TYNDP 2016: 2nd Public Workshop on Scenario Development

11-03-2015

TYNDP 2016 Task Force Scenario Building

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Introduction on Visions for TYNDP2016

Cindy Bastiaensen - Task Force Scenario Building

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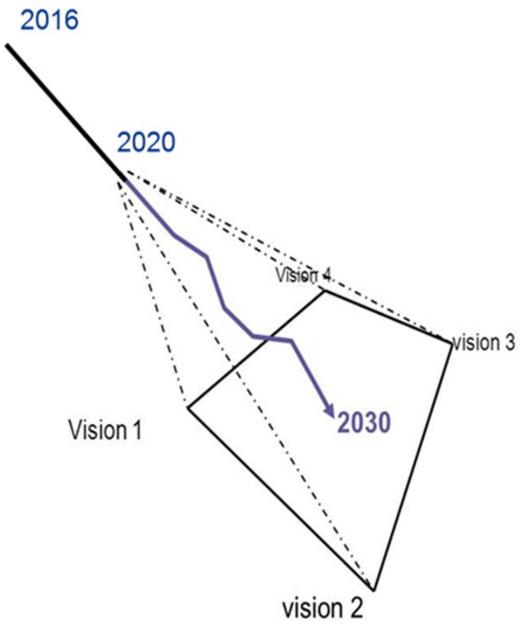
TYNDP16: 1 scenario for 2020 and 4 Visions for 2030



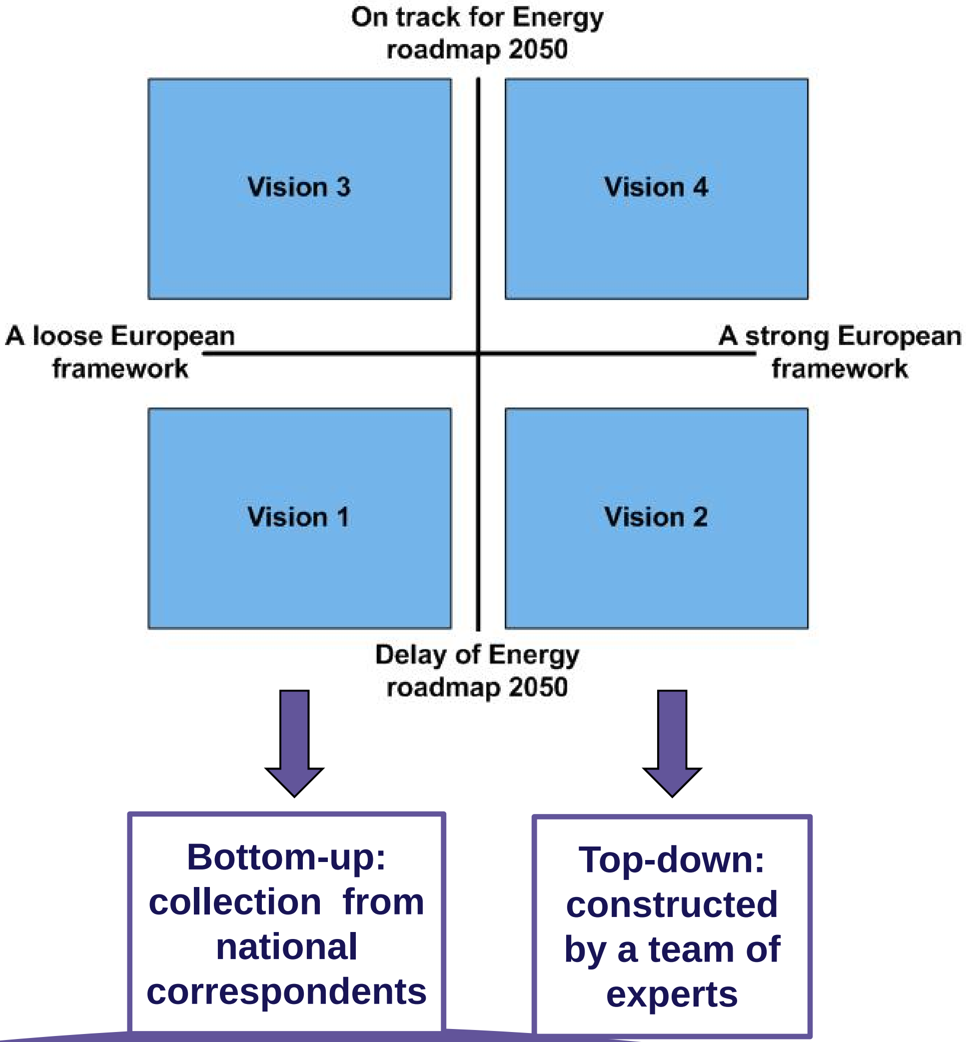
Objectives for the 2030 visions:

- Look beyond 2020
- Bridge between the European energy targets for 2020 and 2050
- Differ enough from each other
- The visions are not forecasts (no probability attached to the visions).

2020: the last point in time before uncertainties increase to a level where the future requires a broader envelope of potential futures

2030: the pathway realised in the future falls with a high level of certainty in the range described by the four visions

Construction process for 2030 visions



Basis:
Construction of 4 extreme visions around 2 fixed axes

Variable:

- **Storyline and parameters**
- **Boundary conditions and default values**
- **Methodology how to construct the top-down visions**
- **…**

Construction process for 2030 visions

For each Vision: create a storyline based on different parameters

Economy and Market

- Economic and financial conditions
- New market designs
- National schemes regarding R&D expenses
- Merit order : primary fuel pricing - carbon pricing

Demand

- Energy efficiency developments
- New usages (Heat pumps, Electric vehicles)
- Demand response potential

Generation

- RES (wind, solar, RoR, biomass)
- Flexibility of generators
- Back up capacity (nuclear, CCS)
- Decentralized and centralized storage

Grid

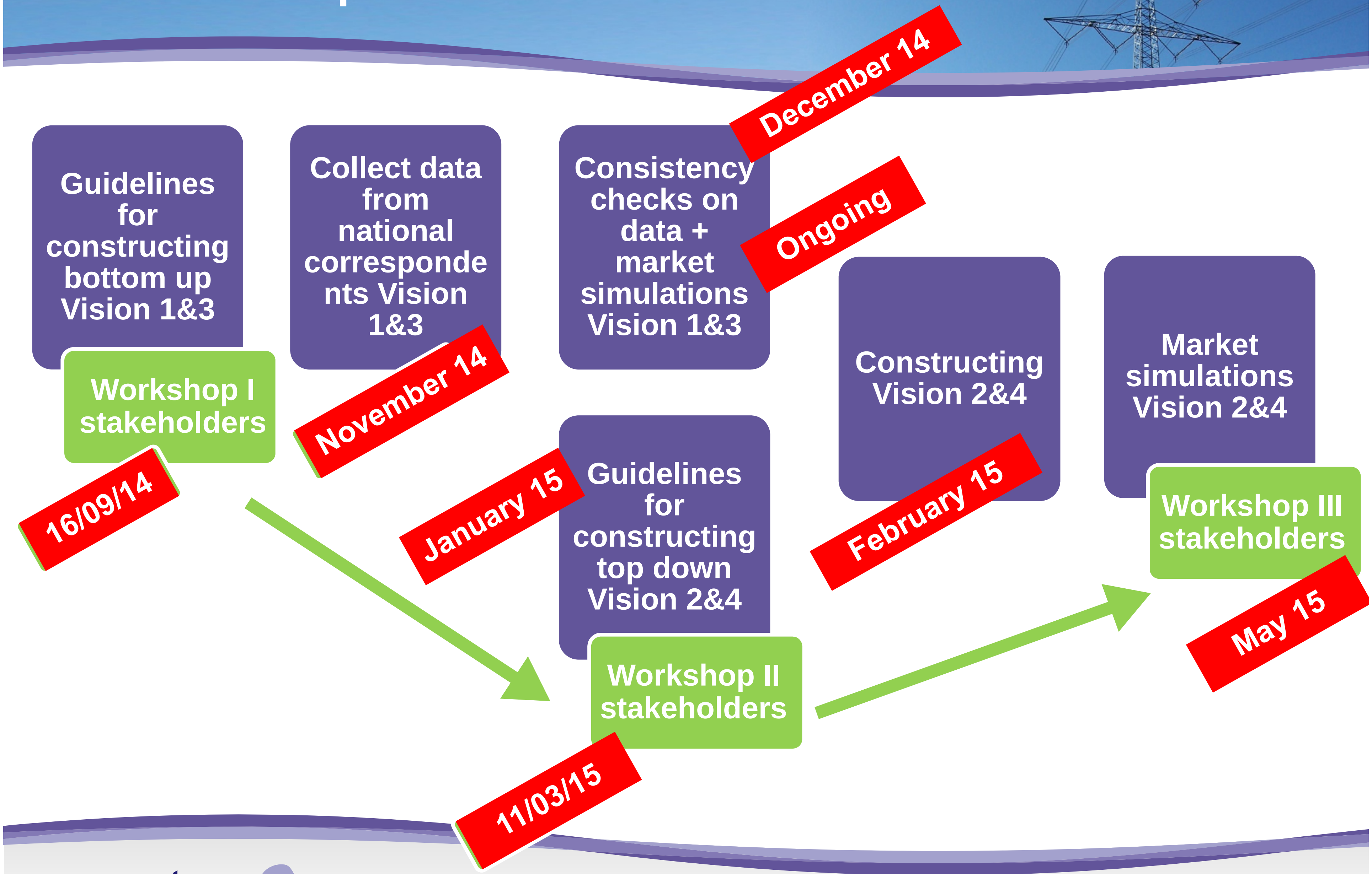
- smart grid and the impact on load & generation patterns

Information is gathered through workshops/consultations

Comments of different parties are taken into account

- **Stakeholders**
- **National correspondents (LAC)**
- **Regional groups**
- **Team involved in previous TYNDP**
- **…**

Construction process for 2030 visions



Implementation of the stakeholders’ feedback

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Main comments from previous consultations/workshops

- Public consultation
- Network Development Stakeholder Group
- Questionnaires
- National correspondents
- PEMS expert team
- Regional Groups
- …

Main comments from previous consultations/workshops

Main comments: 4 clusters

General

- Visions should be more divergent
- Clarification on adequacy criteria used
- Intermediate time-step
- CO_2 price unrealistically high

Demand

- Underpin the expected impact of efficiency measures on electricity consumption
- Demand growth is too much for Vision 4 and energy efficiency is not well reflected

Thermal Reduction

- Generation capacity: sufficient return of investment?
- Thermal units should be optimized in EU visions: nuclear almost the same for all visions
- Combination of high RES, high demand and high amount of inflexible generation: system not cost-effective

RES Optimization

- Upper limits for wind capacity
- Distribution of RES capacity over the different countries
- RES should be optimized in EU visions

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop / stakeholders

- Preparatory document distributed before the workshop
    - Background and extra explanation for each topic
    - Specific questions for each topic

General	Thermal reduction
Demand	RES optimization

- About 50 participants: representing a wide variety on interests: NGOS, regulators, producers, consumers, industry representative, etc

- Brainstorm in 3 groups on what to improve

- Detailed overview of input from stakeholder online:

https://www.entsoe.eu/news-events/events/Pages/Events/TYNDP-2016-2nd-Public-Workshop.aspx?EventWorkshopId=176

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop I stakeholders

Which parameters shall be considered when building contrasting visions for 2030?

Group 1	Group 2	Group 3
Overall economic conditions	renewable in distributed system	Geographical distribution of RES
Res-policies	storage	EU policies
RES-technological evolution	load	**Security of Supply in gas sector**
Distributed storage and generation in the grid	economic development	**Nuclear phase out**
Political stability	generation mix	Development of Smart grids
10-15% transmission capacity enforced	fuel prices (nuclear and gas)	Assumption of electricity storage (how matter this technical?)
Industrial development	technologies level	Consistent set of parameters in Vision 4 (sensitivities studies- more efficiency) -> more visions
Fuel prices	regulatory evolution	Flexible demand
Relevant legal constraints for RES	**capacity market**	Public acceptance
Res from Central East and Mediterranean	smart grid	High CO2 prices

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Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop / stakeholders

Level of adequacy for 2030: % of back-up capacity

The opinions were divergent on this topic stretching from all the visions should be European adequate to only one vision out of four (e.g. Vision 1 – stagnation) shall be nationally adequate.
Also the national adequacy is highly dependent on the political moves. In addition considering RES integration the adequacy can be also looked from the regional perspective.

	V1	V2	V3	V4
Adequacy	National - not autonomous limited back-up capacity	European - less back-up capacity than V1	National - autonomous high back-up capacity	European - less back-up capacity than V3

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop / stakeholders

What merit order is to be expected for each of the 2030 visions?

Visions	Group 1	Group 2	Group 3
vision 1	In all scenarios: gas should come before coal. (Can we reach the EU targets when lignite & coal comes before gas in the merit order?) Use IEA for fuel price sources.	no clear preference but ranges should be considered looking at the political situation security of supply economic development, CO_2 value and interconnection capacities	Coal vs gas, biofuel not first
vision 2			
vision 3			Biofuel first and gas before coal
vision 4			Biofuel first and gas before coal

	Slowest progress	Constrained progress	National green transition	European green revolution
	V1	V2	V3	V4
CO_2 and primary fuel prices	low CO_2 price, high fuel price	low CO_2 price, high fuel price	high CO_2 price, low fuel price	high CO_2 price, low fuel price
Merit order	Coal before gas	Coal before gas	Gas before coal	Gas before coal

	vision 1 2030 Fuel prices (€/ net GJ)	vision 2 2030 Fuel prices (€/ net GJ)	vision 3 2030 Fuel prices (€/ net GJ)	vision 4 2030 Fuel prices (€/ net GJ)
Nuclear	0,46	0,46	0,46	0,46
Lignite	1,1	1,1	1,1	1,1
Hard coal	3,01	3,01	2,8	2,19
Gas	9,49	9,49	7,23	7,23
Light oil	17,34	17,34	13,26	13,26
Heavy oil	13,7	13,7	9,88	9,88
Oil shale	2,3	2,3	2,3	2,3
CO_2 prices (€/ton)	17	17	71	76
Source	IEA "Current Policies"	IEA "Current Policies"	IEA "450" except coal price IEA "New Policies"	IEA "450" except CO_2 price (UK FES High)

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop / stakeholders

What is the trend for the following parameters: electric vehicles, heat pumps, demand response?

Group 1	vision 1	vision2	vision 3	vision 4
Electrical vehicles	growth	not specified	lower	lower
Heat pumps	lower	lower	lower	stagnate or growth
Demand response	stagnate or growth	not specified	stagnate	stagnate
Group 2	**vision 1**	**vision2**	**vision 3**	**vision 4**
Electrical vehicles	lower	not specified	stagnate	stagnate
Heat pumps	stagante	stagnate	stagnate	uncertain
Demand response	Stagnate or higher	not specified	increase	increase
Group 3	**vision 1**	**vision2**	**vision 3**	**vision 4**
Electrical vehicles	0%	higher	higher	higher (10%)
Heat pumps	higher	higher	higher	higher
Demand response	higher (5%)	higher	higher	higher (20%)

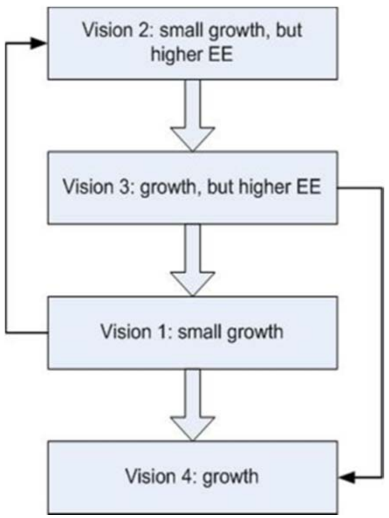
	V1	V2	V3	V4
Demand response	As today 0%	Partially used 5%	Partially used 5%	Fully used 20%
EV	No commercial break through of electric plug-in vehicles 0%	Electric plug-in vehicles (flexible charging) 5%	Electric plug-in vehicles (flexible charging) 5%	Electric plug-in vehicles (flexible charging and generating) 10%
HP	Minimul level 1%	Intermediate level 5%	Intermediate level 5%	Maximum level 9%

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop I stakeholders

Trend of demand for each 2030 vision compared to today?

Visions	Group 1	Group 2	Group 3
Vision 1	higher	higher	higher
Vision 2	stagnate	higher	higher
Vision3	higher	lower	lower
Vision 4	higher	lower	lower



Group 1	vision 1	vision2	vision 3	vision 4
Economic growth	lower	growth	not specified	stagnate
Energy efficiency	lower	not specified	stagnate	stagnate
Group 2	**vision 1**	**vision2**	**vision 3**	**vision 4**
Economic growth	stagnate	lower	not specified	increase
Energy efficiency	stagnate	not specified	increase	increase
Group 3	**vision 1**	**vision2**	**vision 3**	**vision 4**
Economic growth	do not consider	do not consider	do not consider	do not consider
Energy efficiency	higher	higher	higher	higher

	V1	V2	V3	V4
Electricity demand	Increase (stagnation to small growth)	Decrease (small growth but higher EE)	Decrease (growth but higher EE)	Increase (growth demand)

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop / stakeholders

What generation technologies shall be considered for the thermal reduction in the top down visions?

Group 1	Group 2	Group 3
The thermal reduction is highly sensitive of the political decisions. The old gas conventional units are expected to be closed by 2030. The generation capacity portfolio is expected to be reduced in the two top down visions.	The reduction in thermal is highly dependable on the CO2 price and RES capacity. Hard coal, lignite is expected to reach new level of flexibility. Gas: reduction of OCGG, more CCGT Profitability of power plant.	Optimal solution for thermal reductions in V2 & V4 needs to be developed. IED & Bref will reduce a large share of the thermal production units. Grid Reasons or security of supply needs to be considered If ETS functions properly then is expected to eliminate the hard coal and lignite. CCS is unlikely to be commercially deployed by 2030. If renewables encounter large development then will be no room for the nuclear units.

New methodology for thermal reduction!

Main comments from previous stakeholders' interactions- Workshop 16 Sept 2014

Workshop / stakeholders

If you are given the task to optimize renewables in Europe how would you do that? Consider parameters, process, method, sources, and outcomes

- The exercise of ENTSO-E should be an optimal approach to the whole system: RES, transmission and production
- Potential limitations by infrastructure
- Cleaner objective formulation (costs, CO_2)
- Relate RES to security of supply (not national)
- Market perspective: socio-economic, system cost or the business case for the individual unit
- Highest limit for RES : EWEA, EPIA, ESTELLA
- National plans for 2020 as the lower limit for RES
- Objectives should be linked to storyline

⇨ ***New methodology for RES optimization!***

Final assumptions for TYNDP 2016 Visions

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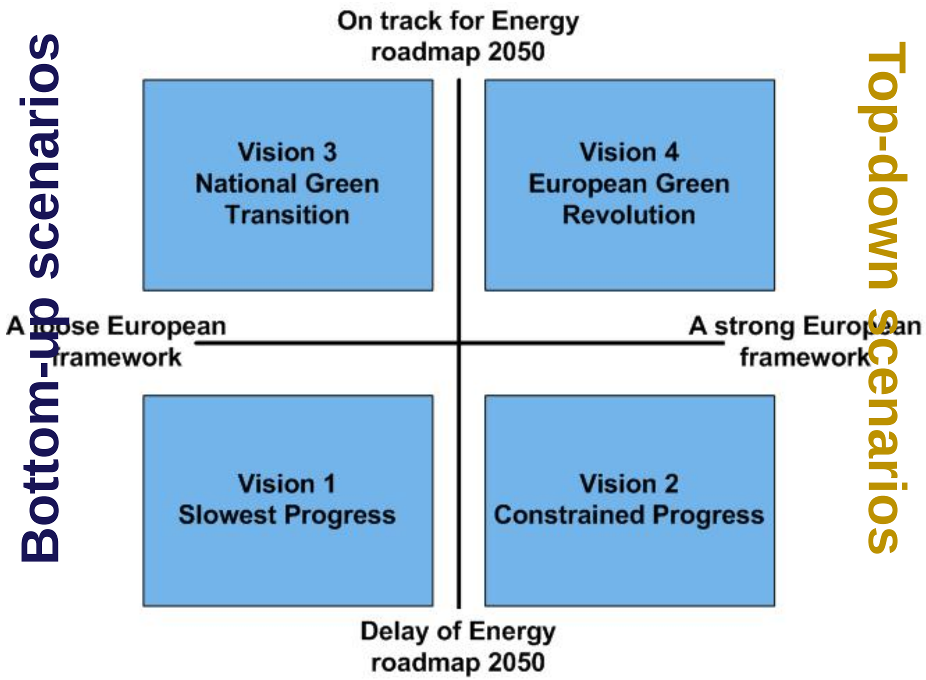
TYNDP16 Visions



Names changed:

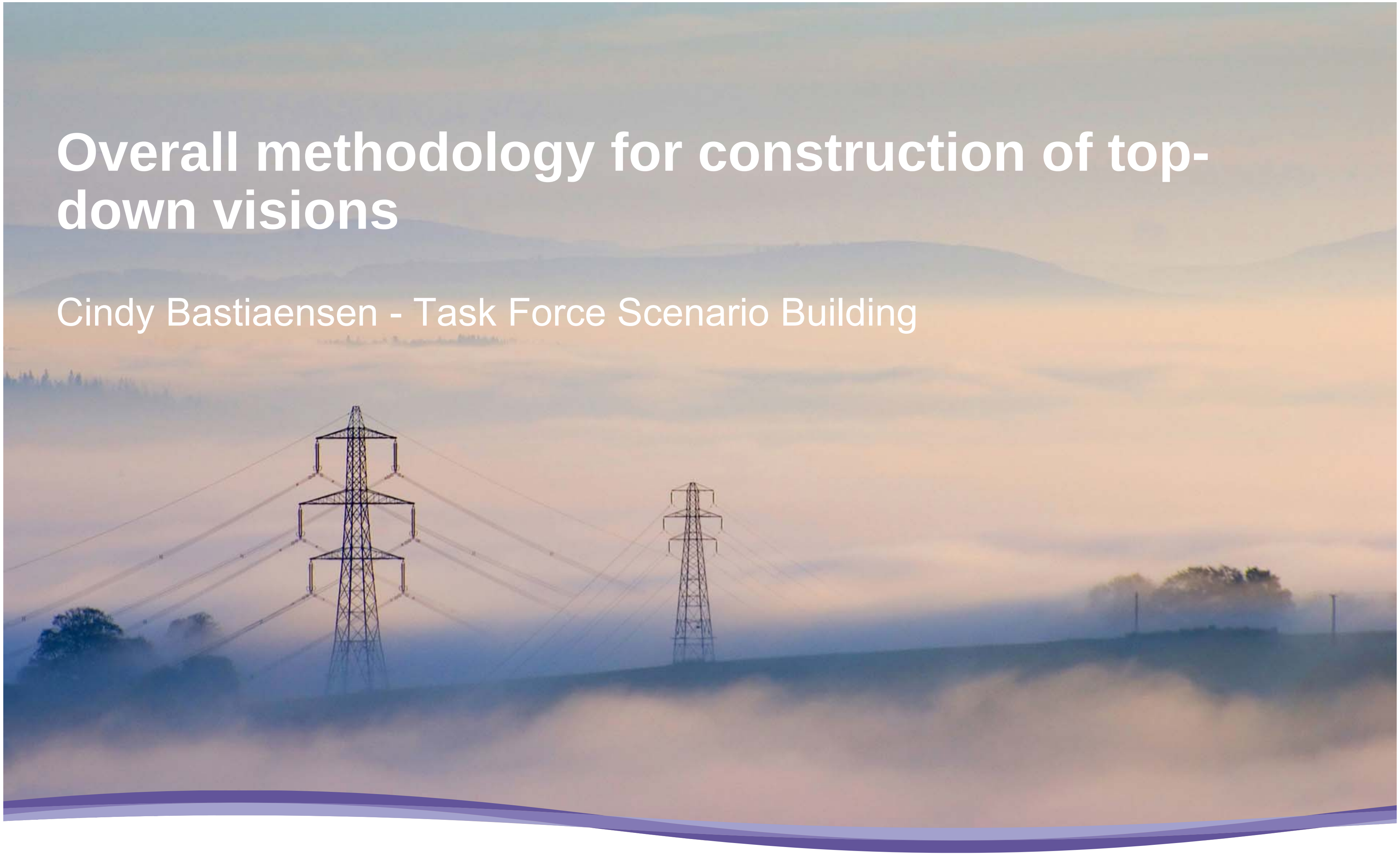
- **To reflect the changes from 2014 (and avoid confusion)**
- **To better reflect the content of the Visions**

TYNDP16 Visions

	Slowest progress	Constrained progress	National green transition	European green revolution
	V1	V2	V3	V4
Economic and financial conditions	Least favorable	Less favorable	More favorable	Most favorable
Focus of energy policies	National	European	National	European
Focus of R&D	National	European	National	European
CO2 and primary fuel prices	low CO2 price, high fuel price	low CO2 price, high fuel price	high CO2 price, low fuel price	high CO2 price, low fuel price
RES	Low national RES (>= 2020 target)	Between V1 and V3	High national RES	On track to 2050
Electricity demand	Increase (stagnation to small growth)	Decrease (small growth but higher EE)	Decrease (growth but higher EE)	Increase (growth demand)
Demand response	As today 0%	Partially used 5%	Partially used 5%	Fully used 20%
EV	No commercial break through of electric plug-in vehicles 0%	Electric plug-in vehicles (flexible charging) 5%	Electric plug-in vehicles (flexible charging) 5%	Electric plug-in vehicles (flexible charging and generating) 10%
HP	Minimul level 1%	Intermediate level 5%	Intermediate level 5%	Maximum level 9%
Adequacy	National - not autonomous limited back-up capacity	European - less back-up capacity than V1	National - autonomous high back-up capacity	European - less back-up capacity than V3
CCS (only expected in V4)	Not commercially implemented	Not commercially implemented	Not commercially implemented	Partially implemented
Nuclear	National acceptance for existing and new (with and witout FID) units	Public acceptance	National acceptance only for existing (or final investement decision is made or national support shemes) units	No public acceptance
Merit order	Coal before gas	Coal before gas	Gas before coal	Gas before coal
Storage	As planned today	As planned today	Decentralized	Centralized
Smart grid	As today	Partially	Partially	Fully
Grid	As planned today	As planned today	Extended netwerk	Extended netwerk

Overall methodology for construction of top-down visions

Cindy Bastiaensen - Task Force Scenario Building



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Construction process for 2030 visions

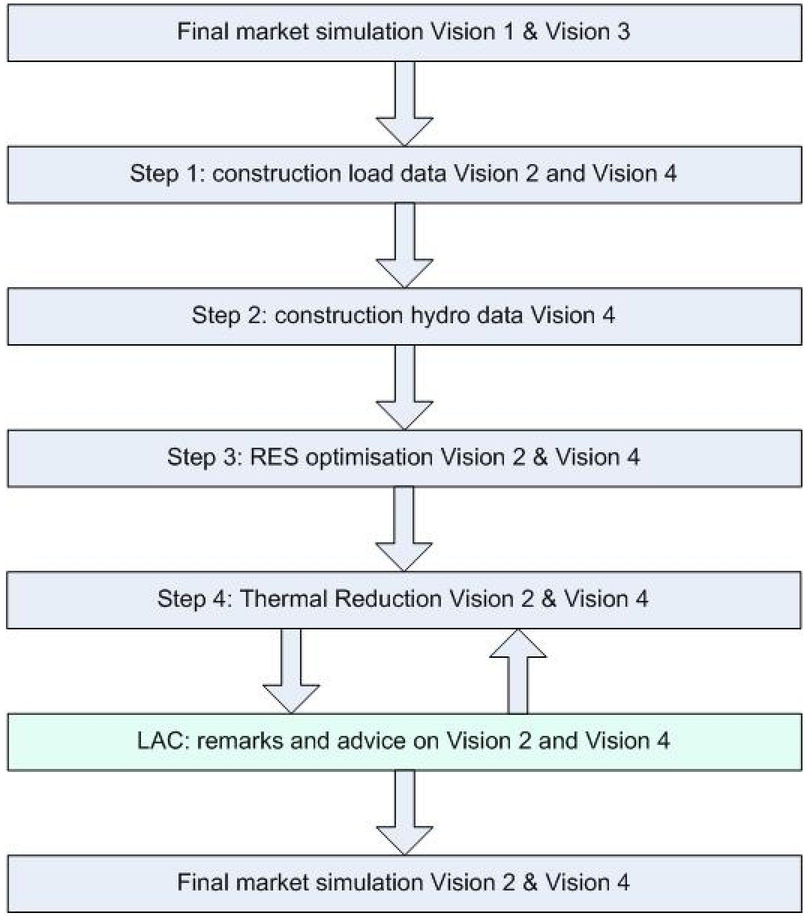
Vision 1 → Lower demand, Increased demand response, Increased EV and HP, Optimization of RES, Optimization of thermal power → Vision 2

Vision 3 → Higher demand, Increased demand response, Increased EV and HP, Centralised storage, Optimization of RES, Optimization of thermal power → Vision 4

Constructed from bottom-up input from TSO's based on guidelines

Modified and optimized according to a European framework

Construction process for 2030 visions



Vision 2 and 4 are constructed by a team of experts based on guidelines.

The guidelines are written taking into account feedback from stakeholders.

Construction process for 2030 visions

Differences compared to TYNDP 2014

No adaptation of NTC

In the simulations the NTC values for Vision 2 are the same as for Vision 1. For Vision 4 they are the same as for Vision 3. The guidelines don't include a revision methodology for the NTC values.

No specific adequacy runs

The purpose of the 2030 visions is not to perform a generation adequacy assessment, but to develop an adequate grid infrastructure in the future. The adequacy level is described in the storyline of each vision.

Adequacy level for Vision 1 is not autonomous

In the Vision 1 it was allowed to count up to 20% of the peak load on neighbouring countries. Because of this, an adequacy problem for Vision 1 could occur.

RES optimization

In the TYNDP2014 a RES optimization is only performed for Vision 4 in order to reach EU target for 2030. A new methodology for RES optimization is developed and applied to Vision 2 and 4. The optimization handles extra RES capacity, but also re-allocates the RES over the different countries.

Construction process for 2030 visions

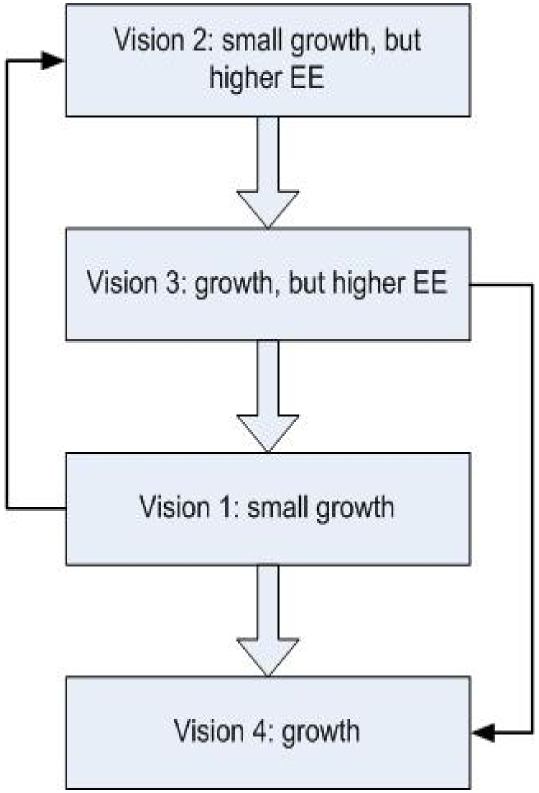
Construction of load data for Vision 2 and Vision 4

Step 1: scaling due to the change in energy efficiency savings

Step 2: scaling due to additional level of electric vehicles

Step 3: Scaling due to additional level of heat pumps

Step 4: Shifting load from hours with high load to hours with lower load due to additional level of peak shaving



Construction process for 2030 visions

Construction of hydro data for Vision 4

Vision 3

Additional decentralized storage facilities are implemented.

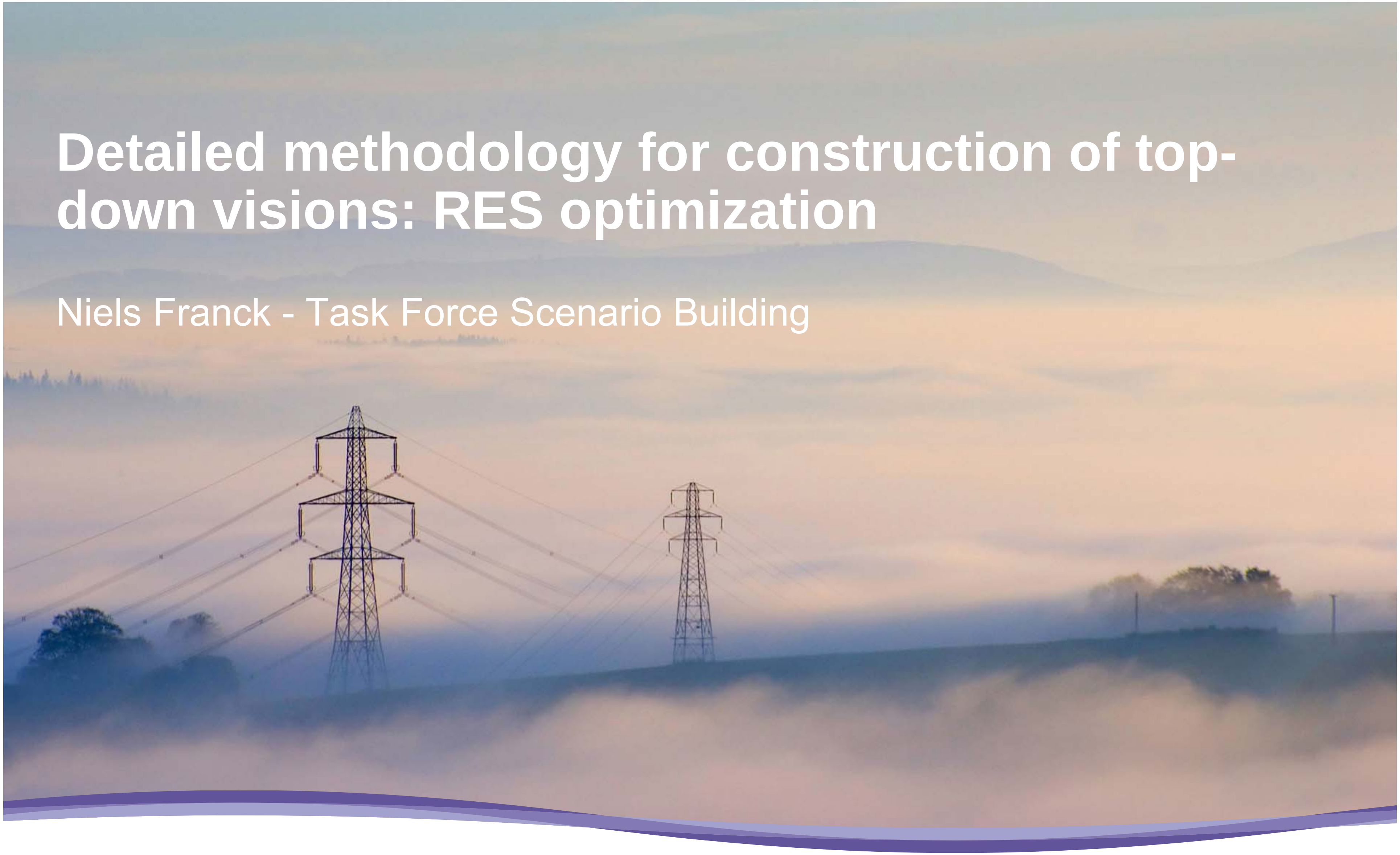
Vision 4:

Decentralized storage facilities are (partially) replaced by centralized pure pump storage in hydro countries (Alpine, Pyrenees & Scandinavian countries).

In Vision 4 the common framework is that the European commission will subsidize additional hydro infrastructure of interest for the European electric system but not necessary for the country itself.

Detailed methodology for construction of top-down visions: RES optimization

Niels Franck - Task Force Scenario Building



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What is RES optimisation

Availability of RES resources : Solar, wind, hydro, biomass

Price of utilizing RES

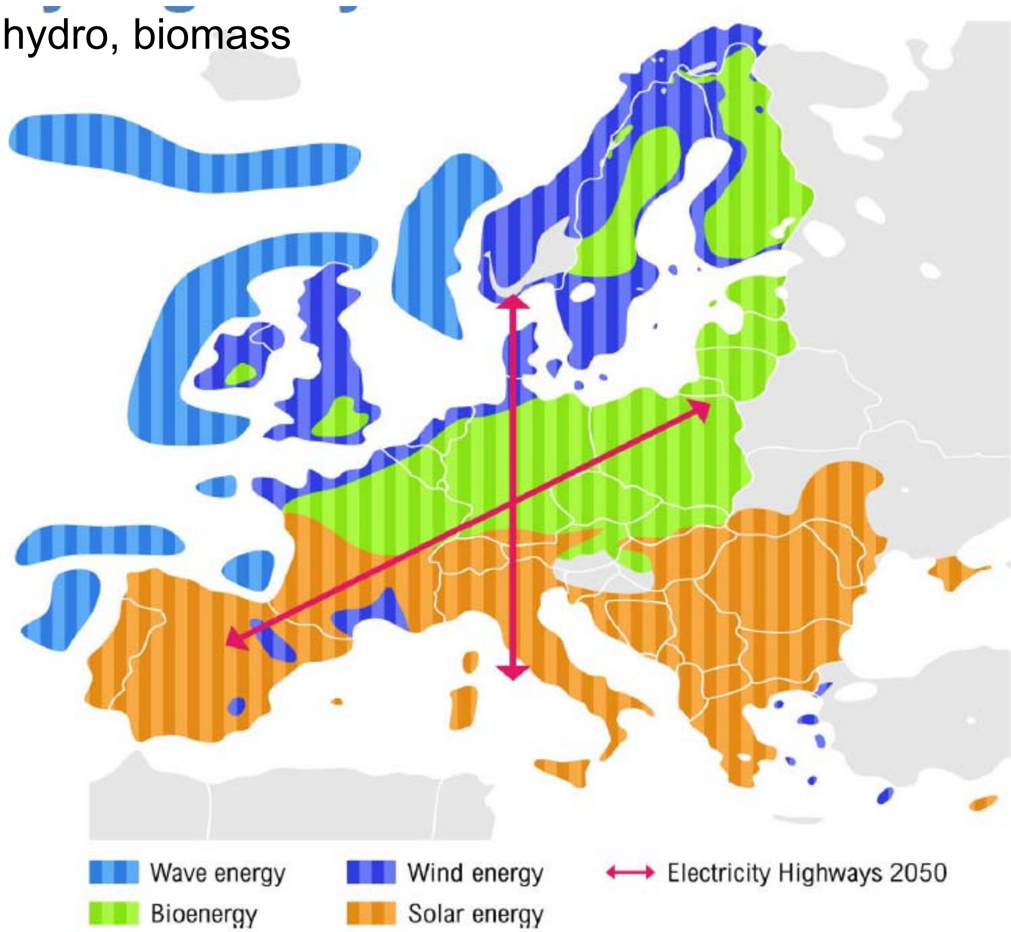
Existing RES penetration

Demand

Interconnectors

Value of RES production

How to distribute RES in Europe in a cost effective way



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The Storyline

Focus on cost and large scale RES penetration
European focus rather than a national focus

European Green certificates
Call for tender for RES
Joint planning
…

RES optimization

Optimization of RES

- Re-allocating the RES (based on European targets) among all ENTSO-E countries
- Principal variables to monitor are the Revenues per installed MW per technology and per country

$$R_{x,c} = \frac{\sum_{h=1}^{8760} (LMP_{h,c} * Generation_{h,x,c})}{Inst.Capacity_{x,c}} \quad (€/MW)$$

x = Onshore, Offshore and PV

c = Country

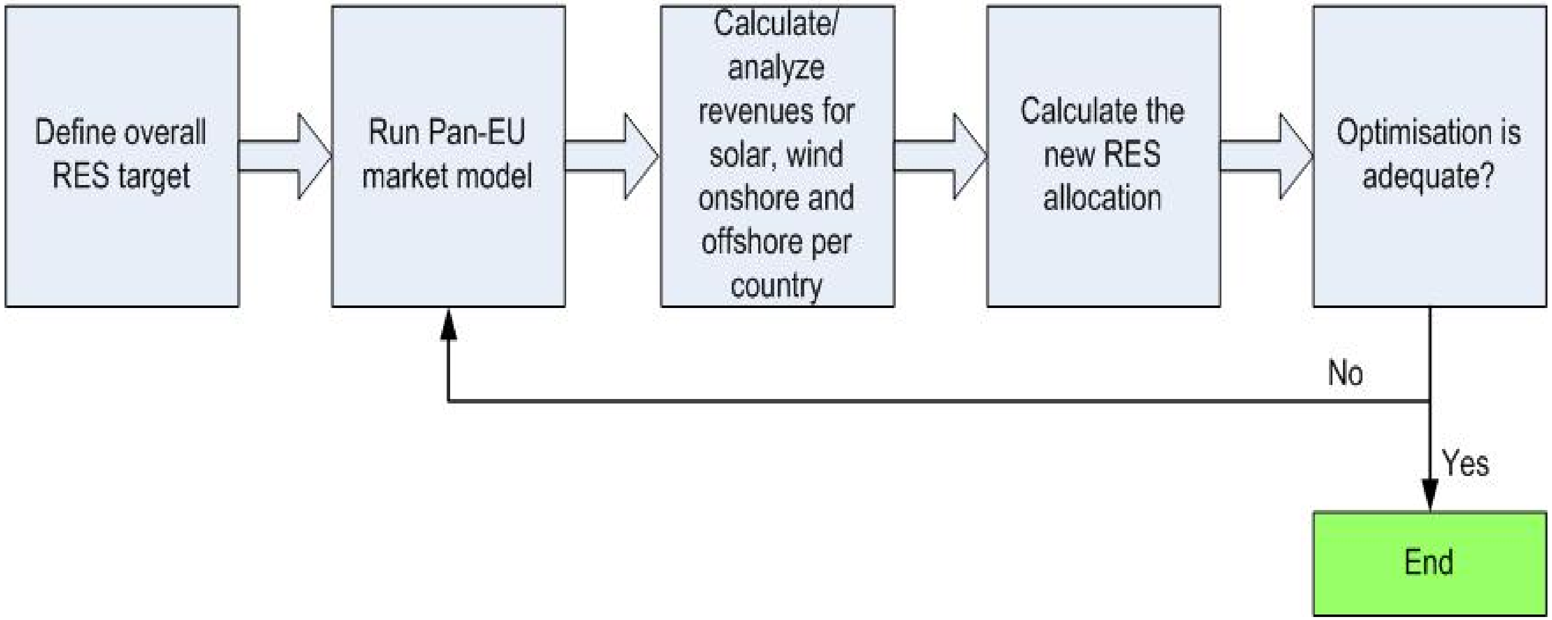
h = Hour

- The purpose is reaching for each country an Rx,c very closed or equal to a weighted average revenue
- A market model together with an Excel macro are the necessary tools to do the RES optimization using a gradient method (iterative process)

RES optimization

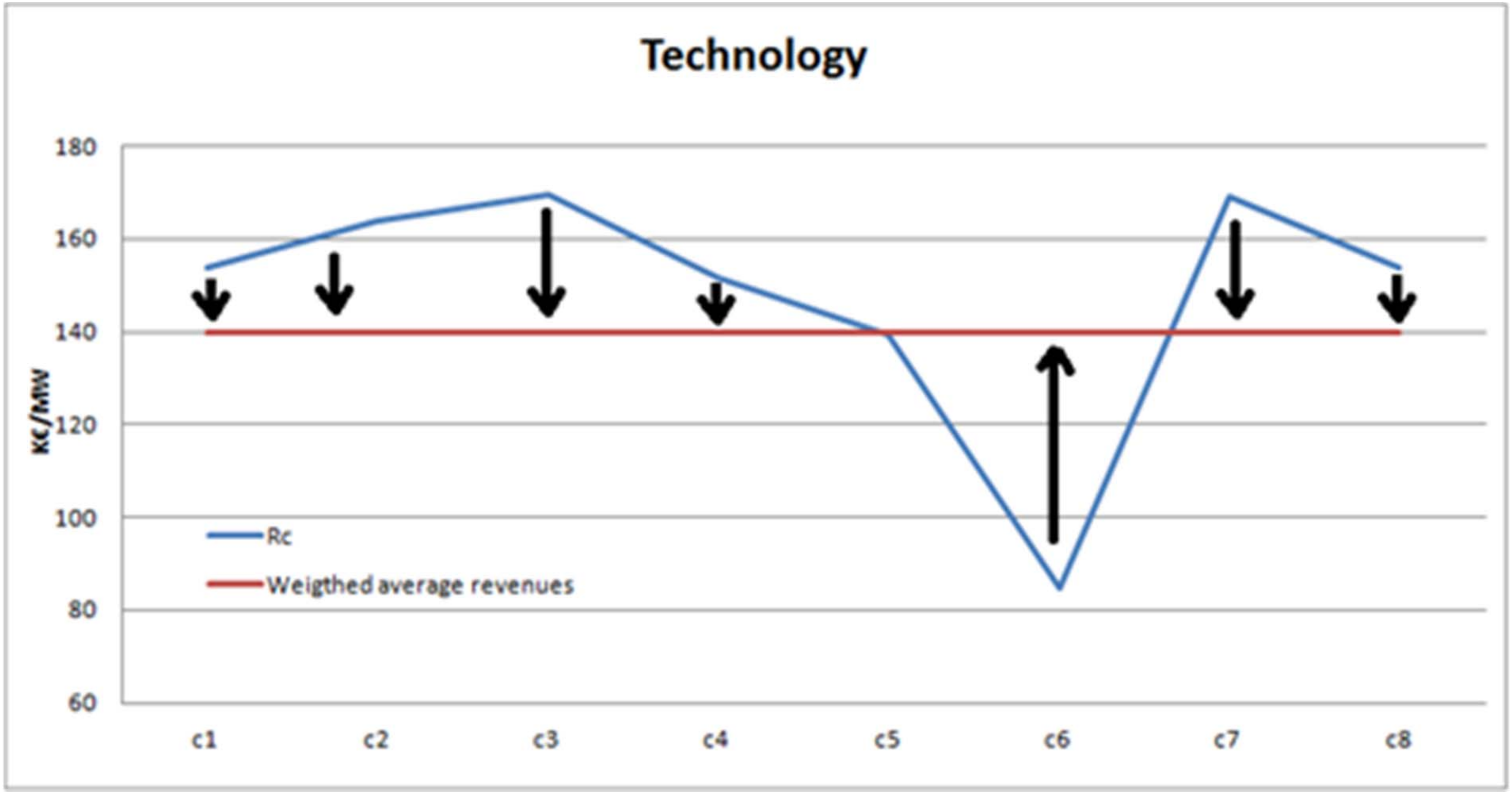
Optimization of RES

$$R_{x,c} = \frac{\sum_{h=1}^{8760} (LMP_{h,c} * Generation_{h,x,c})}{Inst.Capacity_{x,c}} \qquad (€/MW)$$



RES optimization

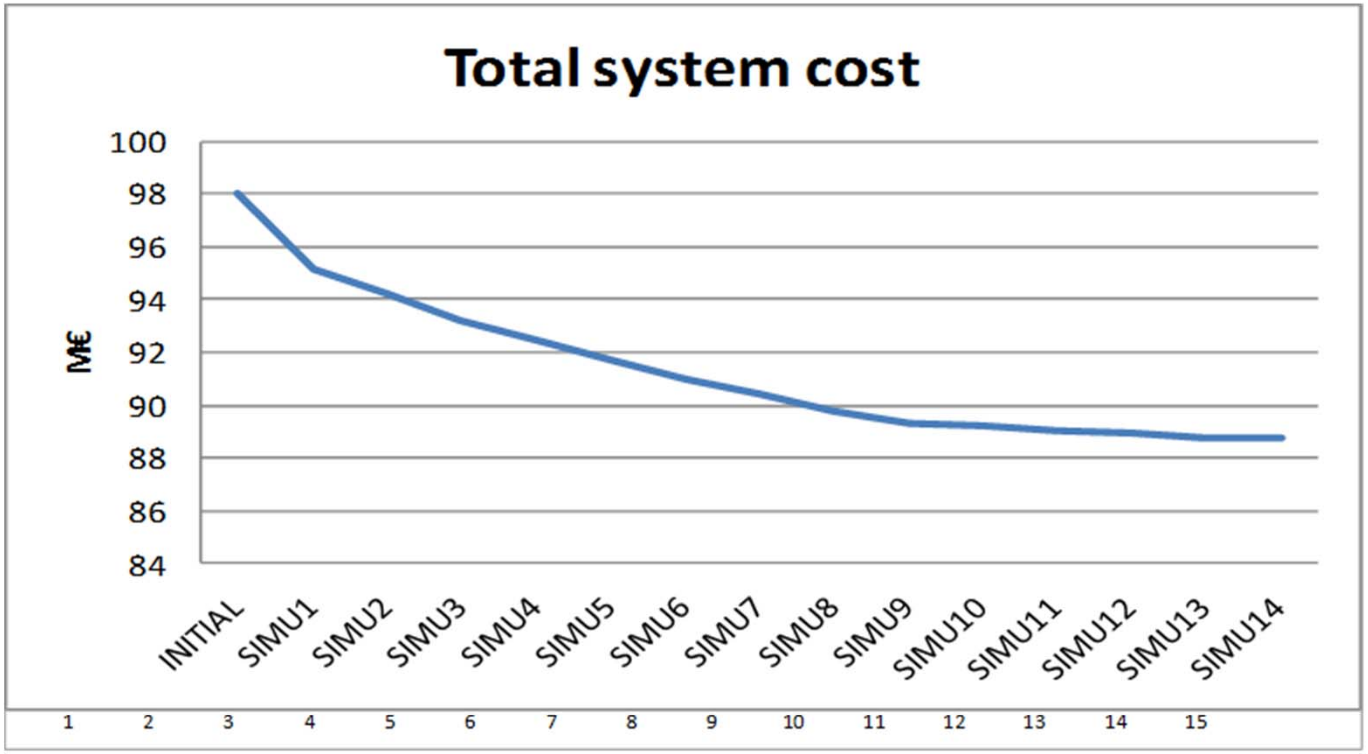
Optimization of RES



RES optimization

Optimization of RES

Example from testing the methodology (14 iterations)



Some limitations – This is a first step

- Minimum RES level per country
  (Vision 2, 2020 Expected progress, Vision 4 between vision 1 and 3)
- No re-allocation between PV, offshore wind and onshore wind
- Assuming same cost per country and only one profile per tech per country.

Detailed methodology for construction of top-down visions: Thermal reduction

Jürgen Apfelbeck - Task Force Scenario Building

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Agenda – Reduction of thermal generation

- Goal - optimizing thermal generation capacity from a Pan-European perspective
- Methodology: three step approach
- Algorithm reduction of thermal generation

Goal – Optimizing thermal generation from a pan-European perspective

The definition of the Visions and their basic approach how they are built has impact on the thermal power plant portfolio:

Vision 3: Isolated adequacy

- Visions 3 based on the assumption of a loose European framework and has the focus on the **national perspective**
  - The assumptions of Vision 3 imply that each country is isolated adequate meaning that each country is capable of covering its own peak load
  - From system perspective there is redundancy in generation capacity due to the possibility to share generation capacity via interconnectors

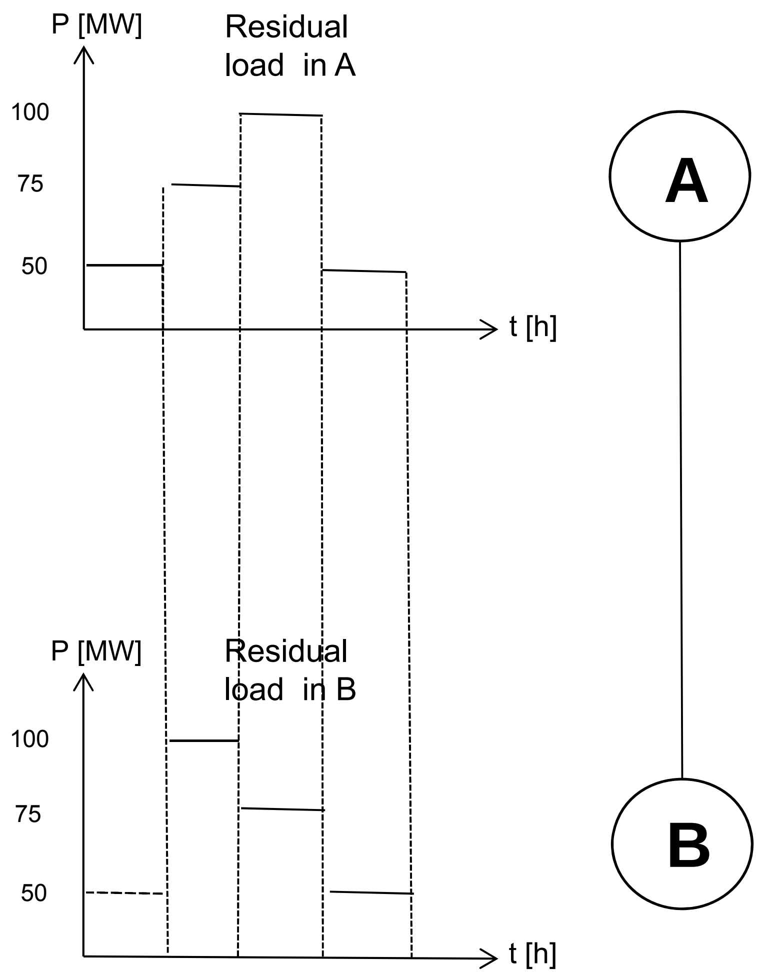
Vision 4: Total system adequacy

- Vision 4 is based on the assumption of a strong European framework and has the focus on the **pan-European perspective**
  - The assumptions of Vision 4 imply total system adequacy meaning that the peak load of each country can be covered, but not necessarily by its own generation portfolio
  - In contrast to Vision 3, there is the possibility to share generation capacity via interconnectors, the overall system is closer to a global optimum

Background – Optimizing thermal generation

The following example shows the potential to reduce the thermal generation:

- The generation capacity requirement with the assumption of isolated adequacy is 100 MW for each model region. This means 200 MW generation capacity in total
- In case of sufficient interconnection (at least 25 MW) the overall generation capacity requirement in this example system is 175 MW
  - ➢ The residual peak load of 100 MW in model region A and B is at different time periods
  - ➢ If there are no transmission losses, several solutions are equally optimal. If one assumes 100 MW generation capacity as starting solution, 25 MW could be reduced in model region A or model region B.



Methodology – Three step approach

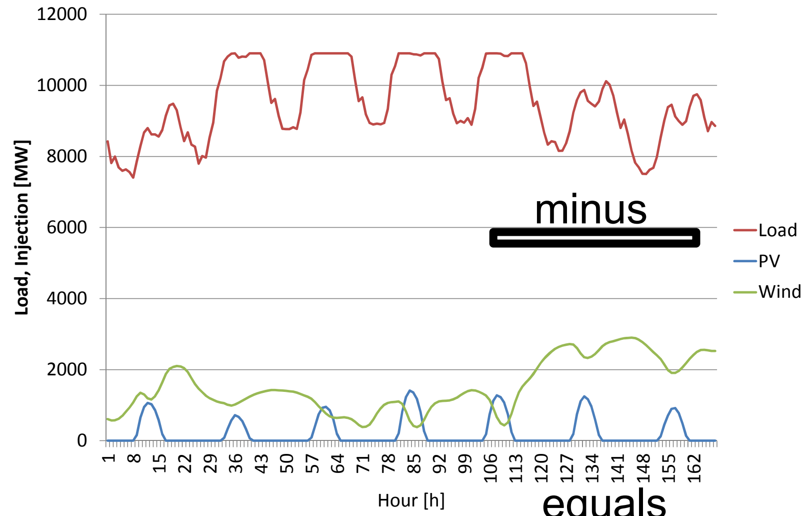
3-step methodology:

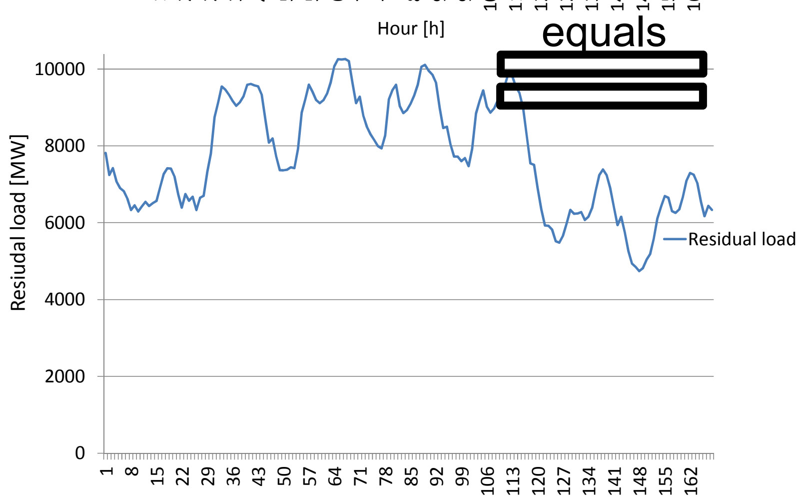
1) Determination of residual load. Inclusion of time series based generation (Wind, PV, ROR, Othres…)

2) Scaling down residual load. Consideration of inflow to Hydro reservoirs on national level without exchanges to determine relevant load for thermal generation units

Alternative: Step 1 and 2 can be performed using a full electricity market model; this approach is more accurate, but also more complex

3) Application or algorithm for reduction of thermal generation capacities with inclusion of cross border exchanges





Methodology – Three step approach

General description of steps:

- Determination of residual load after consideration of non-controllable renewable generation
  - Non-controllable generation like PV, wind onshore, run-of-river strongly,…: dispatch depends on supply; in many countries, there is priority feed in for these units
  - The difference of load and the injection of non-controllable generation has to be covered by dispatchable units
- Determination of residual load after consideration of hydro reservoir
  - In contrast to run-of river power plants, hydro reservoirs have controllable inflow, so the generation based on controllable inflow can be adapted to correlate with the relevant load (storage management)
  - The relevant load for hydro reservoir is the residual load after reduction of injection by non-controllable res generation
- Reduction of thermal power stations
  - After determination of the load that has to be met by thermal power plants, the portfolio of thermal power plants is optimized
  - The economic criterion for the optimization of the thermal power plant portfolio is the trade-off between fixed costs and variable generation costs

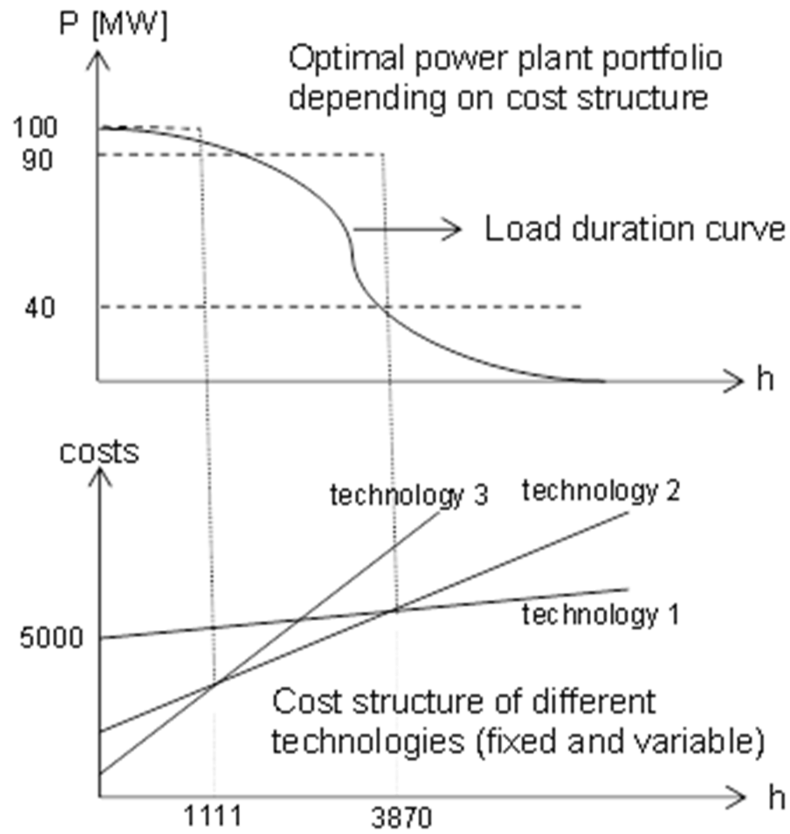
Algorithm – Thermal reduction

Optimal thermal power plant portfolio depends on:

- The shape of the residual load
- The cost structure of the generation technologies

From an economic point of view, power plant technologies with relatively high fixed costs should cover load levels which occur in a high number of hours of the year.

- The economic criteria for a technology change is the number of fullload hours for which higher variable costs overcompensate higher fixed costs
- The optimal installed generation capacity per technology corresponds to the load level of the load duration curve at the corresponding no. of hours



Algorithm – Thermal reduction

Example:

Technology	Fixed cost [€/MW]	Var. cost [€/MWh]
T1	5000	0.125
T2	2000	0.9
T3	1000	1.8

- Taking the example cost data, generation technology T3 is best for load situation that occur more than 3870 hours/p.a. The overall generation costs are 5484 €. The corresponding generation capacity is 40 MW (intersection of load duration curve and 3870 of the figure on the previous slide
- Generation technology T2 is economically best for load situations that occur between 1111 and 3870 hours/p.a. Following the load duration curve on the previous slide, this is the case for load situations between 40 and 90 MW, which indicates 50 MW of T2 from an economic point of view.

Algorithm – Thermal reduction

Algorithm logic

- Starting point for the thermal generation portfolio of Vision 4 is the power plant portfolio of Vision 3
- The reduction of thermal power plant capacity leads to a reduction in fixed generation costs, represented by the power plants and their associated fixed costs.
- If a power plant is removed it is not available for electricity generation. As a consequence, variable generation costs are likely to increase if the power plant has low electricity generation costs, because power plants with higher variable generation costs are used instead
- Optimization for the reduction of thermal generation capacities with the objective to have the best trade-off between fixed generation cost and variable generation costs

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Algorithm – Thermal reduction

The described methodology can be formulated as an optimization problem with the following equations:

- Objective function:

  Min $\rightarrow \sum_{Area} VarCost_{Area} + \sum_{Area} FixCost_{Area}$

  where *VarCost*$_{Area}$ is the sum over all timesteps *t* and generation technologies *tech* of electricity generation *VGen*$_{Area,tech,t}$ times the variable generation cost per unit *PMCost*$_{tech}$ and *FixCost*$_{Area}$ is the negative sum over all technologies *tech* of capacity reduction *VCapRed*$_{Area,\ tech}$ times the fix cost per unit *PfixCost*$_{tech}$.

- subject to:

$$\sum_{\boldsymbol{tech}} VGen_{Area,\boldsymbol{tech},\boldsymbol{t}} + \sum_{BArea} Vexch_{BArea,Area,\boldsymbol{t}} = ResLoad\_Hyd_{Area,\boldsymbol{t}} + \sum_{CArea} Vexch_{Area,CArea,\boldsymbol{t}}$$

$$VExch_{BArea,CArea,\boldsymbol{t}} \leq BTC_{BArea,CArea}$$

$$VGen_{Area,\boldsymbol{tech},\boldsymbol{t}} \leq \left(PCapstart_{Area,\boldsymbol{tech}} - VCapRed_{Area,\boldsymbol{tech}}\right) * (1 - PMargin)$$

where *VExch*$_{Barea,Carea,t}$ is the electricity exchange, *BTC*$_{Barea,Carea}$, the maximal transmission, *ResLoad_Hyd*$_{Area,t}$ the residual load to be covered by thermal units and *Pcapstart*$_{Area,tech}$, the powerplant portfolio representing the starting point from reduction and *Pmargin*, the required capacity reserve