WP5 – Assessment of the impacts of RES policy design options on future electricity markets

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Impacts of RES on electricity markets and networks

- Merit-order effect
- Price volatility
- Negative prices
- Market power
- Balancing needs and costs
- Generation adequacy
- Network effects: grid operation and investment

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Impacts Analysed

- Merit-order, prices (EU)
- Market value of RES (EU)
- Price volatility (EU)
- Balancing needs and costs (Spain)
- System adequacy (Central Western Europe)
- Network effects: grid operation and investment (South Western Europe)

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Starting Assumptions

- Policy scenarios
  - No policy
  - HARMFIT
  - HARMQUO
  - NATFIP
- Green-X results for RES capacity and CO_2 prices
- PRIMES High-RES for non-RES capacity, demand, and fuel prices

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Different methodologies

- PowerACE
- ROM
- Ecofys
- TEPES: Network expansion planning model

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PowerACE grid assumption

2 grid scenarios

- Low grid scenario: Half of TYNDP (Ten Year Network Development Plan) is realized in 2020, fully realized until 2030
- High grid scenario: TYNDP is realized until 2020, additional capacity is realized until 2030, additional capacity based on grid modeling

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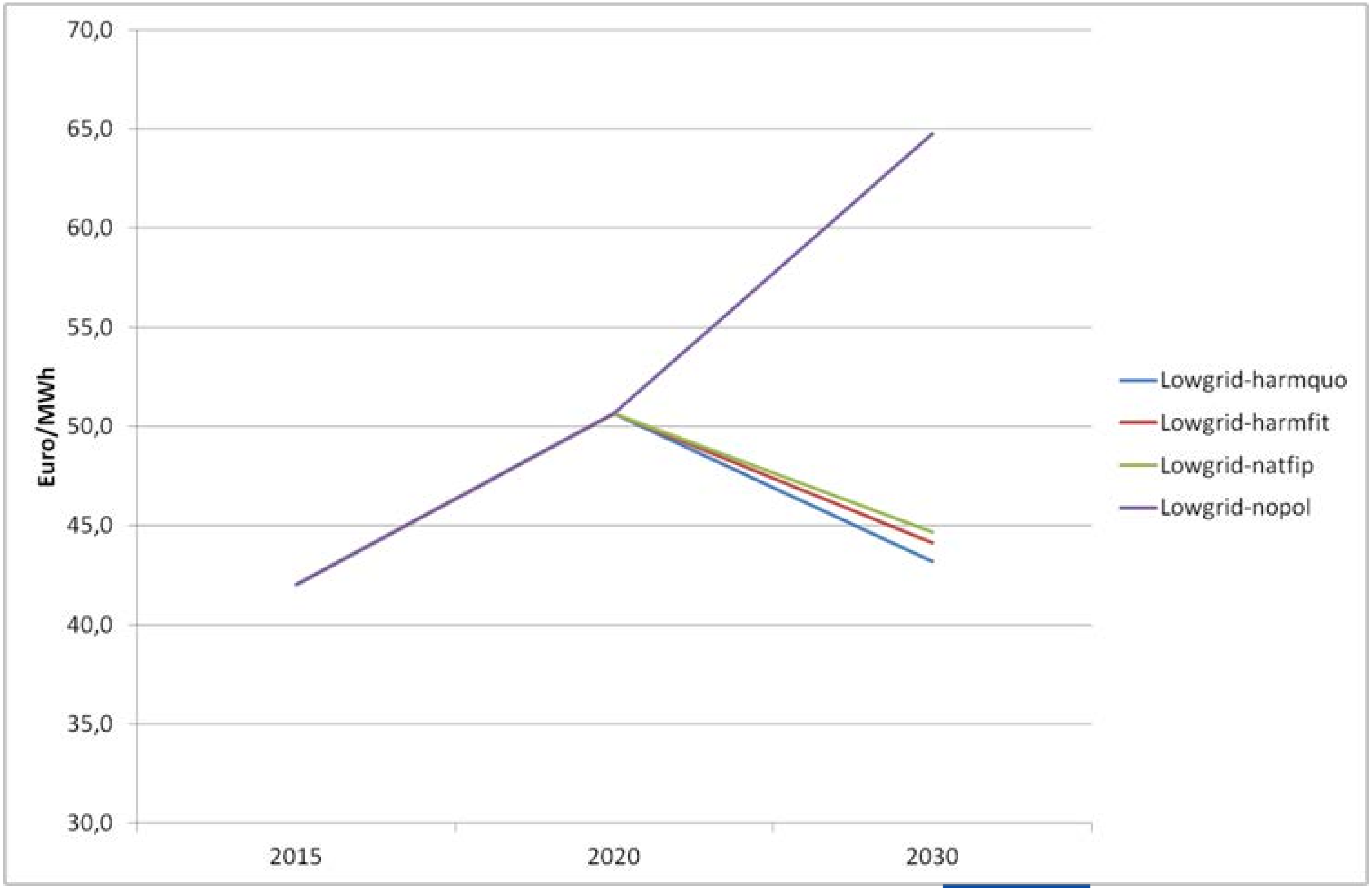
Price Effects - Low grid expansion



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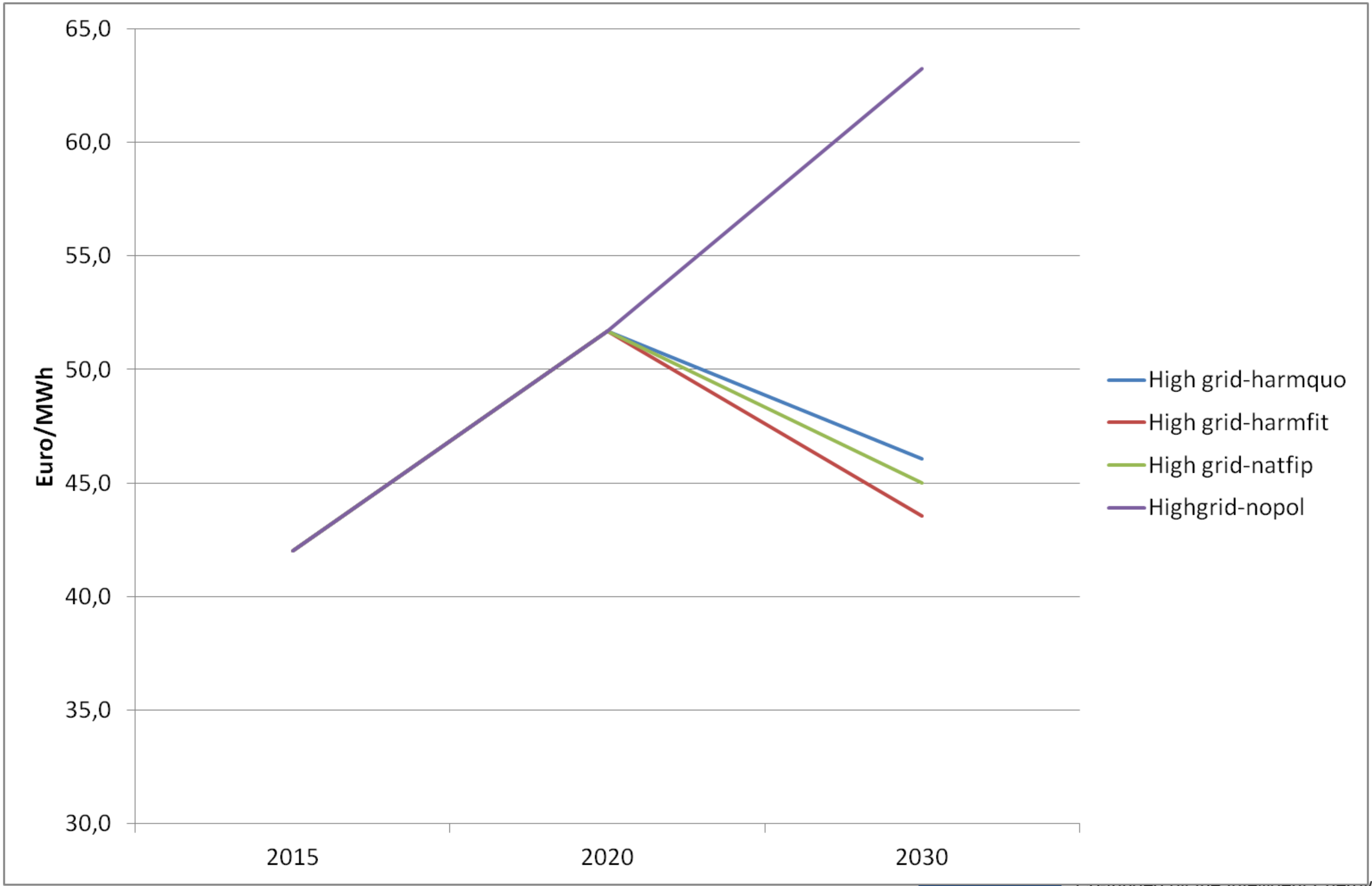
Price Effects – High grid expansion



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Price Effects (II)

- Depend much on grid expansion
  - Particularly for HARMQUO
- Increases in fuel and CO2 prices counteract the merit-order effect
  - We are not assuming a reaction of investment
- After 2030 there is a price reduction
  - Which can be due to overcapacity

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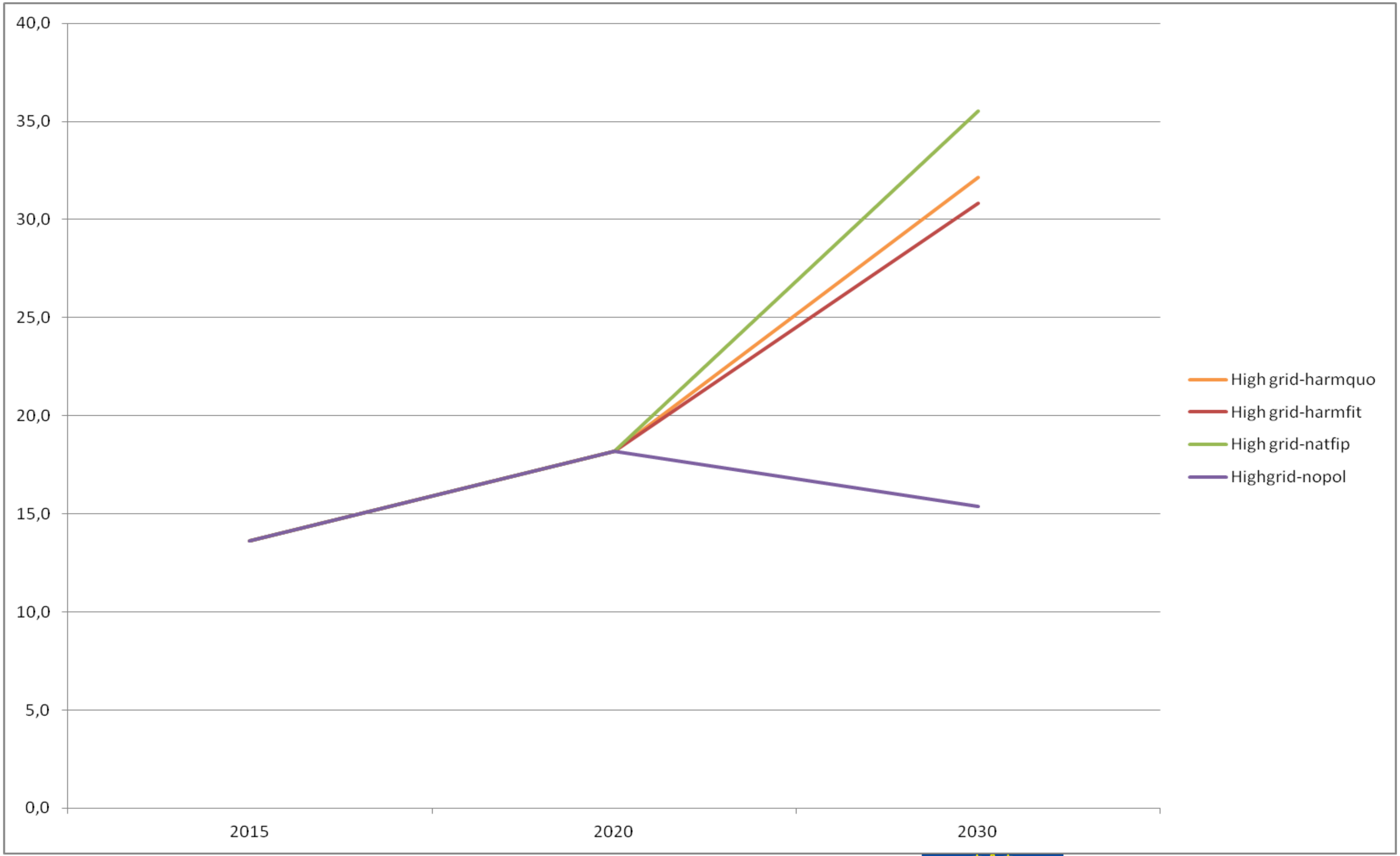
Price Volatility



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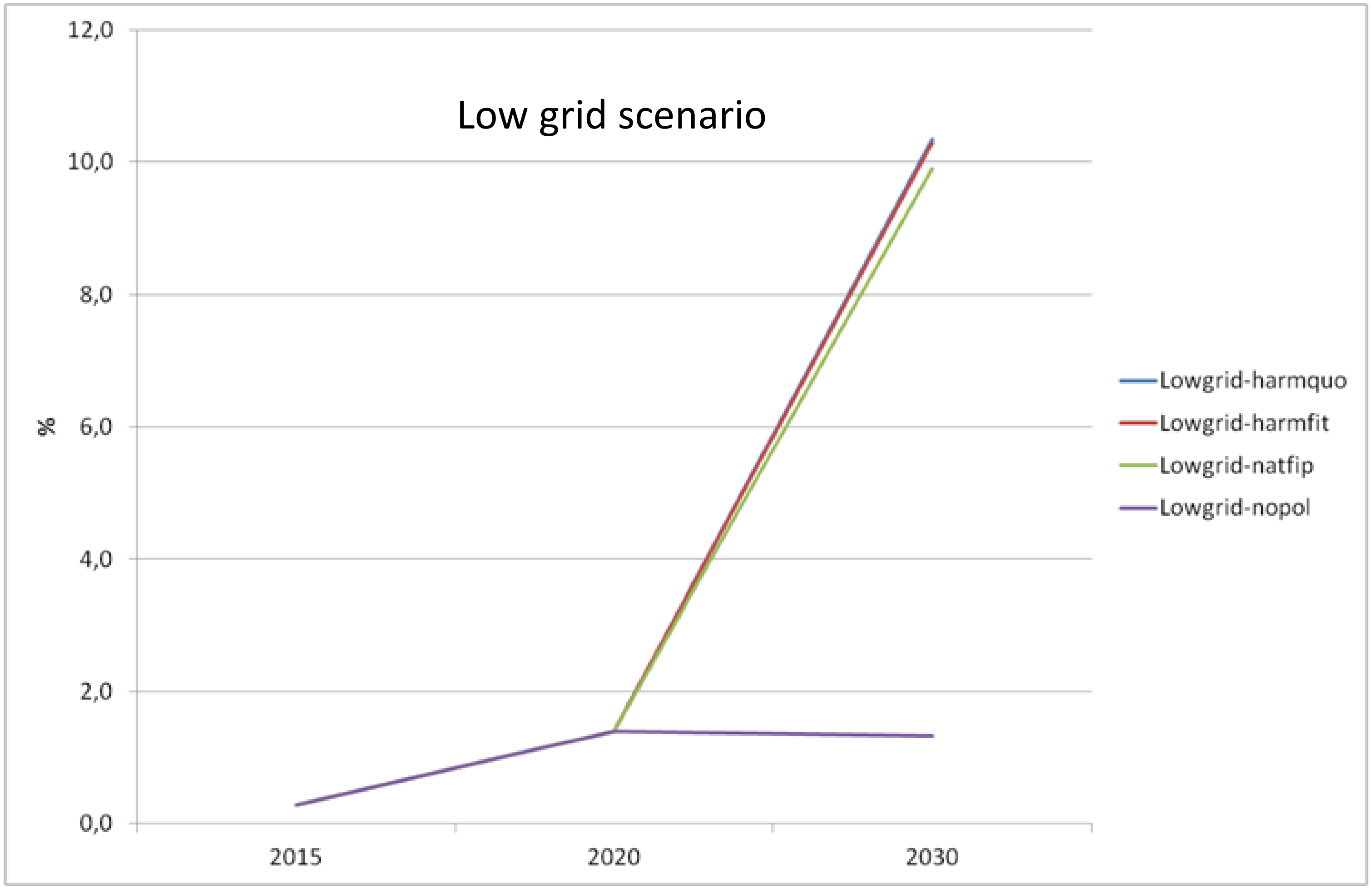
Hours with negative prices (Surplus situations)



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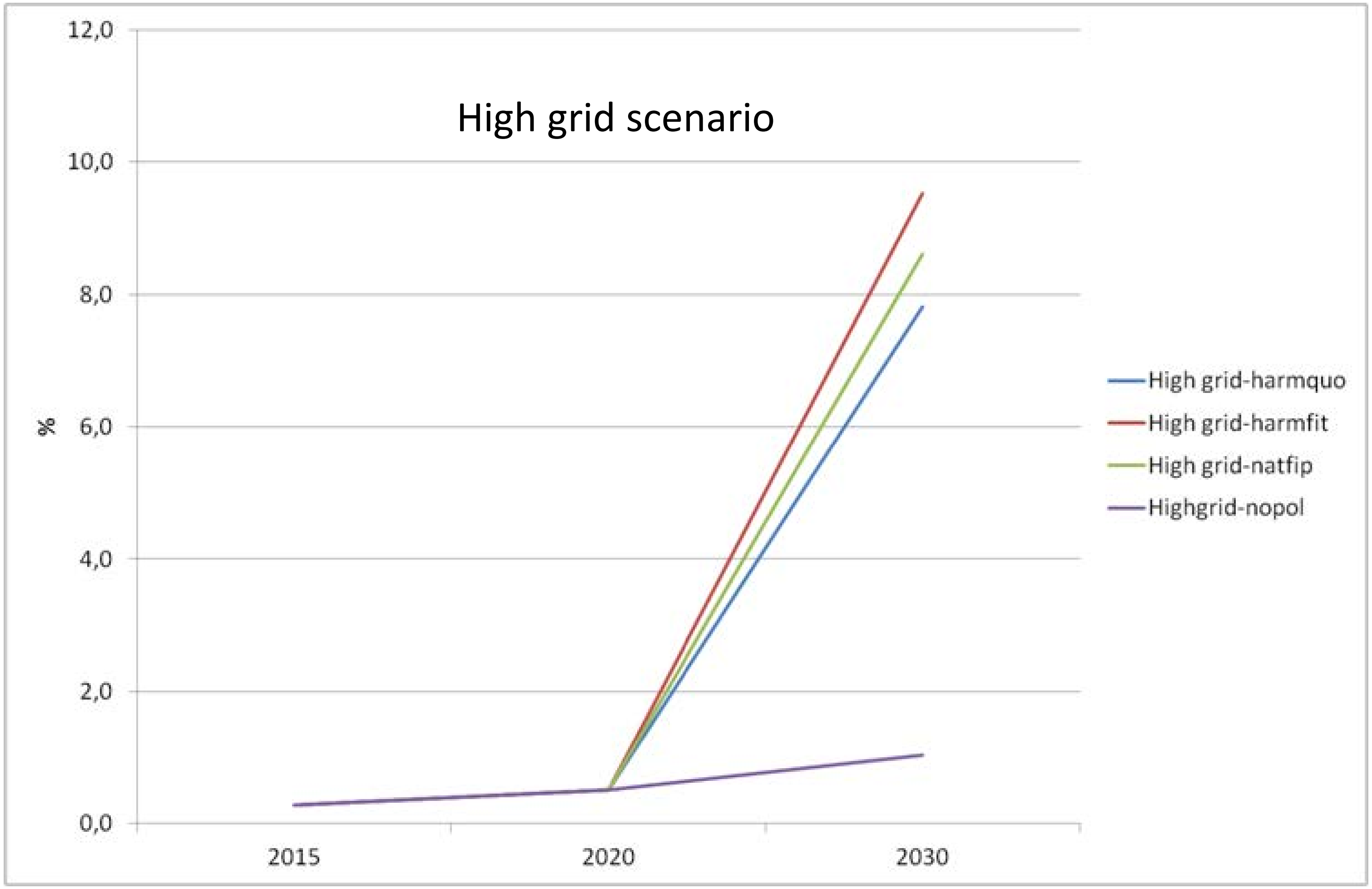
Hours with negative prices (Surplus situations)



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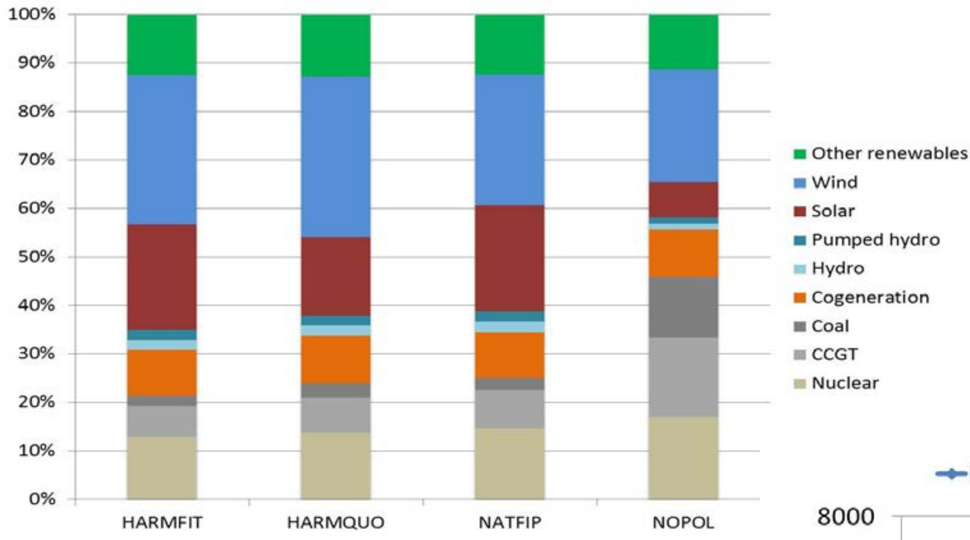
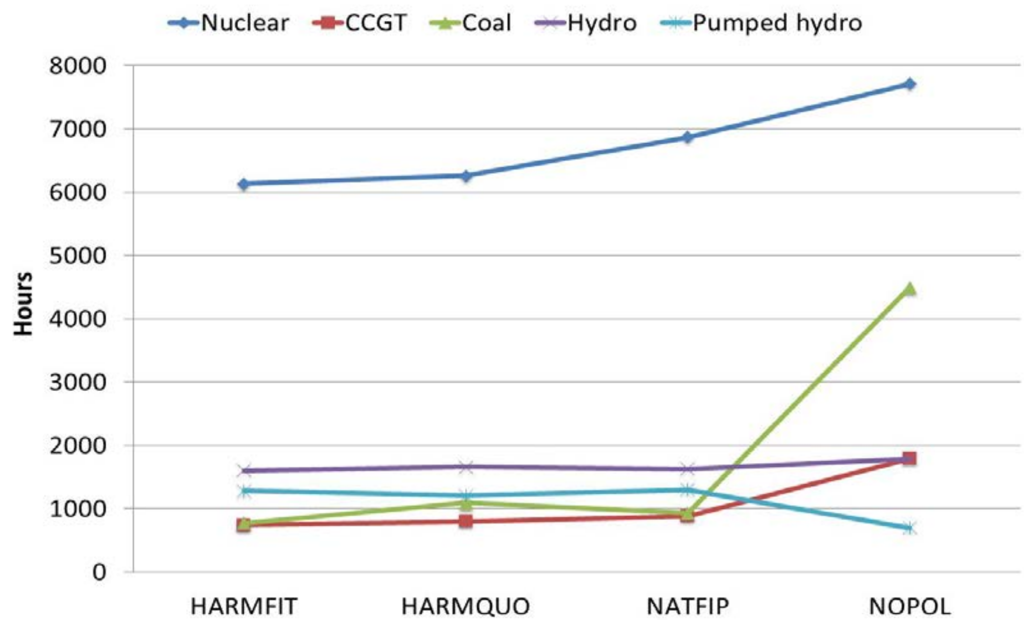
Balancing needs: Changes in the electricity mix





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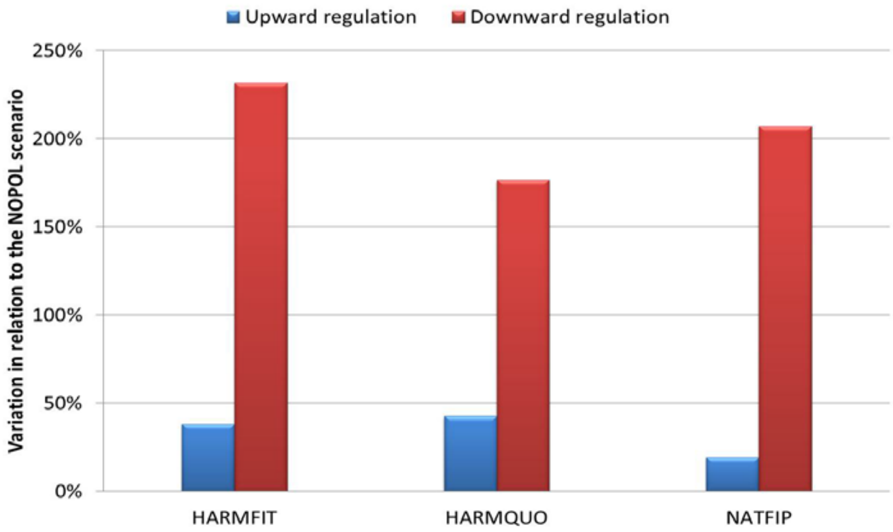
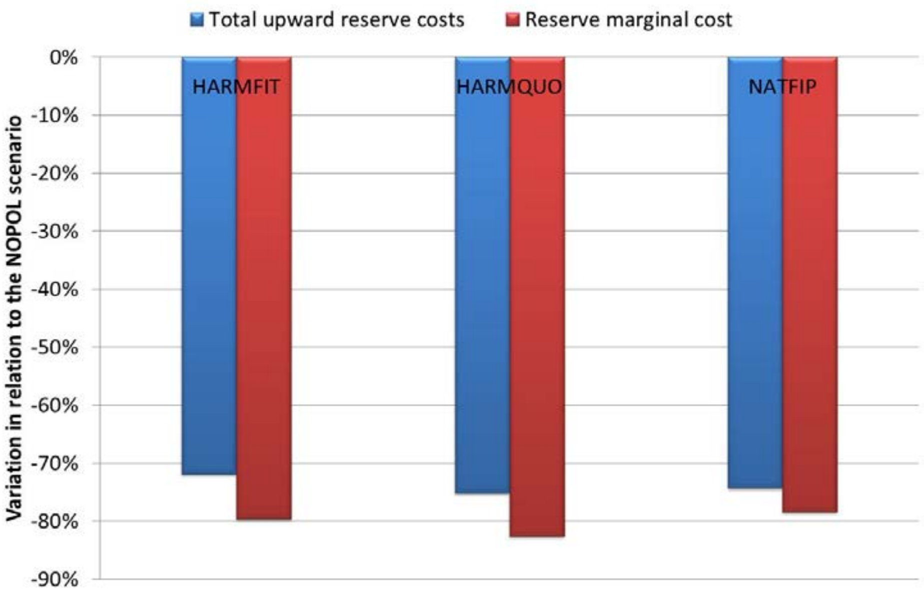
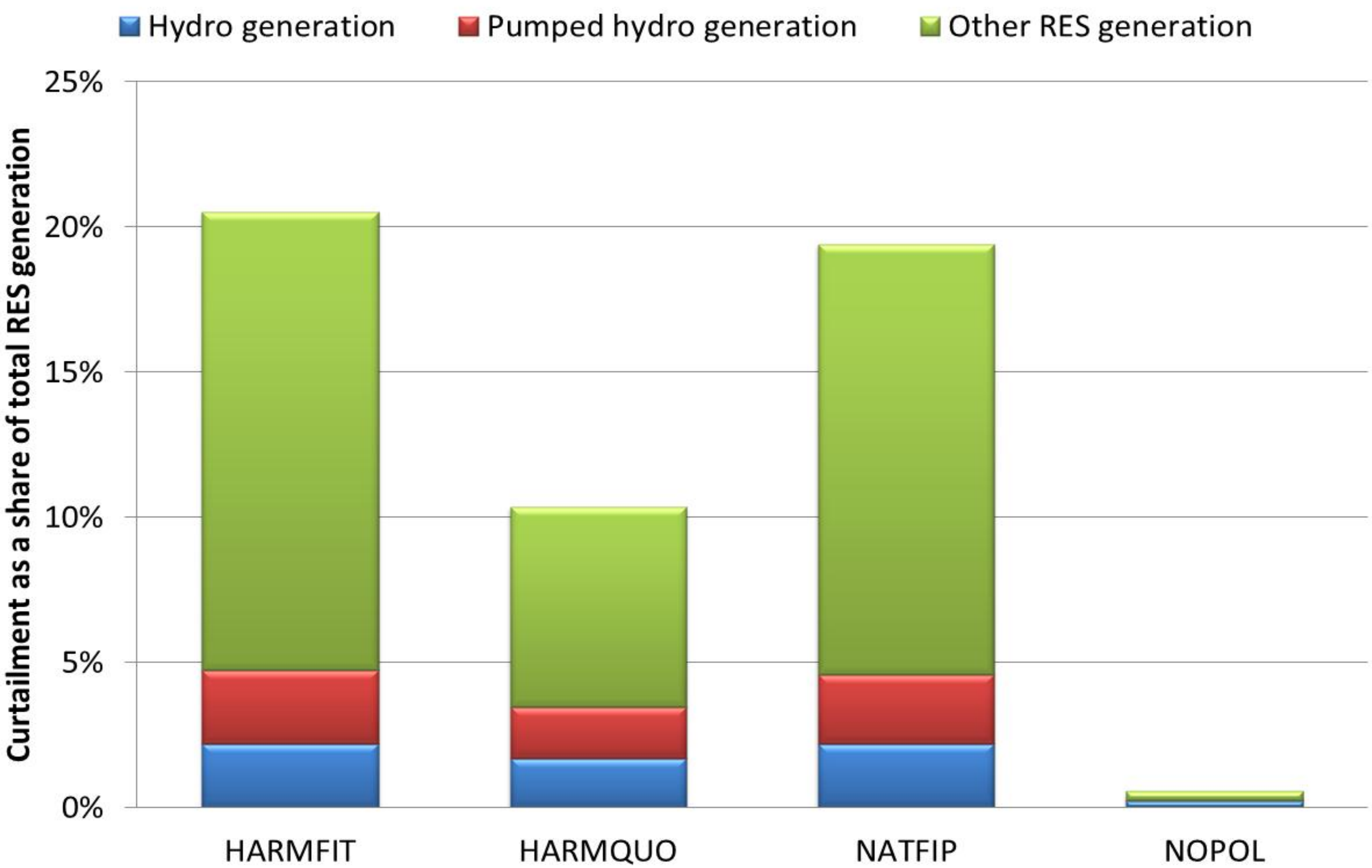
Balancing needs: Changes in reserves





Balancing needs: Curtailment



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Network Effects (I)

[M€ annual]	Harmfit	Harmquo	Natfip	Nopol
ES_C	110	49	72	72
ES_NE	167	122	151	105
ES_NW	79	50	42	46
ES_SE	147	132	146	73
ES_SW	175	120	171	86
FR_C	157	160	138	155
FR_N	130	91	119	160
FR_SE	141	81	105	95
FR_SW	112	110	84	187
PT	61	42	40	32
TOTAL	1279	957	1067	1011

	€/MWh]
Harmfit	2.13
Harmquo	1.68
Natfip	1.76
Nopol	2.43

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Network Effects (II)

- Network costs depend on the signals sent:
  - Renewable resource
  - Market/Network prices
  - Market value of RES
- When RES follow market prices: Lower network costs
- When RES capacity is low: Lower network costs
- When market value of RES is higher: Higher network costs

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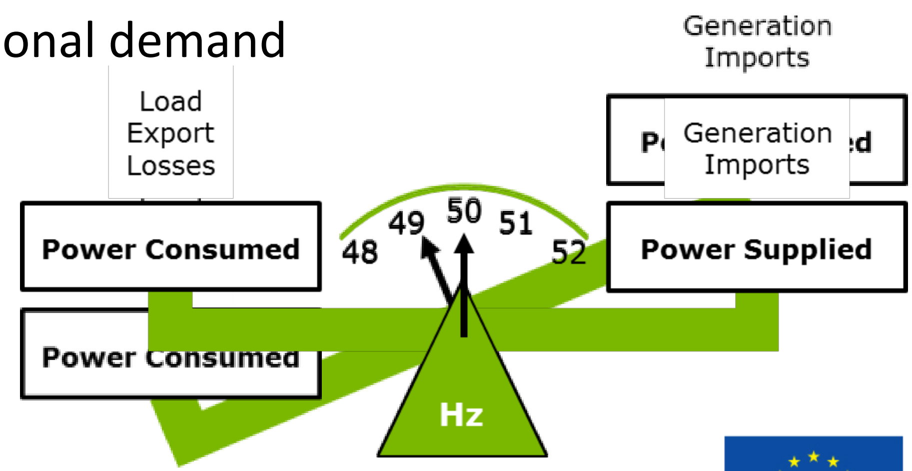
Generation system adequacy

- Generation system adequacy: are there sufficient generating facilities within the system to satisfy demand (all operational instances)?
- The ENTSO-E member countries assess the adequacy of generation capacity every year for existing and future system.
- Calculations are pursued on a national level: each country only takes into consideration power plants built, retired and mothballed inside their national borders and national demand



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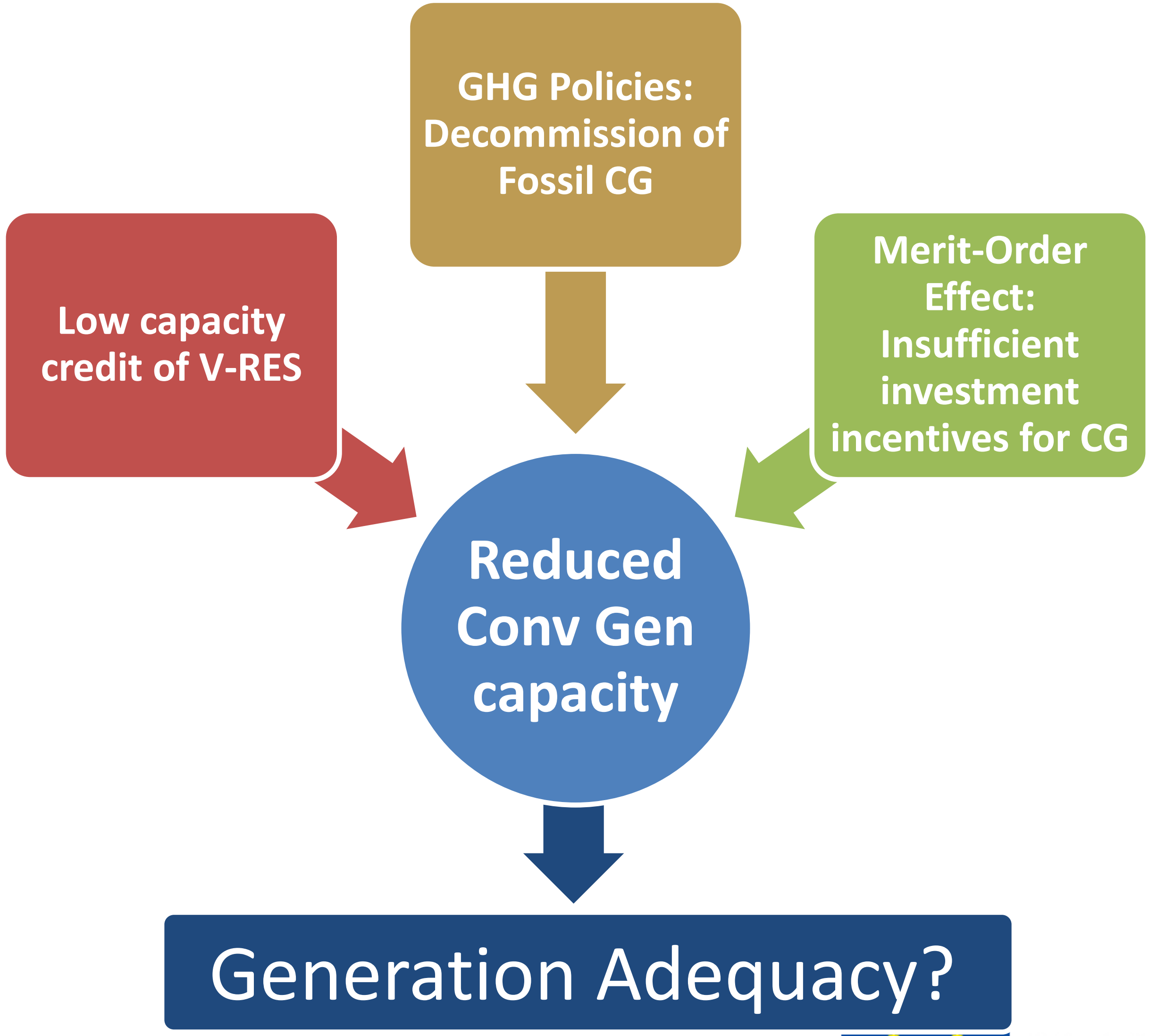
Generation system adequacy: RES Impacts



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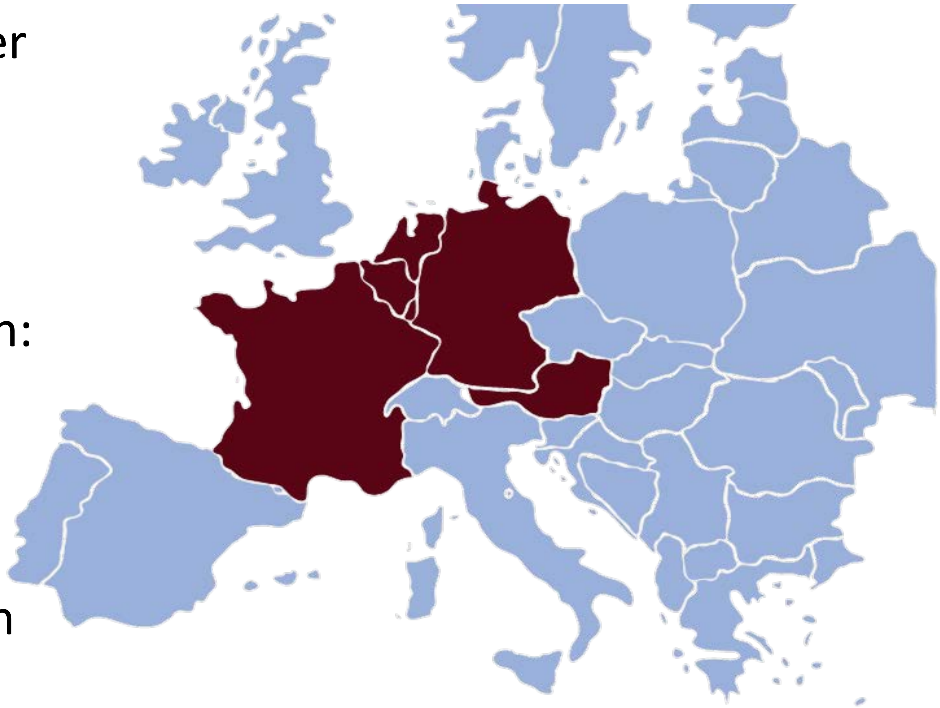
System adequacy on European-scale with multiple areas

- High-RES scenario for 2030
- Stagnating fleet of conventional power plants
- Constant demand
- Three scenarios for market integration:
  1. NO INT: No market integration
  2. INT: Market integration
  3. INT+20: Market integration with increased interconnection



Reliability target: 1 day of loss of load in 10 years
(Loss of Load Expectation = 0.9997)

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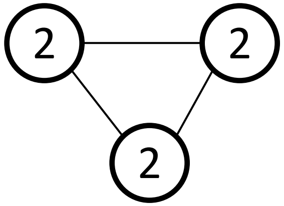
The modeling challenge: Ecofys Multi-area reliability assessment tool

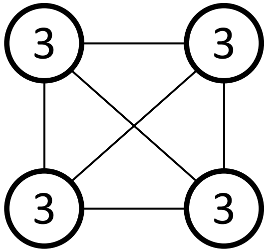
- Complex problem, combinatorial explosion:

  2 states (ON/OFF) for each component = 2^N combinations

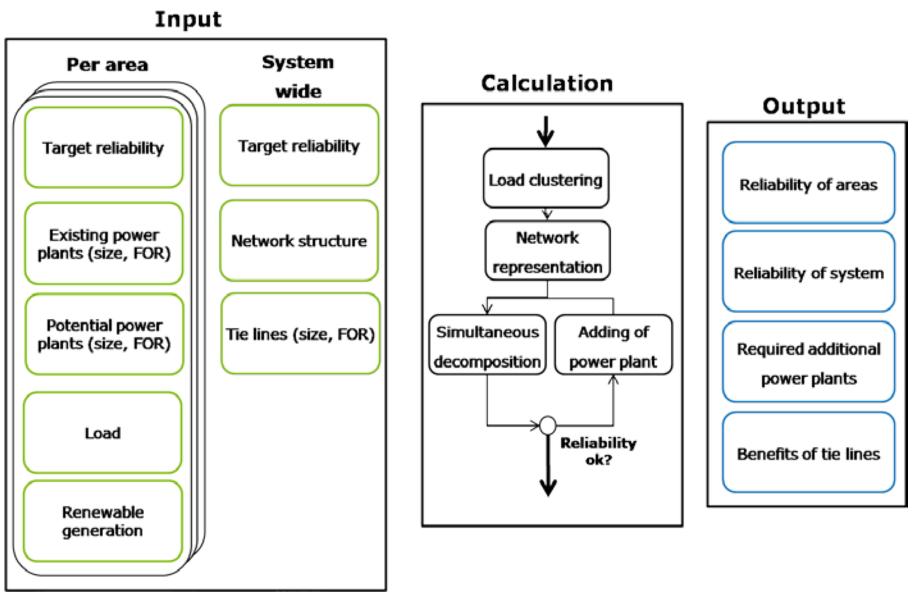
  3 areas, 2 generators, 1 load case: 512 cases

  4 areas, 3 generators, 1 load case: 262 144 cases





- Common approach: Decomposition



Model structure:
- Formulation: maximum network flow problem
- State space decomposition
- Iterative approach to estimate additional capacity needed

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RESULTS: NO INT

- Plants are added stepwise (500MW):

  plant is added to area with lowest reliability

  process stops if reliability target is achieved in all areas

- Additional capacity requirements are vastly different between countries

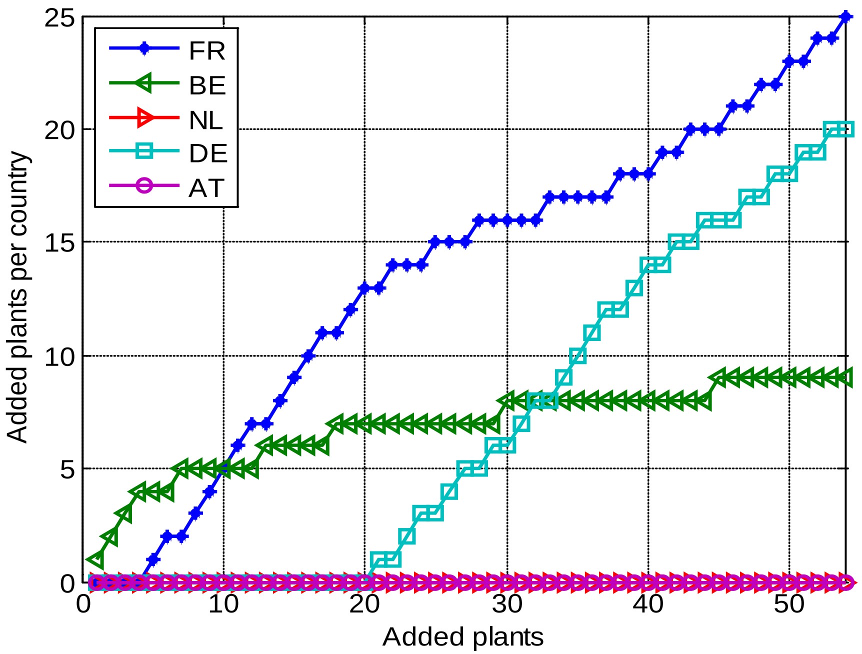
- 54 plants (27GW) are needed:

  25 plants in France

  20 plants in Germany

  9 plants in Belgium

	AT	BE	DE/LU	FR	NL
Margin (GW)	+ 1.9	- 4.1	- 7	- 10.1	+ 2.2



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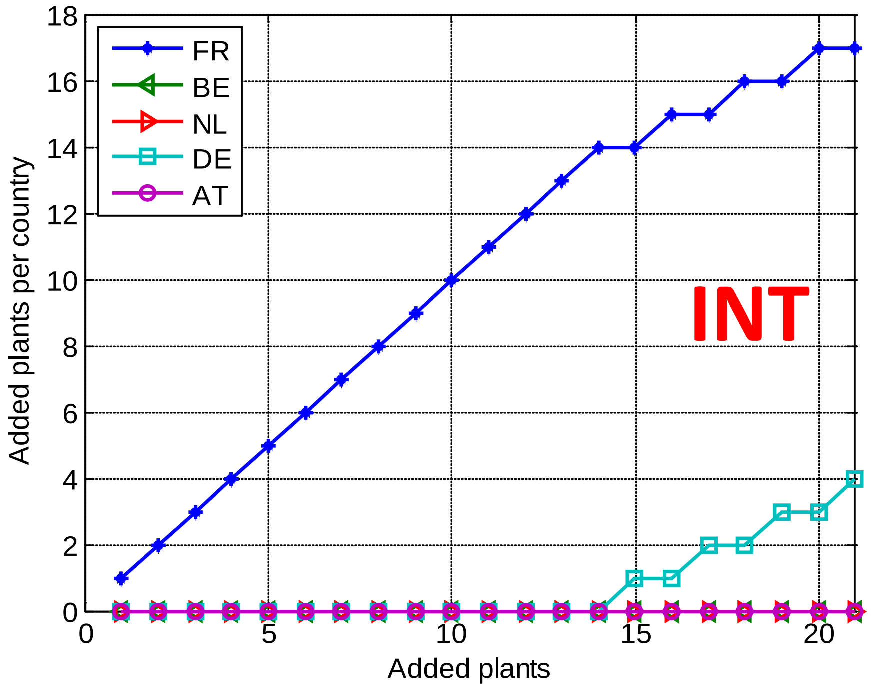
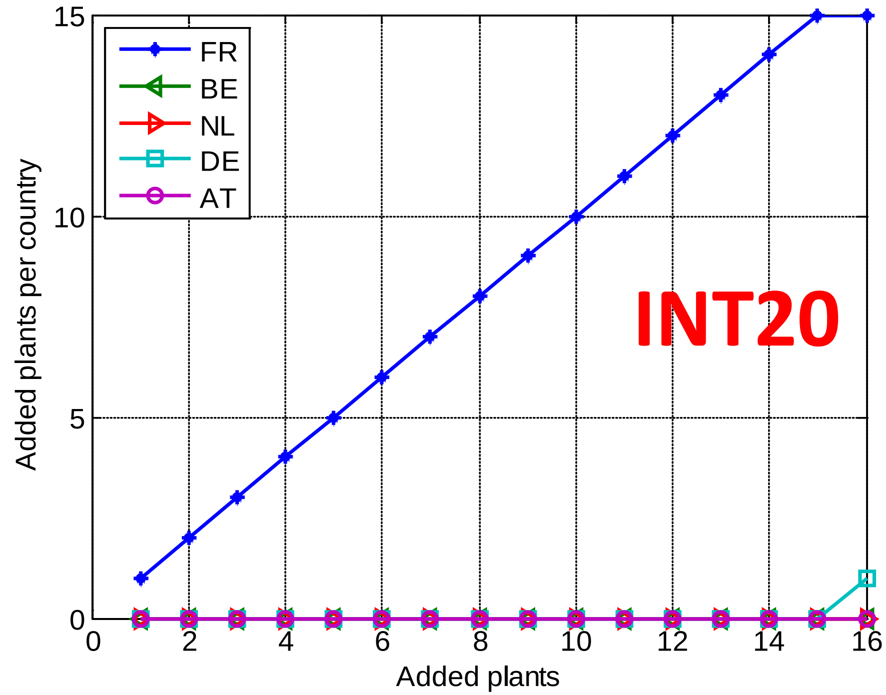
RESULTS: INT – INT20





- Market integration brings a significant reduction to the required capacity

  INT: 10.5GW (21 plants) needed

  INT20: 8GW (16 plants) needed

- Additional capacity is needed mainly in France

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Conclusions – System Adequacy

- Large-scale deployment of RES capacity acts as a disincentive to the deployment of conventional power plants and endangers system adequacy
- Integrated markets: the required amount of back-up capacity more than halves compared to the case of isolated countries.
- Interconnection: further gains in generation system adequacy are achieved (CWE region: a 20% increase in interconnection capacity leads to a 24% decrease in needed backup capacity)
- An integrated system approach for the assessment of the generation system adequacy in Europe would be a more cost-optimal solution. National reliability targets should be changed to European reliability targets.

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Summary of results

- Significant merit-order effect – which may be caused by overcapacity
- Increase in price volatility – dampened by grid reinforcement
- Large risk of loss of adequacy – if there is little integration
- Need for additional capacity – difficult to meet with reduced market prices
- Balancing needs increase very much – but costs may even decrease
- Costs of network expansion rather low – largely dependent on policy instruments

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Overall Conclusions

- Impacts depend mostly on the amount of RES, not as much on their distribution/support system
- Market impacts are mitigated by a stronger grid expansion and market integration
  - That means common rules and common assessment/decisions
- The higher the market value of RES, the stronger the grid reinforcement
  - But market value decreases with RES

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Recommendations (from the lit review and the assessment)

- Improved cross-border transmission policies and better network signals
- Substantial grid investments required
- Need for more flexibility in the system
- Pricing and bidding rules may need to be reconsidered
    - Internalization of non-convex costs

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Some Caveats and Limitations

- We do not assume a joint optimization of the system:
  - Only the impact of RES expansion
  - And assuming that the system does not react to this (grid, conventional)
- The network study does simulate grid expansion, but at a lower detail
- Some results are regional and difficult to extrapolate
- We are not considering the full set of options for flexibility (e.g. demand response)

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Thanks for your attention

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