Regional Group North Sea

Regional Grid Studies as an input to the TYNDP and the Regional Investment Plan

31 March 2014

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RGNS subgroup 1 - grid studies

entsoe

Reliable Sustainable Connected

Grid Studies : agenda

1. Grid studies in the whole study process
2. Grid data gathering campaign
3. From market studies to grid studies
4. Typical load flow results
5. Vision 1 : cross-border flows assessment
6. Vision 1 : typical power flow patterns
7. Vision 1 : grid reinforcements
8. Vision 4 : cross-border flows assessment
9. Vision 4 : grid reinforcements
10. Conclusions on visions 1&4
11. Grid-related indicators for CBA : method
12. Grid-related indicators for CBA : results (next presentation)

Grid Studies in the whole study process

Scenarios
- Installed capacities
- Demand
- Other parameters

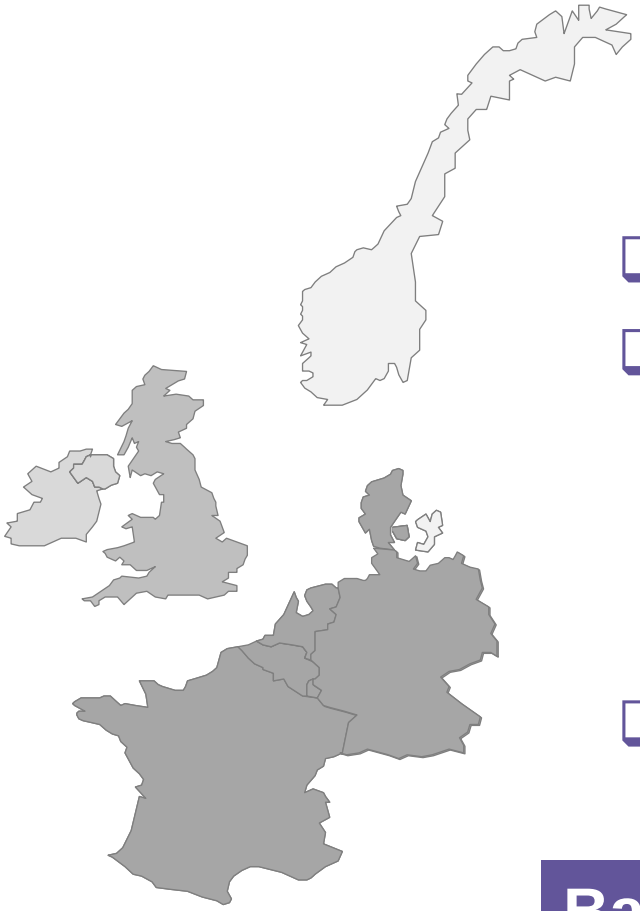
Market simulations
- Power dispatches by hour
- Power exchanges by hour
- Load by hour

Grid simulations
- Load flow patterns and reliability analysis
- Identified bottlenecks
- Proposed solutions

Cost-benefit analysis
- Grid-related indicators
- Market-related indicators
- Other indicators

Selected projects
- Cost and benefits
- Technical parameters

Grid data gathering campaign



- Detailed grid model
  - from 110 kV up to 380 kV
  - including their electrical parameters
  - TSOs in RGNS + continental neighbours
- Grid data gathering campaign
- Compliant with CIM format (IEC standard)

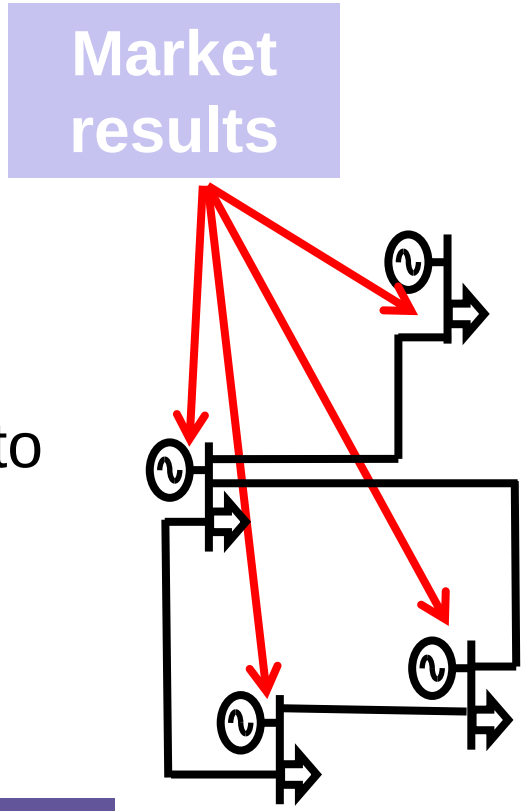
Number of links	~12500
Number of transformers	~9000
Number of busbars-nodes	~17000
Number of loads	~8500
Number of generators	~11300

- 4 asynchronous areas interconnected by DC controllable links

Basis for physical power flow evaluation across the system

From Market Studies to Grid Studies

- Market study results
  - Year-round power dispatches for each plant
  - Year-round load values



- Translated hour by hour on each load and plant in the grid model
- Flows through the DC links set equal to the market flows (controllability)
- Defining operating rules of flexible AC transmission devices (FACTS : PSTs, HVDC etc.)

Create a view on how the power system is stressed through a full year

Typical load flow results

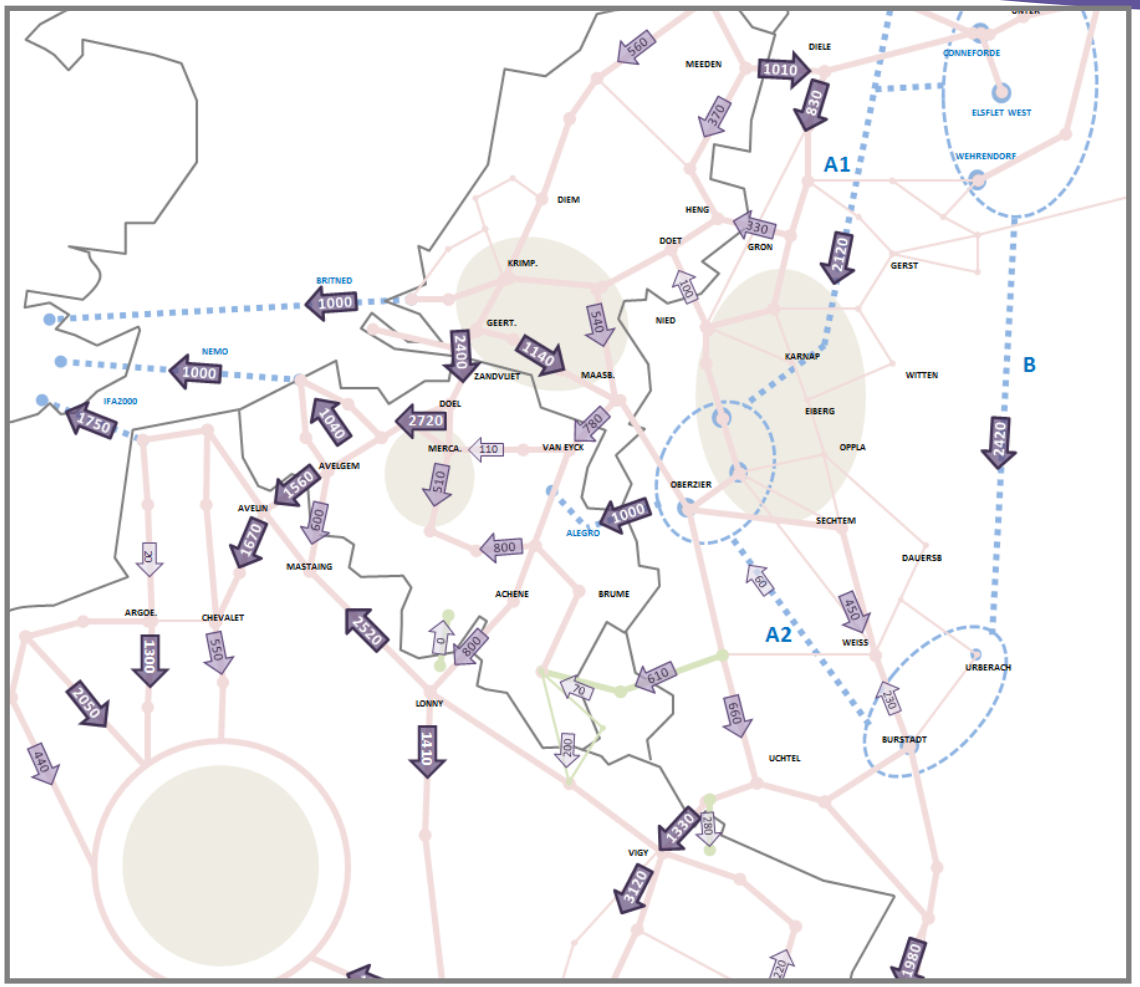


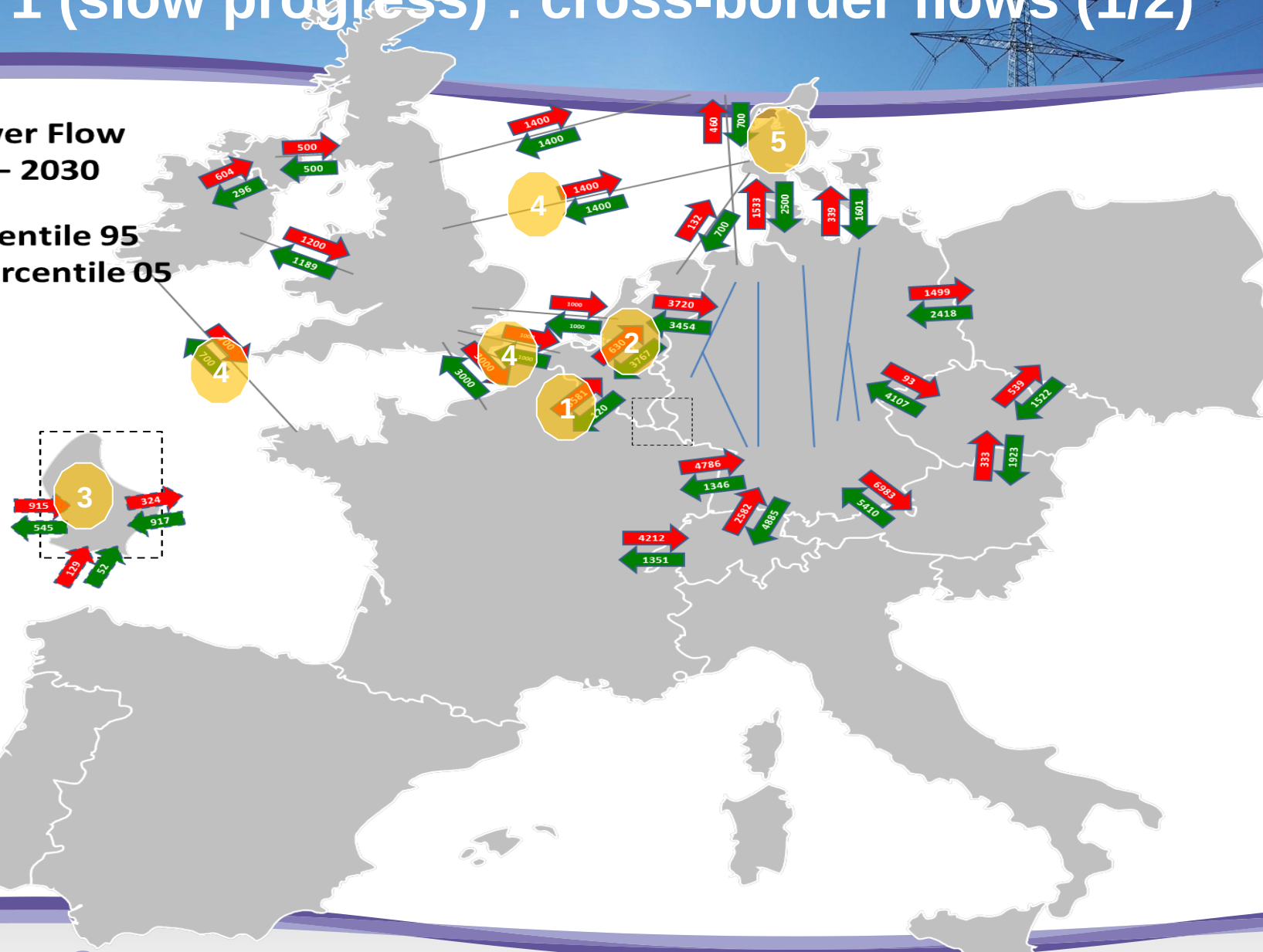
Illustration from vision 1

- Flows from Northern Germany
- To France via Southern Germany
- Through The Netherlands and Belgium
- Export from Mainland to GB and Ireland

Vision 1 (slow progress) : cross-border flows (1/2)

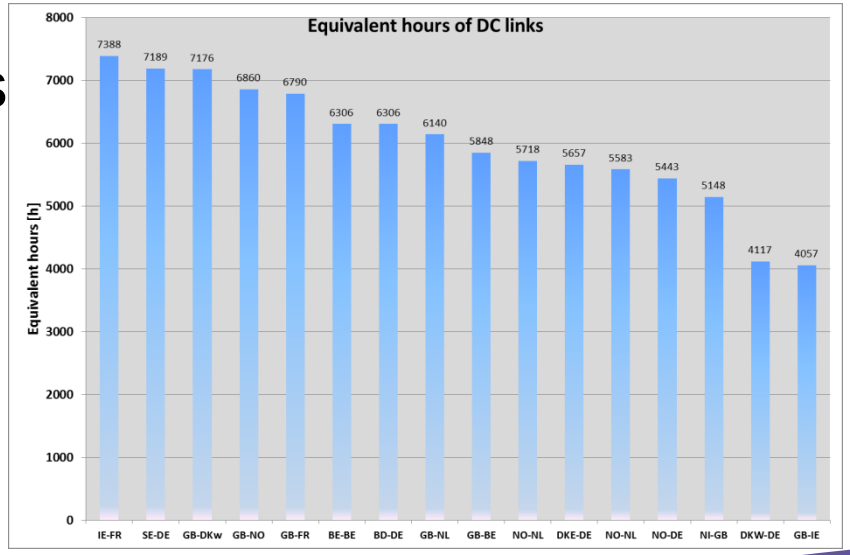
Bulk Power Flow
Vision 1 – 2030

RED : percentile 95
Green : percentile 05



Vision 1 (slow progress) : cross-border flows (2/2)

1. Need for the already planned reinforcement between France and Belgium is confirmed
2. Full use of the PST controllability to manage flows – safe but the extreme flows are more difficult
3. High flows through the 220 kV grid in Luxemburg – safe except for very extreme flows
4. DC links between asynchronous areas are heavily loaded
5. Additional transit flow in DK due To an additional interconnection

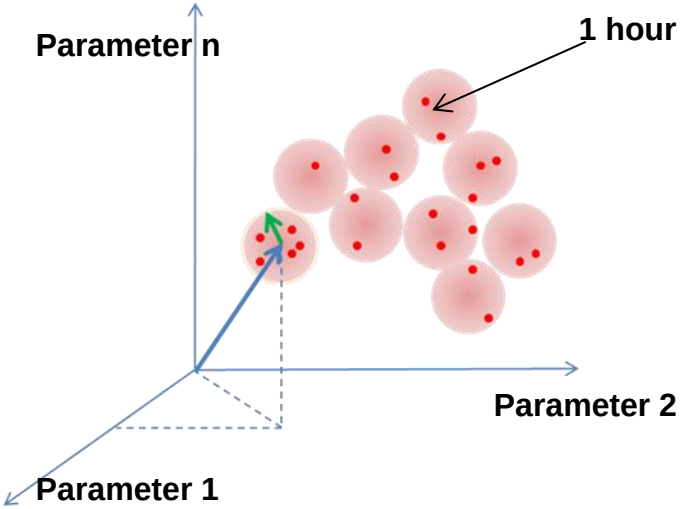


Vision 1 (slow progress) : typical flow patterns (1/3)

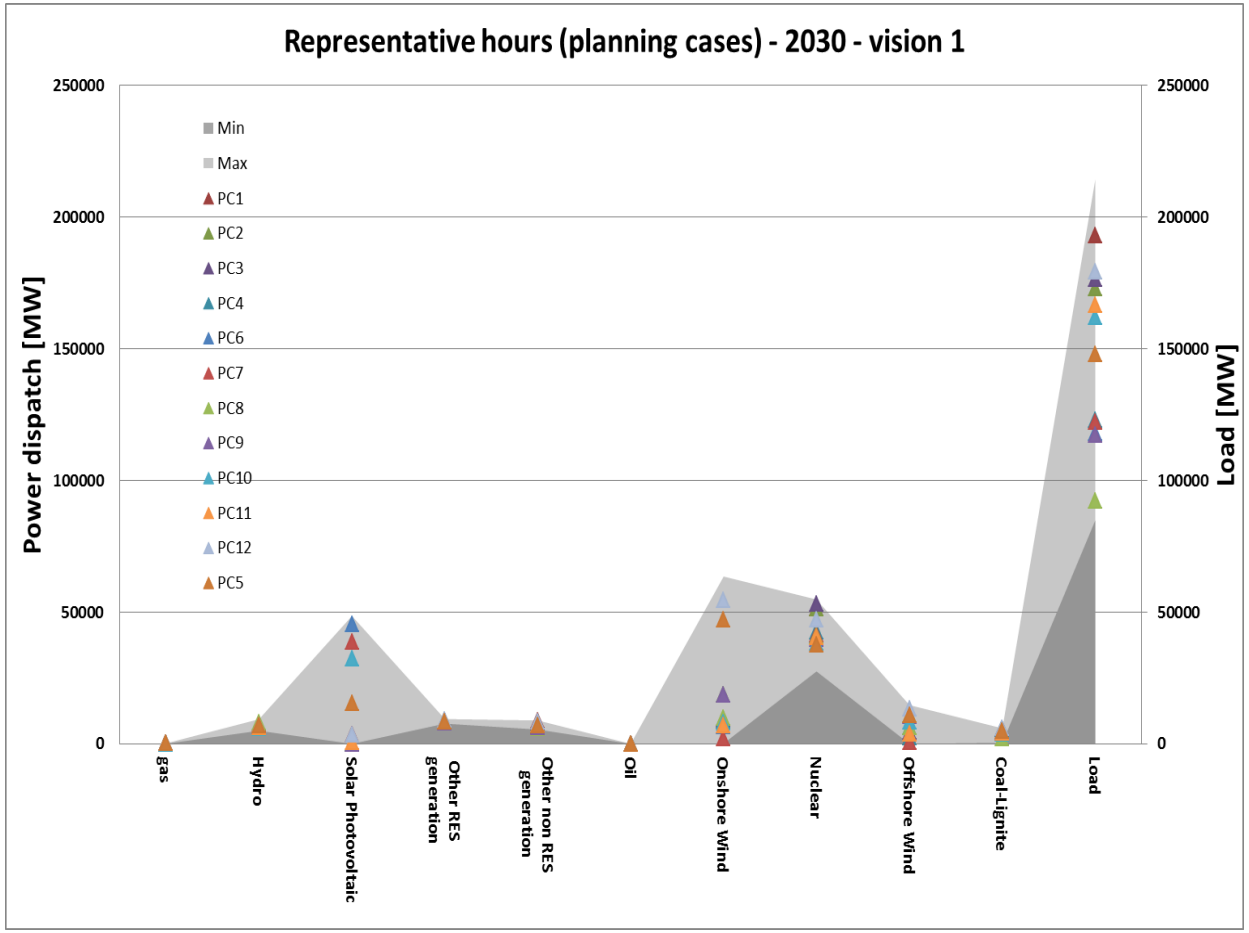
- **Which are typical flow patterns**
  - One year = 8760 hours
  - High-medium low load, High-low wind etc.

- **Year-round simulations are not always achievable for each project CBA**
  - Computation time + data volume
  - Sometimes a need to limit the number of analyzed hours = known as the ***planning cases***

- **A transparent method has been developed**
  1. Target number of representative hours : about 12
  2. Minimizing an error function by best selecting these hours
  3. Each hour belongs to the closest family (***clustering***)
  4. Computing the number of hours these 12 hours are representative for (***weight of each cluster***)



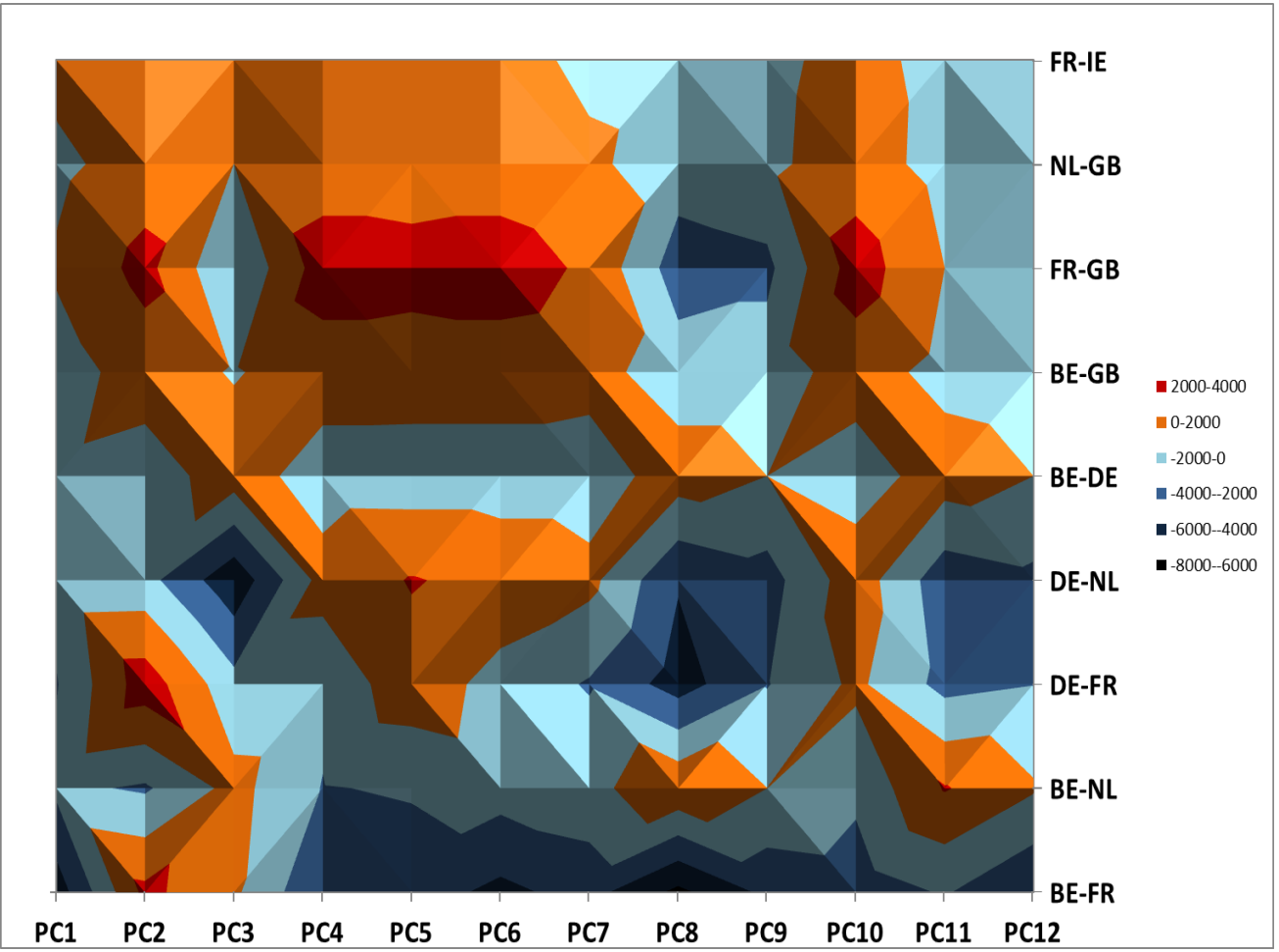
Vision 1 (slow progress) : typical flow patterns (2/3)



12 hours selected covering

- Load spread
- Low-middle-high solar
- Low-middle-high wind
- Export from Mainland to GB and Ireland
- Always low gas

Vision 1 (slow progress) : typical flow patterns (3/3)



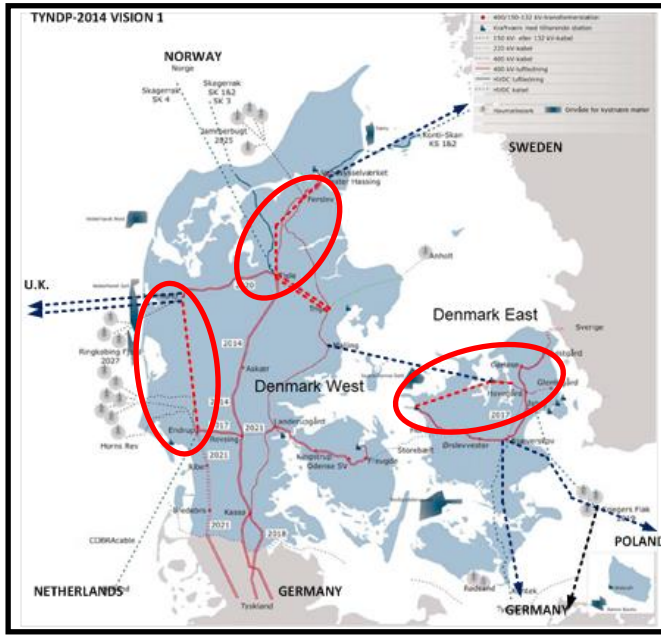
12 hours selected with power flows covering the range of possibilities

- Mainly from FR to BE
- NL-DE, BE-NL and DE-FR : the cases are balanced in both directions
- DC links in the North Sea with cases balanced in both directions

Vision 1 (slow progress) : Grid reinforcements

Which reinforcements should be foreseen in addition to the project already foreseen in the previous TYNDP 2012-2022 ?

- None in NO, DE, FR, NL, IE, NI, GB
- None in the Belgian system but stressed at the upper limit (voltage and dynamic stability under study)
- The evolution of transit flow through Luxemburg should be carefully monitored in the future – Additional PSTs might be needed
- The Danish system should be reinforced to accommodate additional transit flow due to an additional interconnection



Vision 4 (green revolution) : cross-border flows (1/3)

Vision 4 (green revolution) : cross-border flows (2/3)

1. FR-BE border is heavily loaded and often congested in vision 4 even if reinforced (see vision 1)
2. Belgian internal Western 400 kV backbone to be reinforced and creation of a second offshore-onshore corridor to accommodate additional offshore wind
3. Controllability of the PSTs at the BE-NL border to secure the power flows. Extreme situations are stressed
4. DC subsea links very often used at full capacity
5. High flows through the 220 kV grid in Luxemburg – safe except for very extreme flows

Vision 4 (green revolution) : cross-border flows (3/3)

6 Congestions in the Danish 132 kV, 150 kV and to some extent in the 400 kV grids

7 due to the level of renewable power to connect and transmit and due to interconnector operation, constraints in and around London, South Coast, Upper North, in East Anglia & North Wales

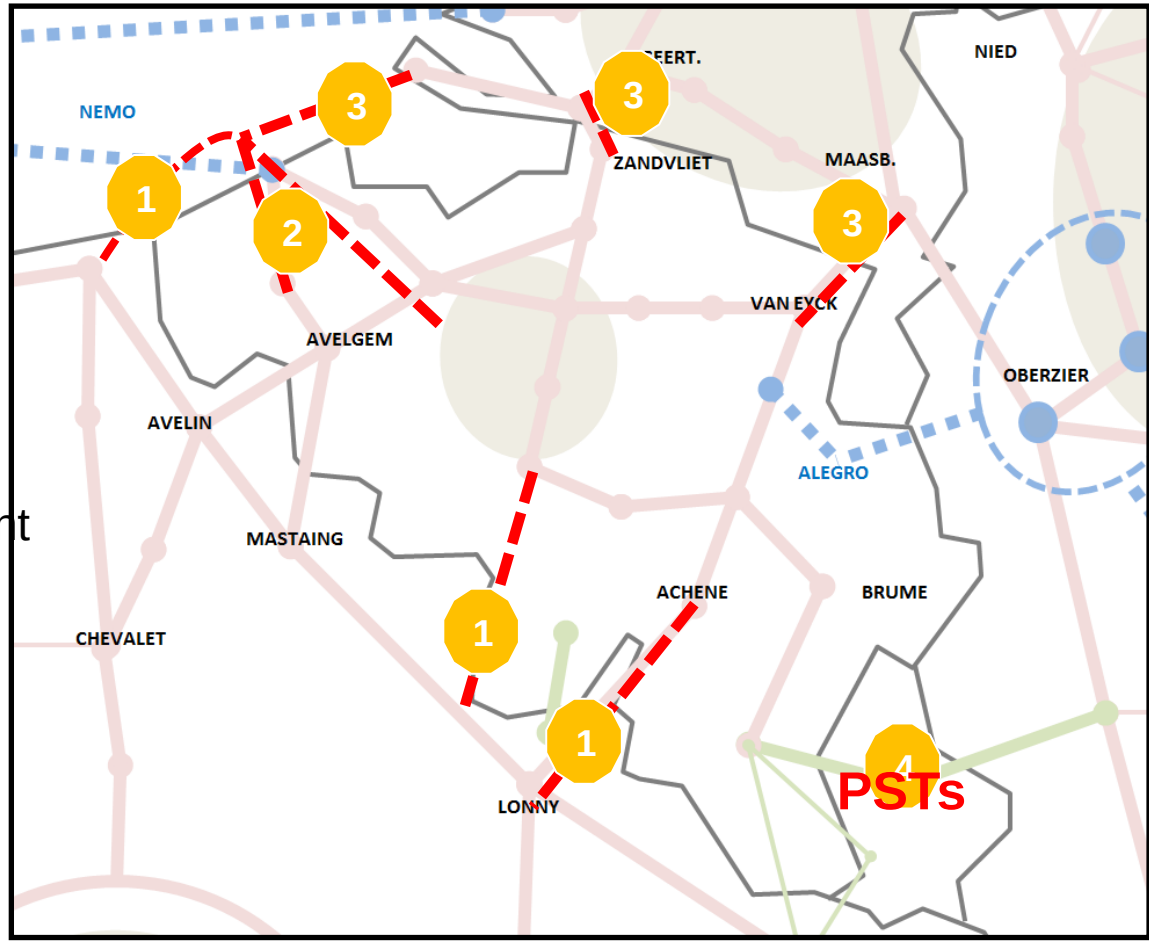
8 The grid is adequate in average cases. Reactive power issues are observed to accommodate vision 4

9 North-South flows higher in vision 4 leading to internal congestions

Vision 4 (green revolution):Grid reinforcements (1/2)

Which reinforcements should be foreseen in addition to the project already foreseen in vision 1?

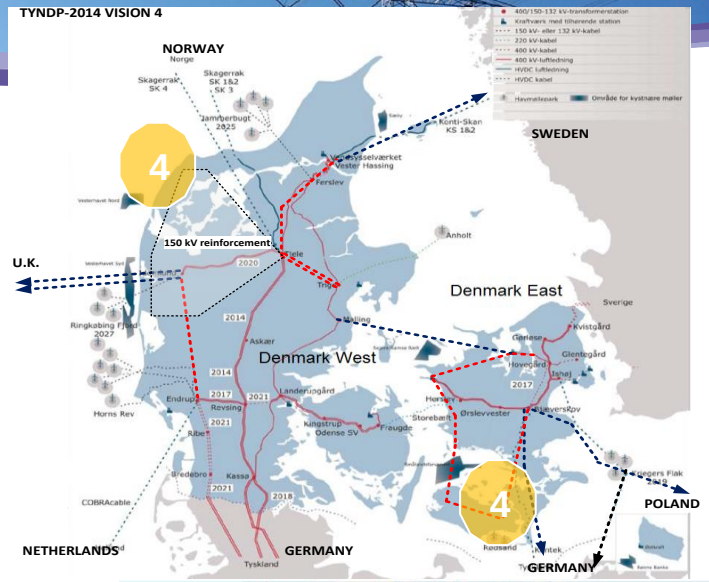
1. Second FR-BE border reinforcement (options HTLS conductors **or** HVDC links
2. Internal Belgian backbone to reinforce from the shore to the center (e.g.: AC 400 kV underground link **+** HVDC link)
3. The NL-BE border at the limit in case of extreme flows. Some options exists if the reinforcement is necessary (HTLS/PSTs **or** HVDC – not proposed in the TYNDP)
4. In Luxemburg, the potential installation of two additional 220 kV PSTs (not proposed in the TYNDP) might be necessary in vision 4



Vision 4 (green revolution) : Grid reinforcements (2)

Which reinforcements should be foreseen in addition to the project already foreseen in vision 1?

- **4** 150 kV reinforcements are necessary in Denmark (West). A 400 kV ring could be necessary in the Southern part of Denmark (East)
- **5** In GB, reinforcements around London, South Coast, Upper North, in East Anglia & North Wales are necessary
- **6** In Germany, additional long distance HVDC connections would relieve the vision 4 additional congestions
- **7** Reactive power issues could lead to the installation of dedicated devices in Ireland (under study)



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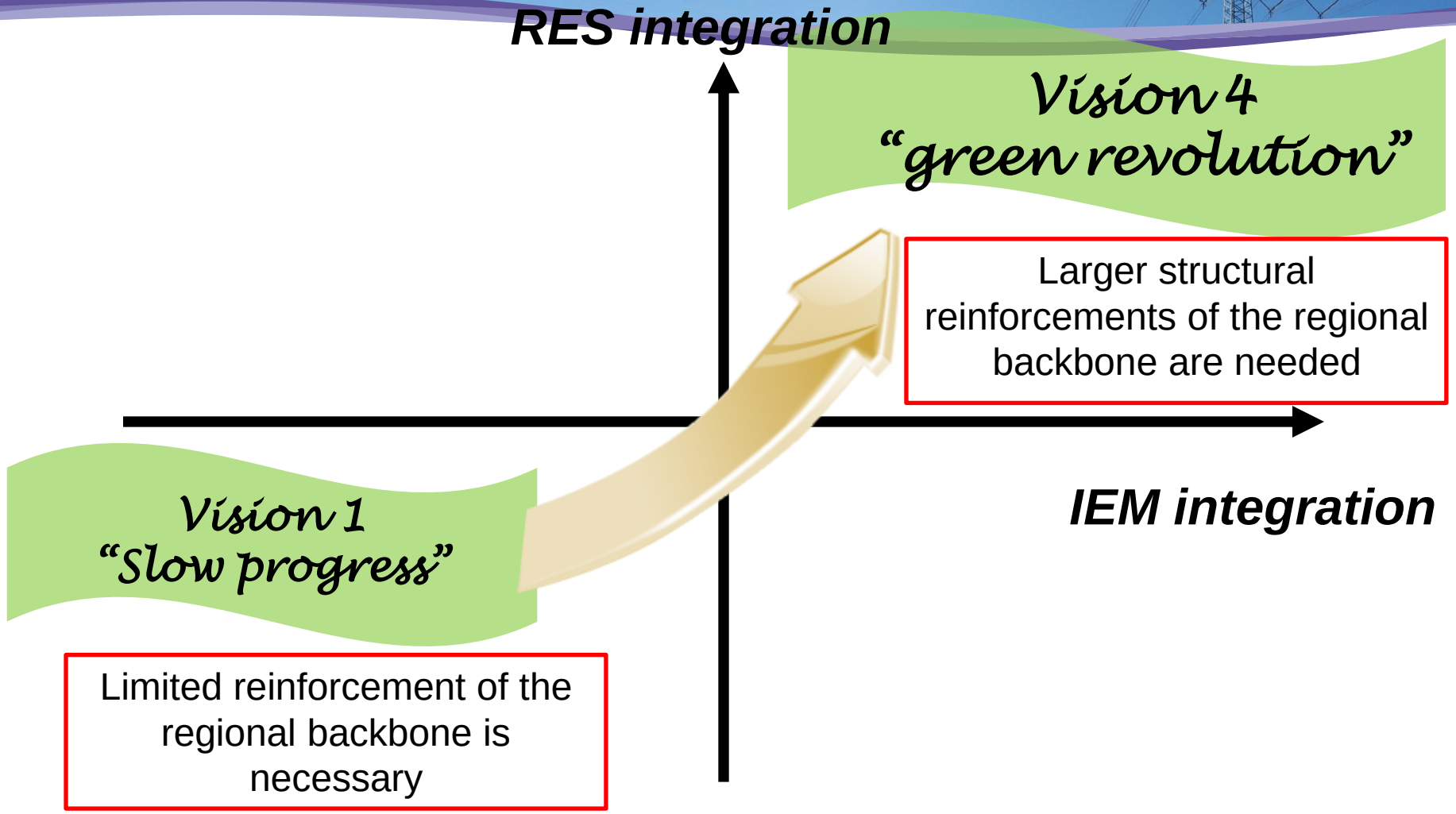
Conclusions on visions 1&4



Grid-related indicators for CBA : method (1/3)

1. Grid transfer capability (GTC)
2. B 1 : SoS improvement (if not X-border)
3. B 3 : RES integration (if not X-border)
4. B 4 : variation in losses
5. B 6 : technical resilience/Safety
6. B 7 : flexibility

General principles

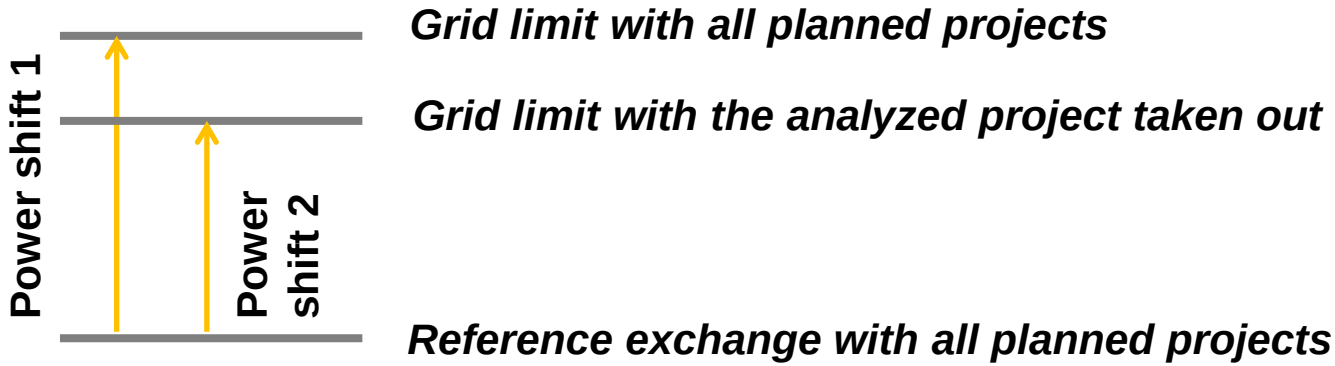
Principle 1 : project clustering according the CBA method

Principle 2 : the yearly indicator value equals the weighted sum of the indicator value calculated in each of the selected planning cases (= hour)

Principe 3 : all planned projects in the reference case – Take One project Out at a Time to analyze it (TOOT method as default)

Grid-related indicators for CBA : method (2/3)

GTC : Grid transfer capability = power shift 1 – power shift 2



B 1 : SoS improvement (if not X-border)

B1 = avoided curtailed load to relieve a congestion with or without the project

B 3 : RES integration (if not X-border)

B3 = avoided curtailed RES to relieve a congestion with or without the project

B 6 : losses variations

B6 = difference in the losses volume in the system with or without the project

Grid-related indicators for CBA : method (3/3)

B 6 : technical resilience/Safety – The project increases the capability to withstand extreme situations i.e.

- ✓ incident during maintenance
- ✓ unstable situation
- ✓ voltage collapse

B 7 : flexibility (adequacy of the system in various development paths), i.e.

- ✓ the project matches in various scenarios
- ✓ the project is still valuable if another reinforcement is delayed
- ✓ the project help sharing balancing services

Thanks for your attention !