# 14th International Conference on the European Energy Market – EEM 2017

## Announcements:

- **The EEM 2017 conference programme booklet is now available for download: *EEM 2017 Conference Programme Booklet***
- **The detailed programme of the parallel sessions is now available for download at the *conference programme page.***
- **Registration for Project Idea Lab now open! Please register *here.* More information about the event available *here.***

Dear Colleagues,

# On how to integrate large quantities of variable renewables into electricity systems


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**Dresden, 6 June 2017**

# CONTENT:

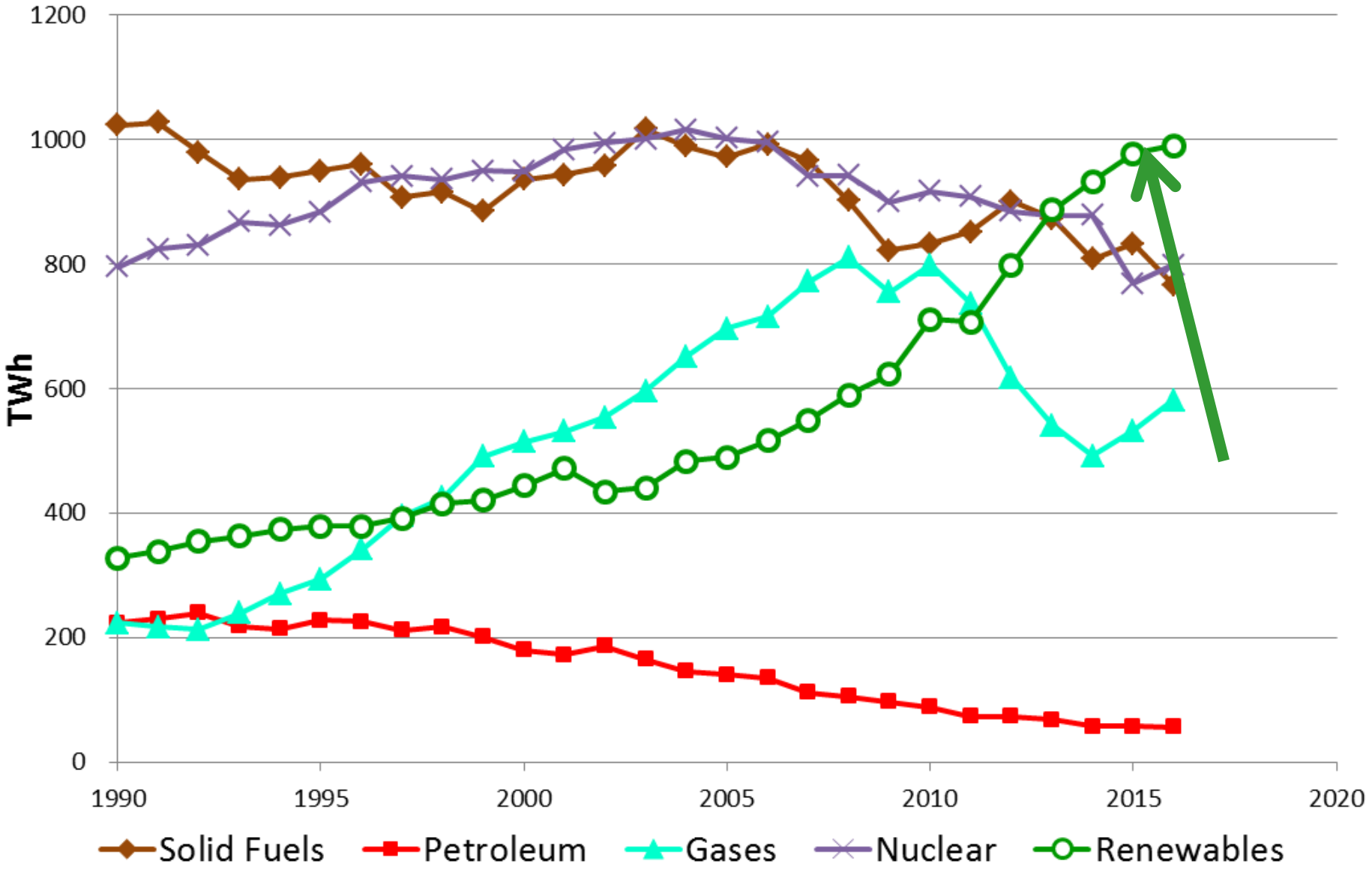
1. Introduction: Motivation
2. Method of approach
3. How variable renewables impact prices in electricity markets
4. The core problem of capacity payments
5. The role of flexibility and sector coupling
6. Balancing groups: A future market design
7. Subsidizing RES: How long?
8. Conclusions

# 1. INTRODUCTION

## Motivation:

* Climate change → Paris agreements
* Phasing out of fossile & nuclear
* Targets for renewables
* Competition & democracy
* It is not possible to squeeze variable renewables into the system by violence
* „Clean energy“ winter package

# Introduction: Electricity generation EU-28



# Core objective

… 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

…. are based on electricity economic point-of-view

# 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 residual loads and electricity spot market prices;**
- **Integration of flexibility in a dynamic framework for price calculation;**

# YEARLY DYNAMIC MODEL

Historical data for econometric analyses and model calibration

Yearly data for scenarios (e.g. demand, capacities deployed, taxes , grid tariffs, carbon price, support schemes … )

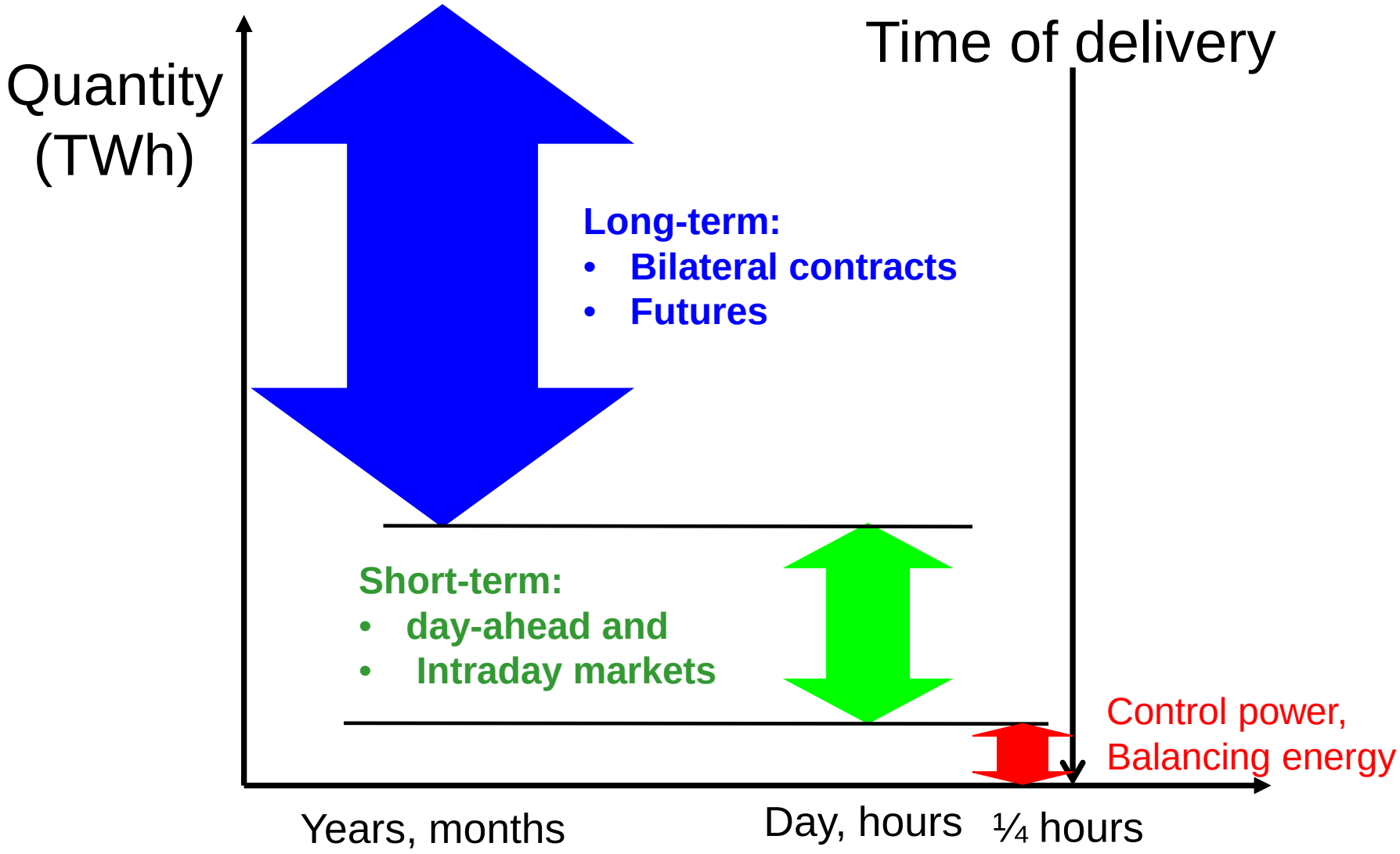
1990 — 2015 — Year X — 2050

Input for year X (demand, capacities…)

Output for year X (wholesale prices, costs, fulload hours

**HOURLY MODEL** for year X

# Elements of electricity markets



# Day-ahead electricity markets

**Expectation of**

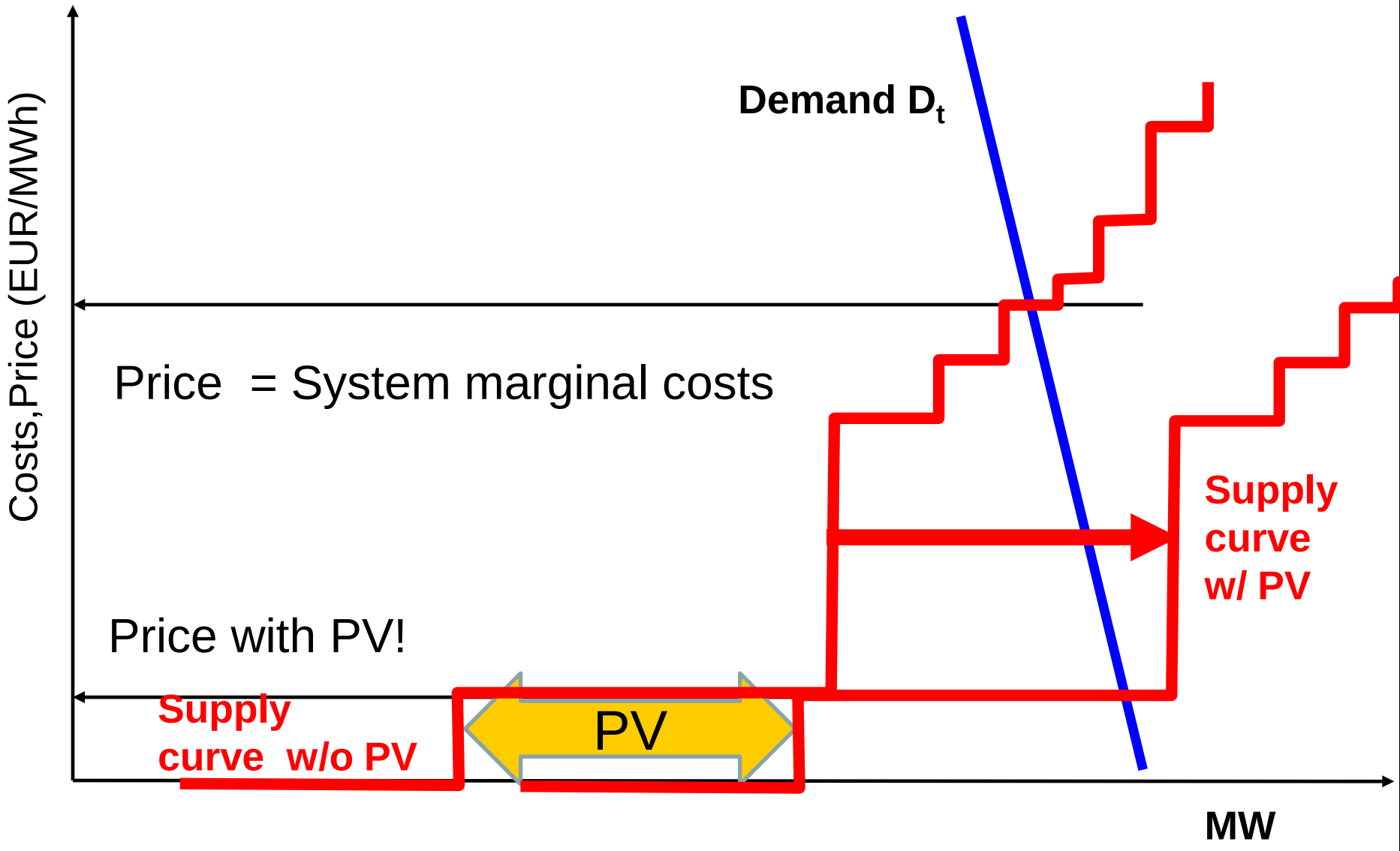
**prices = Short-term marginal costs**

**(Short-term marginal costs = fuel costs)**

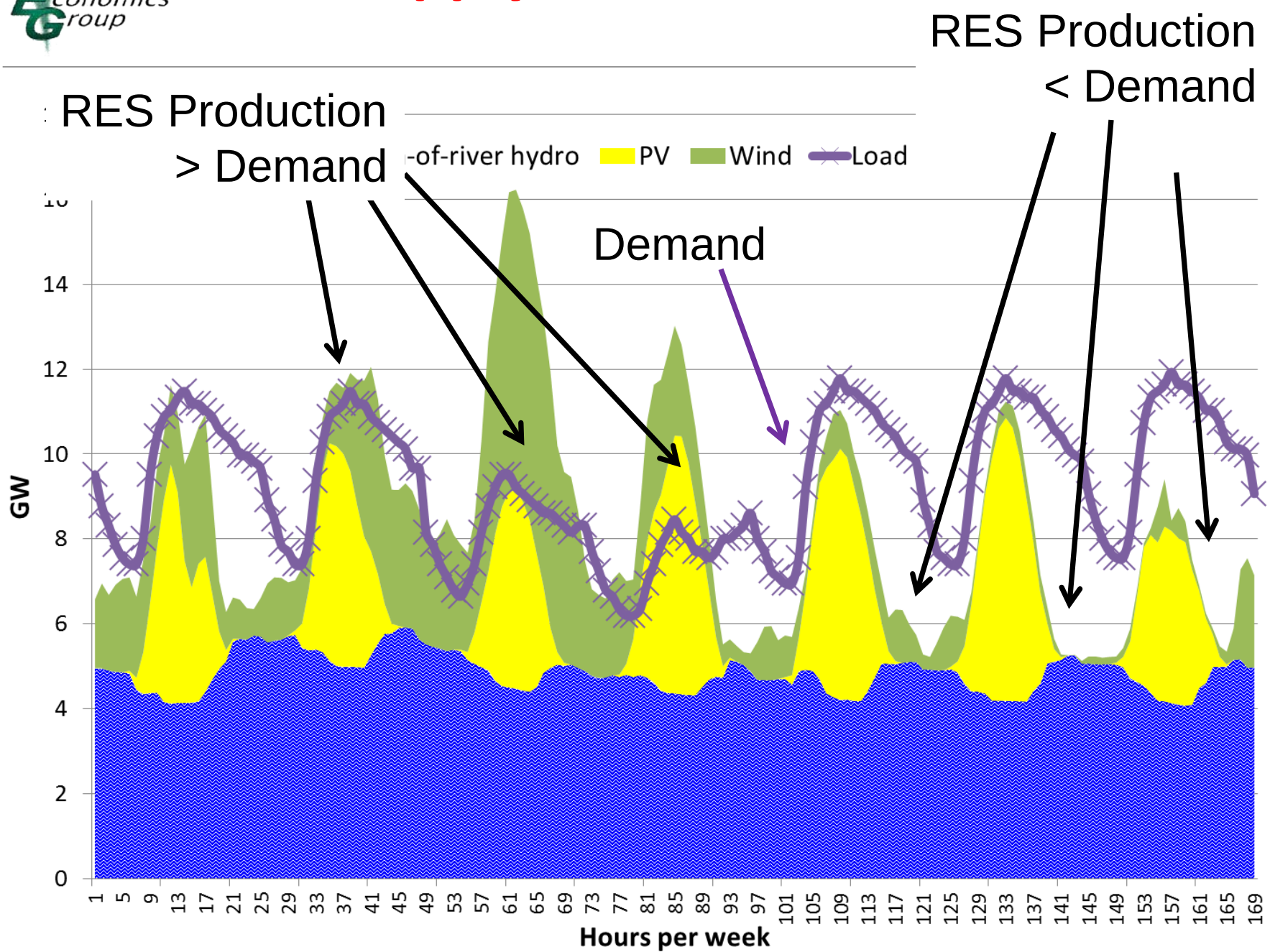
**due to huge depreciated excess capacities at the beginning of liberalisation!**

# 3 HOW VARIABLE RENEWABLES IMPACT PRICES IN ELECTRICITY MARKETS

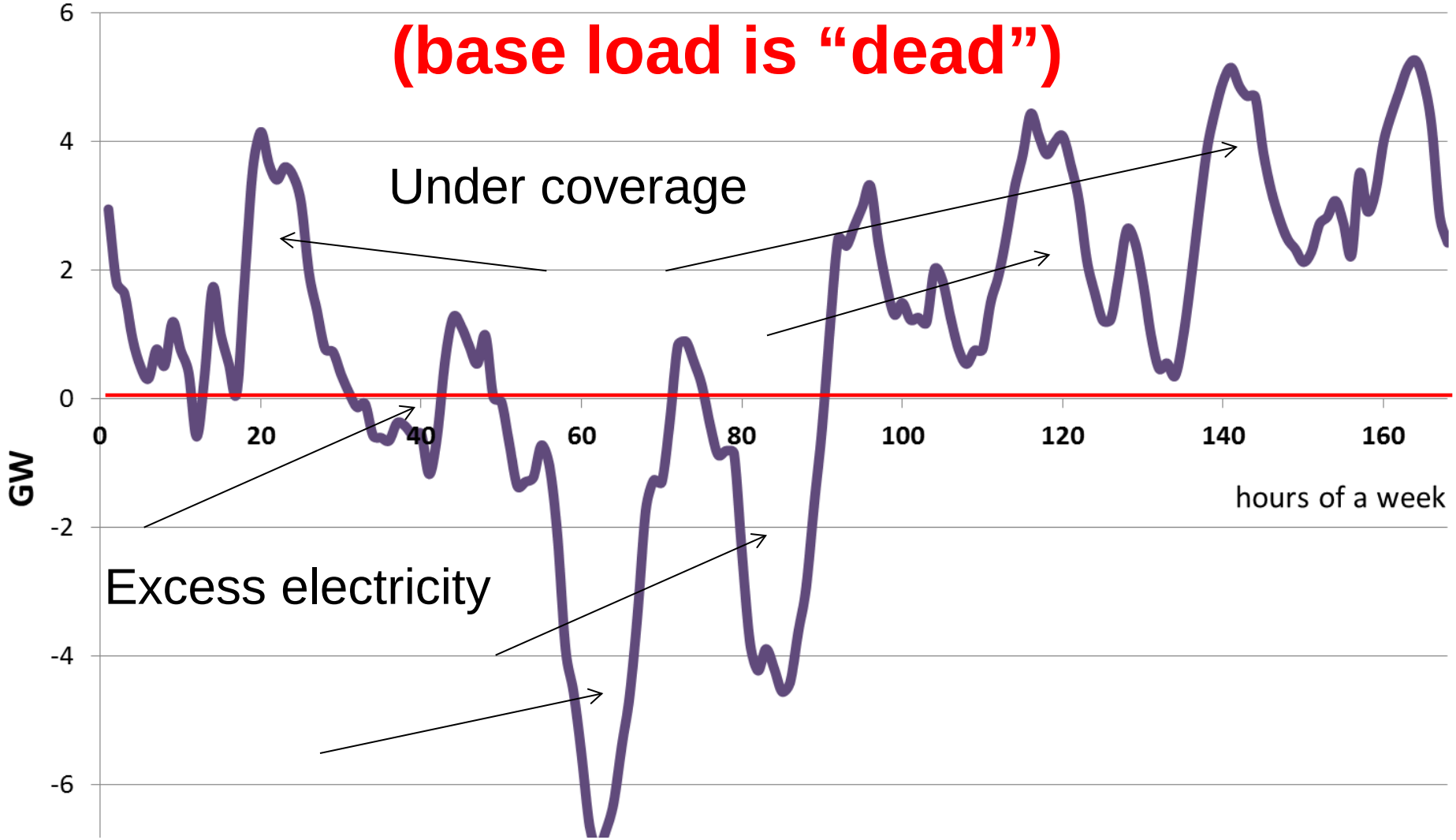
# Example: prices without and with PV



# Supply and Demand



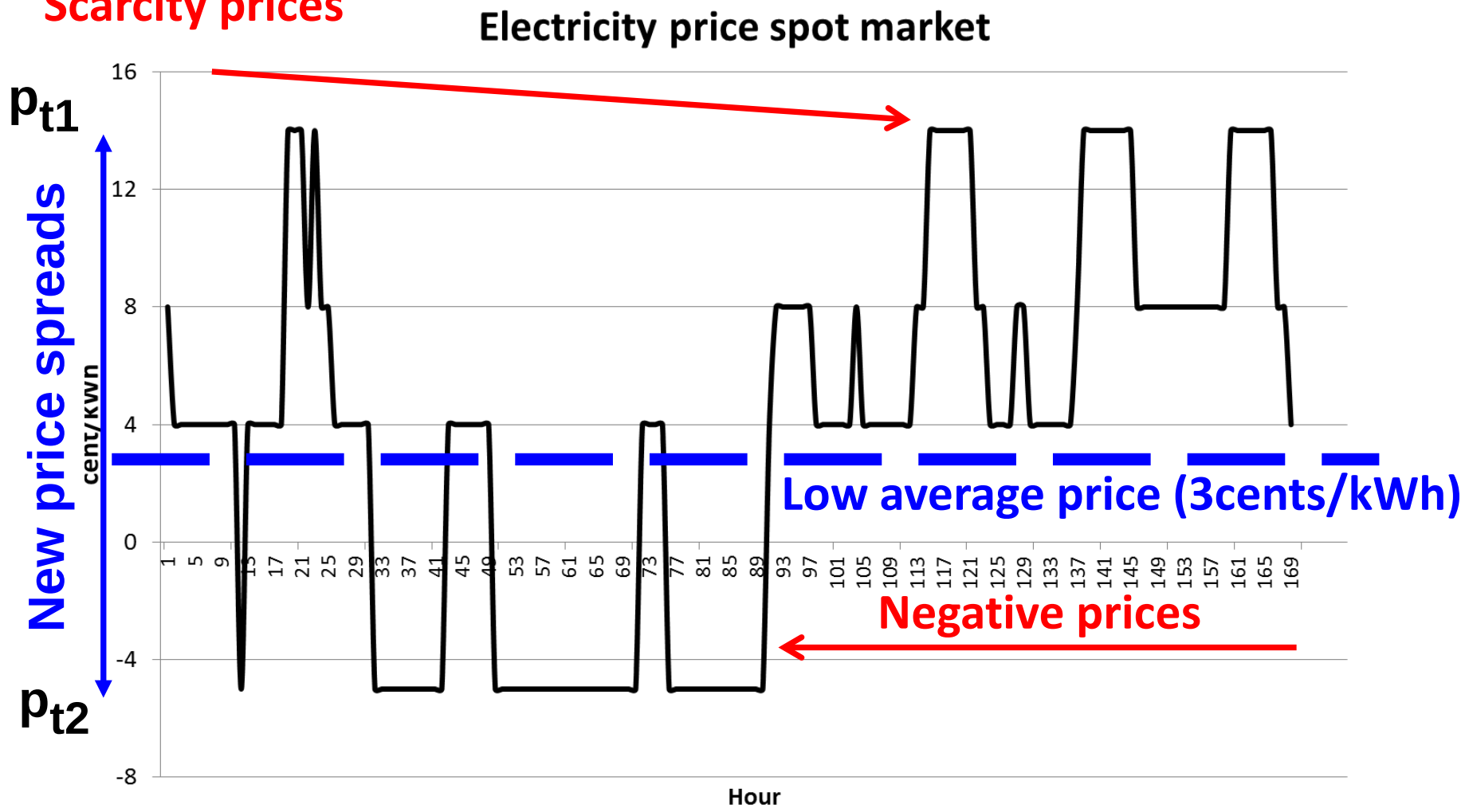
# Key term of the future: Residual load (base load is “dead”)




**Residual load = Load – non-flexible generation**

# Deviation from STMC-pricing in spot markets

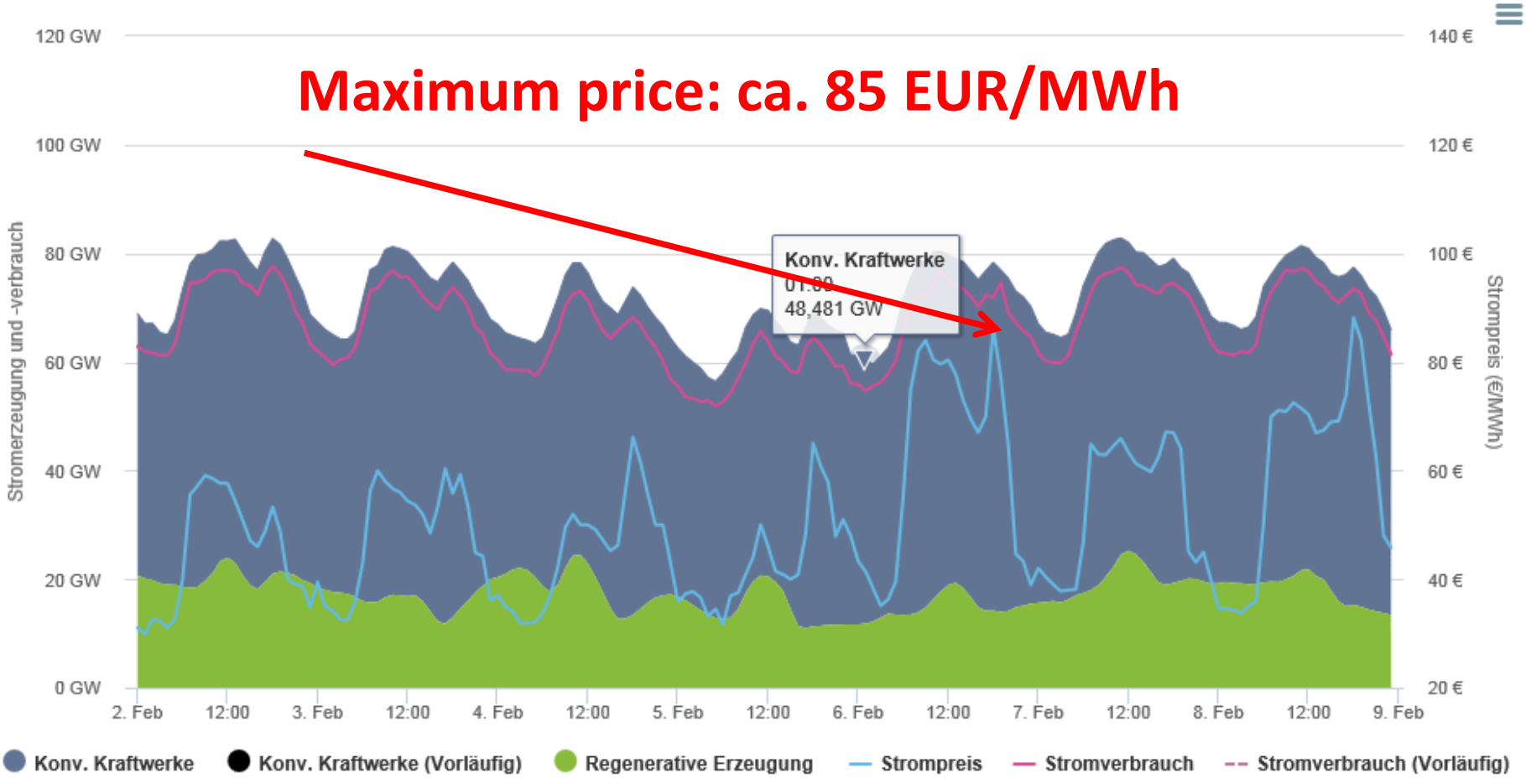
Scarcity prices




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

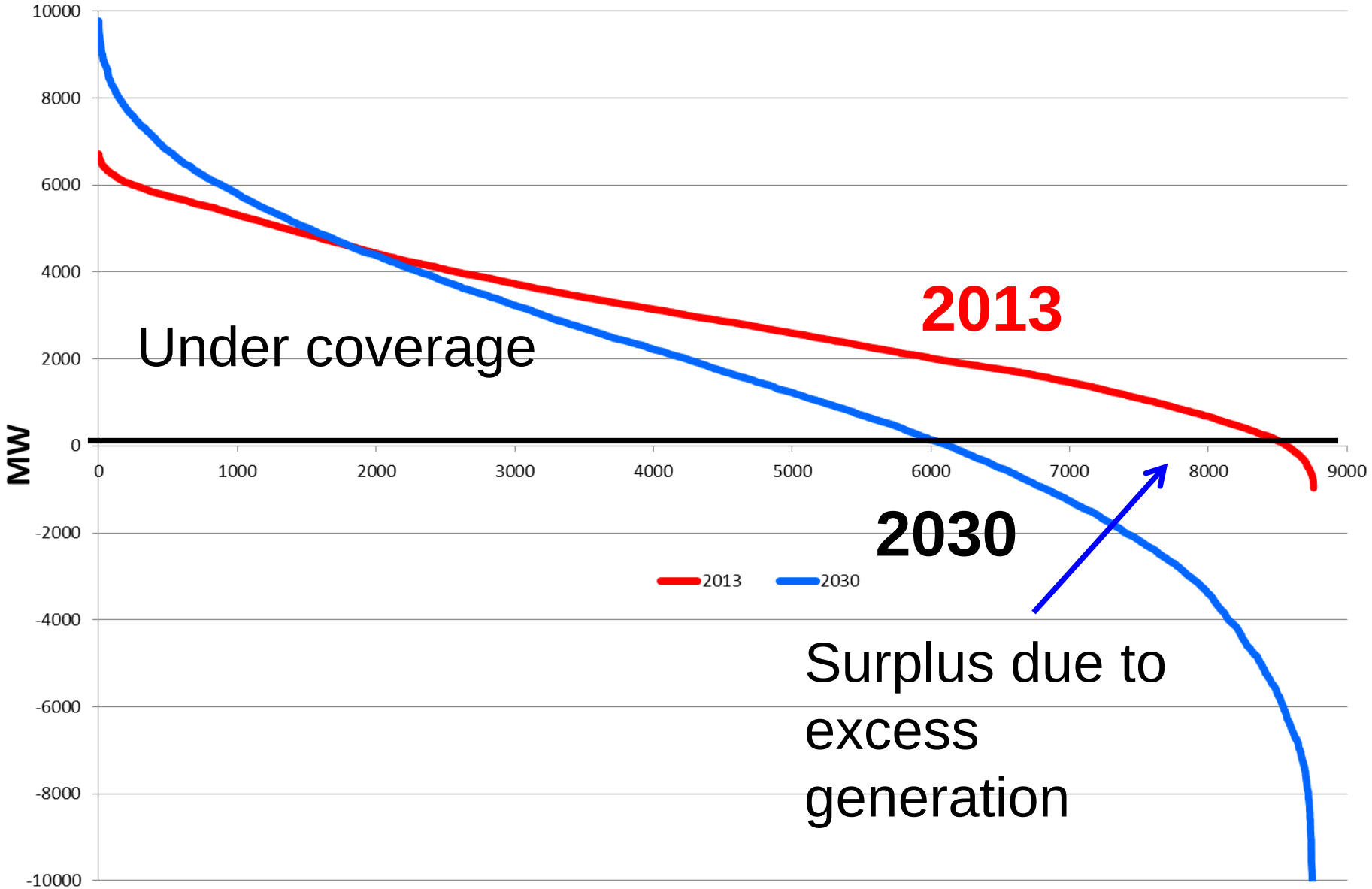
# Remark: Cold - dark – Lull („Kalte Dunkelflaute“)

## Maximum price: ca. 85 EUR/MWh

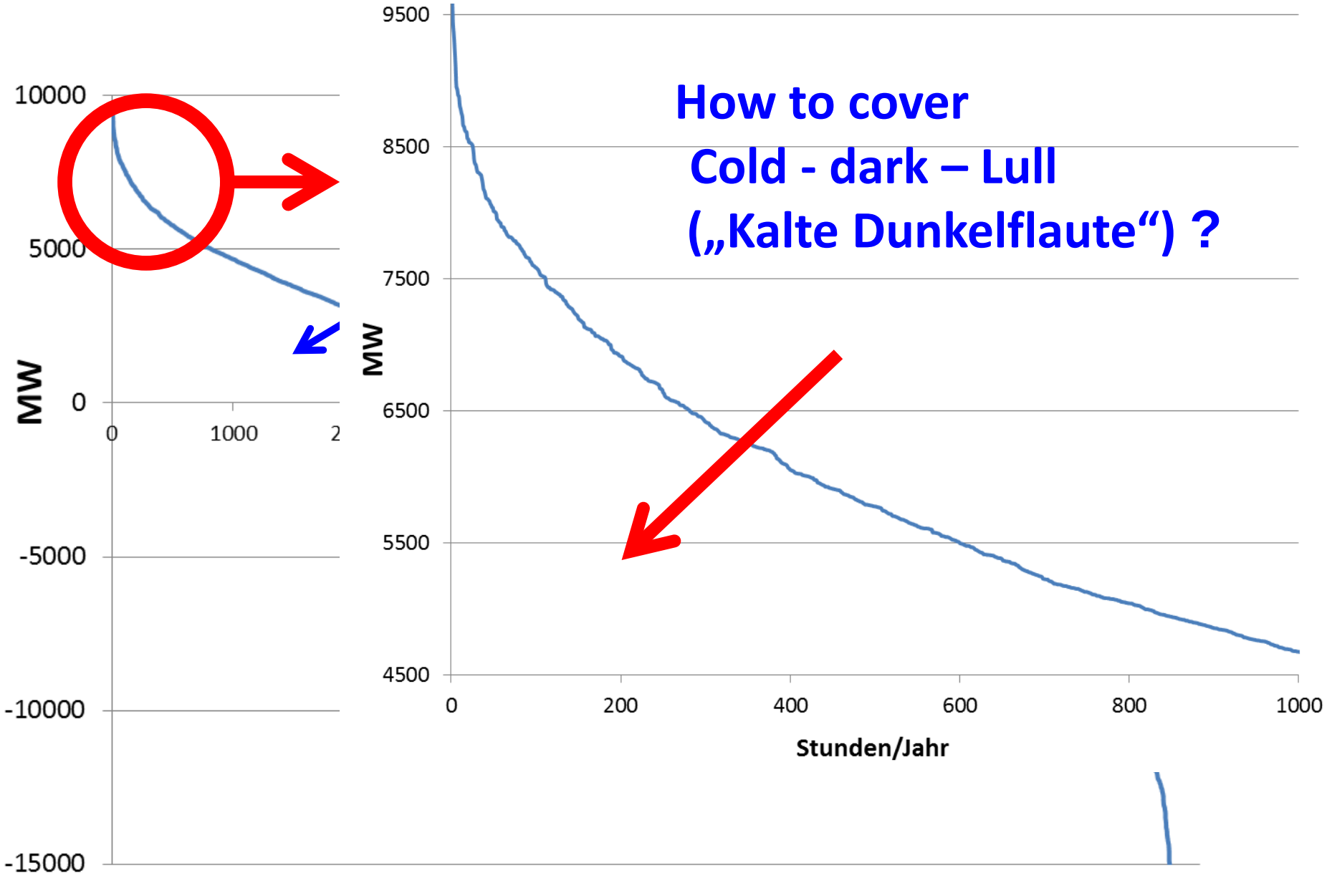



Agora Energiewende; Stand: 16.04.2017, 15:30

# Classified residual load



# Classified residual load



# There are two extreme positions:

**By a regulated capacity „market“ with STMC pricing?**

**or**

**By competition between supply-side and demand-side technologies and behaviour (incl. Storages, grid and other flexibility options) with correct scarcity pricing signals?**

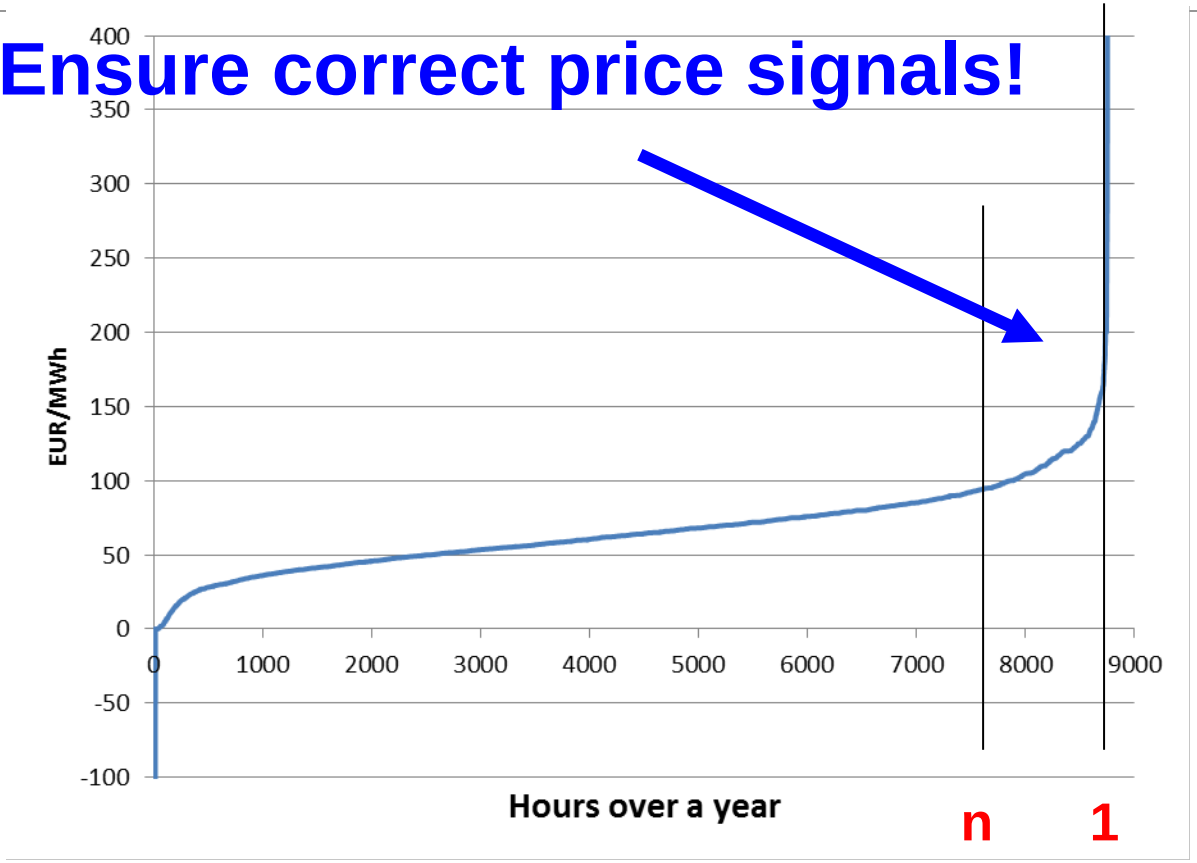
Given a price pattern, showing excess and scarcity prices it would be attractive for a sufficient number of flexible power plant operators to stay in the market!

→

REVISED ENERGY-ONLY MARKET

# Cost duration curve

## Ensure correct price signals!




## Generators stay in the market if:

$$\sum_{t=1}^{n} (p_{ele_t} \cdot q_{ele_t} - c_{f_t}) > (c_{c_y} + c_{O\&M_y})$$

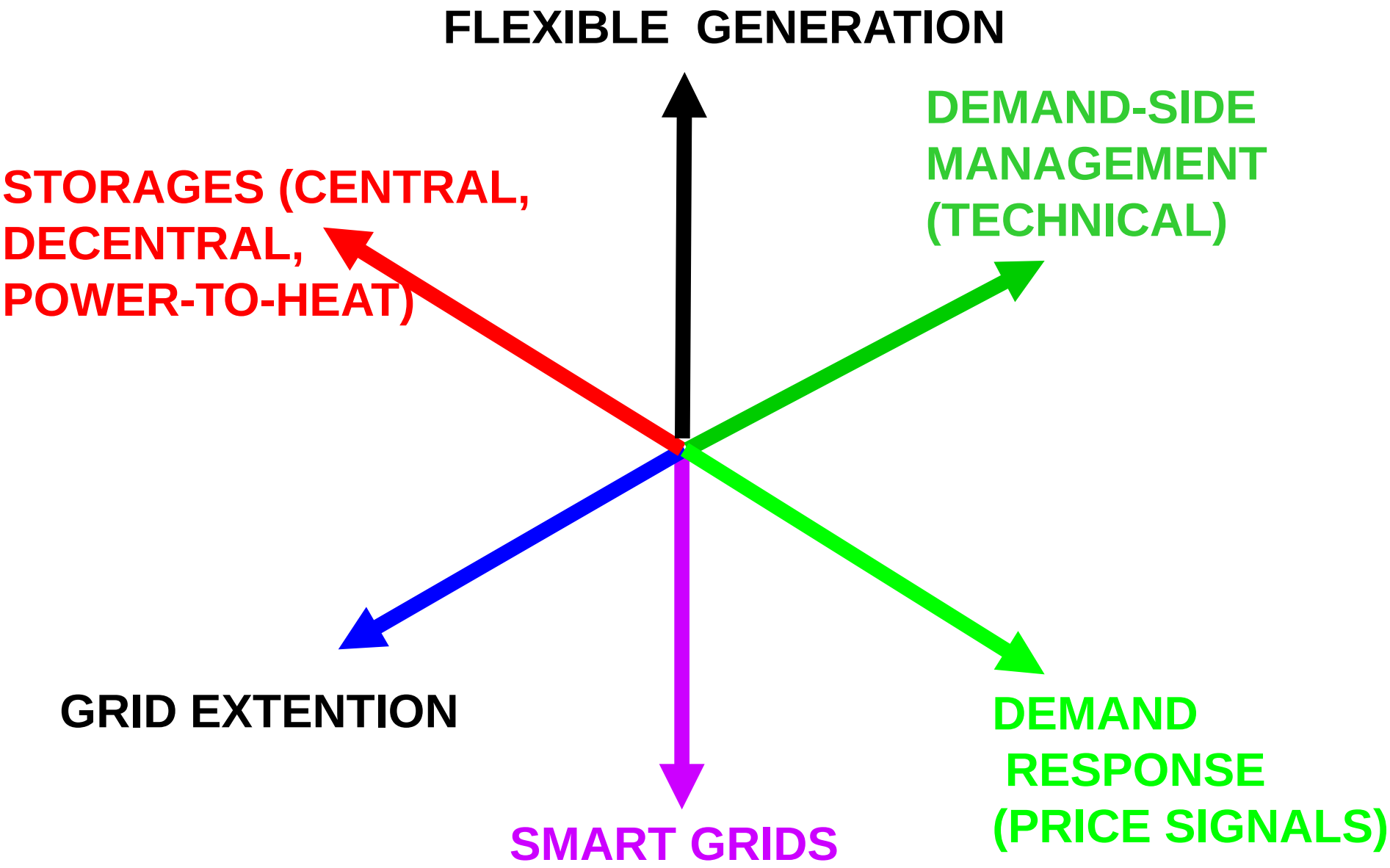
# 4 THE CORE PROBLEMS OF CAPACITY PAYMENTS

**All regulatory capacity payments for power plants destort the EOM and lead to wrong price signals for all other options**

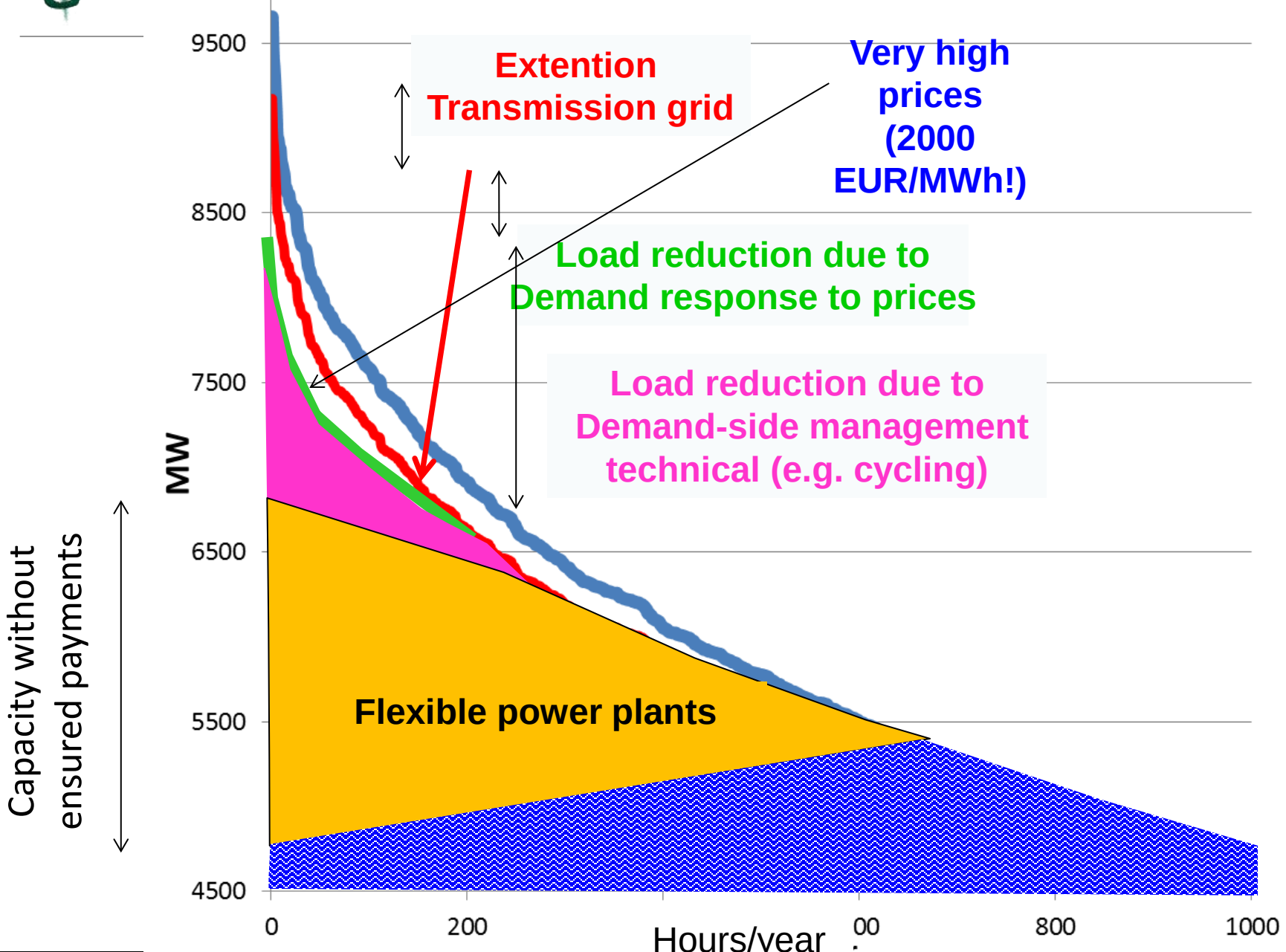
**Price peaks at times of scarce resource should revive the markets and lead to effective competition**

**We should strive to retain system resource adequacy by ensuring correct price signals and without capacity payments**

# 5 THE ROLE OF FLEXIBILITY AND SECTOR COUPLING

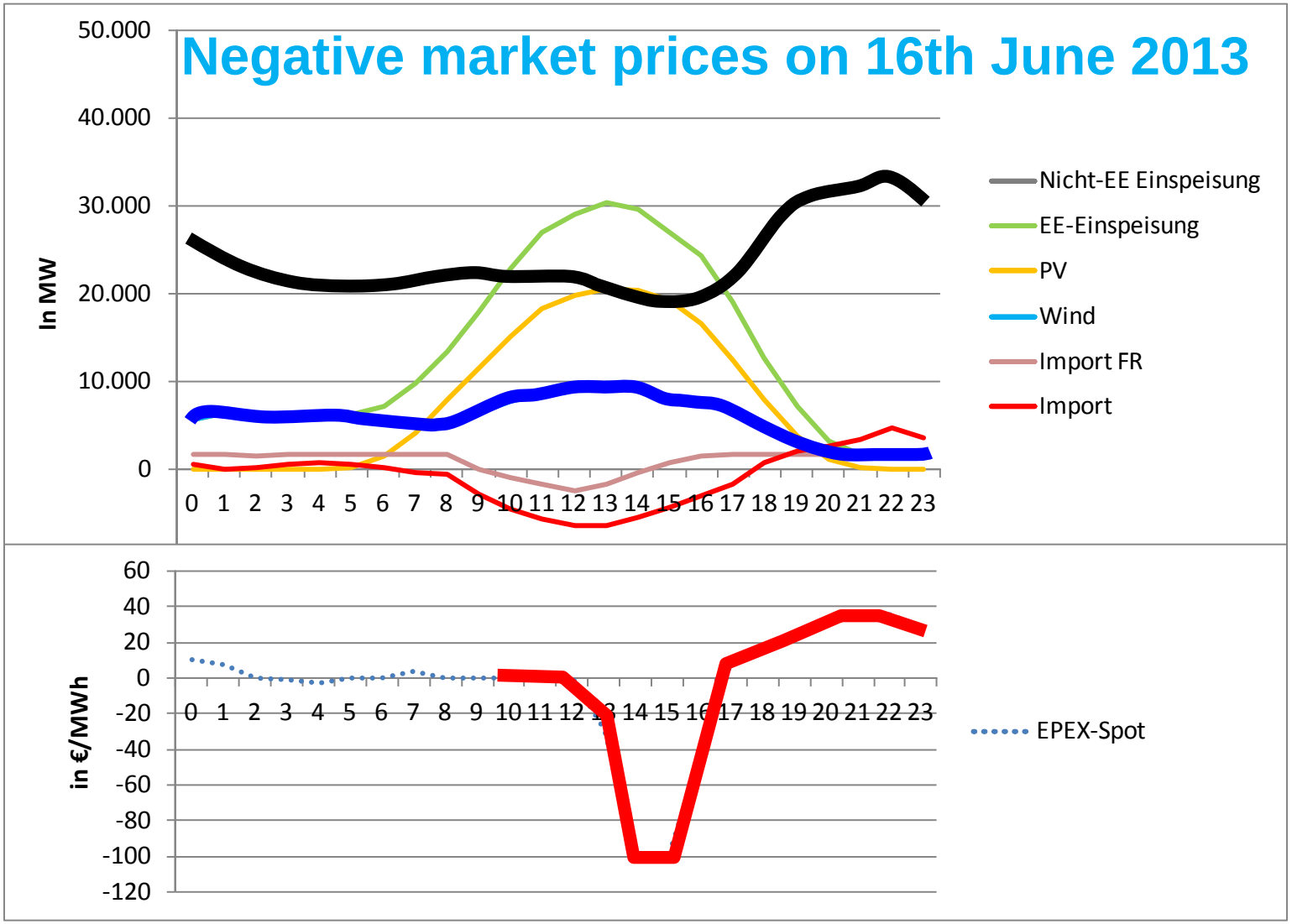


# Flexible coverage of residual load

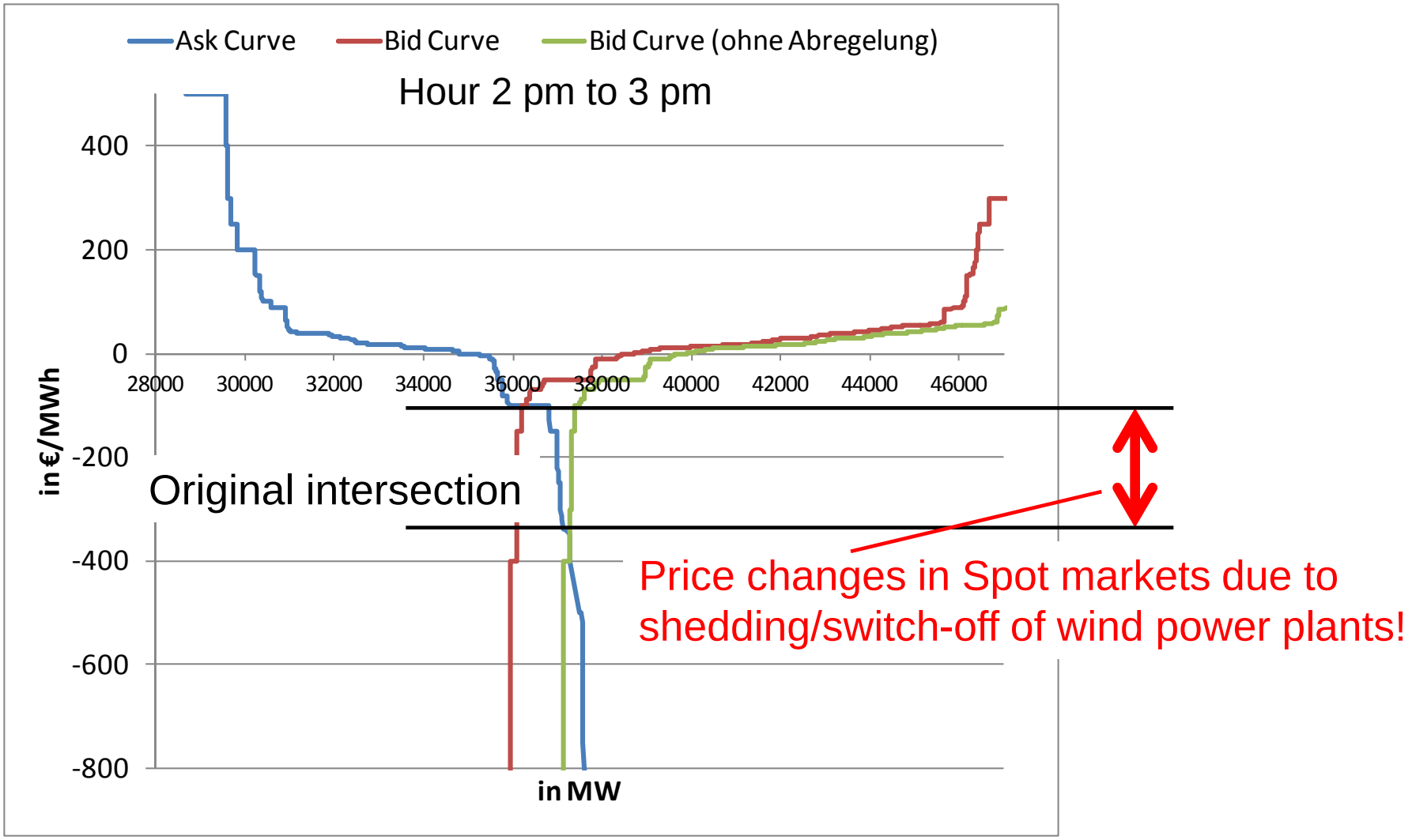


# Flexibility in generation: Variable RES are controllable

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

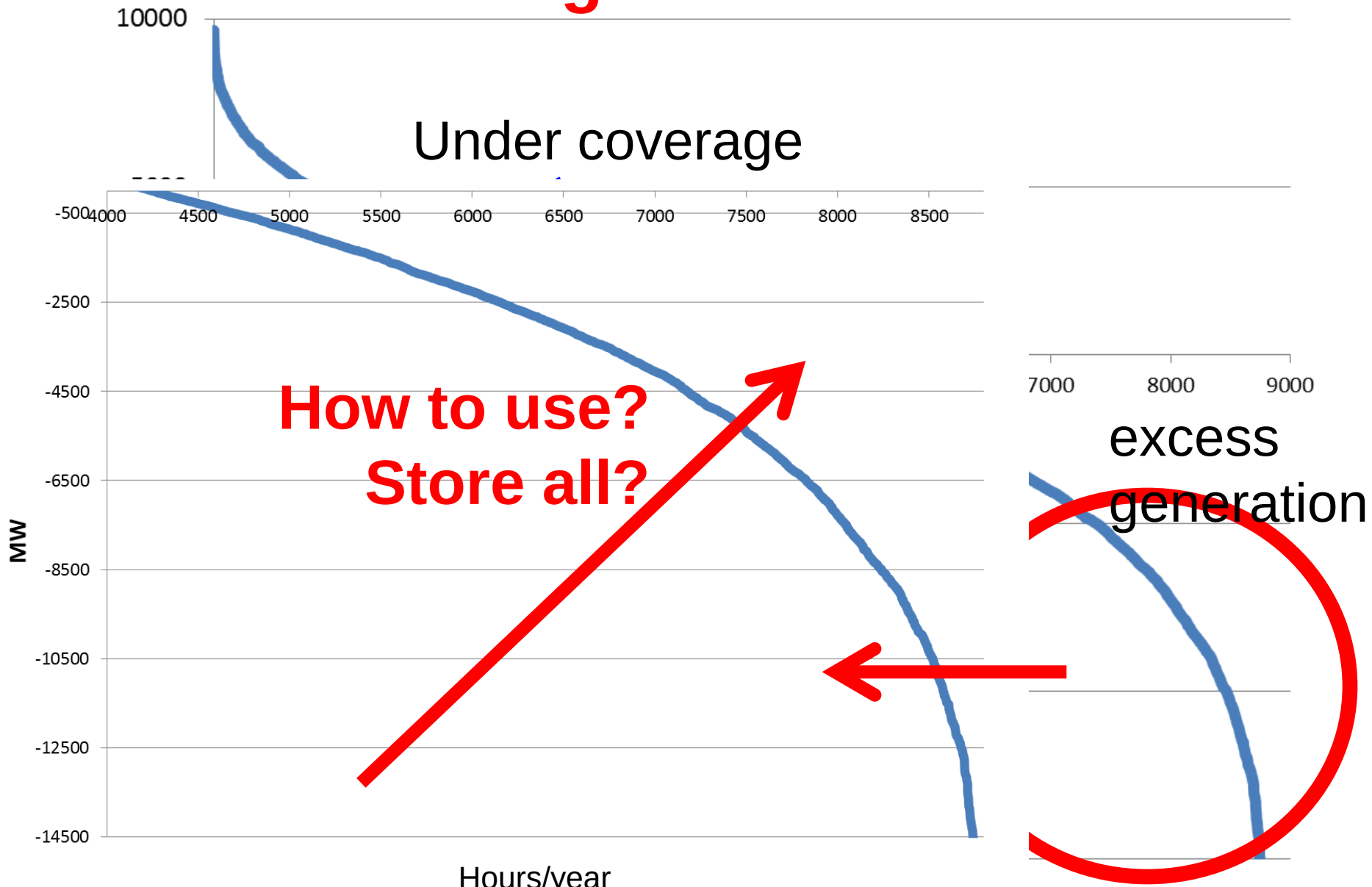


# Impact of switch-off of wind power plants on electricity market prices

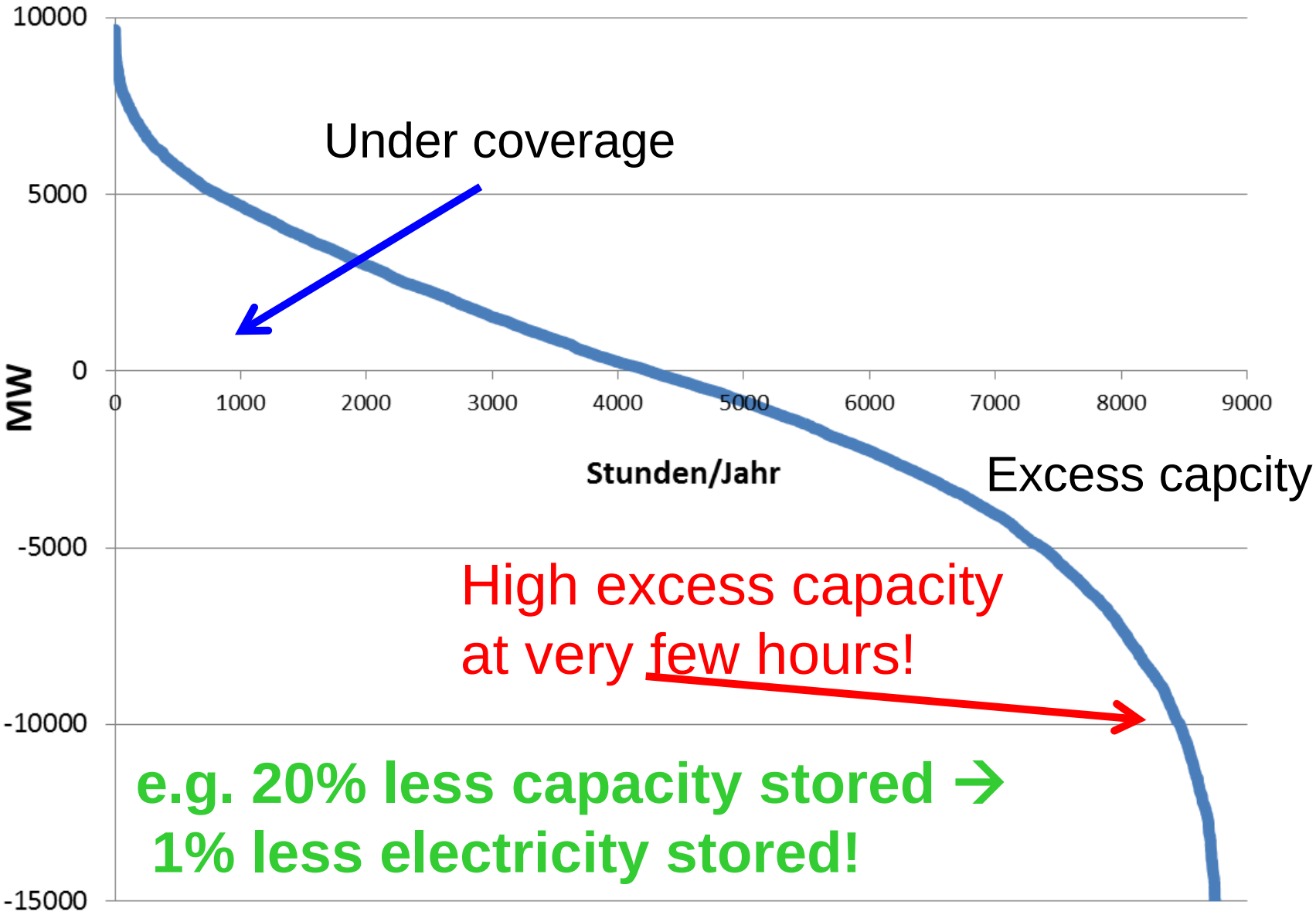



→ Wind power → flexible source!

# Specific question: How much storage do we need?



# Storing every peak?



# 3. The costs of storage

$$C = \frac{\frac{IC \cdot \alpha + C_{OM}}{T} + C_E}{\eta_{STO}} \quad [\frac{EUR}{kWh}]$$

C … Storage costs (EUR per kWh)

$C_E$ … Energy costs (EUR per kWh)

$C_{OM}$ … O&M costs (cent per kWh)

IC … Investment costs (EUR/kW)

$\alpha$ … Capital Recovery factor

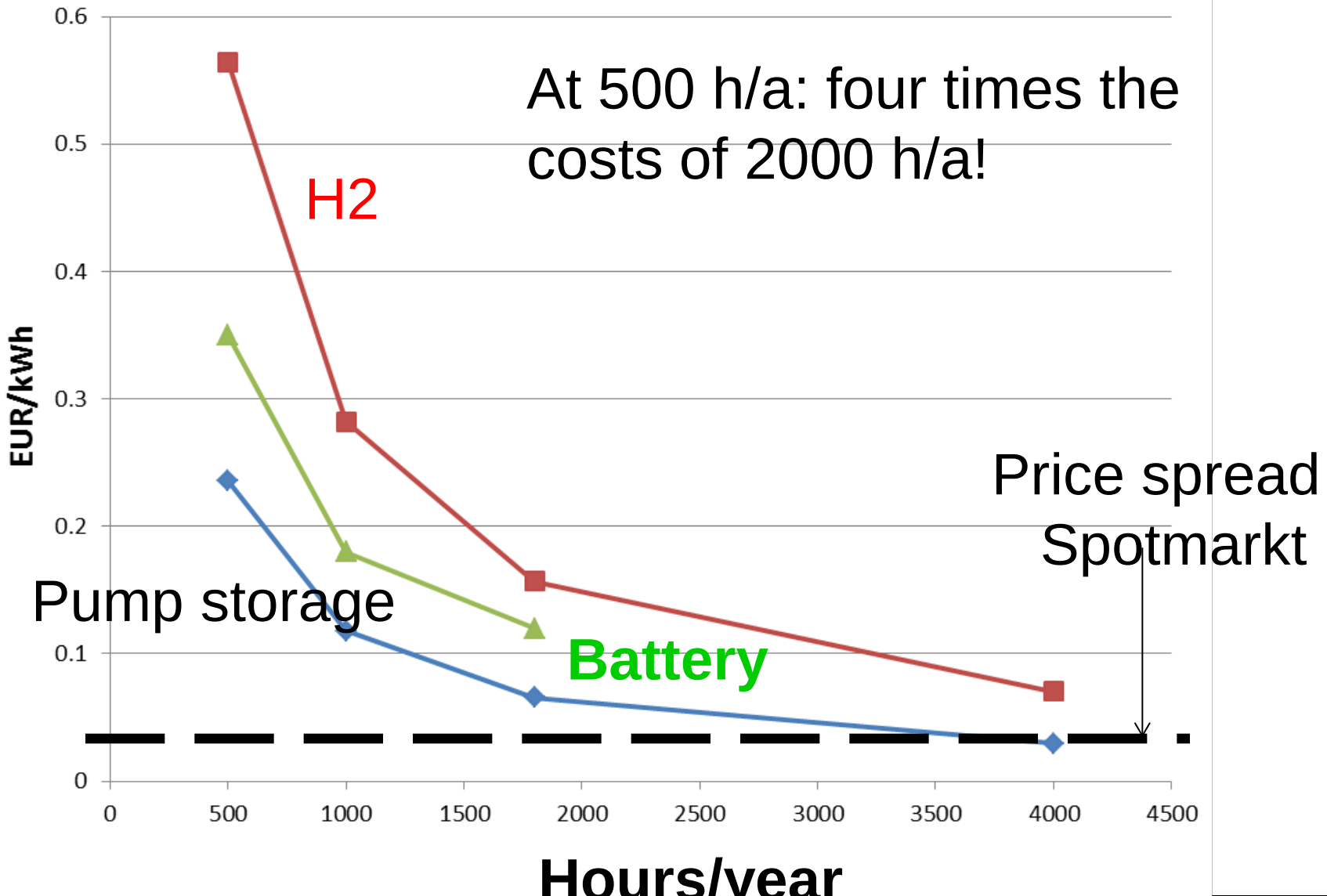
T … Fullloadhours (hours per year)

$\eta_{SP}$ … Efficiency of storage

**Key factors:**

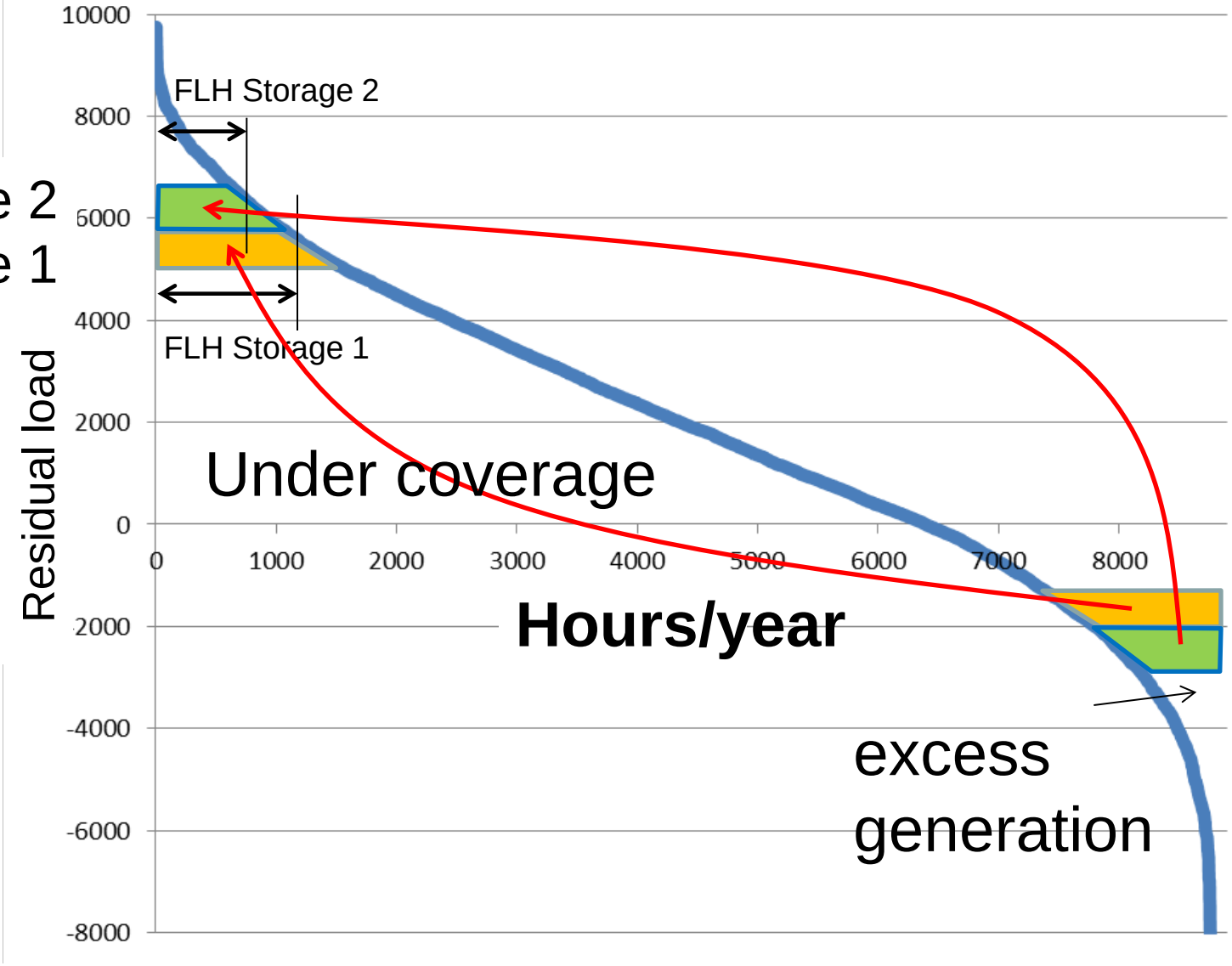
- **T (Fullloadhours)!**
- **$C_E$ (electricity price)**

# Impact of fullloadhours

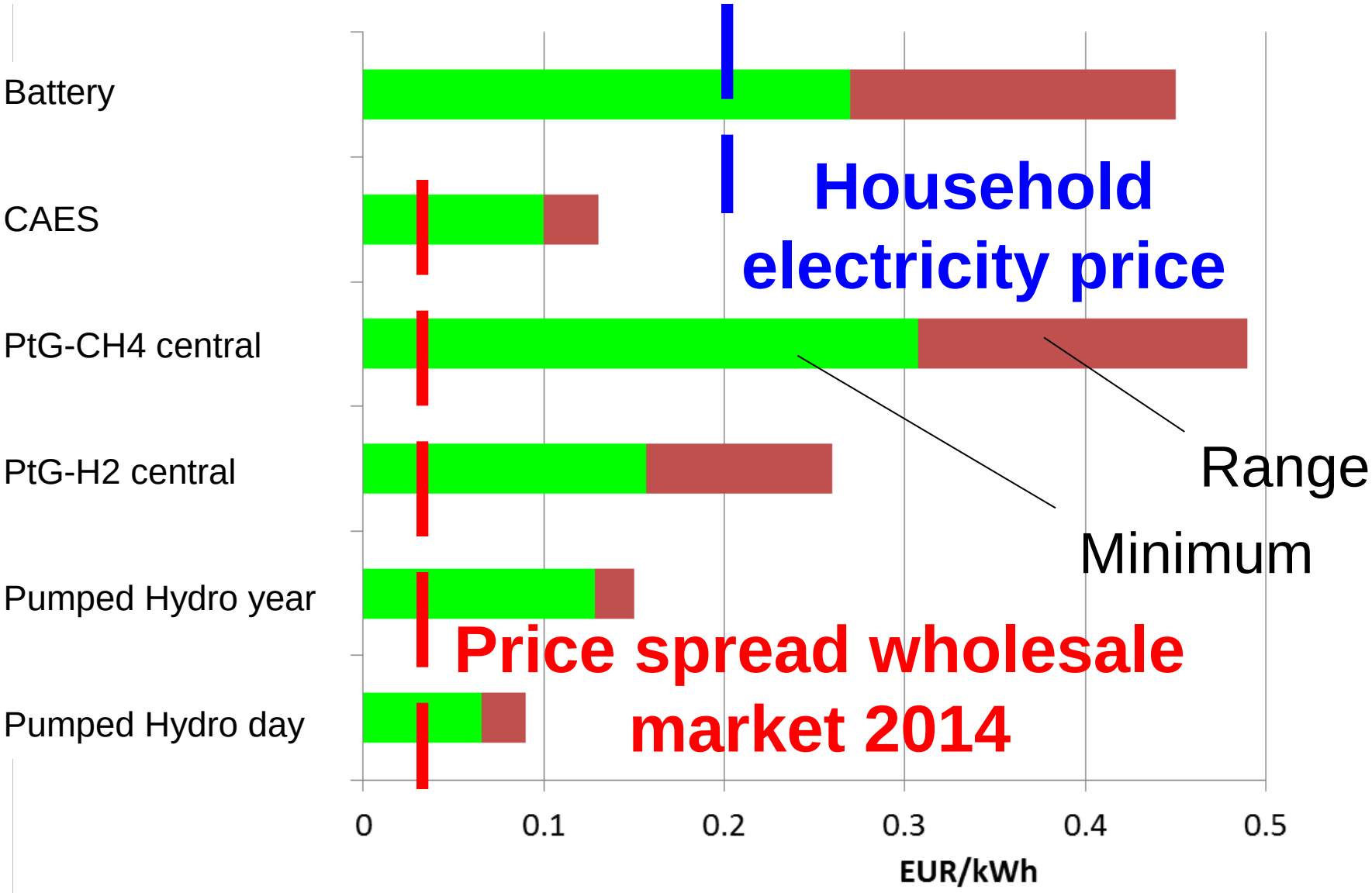


# Decreasing full-load hours of storages

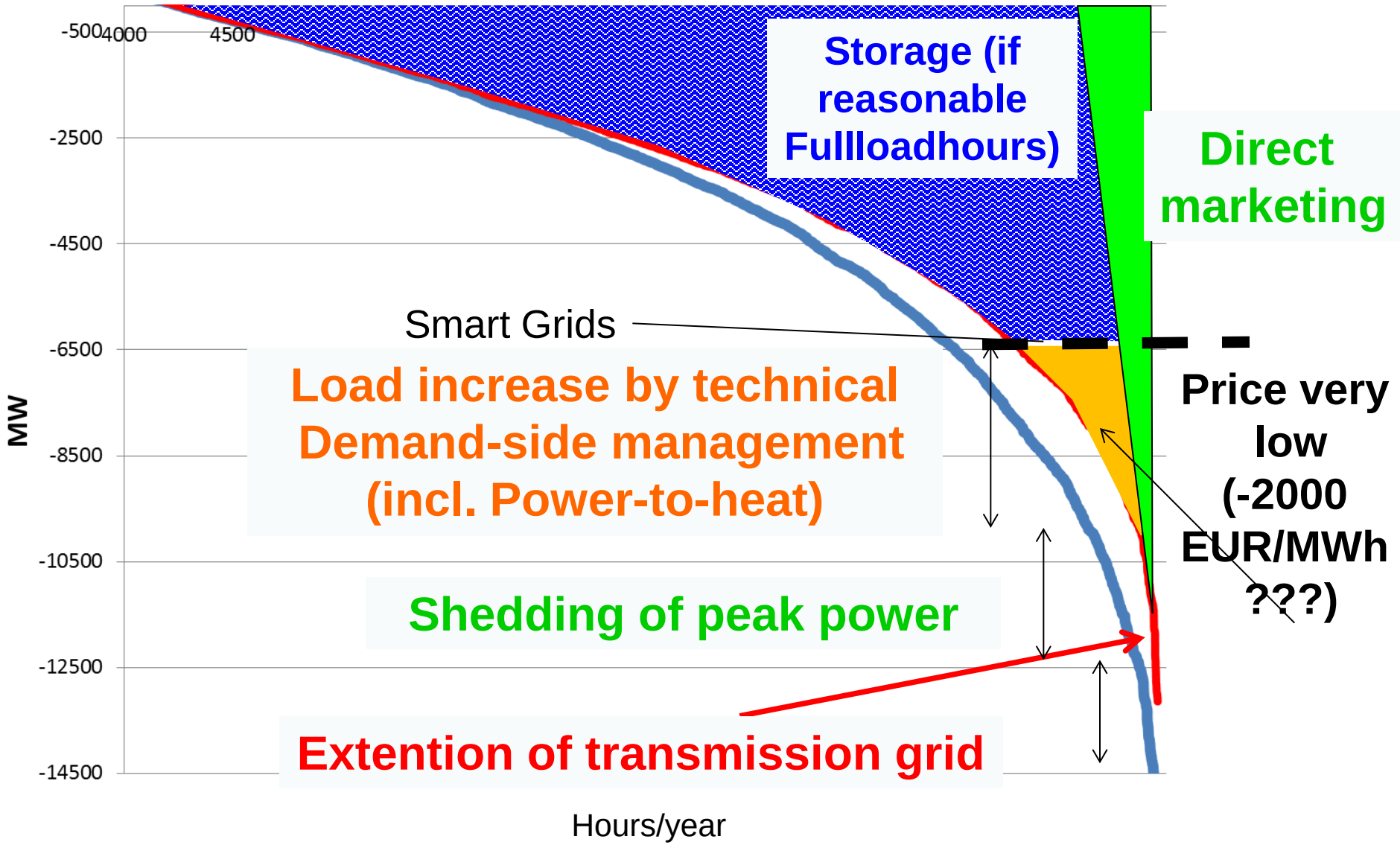
Storage 2
Storage 1



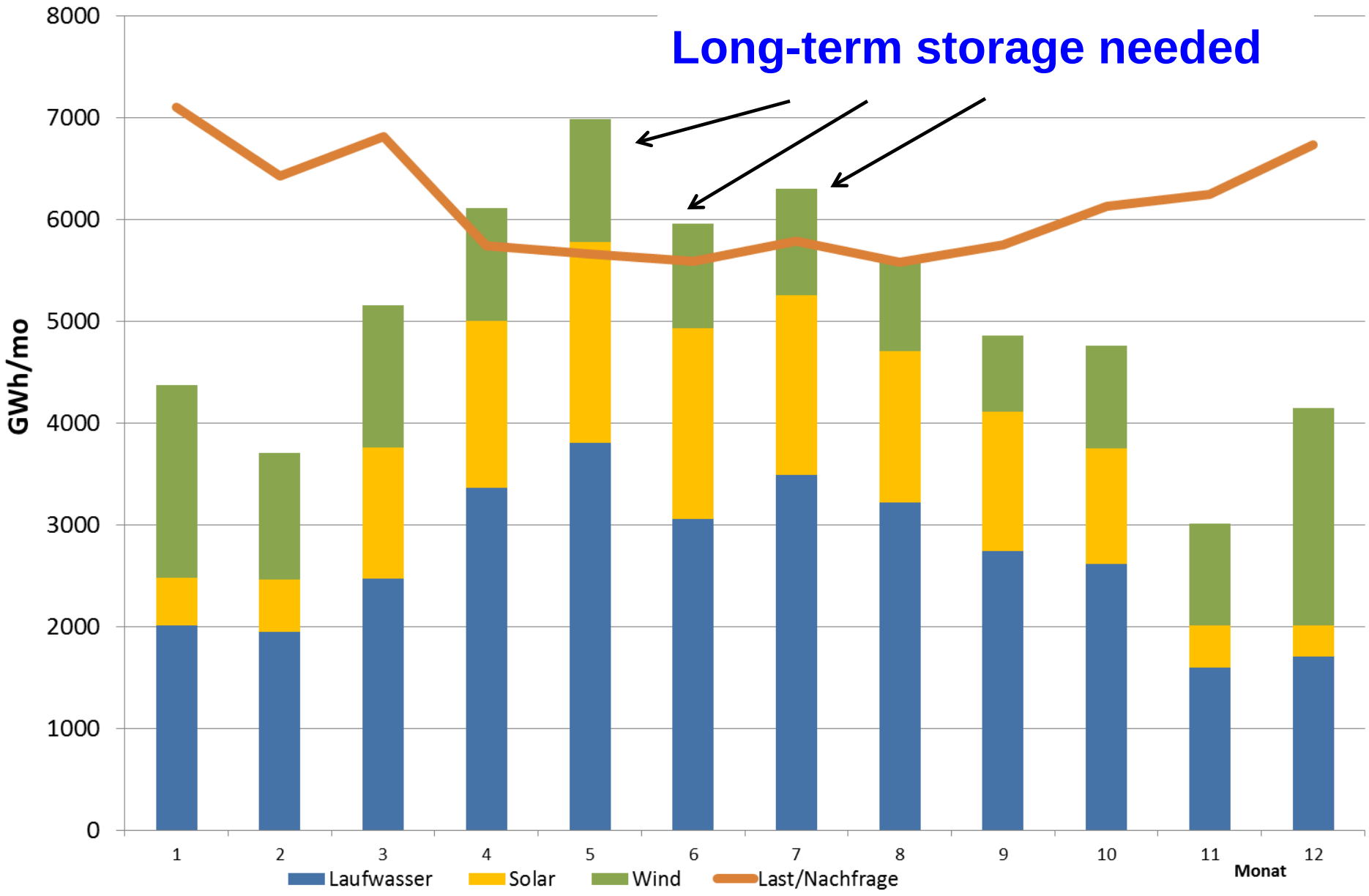
# 3. Range of costs 2014



# Flexible use of excess electricity



# Demand for long-term storage



# Sector coupling / Sector integration

* In times of surplus generation: How to use excess electricity in meaningful way?

Heating/Cooling

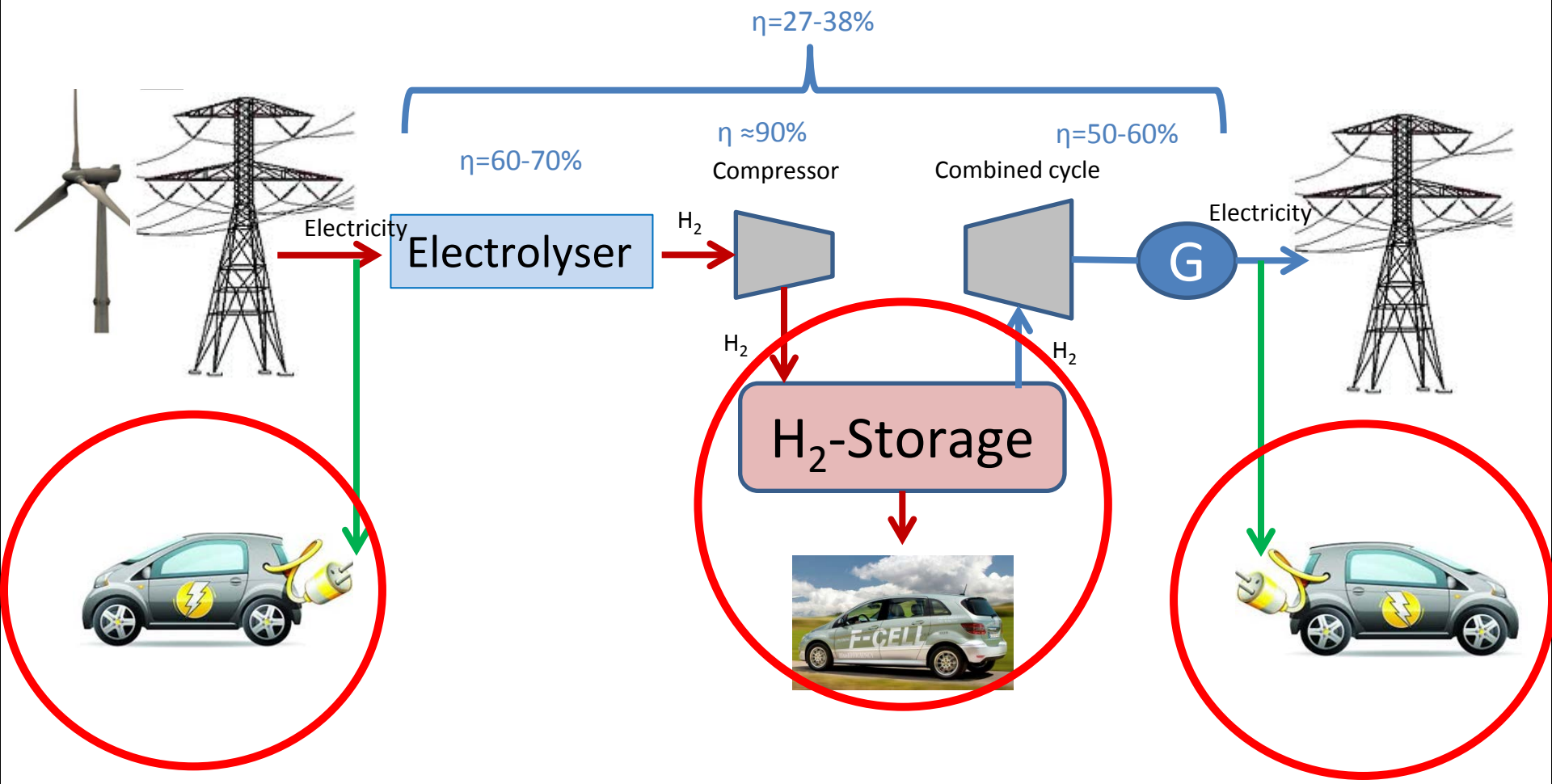
Transport

* Vague simplified suggestions, no convincing long-term solutions

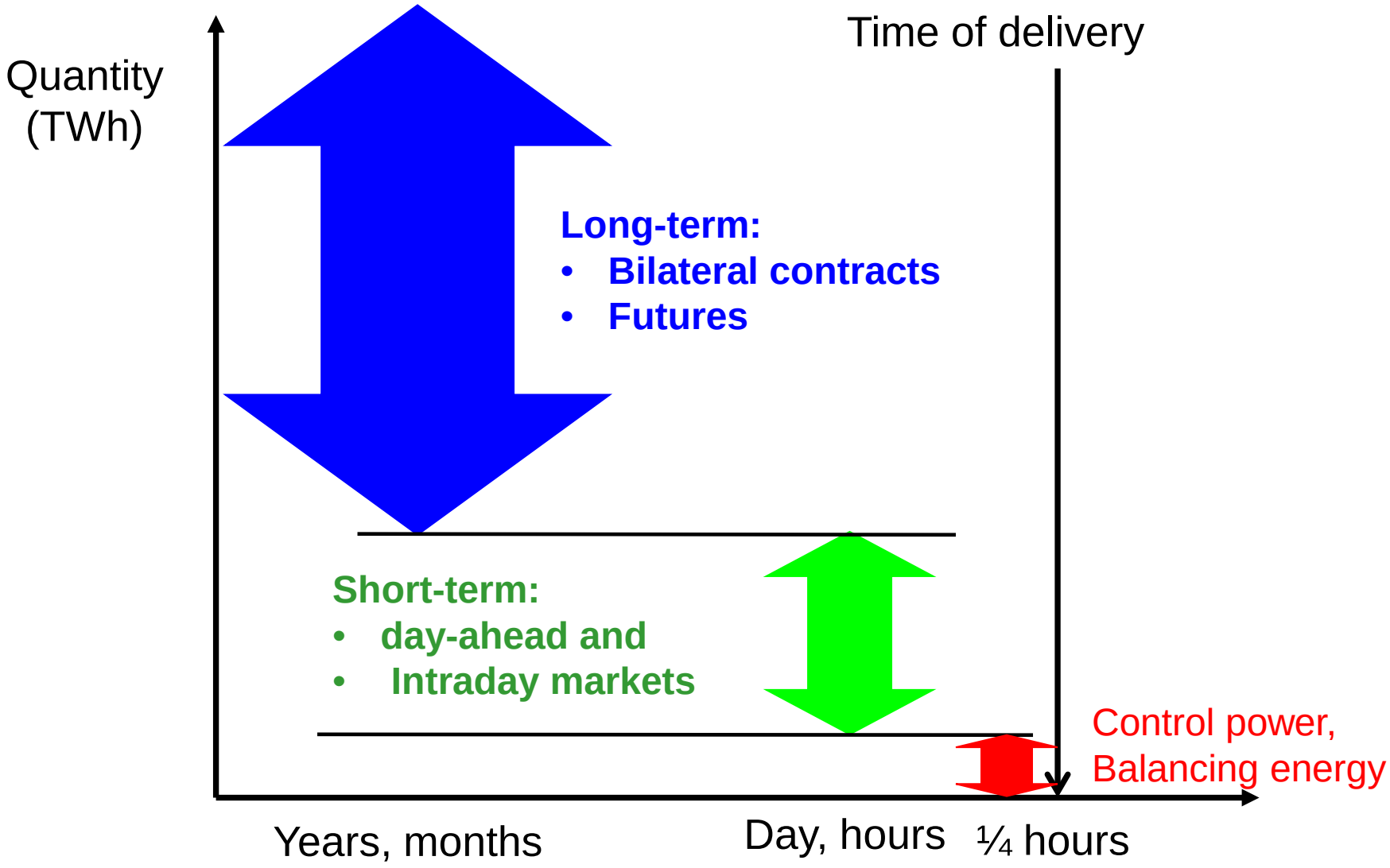
* Central (Ptx approaches, e.g. H2) vs decentral (end user level, E.g. Evs, heat pumps for heating) applications

* How to fit use with time of surplus, e.g of PV for heating ?

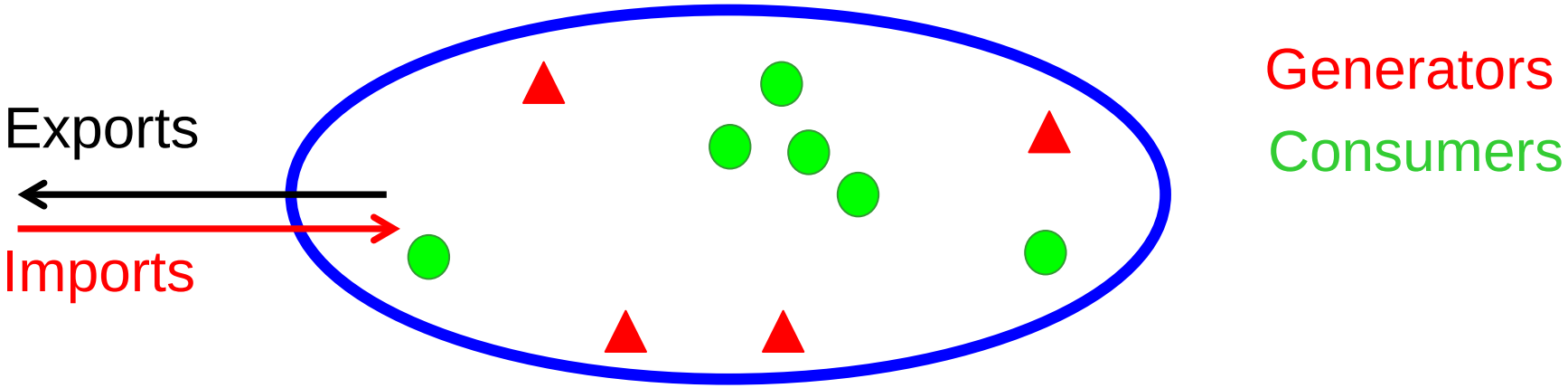
# Sector coupling hydrogen: Storage and fuel in transport?



# Elements of electricity markets



# 6. THE CORE ROLE AND RESPONSIBILITY OF BALANCING GROUPS



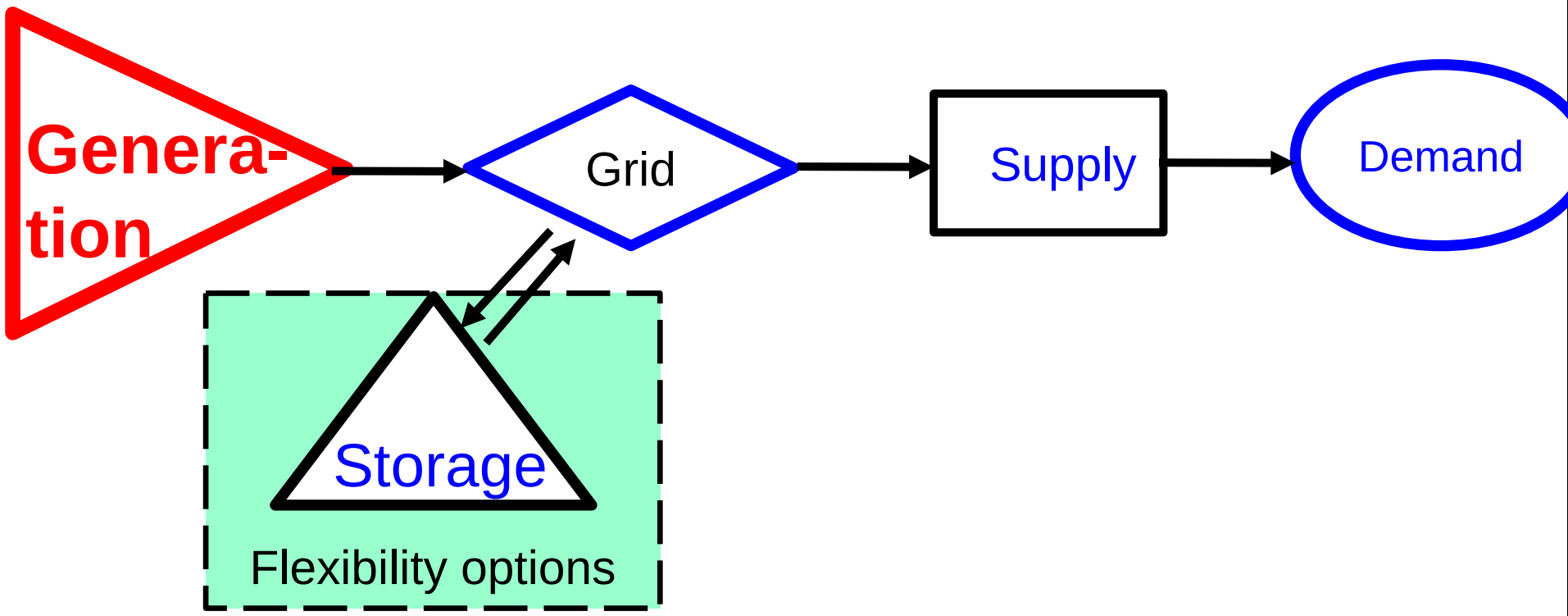

**Balancing group: entity in a control area of an electricity system; it has to ensure that at every moment demand and supply is balanced**

**E.g. municipal utility of Vienna, Dresden, Helsinki**

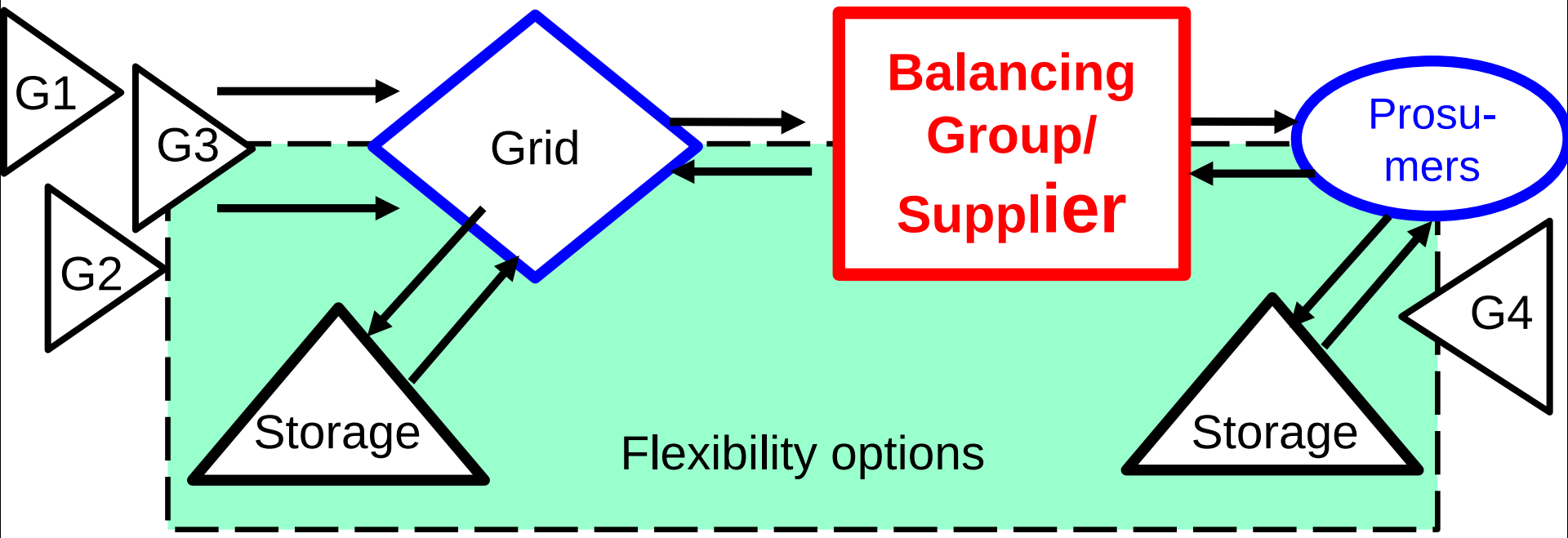
**To meet this target: own generation , storage, flexibility, Trading in long-term, day-ahead and intraday market**

**Every difference → high costs!**

# Old thinking

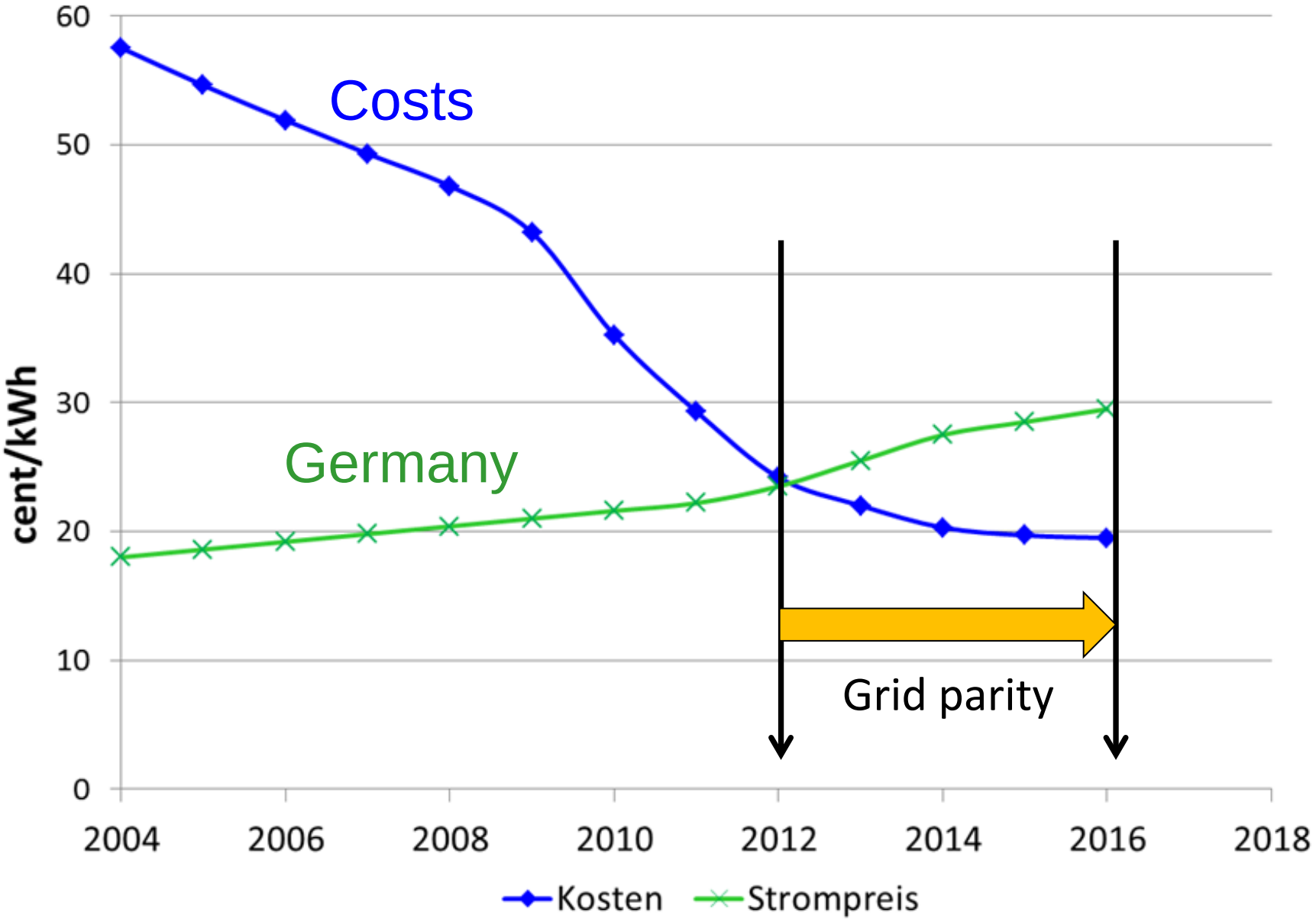


# New Thinking: Making the electricity system more democratic

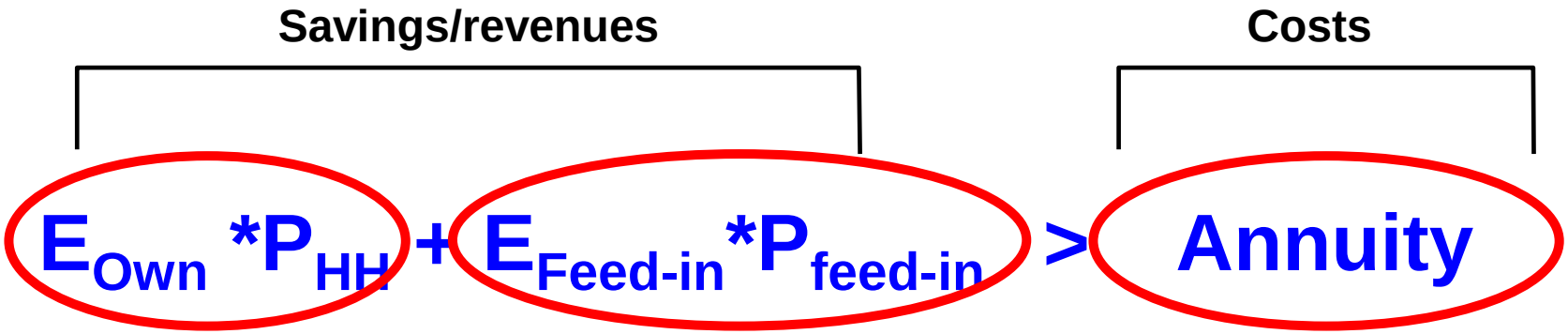


# 7. IS THE TIME FOR SUBSIDIZING RENEWABLES OVER ?

# Grid parity: PV-costs and household electricity prices



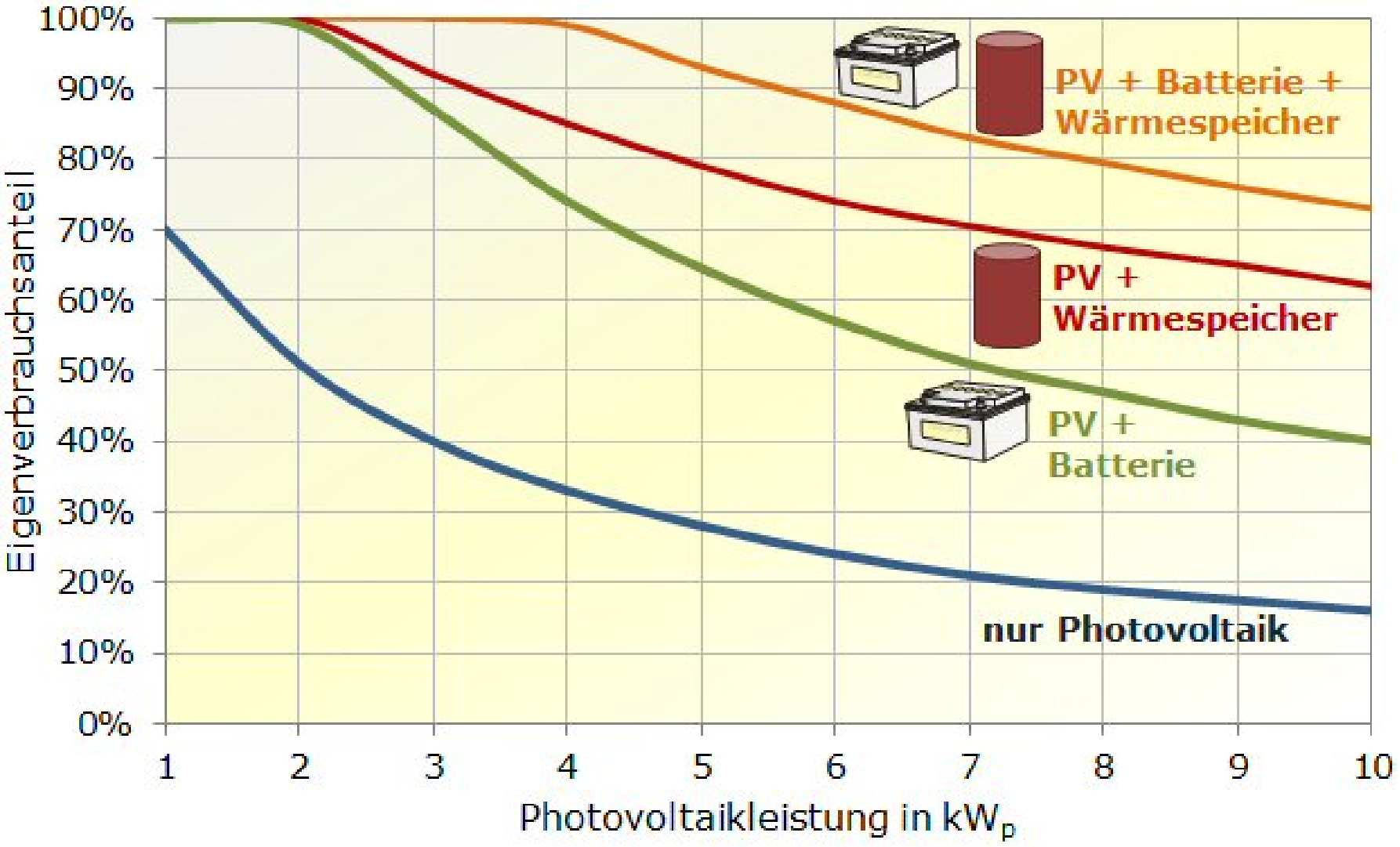
# Assessment of Grid Parity




Grid parity term

**Subsidy still necessary?**

# Share of own consumption



# Bidding Zero for off-shore wind

**Tender for wind farms to be constructed between 2021 and 2025:**

| Project | MW | ct/kWh |
|---|---|---|
| **EnBW** He Dreiht GmbH | 900 | 0.0 |
| **DONG Energy** Borkum Riffgrund West II GmbH | 240 | 0.0 |
| **Dong Energy** Northern Energy OWP West GmbH | 240 | 0.0 |
| **Dong Energy** Gode Wind 03 GmbH | 110 | 6.0* |
| **Weighted average** | **1,490** | **0.44** |

**Source: Innogy**

## Bets on:

- Increasing electricity prices
- Decreasing technology costs
- Sector coupling works

# 8. CONCLUSIONS

- Sustainable electric. system → integration of a broad technology portfolio & demand-side options!
- Larger market areas favourable
- Very important: correct price signals (incl. CO2)
- most urgent: exhaust full creativity of all market participants incl. decentralised PV systems
- The key: Flexibility (incl. dispatchable var RES)! Currently low economic incentives but activities started → very promising!
- Capacity payments: Any CP will distort the system towards more conv. and less RES capacity
- New key player: Balancing group (Supplier), no more the generator