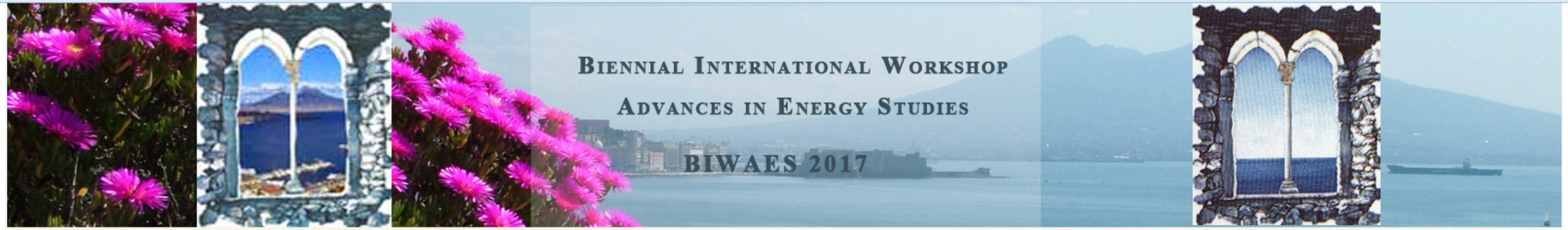




## Energy futures, environment and well-being

### Naples (Italy), 25-28 September 2017

***Topics include:***

- Energy, environment and well-being
- Energy efficiency
- Energy futures
- Social transition and global environmental change
- Sustainability
- Environmental constraints
- Energy metabolism
- Energy costs of water management
- Energy and mobility
- Waste management (energy costs and potential energy conversion)
- Food and commodity chains
- Cleaner production and appropriate resource management
- Innovative Energy Systems
- Energy supply and use (heat, electricity)

*Endorsements*

*Visit Naples*

# How to integrate large shares of variable renewables into electricity systems and markets


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Energy Economics Group, TU Wien


**Napoli, 25 September 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?
9. Conclusions

# 1. INTRODUCTION

## Motivation:

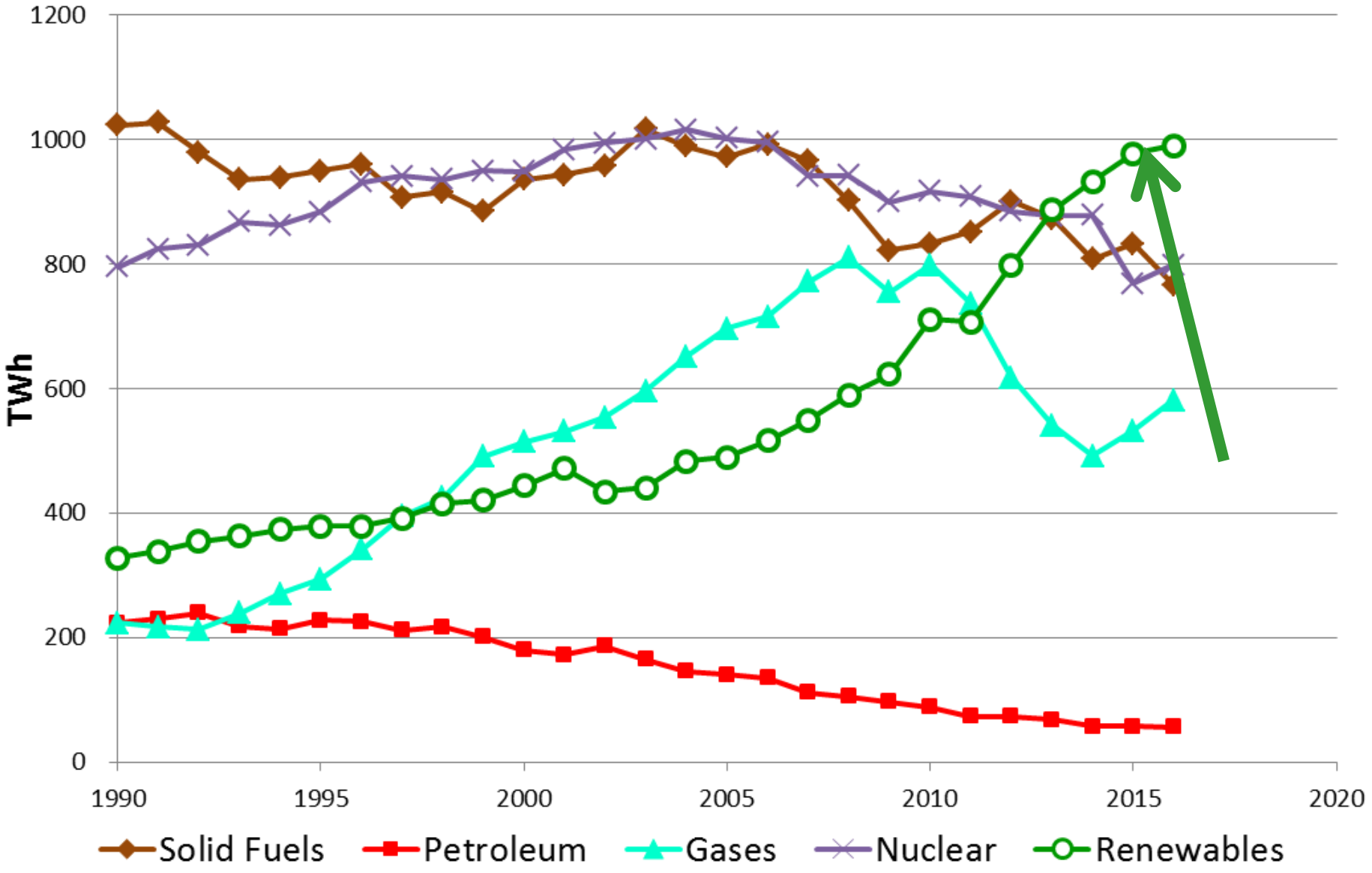
* Climate change → Paris agreements

* Competition & democracy

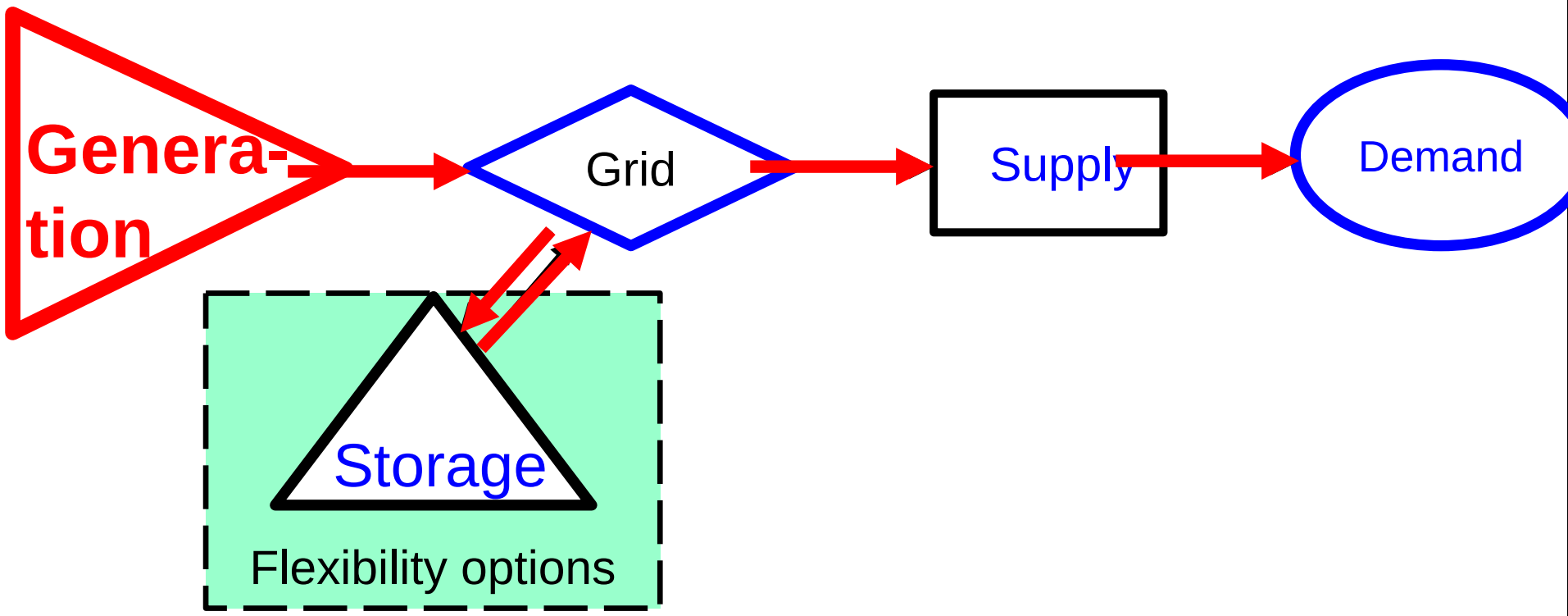
* It is not possible to squeeze variable renewables into the system by violence or planning

* It is necessary to provide proper financial Incentives

# Introduction:
# Electricity generation EU-28



# Old thinking



# 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;**

# Day-ahead electricity markets

**Expectation of**

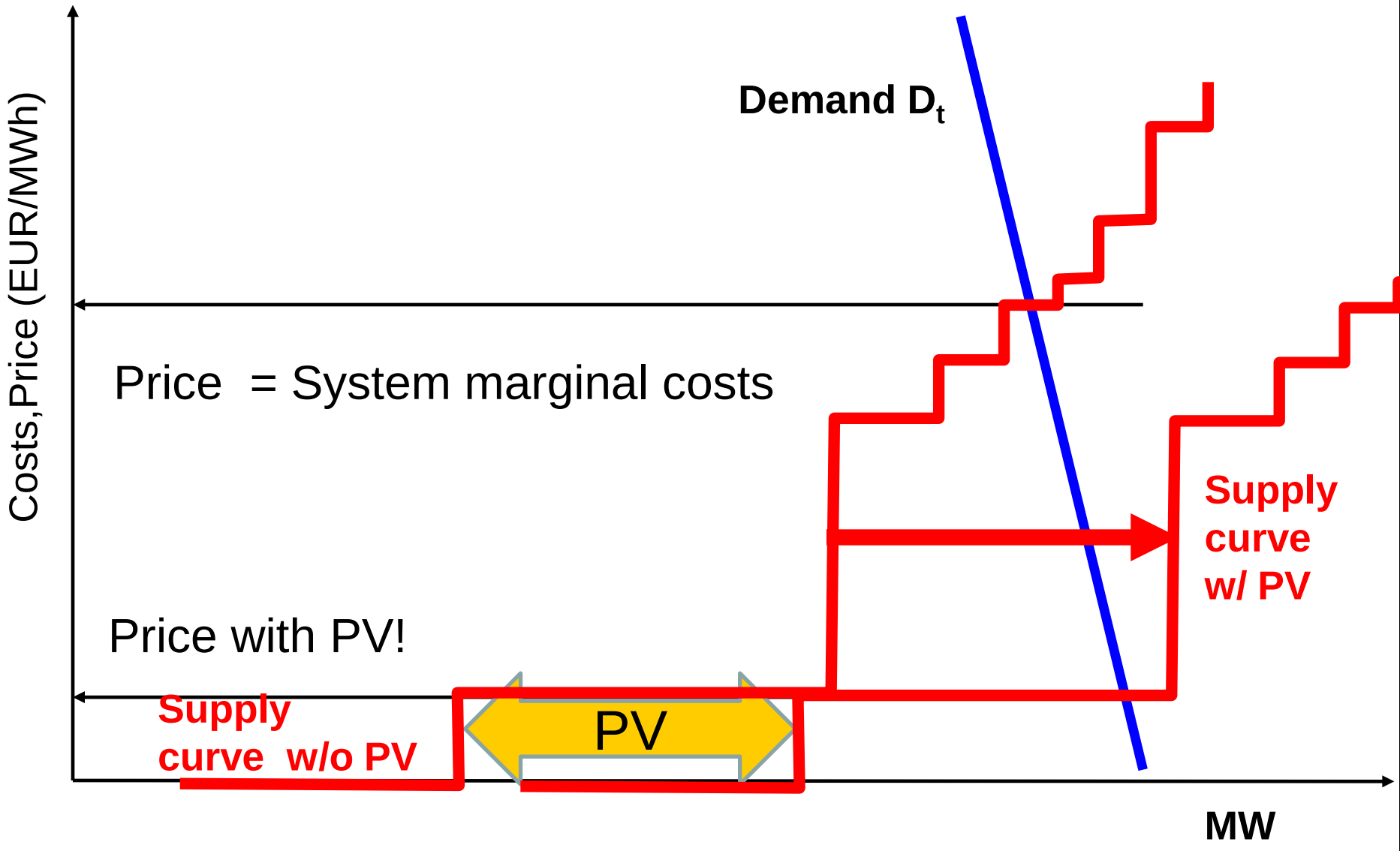
**prices = Short-term marginal costs**

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

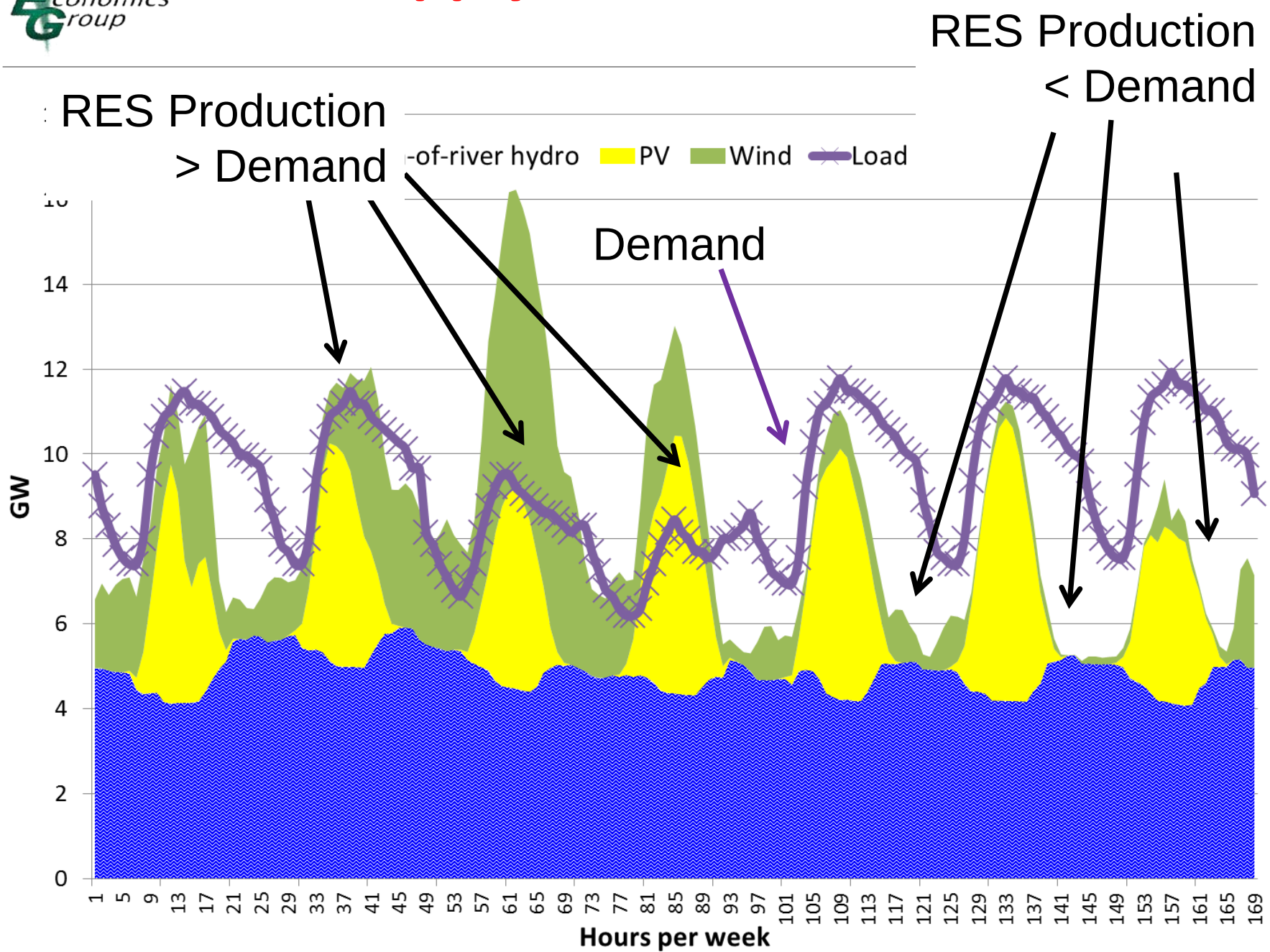
**due to huge depreciated excess capacities at the beginning of liberalisation!**

# 3 HOW VARIABLE RENEWABLES IMPACT THE ELECTRICITY SYSTEM AND PRICES IN ELECTRICITY MARKETS

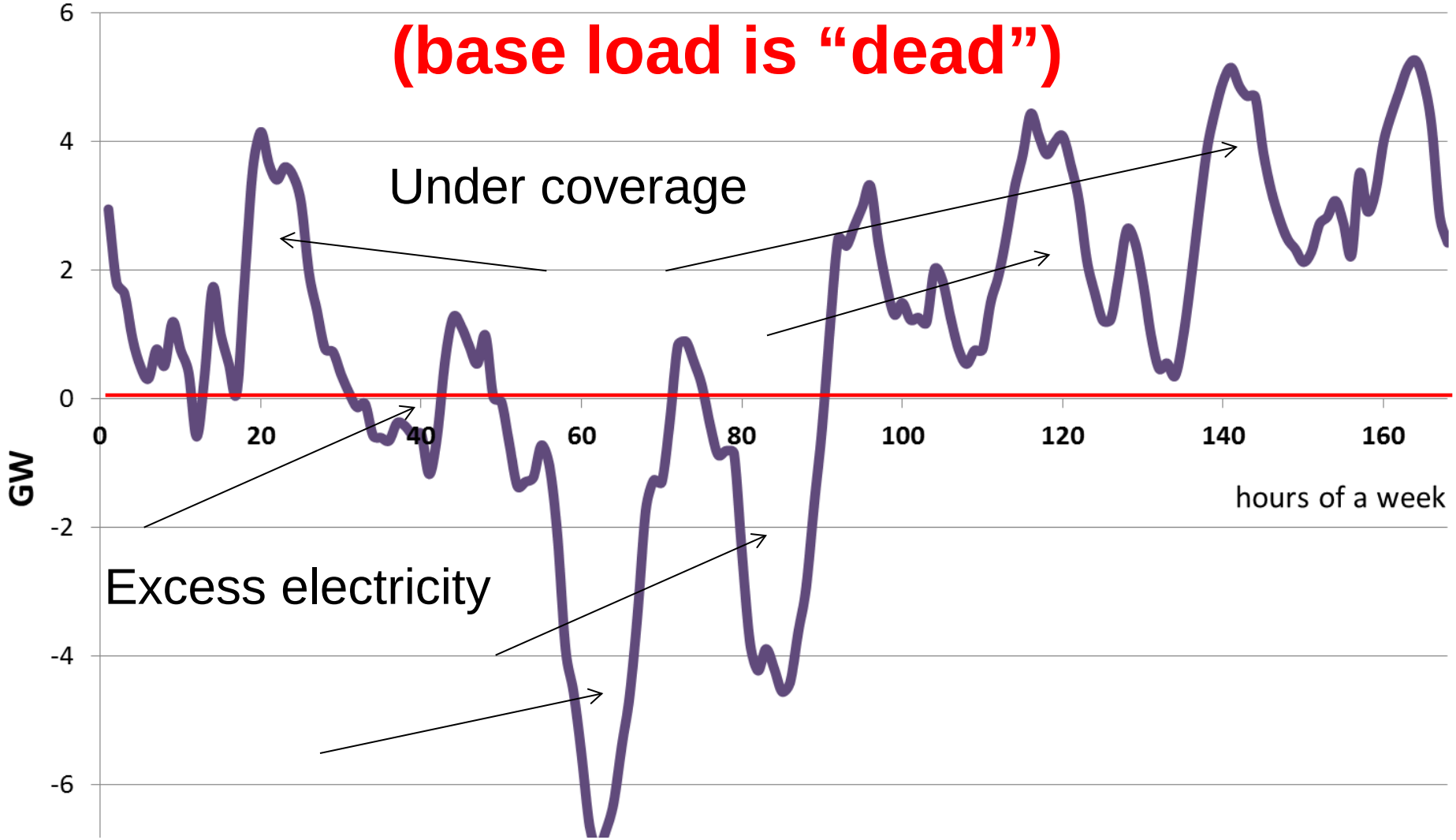
# Example: prices without and with PV



# Supply and Demand



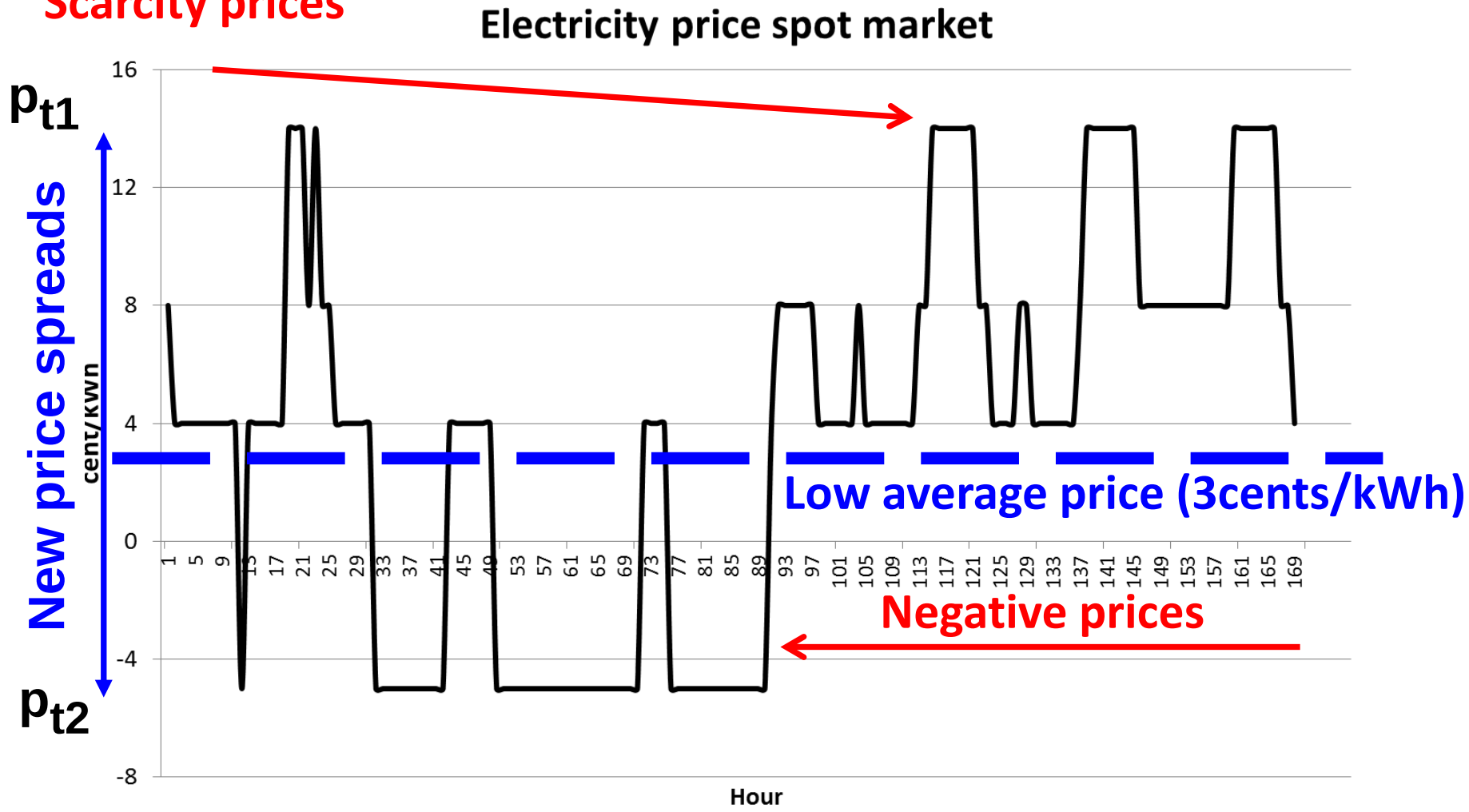
# Key term of the future: Residual load (base load is “dead”)




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

# Deviation from STMC-pricing in spot markets

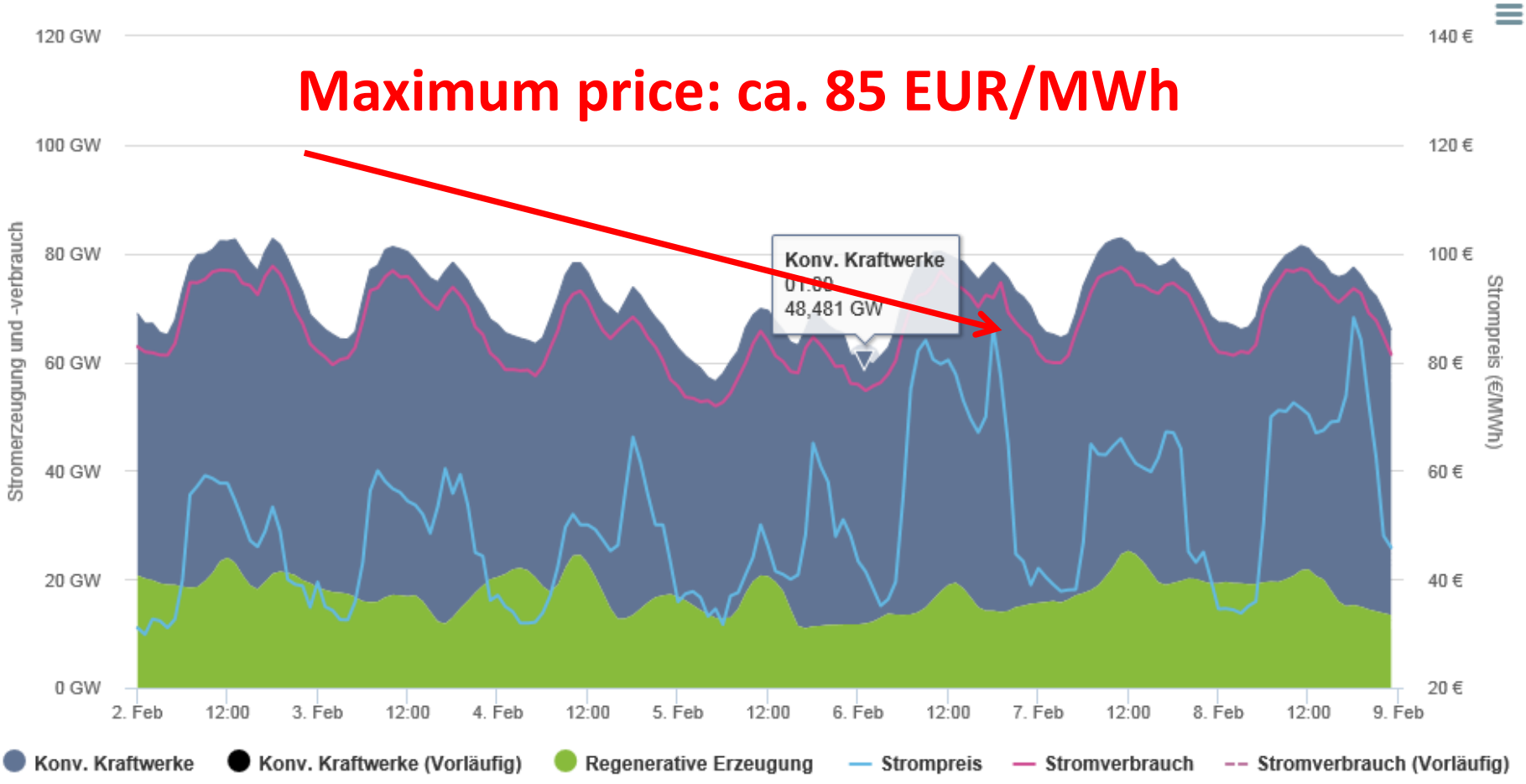
Scarcity prices




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

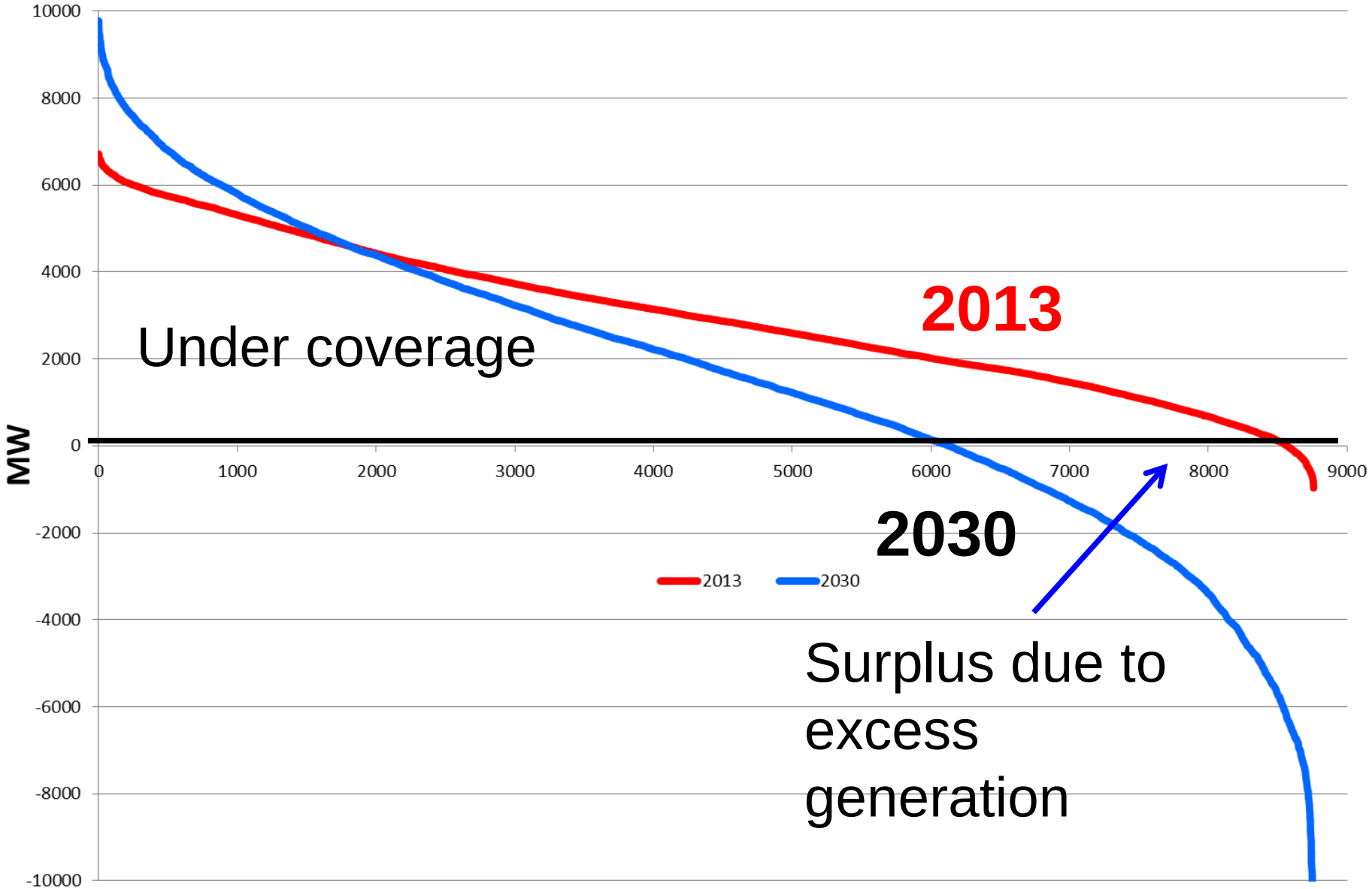
# Remark: Cold - dark – Lull („Kalte Dunkelflaute“)

## Maximum price: ca. 85 EUR/MWh

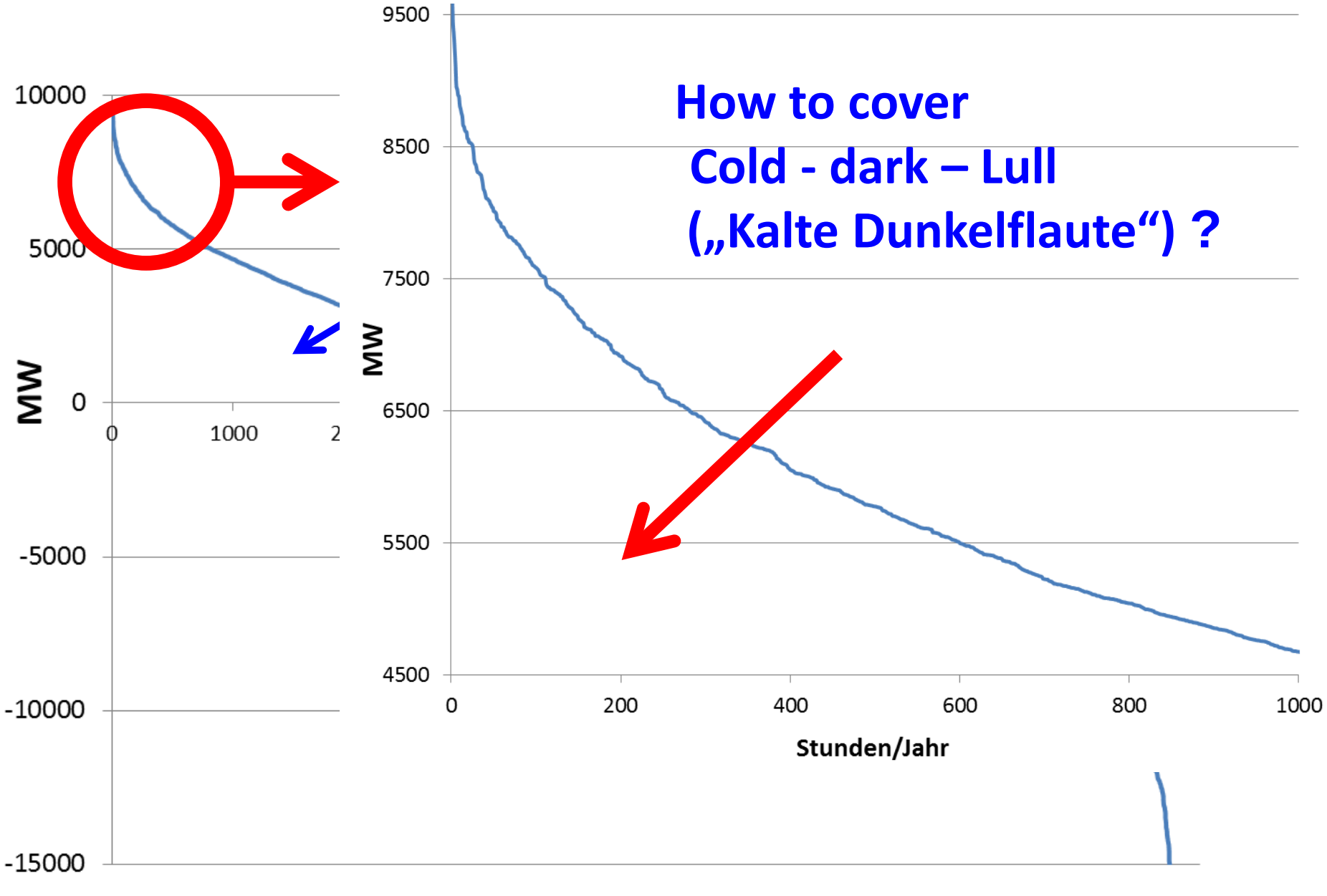



Agora Energiewende; Stand: 16.04.2017, 15:30

# Classified residual load over a year



# 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?**

# 4 THE CORE PROBLEMS OF CAPACITY PAYMENTS

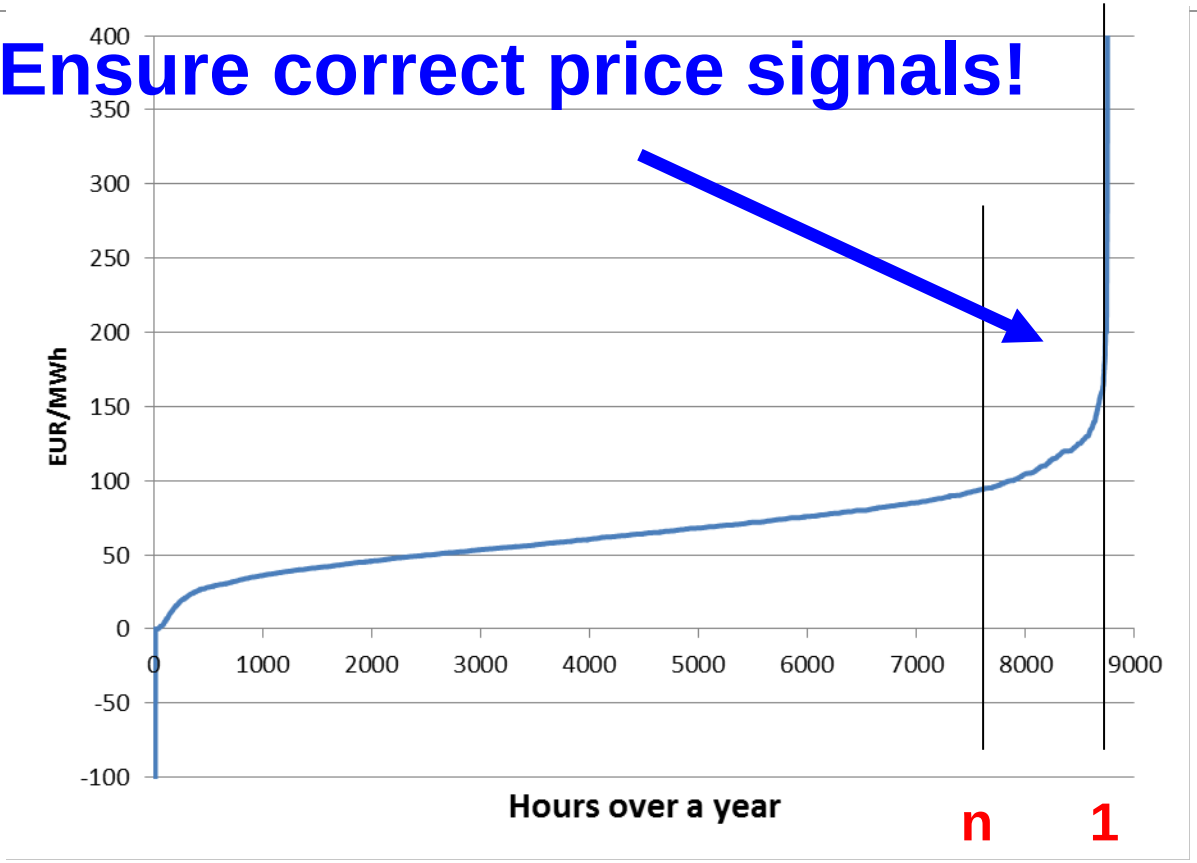
**All regulatory capacity payments for power plants destort the EOM and lead to wrong price signals for all other options**

**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**

# Cost duration curve

## Ensure correct price signals!




## Generators stay in the market if:

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

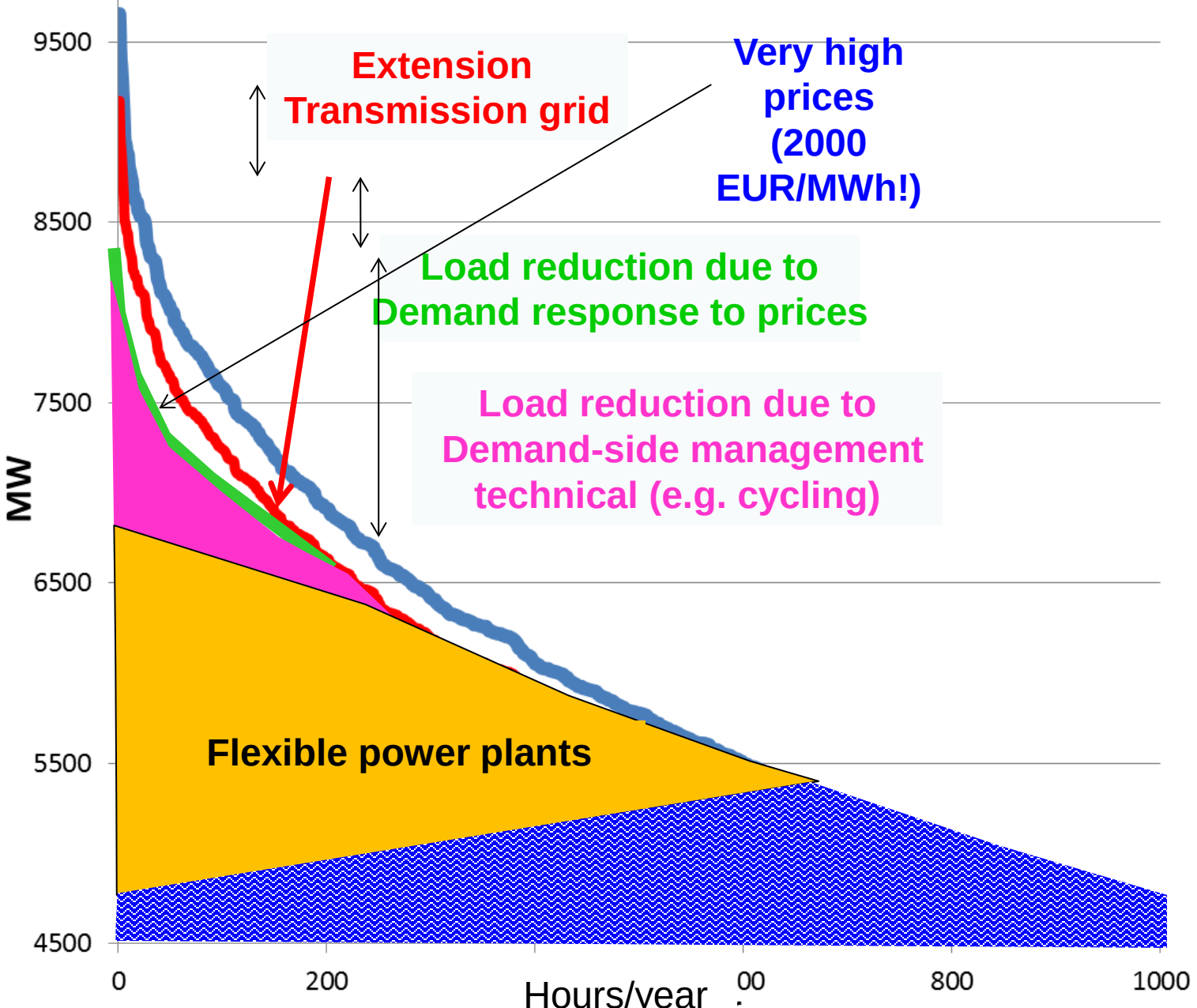
Given a price pattern, showing excess and scarcity prices it would be attractive for a sufficient number of flexible power plant operators to stay in the market!

→

REVISED ENERGY-ONLY MARKET

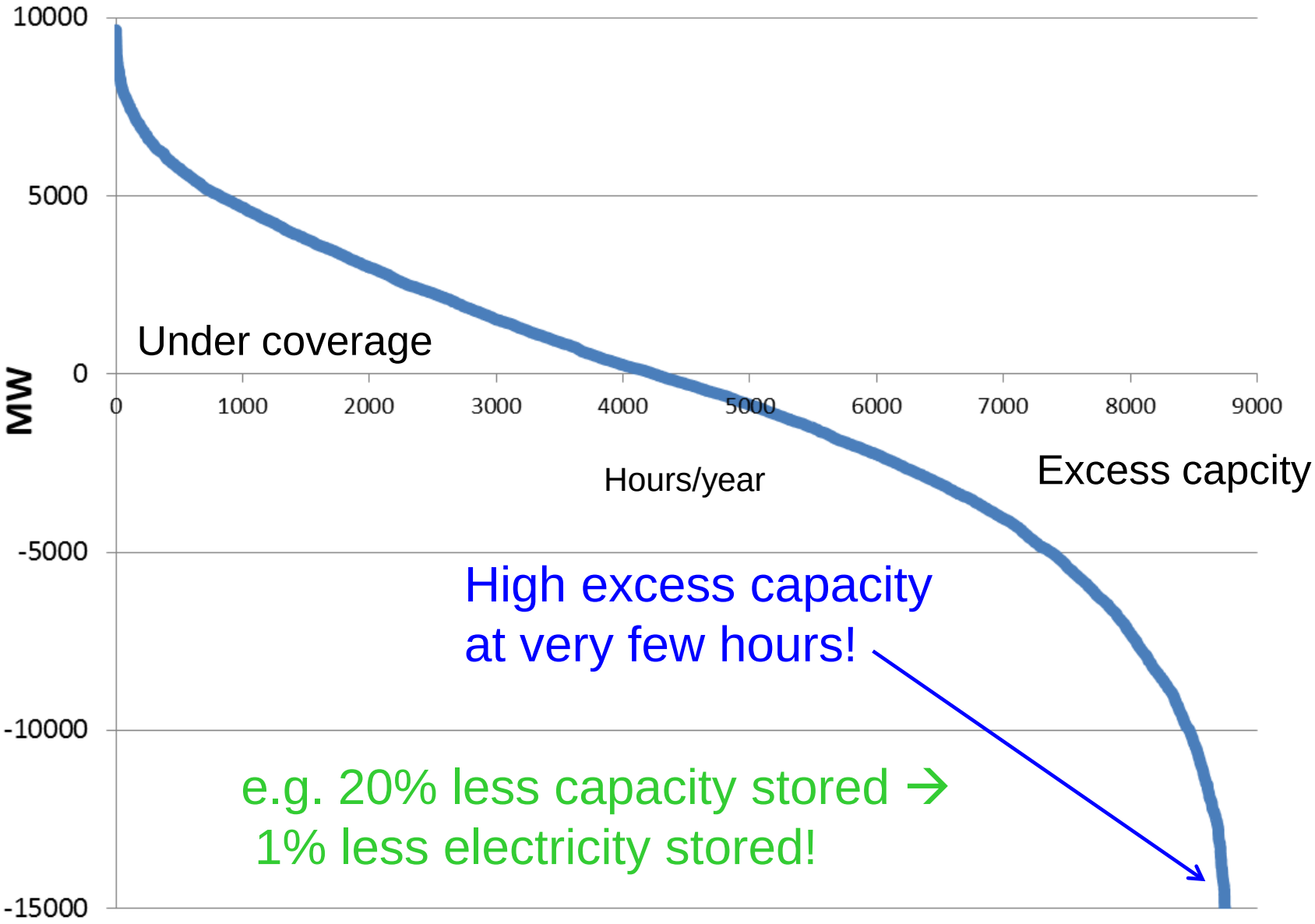
# 5 THE ROLE OF FLEXIBILITY AND SECTOR COUPLING

# Flexible coverage of residual load

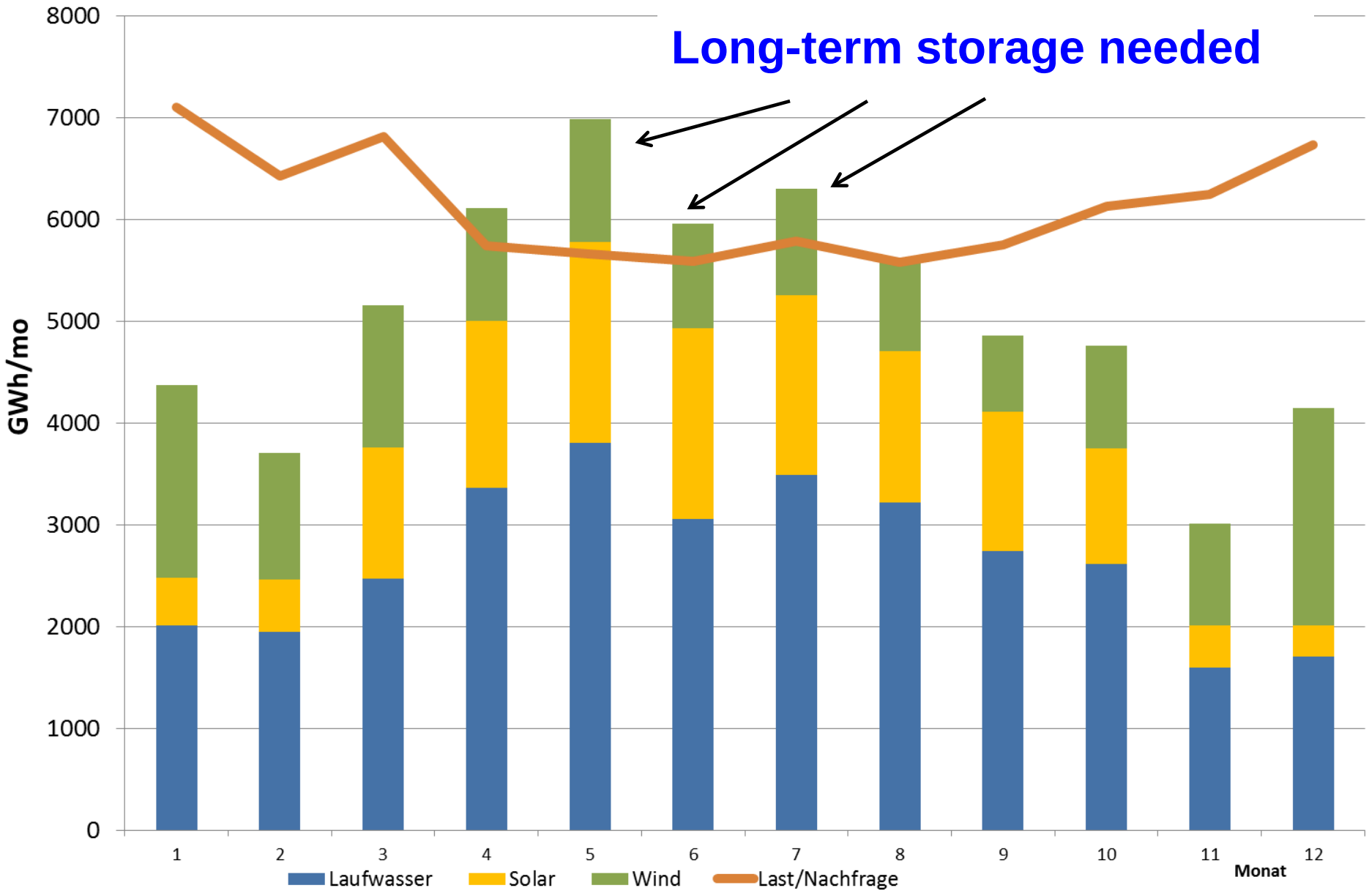



Capacity without ensured payments

# Storing every peak?



# Demand for long-term storage



# Sector coupling / Sector integration

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

Heating/Cooling

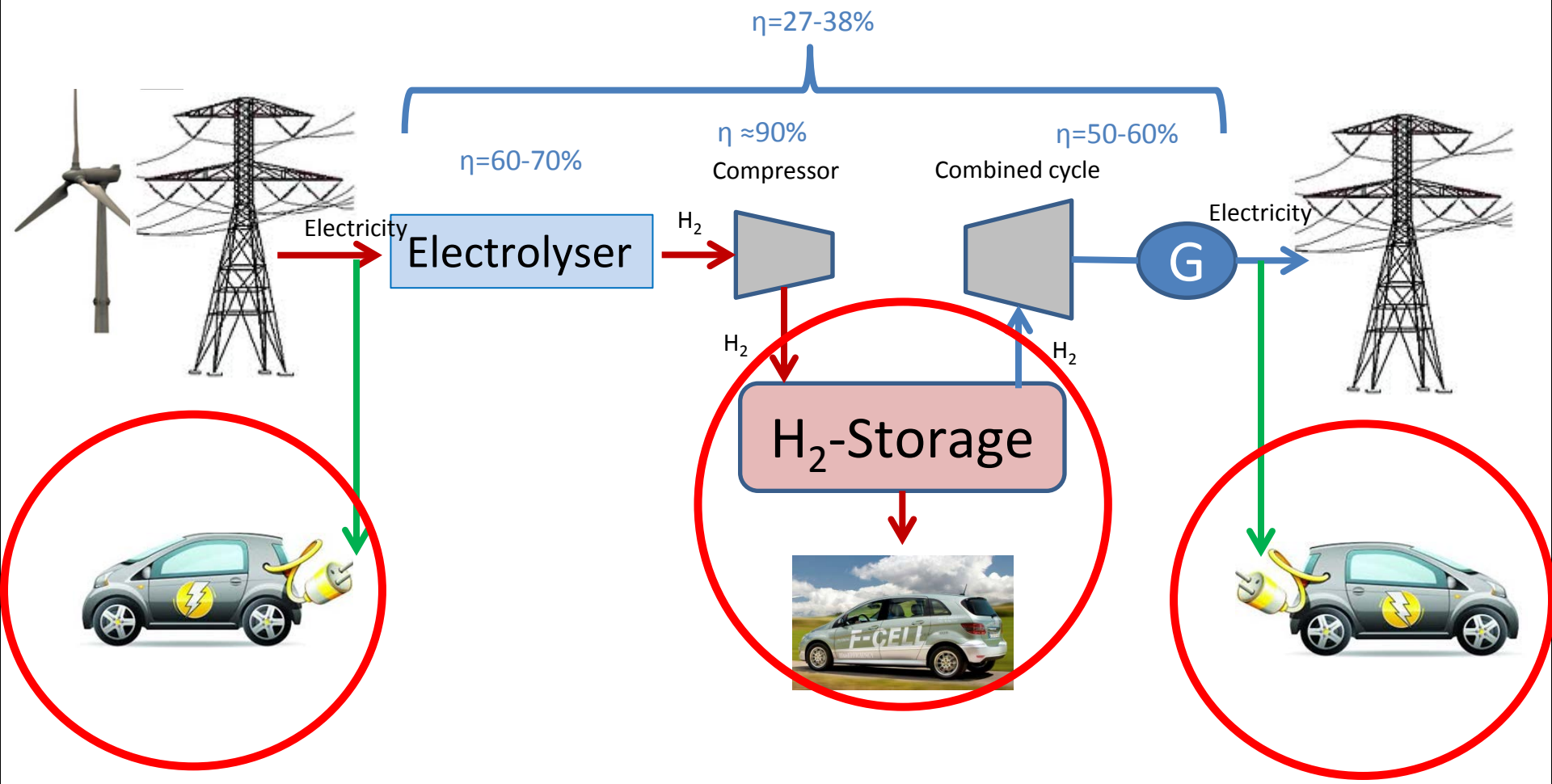
Transport

* Vague simplified suggestions, no convincing long-term solutions

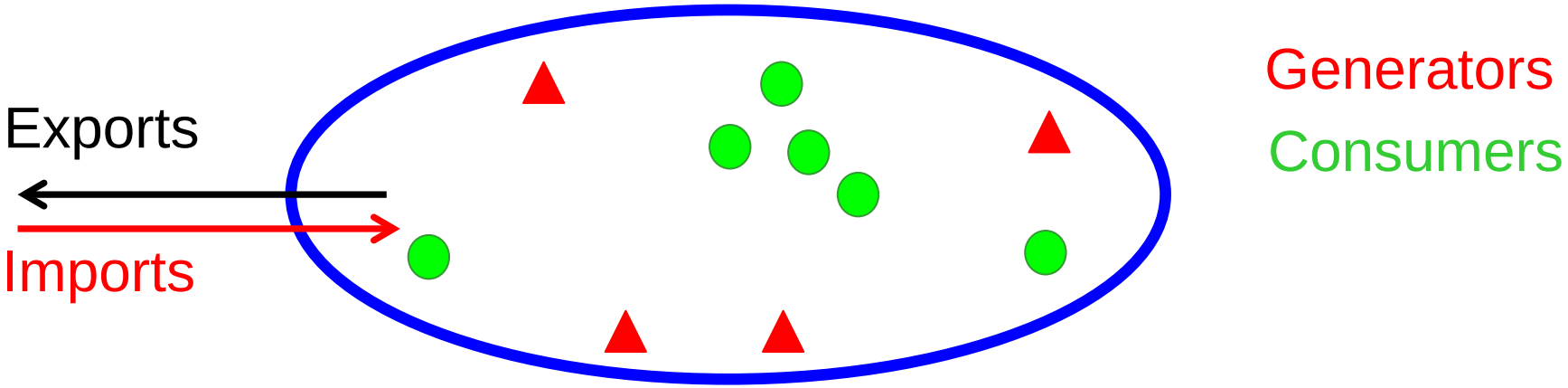
* Central (Ptx approaches, e.g. H2) vs decentral (end user level, E.g. Evs, heat pumps for heating) applications

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

# Sector coupling hydrogen: Storage and fuel in transport?



# 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**

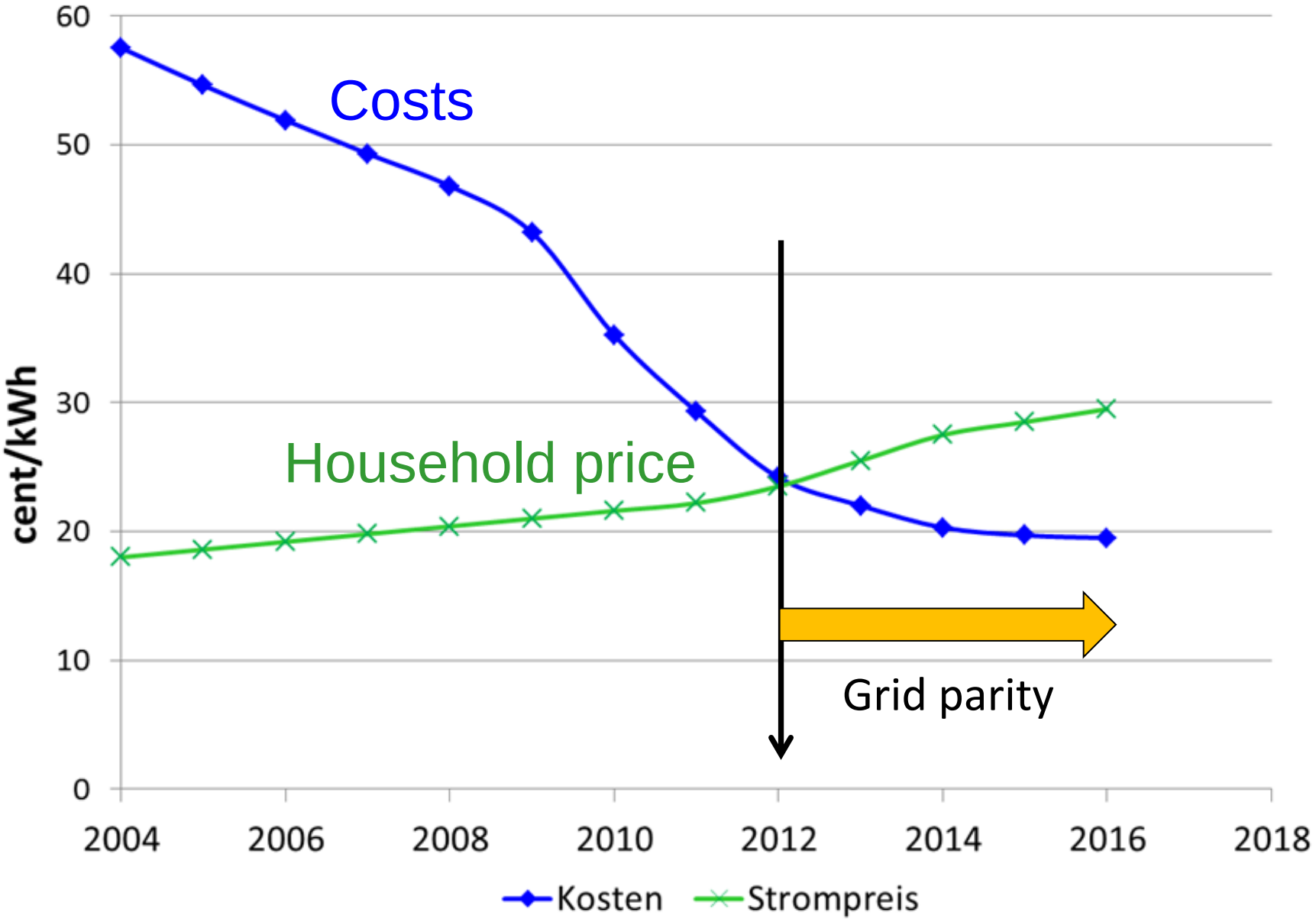
**To meet this target: own generation , storage, flexibility, Trading in long-term, day-ahead and intraday market**

**Every difference → high costs!**

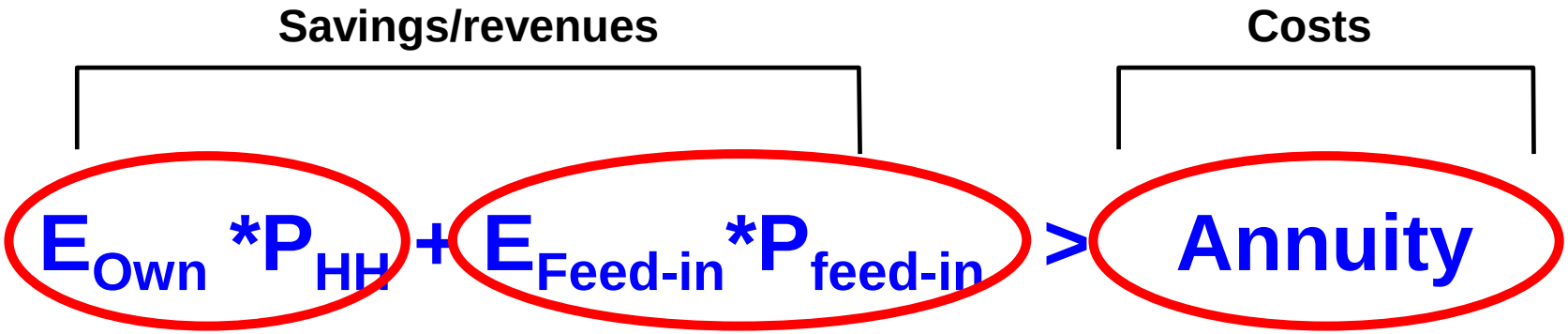
# 7. IS THE TIME FOR SUBSIDIZING RENEWABLES OVER ?

**As long there is no price on CO2 …..**

# Grid parity: PV-costs and household electricity prices



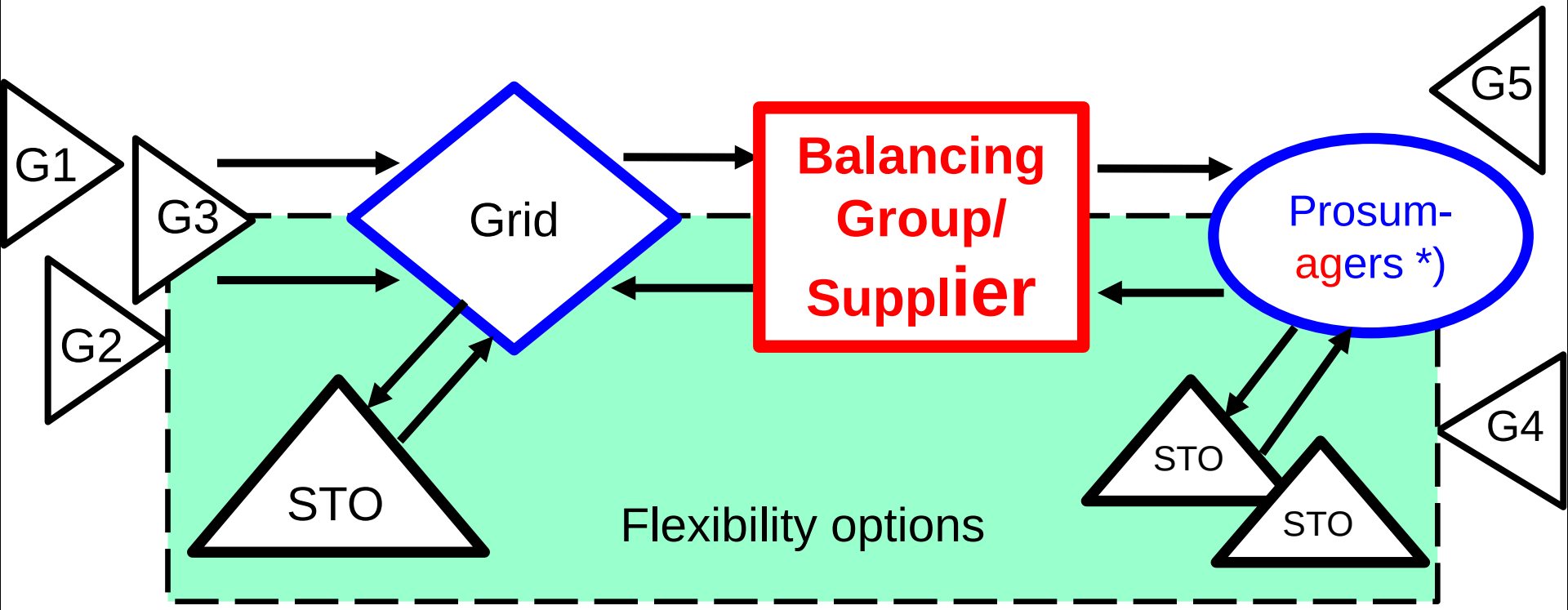
# Assessment of Grid Parity




Grid parity term

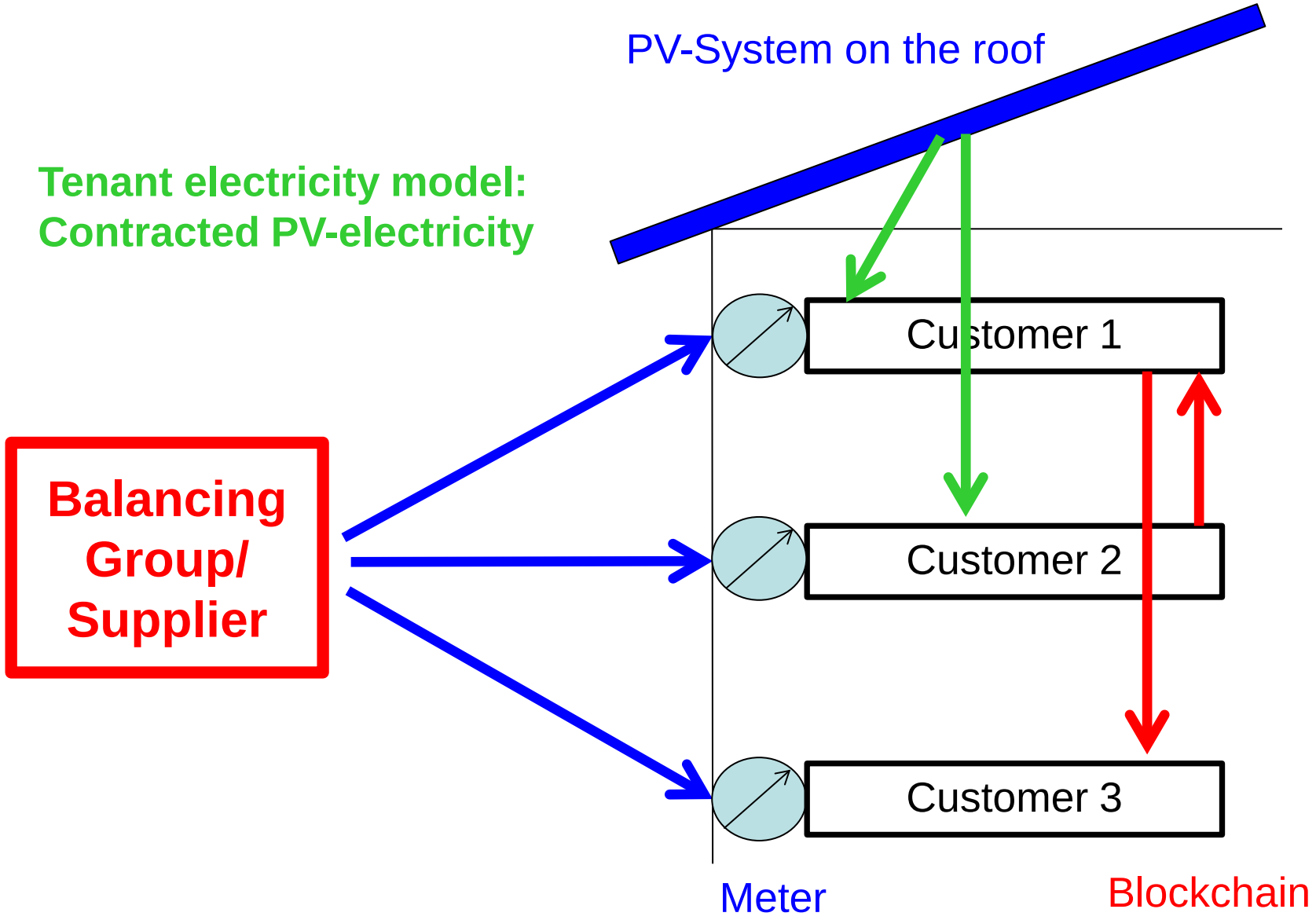
**Subsidy still necessary?**

# New Thinking: Making the electricity system more democratic




*) R. Green

# Tenant electricity model and Blockchain



# 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 for flexibility of all market participants incl. decentralised PV systems
- 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