



PV in the German power market

– An analysis of short-term and long-term effects

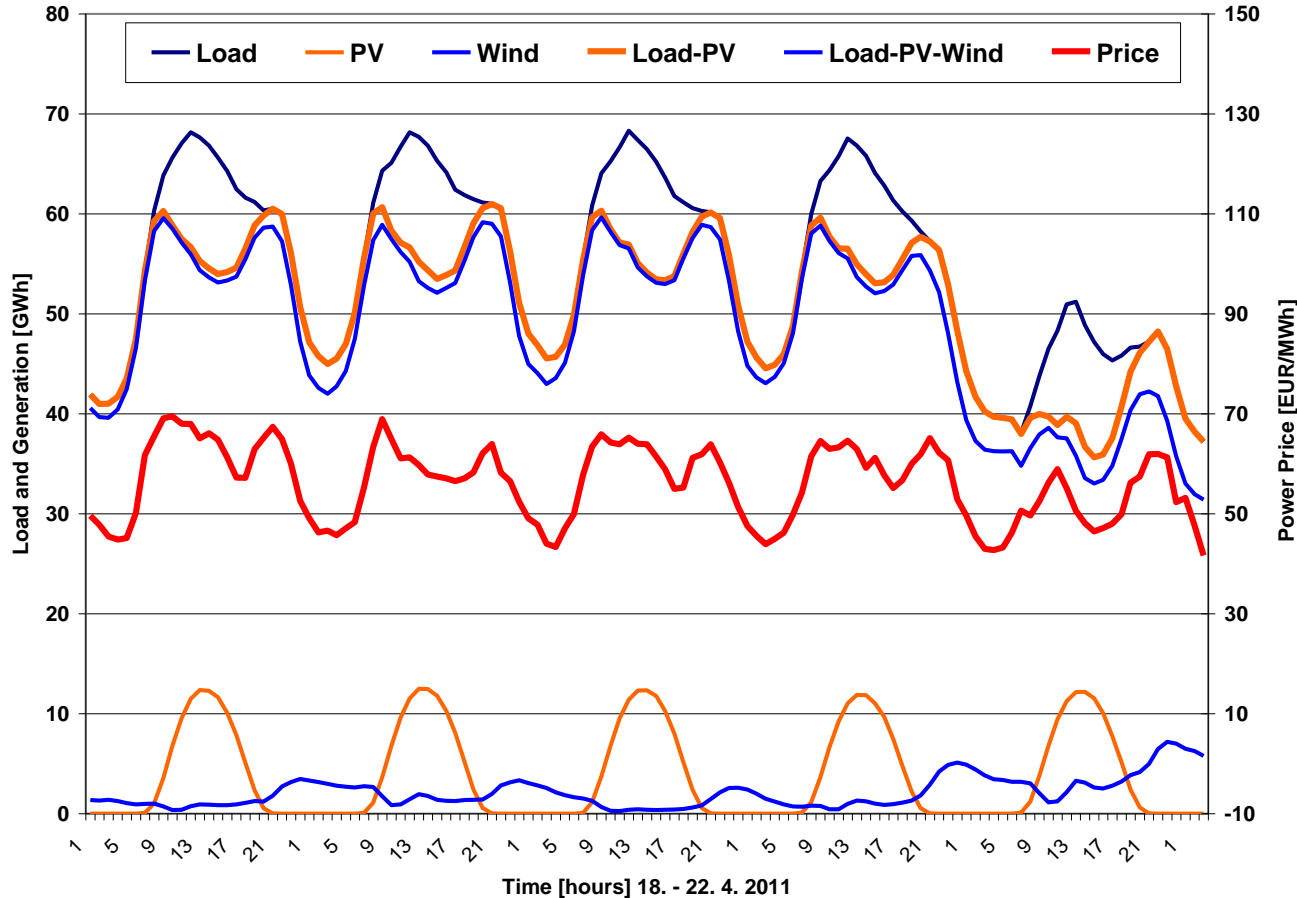
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Introduction and motivation

The sunny week before Easter 2011



Load shows a clear noon peak

Load minus PV shows a valley during the noon peak

Price follows this pattern

Plants tend to stay online during valley and export energy

Source: own illustration, data from EEX, EPEX, ENTSO-E

Methodology

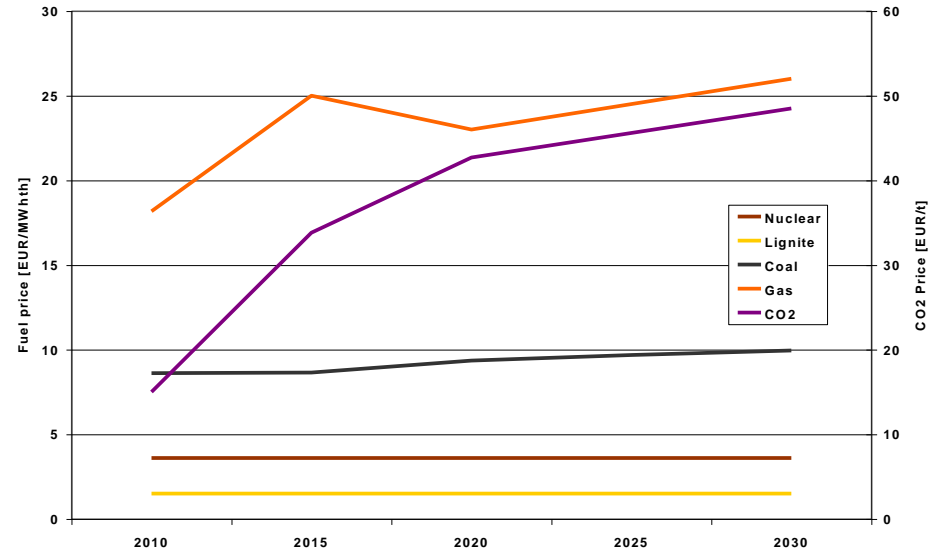
Power Market Optimization Model

- Investments in 5-year steps
- Dispatch in 8760 hours per year
- Ramping costs and constraints
- Part-load costs
- Reserve constraints

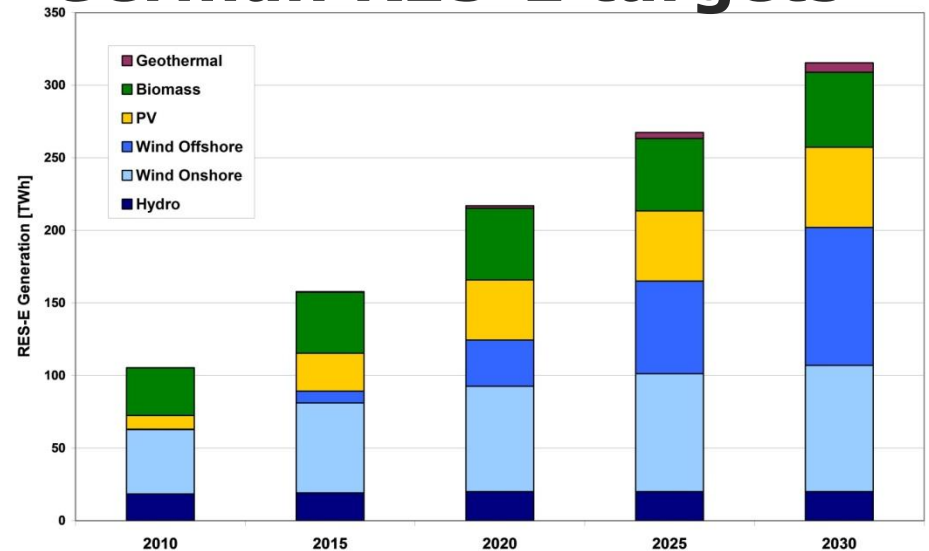
Considered regions



Variable costs

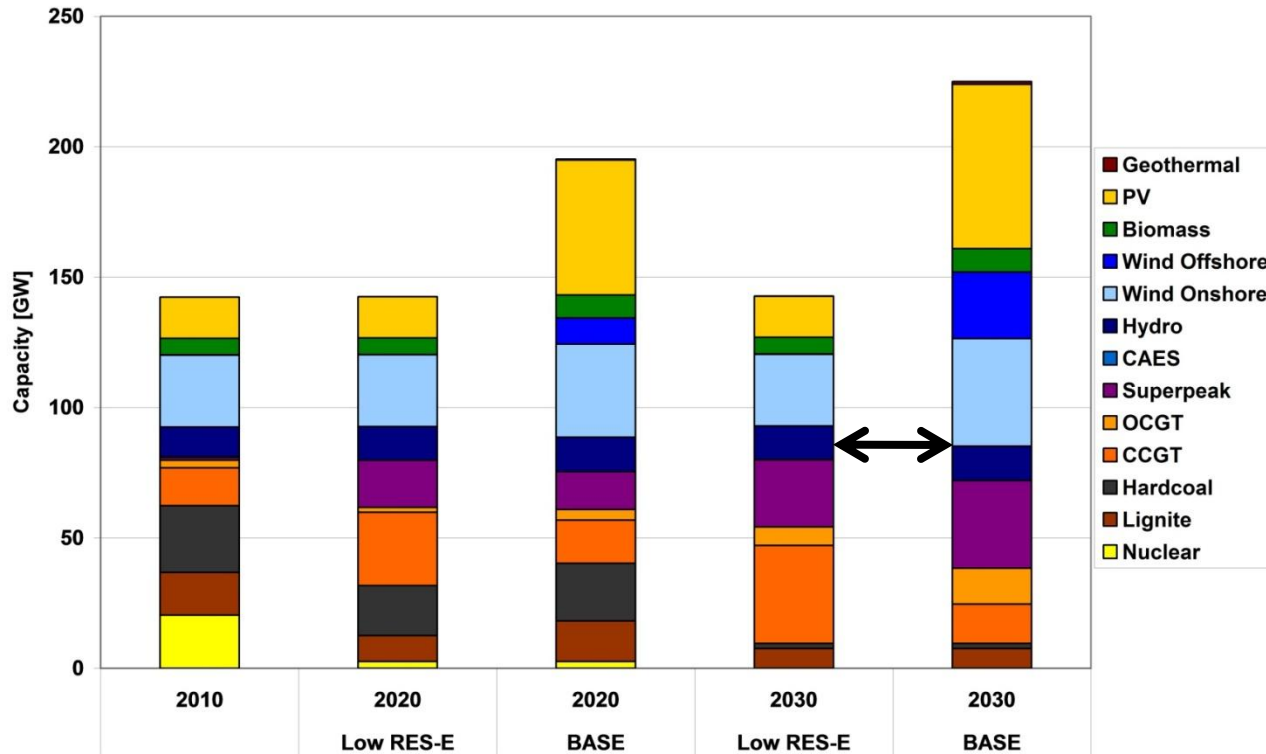


German RES-E targets



Source: NREAP 2010, IEA, 2010, EWI, 2010 and BMU 2010.

Capacity development in two scenarios



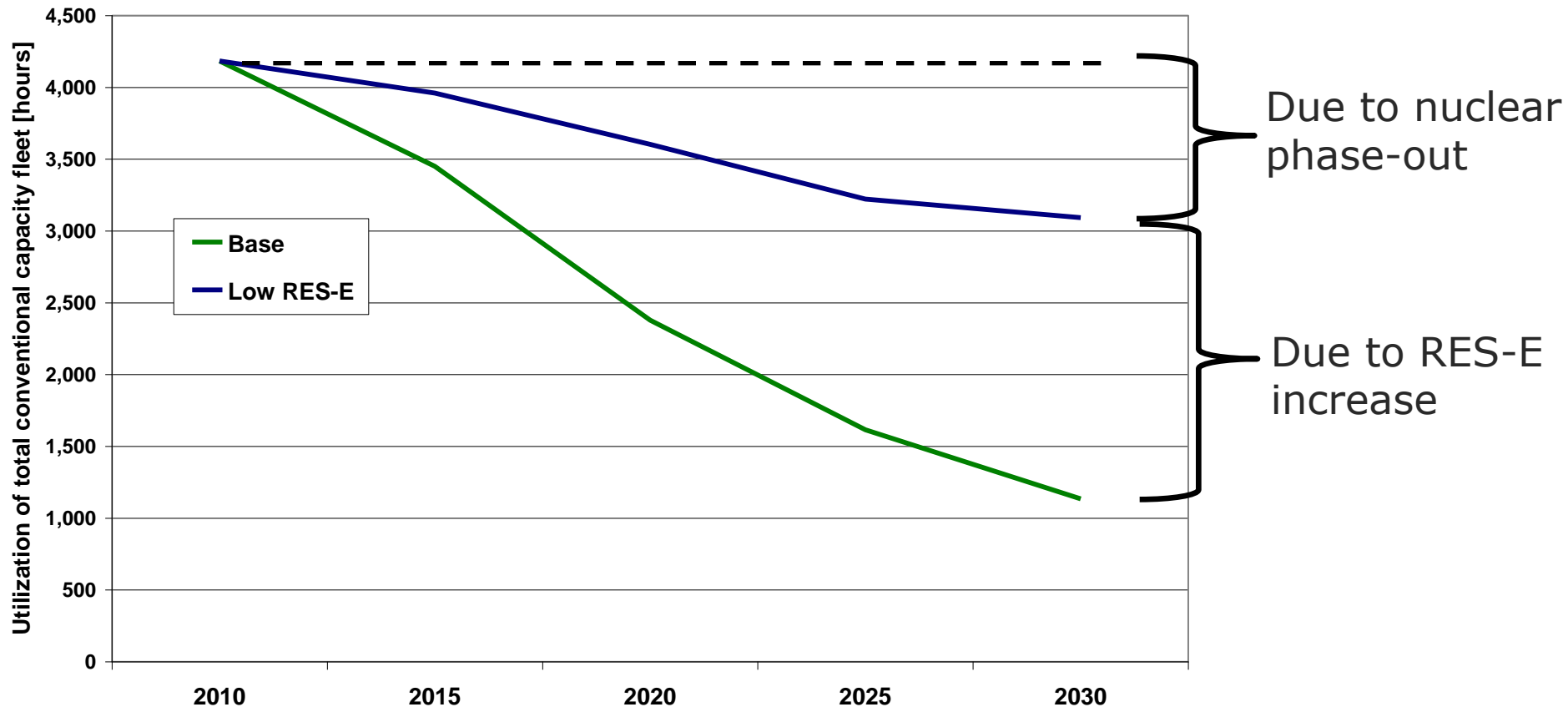
Only little conventional capacity can be substituted due to RES-E

Total capacity increases significantly

No CAES investments

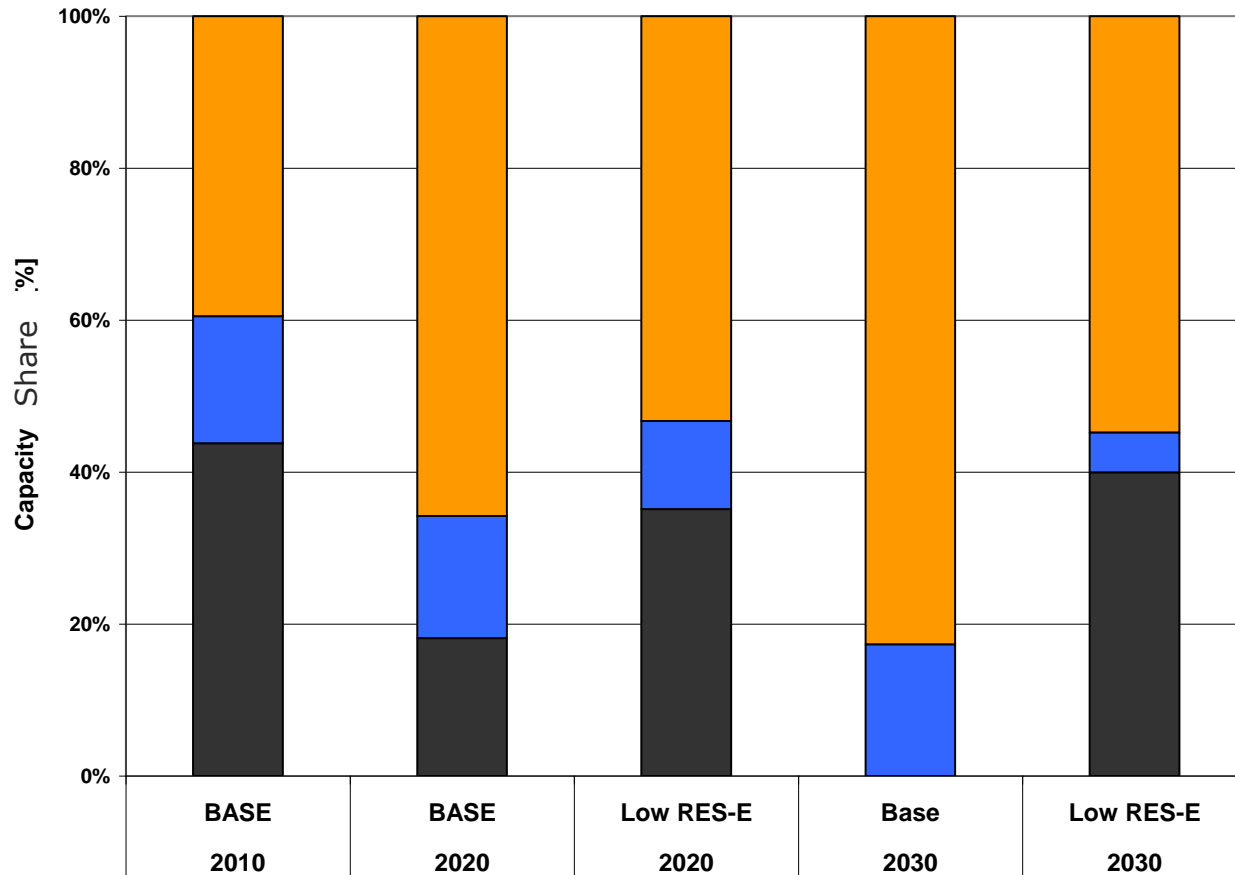
The optimal conventional capacity mix tends to be more peak load oriented with higher RES-E shares!

Utilization of conventional capacity I



Utilization of conventional capacity decreases significantly!!

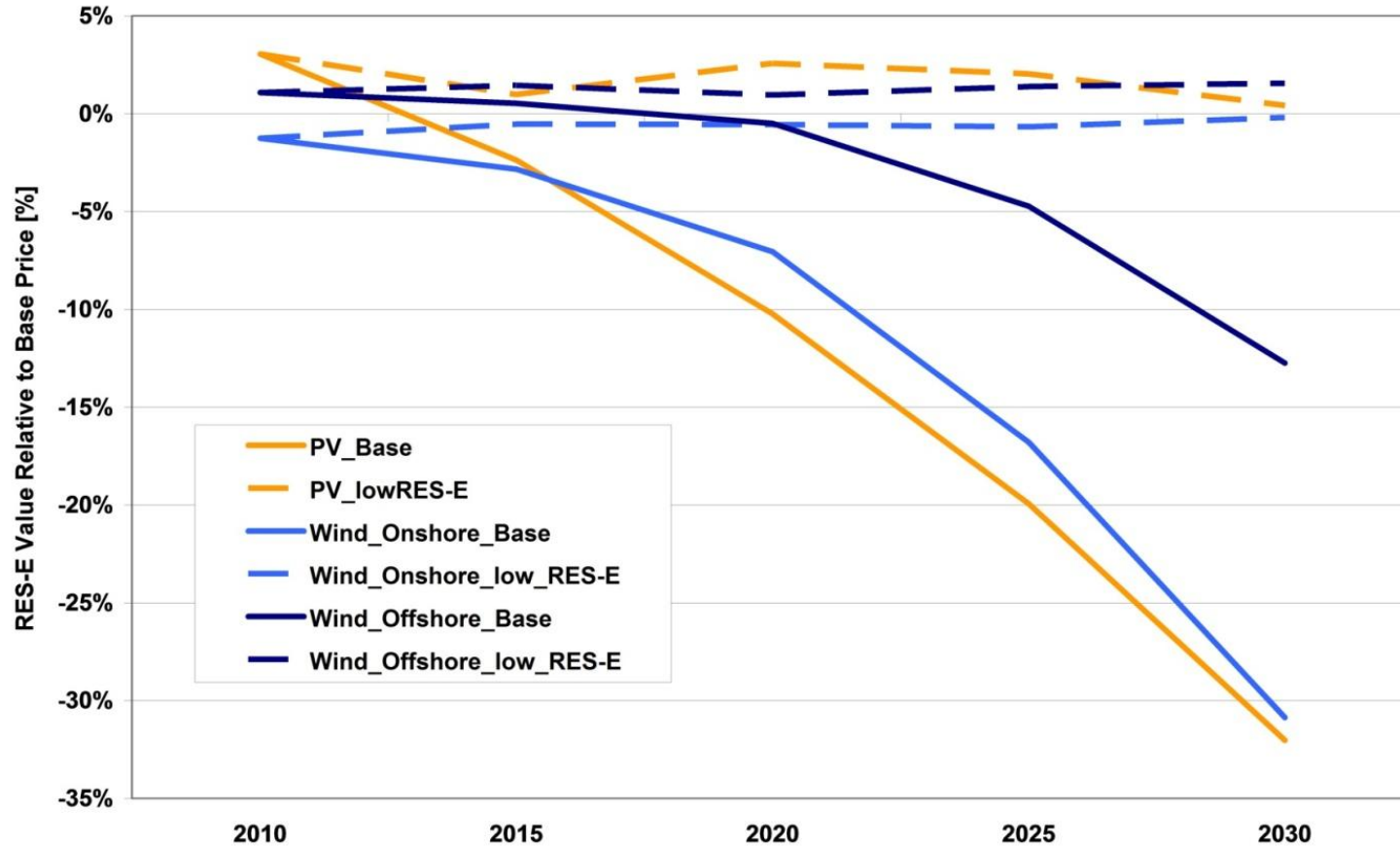
Utilization of conventional capacity II



With constant RES-E share, a stable share of base load generation remains

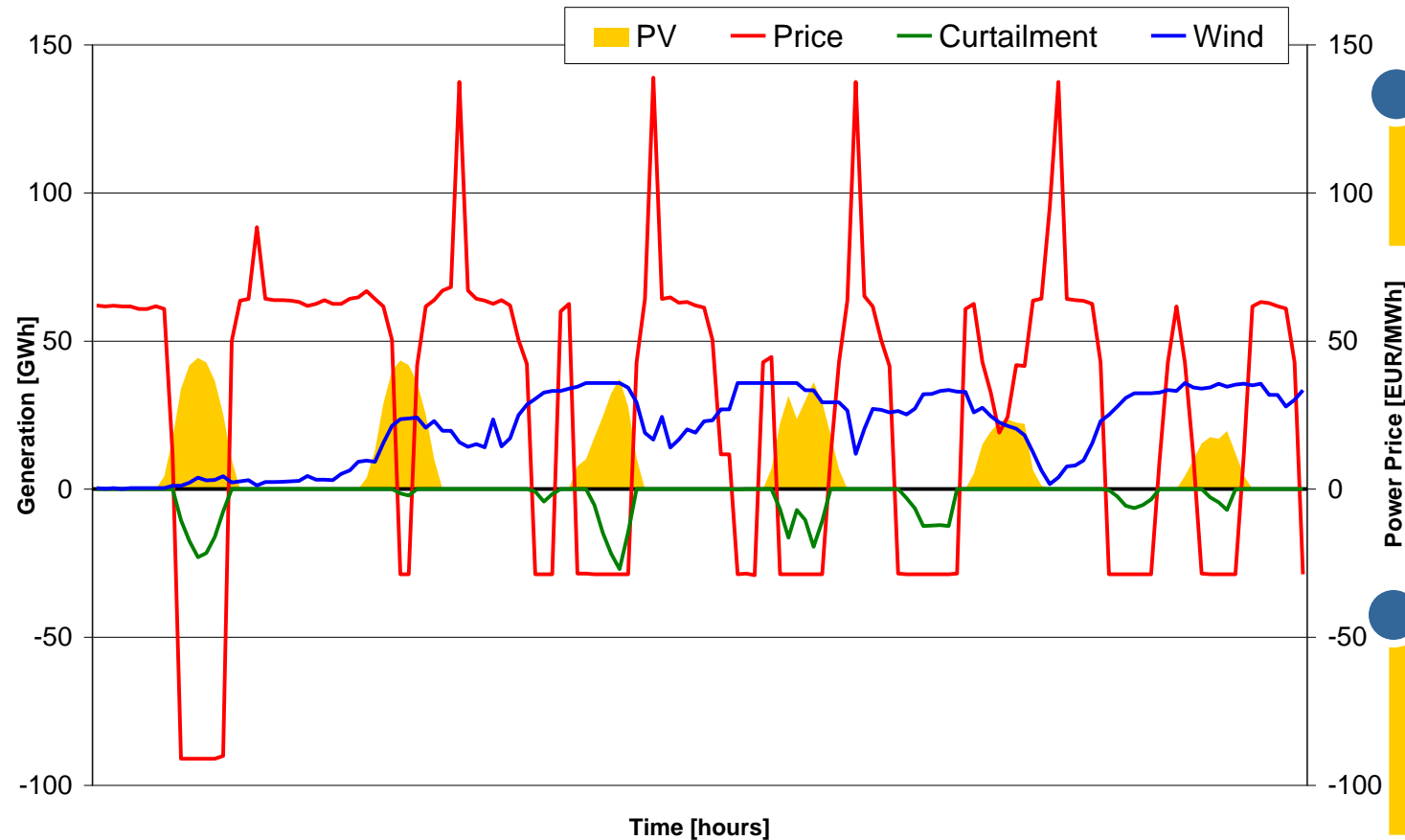
The baseload share shrinks with further RES-E increase

Development of relative RES-E wholesale market value



The relative market value of PV decreases with increasing installed capacities

A very sunny week in 2030

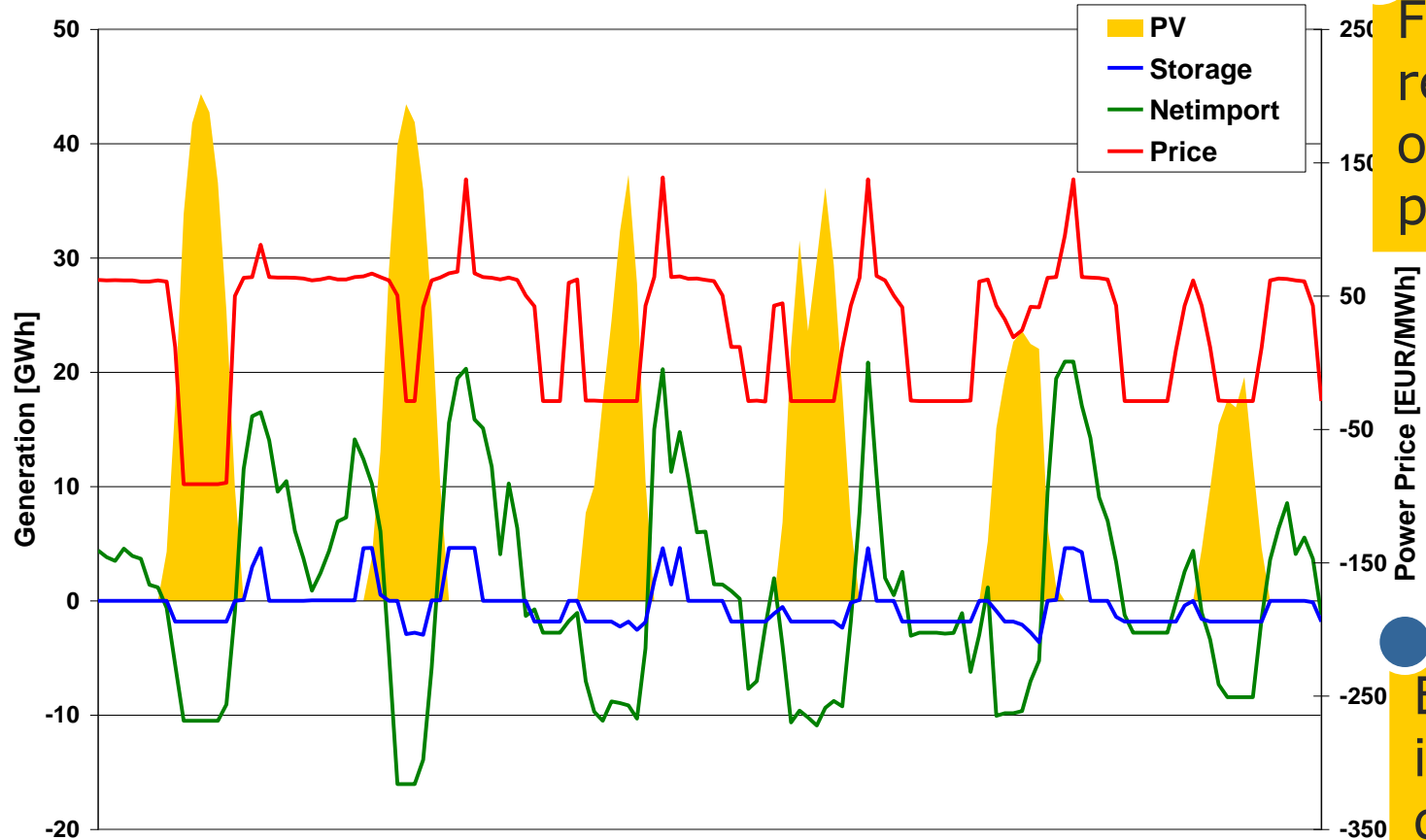


Price volatility increases

Price reacts strongly to weather

Market-driven curtailment occurs in times of negative power prices due to premium system

Behavior of flexibilities



Flexibilities react strongly on RES-E and price patterns

Exports increase during noon

Imports increase at residual morning and evening peak

Pumped hydro storage follows the same pattern

Conclusion

- PV contributes energy to the market during noon peak, but not during evening peak
- With a certain PV concentration the value of the positive correlation between load and sun irradiation vanishes
- A balanced RES-E technology mix is most valuable to the power market
- With an increasing RES-E share, the entire system requires further flexibilities
- In particular the market value of PV could benefit from a short-term storage, such as electro-vehicles, DSM and smart grids

Any Questions?

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