Losses (Meuros/yr) | -6 ±1 | -15 ±10 | 1 ±6 | 0 ±1 | -2 ±2 |
| B5 CO2 Emissions (kT/year) | 1100 ±180 | 800 ±200 | 500 ±100 | ±100 | 100 ±200 |

Comment on GTC:

For 2030 vision 1 only few hours with a flow from the Netherlands to Germany are expected therefore no robust delta GTC value for that direction could be calculated.

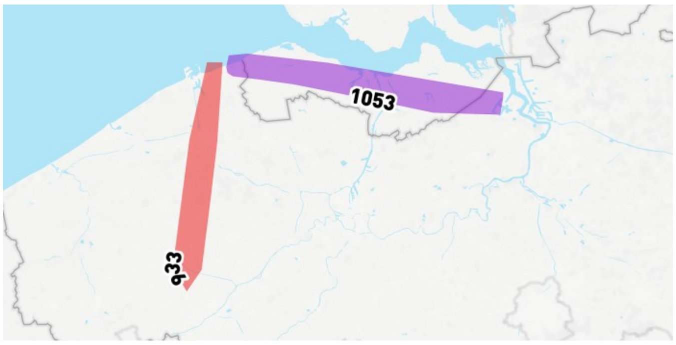
The interconnector increases the market capacity and therefore leads to a better price convergence between Germany and the Netherlands, especially in the coal before gas scenario's. As it is an additional interconnection between the Netherlands and Germany, it contributes to the security of supply.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.98 | 0.42 | 0.35 | 0.28 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.08 | 2.64 | 4.31 | 3.63 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 12.23 | 9.93 | 3.06 | 4.31 |

## Project 120 - 2nd Offshore-Onshore Corridor (Belgium)

This is a conceptual project triggered by high-RES scenarios where up to 4 GW of offshore capacity is envisioned in the Belgian part of the North Sea (note that this 4 GW is not ensured via an official framework at the moment, it merely reflects the potential elaborated via studies). Compared to the current forecast of 2,3 GW of offshore capacity as to which Elia's portfolio is designed, it implies an additional reinforcement under the form a second offshore-onshore corridor. Preliminary analysis indicates that this corridor could consist of multiple reinforcements to different inland locations.Note that such second offshore-onshore corridor would be required in an earlier stage in case of a non-flexible grid access for any offshore capacity above 2,3 GW, as for example the connection of an offshore energy atol.  The determination of optimal location/route, technology as well as potential synergies of such corridor(s) with the development of offshore capacity and interconnectors are subject of further studies.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Belgium (offshore - inland) |
| PCI label | |
| Promoted by | ELIA |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 933 | To integrate the full potential of 4 GW, additional solutions are needed on top op the 1 GW connection to the Antwerp area. This could take the form of a complementary connection towards Izegem, as well as a larger dimensioning of the connection to the Antwerp area. Subject to further studies. | 50% | Offshore Hub OR Stevin - TBD | Antwerp Area OR Izegem - TBD | Under Consideration | 2025 | Investment on time | Long-term potential of energy transition; additional offshore-onshore corridor needed in order to evacuate up to 4GW of offshore wind in the Belgian part of the North Sea. |
| 1053 | To evacuate up to 3.3 GW wind, thus 1 GW more than currenlty planned, preliminary studies indicated that this corridor could consists of a 1 GW DC connection from an offshore platform or nearby Stevin substation in Zeebrugge towards the Antwerp Area (substation Doel could be a possible location). | 50% | Offshore Hub OR Stevin - TBD | Doel (BE) - TBD | Under Consideration | 2025 | Investment on time | Long-term potential of energy transition; additional offshore-onshore corridor needed in order to evacuate up to 4GW of offshore wind in the Belgian part of the North Sea. |

| | |
|---|---|
| | Subject to further studies. |

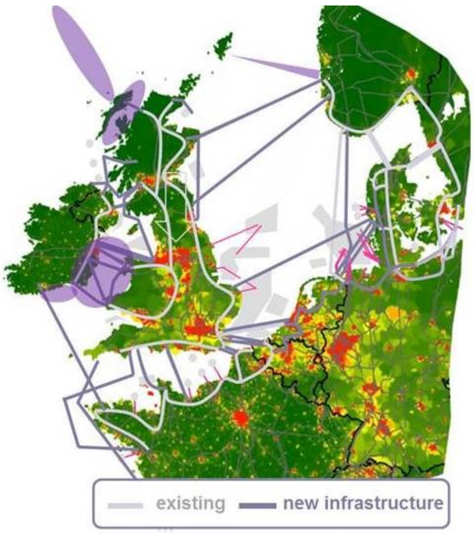
## Additional Information

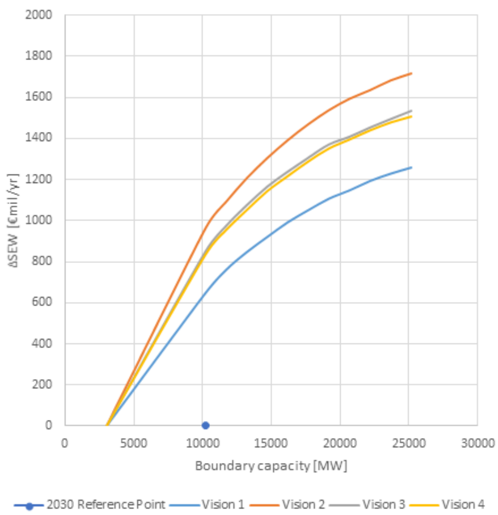
The project is integrated in Elia's National Development Plan 2015-2025 as project under consideration:
http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

## Investment needs

Integration of offshore wind in the Northern Seas is one of the key objectives of the concerned region. Within the high-RES scenarios up to 4 GW offshore wind has been assumed in the Belgian part of the North Sea. Such scenarios would require an additional corridor to integrate the offshore capacity and transport it further inland.

The capacity of such additional corridor and its technical implementation is driven by the potential further evolution of offshore capacity, beyond the currently planned 2,3 GW.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | BE-BEcoast: 2000 |
| | BEcoast-BE: 2000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1100 ±300 |
| Cost explanation | The cost represents the currently total estimated investment cost. The uncertainty range reflects the fact that optimal location, design & capacity is subject of further studies. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | 400 ±40 | 420 ±40 |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | 6410 ±200 | 6650 ±200 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | -2100 ±100 | -2100 ±100 |

The additional offshore capacity is present in the scenarios 2030V3 & 2030V4 related to the high-RES nature of these scenarios. Within these scenarios, the project would generate a significant SEW increase and CO2 savings directly related to the integration of an additional 6-7 TWh of offshore energy in Belgium on annual basis.

Apart from this, the project could generate benefits related to enabling a non-flexible grid access to accommodate the connection of an offshore energy atol (storage).

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 121 - 2nd interconnector Belgium - UK

This project considers the possibility of a second 1 GW HVDC connection, between UK (Kemsley) and a Belgian 380 kV substation in the Antwerp area (Doel, Zandvliet are indicative locations), triggered by the potential for further market integration between UK and Central Europe.The determination of the optimal capacity, location, technology, potentially needed internal grid reinforcements as well as possible synergies with the development of offshore capacity and the long-term concept of a "west-east corridor" in the North Sea area are subject of further studies.

Classification Future Project

Boundary Belgium - Great Britain

PCI label

Promoted by ELIA


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 934 | 2nd interco UK-BE: possibility of a second 1GW HVDC connection, between UK (Kemsley) and a Belgian 380kV substation further inland in the Antwerp area (Doel, Zandvliet are indicative locations). | 100% | Kemsley (UK) for example - TBD | Doel/Zandvliet (BE) for example - TBD | Under Consideration | 2025 | Investment on time | Preliminary studies have indicated potential for further regional welfare & RES integration increase by further increasing the interconnection capacity between Belgium & UK. |

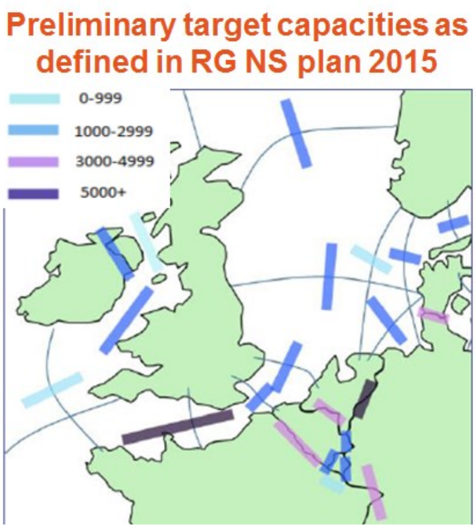
### Additional Information

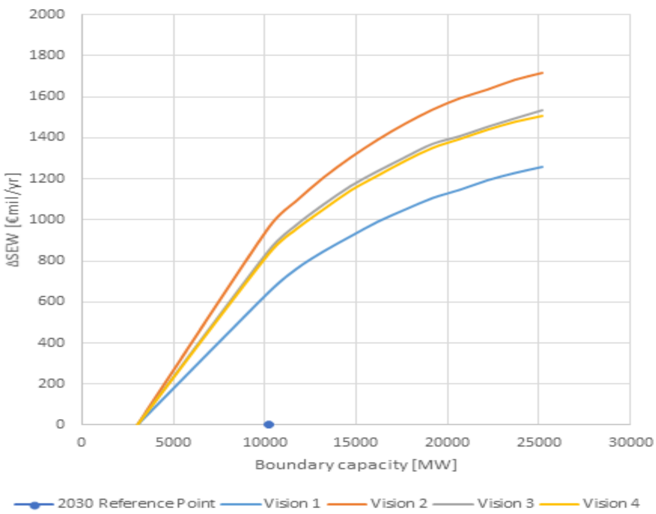
The project is integrated as project under consideration in Elia's National Developmen Plan 2015-2025: http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

### Investment needs

The project contributes to further integration of the UK and Central European power systems, which are characterized by different production mix structures and subsequent wholesale market price deltas.  In the scenario 2030 V1 the main direction of the bulk power flow is from Central Europe to UK given that on average the price is cheaper in Central Europe. In the scenario 2030 V2 a significant higher share of renewables in the UK induces also flows in the direction from UK to Central Europe. A higher share of renewables combined with a merit order switch to 'gas before coal' results in flows mainly going from UK to Central Europe in the 2030 V3 & V4 scenarios.

This project counts for 1 GW of the potential for further integration of transmission capacity on the UK - Central Europe boundary.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | BE-GB: 1000 |
| | GB-BE: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 700 ±150 |
| Cost explanation | The cost represents the currently expected total investment cost.Uncertainty range reflects the fact that optimal location, capacity & route is subject to further studies. |
| S1 | NA |
| S2 | NA |
| B6 | + |

| | |
|---|---|
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 70 ±10 | 60 ±10 | 70 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | 640 ±150 | 640 ±120 | 360 ±130 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 700 ±200 | ±100 | -400 ±100 | -600 ±100 |

An additional 1000 MW link between UK and Belgium creates a significant increase in SEW across the different 2030 scenarios. In visions 2, 3 and 4 the SEW increase is higher than in Vision 1 due to the additional offshore wind in the UK. With respect to the CO2 emissions, the increase in the 2030 V1 scenario is related to the substituation effect of gas being replaced by coal. This effect is counterbalanced by the offshore wind in V2 leading to a neutral impact on CO2 emissions, whilst a substantial decrease is recorded in the 2030 V3 & 2030 V4 scenarios related to the gas & offshore wind replacing coal.

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.31 | 7.72 | 7.00 | 7.00 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.20 | 13.64 | 18.42 | 18.08 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 3.13 | 9.60 | 10.63 | 11.50 |

## Project 123 - LitPol Link Stage 2

The LitPol Link Stage 2 is a continuation of building of the interconnection between Poland and Lithuania in order to achieve the planned transmission capacity of 1000 MW in both directions. Building of additional internal investments in Poland and Lithuania are necessary.The project improves connection the Baltic States to the Continental Europe and Baltic Sea ring. This is PCI project.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Poland - Lithuania |
| PCI label | 4.5 |
| Promoted by | Litgrid; PSE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 335 | Construction of new 400 kV AC double-circuit OHL Ostrołęka - Olsztyn Mątki. | 100% | Ostrołęka (PL) | Olsztyn Mątki (PL) | Design & Permitting | 2018 | Delayed | Delay due to lingering permit granting process and other formal aspects. |
| 373 | Construction of new 400 kV AC double-circuit OHL line Ostrołęka-Stanisławów. | 100% | Ostrołęka (PL) | Stanisławów (PL) | Design & Permitting | 2021 | Investment on time | The investment is in tendering procedure, the contract (design and build scheme) will by signed by Q4 2015. |
| 374 | Construction of new 400 kV AC double-circuit OHL line Kozienice-Siedlce Ujrzanów. | 100% | Kozienice (PL) | Siedlce Ujrzanów (PL) | Design & Permitting | 2019 | Investment on time | Investment on time. |
| 1038 | Construction of the second 500 MW back-to-Back converter station in Alytus | 100% | Alytus | | Planning | 2020 | Investment on time | No change of status. |

### Additional Information

Link to PSE S.A. Development Plan : http://www.pse.pl/index.php?modul=10&gid=402

Description of PCI projects on PSE website: http://www.pse.pl/index.php?dzid=256&did=2063

2nd PCI list: https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

Link to project web page: http://www.litpol-link.com/

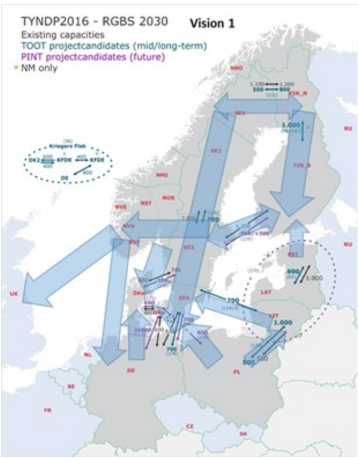
In 2nd PCI list there is position: 4.5.2 Internal line between Stanisławów and Olsztyn Mątki (PL) which corresponds functionally to investments included in project 123.

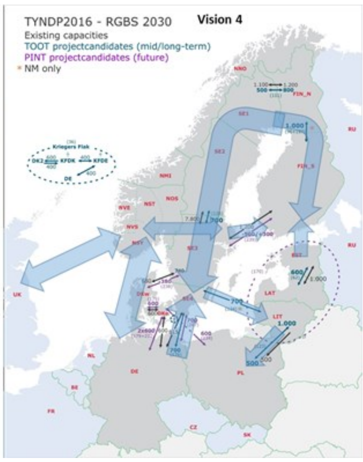
## Investment needs

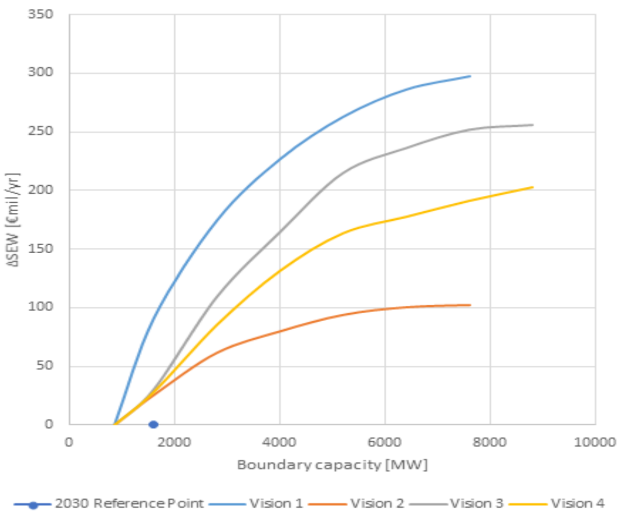
At the end of 2015 was finished LitPol Link project - first 500 MW asynchronous connection on Lithuania-Poland border. The LitPol Link Stage 2 is a continuation of building of the interconnection between Poland and Lithuania in order to achieve the planned transmission capacity of 1000 MW in both directions in 2021. Building of additional internal investments in Poland and Lithuania are necessary. Project will help to further strenghten of Baltics integration into European market.

This is PCI project.

Making the balance between social welfare gain and infrastructure investment costs for increasing levels of interconnection, the optimal level of interconnection ranges from 1 GW to 2,5 GW between the Nordics/Baltics and the Continental Europe East. Compared to the present and planned investments this shows a potential for further projects.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | LT-PL: 500 |
| | PL-LT: 1000 |
| Delta GTC contribution (2030) [MW] | LT-PL: 500 |
| | PL-LT: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 335 |
| Cost explanation | 245 MEUR - Cost of the project on PL side<br>90 MEUR - Cost of the project on LT side |
| S1 | 15-50km |
| S2 | 25-50km |
| B6 | 0 |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 70 ±10 | 80 ±10 | 30 ±10 | 30 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 60 ±10 | 20 ±10 |
| B4 Losses (GWh/yr) | 825 ±82 | 650 ±65 | 300 ±30 | 225 ±25 | 525 ±52 |
| B4 Losses (Meuros/yr) | 35 ±4 | 35 ±4 | 13 ±2 | 13 ±2 | 35 ±4 |
| B5 CO2 Emissions (kT/year) | -400 ±50 | 1400 ±200 | 600 ±100 | -1500 ±200 | -1100 ±200 |

In the PL – LT Direction 1000MW of Delta GTC Was used and in the LT- PL direction 500 MW was used. This is because during the Litpol Link Stage 1 project, a 500 MW DC connection was built, but there will be no power flow in the PL-LT direction, the 500 MW will be in the LT-PL direction. The Litpol Link Stage 2 project add another 500 MW in 2020 and due to improvements in the Polish grid, there will be a power flow of 1000 MW GTC in both directions. The GTC in the LT-PL direction will therefore be 500 MW (1000MW – 500MW) and for the PL-LT direction it will be 1000MW (1000MW – 0MW).

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.85 | 6.89 | 17.24 | 7.66 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 10.25 | 10.62 | 24.71 | 15.77 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 9.87 | 9.56 | 11.56 | 8.50 |

## Project 124 - NordBalt phase 2

Second phase includes the internal network reinforcements in Sweden, Lithuania and Latvia to be able to fully utilize the interconnector between Lithuania and Sweden.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Lithuania - Sweden |
| PCI label | 4.4.2 |
| Promoted by | AST;LITGRID;SVK |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 378 | New single circuit 330 kV OHL Panevezys-Musa. Project is needed to utilise full 700 MW capacity of HVDC connection NordBalt in all regimes. | 21% | Panevezys (LT) | Musa (LT) | Planning | 2023 | Delayed | Project implementation depends on decisions about new nuclear power plant in Lithuania and project 170."Baltic synchronisation". |
| 385 | A part of Kurzeme's ring project | 20% | Grobina (LV) | Imanta (LV) | Under Construction | 2019 | Delayed | The last part of reinforcement for Kurzemes ring project |
| 733 | New single circuit 400 kV OHL | 100% | Ekhyddan (SE) | Nybro/Hemsjö (SE) | Design & Permitting | 2023 | Rescheduled | Commissioning date is current estimation |

### Additional Information

*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realize under the stated time period. The plan is available in Swedish through the following link:*

http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

Main characteristics about project:
NordBalt project information (LITGRID)

## Investment needs

This is second phase of the NordBalt DC interconnector between Lithuania and Sweden that will connect the Baltic grid to the Nordic and integrate the Baltic countries (Estonia, Latvia, Lithuania) with the Nordic electricity market and will also increases security of supply.

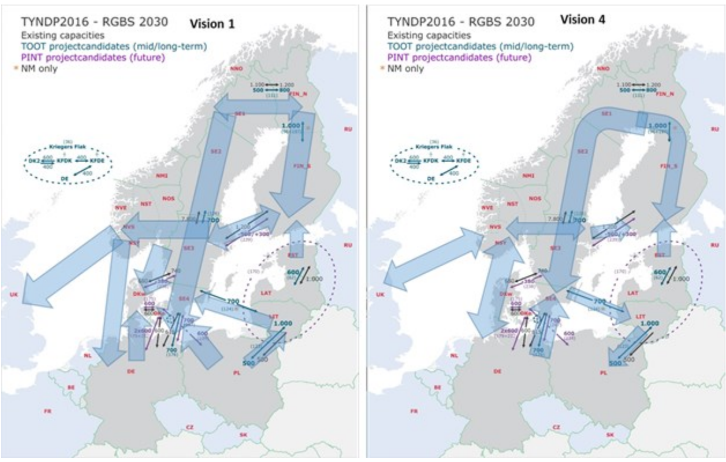
The main driver is to be able to fully utilize the NordBalt interconnection by eliminating bottlenecks in Sweden and Lithuania.

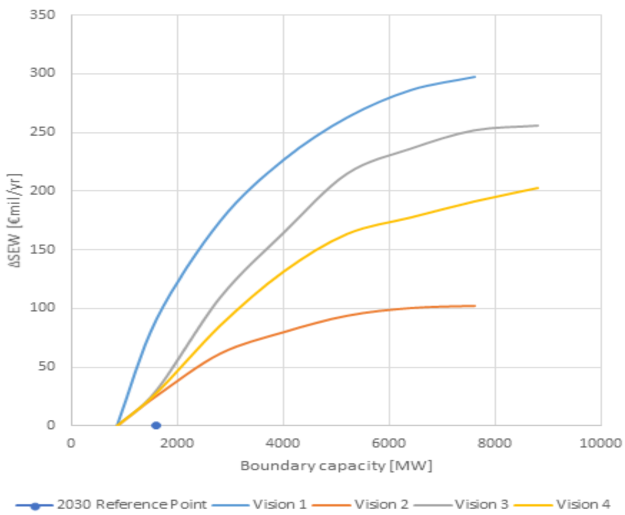
In Sweden new lines between Ekhyddan – Nybro – Hemsjö are built in parallel to existing lines to cope with overloaded underlying distribution network due to increased power flow in the region caused by NordBalt.

In Baltics new lines in Lithuania (Panevezys-Musa) and Latvia (Grobine-Imanta) are planned to strenghten western part of electrical network which is necessary to fully utilise 700 MW DC link capacity.

This is a PCI project.

This project does not directly contribute to the capacity between the Nordic area and the Baltic states. However, it is needed to ensure long term secure operation of the already commissioned 700 MW Nordbalt interconnector (SE-LT). That interconnector is important in order to integrate the Baltic states in European electricity market.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | SE4-LT: 0 |
| | LT-SE4: 0 |
| Delta GTC contribution (2030) [MW] | SE4-LT: 0 |
| | LT-SE4: 0 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 294 ±30 |
| Cost explanation | Early cost estimation:<br>new 330 kV OHL Panevezys-Musa (LT) 17 MEur<br>new 330 kV OHL Ventspils–Imanta (LV) 127 MEur<br>new 400 kV OHL Ekhyddan-Nybro-Hemsjö (SE) 150 MEur |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | -150 ±25 | -150 ±25 | -125 ±25 | -100 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | -7 ±1 | -8 ±1 | -6 ±1 | -6 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

Delta GTC for NordBalt Stage 2 project is 0 MW becouse NordBalt Stage 1 is 700 MW HVDC connection, and Stage 2 has the same 700 MW but has only internal grid improvements in Baltics and in Sweden, to ensure 700 MW capacity in all regimes.

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.30 | 2.13 | 2.77 | 4.69 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 5.60 | 6.67 | 11.76 | 14.20 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.92 | 1.53 | 4.77 | 5.25 |

## Project 126 - SE North-south reinforcements

Reactive measures in substations and series compensations in order to increase capacity between SE2 and SE3. Replacement of ageing overhead lines that also will contribute to the increased capacity. The need for capacity is driven by RES integration in northern Sweden and nuclear decommission in southern Sweden.

Classification Long-term Project

Boundary North-South

PCI label

Promoted by SVK


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 403 | Reinforcements SE2-3 in Sweden | 100% | Sweden bidding area SE2 | Sweden bidding area SE3 | Under Consideration | 2025 | Investment on time | The investment now combine new investments in various reactive compensation components and other reinforcements not yet specified. |

### Additional Information

*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realize under the stated time period. The plan is available in Swedish through the following link:*

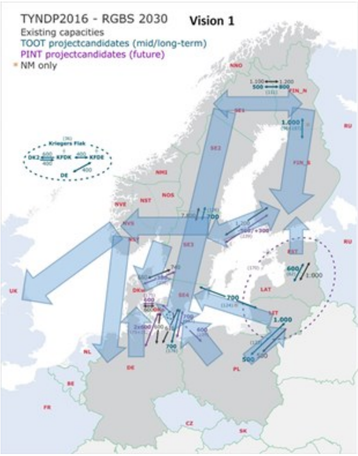
http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

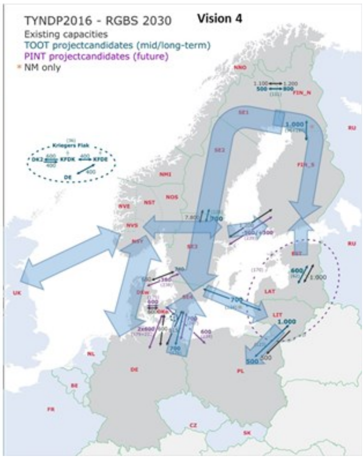
## Investment needs

The need for transmission capacity between northern and southern Sweden is increased when nuclear production is phased out in southern Sweden. In addition new interconnectors between southern Sweden and the continental system further increase the need for transmission. The project is also needed in order to ensure sufficient system adequacy in southern Sweden after the planned phase out 4 nuclear reactors.

This is the first step in replacing aging infrastructure with new. New lines will have a higher capacity than the replaced ones which will contribute to increase inpower transfer capability.

The project do not influence any TYNDP-defined main-boundary of the region however it is needed to fully achieve the benfits of additional capacity between southern Sweden and the Continental and Baltic synchroneus areas.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | SE3-SE2: 500 |
| | SE2-SE3: 500 |
| Delta GTC contribution (2030) [MW] | SE3-SE2: 500 |
| | SE2-SE3: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 400 ±80 |
| Cost explanation | Early cost estimation. Various alternatives under consideration. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 100 ±25 | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 4 ±1 | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±50 | -200 ±100 | ±100 | ±100 | 200 ±100 |

Due to reasons mentioned in the insight report “Nordic and Baltic sea regional planning” SEW results is most likely underestimated for this project.

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

## Project 127 - Central Southern Italy

The project consists in the reinforcement of southern Italy 400 kV network through new 400 kV lines as well as upgrading of existing assets. The activities will involve the network portions between the substation of Villanova and Foggia, Deliceto and Bisaccia as well as Laino and Altomonte.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Italy South - Italy Center |
| PCI label | |
| Promoted by | TERNA |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 86 | New 178km double circuit 400kV OHL between existing Foggia and Villanova 400kV substations, also connected in and out to the Larino and Gissi substations. | 100% | Foggia (IT) | Villanova (IT) | Design & Permitting | 2022 | Delayed | the part Foggia-Gissi still under authorization; the part Villanova Gissi has been commissioned in 2016. |
| 91 | Upgrade of the existing 85km Foggia-Benevento II 400kV OHL | 100% | Foggia (IT) | Benevento II (IT) | Commissioned | 2014 | Investment on time | - |
| 96 | New 30km single circuit 400kV OHL between the future substations of Deliceto and Bisaccia, in the Candela area. | 100% | Deliceto (IT) | Bisaccia (IT) | Design & Permitting | 2022 | Delayed | delay in the permitting process (EIA) |
| 645 | New 400kV OHL between the existing substations of Laino and Altomonte in Calabria. | 100% | Laino (IT) | Altomonte (IT) | Design & Permitting | 2022 | Delayed | delay in the permitting process (EIA) |

### Additional Information

Link to the last release of the Italian National Development Plan http://www.terna.it/en-gb/sistemaelettrico/pianodisviluppodellarete.aspx

## Investment needs

In Italy, the day ahead energy market is split in 6 different bidding zones due to internal congestions on the south to north axis and between the main Islands and the Italian peninsula. Therefore, high power flows from south to north of Italy make necessary additional transmission capacity to evacuate the generation exceeding local load.
The project contributes to overcome internal boundaries which affect power exchanges within price zones and market structure. Furthermore, the project favors the integration of the huge quantity of RES generation installed in southern part of Italy, especially wind and solar power plants.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT South-IT Center : 1200 |
| | IT Center - IT South: 0 |
| Delta GTC contribution (2030) [MW] | IT South-IT Center : 1200 |
| | IT Center - IT South: 0 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 530 ±53 |

| | |
|---|---|
| Cost explanation | The cost comprises the investment item 91 - 400 kV double circuit line "Foggia-Benevento" - which has been already commissioned. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 240 ±40 | 260 ±40 | 260 ±40 | 420 ±60 | 420 ±60 |
| B3 RES integration (GWh/yr) | 3950 ±790 | 3910 ±780 | 3910 ±780 | 4340 ±870 | 4270 ±850 |
| B4 Losses (GWh/yr) | -225 ±25 | -200 ±25 | -175 ±25 | -325 ±32 | -300 ±30 |
| B4 Losses (Meuros/yr) | -10 ±1 | -11 ±2 | -8 ±1 | -19 ±2 | -20 ±2 |
| B5 CO2 Emissions (kT/year) | -2200 ±300 | -2200 ±300 | -2200 ±300 | -2400 ±400 | -2400 ±400 |

The project has been assessed according to the TOOT approach in both market and network analysis.

The mentioned benefits will be achieved according to different future scenarios

## Project 129 - OWP Northsea TenneT Part 4

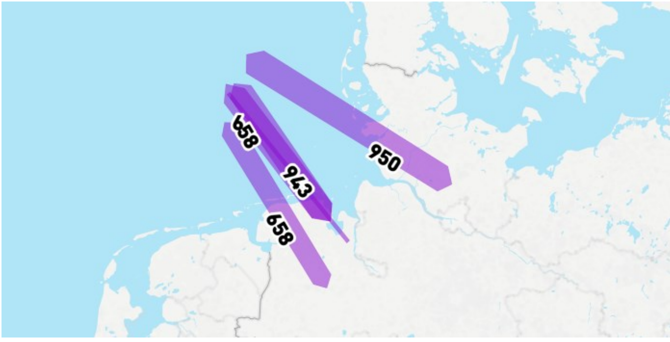
Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the European goal of CO2 reduction and RES integration

Classification Future Project

Boundary inside-DE

PCI label

Promoted by TENNET-DE




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 658 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster BorWin4 (DE) | area of Cloppenburg/East | Under Consideration | 2029 | Investment on time | |
| 943 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | NOR-9-1 | area of Unterweser | Under Consideration | 2035 | Rescheduled | due to new planning |
| 946 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | NOR-11-1 | area of Wilhelmshaven | Under Consideration | 2032 | Rescheduled | |
| 948 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | NOR-12-1 | area of Wilhelmshafen | Under Consideration | 2034 | Rescheduled | |
| 950 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | NOR-13-1 | Kreis Segeberg | Under Consideration | 2031 | Rescheduled | |

## Additional Information

Information on offshore projects within the northern sea promoted by TenneT TSO GmbH (http://www.tennet.eu/de/netz-und-projekte/offshore-projekte.html) in German

## Investment needs

Germany is planning to build a big amount of offshore wind power plants in the North- and Baltic Sea. The OWP will help to reach the European goal of CO2 reduction and RES integration. These offshore infrastructure projects in the North- and Baltic Seas areas, will deliver benefits for the regional society by pooling generation portfolios, integrating markets, lowering CO2 emissions, facilitating the integration of renewables (both onshore as well as offshore) and ensuring sufficient system resilience.

The development of off-shore wind farms in the North of Germany induces needs for undersea connections to these wind farms as well as reinforcements of the grid capacity from North to South. According to German law, these grid connections have to be constructed and operated by the TSO.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project's expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |

| | |
|---|---|
| Delta GTC contribution (2030) [MW] | -: 4500 |
| | -: 4500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 7000 ±1000 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | 870 ±40 | 1110 ±70 |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | 12560 ±290 | 15140 ±50 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | -4700 ±100 | -6000 ±100 |

The need of this project is depending on the expected increase of Offshore wind generation in Germany (especially in the North Sea). Thats why only results for Vision 3 &4 are available.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 130 - HVDC Wolmirstedt to area Isar

2 GW HVDC-connection from North-East Germany (Area of Wolmirstedt), an area with high installed capacities of RES, to the South of Bavaria (area of Isar), an area with high consumption and connections to storage capabilities. Capacity extension to 4 GW is under Investigation (see Project 133).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Project |
| PCI label | 3.12 |
| Promoted by | 50HERTZ;TENNET-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 665 | New DC- lines to integrate new wind generation from control area 50Hertz towards Central/south Europe for consumption and storage. | 100% | Wolmistedt (DE) | Isar (DE) | Planning | 2025 | Delayed | The commissioning date of the investment is delayed due to new preference of underground cable instead of overhead lines by german legal requirement. |

### Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

**Project Homepage:**

http://www.50hertz.com/en/Grid-Extension/Projects/SuedOstLink

**Second PCI-list:**

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

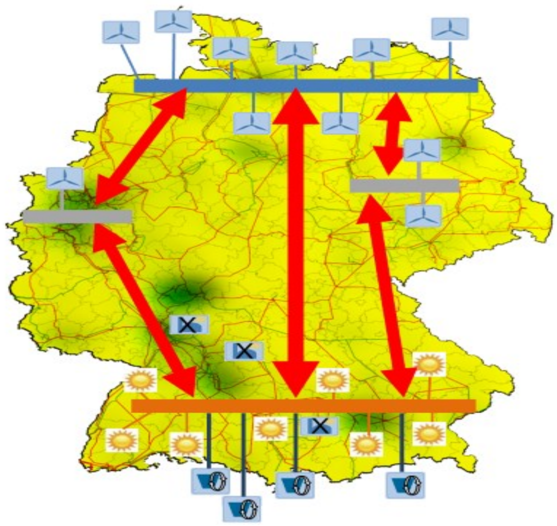
## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

The project connects Sachsen-Anhalt, an area with high installed capacities of RES and Bavaria, an area with high consumption and connections to storage capabilities (RES integration/Austria). It also helps to avoid unscheduled transit flows to neighboring countries and therefore creates possibility to use the relieved interconnectors for energy trading (market integration).

Due to used DC-Technology the project is able to provide reactive power and therefore helps to improve the voltage stability.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed in the 2030 Visions with a double TOOT step compared to the project 204, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | PL+CZ+AT-DE: 650 |
| | DE-PL+CZ+AT: 650 |
| Delta GTC contribution (2030) [MW] | PL+CZ+AT-DE: 650 |
| | DE-PL+CZ+AT: 650 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 2800 ±400 |
| Cost explanation | The high costs reflect the priority of underground cables for DC-lines in Germany. The uncertainty range is high, due to early planning stage the exact realisation is not clear. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 50 ±10 | 160 ±20 | 80 ±10 | 90 ±10 | 80 ±10 |
| B3 RES integration (GWh/yr) | 30 ±10 | 250 ±50 | 110 ±20 | 850 ±170 | 660 ±130 |
| B4 Losses (GWh/yr) | 0 ±25 | 225 ±25 | 75 ±25 | -50 ±25 | 25 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 12 ±1 | 3 ±2 | -3 ±2 | 1 ±2 |
| B5 CO2 Emissions (kT/year) | -100 ±20 | 900 ±100 | 400 ±100 | -700 ±100 | -1000 ±200 |

*Comment on the SEW:*

For the redispatch based benefit calculations only costs resulting from changing generation dispatches leading to different fuel costs (including costs for CO2 emissions) were determined. Whilst the overall redispatch costs, additionally consisting of passed market premiums, costs for holding redispatchable generation and compensation payments for reducing power from RES generation units, were neglected.

Therefore the displayed project benefits are only illustrating the lower limit due to the underestimation of the redispatch costs.

*Comment on the security of supply:*

A low SoS value means that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the S1 and S2 indicators:*

Detailed values for this project are not available due to the early state in the planning process.

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. The mentioned GTC value is the additional crossborder impact of the project.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 132 - RES-Integration in North-West Germany 2

Project 132 consists of a new 380-kV overhead line between Conneforde and Cloppenburg and a new HVDC cable from Emden-East to Osterath. This HVDC has a transfer capacity of 2 GW. North Germany is characterised by a high amount of RES, the feed-in exceeds the local load and therefore there is a high demand for transfer to the load centres in western and southern parts of Germany. With the further installation of additional offshore wind energy, the relevance of this projects increases. The project (and especially the HVDC-line) has a significant relation to the Project Ultranet (Project ID 254), which connects the western part of Germany to the south.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Internal Project |
| PCI label | |
| Promoted by | AMPRION;TENNET-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 661 | New HVDC line from Emden East to Osterath (Length: approx. 300 km) | 100% | Emden East (DE) | Osterath (DE) | Planning | 2025 | Rescheduled | The commissioning date of the investment has been rescheduled due to the postponement of the development of offshore windfarms in the North Sea. |
| 663 | New 380 kV double circuit from Cloppenburg East to Merzen (Length: approx. 55 km) | 100% | Cloppenburg East (DE) | Merzen (DE) | Planning | 2022 | Investment on time | |
| 666 | New 380-kV-lines in existing OHL corridor | 100% | Conneforde (DE) | Cloppenburg (DE) | Planning | 2022 | Investment on time | |

### Additional Information

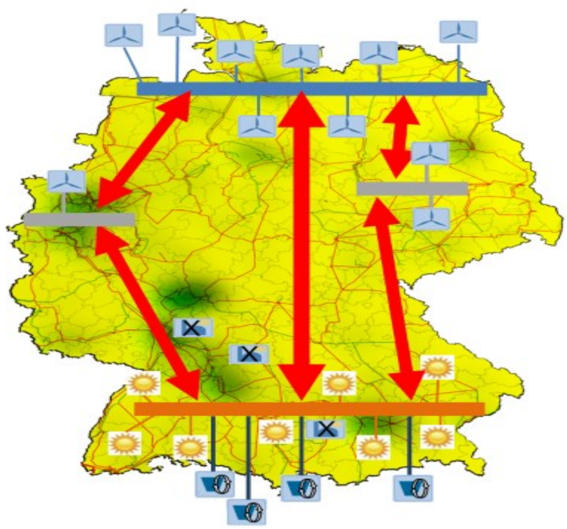
Further information on the project, its investments and their necessity particularly for the German Energiewende can be found in the German grid development plan (in German):
http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0
More detailed information on Investment 663 can be found on the investment websites (in German):

http://netzausbau.amprion.net/projekte/cloppenburg-merzen/projektbeschreibung http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/conneforde-cloppenburg-merzen.html

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and storages (for example Scandinavia)  are required.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |

| | |
|---|---|
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1680 ±200 |
| Cost explanation | The high costs reflect the priority of underground cables for DC-lines in Germany. The uncertainty range is high due to the early planning stage, the exact realisation is not clear. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±< 10 | 150 ±20 | 70 ±10 | 510 ±80 | 310 ±50 |
| B3 RES integration (GWh/yr) | 30 ±10 | 600 ±120 | 220 ±40 | 5720 ±1140 | 3560 ±710 |
| B4 Losses (GWh/yr) | 0 ±25 | -375 ±37 | -275 ±27 | -325 ±32 | -300 ±30 |
| B4 Losses (Meuros/yr) | 0 ±1 | -20 ±2 | -13 ±2 | -19 ±2 | -20 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | 300 ±100 | 200 ±100 | -2900 ±400 | -2100 ±300 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the SEW:*

For the redispatch based benefit calculations only costs resulting from changing generation dispatches leading to different fuel costs (including costs for $CO_2$ emissions) were determined. Whilst the overall redispatch costs, additionally consisting of passed market premiums, costs for holding re- dispatchable generation and compensation payments for reducing power from RES generation units , were neglected.

Therefore the displayed project benefits are only illustrating the lower limit due to the underestimation of the redispatch costs.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

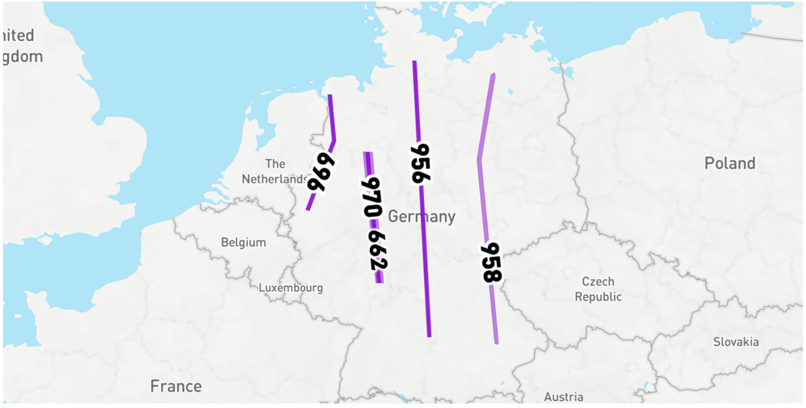
Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 133 - Longterm RES-Integration in Germany

This project consists of four DC corridors from the North of Germany to the South. These corridors are necessary in the long run when the installed RES-generation in the North of Germany increases even more.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Internal Project |
| PCI label | |
| Promoted by | 50HERTZ;AMPRION;TENNET-DE;TRANSNET-BW |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 662 | New HVDC line from Wehrendorf to Urberach (Length: approx. 380 km) | 100% | Wehrendorf (DE) | Urberach (DE) | Under Consideration | >2030 | Rescheduled | The need for this long-term investment was not confirmed by the regulatory authority within the national grid development plan 2014. Therefore the project has been rescheduled and further studies on this project are ongoing. |
| 956 | Further HVDC connections between Schleswig-Holstein and Baden-Würtemberg/Bavaria | 100% | Schleswig-Hostein | Baden-Würtemberg / Bavaria | Under Consideration | >2030 | Investment on time | |
| 958 | New DC- lines to integrate new wind generation form Baltic Sea towards Central/south Europe for consumption and storage. | 100% | Güstrow (DE) | Area of Isar (DE) | Under Consideration | >2030 | Investment on time | |
| 969 | New HVDC connection for RES integration | 100% | Lower Saxony | North Rhine-Westphalia | Under Consideration | >2030 | Investment on time | |
| 970 | New HVDC connection from Northern Germany to Southern Germany in the same corridor as Investment 662. | 100% | Lower Saxony | Hesse/Baden-Würtemberg | Under Consideration | >2030 | Investment on time | |

## Additional Information

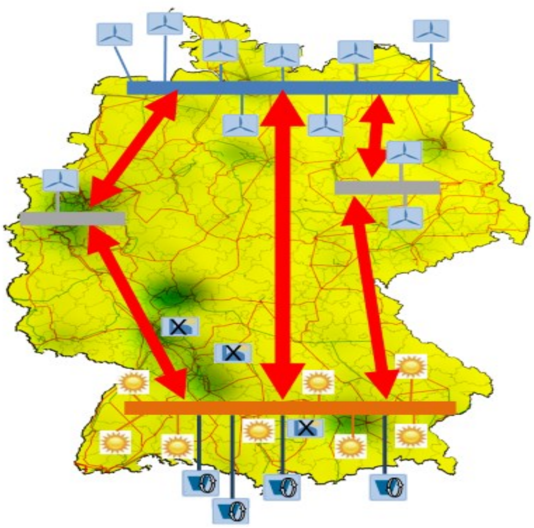
German grid development plan:

http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia or Switzerland) are required.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project's expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |

| | |
|---|---|
| | |
| Delta GTC contribution (2030) [MW] | -: - |
| | -: - |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 20000 ±5000 |
| Cost explanation | The high costs refelct the priority of underground cables for DC-lines in Germany. The uncertainty range is high due to the early planning stage the exact realisation is not clear. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 90 ±10 | 40 ±10 | 530 ±80 | 900 ±130 |
| B3 RES integration (GWh/yr) | N/A | 250 ±50 | 170 ±30 | 5780 ±1160 | 9950 ±1990 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 300 ±100 | ±100 | -2800 ±400 | -5100 ±800 |

As this project is labeled as being a future project it has not been assessed for the EP2020 scenario. For the Visions this project has been assessed using the PINT approach.

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for $CO_2$ emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 134 - Grid Reinforcements in South-West Germany

Project 134 provides significant North-South transmission capacity in Western Germany. The project consists of AC reinforcements and upgrades of existing corridors towards the load centers of Baden-Württemberg and Switzerland.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Project |
| PCI label | |
| Promoted by | AMPRION;TRANSNET-BW |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 176 | Upgrade of transmission capacity of existing 380 kV line (120 km) | 100% | Daxlanden (DE) | Eichstetten (DE) | Planning | 2021 | Rescheduled | No significant change |
| 680 | New line from Urberach to Daxlanden (Length: approx. 219 km) | 100% | Urberach (DE) | Daxlanden (DE) | Planning | 2022 | Investment on time | Commissioning is planned for the end of 2021 / beginning of 2022. Therefore, the commissioning date is set to 2022. |

### Additional Information

Further information on the project, its investments and their necessity particularly for the German Energiewende can be found in the German grid development plan (in German):
http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0
More detailed information on investment 680 can be found on the investment website (in German):
http://netzausbau.amprion.net/projekte/urberach-weinheim/projektbeschreibung

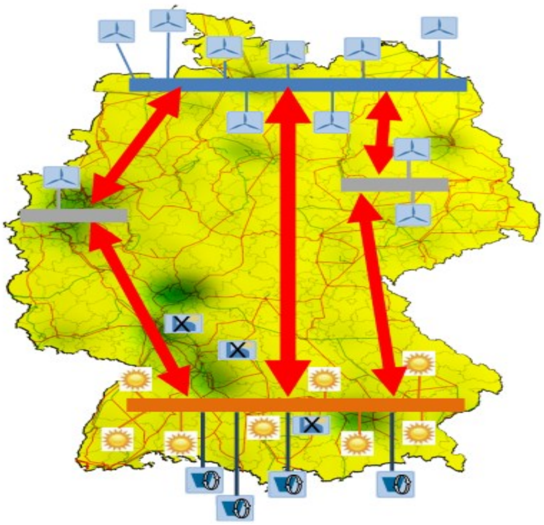
https://www.transnetbw.de/de/uebertragungsnetz/dialog-netzbau/netzverstaerkung-weinheim-karlsruhe

More detailed information on investment 176 can be found on the investment website (in German):
https://www.transnetbw.de/de/uebertragungsnetz/dialog-netzbau/daxlanden-eichstetten

### Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and storages (for example Scandinavia or Switzerland) are required.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
| --- | --- |
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 890 ±130 |

| | |
|---|---|
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 240 ±40 | 360 ±50 | 260 ±40 | 330 ±50 | 270 ±40 |
| B3 RES integration (GWh/yr) | 1440 ±290 | 1680 ±340 | 1030 ±210 | 3430 ±690 | 2350 ±470 |
| B4 Losses (GWh/yr) | -75 ±25 | -275 ±27 | -175 ±25 | 100 ±25 | 75 ±25 |
| B4 Losses (Meuros/yr) | -4 ±1 | -15 ±2 | -8 ±1 | 5 ±2 | 5 ±2 |
| B5 CO2 Emissions (kT/year) | 800 ±130 | 600 ±100 | 600 ±100 | -1500 ±200 | -1000 ±200 |

Comment on GTC:
The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

Comment on the S1 and S2 indicators:
Detailed values are not available due to the early state in the planning process.

Comment on the security of supply:
Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.
Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

Comment on the SEW:
For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.
The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid.

# Project 135 - Grid Reinforcements in Western Germany

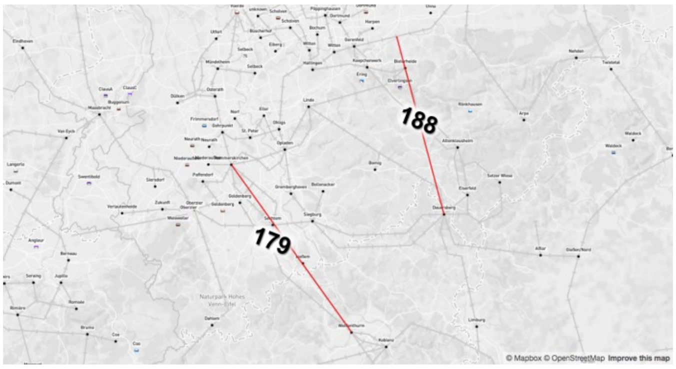
Project 135 provides significant grid reinforcement between Cologne and the Ruhr district (North-West-Germany) and Koblenz/Frankfurt (South-West-Germany) to integrate RES. The project is realised in an existing corridor with an update of a 220 kV- to 380 kV-system and an additional 380 kV overhead line.

Classification: Mid-term Project

Boundary: Internal Project

PCI label:

Promoted by: AMPRION




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 179 | New line from Rommerskirchen to Weißenthurm (Length: approx. 94 km) | 100% | Rommerskirchen (DE) | Weißenthurm (DE) | Under Construction | 2019 | Delayed | The section Rommerskrichen to Sechtem is delayed because the permitting procedures take longer than planned. The 36 km section from Sechtem to Weißenturm is already commissioned. |
| 188 | New lines (Length: approx. 120 km) and extension of several 380/110kV-substations | 100% | Kruckel (DE) | Dauersberg (DE) | Permitting | 2021 | Delayed | Delay due to long permitting process |

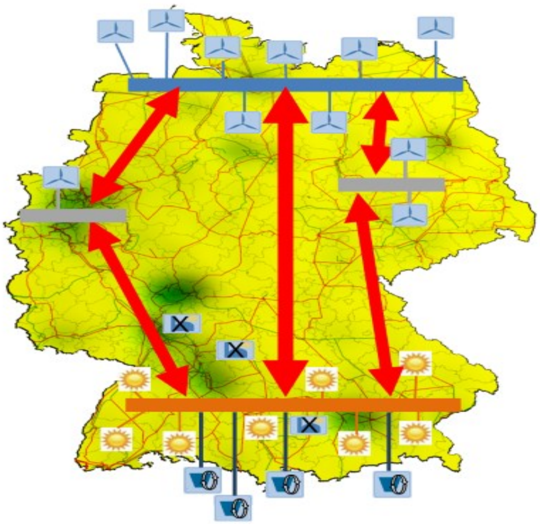
## Additional Information

Further information on the project, its investments and their necessity particularly for the German Energiewende can be found in the German grid development plan (in German):
http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0
Detailed information on Investment 179 can be found on the investment website (in German):
http://netzausbau.amprion.net/projekte/osterath-weissenthurm/projektbeschreibung
Detailed information on Investment 188 can be found on the investment website (in German):
http://netzausbau.amprion.net/projekte/dortmund-frankfurt/projektbeschreibung

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and storages (for example Scandinavia)  are required.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the project 254, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern: - |
| | DE intern: - |
| Delta GTC contribution (2030) [MW] | DE intern: - |
| | DE intern: - |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 900 ±135 |

| | |
|---|---|
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±< 10 | 120 ±20 | 60 ±10 | 30 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | 370 ±70 | 110 ±20 | 200 ±20 | <10 |
| B4 Losses (GWh/yr) | -225 ±25 | -175 ±25 | -225 ±25 | -350 ±35 | -225 ±25 |
| B4 Losses (Meuros/yr) | -10 ±1 | -10 ±2 | -11 ±2 | -21 ±2 | -15 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | 300 ±100 | 200 ±100 | 200 ±100 | 200 ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the SEW:*

For the redispatch based benefit calculations only costs resulting from changing generation dispatches leading to different fuel costs (including costs for CO2 emissions) were determined. Whilst the overall redispatch costs, additionally consisting of passed market premiums, costs for holding re- dispatchable generation and compensation payments for reducing power from RES generation units , were neglected.

Therefore the displayed project benefits are only illustrating the lower limit due to the underestimation of the redispatch costs.

*Comment on the security of supply:*
Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

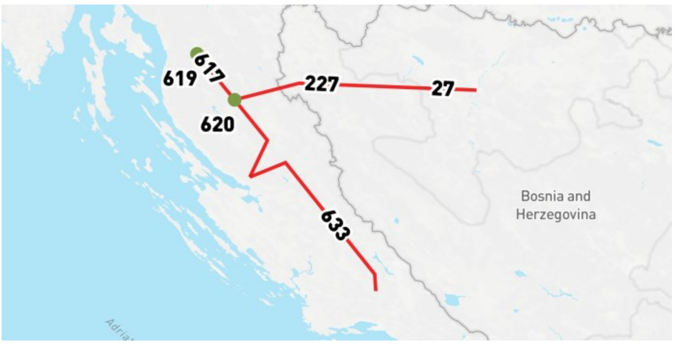
The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 136 - CSE1

The project will contribute in strengthen Croatian transmission grid along its main north-south axis (in parallel with eastern Adriatic coast) allowing for additional long-distance power transfers (including cross border) from existing and new planned power plants (RES/wind/ and conventional/hydro and thermal/) in Croatia (coastal parts) and BiH to major consumption areas in Italy (through Slovenia) and north Croatia.

The increased transfer capacity will support market integration (particularly between Croatia and Bosnia-Herzegovina) by improving security of supply (also for emergency situations), achieving higher diversity of supply&generation sources and routes, increasing resilience and flexibility of the transmission network.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Croatia – Bosnia and Herzegovina |
| PCI label | |
| Promoted by | HOPS;NOS-BIH |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 227 | New 400kV interconnection line between BA and HR | 82% | Banja Luka (BA) | Lika (HR) | Under Consideration | 2030 | Rescheduled | Feasibility study is expected to be launched. |
| 617 | New 55 km single circuit 400 kV OHL replacing aging 220 kV overhead line | 35% | Lika(HR) | Brinje(HR) | Under Consideration | 2025 | Rescheduled | Feasibility study is expected to be launched. |
| 618 | New 60 km single circuit 400 kV OHL replacing aging 220 kV overhead line | 35% | Lika(HR) | Velebit(HR) | Under Consideration | 2025 | Rescheduled | Feasibility study is expected to be launched. |
| 619 | New 400/110 kV substation, 2x300 MVA | 35% | Lika (HR) | | Under Consideration | 2027 | Rescheduled | Feasibility study is expected to be launched. |
| 620 | New 400/220 kV substation, 1x400 MVA | 35% | Brinje (HR) | | Under Consideration | 2025 | Rescheduled | Feasibility study is expected to be launched. |
| 633 | New 100km single circuit 400 kV OHL replacing ageing 220 kV overhead line | 35% | Konjsko(HR) | Velebit(HR) | Under Consideration | 2025 | Rescheduled | Feasibility study is expected to be launched. |

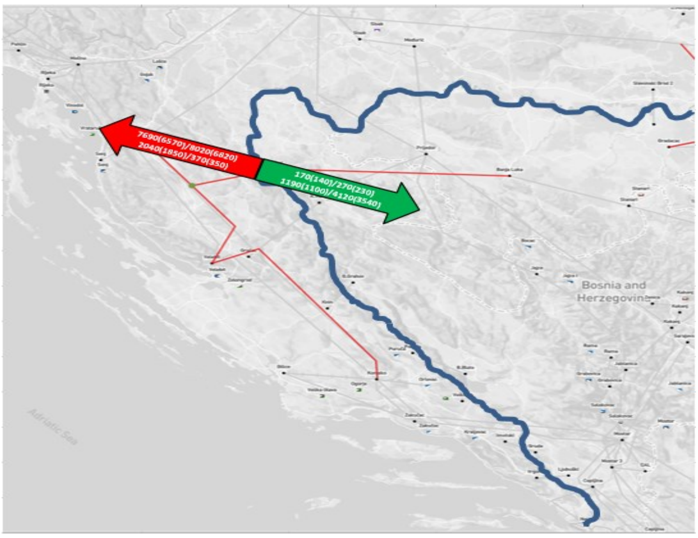
## Additional Information

*PCI page – link to EC platform* http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

## Investment needs

The project in Croatia includes a new 400 kV OHL replacing the aging 220 kV OHL between existing substations Brinje and Konjsko, interdepending with the construction of two new 400/(220)/110 kV substations Brinje and Lika. The new 400 kV interconnection BanjaLuka (BA)-Lika (HR) will support market and RES integration in the area – South and Mid Croatia and North and Mid Bosnia and Herzegovina. The increased transfer capacity will enable higher diversity of supply&generation sources and routes, increasing resilience and flexibility of the transmission network.

Project will increase transmission capacity in range 1200-1670 MW or in average for 52% for dominant direction from East (BA) to West (HR). GTC on the boundary considered will reach up to 1970 MW in 2030.
In opposite direction, GTC increase is in range 1760-1970 MW, or in average for 46% due to the predominant flows is E->W. GTC on the boundary considered will reach up to 500 MW (in predominant direction E->W) in 2030.
Project 136 supports market integration in mid-term, 2020EP, and brings a benefit to SEW of 27 MEUR. On a long-term, largest benefits on SEW of over 15 MEUR in Vision 1.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | HR-BA: 950 |
| | BA-HR: 650 |
| Delta GTC contribution (2030) [MW] | HR-BA: 200 |
| | BA-HR: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 173 ±20 |
| Cost explanation | Uncertainty regarding total length of lines, extra costs due to difficult configuration of terrain construction costs, public tendering, environmental or legal requirements imposed during permit grating process. |
| S1 | Negligible or less than 15km |
| S2 | 15-25km |
| B6 | + |
| B7 | ++ |

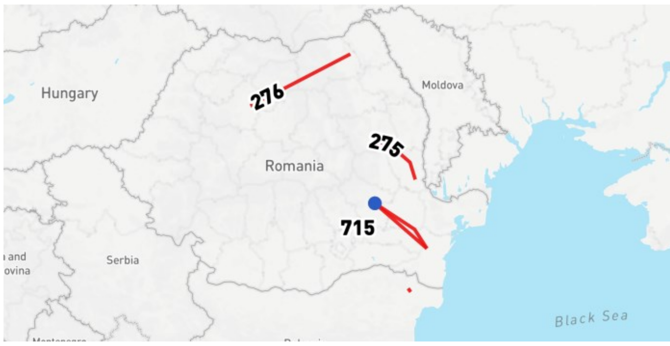
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | 0 | 0 | 0 | 0 | 0 |
| B2 SEW (MEuros/yr) | 30 ±< 10 | 20 ±10 | 10 ±10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 25 ±25 | -75 ±25 | -25 ±25 | 25 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | 1 ±1 | -4 ±1 | -1 ±1 | 1 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | 500 ±50 | 300 ±100 | 300 ±100 | ±100 | ±100 |

Savings in variable generation costs (SEW) and reduction on CO2 emissions are caused by the integration of new RES generation in the system replacing fossil fuel based generation. Therefore the highest values are reached in the scenarios with higher RES integration.

## Project 138 - Black Sea Corridor

The project consists of one 400kV double circuit OHL Cernavoda-Stalpu and Gura Ialomitei, one 400 kV double circuit OHL Smardan-Gutinas and one 400 kV OHL single circuit Suceava – Gadalin, in Romania and also the new 400 kV OHL Dobrujda-Burgas in Bulgaria.  This project allows transfer of generation from the Western cost of the Black Sea towards consumption and storage centers in Central Europe and South-Eastern Europe.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | North-South |
| PCI label | 3.8 |
| Promoted by | TRANSELECTRICA, ESO-EAD |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 273 | Reinforcement of the cross-section between the Western coast of the Black Sea (Eastern Romania) and the rest of the system. New 400kV double circuit OHL between existing substations Cernavoda and Stalpu, with 1 circuit derivation in/out in 400 kV substation Gura Ialomitei, situated in the vicinity of the new line. Line length 159km,2x1380 MVA. | 65% | Cernavoda (RO) | Stalpu (RO) | Permitting | 2020 | Delayed | Longer than expected delay regarding clarification of legal framework for right of land acquirement and regarding environmental permitting procedure. |
| 275 | Reinforcement of the cross-section between the Western coast of the Black Sea (Dobrogea area) and the rest of the system. New 400 kV double circuit OHL (one circuit wired) between existing substations. Line | 45% | Smardan (RO) | Gutinas (RO) | Permitting | 2020 | Investment on time | Rapid increase of wind generation connected in the area. Efforts to be made to speed construction. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | length 140km; 1380 MVA. | | | | | | | |
| 276 | Reinforcement of the cross-section between developing wind generation hub in Eastern Romania and the rest of the system. New 400kV simple circuit OHL between existing substations. Line length 260km, 1204 | 13% | Gadalin (RO) | Suceava (RO) | Permitting | 2023 | Delayed | Longer than expected delay regarding clarification of legal framework for right of land acquirement and regarding environmental permitting procedure. |
| 715 | To reinforce the cross-section between the Black Sea coast wind generation in Romania and Bulgaria and the consumption and storage centers to the West, the 220 kV OHL Stalpu-Teleajen-Brazi is upgraded to 400 kV, as a continuation of the 400 kV d.c. OHL Cernavoda-Stalpu. The 220/110 kV substation Stalpu is upgraded to 400/110kV (1x250MVA). | 65% | Stalpu (RO) | Stalpu (RO) | Permitting | 2020 | Delayed | This project is complementing with project 273. |
| 800 | New 140km single circuit 400kV OHL in parallel to the existing one. | 13% | Varna(BG) | Burgas(BG) | Planning | 2020 | Delayed | Delayed due to lack of funding. |

## Additional Information

In the second PCI list are included the following investments:

3.8.1 Internal line between Varna and Burgas (BG)

3.8.4 Internal line between Cernavoda and Stalpu(RO)

3.8.5 Internal line between Gutinas and Smardan(RO)

The investment OHL 400 kV Suceava - Gadalin is no longer considered a PCI because the contribution to GTC increase was not high enough.

http://www.transelectrica.ro/web/tel/proiecte-de-interes-comun

Clustering approach:

Project 138 “Black Sea corridor” has to be evaluated as a single project including the following investments: 273, 275, 276, and 715 as in TYNDP 2014 report. The investments are completely dependent on each other as the main enhancements in Romania which remove bottlenecks and integrate RES to the network. Clustering of investments had the purpose to identify investments contributing to the increase of transfer capacity on the same corridor. Proposed Project supports market development in South East Europe which is less developed. Based on upper mentioned information it is crucial to cluster all these investment together, to fully utilize the possible benefits.

Romanian National Development Plan (only in Romanian): https://www.transelectrica.ro/web/tel/plan-perspectiva

## Investment needs

The project reinforces the internal corridors in Romania and Bulgaria connecting the Black Sea Coast windy area to the rest of Europe, and also increases the cross-border tranfer capacity between Romania and Bulgaria.

The project 138 aims to increase the transfer capacity in the predominant North-South direction by investments that will create new (boost existing) electricity corridor. The project 138 supports the large scale integration of new RES in the region of the Black Sea Coast in Romania and Bulgaria. Development of intermittent RES will be made possible by the capacity of the grid to transport their generation to consumption and storage centres and to accommodate balancing at regional/continental level.

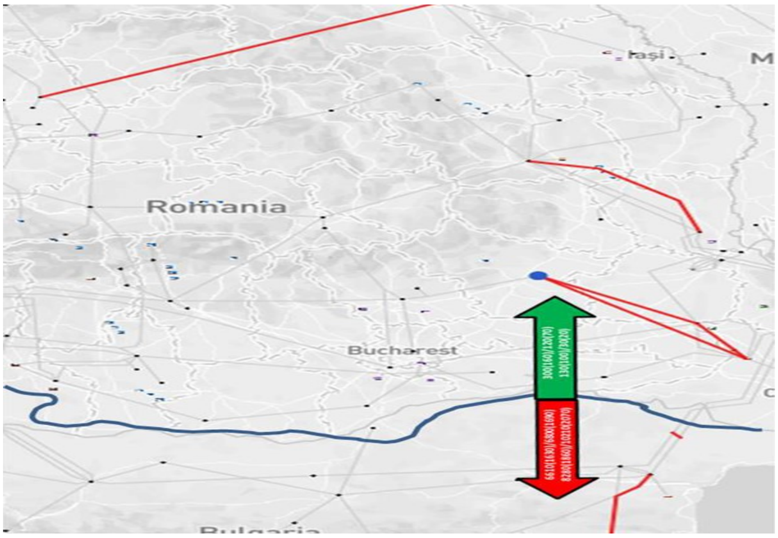
Numbers in the arrows represent annual energy flow [GWh] and refers to each vision 1,2,3,4 respectively. In brackets are given flows when the Project is OUT of operation (TOOT values).

For all visions predominant direction of bulk flows is N->S namely Romania – Bulgaria, due to RES integration in Romanian side.

Project will increase transmission capacity in range 1200-1339 MW or in average for 70% for dominant direction from North (RO) to South (BG, GR). GTC on the boundary considered will reach up to 3329 MW in 2030.

In opposite direction, GTC increase is in range 782-1002 MW, or in average for 157% due to the predominant flows is N->S. GTC on the boundary considered will reach up to 500 MW (in predominant direction N->S) in 2030.

Project 138 supports market integration in mid-term, 2020EP, and brings a benefit to SEW of 60 MEUR. On a long-term, largest benefits on SEW of over 250 MEUR are due facilitation of RES integration in Vision 4.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BG-RO: 1000 |
| | RO-BG: 1200 |
| Delta GTC contribution (2030) [MW] | BG-RO: 800 |
| | RO-BG: 1350 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 298 ±40 |
| Cost explanation | Cost represents the currently expected total project investment cost.<br><br>Uncertainty range related to procurement/construction cost uncertainties. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

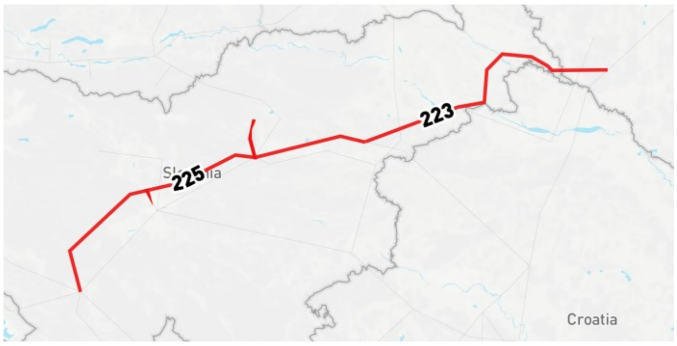
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 60 ±10 | 80 ±10 | 50 ±10 | 40 ±10 | 270 ±40 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 30 ±10 | 140 ±30 |
| B4 Losses (GWh/yr) | 50 ±25 | 25 ±25 | 125 ±25 | -125 ±25 | -150 ±25 |
| B4 Losses (Meuros/yr) | 2 ±1 | 1 ±2 | 6 ±1 | -8 ±2 | -10 ±2 |
| B5 CO2 Emissions (kT/year) | 700 ±100 | 1100 ±200 | 700 ±100 | -900 ±100 | -900 ±100 |

The project contributes to the reduction of generation cost in Europe that is reflected in SeW values for the examined scenarios. In EP2020, Vision 1 and Vision 2, transfer capacity increase brought by new projects, assists market integration internally in the Region and with the rest of Europe. SeW is created due to the capability to increase the generation of cheap thermal production in the Balkan peninsula with an associated increase in CO2 emissions. In Visions 3 and 4, SeW is created mainly because of the increased RES penetration brought by new projects and is accompanied by a corresponding CO2 reduction.

# Project 141 - Slovenia-Hungary corridor

The project consists of a new double circuit 400 kV line Cirkovce-Pince and anew 400 kV Cirkovce substation (Slovenia) by which a new connection to onecircuit of the existing double circuit interconnection line between Hungary andCroatia will be made, thus creating two new cross border interconnection betweenSlovenia and Hungary and between Slovenia and Croatia. Existing 220 kV lines ofthe corridor Cirkovce-Divaca will be upgraded to 400 kV level.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Hungary - Slovenia |
| PCI label | 3.9 |
| Promoted by | ELES;MAVIR |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 223 | New 400 kV connection between Slovenia, Hungary and Croatia | 100% | Cirkovce (SI) | Heviz (HU) Zerjavenec (HR) | Design & Permitting | 2019 | Delayed | ELES is currently in the process of gaining easment from the land owners. |
| 225 | Upgrade of the internal 220 kV lines to 400 kV voltage level. | 100% | Divaca (SI) | Cirkovce (SI) | Design & Permitting | 2025 | Investment on time | The project is splitted in three phases: - 1st phase corridor Divača-Kleče-Beričevo (2020 - in permitting) - 2nd phase corridor Beričevo-Podlog (2025 - under consideration) - 3rd phase corridor Podlog-Cirkovce (2025 - under consideration). |

## Additional Information

**Project PCI website:**

PCI project - 3.9.1

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_9_1_en.pdf

PCI project - 3.9.2

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_9_2_en.pdf

PCI project - 3.9.3

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_9_3_en.pdf

PCI project - 3.9.4

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_9_4_en.pdf

**2nd PCI list:**

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

**Clustering approach:**

To improve secure and reliable operation and to reach the substantial transmission capacity contribution of this project, it is essential to build all investments which are part of the same corridor. After the connection of the new SI-HU/HR cross-border OHL, it is crucial to maintain the secure and reliable operation of Slovenian transmission system. Therefore, three internal investments which are part of upgrading 220 kV grid to 400 kV level are necessary. In the case of building just one investment, the transmission capacity contribution and security of operation will be lower.

Based on upper mentioned facts it is crucial to cluster all these investments together, to fully utilize the possible benefits.

**Slovenian NPD document (only in slovenian):**

http://www.eles.si/za-poslovne-uporabnike/razvoj-in-uporaba-prenosnega-omrezja/strategija-razvoja-elektroenergetskega-sistema-rs.aspx

**Hungarian National Development Plan (only in Hungarian):**

http://www.mavir.hu/documents/10258/15454/HFT_2015.pdf

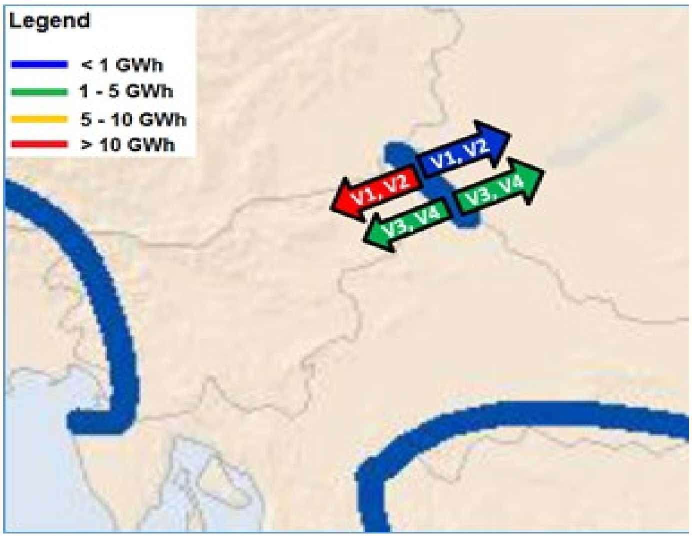
## Investment needs

The project 141 aims to increase the transfer capacity on in the predominant East-West direction by investments that will create new electricity corridors and possibility to access the new energy market and to import/export electricity to surrounding countries. The project 141 supports the large scale integration of new RES in the South East and Central East Europe. Project will improve security and realibility of operatiopn of the Slovenian transmission system which is heavy loaded during the year due to the hight transit flows.

Arrows on the figure represent annual energy flow [GWh] and refers to each vision 1, 2, 3, 4 respectively.

For all visions predominant direction of bulk flows is East->West.

The results showed, that project 141 is adequate for all four visions and there is no need for further investigations on this border.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | SI-HU : 1650 |
| | HU -SI: 650 |
| Delta GTC contribution (2030) [MW] | SI-HU : 800 |
| | HU -SI: 1050 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 345 |
| Cost explanation | The difference in investment cost from TYNDP 2014 is due to the novelation of the investment plan. |
| S1 | More than 100km |
| S2 | 15-25km |
| B6 | 0 |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 10 ±< 10 | 80 ±10 | 80 ±10 | 10 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 25 ±25 | -125 ±25 | -125 ±25 | -100 ±25 | -50 ±25 |
| B4 Losses (Meuros/yr) | 1 ±1 | -7 ±2 | -6 ±1 | -6 ±2 | -4 ±2 |
| B5 CO2 Emissions (kT/year) | 200 ±80 | 900 ±100 | 800 ±100 | -200 ±100 | -300 ±100 |

*Comment on SoS indicator:*

Project 141 is important for managing extreme contingency situations and would play big security role in power evacuation from nuclear power plant located in Krško.

## Project 142 - CSE 4 (2nd BG-GR interconnector and South BG corridor)

The project concerns the construction of a new AC 400kV interconnection between Bulgaria and Greece and new AC 400kV overhead linesat the south part of Bulgaria. This project will increase cross border transfer capacity between Bulgaria and Greece and contribute to the safe evacuation of renewable power in the area.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | North-South |
| PCI label | 3.7.11 |
| Promoted by | ESO;IPTO-SA |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 256 | New interconnection line BG-GR by a 130km single circuit 400kV OHL. | 100% | Maritsa East 1 (BG) | N.Santa (GR) | Permitting | 2021 | Delayed | Delayed due to lack of funding. |
| 257 | New 100km single circuit 400kV OHL in parallel to the existing one. | 100% | Maritsa East 1 (BG) | Plovdiv (BG) | Design & Permitting | 2019 | Delayed | Delayed due to difficulties with the acquisition of the land |
| 258 | New 13km single circuit 400kV OHL in parallel to the existing one. | 100% | Maritsa East 1 (BG) | Maritsa East 3 (BG) | Design & Permitting | 2017 | Delayed | Delayed due to difficulties with the acquisition of the land |
| 262 | New 400kV OHL. Line length 150km. | 100% | Maritsa East 1 (BG) | Burgas (BG) | Design & Permitting | 2021 | Delayed | Delayed due to difficulties with the acquisition of the land |

### Additional Information

- Project website ESO (http://projects.eso.bg/maritsa-east-nea-santa/?en#PROJECT%20OF%20COMMON%20INTEREST)

- Project website IPTO (http://www.admie.gr/en/transmission-system/system-development/projects-of-common-interest/project/article/2194/)

Project 142 includes a new interconnection between Bulgaria and Greece and relevant reinforcements in the 400kV network at the south part of Bulgaria. The later are necessary in order to alleviate congestions in the area of south Bulgaria that are restricting power exchanges through the new interconnector.

## Investment needs

The project 142 aims to increase the transfer capacity in the predominant North-South direction by the construction of a new interconnector between BG and GR and specific enhancements in the South part of the 400kV Bulgarian transmission system.

Project will increase transmission capacity in range of 660-870 MW for dominant direction from north (RO+BG) to south (GR), or in average for 80%. GTC on the boundary considered will reach up to 1000 MW in 2030.

In opposite direction, GTC increase is in range 0-400 MW, or in average for 30%. GTC on the boundary considered will reach up to 650 MW in 2030.

Project 142 support market integration in mid-term, 2020EP, and brings significant benefit to SEW of near 30 MEUR.

On a long-term, largest benefits on SEW appear mainly in Vision 2, as can be seen in the Figure below that depicts SeW:ΔGTC ratios for the 2030 Visions.


## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | GR-RO,BG: 0 |
| | RO,BG-GR: 650 |
| Delta GTC contribution (2030) [MW] | GR-RO,BG: 400 |
| | RO,BG-GR: 850 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 188.2 ±10 |
| Cost explanation | Here are given estimated CAPEX for investments clusterd in the project 142:<br>Investment 256: 400 kV OHL Maritsa East 1 (BG) - Nea Santa (GR) : 66.2 MEUR<br>Investment 257: 400 kV OHL  Maritsa East 1(BG) - Plovdiv (BG): 46 MEUR<br>Investment 258: 400 kV OHL Martitsa East 1(BG)- Maritsa East 3 (BG): 11 MEUR<br>Investment 262: 400 kV OHL Maritsa East 1 (BG) - Burgas (BG): 65 MEUR<br>OPEX are not inlcuded in the listed costs.<br>OHL costs deviate depending on terrain, while SS costs vary depending on arrangement of bubars and switchyards.<br>Uncertainty ranges about 10% of CAPEX. |
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

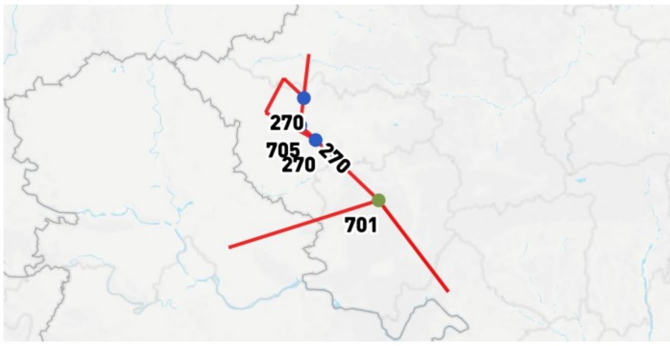
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 20 ±10 | 30 ±10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 30 ±10 | 80 ±20 |
| B4 Losses (GWh/yr) | 0 ±25 | 0 ±25 | -75 ±25 | -175 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 0 ±1 | -4 ±2 | -11 ±2 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 500 ±80 | 400 ±100 | 400 ±100 | ±100 | ±100 |

All the projects of CSE Region contribute to the reduction of generation cost in Europe that is reflected in SeW values for the examined scenarios. In EP2020, Vision 1 and Vision 2, transfer capacity increase brought by new projects, assists market integration internally in the Region and with the rest of Europe. SeW is created due to the capability to increase the generation of low cost thermal production in the Balkan peninsula with an associated increase in $CO_2$ emissions. In Visions 3 and 4, SeW is created mainly because of the increased RES penetration brought by new projects and is accompanied by a corresponding $CO_2$ reduction.

## Project 144 - Mid Continental East corridor

The project consists of one double circuit 400 kV line between Serbia and Romania and reinforcement of the network along the western border in Romania: one new simple circuit 400 kV line from Portile de Fier to Resita and upgrade from 220 kV double circuit to 400 kV double circuit of the axis between Resita and Arad, including upgrade to 400 kV of three substations along this path. The project aims at enhancing the transmission capacity along the East-West corridor in south-eastern and central Europe. It will provide access to the market for more than 1000 MW installed new wind generation in Banat area (Serbia and Romania).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | East-West |
| PCI label | 3.22 |
| Promoted by | TRANSELECTRICA; EMS |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 238 | New 131 km double circuit 400kV OHL between existing substation in Romania and Serbia (63 km on Romanian side and 68 km on Serbian side) 2x1380 MVA. | 50% | Resita (RO) | Pancevo (RS) | Under Construction | 2017 | Investment on time | On Romanian side the line is under construction and the status on Serbian territory is also under construction |
| 269 | New 116 km 400kV OHL single circuit between existing substation 400 kV Portile de Fier and new 400 kV substation Resita; 1380 MVA | 40% | Portile de Fier (RO) | Resita (RO) | Under Construction | 2018 | Delayed | The investment was coordinated with investment no 238. The main problems are right of land along the line path and permitting. |
| 270 | Upgrading of existing 220kV double circuit corridor Resita - Timisoara - Sacalaz – Arad to 400kV double circuit | 25% | Resita (RO) | Arad (RO) | Permitting | 2023 | Delayed | Planned to start after investment 269 is finalized. |
| 701 | New 400 kV substation Resita as development of the existing 220/110 kV substation. | 50% | Resita (RO) | Resita (RO) | Permitting | 2018 | Delayed | This investment is in correlation with investment no 269. |
| 705 | Replacement of 220 kV substation Timisoara with 400 kV substation. | 25% | Timisoara (RO) | Timisoara (RO) | Design | 2023 | Delayed | Investments 269 and 701 have to be finalized first. |

## Additional Information

On the second PCI list are included the following investments:

PCI 3.22.1 Interconnection between Resita (RO) and Pancevo (RS)

PCI 3.22.2 Internal line between Portile de Fier and Resita (RO)

PCI 3.22.3 Internal line between Resita and Timisoara/Sacalaz (RO)

PCI 3.22.4 Internal line between Arad and Timisoara/Sacalaz (RO)

http://www.transelectrica.ro/web/tel/proiecte-de-interes-comun

Clustering approach:

Project 144 aims to enhance the transmission capacity along the East-West corridor in the South-Eastern and Central Europe. GTC was calculated for a common boundary in South East region, between the West borders of Romania and Bulgaria which are main exporters of the area on one hand and Serbia and Hungary on the other hand. The investments 238, 269, 270,701 and 705 are complementing each other as the main enhancements in Romania which remove bottlenecks and integrate RES to the network. Based on upper mentioned information it is crucial to cluster all these investments together, to utilize the possible benefits.

Romanian National development Plan (only in Romanian): http://www.transelectrica.ro/web/tel/plan-perspectiva

## Investment needs

The project 144 enhances the transmission capacity along the East-West corridor in the South-Eastern and Central Europe. The project 144 supports the large scale integration of new RES in the region of South-west Romania and North-East Serbia.

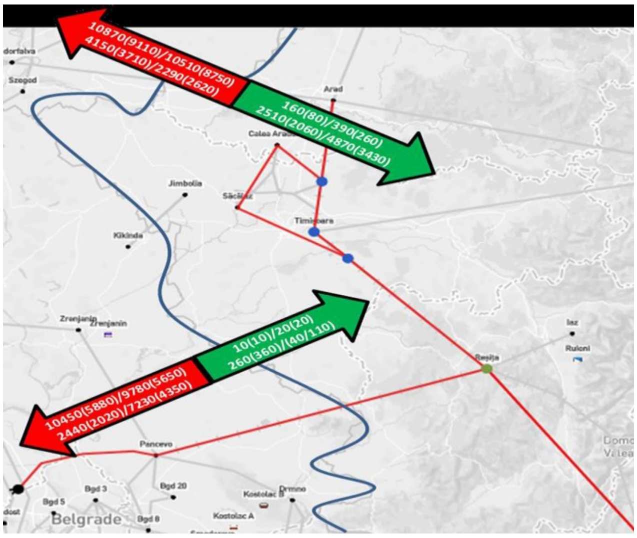
Numbers in the arrows represent annual energy flow [GWh] and refers to each vision 1,2,3,4 respectively. In brackets are given flows when the Project is OUT of operation (TOOT values).

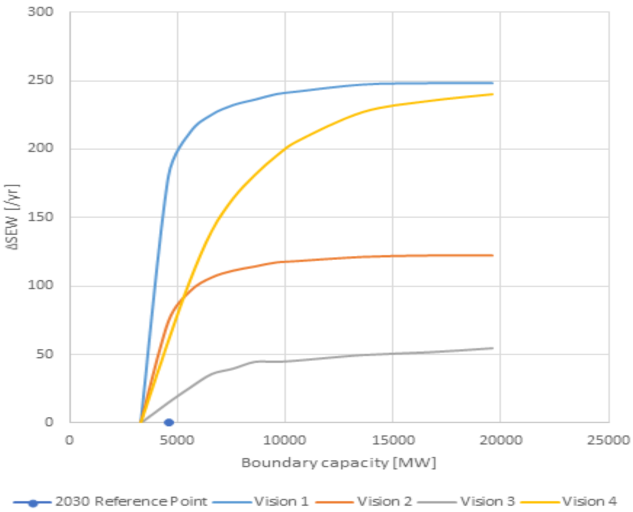
For all For all visions predominant direction of bulk flows is E->W namely Romania – Serbia respectively Romania - Hungary, due to RES integration in Romanian side.

Project will increase transmission capacity in range 960 - 925 MW, or in average for 53% for dominant direction from East (RO) to West (HU+RS+HR+BA+ME). GTC on the boundary considered will reach up to 2585 MW in 2030.

In opposite direction, GTC increase is in range 513 - 750 MW, or in average for 29%. GTC on the boundary considered will reach up to 2855 MW in 2030.

Project 144 supports market integration in mid-term, 2020EP, and brings a benefit to SEW of 50 MEUR. On a long-term, largest benefits on SEW appear in Vision 1, as can be seen in the Figure below that depicts SeW/delta GTC ratios for the 2030 Visions.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | HU,RS,HR,BA,ME-RO: 500 |
| | RO-HU,RS,HR,BA,ME: 950 |
| Delta GTC contribution (2030) [MW] | HU,RS,HR,BA,ME-RO: 750 |
| | RO-HU,RS,HR,BA,ME: 950 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 176 ±25 |
| Cost explanation | Cost represents the currently expected total project investment cost.<br>Uncertainty range related to procurement/construction cost uncertainties |
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 50 ±10 | 90 ±10 | 60 ±10 | <10 | 60 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 30 ±10 | 120 ±20 |
| B4 Losses (GWh/yr) | 25 ±25 | 325 ±32 | 125 ±25 | 75 ±25 | 75 ±25 |
| B4 Losses (Meuros/yr) | 1 ±1 | 17 ±2 | 6 ±1 | 4 ±2 | 5 ±2 |
| B5 CO2 Emissions (kT/year) | 900 ±50 | 1700 ±300 | 1100 ±200 | ±100 | -400 ±100 |

The project contributes to the reduction of generation cost in Europe that is reflected in SeW values for the examined scenarios. In EP2020, Vision 1 and Vision 2, transfer capacity increase brought by new projects, assists market integration internally in the Region and with the rest of Europe. SeW is created due to the capability to increase the generation of cheap thermal production in the South-Eastern region with an associated increase in CO2 emissions. In Visions 3 and 4, SeW is created mainly because of the increased RES penetration brought by new projects and is accompanied by a corresponding CO2 reduction.

## Project 146 - CSE8 Transbalkan Corridor

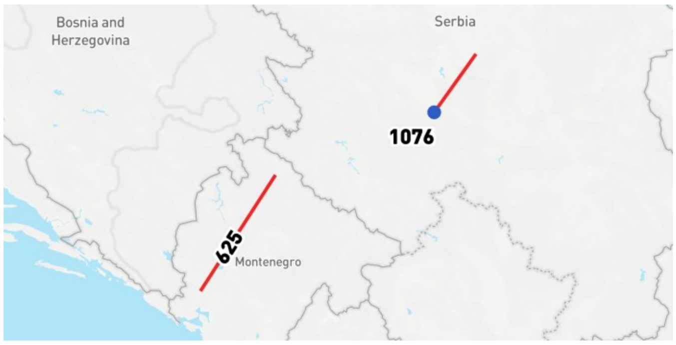
The project aim is to increase transmission capacity and facilitate exchange of energy between north-east part of Europe and south-west of Europe.

Classification Mid-term Project

Boundary East-West

PCI label

Promoted by CGES;EMS;NOS-BIH




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 625 | Reinforcement of the Montenegrin internal 400 kV transmission network | 100% | Lastva (ME) | Pljevlja (ME) | Under Construction | 2016 | Investment on time | on time |
| 1075 | New 400 kV OHL Kragujevac - Kraljevo will allow increase of energy transits from Eastern to Western part of the region | 100% | Kragujevac | Kraljevo | Under Construction | 2019 | Delayed | Del_Financing issues |
| 1076 | This investment is required for constrction of 400 kV OHL Kragujevac - Kraljevo | 100% | Kraljevo | | Under Construction | 2019 | Delayed | Del_Financing issues |

## Additional Information

The Project 146, as a project 227, represents a strategic investment of regional and pan-European significance. When completed, the Transbalkan Corridor will significantly strengthen the critical northeast-southwest and east-west regional and pan-European corridors which are some of the most congested transmission corridors in the Southeast Europe region. The Project consists of the following OHL investments, with a total length of the OHLs of 220 km:

- OHL 400 kV from Pljevlja to new SS Lastva in Montenegro , 160 km and
- OHL 400 kV Kragujevac - Kraljevo, 60 km.

The project will enable power transits directed to new HVDC link towards Italy. Also, this project will enable connection of Renewable energy sources along its route.

## Investment needs

The Project 146 objectives, as project 227, in line with the basic goals of EU energy policy, are to:

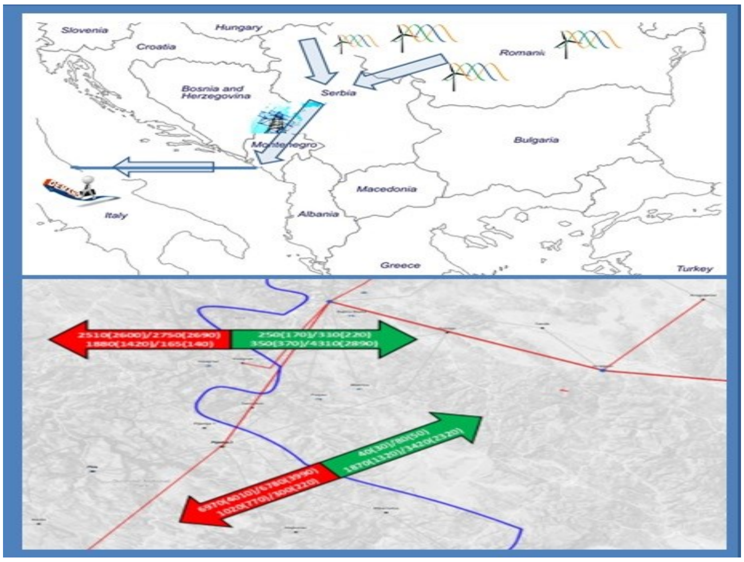
1. improve functioning and reliability of the electricity markets in Serbia, Montenegro and Italy and to overall electricity system in the Balkan region;
2. facilitate further integration and expansion of the 400kV network in the region;
3. facilitate higher level of integration of renewable energy sources in the CSE region;
4. alleviate the congestion on the transmission system that is permanently present in the flow direction from East to West in Serbia that restricts trade across the whole of the region and with Italy;

help bring about the integration of European electricity markets thereby allowing for increased cross border trade and competition among suppliers.

Need for project Transbalkan corridor (146 and 227) was confirmed by network and market simulation identifing bottleneck on the RS-ME-BA border in all regimes because of presence HVDC ME-IT which will have capacity 1200 MW. For the visions 1, 2 and 3 predominant direction of bulk flows is from Serbia to Montenegro. Presence of project Transbalkan corridor will increase transfer electrical power from Serbia to Montenegro and further to Italy for 75%, from 4000 GWh up to 7000 GWh in Visions 1 and 2. Also, presence of project Transbalkan corridor will increase transfer of electrical power in another two visions 3 and 4, from Serbia to Montenegro, for about 300 GWh.

Project will increase transmission capacity by 800 MW for dominant direction from north-east to south-west or in average for 100%. GTC on the boundary considered will reach up to 1900 MW in 2030.

Project Transbalkan corridor support market integration in mid-term, 2020EP, and brings significant benefit to SEW of near 30 MEUR.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is jointly assessed with project 227 as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-HR,BA,RO,RS,BG: 400 |
| | HR,BA,RO,RS,BG-IT: 600 |
| Delta GTC contribution (2030) [MW] | IT-HR,BA,RO,RS,BG: 100 |
| | HR,BA,RO,RS,BG-IT: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 95.6 |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 30 ±10 | 20 ±10 | 20 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 140 ±30 | <10 |
| B4 Losses (GWh/yr) | -150 ±25 | -50 ±25 | 75 ±25 | -250 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | -7 ±1 | -3 ±2 | 3 ±2 | -15 ±2 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 400 ±80 | 400 ±100 | 400 ±100 | ±100 | -100 ±100 |

The projects No 146 and No 227 are assessed jointly because of the facts that they are serial connected and they can give full benefits only in situation when we have all lines in operation from projects 146 and 227.

In scenario EP2020 and Vision 1 we noticed decreasing of losses in our region in case of exsisting project. Reason for this we can find in fact that both investment of the project are upgrading of voltage level from 220 kV to 400 kV. For Vision 4 a slight increase of losses is observed in case when lines are in operation.

## Project 147 - South Balkan (CSE9)

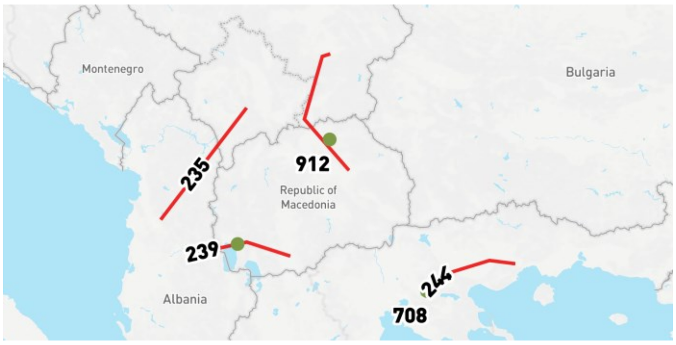
The project is comprised of investments in Serbia, FYR of Macedonia, Albania and Greece. These investments include new AC 400kV overhead lines and relevant substations. The project will increase transfer capacity in the predominant North-South direction of the CSE Region.

Classification Mid-term Project

Boundary North-South

PCI label

Promoted by EMS;IPTO-SA;MEPSO




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 235 | New 400kV OHL Pristina(RS)_Tirana 2(AL) | 100% | Tirana(AL) | Pristina (RS) | Commissioned | 2016 | Investment on time | The project has been commissioned |
| 236 | 400kV OHL Leskovac - Shtip | 100% | Leskovac(RS) | Shtip (MK) | Commissioned | 2015 | Delayed | Project has been commissioned |
| 239 | New cross-border single circuit 400kV OHL between FYR of Macedonia and Albania | 100% | Bitola (MK) | Elbasan (AL) | Design & Permitting | 2020 | Rescheduled | additional investigation of feasibility |
| 244 | Connection of the new 400kV substation in Lagadas in Thessaloniki area to the existing substation of Filippi via a new 110km double circuit 400kV OHL. | 26% | Filippi(GR) | Lagadas (GR) | Under Construction | 2017 | Delayed | Delayd due to dificulties with the acquisition of the land. This issue has been resolved. |
| 707 | New 400/110 kV substation in Ohrid area connected in/out to the new 400 kV line Bitola-Elbasan. | 100% | Ohrid area (MK) | | Design & Permitting | 2020 | Rescheduled | additional investigation of feasibility |
| 708 | New 400kV substation in Lagadas in Thessaloniki area. | 26% | Lagadas (GR) | | Commissioned | 2016 | Investment on time | |
| 912 | 400 kV SS Kumanovo | 100% | Kumanovo | | Under Consideration | 2020 | New Investment | it is a new investment |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1002 | Tirana - Prizren | 100% | SS Skavica | SS Prizren | Planning | 2028 | New Investment | New investment |

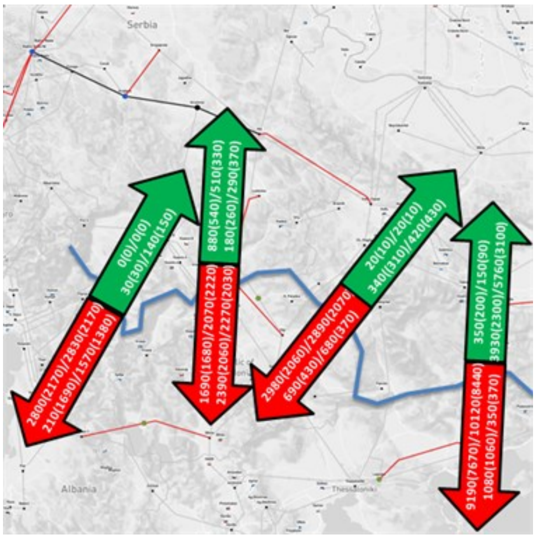
## Additional Information

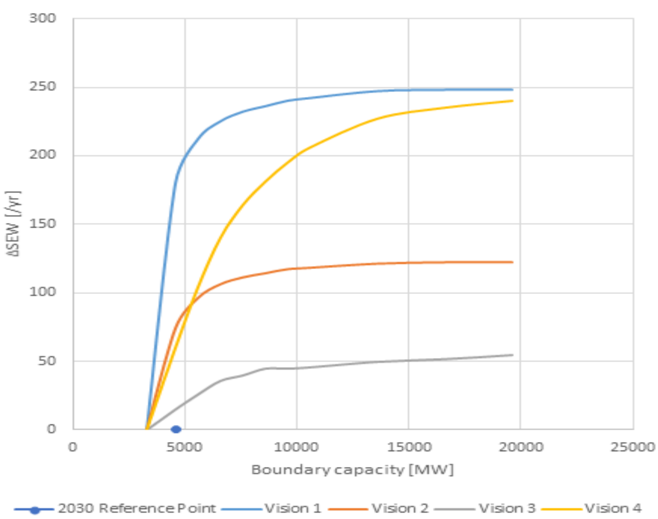
Investment 239 & 707: http://www.mepso.com.mk/en-us/Details.aspx?categoryID=230

## Investment needs

The project 147 aims to increase the transfer capacity in the predominant North-South and East-West directions by investments that will create new (boost existing) electricity corridors. In addition, a part of this project will increase the security of supply in transmission grids in Greece, FYR of Macedonia and Albania. The project 147 supports the large scale integration of new RES in south part of Balkan Peninsula.
For the visions 1, 2 and 3 predominant direction of bulk flows is N->S; Project lead to increase in flows from 700 GWh (vision 4) up to 3100 GWh (vision 1). Due to RES integration in Greece in vision 4 there is bulk flow in opposite direction on GR-BG border, S->N; Project enables more than 2500 GWh increase in transfer in S->N direction.

Project will increase transmission capacity in range of 750-1250 MW for dominant direction from north (RO+BG+RS) to south (AL+MK+GR), or in average for 33%. GTC on the boundary considered will reach up to 4200 MW in 2030.
In opposite direction, GTC increase is in range 200-750 MW, or in average for 27%. GTC on the boundary considered will reach up to 2800 MW in 2030.
Project 147 support market integration in mid-term, 2020EP, and brings significant benefit to SEW of near 250 MEUR. On a long-term, largest benefits on SEW of over 150 MEUR are due facilitation of RES integration in Vision 4.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | AL,MK,GR-RO,RS,BG: 750 |
| | RO,RS,BG-AL,MK,GR: 1250 |
| Delta GTC contribution (2030) [MW] | AL,MK,GR-RO,RS,BG: 200 |
| | RO,RS,BG-AL,MK,GR: 750 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 270 ±30 |
| Cost explanation | Here are given estimated CAPEX for investments clusterd in the project 147:<br>Investment 235: New 400 kV OHL Prishtina (RS) - Tirana (AL): 73.2 MEUR<br>Investment 236: 400 kV OHL Shtip (MK) - Leskovac (AL): 41.8 MEUR<br>Investment 239: 400 kv OHL Bitola (MK) - Elbasan (AL): 61.4 MEUR<br>Investment 244: 400 kV OHL Fillipi - Lagadas: 31.0 MEUR<br>Investment 707: 400 kV SS Ohrid: 13.9 MEUR<br>Investment 708: 400 kV SS Lagadas: 33.8 MEUR<br>Investment 912: 400 kV SS Kumanovo: 15.0 MEUR<br>OPEX are not inlcuded in the listed costs.<br>OHL costs deviate depending on terrain, while SS costs vary depending on arrangement of bubars and switchyards.<br>Uncertainty ranges about 10% of CAPEX. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 250 ±20 | 60 ±10 | 130 ±20 | 30 ±10 | 170 ±30 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 250 ±50 | 650 ±130 |
| B4 Losses (GWh/yr) | -150 ±25 | 25 ±25 | 0 ±25 | -125 ±25 | 100 ±25 |
| B4 Losses (Meuros/yr) | -7 ±1 | 1 ±2 | 0 ±1 | -8 ±2 | 6 ±2 |
| B5 CO2 Emissions (kT/year) | 700 ±100 | 700 ±100 | 700 ±100 | ±100 | -400 ±100 |

All the projects of CSE Region contribute to the reduction of generation cost in Europe that is reflected in SeW values for the examined scenarios. In EP2020, Vision 1 and Vision 2, transfer capacity increase brought by new projects, assists market integration internally in the Region and with the rest of Europe. SeW is created due to the capability to increase the generation of cheap thermal production in the Balkan peninsula with an associated increase in CO2 emissions. In Visions 3 and 4, SeW is created mainly because of the increased RES penetration brought by new projects and is accompanied by a corresponding CO2 reduction.

## Project 150 - Italy-Slovenia

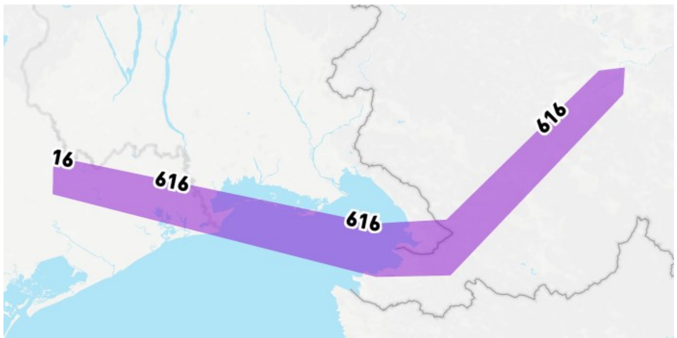
The project consists in a new HVDC link between Salgareda (Italy) and Divača\Beričevo (Slovenia) which will strengthen the connection between Slovenia and Italy.

Classification Mid-term Project

Boundary Slovenia - Italy

PCI label 3.21

Promoted by TERNA;ELES




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 616 | New HVDC interconnection between Italy and Slovenia. | 100% | Slovenia (SI) | Salgareda (IT) | Design & Permitting | 2022 | Investment on time | On Slovenian side: Project in the study phase. On Italian side: Permitting procedure is still in progress. |

### Additional Information

**PCI website:**

https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_21_en.pdf

**2nd PCI list:**

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

**Clustering approach:**

HVDC line represents an international commercial connection and is considered as cluster of one investment.

**Slovenian NDP (only in slovenian):**

http://www.eles.si/za-poslovne-uporabnike/razvoj-in-uporaba-prenosnega-omrezja/strategija-razvoja-elektroenergetskega-sistema-rs.aspx

**Link to the last release of the Italian National Development Plan:**

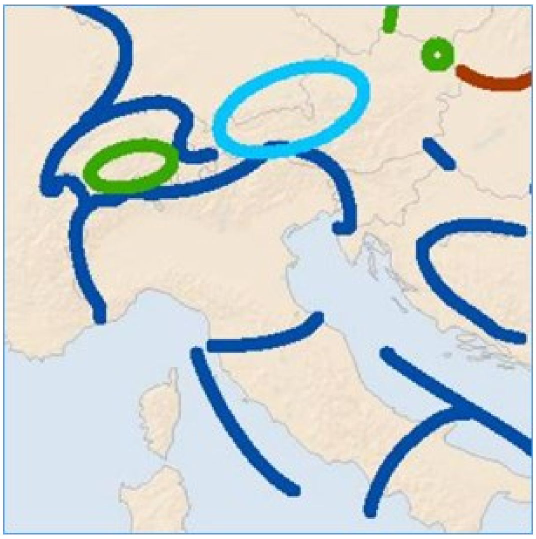
http://www.terna.it/it-it/sistemaelettrico/pianodisviluppodellarete/pianidisviluppo.aspx

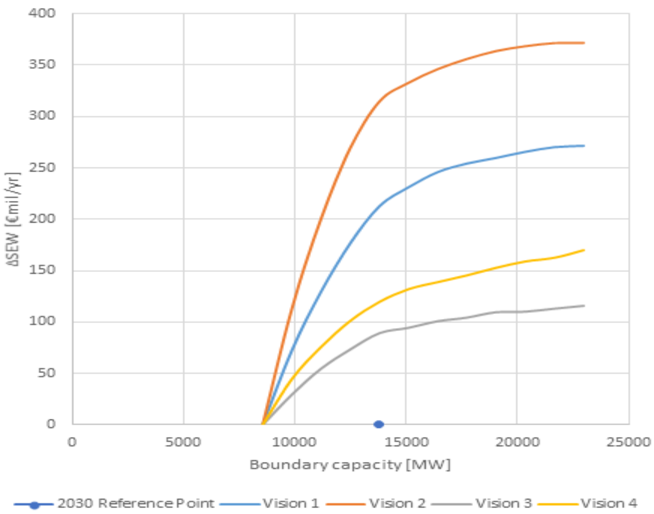
## Investment needs

The project will reduce congestions on Slovenia-Italy border and increase cross-broder transmission capacity on the mentioned border and could at the same time increase the loading of the internal transmission grid. By this a higher market integration is expected (also indicated by an increase of NTC values on Slovenia-Italy border) and even higher level of market coupling could be achieved.

The biggest impact on neighbouring countries is increased security operation, higher market integration, elimination of congestions and increased transmission capacity on the border with Italy and will allow increased operational security in case of outages throughout Slovenia and neighbouring countries.

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for Vision2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.






## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | SI-IT: 1000 |
| | IT-SI: 800 |

| | |
|---|---|
| Delta GTC contribution (2030) [MW] | SI-IT: 950 |
| | IT-SI: 950 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 870 |
| Cost explanation | Downward variation of the total investment cost is 26,4 %. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 70 ±10 | 90 ±30 | 110 ±30 | 20 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 20 ±20 | 40 ±40 |
| B4 Losses (GWh/yr) | 75 ±25 | -200 ±25 | 225 ±25 | 75 ±25 | 125 ±25 |
| B4 Losses (Meuros/yr) | 3 ±1 | -11 ±2 | 10 ±2 | 4 ±2 | 8 ±2 |
| B5 CO2 Emissions (kT/year) | 1700 ±130 | 1600 ±500 | 1100 ±200 | ±100 | -200 ±100 |

*Comment on SoS indicator:*

Slovenia is because of the geographical position exposed to very high power flows. Dynamic analyses has showned that realization of the project 150 would increase transient stability and increase SoS on the regional level and prevent regioanl grid from falling apart to zones.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 5.44 | 5.30 | 1.22 | 1.86 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.65 | 8.85 | 7.12 | 9.59 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.93 | 10.83 | 1.91 | 0.40 |

# Project 151 - Asturian Ring

This project consist of closing the 400kV Asturias Ring in the northern part of Spain, and comprises a new 400 kV OHL line between Gozón and Sama, with two new 400kV substations in Reboria and Costa Verde (Spain) , which main purpose is support the distribution network.

Classification Future Project

Boundary Internal boundary in the north of Spain

PCI label

Promoted by REE


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 522 | New 400kV substation Sama in the new Asturias Ring with connection to Lada and a new reactance. | 100% | Sama (ES) | | Planning | 2020 | Ahead of time | Changes in the Spanish Master Plan, approved after the released of the project candidate list. This project is considered in the assessment as a future project instead a midterm one. |
| 523 | New 400kV substation Reboria in the Asturian ring with 1 transformer 400/220 kV | 100% | Reboria (ES) | | Planning | 2020 | Ahead of time | Changes in the Spanish Master Plan, approved after the released of the project candidate list. This project is considered in the assessment as a future project instead a midterm one. |
| 928 | Asturian Ring. New double circuit Gozon-Reboria-Sama 400 kV (in a phase I only one circuit will be installed). Subestation Costa Verde is under consideration yet and wont be part of phase I | 100% | GOZON (ES) | SAMA (ES) | Planning | 2020 | Ahead of time | Changes in the Spanish Master Plan, approved after the released of the project candidate list. This project is considered in the assessment as a future project instead a midterm one. In a first step only 1 circuit will be installed. Costa Verde wont be part of phase I |

## Additional Information

Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

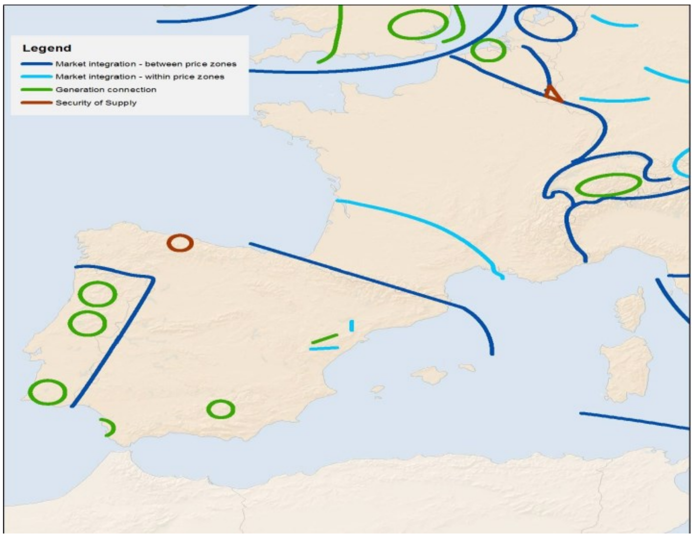
Clustering: the project consists of a new axis connecting Gozón with Sama; with an intermediate new substation in Reboria to give support to local demand and possible future generation.  Also a new substation is required in Sama due to physical imposibilility to connect to the existing Lada substation.All the investments are in series so a lack of any of them do not allow to get the full GTC increase of the project.

The urgency of the project led recently to separate the previous TYNDP project in 2 phases, one before 2020 (proper Ring with only 1 circuit installed), and one after 2020 (second circuit and connection to mainland through Sama-Velilla) The New clustering rules of the TYNDP led to separate the whole project, and maintain only the first section.

## Investment needs

There is a need to ensure the demand of the coastal and central area of Asturias in a future with a very low thermal production.

Constraints are detected in contingency situation in the 220kV network and in the 400kV lines to the spanish mainland (both have been uprated to increase their capacity but in the long term could be not enough). Inaddition, there is a need to introduce new substation in the area to support the distribution network  and potential future generation (Reboria).




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | ROW-central Asturias: [100 ; 1400] |
| | central Asturias-ROW: [0 ; 300] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 25.2 ±2.5 |
| Cost explanation | Values (CAPEX cost) updated according to new definitiion of the project and last Spanish investment standard costs. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

This project contributes to the security of supply of the Asturias area. The results of the CBA show a global increase of the SoS indicator with a reduction of the Expected Energy not Supplied of:

- 2200 MWh/yr in Vision 1
- 1800 MWh/yr in Vision 2
- 2000 MWh/yr in Vision 3
- 2500 MWh/yr in Vision 4

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 153 - France-Alderney-Britain

France-Alderney-Britain (FAB) is a new HVDC subsea interconnector between Exeter (UK) and Menuel (France) with 1,4 GW capacity. The investment has been selected as PCI 1.7.1 in the NSCOG corridor.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | France - Great Britain |
| PCI label | 1.7.1 |
| Promoted by | RTE and FAB LINK limited |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 987 | new HVDC subsea interconnector between Exeter (UK) and Menuel (France) | 100% | Menuel (FR) | Exeter (GB) | Design & Permitting | 2022 | Investment on time | The notifications of the project were approved by the French and British authorities in July 2014. Feasibility studies have been finalised and a final route identified. Consent applications will be made in 2016. |

### Additional Information

More information related to the project can be found on internet platforms : the RTE Project Website for France, and the Official Project Website as well. Added to general project statements, specific information are given for France, Great Britain and Alderney (Public consultation, phases of the project...) .

The project is also part of both System Operator National Development Plans.

In addition the FAB Link project has been confirmed on 27 January 2016 as Project of Common Interest in the priority corridor Northern Seas Offshore Grid (NSOG), included in cluster 1.7 (Commission Delegated Regulation 2016/89 of 18 November 2015).

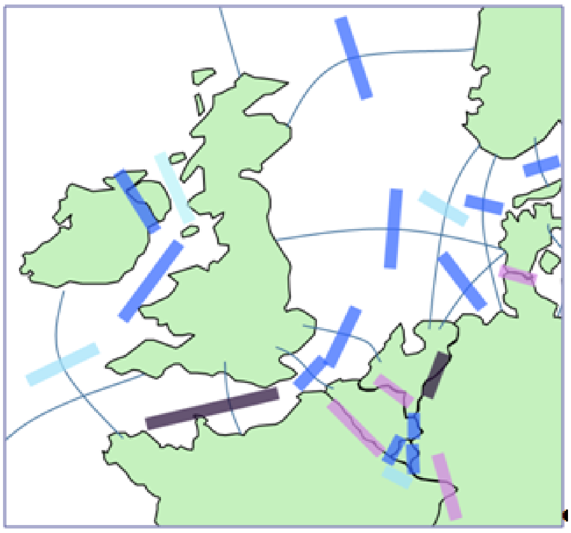
## Investment needs

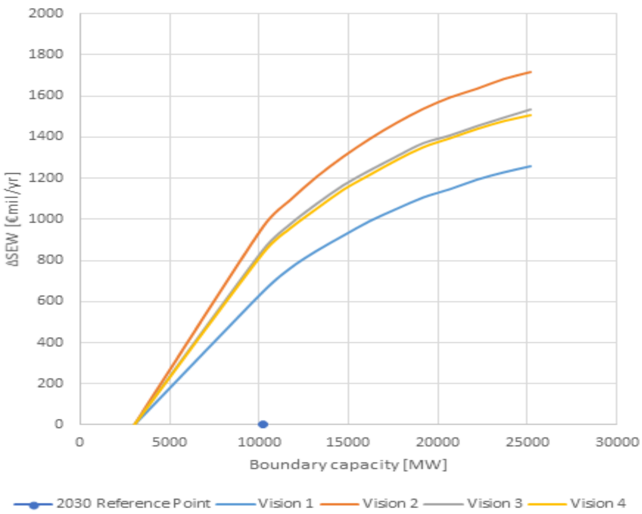
The TYNDP2016 High RES scenario market analysis shows a market-based target capacity between France and Great Britain of more than 5GW. The project has two main objectives. The first one is to increase the interconnection capacity between France and Great Britain, to answer the market needs. The second objective is to integrate additional RES generation : Wind generation in Great Britain, added to a potential of 2,8GW of tidal generation produced from the Cotentin coast that could be connected to this link in the future.

The full capacity (1400MW) can be used without leading to unmanageable critical system failure.

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between Great Britain and the continent . On the SEW/GTC graph we can see that even starting from a 2030 capacity of about 10GW between Great Britain and the continental and Nordics areas, extra capacity still allows savings on the boundary.

FAB link project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between Great Britain and the continent.






## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | GB-FR: 1400 |
| | FR-GB: 1400 |
| Delta GTC contribution (2030) [MW] | GB-FR: 1400 |
| | FR-GB: 1400 |
| Capex Costs 2015 (M€) | 850 ±230 |

| | |
|---|---|
| Source: Project Promoter | |
| Cost explanation | Compared to TYNDP2014, and thanks to most recent bilateral cost evaluations performed by RTE and FAB Link, the estimated cost has been updated.Only CAPEX is considered here. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 120 ±20 | 80 ±10 | 140 ±10 | 120 ±30 | 120 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 980 ±190 | 1160 ±230 | 690 ±220 |
| B4 Losses (GWh/yr) | -125 ±25 | -200 ±25 | 375 ±37 | 850 ±85 | 850 ±85 |
| B4 Losses (Meuros/yr) | -6 ±1 | -11 ±2 | 17 ±2 | 51 ±5 | 57 ±6 |
| B5 CO2 Emissions (kT/year) | 2300 ±330 | 1400 ±400 | 500 ±400 | -800 ±200 | -800 ±100 |

The Social Economic Welfare of the project is promising and close to 120-140M€ / year in all visions and time horizon, except in Vision 1 2030 where it is 80M€ / year.

In 2020, the project decreases the overall losses. This is mainly due to the high flows from France to Great Britain. This energy is directly brought by the project to the south of Great Britain, close to the high demanding area of Great London. Then the AC losses are highly reduced in Great Britain (less need to bring power from the north of the country to the south).

In 2030, even considering the unavoidable losses through the HVDC itself, the project decreases significantly overall losses in Vision 1. In vision 2 the flows are more balanced between the two countries, so the losses increase. In vision 3 and 4, France is mainly importing from Great Britain, and this energy has to reach high demanding areas in France (e.g Great Paris area) but also in all Europe, which explain that the losses are quite high.

Ofgem has published an initial project assesmnet of the Cap and Floor regime for the projects FAB Link, IFA2 VIking Link and Greenlink. This document states that the revenues from the capacity market, for this project in particular could be around 29.4 millions pounds annually.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology.

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.92 | 7.80 | 8.25 | 7.26 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.72 | 13.56 | 19.68 | 18.44 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.60 | 13.49 | 10.67 | 11.29 |

## Project 157 - Aragón-Catalonia south

This project is a reinforcement between Aragón and Cataluña and consists of a new 400 kV double circuit OHL line between Escatrón and La Secuita ( Spain), but one of the circuits operating at 220 kV. This projects also includes new substations in Els Aubals (with direct connection of wind power) and in La Secuita (400/220 kV).

| | |
|---|---|
| Classification | Future Project |
| Boundary | Internal boundary in the east of Spain |
| PCI label | |
| Promoted by | REE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 545 | New single circuit Escatrón-Els Aubals-La Secuita 400kV OHL. | 100% | Escatron (ES) | La Secuita (ES) | Under Consideration | 2027 | Investment on time | The investment progressed as previously planned |
| 546 | New 400kV substation in Els Aubals. | 100% | Els Aubals (ES) | | Under Consideration | 2027 | Investment on time | The investment progressed as previously planned |
| 547 | New 400kV substation in La Secuita with 400/220kV transformer. | 100% | La Secuita (ES) | | Under Consideration | 2027 | Investment on time | The investment progressed as previously planned |

### Additional Information

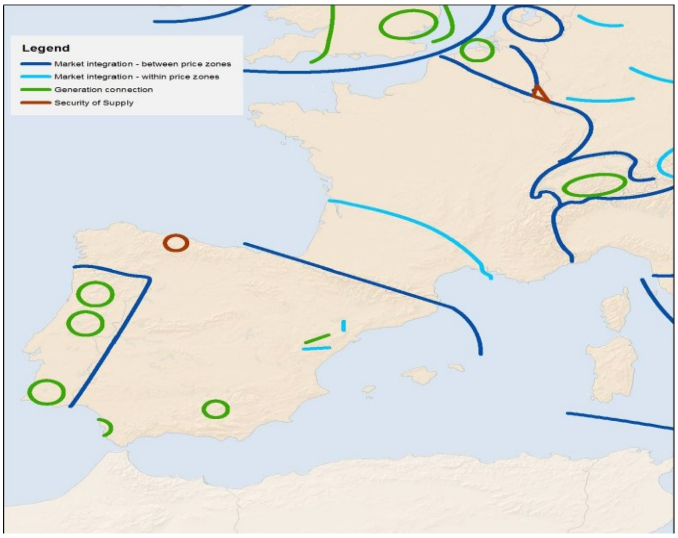
Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

Clustering: the project consists of a new axis between Escatrón and La Secuita that takes advantage of the route to gather the injection of new RES generation in the new substation of Els Aubals. This new RES can not be evacuated by the existing 220kV as would cause additional overloads on top of the existing ones. La Secuita is a new subestation required to connect to the existing axis Vandellos-Pierola with the lowest impact in the territory. All the investments are in series so a lack of any of them do not allow to get the full GTC increase of the project. However Els Aubals substation contributes only to SEW and RES.

## Investment needs

There is a need already existing today to solve the constraints in the 220kV and 400kV between Aragón and Catalunya, which come worse in case of increase of demand in Catalunya and specially in Barcelona city, or with an increase of exports to France.

Also there is a need for a new substation in the area to gather new RES generation, as in case of connecting to the existing network it could be difficultly evacuated by the existing 220kV as it would cause additional overloads on top of the existing and expected ones.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | east-west: [0 ; 2000] |
| | west-east: [200 ; 1000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 117 ±11.7 |
| Cost explanation | Value (CAPEX cost) updated according to last Spanish investment standard costs |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |

| | |
|---|---|
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 30 ±10 | 30 ±10 | 60 ±10 | 80 ±10 |
| B3 RES integration (GWh/yr) | N/A | 680 ±140 | 690 ±140 | 720 ±140 | 830 ±170 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -200 ±100 | -200 ±100 | -200 ±100 | -300 ±100 |

This project solves restrictions that cause spillage of RES energy in the areas of Navarra, Aragón and Tarragona. In addition it allows an increase of RES integration as directly connects wind and solar plants in Els Aubals. Therefore the results of the CBA analysis shows a global decrease of CO2 emissions as well as a global increase in savings in variable generation costs (SEW) and in RES integration indicators.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

# Project 158 - Massif Central South

The project will develop in the north-to-south direction in the south of the Massif Central area (France), between Rueyres and La Gaudière. It will mainly consists in a new double-circuit 400-kV overhead line substituting to the existing 400-kV single circuit line.

This project is needed for integrating existing and future RES generation in the area, including possible pump storage.

Classification Long-term Project

Boundary Internal boundary in France North-South

PCI label

Promoted by RTE


## Investments

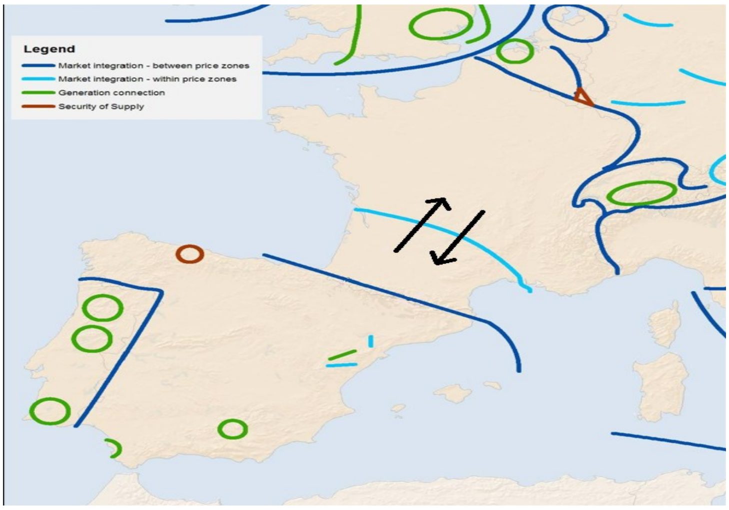
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 597 | Gaudière-Rueyres | 100% | La Gaudière (FR) | Rueyres (FR) | Planning | 2025 | Rescheduled | Further studies performed after TYNDP2014 confirmed the feasibility of the project. The commisionning date follows the amount of generation installation in the area (Hydro, Solar and Wind). |

## Additional Information

The project mainly consists in a new 400kV line substituting to the existing one.
French National Development Plan http://www.rte-france.com/sites/default/files/schema_decennal_de_developpement_du_reseau_edition_2015_syntese.pdf

## Investment needs

The main driver for the project is the integration of existing and new wind, solar and hydro generation in the Massif Central (France) including possible pump storage. Furthermore, this axis is essential for french energy transition and enables needed exchanges of renewable energy between north and south of France. This project stay linked to the evolution of the energetic mix of this area, and is also robust to ensure future evolution.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | South-[FR] North : 3000 |
| | [FR] North - South: 3000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 310 ±60 |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | 200 ±30 | 200 ±30 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | -100 ±25 | -150 ±25 | -225 ±25 | -125 ±25 |
| B4 Losses (Meuros/yr) | N/A | -6 ±2 | -7 ±1 | -14 ±2 | -9 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | -700 ±140 | -700 ±140 |

This project allows also evacuation of 1500 MW of potential new RES.

Internal projects in France are necessary in the reference case for 2030 network. As they are linked to the internal hypothesis like future RES integration, their assessment can not be done only with the standard market studies (only one node per country), as they are taking into account internal redispatching.

Thus, the SEW indicator has been calculated to assess the internal redispatching necessary to respect the market based flows between France and Spain (8 GW for 2030 visions)

## Project 164 - N-S Eastern DE_central section

North-South transmission in Germany. AC links from Northern Germany towards the load centers of Bavaria and Baden-Württemberg.


| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | inside-inside |
| PCI label | |
| Promoted by | TENNET-DE |

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 149 | New 380kV double circuit OHL Dollern - Stade including new 380kV switchgear in Stade. Length 14km. | 100% | Dollern (DE) | Stade (DE) | Permitting | 2023 | Delayed | Delay due to long permitting process |
| 157 | New 380kV double circuit OHL Wahle - Mecklar including two new substations. Length: 210km. | 100% | Wahle (DE) | Mecklar (DE) | Permitting | 2021 | Delayed | Delay due to long permitting process |
| 677 | New 380 kV line in existing OHL corridor Dollern-Sottrum-Wechold-Landesbergen (130 km) | 100% | Dollern (DE) | Landesbergen (DE) | Permitting | 2023 | Delayed | Delay due to long permitting process |
| 685 | New double circuit OHL 380-kV-line (130 km). Due to ongoing political discussions a change of the connection point Grafenrheinfeld is under consideration. | 100% | Mecklar (DE) | Grafenrheinfeld (DE) | Planning | 2022 | Investment on time | |

### Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

Information on Investments 149 and 677 (in German)

http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/stade-landesbergen.html

Information on Investment 157 (in German)

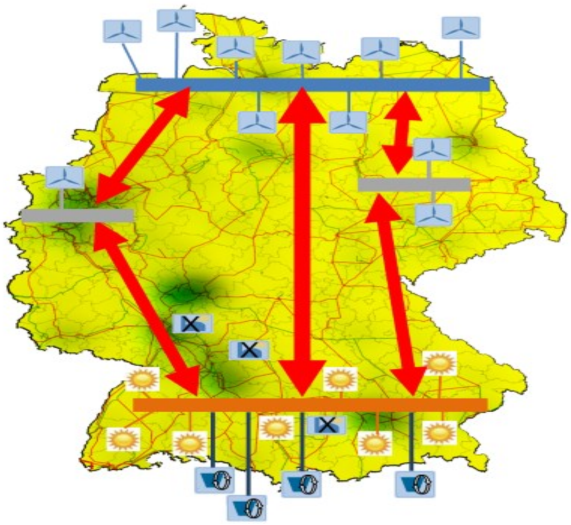
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/wahle-mecklar.html

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the transmission capacity inside Lower Saxony, an area with increasing generation from RES and from Lower Saxony over Hessen to Bavaria, an area with decreasing conventional power generation and high consumption. It acts as one of the central North-South connection in Germany and therefore also helps to maintain the system security in this area.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the project 235, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1110 ±170 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 140 ±20 | 290 ±40 | 360 ±50 | 540 ±80 | 20 ±10 |
| B3 RES integration (GWh/yr) | 680 ±140 | 2060 ±410 | 3580 ±720 | 6170 ±1230 | 420 ±80 |
| B4 Losses (GWh/yr) | -250 ±25 | 25 ±25 | 250 ±25 | -25 ±25 | -275 ±27 |
| B4 Losses (Meuros/yr) | -11 ±1 | 1 ±2 | 11 ±2 | -2 ±2 | -19 ±2 |
| B5 CO2 Emissions (kT/year) | -800 ±120 | -400 ±100 | -1600 ±200 | -3900 ±600 | -300 ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 167 - Viking DKW-GB

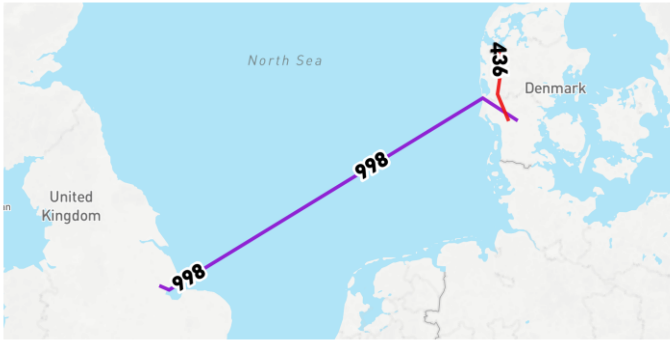
This project, known as Viking Link and under development by National Grid Inter-connector Holdings Limited and Energinet.dk, investigates a ~760 km connection be-tween Denmark West and Great Britain by two parallel HVDC subsea cables and relat-ed substations on both ends.

Classification Mid-term Project

Boundary Denmark- West - Great Britain

PCI label 1.14

Promoted by Energinet.dk;NGIHL




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 436 | new 95 km single circuit 400 kV line | 20% | Idomlund (DK) | Endrup (DK) | Planning | 2022 | Investment on time | The connection to GB requires this upgrade of the internal Danish grid in order to harvest the full benefits of the Viking link. As this investment serves multi-purposes, only part of it is allocated to the Viking project |
| 998 | 1400 MW connection DKW-GB | 100% | Revsing (DKW) | Bicker Fen (GB) | Permitting | 2022 | Investment on time | Feasibility study finalized, UK cap and floor regulation awarded, public consultation ongoing, permit procedure ongoing, pre-application procedure started. supplier engagement ongoing, preparation of tender package for cables and converter ongoing. |

### Additional Information

Project Website:

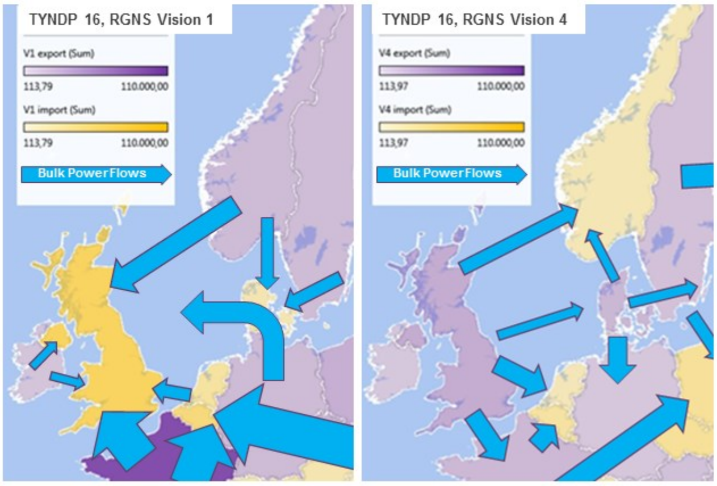
http://viking-link.com

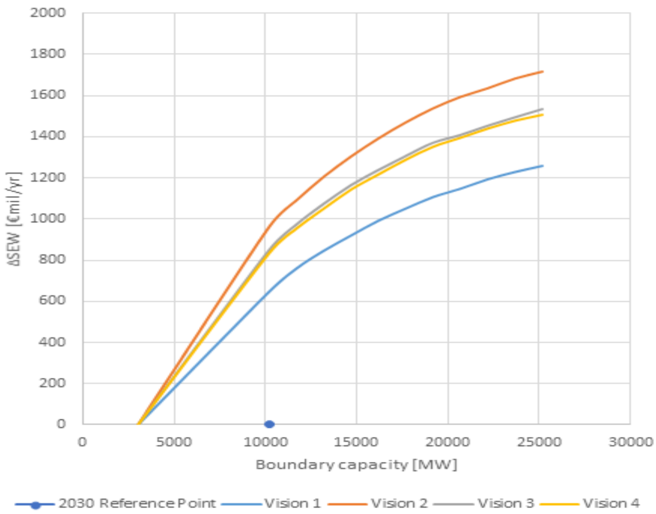
### Investment needs

The bulk flows in this region go along the North-South axis and to/from Great Britain – a direction being covered by this project. The project is the first connection between both countries, facilitating major flows across this rather long distance.

Structure of both power systems differs in almost all visions, triggering flows. Especially in the green Visions the RES (= wind) exchanges are facilitated, as the correlation of wind is small between DKW and GB.

The technology expected to be used will facilitate a significant improvement of the security of supply of the countries involved. Active and reactive power can be controlled independently; meaning that the project can significantly contribute to  ensure voltage stability .




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | GB-DKW: 1400 |
| | DKW-GB: 1400 |
| Delta GTC contribution (2030) [MW] | GB-DKW: 1400 |
| | DKW-GB: 1400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1970 ±395 |
| Cost explanation | Undiscounted total at time of delivery. Capex only. Project is 1,2 investments. Cost increase compared to TYNDP14, project capacity increased, route changed since then. Cable market is pressed. |
| S1 | NA |

| | |
|---|---|
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 150 ±40 | 90 ±10 | 140 ±10 | 110 ±10 | 110 ±10 |
| B3 RES integration (GWh/yr) | 20 ±10 | 60 ±50 | 990 ±170 | 770 ±100 | 720 ±200 |
| B4 Losses (GWh/yr) | 0 ±25 | 325 ±32 | 325 ±32 | 700 ±70 | 725 ±72 |
| B4 Losses (Meuros/yr) | 0 ±1 | 17 ±2 | 14 ±2 | 42 ±4 | 48 ±5 |
| B5 CO2 Emissions (kT/year) | 2900 ±430 | 1700 ±100 | 600 ±300 | -700 ±100 | -700 ±200 |

The TYNDP16 indicators (SEW, RES, CO2) are less optimistic compared to the TYNDP14 indicators, which can be explained by the changed scenarios since the TYNDP14 edition. For the new scenarios, RES installations had been rearranged between countries, especially in the RGNS region, especially concerning Great Britain, e.g. integrating less RES in the TYNDP16 in Vision 4 compared to the 2014 edition. Additionally differences in demand development account for changed regional flows.

This explains why the Vision 1 CO2 project indicators show bigger CO2 emissions in the 2016 edition compared to 2014 edition; while the CO2 savings in Vision 4 are less optimistic in the 2016 edition.

Ofgem has published an initial project assesmnet of the Cap and Floor regime for the projects FAB Link, IFA2 VIking Link and Greenlink. This document states that the revenues from the capacity market, for this project in particular could be around 21 millions pounds annually.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology.

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

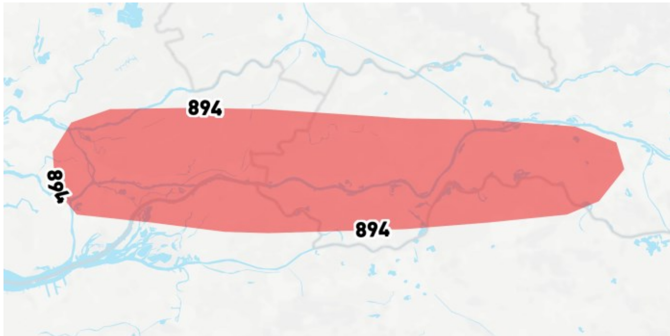
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 5.53 | 6.89 | 6.82 | 6.31 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 10.20 | 12.52 | 18.12 | 17.06 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 18.00 | 18.91 | 19.20 | 17.70 |

In each Vision there is a price differential between DK and GB and a difference in average of marginal costs, causing power exchanges. Flows follow the region's general main direction either into or out of Great Britain.

# Project 168 - Spaak NL

Project 168 "Spaak" associates to project 103 the "Dutch ring"as a second phase long term investment , to be commissioned in 2030.Both projects reinforce the Dutch grid to accommodate new conventional and renewable generation, to handle new flow patterns and to facilitate the cross-border capacity increase with neighbouring countries.The two projects have been assessed as a whole and share the same common assessment.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Netherlands - Germany |
| PCI label | |
| Promoted by | TENNET-NL |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 894 | Spaak | 100% | Krimpen aan de Ijssel | Dodewaard | Under Consideration | >2030 | Investment on time | This conceptual future project could become relevant when large amounts wind power need to be transported from west to east. Internal studies have shown that an AC solution as in the project list is not very likely. This project is investigated as one of the options together with other projects (e.g. 256) and has no formal status within TenneT. |

## Additional Information

This future project will become relevant when large amounts of offshore wind need to be transport from the Western part of the  country toward the East and Germany. It is defined as a future project, because a new AC 380 kV  West-East connection within the Netherlands is only one of the alternatives for the transportation of bulk energy.

# Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NL-DE: 0 |
| | DE-NL: 200 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | 30 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 200 ±100 | 200 ±100 | ±100 | ±100 |

The project will better facilitate Bulk Power flows from East to West and vice versa, resulting in integration of more renewable resources, especially offshore wind in the Netherland and wind energy in Northern Germany.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.98 | 0.42 | 0.35 | 0.28 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.08 | 2.64 | 4.31 | 3.63 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 12.23 | 9.93 | 3.06 | 4.31 |

## Project 170 - Baltic synchronization

Based on geographical location and the feasibility studies carried out so far, the Baltic States are focusing on three main synchronising/desynchronising scenarios which are:• Baltic States synchronous operation with continental Europe (HVAC Lithuania-Poland interconnector), and also soft coupling supported by existing HVDC-links;• Baltic States synchronous operation with Nordic countries (HVAC Estonia-Finland), and also soft coupling supported by existing HVDC links;• Baltic States isolated island operation, however soft coupling supported by HVDC links.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Baltics - Nordic - Continental Europe |
| PCI label | |
| Promoted by | AST;ELERING;LITGRID |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 380 | New single circuit 330kV OHL VAE-Kruonis. | 100% | Visaginas (LT) | Kruonis (LT) | Under Consideration | 2024 | Delayed | Investment implementation time depends from decisions about new Visaginas NPP and project 170. Baltic synchronization". |
| 382 | New single circuit 330kV OHL (943 MVA, 50km). | 100% | Vilnius (LT) | Neris (LT) | Planning | 2024 | Delayed | Investment implementation time depends from decisions about new Visaginas NPP and project 170. Baltic synchronization" |
| 1004 | internal reinforcement of Paide-Sindi 330kV overhead line | 100% | Sindi | Paide | Cancelled | 2025 | Cancelled | we have developed an operational procedure to overcome the overloading issues, therefore the investment can be postponed |
| 1010 | Tartu (EE)-Valmiera (LV) 330 kV overhead line reconstruction | 100% | Tartu | Valmiera | Under Consideration | 2025 | Rescheduled | Baltic States desinchronisation |
| 1011 | Reinforcement of Valmiera (LV) - Tsirguliina (EE) 330 kV crossborder overhead line | 100% | Tsirguliina | Valmiera | Under Consideration | 2025 | Rescheduled | - |
| 1012 | Tartu-Balti 330 kV overhead line reinforcement | 100% | Balti | Tartu | Planning | 2024 | Rescheduled | - |

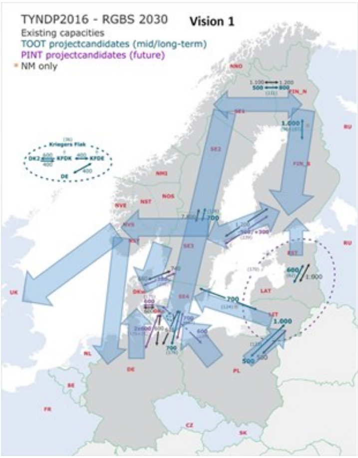
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1013 | internal reinforcement of Eesti-Tsirguliina 330kV overhead line | 100% | Eesti | Tsirguliina | Planning | 2025 | Rescheduled | - |
| 1034 | New 400 kV interconnection line from substation in Lithuania to state border. | 100% | New planned 400 kV Marijampole substation or exicting 400 kV Aytus substation. | State border | Under Consideration | 2031 | New Investment | New line routing and implementation time depends from decisions for project 170. “Baltic synchronization”. |
| 1063 | Investment increases transmission capacity within Baltic States | 100% | TEC1 | TEC2 | Under Consideration | 2025 | Rescheduled | - |
| 1064 | The investment increases transmission capacity within Baltic States | 100% | Viskali (LV) | Musa (LT) | Under Consideration | 2025 | Rescheduled | Comissioning date changed from 2030 to 2025, to avoid splitting project 170."Baltic synchronisation" in two stages. |
| 1065 | Investment increases transmission capacity on border LT-LV | 100% | Aizkraukle (LV) | Panevežys (LT) | Under Consideration | 2025 | Rescheduled | Comissioning date changed from 2030 to 2025, to avoid splitting project 170."Baltic synchronisation" in two stages. |
| 1117 | B2B station in Narva connecting Estonia and Russia by existing 330 kV AC line | 100% | Eesti | | Planning | 2024 | New Investment | The investment is related to Baltic synchronisation cluster. |
| 1118 | Voltage stabiliser units (SVC), AGC systems; WAMS, WAMPAC systems; PSS units at power stations | 100% | Eesti 330 kV | | Planning | 2024 | New Investment | New investment |

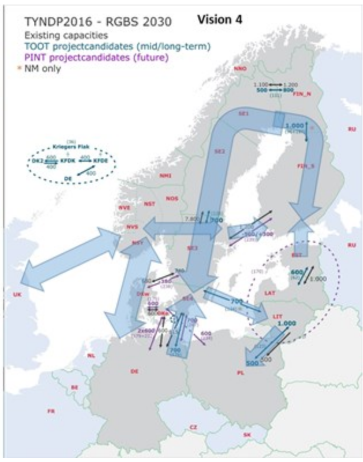
## Additional Information

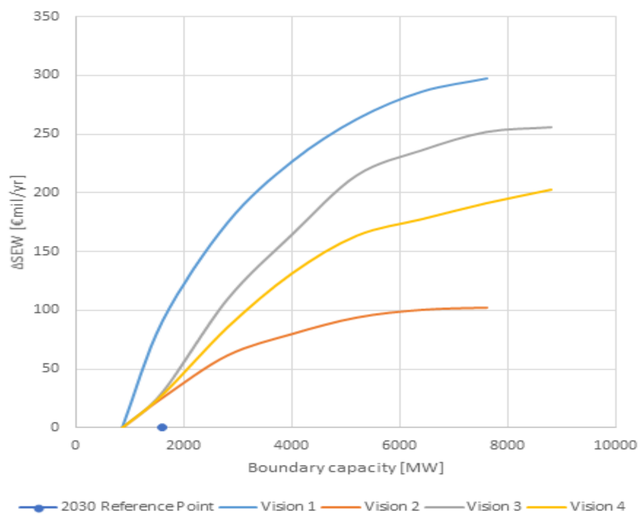
The power system of the Baltic States which includes Estonia, Latvia, Lithuania (Baltic Integrated Power System) currently is operating in parallel with the Integrated/Unified Power System (IPS/UPS) of Russia and Belarus. The Russian power system ensures primary power reserves for the frequency regulation and the secure system operation within BRELL (Belarus, Russia, Estonia, Latvia and Lithuania) ring.

Besides the interconnections with Russia and Belarus, the Baltic States have interconnectors with the Nordic countries via Finland (Estlink 1 and Estlink 2) and Sweden (NordBalt), and an interconnector to Poland towards Continental Europe.
A common goal for the Baltic States is greater energy supply independence through the diversification of primary energy sources. Furthermore the integration of Latvia, Lithuania and Estonia within common EU energy market has been identified as a strategic priority for Baltic States in the previous Pan-European TYNDPs 2012 and 2014 and it is a strategic priority for all three countries.

## Investment needs




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | LT-PL: 0 |
| | PL-LT: 0 |
| Delta GTC contribution (2030) [MW] | LT-PL: 0 |
| | PL-LT: 0 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1069 ±200 |
| Cost explanation | Baltic synchronisation project high costs are because they covers a lot of new projects - new long 330 kV HVAC lines; DC convertor stations on borders with Russia, Belarusia and/or Kaliningrad area; internal grid reinforcements (e.g. Voltage stabiliser units, upgrades of PSS in power stations); internal 110 kV network reinforcement required for synchronization and separation of 110kV Baltic grid from IPS/UPS system; additional studies.<br><br>High uncertainty range is becouse currently under investigation are 3 options of Baltic synchronisation (Baltic States synchronous with continental Europe, synchronous with Nordic countries, Baltics in island operation but soft coupling by HVDC ), and each option would have different costs, and only first option has significant studies carried out yet. |

| | |
|---|---|
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

Because immaturity of project the CBA evaluation was not conducted.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.85 | 6.89 | 17.24 | 7.66 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 10.25 | 10.62 | 24.71 | 15.77 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 9.87 | 9.56 | 11.56 | 8.50 |

## Project 172 - ElecLink

Eleclink is a new FR – UK interconnection cable with 1000 MW capacity through the channel Tunnel between Sellindge (UK) and Mandarins (FR). Converter stations will be located on Eurotunnel concession at Folkestone and Coquelles.

This HVDC interconnection is a PCI project (Project of Common Interest) no. 1.7.3.

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | France - Great Britain |
| PCI label | PCI number 1.7.3 |
| Promoted by | ElecLink |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1388 | | 100% | Sellindge (UK) | Mandarins (FR) | Design & permitting | 2018 | Delayed | |

### Additional Information

Project Website

http://www.eleclink.co.uk/index.php

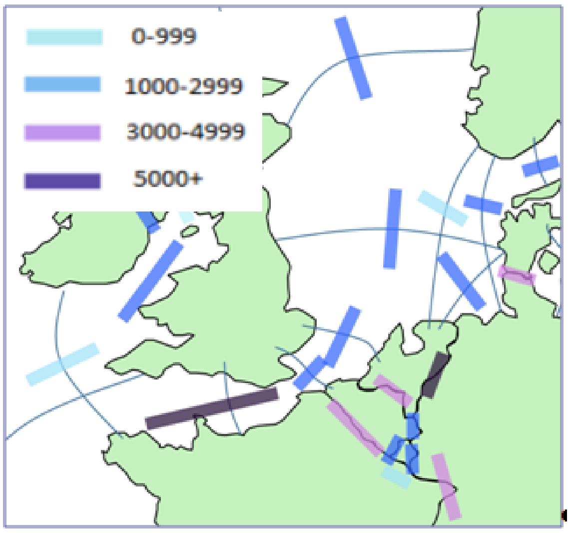
## Investment needs

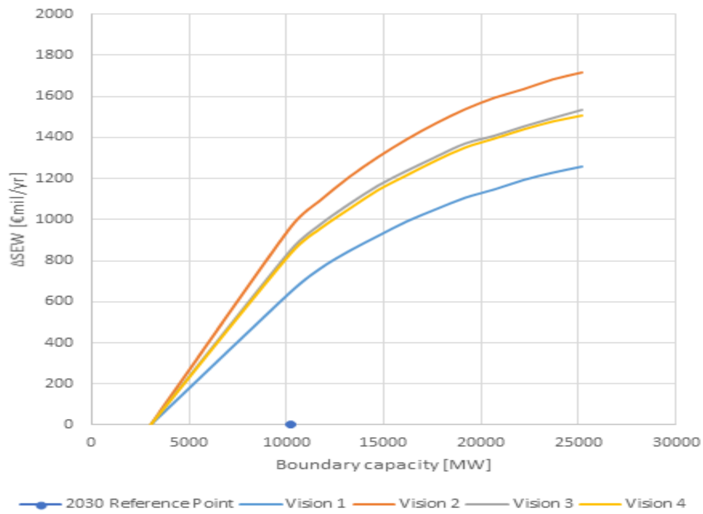
This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

The project promoter states *"The Chosen connection points on both French and British transmission grid allow a safe operation in 2020 and 2030. The full capacity (1000MW) can be used without leading to unmanageable critical system failure."*

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between Great Britain and the continent . On the SEW/GTC graph we can see that even starting from a 2030 capacity of about 10GW between GB and the continental and Nordics areas, extra capacity still allows savings on the boundary.

Eleclink project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between Great Britain and the continent.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | GB-FR: 1000 |
| | FR-GB: 1000 |
| Delta GTC contribution (2030) [MW] | GB-FR: 1000 |
| | FR-GB: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 350 ±90 |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 90 ±20 | 60 ±10 | 100 ±10 | 90 ±20 | 80 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 740 ±200 | 910 ±280 | 520 ±150 |
| B4 Losses (GWh/yr) | -325 ±32 | 475 ±47 | 725 ±72 | 950 ±95 | 975 ±97 |
| B4 Losses (Meuros/yr) | -15 ±2 | 25 ±3 | 33 ±4 | 56 ±6 | 65 ±7 |
| B5 CO2 Emissions (kT/year) | 1600 ±230 | 1000 ±200 | 400 ±400 | -600 ±200 | -600 ±200 |

The Social Economic Welfare of the project is promising and close to 80-100M€ / year in all visions and time horizon, except in Vision 1 2030 where it is 60M€ / year.

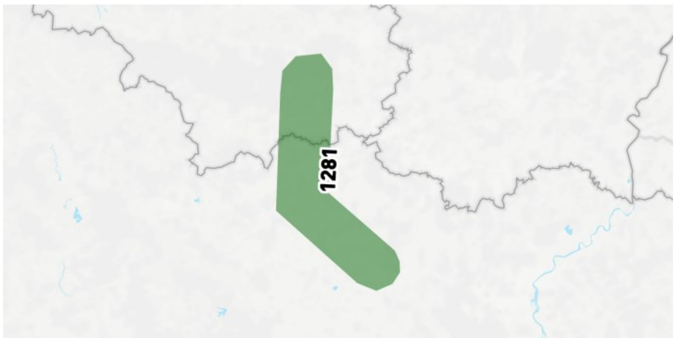
The project's SEW accounts for savings in generation fuel and operating costs. Connecting an "electric peninsula" the project also enables savings in generation capacity, which are not accounted in the SEW. These avoided investments in generation can represent a yearly equivalent, over several decades, of about several tens of millions euros of additional economic benefits.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.92 | 7.80 | 8.25 | 7.26 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.72 | 13.56 | 19.68 | 18.44 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.60 | 13.49 | 10.67 | 11.29 |

## Project 173 - FR-BE Phase 2 (study): Aubange-Moulaine

The reference solution consists in the installation of two phase shifting transformers, one on each of the 225kV circuits of the Aubange-Moulaine cross-border line. This project targets the alleviation of the Aubange-Moulaine axis as bottleneck on the French-Belgium border, related to the perspective of higher bulk power flows creating structural congestion on this axis. The bilateral study between RTE and Elia will further evaluate the planning and the cost-benefit analysis of the reference solution, hereby not excluding alternative solutions.

| | |
|---|---|
| Classification | Future Project |
| Boundary | France - Belgium |
| PCI label | |
| Promoted by | ELIA;RTE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1281 | This project under consideration envisions the reinforcement of the Aubange-Moulaine cross-border line via the installation of two phase shifting transformers, one on each of the 225kV circuits of the Aubange-Moulaine cross-border overhead line. | 100% | Aubange (BE) | Moulaine (FR) | Under Consideration | 2020 | New Investment | Project introduced in TYNDP16 related to congestion signals picked up vibilateral studies and confirmed in RG NS Common Planning Study. |

### Additional Information

The project is integrated as project under consideration in Elia's National Development Plan 2015-2025:
http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

## Investment needs

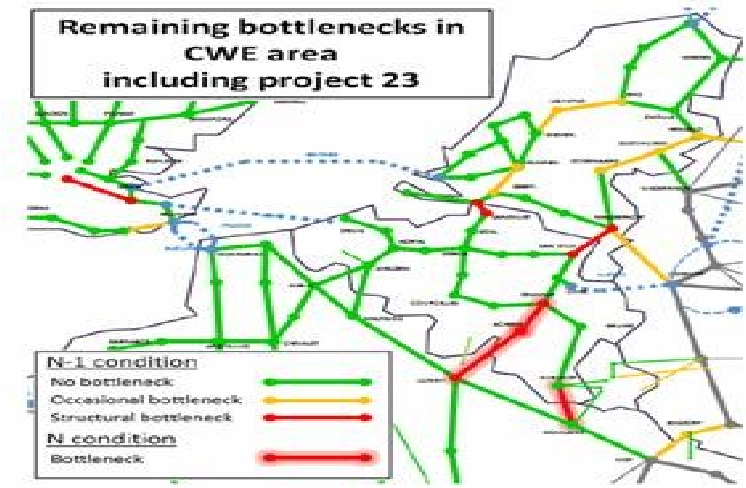
The main driver is relieving congestion on the French-Belgium border resulting from higher bulk power flows within the CWE area, transporting energy through and to Belgium.

The 225kV axis between Aubange and Moulaine is electrically speaking highly influenced by both France - Belgium and France - Germany cross border flows. Solving this bottleneck secures the contribution of project 23 (HTLS upgrade

Avelin/Mastaign - Horta) within a broader scenario framework and unlocks the potential for additional GTC increase on the FR-BE border.

Both this project 173 'France Belgium Phase 2' as well as project 280 'France Belgium Phase 3' are complementary to project 23 in enabling the potential of market exchanges. Their respective contribution is quantified via a GTC increase on top of the GTC contribution of project 23.

TYNDP analyses showed that a 1-GW capacity increase on this border provides an additional SEW of about 20-40 M€ depending on the vision.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed jointly with project 280.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-BE: [400 ; 500] |
| | BE-FR: [400 ; 500] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 20 ±10 |
| Cost explanation | The provided cost refers to the total expected investment cost of the reference solution, subject to outcome of ongoing bilateral studies. |
| S1 | NA |
| S2 | NA |

| | |
|---|---|
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | 20 ±10 | 20 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 780 ±160 | 180 ±60 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | ±100 | 200 ±200 | -100 ±100 | ±100 | -200 ±100 |

The GTC increase is related to the presented reinforcement option, meaning the possibility to sustain higher flows on the Belgian - French border via the addition of PSTs. This value is subject to further evaluation in bilateral studies. This project 173 'FR-BE Phase 2' has been assessed together with project 280 'FR-BE Phase 3' in PINT (i.e. on top of project 23) and the CBA indicators (SEW, RES, CO2, losses) refer to both projects 173 and 280 together.

The increase in SEW emphasizes the complementary value of this project on top of project 23, in relieving congestion on the French-Belgium border. The higher RES integration benefits in Visions 3 and 4 relate to the nature of these scenarios. With regards to CO2 emissions, the project can be considered to have a neutral effect.

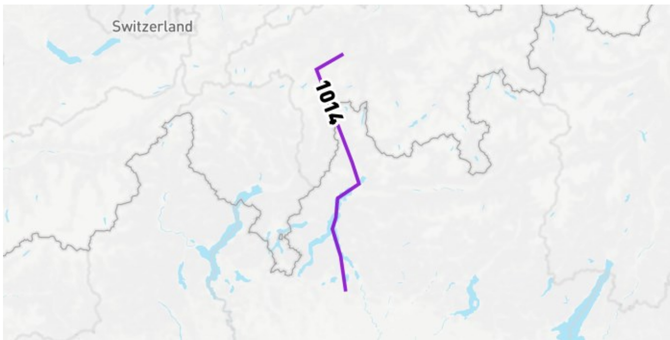
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.62 | 1.05 | 2.31 | 1.45 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.36 | 4.64 | 10.48 | 8.08 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 17.81 | 16.19 | 1.00 | 0.66 |

## Project 174 - Greenconnector

Greenconnector is an HVDC interconnector project between Italy and Switzerland for power transport using DC cables rather than overhead lines. The route length is about 150 km. The design power is 1000 MW (1200 MW in overload condition), while the DC voltage is +/- 400 kV DC. Two cables will be installed, working with a bipolar scheme. Great part of the cables route will exploit a section of an existing oil pipeline, no longer in service since January 1997. This pipeline crosses the Italian and Switzerland border at Splügenpass and is running close by the two end stations of the Greenconnector project (Sils in Graubunden Canton and Verderio Inferiore, Lecco). The cables will be pulled inside the pipeline itself, reducing the amount of civil works required before and after cable laying and therefore limiting even temporary environmental impact. For about 47 km the cables will run across the Como lake.

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | Italy - Switzerland |
| PCI label | |
| Promoted by | Worldenergy SA |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1014 | Greenconnector is an environmentally friendly HVDC interconnector, based on underground and submarine cables, between Italy and Switzerland, with a design power of 1000 MW (1200 MW in overload condition) and a voltage of +/- 400 kV DC. | 100% | Verderio | Sils i.D. | Design & permitting | 2021 | | |

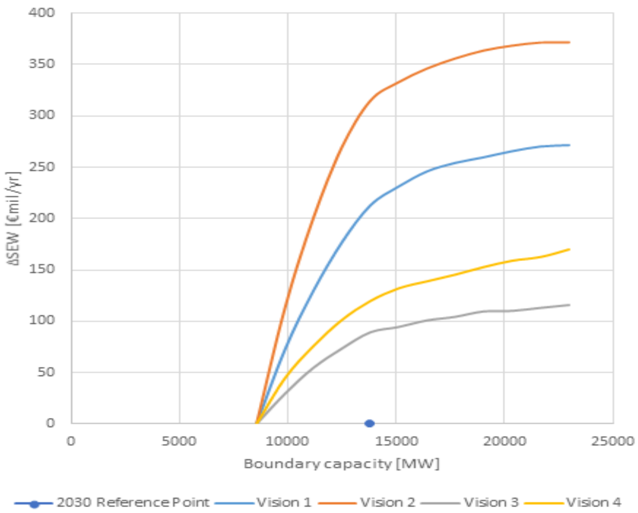
## Additional Information

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list).

The Greenconnector project will increase the grid transfer capability on the Northern Italian border in both directions, with a significant impact on market integration and system flexibility. Various simulations have shown that the Greenconnector project achieves this result in an effective way under a variety of scenarios. The consequent increase in the exchange of power (including renewable sources) across the north-south axis will contribute to the use of more efficient generation capacity in Europe.

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for Vision2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-CH: 800 |
| | CH-IT: [800 ; 1200] |
| Delta GTC contribution (2030) [MW] | IT-CH: 850 |
| | CH-IT: 850 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 600 ±60 |
| Cost explanation | |

| | |
|---|---|
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 70 ±10 | 20 ±10 | 40 ±20 | 10 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 30 ±30 | 60 ±50 |
| B4 Losses (GWh/yr) | -250 ±25 | -50 ±25 | -50 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | -11 ±1 | -3 ±2 | -2 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 1400 ±110 | 400 ±200 | 600 ±200 | -100 ±100 | -300 ±100 |

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.46 | 0.67 | 0.38 | 0.59 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.89 | 3.56 | 4.20 | 4.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.55 | 9.18 | 1.81 | 2.12 |

## Project 175 - Great Belt II

This project candidate includes an HVDC connector between Denmark-West (DKW) and Denmark-East (DKE). The connector is called Great Belt-2. It could among other variants be located between the 400 kV substation Malling in DKW and the reconstructed 400 kV substation Kyndby in DKE.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Denmark-West - Denmark-East |
| PCI label | |
| Promoted by | Energinet.dk |


### Investments

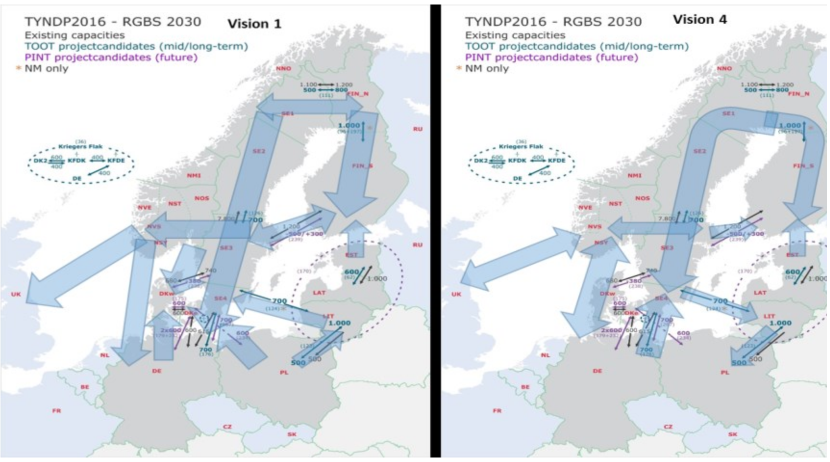
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1000 | HVDC connection DKW-DKE | 100% | Malling (DKW) | Kyndby (DKE) | Under Consideration | 2030 | Investment on time | optional candidate project from TYNDP14 |

### Additional Information

The second interconnector between DK1 and DK2 is a project carried over from the TYNDP14 project. The connection has more recently surfaced in the "Redegørelse for Elforsyningssikkerhed 2015" made by Energinet, published in September 2015 as a case that will be investigated in the future. The screening project is currently being set up as an internal project with the aim of determining the effect on security of supply, the alignment of the project as well as the capacity.

### Investment needs

The project is founded in the utilisation of wind energy, enabeling flows between the two regions of Denmark, and also linking the nordic syncroneus area closer to the central European system. Additionally the project is relevant in helping secure adequacy in Denmark East where the generation margin is expected to be more tight than in Denmark West.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | DKW-DKE: 600 |
| | DKE-DKW: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 250 ±50 |
| Cost explanation | The project is only at the screening stage, hence all parameters in relation to design, technology choise, allignment and tendering are open. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 10 ±10 | 40 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | -100 ±100 | ±100 | ±100 |

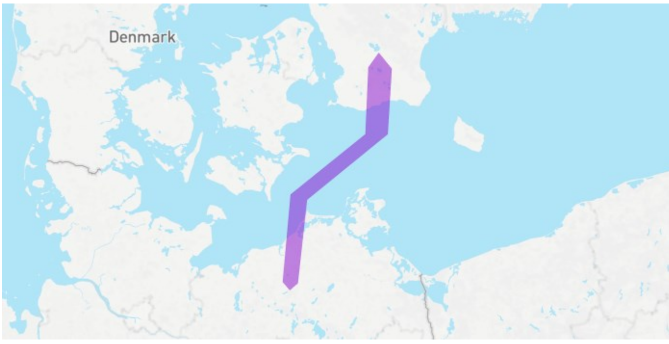
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.25 | 1.88 | 1.41 | 1.55 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.52 | 7.71 | 8.52 | 8.62 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 0.26 | -1.18 | 0.01 | -0.62 |

## Project 176 - Hansa PowerBridge 1

New HVDC interconnector between Sweden (SE4) and Germany (50 Hertz) aiming to enhance the integration of the Nordic and the continental power market. Moreover the interconnector facilitates RES integration and increases the system adequacy in both systems.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Germany - Sweden |
| PCI label | |
| Promoted by | 50HERTZ;SVK |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 995 | New DC cable interconnector between SE and DE | 100% | Station SE4 | Güstrow (DE) | Planning | 2025 | Investment on time | RGBS common investigations for TYNDP 2014 |

### Additional Information

*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realize under the stated time period. The plan is available in Swedish through the following link:*

http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

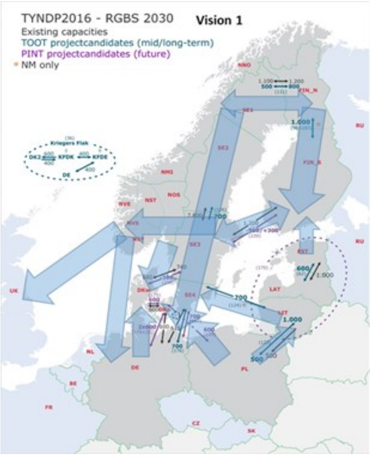
The German national development plan was published in 2016 and is available under the following link:

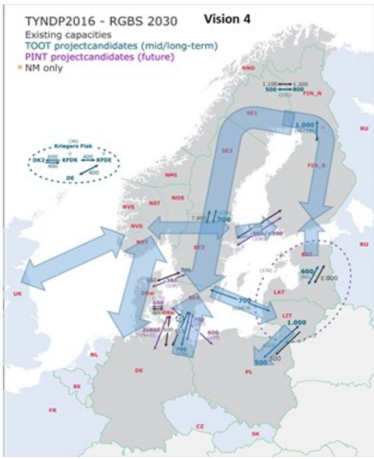
http://www.netzentwicklungsplan.de/en

## Investment needs

The main driver is market integration of the Nordic hydro/nuclear/RES dominated system with the German thermal/RES based system. The increase of renewable power in Sweden and Germany will lead to an increased need for trade in situations with high surplus due to high wind power production. Flows are expected to be balanced on an annual level with southbound flow during peak hours and when the hydro inflow in Sweden are high and northbound in periods of high RES generation in Germany and during nights. System adequacy is enhanced in Germany which will increase the import potential in period of low wind and solar generation. Also the system adequacy in southern Sweden is enhanced since it given more import capacity in a future with less available nuclear generation capacity.

The project contributes with 700 MW at the boundary between the Nordic and the Continental synchronous areas. After this project the capacity between Sweden and Germany would be 1315 MW in both directions. As indicated by the capacity analysis figure there is a high potential for SEW benefit at this boundary.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | SE4-DE: 700 |
| | DE-SE4: 700 |
| Delta GTC contribution (2030) [MW] | SE4-DE: 700 |
| | DE-SE4: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 660 ±70 |
| Cost explanation | Early cost estimation. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

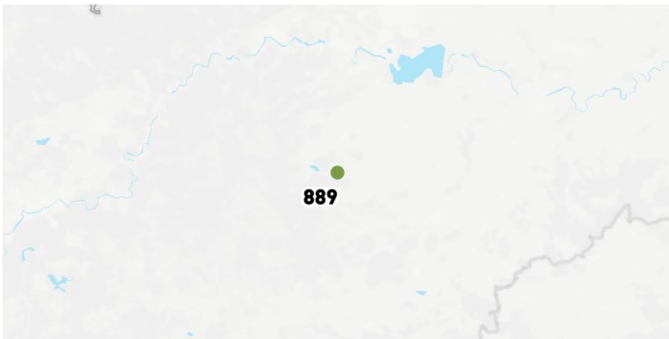
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 40 ±10 | 40 ±10 | 20 ±10 | 40 ±10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±10 | <10 | 280 ±60 | 190 ±40 |
| B4 Losses (GWh/yr) | 250 ±25 | 275 ±27 | 275 ±27 | 325 ±32 | 225 ±25 |
| B4 Losses (Meuros/yr) | 10 ±1 | 14 ±2 | 12 ±2 | 19 ±2 | 15 ±2 |
| B5 CO2 Emissions (kT/year) | -600 ±100 | -300 ±100 | -900 ± | 300 ±100 | ±100 |

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 5.37 | 9.92 | 9.61 | 7.81 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 12.49 | 15.94 | 20.92 | 17.38 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.66 | 8.91 | 14.56 | 13.35 |

## Project 177 - PST Hradec

Installation of 4 Phasing Shifting Transformers (PSTs) at the substation Hradec on the 400 kV interconnector (double-circuit line) between Hradec on the Czech Republic side and Rohrsdorf on the German side.  The 4 PSTs in Hradec, each  has rated throughput power of 850 MVA, 2 PSTs units installed in parallel for each tie-line of the double circle line and with a total rated throughput power of 1700 MVA per circuit, with a phase angle of up to 30° and 65 possible settings (-32,...0,...+32) for a rated voltage of 420 kV.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Czech - Germany |
| PCI label | N/A - the project is not in the PCI list |
| Promoted by | CEPS |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 889 | New PST in substation Hradec | 100% | Hradec | | Under Construction | 2016 | Investment on time | Progress as planned |

### Additional Information

Information about this project is available on the national 10-year development plan which can be found under this link:

http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/Documents/Rozvoj%20PS/Pl%c3%a1n%20rozvoje%20p%c5%99enosov%c3%a9%20soustavy%20%c4%8cesk%c3%a9%20republiky%202016%20-%202025_final.pdf

## Investment needs

This project will enable CEPS to effectively deal with the unplanned cross-border flows on the Rohrsdorf (DE) - Hradec (CZ) interconnector on both directions and therefore ensure the security of the Czech transmission grid including neighboring grids from a mid-term and along-term perspective. Further, the PSTs will guarantee a very high degree of flexibility and ensure secure operation of the adjacent infrastructure, while keeping the cross-border flows with safe limits

Further market based capacity increase has not been evaluated, due to the fact that the investigation which is relevant to the market based capacity increase was considered for Polish synchronous profile PL-DE/CZ/SK. This boundary (CZ-DE) that relates to the Project 35, 177 and 200 is mostly stressed by unscheduled flows caused by volatile production of RES. This fact can be explored when investigating the dependency that describes the higher benefit of each GW when considering higher prices of CO2 emissions and higher RES installed capacity.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the project 35, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-CZ: 500 |
| | CZ-DE: 0 |
| Delta GTC contribution (2030) [MW] | DE-CZ: 550 |
| | CZ-DE: 150 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 52 ±10 |
| Cost explanation | As preparation of the investment item continues, technical requirements are detailed specified to reflect different technical, safety, environmental and legal requirements imposed from different permit grating processes (land and construction permit) which usually as a result affects cost estimation of the investment which were previously given. The difference in currency exchange rate was also taken into consideration.<br><br>The cost value includes only CAPEX cost. |
| S1 | NA |
| S2 | NA |
| B6 | + |

| | |
|---|---|
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | 20 ±0 | 40 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 310 ±30 | 160 ±30 |
| B4 Losses (GWh/yr) | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | ±100 | -200 ±100 | -700 ±100 |

Project 177 mainly will guarantee a very high degree of flexibility and ensure secure operation of the adjacent infrastructure by regulating the mentioned unscheduled flows and keeping the cross-border flows within safe limits and ensuring N-1 security in relevant part of the Central East part of the region. According to the CBA methodology the impact of PST itself is negative in losses, however benefits explored by the optimization of capacity on this particular border (CZ-DE) leads to significant Social Economic Welfare, RES integration and CO2 reduction.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.55 | 0.51 | 3.42 | 4.78 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.06 | 2.74 | 12.85 | 14.47 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 4.13 | 4.77 | 6.65 | 7.78 |

The installation of PSTs will provide a very high degree of flexibility and ensure secure operation of the adjacent infrastructure, while keeping the prevailing cross-border flows in the direction of DE-CZ-AT-SK with safe limits.

## Project 179 - DKE - DE

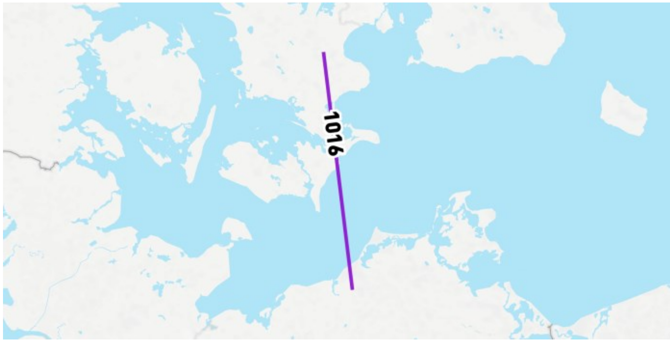
This project includes a HVDC subsea interconnector between Denmark-East (DKE) and Germany (DE) and is called Kontek-2. A final grid-connection solution is not prepared yet; one of the possible alternatives could establish the Danish HVDC converter station in the area of Lolland- Falster. This alternative comprises among other things an HVDC converter station being connected to the existing 400 kV substation Bjæverskov via 400 kV underground cables and/or 400 kV OHL.

Classification Future Project

Boundary Denmark-East - Germany

PCI label

Promoted by 50HERTZ;Energinet.dk




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1016 | new 600 MW HVDC subsea cable | 100% | Bjæverskov (DK2) | Bentwisch (DE) | Under Consideration | 2030 | Investment on time | optional candidate project from TYNDP14 |

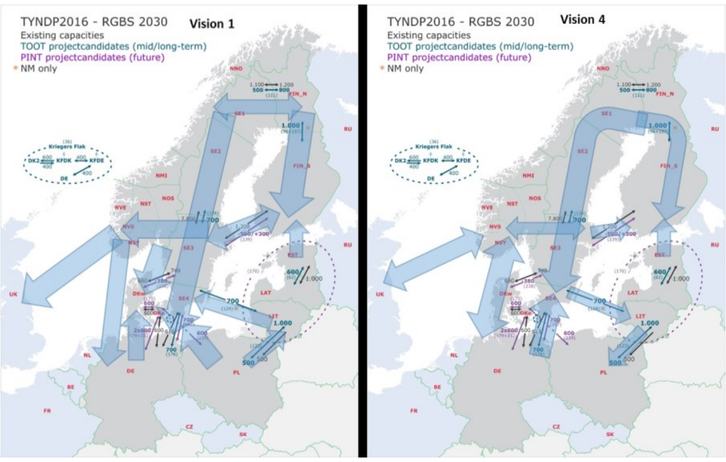
### Additional Information

A project candidate identified in the TYNDP14 process which was carried over into the TYNDP16 project as a potential future project.

### Investment needs

The project will serve as connection between the Nordic and central European power systems either transporting hydro power from the Nordic area to continental Europe or transporting wind and thermal power from the continent to the Nordics in times of low hydro levels.

The project candidate will serve as a part of the capacity that could be counted as a part of the capacity identified in the capacity analysis as having significant marginal benefit. On the boundary there are significant benefits to be gained by increasing capacity in the 4 visions. The marginal benefit on the boundary evens out somewhere between 15 and 20GW depending on the vision and not accounting for the investment cost.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project's expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | DE-DKE: 600 |
| | DKE-DE: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 360 ±100 |
| Cost explanation | Kontek 2 is a future project, hence all parameters in relation to design, technology choise, allignment and tendering are open. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 40 ±10 | 130 ±30 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 400 ±100 | -300 ±100 | ±100 | ±100 |

In the TYNDP16 visions there are only marginal benefits of constructing a second Kontek connection with the socio economic benefits being less than €10 million in all visions. The assessment is done as a PINT project. Likewise there is only very small influences of the CO2 emission and the curtailment of RES.

This HVDC project increases security of supply (adequacy, voltage stability) in DKE, which is not valued accordingly in the TYNDP.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.73 | 4.07 | 4.19 | 3.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.02 | 11.08 | 14.79 | 13.26 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.92 | 8.57 | 11.80 | 9.05 |

## Project 183 - DKW-DE, Westcoast

The project consists of a new 400 kV line from Endrup (Denmark) to Niebüll (Germany), adding more transfer capacity at the West Coast between these countries. On the Danish side, this project includes the establishment of a 400 kV AC system from the existing 400 kV substation Endrup to the border, from where the interconnector continues to Niebüll. The project is labelled by the EC as project of common interest (PCI 1.3.1).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Denmark-West - Germany |
| PCI label | 1.3.1 |
| Promoted by | Energinet.dk;TENNET-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1018 | planning new 380 kV overhead line | 100% | Niebüll (DE) | Endrup (DKW) | Planning | 2022 | Investment on time | project planning and technical design is progressing |

### Additional Information

Project websites:
http://anlaegsrapport.dk/2014_2015/eltransmission/Sider/Mulig-400%20kV%20forbindelse%20til%20Tyskland.aspx

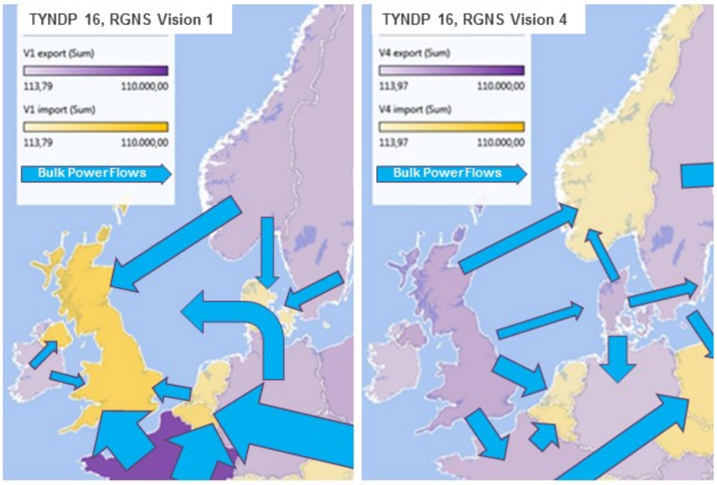
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/westkuestenleitung.html

The project has been investigated with 500 MW in the scope of the TYNDP, whereas on bilateral basis current investigations consider 1000 MW based on a different technical setup

## Investment needs

Main bulk flow direction in this local area (DE North, DK West) is along the North-South axis (main direction depending on the Vision). Project contributes to bearing these flows. RES integration (mainly wind energy, both on- and offshore) in this local area keeps on increasing, thus the grid infrastructure needs to be upgraded respectively.

Project estimations show that the project improves the SoS of the region (esp. DKW and Northern DE).




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DKW-DE: 500 |
| | DE-DKW: 500 |
| Delta GTC contribution (2030) [MW] | DKW-DE: 500 |
| | DE-DKW: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 210 ±42 |
| Cost explanation | Undiscounted total at time of delivery. Capex only. Project is one investment. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 10 ±10 | <10 | <10 | 10 ±10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 60 ±10 | 170 ±150 |
| B4 Losses (GWh/yr) | 0 ±25 | 25 ±25 | 25 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 1 ±2 | 1 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | -200 ±100 | -200 ±100 | 100 ±200 |

The TYNDP16 indicators (SEW, RES, CO2) are less optimistic compared to the TYNDP14 indicators, which can be explained by the changed scenarios. Since the TYNDP14 edition scenarios have further developed with major movements of RES between countries and differences in demand development.

The project facilitates to integrate the Viking Link interconnector into the Danish Power System. This complementarity is not valued by the TYNDP-CBA.

The project is also closely linked to project 258 (PCI 1.3.2), as these projects are serially directly connected and thus complementing each other.

Therefore also the benefits should be considered as strongly being related to each other.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.48 | 2.49 | 2.99 | 1.91 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.09 | 8.66 | 12.68 | 10.41 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.87 | 10.40 | 13.06 | 9.92 |

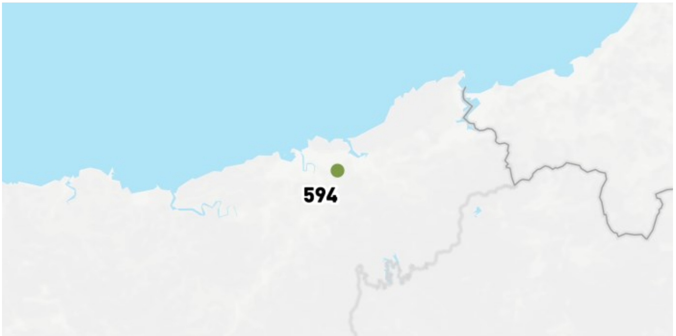
In each Vision there is a price differential between DK and its neighbours, causing bilateral exchanges or even transit flows, which proceed through the Northern German grid.

The project releases congestions in the underlying distribution grid.

## Project 184 - PST Arkale

This project is a new PST (phase shifting transformer) in the Spanish substation Arkale 220 kV with affection to the Arkale-Argia cross border line between France and Spain. This device is required to increase the France-Spain exchange capacity, especially from Spain to France, and not only is able to have an independent good impact in the exchange capacity without taking into account the Eastern and Western interconnections, but also helps making the most of these projects. In addition, as this project avoids the tripping of the Arkale-Argia tie line in case of contingencies, it helps improving the Security of supply in the French Basque country.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Spain - France |
| PCI label | 2.8 |
| Promoted by | REE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 594 | New PST in Arkale-Argia 220 kV interconnection line | 100% | Arkale (ES) | | Permitting | 2017 | Delayed | Delays because of closure on budget and financing |

### Additional Information

Project website

http://www.ree.es/es/actividades/gestor-de-la-red-y-transportista/proyectos-de-interes-comun-europeos-pic ;

*PCI page – link to EC platform* http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

Other links

*Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

*Inter-Governmental agreement (Madrid Declaration)*
https://ec.europa.eu/energy/sites/ener/files/documents/Madrid%20declaration.pdf

One of the main concerns in South Western Europe is the low interconnection capacity FR-ES, too low to enable the Iberian Peninsula to fully participate in the Internal Electricity Market, and with an interconnection ratio far from the 10%

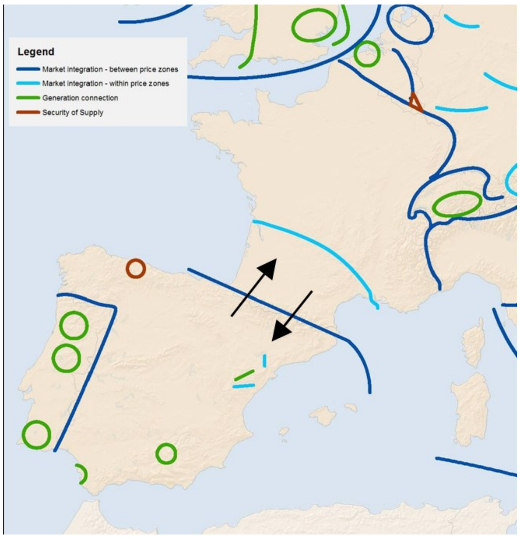
## Investment needs

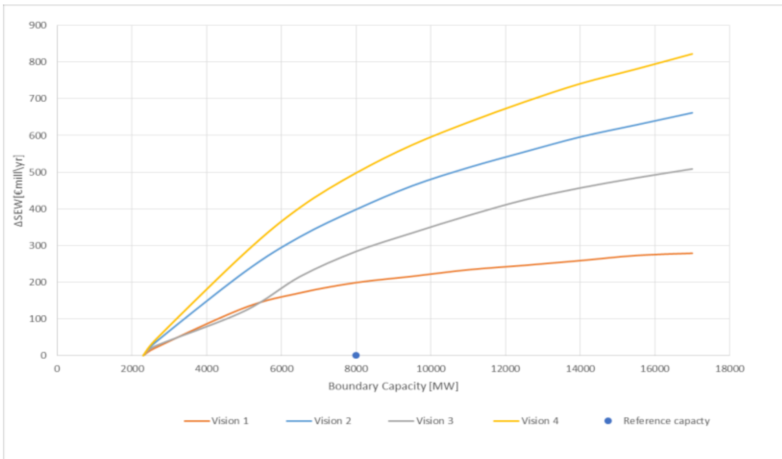
objective. In 2014, congestion in the FR-ES border was 71% with an average price-spread of around 17€/MWh. In 2015 the new Eastern Interconnection was commissioned after more than 30 years. However it is considered not enough, neither in the short nor long term.

PST in Arkale will be the next investment in the FR-ES border helping to increase the exchange capacity, especially from Spain to France. Not only has the project itself a remarkable impact on the exchange capacity but it also helps making the most of the recent Eastern and future Western interconnections.

In addition, as this project avoids the tripping of the Arkale-Argia tie line in case of contingencies, it helps improving the Security of supply in the French Basque country, which has certain risk with the current network.

The curves in the right show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases (beyond 5 GW, boundary capacity is supposed to increase simul-taneously by homothetical steps, 1/3 MIBEL-GB, 1/3 MIBEL-FR, 1/3 MIBEL-IT). So no assessment per project are behind these values. This study should be considered as an additional analysis with re-spect to the CBA assessment analysis. In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 (where RES optimization has been carried out) in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Mid-Term and Long Term projects on the French-Spanish border were assessed according to their maturity and expected commissioning dates taking into account the following order; PST in Arkale (project 184), Biscay Gulf (Project 16), Navarra-Landes (Project 276), Aragon-Atlantic Pyrenees (Project 270).
The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | FR-ES: 100 |
| | ES-FR: 500 |
| Delta GTC contribution (2030) [MW] | FR-ES: 100 |
| | ES-FR: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 23 ±3 |
| Cost explanation | CAPEX cost. Procurement / construction cost uncertainties |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | 20 ±10 | 30 ±0 | 30 ±0 | 50 ±10 |
| B3 RES integration (GWh/yr) | 20 ±10 | 160 ±80 | 330 ±120 | 220 ±40 | 270 ±40 |
| B4 Losses (GWh/yr) | 100 ±25 | 100 ±25 | 75 ±25 | 75 ±25 | 100 ±25 |
| B4 Losses (Meuros/yr) | 4 ±1 | 5 ±2 | 3 ±2 | 4 ±2 | 6 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±80 | ±100 | ±100 | -200 ±0 | -500 ±100 |

Savings in variable generation costs (SEW) in 2020 and 2030 V1 are caused by a decrease of CCGTs in the Iberian Peninsula compensated by an increase of coal in Germany and Central Europe. This situation results in a global increase of $CO_2$ emissions.

In 2030 V3 and V4 the SEW is caused mainly by a decrease of CCGTs in Central Europe replaced by nuclear and RES in the region. This situation results in a global decrease of $CO_2$ emissions. In addition, SEW is higher is the V4 top-down vision, which imply higher efficiency of a European common approach for optimizing the location of RES versus national and independent approaches of RES policies.

The project contributes to avoid ENS at local level in the French Basque Country ( Bayonne-Anglet-Biarritz ) and also will improve the security of supply on the Spanish side. In addition, an increased transfer capacity between Iberia and the rest of Europe would improve the system security and its robustness from the dynamic point of view.

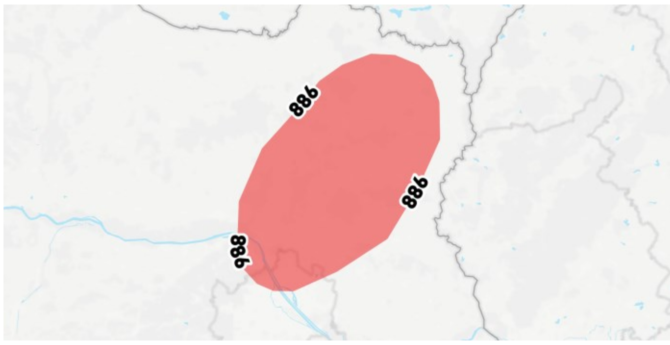
| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.61 | 3.67 | 4.24 | 5.80 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 6.35 | 9.91 | 15.13 | 16.55 |

| | | | | |
|---|---|---|---|---|
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 15.07 | 10.58 | 9.91 | 13.75 |

## Project 186 - east of Austria

To allow the grid integration of the planned renewable energy generation (mainly wind power) in the north-eastern part of Austria ("Weinviertel") the transmission grid infrastructure (currently a rather weak 220kV line) has to be enforced and new substations for the connection need to be erected.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | outside-inside |
| PCI label | |
| Promoted by | APG |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 886 | To allow the grid integration of the planned renewable energy generation (mainly wind power) in the north-eastern part of Austria ("Weinviertel") and to cover the foreseen load growth in that region the transmission grid infrastructure has to be enforced and new substations for the connection need to be erected. | 100% | Seyring | Neusiedl/Zaya | Design | 2021 | Investment on time | Start of the authorisation process (EIA) in mid 2016. |

### Additional Information

Project homepage (only available in German language)

https://www.apg.at/de/projekte/Weinviertelleitung

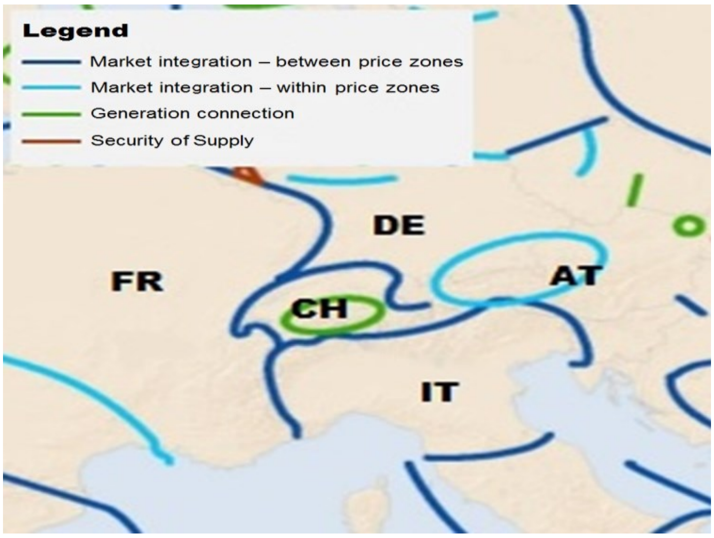
## Investment needs

The erecting of the existing 220-kV-line Bisamberg – Sokolnice was started during the 2nd world war and was finally commissioned in 1958. It passes the eastern part of the "Weinviertel"-region, where a huge amount of renewables is installed recently.

End of 2015, an amount of 670MW of wind turbines was already installed in this region. Based on the governmental plans of the federal state of Lower Austria, this value is expected to reach up to 1500MW. Additional potential exists for the installation of photovoltaic.

The connection of this amount of RES is not possible with the given capacity of the line. The existing 220-kV-line cannot be updated to fulfil these future needs due to its age and design.

The project is designed to meet the demand in the connection of wind generation capacities and to transmit it in the most efficient way to the load centers and/or to the pump storage powerplants in the western area of Austria.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Outside: 1500 |
| | Inside: 1500 |
| Delta GTC contribution (2030) [MW] | Outside: 1500 |
| | Inside: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 200 ±50 |

| | |
|---|---|
| Cost explanation | The cost represents the currently expected total investment cost. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 80 ±20 | 110 ±10 | 100 ±10 | 190 ±10 | 190 ±0 |
| B3 RES integration (GWh/yr) | 1940 | 1940 ±0 | 1940 ±0 | 2620 ±20 | 2650 ±0 |
| B4 Losses (GWh/yr) | -150 ±25 | 25 ±25 | 50 ±25 | -25 ±25 | -100 ±25 |
| B4 Losses (Meuros/yr) | -7 ±1 | 1 ±2 | 2 ±1 | -2 ±2 | -7 ±2 |
| B5 CO2 Emissions (kT/year) | -1600 ±80 | -6100 ±5000 | -1400 ±0 | -1100 ±100 | -1100 ±100 |

# Project 187 - St. Peter - Pleinting

Increase of the cross border transmission capacity by erecting a new 380kV line between St. Peter (Austria) and Pleinting (Germany). This leads to an improved connection of the very high amount of RES in Germany and the pump storages in the Austrian Alps.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Austria - Germany |
| PCI label | |
| Promoted by | APG;TENNET-DE |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 997 | new 380-kV-line Pleinting (DE) - St. Peter (AT) | 100% | Pleinting (DE) | St. Peter (AT) | Planning | 2022 | Investment on time | Investment on time relative to TYNDP14 |

## Additional Information

This project is highly connected to and partly based on Project 47/Investment 212.

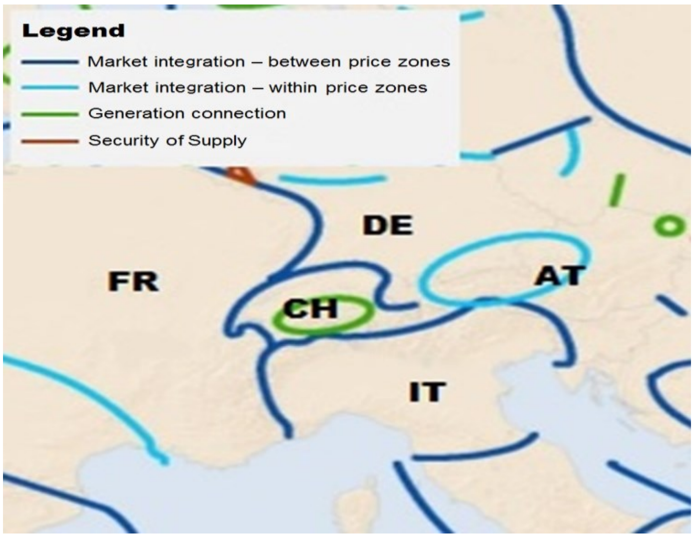
German grid development plan:

http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0

## Investment needs

Increase of the cross border transmission capacity by erecting a new 380kV line between St. Peter (Austria) and Pleinting (Germany). This leads to an improved connection of the very high amount of RES in Germany and the pump storages in the Austrian Alps.

For this border, no specific capacity analysis has been done in TYNDP16. According to the CBA results of the latest project on this border (P198), the benefit SEW provided by a standard 1 GW capacity increase can be assessed between 20M€ and 50M€  in the 2030 visions except in Vision 2 where it is lower.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed in the 2030 Visions with a double TOOT step compared to the project 198 , which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project’s expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | DE-AT: 1500 |
| | AT-DE: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 180 ±30 |
| Cost explanation | The cost represents the currently expected total investment cost. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±30 | 30 ±30 | 90 ±30 | 60 ±10 |
| B3 RES integration (GWh/yr) | N/A | 20 ±10 | <10 | 860 ±70 | 600 ±240 |
| B4 Losses (GWh/yr) | N/A | 175 ±25 | 250 ±25 | 500 ±50 | 300 ±30 |
| B4 Losses (Meuros/yr) | N/A | 9 ±2 | 11 ±2 | 30 ±3 | 20 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | 800 ±900 | 300 ±300 | -400 ±400 | -300 ±100 |

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.29 | 0.13 | 2.23 | 1.85 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.26 | 1.29 | 10.38 | 9.64 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 5.14 | 4.40 | 6.82 | 7.09 |

## Project 189 - Irish Scottish Links on Energy Study (ISLES)

The project promoter states "ISLES consists of a coordinated offshore grid in the Irish sea and west of Scotland, providing market-to-market interconnection and connection to renewable generation functionalities. The concept ISLES 'zones' consist of a number of complementary multi-terminal HVDC connections that can be operated without the need for DC breakers and without breaching existing onshore loss of in feed limits but which can be reconfigured post-fault to re-establish power transfer paths.  The benefits of the design would be that offshore wind or tidal power can be brought to either of two shores, there would be reduced redundancy in connections and, in particular, interconnection capacity would be provided between the GB market and the Single Electricity Market on the island of Ireland.  Thus while not 'dedicated to security of supply', realising the ISLES vision would make a significant contribution towards it. Two 'Zones' have been identified:Northern ISLES Corridor (PCI 1.9.2)Southern ISLES Corridor (PCI 1.9.3)"

| | |
|---|---|
| Classification | Future Project |
| Boundary | UK -  Ireland |
| PCI label | |
| Promoted by | the Department of Enterprise, Trade and Investment in Northern Ireland, the Department of Communications, Energy and Natural Resources in Ireland, and the Scottish Government |

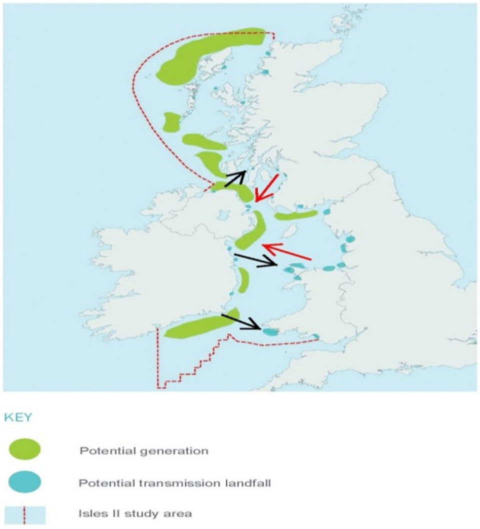
| Investments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
| 1389 | | 100% | Argyll Hub | N/A | Under consideration | >2030 | | |
| 1390 | | 100% | Coleraine Hub | N/A | Under Consideration | >2030 | | |
| 1391 | | 100% | coolkeeragh hub | N/A | Under Consideration | >2030 | | |
| 1392 | | 100% | Argyll hub | Coleraine | Under Consideration | >2030 | | |
| 1393 | | 100% | Coolkeeragh | Coolkeeragh hub | Under Consideration | >2030 | | |
| 1394 | | 100% | Coleraine substation | Coolkeeragh hub | Under Consideration | >2030 | | |
| 1395 | | 100% | Southern Hub | n/a | Under Consideration | >2030 | | |
| 1396 | | 100% | Coleraine hub | Coolkeeragh hub | Under Consideration | >2030 | | |
| 1397 | | 100% | Southern Hub UK | Trawsfynydd | Under Consideration | >2030 | | |
| 1398 | | 100% | Hunterston | Coleraine | Under Consideration | >2030 | | |
| 1399 | | 100% | Southern Hub | Trawsfynydd | Under Consideration | >2030 | | |
| 1400 | | 100% | Trawsfynydd | n/a | Under Consideration | >2030 | | |
| 1401 | | 100% | Southern Hub | Pembroke | Under Consideration | >2030 | | |
| 1402 | | 100% | Southern Hub | Pembroke | Under Consideration | >2030 | | |
| 1403 | | 100% | Southern Hub | Lodgewood | Under Consideration | >2030 | | |
| 1404 | | 100% | Southern Hub | Lodgewood | Under Consideration | >2030 | | |
| 1406 | | 100% | Pembroke | n/a | Under Consideration | >2030 | | |
| 1408 | | 100% | Lodgewood | n/a | Under Consideration | >2030 | | |
| 1411 | | 100% | Central Hub | Southern Hub | Under Consideration | >2030 | | |
| 1412 | | 100% | Central Hub | n/a | Under Consideration | >2030 | | |
| 1413 | | 100% | Central Hub | Dunstown | Under Consideration | >2030 | | |
| 1414 | | 100% | Central Hub | Dunstown | | >2030 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1415 | | 100% | Central hub | Trawsfynydd | | >2030 | |
| 1416 | | 100% | Central Hub | Trawsfynydd | | >2030 | |
| 1417 | | 100% | Trawsfynydd | n/a | | >2030 | |
| 1418 | | 100% | Dunstown | n/a | | >2030 | |
| 1419 | | 100% | Central Hub | Woodland | | >2030 | |
| 1420 | | 100% | Central Hub | Woodland | | >2030 | |
| 1421 | | 100% | Northern Hub | Central Hub | | >2030 | |
| 1422 | | 100% | Northern Hub | n/a | | >2030 | |
| 1423 | | 100% | Northern Hub | Louth | Under Consideration | >2030 | |
| 1424 | | 100% | Northern Hub | Louth | Under Consideration | >2030 | |
| 1425 | | 100% | Northern Hub | Louth | Under Consideration | >2030 | |
| 1426 | | 100% | Louth | n/a | Under Consideration | >2030 | |
| 1427 | | 100% | Woodland | n/a | Under Consideration | >2030 | |
| 1428 | | 100% | Northern Hub | Louth | Under Consideration | >2030 | |
| 1429 | | 100% | Northern Hub | Louth | Under Consideration | >2030 | |

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

The project promoter states "*The area, the subject of the ISLES initiative, encompasses the Irish Sea, the straits of Moyle and the western coastal waters of Scotland. The three partners in ISLES consider that there are significant regional benefits to be gained by taking a coordinated approach to delivery of electricity generation and transmission in the ISLES zone. This is a zone with significant wind,wave and tidal resources suitable for the deployment of offshore renewable energy technologies. The deployment of such technologies can make a significant contribution to transitioning to a low carbon energy system."*




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The project aims to enable the development of an offshore grid to integrate the large marine renewable sources in the Irish sea. A simplified project was studied for the CBA assessment, as the nature of the project is highly dependent on the development of offshore renewable generation. As a result, the CBA figures will not be reflective of the full list of investments provided in the project details. The project allows for the export of additional renewable generation between the island of Ireland and Great Britain that would otherwise be curtailed, as reflected in the RES integration figures. The project contributes to the reduction of marginal cost differences between the Irish and British markets.
The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-GB: 1000 |
| | GB-IE: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 7840 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 10 ±10 | 50 ±10 | 40 ±10 |
| B3 RES integration (GWh/yr) | N/A | 440 ±90 | 100 ±20 | 720 ±190 | 680 ±130 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 200 ±100 | -100 ±100 | -200 ±100 | -300 ±100 |

With regard to the results of the CBA undertaken by ENTSO-E, the partners note the project would have clear SEW benefits mostly relating to savings through reductions in the use of generation fuel and operating costs of conventional plant. A conclusion has been made that the principal benefits are in relation to improved integra-tion of renewables, which would have a consequent benefit in terms of the reduction of C02 emissions."

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by EirGrid and National Grid which concluded that there are additional benefits of 24 million euros from avoided investment in generation capacity.

The project's SEW accounts for saving in generation fuel and operat-ing costs. The project could also enable savings by avoiding invest-ment in generation capacity, in particular for projects connecting electric peninsulas. This aspect has not been considered in the CBA methodology

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

As the accurate location and project scope are still under investiga-tion, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 190 - NorthConnect

A 650 km long subsea interconnector between Norway and Scotland is planned to be realized in 2022. The interconnector is planned to be a 500 kV, 1400 MW HVDC subsea interconnector between western Norway (Simadalen) and eastern Scotland (Peterhead), UK.

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | Great Britain - Norway |
| PCI label | PCI 1.10 |
| Promoted by | NorthConnect |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1382 | A 500 kV 1400 MW HVDC subsea interconnector between western Norway and eastern Scotland. | 100% | Sima | Peterhead | Design | 2022 | Delayed | |

### Additional Information

PCI 1.10.

There is only one PCI between UK and Norway, however two potential projects (110 and 190)

Project Website:

http://northconnect.no/

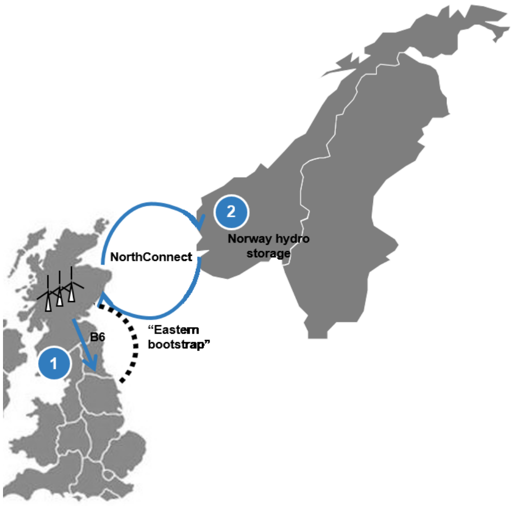
## Investment needs

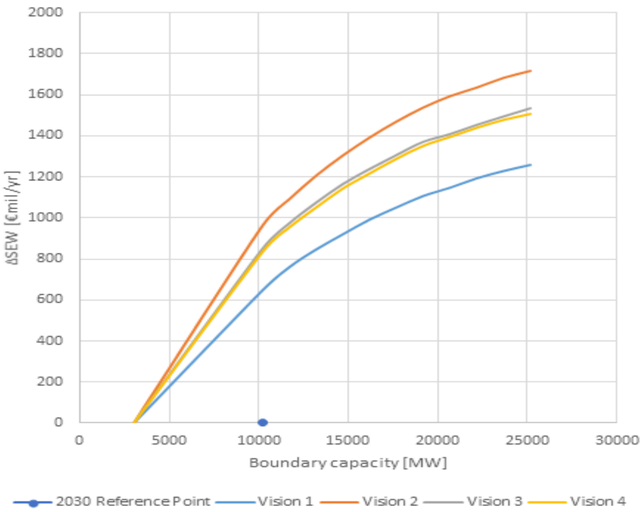
This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

The NorthConnect subsea interconnector between Norway and Scotland/Great Britain is developed against a background of growing renewables generation and increasing pressure on capacity margins in GB. The decision to develop a project that enhances the links between the GB and the Norwegian market is based on the rationale of fundamentally different and complementary electricity mixes. As a result, NorthConnect is expected to generate material benefits for both countries. NorthConnect will improve security of supply on both sides of the cable, in Norway in dry years, in Great Britain in periods of high demand and low intermittent production. The benefits between wet/normal/dry years are non-linear, and experience of interconnectors to Norway in operation also demonstrate significantly higher values than project calculated (normal year) in advance. Linking the two markets, Norway to GB, will facilitate more renewable integration, and the interconnector will benefit both countries.

The project promtor states comments on the ENTSO-E CBA results as quoted below, believing that the project has a higher benefit than reflected by the result of ENTSO-E. References to public available material proving these statements have been made;

*"The NorthConnect project is also more valuable in terms of benefits because:*
*• It relieves B6 congestion between Scotland and England for high wind periods due to export from Scotland to Norway. This postpones Scotland/England grid investment and opens up a new market for Scottish wind;*
*• It is the shortest distance between UK and Norway (see Regional Map) below;*
*• It connects to the Norwegian NO5 zone (unlike any other interconnectors) and the local cluster of Pelton turbine hydro facilities is well able to absorb high load fluctuations."*




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | NO-GB: 1400 |
| | GB-NO: 1400 |
| Delta GTC contribution (2030) [MW] | NO-GB: 1400 |
| | GB-NO: 1400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1613 |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 190 ±30 | 140 ±10 | 190 ±10 | 170 ±30 | 140 ±10 |
| B3 RES integration (GWh/yr) | 90 ±20 | 150 ±150 | 850 ±60 | 840 ±170 | 870 ±390 |
| B4 Losses (GWh/yr) | 2900 ±290 | 370 ±30 | 200 ±25 | 175 ±25 | 795 ±105 |
| B4 Losses (Meuros/yr) | 125 ±13 | 20 ±2 | 9 ±1 | 10 ±2 | 53 ±7 |
| B5 CO2 Emissions (kT/year) | 2200 ±350 | 1500 ±400 | 700 ±300 | -900 ±300 | -900 ±600 |

A large part of the value driver of connecting Scotland/GB to Norway is weather stochastics and volatility, both in terms of SEW values and in terms of increased RES and decreased CO2-emissions. Simplifications in The Pan-European analysis within the TYNDP CBA, such as related to Norwegian hydrological stochastics, significantly underestimates the beneficial effects of connecting these two fundamentally different electricity systems. A complete modelling of these effects would require a comprehensive time series of wind and hydro, covering 30-50 years with sufficient time resolution. As the TYNDP CBA includes only a 'normal' year simplification and does not therefore include wet and dry hydrological years, the analysis will significantly underestimate the SEW for NorthConnect.

Capturing the complete characteristics of the GB system might also require modeling GB as two zones, north (Scotland) and south. This could improve the modelling ability to represent the value of the interconnector in terms of grid benefits in both countries including reducing Scottish wind curtailment and grid congestion around the B6 boundary between Scotland and England. However, based on the scenario results an export from Norway to Great Britain is more likely, a situation which normally will increase congestions around the B6 boundary."

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 22.55 | 13.64 | 13.11 | 11.69 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.66 | 18.45 | 24.55 | 21.62 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 9.28 | 18.63 | 21.88 | 18.17 |

The 2nd PCI list stated one 1400 MW interconnector between Norway and Great Britain (however two competing projects, 110 and 190). Based on this the TYNDP Reference Grid 2030 included only one interconnector Norway-GB. As the North Sea Link already is under construction while no permission is given nor investment decision for NorthConnect is taken, the North Sea Link is the one project included in the TYNDP Reference Grid. In the CBA-assessment both projects are assessed by TOOT getting the same CBA-values (except losses)

## Project 191 - OWP TenneT Northsea Part 2

Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the European goal of CO2 reduction and RES integration

Classification Long-term Project

Boundary inside-DE

PCI label

Promoted by TENNET-DE


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 656 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster BorWin3 | Emden/Ost (DE) | Under Construction | 2019 | Delayed | due to the project |
| 952 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster DolWin 5 (NOR-1-1) | Halbemond | Under Consideration | 2024 | Rescheduled | |
| 953 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster DolWin 6 (NOR-3-3) | Emden/East | Under Consideration | 2023 | Delayed | due to the project |

## Additional Information

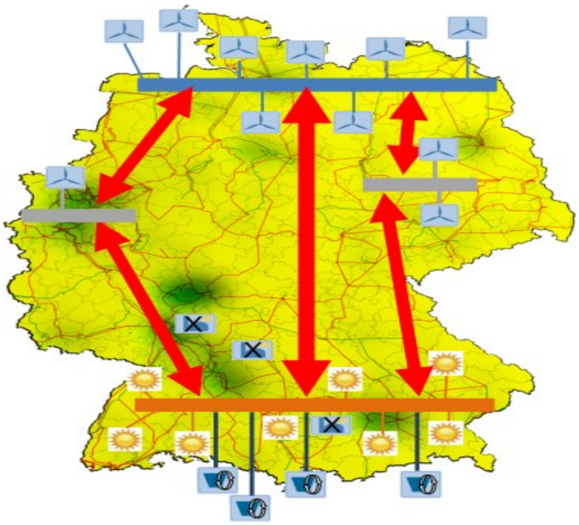
Information on offshore projects within the northern sea promoted by TenneT TSO GmbH (http://www.tennet.eu/de/netz-und-projekte/offshore-projekte.html) in German

## Investment needs

Germany is planning to build a big amount of offshore wind power plants in the North- and Baltic Sea. The OWP will help to reach the European goal of CO2 reduction and RES integration. These offshore infrastructure projects in the North- and

Baltic Seas areas, will deliver benefits for the regional society by pooling generation portfolios, integrating markets, lowering CO2 emissions, facilitating the integration of renewables (both onshore as well as offshore) and ensuring sufficient system resilience.

The development of off-shore wind farms in the North of Germany induces needs for undersea connections to these wind farms as well as reinforcements of the grid capacity from North to South. According to German law, these grid connections have to be constructed and operated by the TSO.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project’s expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | -: 2700 |
| | -: 2700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 4000 ±1000 |
| Cost explanation | |
| S1 | More than 100km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 560 ±40 | 480 ±30 | 610 ±30 | 700 ±40 |
| B3 RES integration (GWh/yr) | N/A | 9690 ±10 | 9710 ±10 | 8860 ±90 | 9370 ±30 |
| B4 Losses (GWh/yr) | N/A | 625 ±62 | 700 ±70 | 750 ±75 | 1250 ±125 |
| B4 Losses (Meuros/yr) | N/A | 33 ±4 | 32 ±4 | 44 ±5 | 83 ±9 |
| B5 CO2 Emissions (kT/year) | N/A | -5700 ±100 | -6800 ±300 | -3300 ±100 | -3800 ±100 |

The need of this project is depending on the expected increase of Offshore wind generation in Germany (especially in the North Sea). That is why only results for Vision 1, 2, 3 &4 are available.

## Project 192 - OWP Northsea TenneT Part 3

Connection of offshore wind parks in the North Sea to Germany. Mainly subsea DC cable. The OWP will help to reach the European goal of CO2 reduction and RES integration

Classification Future Project

Boundary inside-DE

PCI label

Promoted by TENNET-DE


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 211 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster DolWin 4 (NOR 3-2) | area of Cloppenburg | Under Consideration | 2028 | Delayed | delayed due to the project |
| 659 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster SylWin2 (DE) | Büttel (DE) | Under Consideration | 2026 | Delayed | due to the project |
| 954 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster BorWin 5 (NOR-7-1) | area of Cloppenburg/East | Under Consideration | 2025 | Rescheduled | |
| 955 | New HVDC transmission system consisting of offshore platform, cable and converters. | 100% | Cluster BorWin6 (NOR-7-2) | area of Wilhelmshafen | Under Consideration | 2030 | Rescheduled | |

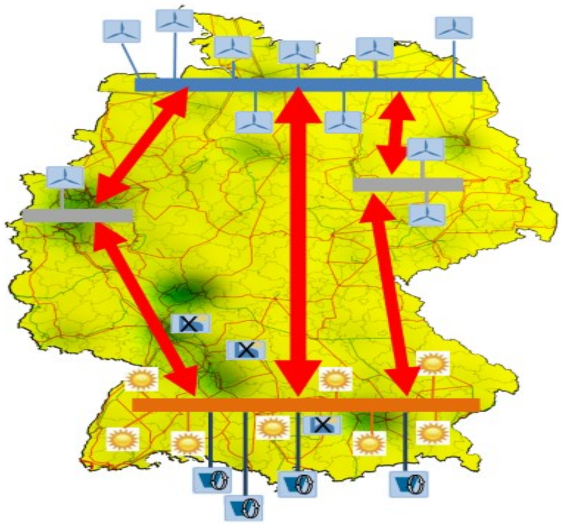
### Additional Information

Information on offshore projects within the northern sea promoted by TenneT TSO GmbH (http://www.tennet.eu/de/netz-und-projekte/offshore-projekte.html) in German

## Investment needs

Germany is planning to build a big amount of offshore wind power plants in the North- and Baltic Sea. The OWP will help to reach the European goal of CO2 reduction and RES integration. These offshore infrastructure projects in the North- and Baltic Seas areas, will deliver benefits for the regional society by pooling generation portfolios, integrating markets, lowering CO2 emissions, facilitating the integration of renewables (both onshore as well as offshore) and ensuring sufficient system resilience.

The development of off-shore wind farms in the North of Germany induces needs for undersea connections to these wind farms as well as reinforcements of the grid capacity from North to South. According to German law, these grid connections have to be constructed and operated by the TSO.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project’s expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | -: 3600 |
| | -: 3600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 6000 ±1000 |
| Cost explanation | |
| S1 | NA |

| | |
|---|---|
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | 800 ±40 | 910 ±60 |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | 11510 ±180 | 12320 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | -4400 ±500 | -5200 ±100 |

The need of this project is depending on the expected increase of Offshore wind generation in Germany (especially in the North Sea). Thats why only results for Vision 3 &4 are available.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 193 - Godelleta-Morella/La Plana

This project consist of a new OHL 400 kV AC axis Godelleta-Morella/La Plana (Spain).

| | |
|---|---|
| Classification | Future Project |
| Boundary | Internal boundary in the east of Spain |
| PCI label | 2.26 |
| Promoted by | REE |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 927 | Southern part of the new Cantabric Mediterranean axis. | 100% | La Plana/Morella | Godelleta | Under Consideration | 2023 | Investment on time | The investment progressed as previously planned |

## Additional Information

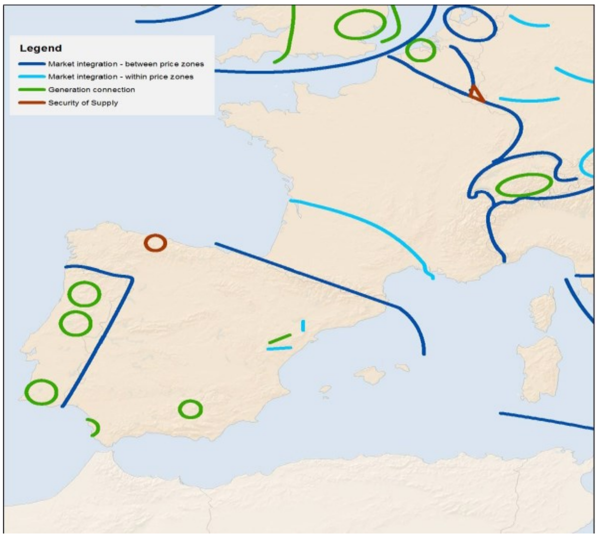
Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

Clustering: the project consists of a unique investment. A double circuit, one circuit connecting Godelleta and Morella and the other Godelleta and La Plana.

## Investment needs

Congestions are expected in the 400 kV axis due to important south-north flows between Castellón and Valencia in both directions caused mainly by renewable energy sources (wind onshore wind but mainly solar), and can result in dumped energy without the project. The Important demand in the touristic Levante coast influences highly the flows.

In addition a reinforcement is needed in this area to complement the reinforcement of the Cantabric-Mediterranean axis needed to accommodate geographical unbalances between North and Levante, which in addition are highly influenced by the exchanges with France,especially in case of high flows in the border.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | south-north: [1100 ; 2400] |
| | north-south: [800 ; 2300] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 69 ±6.9 |
| Cost explanation | Values (CAPEX cost) updated according to last Spanish investment stardard costs |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 150 ±20 | 110 ±20 | 60 ±10 | 70 ±10 |
| B3 RES integration (GWh/yr) | N/A | 50 ±10 | 80 ±20 | 150 ±30 | 330 ±70 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -300 ±100 | -300 ±100 | -200 ±100 | -300 ±100 |

*Savings in variable generation costs (SEW) are caused in V1 and V2 by substitution of gas by coal and in V3 and V4 by substitution of gas by renewable energy sources. Also, the solution of potential constraints, mainly in V1 and V2 are reflected in the results*.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 194 - Cartuja

This project includes a new 400 kV double circuit Cartuja-Arcos de la Frontera and a new substation Cartuja 400 kV.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Internal boundary in the south of Spain |
| PCI label | |
| Promoted by | REE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 561 | New 400kV substation Cartuja with a 400/220kV transformer. | 100% | Cartuja (ES) | | Under Consideration | 2029 | Rescheduled | Rescheduled due to changes in the Spanish Master Plan that consider a delay in the commissioning of the renewable generation link to this project |
| 929 | New double circuit Cartuja-Arcos 400 kV | 100% | Cartuja | Arcos | Under Consideration | 2029 | Rescheduled | Rescheduled due to changes in the Spanish Master Plan that consider a delay in the commissioning of the renewable generation link to this project |

### Additional Information

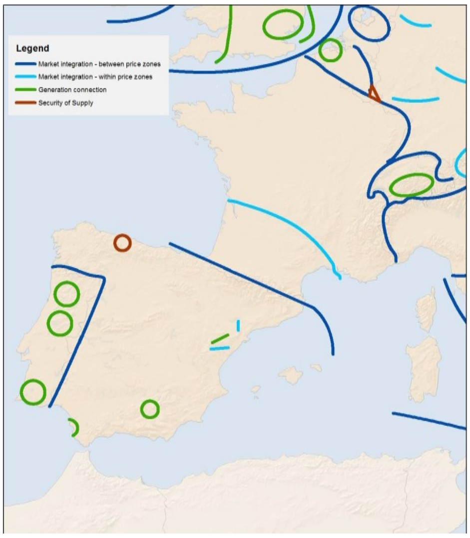
Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

Clustering: the project consists of a new substation (Cartuja) and a double circuit that connect this new substation to the existing network (Arcos-Cartuja). Both investments are necessary to get the full GTC increase of the project. Possible connection to 220kV network in the area is not included in the project.

## Investment needs

The future 400 kV Cartuja substation intends to be the connection point of an important amount of wind power energy in the coastal area of Cadiz, mainly offshore but also onshore. Around 750 MW of wind are considered in Vision 1 in the Cartuja 400kV substation, and around 1300 MW are considered in Vision 3 and 4.

In addition in case of low wind production, a reinforcement of the network in this area will be useful as an additional injection for secure the load in the area of Cadiz.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | ROW-Cartuja: [450 ; 750] |
| | Cartuja-ROW: [750 ; 850] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 39.6 ±4 |
| Cost explanation | Values (CAPEX cost) updated according to last Spanish investment stardard costs. |
| S1 | Negligible or less than 15km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 90 ±10 | <10 | 110 ±20 | 130 ±20 |
| B3 RES integration (GWh/yr) | N/A | 710 ±140 | <10 | 1730 ±350 | 1830 ±370 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -300 ±100 | ±100 | -400 ±100 | -400 ±100 |

Savings in variable generation costs (SEW) are caused mainly by the integration of new RES generation in the system. Therefore higher values are in the scenarios with higher RES considered. Vision 2 does not consider any offshore wind capacity so no benefit is attached to this project.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 197 - N-S Finland P1 stage 2

Several 400 kV AC lines are planned in Finland to be built to increase the North-South transmission capacity thus enabling the integration of new renewable and conventional generation in northern Finland and to compensate dismantling of obsolescent existing 220 kV lines. This project is 400 kV overhead line from connecting North Finland to South.

Classification Long-term Project

Boundary Finland North-South

PCI label

Promoted by FINGRID


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 742 | New single circuit 400 kV OHLs will be built from middle Finland to Oulujoki Area to increase the capacity between North and South Finland. | 100% | Pyhänselkä (FI) | Petäjävesi (FI) | Design & Permitting | 2023 | Investment on time | Progresses as planned |

## Additional Information

The project consist of 400 kV overhead line, series compensation of the line and substation extensions at the terminal substations.

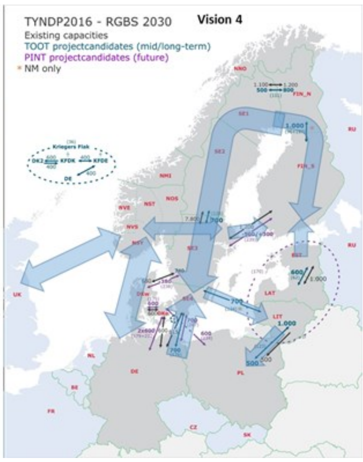
Fingrid has published a national development plan in 2015. The investment plan presents a detailed look of the projects. The plan is available in Finnish:

http://www.fingrid.fi/fi/asiakkaat/asiakasliitteet/Kehittämissuunnitelma/Kantaverkon_kehittämissuunnitelma%202015%20-%202025.pdf

## Investment needs

This project is needed to facilitate the increased bulk power flows from North Finland to South Finland.

Incresed RES in Northern Finland and additional cross border capacity between Northern Sweden and Northern Finland would create a bottle neck between North and South Finland wiithout this project.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | -: 850 |
| | -: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 90 ±10 |
| Cost explanation | Early cost estimation. |
| S1 | NA |
| S2 | NA |
| B6 | N/A |
| B7 | N/A |

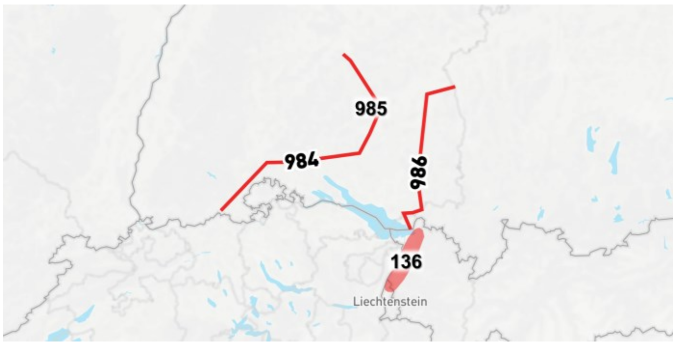
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | -25 ±25 | -50 ±25 | -50 ±25 | -75 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | -3 ±2 | -2 ±1 | -5 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

This project is internal to Finnish price area and does not have direct cross-border capacity impact. As such the Pan European market modeling is inadequate to calculate SEW benefits for this project. The BTC increase is related to capacity between Finland North and Finland South. The only calculated indicators are losses. Losses are decreasing by addition of this project in all scenarios.

## Project 198 - Area of Lake Constance

The transmission capacity of the 380-kV-grid in this grid area and especially the cross-border lines between Germany and Austria are extended significantly by this project. Capacity overloads with existing lines are eliminated and therefore connection between the German and the Austrian transportation grid is strengthened.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Germany - Austria |
| PCI label | 2.11 |
| Promoted by | AMPRION; TRANSNET-BW; VUEN |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 136 | Bodensee study (border DE-AT - Meiningen - Rüthi) | 20-80% | Border area (DE-AT) | Rüthi (CH) | Under Consideration | 2023 | Delayed | Due to the changed market and grid situation in this area, there is a need for an update of the current study and its findings. |
| 984 | line from Herbertingen to Tiengen (Length: approx. 115 km) | 20-80% | Herbertingen (DE) | Tiengen (DE) | Planning | 2020 | Investment on time | |
| 985 | line from Rommelsbach to Herbertingen (Length: approx. 62 km) | 20-80% | Rommelsbach (DE) | Herbertingen (DE) | Permitting | 2019 | Delayed | Delay due to long permitting process |
| 986 | line from Wullenstetten to border area DE-AT (Length: approx. 94 km) | 20-80% | Wullenstetten (DE) | Austrian National border (AT) | Planning | 2020 | Investment on time | |

### Additional Information

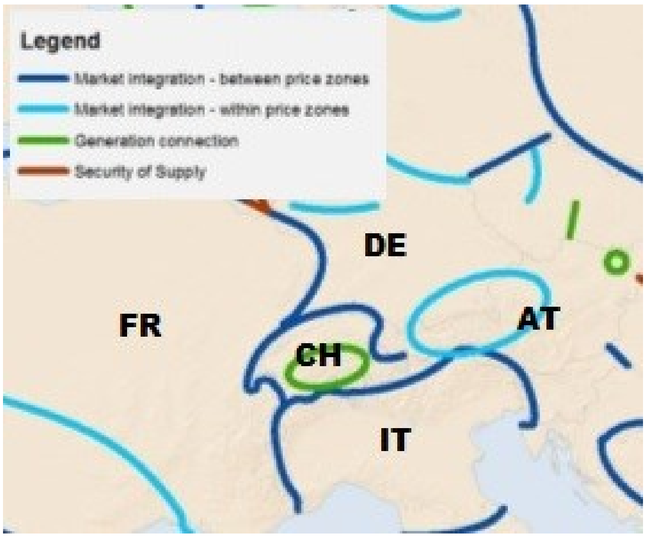
http://www.netzentwicklungsplan.de/ (German network development plan in German)

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf (Second PCI-List)

## Investment needs

The project is part of the grid development in the Continental Central South (CCS) region, which is composed of Austria, France, Germany, Italy, Slovenia and Switzerland. This region is characterised by an increasing penetration of generation from RES mainly at the corners of the region (DE, IT, FR) and the reduction of nuclear generation in Germany, Switzerland and France. The connection of variable RES generation mainly in Germany and Italy with pump storage power plants in the Alps leads to wide area power flows especially in North-South direction and triggers market exchange on the German border towards Austria, Switzerland and France and on the northern borders of Italy. In this context, the project contributes to the integration of RES, supports market integration and ensures system security as well as security of supply in the CCS region.

For this border, no specific capacity analysis has been done in TYNDP16. According to the CBA results of the latest project on this border (P198), the benefit SEW provided by a standard 1 GW capacity increase can be assessed between 20M€ and 50M€  in the 2030 visions except in Vision 2 where it is lower."




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed in the 2020 scenario with a double PINT step compared to the project 187, which is commissioned earlier.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | DE-AT: 1000 |

| | AT-DE: 1000 |
|---|---|
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 460 ±70 |
| Cost explanation | The cost represents the currently expected total investment cost. |
| S1 | 50-100km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 20 ±20 | <10 | 50 ±0 | 40 ±10 |
| B3 RES integration (GWh/yr) | <10 | 20 ±10 | <10 | 540 ±40 | 300 ±20 |
| B4 Losses (GWh/yr) | N/A | 170 ±30 | 125 ±25 | -75 ±25 | 80 ±160 |
| B4 Losses (Meuros/yr) | N/A | 9 ±2 | 6 ±1 | -5 ±2 | 5 ±11 |
| B5 CO2 Emissions (kT/year) | ±100 | 200 ±300 | ±100 | -200 ±200 | -300 ±100 |

*The project leads to a GTC increase between Austria and Germany of 1000 MW in both directions. Due to higher exchanges the losses might slightly increase*

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.29 | 0.13 | 2.23 | 1.85 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.26 | 1.29 | 10.38 | 9.64 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 5.14 | 4.40 | 6.82 | 7.09 |

## Project 199 - Lake Geneva South

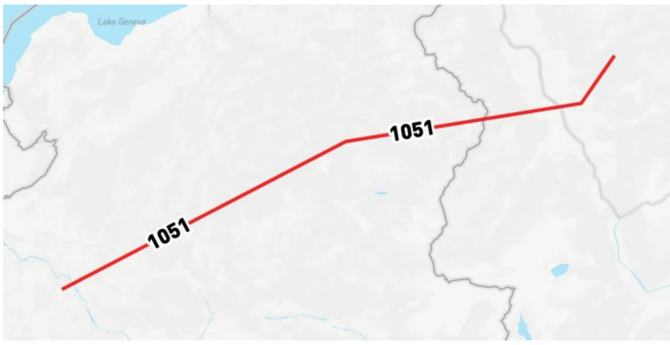
This project comes on top of "Lake Geneva West" and "upstream grid reinforcement in France" projects. It consists in upgrading the existing 225 kV overhead line south of Lake Geneva, possibly to 400 kV.

Classification Future Project

Boundary France - Switzerland

PCI label

Promoted by RTE;SWISSGRID




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1051 | Upgrade of the existing double circuit 225 kV line, possibly to a single 400 kV line | 100% | CORNIER (FR) | CHAVALON (CH) | Under Consideration | 2026 | Rescheduled | In-depth feasibility studies are needed to find the most suitable solution taking into account socio-environmental conditions. The commissioning date is being reassessed accordingly. |

## Additional Information

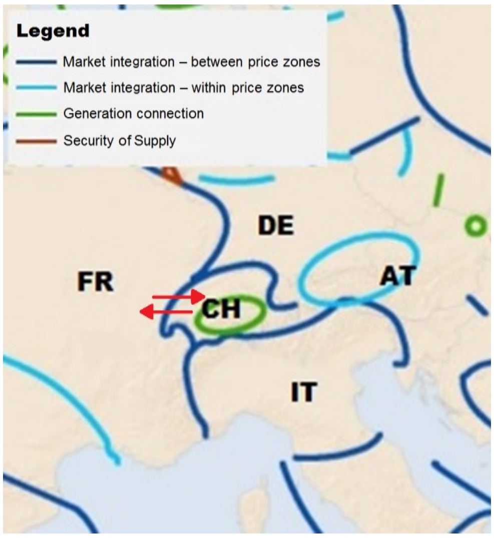
Link to the latest Fench National Development Plan

http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

## Investment needs

This investment is the latest phase of the optimization of the existing grid around the Geneva Lake. After the reinforcement of the grid in France and the implementation of Phase Shifter Transformers to have a better balance of the flows around Lake Geneva, the critical branch is the double circuit 225 kV line between Cornier (FR) and Riddes (CH) and Saint Triphon (CH).
Then, upgrading the critical branch provides higher capacity for the market exchanges in both directions. Direction of physical flows in the south of Geneva Lake are mainly dependant of the hydro generation (turbining or pumping) in the Valais area (CH).

Analyses on this border showed that the benefit SEW provided by a standard 1 GW capacity increase is around 10M€ in all 2030 visions except in Vision 4 where it is higher.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double PINT step compared to the project 253, which is commissioned earlier.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-CH: 750 |
| | CH-FR: 1300 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 120 ±30 |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost.<br>The range reflects the current uncertainty in project scope due to specific geographical conditions. |
| S1 | NA |
| S2 | NA |
| B6 | 0 |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 0 ±0 | <10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | 0 ±0 | <10 | <10 | <10 | 20 ±20 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | 0 ±0 | ±100 | ±100 | ±100 | ±100 |

For the assessment, the existing 225-kV line was supposed upgraded to 400-kV.

The SEW provided by this project remains quite stable for all visions, except for Vision 4 where it is higher, linked to higher amount of integrated RES.

The impact of the project on CO2 emissions can be considered as neutral.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.43 | 1.07 | 0.81 | 1.96 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.77 | 4.58 | 6.21 | 10.10 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.29 | 7.85 | 2.35 | 3.96 |

The above table shows that the prices convergence is quite good in the reference case (taking into account the planned projects) in all scenarios. The portfolio of projects on this border helps reducing the gap between market prices significantly, especally in V1 and 2.

Nevertheless the standard deviation of price differential remains significant, especially in the visions with high RES; in this respect, projects on this border provide market players with additional hedging against prices volatility. This additional benefit is not captured in the SEW.

## Project 200 - CZ Northwest-South corridor

A corridor of internal 400 kV overhead lines inside the Czech Republic connecting new 420 kV substations between Vernerov, Vitkov and existing substation Prestice in the northwest-south direction incuding looping of existing 400 kV overheadline (V413: Reporyje-Prosenice) into the existing substation 420 kV Mirovka. The project consists of building of two new 420 kV substations Vernerov and Vitkov, building of two 400 kV overhead lines involving changing a 220 kV double-circuit lines to 400 kV double-circuit lines with a capacity of 2x1730 MVA between Vernerov-Vitkov and Vitkov-Prestice and building a new double-circuit overhead line between Mirovka and V413.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Czech - Germany |
| PCI label | 3.11.1; 3.11.2 |
| Promoted by | CEPS |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 306 | New 400/110kV substation | 100% | Vitkov (CZ) | | Design & Permitting | 2020 | Investment on time | Progress as planned |
| 307 | New 400/110kV substation | 100% | Vernerov (CZ) | | Under Construction | 2017 | Investment on time | Progress as planned |
| 308 | New double 400kV OHL | 100% | Vernerov (CZ) | Vitkov (CZ) | Design & Permitting | 2023 | Delayed | Based onCEPS request the competent authority is still in the process to changethe status of the project to "public-interest project". |
| 309 | New double 400kV OHL | 100% | Vitkov (CZ) | Prestice (CZ) | Design & Permitting | 2020 | Ahead of time | Changes due to the delay of other investment connecting substation Vitkov |
| 312 | Upgrade of 400/110kV substation | 100% | Mirovka (CZ) | | Design & Permitting | 2020 | Investment on time | Progress as planned |
| 314 | New double 400kV OHL | 40% | Mirovka (CZ) | V413 (CZ) | Design & Permitting | 2018 | Ahead of time | Project rescheduled due to changes of transmission projects to harmonize construction phases. |

### Additional Information

Information about PCI can be found on the CEPS website

PCI 3.11.1: http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/projekty-spolecneho-zajmu/Stranky/Vnitrostátní-vedení-Přeštice-Kočín-PCI-3.11.1.aspx

PCI 3.11.2: [http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/projekty-spolecneho-zajmu/Stranky/Vnitrostátní-vedení-Kočín-Mírovka-PCI-3.11.2.aspx](http://www.ceps.cz/CZE/Cinnosti/Technicka-infrastruktura/projekty-spolecneho-zajmu/Stranky/Vnitrostátní-vedení-Kočín-Mírovka-PCI-3.11.2.aspx)

EC transparency platform also provides information about these PCI:
3.11.1: https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_11_1_en.pdf

3.11.2: https://ec.europa.eu/energy/sites/ener/files/documents/pci_3_11_2_en.pdf

## Investment needs

Part of the corridor North-South electricity interconnections in central Eastern and South Eastern Europe aiming at increasing the transmission capacity in the western part of the Czech grid and therefore enabling the accomodation of the prevailing power flows in the north-west and west-east direction for the entire Central Eastern Europe. Moreover, the project will enable the connection of Renewable Energy Sources in the Karlovary region, reduce infrastructure vulnerability and ensure security of supply in the western region of the Czech Republic.

Separate market based capacity increase has not been evaluated, due to the fact that the investigation which is relevant to the market based capacity increase was considered for Polish synchronous profile PL-DE/CZ/SK. This boundary (CZ-DE) that relates to the Project 35, 177 and 200 is mostly stressed by unscheduled flows caused by volatile production of RES. This fact can be explored when investigating the dependency that describes the higher benefit of each GW when considering higher prices of CO2 emissions and higher RES installed capacity.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project complements project 35 and is commissioned at a later time. In the 2030 visions both projects are assessed as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-CZ: 500 |
| | CZ-DE: 300 |
| Delta GTC contribution (2030) [MW] | DE-CZ: 500 |
| | CZ-DE: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 290±58 |
| Cost explanation | As preparation of the investment items continues, route and technology(e.g. type of towers) are detailed specified to reflect differenttechnical, safety, environmental and legal requirements imposed fromdifferent permit grating processes (e.g. EIA, land and constructionpermit) which usually as a result |

| | |
|---|---|
| | affects cost estimation of theinvestment which were previously given. The difference in currencyexchange rate was also taken into consideration.<br><br>The cost value includes only CAPEX cost. |
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 0 ±0 | 20 ±10 | 20 ±0 | 40 ±0 | 50 ±10 |
| B3 RES integration (GWh/yr) | 0 ±0 | 240 ±10 | 230 ±10 | 540 ±40 | 390 ±80 |
| B4 Losses (GWh/yr) | 0 ±25 | -625 ±62 | -125 ±25 | -25 ±25 | -50 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | -34 ±4 | -6 ±1 | -2 ±2 | -4 ±2 |
| B5 CO2 Emissions (kT/year) | 0 ±0 | -100 ±100 | -100 ±100 | -200 ±0 | -500 ±100 |

Project 200 is 100% dependent on the Project 35, these 2 projects have been evaluated by CBA methodology simultaneously together and it resulted into having same CBA results. Evaluation of benefits in this way stems from the topology, when projects are predominately in series connection and GTC increase and other benefits can only reached by when all these related projects are realized. CBA results according to the common methodology indicates that there are generally decreasing benefits in losses from Vision 1 to Vision 4 with minimum benefit in Vision 3 (high RES), on the other hand increasing benefits from Vision 1 to Vision 4 in CO2.

Project 200 together with project 35 brings additional benefits not covered by common CBA methodology, which are mostly linked to the security of supply and system flexibility. These projects will help to eliminate overloads in N-1 situation in case of high parallel flows across Czech power grid caused by power flow transits from northern part of the Europe to southern or east-south Europe and therefore facilitate RES integration.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.55 | 0.51 | 3.42 | 4.78 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.06 | 2.74 | 12.85 | 14.47 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 4.13 | 4.77 | 6.65 | 7.78 |

The transmission capacity of the 220 kV grid in the western part of the Czech grid has already exhausted which in some operation cases cause violation of the security criteria N - 1. The project which involves the changing of the current 220 kV grid (substations and overhead lines) to 400 kV grid ensure to eliminate the congestion in this part of the grid. Moreover, it is also planned that the operation of the 220 kV will be decommissioned step-by-step between 2019 - 2040, so reinforcement brough by the project not only eliminates the congestion in this part of the grid but also replaces the 220 kV grid to be decommisioned.

## Project 203 - Aragón-Castellón

The project consists of two 400kV axis Mudejar-Morella and Mezquita-Morella that converge in an axis Morella-La Plana. The project also includes a new 400kV substation Mudejar with connection to the axis Aragón-Teruel (Spain).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal boundary in the east of Spain |
| PCI label | 2.25 (2.25.1 & 2.25.2) |
| Promoted by | REE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 537 | Southern part of the new Cantabric-Mediterranean axis. New 400kV substation Mudejar. | 100% | Mudejar (ES) | | Commissioned | | Commissioned ahead of time | |
| 538 | New double circuit Morella-La Plana 400kV-OHL. | 100% | Morella (ES) | La Plana(ES) | Permitting | 2018 | Investment on time | The investment progressed as previously planned |
| 1069 | Mezquita-Morella 400 kV line | 30-60% | Mezquita | Morella | Permitting | 2017 | Investment on time | Final phase of permitting. Construction will start soon. |
| 1070 | Mudejar-Morella 400 kV | 100% | Mudejar | Morella | Commissioned | | Commissioned ahead of time | |

### Additional Information

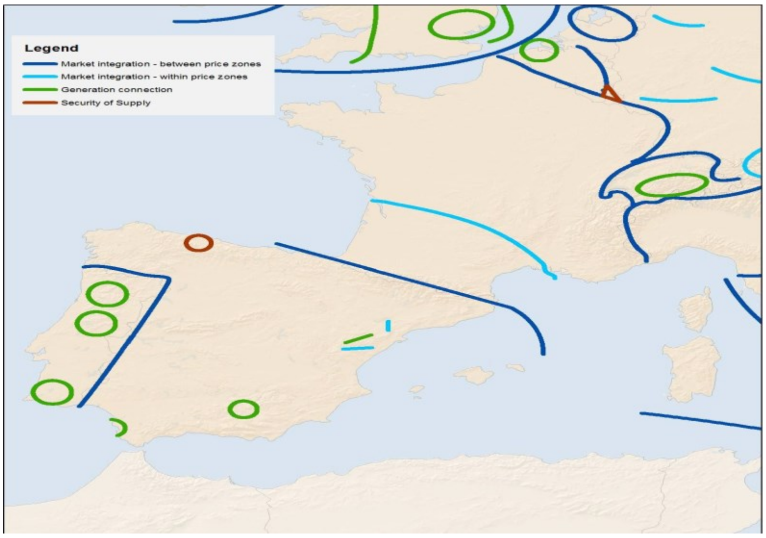
Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

Clustering: The objective of this project is to solve the congestion in the existing line Aragón-Morella-La Plana 400kV, which can not be uprated . Therefore a new parallel axis with higher capacity will be built and the old line will be decommissioned. For such a purpose as Aragón subestation can not be extended to be an extreme of the new double circuit, a new subestation in Mudejar is required. The whole axis is in series so that all is required for the GTC increase. The other investment Mezquita-Morella 400kV gathers RES in Muniesa and Mezquita area. This investment need to be clustered because without  it the flows could go up to Aragón (causing overloads in the 220kV Mezquita-Aragón)  to go down in the Aragón-Morella axis increasing the load of it, and increasing losses.

## Investment needs

There is a need for solving the already current congestion in the existing line Aragón-Morella-La Plana 400kV, which can not be uprated, in order to accommodate increasing flows from Aragón to Levante and viceversa. Therefore a new parallel axis with higher capacity is required and the old line will be decommissioned.

A reinforcement in this axis will represent also the reinforcement of the Cantabric-Mediterranean axis, needed to accommodate geographical unbalances between Northern Spain and the Mediterranean area, which otherwise would produce congestions in the 400 kV corridors, which can get much worse with high exchanges between Spain and France.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | south-north: 1000 |
| | north-south: 1400 |
| Delta GTC contribution (2030) [MW] | south-north: [400 ; 2000] |

| | |
|---|---|
| | north-south: [400 ; 1600] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 130 ±13 |
| Cost explanation | CAPEX cost +-10% uncertainty (procurement / construction cost uncertainties) |
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 70 ±10 | 140 ±20 | 110 ±20 | 120 ±20 | 190 ±30 |
| B3 RES integration (GWh/yr) | 10 ±< 10 | 40 ±10 | 50 ±10 | 390 ±80 | 550 ±110 |
| B4 Losses (GWh/yr) | -100 ±25 | 50 ±25 | 25 ±25 | -50 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | -5 ±1 | 2 ±2 | 1 ±1 | -3 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | -200 ±40 | ±100 | ±100 | ±100 | -100 ±100 |

Savings in variable generation costs (SEW) are caused in V1 and V2 by substitution of gas by coal and in V3 and V4 by substitution of gas by renewable energy sources. Also, the solution of potential constraints are reflected in the results.

## Project 204 - Grid extension between Thuringa and Bavaria

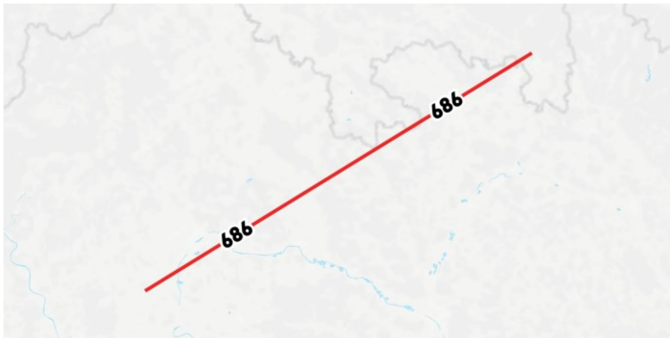
New 380-kV-OHL between Altenfeld (Thuringa) and Grafenrheinfeld (Bavaria) due to increase of RES in Northern Germany

Classification Long-term Project

Boundary Internal Project

PCI label

Promoted by 50HERTZ;TENNET-DE




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 686 | New double circuit OHL 380-kV-line (130 km) | 100% | Schalkau / area of Altenfeld (DE) | area of Grafenrheinfeld (DE) | Planning | 2024 | Investment on time | In time relative to TYNDP14. |

### Additional Information

**German grid development plan:**

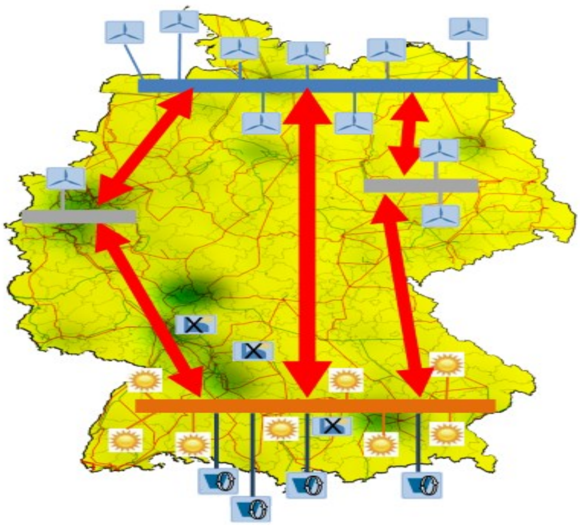
http://www.netzentwicklungsplan.de/en

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the transmission capacity between Thuringia, an area with increasing generation capacity including high amounts of RES, and Bavaria, an area with decreasing conventional power generation and high consumption, and will therefore help relieving the already highly loaded lines between these areas.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 160 ±24 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |

| | |
|---|---|
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 30 ±10 | 20 ±10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±10 | <10 | 50 ±10 | 30 ±10 |
| B4 Losses (GWh/yr) | -200 ±25 | -175 ±25 | -200 ±25 | -25 ±25 | -25 ±25 |
| B4 Losses (Meuros/yr) | -9 ±1 | -10 ±2 | -9 ±1 | -2 ±2 | -2 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | 200 ±100 | 100 ±100 | ±100 | ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

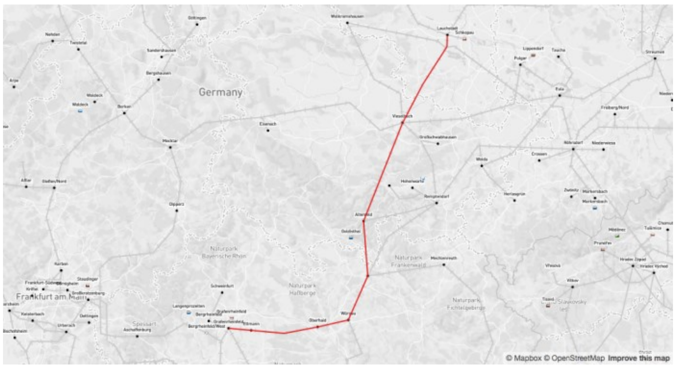
For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 205 - South-West Interconnector

The South-West Interconnector is a new 380 kV overhead line, constructed by 50Hertz and Tennet between Bad Lauchstädt (Saxony-Anhalt) and Redwitz/Grafenrheinfeld (Bavaria).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Project |
| PCI label | 3.13 |
| Promoted by | 50HERTZ;TENNET-DE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 153 | Upgrade of 220kV connection Redwitz - Grafenrheinfeld to 380kV | 100% | Redwitz (DE) | Grafenrheinfeld (DE) | Commissioned | 2015 | Investment on time | in time relative to TYNDP14 |
| 193 | New 380kV double-circuit OHL between the substations Vieselbach-Altenfeld-Redwitz with 215km length combined with upgrade between Redwitz and Grafenrheinfeld (see investment 153). The Sections Lauchstädt-Vieselbach and Vieselbach-Altenfeld has already been commissioned. | 100% | Vieselbach (DE) | Redwitz (DE) | Under Construction | 2016 | Delayed | 3rd section (Altenfeld – Redwitz) is under construction now, long permitting process with strong public resistance. |

### Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

**Project Homepage:**

http://www.50hertz.com/en/Grid-Extension/Projects/South-West-Interconnector

**Second PCI-List:**

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

Project Specific Websites

http://www.50hertz.com/en/Grid-Extension/Projects-of-Common-Interest-PCI

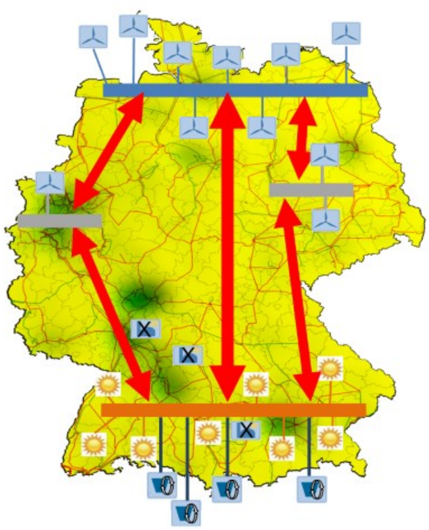
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/altenfeld-redwitz.html

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the transmission capacity between Thuringia, an area with increasing generation capacity including high amounts of RES, and Bavaria, an area with decreasing conventional power generation, and will therefore help relieving the already highly loaded lines between these areas.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a multiple TOOT step compared to the projects 130 and 204, which are commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| **General CBA Indicators** | |
|---|---|
| Delta GTC contribution (2020) [MW] | CZ-DE: 550 |
| | DE-CZ: 550 |
| Delta GTC contribution (2030) [MW] | CZ-DE: 550 |
| | DE-CZ: 550 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 400 ±20 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | 50-100km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| **Scenario specific CBA indicators** | **EP2020** | **Vision 1** | **Vision 2** | **Vision 3** | **Vision 4** |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 150 ±20 | 460 ±70 | 300 ±50 | 140 ±20 | 110 ±20 |
| B3 RES integration (GWh/yr) | <10 | 1350 ±270 | 730 ±150 | 1170 ±230 | 1180 ±240 |
| B4 Losses (GWh/yr) | 575 ±57 | 750 ±75 | 600 ±60 | 300 ±30 | 275 ±27 |
| B4 Losses (Meuros/yr) | 24 ±3 | 40 ±5 | 27 ±3 | 18 ±2 | 18 ±2 |
| B5 CO2 Emissions (kT/year) | 1100 ±170 | 1400 ±200 | 1000 ±200 | -300 ±100 | -400 ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. The mentioned GTC value is the additional crossborder impact of the project.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover  the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 206 - Reinforcement Southern DE

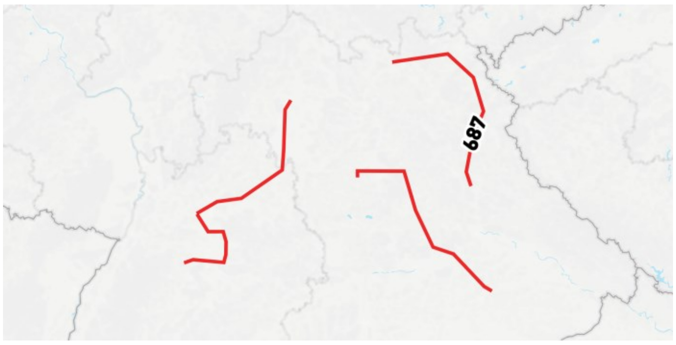
"AC-busbar" in Southern Germany for energy dispatching within Bavaria and Baden-Württemberg and gathering solar energy.

Classification Long-term Project

Boundary inside-inside

PCI label

Promoted by TENNET-DE;TRANSNET-BW




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 682 | Extension of existing 380 kV line Großgartach - Endersbach (32 km) | 100% | Großgartach (DE) | Endersbach (DE) | Planning | 2020 | Rescheduled | Standard processing |
| 687 | New double circuit OHL 380 kV line in existing OHL corridor Redwitz-Mechlenreuth-Etzenricht-Schwandorf (185 km) | 100% | Redwitz (DE) | Schwandorf (DE) | Permitting | 2023 | Delayed | Delay due to long permitting process |
| 688 | New 380 kV line in existing OHL corridor Raitersaich - Ludersheim -Sittling - Altheim | 100% | Raitersaich (DE) | Altheim (DE) | Planning | 2024 | Investment on time | in time relative to TYNDP 2014 |
| 990 | Additional 380-kV-circuit on existing OHL | 100% | Grafenrheinfeld (DE) | Großgartach (DE) | Planning | 2020 | Rescheduled | Standard processing |

### Additional Information

German grid development plan:

http://www.netzentwicklungsplan.de/en

Information on investment 687 (in German)
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/ostbayernring.html

Information on investment 990 (in German)

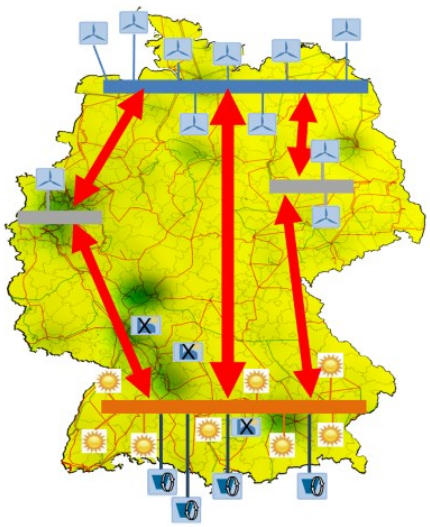
https://www.transnetbw.de/de/uebertragungsnetz/dialog-netzbau/grafenrheinfeld-kupferzell–grossgartach

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia or Switzerland) are required.

This project will increase the transmission capacity in Bavaria and Baden-Württemberg. It will help to strengthen the transmission grid in that region in order to cope with the increasing energy from RES.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| **General CBA Indicators** | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 570 ±90 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 70 ±10 | 160 ±20 | 60 ±10 | 70 ±10 |
| B3 RES integration (GWh/yr) | <10 | 130 ±30 | 270 ±50 | 700 ±140 | 700 ±140 |
| B4 Losses (GWh/yr) | -250 ±25 | -75 ±25 | 0 ±25 | -75 ±25 | -25 ±25 |
| B4 Losses (Meuros/yr) | -11 ±1 | -4 ±1 | 0 ±1 | -5 ±2 | -2 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | 300 ±100 | 700 ±100 | -200 ±100 | -200 ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high  in some situations. The practical handling of such big redispatch volumes is critical.

Moreover  the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

# Project 207 - Reinforcement Northwestern DE

Integration of on- and offshore RES in Lower Saxony

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | inside-inside |
| PCI label | |
| Promoted by | TENNET-DE |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 675 | Upgrade of 220-kV-circuit Unterweser-Conneforde to 380kV , Line length: 32 km. | 100% | Conneforde (DE) | Unterweser (DE) | Under Consideration | 2024 | Investment on time | on time relative to TYNDP14 |
| 676 | New 380 kV line in existing OHL corridor Dollern - Elsfleht/West Length:100 km | 100% | Dollern (DE) | Elsfleht/West (DE) | Planning | 2024 | Investment on time | on time relative to TYNDP14 |
| 939 | New 380-kV-line in existing OHL corridor | 100% | Conneforde | Emden/Ost | Permitting | 2021 | Delayed | Delay due to long permitting process |
| 940 | New 380-kV-line Emden - Halbemond for RES integration | 100% | Emden/Ost | Halbemond | Planning | 2022 | Delayed | Delay due to long permitting process |

## Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

Information on Investment 939 (in German)

http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/emden-conneforde.html

Information on Investment 940 (in German)

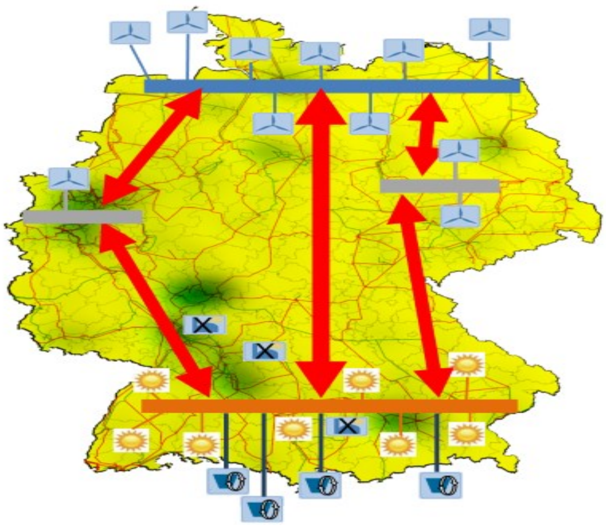
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/halbemond-emdenost.html

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the capacity within Lower Saxony and will help to solve the transmission constraints of the grid in the northern part of Lower Saxony caused by the huge amount of increasing RES in this area.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 610 ±90 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 230 ±30 | 200 ±30 | 400 ±60 | 220 ±30 |
| B3 RES integration (GWh/yr) | <10 | 4880 ±980 | 4350 ±870 | 5200 ±1040 | 2810 ±560 |
| B4 Losses (GWh/yr) | -25 ±25 | 25 ±25 | 100 ±25 | -75 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 1 ±2 | 4 ±2 | -5 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | -3300 ±500 | -3700 ±500 | -4100 ±600 | -2000 ±300 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

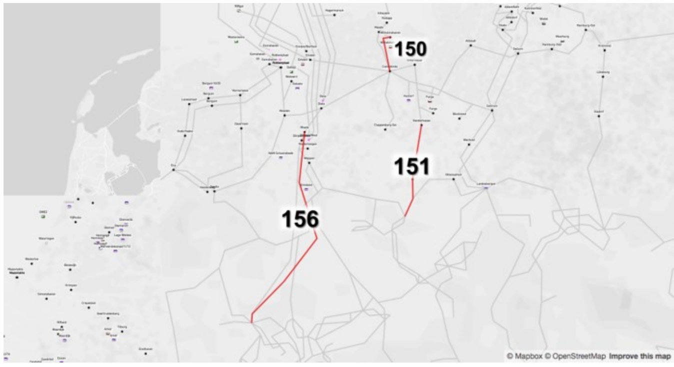
For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for $CO_2$ emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

# Project 208 - RES-Integration in North-West Germany 1

Project 208 consists of a new 380 kV overhead line (partly in an existing corridor) for up to four 380 kV systems. The project is needed for integration of on- and offshore wind energy and transport to the load centres in western and southern parts of Germany.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Project |
| PCI label | |
| Promoted by | AMPRION;TENNET-DE |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 150 | New 380kV double circuit (OHL+ underground cable) Conneforde - Wilhelmshaven including new 380kV switchgear Fedderwarden | 100% | Conneforde (DE) | Fedderwarden (DE) | Permitting | 2020 | Delayed | Delay due to long permitting process |
| 151 | New line (Length: approx. 95 km), extension of existing line, construction of substations and 380/110kV-transformers | 100% | Wehrendorf (DE) | Ganderkesee (DE) | Permitting | 2021 | Delayed | Long permitting process and additional longer constructing phase due to requirement of underground cable in some parts of the line. |
| 156 | New line from Dörpen to Niederrhein (Length: approx. 182 km) | 100% | Niederrhein (DE) | Dörpen/West (DE) | Permitting | 2019 | Delayed | Delay due to long permitting process |

## Additional Information

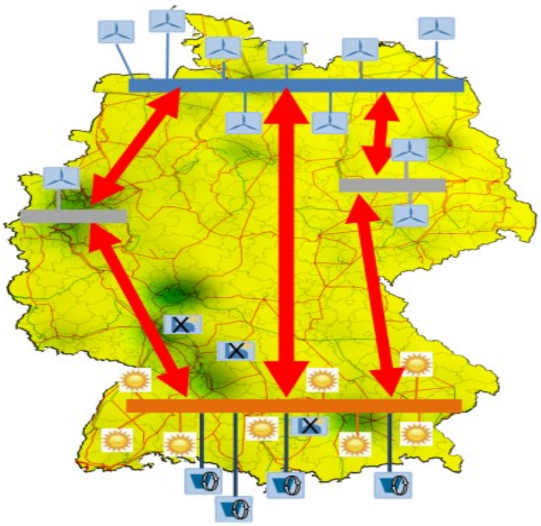
Further information on the project, its investments and their necessity particularly for the German Energiewende can be found in the German grid development plan (in German):
http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0
More detailed information on Investment 156 can be found on the investment website (in German):
http://netzausbau.amprion.net/projekte/wesel-meppen/projektbeschreibung

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and storages (for example Scandinavia) are required.

This project will increase the transmission capacity between Lower Saxony and North Rhine-Westphalia and will help to integrate big amounts of energy from both on- and offshore wind turbines.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the project 132, which is commissioned later.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 810 ±120 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 120 ±20 | 410 ±60 | 310 ±50 | 600 ±90 | 670 ±100 |
| B3 RES integration (GWh/yr) | 250 ±50 | 2540 ±510 | 1800 ±360 | 1150 ±230 | 7170 ±1430 |
| B4 Losses (GWh/yr) | -200 ±25 | -175 ±25 | -175 ±25 | -100 ±25 | 175 ±25 |
| B4 Losses (Meuros/yr) | -9 ±1 | -10 ±2 | -8 ±1 | -6 ±2 | 11 ±2 |
| B5 CO2 Emissions (kT/year) | -100 ±20 | ±100 | 200 ±100 | -6800 ±1000 | -3900 ±600 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the SEW:*

For the redispatch based benefit calculations only costs resulting from changing generation dispatches leading to different fuel costs (including costs for CO2 emissions) were determined. Whilst the overall redispatch costs, additionally consisting of passed market premiums, costs for holding re- dispatchable generation and compensation payments for reducing power from RES generation units , were neglected.

Therefore the displayed project benefits are only illustrating the lower limit due to the underestimation of the redispatch costs.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 209 - Reinforcement Northeastern DE

New 380-kV-lines in the area of Schleswig-Holstein mainly for integration of Onshore-Wind.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | inside-inside |
| PCI label | |
| Promoted by | TENNET-DE |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 935 | New 380-kV-line Kreis Segeberg - Lübeck - Siems - Göhl | 100% | Kreis Segeberg | Göhl | Planning | 2022 | Delayed | Delay due to long permitting process |

## Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

Project webpage (in German)

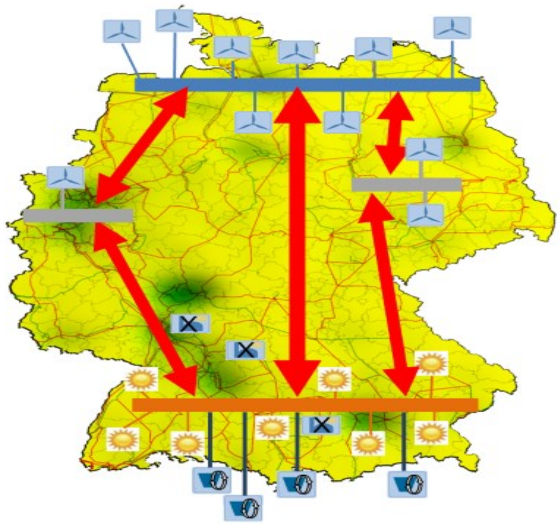
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/ostkuestenleitung.html

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the capacity within Schleswig-Holstein as well as from Schleswig-Holstein to the south and will help to solve the transmission insufficiency of the grid in this area caused by the huge amount of increasing RES in the eastern part of Schleswig-Holstein. Furthermore it will reduce overload induced interventions to the Baltic Cable flow in both directions even under n-1-situations.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE intern |
| | DE intern |
| Delta GTC contribution (2030) [MW] | DE intern |
| | DE intern |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 160 ±30 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |

| | |
|---|---|
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 70 ±10 | 20 ±10 | <10 | 80 ±10 | <10 |
| B3 RES integration (GWh/yr) | 40 ±10 | 410 ±80 | 180 ±40 | 970 ±190 | 60 ±10 |
| B4 Losses (GWh/yr) | -150 ±25 | -125 ±25 | -125 ±25 | -125 ±25 | -150 ±25 |
| B4 Losses (Meuros/yr) | -7 ±1 | -7 ±2 | -6 ±1 | -8 ±2 | -10 ±2 |
| B5 CO2 Emissions (kT/year) | 400 ±60 | -300 ±100 | -200 ±100 | -800 ±100 | ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high  in some situations. The practical handling of such big redispatch volumes is critical.

Moreover  the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 210 - Wurmlach (AT) - Somplago (IT) Interconnection

"Somplago - Wurmlach interconnection is a third party cross-border electrical line promoted by Alpe Adria Energia SpA. The project concerns a 220kV a.c. merchant line, 300 MVA from Somplago substation to Wurmlach substation, including a 300MW Phase Shift Transformer, located in Austria".

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | Austria - Italy |
| PCI label | |
| Promoted by | Alpe Adria Energia SpA |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1380 | | 100% | SOMPLAGO | WURMLACH | Permitting | 2018 | Delayed | |

### Additional Information

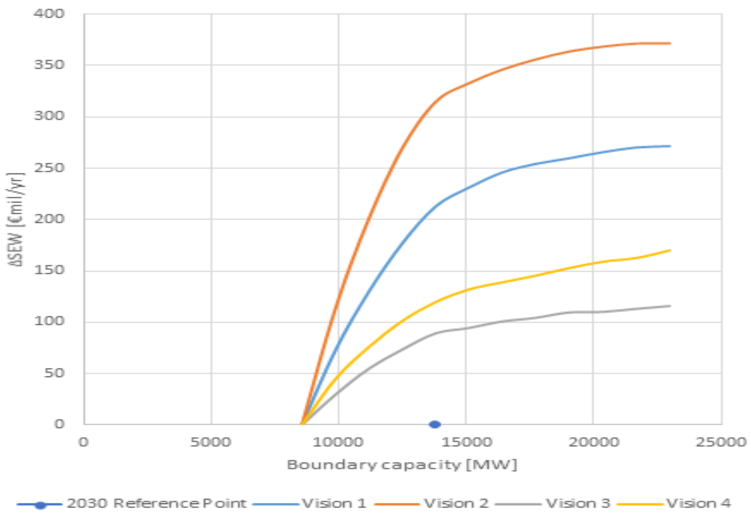
Project website:

https://www.enel.it/it-it/impianti/progetti_speciali/alpe_adria_energia/

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for V2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-AT: 150 |
| | AT-IT: 150 |
| Delta GTC contribution (2030) [MW] | IT-AT: 150 |
| | AT-IT: 150 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 60 |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±< 10 | <10 | 10 ±10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 20 ±30 | 10 ±30 |
| B4 Losses (GWh/yr) | 0 ±25 | -200 ±25 | 0 ±25 | 25 ±25 | -25 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | -11 ±2 | 0 ±1 | 1 ±2 | -2 ±2 |
| B5 CO2 Emissions (kT/year) | 600 ±40 | 200 ±0 | 200 ±0 | ±100 | ±100 |

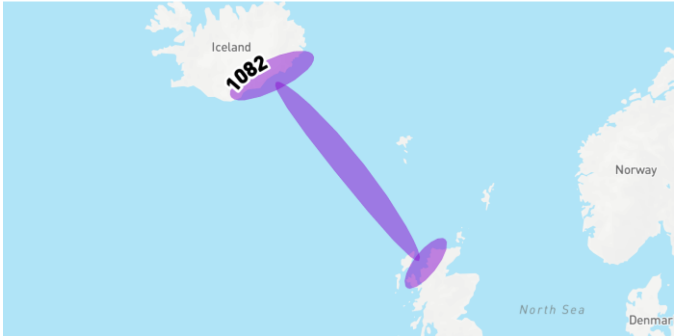
The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.43 | 1.14 | 1.42 | 0.91 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.97 | 4.50 | 8.33 | 5.85 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 11.00 | 13.20 | 2.11 | 2.01 |

## Project 214 - Interco Iceland-UK

Interconnector (Sea cable) between Iceland and Great Britain. The Cable is DCwith 800-1200 MW capacity and over 1.000 km long. 99.98% of the generation in Icelandis RES. Icelands hydro generation is highly flexible and ideal for complementingintermittency of GB’s growing wind sector.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Iceland - Great Britain |
| PCI label | |
| Promoted by | LANDSNET;NGIHL |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1082 | Interco Iceland-UK | 100% | tbd | tbd | Under Consideration | 2030 | New Investment | Increased RES integration and market coupling |

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

### General CBA Indicators

| | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IS-GB: 1200 |
| | GB-IS: 1200 |
| Capex Costs 2015 (m€)<br>Source: Project Promoter | |
| Cost explanation | |
| S1 | |
| S2 | |

| | |
|---|---|
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 370 ±10 | 320 ±20 | 330 ±50 | 380 ±10 |
| B3 RES integration (GWh/yr) | N/A | 5710 ±10 | 5430 ±160 | 4750 ±810 | 5470 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -2300 ±100 | -3000 ±200 | -1500 ±300 | -2100 ±100 |

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 216 - Massif Central North

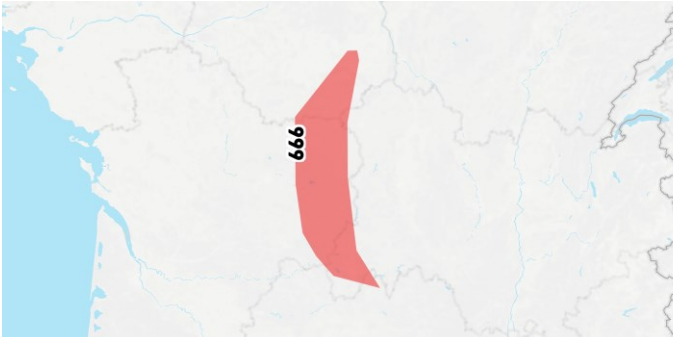
The project is a grid reinforcement in an existing corridor. The precise description of the project needs additional studies.

Classification Long-term Project

Boundary Internal boundary in France North-South

PCI label

Promoted by RTE




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 999 | grid reinforcement between Marmagne and Rueyres | 100% | Marmagne or Eguzon | Rueyres | Under Consideration | 2030 | Investment on time | This long term investment is needed for scenarios with high RES development in the area, especially wind and hydro and/or with high exchanges with Spain as in all 2030 visions (8GW); additional studies are in progress for better investment definition. |

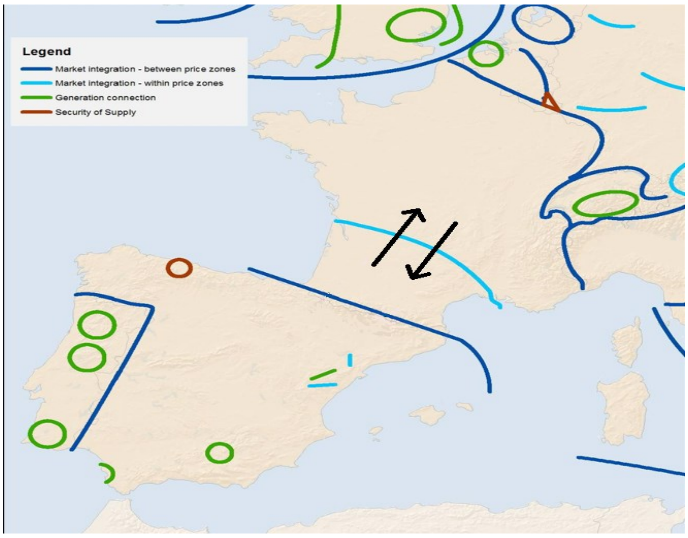
## Additional Information

This project is a grid reinforcement and several strategies are still under consideration to find the best option using the existing corridors.

French National Development Plan http://www.rte-france.com/sites/default/files/schema_decennal_de_developpement_du_reseau_edition_2015_syntese.pdf

## Investment needs

The main driver for the project is the integration of existing and new wind, solar and hydro generation in the Massif Central (France) including possible pump storage. Furthermore, this axis is essential for french energy transition and enables needed exchanges of renewable energy between north and south of France. This project stay linked to the evolution of the energetic mix of this area, and is also robust to ensure future evolution.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | South-[FR] North : 3000 |
| | [FR] North - South: 3000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 500 ±100 |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 50 ±10 | 200 ±30 | 250 ±40 | 200 ±30 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | -100 ±25 | -175 ±25 | -175 ±25 | -150 ±25 |
| B4 Losses (Meuros/yr) | N/A | -6 ±2 | -8 ±1 | -11 ±2 | -10 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | -200 ±100 | -700 ±100 | -900 ±100 | -700 ±100 |

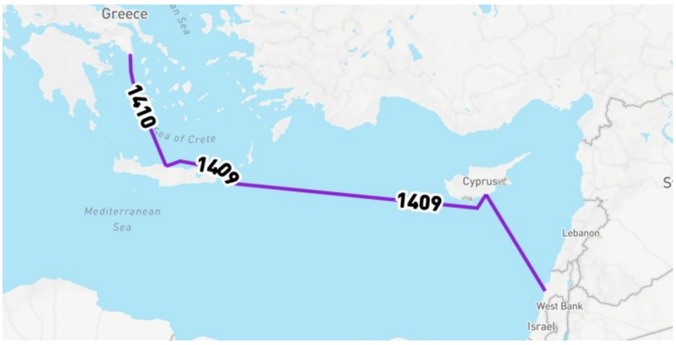
Internal projects in France are necessary in the reference case for 2030 network. As they are linked to the internal hypothesis like future RES integration, their assessment can not be done only with the standard market studies (only one node per country)., as they are taking into account internal redispatching.

Thus, the SEW indicator has been calculated to assess the internal redispatching necessary to respect the market based flows between France and Spain (8 GW for 2030 visions)

## Project 219 - EuroAsia Interconnector

The Euro Asia Interconnector consists of a 400 kV DC underwater electric cable and any essential equipment and/or installation for interconnecting the Cypriot, Israeli and the Greek transmission networks (offshore). The Interconnector will have a capacity of 2000 MW and a total length of around 820 nautical miles/around 1518 km (approx. 329 km between CY and IL, 879 km between CY and Crete and 310 km between Crete and Athens) and allow for reverse transmission of electricity

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | Cyprus - Greece - Israel |
| PCI label | |
| Promoted by | EuroAsia Interconnector |

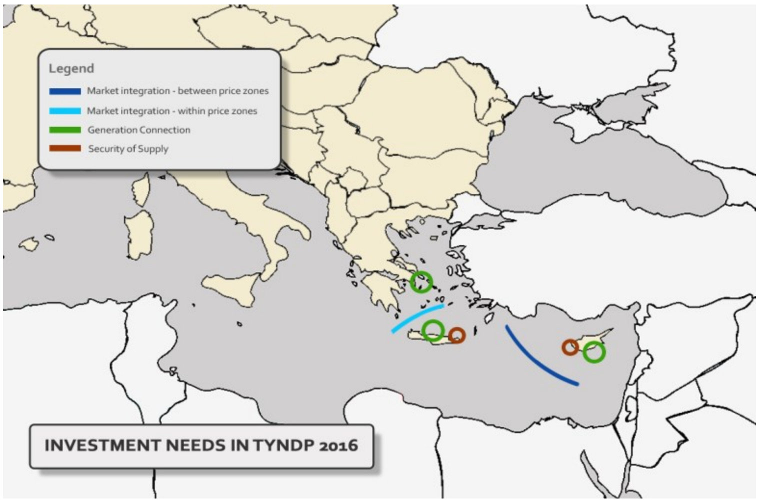



## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1407 | | 100% | Hadera Site | Vasilikos Site | Planning | 2019 | | |
| 1409 | | 100% | Vasilikos Site | Korakia (Crete)Site | Planning | 2022 | | |
| 1410 | | 100% | Korakia (Crete)Site | Athens Site | | 2020 | | |

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | CY-GR: 2000 |
| | GR-CY: 2000 |
| Delta GTC contribution (2030) [MW] | CY-GR: 2000 |
| | GR-CY: 2000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 4246.9 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 360 ±40 | 660 ±100 | 580 ±90 | 1010 ±150 | 1120 ±170 |
| B3 RES integration (GWh/yr) | 750 ±50 | 4080 ±820 | 4070 ±810 | 3260 ±650 | 3010 ±600 |
| B4 Losses (GWh/yr) | 1250 ±125 | 1100 ±110 | 1100 ±110 | 1225 ±122 | 2050 ±205 |
| B4 Losses (Meuros/yr) | 54 ±5 | 59 ±6 | 51 ±5 | 73 ±7 | 137 ±14 |
| B5 CO2 Emissions (kT/year) | ±100 | -5600 ±800 | -6800 ± | -2300 ±300 | -1300 ±200 |

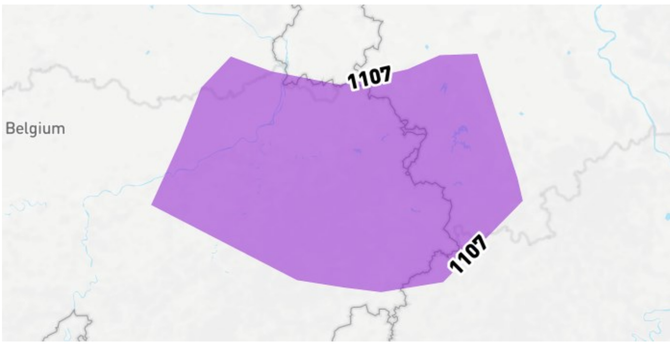
Congestion is manifested when there are market opportunities between two market areas. Such opportunities cannot be achieved, due to an interconnection capacity limitation. Based on the results of the Cost-Benfit-Analysis Study the interconnector is almost in full utilised in the direction Israel to Cyprus to Crete to mainland Greece. Thus, congestions are expected to be substantial.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.01 | 0.01 | 0.01 | 0.01 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 0.00 | 0.00 | 0.00 | 0.00 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 0.00 | 0.00 | 0.00 | 0.00 |

## Project 225 - 2nd interconnector Belgium - Germany

This project considers the possibility of a second 1GW interconnection (DC is an option) between Belgium and Germany. Preliminary studies have indicated potential for further regional welfare increase by further increasing the interconnection capacity between Belgium and Germany.The determination of the optimal capacity, location, technology, potentially needed internal grid reinforcements and possible synergies with the long-term concept of a "west-east corridor" in the North Sea area are subject of further studies. In this context, Elia and Amprion are conducting a bilateral study.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Belgium - Germany |
| PCI label | |
| Promoted by | AMPRION;ELIA |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1107 | 2nd Interconncetor BE-DE: envisions the possibility of a second 1 GW HVDC interconnection between Belgium and Germany. Subject to further studies. | 100% | to be defined (BE) | to be defined (DE) | Planning | 2025 | Rescheduled | The project has been rescheduled with an indicative date of 2025 related to its potential to security-of-supply (adequacy) contribution within a context of planned nuclear phase out. The evaluation of this potential as well as interaction with reinforcements on neighboring borders are subject of further studies. |

## Additional Information

The project is integrated in Elia's National Development Plan 2015-2025 (http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025) and is being put forward as part of the reference in the scenario framework for the new German National Development Plan (NEP edition 2017).

## Investment needs

The transition of the energy mix in Belgium and Germany is characterized by a planned nuclear phase out and an ambitious target for the integration of RES. This generates a corresponding potential to develop transmission capacity between the Belgian and German power systems, enabling the utilization of the cheapest available energy across the border.

The ALEGrO-link (project 92) develops a first 1 GW interconnection capacity on the DE-BE border. The potential for further development of interconnection capacity between Germany and Belgium is captured via project # 225 and preliminary quantified as 1 GW. This quantification is subject to further studies evaluating the feasability of different implemenation options, the potential to security-of-supply (adequacy) contribution within context of planned nuclear phase out, as well as interaction with reinforcements on neighbouring borders.


## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | DE-BE: 1000 |
| | BE-DE: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 500 ±100 |
| Cost explanation | The cost represents the currently expected total investment cost.Uncertainty range reflects the fact that optimal location, capacity & route is subject to further studies |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | <10 | 10 ±10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | 10 ±10 | 10 ±10 | 170 ±70 | 80 ±20 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 400 ±100 | ±100 | ±100 | -100 ±200 |

Highest SEW values in the coal before gas scenario 2030V1 due to replacement of gas-fired production in Belgium with cheaper production, such as coal-fired production, from Germany. In 2030V3 & 2030 V4 the evolution in the production park is combined with a merit order switch between gas and coal, leading gas-fired production setting the price during most of the year and consequently a smaller potential for price convergence.

The substitution effect of gas-coal is reflected in the CO2 impact indicator.

A further elaboration of the benefits is ongoing within the bilateral study that Elia and Amprion are conducting, hereby assessing the contribution of the project for market integration, RES integration and security of supply, and also evaluating the interaction with reinforcements on neighboring borders as well as the potential need for complementary internal grid reinforcements.

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.50 | 0.55 | 1.22 | 0.88 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 5.10 | 3.02 | 7.92 | 6.34 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 13.64 | 12.40 | 6.55 | 7.83 |

## Project 227 - CSE8 Transbalkan Corridor

The project aim is to increase transmission capacity within Serbia and facilitateexchange of energy between north-east part of Europe and south-west ofEurope.

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | inside-outside |
| PCI label | |
| Promoted by | EMS, CGES, NOSBiH |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 627 | New double 400kV OHL between Serbia and B&H. | 100% | Bajina Basta (RS) | Visegrad (BA) | Design & Permitting | 2022 | Delayed | Del_ Financing issues |
| 628 | Double circuit 400 kV OHL between upgraded substation Bajina Basta and substation Obrenovac | 100% | SS Bajina Basta (RS) | SS Obrenovac (RS) | Design & Permitting | 2021 | Delayed | Del_ Financing issues |
| 630 | New double 400kV OHL between Serbia and Montenegro. | 100% | Bajina Basta (RS) | Pljevlja (ME) | Design & Permitting | 2022 | Delayed | Del_ Financing issues |
| 631 | 400/220 kV substation in Bajina Basta, upgrading an existing substation to 400 kV voltage level | 100% | Bajina Basta (RS) | | Design & Permitting | 2021 | Delayed | Del_ Financing issues |

### Additional Information

The Project 227 represents a strategic investment of regional and pan-European significance. Serbia has borders with eight countries in the heart of the Balkans. Because of its geographical position, Serbia's transmission network represents a vital link among the transmission systems of the region for purposes of creating a market and increasing efficiencies for the regional system. When completed, the Transbalkan Corridor will significantly strengthen the critical northeast-southwest and east-west regional and pan-European corridors which are some of the most congested transmission corridors in the Southeast Europe region. The Project consists of the following OHL investments, with a total length of the OHLs of 195km:

- Upgrade of transmission network in Western Serbia at 400 kV voltage level between SS Obrenovac and SS Bajina Basta, which implies new double 400 kV OHL SS Obrenovac – SS Bajina Basta, reconstruction of existing SS Obrenovac and SS Bajina Basta, 111 km,
- New 400 kV interconnection between Serbia, Bosnia and Hercegovina and Montenegro, which implies double 400 kV OHL between SS Bajina Basta, SS Visegrad (BiH), and SS Pljevlja (Montenegro), 84 km.

For upgrade of transmission network in Western Serbia at 400 kV voltage level between SS Obrenovac and SS Bajina Basta, Feasibility Study, Preliminary Design and Environmental Impact Assessment Study, funded by WBIF, were completed in 2011.

For new 400 kV interconnection between Serbia, Bosnia and Hercegovina and Montenegro, Feasibility Study, Preliminary Design and Environmental and Social Impact Assessment Study, funded by WBIF, were completed in 2015.

## Investment needs

The Project 227 objectives, in line with the basic goals of EU energy policy, are to:

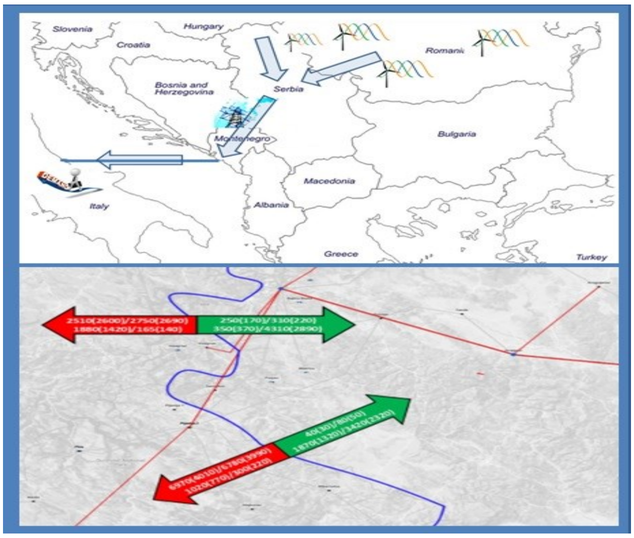
1. improve functioning and reliability of the electricity markets in Serbia, Montenegro, Bosnia and Herzegovina, Romania and Italy and to overall electricity system in the Balkan region;
2. facilitate further integration and expansion of the 400kV network in the region;
3. facilitate higher level of integration of renewable energy sources in the CSE region;
4. alleviate the congestion on the transmission system that is permanently present in the flow direction from East to West in Serbia that restricts trade across the whole of the region and with Italy;
5. help bring about the integration of European electricity markets thereby allowing for increased cross border trade and competition among suppliers.

Need for project Transbalkan corridor (146 and 227) was confirmed by network and market simulation identifing bottleneck on the RS-ME-BA border in all regimes because of presence HVDC ME-IT which will have capacity 1200 MW. For the visions 1, 2 and 3 predominant direction of bulk flows is from Serbia to Montenegro. Presence of project Transbalkan corridor will increase transfer electrical power from Serbia to Montenegro and further to Italy for 75%, from 4000 GWh up to 7000 GWh in Visions 1 and 2. Also, presence of project Transbalkan corridor will increase transfer of electrical power in another two visions 3 and 4, from Serbia to Montenegro, for about 300 GWh.

Project will increase transmission capacity in range of 350-800 MW for direction from north-east to south-west or in average for 100%. GTC on the boundary considered will reach up to 1900 MW in 2030.

In opposite direction, GTC increase is in range 100-1050 MW, or in average for 80%. GTC on the boundary considered will reach up to 1850 MW in 2020EP.

Project Transbalkan corridor support market integration in mid-term, 2020EP, and brings significant benefit to SEW of near 30 MEUR.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is jointly assessed with project 146 as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-HR,BA,RO,RS,BG: 350 |
| | HR,BA,RO,RS,BG-IT: 1050 |
| Delta GTC contribution (2030) [MW] | IT-HR,BA,RO,RS,BG: 50 |
| | HR,BA,RO,RS,BG-IT: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 131 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 30 ±10 | 20 ±10 | 20 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 140 ±30 | <10 |
| B4 Losses (GWh/yr) | -150 ±25 | -50 ±25 | 75 ±25 | -250 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | -7 ±1 | -3 ±2 | 3 ±2 | -15 ±2 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | 400 ±80 | 400 ±100 | 400 ±100 | ±100 | -100 ±100 |

The projects No 227 and No 146 are assessed jointly because of the facts that they are serial connected and they can give full benefits only in situation when we have all lines in operation from projects 227 and 146.

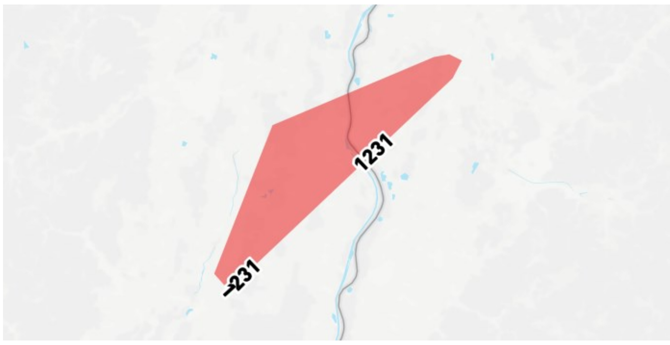
In scenario EP2020 and Vision 1 we noticed decreasing of losses in our region in case of exsisting project. Reason for this we can find in fact that both investment of the project are upgrading of voltage level from 220 kV to 400 kV. For Vision 4 a slight increase of losses is observed in case when lines are in operation.

# Project 228 - Muhlbach - Eichstetten

Operation of a second circuit at 400kV OHL Muhlbach - Eichstetten, instead of the currently operated circuit Eichstetten - Vogelgrun at 225kV. Some restructurations on the existing grid may be necessary in the area.

Reinforcement of the existing circuit at 400kV OHL Muhlbach - Eichstetten in order to increase the thermal capacity of the line.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | France - Germany |
| PCI label | |
| Promoted by | RTE;TransnetBW |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1231 | Operation of a second circuit at 400kV OHL Muhlbach - Eichstetten, instead of the currently operated circuit Eichstetten - Vogelgrun at 225kV and reinforcement of the existing circuit 400kV OHL Muhlbach - Eichstetten | 100% | Muhlbach | Eichstetten | Planning | 2025 | Rescheduled | The detailed timeline of the investment is under definition but it is expected works should be completed slightly before initially thought. |

## Additional Information

The Muhlbach - Eichstetten project is part of the 2015 French National Development Plan and of the German Grid development plan (http://www.netzentwicklungsplan.de)

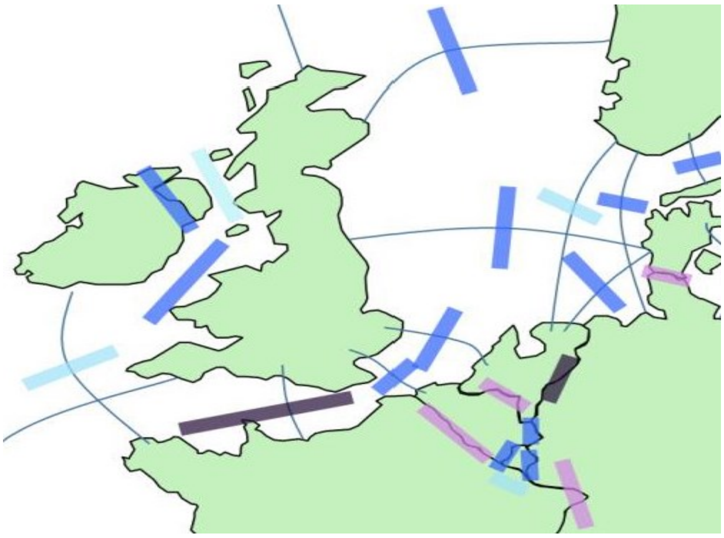
## Investment needs

For the 2030 time horizon, the Continental Central South (CCS) Regional Investment Plan published for consultation in July 2015 stated that market-based target capacity on the French-German border is 4,8GW.

The e-Highway2050 project results published end of 2015 gave the required target capacity to cover very the long term need until 2050. Encompassing a wide range of possible future developments, eHighway2050 study showed that a target capacity of approximately 5 GW is sufficient to cover the very long term need in most of the scenarios. Only the 100% renewable scenario (X7) leads to significantly different results, with a target capacity of approximately 9 GW.

The Muhlbach - Eichstetten project is part of the solution to reach the target capacity of 4,8GW, by upgrading the capacity on France - Germany border by approximately 300MW.

TYNDP analyses showed that a 1-GW capacity increase on the DE-FR border in 2030 on top of current capacity provides an additional SEW of about 20-40 M€ depending on the vision; higher values are observed for visions with high RES.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-DE : 300 |
| | DE - FR: 300 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 42 ±8 |
| Cost explanation | Only CAPEX is considered here. |
| S1 | Negligible or less than 15km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 10 ±0 | <10 | 10 ±0 | 10 ±0 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 160 ±0 | 90 ±10 |
| B4 Losses (GWh/yr) | N/A | 100 ±50 | 100 ±25 | 125 ±25 | 95 ±35 |
| B4 Losses (Meuros/yr) | N/A | 5 ±3 | 4 ±2 | 7 ±2 | 6 ±3 |
| B5 CO2 Emissions (kT/year) | 100 ±20 | 100 ±0 | ±100 | ±100 | -100 ±0 |

The project provides an increase of GTC by 300MW on both directions. The losses increase is mainly due to flexibility in market exchanges allowed by the project.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.35 | 0.97 | 3.50 | 2.30 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.97 | 4.44 | 12.93 | 10.15 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.44 | 6.30 | 6.06 | 7.13 |

## Project 229 - GerPol Power Bridge II

Project consist from following investments: indentation to the 2x400 kV line Baczyna-Plewiska (new routes: Baczyna-Zielona Góra, Zielona Góra-Plewiska), 2x400 kV line Zielona Góra - Gubin, crossborder line 2x400 kV line Gubin (PL)-Eisenhuettenstadt (DE), new station Zielona Góra, new station Gubin (with Phase Shifting Transformers).

| | |
|---|---|
| Classification | Future Project |
| Boundary | Poland - Germany |
| PCI label | 3.14 |
| Promoted by | 50Hertz; PSE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1270 | Baczyna-Zielona Góra | 100% | Baczyna-Plewiska Indentation | Zielona Góra | Under Consideration | >2030 | Investment on time | |
| 1271 | Zielona Góra - Plewiska | 100% | Zielona Góra | Plewiska | Under Consideration | >2030 | Investment on time | |
| 1272 | Zielona Góra | 100% | Zielona Góra | | Under Consideration | >2030 | Investment on time | |
| 1273 | Zielona Góra - Gubin | 100% | Zielona Góra | Gubin | Under Consideration | >2030 | Investment on time | |
| 1274 | Gubin | 100% | Gubin | | Under Consideration | >2030 | Investment on time | |
| 1275 | Gubin - Eisenhuettenstadt | 100% | Gubin | Eisenhuettenstadt | Under Consideration | >2030 | Investment on time | |

### Additional Information

Link to PSE S.A. Development Plan where in Chapter 6.2. Construction of the third Poland-Germany interconnection there is more detailed description of the project and its influence : http://www.pse.pl/index.php?modul=10&gid=402

2nd PCI list: https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

Description of PCI projects on PSE website: http://www.pse.pl/index.php?dzid=256&did=2063

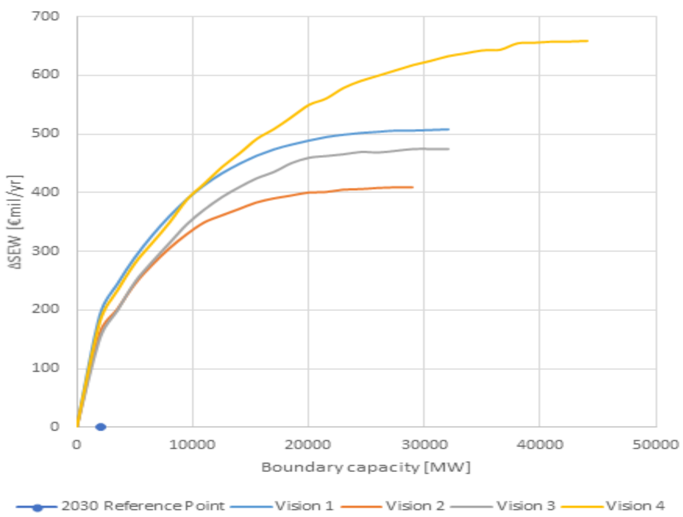
In 2nd PCI list there is position: 3.14.1 Interconnection between Eisenhuettenstadt (DE) and Plewiska (PL) which corresponds funcionally to investments included in project 229.

## Investment needs

The project contributes to the following:
• Increase of market integration between member states - additional NTC of 1500 MWimport on PL-DE/SK/CZ synchronous profile,
• Integration of additional Renewable Energy Sources on the area of western and north-western Poland as well as eastern part of Germany.

The analyses show that high dependency of prices in Poland are strictly relevant with CO2-prices. Self-sufficiency of Poland allow sustain on high level the security of supply at the expense of high energy prices. The emissions are dependent on the visions, where low CO2-prices leads to increased coal-fired production hence increased emissions. Implementation in Poland high efficiency coal technology allow decrease level of emissions significantly.

Making the balance between societal welfare gain and infrastructure investment costs for increasing levels of interconnection, the optimal level of interconnection ranges from 2,5 GW to 4,5 GW. Compared to the present and planned investments this shows a potential for further projects.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project’s expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | DE-PL: 1500 |
| | PL-DE: 0 |

| | |
|---|---|
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 200 ±50 |
| Cost explanation | This project is scheduled in 2030 and is under consideration. The tenders for the investments have not been proceeded. |
| S1 | NA |
| S2 | NA |
| B6 | 0 |
| B7 | 0 |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | 80 ±10 | 110 ±20 |
| B3 RES integration (GWh/yr) | N/A | 10 ±10 | <10 | <10 | 410 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | -4300 ±600 | -3300 ±800 |

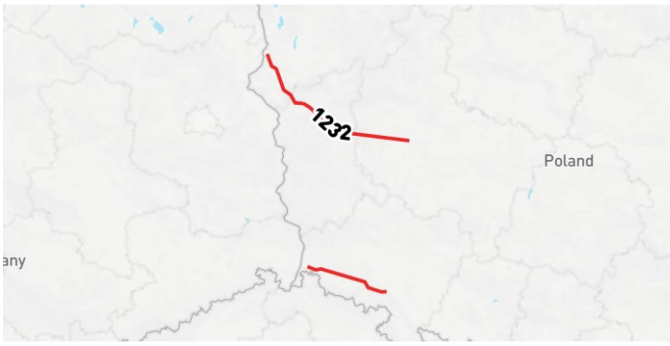
Detailed TYNDP project CBAs show that average SEW contributions per project in the perimeter of this boundary range from 40 to 82MEuro/year. This corresponds to about 95 MEuro/year per additional GW of transfer capacity.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 230 - GerPol Power Bridge I

The reinforcements in the Polish transmission network in western part of the country near Polish/German border. Construction new AC 2x400 kV lines Mikułowa - Świebodzice, Krajnik - Baczyna and Baczyna - Plewiska.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Poland - Germany |
| PCI label | 3.14 |
| Promoted by | 50Hertz; PSE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 353 | Krajnik-Baczyna | 100% | Krajnik (PL) | Baczyna (PL) | Planning | 2021 | Investment on time | The investment will enter the tendering procedure in 2016 and will be realized in design and build scheme. The line is planned to be operational in 2020. |
| 355 | Mikułowa - Świebodzice | 100% | Mikułowa (PL) | Świebodzice (PL) | Planning | 2021 | Investment on time | The investment will enter the tendering procedure in 2016 and will be realized in design and build scheme. The line is planned to be operational in 2020. |
| 1035 | New 400/110 kV Substation Baczyna | 100% | Baczyna | | Permitting | 2020 | Delayed | The investment is in the tendering procedure (design and build scheme). The investment is planned to be completed in 2020. Change of commissioning date compared to previous reprting due to realization schedule of other investements (line Krajnik-Baczyna and Baczyna-Plewiska). |
| 1232 | Baczyna - Plewiska | 100% | Baczyna | Plewiska | Planning | 2020 | New Investment | |

### Additional Information

Link to PSE S.A. Development Plan where investments of this project are included :
http://www.pse.pl/index.php?modul=10&gid=402

2nd PCI list: https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

Description of PCI projects on PSE website: http://www.pse.pl/index.php?dzid=256&did=2063

All investments in the 230 project complement each other in bringing the desired increase of Grid Transfer Capability on the Polish-German border. Vast majority of investents in this cluster connect directly to border substations and have direct impact on border flows. The implementation of the project 230 is a prerequisite to achieve the increase of transfer capability brought by project 229. The following investments from cluster 230 are included in 2nd PCI list : 3.14.2 Internal line between Krajnik and Baczyna (PL), 3.14.3 Internal line between Mikułowa and Świebodzice (PL).

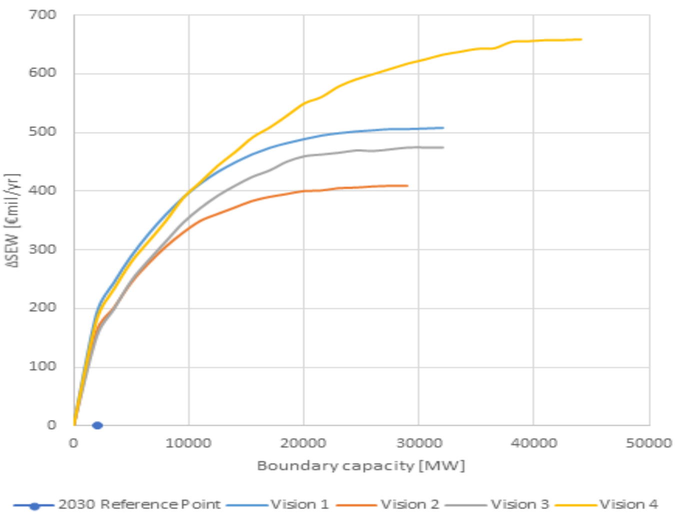
## Investment needs

Project contributes to the following:

• Increase of market integration between member states - additional NTC of 1500 import and 500 MW export on PL-DE/SK/CZ synchronous profile,
• Integration of additional Renewable Energy Sources on the area of western and north-western Poland as well as eastern part of Germany,
• Improving network security - project contributes to increase of security of supply and flexibility of the transmission network (security of supply of Poznań agglomeration area).

The analyses show that high dependency of prices in Poland are strictly relevant with CO2-prices. Self-sufficiency of Poland allow sustain on high level the security of supply at the expense of high energy prices. The emissions are dependent on the visions, where low CO2-prices leads to increased coal-fired production hence increased emissions. Implementation in Poland high efficiency coal technology allow decrease level of emissions significantly.

Making the balance between societal welfare gain and infrastructure investment costs for increasing levels of interconnection, the optimal level of interconnection ranges from 2,5 GW to 4,5 GW. Compared to the present and planned investments this shows a potential for further projects.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DE-PL: 1000 |
| | PL-DE: 500 |
| Delta GTC contribution (2030) [MW] | DE-PL: 1500 |
| | PL-DE: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 292 ±20 |
| Cost explanation | Tenders have still not beed finished for all of the investments. |
| S1 | More than 100km |
| S2 | Negligible or less than 15km |
| B6 | N/A |
| B7 | N/A |

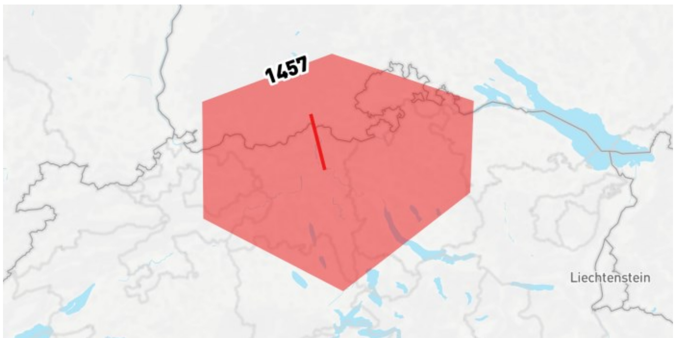
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 40 ±10 | 60 ±10 | 50 ±10 | 140 ±10 | 140 ±20 |
| B3 RES integration (GWh/yr) | 10 ±< 10 | 20 ±10 | 10 ±10 | 770 ±70 | 460 ±10 |
| B4 Losses (GWh/yr) | -275 ±27 | 75 ±25 | -125 ±25 | -225 ±25 | 800 ±80 |
| B4 Losses (Meuros/yr) | -12 ±1 | 4 ±1 | -6 ±1 | -14 ±2 | 53 ±6 |
| B5 CO2 Emissions (kT/year) | -100 ±100 | 600 ±100 | ±100 | -3900 ±1500 | -4200 ±400 |

Detailed TYNDP project CBAs show that average SEW contributions per project in the perimeter of this boundary range from 40 to 82MEuro/year. This corresponds to about 95 MEuro/year per additional GW of transfer capacity.

## Project 231 - Concept Project DE-CH

This concept project focuses on increasing the transmission capacity between Germany and Switzerland. One already identified investment is the upgrade of a 220 kV crossborder line to 380 kV between the substations of Tiengen (DE) and Beznau (CH). It significantly contributes to eliminating bottlenecks on the existing 220 kV line and to increasing the transmission capacity between Switzerland and Germany. The further increase of the target transfer capacity must be trilaterally investigated in detail and may require additional measures (e.g. upgrades, reinforcements or new assets) to be reached.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Germany - Switzerland |
| PCI label | |
| Promoted by | swissgrid;Amprion;TransnetBW |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1282 | Upgrade of existing line from 220 kV to 380 kV between substations Beznau (CH) and Tiengen (DE) including internal reinforcements | 100% | Beznau (CH) | Tiengen (DE) | Planning | 2030 | New Investment | |
| 1457 | Additional necessary measures to reach pre-defined target capacity | 100% | | | Under Consideration | 2030 | New Investment | |

### Additional Information

The investment 1282 is part of the German Grid development plan - http://www.netzentwicklungsplan.de/ (in German)

### Investment needs

The project is part of the grid development in the Continental Central South (CCS) region, which is composed of Austria, France, Germany, Italy, Slovenia and Switzerland. This region is characterised by an increasing penetration of generation from RES mainly at the corners of the region (DE, IT, FR) and the reduction of nuclear generation in Germany, Switzerland and France. The connection of variable RES generation mainly in Germany and Italy with pump storage power plants in the Alps leads to wide area power flows especially in North-South direction and triggers market exchange on the German border towards Austria, Switzerland and France and on the northern borders of Italy. In this context, the project contributes to the integration of RES, supports market integration and ensures system security as well as security of supply in the CCS region.


## Project Cost Benefit Analysis

A delta GTC of 1000 MW has been considered for the CBA assessment. This assessment has been performed in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | CH-DE: [700 ; 1000] |
| | DE-CH: [700 ; 1000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | The project has yet a conceptual status and the project cost depend on the final definition of the project.<br><br>Due to the early stage of the planning process the detailed values of S1/S2 indicators are not available. |
| S1 | NA |
| S2 | NA |
| B6 | + |

| | |
|---|---|
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 10 ±10 | <10 | 30 ±10 | 20 ±0 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 450 ±30 | 240 ±0 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 200 ±100 | ±100 | ±100 | ±100 |

*The project leads to a GTC increase on the border between Germany and Switzerland of up to 1000 MW until the year 2030. This results in a total net transfer capacity of about 4300 MW for DE->CH and 5700 MW for CH->DE.*

*Additional measures to be commissioned beyond the year 2030 are still under consideration and will be investigated in future studies. This may eventually lead to a further capacity increase beyond the year 2030 that is not yet reflected in project 231.*

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.25 | 0.60 | 3.27 | 2.17 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.75 | 3.12 | 12.68 | 10.54 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 5.50 | 4.97 | 6.58 | 6.92 |

## Project 232 - Kontek-3

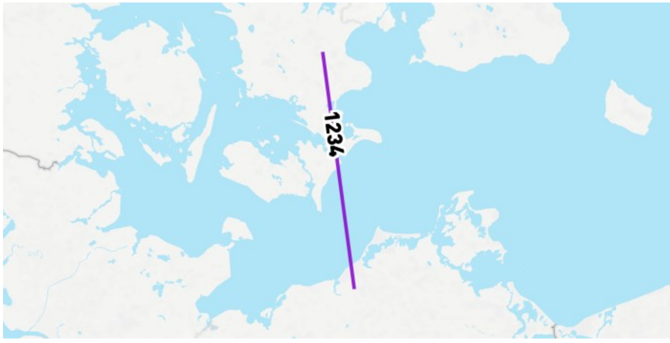
The third HVDC connector between Denmark-East and Germany

Classification: Future Project

Boundary: Denmark-East - Germany

PCI label:

Promoted by: 50Hertz Transmission;Energinet.dk.




| Investments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
| 1234 | HVDC connection DKE-DE | 100% | | | Under Consideration | 2030 | New Investment | |

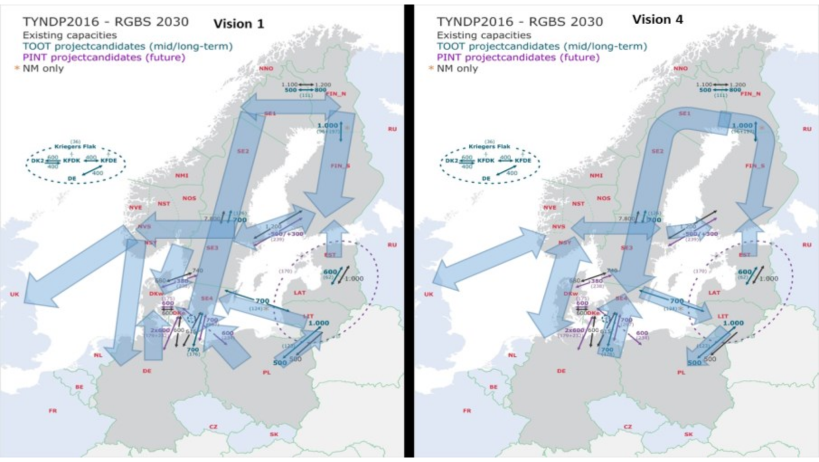
## Additional Information

A project candidate identified in the TYNDP14 process which was carried over into the TYNDP16 project as a potential future project.

## Investment needs

The project will serve as connection between the Nordic and central European power systems either transporting hydro power from the Nordic area to continental Europe or transporting wind and thermal power from the continent to the Nordics in times of low hydro levels.

The project candidate will serve as a part of the capacity that could be counted as a part of the capacity identified in the capacity analysis as having significant marginal benefit. On the boundary there are significant benefits to be gained by increasing capacity in the 4 visions. The marginal benefit on the boundary evens out somewhere between 15 and 20GW depending on the vision and not accounting for the investment cost.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double PINT step compared to the project 238, which is commissioned earlier.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

## General CBA Indicators

| | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project’s expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | DKE-DE: 600 |
| | DE-DKE: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 360 ±100 |
| Cost explanation | The project is a future project, hence all parameters in relation to design, choise of technology, allignment and tendering are open. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | 60 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | -300 ±100 | -200 ±100 | -100 ±100 |

In the TYNDP16 visions there are only marginal benefits of constructing a second Kontek connection with the socio economic benefits being less than €10 million in all visions. The assessment is done as a PINT project. Likewise there is only very small influences of the CO2 emission and the curtailment of RES.

This HVDC project increases security of supply (adequacy, voltage stabiity) in DKE, which is not valued accordingly in the TYNDP.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.73 | 4.07 | 4.19 | 3.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.02 | 11.08 | 14.79 | 13.26 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.92 | 8.57 | 11.80 | 9.05 |

## Project 233 - Spanish Pumping

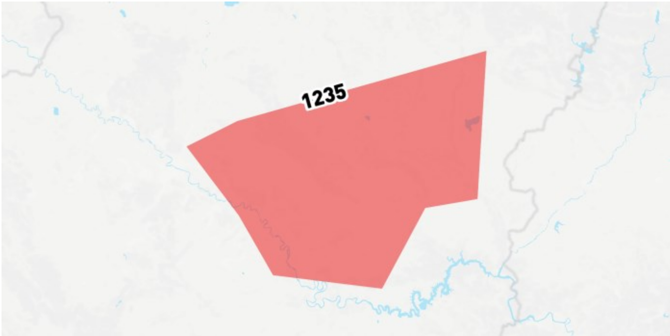
Conceptual Project included in the TYNDP2016 due to the intention of 3rd party promoters to promote the inclusion of new storage facilities in the area of Aragón

Classification Future Project

Boundary Internal boundary in Spain (generation)

PCI label

Promoted by REE



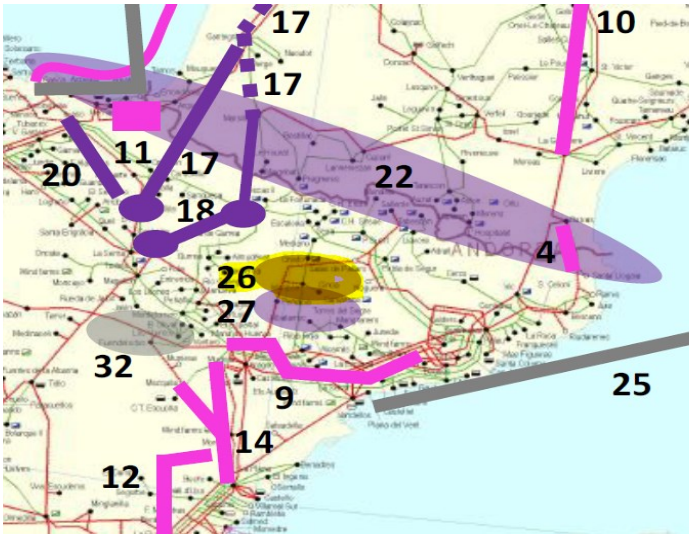

## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1235 | Conceptual Project included in the TYNDP 2016 due to the intention of 3rd party promoters to promote the inclusion of new storage facilities in the area of Aragón | 100% | | | Under Consideration | 2025 | New Investment | |

## Investment needs

This project has been included in the TYNDP due to the intention of 3rd party promoters to promote the inclusion of new storage facilities in the area of Aragón, where is it wellknown by the TSO that the transmission network in the area is not enough strong to integrate big storage capacities.

However, the project is yet a conceptual future project that depends not only on new applications to access the network but also the flow profiles expected in the 2030 scenarios, and should be analysed at national level according to official procedures.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | -: 0 |
| | -: 0 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | As the project is yet a conceptual one the cost will depend on the final definition of the project. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 30 ±10 | 30 ±10 | 10 ±10 | 120 ±20 |
| B3 RES integration (GWh/yr) | N/A | <10 | 210 ±40 | 30 ±10 | 410 ±80 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 1400 ±200 | ±100 | ±100 | -600 ±100 |

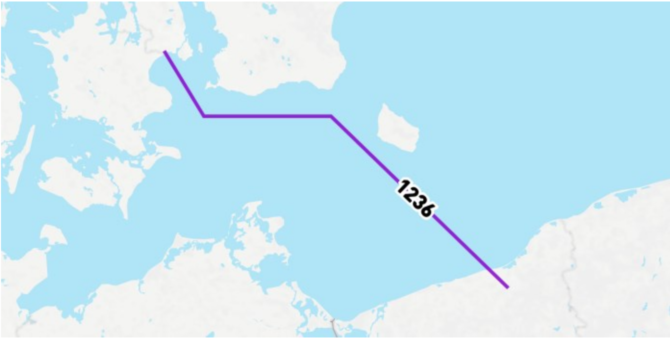
Results of CBA indicators assume the full integration of a new pumping storage power plant of 3100-3000 MW in the area of Aragón, without any network restrictions.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 234 - DKE-PL-1

The first HVDC connector between Denmark-East and Poland.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Denmark-East - Poland |
| PCI label | |
| Promoted by | Energinet.dk |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1236 | HVDC connection DKE-PL | 100% | Avedøre (DK) | Dunowo (PL) | Under Consideration | >2030 | New Investment | |

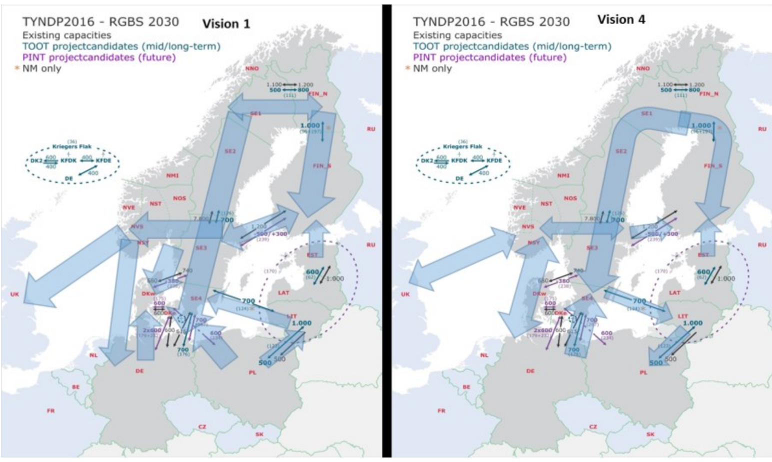
### Additional Information

A project candidate briefly mentioned in the Regional Group Baltic Sea regional investment plan 2014 as a conceptual project. It is now a joint PSE-Energinet.dk screening with the aim of assessing the feasibility, challenges and benefits of a possible interconnector.

### Investment needs

The interconnector is mainly based on market integration, where the different makeup of the Danish wind dominated power system with close links to the Nordic hydro power can supplement the mainly coal and lignite based Polish power system. In the visions 1 and 2 the power flows are dominant out of Poland to Denmark as the price of coal fired generation is low, while in visions 3 and 4 the CO2 price makes the coal fired generation last in the merit order, hence the flows are mainly from Denmark to Poland.

The project could be a part of the projects that could make up the capacity with some benefit on the boundary between the Baltic/Nordic areas and Poland. Poland will either be a significant surplus or deficit area in terms of energy depending on the CO2 price, hence there is in all 4 visions reasonable benefit in 1000 -2500MW of capacity.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | PL-DKE: 600 |
| | DKE-PL: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 700 ±100 |
| Cost explanation | The project is at the screening stage, hence all parameters in relation to design, choice of technology, alignment and tendering are open. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 50 ±10 | 30 ±10 | 40 ±10 | 50 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 130 ±30 | 250 ±50 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 900 ±100 | 200 ±100 | -1900 ±300 | -1500 ±200 |

The benefit of the project lies in the range of €30-60m depending on the vision not accounting for cost. The impact on the RES integration is in the visions 1-2 marginal while in vision3-4 it reduces curtailment with 170-250GWh per year. In vision 1 and 2 the project will lead to increased $CO_2$ emissions as coal fired power plants get better access to the European electricity market and forces out gas fired generation. In vision 3-4 the project will result in significant reductions of $CO_2$ emissions as wind power and gas fired power get better access to the Polish market reducing the coal fired generation.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 235 - HVDC Brunsbüttel/Wilster to Großgartach/Grafenrheinfeld

4 GW HVDC connection from Northern Germany (areas of Brunsbüttel/Wilster) to Bavaria / Baden-Württemberg (areas of Großgartach/Grafenrheinfeld).North Germany is characterised by a high amount of RES, the feed-in exceeds the local load and therefore there is a high demand for transfer to the load centres in southern parts of Germany. With the further installation of additional renewable energy, the relevance of this projects increases.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Inside Germany |
| PCI label | 2.10 |
| Promoted by | TenneT TSO;TransnetBW |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 664 | New DC-lines to integrate new wind generation from Northern Germany towards Southern Germany and Southern Europe for consumption and storage. | 100% | Brunsbüttel, Wilster | Großgartach, Grafenrheinfeld | Planning | 2025 | Delayed | The commissioning date of the investment is delayed due to new preference of underground cable instead of overhead lines by german legal requirement. |

### Additional Information

German grid development plan:

http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0

Project specific web page (in German):

http://suedlink.tennet.eu/home.html

https://www.transnetbw.de/de/uebertragungsnetz/dialog-netzbau/sued-link

Second PCI-list:

https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pdf

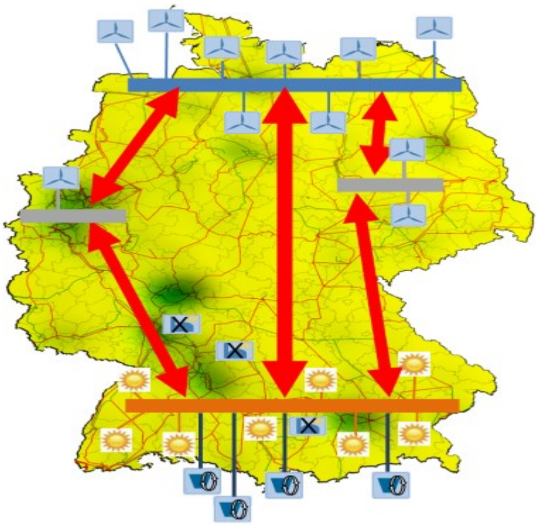
## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia or Switzerland) are required.

Due to used DC-Technology the project is able to provide reactive power and therefore helps to improve the voltage stability.

This project will both directly connect Schleswig-Holstein and Lower Saxony, areas with huge amount of installed onshore wind turbines and big amounts of offshore wind farms with the southern part of Germany, an area with high consumption and connection to storage capabilities in the Alps. Furthermore it will in general significantly increase the transmission capacity to Norway, Sweden and Denmark, areas with high amounts of RES and storage plants.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | NO&DKW -DE: 1800 |
| | DE-NO&DKW : 1800 |
| Delta GTC contribution (2030) [MW] | NO&DKW -DE: 1800 |
| | DE-NO&DKW : 1800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 6500 ±1300 |
| Cost explanation | The high costs reflect the priority of underground cables for DC-lines in Germany.<br><br>The uncertainty range is high, due to early planning stage the exact realisation is not clear. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 200 ±30 | 300 ±40 | 330 ±50 | 770 ±120 | 910 ±140 |
| B3 RES integration (GWh/yr) | 870 ±170 | 1220 ±240 | 2860 ±570 | 8090 ±1620 | 9680 ±1940 |
| B4 Losses (GWh/yr) | -150 ±25 | -50 ±25 | -100 ±25 | 175 ±25 | 375 ±37 |
| B4 Losses (Meuros/yr) | -7 ±1 | -3 ±2 | -5 ±2 | 10 ±2 | 25 ±3 |
| B5 CO2 Emissions (kT/year) | -2100 ±320 | 200 ±100 | -2600 ±400 | -4600 ±700 | -5400 ±800 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. The mentioned GTC value is the additional crossborder impact of the project.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

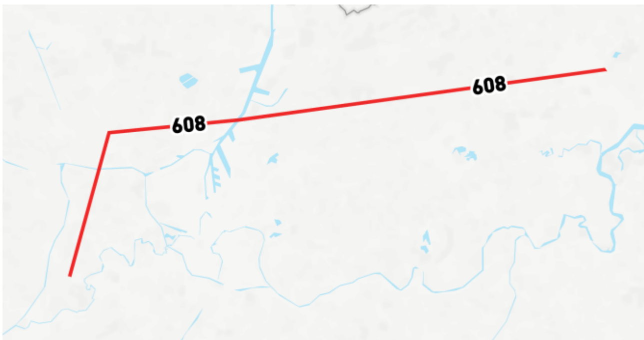
The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

# Project 236 - Internal Belgian Backbone West

Project consists of replacing the conductors of the ~50km double circuit 380 kV overhead line between the substations of Horta and Mercator with high performance conductors, hereby doubling the transport capacity of this important corridor.This internal corridor at the west side of Belgium needs to be upgraded in order to transport higher bulk power flows resulting from offshore wind integration and development of interconnection capacity on the BE-UK/FR/NL borders.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Belgium Backbone West |
| PCI label | 2.24 |
| Promoted by | Elia System Operator |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 608 | Upgrade the double-circuit 380kV overhead line Horta-Mercator with high performance conductors. | 100% | Horta (BE) | Mercator (BE) | Permitting | 2019 | Investment on time | The expected commissioning date of 2019 is based on the hypothesis of acquiring all necessary permits as planned. |

## Additional Information

The project is integrated in Elia's National Developmen Plan 2015-2025: http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

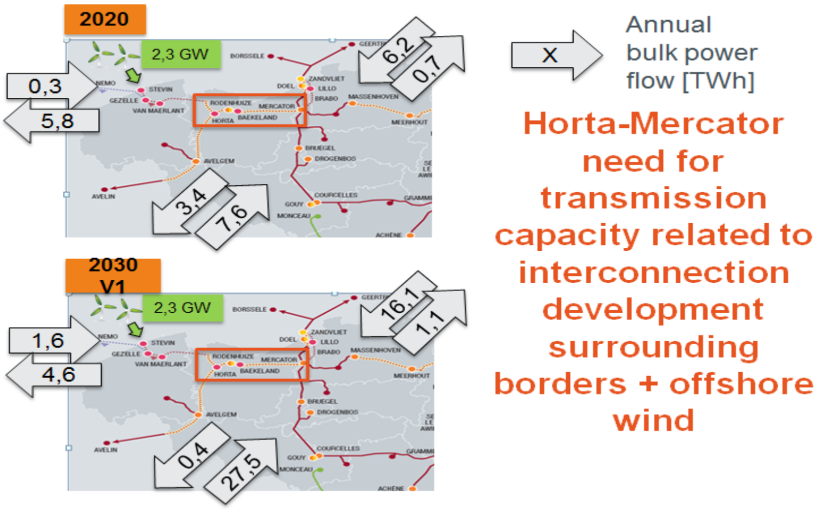
More information can be found back on the project's detailed website: http://www.elia.be/en/projects/grid-projects/Mercator-Horta

## Investment needs

Developing transmission capacity along this corridor is key to facilitate the European energy market and allow more import of electricity to Belgium from abroad.

The increased capacity will also make it possible to connect new generation units to the grid. The Mercator-Horta axis is very important, for example, for the integration of offshore wind farms in the Belgian part of the North Sea.

This project doubles the capacity of the Horta-Mercator corridor aligned with the 2,3GW capacity of offshore wind and the market exchange reference capacities on the BE-UK/FR/NL borders.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE: 1500 |
| | BE: 1500 |
| Delta GTC contribution (2030) [MW] | BE: 1500 |
| | BE: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 100 ±15 |
| Cost explanation | Presented costs represent the total current expected project investment cost. Uncertainty range reflects procurement/construction cost uncertainties. |
| S1 | Negligible or less than 15km |
| S2 | 15-25km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | 10 ±10 | 80 ±10 | 80 ±10 | 130 ±20 |
| B3 RES integration (GWh/yr) | <10 | <10 | 590 ±120 | 950 ±190 | 760 ±150 |
| B4 Losses (GWh/yr) | -70 ±25 | -80 ±25 | -150 ±25 | 80 ±25 | 250 ±25 |
| B4 Losses (Meuros/yr) | -4 ±2 | -5 ±2 | -7 ±1 | 4 ±2 | 16 ±2 |
| B5 CO2 Emissions (kT/year) | 400 ±100 | 200 ±100 | 200 ±100 | -400 ±100 | -800 ±100 |

The GTC expresses the doubling in capacity of the transmission corridor.

The benefits of this project are related to the benefits of developing interconnection capacity on the BE-UK/FR/BE borders, the latter only being able to fully materialize via this internal project. Same approach has been applied for the losses. The CBA indicators for this project 236 thus reflect the trends explained in projects 23, 24 & 74.

## Project 237 - COBRA-2

The second HVDC connector between Denmark-West and The Netherlands.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Denmark-West - Netherlands |
| PCI label | |
| Promoted by | Energinet.dk.dk;TenneT TSO |


## Investments

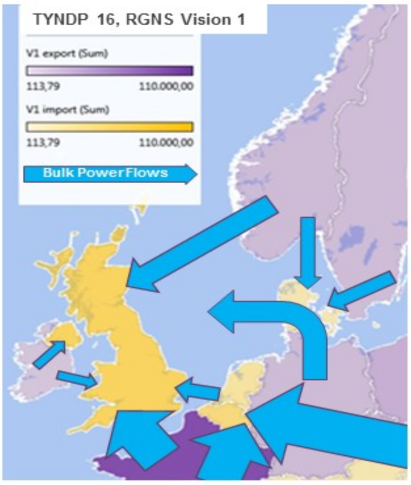
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1239 | The second HVDC connectio between DK-W and NL, "COBRA 2" | 100% | | | Under Consideration | 2030 | New Investment | potential project resulting from common planning studies analysis from ENTSO-E RGNS. |

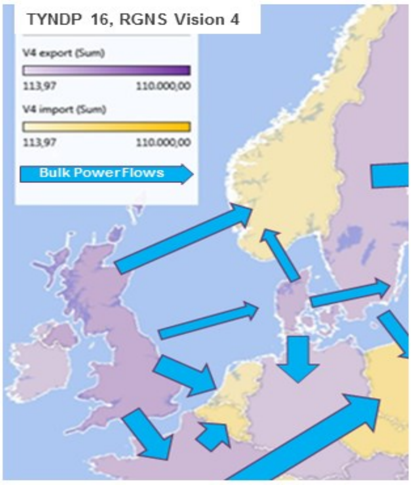
## Additional Information

Project is proposed by ENTSO-E common grid study, which found some potential when assessing the option against TYNDP14 Vision 4.

## Investment needs

The main bulk flow direction in this region is along the North-South axis and West-East axis as well. According to the TYNDP analysis, the net flow direction for this project is from DKW to NL, the amount of it depending on the Vision. Especially in the green Visions the hourly flows and directions can vary a lot due to transporting variable RES, which cause higher overall flows in both directions.
Overall RES integration (mainly wind energy, both on- and offshore) in this local area keeps on increasing, thus the grid infrastructure needs to be upgraded respectively. The project bypasses a congested onshore grid area and contributes to release bottlenecks.






## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NL-DKW: 700 |
| | DKW-NL: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 620 ±60 |
| Cost explanation | same as COBRA I (project 71) |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | 10 ±10 | 10 ±10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | 20 ±20 | 40 ±40 | 70 ±40 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 200 ±100 | -100 ±100 | -100 ±100 | -200 ±200 |

This future project was assessed using the PINT methodology, i.e. on top of all reference case projects. This explains why COBRA II has in general smaller indicators than the mid-term project COBRA, which is part of the reference case.

The need for COBRA 2 was identified under the Vision 4 scenario setting of TYNDP 2014 with higher assumption regarding the RES levels in some countries around the North Sea driving the need for the cable. With the adjusted RES levels in the TYNDP 2016 scenarios, the need for the COBRA 2 cable is not evident for the 2030 time horizon, but will most likely reoccur in further future (2040 time horizon) high RES scenario's.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.15 | 2.82 | 3.30 | 2.16 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.60 | 9.00 | 13.28 | 10.94 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.88 | 19.76 | 15.54 | 13.48 |

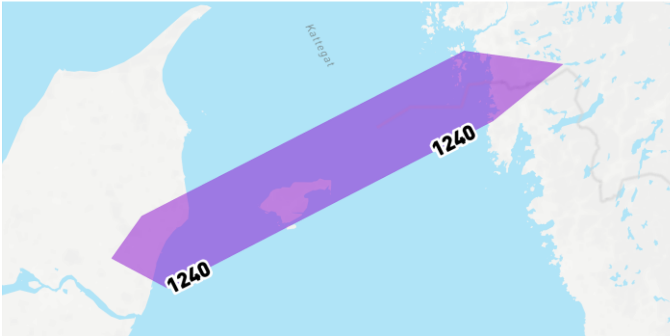
In each Vision there is a price differential between DK and the NL and a difference in average of marginal costs, causing power exchanges.

The project bypasses a congested onshore grid area, facilitating especially in the green Visions exchanges of RES (=wind) energy to where it is needed. In general the wind is moderately correlated between DKW and NL.

## Project 238 - Kontiskan 2

Renewal of the existing Kontiskan 2 HVDC connectors between Denmark-West (DK1) and Sweden (SE3) to maintain capacity between Sweden and Denmark.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Denmark-West - Sweden (SE3) |
| PCI label | |
| Promoted by | Energinet.dk.dk;Svenska Kraftnät |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1240 | Complete reinvestment of existing HVDC interconnector. | 100% | Lindome (SE3) | Vester Hassing (DkV) | Under Consideration | >2030 | New Investment | |

## Additional Information

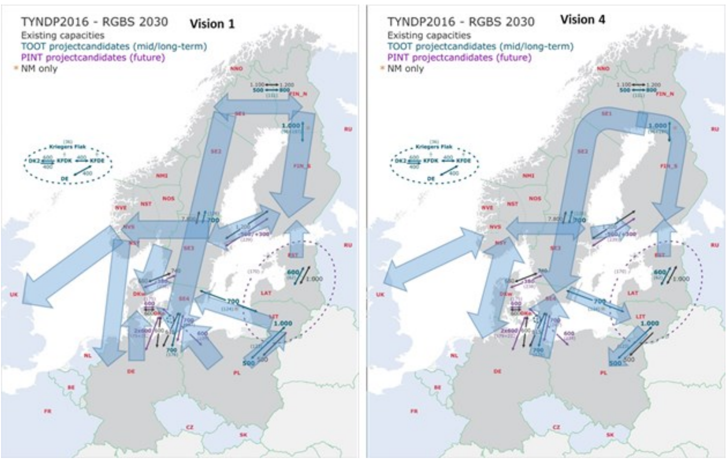
*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realise under the stated time period. The plan is available in Swedish through the following link:*

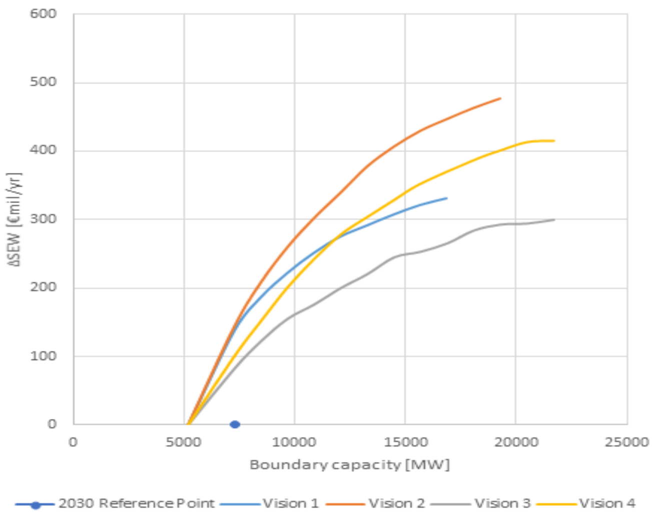
http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

## Investment needs

Konti-Skan 2 is the older of the two HVDC-connections between western Denmark and Sweden and is due for reinvestment over the comming 10-15 years. Konti-Skan 2 will be renewed with the same capacity as today.

The reinvestment will help ensure that the transmission capacity between the nordic synchronous area and the continental is maintained. This project maintains 350 MW capacity at the boundry.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | SE3-DKW: 350 |
| | DKW-SE3: 350 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | Future project, no cost estimation available as it very much depends on an assessments of the components state, thus the level of investment needed. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | 20 ±10 | 10 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 180 ±40 | 160 ±30 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -400 ±100 | -600 ± | ±100 | -300 ±100 |

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

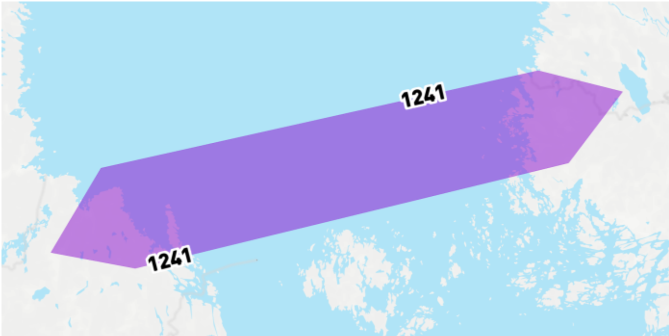
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.89 | 7.74 | 6.81 | 7.07 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 12.27 | 14.63 | 17.90 | 16.35 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.12 | -0.56 | 2.82 | 9.07 |

## Project 239 - Fenno-Skan 1 renewal

Renewal of the existing 400 kV HVDC cable interconnection between Finland and Sweden. The projects capacity is estimated to range between 500-800 MW which could mean an updgrade compared to today.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Finland-Sweden (SE3) |
| PCI label | |
| Promoted by | Fingrid;Svenska Kraftnät |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1241 | Complete re-investment of existing HVDC cable | 100% | Dannebo (SE3) | Rauma (FI) | Under Consideration | 2030+ | New Investment | |

### Additional Information

*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realize under the stated time period. The plan is available in Swedish through the following link:*

http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

Fingrid has published a national development plan in 2015. The investment plan present a detailed look of the projects. The plan is available in Finnish:

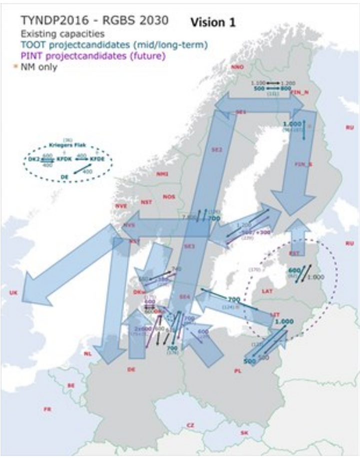
http://www.fingrid.fi/fi/asiakkaat/asiakasliitteet/Kehittämissuunnitelma/Kantaverkon_kehittämissuunnitelma%202015%20-%202025.pdf

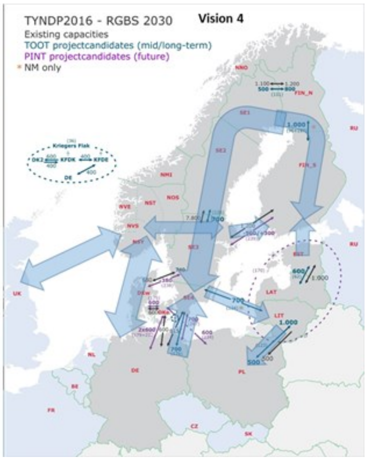
## Investment needs

Fenno-Skan 1 is the older of the two HVDC-connections between Finland and Sweden and is due for reinvestment. It is not yet decided whether Fenno-Skan 1 should be renewed with the same capacity as today (500 MW) or if it should be higher to match Fenno-Skan 2 (800 MW). Evaluation of the need for interconnection capacity between Sweden and Finland is also made by Svenska kraftnät and Fingrid in a separate bilateral study.

The project do not influence the TYNDP-defined main-boundary of the region. However the project candidate maintains 500 MW capacity between Sweden and Finland and if the link is upgraded it increases the capacity with 300 MW. There are several drivers for additional capacity at this border such as:

- System adequacy
- Increased flexibility and market integration in different weather years
- Reduced dependency of Finland on Non-ENTSO-e member countries




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | SE3-FI: [500 ; 800] |
| | FI-SE3: [500 ; 800] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 500 ±50 |

| | |
|---|---|
| Cost explanation | Early cost estimation. |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 10 ±10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -200 ±100 | ±100 | ±100 | ±100 |

Cost Benefit analysis in TYNDP 2016 does not take into account different hydrological years, but instead an average hydro year is used. Interconnectors in the Nordic countries give higher SEW benefits in extreme weather years.

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.14 | 0.14 | 1.73 | 4.03 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 1.66 | 1.55 | 9.37 | 12.30 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.01 | 1.51 | 6.64 | 12.37 |

# Project 240 - 380-kV-grid enhancement between Area Güstrow/Bentwisch and Wolmirstedt

380-kV-grid enhancement between the areas Güstrow/Bentwisch and Wolmirstedt.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Project |
| PCI label | |
| Promoted by | 50Hertz Transmission |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 200 | 380-kV-grid enhancement and structural change area Magdeburg/Wolmirstedt, incl. 380-kV-line Güstrow-Wolmirstedt (195 km) | 100% | Güstrow (DE) | Wolmirstedt (DE) | Permitting | 2020 | Investment on time | Investment on time |
| 1242 | AC Upgrade of existing line between Bentwisch and Güstow | 100% | Bentwisch (DE) | Güstrow (DE) | Under Consideration | 2025 | New Investment | |

## Additional Information

**German grid development plan:**

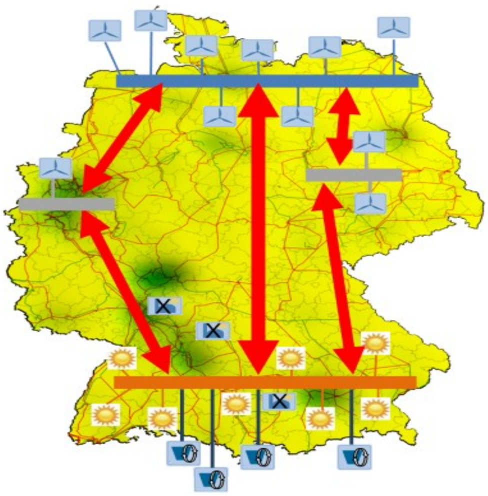
http://www.netzentwicklungsplan.de/en

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the capacity from Mecklenburg-Vorpommern to the south of Germany and will help to solve the transmission insufficiency of the grid in this area caused by the huge amount of increasing RES. It will also help to increase the technical possibility in this area to integrate the expected new Interconnectors to Scandinavia (e.g. Hansa PowerBridge).



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Internal DE: |
| | Internal DE: |
| Delta GTC contribution (2030) [MW] | Internal DE: |
| | Internal DE: |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 370 ±60 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 190 ±30 | 150 ±20 | 410 ±60 | 390 ±60 |
| B3 RES integration (GWh/yr) | 130 ±30 | 2020 ±400 | 1750 ±350 | 4890 ±980 | 4610 ±920 |
| B4 Losses (GWh/yr) | -25 ±25 | 250 ±25 | 225 ±25 | 175 ±25 | 150 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 13 ±2 | 10 ±2 | 10 ±2 | 10 ±2 |
| B5 CO2 Emissions (kT/year) | -100 ±20 | -1000 ±200 | -1000 ±200 | -2400 ±400 | -2200 ±300 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. Therefore the influence on crossborder capacities was not calculated. For the assessment of the project a detailed grid model was used.

Therefore the displayed project benefits are only illustrating the lower limit due to the underestimation of the redispatch costs.

*Comment on the S1 and S2 indicators:*

Detailed values for this project are not available due to the early state in the planning process.

*Comment on the security of supply:*

A low SoS value means that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the redispatch based benefit calculations only costs resulting from changing generation dispatches leading to different fuel costs (including costs for CO2 emissions) were determined. Whilst the overall redispatch costs, additionally consisting of passed market premiums, costs for holding redispatchable generation and compensation payments for reducing power from RES generation units, were neglected.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 241 - Upgrading of existing 220 kV lines between HR and BA to 400 kV lines

Upgrading of existing 220 kV lines between SS Đakovo (HR) and SS Tuzla/Gradačac (BA) to 400 kV lines.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Croatia - Bosnia and Herzegovina |
| PCI label | |
| Promoted by | HOPS;NOS BiH |

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1276 | Upgrading of existing 220 kV line between SS Đakovo (HR) and SS Tuzla (BA) to 400 kV line. | 80% | Đakovo | Tuzla | Under Consideration | 2030 | New Investment | Based on the results by the Common Planning Studies based on Vision 4.Project will increase the transfer capacity between BA and HR in order to accommodate connection of RES and improve market integration. |
| 1277 | Upgrading of existing 220 kV line between SS Đakovo (HR) and SS Gradačac (BA) to 400 kV line. | 80% | Đakovo | Gradačac | Under Consideration | 2030 | New Investment | Based on the results by the Common Planning Studies based on Vision 4.Project will increase the transfer capacity between BA and HR in order to accommodate connection of RES and improve market integration. |
| 1278 | Upgrading of existing 220 kV SS Đakovo to 400 kV | 30% | Đakovo | | Under Consideration | 2030 | New Investment | Based on the results by the Common Planning Studies based on Vision 4.Project will increase the transfer capacity between BA and HR in order to accommodate connection of RES and improve market integration. |
| 1279 | New double 400 kV line between SS Đakovo and location Razbojište | 40% | Đakovo | Razbojište | Under Consideration | 2030 | New Investment | Based on the results by the Common Planning Studies based on Vision 4.Project will increase the transfer capacity between BA and HR in order to accommodate connection of RES and improve market integration. |

## Additional Information

The project 241, as new candidate transmission project has been proposed to be assessed in the TYNDP 2016, based on the results of common planning studies performed in the CSE Region during preparation of Regional investment plan 2015. The project assumes upgrade of existing 220 kV lines between SS Đakovo (HR) and SS Tuzla (BH) and SS Gradačac (BH) to 400 kV, with additional internal new double 400 kV line connecting SS Đakovo to existing 400 kV line Žerjavinec - Ernestinovo. This project is under consideration and there is a need for pre-feasibility study.

## Investment needs

The Project 241 objectives, in line with the basic goals of EU energy policy, are to:

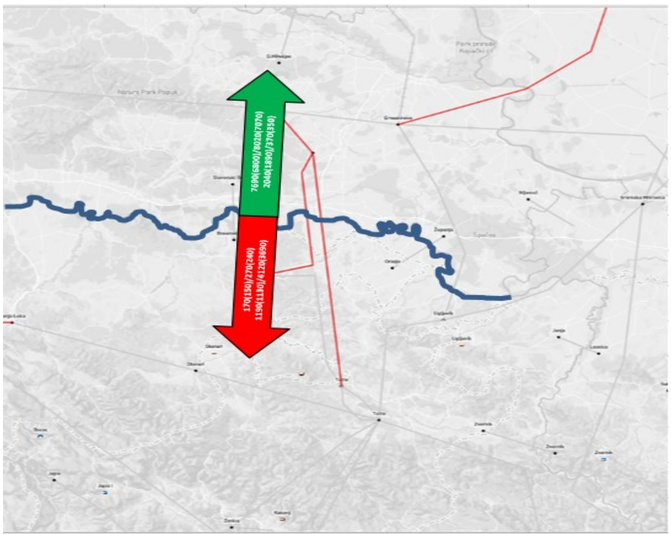
1.improve functioning and reliability of the electricity markets in Croatia and Bosnia and Herzegovina ;

2.facilitate further integration and expansion of the 400kV network in the region;

3.increase value of GTC on the border HR - BH which will facilitate higher level of market exchanges

The project No 241 has been proposed to be assessed in the TYNDP 2016, based on the results of common planning studies performed in the CSE Region during preparation of Regional investment plan 2015.

Project will increase transmission capacity in range 1200-1530 MW or in average for 27% for dominant direction from South (BA) to North (HR). GTC on the boundary considered will reach up to 3100 MW in 2030.
In opposite direction, GTC increase is in range 2890-3130 MW, or in average for 8% due to the predominant flows is S->N. GTC on the boundary considered will reach up to 330 MW (in predominant direction S->N) in 2030.
Project 241 supports market integration in mid-term, 2020EP, and brings a benefit to SEW of 16 MEUR. On a long-term, largest benefits on SEW of over 12 MEUR in Vision 1.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | BA-HR: 350 |
| | HR-BA: 250 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 62 ±6 |
| Cost explanation | Uncertainty regarding total length of lines, public tendering, environmental or legal requirements imposed during permit grating process. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

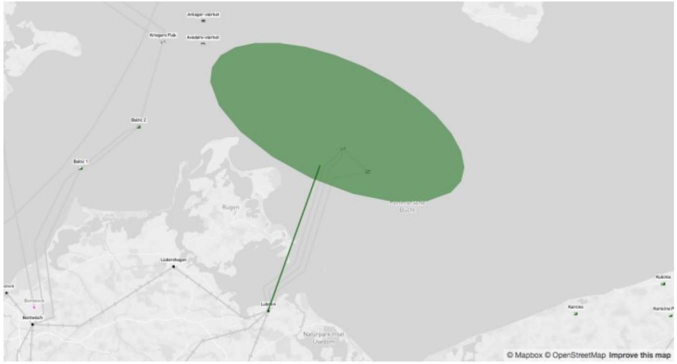
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | 0 | 0 | 0 | 0 | 0 |
| B2 SEW (MEuros/yr) | 20 ±10 | 10 ±10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | 25 ±25 | 150 ±25 | 25 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | N/A | 1 ±2 | 7 ±1 | 1 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | 200 ±30 | 300 ±100 | 200 ±100 | ±100 | ±100 |

Savings in variable generation costs (SEW) and possible reduction on CO2 emissions are caused by the integration of new RES generation in the system replacing fossil fuel based generation. Therefore the highest values are reached in the scenarios with higher RES integration.

## Project 242 - Offshore Wind Baltic Sea (I)

AC grid connections connecting Offshore Wind Farms in Cluster 1 of the Baltic Sea (see German Offshore Grid Development Plan). Cluster 1 is located north east of Rügen in the German Exclusive Economic Zone.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Boundary in North-East Germany |
| PCI label | |
| Promoted by | 50Hertz Transmission |



### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 194 | Grid Connection of offshore wind farms (using AC-technology). | 100% | OWF Cluster Baltic Sea East (DE) | Lubmin (DE) | Under Construction | 2018 | Investment on time | The investment is split into different stages with different commissioning dates (starting in 2017) depending on the predicted installed capacity of offshore wind. For further informations see the national "Offshore Grid Development Plan" |

### Additional Information

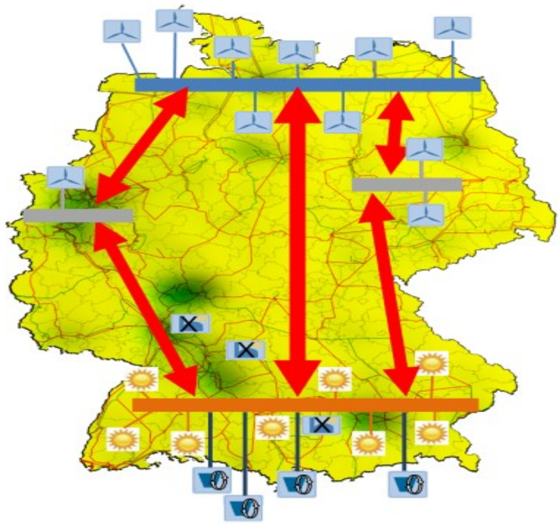
**German grid development plan:**

http://www.netzentwicklungsplan.de/en

### Investment needs

Germany is planning to build a big amount of offshore wind power plants in the North- and Baltic Sea. The OWP will help to reach the European goal of CO2 reduction, share of RES and ther integration. These offshore infrastructure projects in the Baltic Seas area, will deliver different benefits (lowering CO2 emissions, facilitating the integration of renewables and ensuring sufficient system resilience, increasing share of RES).

The development of off-shore wind farms in the North of Germany induces needs for undersea connections to these wind farms as well as reinforcements of the grid capacity from North to South. According to German law, these grid connections have to be constructed and operated by the TSO.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

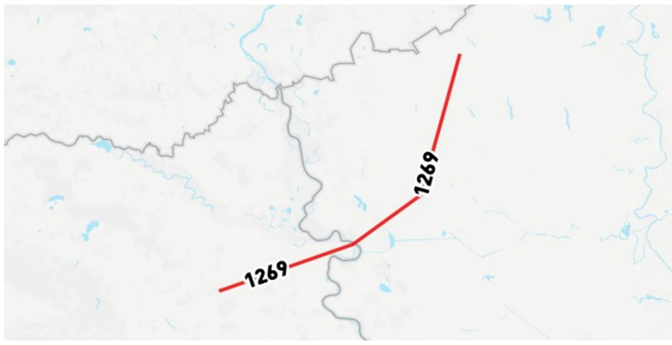
| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | The project contains a connection of offshore generation only and no interconnection. Hence the value for delta GTC is based on the physical capacity of the connection and the installed power itself. |
| | Internal DE: 1100 |
| Delta GTC contribution (2030) [MW] | The project contains a connection of offshore generation only and no interconnection. Hence the value for delta GTC is based on the physical capacity of the connection and the installed power itself. |
| | Internal DE: 1100 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1800 ±200 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | 0 |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 160 ±30 | 230 ±20 | 200 ±10 | 230 ±10 | 270 ±20 |
| B3 RES integration (GWh/yr) | 3940 ±790 | 3940 ±10 | 3950 ±10 | 3420 ±90 | 3690 ±20 |
| B4 Losses (GWh/yr) | 250 ±25 | 375 ±37 | 450 ±45 | 250 ±25 | 225 ±25 |
| B4 Losses (Meuros/yr) | 10 ±1 | 20 ±2 | 21 ±2 | 14 ±2 | 15 ±2 |
| B5 CO2 Emissions (kT/year) | -3100 ±460 | -2400 ±400 | -2800 ±100 | -1300 ±0 | -1400 ±200 |

## Project 243 - New 400 kV interconnection line between Serbia and Croatia

Construction of new 400 kV interconnection line Sombor (RS) - Ernestinovo (HR)

| | |
|---|---|
| Classification | Future Project |
| Boundary | Croatia - Serbia |
| PCI label | |
| Promoted by | HOPS;JP EMS |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1269 | New 400 kV interconnection line between Sombor (RS) and Ernestinovo (HR) will increase transfer capacity between Croatia and Serbia in the East - West direction that is from Romania, Serbia and Bulgaria towards Croatia, Slovenia and Italy. | 100% | Ernestinovo | Sombor | Under Consideration | 2030 | New Investment | Based on the results by the Common Planning Studies based on Vision 4.Project will increase the transfer capacity between RS and HR in order to accommodate connection of RES and improve market integration. |

## Additional Information

The project 243, as new candidate transmission project has been proposed to be assessed in the TYNDP 2016, based on the results of common planning studies performed in the CSE Region during preparation of Regional investment plan 2015. The project assumes construcion of new single 400 kV interconnection line between Croatia and Serbia (length is approximatly 70 km). This project is under consideration and there is a need for pre-feasibility study.

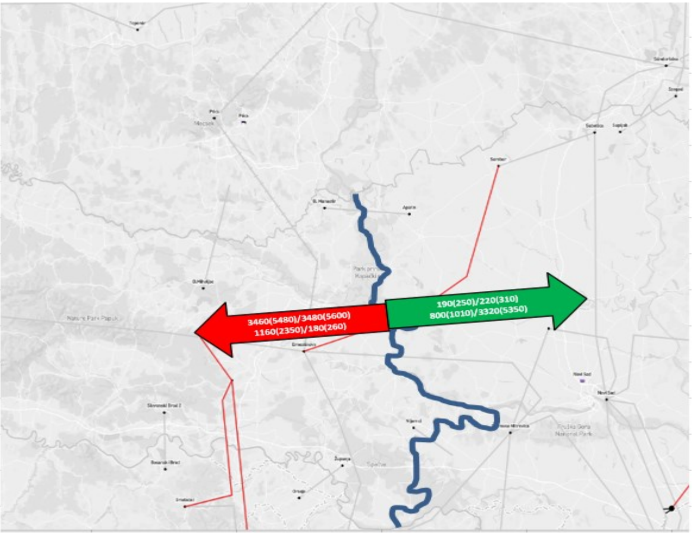
## Investment needs

The Project 243 objectives, in line with the basic goals of EU energy policy, are to:

1. improve functioning and reliability of the electricity markets in Croatia and Serbia;
2. facilitate further integration and expansion of the 400kV network in the region;
3. increase value of GTC on the border HR -RS which will facilitate higher level of market exchanges

The projects No 243, No 273 (closing of 400 kV ring around Belgrade region) and No 268 (upgading existing single 400 kV interconnection line between RO and RS to double 400 kV line) has been proposed to be assessed in the TYNDP 2016, based on the results of common planning studies performed in the CSE Region during preparation of Regional investment plan 2015. Such outputs defined in common planning study arise from need for high level of transmission capacities on the direction East - West. These projects are located on the relative small geografic region and they are interdependent. Because of that, there is a need for re-clustering of this projects in next period.

Project will increase transmission capacity in range 410-1160 MW or in average for 182% for dominant direction from East (RS) to West (HR). GTC on the boundary considered will reach up to 1160 MW in 2030.
In opposite direction, GTC increase is in range 490-790 MW, or in average for 63% due to the predominant flows is E->W. GTC on the boundary considered will reach up to 750 MW (in predominant direction E->W) in 2030.
Project 243 supports market integration and brings a benefit to SEW of 8 MEURin Vision 1.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | HR-RS: 750 |
| | RS-HR: 300 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 19 ±2 |

| | |
|---|---|
| Cost explanation | Uncertainty regarding total length of line, public tendering, environmental or legal requirements imposed during permit grating process. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | 0 | 0 | 0 | 0 | 0 |
| B2 SEW (MEuros/yr) | 230 ±20 | 10 ±10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | 3940 ±10 | <10 | <10 | 10 ±10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | -2400 ±400 | 200 ±100 | 100 ±100 | ±100 | ±100 |

Savings in variable generation costs (SEW) and possible reduction on CO2 emissions are caused by the integration of new RES generation in the system replacing fossil fuel based generation. Therefore the highest values are reached in the scenarios with higher RES integration.

The location of this new generation is further from the load centres and this new renewable generation is replacing conventional generation located closer the load centres.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 244 - Vigy - Uchtelfangen area

Upgrade of existing transmission OHL between Vigy and Uchtelfangen (or beyond) to increase its capacity. Dynamic Line Rating (DLR) or High Temperature Low Sag (HTLS) conductors are the two investigated options.

Classification Long-term Project

Boundary France - Germany

PCI label

Promoted by Amprion;RTE


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1245 | Upgrade of existing transmission overhead line between Vigy and Uchtelfangen (or beyond) to increase its capacity (Length: approx. 65 km) | 100% | Vigy (FR) | Uchtelfangen (DE) | Planning | 2030 | Investment on time | |

## Additional Information

The Vigy - Uchtelfangen project is part of the 2015 French National Development Plan.*Amprion and RTE signed a joint* Memorandum Of Understanding, in order to investigate deeply this project.

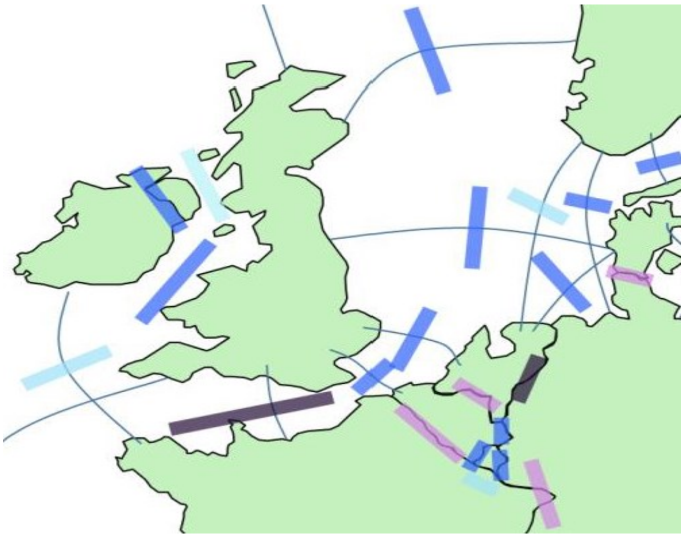
## Investment needs

For the 2030 time horizon, the Continental Central South (CCS) Regional Investment Plan, published for consultation in July 2015, stated that market-based target capacity on the French-German border is 4.8GW.

The e-Highway2050 project results published end of 2015 indicated the required target capacity to cover the long term need until the year 2050. Encompassing a wide range of possible future developments, eHighway2050 study showed that a target capacity of approximately 5 GW is sufficient to cover the very long term need in most of the scenarios. Only the 100% renewable scenario (X7) leads to significantly different results, with a target capacity of approximately 9 GW.

The Vigy - Uchtelfangen project is one of the key answers to reach the 2030 target capacity of 4.8GW, by upgrading the capacity on the France - Germany border by approximately 1.5GW.

TYNDP analyses showed that a 1-GW capacity increase on the DE-FR border in 2030 on top of current capacity provides an additional SEW of about 20-40 M€ depending on the vision; higher values are observed for visions with high RES.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-DE: 1500 |
| | DE-FR: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 25 ±15 |
| Cost explanation | The relative high uncertainty compared to the cost is explained by the different kind of technical solutions that are still under investigations to upgrade this 400kV axis. Dynamic Line Rating added to substations upgrades is the most promising solution, and would allow to maintain the cost close to 10M€. An other solution could consist on using high temperature low SAG conductors, which would lead to higher cost. Only CAPEX is considered here. |

| | |
|---|---|
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±10 | 40 ±10 | 30 ±10 | 70 ±20 | 60 ±10 |
| B3 RES integration (GWh/yr) | 20 ±10 | 20 ±10 | <10 | 790 ±30 | 390 ±30 |
| B4 Losses (GWh/yr) | N/A | 570 ±50 | 380 ±50 | 480 ±80 | 440 ±80 |
| B4 Losses (Meuros/yr) | N/A | 30 ±3 | 17 ±3 | 28 ±5 | 29 ±6 |
| B5 CO2 Emissions (kT/year) | 1500 ±820 | 800 ±500 | ±100 | -200 ±200 | -500 ±100 |

The estimated delta GTC value of 1.5GW is very promising, especially as this is a conservative result. Potentially, the delta GTC could reach up to 3GW in both directions. The ratio GTC/cost is very interesting for this project that would significantly improve transmission capacity between the two countries.

Regarding the losses, analysis shows high delta losses values. The project in itself does not create additional losses. The losses increase is explained by the high increase in transfer capacity between France and Germany that this project is offering (1.5GW). This gives much more flexibility to the overall european market, allowing cheaper energy to circulate all over Europe. Then, the related flows in the transmission grid to transfer cheaper energy lead to higher losses.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.35 | 0.97 | 3.50 | 2.30 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.97 | 4.44 | 12.93 | 10.15 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.44 | 6.30 | 6.06 | 7.13 |

## Project 245 - 201 Upgrade Meeden - Diele

Increase of the interconnection capacity between The Netherlands and Germany by approximately 500 MW by adding one new phase shifting transformer and apply dynamic line rating on the existing 400 kV double circuit tie line between Meeden and Diele. The project will increase the cross border capacity and hence increase the market capacity between the two countries. This will lead to better price convergence in the region. Furthermore the energy from RES sources can better be integrated in the Dutch and German system, avoiding spillage and in extreme cases the increase of the interconnection capacity and controllability helps in securing the system.

| | |
|---|---|
| Classification | Mid-term project |
| Boundary | Netherlands - Germany |
| PCI label | |
| Promoted by | TenneT TSO;TenneT TSO GmbH |


## Investments

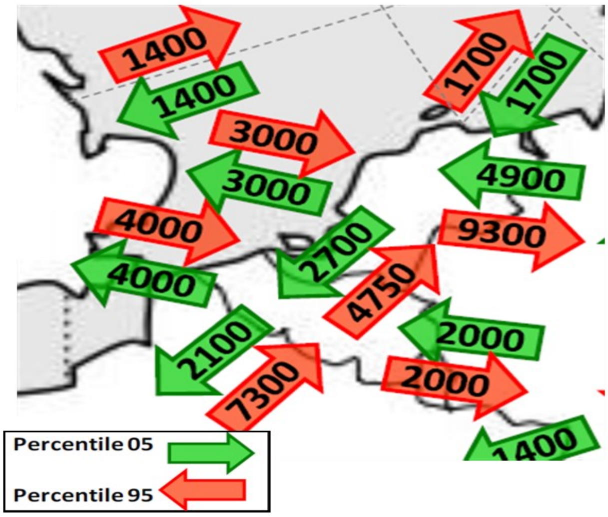
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1246 | Upgrade of existing interconnection to 2x1950MVA | 100% | Meeden [NL] | Diele [DE] | Planning | -2019 | Investment on time | Engineering completed, permits requested, construction planned. |

## Additional Information

The project will better facilitate Bulk Power flows from East to West and vice versa, resulting in integration of more renewable resources, especially wind energy in Northern Germany.

## Investment needs

The North Sea Region is characterized by a significant increase in RES generation (especially offshore wind). The grid has to be developed in order to support these new exchange possibilities, facilitating the access to the most economic energy mix, while minimizing grid congestions. High flows in both directions West-East and North-South are expected. The project strengthens the European single market especially in the CWE-Region. It increases the interconnection capacity between The Netherlands and Germany and therefore the security of supply.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | NL-DE: 0 |
| | DE-NL: 0 |
| Delta GTC contribution (2030) [MW] | NL-DE: n/a |
| | DE-NL: 300 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 90 ±50 | 50 ±50 |
| B4 Losses (GWh/yr) | 0 ±25 | 25 ±25 | 25 ±25 | -75 ±25 | -75 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 1 ±2 | 1 ±1 | -5 ±2 | -5 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±50 | 200 ±100 | 200 ±100 | ±100 | 100 ±200 |

comment on GTC:

Due to internal constraints in the NL the GTC contribution in 2020 is limited. With the partial completion of project 103, the Ring NL, the major grid contraints will be mitigated and a higher GTC value can be facilitated.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.98 | 0.42 | 0.35 | 0.28 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.08 | 2.64 | 4.31 | 3.63 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 12.23 | 9.93 | 3.06 | 4.31 |

## Project 247 - AQUIND Interconnector

The Project is to develop a high voltage direct current subsea interconnector power transmission cable between the United Kingdom and France with the total capacity of up to 2000MW and other associated installations as explained herein. The interconnector will land and connect to the United Kingdom grid in the South East of England. The connection point in France will be on the Normandy Coast.

| | |
|---|---|
| Classification | Future project |
| Boundary | France - Great Britain |
| PCI label | |
| Promoted by | Aquind Limited |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1381 | New subsea HVDC link between France and the UK | 100% | Lovedean (UK) | Le Havre (FR) | Planning | 2020 | New Investment | Planning status (though the project is simultaneously progressing some elements of the design and permitting activities) |

### Additional Information

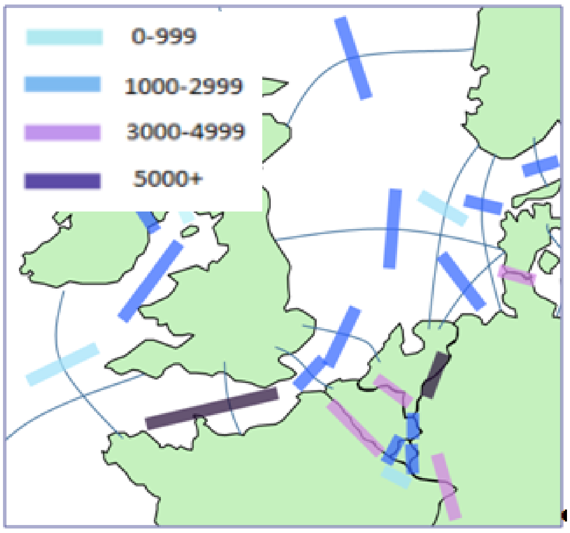
Project and company website - www.aquind.co.uk

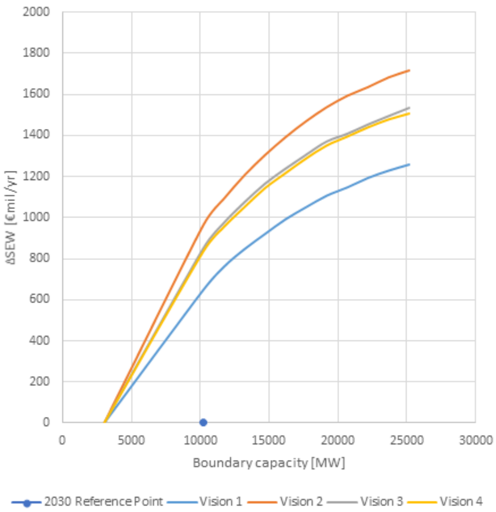
## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list).

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between Great Britain and the continent . On the SEW/GTC graph we can see that even starting from a 2030 capacity of about 10GW between GB and the continental and Nordics areas, extra capacity still allows savings on the boundary.

This project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between Great Britain and the continent.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB-FR: 2000 |
| | FR-GB: 2000 |
| Capex Costs 2015 (M€)<br><br>Source: Project Promoter | 1400 |
| Cost explanation | A number of scenarios have been costed depending on the technology used, the build method and the capacity of the Project. The expected investment requirements are estimated at £1 – 1.1bn, based on a single 1800MW bi--- polar scheme using Voltage Source Converters.<br><br>The lowest estimated investment costs are £700m, based on a s ingle 1800MW bi-polar scheme using the conventional Line C ommutated Converter (LCC) technology. The highest estimate d investment costs are £1,320m, based on two parallel links of 1000MW each, using the Voltage Source Converter (VSC) tec |

| | |
|---|---|
| | hnology. Each development scenario has its advantages and dis advantages and the Promoter would like to retain flexibility of choice until a certain point. The €/ exchange rates at the procur ement and construction stages of the Project may be a key facto r influencing the final investment requirements for the Project due to a potentially high share of capital expenditure arising fro m the countries within the single currency zone. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 80 ±10 | 140 ±10 | 120 ±20 | 130 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | 840 ±560 | 1330 ±440 | 750 ±290 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 1600 ±300 | 400 ±400 | -700 ±100 | -900 ±400 |

Regarding GTC assessment :

- On the French side, depending on the final connection location, additional analysis will have to be performed in order to assess curtailment level needed to ensure N and N-1 safe operation of the French transmission system.

Regarding SEW assessment :

- The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.92 | 7.80 | 8.25 | 7.26 |

| | | | | |
|---|---|---|---|---|
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.72 | 13.56 | 19.68 | 18.44 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.60 | 13.49 | 10.67 | 11.29 |

## Project 248 - Offshore Wind Baltic Sea (II)

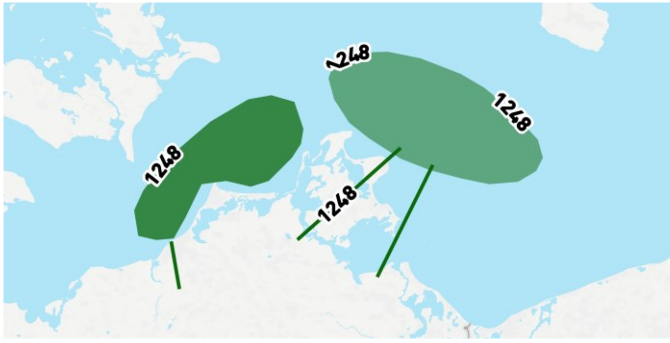
AC grid connections connecting Offshore Wind Farms in Cluster 1, 2 or 4 of the Baltic Sea (see German Offshore Grid Development Plan). Clusters are located north east of Rügen mainly in the German Exclusive Economic Zone.

Classification: Long-term Project

Boundary: Internal Boundary in North-East Germany

PCI label:

Promoted by: 50Hertz Transmission




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1248 | Grid Connection of offshore wind farms (using AC-technology). | 100% | | | Under Consideration | 2026 | Investment on time | |

## Additional Information

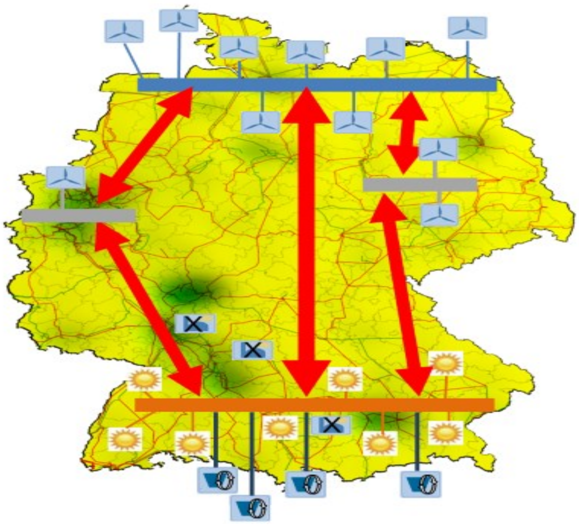
**German grid development plan:**

http://www.netzentwicklungsplan.de/en

## Investment needs

Germany is planning to build a big amount of offshore wind power plants in the North- and Baltic Sea. The OWP will help to reach the European goal of CO2 reduction, share of RES and ther integration. These offshore infrastructure projects in the Baltic Seas area, will deliver different benefits (lowering CO2 emissions, facilitating the integration of renewables and ensuring sufficient system resilience, increasing share of RES).

The development of off-shore wind farms in the North of Germany induces needs for undersea connections to these wind farms as well as reinforcements of the grid capacity from North to South. According to German law, these grid connections have to be constructed and operated by the TSO.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project's expected commissioning date and status, according to the EC guidelines the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | Internal DE: 1100 |
| | The project contains a connection of offshore generation only and no interconnection. Hence the value for delta GTC is based on the physical capacity of the connection and the installed power itself. |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1200 ±800 |
| Cost explanation | The costs of this project are depending strongly on the expected increase of Offshore wind generation in Germany (especially in the Baltic Sea) and the therefore needed numbers of grid connections. |
| S1 | NA |
| S2 | NA |
| B6 | 0 |
| B7 | + |

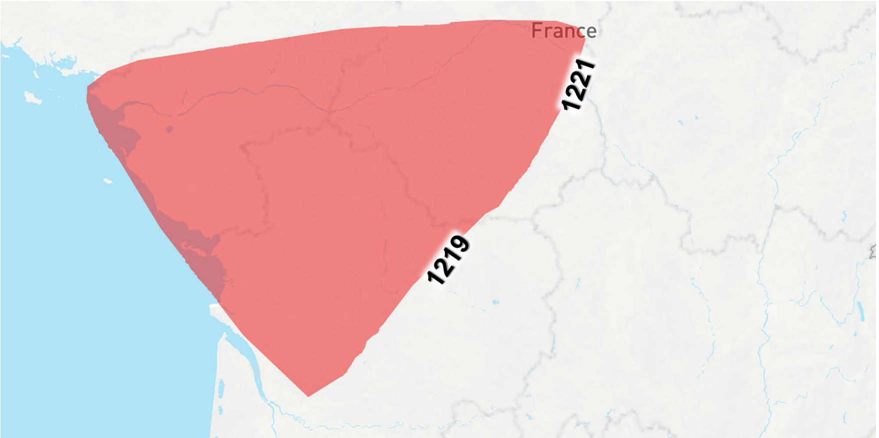
| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 30 ±10 | N/A | 320 ±10 | 370 ±20 |
| B3 RES integration (GWh/yr) | N/A | 460 ±90 | N/A | 4610 ±110 | 5020 ±1000 |
| B4 Losses (GWh/yr) | N/A | -100 ±25 | N/A | 200 ±25 | 200 ±25 |
| B4 Losses (Meuros/yr) | N/A | -6 ±2 | N/A | 11 ±2 | 13 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | -300 ±100 | N/A | -1700 ±0 | -2000 ±300 |

The need of this project is depending on the expected increase of Offshore wind generation in Germany (especially in the Baltic Sea). Thats why only results for Vision 1, 3 &4 are available.

## Project 249 - Façade Atlantique

Investments in France. Upgrade of the North-South 400 kV corridor between Nouvelle Aquitaine and Vallée de la Loire . Exact scope of the project will be defined in the follow up of the studies.
The investments below (1219 & 1221) were considered for the assessment.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Internal boundary in south-western France |
| PCI label | |
| Promoted by | RTE |




### Investments

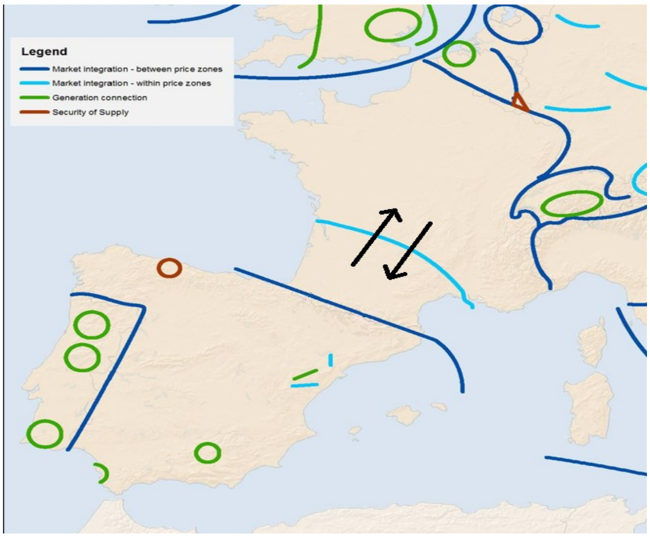
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1219 | Grid reinforcement between Cubnezais and Marmagne | 100% | Cubnezais | Marmagne | Under Consideration | 2030 | New Investment | This investment is necessary to transmit the RES generation from France and Iberian peninsula |
| 1221 | upgrade of existing 400kV lines between Marmagne and Tabarderie | 100% | Marmagne | Tabarderie | Under Consideration | 2030 | New Investment | This investment is necessary to accomodate the north to south and south to north flows increased by large changes in the generation pattern. |

### Additional Information

French National Development Plan http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

### Investment needs

This long term investment is needed for internal constraints, depending of energy transition in south-west area of France (in particular with high development of PV generation or nuclear decommissionning). Besides, in all 2030 scenarios, the project is always needed, due to the 8GW France-Spain exchanges; additional studies are needed for better investment definition.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | South West-[FR] North East : 3000 |
| | [FR] North East - South West: 3000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 700 ±200 |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 170 ±30 | 600 ±90 | 710 ±110 | 550 ±80 |
| B3 RES integration (GWh/yr) | N/A | 2050 ±410 | 3550 ±710 | 2910 ±580 | 8570 ±1710 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -600 ±100 | -2100 ±300 | -2400 ±400 | -1900 ±300 |

Internal projects in France are necessary in the reference case for 2030 network. As they are linked to the internal hypothesis like future RES integration, their assessment can not be done only with the standard market studies  (only one node per country), as they are taking into account internal redispatching.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

Thus, the SEW indicator has been calculated to assess the internal redispatching necessary to respect the market based flows between France and Spain (8 GW for 2030 visions)

## Project 250 - Merchant line "Castasegna (CH) - Mese (IT)"

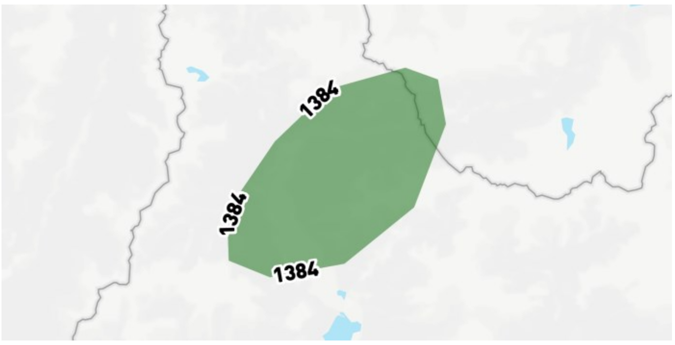
"The planned Transmission project is a merchant line on the swiss-italian border between Castasegna (CH) and Mese (IT). The planned Cable connection in 220 kV AC has a length of around 14 km, 13.5 of witch in Italy. In connection with the realisation of the project a Rationalisation of the 380 and 132 kV Grid in the region Mese (Provincia di Sondrio) is planned. The expected NTC increase is around 200 MW. The main Project elements are (merchant line):220 kV Connection to the Swiss HVG in Castasegna220 kV Cable line of around 14 km between Castasegna and Mese220/380 kV Substation with PST 250 MVA in Mese The Grid Rationalisation in the Region of Mese foresees the following actions:Displacement of 2 km of the 380 kV Line ""Soazza – Bulciago""Realisation of a new 380/132 kV Substation in Mese (Transformation 2 x 250 MVA)Displacement of 0.8 km of 132 kV LinesRealisation of 2.6 km of 132 kV Cable connectionsDemolition of 2.45 km of 380 kV line and 2.3 km of 132 kV lines"

Classification Mid-term project

Boundary Italy - Switzerland

PCI label

Promoted by Repower



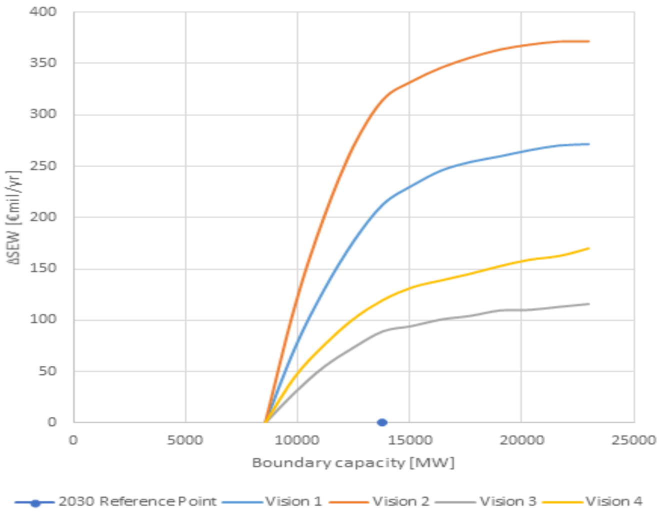

## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1384 | The consist in a 220kV AC cable line which connects the Castasegna (CH) substation to a new substation in Mese (IT) | 80-100% | Castasegna | Mese | Design & permitting | 2019 | | |

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

The high SEW/GTC values in the V2 and V1 are mainly related to the lower CO2 value used in the scenarios that makes coal generation cheaper than gas and leads to higher Italian import, especially for Vision2. On the opposite side in V3 and V4, the higher CO2 costs and the higher RES generation capacity lead to a different use of the Italian Northern boundary, characterized by a lower SEW, but higher RES integration indicators values.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Projects 26, 31, 150, 174, 21, 210 and 250 at the North-Italian boundary are assessed with multiple TOOT steps to reflect the sequence of expected commissioning dates.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | IT-CH: 100 |
| | CH-IT: 100 |
| Delta GTC contribution (2030) [MW] | IT-CH: 100 |
| | CH-IT: 100 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 90 |
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | N/A |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±< 10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | 10 ±10 |
| B4 Losses (GWh/yr) | -25 ±25 | 0 ±25 | 0 ±25 | 75 ±25 | 100 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | 0 ±1 | 0 ±1 | 4 ±2 | 6 ±2 |
| B5 CO2 Emissions (kT/year) | 400 ±30 | ±100 | 100 ±100 | ±100 | ±100 |

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.46 | 0.67 | 0.38 | 0.59 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.89 | 3.56 | 4.20 | 4.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.55 | 9.18 | 1.81 | 2.12 |

## Project 251 - Audorf-Dollern

New 380-kV-line Audorf – Hamburg/Nord – Dollern” in existing 220-kV-corridor. Main focus of the project is the integration of onshore-RES – mainly wind – in Schleswig-Holstein. The project is labeled as PCI 1.4.2. and 1.4.3.  It is the southbound connection of PCI 1.4.1. and is necessary to increase the GTC between Dänemark/West and Germany by 720/1000 MW.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Inside Germany |
| PCI label | 1.4.2, 1.4.3 |
| Promoted by | Tennet-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 147 | New 380kV double circuit OHL Dollern - Hamburg/Nord | 100% | Dollern (DE) | Hamburg/Nord (DE) | Under Construction | 2018 | Delayed | Delay due to long permitting process |
| 148 | New 380kV double circuit OHL Audorf - Hamburg/Nord including two new 380/220kV transformers in substation Audorf. Length 65km. | 100% | Audorf (DE) | Hamburg/Nord (DE) | Under Construction | 2018 | Delayed | Delay due to long permitting process |

### Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

Information on Investment 147 (in German)

http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/hamburgnord-dollern.html

Information on Investment 148 (in German)

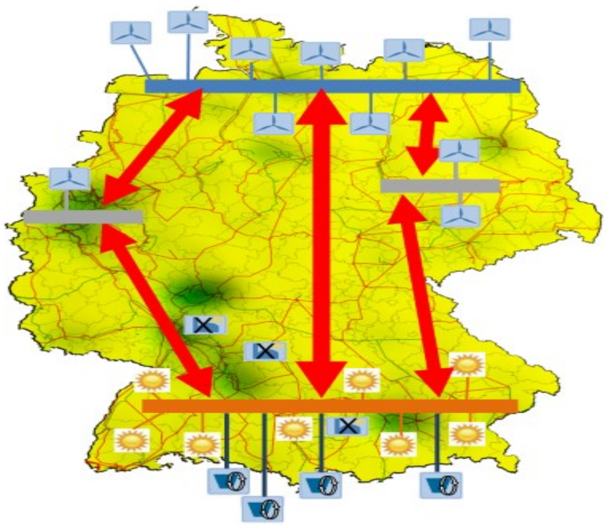
http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/audorf-hamburgnord.html

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the transmission capacity from Denmark and Schleswig-Holstein to Lower Saxony and it will increase the interconnection capacity between Denmark and Germany. Furthermore it helps integrating and transporting high amounts of RES even under n-1-situations.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DKW -DE: 1000 |
| | DE-DKW : 700 |

| | |
|---|---|
| Delta GTC contribution (2030) [MW] | DKW -DE: 1000 |
| | DE-DKW : 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 330 ±50 |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | 15-50km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 50 ±10 | 30 ±10 | 140 ±20 | 90 ±10 | 50 ±10 |
| B3 RES integration (GWh/yr) | 930 ±190 | 70 ±10 | 210 ±40 | 980 ±200 | 590 ±120 |
| B4 Losses (GWh/yr) | -275 ±27 | -225 ±25 | -125 ±25 | -175 ±25 | -475 ±47 |
| B4 Losses (Meuros/yr) | -12 ±1 | -12 ±1 | -6 ±1 | -11 ±2 | -32 ±3 |
| B5 CO2 Emissions (kT/year) | -1000 ±150 | ±100 | -300 ±100 | -800 ±100 | -500 ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. The mentioned GTC value is the additional crossborder impact of the project.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high  in some situations. The practical handling of such big redispatch volumes is critical.

Moreover  the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

## Project 252 - Internal Belgian Backbone East

This project englobes the development of the internal backbone at the east side of Belgium driven by the perspective of evolutions in the production park (for example the potential connection of new gas-fired power plants) as well as the further development of interconnection capacity on the surrounding borders. Towards the 2020-2025 horizon the reinforcement would double the capacity of the Meerhout-VanEyck-Gramme axis by i) installing a second 380 kV circuit on the ~90km line between Meerhout and Van Eyck and ii) upgrading the ~90km long Gramme-VanEyck axis to HTLS conductors.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Belgian Backbone East |
| PCI label | |
| Promoted by | Elia System Operator |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1050 | Conditional upgrade of the 380kV line Van Eyck-Gramme: further reinforcement of the 380 kV overhead line Gramme-Van Eyck to HTLS. | 100% | Van Eyck | Gramme | Under Consideration | 2025 | Investment on time | The need for this investment towards 2020-2025 horizon is to be further monitored in accordance with the evolution of transitflux/interconnection capacity on the surrounding borders, and with the evolution in the production park i.e. planned nuclear phase out and potential of new production units that could be deployed within the area. |
| 1456 | Upgrade of the existing 380kV overhead line by placing a 2nd 380kV circuit on the existing pylons. | 100% | Massenhoven (BE) | Van Eyck (BE) | Under Consideration | 2025 | Investment on time | The need for this project towards 2020-2025 horizon is to be further monitored in accordance with the evolution of transitflux/interconnection capacity on the surrounding borders, and with the perspective of evolution in the production park. |

## Additional Information

The project is integrated as project under consideration in Elia's National Development Plan 2015-2025:
[http://www.elia.be/fr/grid-data/grid-development/plans-d-investissements/federal-development-plan-2015-2025](http://www.elia.be/fr/grid-data/grid-development/plans-d-investissements/federal-development-plan-2015-2025)

## Investment needs

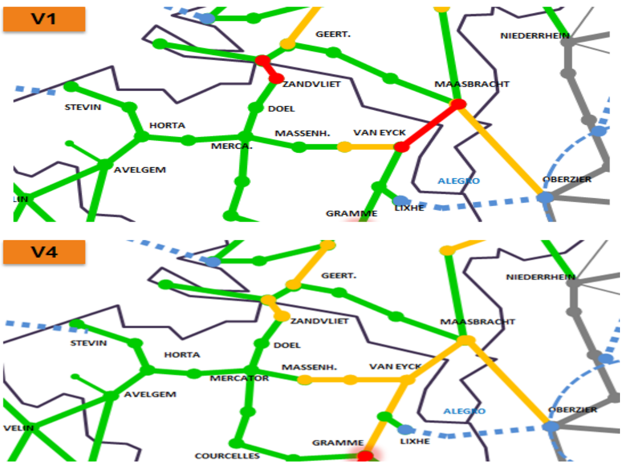
Production park evolution in Belgium is characterized by a planned nuclear phase out between 2022 and 2025, and the potential integration of new gas-fired production units along the north-eastern part of the internal backbone.

Furthermore, there is a perspective of developing additional interconnection capacity between Belgium and/or Netherlands & Germany, as captured via projects 262 and 225 respectively.

Such (combination of) evolutions would translate into increased bulk power flows over the concerned transmission corridor in the eastern part of Belgium, resulting into a need to develop additional tranmission capacity over this corridor.

The solution under investigation puts forward a doubling of the current transport capacity of the concerned transmission corridor.

Zoom on bottlenecks in 2030 around the BE-NL border




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE: 1400 |
| | BE: 1400 |
| Delta GTC contribution (2030) [MW] | BE: 1400 |
| | BE: 1400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 150 ±30 |
| Cost explanation | Reported cost is the currently expected total investment cost. Uncertainty range reflects uncertainty in procument/construction costs. |
| S1 | 15-50km |
| S2 | 25-50km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±20 | 30 ±10 | <10 | 20 ±10 | <10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±10 | 20 ±10 | 240 ±50 | 110 ±20 |
| B4 Losses (GWh/yr) | -25 ±25 | -25 ±25 | -25 ±25 | -25 ±25 | -25 ±25 |
| B4 Losses (Meuros/yr) | -2 ±2 | -2 ±2 | -1 ±1 | -2 ±2 | -2 ±2 |
| B5 CO2 Emissions (kT/year) | 500 ±100 | 500 ±100 | ±100 | ±100 | -300 ±100 |

The GTC expresses the doubling in capacity of the transmission corridor.

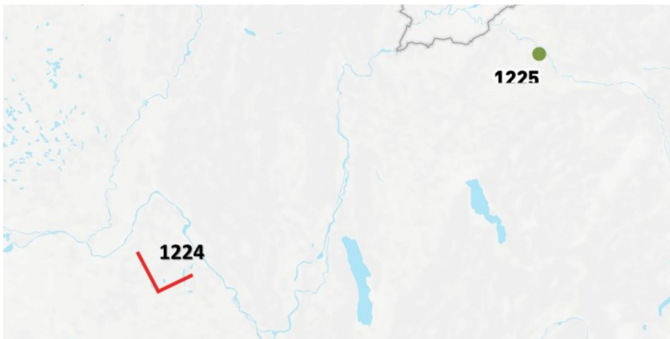
The benefits of this project are related to the benefits of further developing interconnection capacity on the BE-NL/DE borders. Same approach has been applied for the losses. The CBA indicators for this project 252 thus reflect the trends explained in projects 225 & 262.

Additionally, the project would enable integration of new production units implying an inherent contribution in securing the adequacy in Belgium within the perspective of planned nuclear phase out.

# Project 253 - Upstream reinforcement in France to increase FR-CH capacity

The project consists in attracting the flows to the interconnection south of Lake Geneva in order to alleviate the congestion on the link west to Lake Geneva . It is necessary before implementing Project 199  "Lake Geneva South" project but could not be clustered due to the 5-year clustering rule. It consists of a phase-shifter in Cornier substation (FR) together with an uprate of the existing Creys-St Vulbas 400-kV double-circuit OHL to increase its capacity.

| | |
|---|---|
| Classification | Future Project |
| Boundary | France - Switzerland |
| PCI label | |
| Promoted by | RTE |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1224 | Uprate of the 400 kV axis Creys – Saint Vulbas | 100% | Creys(FR) | Saint Vulbas (FR) | Under Consideration | 2020 | New Investment | |
| 1225 | Implementation of a PST within Cornier substation | 100% | Cornier (FR) | | Under Consideration | 2020 | New Investment | |

## Additional Information

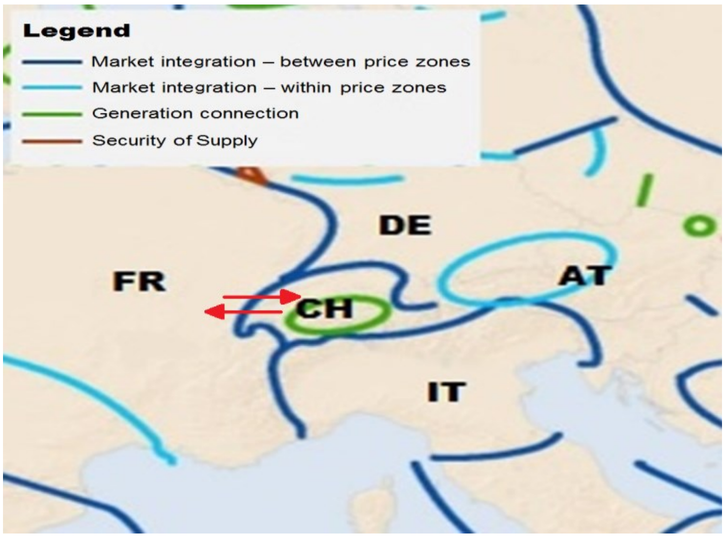
Link to the French National Development Plan
http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

## Investment needs

The need for the project arose in the Common Planning Studies of Spring 2015, where market-based target capacity showed an interest to increase the capacity on the France-Switzerland border in order to accomodate the Long Term high RES scenario.

Projects 22 (Lake Geneva West) and 199 (Lake Geneva South) were already envisaged, but more detailed grid studies showed the interest of reinforcing the upstream grid in France and controlling the flows by a phase-shifter in order to divert the flows from the current bottleneck and take full benefit of the other projects.

Analyses on this border showed that the benefit SEW provided by a standard 1 GW capacity increase is around 10M€ in all 2030 visions except in Vision 4 where it is higher.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-CH: 650 |
| | CH-FR: 100 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 50 ±10 |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 10 ±0 | 20 ±20 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | ±100 | ±100 | ±100 |

The projects on the France-Switzerland border were all assessed via a multiple TOOT/PINT methodology according to their maturity and expected commissioning date, taking into account the capacity increases confirmed by the grid studies. This project was assessed on top of project 22 and before project 199 and conceptual projects 274 and 275.

The project increases access to hydro generation in the Alps and beyond Switzerland to Italy, where prices are generally higher. Its benefits is especially high in Vision 4.
Nevertheless, the benefits over lifetime outweight the investment cost in all the visions.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.43 | 1.07 | 0.81 | 1.96 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 2.77 | 4.58 | 6.21 | 10.10 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.29 | 7.85 | 2.35 | 3.96 |

The above table shows that the prices convergence is quite good in the reference case (taking into account the planned projects) in all scenarios. The portfolio of projects on this border helps reducing the gap between market prices significantly, especally in V1 and 2.

Nevertheless the standard deviation of price differential remains significant, especially in the visions with high RES; in this respect, projects on this border provide market players with additional hedging against prices volatility. This additional benefit is not captured in the SEW.

## Project 254 - Ultranet

The Ultranet project consists of a 2 GW HVDC-connection from the Region of Osterath (Rhineland) to the Region of Philippsburg (Baden-Württemberg). It's a pilot project with DC circuits on the same pylons as AC lines and will therefore deliver profund knowledge on combined AC/DC-corridors. Ultranet has also a strong correlation to investment 661 of project 132 - Corridor A-North. These two DC-Lines together transport offshore and onshore wind from the North of Germany to the South.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Internal Project |
| PCI label | 2.9 |
| Promoted by | Amprion;TransnetBW |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 660 | New HVDC line from Osterath to Philippsburg (Length: approx. 340 km) | 100% | Osterath (DE) | Philippsburg (DE) | Permitting | 2021 | Delayed | Delays due to permit granting reasons. |

## Additional Information

Further information on the project and its interaction with other projects can be found in the German Grid Development plan (in German):
http://www.netzentwicklungsplan.de/content/der-netzentwicklungsplan-0
And on the project specific websites (in German):
http://netzausbau.amprion.net/projekte/ultranet/projektbeschreibung
https://www.transnetbw.de/de/ultranet/

The project is also part of the current PCI-List (in English):

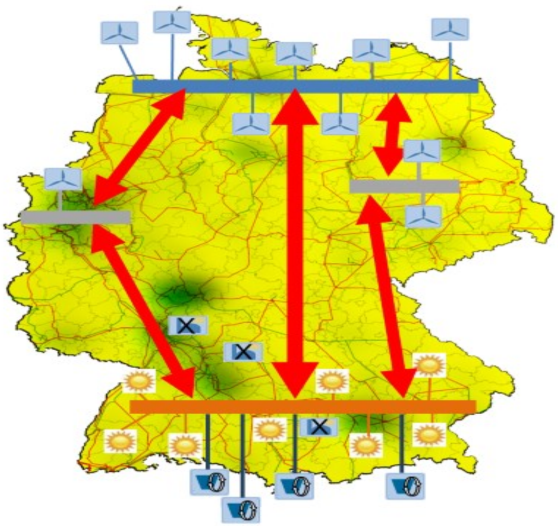
http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:JOL_2016_019_R_0001&from=EN

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SoS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and storages (for example Scandinavia or Switzerland)  are required.

As a pilot project for DC technology, it is designed together with the investment 661 which will be connect offshore fields from the North Sea to middle part of Germany. This project will connect the middle part of Germany to the southern part of Germany.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | CH-DE & NL-DE: 600 |
| | DE-CH & DE-NL: 600 |
| Delta GTC contribution (2030) [MW] | CH-DE & NL-DE: 600 |
| | DE-CH & DE-NL: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1070 ±160 |

| | |
|---|---|
| Cost explanation | |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 30 ±< 10 | 70 ±10 | 40 ±10 | 30 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | <10 | 70 ±10 | 70 ±10 | 250 ±50 | 240 ±50 |
| B4 Losses (GWh/yr) | 0 ±25 | 125 ±25 | 100 ±25 | 0 ±25 | 25 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 6 ±2 | 4 ±2 | 0 ±1 | 1 ±2 |
| B5 CO2 Emissions (kT/year) | 300 ±50 | 400 ±100 | 200 ±100 | ±100 | ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. The mentioned GTC value is the additional crossborder impact of the project.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 255 - Connection Navarra-Basque Country

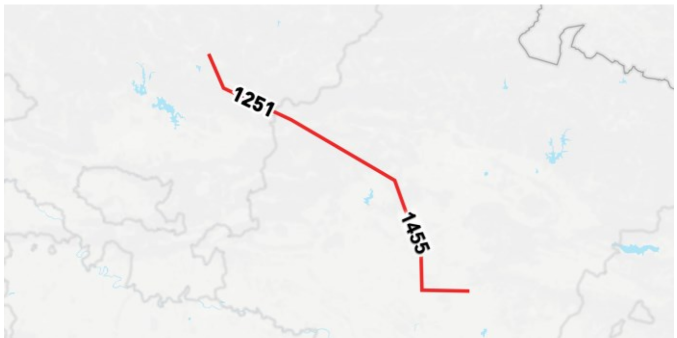
New OHL 400kV double circuit Ichaso-Castejón/Muruarte 400kV

Classification: Mid-term Project

Boundary: Internal boundary in Spain Navarra-Basque Country or ES-FR

PCI label

Promoted by: REE




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1251 | | 100% | Muruarte | Ichaso | Planning | 2020 | New Investment | |
| 1455 | | 100% | Castejón | Ichaso | Planning | 2020 | New Investment | |

### Additional Information

Useful link: *Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

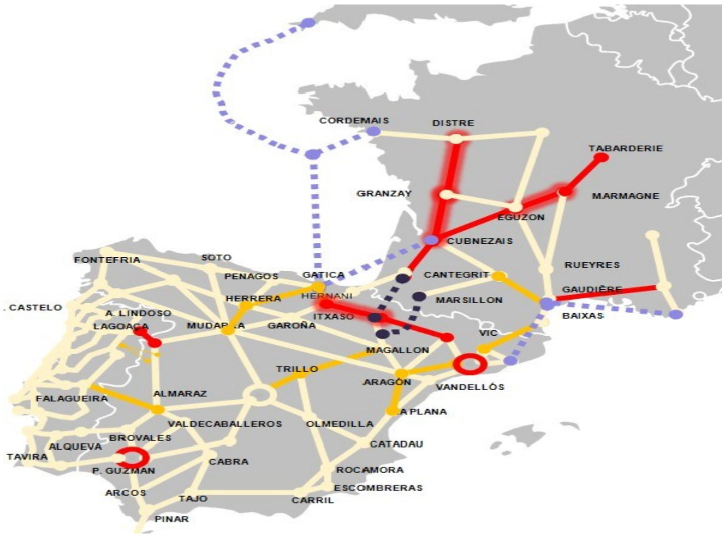
Clustering: The project consists of a unique investment. A double circuit, one circuit connecting Ichaso and Castejón and and the other Ichaso and Muruarte. The intersection allows minimizing the impact in the territory.

### Investment needs

Congestions occur already today in the 220kV network between Navarra and the Basque Country, which lead to the redispacht of some thermal generation and the curtailment of RES. This situation today increases in future scenarios.

In addition there is also a need to connect the planned North axis between Galicia and the Basque Country with the Mediterranean through a robust path that allows flows in both directions.

*Moreover, in the long term, there is a need to have a robust enough network in the area to connect and integrate flows from/to the future FR-ES interconnection Navarra-Atlantic Pyrenees.*




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | east-west: 1750 |
| | west-east: 1000 |
| Delta GTC contribution (2030) [MW] | east-west: [400 ; 750] |
| | west-east: [250 ; 3000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 72 ±7.2 |
| Cost explanation | CAPEX cost |
| S1 | 50-100km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±< 10 | 30 ±10 | 40 ±10 | 70 ±10 | 90 ±10 |
| B3 RES integration (GWh/yr) | 50 ±10 | 20 ±10 | 30 ±10 | 140 ±30 | 270 ±50 |
| B4 Losses (GWh/yr) | 25 ±25 | -100 ±25 | 100 ±25 | 50 ±25 | 75 ±25 |
| B4 Losses (Meuros/yr) | 1 ±1 | -6 ±2 | 4 ±2 | 2 ±2 | 5 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | -800 ±100 | -900 ±100 | -600 ±100 | -700 ±100 |

Savings in variable generation costs (SEW) are caused in V1 and V2 by substitution of gas by coal and RES and in V3 and V4 by substitution of gas by RES. Also, the solution of constraints in the 220kV network in the region, are reflected in the results.

## Project 256 - Long-term conceptual interconnector DE-NL

Market analysis revealed the need for additional cross-border capacity between Germany and The Netherlands. Therefore, a bilateral study is started to investigate options for a further increase in addition to existing and planned interconnections.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Germany - Netherlands |
| PCI label | |
| Promoted by | Amprion;TenneT TSO |


### Investments

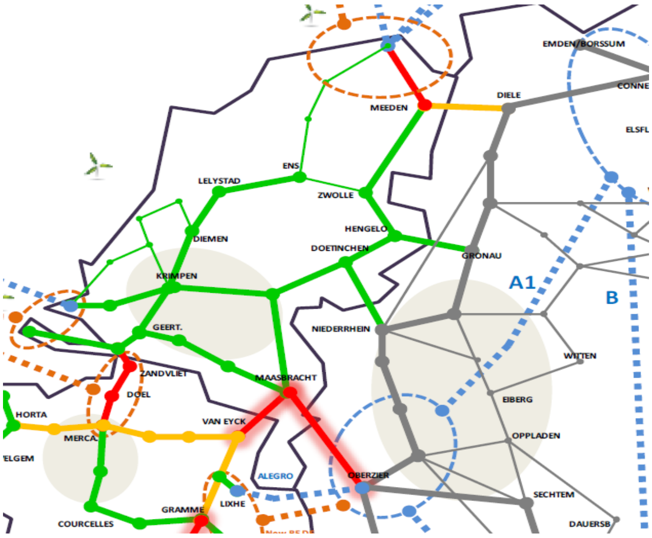
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1252 | A bilateral study to investigate different options is ongoing | 100% | to be defined (DE) | to be defined (NL) | Under Consideration | >2030 | New Investment | Concept, under investigation |

### Additional Information

A conceptual project to reinforce the NL-DE border between Amprion and TenneT, facilitating an increase of the market capacity between Germany and the Netherlands.

### Investment needs

The Common Planning Studies 2015 as well as the calculations in TYNDP 2016 showed that even with the planned grid reinforcements at the German-Dutch border in service there are still bottlenecks on the DE-NL border and a potential to increase the market capacity. Therefore, further possible future reinforcements of this border are under investigation.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

## General CBA Indicators

| | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NL-DE: n/a |
| | DE-NL: [1000 ; 2000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | "For the realisation of this project different options are under investigation. So far no decision is taken on what option will be chosen. Therefore it's not possible to give a cost range." |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 10 ±10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | 10 ±10 | 10 ±10 | <10 | 20 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 300 ±100 | ±100 | ±100 | -200 ±100 |

Comment on GTC:

For the realisation of this projects different options are under investigation. So far no decision is taken on what option will be chosen. Delta GTC value is dpendent on the chosen option.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.98 | 0.42 | 0.35 | 0.28 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.08 | 2.64 | 4.31 | 3.63 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 12.23 | 9.93 | 3.06 | 4.31 |

## Project 257 - Douro Spanish-Portuguese reinforcement

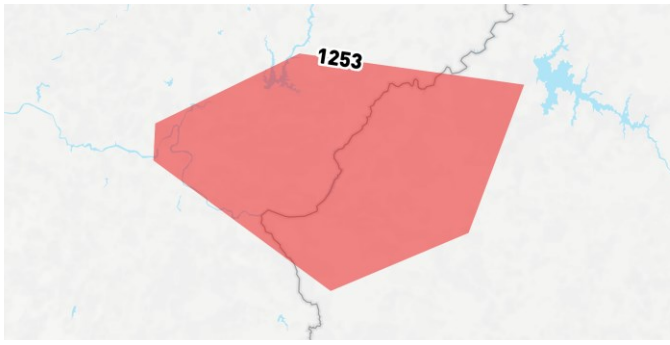
A new cross border Spanish-Portuguese reinforcement in the area of Douro river (conceptual project not defined)

Classification Future Project

Boundary Spain - Portugal

PCI label

Promoted by REE;REN




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1253 | | 100% | | | Under Consideration | 2030 | New Investment | New investment |

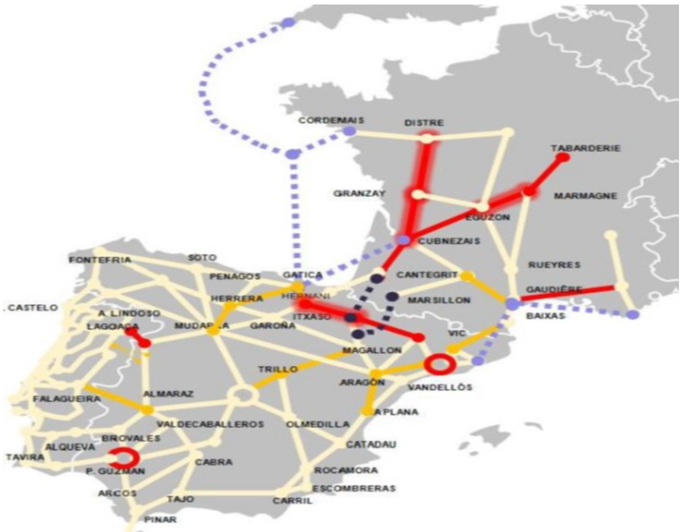
### Additional Information

A new cross border Spanish-Portuguese reinforcement in the area of Douro river (conceptual project not defined in this TYNDP release)

### Investment needs

Market analysis performed during the Common Planning Studies 2015, considering high RES scenarios (TYNDP 2014 Vision 4), revealed potential benefits in an increase of 1 GW in the interconnection capacity between Portugal and Spain (in both directions), from 3.2 GW to 4.2 GW.
The results of the network studies performed during the Common Planning Studies 2015 which considered the most up-to-date information available at that time concerning the expected future demand and generation as well as their location showed that the planned new northern interconnection between Galicia in Spain and Minho in Portugal (Project 4) could allow to reach up to 4.2 GW in the direction from Spain to Portugal. In the opposite direction, from Portugal to Spain, the studies performed with the new northern interconnection (Project 4) showed that the new interconnection values could only reach up to 3.5 GW, limited by bottlenecks in the Douro river region, highly affected by the hydro and wind production in the north area.
Thus, and beyond the new northern interconnection between Galicia an Minho (Project 4), a new conceptual project consisting of new reinforcements in the Portuguese and Spanish networks at the Douro region has been proposed for a CBA assessment in the ENTSO-E TYNDP 2016 framework.

The GTC is common to all Visions, so a comparison between the ratio SEW/GTC only depends from the SEW values. The SEW reflects the benefit of a higher market integration provided by the increase of the interconnection capacity allowing a better optimization of the generation mix. For a GTC increase of 1 GW the ratio SEW/GTC is in the range 2 to 6 M€/GW/year (depending on the scenario).




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | PT-ES: 700 |
| | ES-PT: 300 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | As the project is considered a conceptual project (with no definition of investments) the cost isn't available. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | 10 ±<10 | <10 | 40 ±20 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

As the project is considered a conceptual project with no definition of investments, only CBA indicators coming from market studies are provided.  The GTC increase corresponds therefore to the need resulting from the Common Planning Studies in the RgIP 2015.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.54 | 1.18 | 0.48 | 2.08 |
| Standard deviation marginal cost difference in the reference case  [€/MWh] | 3.65 | 6.23 | 5.31 | 11.39 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 4.96 | 8.37 | 4.10 | 8.92 |

## Project 258 - Westcoast line

New 380-kV-line Brunsbüttel – Niebül inside Schleswig – Holstein. Main focus of the project is the integration of onshore-RES – mainly wind – in Western Schleswig-Holstein. The project is labeled as PCI 1.3.2. It is the southbound connection of PCI 1.3.1. and is necessary to increase the GTC between Dänemark/West and Germany by 500 MW.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Inside Germany |
| PCI label | 1.3.2 |
| Promoted by | Tennet-DE |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 667 | New 380-kV-line and around 10 new transformers for integration of onshore Wind in Schleswig-Holstein, increase NTC DE-DK | 100% | Brunsbüttel (DE) | Niebüll | Permitting | 2018 | Investment on time | in time relative to TYNDP14 |

### Additional Information

**German grid development plan:**

http://www.netzentwicklungsplan.de/en

Project webpage (in German)

http://www.tennet.eu/de/netz-und-projekte/onshore-projekte/westkuestenleitung.html

Second PCI-list

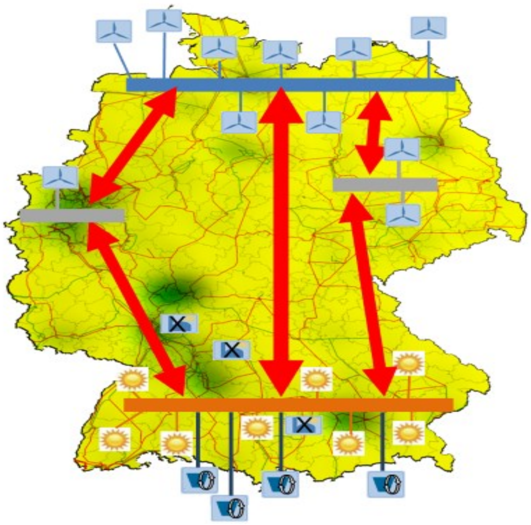
https://ec.europa.eu/energy/sites/ener/files/documents/5_2%20PCI%20annex.pd

## Investment needs

In order to meet the goals of the European and especially German energy policy (German Energiewende) the RES generation in Germany will be increasing strongly. With the current grid, this would lead to internal bottlenecks which occur due to high power flows mainly in the north-south direction. To reduce the related necessary amount of RES generation curtailment as well as conventional redispatch additional North-South transmission capacities in Germany are needed.

Moreover, due to the nuclear phase out in Germany, the amount of reliable available generation capacity in southern Germany will decrease. To retain the security of supply (SOS) of this area at an acceptable level, additional transmission capacities towards areas with conventional generation units, RES and connections to storage (for example Scandinavia) are required.

This project will increase the capacity within Schleswig-Holstein, the transmission capacity from Denmarkand and will help to solve the transmission constraints of the grid in this area caused by the huge amount of increasing RES especially in the western part of Schleswig-Holstein.



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | DKW -DE: 500 |
| | DE-DKW : 500 |
| Delta GTC contribution (2030) [MW] | DKW -DE: 500 |
| | DE-DKW : 500 |
| Capex Costs 2015 (M€) | 250 ±40 |

| | |
|---|---|
| Source: Project Promoter | |
| Cost explanation | Costs based on standard costs for OHL taken from German Grid Development Plan |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 20 ±< 10 | 60 ±10 | 50 ±10 | 80 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | 200 ±40 | 1230 ±250 | 850 ±170 | 780 ±160 | 280 ±60 |
| B4 Losses (GWh/yr) | -50 ±25 | -25 ±25 | 75 ±25 | 25 ±25 | 25 ±25 |
| B4 Losses (Meuros/yr) | -3 ±1 | -2 ±2 | 3 ±2 | 1 ±2 | 1 ±2 |
| B5 CO2 Emissions (kT/year) | -400 ±60 | -1000 ±200 | -1000 ±200 | -800 ±100 | -300 ±100 |

*Comment on GTC:*

The main goal of this project is to solve internal bottlenecks. The mentioned GTC value is the additional crossborder impact of the project.

*Comment on the S1 and S2 indicators:*

Detailed values are not available due to the early state in the planning process.

*Comment on the security of supply:*

Low SoS values mean that theoretically in nearly all situations (n-1)-security can be reached via redispatch. However the necessary amount of redispatch (internal and crossborder) can be very high in some situations. The practical handling of such big redispatch volumes is critical.

Moreover the quick decommissioning of nuclear power plants in Germany has led to the "Reservekraftwerksverordnung" regulation, which goal is to ensure the security of supply until the necessary investments for the grid have been realized, especially in Southern Germany. This regulation is only temporary and shall ensure the system security thanks to contracted reserve power plants dedicated to the security of supply. (See also: http://www.bundesnetzagentur.de/)

*Comment on the SEW:*

For the re-dispatch based benefit calculations only generation dispatch costs leading to differential fuel costs (including costs for CO2 emissions) were considered. In contrast to the overall redispatch costs, passed market premiums, costs for the provision of redispatchable generation and compensation payments for reducing power from RES generation units were neglected. Due to the underestimation of the re-dispatch costs, the determined project benefits are only illustrating the lower bound.

The German Renewable Energy Sources Act (EEG) obligates the Transmission System Operator to pay a monetary compensation for the curtailment of renewable generation units. In the Monitoring Report 2015, published by the German NRA, the average payment (in the year 2014) for the curtailment of wind energy was 7.24 ct/kWh, 31 ct/kWh for the curtailment of solar energy and 16.65 ct/kWh for the curtailment of biomass energy. The share of the curtailment of wind energy was 77.3 %, followed by solar energy with 15.5 % and biomass energy with 7.1 %. This compensation payment can be seen as costs that in the end have to be borne by the electricity consumers connected to the power grid

## Project 259 - HU-RO

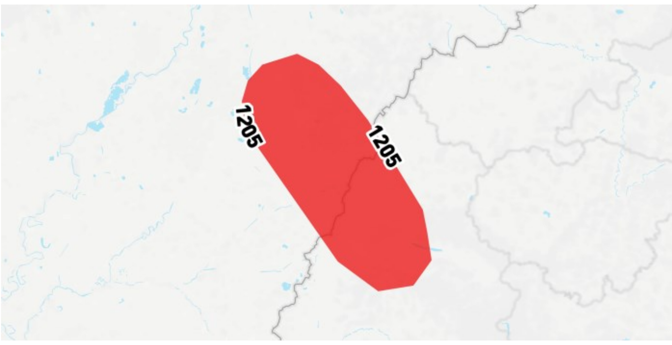
400kV OHL between Hungary and Romania. In Romania a new transformer 400/220kV in Rosiori substation is necessary as internal investment associated to this project.

Classification Future Project

Boundary Hungary-Romania

PCI label

Promoted by MAVIR ZRt;Transelectrica




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1205 | 400kV OHL Jozsa-Oradea | 100% | Jozsa | Oradea | Under Consideration | >2030 | New Investment | |

### Additional Information

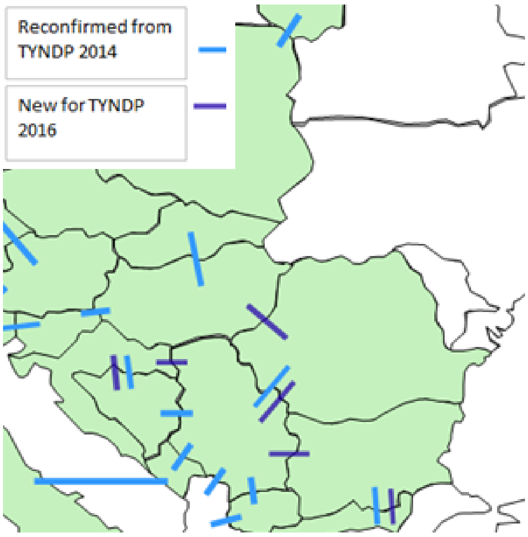
The project is under consideration and is not included in the Romanian national development plan.

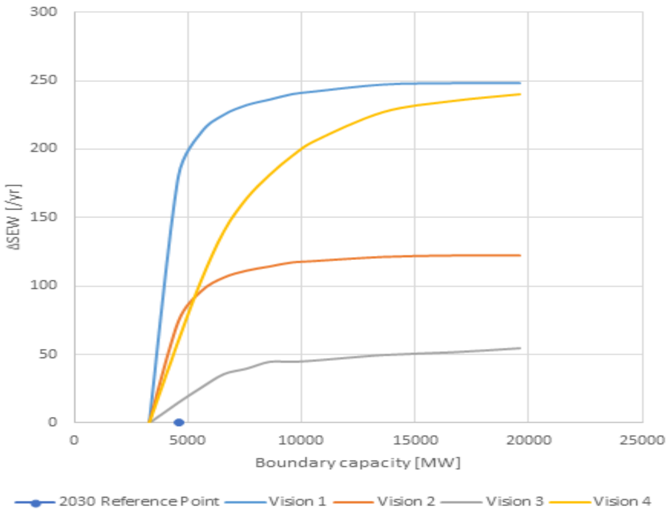
To ensure consistency with the CCE Regional Investment Plan and TYNDP, the project was included in the 2015 Hungarian National Development Plan. Link (only in Hungarian):
http://www.mavir.hu/documents/10258/15454/HFT_2015.pdf

## Investment needs

The project was identified during the Common Planning Studies phase in 2015, which was performed based on TYNDP2014 Vision 4. The project will increase the cross-border transfer capacity between Hungary and Romania.

In the long term, the largest SEW benefit appears in Vision 1, as can be seen in the Figure below that depicts Delta SEW/GTC ratios for the 2030 Visions for the Eastern Balkan Boundary.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | HU-RO: 200 |
| | RO-HU: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 198 ±51 |
| Cost explanation | The estimated cost was calculated during Common Planning Study using standard cost for different types of network elements. In the Regional Investment Plan a range was considered for each candidate project. The uncertainty range cost +/- 51M€ covers the range [0-249]M€ mentioned for this project in RgIP. The estimated cost included also the reinforcements identified during the GTC calculation process. |
| S1 | NA |
| S2 | NA |
| B6 | N/A |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | 10 ±10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 400 ±100 | 300 ±100 | ±100 | -200 ±100 |

During the GTC calculation for Direction Romania to Hungary due to the increased power flow from SW to NW part of Romania the following internal reinforcements were identified:

- reconductoring 220 kV OH line Urechesti-Tg. Jiu- Paroseni- Baru Mare-Hasdat;
- new transformer 400/220 kV Resita

The biggest value of the SEW was obtained in Vision 1 due to increase of cheap thermal production and is associated with an increase of CO2 emissions.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.52 | 4.07 | 1.64 | 3.29 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 10.81 | 7.88 | 9.20 | 12.70 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.24 | 3.70 | 6.70 | 12.11 |

## Project 260 - New Great Britain - Netherlands Interconnector

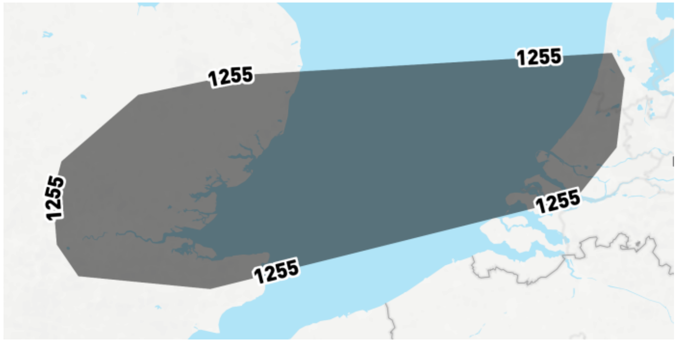
This project considers the possibility of a second 1 GW HVDC connection, between UK and the Netherlands. The projects is triggered by the potential for further market integration between UK and Central Europe. The determination of the optimal capacity, location, technology, potentially needed internal grid reinforcements as well as possible synergies with the development of offshore capacity and the long-term concept of a "west-east corridor" in the North Sea area are subject of further studies.

Classification Future Project

Boundary Great Britain - Netherlands

PCI label

Promoted by National Grid;TenneT TSO BV




### Investments

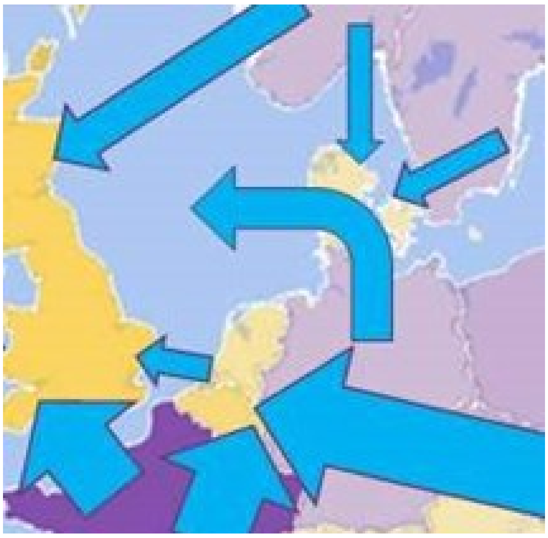
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1255 | a second 1 GW HVDC connection, between UK and the Netherlands | 100% | | | Under Consideration | 2030 | Investment on time | Preliminary studies have indicated potential for further regional welfare & RES integration increase by further increasing the interconnection capacity between Netherlands & UK. |

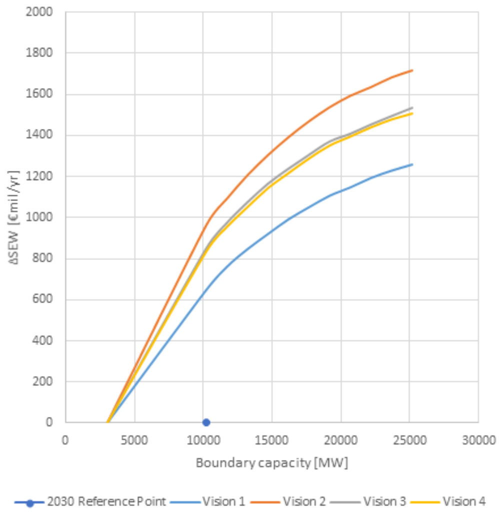
### Additional Information

Project is proposed by ENTSO-E common grid study, which found potential when assessing against TYNDP14 Vision 4.

### Investment needs

The project contributes to further integration of the UK and Central European power systems, which are characterized by different production mix structures and subsequent wholesale market price deltas. In the scenario 2030 V1 the main direction of the bulk power flow is from Central Europe to UK given that on average the price is cheaper in Central Europe. In the scenario 2030 V2 a significant higher share of renewables in the UK induces also flows in the direction from UK to Central Europe. A higher share of renewables combined with a merit order switch to 'gas before coal' results in flows mainly going
from UK to Central Europe in the 2030 V3 & V4 scenarios. This project counts for 1 GW of the potential for further integration of transmission capacity on the UK - Central Europe
boundary.






| Project Cost Benefit Analysis |
|---|

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NL-GB: 1000 |
| | GB-NL: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | For the realisation of this project different options are under investigation. So far no decision is taken on what option will be chosen. Therefore it's not possible to give a cost range. |
| S1 | More than 100km |
| S2 | More than 50km |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 70 ±10 | 70 ±20 | 70 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | 640 ±140 | 640 ±140 | 390 ±120 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 800 ±100 | ±100 | -400 ±100 | -800 ±400 |

This project causes significant savings in generation fuel and operating costs resulting in high SEW across all scenarios. The increased interconnection may also displace potential investments in generation resulting in additional benefit.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.82 | 7.77 | 7.49 | 7.27 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.55 | 13.62 | 18.98 | 18.32 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.24 | 7.43 | 8.02 | 8.78 |

## Project 261 - Long-term conceptual "West-East corridor" in North Sea

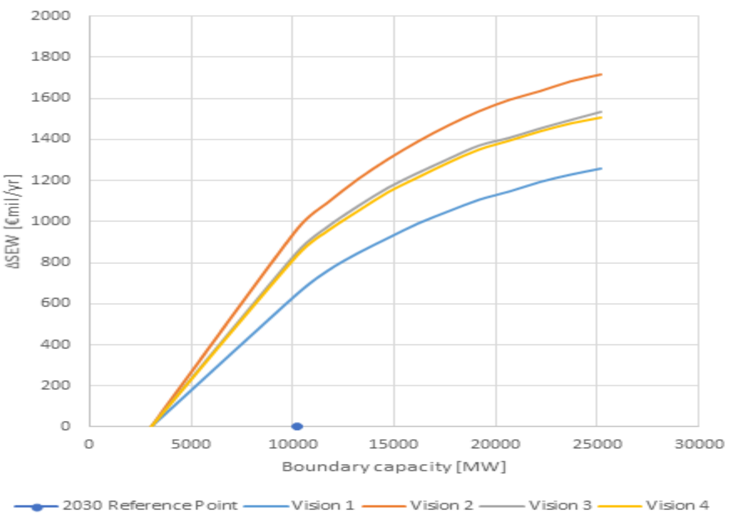
Potential synergies between interconnectors and internal grid reinforcements, enabling further market integration between Great Britain and Central Europe, is to be further studied within the concept of a "west-east corridor"

| | |
|---|---|
| Classification | Future Project |
| Boundary | Great Britain - Central Europe |
| PCI label | |
| Promoted by | Amprion;Creos Luxembourg;Elia System Operator;National Grid;RTE;TenneT TSO |

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1256 | | 100% | | | | | Investment on time | |

### Investment needs




### Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | |
| | |
| Delta GTC contribution (2030) [MW] | |
| | |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | |
| S1 | |
| S2 | |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 262 - Belgium-Netherlands: further evolution

The reference solution envisions the reinforcement of the cross-border lines Zandvliet (BE) - Kreekrak (NL) or Van Eyck (BE) -Maasbracht (NL) with high performance (HTLS) conductors combined with the installation of additional phase shifting transformers. The bilateral study will further evaluate its planning, precise scope and cost-benefit analysis.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Belgium - Netherlands |
| PCI label | |
| Promoted by | Elia System Operator;TenneT TSO |

## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1257 | Reinforcement of the cross-border lines Zandvliet (BE) - Kreekrak (NL) or Van Eyck (BE) -Maasbracht (NL): replacing the current conductors with high performance (HTLS) conductors combined with the installation of additional phase shifting transformers. | 100% | Van Eyck (BE) OR Zandvliet (BE) - TBC | Maasbracht (NL) OR Kreekrak (NL) - TBC | Under Consideration | 2022 | New Investment | This project is introduced in the TYNDP16 via a Common Planning Study elaborated within the Regional Group North Sea and is being studied by TenneT NL and Elia. |

## Additional Information

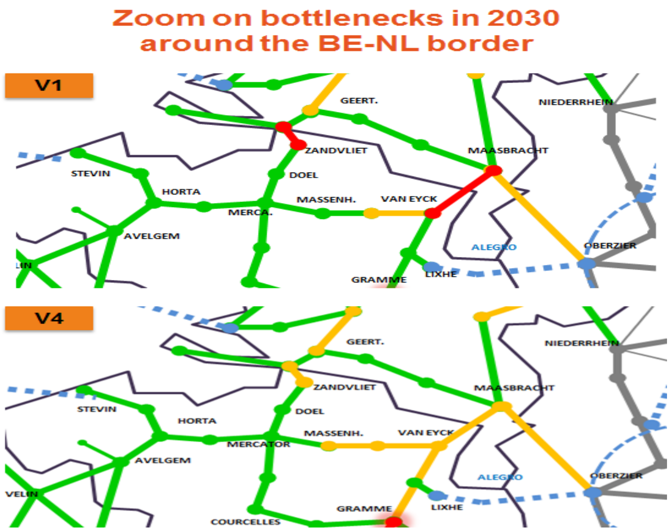
The project is integrated as project under consideration in Elia's National Developmen Plan 2015-2025: http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

## Investment needs

Increasing integration of wind in the northern part of Germany results into higher and more volatile bulk power flows that can be exported from Germany in favorable meteorological conditions, through the Netherlands and into/through Belgium. This creates potential for further reinforcement of the border between Belgium and Netherlands in securing an adequate level of interconnection capacity and subsqequent market coupling within CWE.

A need has been identified to develop additional interconnection capacity between Belgium and The Netherlands. Market analysis (Common Planning Study as part of the TYNDP 16 proces) as well as bilateral studies indicate that additional interconnection capacity is relevant from market integration as well as security-of-supply perspective.A bilateral study has started to investigate the options for developing interconnection capacity between Belgium and The Netherlands, in addition to existing BRABO project.

The project envisions to further develop the interconnection capacity between Belgium and The Netherlands in addition to the BRABO project, quantified by a further 1 GW increase. This quantification is subject to ongoing bilateral studies analyzing different implementation options.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | BE-NL: 1000 |
| | NL-BE: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 60 ±10 |
| Cost explanation | The provided cost represents the currently expected total investment cost. Cost uncertainty reflects the different options being investigated, as well as procurement/construction cost uncertainties. |

| | |
|---|---|
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 70 ±70 | 30 ±30 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 100 ±100 | ±100 | ±100 | -100 ±200 |

The increase in SEW is stable across the different 2030 scenarios. With respect to the CO2 impact, the project has a neutral effect.

A further elaboration of the benefits will be conducted within the bilateral study, hereby assessing the potential contribution of the project in securing the supply of Belgium (adequacy) and also evaluting the interaction with reinforcements on neighbouring borders.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.52 | 0.13 | 0.88 | 0.60 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.08 | 1.49 | 6.41 | 5.06 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.65 | 2.66 | 4.08 | 3.78 |

# Project 263 - Swiss Roof II

This project increases the capacity between CH and its neighbours DE and AT. This enables to connect large renewable generation in Northern Europe to pump storage devices in the Alps, thus noticeably increasing the mutual balancing between both regions.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Switzerland - Germany; and Switzerland - Austria |
| PCI label | |
| Promoted by | swissgrid |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1258 | Integration of the new 380 kV tie-line Rüthi (CH) - Meiningen (AT) through optimisations between Rüthi and Grynau, Rüthi and Bonaduz and the construction of a new 380 kV substation and a new 380/220 kV transformer in Rüthi. | 80-100% | Rüthi | Grynau & Bonaduz | Under Consideration | 2023 | Investment on time | |

## Additional Information

Project Swiss Roof II comprises parts of the TYNDP 2014 project Swiss Roof that do not belong to the Swiss Strategic Grid 2025.

## Investment needs

Compared to project Swiss Roof I, project Swiss Roof II further integrates the Swiss transmission grid into Europe by increasing the cross-border capacity between Switzerland and the Swiss Roof.


## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | Swissroof-CH: 350 |
| | CH-Swissroof: 800 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 34 ±7 |
| Cost explanation | The CAPEX/OPEX split is about 100%/0%. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | 30 ±10 | 10 ±10 | 50 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | <10 | 10 ±10 | <10 | 750 ±150 | 350 ±30 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | ±100 | 500 ±100 | 100 ±100 | -100 ±0 | -100 ±100 |

In V3&V4 the project helps to integrate the renewable generation installed in the North and replace thermal generation. In more conservative scenarios V1&V2 the project allows cheaper coal generation in the North to replace more expensive gas generaiton in the South which leads to higher CO2 emissions.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.97 | 0.48 | 1.04 | 0.33 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.11 | 2.85 | 7.18 | 4.11 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.49 | 4.02 | 0.91 | 1.66 |

## Project 264 - Swiss Roof I

This project increases the capacity between CH and its neighbours DE and AT. This enables to connect large renewable generation in Northern Europe to pump storage devices in the Alps, thus noticeably increasing the mutual balancing between both regions.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Switzerland - Germany; and Switzerland - Austria |
| PCI label | |
| Promoted by | swissgrid |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1259 | Optimization of the existing route by voltage conversion to 380 kV, partial reinforcement including a new 380/220 kV transformer in Beznau. | 20-30% | Beznau | Mettlen | Design & Permitting | 2025 | Investment on time | |
| 1284 | Reinforcement of the existing route | 20-30% | Pradella | La Punt | Design & Permitting | 2020 | Investment on time | |
| 1287 | Optimization of the existing route by voltage conversion to 380 kV including a new 380/220 kV transformer in Mühleberg. | 20-30% | Bassecourt | Mühleberg | Design & Permitting | 2025 | Investment on time | |
| 1288 | Reinforcement of the existing 220 kV line to 380 kV | 20-30% | Mettlen | Ulrichen | Design & Permitting | 2025 | Investment on time | |

## Additional Information

Project Swiss Roof I is the part of the TYNDP 2014 project Swiss Roof that belongs to the Swiss Strategic Grid 2025.

*Link to the Swiss Strategic Grid 2025:*

https://www.swissgrid.ch/swissgrid/en/home/grid/grid_expansion.html

## Investment needs

Project Swiss Roof I increases the integration of the Swiss transmission grid into Europe and helps connect the existing and new Swiss storage and pump storage power plants located in the Alps to the Swiss Mittelland.


## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Swissroof-CH : 1600 |
| | CH - Swissroof: 1100 |
| Delta GTC contribution (2030) [MW] | Swissroof-CH : 2000 |
| | CH - Swissroof: 2000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 591 ±118 |
| Cost explanation | The CAPEX/OPEX split is about 100%/0%. |
| S1 | Negligible or less than 15km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 110 ±20 | 70 ±20 | 40 ±10 | 90 ±10 | 40 ±10 |
| B3 RES integration (GWh/yr) | <10 | 20 ±10 | <10 | 920 ±180 | 500 ±40 |
| B4 Losses (GWh/yr) | 750 ±50 | -175 ±25 | -175 ±25 | -50 ±25 | -50 ±25 |
| B4 Losses (Meuros/yr) | 32 ±2 | -10 ±2 | -8 ±1 | -3 ±2 | -4 ±2 |
| B5 CO2 Emissions (kT/year) | 1900 ±290 | 1300 ±900 | 400 ±100 | -300 ±100 | -100 ±300 |

In V3&V4 the project helps to integrate the renewable generation installed in the North and replace thermal generation. In more conservative scenarios V1&V2 the project allows cheaper coal generation in the North to replace more expensive gas generaiton in the South which leads to higher CO2 emissions.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.97 | 0.48 | 1.04 | 0.33 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 4.11 | 2.85 | 7.18 | 4.11 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.49 | 4.02 | 0.91 | 1.66 |

## Project 265 - Swiss Ellipse II

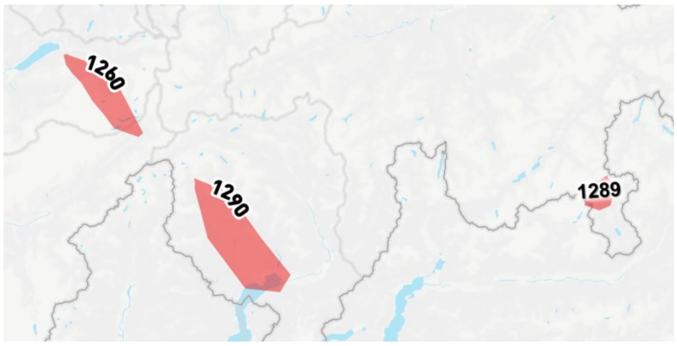
The project helps accommodate new pumping storage units which mainly support the increasing RES generation in the European areas with solar and wind generation.

Classification Long-term Project

Boundary Switzerland

PCI label

Promoted by swissgrid




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1260 | Voltage increase to 380 kV of line Innertkirchen – Ulrichen and construction of a new 380 kV substation and a new 380/220 kV transformer in Innertkirchen in order to connect the new pump storage power plant. | 30-40% | Innertkirchen | Ulrichen | Planning | 2029 | Investment on time | |
| 1289 | new 380 kV substation in Golbia | 30-40% | | | Planning | 2029 | Investment on time | |
| 1290 | reinforcement of the infrastructure in canton Tessin | 30-40% | | | Planning | 2029 | Investment on time | |

## Additional Information

By further integrating Alpine storage and pump storage power plants, Project Swiss Ellipse II constitutes a long-term complement to project Swiss Ellipse I.

## Investment needs

Compared to project Swiss Ellipse I, project Swiss Ellipse II further integrates Alpine storage and pump storage power plants into the transmission grid.


## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | Export-CH: 1650 |
| | CH-Export: 1650 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 194 ±39 |
| Cost explanation | The CAPEX/OPEX split is about 100%/0%. |
| S1 | Negligible or less than 15km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±0 | 40 ±10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 70 ±10 | 10 ±0 |
| B4 Losses (GWh/yr) | N/A | 0 ±25 | 0 ±25 | -100 ±25 | -100 ±25 |
| B4 Losses (Meuros/yr) | N/A | 0 ±1 | 0 ±1 | -6 ±2 | -7 ±2 |
| B5 CO2 Emissions (kT/year) | N/A | 1600 ±0 | 1100 ±200 | -300 ±100 | ±100 |

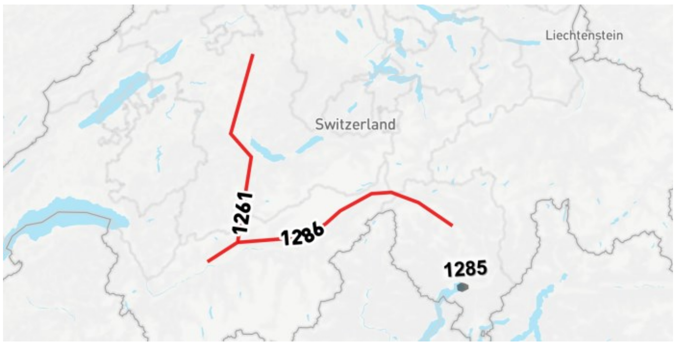
Pump storage in the Swiss Alps helps to integrate renewable generation in scenarios V3&V4. However, not all benefits for the system are captured in the present long-term study.

By the nature of the scenarios V1&V2 this project allows the replacement of more expensive gas generation by the less expensive coal generation and increases the North-South flow.

## Project 266 - Swiss Ellipse I

The project helps accommodate new pump storage units which mainly support the increasing RES generation in the European areas with solar and wind generation.

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Switzerland |
| PCI label | |
| Promoted by | swissgrid |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1261 | Chippis - Bickigen: Optimisation of the existing route by voltage conversion to 380 kV Chamoson - Chippis: Reinforcement by new construction of a 380 kV route New 380/220 kV transformer in Chippis | 30-40% | Bickigen | Chamoson | Design & Permitting | 2019 | Investment on time | |
| 1286 | Reinforcement by new construction of a 380 kV route including a new 380/220 kV transformer in Mörel | 30-40% | Chippis | Lavorgo | Design & Permitting | 2024 | Investment on time | |
| 1285 | New construction to connect the Avegno - Gorduno line to the Magadino substation | 30-40% | | | Design & Permitting | 2019 | Investment on time | |

### Additional Information

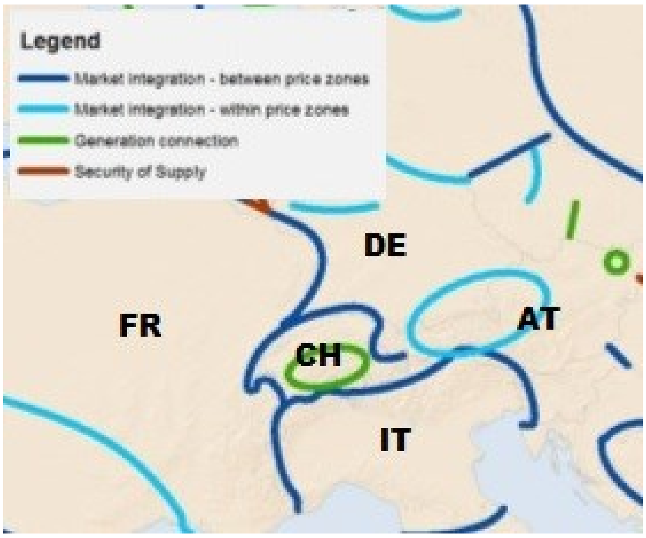
Project Swiss Ellipse I is the part of the TYNDP 2014 project Swiss Ellipse that belongs to the Swiss Strategic Grid 2025. Project

*Link to the Swiss Strategic Grid 2025:*

https://www.swissgrid.ch/swissgrid/en/home/grid/grid_expansion.html

## Investment needs

Swiss Ellipse I creates a 'generation bus' running through the Swiss Alps and helps connect the existing and new Swiss storage and pump storage power plants located in the Alps to the Swiss Mittelland.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Export-CH: 1900 |
| | CH-Export: 1900 |
| Delta GTC contribution (2030) [MW] | Export-CH: 2400 |
| | CH-Export: 2400 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 553 ±111 |
| Cost explanation | The CAPEX/OPEX split is about 100%/0%. |
| S1 | Negligible or less than 15km |

| | |
|---|---|
| S2 | Negligible or less than 15km |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 50 ±< 10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 70 ±10 | 70 ±0 |
| B4 Losses (GWh/yr) | 525 ±52 | -75 ±25 | -75 ±25 | -575 ±57 | -550 ±55 |
| B4 Losses (Meuros/yr) | 22 ±3 | -4 ±1 | -4 ±2 | -35 ±4 | -37 ±4 |
| B5 CO2 Emissions (kT/year) | 500 ±30 | 600 ±0 | ±100 | -300 ±100 | ±100 |

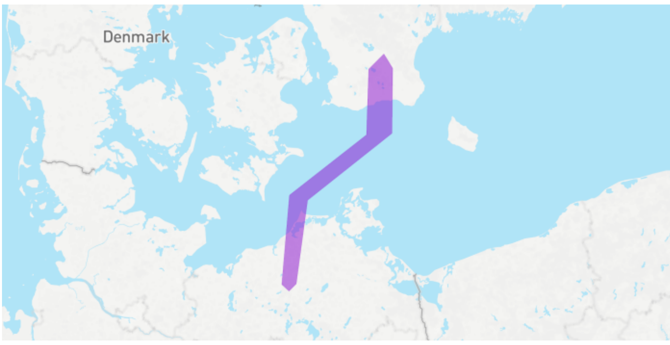
Pump storage in the Swiss Alps helps to integrate renewable generation in scenarios V3&V4. However, not all benefits for the system are captured in the present long-term study.

By the nature of the scenarios V1&V2 this project allows the replacement of more expensive gas generation by the less expensive coal generation and increases the North-South flow.

## Project 267 - Hansa PowerBridge 2

Possible second HVDC cable interconnector between southern Sweden (Bidding area SE4) and Germany (50Hertz). This project candidate is driven by market based target capacities found in the Common Planning Studies by Regional Group Baltic Sea.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Sweden (SE4)-Germany |
| PCI label | |
| Promoted by | 50Hertz Transmission;Svenska Kraftnät |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1262 | New DC cable interconnector between Sweden and Germany. | 100% | Substation SE4 | Güstrow (DE) | Under Consideration | 2030 | New Investment | |

### Additional Information

*Svenska kraftnät has published a national development plan in 2015. The purpose of the plan is to be an investment plan for the following ten years, 2016-2025. The investment plan presents a detailed look of the projects Svenska kraftnät intends to realize under the stated time period. The plan is available in Swedish through the following link:*

http://www.svk.se/siteassets/om-oss/rapporter/natutvecklingsplan-2016-2025.pdf (Swedish)

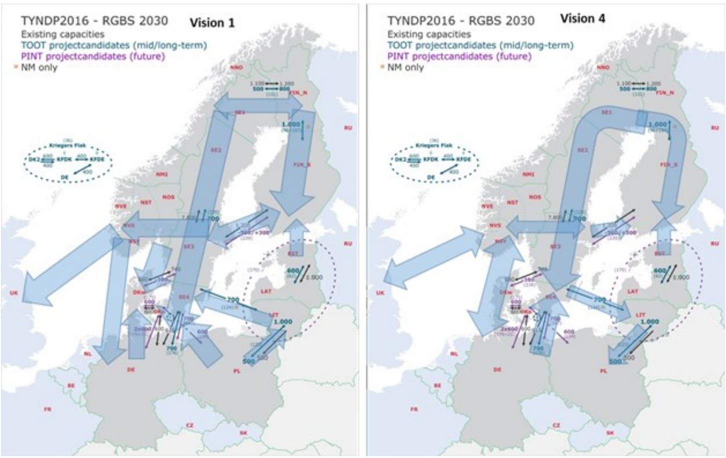
The German national development plan was published in 2016 and is available under the following link:

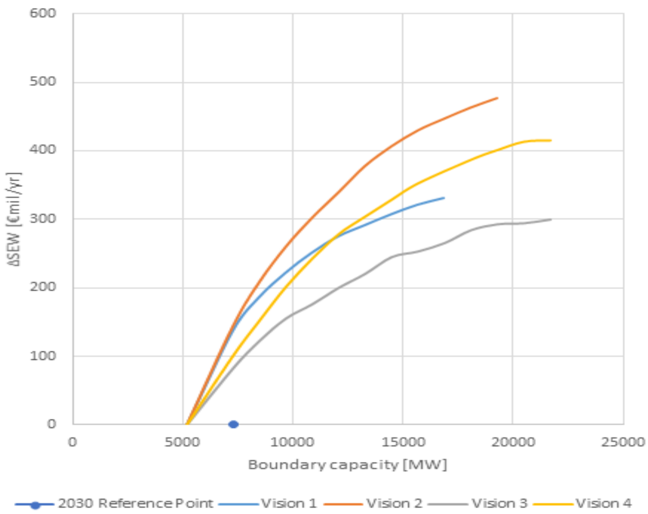
http://www.netzentwicklungsplan.de/en

## Investment needs

The drivers (social economic welfare, renewables integration and system adequacy) are similar to project 176 Hansa PowerBridge I. However, the need for Hansa PowerBridge 2 is highly dependent on the development of the power system beyond 2025. Hansa PowerBridge 2 is therefore considered by Svenska kraftnät and 50Hertz as a possible future project which has to be further evaluated.

The project candidate contributes with an additional 700 MW at the boundary between the Nordic and the Continental synchronous areas. That would bring the capacity between Sweden and Germany to 2015 MW in both directions. As indicated by the capacity analysis figure there is a potential for SEW benefits at that level of capacity. This does however assume that internal grids are reinforced sufficiently so that they do not limit the trade. This will add to the cost of the project candidates, something that is not mentioned here.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Considering the project's expected commissioning date and status, according to the EC guideline the CBA has been performed only for 2030 horizon. |
| | |
| Delta GTC contribution (2030) [MW] | SE4-DE: 700 |
| | DE-SE4: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 660 ±70 |
| Cost explanation | Early cost estimation. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 30 ±10 | 40 ±10 | 20 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | N/A | 10 ±10 | <10 | 210 ±40 | 170 ±30 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | -800 ± | ±100 | 100 ±100 |

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 5.37 | 9.92 | 9.61 | 7.81 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 12.49 | 15.94 | 20.92 | 17.38 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 8.66 | 8.91 | 14.56 | 13.35 |

## Project 268 - Upgrading existing single 400 kV interconnection line between Romania and Serbia to double 400 kV line

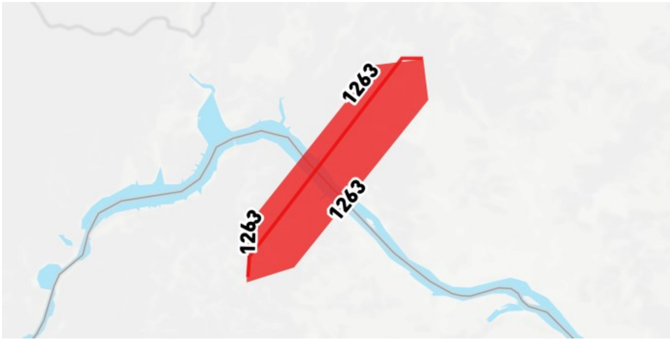
Upgrading existing single 400 kV interconnection line between Romania and Serbia to double 400 kV line

Classification Future Project

Boundary Romania - Serbia

PCI label

Promoted by JP EMS;Transelectrica




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1263 | The second wired of the existing AC transmission line | 100% | Portile de Fier | Djerdap | Under Consideration | 2035 | Investment on time | |

### Additional Information

The project 268, as new candidate transmission project has been proposed to be assessed in the TYNDP 2016, based on the results of common planning studies performed in the CSE Region during preparation of Regional investment plan 2015. The project assumes upgrading existing single 400 kV interconnection line between Romania and Serbia to double 400 kV line (length is approximatly 2 km)

### Investment needs

The Project 268 objectives, as well as project 273, in line with the basic goals of EU energy policy, are to:

1. improve functioning and reliability of the electricity markets in Serbia and Romania;
2. facilitate further integration and expansion of the 400kV network in the region;
3. facilitate higher level of integration of renewable energy sources in Serbia and Romania;
4. increase value of GTC on the border RO -RS which will facilitate higher level of market exchanges

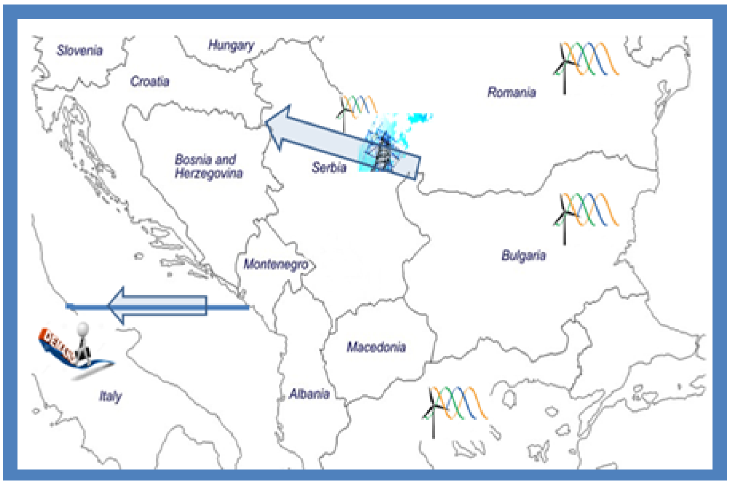
The project No 268 and project No 273 (closing of 400 kV ring around Belgrade region) have serial impact on the value of GTC on the border RO - RS (according to the internal pre- feasibility study performed by EMS experts) and from regional level both of the projects will give benefits if we realise both projects. Because of that, these projects will be re-clustered in next period.

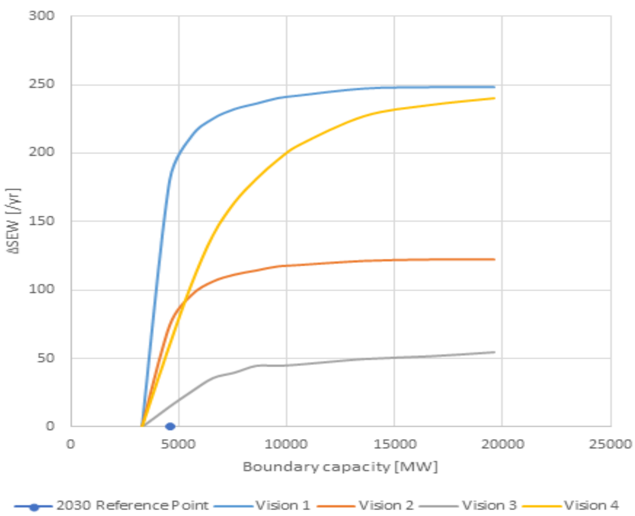
Need for project was confirmed by network and market simulation identifing bottleneck on the RO-RS border in some regimes. Presence of projects 273 and 268 will increase transfer electrical power from Romania to Serbia up to 2000

GWh in Vision 1 and up to 1000 GWh, in Vision 4.

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity along the East-West corridor in the South-Eastern Europe between RO,BG on the one hand and RS,HR,BA,MK,ME,AL on the other hand. In the SEW/GTC – curve we can see that the increase from todays capacity to the 2030-level (blue point on the picture) is having a large SEW-value for all the scenarios. On the picture we also can see that even starting from a capacity marked by blue color, extra capacity still allows savings on the boundary between the West borders of Romania and Bulgaria and the Western Balkan region in all four visions. The biggest savings on the boundary could be achieved in Vision 4.

This project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between the West borders of Romania and Bulgaria and the Western Balkan region.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is jointly assessed with project 273 as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | RS-RO: 500 |
| | RO-RS: 550 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 4 ±1 |
| Cost explanation | Uncertainty regarding total length of line, public tendering, environmental or legal |

| | |
|---|---|
| | requirements imposed during permit grating process. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | 10 ±10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | 60 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 300 ±100 | 200 ±100 | ±100 | ±100 |

*The biggest value of the SeW was obtained in Vision 1 due to increase of cheap thermal production and is associated with an increase of CO2 emissions.*

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.30 | 2.45 | 0.45 | 2.87 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.24 | 6.48 | 4.89 | 12.31 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.11 | 3.56 | 7.92 | 24.81 |

## Project 269 - Uprate the western 220kV Sevilla Ring

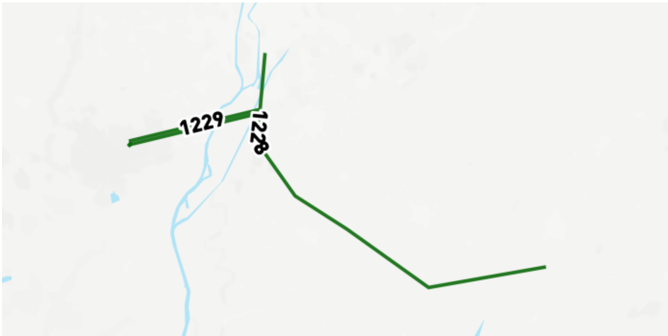
Uprate the 220 kV lines D.Rodrigo-Aljarafe and Aljarafe-Santiponce to increase their capacity

Classification Mid-term Project

Boundary Spain - Portugal

PCI label

Promoted by REE




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1228 | Upgrade of existing 220 kV line Don Rodrigo-Aljarafe | 100% | D.Rodrigo | Aljarafe | Planning | 2017 | New Investment | |
| 1229 | Upgrade of existing 220 kV line Aljarafe-Santiponce | 100% | Aljarafe | Santiponce | Planning | 2019 | New Investment | |

### Additional Information

Useful links

*Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

*XXII Portuguese-Spanish Summit (main conclusions)*

http://www.erse.pt/pt/mibel/construcaoedesenvolvimento/Documents/CONCLUS%C3%95ES%20CIMEIRA_BADAJOZ_2006.pdf

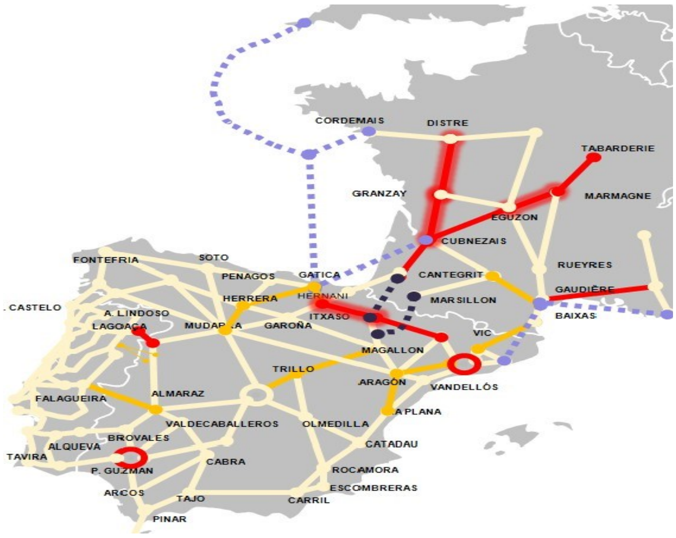
Clustering: The project consists of two uprates of two lines, which can be considered as individual investments. Both investments are in series so a lack of any of them do not allow to get the full GTC increase of the project

## Investment needs

In 2006 the Spanish and Portuguese governments set a the goal to reach 3000 MW of exchange capacity in the ES-PT border in order to reach a complete operational Iberian Electricity Market (MIBEL).

In 2014 the new Southern interconnection Puebla de Guzman (ES) – Tavira (PT) entered into full operation, reinforcing the capacity, mainly on the direction Portugal to Spain, and reducing the congestion in around 6%.

However already today and still in the future there are some limitations in the Portugal to Spain direction in certain summer situations with some restrictions of NTC due to overloads in the area of Sevilla, in 220 kV lines with very low capacity. Projects solving these constraints were frozen by the Spanish RD13/2012, although now with the new National Master Plan approved in 2015 they can progress




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a double TOOT step compared to the ES-PT project, which is commissioned earlier.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | PT-ES: 500 |
| | ES-PT: 0 |
| Delta GTC contribution (2030) [MW] | PT-ES: 500 |
| | ES-PT: 0 |

| | |
|---|---|
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1 ±0.1 |
| Cost explanation | CAPEX cost |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 50 ±25 | 0 ±25 | 0 ±25 | 0 ±25 | 0 ±25 |
| B4 Losses (Meuros/yr) | 2 ±1 | 0 ±1 | 0 ±1 | 0 ±1 | 0 ±2 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | ±100 | ±100 | ±100 |

Savings for this project are quite low compared to other TYNDP projects, although the investments are simple uprates which cost is not high either. The project increases the GTC in the PT-ES direction mainly, and this direction of flows is not expected to be very relevant according to the market studies in 2020 and in 2030, except for certain flows to export RES from Portugal in the green top-down vision.

The project does neither contribute to avoid ENS at national level (as scenarios are build to fulfil adequacy requirements) nor at local level in the area of the connection points (Sevilla). However higher capacities in the Sevilla ring would improve the system security and its robustness.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.54 | 1.18 | 0.48 | 2.08 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.65 | 6.23 | 5.31 | 11.39 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 4.96 | 8.37 | 4.10 | 8.92 |

## Project 270 - FR-ES project -Aragón-Atlantic Pyrenees

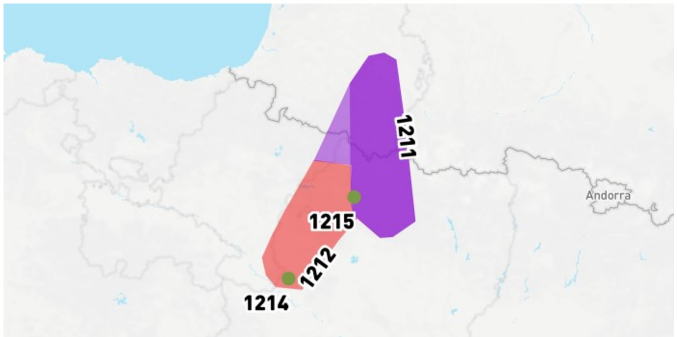
This project consist of a new interconnection between France and Spain located in the Central part of the Pyrenees between Aragón region (Spain) and Marsillon (France). Internal reinforcements in Spain complement the cross border section, such as a new 400 kV line between Ejea de los Caballeros and Aragón region, including both substations. Included in the Madrid Declaration, this project aims at improving the interconnection between Iberia and mainland Europe, allowing for higher integration of RES in Iberia, especially solar and helping Spain to come closer to the 10% interconnection ratio objective.

Classification Long-term Project

Boundary Spain - France

PCI label part of PCI 2.27. Capacity increase between Spain and France (generic project)

Promoted by REE;RTE




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1211 | New axis Aragon region-Marsillon (DC) | 100% | Aragón region | Marsillon | Planning | 2025 | New Investment | |
| 1212 | New axis Ejea- Aragon region 400 kV | 100% | Ejea de los Caballeros | Aragón region | Planning | 2025 | New Investment | |
| 1214 | new 400 kV Ejea de los Caballeros substation and connection to the lines La Serna-Magallon and Magallon Penalba | 100% | Ejea de los Caballeros | | Planning | 2025 | New Investment | |
| 1215 | New 400 kV Aragon region substation and connection to existing network and future cross border project | 100% | Aragón region | | Planning | 2025 | New Investment | |

## Additional Information

Project website

http://www.ree.es/es/actividades/gestor-de-la-red-y-transportista/proyectos-de-interes-comun-europeos-pic ;

PCI page – link to EC platform http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

PCI 2.27 refers to a generic project for the capacity increase between Spain and France. In TYNDP 2016 this generic project is better defined with TYNDP projects 276 and 270, that according to clustering rules should be independent projects.

Other links

*Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

*French National Development Plan*

http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

*Inter-Governmental agreement (Madrid Declaration)*
https://ec.europa.eu/energy/sites/ener/files/documents/Madrid%20declaration.pdf

*Constitution of the High Level Group on Interconnections for South West Europe*

http://europa.eu/rapid/press-release_IP-15-5187_en.htm

## Investment needs

One of the main concerns in South Western Europe is the low interconnection capacity betweeen France and Spain, too low to enable the Iberian Peninsula to fully participate in the internal electricity market, and with an interconnection ratio far from the 10% objective.

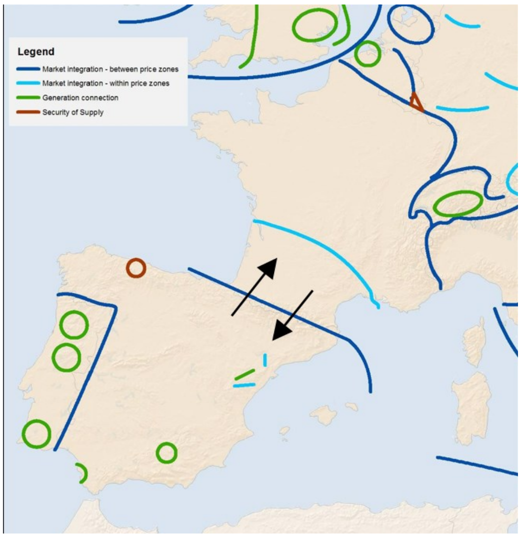
The ENTSOE CSW Regional Investment Plan published in 2015 established the future market interest of increasing the cross border capacity from 5GW reached with planned reinforcements to 8GW. The need for further development in this border is also robust in the long term according to EH2050 project.

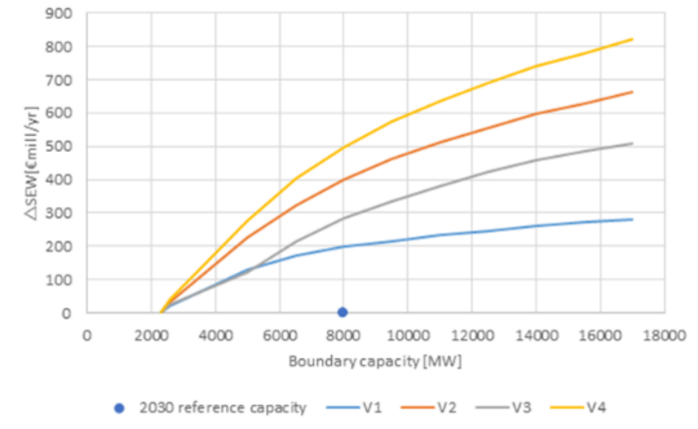
In addition, the Madrid Declaration in 2015, signed by the EC, and Governments of France, Spain and Portugal, together with the EIB establishes the need and political commitment to further develop the interconnection after the PST in Arkale and the Biscay Gulf project in order to reach around 8 GW in the French-Spanish border. This project is one of the two additional projects needed to reach this objective capacity .

The curves in the right show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases (beyond 5 GW, boundary capacity is supposed to increase simultaneously by homothetical steps, 1/3 MIBEL-GB, 1/3 MIBEL-FR, 1/3 MIBEL-IT). So no assessment per project are behind these values. This study should be considered as an aditional analysis respect to the CBA assessment analysis.

In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 (where RES optimization has been carried out) in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.

Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Mid-Term and Long Term projects on the French-Spanish border were assessed according to their maturity and expected commissioning dates taking into account the following order: PST in Arkale (project 184), Biscay Gulf (Project 16), Navarra-Landes (Project 276), Aragon-Atlantic Pyrenees (Project 270).
The reference grid taken into account for 2030 includes the projects;

- Façade Atlantique (249) in France
- Massif Central North (216) in France
- Massif Central South (158) in France
- PST Arkale (184) in Spain
- Navarra Basque Country (255) in Spain

The reference grid also includes Navarra-Landes Interconnection (276) between France and Spain.
The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

The project's SEW accounts for saving in generation fuel and operating costs. The project can also enable savings in generation capacity, in particular for projects connecting "electric peninsulas". These avoided investments in generation can represent a yearly equivalent, over several decades, of about several tens of millions euros of additional economic benefits.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-ES: 1500 |
| | ES-FR: 1500 |
| Capex Costs 2015 (M€) | 1200 ±120 |
| Source: Project Promoter | |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 40 ±10 | 20 ±10 | 30 ±10 | 40 ±10 | 80 ±10 |
| B3 RES integration (GWh/yr) | <10 | 50 ±40 | 150 ±20 | 110 ±70 | 370 ±50 |
| B4 Losses (GWh/yr) | N/A | 525 ±52 | 775 ±77 | 650 ±65 | 925 ±92 |
| B4 Losses (Meuros/yr) | N/A | 28 ±3 | 35 ±4 | 39 ±4 | 62 ±6 |
| B5 CO2 Emissions (kT/year) | ±100 | ±100 | -100 ±100 | -300 ±100 | -900 ±100 |

Savings in variable generation costs (SEW) in 2020 and 2030 V1 are caused by a decrease of CCGTs in the Iberian Peninsula compensated by an increase of coal in Germany and Central Europe. Value in 2020 is higher as there is more coal. Nevertheless, the global impact on CO2 emissions is low.

In 2030 V3 and V4 the SEW is caused mainly by a decrease of CCGTs in Central Europe replaced by RES in the region. This situation results in a global decrease of CO2 emissions. In addition, SEW is higher is the V4 top-down vision, which imply higher efficiency of a European common approach for optimizing the location of RES versus national and independent approaches of RES policies, resulting in high amount of additional RES in Iberia, mainly solar.

The project increases flows in both directions but specially imports of the Iberian Peninsula in 2020 and 2030 V1 and exports in 2030 V3 and V4.

The project does neither contribute to avoid ENS at national level (as scenarios are build to fulfil adequacy requirements) nor at local level in the area of the connection points. However an increased transfer capacity between Iberia and the rest of Europe would improve the system security and its robustness from the dynamic point of view.

The project also contributes to the stability of the system and helps for a full-integrated European internal energy market. These additional benefits are not accounted in the SEW as they are difficult to monetize.

Losses increase in all the scenarios as the project allows higher long transit power flows on long distances in order to supply the demand with the cheapest generation throughout western Europe. The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round and European-wide computation. The results must however be considered with caution, and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.61 | 3.67 | 4.24 | 5.80 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 6.35 | 9.91 | 15.13 | 16.55 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 15.07 | 10.58 | 9.91 | 13.75 |

The project reduces the congestion rate in a range from 7 to 10% in 2030, depending on the scenario. After the commissioning of the project the congestions are limited to 16-34%. Moreover the project increases the interconnection ratio of Spain in 1% in 2030.

## Project 271 - Long term conceptual project "Northern Seas offshore grid infrastructure"

A list of individual projects of the TYNDP 2016 projects develop into a global scheme for offshore grid infrastructure in the Northern Seas. The individual projects are described one by one on individual project sheets, while this global scheme indicates the overall value of all projects together. More information can be found in the Insight Report on regional infrastructure planning - North Seas.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Countries around the Northern Seas |
| PCI label | |
| Promoted by | EirGrid;Elia System Operator;Energinet.dk.dk;Creos Luxembourg;National Grid;RTE;TenneT TSO GmbH;SONI;Statnett;TenneT TSO |

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1264 | | 100% | | | | | Investment on time | |

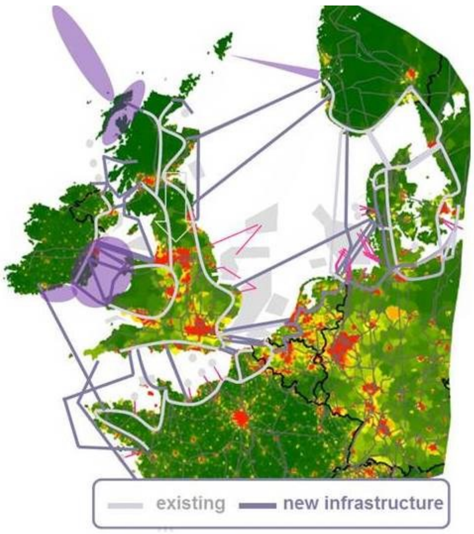
### Additional Information

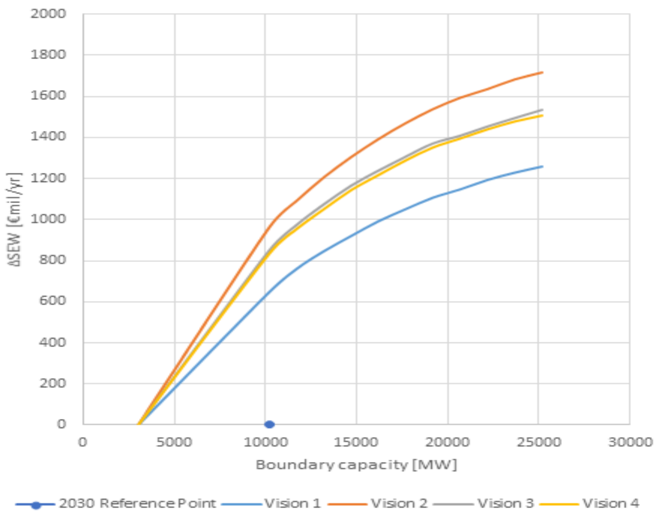
See Insight Report on the North Seas Region

## Investment needs

The Regional bulk power flow direction is along the North-South axis, and the West-East axis, amounts and direction depending on the Vision, see example given in the picture. The overall regional on- and offshore RES integration keeps on increasing, thus the grid infrastructure needs to be upgraded respectively.

Many projects of this Northern Seas offshore grid infrastructure cross the Region's main boundaries.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | |
| | |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 18000 ±6000 |
| Cost explanation | Rough estimate based on average project costs (CAPEX at time of delivery). Individual parts of this conceptual project have different maturity status . Not all future projects might materialise, as some are competing. Cost only refer to target capacities. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 1990 ±110 | 2520 ±10 | 2380 ±170 | 2540 ±80 |
| B3 RES integration (GWh/yr) | N/A | 15250 ±150 | 26280 ±2280 | 28800 ±3500 | 24290 ±2010 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 9900 ±300 | -8000 ±2000 | -12700 ±2800 | -16100 ±3400 |

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 272 - Network upgrade in Central Serbia from 220 kV to 400 kV voltage level

This project is linked with the new double 400 kV tie line between Bulgaria and Serbia project which is the outcome from Common Planning Studies during making RegIP2015. This project will increase transmission capacity in the East - West corridor (from Bulgaria and Turkey to West Balkan and Italy). With realization of this project an internal botlenecks in RS will be resolved which will have direct impact on increasing BTC values on the following borders: BG-RS, ME-RS and BA-RS.

| | |
|---|---|
| Classification | Future Project |
| Boundary | |
| PCI label | |
| Promoted by | JP EMS |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1218 | OHL 400 kV SS Nis 2 - SS Krusevac 1 | 100% | SS 400/110 kV Nis 2 | SS 400/220/110 kV Krusevac 1 | Under Consideration | 2034 | New Investment | |
| 1220 | SS 400/220/110 Krusevac 1 | 100% | SS 220/110 kV Krusevac 1 | | Under Consideration | 2034 | New Investment | |
| 1222 | OHL 400 kV SS Kraljevo 3 - SS Krusevac 1 | 100% | SS 400/220/110 kV Krusevac 1 | SS 400/220/110 kV Kraljevo 3 | Under Consideration | 2034 | New Investment | |
| 1223 | OHL 400 kV SS Kraljevo 3 - SS Bajina Basta | 100% | SS 400/220/110 kV Kraljevo 3 | SS 400/220 kV Bajina Basta | Under Consideration | 2030 | New Investment | |

### Additional Information

Overall project is upgrading voltage level from 220 kV to 400 kV in Central Serbia from Nis to Bajina Basta . The project has investments with a total length of OHLs of 235 km.

For one investment of this project, OHL 400 kV Kraljevo - Bajina Basta, Feasibility Study, Preliminary Design and Environmental Impact Assessment Study, funded by WBIF, is currently ongoing.

## Investment needs

One of the reasons for upgrade to the 400 kV voltage level is the very old and unreliable 220 kV network that connects the major substations in that part of the Serbian transmission network. In upgrading to 400kV, the transfer capacity, security of supply, system reliability and system operation will be significantly enhanced. Additionally, the 400kV upgrade will make possible the operation of two pump storage Hydro Power Plants with more than 1.3 GW of installed capacity (the existing pump storage Bajina Basta of 2*300 MW and in future, the planned pump storage Bistrica which will have a capacity of at least 700 MW). The strengthening of the transmission system (to enable the connection of pumped storage HPP) is a required precondition, from the regional perspective, which through system balancing will allow the development and connection of significant amounts of fluctuating new renewable energy sources from wind and solar energy in the region.

The project No 272 and project No 277 (new double 400 kV interconnection line between BG and RS) are serial connected and from regional level both of the projects will give benefits if we realize both projects. Because of that, these projects will be re-clustered in next period.

Need for project was confirmed by network and market simulation identifing bottleneck on the BG-RS border in some regimes. Presence of projects 277 and 272 will increase transfer electrical power from Bulgaria to Serbia from 300 GWh up to 1700 GWh, in Visions 4 and 1, respectively. Also, presence of projects 277 and 272 will increase transfer electrical power in another direction, from Serbia to Bulgaria from 100 GWh up to 1500 GWh in Visions 1 and 4, respectively.

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity along the East-West corridor in the South-Eastern Europe between RO,BG on the one hand and RS,HR,BA,MK,ME,AL on the other hand. In the SEW/GTC – curve we can see that the increase from todays capacity to the 2030-level (blue point on the picture) is having a large SEW-value for all the scenarios. On the picture we also can see that even starting from a capacity marked by blue color, extra capacity still allows savings on the boundary between the West borders of Romania and Bulgaria and the Western Balkan region in all four visions. The biggest savings on the boundary could be achieved in Vision 4.

These projects(272 and 277) are one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between the West borders of Romania and Bulgaria and the Western Balkan region.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is jointly assessed with project 277 as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | RS-BGMRO: 50 |
| | BGMRO-RS: 200 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 110 ±11 |
| Cost explanation | Uncertainty regarding total length of line, public tendering, environmental or legal requirements imposed during permit grating process. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 300 ±100 | 200 ±100 | ±100 | ±100 |

The biggest value of the SeW was obtained in Vision 1 due to increase of cheap thermal production and is associated with an increase of CO2 emissions

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 273 - Closing of 400 kV ring around Belgrade region

This project will close the 400 kV ring around region of Belgrade. The project will increase transmission capability in the direction EAST - WEST and increase reliability of supply of Belgrade city. With realization of this project an internal bottlenecks in RS will be resolved which will have direct impact on increasing BTC values on the border RO-RS.

| | |
|---|---|
| Classification | Future Project |
| Boundary | |
| PCI label | |
| Promoted by | JP EMS |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1209 | | 100% | SS 400/110 kV Belgrade | | Under Consideration | 2035 | New Investment | |
| 1217 | | 100% | SS 400/220/110 kV Pancevo 2 | SS 400/110 kV Belgrade West | Under Consideration | 2035 | New Investment | |

### Additional Information

This project consists of new OHL Pančevo - new SS Belgrade west. This project is under consideration and expert within EMS did the internal pre- feasibility study. Such pre-feasibility study showed the benefits to national as well as to regional level. Also the need for this project we observed through the network study performed in the proces of making Common planning study in CSE. In Common planning study it is noticed internal overloading in Belgrade region which will be resolved by construction of this line.

### Investment needs

The Project 273 objectives, in line with the basic goals of EU energy policy, are to:

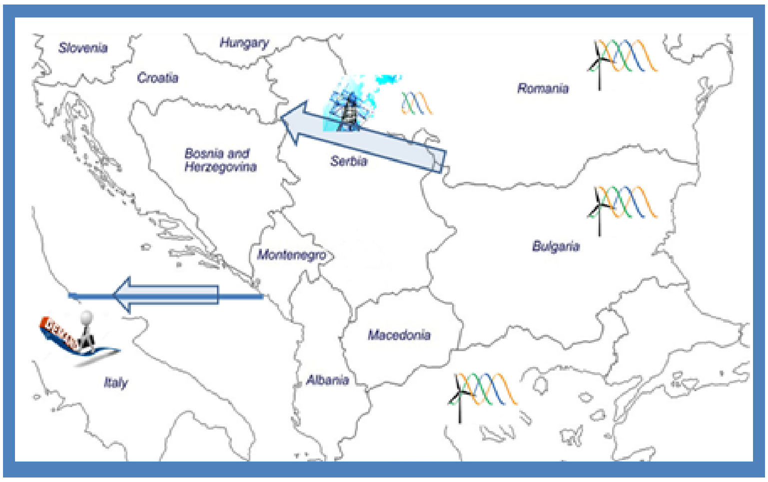
1. improve functioning and reliability of the electricity markets in Serbia and Romania;
2. facilitate further integration and expansion of the 400kV network in the region;
3. facilitate higher level of integration of renewable energy sources in the south Banat region (Serbia and Romania);
4. closing the 400 kV electricity ring around Belgrade will increase reliability of suppling consumers in Belgrade region

The project No 273 and project No 268 (upgrading existing single 400 kV interconnection line between RO and RS to double 400 kV line) have serial impact on the value of GTC on the border RO - RS (according to the internal pre- feasibility study) and from regional level both of the projects will give benefits if we realise both projects. Because of that, these projects will be re-clustered in next period.

Need for project was confirmed by network and market simulation identifing bottleneck on the RO-RS border in some regimes. Presence of projects 273 and 268 will increase transfer electrical power from Romania to Serbia up to 2000 GWh in Vision 1 and up to 1000 GWh, in Vision 4.

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity along the East-West corridor in the South-Eastern Europe between RO,BG on the one hand and RS,HR,BA,MK,ME,AL on the other hand. In the SEW/GTC – curve we can see that the increase from todays capacity to the 2030-level (blue point on the picture) is having a large SEW-value for all the scenarios. On the picture we also can see that even starting from a capacity marked by blue color, extra capacity still allows savings on the boundary between the West borders of Romania and Bulgaria and the Western Balkan region in all four visions. The biggest savings on the boundary could be achieved in Vision 4.

These projects (273 and 268) are one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between the West borders of Romania and Bulgaria and the Western Balkan region.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is jointly assessed with project 268 as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

## General CBA Indicators

| | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | RS-RO: 0 |
| | RO-RS: 100 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 35 ±4 |
| Cost explanation | Uncertainty regarding total length of line, public tendering, environmental or legal requirements imposed during permit grating process. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | 10 ±10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | 60 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 300 ±100 | 200 ±100 | ±100 | ±100 |

The biggest value of the SeW was obtained in Vision 1 due to increase of cheap thermal production and is associated with an increase of $CO_2$ emissions

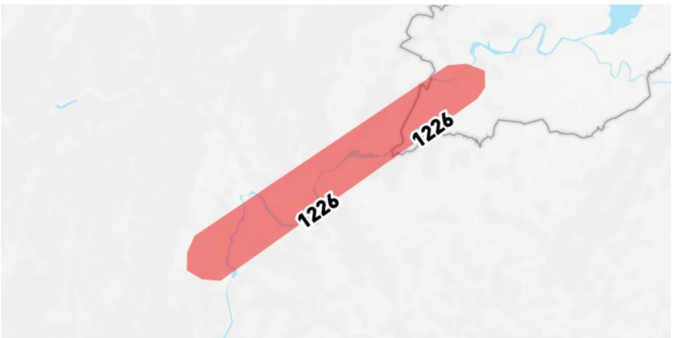
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.30 | 2.45 | 0.45 | 2.87 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.24 | 6.48 | 4.89 | 12.31 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 7.11 | 3.56 | 7.92 | 24.81 |

## Project 274 - Concept project France-Switzerland 400kV AC

The project consists of a new 400-kV cross-border line between France and Switzerland. Being at very early conceptual stage, project scope is not defined.

| | |
|---|---|
| Classification | Future Project |
| Boundary | France - Switzerland |
| PCI label | |
| Promoted by | RTE;swissgrid |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1226 | New 400-kV line between France and Switzerland (concept) | 100% | | | Under Consideration | 2030 | New Investment | |

## Additional Information

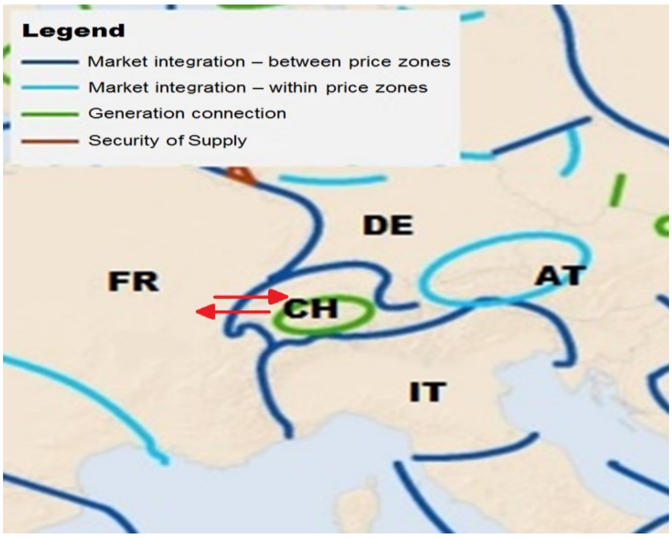
Link to the Regional Investment Plan of Continental Central South area published in 2015:

https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/rgips/Regional%20Investment%20Plan%202015%20-%20RG%20CCS%20-%20Final.pdf

## Investment needs

This project is one of the two concept projects stemming from the Common Planning Studies conducted in 2015, which showed the potential interest of increasing the capacity on the French-Swiss border in the Long Term High RES scenario of TYNDP2014.

Analyses on this border showed that the benefit SEW provided by a standard 1 GW capacity increase is around 10M€ in all 2030 visions except in Vision 4 where it is higher.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a multiple PINT step compared to the projects 253, 199 and 275, which are all commissioned earlier.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | |
| | |
| Capex Costs 2015 (m€)<br>Source: Project Promoter | |
| Cost explanation | This project is a concept project. As project scope is not defined, cost is not available. |
| S1 | NA |
| S2 | NA |
| B6 | N/A |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

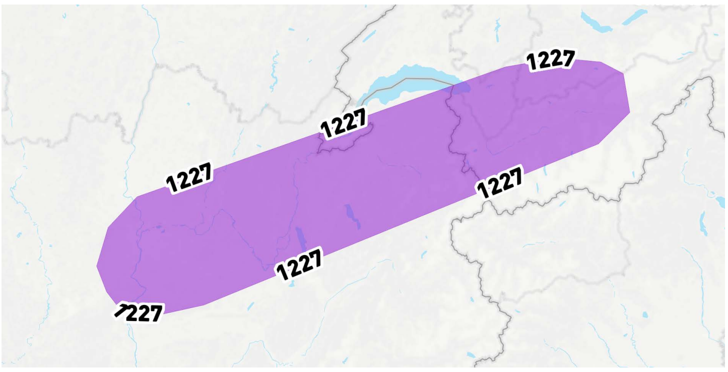
The above table shows low benefits in all visions. It is very likely that they would not overweight the cost of a possible project shaping this concept.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 275 - Concept project France-Switzerland HVDC

This project is a new HVDC between France and Switzerland.
Being at early conceptual stage, project scope is not defined.

Classification Future Project




Boundary France - Switzerland

PCI label

Promoted by RTE;swissgrid

### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1227 | New cross-border HVDC line between France and Switzerland (concept) | 100% | | | Under Consideration | 2030 | New Investment | |

### Additional Information

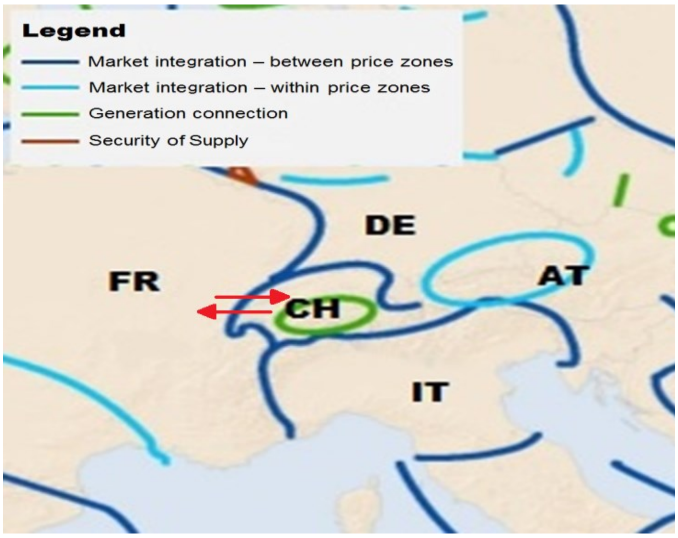
Link to the Regional Investment Plan of Continental Central South area published in 2015:

https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/rgips/Regional%20Investment%20Plan%202015%20-%20RG%20CCS%20-%20Final.pdf

## Investment needs

This project is one of the two concept projects that stemmed from the Common Planning Studies conducted in 2015 in order to meet the market-based target capacity for the Long Term High RES scenario of TYNDP2014.

Analyses on this border showed that the benefit SEW provided by a standard 1 GW capacity increase is around 10M€ in all 2030 visions except in Vision 4 where it is higher.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed with a triple PINT step compared to the projects 253 and 199, which are commissioned earlier.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | |
| | |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | This project is a concept project. As project scope is not defined, cost is not available. |
| S1 | NA |
| S2 | NA |

| | |
|---|---|
| B6 | N/A |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | <10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

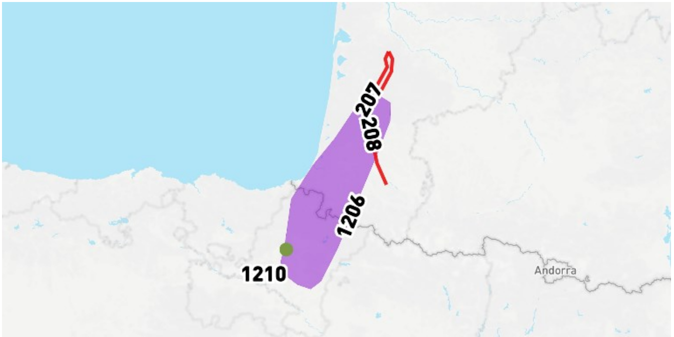
The above table shows very low benefits. It is very likely that they would not overweight the cost of a possible project shaping this concept.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 276 - FR-ES project -Navarra-Landes

This Project consist of a new interconnection between France and Spain in the Western part of the Pyrenees between Pamplona area (Spain) and Cantegrit (France). The project is considered as a HVDC project of 2x1000 MW. Internal reinforcements complement the cross border section, such as the upgrade of the connections of Cantegrit with Saucats and Marsillon, and the connection of the new Pamplona area substation. Included in the Madrid Declaration, this project aims at improving the interconnection between Iberia and mainland Europe, allowing for higher integration of RES in Iberia, especially solar and helping Spain to come closer to the 10% interconnection ratio objective.

| | |
|---|---|
| Classification | Long-term Project |
| Boundary | Spain - France |
| PCI label | part of PCI 2.27. Capacity increase between Spain and France (generic project) |
| Promoted by | REE;RTE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1206 | HVDC Pamplona area (Spain) - Cantegrit (France) | 100% | Pamplona area | Cantegrit | Planning | 2025 | New Investment | |
| 1207 | Upgrade of exisiting Cantegrit-Saucats lines | 50-60% | Cantegrit | Saucats | Planning | 2025 | New Investment | |
| 1208 | Upgrade of existing 2*225 kV line Cantegrit-Marsillon to 1*400 kV | 30-40% | Cantegrit | Marsillon | Planning | 2025 | New Investment | |
| 1210 | New substation Pamplona area 400 kV and connection to the existing lines | 100% | Pamplona area | | Planning | 2025 | New Investment | |

### Additional Information

Project website

http://www.ree.es/es/actividades/gestor-de-la-red-y-transportista/proyectos-de-interes-comun-europeos-pic ;

PCI page – link to EC platform http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/m/main.html

PCI 2.27 refers to a generic project for the capacity increase between Spain and France. In TYNDP 2016 this generic project is better defined with TYNDP projects 276 and 270, that according to clustering rules should be independent projects.

Other links

*Spanish National Development Plan*
http://www.minetur.gob.es/energia/planificacion/Planificacionelectricidadygas/desarrollo2015-2020/Paginas/desarrollo.aspx

*French National Development Plan*

http://www.rte-france.com/fr/article/schema-decennal-de-developpement-de-reseau

*Inter-Governmental agreement (Madrid Declaration)*
https://ec.europa.eu/energy/sites/ener/files/documents/Madrid%20declaration.pdf

*Constitution of the High Level Group on Interconnections for South West Europe*

http://europa.eu/rapid/press-release_IP-15-5187_en.htm

## Investment needs

One of the main concerns in South Western Europe is the low interconnection capacity betweeen France and Spain, too low to enable the Iberian Peninsula to fully participate in the internal electricity market, and with an interconnection ratio far from the 10% objective.

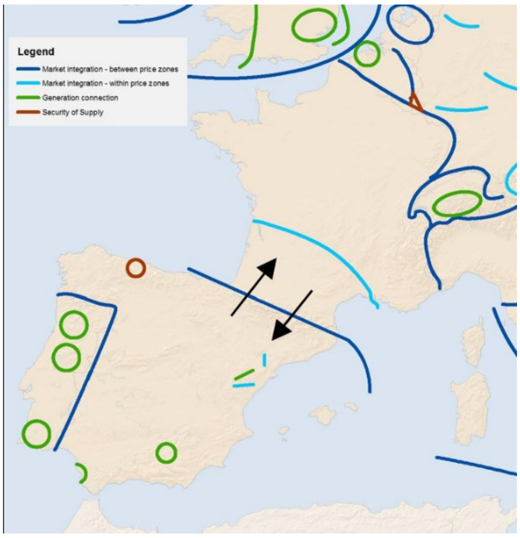
The ENTSOE CSW Regional Investment Plan published in 2015 established the future market interest of increasing the cross border capacity from 5GW reached with planned reinforcements to 8GW. The need for further development in this border is also robust in the long term according to EH2050 project.

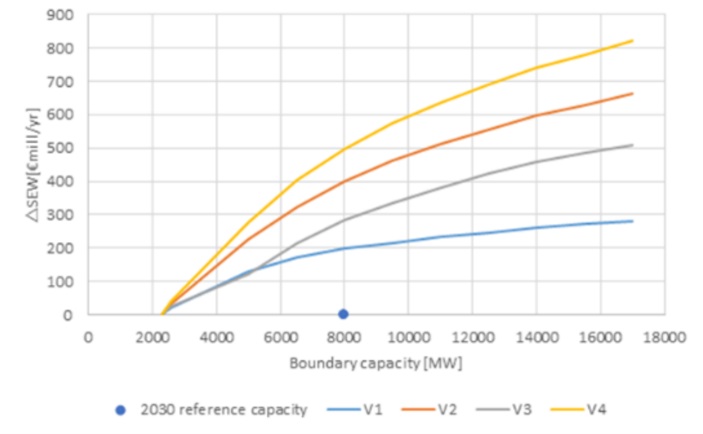
In addition, the Madrid Declaration in 2015, signed by the EC, and Governments of France, Spain and Portugal, together with the EIB establishes the need and political commitment to further develop the interconnection after the PST in Arkale and the Biscay Gulf project in order to reach around 8 GW in the French-Spanish border. This project is one of the two additional projects needed to reach this objective capacity .

The curves in the right show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases (beyond 5 GW, boundary capacity is supposed to increase simultaneously by homothetical steps, 1/3 MIBEL-GB, 1/3 MIBEL-FR, 1/3 MIBEL-IT). So no assessment per project are behind these values. This study should be considered as an aditional analysis respect to the CBA assessment analysis.

In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 (where RES optimization has been carried out) in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.

Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

Mid-Term and Long Term projects on the French-Spanish border were assessed according to their maturity and expected commissioning dates taking into account the following order: PST in Arkale (project 184), Biscay Gulf (Project 16), Navarra-Landes (Project 276), Aragon-Atlantic Pyrenees (Project 270). The reference grid taken into account for 2030 includes the project Façade Atlantique (245) in France, Massif central north (216) in France and Massif central south (158) in France and PST Arkale (184) and Connection Navarra-Basque Country (255) in Spain.

The reference grid taken into account for 2030 includes the projects;

- Façade Atlantique (249) in France
- Massif Central North (216) in France
- Massif Central South (158) in France
- PST Arkale (184) in Spain
- Navarra Basque Country (255) in Spain

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

The project’s SEW accounts for saving in generation can fuel and operating costs. The project can also enable savings in generation capacity, in particu-lar for projects connecting “electric peninsulas”. These avoided investments in generation can represent a yearly equivalent, over several decades, of about several tens of millions euros of additional economic benefits

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-ES: 1500 |
| | ES-FR: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1470 ±150 |
| Cost explanation | The cost value provided for the project corresponds to the CAPEX cost |
| S1 | More than 100km |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 80 ±20 | 40 ±10 | 50 ±10 | 50 ±20 | 100 ±10 |
| B3 RES integration (GWh/yr) | <10 | 100 ±80 | 270 ±110 | 180 ±80 | 450 ±70 |
| B4 Losses (GWh/yr) | N/A | 600 ±60 | 875 ±87 | 725 ±72 | 875 ±87 |
| B4 Losses (Meuros/yr) | N/A | 32 ±4 | 40 ±4 | 43 ±5 | 59 ±6 |
| B5 CO2 Emissions (kT/year) | 700 ±350 | 200 ±200 | ±100 | -400 ±0 | -1100 ±100 |

Savings in variable generation costs (SEW) in 2020 and 2030 V1 are caused by a decrease of CCGTs in the Iberian Peninsula compensated by an increase of coal in Germany and Central Europe. Value in 2020 is higher as there is more coal. This situation results in a global increase of CO2 emissions is low.

In 2030 V3 and V4 the SEW is caused mainly by a decrease of CCGTs in Central Europe replaced by RES in the region. This situation results in a global decrease of CO2 emissions. In addition, SEW is higher is the V4 top-down vision, which imply higher efficiency of a European common approach for optimizing the location of RES versus national and independent approaches of RES policies, resulting in high amount of additional RES in Iberia, mainly solar.

The project increases flows in both directions but specially imports of the Iberian Peninsula in 2020 and 2030 V1 and exports in 2030 V3 and V4.

The project does neither contribute to avoid ENS at national level (as scenarios are build to fulfil adequacy requirements) nor at local level in the area of the connection points. However an increased transfer capacity between Iberia and the rest of Europe would improve the system security and its robustness from the dynamic point of view.

The project also contributes to the stability of the system and helps for a full-integrated European internal energy market. These additional benefits are not accounted in the SEW as they are difficult to monetize.

Losses increase in all the scenarios as the project allows higher long transit power flows on long distances in order to supply the demand with the cheapest generation throughout western Europe. The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round and European-wide computation. The results must however be considered with caution, and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.61 | 3.67 | 4.24 | 5.80 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 6.35 | 9.91 | 15.13 | 16.55 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 15.07 | 10.58 | 9.91 | 13.75 |

The project reduces the congestion rate in a range from 7 to 13% in 2030, depending on the scenario. After the commissioning of the project the congestions are limited to 26-41%. Moreover the project increases the interconnection ratio of Spain in 1% in 2030.

## Project 277 - New double 400 kV interconnection line between Bulgaria and Serbia

New double 400 kV interconnection line between Bulgaria and Serbia

Classification Future Project

Boundary Bulgaria - Serbia

PCI label

Promoted by ESO EAD;JP EMS


| Investments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
| 1266 | This investment has been defined in the framework of common planning studies in RegIP2015 in CSE. | 100% | Sofia West (BG) | Nis 2 (RS) | Under Consideration | 2034 | Investment on time | |

## Additional Information

The project 277, as new candidate transmission project has been proposed to be assessed in the TYNDP 2016, based on the results of common planning studies performed in the CSE Region during preparation of Regional investment plan 2015. The project assumes construcion of new double 400 kV interconnection line between Bulgaria and Serbia (length is approximatly 85 km). This project is under consideration and there is a need for pre-feasibility study which will precise exact variant solution.

## Investment needs

The Project 277 objectives, in line with the basic goals of EU energy policy, are to:

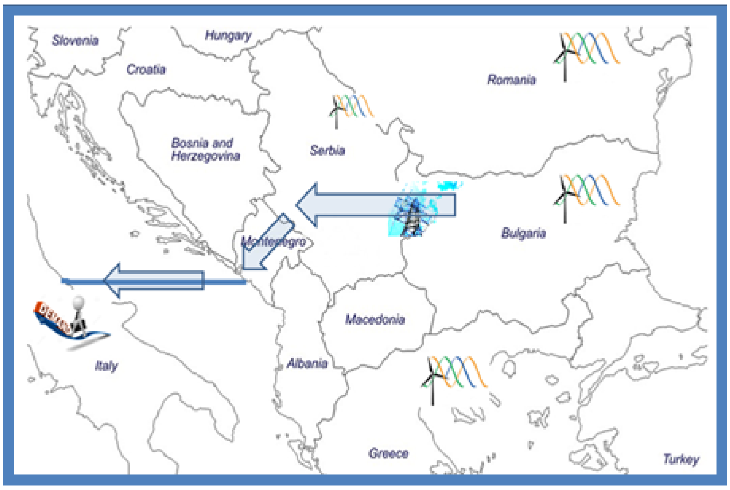
1. improve functioning and reliability of the electricity markets in Serbia and Bulgaria;
2. facilitate further integration and expansion of the 400kV network in the region;
3. increase value of GTC on the border BG -RS which will facilitate higher level of market exchanges

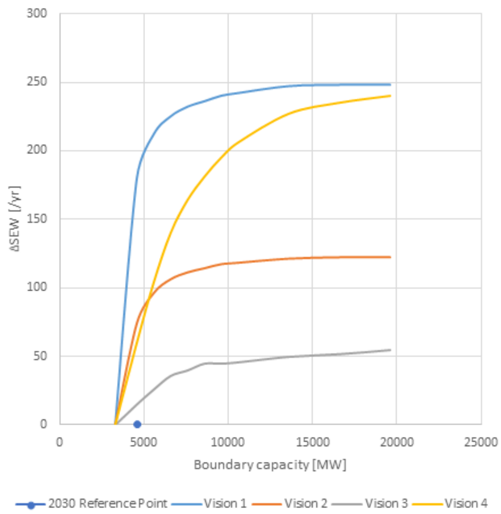
The project No 277 and project No 272 (network upgrade in Central Serbia from 220 kV to 400 kV voltage level) are serial connected and from regional level both of the projects will give benefits if we realize both projects. Because of that, these projects will be re-clustered in next period.

Need for project was confirmed by network and market simulation identifing bottleneck on the BG-RS border in some regimes. Presence of projects 277 and 272 will increase transfer electrical power from Bulgaria to Serbia from 300 GWh up to 1700 GWh, in Visions 4 and 1, respectively. Also, presence of projects 277 and 272 will increase transfer electrical power in another direction, from Serbia to Bulgaria from 100 GWh up to 1500 GWh in Visions 1 and 4, respectively.

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity along the East-West corridor in the South-Eastern Europe between RO,BG on the one hand and RS,HR,BA,MK,ME,AL on the other hand. In the SEW/GTC – curve we can see that the increase from todays capacity to the 2030-level (blue point on the picture) is having a large SEW-value for all the scenarios. On the picture we also can see that even starting from a capacity marked by blue color, extra capacity still allows savings on the boundary between the West borders of Romania and Bulgaria and the Western Balkan region in all four visions. The biggest savings on the boundary could be achieved in Vision 4.

This project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between the West borders of Romania and Bulgaria and the Western Balkan region.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is jointly assessed with project 272 as one corridor.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | RS-BG: 400 |
| | BG-RS: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 52 ±5 |

| | |
|---|---|
| Cost explanation | Uncertainty regarding total length of line, public tendering, environmental or legal requirements imposed during permit grating process. |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | <10 | <10 | 10 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 300 ±100 | 200 ±100 | ±100 | ±100 |

The biggest value of the SeW was obtained in Vision 1 due to increase of cheap thermal production and is associated with an increase of CO2 emissions

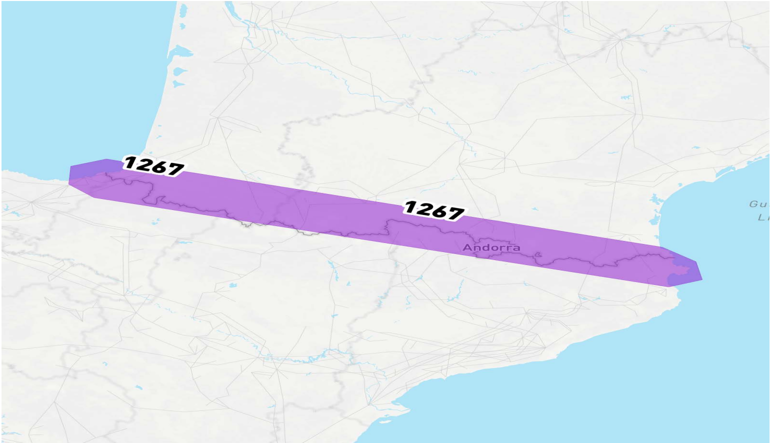
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 2.80 | 1.71 | 1.66 | 2.10 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 7.36 | 5.26 | 8.76 | 8.17 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 0.80 | 0.55 | 7.45 | 8.96 |

## Project 278 - Additional project France - Spain

Additional cross border project in the French-Spanish border if needed in order tobe closer to the 10% interconnection ratio for Spain.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Spain - France |
| PCI label | |
| Promoted by | RTE;REE |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1267 | | 100% | | | Under Consideration | 2030 | Investment on time | |

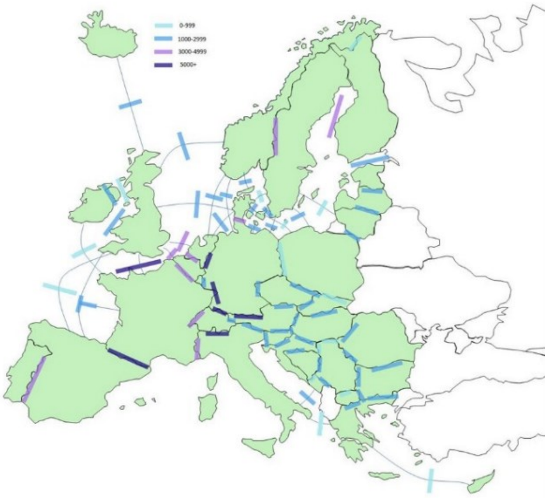
### Additional Information

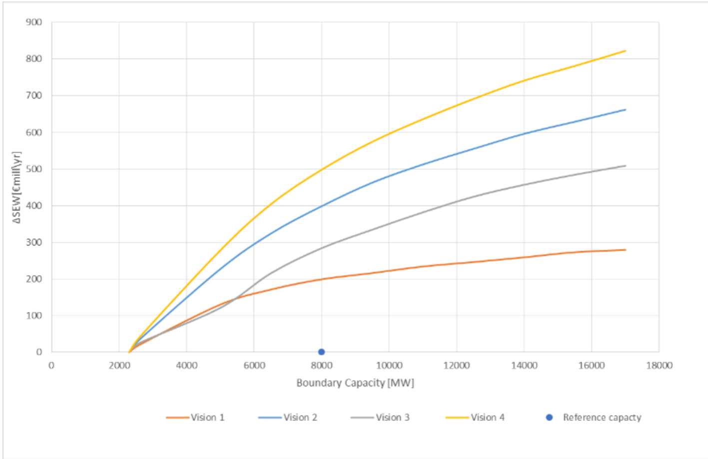
A new cross border project in the French-Spanish border proposed in order to be closer to the 10% interconnection ratio.

### Investment needs

The Common Planning  Studies in the RgIP 2015 pointed out a need for an additional project on the Spanish-French border in order to fulfill the 10% interconnection ratio set by the European Commision : In 2030, the interconnection ratio for Spain with the planned projects was computed in the range of 7-9%, depending on the scenario (the visions with high RES having higher installed capacities and therefore showing lower ratios), and without taking into consideration 3rd party projects as no non-ENTSOE member project fulfilled the legal criteria of the draft EC Guidelines to be included in the plan.

Therefore a new conceptual French-Spanish project, without definition was included in the list of projects to be assessed in the TYNDP 2016.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-ES: 1500 |
| | ES-FR: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | As the project is a conceptual one (with no definition of investments) the cost is not available |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 10 ±10 | 20 ±0 | 30 ±0 | 60 ±10 |
| B3 RES integration (GWh/yr) | N/A | 30 ±30 | 100 ±20 | 60 ±30 | 270 ±50 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | -100 ±0 | -300 ±0 | -800 ±100 |

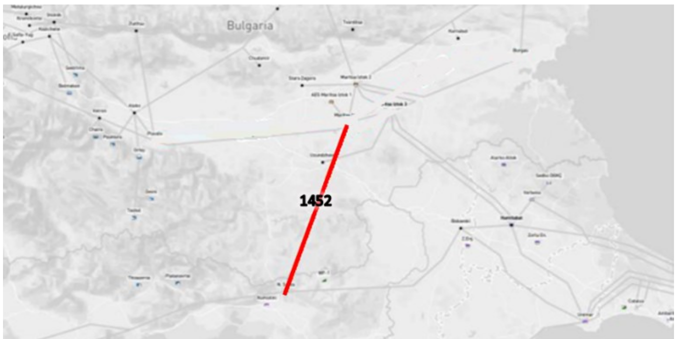
As the project is considered a conceptual project with no definition of investments, only CBA indicators coming from market studies are provided. The GTC increase corresponds to the fulfillment of 10% interconnection ratio.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 279 - Third interconnector between Bulgaria and Greece

The new project concerns the construction of a new 400kV overhead line between the substations Nea Santa (GR)-Maritsa East 1 (BG).

| | |
|---|---|
| Classification | Future Project |
| Boundary | Bulgaria - Greece |
| PCI label | |
| Promoted by | IPTO;ESO EAD |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1452 | This investment has been defined in the framework of common planning studies in TYNDP 2016 | 100% | Maritsa East 1 (BG) | Nea Santa (GR) | Under Consideration | 2030 | Investment on time | |

## Investment needs

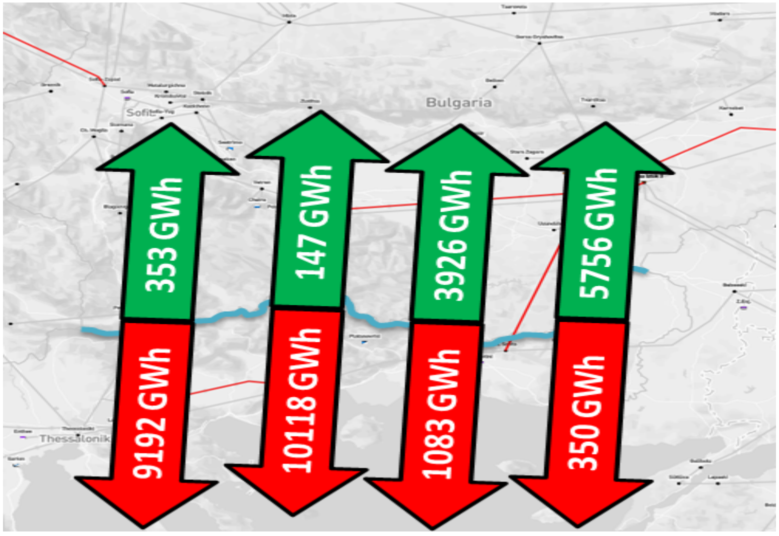
The project necessity stems from the need to increase the transfer capacity between Greece and Bulgaria in order to accomodate connection of RES and improve market integration, according to the results by the Common Planning Studies based on TYNDP2014 Vision 4.

Numbers in the arrows represent annual energy flow [GWh] and refer to each vision 1,2,3,4 respectively. For the visions 1,2 predominant direction of bulk flows is N->S. Due to RES integration in Greece in Visions 3 and 4 there is bulk flow in opposite direction, S->N, on GR-BG border.

Project will increase transmission capacity in the long term by 440MW for dominant direction from north (RO+BG) to south (GR) that corresponds to an approximately 30% increase of the total capacity in the BG-GR borders

In the opposite direction, transfer capacity increase will be about 240MW that corresponds to an approximately 23% increase of the total capacity in the BG-GR borders.

On the long-term, largest benefits on SEW appear mainly in Vision 4, as can be seen in the Figure below that depicts SeW:ΔGTC ratios for the 2030 Visions.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GR-BG: 250 |
| | BG-GR: 450 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 10 ±10 | <10 | 10 ±10 | 40 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 110 ±20 | 410 ±80 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 100 ±100 | ±100 | ±100 | -200 ±100 |

All the projects of CSE Region contribute to the reduction of generation cost in Europe that is reflected in SeW values for the examined scenarios. In EP2020, Vision 1 and Vision 2, transfer capacity increase brought by new projects, assists market integration internally in the Region and with the rest of Europe. SeW is created due to the capability to increase the generation of low cost thermal production in the Balkan peninsula with an associated increase in CO2 emissions. In Visions 3 and 4, SeW is created mainly because of the increased RES penetration brought by new projects and is accompanied by a corresponding CO2 reduction.

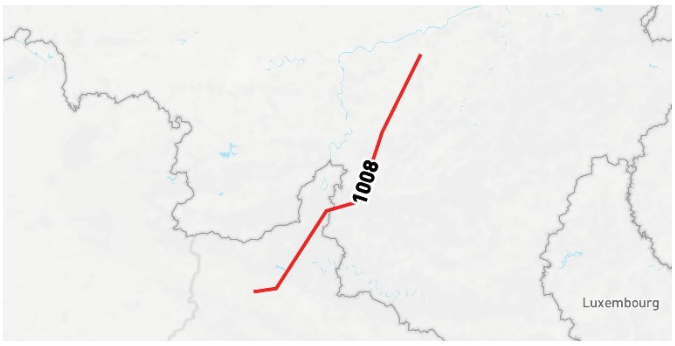
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 1.54 | 2.03 | 4.64 | 12.04 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 5.39 | 6.13 | 16.14 | 24.96 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 12.44 | 14.96 | 10.98 | 20.07 |

## Project 280 - FR-BE Phase 3 (study)

The project aims at sustaining further market integration within the long-term perspective of the energy transition and subsequent need to develop interconnection capacity on the French-Belgium border whilst alleviating Lonny-Achène-Gramme as bottleneck. The reference solution envisions the replacement of the current conductors on the ~75km Lonny-Achène-Gramme AC cross-border line with high performance conductors.The bilateral study between RTE and Elia will further evaluate the feasability, the planning and the cost-benefit analysis of the reference solution, taking into account the complementariness with the FR-BE Phase II study project as well as possible synergies with the long-term concepts of an "offshore grid" & "west-east corridor" within the North Sea region. Hereby not excluding alternative / complementary solutions such as the installation of a PST or the creation of a HVDC corridor (onshore or offshore).

| | |
|---|---|
| Classification | Future Project |
| Boundary | France - Belgium |
| PCI label | |
| Promoted by | ELIA; RTE |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1008 | This project under consideration envisions the reinforcement of Lonny-Achène-Gramme cross-border line via the replacement of its existing conductors with high performance (HTLS) conductors. | 100% | Lonny (FR) | Gramme (BE) | Under Consideration | 2025 | Investment on time | Related to the long-term perspective of the energy transition. Subject to further studies to determine techno-economic most optimum solution taking into account the feasability of different solutions. |

## Additional Information

The project is integrated as project under consideration in Elia's National Development Plan 2015-2025:
http://www.elia.be/en/grid-data/grid-development/investment-plan/federal-development-plan-2015-2025

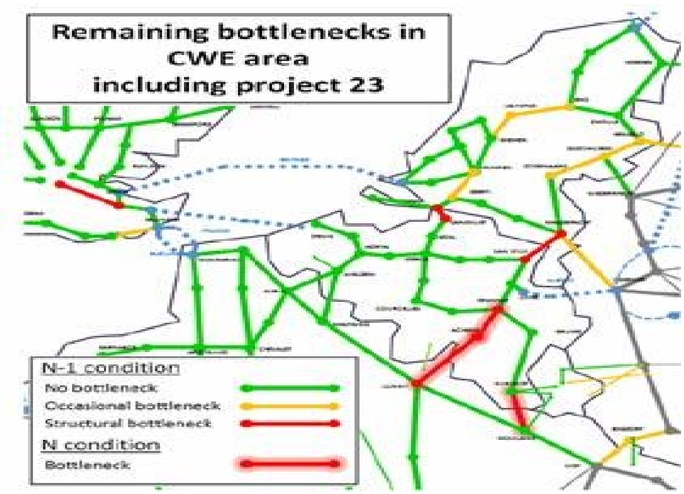
## Investment needs

Evolution in the generation mix between 2020 and 2030 triggers higher bulk power flows in general on the FR-BE axis, where the effect of the planned nuclear phase out in Belgium makes Lonny-Achène-Gramme in particular prone to congestion.

Solving this bottleneck secures the contribution of project 23 (HTLS upgrade Avelin/Mastaign - Horta) within a broader scenario framework and unlocks the potential for additional GTC increase on the FR-BE border. The potential for additional GTC integrates the interaction between the 400kV axis Lonny-Achène-Gramme and the 225kV axis Aubange-Moulaine and their respective reinforcement options.

Both this project 280 'France Belgium Phase 3' as well as project 173 'France Belgium Phase 2' are complementary to project 23 in enabling the potential of market exchanges. Their respective contribution is quantified via a GTC increase on top of the GTC contribution of project 23.

TYNDP analyses showed that a 1-GW capacity increase on this border provides an additional SEW of about 20-40 M€ depending on the vision.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project is assessed jointly with project 173.The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | FR-BE: [1000] |
| | BE-FR: [1000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 100 ±25 |
| Cost explanation | The provided cost refers to the total expected investment cost of the reference solution, subject to outcome of ongoing bilateral studies. |
| S1 | NA |

| | |
|---|---|
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | <10 | <10 | 20 ±10 | 20 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 780 ±160 | 180 ±60 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | ±100 | 200 ±200 | -100 ±100 | ±100 | -200 ±100 |

The GTC increase is related to the presented reinforcement option, meaning the possibility to sustain higher flows on the Belgian - French border via upgrade of the existing line to high-performance conductors. This value is subject to further evaluation in bilateral studies. This project 280 'FR-BE Phase 3' has been assessed together with project 173 'FR-BE Phase 2' in PINT (i.e. on top of project 23) and the CBA indicators (SEW, RES, CO2, losses) refer to both projects 173 and 280 together.

The increase in SEW emphasizes the complementary value of this project on top of project 23, in relieving congestion on the French-Belgium border. The higher RES integration benefits in Visions 3 and 4 relate to the nature of these scenarios. With regards to CO2 emissions, the project can be considered to have a neutral effect.

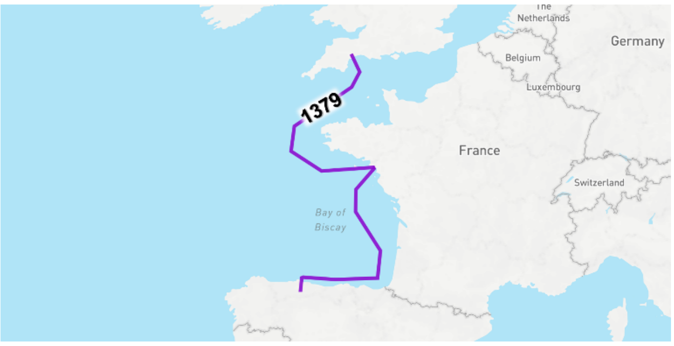
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.62 | 1.05 | 2.31 | 1.45 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.36 | 4.64 | 10.48 | 8.08 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 17.81 | 16.19 | 1.00 | 0.66 |

## Project 281 - ANAI: Abengoa Northern Atlantic Interconnection

ANAI project is a new interconnection line proposed by Inabensa (Abengoa).
ANAI project will connect Spain - France - United Kingdom with a subsea multiterminal (with Voltage Source Converters) High Voltage Direct Current cable with 2,000 Megawatt of power grid transfer capability.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Spain - France - United Kingdom |
| PCI label | |
| Promoted by | Abengoa |




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1379 | This investment consists of a 2GW HVDC line which connects the substation in Soto de Ribera (Spain) with the substation in Exeter, through the substation Cordemais (France) | 100% | Soto de Ribera | Exeter | Under Consideration | 2026 | | Under evaluation by ENTSO-E |

## Investment needs

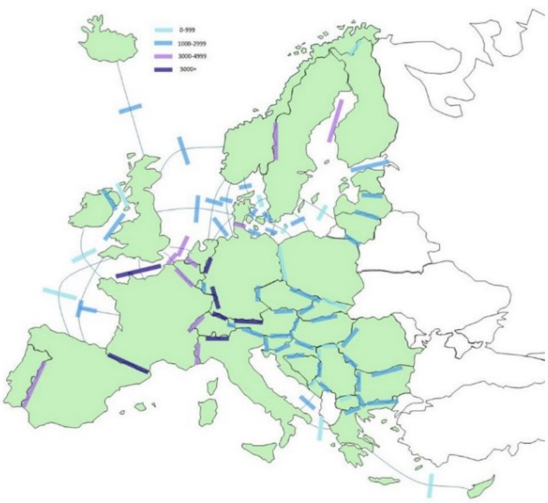
This project was promoted for TYNDP inclusion by a non-ENTSO-E member. An application process was set out by ENTSO-E in Q2/2015 followed by a public consultation. At the time of closure of the consultation, this project did not demonstrate compliance with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups.

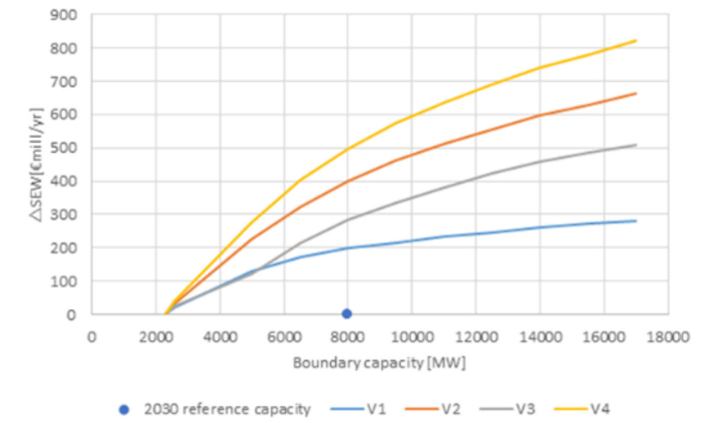
The European Council in October 2014 called for speedy implementation of all the measures to meet the target of achieving by 2020 an interconnection level of at least 10 % of their installed electricity production capacity for all Member States. It also included an indicative objective for 2030, to enhance this threshold to 15% while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions.

The Common Planning Studies performed in the ENTSO-E Regional Investment Plan published in 2015 tested for CSW region the borders of Spain with France, Portugal, Great Britain and Italy in order to increase the interconnection level of the Iberian Peninsula. The study concluded that additional interconnections to GB and IT although could give certain savings in variable generation cost would not be cost-effective due to the high investment cost estimated;  that is, high length of the links (900-1200 km) that have to be adapted to particularities of the seabed regarding depths, slopes, canyons, etc…increasing standard costs while also considering socio-environmental constraints like protected areas, commercial ports and leisure marinas.

The curves in the right show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases. In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.

Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.






## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The project has been assessed as a multiterminal HVDC link.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | Boundary Iberia-central EU: 2000 MW both directions |
| | Boundary GB-central EU: 1800 MW both directions |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 3700 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 60 ±10 | 150 ±10 | 160 ±20 | 160 ±20 |
| B3 RES integration (GWh/yr) | N/A | 40 ±40 | 990 ±290 | 1100 ±210 | 920 ±160 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 1400 ±200 | 500 ±200 | -1100 ±100 | -1600 ±200 |

Savings in variable generation costs (SEW) in 2030 V1 are caused by a decrease of CCGTs in the Iberian Peninsula compensated by an increase of cheap coal in the UK and Central Europe. This situation results however in a global increase of $CO_2$ emissions.

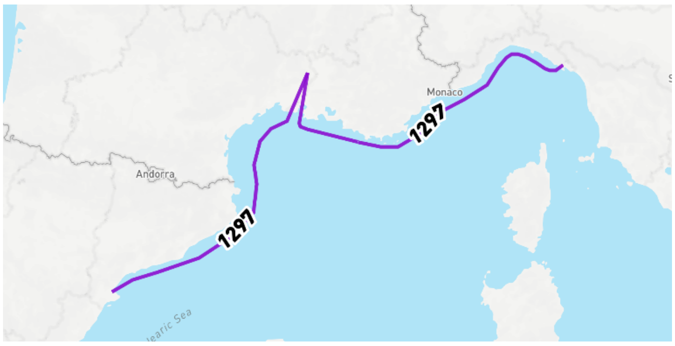
In both 2030 V3 and V4, there is a replacement of gas by less expensive technologies like nuclear and renewable energy. This produces a higher SEW than in V1 and a global decrease of $CO_2$ emissions. There is additionally a high integration of RES in the area that leads to very positive values of the RES indicator.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 282 - ASEI: Abengoa Southern Europe Interconnection

ASEI project is a newinterconecnnection line developed by Inabensa (Abengoa).
ASEI will connect Spain - France - Italy with a subsea HVDC VSC technology with 2GW power grid transfer capability.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Spain - France - Italy |
| PCI label | |
| Promoted by | Abengoa |




| Investments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
| 1297 | This investment consists of a 2GW HVDC line which connects the substation in Vandellós (Spain) with the substation in La Spezia (Italy), through the substation Tavel (France) | 100% | Vandellos | La Spezia | Under Consideration | 2025 | New Investment | |

## Investment needs

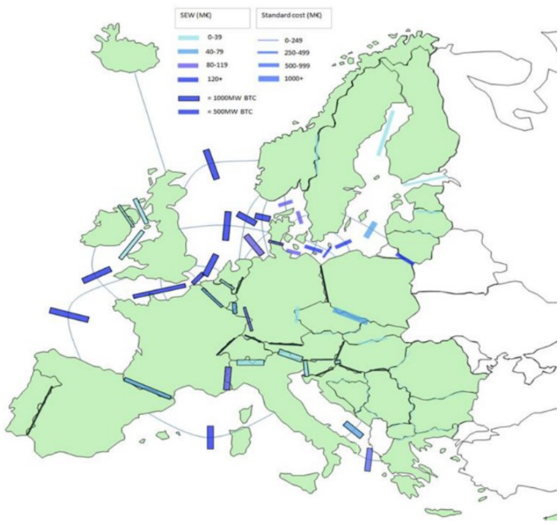
This project was promoted for TYNDP inclusion by a non-ENTSO-E member. An application process was set out by ENTSO-E in Q2/2015 followed by a public consultation. At the time of closure of the consultation, this project did not demonstrate compliance with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups.

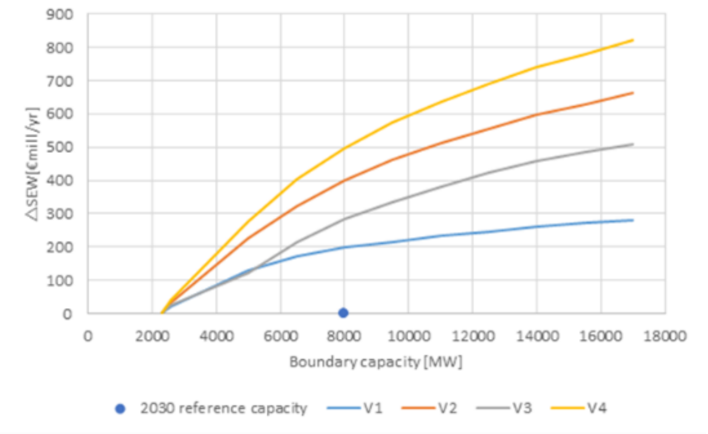
The European Council in October 2014 called for speedy implementation of all the measures to meet the target of achieving by 2020 an interconnection level of at least 10 % of their installed electricity production capacity for all Member States. It also included an indicative objective for 2030, to enhance this threshold to 15% while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions.

The Common Planning Studies performed in the ENTSO-E Regional Investment Plan published in 2015 tested for CSW region the borders of Spain with France, Portugal, Great Britain and Italy in order to increase the interconnection level of the Iberian Peninsula. The study concluded that additional interconnections to GB and IT although could give certain savings in variable generation cost would not be cost-effective due to the high investment cost estimated;  that is, high length of the links (900-1200 km) that have to be adapted to particularities of the seabed regarding depths, slopes, canyons, etc…increasing standard costs while also considering socio-environmental constraints like protected areas, commercial ports and leisure marinas.

The curves in the right show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases. In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.

Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.






## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The project has been assessed as a multiterminal HVDC link.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | Boundary Iberia-rest of EU: 700 MW IB-->rest of EU; 0 MW rest of EU-->IB |
| | Boundary FR-IT: 1000 MW both directions |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 2600 |

| | |
|---|---|
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 10 ±10 | <10 | 10 ±10 | 60 ±20 |
| B3 RES integration (GWh/yr) | N/A | 20 ±20 | <10 | 20 ±10 | 170 ±50 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 100 ±100 | ±100 | -100 ±100 | -600 ±100 |

The not very high savings in variable generation costs (SEW) in 2030 V1 are caused by a decrease of CCGTs in the Iberian Peninsula compensated by an increase of cheap coal in the UK and Central Europe. This situation results however in a global increase of CO2 emissions.

In both 2030 V3 and V4, there is a replacement of gas by less expensive technologies like nuclear and renewable energy. This produces a higher SEW especially in V4, and also a global decrease of CO2 emissions in both V3 and V4.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 283 - TuNur

TuNur is aimed to connect to the European network a Concentrated Solar Power plant with storage to be located in Rejim Maatoug, Kebili, Tunisia.  The connection point to the ENTSO-E network is located in Montalto di Castro, Lazio, Italy. The transmission project will comprise +/- 500kV DC submarine cables from the Tunisian Northern coast to Montalto di Castro, DC overhead lines in Tunisia from the power plant to the shoring point, and HVDC converter stations at the terminal points.

Classification: Future Project

Boundary: Tunisia, Italia

PCI label:

Promoted by: TuNur Ltd


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1378 | HVDC overhead line in Tunisia and submarine cable to Montalto | 100% | Rejim Maatoug 400kV | Montalto 400kV | Permitting | 2020 | | |
| 1430 | 400kV AC underground cable from Montalto HVDC converter to Terna station | 100% | Rejim Maatoug 400 kV | Montalto 400 kV | Permitting | 2020 | | |

## Additional Information

www.tunur.tn

www.nurenergie.com

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

To determine the expected grid transfer capability on the Tunisia - Italy border due to the investigated TuNur project several load-flow analyses were carried out considering power flows in both ways, with network in regular and contingency condition. Both in terms of market analyses and according TSOs, there are no potential interferences between the TuNur and Elmed projects, although interesting the same countries. The performed calculations, considering that the GTC value adopted as a basis for benefit calculation must be valid at least 30 % of the time, show that the contribution of the TuNur project to the GTC of Tunisia/Italy Centre-South boundary can be assumed at least equal to 1250 MW, both ways.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | TN-IT: 1000 |
| | IT-TN: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 2700 ±200 |
| Cost explanation | The total TuNur project expenditures are estimated between 2500 M€ and 2900 M€, included contingencies. |
| S1 | NA |
| S2 | NA |
| B6 | N/A |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 80 ±10 | 30 ±0 | 100 ±20 | 50 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 600 ±120 | 100 ±20 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 600 ±100 | ±100 | -400 ±100 | -200 ± 30 |

Benefit B2 for improvement of socio-economic welfare for year 2030 can be estimated equal to about 81 M€ (in visions 1 and 2) and about 53.5 M€ (in visions 3 and 4).

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 284 - LEG1

LEG1 is a HVDC Interconnection Subsea cable project of min. 2000 MW allowing for an electricity exchange between Europe and the South-Eastern Mediterranean Countries. The bidirectional interconnector will link Libya and Egypt, via Tobruk, to Crete (Greece) allowing Europe to interconnect with existing/planned regional networks, including ELTAM, GCC and EIJLLPST (Eight Country interconnection projects). LEG1 creates a new electricity exchange place enabling Europe to export production surpluses to a market serving over 500 million North African users with high electricity demand. It also supports Europe’s energy security and climate objectives by accessing RES generation capacity in Libya, Egypt and Saudi Arabia. The HVDC submarine cable, running no deeper than 2500m below the sea, takes the shortest, most direct path through the Mediterranean seabed (347km offshore) and will challenge European cable industries in their advanced technology capability. Commissioning date is planned for 2019.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Greece, Egypt, Libya |
| PCI label | |
| Promoted by | GreenPower 2020 |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1405 | | 100% | SALOUM (EG), TOBRUK (LIBYA) | MIRES (GR Crete) | Under consideration | 2019 | | |

### Additional Information

The proposed LEG1 link presents a new strategic opportunity in creating an electricity exchange between Europe, Middle-East countries and Africa. It is an integrated project in line with the EU’s energy and climate objectives while supporting socio-economic developments in the southern/eastern Mediterranean region and Central and Eastern Africa.

Through LEG1, the electricity network of emerging countries of the Middle-East region will be linked to the European grid before 2020. It will allow export of surplus of electricity from Europe and the import of renewable power from the Middle East into Europe.

With an offshore distance of only 347 km by submarine cable, LEG1 is the shortest connection between Europe and eight countries of South/East Mediterranean. Several onshore interconnections already exist including the land network between Tobruk (Libya) and Sallum (Egypt) as well as between Israel and Jordan.

Solar radiation is excellent on both sides of the Egyptian and Libyan borders and wind energy provides further potential. Libya alone is able to guarantee a supply of solar energy of 3,000 hours per year in addition to the 5,760 hours per year from conventional generation capacity.

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list.

The project gained endorsement of both public and private stakeholders, including a Memorandum of understanding with ADMIE (Greek TSO), Libyan Ministry of Electricity and Renewable Energy, League of Arab States, Arab Regulators Forum, and DESERTEC Foundation.


## Project Cost Benefit Analysis

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Greece-Libya: 2000MW |
| | Libya-Greece: 2000MW |
| Delta GTC contribution (2030) [MW] | Greece-Libya: 2000MW |
| | Libya-Greece: 2000MW |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1015 |
| Cost explanation | The investment cost for direct current (DC) links are mainly driven by the costs of: the DC converter stations; the cables; laying down of the cables; and protection of cables. |
| S1 | NA |
| S2 | NA |

| | |
|---|---|
| B6 | + |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 285 - GridLink

UK - France 1.5GW HVDC (VSC) Interconnector

| | |
|---|---|
| Classification | Future Project |
| Boundary | UK, France |
| PCI label | |
| Promoted by | Elan Energy Ltd |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1383 | The GridLink project is a 1.4GW HVDC (VSC) interconnector between the UK (Kingsnorth) and France (Warande)" | 100% | Kemsley (Sittingbourne, UK) | Warande (Gravelines, France) | Planning | 2021 | New Investment | |

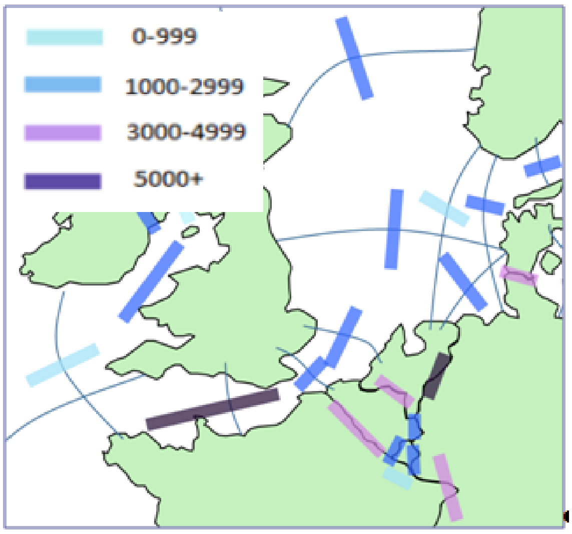
### Additional Information

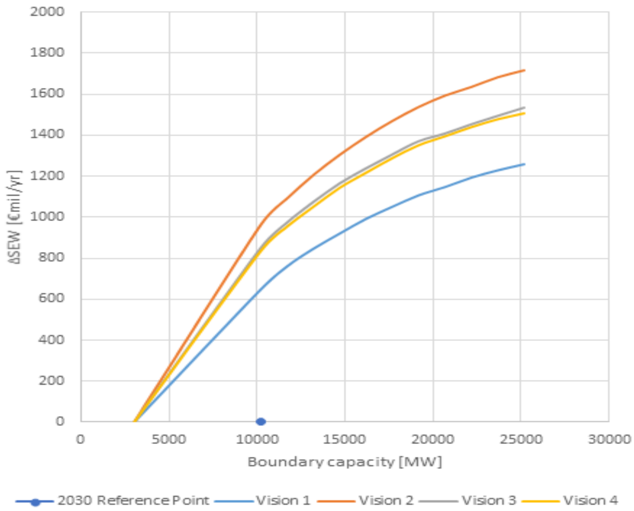
### Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member. An application process was set out by ENTSO-E in Q2/2015 followed by a public consultation. At the time of closure of the consultation, this project did not demonstrate compliance with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

Market based capacity analysis performed in the TYNDP2016 show the need to increase the interconnection capacity between Great Britain and the continent . On the SEW/GTC graph we can see that even starting from a 2030 capacity of about 10GW between GB and the continental and Nordics areas, extra capacity still allows savings on the boundary.

This project is one of the links that will contribute in the future to increase the capacity on the boundary, and then facilitate energy exchanges between Great Britain and the continent.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | GB-FR: 1500 |
| | FR-GB: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 600 |
| Cost explanation | Construction capital costs |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 70 ±10 | 120 ±20 | 110 ±20 | 110 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | 870 ±170 | 1190 ±240 | 580 ±200 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 1300 ±400 | 500 ±100 | -700 ±100 | -800 ±100 |

On the French side, depending on the final connection location, additional analysis will have to be performed in order to assess curtailment level needed to ensure N and N-1 safe operation of the French transmission system.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 4.92 | 7.80 | 8.25 | 7.26 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 9.72 | 13.56 | 19.68 | 18.44 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 16.60 | 13.49 | 10.67 | 11.29 |

# Project 286 - Greenlink

An interconnector link between Ireland and Wales, making use of both subsea and onshore underground cables.The link will connect the EirGrid and National Grid transmission systems via HVDC tech-nology.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Ireland - Wales UK |
| PCI label | |
| Promoted by | Element Power |


## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1385 | A new 170km 500MW HVDC interconnector connecting south west Wales to south east Ireland | 100% | Great Island (to be confirmed) | Pembroke (to be confirmed) | Design | 2022 | Delayed | A pure interconnector with Ofgem IPA approval. |

## Additional Information

Project website http://www.greenlinkinterconnector.eu/

Stakeholders should consult the project website for the most up to date information on the Greenlink Interconnector project.

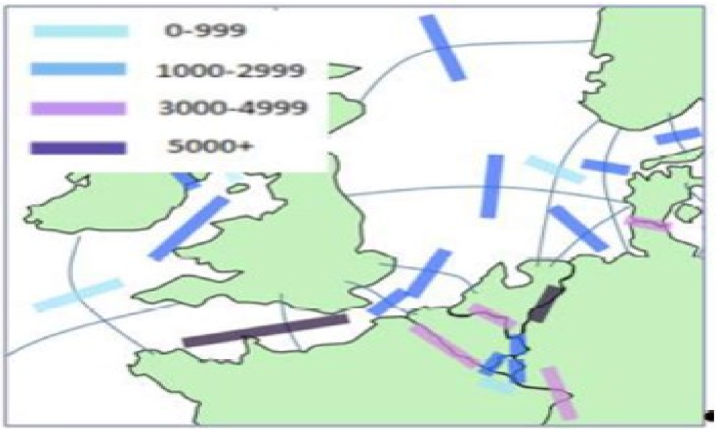
## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

Greenlink provides a third interconnector between the island of Ireland and Great Britain. Connecting Pembroke in south west Wales to Great Island in south east Ireland it connects to strong points in the two transmission systems with 4x 400kV transmission circuits existing at Pembroke and 3 x220kV circuits plus 4x110kV interconnected transmission circuits at Great Island. Greenlink complements the existing interconnectors, Moyle in the Northern Ireland and EWIC in the middle of Ireland and will provide interconnectivity to France via the proposed Celtic interconnector project 107. EirGrid's 2016 Generation Capacity Statement shows Irish wind growing from 3GW capacity at the end of 2016 to between 4.5 and 5GW by 2025. To reduce curtailment and prevent increased system operation costs further interconnection will be needed.

The combined capacities of Moyle and EWIC are currently 950MW from GB to Ireland and 795MW from Ireland to GB. The Moyle link suffers from transmission bottlenecks in Scotland and has had cable reliability issues. EWIC had a fault in September 2016 and is expected to be out of service until end February 2017. From November 2017 the export capacity from the Island of Ireland to GB will be lowered and limited to 585MW (505MW EWIC and 85MW Moyle). In July 2016 Scottish Power reduced the scope of its Dumfries and Galloway reinforcement scheme and that reduced scheme will not relieve the 80MW export limit for Moyle. Greenlink Interconnector would provide capacity for at least 500MW of additional import and export capacity between Ireland and GB. Pembroke substation in Wales is located on a radial spur with future transmission bottlenecks indicated. Greenlink interconnection would provide additional export capacity for the region if needed.

In conjunction with Moyle and EWIC an interconnector between Great Island and Pembroke would allow great flexibility to EirGrid and National Grid (using SO to SO trades) in overcoming bottlenecks in their systems by routing power via their neighbours, e.g. from Scotland to southern England via Northern Ireland, Republic of Ireland and Wales. The Island of Ireland is isolated in terms of electricity and renewable energy as its considerable wind energy resources are not able to operate fully in a European market due to the limitations of wind integration on the Irish grid. Greenlink interconnector will provide additional interconnection capacity enabling more wind development with reduced curtailment of wind in the Island of Ireland. Greenlink interconnector will provide more capacity between island of Ireland and GB and into continental Europe via the GB to continental Europe interconnectors both present and planned. This capacity will help to converge market prices and enable the exploitation of renewable energy sources from (historically) individual and limited Member State based markets into an integrated single European market. Other benefits include increased security of supply, flexibility, capacity, system service provision and resilience in GB and Ireland via this HVDC VSC interconnection.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |

| | |
|---|---|
| Delta GTC contribution (2030) [MW] | IE-GB: 700 |
| | GB-IE: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 400 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | <10 | 30 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | N/A | 270 ±70 | 100 ±20 | 450 ±90 | 380 ±80 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | -100 ±100 | ±100 | -500 ±300 |

The project connects the island of Ireland to Great Britain, allowing for the export of additional renewable generation that would otherwise be curtailed, as reflected in the RES integration figures. The project contributes to the reduction of marginal cost differences between the Irish and British markets.

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by Eirgrid and National Grid which concluded that there are additional benefits of 24 million euros of from the avoided investment in generation capacity.

Ofgem has also published an initial project assesmnet of the Cap and Floor regime for the projects FAB Link, IFA2 VIking Link and Greenlink. This document states that the revenues from the capacity market, for this project in particular could be around 23.6 millions pounds annually.

The project’s SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology.

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 287 - Greenwire South

Interconnection between Ireland and Great Britain with the option of wind directly connected to Great Britain system and system to system (Ireland to Great Britain) interconnection. Using underground and subsea cables.Connecting EirGrid; and/or AC networks in Ireland for directly connected wind; to National Grid. Utilising high voltage direct current (HVDC) and high voltage AC underground cables.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Ireland and Great Britain |
| PCI label | |
| Promoted by | Element Power |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1439 | HVDC subsea and onshore underground cable | 100% | Grenwire South Hub | Pembroke (to be confirmed) | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1441 | 500MW HVDC back to back converter and associated underground HVAC and HVDC cables | 100% | Grenwire South Hub | Dunstown, Laois or other tbc | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1442 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Grenwire South Hub | Greenwire South substation AC1 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1443 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Grenwire South Hub | Greenwire South substation AC2 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1444 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Grenwire South Hub | Greenwire South substation AC3 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1445 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Grenwire South Hub | Greenwire South substation AC4 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |

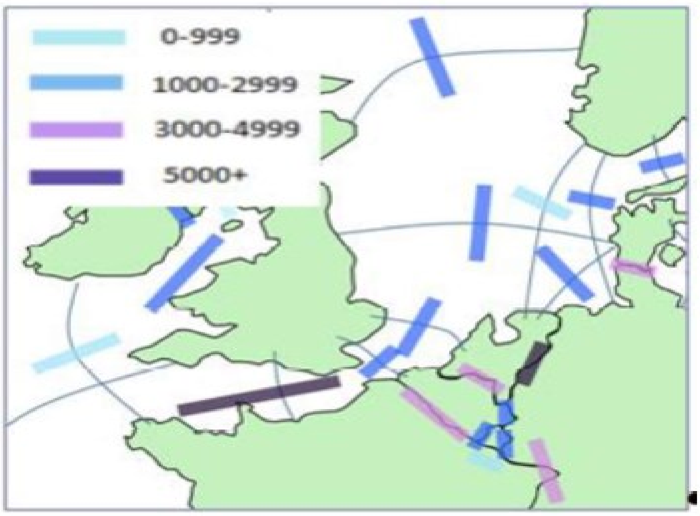
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1446 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Grenwire South Hub | Greenwire South substation AC5 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |

## Additional Information

Refer to web site http://www.elpower.com/expertise/transmission-grid-services

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)



## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The project connects the island of Ireland to Great Britain. The design of the project is such that there is both interconnection capacity between Ireland and Great Britain, and the connection of additional RES generation directly to Great Britain. This is reflected in both the large RES integration figures and the significant SEW figures, as the project enables savings in generation fuel and operating costs, and savings in generation capacity. The project contributes to the reduction of marginal cost differences between the Irish and British markets.
The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-GB: 1300 |
| | GB-IE: 1300 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 850 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 250 ±20 | 160 ±20 | 210 ±30 | 230 ±20 |
| B3 RES integration (GWh/yr) | N/A | 3830 ±20 | 3130 ±630 | 2940 ±590 | 3490 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -1600 ±100 | -1700 ±100 | -900 ±100 | -600 ±400 |

The project connects the island of Ireland to Great Britain. The design of the project is such that there is both interconnection capacity between Ireland and Great Britain, and the connection of additional RES generation directly to Great Britain. This is reflected in both the large RES integration figures and the significant SEW figures, as the project enables savings in generation fuel and operating costs, and savings in generation capacity. The project contributes to the reduction of marginal cost differences between the Irish and British markets.

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by Eirgrid and National Grid which concluded that there are additional benefits of 24 million euros of from the avoided investment in generation capacity.

The project’s SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

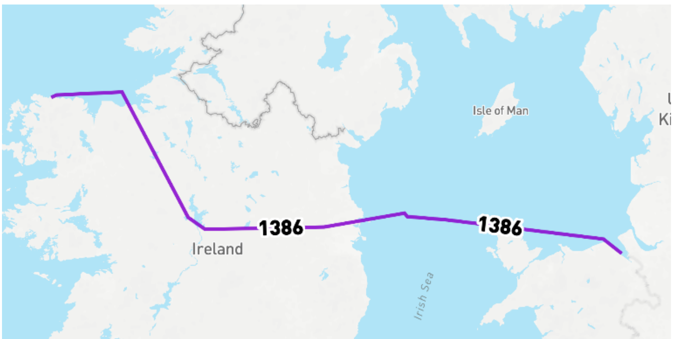
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 289 - MAREX UK-Ireland Intrconnector

1500MW VSC bipole HVDC interconnector linking UKNG and EIRGRID, submarine Connah's Quay UK to Dublin, OHL/underground cable/submarine cable/OHL Dublin-Bellacorick EIRGRID

| | |
|---|---|
| Classification | Future Project |
| Boundary | UK-Ireland |
| PCI label | |
| Promoted by | Organic Power Ltd. |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1386 | | 100% | Connah's Quay | Finglas Dublin | Under Consideration | 2020 | | |
| 1387 | | 100% | Finglas Dublin | Bellacorick Mayo | Under Consideration | 2020 | | |

### Additional Information

### Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

### Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project connects renewable generation and storage facilities on the west of Ireland directly to Great Britain. It also allows for some interconnection capacity between the island of Ireland and Great Britain. A simplified project was studied for the CBA assessment, as a result of uncertainties in the modelling of the storage facility. As a result, the CBA figures will not be fully reflective of the project. The interconnection aspect of the project contributes to the reduction of marginal cost differences between the Irish and British markets, and the integration of RES generation that would otherwise be curtailed.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-GB: 1500 |
| | GB-IE: 1500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1300 ±200 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 10 ±10 | 50 ±10 | 50 ±10 |
| B3 RES integration (GWh/yr) | N/A | 380 ±110 | 130 ±30 | 740 ±10 | 550 ±140 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 400 ±400 | -100 ±100 | -200 ±100 | -200 ±100 |

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by EirGrid and National Grid which concluded that there are additional benefits of 24 million euros from avoided investment in generation capacity.

The project's SEW accounts for savings in both generation fuel and operating costs. The project could also enable savings by avoiding investment in generation capacity, in particular for projects connecting electric peninsulas. This aspect has not been considered in the CBA methodology.

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

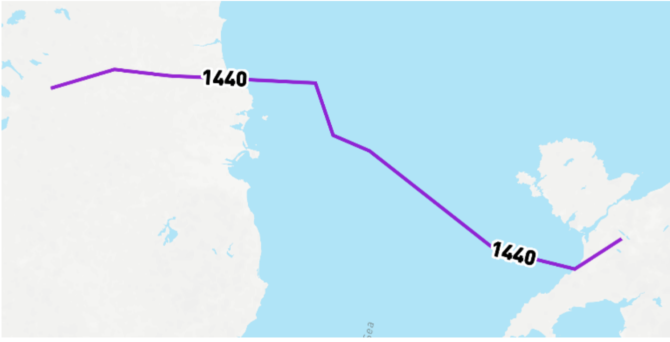
As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 290 - Greenwire North

Interconnection between Ireland and Great Britain with the option of wind directly connected to Great Britain system and system to system (Ireland to Great Britain) interconnection. Using underground and subsea cables.Connecting EirGrid; and/or AC networks in Ireland for directly connected wind; to National Grid. Utilising high voltage direct current (HVDC) and high voltage AC underground cables.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Ireland and Great Britain |
| PCI label | |
| Promoted by | Element Power |

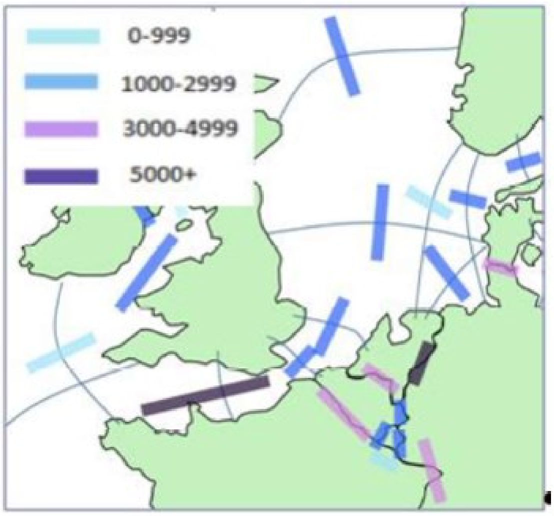



### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1440 | HVDC subsea and onshore underground cable. | 100% | Greenwire North Hub | Pentir (to be confirmed) | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1447 | 500MW HVDC back to back converter and associated underground HVAC and HVDC cables. | 100% | Greenwire North Hub | Woodlands or new Midlands 400/220V substation tba | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1369 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Greenwire North Hub | Woodlands or new Midlands 400/220V substations tba | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1448 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Greenwire North Hub | Greenwire North substation AC2 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1449 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Greenwire North Hub | Greenwire North substation AC3 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |
| 1450 | Underground HVAC (e.g 400kV) cables and termninal substation for MV windfarm collection network. | 100% | Greenwire North Hub | Greenwire North substation AC4 | Planning | 2023 | Delayed | Awaiting international contracts for renewable energy |

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-GB: 1000 |
| | GB-IE: 1000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 800 |
| Cost explanation | |
| S1 | NA |

| | |
|---|---|
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 200 ±10 | 130 ±20 | 150 ±20 | 180 ±10 |
| B3 RES integration (GWh/yr) | N/A | 2960 ±30 | 2360 ±470 | 2060 ±180 | 2740 ±30 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | -1200 ±100 | -1400 ±100 | -600 ±100 | -800 ±100 |

The project connects the island of Ireland to Great Britain. The design of the project is such that there is both interconnection capacity between Ireland and Great Britain, and the connection of additional RES generation directly to Great Britain. This is reflected in both the large RES integration figures and the significant SEW figures, as the project enables savings in generation fuel and operating costs, and savings in generation capacity. The project contributes to the reduction of marginal cost differences between the Irish and British markets.

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by EirGrid and National Grid which concluded that there are additional benefits of 24 million euros from avoided investment in generation capacity.

The project's SEW accounts for savings in both generation fuel and operating costs. The project could also enable savings by avoiding investment in generation capacity, in particular for projects connecting electric peninsulas. This aspect has not been considered in the CBA methodology

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 291 - Greenwire Loop

A link between Greenwire North converter station and Greenwire South converter station in the Republic of Ireland. This link creates the opportunity for loop flows from North to South Wales - e.g. Pen-tir to Pembroke and vice versa. The link will be underground cable; the precise technology and voltage is dependent on the design of Greenwire North and Greenwire South.

| | |
|---|---|
| Classification | Future Project |
| Boundary | North and South Wales |
| PCI label | |
| Promoted by | Element Power |


## Investments

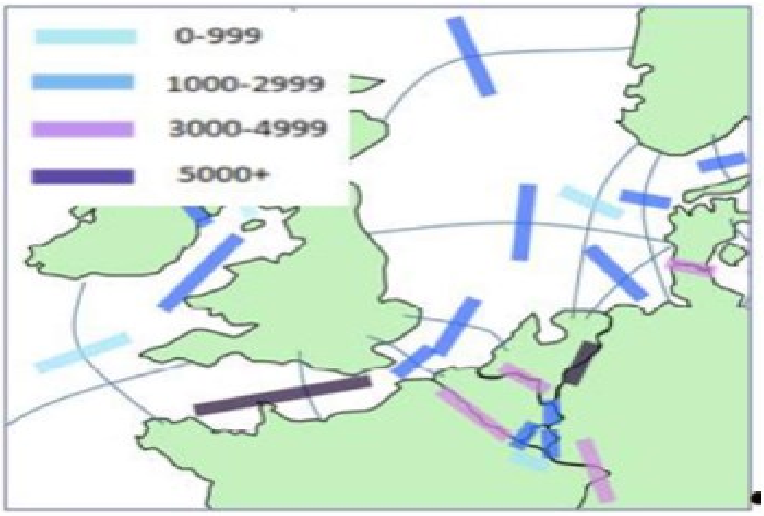
| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1454 | | 100% | Greenwire North Hub | Grenwire South Hub | Under Consideration | 2022 | New Investment | |

## Additional Information

The purpose of this project is to connect project 1439 from the South of Wales to Ireland and project 1440 from North of Wales to Ireland.

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)




## Project Cost Benefit Analysis

The project, proposed by Element power, fails to meet all the re-quirements of the EC guidelines governing the application to the PCI list. This project is an internal connection between project 287 and 290. Due to the nature of the project, no CBA assessment has been performed by ENTSO-E. Element power agreed with ENTSO-E that it is yet not possible to compute SEW and related indicators.

A technical description of the project must be developed before network analysis can be performed, and a GTC calculated.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indica-tors, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | -: - |
| | -: - |
| Delta GTC contribution (2030) [MW] | IE-GB: 700 |
| | GB-IE: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 50 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | N/A |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B3 RES integration (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | N/A | N/A | N/A | N/A |

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by EirGrid and National Grid which concluded that there are additional benefits of 24 million euros from avoided investment in generation capacity.

The project's SEW accounts for savings in both generation fuel and operating costs. The project could also enable savings by avoiding investment in generation capacity, in particular for projects connecting electric peninsulas. This aspect has not been considered in the CBA methodology

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 292 - Greenconnect

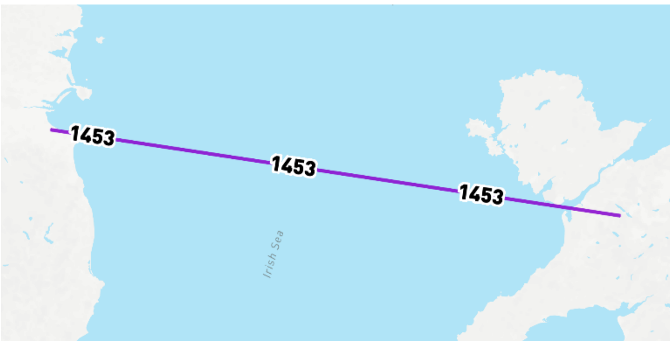
An interconnector link between Ireland and North Wales, making use of both subsea and onshore underground cables. The link will connect the EirGrid and National Grid transmission systems via HVDC technology.

Classification Future Project

Boundary Ireland - North Wales UK

PCI label

Promoted by Element Power




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1453 | A subsea HVDC interconnector between Wales and Ireland | 100% | Dublin Area ( to be agreed) | Pentir (to be agreed) | Under Consideration | 2023 | New Investment | |

## Additional Information

Web site: http://www.elpower.com/expertise/transmission-grid-services

## Investment needs

This project was promoted for TYNDP inclusion by a non-ENTSO-E member, complying with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups. (additional statement needed from RG in case the project relates to an investment need for which a TSO project is in the list)

## Project Cost Benefit Analysis

However, the technical description of the project must still be developed before network analysis can be performed, and a GTC can be computed. Element power also agreed with ENTSOE that it is yet not possible to compute SEW and related indicators.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IE-GB: 700 |
| | GB-IE: 700 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 400 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | <10 | 30 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | N/A | 270 ±70 | 100 ±20 | 450 ±90 | 380 ±80 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | -100 ±100 | ±100 | -100 ±100 |

The project connects the island of Ireland to Great Britain, allowing for the export of additional renewable generation that would otherwise be curtailed, as reflected in the RES integration figures. The project contributes to the reduction of marginal cost differences between the Irish and British markets.

Ofgem has published a cost benefits analysis of GB interconnections. In this document it states that there was a study conducted by EirGrid and National Grid which concluded that there are additional benefits of 24 million euros from avoided investment in generation capacity.

The project's SEW accounts for savings in both generation fuel and operating costs. The project could also enable savings by avoiding investment in generation capacity, in particular for projects connecting electric peninsulas. This aspect has not been considered in the CBA methodology

Link to the OFGEM study: https://www.ofgem.gov.uk/ofgem-publications/93792/ipamarch2015consultation-final-pdf

As the accurate location and project scope are still under investiga-tion, B4 indicator (impact on losses) was not assessed.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case  [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 293 - Southern Aegean Interconnector

The project refers to the construction of a submarine DC transmission link to connect the licensed RES plants (mentioned above) at the South Aegean Sea to mainland Greece and the islands of Crete, Kos and the Dodecanese. The capacity of the link will be 600-800MW both directions using HVDC (High Voltage Direct Current) technology. VSA conversion technology in conjunction with plastic (XLPE) cables will be used.

The licensed RES projects consist of wind and solar power plants located on 23 small uninhabited islands. The link will be used for transmitting electricity from the RES plants mentioned above to the mainland and the island of Crete. More specifically, the power produced in each island will be transferred to the island of Levitha where the main conversion station will be built acting as a hub.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Greece |
| PCI label | |
| Promoted by | Kykladika Meltemia SA |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1431 | | 100% | LAVRIO | LEVITHA | Design & permitting | 2020 | Investment on time | |
| 1432 | | 100% | LEVITHA | KORAKIA CRETE | Design | 2021 | Investment on time | |
| 1433 | | 100% | Levitha | Syrna | Design | 2020 | Investment on time | |
| 1434 | | 100% | KINAROS | LEVITHA | Design | 2021 | Investment on time | |
| 1435 | | 100% | Kandeliousa | Syrna | Design | 2021 | Investment on time | |
| 1436 | | 100% | Kandeliousa | Pergousa | Design | 2021 | Investment on time | |

### Additional Information

www.eunice-group.com

### Investment needs

These connections will be AC submarine cables (150 kV or 220 kV). The main link will be an HVDC link connecting the island of Levitha to both the metropolitan area of Athens and the island of Crete; the 400kV substation at Lavrion area will be the connection point in the Athens area and Korakia will be the connection point in Crete (located in the north coast). Both links will consist of two parallel cables in order to increase the reliability of each link; two converter stations are foreseen in Levitha and relevant converter stations in Lavrion and Korakia. Illustrative routing of the links is shown in the attached Entso-e map.

The connection to Crete gives further possibilities for power transmission to Cyprus and further to Israel through the "EuroAsia Interconnector" (already accepted as a PCI by the E.C.). It is also possible to further extend this link to the main islands of the Dodecanese complex (namely Kos, Leros, Kalymnos, Nisyros, Tilos) in order to allow the supply of these islands and at the same time the supply of a complex of other smaller islands already connected to the main ones. This is a short link (10km to 15km long) and more likely it will be an AC one.

All the installations on the islands (converter stations, substations etc) will be of closed type using GIS technology.

The project increases the transfer capacity between Mainland Greece and Crete-Kos Islands and further on to Cyprus (through EuroAsia Interconnector). The project will provide the system with 1.9 TWh/year wind energy.


## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | -: - |
| | -: - |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1800 |

| Cost explanation | |
|---|---|
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 70 ±10 | 60 ±10 | 90 ±10 | 80 ±10 |
| B3 RES integration (GWh/yr) | N/A | 1340 ±270 | 1350 ±270 | 1200 ±240 | 990 ±200 |
| B4 Losses (GWh/yr) | N/A | 42.75 | 42.75 | 42.39 | 40.60 |
| B4 Losses (Meuros/yr) | N/A | 2.4 | 2.1 | 2.6 | 2.9 |
| B5 CO2 Emissions (kT/year) | N/A | -1000 ±200 | -1100 ± | -600 ±100 | -400 ±100 |

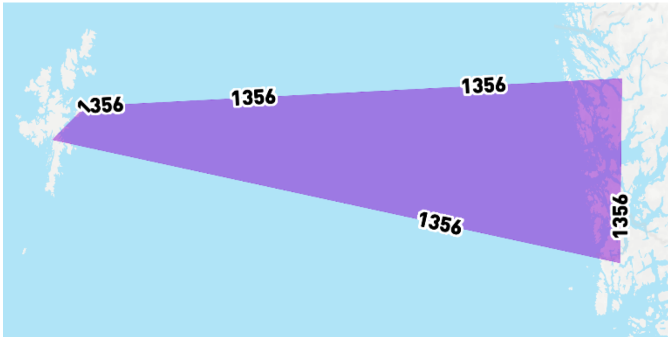
The project is key to enable RES development. When no SEW has been valued, the RES indicator can be monetised, resulting in about several tens millions euros/yr per TWh of enabled RES.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 294 - Maali

An interconnector link between Shetland Scotland UK and Norway. Using subsea and onshore underground cables. Connecting Statnett and National Grid networks / systems. Utilising high voltage direct current subsea and onshore cable.

| | |
|---|---|
| Classification | Future Project |
| Boundary | GB - NO |
| PCI label | |
| Promoted by | Element Power |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1356 | A new 380km 600MW HVDC interconnector connecting Hordaland Norway to Shetland Scotland. | 100% | Kergord Shetland tba | tba near Bergen-Mongstad or Karsto-Blafalli | Under consideration | 2023 | | Viking Windfarm Shetland and HVDC to Scotland |

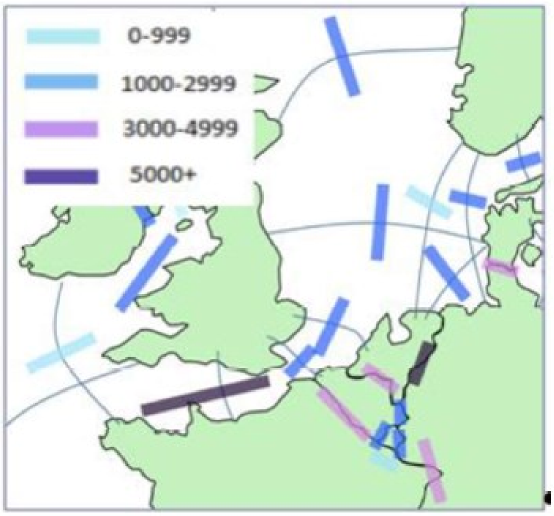
### Additional Information

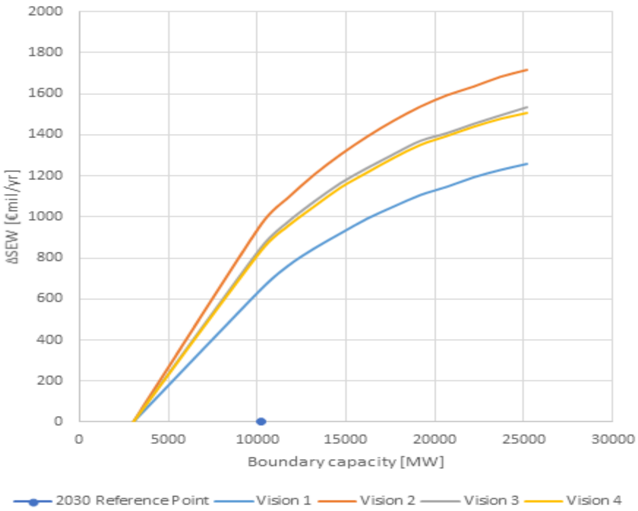
Web site: [http://www.elpower.com/expertise/transmission-grid-services](http://www.elpower.com/expertise/transmission-grid-services)

## Investment needs

Project promoter states: "*By linking the Shetland Isles with Norway the Maali project will connect Norway to the north of Scotland and the rest of GB via the proposed Shetland to Scottish Mainland HVDC interconenctor. In the process Maali will deliver increased security of supply to Shetland, and provide a means to export surplus wind power in Shetland and Scotland to Norway; reducing north south flows and transmission bottlenecks in Great Britain; and improving sustainability of energy supplies and ecomonic welfare in all these localities*"

Maali builds on the proposal by TSO Scottish Hydro Electric Transmission to connect Shetland to Scotland via a new 600MW HVDC link. That connection will enable the development of more than 600MW of renewable energy resources on Shetland, including the 457MW Viking wind farm, and will play a role in decarbonising the current isolated Shetland Power system, which is currently running substantially on diesel generators. Building on this connection from Shetland to Scotland, Maali will further connect Shetland to Norway, thereby both increasing the value and utilisation of the HVDC Shetland-Scotland link, increasing security of supply on Shetland though two HVDC links and enabling even greater future development of untapped renewable energy resources on Shetland. Shetland has an excellent wind regime with the Burradale turbines regularly exceeding an annual capacity factor of 50% and Viking windfarm modelled with a 44% average capacity factor. Because of its location, 170km north of the Scottish mainland, the wind generation is not highly correlated with other UK wind resources which increases its value. Maali will enable Shetland and Scotland to export wind generation during high wind periods to Norway thereby alleviating several transmission boundary constraints between northern Scotland and southern England. In low wind periods Maali will enable Scotland to import power from Norwegian Hydro as an alternative to imports from England, helping to decarbonise both electricity and the wider economy through use of electric vehicles and electric heat pumps for space heating in commercial and domestic buildings. The proposed connection location in Norway is in the Hordaland region, which is further north than other existing and proposed HVDC links to Denmark, Germany, Netherlands and UK, and therefore helps disperse the HVDC links around the Statnett network aiding system stability.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NO-GB: 600 |
| | GB-NO: 600 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 500 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |

| | |
|---|---|
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 60 ±10 | 80 ±10 | 60 ±10 | 50 ±10 |
| B3 RES integration (GWh/yr) | N/A | 90 ±10 | 550 ±110 | 480 ±100 | 160 ±10 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 800 ±100 | ±100 | -400 ±100 | -300 ±100 |

In order to analyse the whole European market in one pan-European market model simplifications are made. Among these is the assumption of modelling the UK-market in one market-node. As no market description of Shetland has been delivered by the project promoter, the assumption is taken that Shetland do have the same market-price as UK. Hence for the CBA-assessment of project 294, the market price of Shetland is the same as London. This is of course a very rough estimation influencing the quality of the CBA-assessment."

Connections to the Nordics can bring potential balancing market benefits in the intraday market which has not been considered in the CBA analysis, the benefits are increased for markets with a lot of wind or hydro as the output can vary a lot from the forecasts.

The Shetland HVDC interconnector is a prerequesite.

The project’s SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 22.55 | 13.64 | 13.11 | 11.69 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.66 | 18.45 | 24.55 | 21.62 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 9.28 | 18.63 | 21.88 | 18.17 |

## Project 295 - Gallant

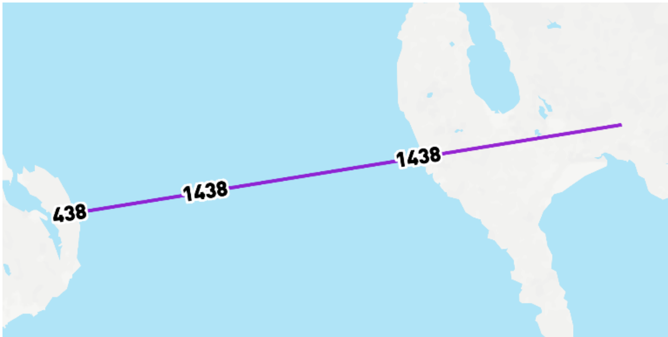
An interconnector link between South West Scotland and Northern Ireland. Using subsea and onshore underground cables. Connecting Northern Ireland Electricity/SONI and Scottish Power / National Grid networks / systems. Utilising high voltage direct current technology.

Classification Future Project

Boundary Northern Ireland – Scotland

PCI label

Promoted by Element Power




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1438 | A new 70km 500MW HVDC interconnector connecting Kilroot in Northern Ireland to Glenluce, Newton Stewart or Tongland in Scotland. | 100% | Glenluce | Kilroot | Under consideration | 2023 | | Dumfries and Galloway strategic reinforcement |

### Additional Information

The project promoter states: "*Gallant provides a strategic reinforcement to the networks with large renewable energy generation potential in South West Scotland and Northern Ireland. Gallant will supplement the current Moyle link and integrate with the proposed Dumfries and Galloway transmission reinforcements, increasing security of supply to the connected locations and providing further meshing of these networks*".

Web site: http://www.elpower.com/expertise/transmission-grid-services

### Investment needs

Gallant builds on the proposal by TSO Scottish Power Transmission to reinforce the transmission network in south west Scotland the Dumfries and Galloway strategic reinforcement. There is 2.4GW of renewable generation contracted to connect to the transmission system in south west Scotland by 2022. With the transmission reinforcements in south west Scotland, Gallant will further connect Scotland to Northern Ireland, thereby both increasing the value and utilisation of the Dumfries and Galloway reinforcements, increasing security of supply in Northern Ireland and south west Scotland though two HVDC links (Moyle and Gallant) and enabling more development of renewable energy resources in both regions with reduced constraints and curtailments.

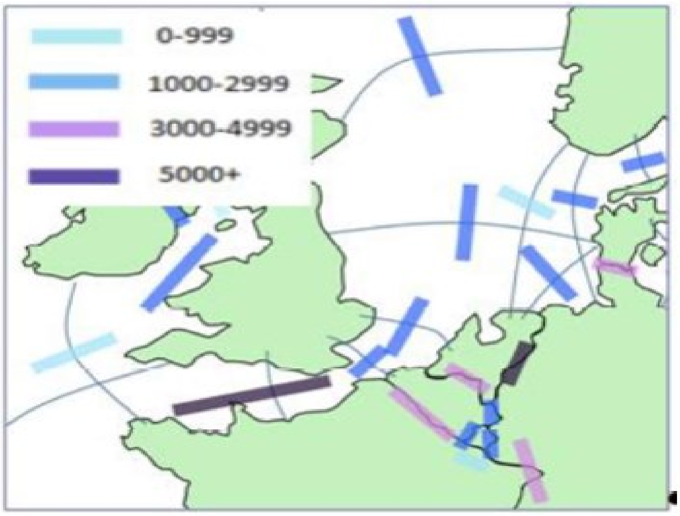
Gallant will enhance the ability of the power systems in Northern Ireland and south west Scotland to manage variable wind generation by using SO to SO trades as well as market arbitrage to maximise renewable generation and minimise the costs and CO2 emissions of fossil fuel generation required for system stability and operation in Northern Ireland.

The proposed connection location is Kilroot in Northern Ireland a strong point on the Irish grid connected with 4x 275kV circuits aiding power flows and system stability. Gallant will increase the links from Ireland to Scotland and Northern England which are also being linked to Norway through the projects 110 NSN - North Sea Link, 190 NorthConnect and 294 Maali, these combined projects will facilitate the development and use of wind resources in Ireland linked to long term storage in Norway and onward routes to market in the rest of northern and eastern Europe.

The project has been proposed by a non-ENTSO-E member, according to official application process set up by ENTSOE according to the EC guidelines.

The claimed investment does not result from planning studies co-ordinated in entsoe Regional Groups and has not been identified as applicable at a Pan-european level.

The project has been proposed by Element power, failing to match all requirements of the EC guidellines governing the application to the PCI list. ENTSO-E however strived to assess as much as possible the project CBA.
However, the technical description of the project must still be developed before network analysis can be performed, and a GTC can be computed. Element power also agreed with ENTSOE that it is yet not possible to compute SEW and related indicators.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | NI-GB: 500 |

| | |
|---|---|
| | GB-NI: 500 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 250 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 20 ±10 | 10 ±10 | 30 ±10 | 30 ±10 |
| B3 RES integration (GWh/yr) | N/A | 220 ±50 | 80 ±20 | 400 ±80 | 290 ±60 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | -100 ±100 | -200 ±100 |

The project connects the island of Ireland to Great Britain, allowing for the export of additional renewable generation that would otherwise be curtailed, as reflected in the RES integration figures. The project contributes to the reduction of marginal cost differences between the Irish and British markets.

The project's SEW accounts for saving in generation fuel and operating costs. The project could also enable savings avoiding investments in generation capacity, in particular for projects connecting electric peninsulas. The aspect has not been considered in the CBA methodology

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 6.35 | 2.53 | 7.29 | 5.39 |
| Standard deviation marginal cost difference in the reference case [€/MWh] | 16.37 | 8.81 | 19.63 | 16.22 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 2.33 | 3.87 | 1.91 | 3.43 |

## Project 296 - Britib

Interconnection project between South-West England (United Kingdom), Cordemais (France) and Basque Country (Spain) in a multiterminal HVDC configuration of 525-600 kV with 3 inputs/outputs of 1800 MW each, and a mostly subsea route from Spain to Great Britain along the French coast of about 1330 km in total.

| | |
|---|---|
| Classification | Future Project |
| Boundary | Spain, France, United Kingdom |
| PCI label | |
| Promoted by | ACS Cobra |


### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1437 | New HVDC interconnection (e-Highway) as first piece of the North-South West priority corridor in Western Europe. | 100% | Gatica/Hernani, Cordemais and Langage/Indian Queens | Gatica/Hernani, Cordemais and Langage/Indian Queens | Under Consideration | 2021/2022 | Delayed | Delayed due to awaiting PCI status. |

### Additional information

The following studies were performed and partially financed by the European Commission through the TEN-E 2011 program:

- Connection points and network feasibility studies
- Facilities electromechanical implementation
- Configuration and converter technology assessment
- Cable technology, losses and deployment assessments
- Land environmental study
- Cable route high-level feasibility study
- Cable route desktop evaluation and sea environmental assessment
- Economic analysis and financial modelling
- Cost-Benefit Analysis
- Legal and regulatory analysis

## Investment needs

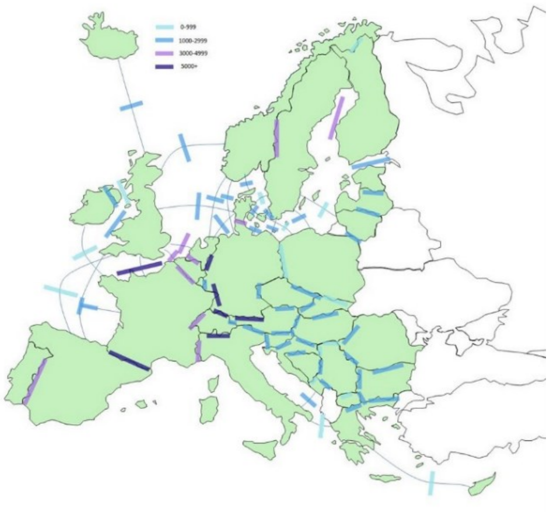
This project was promoted for TYNDP inclusion by a non-ENTSO-E member. An application process was set out by ENTSO-E in Q2/2015 followed by a public consultation. At the time of closure of the consultation, this project did not demonstrate compliance with the EC's draft guidelines for treatment of all promoters. This project proposal does not result directly from planning studies coordinated in ENTSO-E's Regional Groups.

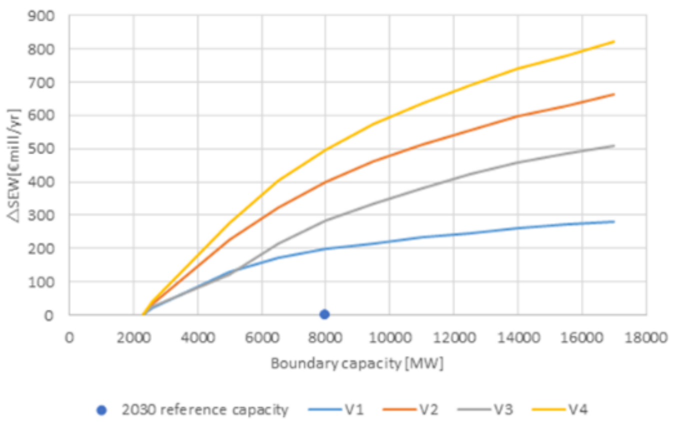
The European Council in October 2014 called for speedy implementation of all the measures to meet the target of achieving by 2020 an interconnection level of at least 10 % of their installed electricity production capacity for all Member States. It also included an indicative objective for 2030, to enhance this threshold to 15% while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions.

The Common Planning Studies performed in the ENTSO-E Regional Investment Plan published in 2015 tested for CSW region the borders of Spain with France, Portugal, Great Britain and Italy in order to increase the interconnection level of the Iberian Peninsula. The study concluded that additional interconnections to GB and IT although could give certain savings in variable generation cost would not be cost-effective due to the high investment cost estimated;  that is, high length of the links (900-1200 km) that have to be adapted to particularities of the seabed regarding depths, slopes, canyons, etc…increasing standard costs while also considering socio-environmental constraints like protected areas, commercial ports and leisure marinas.

The curves below show how the Socio-Economic welfare of Iberian Peninsula- central Europe boundary evolves when exchange capacity increases. In Vision 1, in which the main interest of cross-border development is to substitute gas by coal generation, the curve saturates much earlier than for Vision 4 in which additional capacity mainly allows better integration of RES, especially in the Iberian Peninsula, as well as some substitution of coal by gas generation.

Further development beyond the point where the cost of additional projects is not balanced by the SEW may be driven by additional considerations, like the fulfilment of 10% interconnection rate.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | Boundary Iberia-central EU: 0 MW IB-->central EU; 1400 MW centralEU-->IB |
| | Boundary GB-central EU: 1800 MW both directions |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 2450 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | + |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 50 ±10 | 140 ±10 | 140 ±20 | 100 ±20 |
| B3 RES integration (GWh/yr) | N/A | <10 | 870 ±290 | 1040 ±180 | 540 ±140 |
| B4 Losses (GWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | 1400 ±200 | 600 ±200 | -800 ±100 | -900 ±100 |

Savings in variable generation costs (SEW) in 2030 V1 are caused by a decrease of CCGTs in the Iberian Peninsula compensated by an increase of cheap coal in the UK and Central Europe. This situation results however in a global increase of CO2 emissions.

In both 2030 V3 and V4, there is a replacement of gas by less expensive technologies like nuclear and renewable energy. This produces a higher SEW than in V1 and a global decrease of CO2 emissions. There is additionally a high integration of RES in the area that leads to very positive values of the RES indicator.

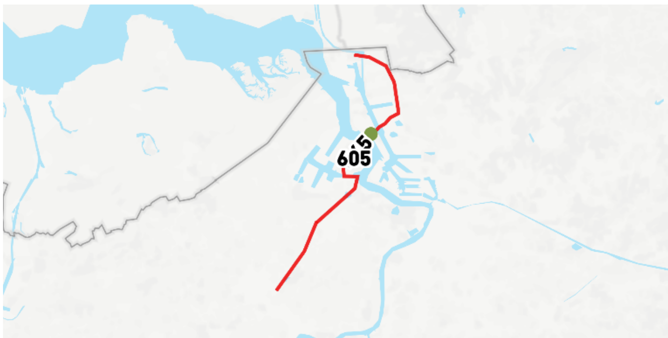
For the assessment were considered Hernani in Spain, Cordemais in France and Indians Queens in GB.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed

## Project 297 - Belgian North Border: BRABO II + III

Realization of a new 380 kV corridor between Zandvliet and Mercator consisting of a double-circuit AC overhead line, including a new substation 380kV in Lillo. BRABO II and III sustain the development of interconnection capacity on the Belgian North Border towards a broader scenario framework, hereby securing the supply of electricity around the Antwerp harbour area in light of the increasing industrial demand (mainly applicable to BRABO II), as well as developing capacity for the potential integration of new production / interconnectors in the Antwerp area (mainly aplicable to BRABO III).

| | |
|---|---|
| Classification | Mid-term Project |
| Boundary | Zandvliet-Mercator |
| PCI label | 2.23 |
| Promoted by | ELIA |




### Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 445 | New double 380kV AC overhead line Zandvliet - Lillo - Liefkenshoek, where the new line will be the temporarily connected to the existing 380kV line Doel-Mercator. | 100% | Zandvliet | Lillo - Liefkenshoek | Design & Permitting | 2020 | Delayed | Progress made in permitting procedures brought clarification to preferential trajectory. Planning has been reviewed accordingly with 2020 based upon the hypothesis of acquiring all necessary permits as currently planned. |
| 604 | Upgrade of an existing 150kV AC overhead line to a 380kV AC overhead line between the site Liefkenshoek and the substation Mercator. | 100% | Liefkenshoek (BE) | Mercator (BE) | Design & Permitting | 2023 | Rescheduled | BRABO III will be realized sequentially after BRABO II in anticipation of potential future integration of production unit / interconnectors in the Antwerp area, hereby safeguarding the long-term character of the increase of interconnection capacity of the North Border. |
| 605 | New substation Lillo 380 | 100% | Lillo (BE) | | Design & Permitting | 2019 | Delayed | Progress made in permitting procedures brought clarification to preferential trajectory. Planning has been reviewed accordingly with 2019 based upon the hypothesis of acquiring all necessary permits as currently planned. |

## Additional Information

This project is integrated in Elia's National Development Plan 2015-2025: http://www.elia.be/nl/grid-data/grid-development/investeringsplannen/federal-development-plan-2015-2025

Additional information can be found back on the project's dedicated website: http://www.elia.be/nl/projecten/netprojecten/brabo

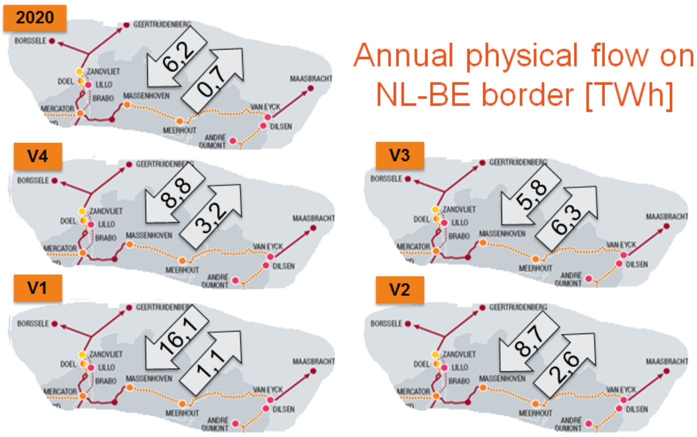
## Investment needs

Increasing integration of wind in the northern part of Germany results into highe and more volatile bulk power flows that can be exported from Germany in favorable meteorological conditions, through the Netherlands and into/through Belgium. This creates congestions on the Belgian North Border, especially in winter conditions with large North-South oriented flows in the CWE region. The Belgian North Border has to be reinforced to alleviate these congestions which would otherwise limit the potential for market exchanges within the CWE zone.

This project # 297 constitutes phases II & III of the BRABO project (phase I is listed as project # 24). Phases II and III make the increase of interconnection capacity on the Belgian North Border more robust towards (potential) future evolutions.

Phase II hereby creates a synergy with securing the supply of electricy around the Antwerp harbour area and is planned to be realized by 2020.

Elia plans to sequentially realize Phase III by 2023, safeguarding the increased interconnection capacity to future evolutions such as the potential integration of new production - for example offshore capacity above 2,3 GW as listed in project under consideration # 120 - and/or the integration of a 2nd interconnector between Belgium and UK as listed in project under condiseration # 121.




## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

The results must however be considered with caution and not totally reliable due to their very high sensitivity to assumptions regarding the detailed location of generation which are not secured.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | BE-NL: 1000 |
| | NL-BE: 1000 |
| Delta GTC contribution (2030) [MW] | BE-NL: [700 ; 1000] |
| | NL-BE: [700 ; 1000] |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 120 ±30 |
| Cost explanation | The provided cost represents the currently expected total investment cost. Uncertainties are related to procurement & construction. |
| S1 | Negligible or less than 15km |
| S2 | Negligible or less than 15km |
| B6 | + |
| B7 | + |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | 10 ±10 | 10 ±10 | <10 | 20 ±10 | 20 ±10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 10 ±20 | 200 ±60 | 120 ±50 |
| B4 Losses (GWh/yr) | 0 ±25 | 0 ±25 | 0 ±25 | -25 ±25 | -25 ±25 |
| B4 Losses (Meuros/yr) | 0 ±1 | 0 ±1 | 0 ±1 | -2 ±2 | -2 ±2 |
| B5 $CO_2$ Emissions (kT/year) | 200 ±100 | 200 ±100 | ±100 | ±100 | ±100 |

Project 297 plays a complementary role to project 24, in the sense that it sustains the benefits as mentioned in project 24 and related to the 1000 MW increase of interconnection capacity on the BE-NL border.

Each investment item of which the new corridor is made up is needed in relation to the mentioned drivers of the project, and can consequently be considered as 'necessary and 100% contributing' to achieve the reported GTC increase.

From a grid perspective there is slight decrease in losses related to the creation of a new corridor in parallel to an existing one with a lower impedance as result.

The project's SEW accounts for savings in generation fuel and operation cost. The project could also enable savings by avoided investments in generation capacity. This has not been considered by the CBA analysis.

| Complementary information about the border on which the project is located | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|
| Average marginal cost difference in the reference case [€/MWh] | 0.52 | 0.13 | 0.88 | 0.60 |

| | | | | |
|---|---|---|---|---|
| Standard deviation marginal cost difference in the reference case [€/MWh] | 3.08 | 1.49 | 6.41 | 5.06 |
| Reduction of marginal cost difference due to all mid-term and long-term projects [€/MWh] | 1.65 | 2.66 | 4.08 | 3.78 |

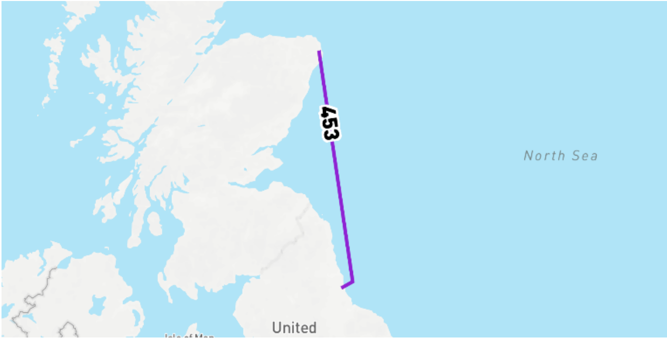
# Project 298 - Anglo-Scottish Cluster -2

Classification Long-term Project

Boundary GB Internal North-South

PCI label

Promoted by NGT;SHETL




## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 453 | New 2000MW HVDC Link on the East Coast of the UK | 100% | Peterhead (GB) | Hawthorn Pit (GB) | Under Consideration | 2023 | Rescheduled | Changes in the generation background |

## Investment needs

The indicators B6/B7 reflect particular technical system aspects of projects based on a summation of qualitative 2015 performance indicators, in line with the CBA methodology; these cannot be used as a proxy for the security of supply indicator.

## Project Cost Benefit Analysis

This project has been assessed by ENTSO-E in line with the Cost Benefit Analysis methodology, approved by the EC in February 2015.

This project alleviates North to South congestion in the UK, and was recommended in the Network Options Assessment

The assessment of losses variations induced by the projects improved in the TYNDP 2016 compared to the TYNDP 2014 with a comprehensive all year round computations on a wide-area model capturing all relevant flows.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | GB Internal: - |
| | GB Internal: - |
| Delta GTC contribution (2030) [MW] | GB Internal: 2000 |
| | GB Internal: 2000 |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 1460 |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | N/A |
| B7 | N/A |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 40 ±10 | 40 ±10 | 60 ±10 | <10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | <10 | <10 |
| B4 Losses (GWh/yr) | 0 ±0 | N/A | N/A | N/A | N/A |
| B4 Losses (Meuros/yr) | 0 ±0 | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | 200 ±100 |

The project brings multiple benefits, alleviating forecast constraints on the network, reducing curtailment and facilitating a reduction in carbon emissions.

Vision 4 is a scenario with less demand on the system, which results in less constraint costs across the whole system, therefore the development of reinforcements will generate less savings.

As the accurate location and project scope are still under investigation, B4 indicator (impact on losses) was not assessed.

## Project 299 - SACOI3

The project consists in a HVDC link among Italy mainland, Corsica and Sardinia that will replace the existing link (SACOI 2) close to the end of its lifetime. The new HVDC will ensure an improvement in technological performance and an increase of the transmission capacity among the three areas involved.


Classification Long-term Project

Boundary Italy-Corsica

PCI label

Promoted by Terna

## Investments

| Investment ID | Description | GTC Contribution | Substation 1 | Substation 2 | Present Status | Commissioning Date | Evolution since TYNDP 2014 | Evolution Driver |
|---|---|---|---|---|---|---|---|---|
| 1458 | New HVDC line between Italy mainland, Corsica and Sardinia replacing the existing link SACOI2 | 100% | Codrongianos | Suvereto | Design | 2023 | Investment on time | Project rescheduled to meet the target commissioning date 2023 |

## Investment needs

At the present time the Corsican demand is covered mainly by the existing HVDC SACOI 2, built between 1964 and 1967, currently close to the end of the useful lifetime, and not available anymore after 2023. The new tri-terminal HVDC link among Italy mainland, Corsica and Sardinia will ensure the possibility to keep the Corsica Island connected to the European grid, also after 2023, via the Italian transmission system, and at the same time will allow supplying the Corsican demand by more efficient, and low $CO_2$ emission, generation located in Italy and in the rest of European countries. Moreover, the project is of major importance for the Security of Supply of the Corsican and Sardinian systems, for the improvement of RES usage and decrease of $CO_2$ emissions.

| General CBA Indicators | |
|---|---|
| Delta GTC contribution (2020) [MW] | Delta GTC was not checked for 2020 and the 2030 values were considered for SEW, RES and CO2 assessment. |
| | |
| Delta GTC contribution (2030) [MW] | IT Sardinia - IT Central North: 400; IT Central North - IT Sardinia: 400 |
| | IT - FR (Corsica): 100; FR (Corsica) - IT: 100; |
| Capex Costs 2015 (M€)<br>Source: Project Promoter | 700 ±50 (Including DC/AC converter station in Corsica) |
| Cost explanation | |
| S1 | NA |
| S2 | NA |
| B6 | ++ |
| B7 | ++ |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B1 SoS (MWh/yr) | N/A | N/A | N/A | N/A | N/A |
| B2 SEW (MEuros/yr) | N/A | 80 ±10 | 80 ±10 | 90 ±10 | 90 ±10 |
| B3 RES integration (GWh/yr) | N/A | <10 | <10 | 190 | 160 |
| B4 Losses (GWh/yr) | N/A | 7 | 8 | 7 | 8 |
| B4 Losses (Meuros/yr) | N/A | N/A | N/A | N/A | N/A |
| B5 CO2 Emissions (kT/year) | N/A | ±100 | ±100 | ±100 | ±100 |

The power system of Corsican island has been modelled with the most recent available data, in fact the Corsican Operator communicated the urgent need of the project just after publication of the ENTSO-E Scenario Development Report 2016.

As for most of the projects, ENTSO-E methodology does not provide SoS figures, however the following consideration is relevant for both Corsican and Sardinia power system.

The existing Sardinia – Corsica – Italy link is approaching the end of its lifetime (< 2023) and, according to the Corsican Energy Plan (PPE), the supply of Corsican load under security conditions could not be possible without the SACOI link. Refurbishment of the link and upgrade of the terminal point in Lucciana will make possible to avoid the urgent installation (by 2023) of about 60 MW of diesel engines and an open cycle power station, mainly necessary for security reasons.

Regarding the Sardinian system, taking into account that all the existing power plants are very aged (three main generation poles commissioned between 1986 and 2000), SACOI is essential for guaranteeing Security of Supply and Resilience. Without the SACOI link it will be necessary to refurbish the oldest power plants present in Sardinia, in order to have satisfying performance and availability indexes. At present, any unavailability of the existing SACOI leads to higher needs of resources able to provide the necessary ancillary services in Sardinia.

## Project 1000 - Hydro Pump Storage Power Plant Pfaffenboden in Molln

The hydro pumped storage plant Pfaffenboden in Molln is essential for the further increase of renewable energy production in Austria, as well as the neighbouring countries, like Germany or the Czech Republic. The reason behind is that base load power stations (e.g. coal-fired power stations or nuclear power stations) are increasingly substituted by fluctuating renewables (e.g. wind or photovoltaic). Therefore the need for quick and flexible storages will further increase in the near future. As a result the stabilization of the electricity grid through hydro pumped storage plant is essential.


| | |
|---|---|
| Boundary | Austria |
| Promoted by | Wien Energie GmbH |

## Project Details

| | |
|---|---|
| Commisioning Date | 2019 |
| Type of Storage | Hydro Pump Storage |
| Max Active Power (MW) | 300 |
| Storage Capacity (GWh) | 1.8 |

## Storage Analysis

In addition to the well known benefits of the hydro pumped storage technology the project in Molln has, due to the connection to the high level multinational transmission grid, positive impacts on the neighbouring electricity markets of Germany and the Czech Republic.

## Additional Information

Besides the positive impacts on the enviroment due to the increaded integration of RES, no significant impacts on nature conservation areas and the environment are expected, as a result of all necessary screening and permitting procedures.

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Turbine | 300 |
| | Pumping | 326,4 |
| Cost [Meuros] | | 340 |

## Scenario specific CBA indicators

| | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 +/- | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | -10 +/- | <10 | <10 | -30 +/- 10 | 10 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | 200 +/- 100 | 100 +/- 100 | +/-100 | 300 +/- 100 | +/-100 +/- 100 |

## Capability for ancillary services

voltage control, frequency control
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Austria enables saving in generation capacity of 10 - 13 Meuro/year

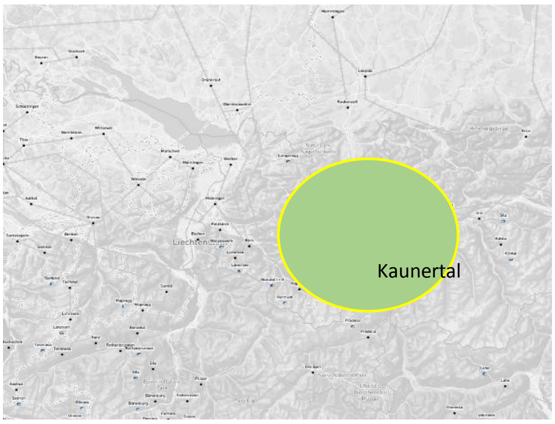
## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |

## Project 1001 - Kaunertal Extension Project

Extension of the existing Kaunertal hydro storage power station by: the new pumped hydro storage power station Versetz and the new reservoir Platzertal including new water intakes, the additional power stations Prutz 2, Imst 2 and Haiming.




| | |
|---|---|
| Boundary | Austria |
| Promoted by | TIWAG |

## Project Details

| | |
|---|---|
| Commisioning Date | 2028 |
| Type of Storage | Pumped Hydro Storage |
| Max Active Power (MW) | 1076 |
| Storage Capacity (GWh) | 152 |

## Storage Analysis

Highly efficient (economical, technical) cross-Border, national and regional support of system stability security of supply RES-E integration as well as low cost RES-E generation and electricity storage improvement of power gen. efficiency (load shedding) reduction of energy dependency substitution of fossil energy demand CO2 reduction by market based products and contributing to the achievement of sustainability, climate and energy policy targets at national/regional level corresponding with EU policy.

## Additional Information

Meanwhile, RES-E share amounts more than 30 % EU-wide. In a longer run, Austria and Germany aim to reach a RES-E penetration of close to 100 %.

All relevant strategy studies and policy papers expect an exponential increase of flexibility capacity demand from now on and an additional significant increase of storage capacity from 2025 on to meet energy shifting demand primarily in the longer time range (hourly, daily, weekly and seasonly) that cannot be met by decentralized storage technologies or flexibility technologies (DSM, ...).

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Turbine | 1076 |
| | Pumping | 390 |
| Cost [Meuros] | | 1254 |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 50 +/- 10 | 70 +/- 10 | 60 +/- 10 | 70 +/- 10 | 70 +/- 10 |
| B3 RES integration (GWh/yr) | <10 +/- | 910 +/- 180 | 910 +/- 180 | 800 +/- 160 | 840 +/- 170 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | 70 |
| B4 Losses (Meuros/yr) | 70 +/- 10 | 70 | 70 +/- 10 | 70 +/- 10 | 70 +/- 10 |
| B5 CO2 Emissions (kT/year) | -300 +/- 10 | -200 +/- 10 | -700 +/- 100 | -300 +/- 100 | -400 +/- 100 |

**Capability for ancillary services**

1) all sorts of load frequency control reserves for
- primary control
- secondary control
- tertiary control

2) U/Q-control
3) black start capability

All sorts of (future) flexibility products for balancing in the steady state and the dynamic operational modus
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Austria enables saving in generation capacity of 34 - 43 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1002 - iLand

iLand consists in building a innovative hydro-pumped storage facility on an artificial island off the coast of Belgium (approximately 5 km offshore with an imprint of 4 x 2,5 km). iLand should provide a total hydraulic storage capacity of ca. 2,2 GWh, i.e., a total net storage capacity of 2,0 GWh, assuming a 90% efficiency in turbine-mode, and a net annual electricity generation of approximately 750 GWh.
Flexible access is being considered due to the specific nature of iLand and its complementarity with offshore wind. iLand would be able to store energy during peak wind periods and inject energy into the grid when there is little wind.
iLand is thus not dependent on specific grid enhancements, which could suffer delays. Flexible access also enables TSOs to better maintain security of supply and allows for more efficient grid management.
iLand will enable a significant increase in the regional balancing capabilities of the Belgian grid and the grids of the Netherlands and France. Even the UK will benefit from iLand's balancing properties if it is connected to the pending "NEMO" interconnector between Belgium and the UK.

| | |
|---|---|
| Boundary | Belgium |
| Promoted by | THV iLand |

## Project Details

| | |
|---|---|
| Commisioning Date | 2021 |
| Pumped Hydro Type of Storage - Offshore | |
| Max Active Power (MW) | 550 |
| Storage Capacity (GWh) | 2 |

## Storage Analysis

iLand is the industrial result of a process initiated by the Belgian Government to cope with the needs of market integration, flexibility, sustainability and secure system operation of both the European and national electricity systems. The project is especially necessary in light of the growing impact of RES integration to meet the European goal of 27% RES by 2030. Despite initially focusing on Belgium, iLand's developers see potential in, and are committed to, developing iLand as a project of European significance: iLand is essential to achieving the European Energy Union objectives and its crossborder significance will continue to grow as other TSOs are involved.
iLand will significantly contribute, and is necessary, to the investment needs in the NSOG priority corridor as identified in the EIR. The projected installed capacity (250-1.000 MW) and net annual electricity generation (750 GWh/year) of iLand largely exceed the thresholds imposed by the EIR to confer upon a project a "significant cross-border impact", even when located in a single Member State (like iLand).
iLand contributes to all three of the EU energy policy pillars. Indeed, iLand will enhance market integration by improving balancing capabilities both within the Belgian network and also, through indirect interconnections, within the overall NSOG area. iLand will also contribute to sustainability by allowing for increased integration of RES into the grid because its flexibility will help alleviate offshore wind intermittency issues. iLand will also contribute to security of supply by providing service for flexibility and black start capacity.

| | |
|---|---|
| Cost [Meuros] | 1327 |

## Scenario specific CBA

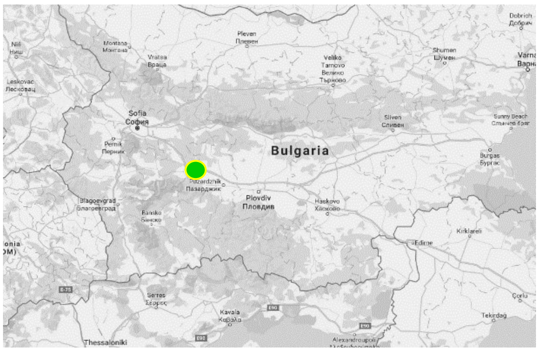
| indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | 10 +/- 10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 70 +/- 70 | 60 +/- 40 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -100 +/- 200 | 200 +/- 200 | 300 +/- 100 | +/-100 | +/-100 +/- 100 |

| Capability for ancillary services |
|---|
| As the need for flexibility will grow fast with increasing RES penetration in the power system, and as ancillary services offer an important market channel for the supply of flexibility to the grid, the iLand infrastructure is designed for maximum capability for the supply of ancillary services, as was indicated in the flexibility indicator.<br>As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Belgium enables saving in generation capacity of 18 - 23 Meuro/year |

| Complementary Information | |
|---|---|
| This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter. | |
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1003 - PCI hydro-pumped storage in Bulgaria - Yadenitsa

Chaira PSHPP has a generating capacity of 864 MW (4 units x 216 MW) and a pumping capacity of 788 MW (4 units x 197 MW). The upper reservoir of Chaira PSHPP is Belmeken Dam with usable storage of 141 million m3. The lower reservoir is Chaira Dam with usable storage of 4.2 million m3. The usable storage of Chaira Dam allows full capacity operation in a generating mode for 8.5 hours, and 10.7 hours in a pumping mode, respectively. The construction of Yadenitsa Dam will increase the capacity of the lower reservoir by 9 million m3 and thus will increase the possibilities of using Chaira PSHPP. The connection between the two water storages, the existing lower reservoir - Chaira Dam and Yadenitsa Dam planned for construction, will be done by a reversible pressure tunnel based on the principle of interconnected vessels. The increased volume of the lower reservoir of Chaira PSHPP will enable switching to a mode of weekly balancing of the waters processed by the power plant in both generating and pumping modes. The four hydro power units of the power plant will be able to operate at full capacity in a generating mode for 20 hours and in a pumping mode for 22 hours, respectively.




| | |
|---|---|
| Boundary | Bulgaria |
| Promoted by | NATSIONALNA ELEKTRICHESKA KOMPANIA EAD |

## Project Details

| | |
|---|---|
| Commisioning Date | 2021 |
| Type of Storage | Pumped Storage Hydro Power Plant |
| Max Active Power (MW) | 864 |
| Storage Capacity (GWh) | 5.2 |

## Storage Analysis

The increased operating potential of Chaira PSHPP by the construction of Yadenitsa Dam will enable optimization of the generating capacities structure, taking part in loads covering in the Electric Power System (EPS). On one hand, the part of base load in the load diagram will be increased, thus providing continuous round-the-clock operation of the NPP and the TPPs at optimal efficiency, whereas on the other hand the fluctuations in the loading of the most flexible TPP capacities will be reduced on the account of additional loading of Chaira PSHPP in generating/pumping modes. As before, Chaira PSHPP together with the installed capacities in the HPPs, will continue to participate in covering the peak loads of the load diagram.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 176 |

## Scenario specific CBA indicators

| | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 | <10 | <10 | <10 | <10 |

| | | | | | |
|---|---|---|---|---|---|
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | <10 | 10 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | 300 +/- 10 | 300 +/- 10 | 300 +/- 100 | +/-100 +/- 0 | +/-100 +/- 100 |

**Capability for ancillary services**

In a situation of reduced power generation from the conventional power plants and growing production from renewable energy sources, the construction of Yadenitsa Dam will increase the regulating potential of Chaira PSHPP, which is a key factor for a reliable management of the Electric Power System in real time. At present Chaira PSHPP is a major provider of ancillary services and will continue to play an important role for the EPS frequency control.  As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Bulgaria enables saving in generation capacity of 28 - 35 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1004 - Muuga HPSPP

Promoted by Energiasalv OÜ

### Project Details

Commisioning Date 2023 hydro pump

Type of Storage storage

Max Active Power (MW) 500

Storage Capacity (GWh) 6

### Storage Analysis

Privileged Location
Near France, near 3 nuclear reactors within 60 km radius, near large consumption centres (minimize transport losses) Social And Institutional Support

Technically Feasible:
Enough water column in Ribaroja's reservoir, independently of the evolution of climate change and alternation of dry/wet years. Enough backpressure in pumps. Few materials in suspension, which could wear impellers at pressures of 40 atmospheres.

Environmentally Viable
No effects to environmental protected areas, cultural or archaeological heritage, either residential areas in case of breakage of higher rafts.
Minimum impact on the landscape.
ECONOMICALY VIABLE : M€ investment / Mw installed < 0,7

### Additional Information

Ideal to future offshore wind farm project associated to the Zèfir Project, allowing energy denuclearization of the area.

### General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Turbine 500<br>Pumping 500 | |
| Cost [Meuros] | 330 | |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | 10 | <10 +/- 0 | <10 | 40 +/- 10 | 10 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -200 +/- 10 | 100 +/- 10 | +/-100 | -100 +/- 100 | 300 +/- 100 |

### Capability for ancillary services

Important role in secondary regulation in the System's frequency.
According to ENTSO's CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical
Polygon of Tarragona, as a closed network electric distribution (2009/72 / EC) thereby increasing their competitiveness by lowering the price of Mw

Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance. Important role in secondary regulation in the System's frequency.
According to ENTSO's CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical
Polygon of Tarragona, as a closed network electric distribution (2009/72 / EC) thereby increasing their competitiveness by lowering the price of Mw
Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Estonia enables saving in generation capacity of 16 - 20 Meuro/year

## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |

## Project 1005 - CAES Cheshire, UK

Compressed air energy storage using air storage caverns to be developed in salt deposits. Technical capability, per 24 hrs: 230 MW compression x 6 hrs, 268 MW generation x 6 hrs, 230 MW compression x 6 hrs, 268 MW generation x 6 hrs. Envisaged operation over 24 hrs = 250 MW compression 4-6 hrs; generation 50-268 MW over 6-10 hrs

| | |
|---|---|
| Boundary | Great Britain |
| Promoted by | Gaelectric Energy Storage Ltd |

## Project Details

| | |
|---|---|
| Commisioning Date | 2022 |
| Type of Storage | Compressed air energy storage |
| Max Active Power (MW) | 268 |
| Storage Capacity (GWh) | 1.608 |

## Storage Analysis

Balancing of generation & demand profile. Provision of system services to support integration of variable renewables. Potential to provide balancing services to mitigate wind/solar forecast error.

## Additional Information

Start-up time to full output: Compression, 5 mins; Generation, 10 mins. Min stable level: 10% of max MW output. Ramp rate: 20% of max MW output per minute. Additional: ENTSO-E regional/Europe system-wide CBA may underestimate substantially the benefits of the project as compared to project-specific, local system-specific analysis using industry-standard tools such as PLEXOS.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 275 |

## Scenario specific CBA indicators

| | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | 110 +/- 20 | 40 +/- 20 | 30 +/- 30 | 70 +/- 20 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -100 | +/-100 | +/-100 | +/-100 | -100 +/- 100 |

## Capability for ancillary services

Frequency regulation: Response time = approx 1 minute; Duration = minutes; Cycle = minutes. Spinning reserves: Response time = Seconds to <10 minutes; Duration = 10-120 minutes; Cycle = days. Electricity supply reserve capacity: Response time, Duration & Cycle = Varies. Load Following: Response time = Varies, within minutes; Duration = 120-240 minutes in increments as short as 5 minutes; Cycle = Varies. Black Start: Duration = Varies, hours to days; Cycle = Varies. Synchronous inertial response: Response time = within minutes; Duration & Cycle = Varies. Capable of providing Primary Operating Reserve, Secondary Operating Reserve and Tertiary Operating Reserve in both Compression and Generation Modes. Capable of providing Fast Frequency Response in Generation Mode.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Great Britain enables saving in generation capacity of 9 - 11 Meuro/year

## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1006 - Pumped Storage Complex with two independent upper reservoirs: Agios Georgios & Pyrgos

The project consists of two upper reservoirs, Ag. Georgios & Pyrgos. As lower reservoir of the complex, it is considered the existing, artificial reservoir of Kastraki (PPC ownership). The purpose of the project is to absorb wind, photovoltaic or thermal energy for pumping in order to store water to the upper reservoirs during low load consumption or renewables overproduction periods. Subsequently, energy is recovered via turbine mode during the peak load. The electromechanical equipment will be installed in two independent power houses, on the right banks of the Kastraki reservoir. Total installed capacity is 680 MW.


Boundary Greece

Promoted by TERNA ENERGY S.A

## Project Details

| | |
|---|---|
| Commisioning Date | 2021 |
| Type of Storage | Hydro (pumped storage) |
| Max Active Power (MW) | 594 |
| Storage Capacity (GWh) | 3436 |

## Storage Analysis

1) Market integration
Pumped storage schemes play a key role in enabling energy systems develop low-carbon electricity production. They supply more flexibility and balancing to the grid, providing a back-up to intermittent renewable energy, facilitating the entrance of renewables, accelerating the de-carbonization of the electricity grid, improving the security and efficiency of electricity transmission and distribution (reducing unplanned loop flows, grid congestion, voltage and frequency variations), stabilizing market prices for electricity, while also ensuring a higher security of energy supply. This project offers significant assistance in the accomplishment of the above target. 2) Sustainability
Considering recent evolution of off-shore wind power, which together with solar are currently considered to hold most promise in the next few decades in Europe, an immense storage capacity is required. A solution enabling sustainability of future energy supply, is the construction of additional pumped-hydro storage

schemes.
Energy storage is a precondition for any sustainable energy policy in Europe, which has two main targets: a) Increase the share of RES, transmissions and Security of supply
b) Reduce dependency on imported fossil fuels and CO2 emissions.
Pumped storage systems represent a giant rechargeable battery, able to store energy at any time, usually regardless of the weather. Pumped storage units can start up in a few minutes, in an emergency situation, to provide the necessary reserve capacity. Additionally, this pumped storage complex will assist the EU target of greenhouse gas emissions reduction by avoiding an estimate of 693.600 tons in CO2. 3) Secure System Operation
The Greek grid system is not flexible and stable enough, to accommodate large amount of intermittent RES penetration in the near future. The major production share is based on conventional thermal units (lignite and combined cycle) with high technical minima and inability of adaptation to frequent capacity fluctuations. In order to ensure efficient integration of RES and better adjustment of thermal plant operation, hydro pumped storage power plants are crucial for a secure supply of electricity and as a back-up for intermittent renewables, since they can provide large-scale storage capacity and several distinct ancillary services to the system.

**General CBA indicators**

| | |
|---|---|
| Cost [Meuros] | 502 |

**Scenario specific CBA**

| indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 | <10 | <10 | 10 +/- 10 | 40 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | <10 | <10 | 230 +/- 50 | 650 +/- 130 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | 80 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | 100 +/- 10 | 100 +/- 10 | 100 +/- 100 | +/-100 | -200 +/- 100 |

**Capability for ancillary services**

Frequency control, voltage control, spinning reserve, standing reserve, black start, remote automatic generation control, grid loss compensation and emergency control action.
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Greece enables saving in generation capacity of 19 - 24 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |

## Project 1007 - MAREX storage

Store excess wind production sourced from EIRGRID, and that sourced directly from windfarms connected on the MAREX system, provide grid services to EIRGRID and UKNG,import- export power to and from storage as market dictates, net export of 7TWhr per year to UK from Irish wind

| | |
|---|---|
| Boundary | Ireland |
| Promoted by | Organic Power Ltd. |

### Project Details

| | |
|---|---|
| Commisioning Date | 2020 |
| Type of Storage | PHES pure pumping |
| Max Active Power (MW) | 1500 |
| Storage Capacity (GWh) | 6 |

### General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 500 |

### Scenario specific CBA indicators

| | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 +/- | 20 +/- 10 | 30 +/- 10 | 40 +/- 10 | 30 +/- 10 |
| B3 RES integration (GWh/yr) | <10 +/- | 320 +/- 60 | 410 +/- 80 | 460 +/- 90 | 450 +/- 90 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | 20 +/- 10 | 20 | 20 +/- 10 | 20 +/- 10 | 20 +/- 10 |
| B5 CO2 Emissions (kT/year) | -100 +/- 100 | 400 +/- 100 | 600 +/- 100 | -200 +/- 100 | -200 +/- 100 |

### Capability for ancillary services

concieved to store excess wind production in Ireland for export to UK, provide grid services to UKNG and EIRGRID, and to trade power between UK and Ireland
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Ireland enables saving in generation capacity of 48 - 60 Meuro/year

### Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1008 - Battery storage in South Italy

The project consists in the installation of 250 MW of storage systems (Batteries) on critical 150 kV transmission network in South Italy. The battery energy storage systems allow a better integration of Renewable Energy Sources into the power system, avoiding RES generation curtailment in case of exceeding generation respect to grid transport capacities, by storing energy surpluses in security conditions. This energy will be released later, when this does not lead to network congestions. Batteries are characterized by removable, modular and flexible installations; these characteristics allow installations in a wide variety of sites and the possible replacement depending on the needs that could arise in the medium / long term.

| | |
|---|---|
| Boundary | Italy |
| Promoted by | Terna |

## Project Details

| | |
|---|---|
| Commisioning Date | 2030 |
| Battery Energy Storage Type of Storage System (BESS) | |
| Max Active Power (MW) | 250 |
| Storage Capacity (GWh) | 1.7 |

## Storage Analysis

The project hereby described will allow, a better integration of Renewable Energy Sources into the power system, avoiding RES generation curtailment in case of exceeding generation respect to grid transport capacities, by storing energy surpluses in security conditions and releasing it later, avoiding network congestions. Moreover, the battery energy storage system may compensate the RES intermittent generation by increasing primary and tertiary reserve availability. The analysis performed has showed benefits in terms of SEW increase for the project, especially in the high RES scenarios.

The project has been included in the TYNDP in order to evaluate it in long term scenarios (2030), with RES penetration values much higher than the current ones. The commissioning date is in the long-term (2030) and the development of the project is subject to the positive completion of the pilot phase (35 MW) assessment and the actual evolution of RES scenario.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 750 |

| Scenario specific CBA | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | 30 +/- 10 | 10 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 250 +/- 50 | 90 +/- 20 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | +/-100 | +/-100 | +/-100 | +/-100 +/- 100 |

## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1009 - Kruonis pumped storage power plant extension

Currently Kruonis PSPP has 4 units with total installed capacity of 900 MW and provides generation, secondary reserve and system balancing services. However, it has only limited power generation and regulation flexibility (fixed 220 MW in pump mode), which will not be sufficient for the system stability in the future due to the increasing share of the intermittent generation in the system. To deal with this issue it is planned to extend Kruonis PSPP with an additional 225 MW asynchronous unit. The new unit will have pump mode ranging from 110 to 225 MW and the cycle efficiency of up to 78% (increase by 4%).

| | |
|---|---|
| Boundary | Lithuania |
| Promoted by | Lietuvos energijos gamyba |

## Project Details

| | |
|---|---|
| Commisioning Date | 2020 |
| Type of Storage | Pure hydro pumping |
| Max Active Power (MW) | 225 |
| Storage Capacity (GWh) | 10.8 |

## Storage Analysis

- Integration of renewable energy generation in the region;
- Increase of flexibility and reliability of the whole Baltic transmission system;
- Expansion of new production capacities in the region.

## Additional Information

The extended Kruonis PSPP will contribute significantly to the flexibility and reliability of the whole Baltic transmission system.

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Turbine | 225 |
| | Pumping | 225 |
| Cost [Meuros] | 160 | |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | 10 | <10 | <10 | 20 +/- 10 | 10 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | 300 +/- 10 | 100 +/- 10 | 200 +/- 100 | -100 +/- 100 | -300 +/- 100 |

## Capability for ancillary services

It is planned that the new unit would operate within 110-225 MW range in pump mode (compared to fixed 220 MW of existing 4 units) and within 55-225 MW range in generation mode (compared to 160-225 MW of existing 4 units). Such increase of flexibility would enable the plant to offer additional regulation services for the electricity market by offering new range regulation capacities (eg. regulations of minor fluctuations +/- 50 MW).
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Lithuania enables saving in generation capacity of 7 - 9 Meuro/year

## Complementary Information

| | |
|---|---|
| This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter. | |
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |

## Project 1010 - CAES Larne, Northern Ireland

Compressed air energy storage using air storage caverns to be developed in salt deposits. Technical capability, per 24 hrs: 250 MW compression x 6 hrs, 330 MW generation x 6 hrs, 250 MW compression x 6 hrs, 330 MW generation x 6 hrs. Envisaged operation over 24 hrs = 250 MW compression 4-6 hrs; generation 70-330 MW over 6-10 hrs

Boundary Northern Ireland

Promoted by Gaelectric Energy S torage Ltd

## Project Details

| | |
|---|---|
| Commisioning Date | 2020 |
| Type of Storage | Compressed air energy storage |
| Max Active Power (MW) | 330 |
| Storage Capacity (GWh) | 2 |

## Storage Analysis

Provisiopn of system services and capacity via the DS3 and Reliability Option processes. Addressing acute security of supply issues in Northern Ireland. Balancing of generation & demand profile. Provision of system services to support integration of variable renewables. Potential to provide balancing services to mitigate wind/solar forecast error.

## Additional Information

Start-up time to full output: Compression, 5 mins; Generation, 10 mins. Min stable level: 10% of max MW output. Ramp rate: 20% of max MW output per minute. Additional: ENTSO-E regional/Europe system-wide CBA underestimates substantially the benefits of the project as compared to project-specific, local system-specific analysis using industry-standard tools such as PLEXOS.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 329 |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <100M€ |
| B3 RES integration (GWh/yr) | <10 | 60 +/- 20 | 90 +/- 10 | 50 +/- 50 | 140 +/- 50 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -100 | +/-100 | +/-100 | +/-100 | +/-100 +/- 100 |

## Capability for ancillary services

Frequency regulation: Response time = approx 1 minute; Duration = minutes; Cycle = minutes. Spinning reserves: Response time = Seconds to <10 minutes; Duration = 10-120 minutes; Cycle = days. Electricity supply reserve capacity: Response time, Duration & Cycle = Varies. Load Following: Response time = Varies, within minutes; Duration = 120-240 minutes in increments as short as 5 minutes; Cycle = Varies. Black Start: Duration = Varies, hours to days; Cycle = Varies. Synchronous inertial response: Response time = within minutes; Duration & Cycle = Varies. Capable of providing Primary Operating Reserve, Secondary Operating Reserve and Tertiary Operating Reserve in both Compression and Generation Modes. Capable of providing Fast Frequency Response in Generation Mode.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Northern Ireland enables saving in generation capacity of 11 - 14 Meuro/year

## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1011 - Reversible pumped-storage hydro-electric exploitation "MONT-NEGRE" power 3300 MW
## Zaragoza, Spain

The Project is located in the Ribarroja Reservoir, where the Segre River flows into the Ebro River (Mequinenza, Zaragoza). The exploitation works with compensation reservoirs. The upper reservoir (Mont-Negre), to be constructed, will have a capacity of 118Hm3. The reservoir's depth is of 36m, and its sheet of water's maximum height will be of 398m. The reservoir will have a perimeter dike of 8050m and its sheet of water will have 330Has of surface.

The lower reservoir currently exists and it has a capacity of 207Hm3. It has a maximum depth of 60m and its height is of 76m. There is an underground power plant with a length of 502m and a height of 122m. It is also fully equipped with medium voltage transformers, alternators and turbines. There are five vertical pipes of 338m, with a diameter of 13,4m, between the upper reservoir and the power plant, as well as twelve pipes (one per turbine) with a diameter of 5.73m each. Pipes connecting the power plant to the lower reservoir are 1760m long.

The electromechanical equipment includes 12 reversible Francis turbines of 275MW each. There are 12 synchronous alternators of 300MVA (generated voltage 20kV), 48 medium voltage transformers (output voltage 45kV and unitary power 80MVA) and a high voltage transformer unit (voltage steps 45/220/400kV).


| | |
|---|---|
| Boundary | Spain |
| Promoted by | Ingenieria Pontificia S.L. |

## Project Details

| | |
|---|---|
| Commisioning Date | 2020 |
| Type of Storage | Pure pumping |
| Max Active Power (MW) | 3300 |
| Storage Capacity (GWh) | 75.11 |

## Storage Analysis

The motivation for this Project responds to the possibility of storing the produced energy surplus in order to use it during consumption peaks. The pure pumping exploitation designed constitutes a flexible generator set.

The "Mont-Negre" exploitation will promote the three pillars of the European energy policy:

- 75108MWh of accumulated energy will ensure the market integration of the interconnected nations.
- The hydraulic system's mechanical nature will guarantee the European network sustainability, since it is able to feed on both natural energy and energy produced with flat curve.
- The plant's hydraulic nature will provide the system with an immediate response to its unexpected needs and it will increase its resilience. The plant, therefore, will contribute to the security and the continuity of electrical supply in the interconnected network.

This plant will play a key role in the achievement of Europe's target 20/20/20.

## Additional Information

The "Mont-Negre" exploitation will surpass the 2850MW of the Lewiston/Niagara Power Plant (USA), which has so far been the

The "Mont-Negre" project meets the latter part of the last century's need for energy storage in South-western Europe due to the adaptation of the production curve to that of the consumption.

| General CBA indicators | | |
|---|---|---|
| Delta GTC contribution (2020) [MW] | Pumping | 1100 |
| | Turbine | 1100 |
| Delta GTC contribution (2030) [MW] | Pumping | 1100 TOOT Mequinenza; 1310 PINT MontNegre |
| | Turbine | 870 TOOT Mequinenza;1580 PINT MontNegre |
| Cost [Meuros] | 1634 | |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 | 20 +/- 10 | 10 +/- 10 | 10 +/- 10 | 50+/- 10 |
| B3 RES integration (GWh/yr) | -10 | <10 | 80 +/- 20 | 20 +/- 10 | 190 +/- 40 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | 20 +/- 10 | 20 | 20 +/- 10 | 20 +/- 10 | 20 +/- 10 |
| B5 CO2 Emissions (kT/year) | 200 +/- 100 | 800 +/- 100 | -200 +/- 100 | +/-100 | -200 +/- 100 |

**Capability for ancillary services**

The capacity of said reservoirs guarantees a provision of 3,300MW for 22.76h. The exploitation has the possibility of handling mains voltage drops with the immediate response of up to 75108MWh.

There are 12 synchronous units of 275MW that operate with turbine or pump which enable both mains frequency control and safe settings of electronic parameters.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of
106 - 133 Meuro/year

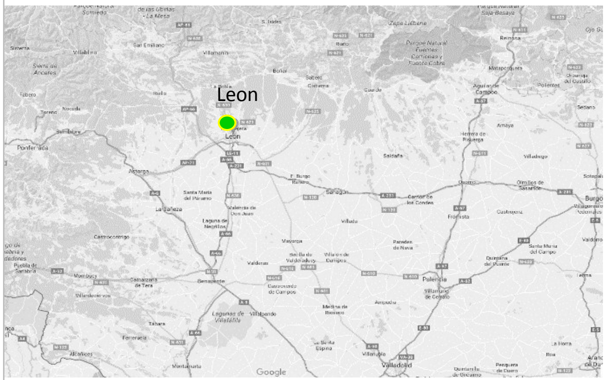
**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1012 - Purifying -Pumped Hydroelectric Energy Storage (P-PHES Navaleo)

P-PHES NAVALEO in Leon, Spain, is pure pumped plant with an installed capàcity of 552 Mw. (3 x 184 Mw.) in generating mode and 548 Mw in pumping mode and generate an annual capacity between 700 - 1000 Gwh. The projects consists in two reservoirs with a volume of 2,23 Mio m3. The total rated flow are 90 m3/s in generating mode and 70 m3/s in pumping mode. Normal static head is 710 m. The cycle efficiency is up to 79%.




| | |
|---|---|
| Boundary | Spain |
| Promoted by | CDR TREMOR S.L. |

## Project Details

| | |
|---|---|
| Commisioning Date | 2018 |
| Type of Storage | Pure pumping plant |
| Max Active Power (MW) | 541 |
| Storage Capacity (GWh) | 3.5 |

## Storage Analysis

P-PHES NAVALEO use abandoned mine water that being the cause of the failure of "bad ecological status" under Directive 2000/60/CE Water Framework in the region of Castilla-León where more than 5.500 MW. of wind power are currently in operation with projects for another additional 1.500 MW. that can not be incorporated. P-PHES NAVALEO project reconciles energy storage with water purification. Furthermore has a guaranteed supply of 100% throughout the whole year.

## Additional Information

The project has a high environmental force because all its elements (excavated reservoirs, roundhouse, ...) are located outside the rivers, so that they do not affect environmental flows or living fish species, neither detracts the necessary water from the rivers for other uses (water supply, irrigation, industrial, recreational, ...) and therefore it is not sensitive to periods in which it is necessary to modify the production/consumption to meet such uses

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2020) [MW] | Pumping | 541 |
| | Turbine | 541 |

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Pumping 541<br>Turbine 541 | |
| Cost [Meuros] | 258 | |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 +/- | 10 +/- 10 | 10 +/- 10 | <10 +/- 0 | 20 +/- 10 |
| B3 RES integration (GWh/yr) | -10 +/- | <10 +/- 0 | 40 +/- 10 | 10 +/- 10 | 80 +/- 20 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | 10 +/- 10 | 10 | 10 +/- 10 | 10 +/- 10 | 10 +/- 10 |
| B5 CO2 Emissions (kT/year) | 100 +/- 10 | 200 +/- 10 | +/-100 +/- 0 | -100 +/- 100 | -200 +/- 100 |

**Capability for ancillary services**

Considering that the water starting time in the penstock of the power plant is lower than 2 s. , and the plant will be equipate with frecuency converters P-PHES NAVALEO will provide a very fast time response to activate frequency containment reserves, can participate in primary frequency control, helping to maintain the instantaneous balance between generation and demand and being used for both primary and secondary regulation in the electricity grid and can provide the full range of grid-stabilising services: Back-up,Black start capability, Load-frequency control (spinning and non-spinning reserve) and voltage control. furthermore, the plant would be equipated with variable speed technology.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of
17 - 21 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | +/++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1013 - CAES Zuidwending, NL

Compressed air energy storage using air storage caverns to be developed in salt deposits. Technical capability, per 24 hrs: 250 MW compression x 6 hrs, 330 MW generation x 6 hrs, 250 MW compression x 6 hrs, 330 MW generation x 6 hrs. Envisaged operation over 24 hrs = 250 MW compression 4-6 hrs; generation 70-330 MW over 6-10 hrs

| | |
|---|---|
| Boundary | The Netherlands |
| Promoted by | Gaelectric Energy Storage Ltd |

## Project Details

| | |
|---|---|
| Commisioning Date | 2021 |
| Type of Storage | Compressed air energy storage |
| Max Active Power (MW) | 330 |
| Storage Capacity (GWh) | 2.64 |

## Storage Analysis

Balancing of generation & demand profile. Provision of system services to support integration of variable renewables. Potential to provide balancing services to mitigate wind/solar forecast error.

## Additional Information

Start-up time to full output: Compression, 5 mins; Generation, 10 mins. Min stable level:  10% of max MW output. Ramp rate: 20% of max MW output per minute. Additional: ENTSO-E regional/Europe system-wide CBA may underestimate substantially the benefits of the project as compared to project-specific, local system-specific analysis using industrystandard tools such as PLEXOS.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 275 |

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | 40 +/- 10 | <10 | 40 +/- 40 | 40 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | 0 | +/-100 | +/-100 | +/-100 | -200 +/- 100 |

## Capability for ancillary services

Frequency regulation: Response time = approx 1 minute; Duration = minutes; Cycle = minutes. Spinning reserves: Response time = Seconds to
<10 minutes; Duration = 10-120 minutes; Cycle = days. Electricity supply reserve capacity: Response time, Duration & Cycle = Varies. Load Following: Response time = Varies, within minutes; Duration = 120-240 minutes in increments as short as 5 minutes; Cycle = Varies. Black Start: Duration = Varies, hours to days; Cycle = Varies. Synchronous inertial response: Response time = within minutes; Duration & Cycle = Varies. Capable of providing Primary Operating Reserve, Secondary Operating Reserve and Tertiary Operating Reserve in both Compression and Generation Modes. Capable of providing Fast Frequency Response in Generation Mode.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of The Netherlands enables saving in generation capacity of 11 - 14 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1014 - Coire Glas

A pumped hydro project with consent granted for up to 600MW capacity and a storage capacity of up to 30GWh. Located at Loch Lochy in Scotland.


| | |
|---|---|
| Boundary | UK |
| Promoted by | SSE |

## Project Details

| | | | |
|---|---|---|---|
| Commisioning Date | 2023 | | |
| Type of Storage | Hydro Pumped Storage | | |
| Max Active Power (MW) | 600 | Storage Capacity (GWh) | 30 |

## Storage Analysis

Bulk storage such as that which could be provided by Coire Glass pumped hydro station would provide a number of important benefits to the UK and, through Project TERRE potentially the European, electricity system. These benefits include storing energy for longs periods at times of excess supply for release at times of shortfall several days later; providing a range of energy security and system cost benefits and supporting a diversified electricity system at lower overall cost; providing a range of balancing and reserve services; and reducing the requirement for additional transmission investment. Inclusion on the TYNDP 2016 and subsequent status as a European Project of Common Interest will aid in raising the profile of the project and help in highlighting the numerous benefits that the project's delivery could achieve. Further it would provide the project's developer with potential access to funding to support further investigation into delivering the benefits of large storage scale pumped hydro.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 1100 |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|

| indicators | | | | | |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | 40 +/- 10 | 60 +/- 10 | 40 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 380 +/- 80 | 470 +/- 90 | 380 +/- 80 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -100 +/- 100 | 400 +/- 100 | 600 +/- 100 | -300 +/- 100 | -200 +/- 100 |

**Capability for ancillary services**

Coire Glas would be capable of providing a range of ancillary services including Frequency Response, Fast Reserve, Reactive Power and Black Start
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of UK enables saving in generation capacity of 19 - 24 Meuro/year

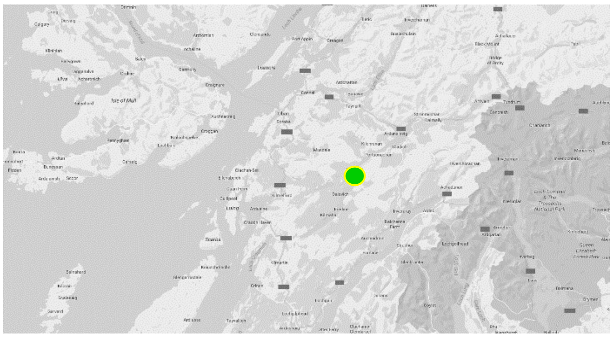
**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1015 - Cruachan II

Up to 600MW pumped storage facility at Cruachan, Argyll, Scotland



| | |
|---|---|
| Boundary | UK - Scotland |
| Promoted by | Scottish Power |

## Project Details

| | |
|---|---|
| Commisioning Date | 2025 |
| Type of Storage | Pump Storage |
| Max Active Power (MW) | 600 |
| Storage Capacity (GWh) | 7.2 |

## Storage Analysis

Cruachan II is a proposed reversible pumped-storage hydroelectric power station which would be located west of Dalmally on the banks of Loch Awe in Argyll and Bute, Scotland adjacent to the existing Cruachan hydro-electric pumped storage generating station.

Cruachan II would generate up to 600MW of electricity, using water from an upper reservoir on Ben Cruachan to drive the turbines. The turbines to be used at Cruachan II, would operate both as pumps and generators, which would be housed in a new cavern located within Ben Cruachan.

Cruachan II would go from standby to full production very rapidly, thus it could used to deal with periods of peak demand on the grid, and intermittency of renewables.

Cruachan II power station would support effective energy management in the market by minimizing changes in output from conventional generating sets by in effect, storing the excess generated electricity when demand is low.

As a pressing energy issue is the fact that there is not enough capacity to store electricity. To meet global climate change targets it is necessary to double the current levels of renewable energy capacity. In order to make the most of those renewable energy generation, there is need for more storage capacity such as Cruachan II to be rapidly delivered.

Pumped storage hydro is the most cost effective form of large scale electricity storage, and Scotland has the landscape and resource potential to deliver a new generation of projects.

## Additional Information

Scotland's National Planning Framework 3 (2014) (NPF3) has recognised that increasing the capacity of pumped storage hydro-electricity can complement Scotland's ambitions for more renewable energy capacity.

The NPF3 has identified a new pumped storage facility at Cruachan as a national development.

Initial engagement with key stakeholders (local and central government, various NGOs) has been positive.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 688 |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | 40 +/- 10 | 40 +/- 10 | 40 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 370 +/- 70 | 460 +/- 90 | 370 +/- 70 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -100 +/- 100 | 400 +/- 100 | 500 +/- 100 | -300 +/- 100 | -200 +/- 100 |

## Capability for ancillary services

The plant will be able to provide the following services:

(i) Balancing Mechanism (Bid & Offer instructions delivered within 60 seconds);
(ii) Frequency Response (Primary, Secondary, High); (iii) Reactive Power (MVar Lead & Lag);
(iv) Reserve Services (Spin-Gen, Spin-Gen with Low Frequency Relay, Spin-Pump, Spin-Pump with High Frequency Relay, Pump De-Load, Rapid Start); (v) Black Start.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of UK - Scotland enables saving in generation capacity of 19 - 24 Meuro/year

## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1016 - ANGS: Abengoa Northern Germany Storage

The MSS system draws electricity from the grid, converts it into thermal energy stored in hot molten salt, and then later converts the stored thermal energy to electricity using a conventional Rankine cycle power plant.
The TES system consists of a hot salt tank at 1,050 degrees Fahrenheit (“°F”), a cold salt tank at 560 °F, and the inventory of molten salt.
The charging system consists of a collection of electric resistance heaters and a set of pumps to move the fluid between the tanks. During charging, cold salt is pumped through the electric heaters and into the hot storage tank. The electric heaters are connected in parallel and isolation valves allow specific heaters to be turned on/off. By varying the number of operating heaters, the charge rate can be easily varied.
In order to deliver electricity, steam is generated by pumping salt from the hot storage tank through the steam generation system (“SGS”). The cooled salt at the outlet of the SGS is returned to the cold salt storage tank. The steam is used to drive a conventional Rankine cycle power plant.
Charging and discharging are carried out by separate systems which allow each to be independently sized to optimally meet their respective needs.

| | |
|---|---|
| Boundary | Germany |
| Promoted by | Abengoa |

## Project Details

| | | | |
|---|---|---|---|
| Commisioning Date | 2019 | Type of Storage | Molten salt |

| | |
|---|---|
| Max Active Power (MW) | 140 |
| Storage Capacity (GWh) | 1680 |

## Storage Analysis

1.- The German electric sector is the greatest in generation capacity. Furthermore, it is the sector with most renewable generation capacity, in terms of installed capacity, providing more than 25% of the energy consumed in the country.

2.- Electricity prices have suffered a progressive decrease in recent years, as shown in the following figure. This is due to the combination of factors such as excess of low cost generation capacity, with stable demand, due to the economic crisis, and increased efficiency in end-use energy.

3.- Aligning with the German plan called Energiewende, in order to reduce drastically fossil fuel generation with 2022 horizon.

4.- The plant would be connected at 400 kV, and it will support the new wind farms forecasted to be developed at Northern Germany, and will help to solve current and future the congestion problems in the North-South transmission lines.

## Additional Information

MSS is a commercially available technology, technically mature and widely available. All major equipment and components are commercially available today. The technology has been demonstrated commercially in both parabolic trough and tower STE plants.

Abengoa Solar has been working on TES with molten salt for three years with a pilot plant at its R&D center in Spain where all major components for Abengoa Solar’s commercial solar plants are tested. Abengoa Solar’s commercial solar plants have been designed with a greater than 30-year lifetime. Abengoa recently commissioned the world’s largest parabolic trough plant, Solana, with six hours of TES, in the U.S.

## General CBA indicators

| | |
|---|---|
| Cost [Meuros] | 350 |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | 10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | 10 | 10 +/- 10 | <10 | 90 +/- 20 | 60 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | 200 +/- 10 | 200 +/- 10 | -100 +/- 100 | +/-100 +/- 0 | -200 +/- 100 |

## Capability for ancillary services

A MSS energy storage system can follow economic dispatch and provide a range of ancillary services including loadfollowing, spinning or non-spinning reserves, regulation up/down, frequency response, inertial response, reactive power, and voltage control. It combines operational flexibility with high capacity value, and is therefore well suited to provide the flexible capacity requirements needed in systems with increased intermittent generation.
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Germany enables saving in generation capacity of 9 - 11 Meuro/year

## Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | 0 |
| Response time to reach the available power | 0 |
| Total time during which available power can be sustained | + |
| Power that is continuously available within the activation time | + |

## Project 1017 - ASSS: Abengoa Southern Spain Storage

Inabensa propose a stand-alone Battery Energy Storage System (BESS), using Lithium ion batteries. It will be connected to the grid through the nearest MV/HV substation; voltage at connection 400 kV.
The proposed BESS has 225 MW of rated power capacity that can operate for three hours. The useful energy capacity reach 625 MWh.
The maximum reactive power will be 235 MVAr. Specific operating flexibility has been defined by Inabensa; the system shall be capable of discharging from 100% to 0% useable State of Charge (SOC) of its rated energy, then charging it to back to 100% SOC. The BESS is designed for performing 1 cycle perd day, for up to 365 days per year, excluding time for planned maintenance and/or forced outages for a minimum of 10 years.
Each block – unit has one Power Conversion System (PCS) with four independent DC inputs of 1 MW. One battery container is connected to each DC input, so that the unit –block contains 8 battery containers.
A Control Center Container is added to the plant. These containers will include all communication and control equipment and a UPS to provide services to all containers auxiliaries' services.

| | |
|---|---|
| Boundary | Spain |
| Promoted by | Abengoa |

## Project Details

| | | | |
|---|---|---|---|
| Commisioning Date | 2019 | Type of Storage | Battery |
| Max Active Power (MW) | 225 | | |
| Storage Capacity (GWh) | 0.675 | | |

## Storage Analysis

1.- The most significant benefit of a storage plant is the contribution to the security and continuity of the electricity supply, thanks to the capability of quick response of the Battery Energy Storage System (BESS).

2.- A storage plant will permit to integrate new renewable generation capacity due to meet three key challenges to accommodate: output variability, a temporal (time-related) mismatch between generation and demand, and undesirable electrical effects caused by renewable generation.

3.- ANSS is the increased efficiency of the system, among other reasons, due to:
•The quick response of the ESS control permits to operate balancing the deviation of the renewable plant respect to the scheduled power, eliminating frequency fluctuations. •The storage device will remain in operation in network undervoltage and overvoltage conditions. The BESS will be able to inject reactive power during the disturbance too.
•It will be able to provide an immediate real power primary frequency response.
•The BESS is able to control voltage in the interconnection point. This function used for the voltage control is similar to the way a conventional generation (AVR) works.

## Additional Information

The Spanish electric system is currently immersed in a transformation process, with a trend to an increase of the share of renewable and natural gas generation, instead of coal and nuclear generation.

Abengoa Southern Spain Storage project will increase the reliability of the Spanish electric system, improving the security of the supply and the supporting the integration of current and new renewable generation capacity.

ASSS project is an achievable goal that would help to improve the performance of European Electric System.

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) | Pumping | 225 |
| [MW] | Turbine | 225 |

| Cost [Meuros] | 400 | | | | |
|---|---|---|---|---|---|
| **Scenario specific CBA** | **EP2020** | **Vision 1** | **Vision 2** | **Vision 3** | **Vision 4** |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 20 +/- 10 | <10 | 20 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | | 100 +/- 100 | +/-100 | +/-100 | +/-100 |

**Capability for ancillary services**

BESS is a source of power, with a low response time (0.2 seconds), which can be used for a large number of applications supporting power to the grid and support renewable energy included: Regulation, Spinning Reserve, Nonspinning reserve, Voltage support.

Ancillary services that can be included: Spinning Reserves, Non Spinning Reserves, Regulation up, Regulation down.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of 14 - 18 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |

## Project 1018 - ANSS: Abengoa Northern Spain Storage

Inabensa propose a stand-alone Battery Energy Storage System (BESS), using Lithium ion batteries.
It will be connected to the grid through the nearest MV/HV substation; voltage at connection 400 kV.
The proposed BESS has 225 MW of rated power capacity that can operate for three hours. The useful energy capacity reach 625 MWh.
The maximum reactive power will be 235 MVAr. Specific operating flexibility has been defined. The system shall be capable of discharging from 100% to 0% useable State of Charge (SOC) of its rated energy, then charging it to back to 100% SOC. The BESS is designed for performing 1 cycle perd day, for up to 365 days per year, excluding time for planned maintenance and/or forced outages for a minimum of 10 years.
Each block – unit has one Power Conversion System (PCS) with four independent DC inputs of 1 MW. One battery container is connected to each DC input, so that the unit – block contains 8 battery containers.
Control Center Container is added to the plant. They will include all communication and control equipment and a UPS to provide services to all containers auxiliaries' services.

| | |
|---|---|
| Boundary | Spain |
| Promoted by | Abengoa |

## Project Details

| | | | |
|---|---|---|---|
| Commisioning Date | 2019 | Type of Storage | Battery |
| Max Active Power (MW) | 225 | | |
| Storage Capacity (GWh) | 0.675 | | |

## Storage Analysis

1.- The most significant benefit of a storage plant is the contribution to the security and continuity of the electricity supply, thanks to the capability of quick response of the Battery Energy Storage System (BESS).

2.- A storage plant will permit to integrate new renewable generation capacity due to meet three key challenges to accommodate: output variability, a temporal (time-related) mismatch between generation and demand, and undesirable electrical effects caused by renewable generation.

3.- ANSS is the increased efficiency of the system, among other reasons, due to:
•The quick response of the ESS control permits to operate balancing the deviation of the renewable plant respect to the scheduled power, eliminating frequency fluctuations.
•The storage device will remain in operation in network undervoltage and overvoltage conditions. The BESS will be able to inject reactive power during the disturbance too.
•It will be able to provide an immediate real power primary frequency response.
•The BESS is able to control voltage in the interconnection point. This function used for the voltage control is similar to the way a conventional generation (AVR) works.

## Additional Information

The Spanish electric system is currently immersed in a transformation process, with a trend to an increase of the share of renewable

Abengoa Southern Spain Storage project will increase the reliability of the Spanish electric system, improving the security of the supply and the supporting the integration of current and new renewable generation capacity.

ANSS project is an achievable goal that would help to improve the performance of European Electric System.

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) | Pumping | 225 |

| | | | | | |
|---|---|---|---|---|---|
| [MW] | Turbine 225 | | | | |
| Cost [Meuros] | 400 | | | | |
| **Scenario specific CBA** | **EP2020** | **Vision 1** | **Vision 2** | **Vision 3** | **Vision 4 indicators** |
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 20 +/- 10 | <10 | 20 +/- 10 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | | 100 +/- 100 | +/-100 | +/-100 | +/-100 |

**Capability for ancillary services**

BESS is a source of power, with a low response time (0.2 seconds), which can be used for a large number of applications supporting power to the grid and support renewable energy. Ancillary Services included: Regulation, Spinning Reserve, Non-spinning reserve, Voltage support.

Ancillary services that can be included: Spinning Reserves, Non Spinning Reserves, Regulation up, Regulation down.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of 14 - 18 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | + |

## Project 1019 - TWO REVERSIBLE HIDROELECTRIC PLANTS: GIRONES & RAIMATS IN SPAIN

The two Pumped Hydroelectric Storage stations, GIRONES & RAÏMATS , have their common take on the right bank of the reservoir named Riba-roja , at the EBRO river, 1.5 km upstream of the dam. They are located on the Terres de l'Ebre, Tarragona (Spain). Its online design will allow to build them in two phases depending of the demand scenario. Its online design will allow to build them in two phases depending of the demand scenario. The total flow requested of 762 m3/s comes to pump the volume of water between the elevation 70 (normal maximum level of the Riba-roja's reservoir) and a decrease of 1.5 m over a period of 8 hours on continued operation. This is driven by two parallel low pressure galleries with 10 m indoor diameter, underground toward the Girones's cavern. Two alternatives with the same 3 Gw installed power are developed: A) UNIQUE OPERATOR (selected layout): a single cavern in GIRONÉS is projected to house the teams of the two PHS with only one tunel for acces into it. Each of the 6 groups of GIRONES (90 m3/s, 370 Mw pumping / 300 Mw turbinate) are connected to the bottom of the upper raft (Hm3 21,50; 22196 Mwh stored) by a high pressure water well of 6 m inside diameter. The 4 RAÏMATS's groups (55 m3/s, 295 MW pumping / 239 MW turbinate) will do so at their upper raft (8,55 Hm3; 10179 Mwh stored energy) through a rack composed by 4 pipes of 4 m diameter each one. Budget without VAT: 2.007 M €. B) TWO OPERATORS: Each plant can operate independently of the other. One of the low-pressure galleries stretches 4,5 km underground until the second RAÏMATS's cavern, needing a second road tunnel as an access to it. With a total budget of 1.899 M€, the capacity of the GIRONES's raft is reduced to 13,8 Hm3.

According to the preliminary and informative REE's report, the GIRONES 400 kV network connection is foreseen in SE NEW MEQUINENZA from 2020 and RAÏMATS (2nd phase) in the SE of PEÑALBA and OSERA

| | |
|---|---|
| Boundary | Spain |
| Promoted by | Grupo Romero Polo |

## Project Details

| | | | |
|---|---|---|---|
| Commisioning Date | 2024 | Type of Storage | Pure Pumping |
| Max Active Power (MW) | 3400 | Storage Capacity (GWh) | 24.5 |

## Storage Analysis

Privileged Location:
Near France, near 3 nuclear reactors within 60 km radius, near large consumption centres (minimize transport losses) SOCIAL AND INSTITUTIONAL SUPPORT TECHNICALLY FEASIBLE:
Enough water column in Ribaroja's reservoir, independently of the evolution of climate change and alternation of dry/wet years.
Enough backpressure in pumps. Few materials in suspension, which could wear impellers at pressures of 40 atmospheres.
Environmentaly Viable
No effects to environmental protected areas, cultural or archaeological heritage, either residential areas in case of breakage of higher rafts.
Minimum impact on the landscape.
Economicaly Viable : M€ investment / Mw installed < 0,7

## Additional Information

Ideal to future offshore wind farm project associated to the Zèfir Projet, allowing energy denuclearization of the area.

## General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Pumping | 1470 |
| | Turbine | 820 |

| | |
|---|---|
| Cost [Meuros] | 1900 |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 +/- | 20 +/- 10 | 10 +/- 10 | 10 +/- 10 | 60 +/- 10 |
| B3 RES integration (GWh/yr) | <10 +/- | <10 | 60 +/- 10 | 20 +/- 10 | 210 +/- 40 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | 20 +/- 10 | 20 | 20 +/- 10 | 20 +/- 10 | 20 +/- 10 |
| B5 CO2 Emissions (kT/year) | -100 +/- 100 | 600 +/- 100 | -100 +/- 100 | +/-100 | -300 +/- 100 |

**Capability for ancillary services**

Important role in secondary regulation in the System's frequency.
According to ENTSO's CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical
Polygon of Tarragona, as a closed network electric distribution (2009/72 / EC) thereby increasing their competitiveness by lowering the price of Mw
Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance. Important role in secondary regulation in the System's frequency.
According to ENTSO's CBA analysis, the pumping / turbinate ratio will be approximately 2. To provide storage capacity in rafts, a continuous supply is raised at some time intervals to the main consumers at Petrochemical
Polygon of Tarragona, as a closed network electric distribution (2009/72 / EC) thereby increasing their competitiveness by lowering the price of Mw
Supply of Passive Safety to nuclear reactors Asco I and II, by having available 10 Hm3 of water at 45 atm pressure less than 10 Km of distance.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of 197 - 246 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | + |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1020 - GIBREX STORAGE

Provide storage to reduce/eliminate constraing off/curtailment of wind energy in Galicia Spain, and North Portugal. Provide grid services to REE and REN. Trade power as market dictates.

| | |
|---|---|
| Boundary | Spain |
| Promoted by | Organic Power Ltd. |

### Project Details

| | |
|---|---|
| Commisioning Date | 2022 |
| Type of Storage | PHES pure pumping |
| Max Active Power (MW) | 1500 |
| Storage Capacity (GWh) | 10 |

### General CBA indicators

| | | |
|---|---|---|
| Delta GTC contribution (2030) [MW] | Pumping | 1500 |
| | Turbine | 1500 |
| Cost [Meuros] | 800 | |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | <10 | <10 | 10 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 30 +/- 10 | 10 +/- 10 | 160 +/- 30 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | | +/-100 | -100 +/- 100 | +/-100 | -100 +/- 100 |

### Capability for ancillary services

Black start, quick response demand/generation, frequency modulation via VSC
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Spain enables saving in generation capacity of
96 - 120 Meuro/year

### Complementary Information

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1021 - Donegal Storage Project

upper reservoir will be located in a natural glacial valley 5.5km long, with an average width of 1.3km. The reservoir will be formed by a 1.3km long rock-fill dam of average height 35m located 2.5 km from the Atlantic coast. It will provide a storage capacity between 90,000MWh and 120,000MWh subject to final design. A power house constructed over-ground will be located at the coast and contain 10 x 150MW reversible pump/turbine motor/generators. These will be connected to the dam by 10 penstocks laid in shallow trenches backfilled to minimise visual impact. The ocean will act as the lower reservoir. Although the project is planned primarily for Irish use. It will be connected by undersea cable through the UK to the main European grid. A direct interconnection from Ireland to France is planned for the future.

Ireland and Northern Boundary
Ireland

Promoted
Pump Storage Energy Ltd.
by

## Project Details

Commisioning Date 2022

Hydro Pump
Type of Storage
Storage

Max Active Power (MW) 1500 Storage Capacity (GWh) 120

## Storage Analysis

The project topology is expected to result in a low capital cost in comparison to conventional pumped storage plants. Ireland currently has 2500MW wind turbine capacity. This is supplying close to 20% electricity generation from renewable sources, contributing to the 40% target agreed with the EU for 2020. This is already causing curtailment, which will increase as wind capacity expands. The Donegal plant will substantially reduce curtailment. Pumping energy will be supplied by both curtailed wind and off peak thermal generation. The increased pumping load will improve the load factor of thermal generation by permitting greater base load operation of thermal plant. This can contribute to reduced production costs and electricity prices. The resulting increase in efficiency, together with increased wind generation from less curtailment, will reduce carbon dioxide emissions. The low capital cost combined with the other advantages is planned to permit the Donegal project to trade competitively.

## Additional Information

Donegal will be the first large scale sea water pumped scheme in the World. As such, it is expected to be a flagship project, which will attract considerable interest. It is planned to permit leisure water sport activities on the large reservoir. A number of considerable community benefits are anticipated from the project.

## General CBA indicators

Cost [Meuros] 0

| Scenario specific CBA indicators | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | 40 +/- 10 | 70 +/- 10 | 120 +/- 20 | 90 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | 590 +/- 120 | 660 +/- 130 | 1390 +/- 280 | 1110 +/- 220 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |

| | | | | | |
|---|---|---|---|---|---|
| B4 Losses (Meuros/yr) | 40 +/- 10 | 40 | 40 +/- 10 | 40 +/- 10 | 40 +/- 10 |
| B5 CO2 Emissions (kT/year) | +/- 100 | 600 +/- 100 | 1000 +/- 200 | -600 +/- 100 | -400 +/- 100 |

**Capability for ancillary services**

The project is capable of supplying extensive spinning reserve and reactive power
As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Ireland and Northern Ireland enables saving in generation capacity of 96 - 120 Meuro/year

**Complementary Information**

This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter.

| | |
|---|---|
| Response time to activate Frequency Containment Reserves | ++ |
| Response time to reach the available power | ++ |
| Total time during which available power can be sustained | ++ |
| Power that is continuously available within the activation time | ++ |

## Project 1022 - CARES (Compressed Air Renewable Energy Storage)

Transmission grid-scale energy storage innovative adiabatic Compressed Air Energy Storage (CAES). Our installations of 500MW, 6-21GWh with zero or low emissions, operate at 68-70% round trip efficiency, at a cost of £350m (€420m), and a levelised cost less than half that of gas-fired peaking plants, and use existing, off-the-shelf equipment. Addresses the entire energy trilemma: the world's most cost-effective and widely implementable large scale energy storage technology, up to 100% clean, turning locally generated renewable energy into dispatchable electricity. Potential to store the entire continent's energy requirements for over a week; potential globally is greater still.


| | |
|---|---|
| Boundary | Great Britain |
| Promoted by | Storelectric Ltd |

## Project Details

| | |
|---|---|
| Commisioning Date | 2017 |
| Type of Storage | Adiabatic CAES (Compressed Air Energy Storage) |
| Max Active Power (MW) | 500 |
| Storage Capacity (GWh) | 2.5 |

## Storage Analysis

Sustainability: enables renewable energy to power entire grids by matching intermittent generation cleanly with variable demand.
Energy security 1: keeping electricity grids supplied with both baseload and renewable electricity when most generation will be renewable.
Energy security 2: enables locally generated energy from local resources (wind, sun, tides, waves etc.) to power grids independently of foreign countries.
Market integration: enables interconnectors to carry much more energy, and helps overcome grid bottlenecks by smoothing loads.

Reducing prices: profitable without subsidy in a level regulatory playing field; reduces subsidies for renewables as it enables all their power to be sold profitably.
Closing fossil fuelled power stations: unlike batteries etc., our long durations provide reliable power to enable power stations to close without risks at night or during major adverse weather patterns.
European potential: salt basins mean these plants can be built in most countries, and in future other geologies will be developed to extend coverage still further.
Environmental impact: by enabling closure of fossil fuelled power stations and improving the economics of renewables while reducing upwards price pressure on electricity, CARES enables entire grids to become clean – and then to replace fossil fuels increasingly in heating, transportation and industry.

**Additional Information**

- A novel configuration of existing technologies well proven at similar scales and similar load profiles, whose integration is considered by engineering partners to be simple.
- Partnered by Siemens, Balfour Beatty, PriceWaterhouse Coopers and others.
- Already received enquiries from Netherlands, Germany, North Africa (for providing solar power to southern Europe), the Middle East and beyond.
- CARES is a 2-plant project: a 20MW initial plant and a 500MW follow-on. The small plant will prove and optimise the technology, thereby enabling the large plant to be financed and built.
- Dozens of financiers have expressed interest in funding future plants after the first.
- Roll-out will be in special joint venture companies that will compete with each other within their markets, avoiding excessive market leverage.

**General CBA indicators**

| | |
|---|---|
| Cost [Meuros] | 560 |

| Scenario specific CBA | EP2020 | Vision 1 | Vision 2 | Vision 3 | Vision 4 indicators |
|---|---|---|---|---|---|
| B2 SEW (MEuros/yr) | <10 | <10 | 10 +/- 10 | 20 +/- 10 | 20 +/- 10 |
| B3 RES integration (GWh/yr) | <10 | <10 | 190 +/- 120 | 180 +/- 180 | 210 +/- 100 |
| B4 Losses (GWh/yr) | <10 | <10 | <10 | <10 | <10 |
| B4 Losses (Meuros/yr) | <10 | <10 | <10 | <10 | <10 |
| B5 CO2 Emissions (kT/year) | -100 +/- 100 | 100 +/- 100 | 200 +/- 100 | +/-100 | -200 +/- 100 |

**Capability for ancillary services**

CARES offers:
- All balancing services;
- All frequency response services over 10 seconds response time;
- Inertia;
- Reactive power;
- Demand turn-up and absorption of unwanted generation;
- Long term storage, even inter-seasonal.

As the project is based on the storage technology, it can also contribute to the power and frequency control and earn revenues that are not valued in this assessment This storage project of Great Britain enables saving in generation capacity of 33 - 41 Meuro/year

| Complementary Information | |
|---|---|
| This additional information has been provided based on a preliminary version of the CBA 2.0, in coordination with the European Association or Storage of Energy (EASE). Each of the four below KPIs are scored from 0 to ++ based on the technical characteristics provided by each project promoter. | |
| Response time to activate Frequency Containment Reserves | + |
| Response time to reach the available power | 0 |
| Total time during which available power can be sustained | + |
| Power that is continuously available within the activation time | ++ |