How to integrate large amounts of variable renewables in electricity systems

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1. INTRODUCTION

Motivation:

* Climate change → Paris agreements

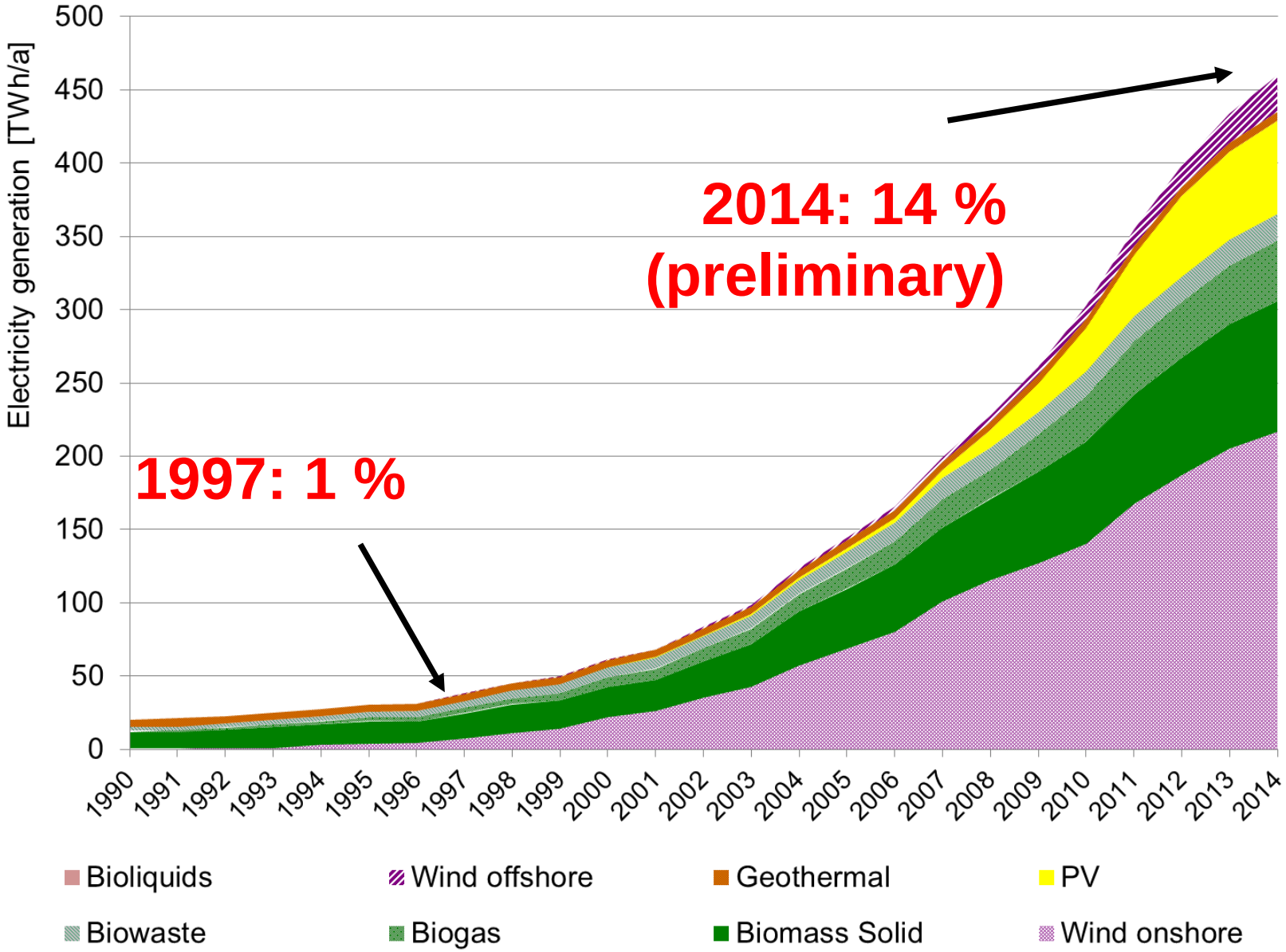
* Phasing out of fossile & nuclear

* EU-Targets for renewables (27% by 2030)

* Competition & democracy

* It is not possible to squeeze variable renewables into the system by violence

Development of electricity from new renewables in EU-28



Core objective/ our contribution:

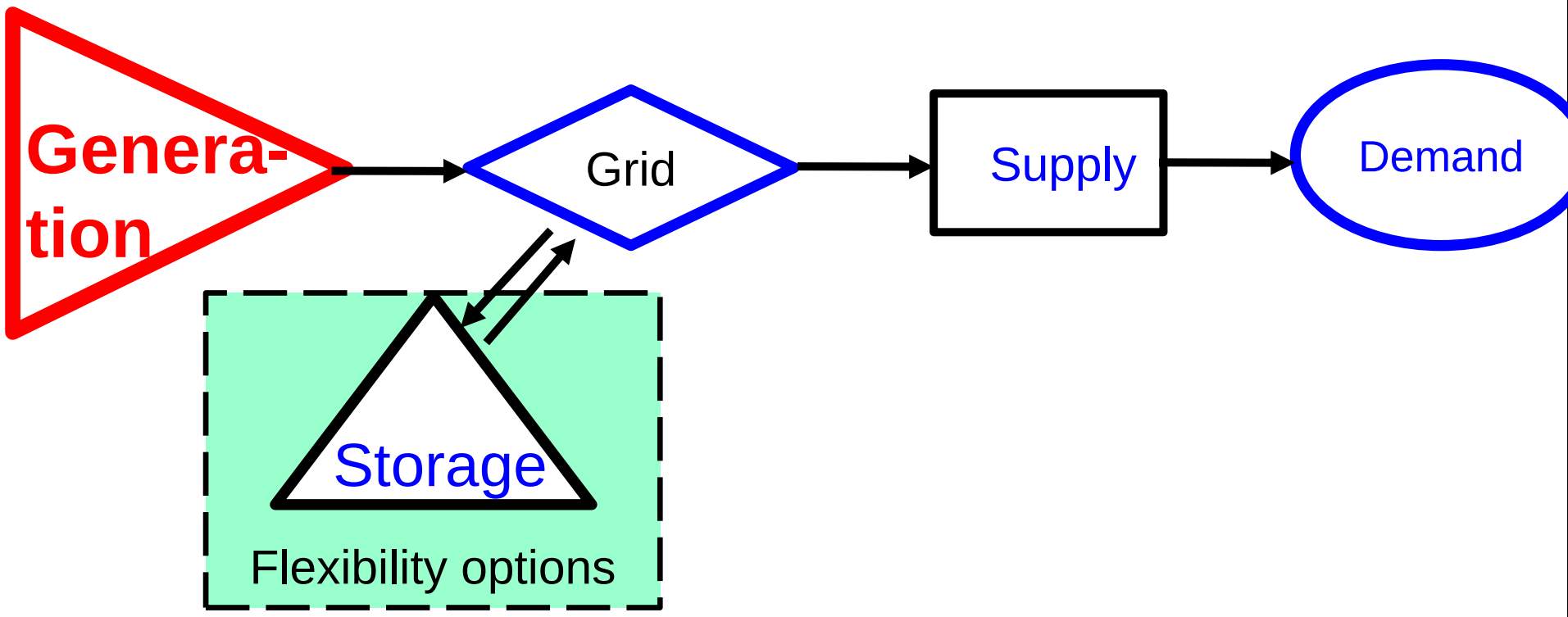
… to identify the major boundary conditions to integrate even larger amounts of variable renewables into the electricity system

Very important:

Our reflections apply in principle to every electricity system world-wide!

…. Based on electricity economic point-of-view!

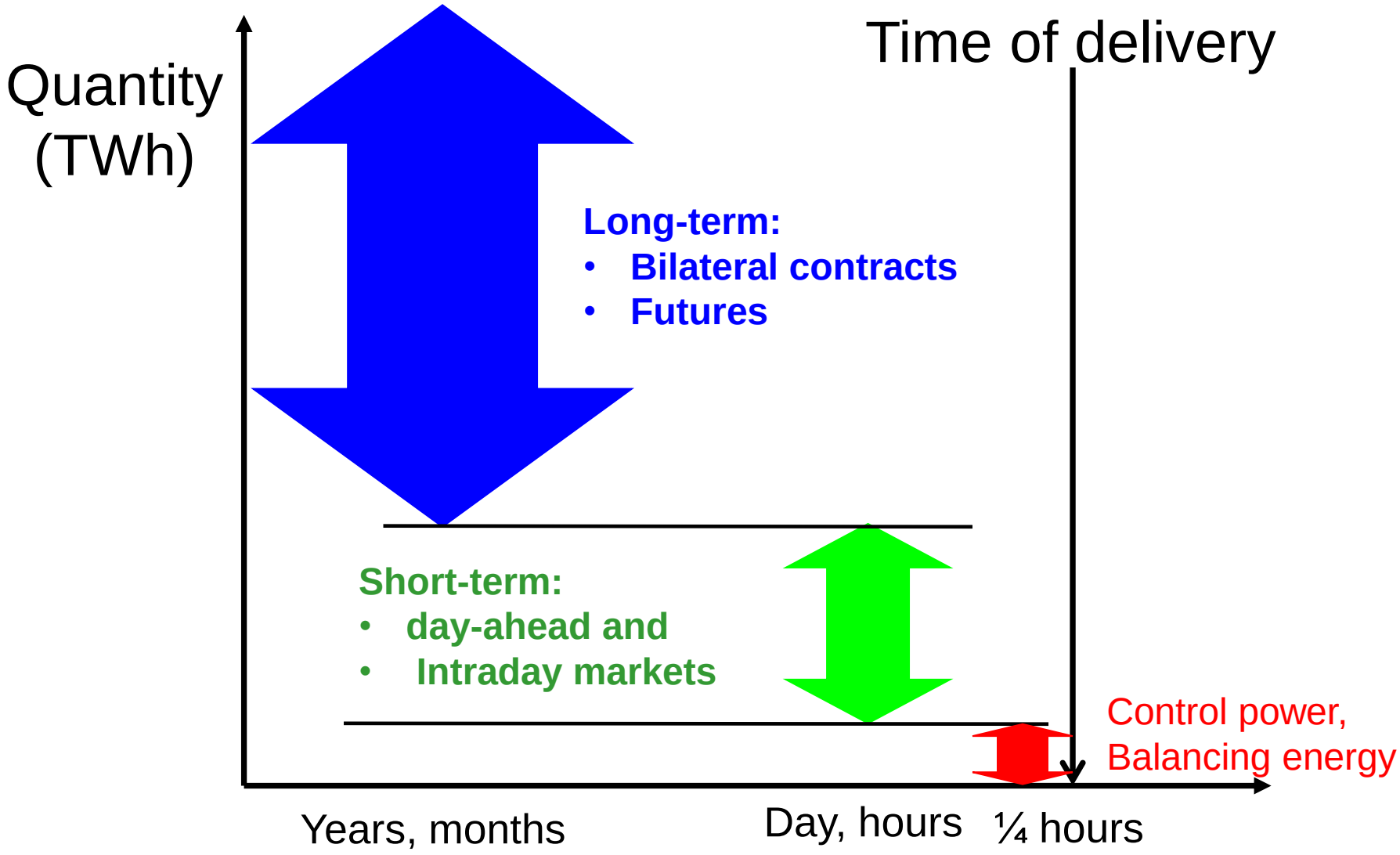
Old thinking:



2 METHOD OF APPROACH

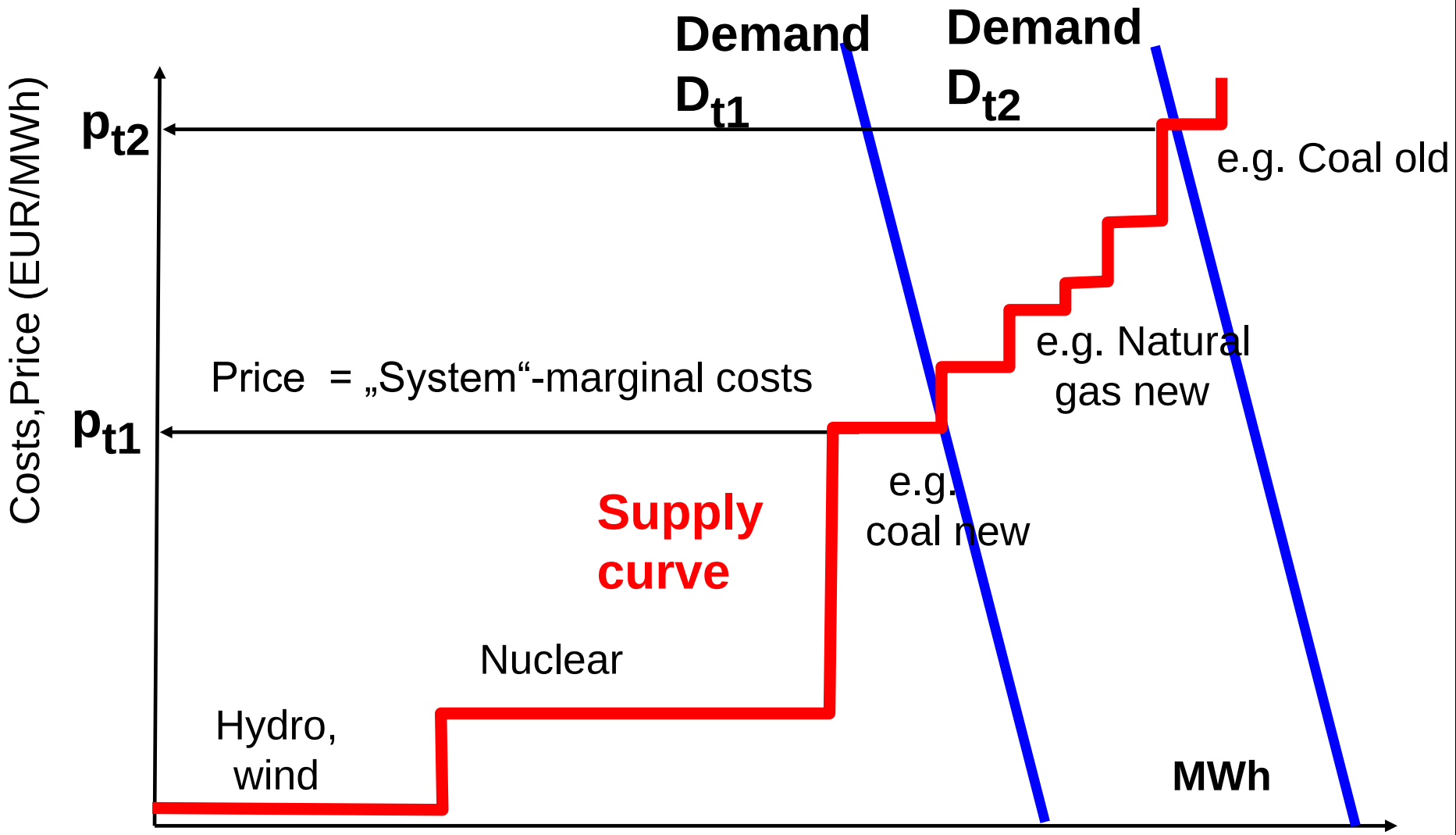
- Identification of hourly residual load over a year for various scenarios with large quantities of variable renewables;
- Applying a fundamental model to calculate (static) hourly electricity spot market prices;
- Integration of flexibility in a dynamic framework for price calculation;
- Developing a corresponding incentive-based framework;

Elements of electricity markets



How prices come about in electricity spot markets (day-ahead and intraday markets):

Competition: Prices = Marginal Costs at every hour



In day-ahead electricity markets:

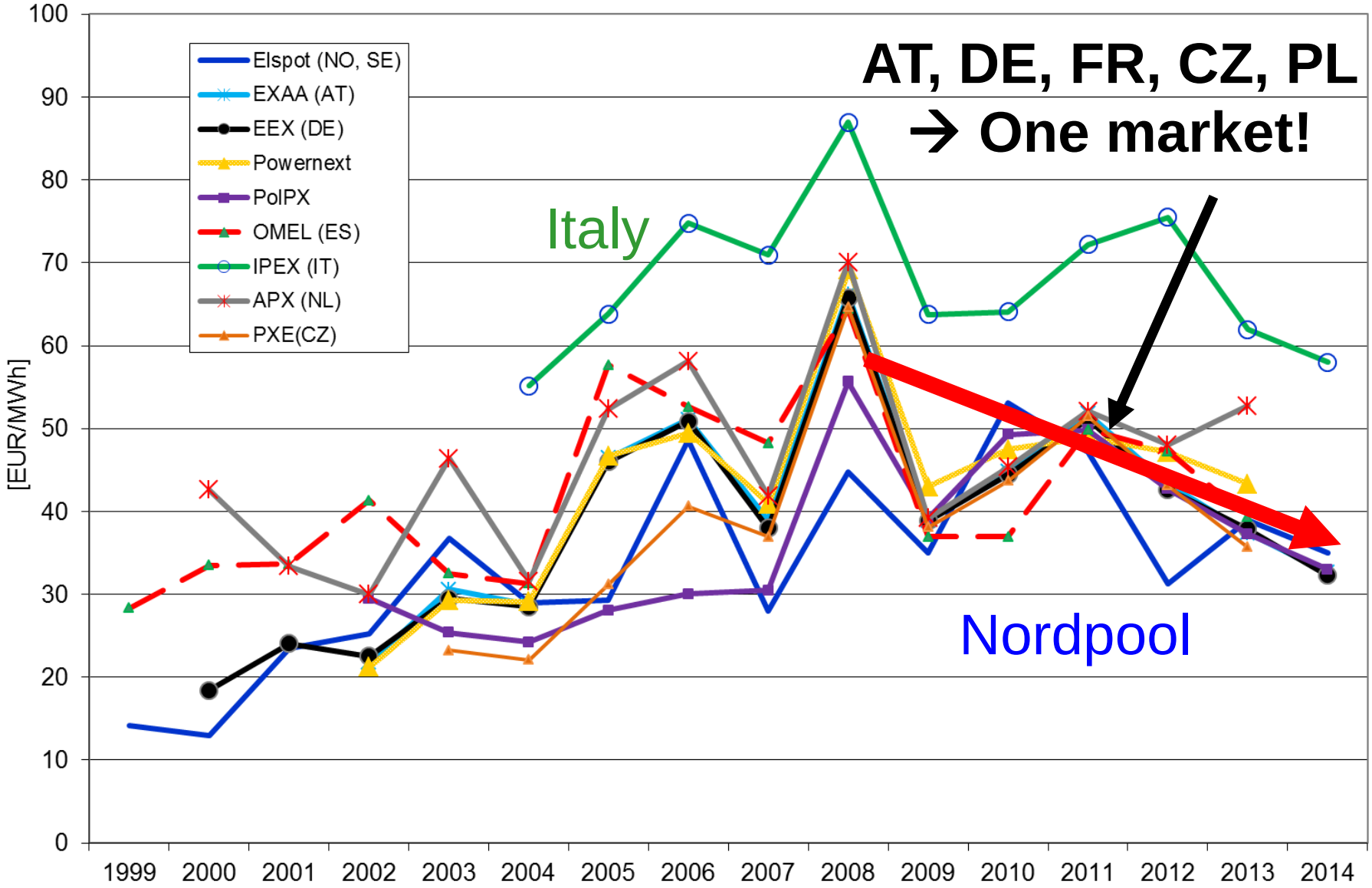
Expectation of:

prices = Short-term marginal costs:

(Short-term marginal costs = fuel costs)
due to huge depreciated excess capacities at the beginning of liberalisation!

3 HOW VARIABLE RENEWABLES IMPACT PRICES IN ELECTRICITY MARKETS

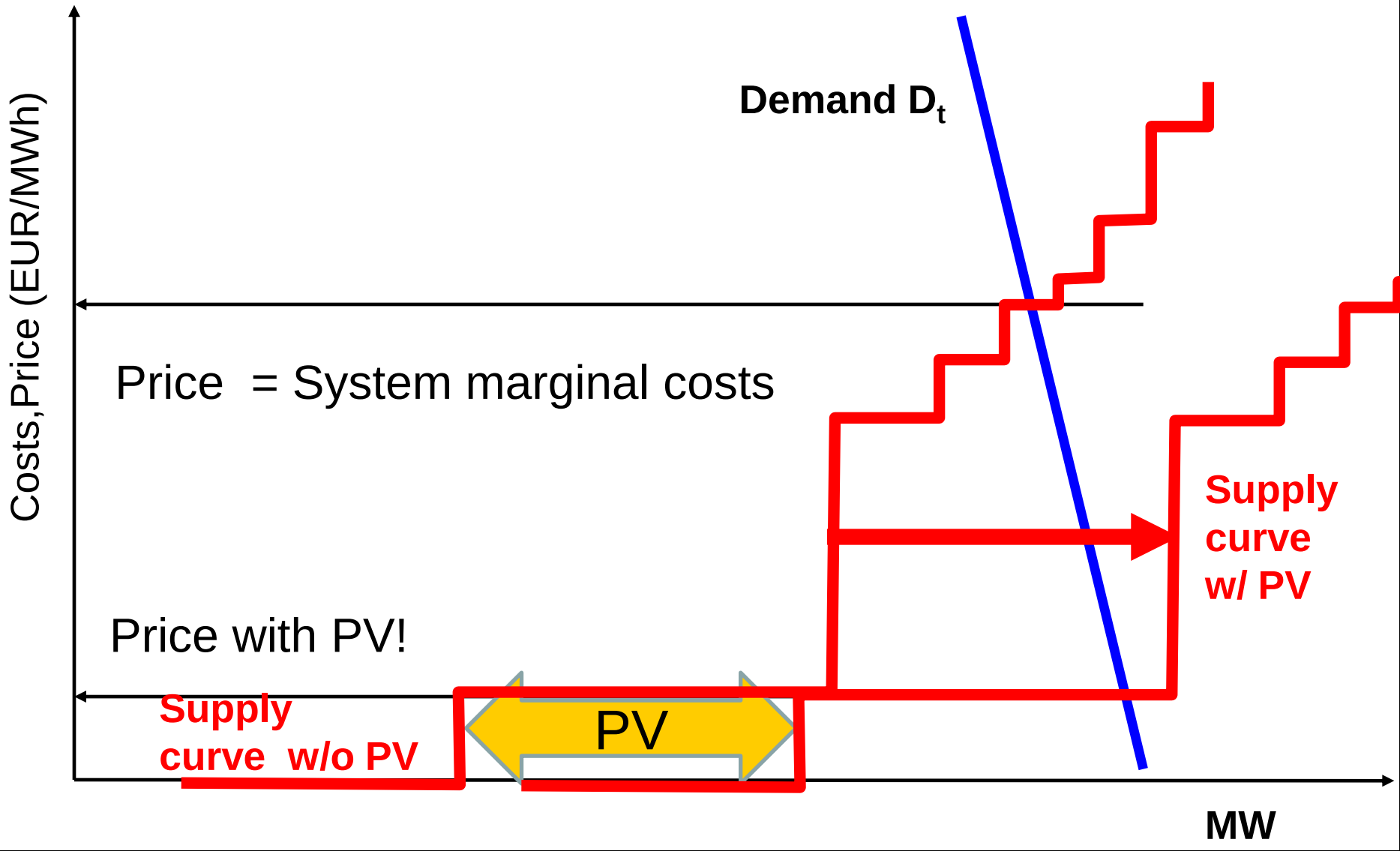
Development of day-ahead electricity prices in Europe per year



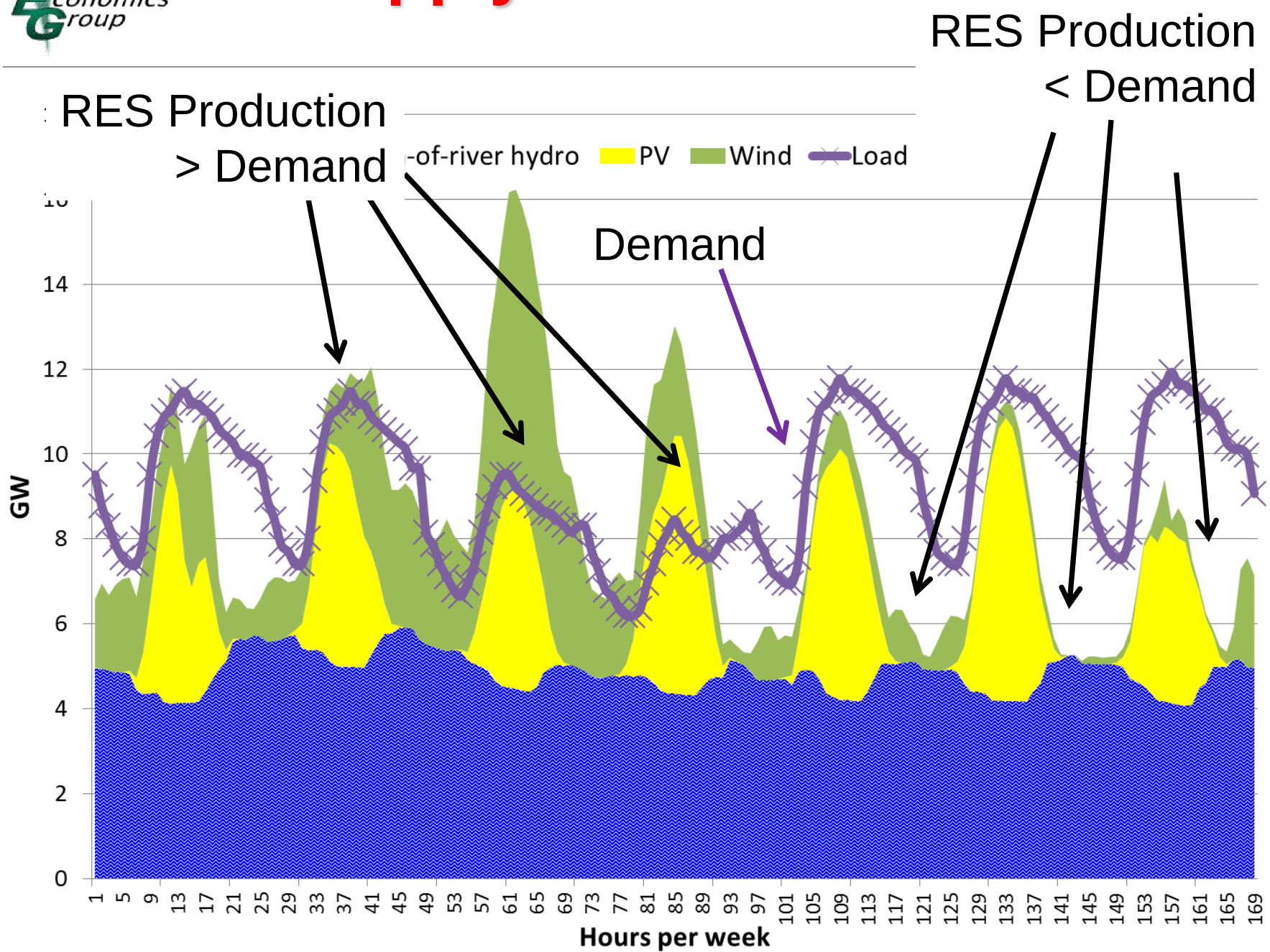
WHY?

STMC = 0!

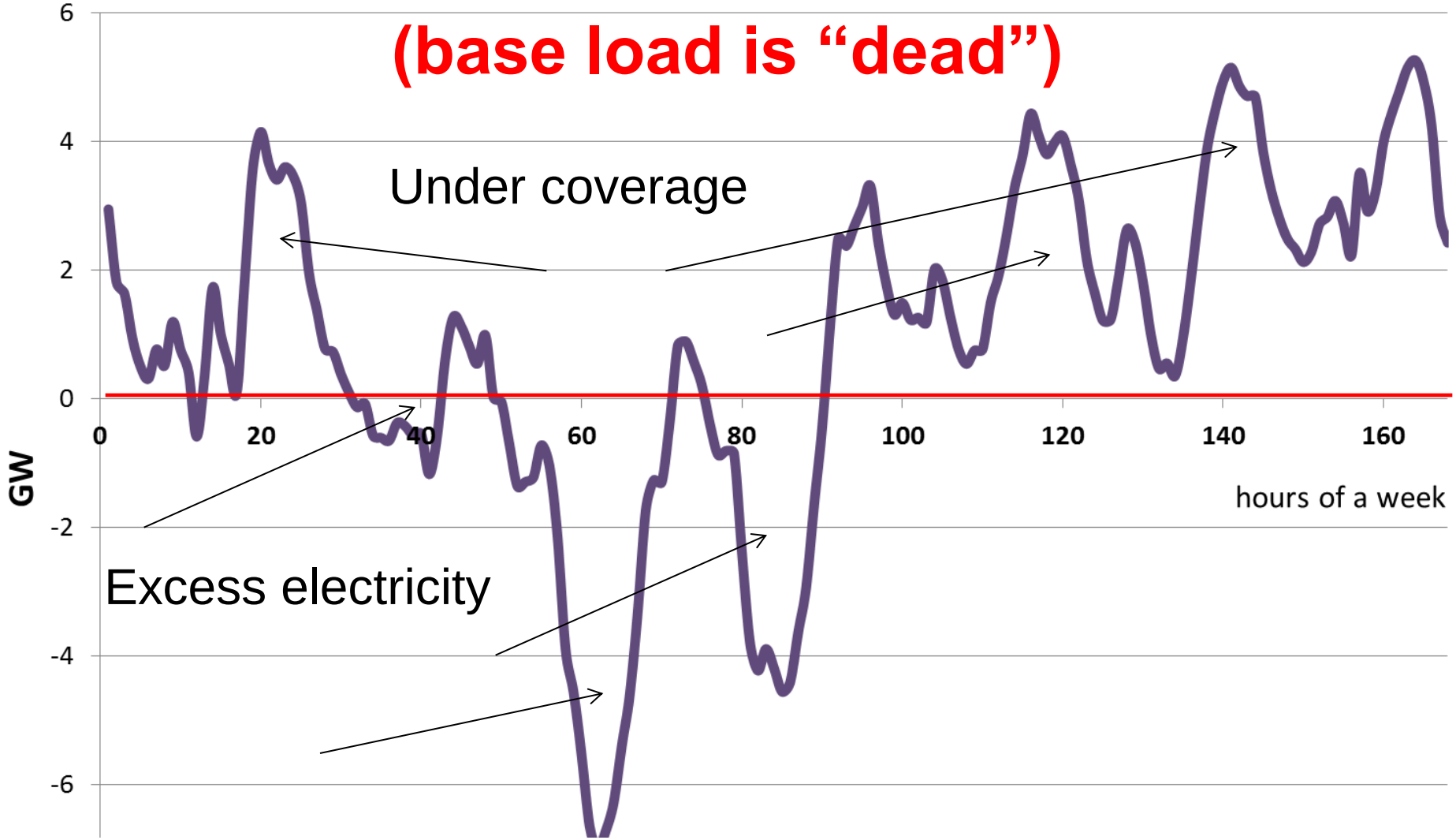
Example: prices without and with PV



Supply and Demand

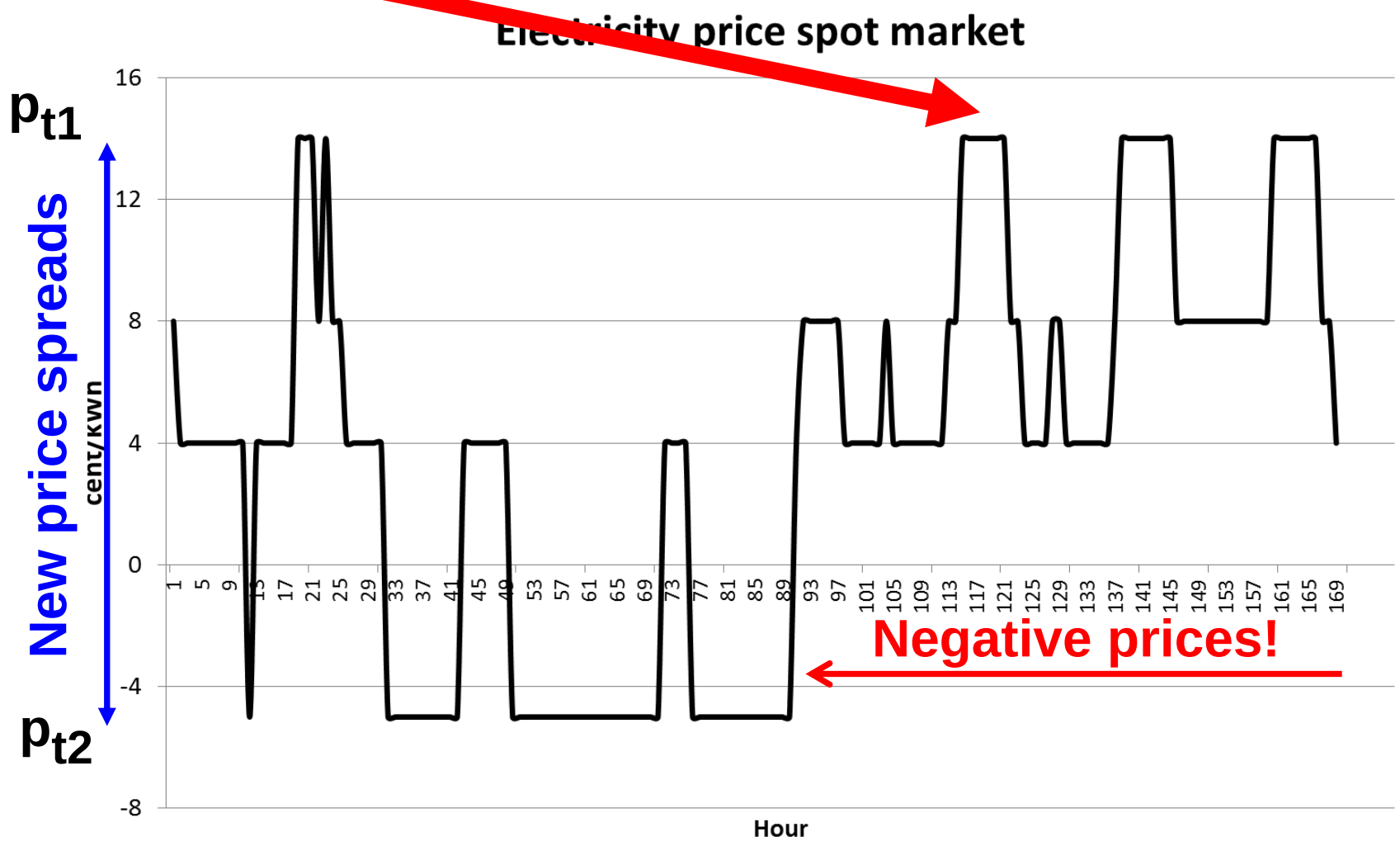


Key term of the future: Residual load (base load is “dead”)



Residual load = Load – non-flexible generation

Are these prices TOO HIGH?



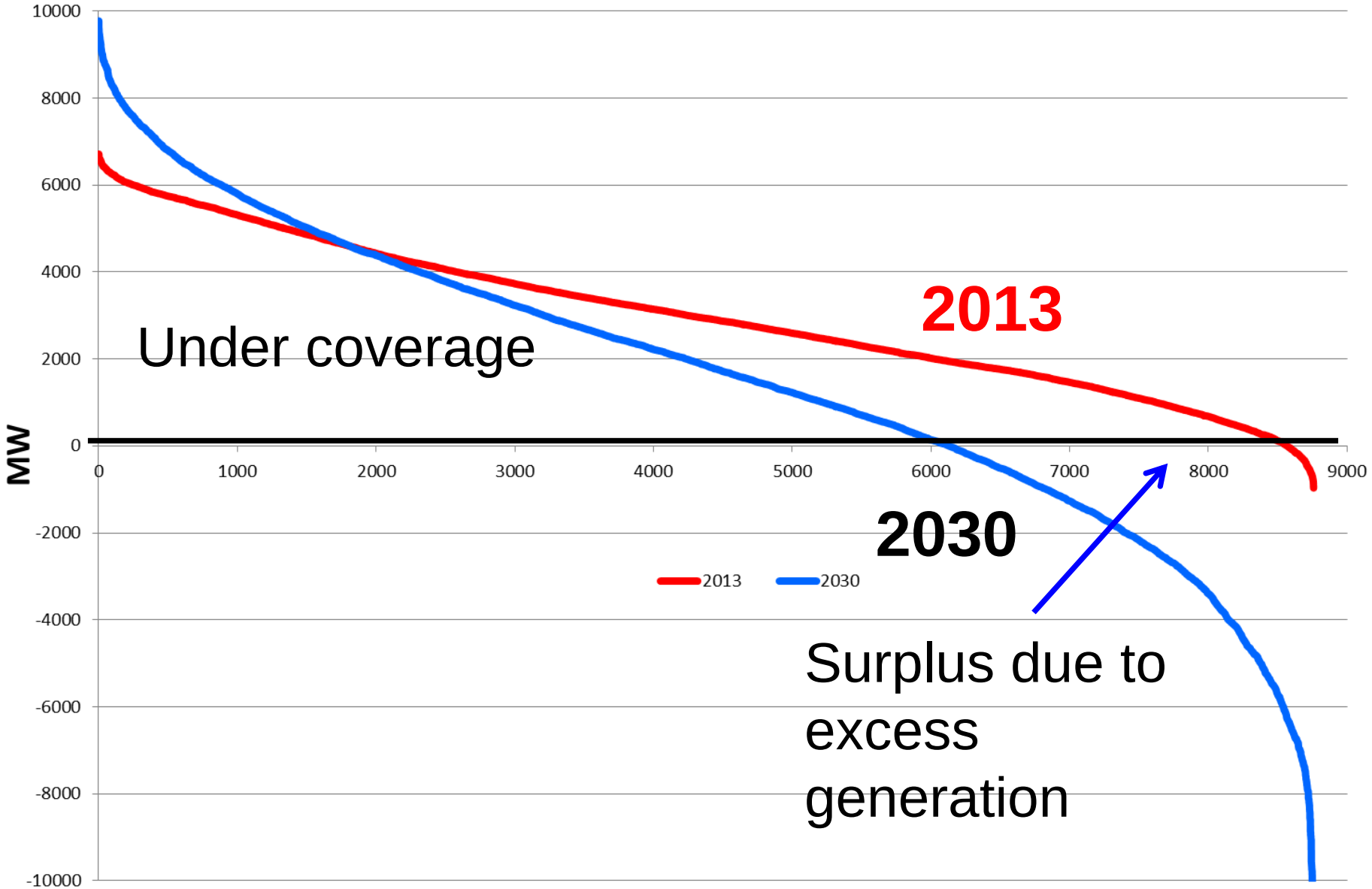
→ These price spreads provide incentives for new flexible solutions!!!!

Given this price pattern, showing excess and scarcity it would be attractive for a sufficient number of flexible power plant operators to stay in the market!

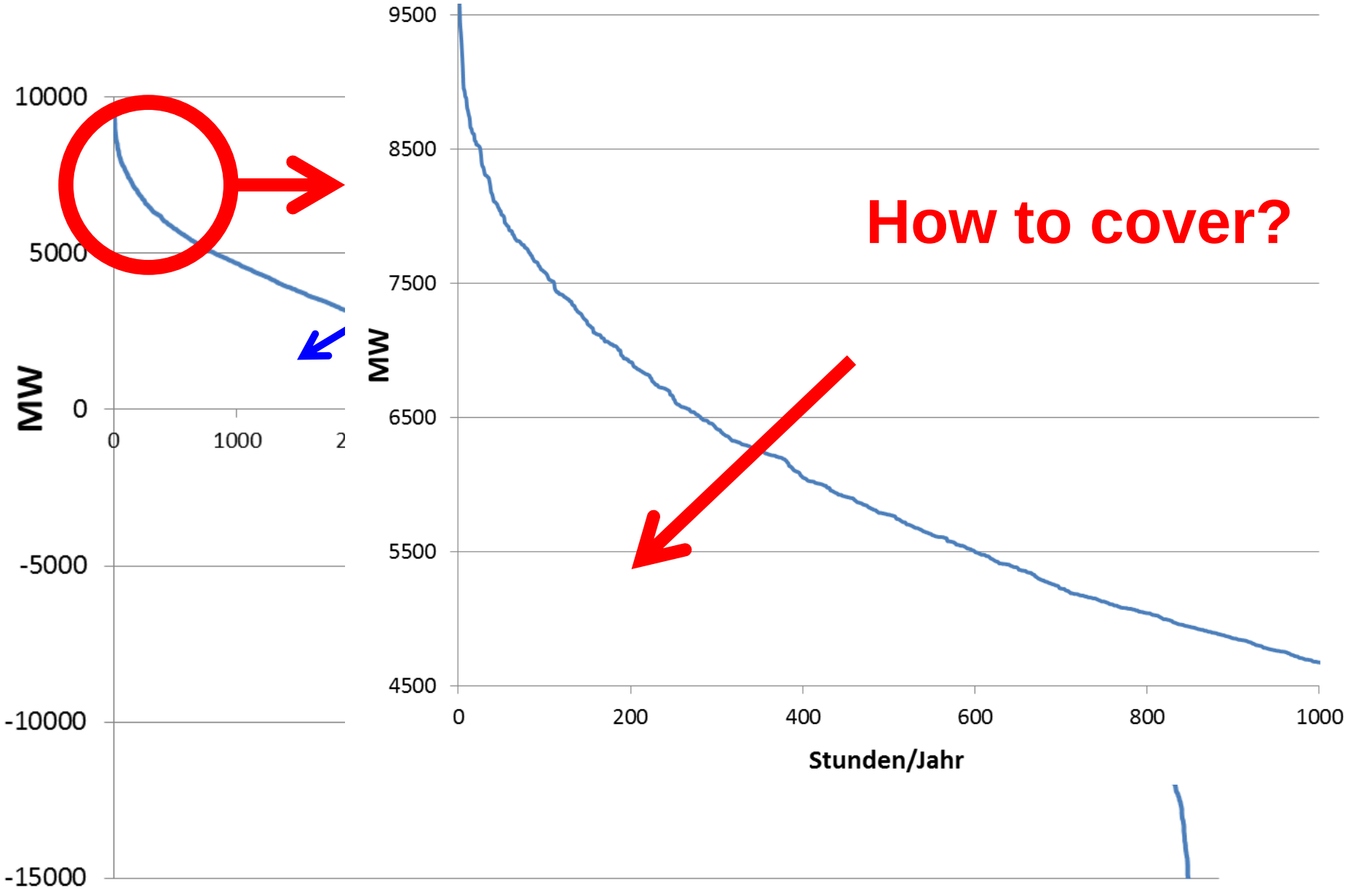
→

REVISED ENERGY-ONLY MARKET

Classified residual load



Classified residual load

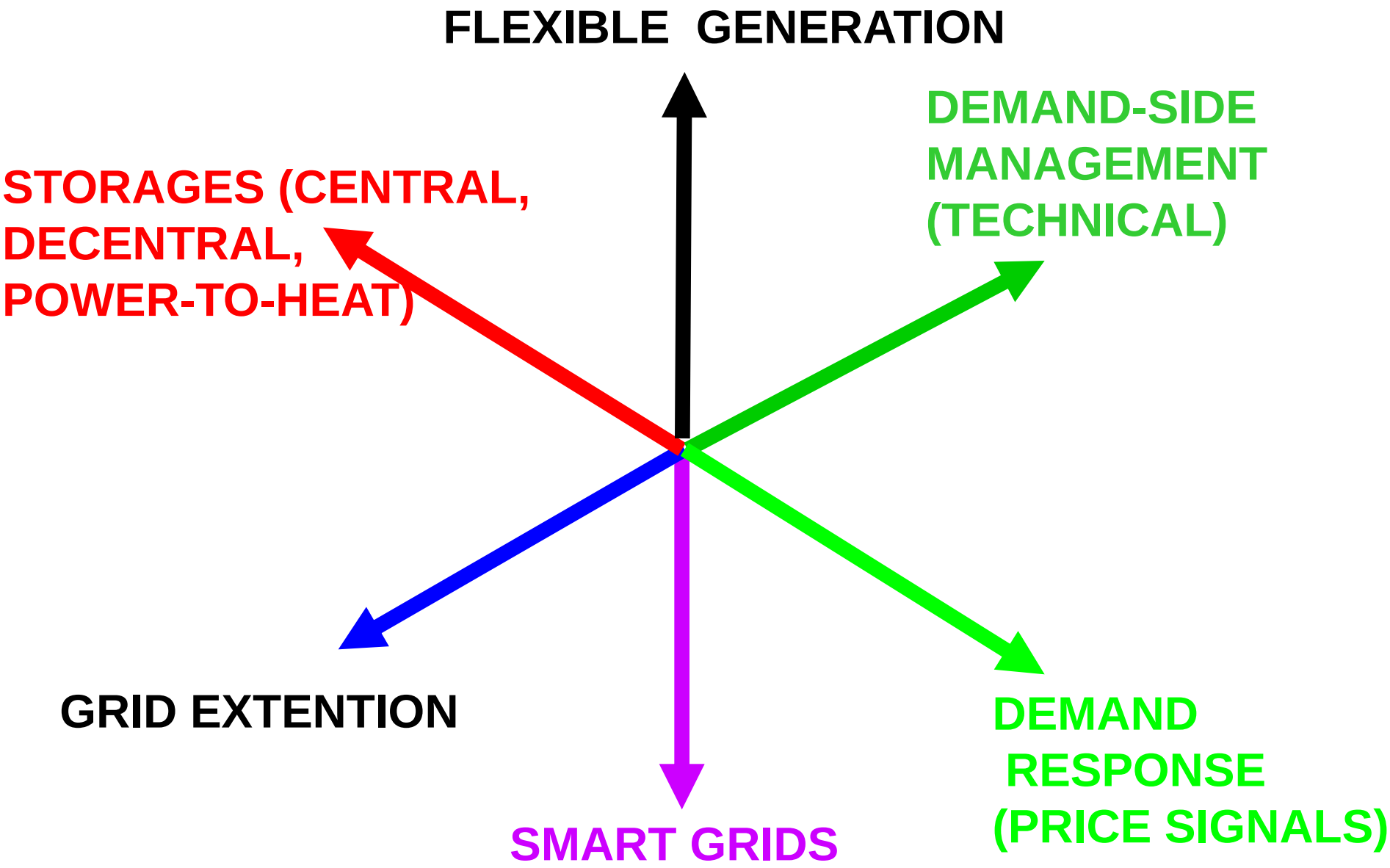


By a regulated capacity „market“ ?

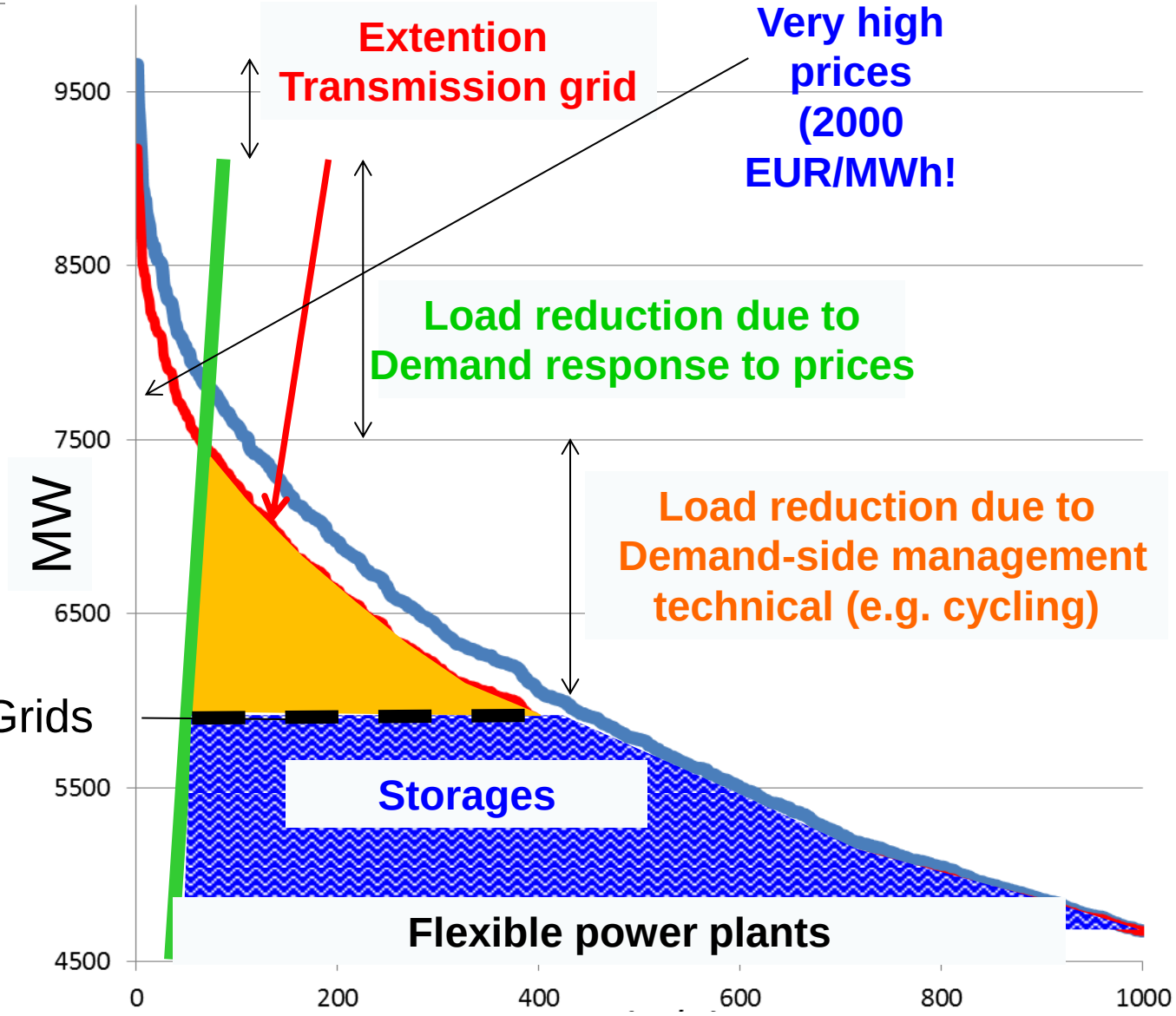
or

By competition between supply-side and demand-side technologies and behaviour (incl. Storages, grid and other flexibility options)?

4 THE CORE ROLE OF FLEXIBILITY



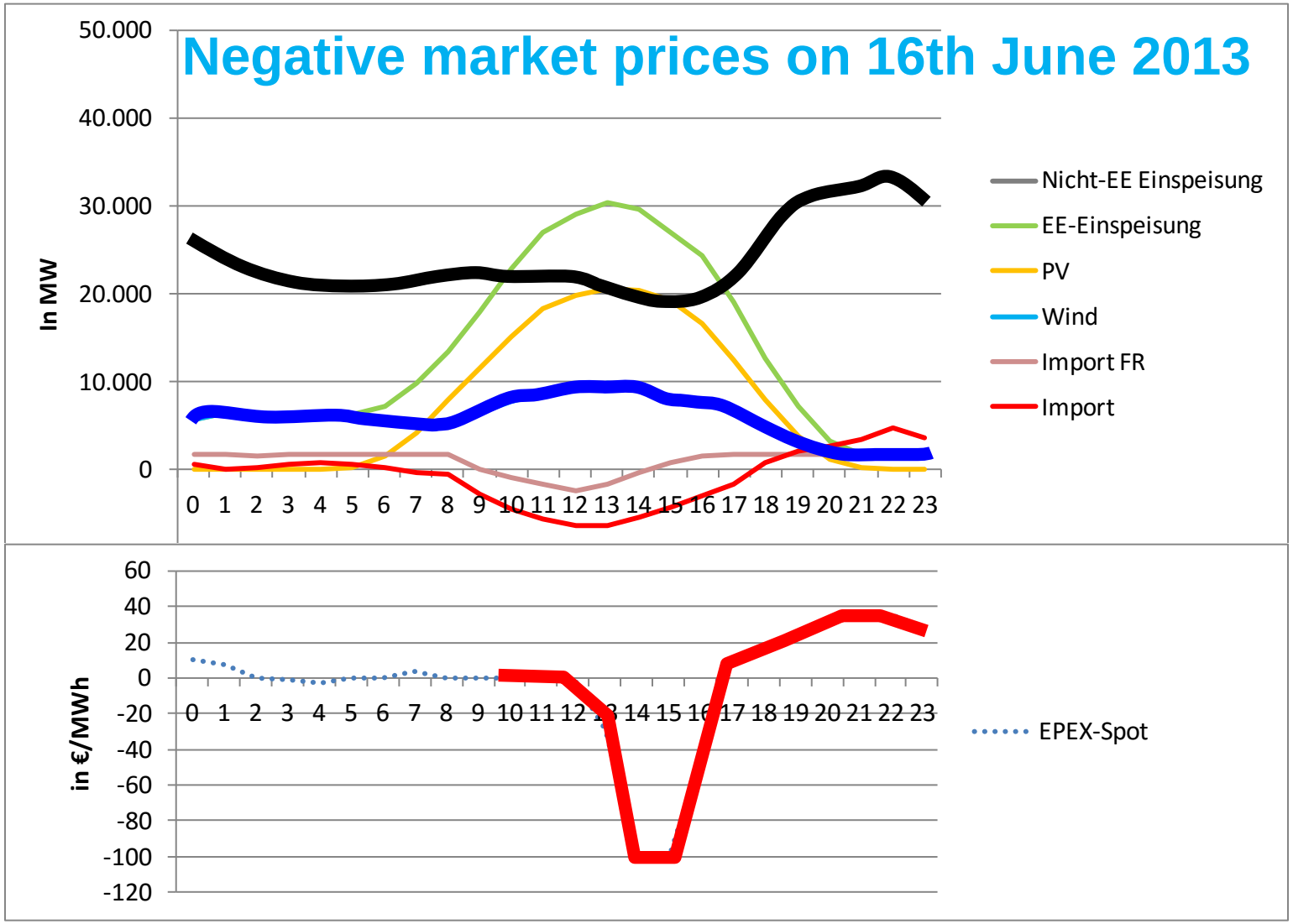
Flexible coverage of residual load



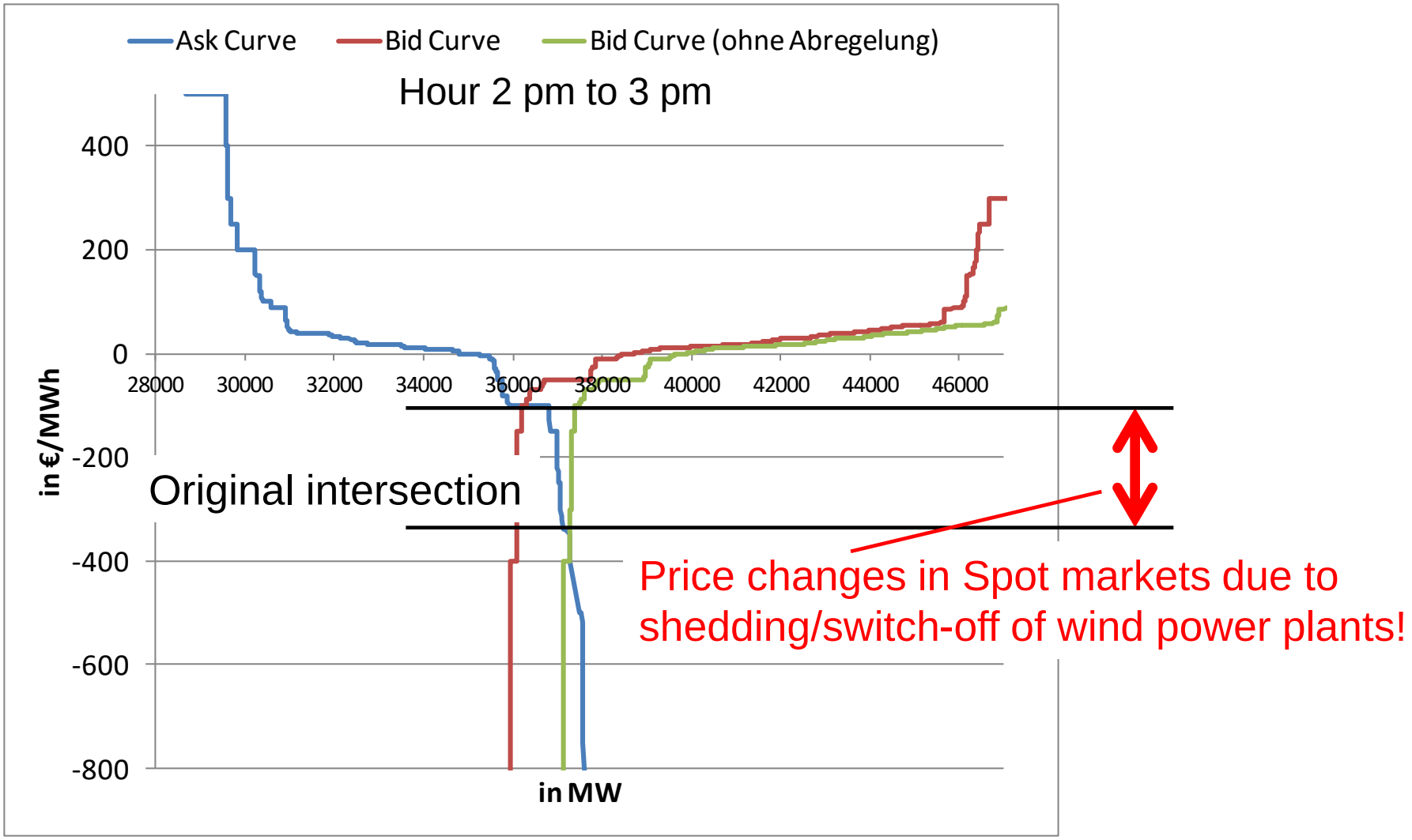
Smart Grids

Flexibility in generation: Variable RES are controllable

Problem: high impact of temporarily large quantities of variable RES (?) on electricity market prices

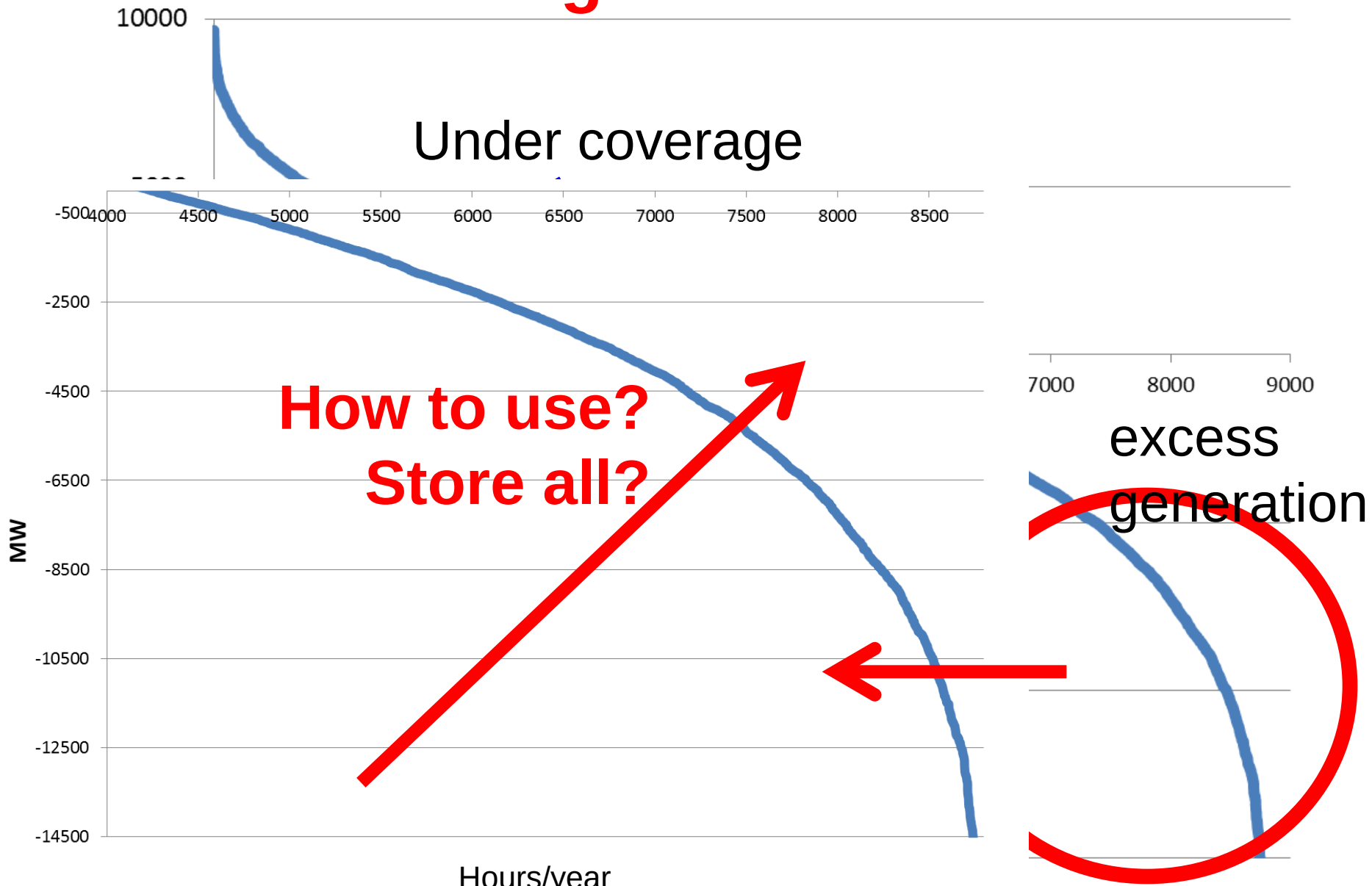


Impact of switch-off of wind power plants on electricity market prices

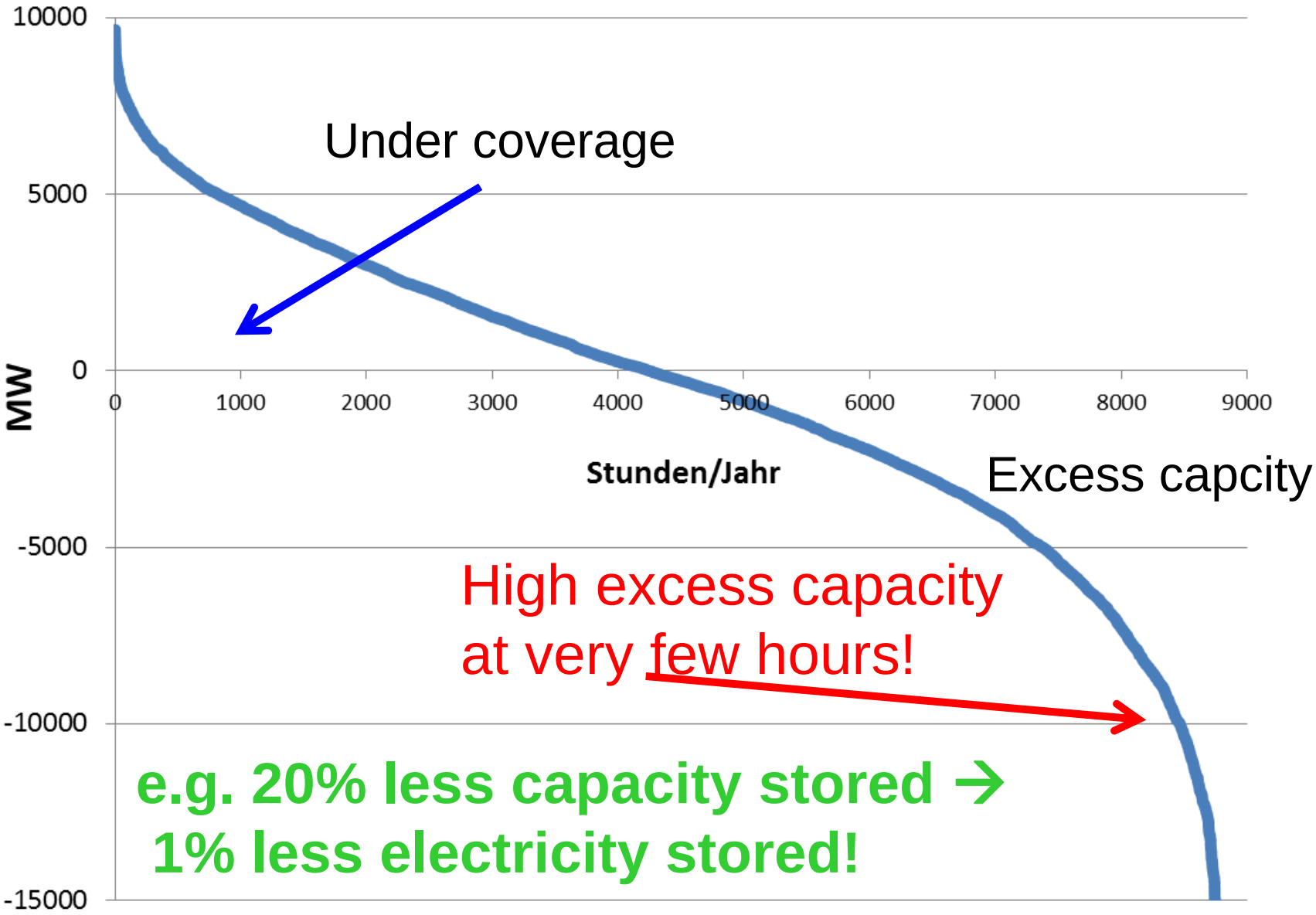


→ **Wind power → flexible source!**

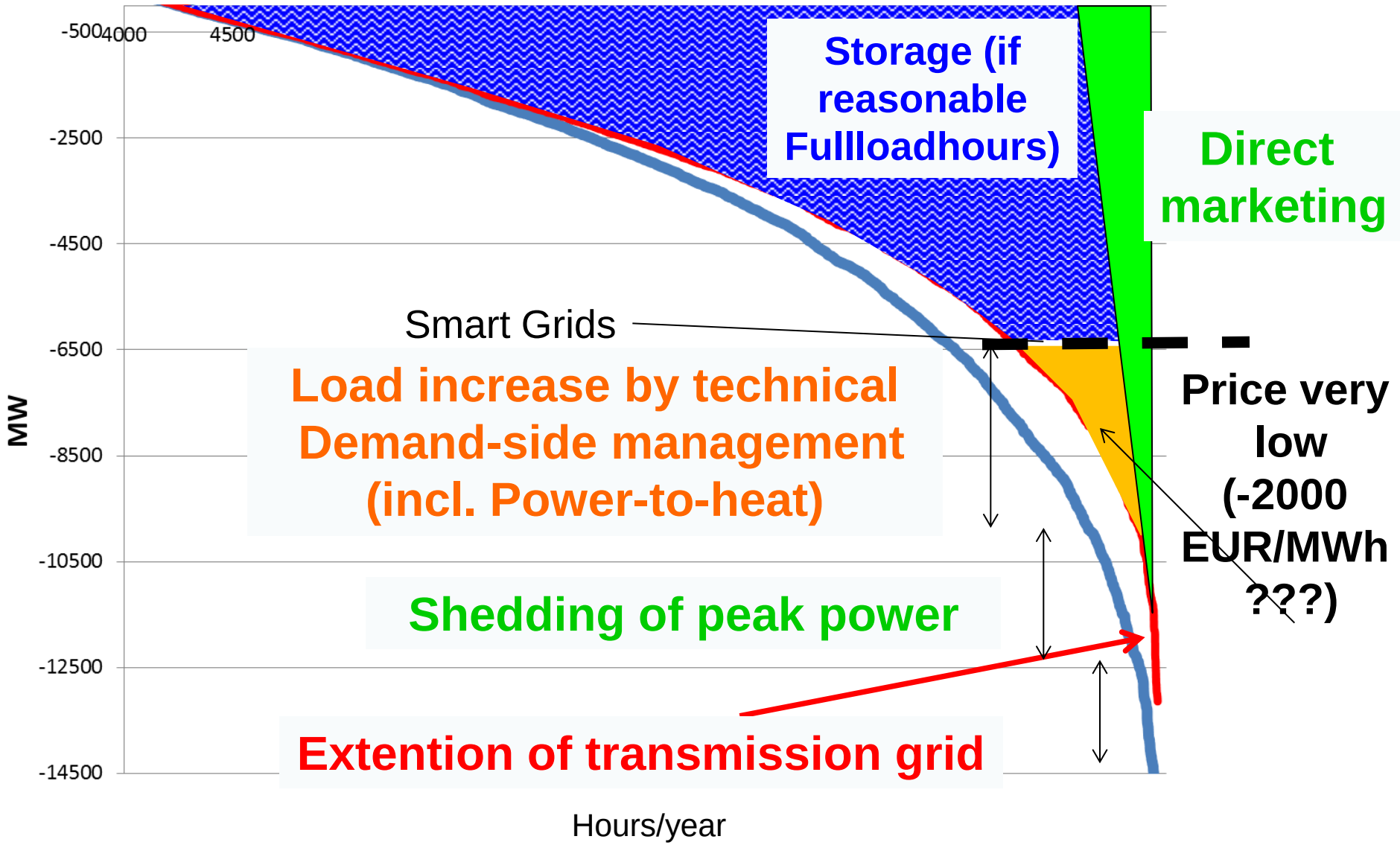
Specific question: How much storage do we need?



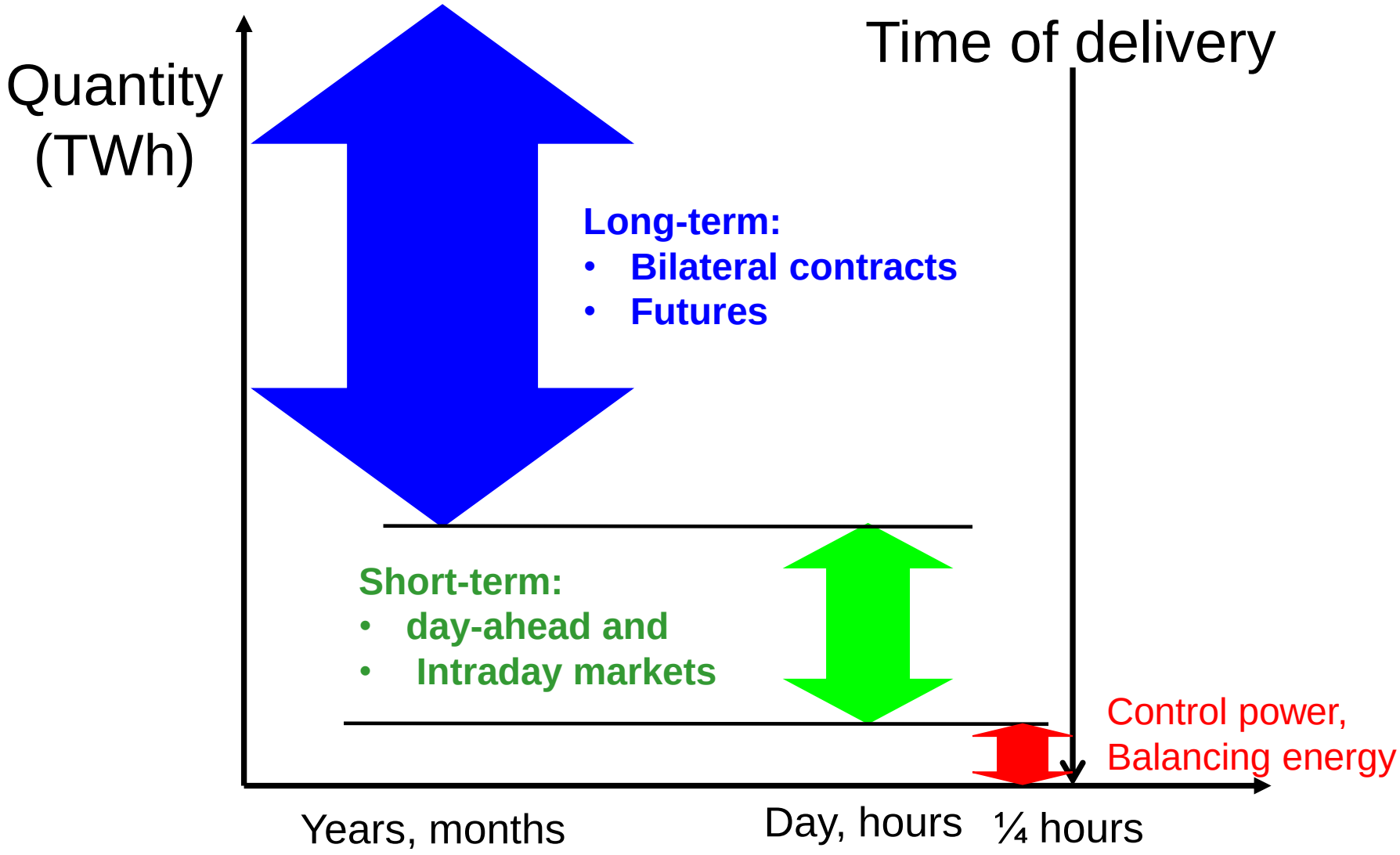
Storing every peak?



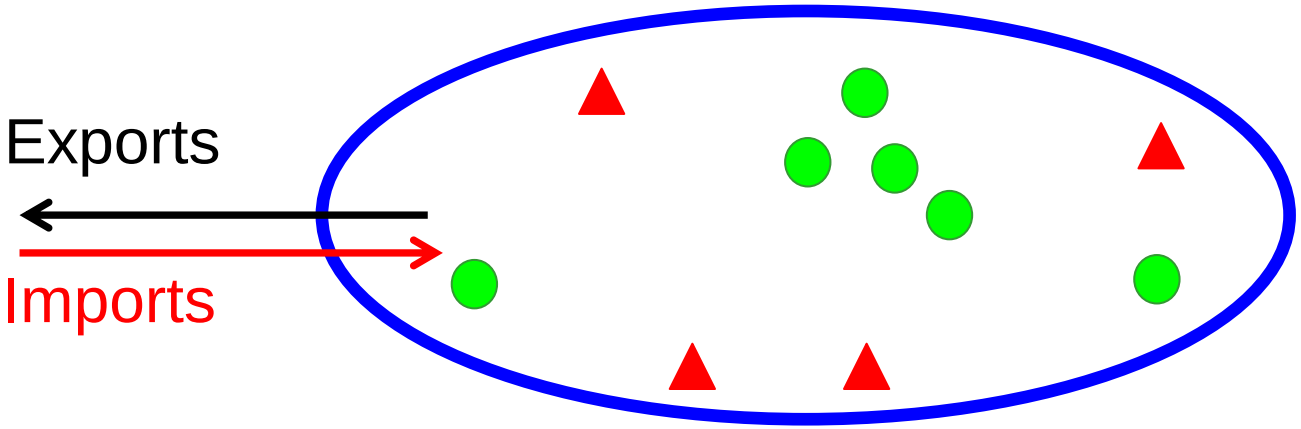
Flexible use of excess electricity



Elements of electricity markets



The core role and responsibility of balancing groups



Generators

Consumers

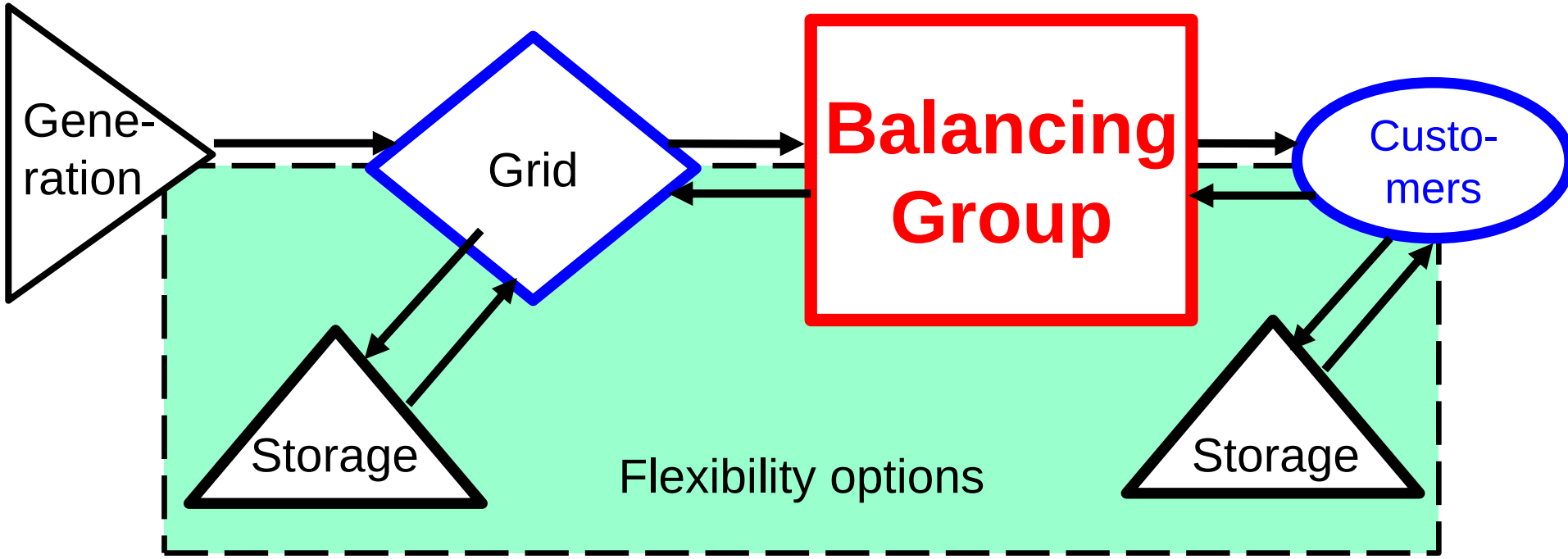
Balancing group: entity in a control area of an electricity system. has to ensure that at every moment demand and supply is balanced

E.g. municipal utility of Zagreb, Ljubljana, Vienna

To meet this target: own generation , storage, flexibility, Trading in long-term, day-ahead and intraday market

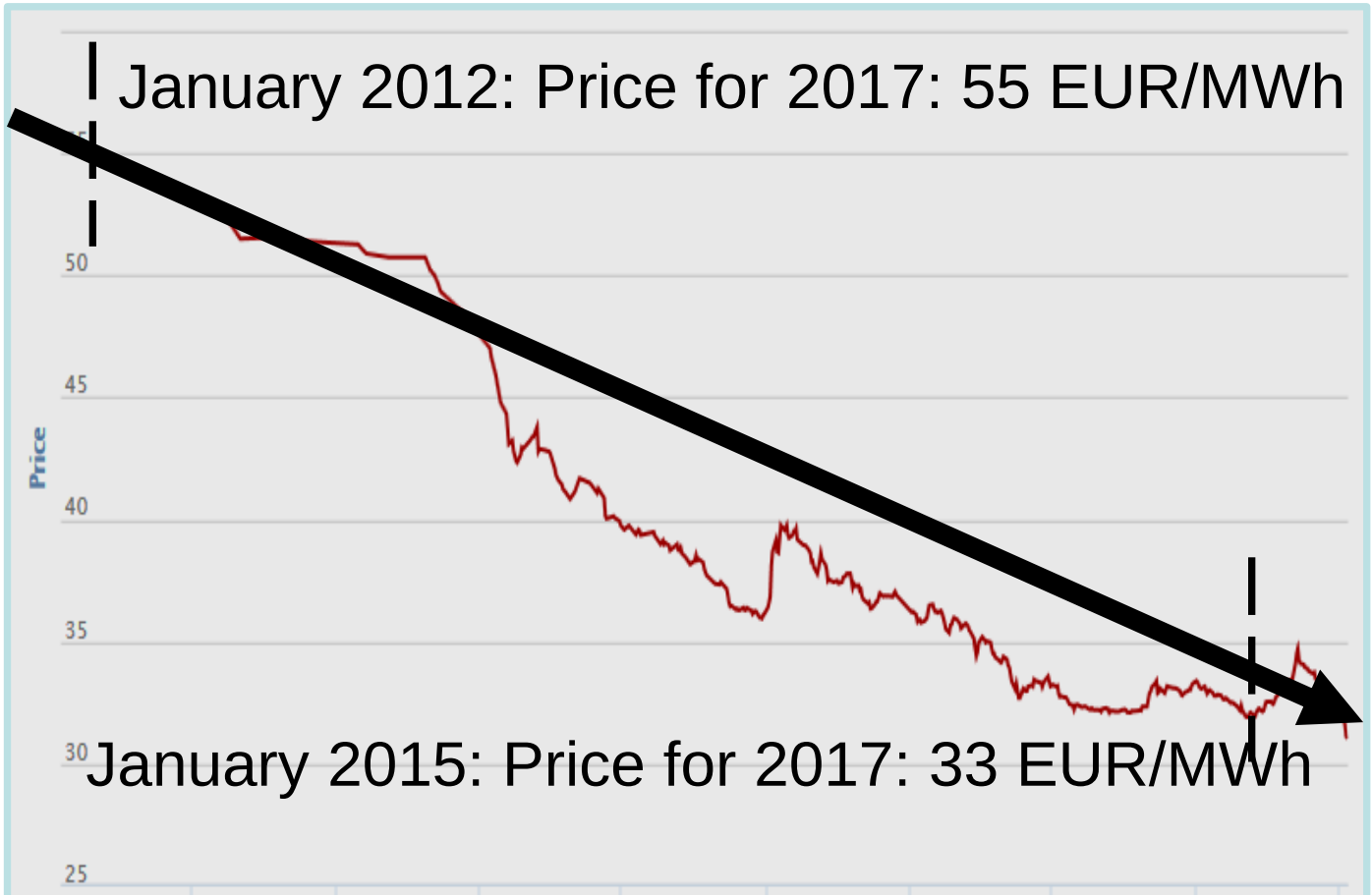
Every difference → high costs!

New Thinking:



Example for long-term contracts

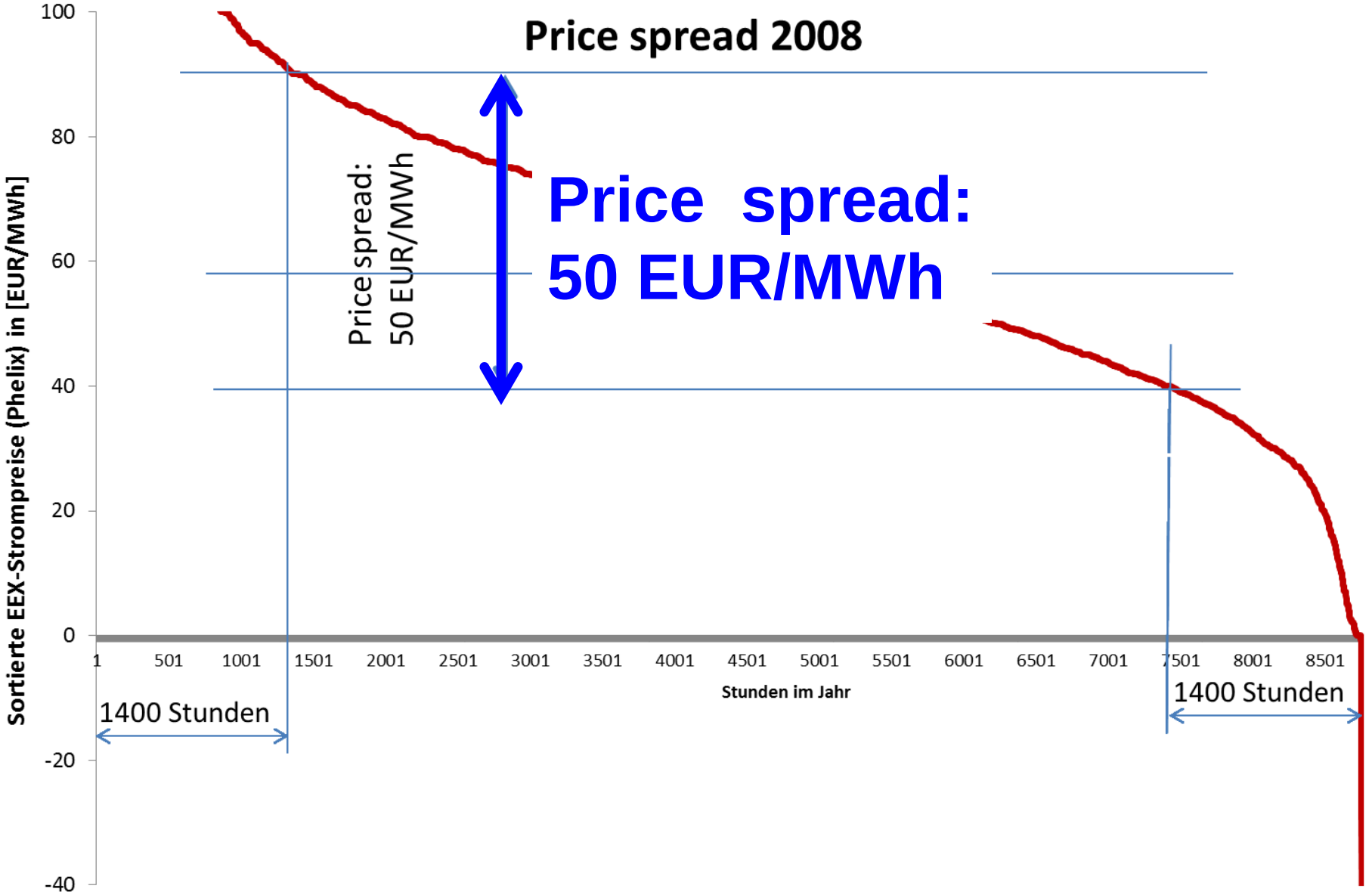
Prices for 2017 until 2015, Germany:

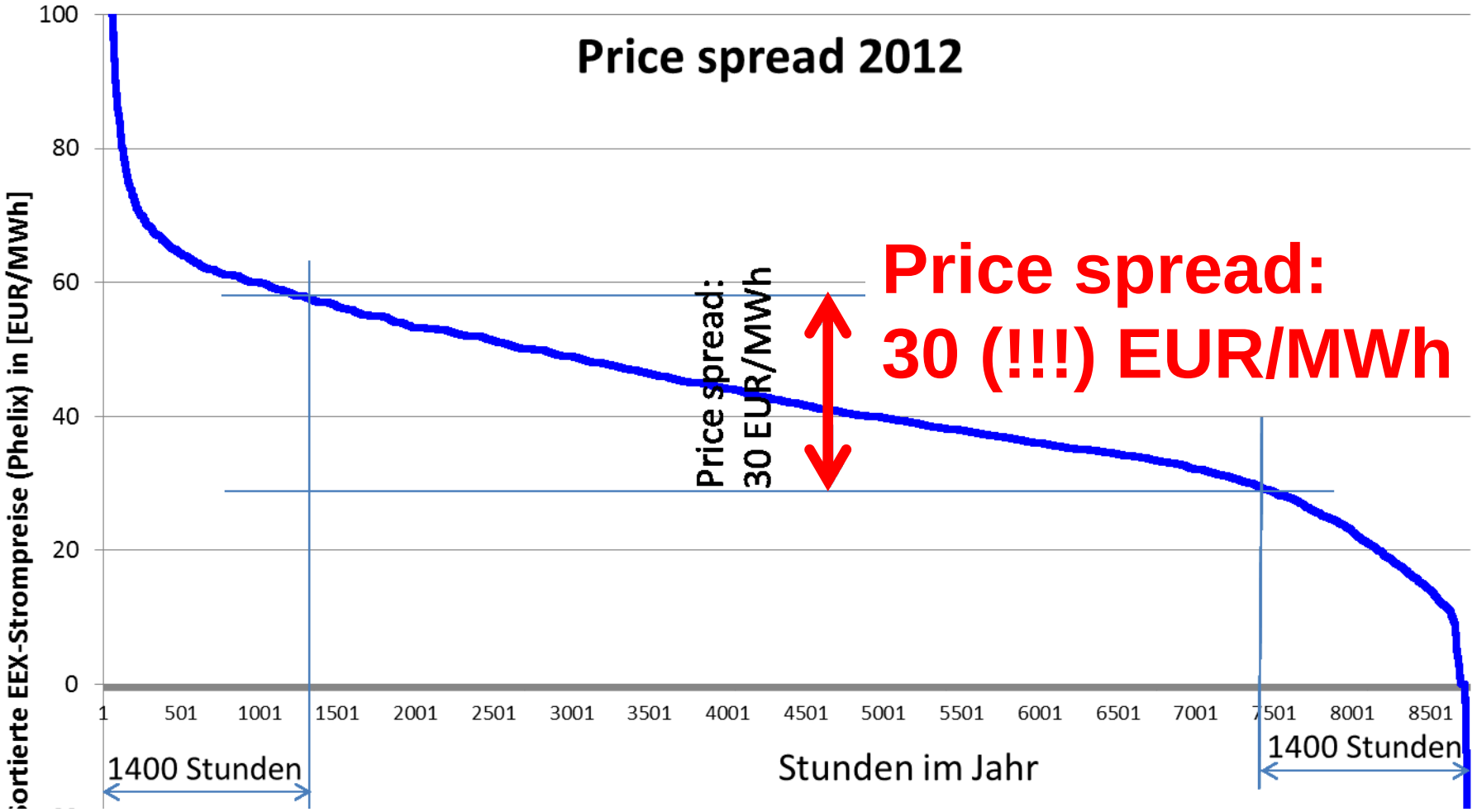


EUR/MWh

Time : 2012 to 2015

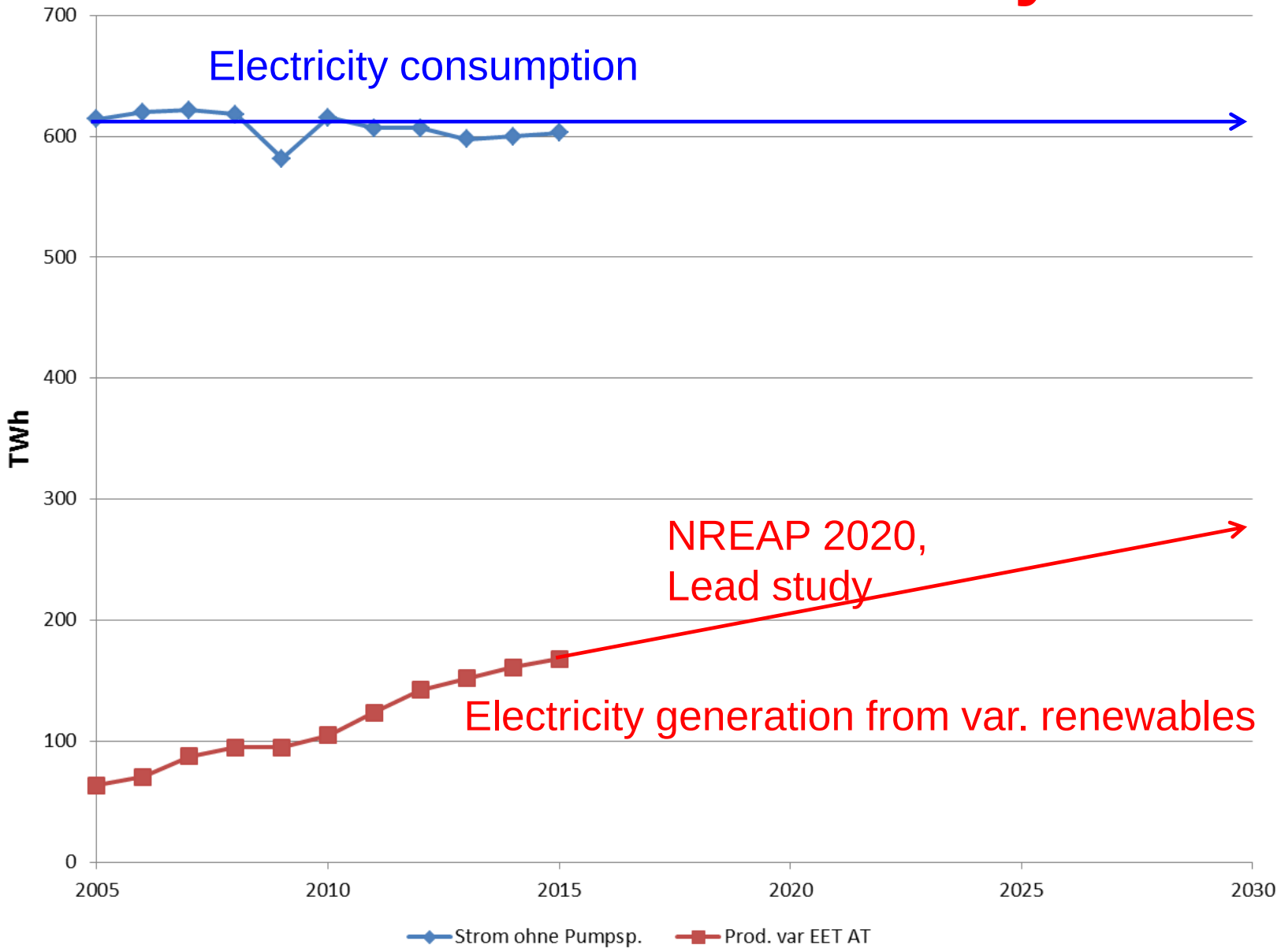
ECONOMIC INCENTIVES:





→ There is no incentive today to launch flexibility measures (except in the control power market)!

Electricity consumption over time in Germany



Further issues of market design

* Shorter trading lead times

* Shorter trading intervals

* Shorter forecasting lead times

* Revisit grid issues: How will the grid of the future look like?

6. CONCLUSIONS

- A sustainable electricity system is a question of integrating a broad portfolio of technologies and demand response options!
- Very important: correct price signals!!!
- most important now: exhaust the full potential of the creativity of all market participants!
- The key: Flexibility! Yet, currently no economic incentives but activities started → very promising!
- calls for capacity markets: a last try of the old generation-focused system to survive
- New key player: Balancing group, no more the generator!