

New challenges in electricity markets

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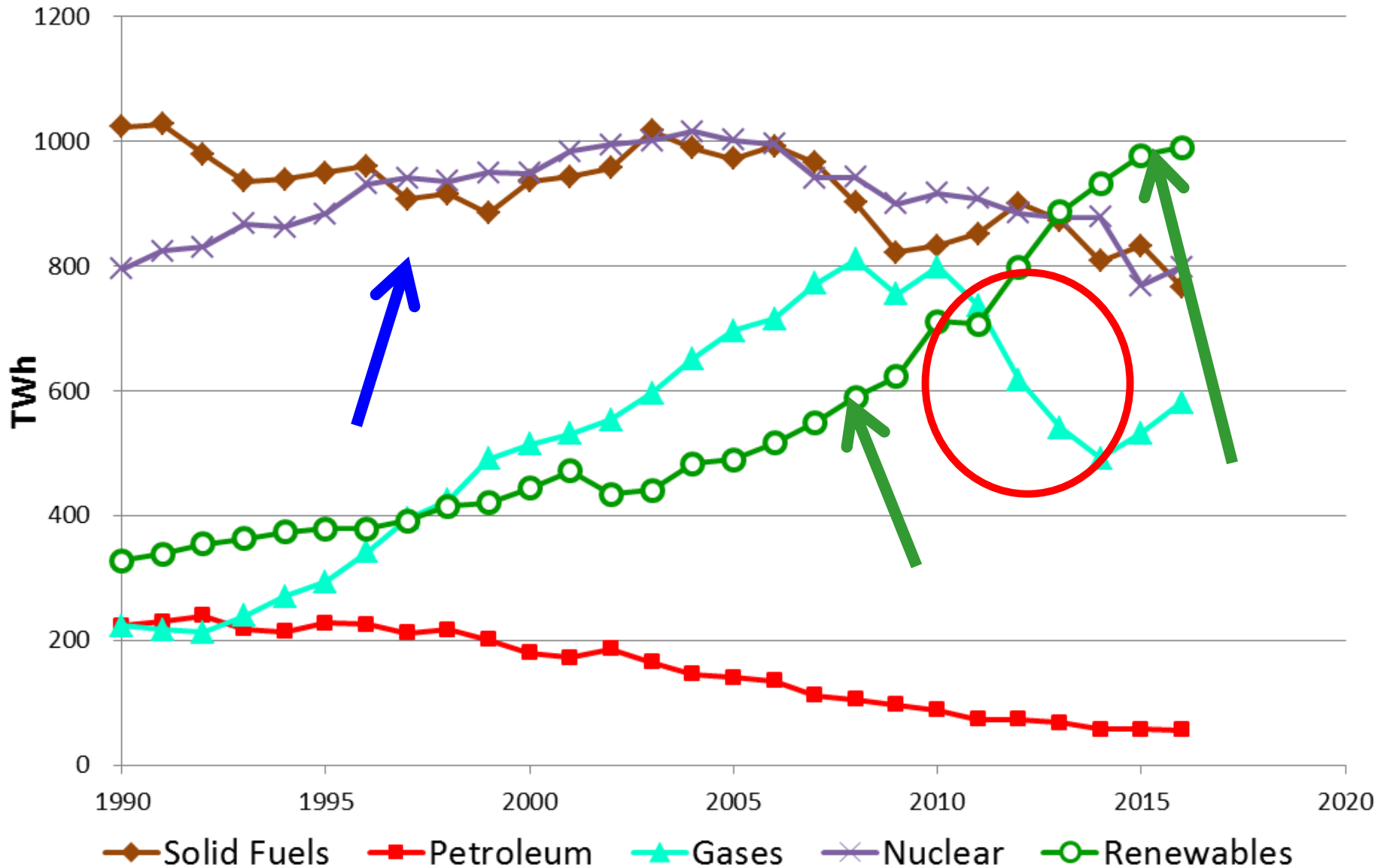
CONTENT:



- 1. Introduction: Recent developments**
- 2. How prices come about in electricity markets**
- 3. Impact of variable renewables on prices**
- 4. Supply security and dimensions of electricity markets**
- 5. Flexibility**
- 6. Subsidizing renewables**
- 7. Conclusions**

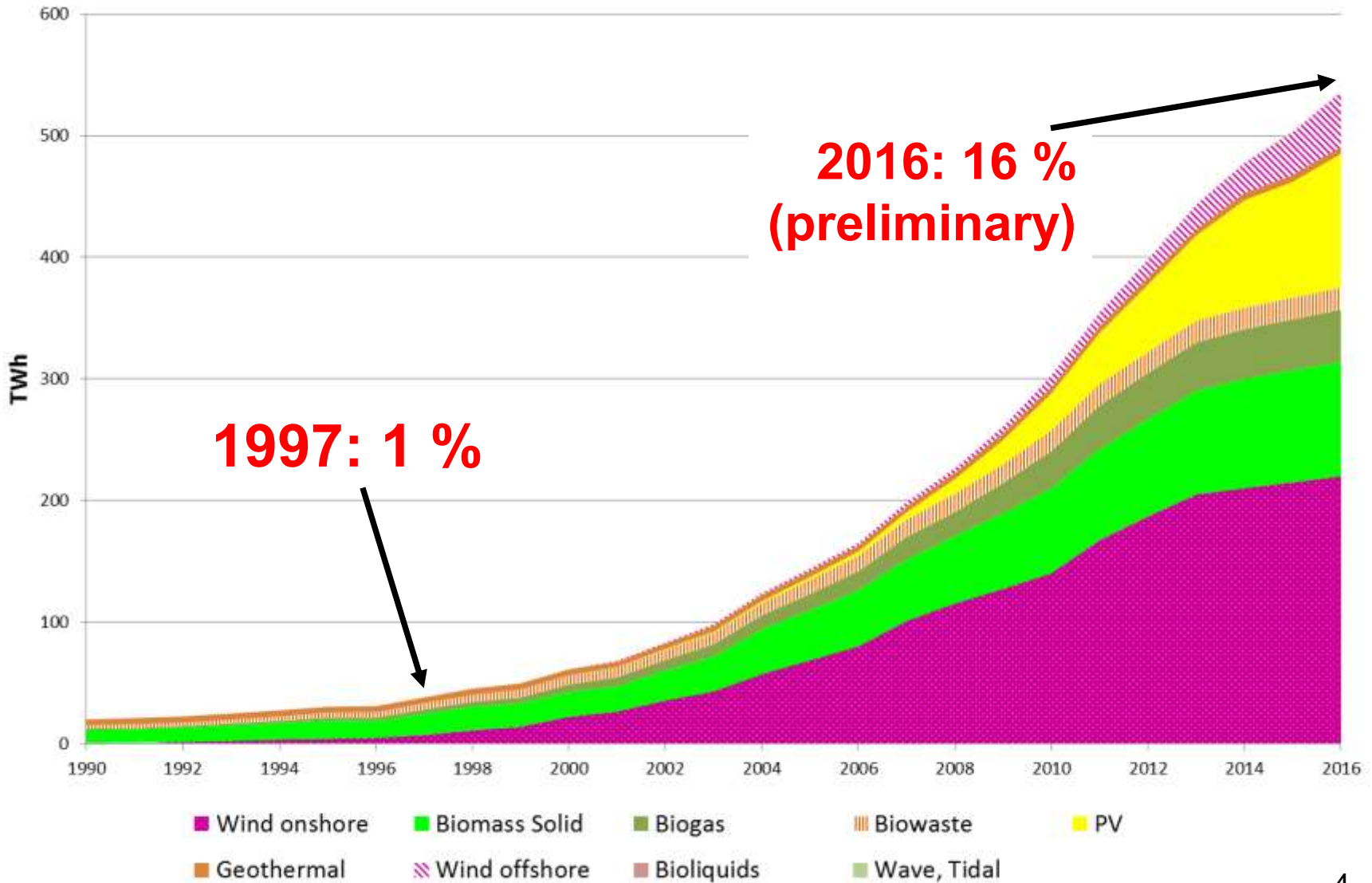


1. Introduction: Electricity generation EU-28





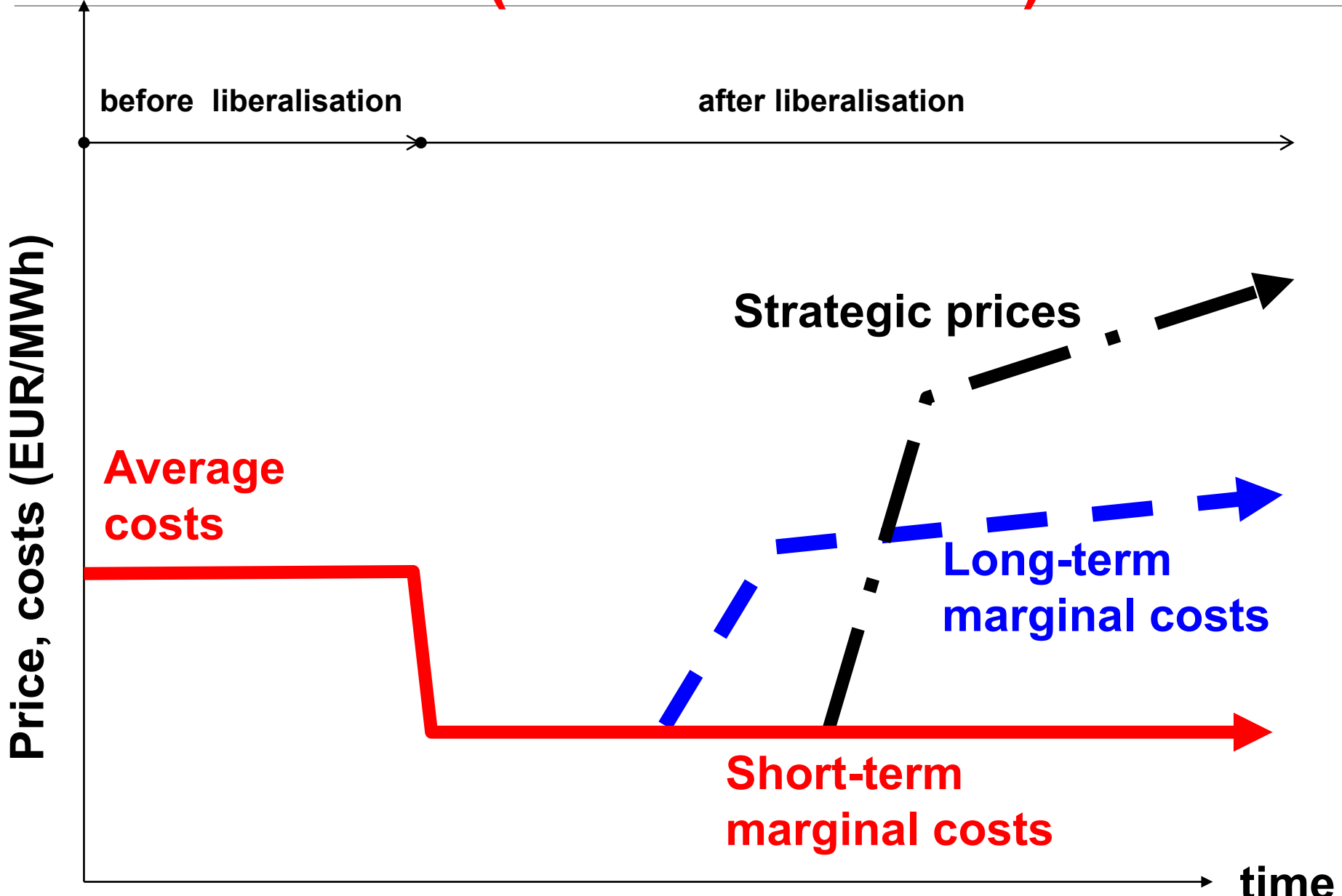
EU-28: Electricity generation from „new“ RES



Source: EUROSTAT, own estimations



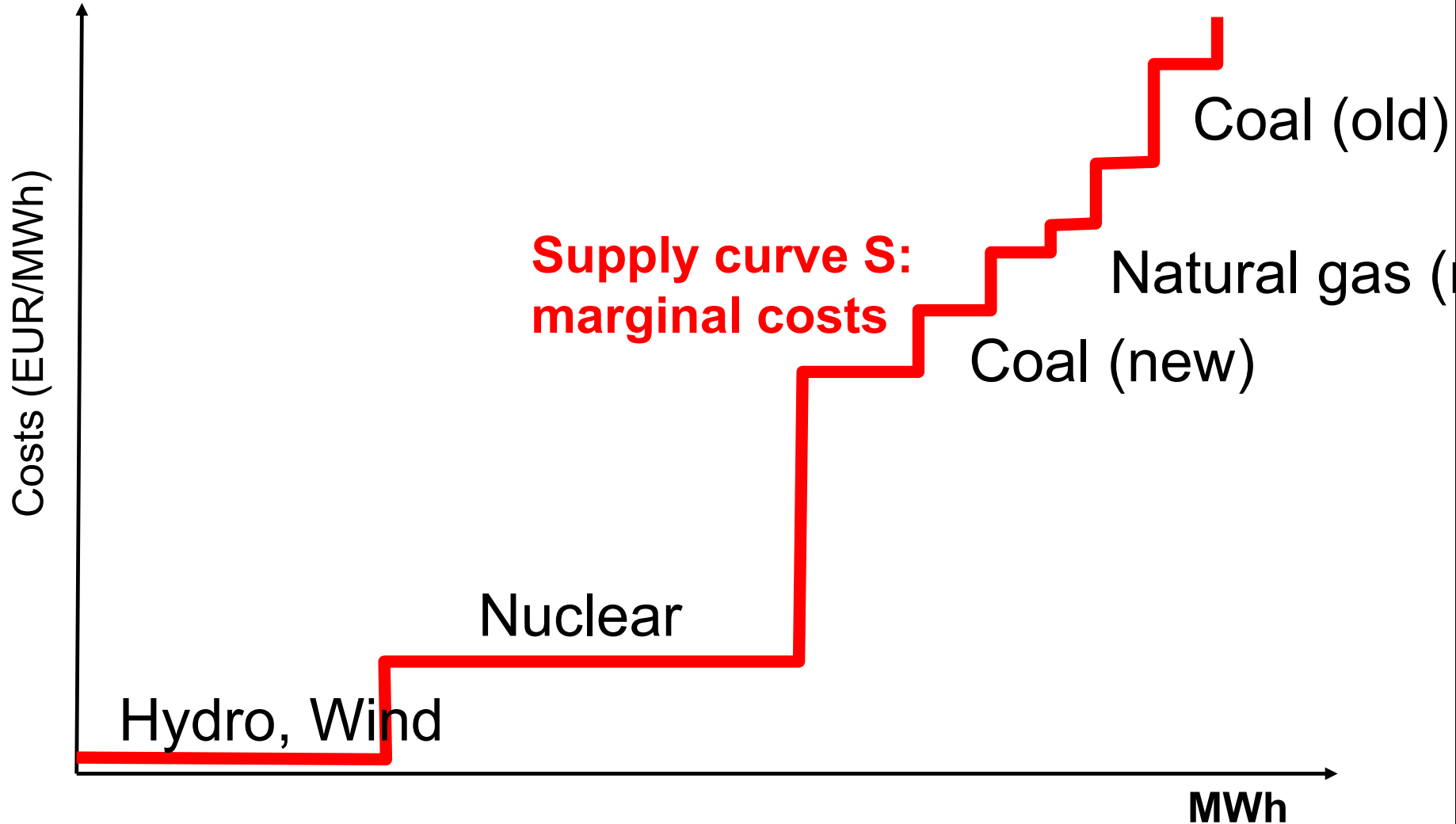
2. HOW PRICES COME ABOUT (SOME THEORY)



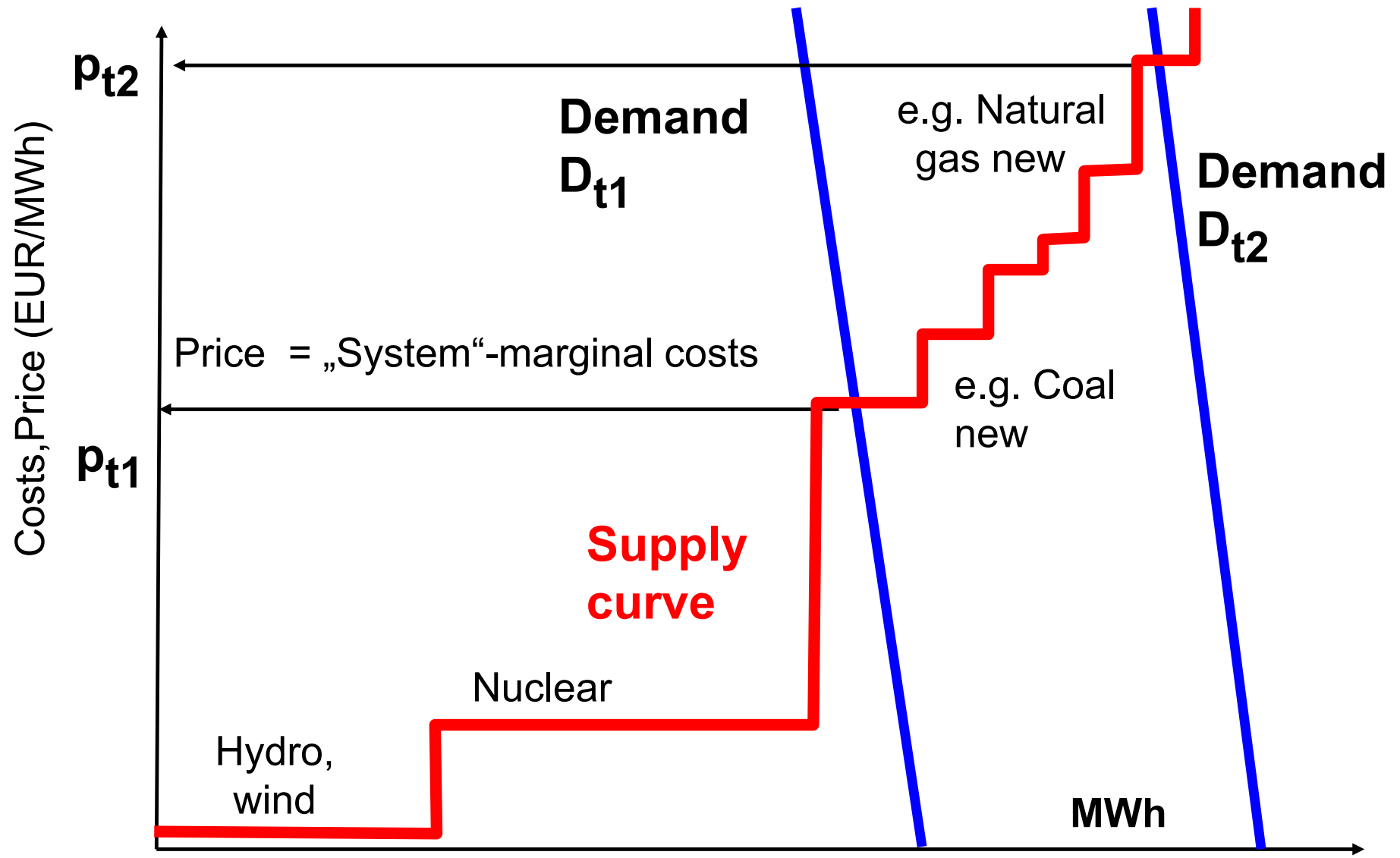


The *MERIT-ORDER* curve of supply

based on short-term marginal costs (MC)

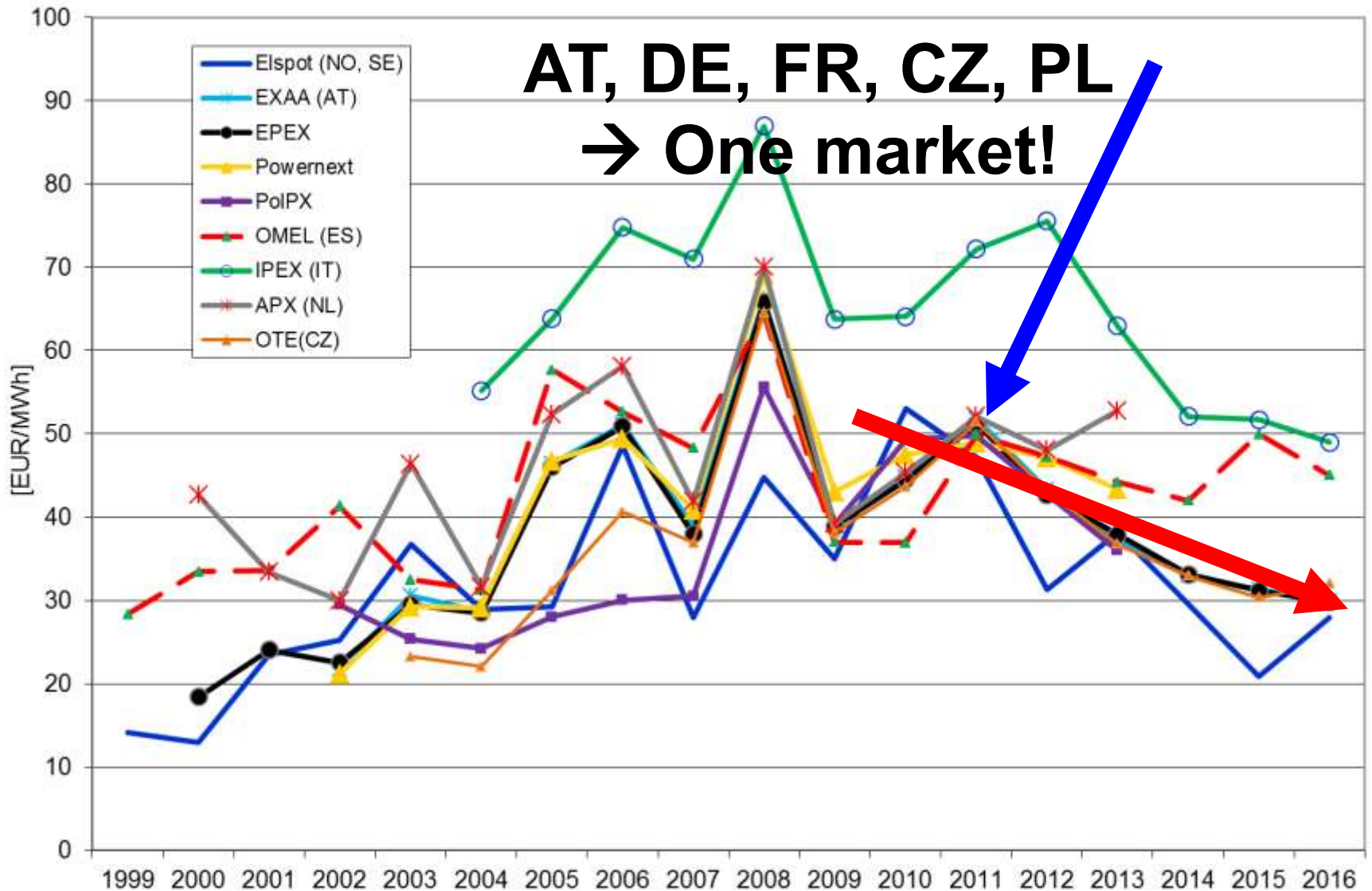


BASIC PRINCIPLE OF COMPETITION: PRICE = MARGINAL COSTS





Development of day-ahead electricity prices in Europe per year

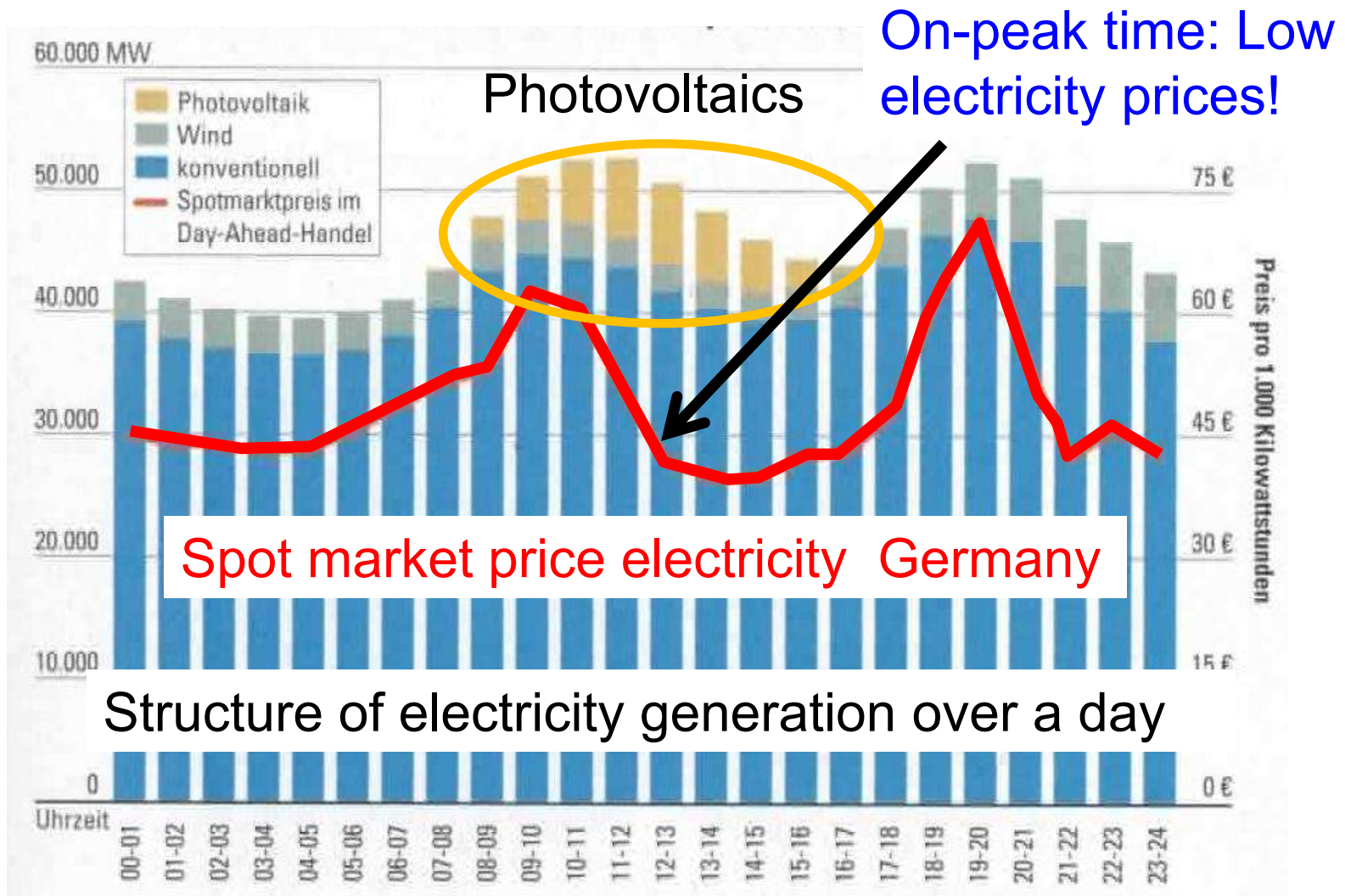


WHY?

STMC = 0!



PV AFFECTS THE ELECTRICITY MARKET PRICE IN GERMANY



LONG-TERM VS SHORT-TERM MARGINAL COSTS



What are marginal costs (MC)?

$$MC = C'(X) = dC(x)/dX$$

Marginal costs are the increment of costs due to a generation of one additional unit of kWh

$$P = MC$$

Short-term marginal costs (STMC):

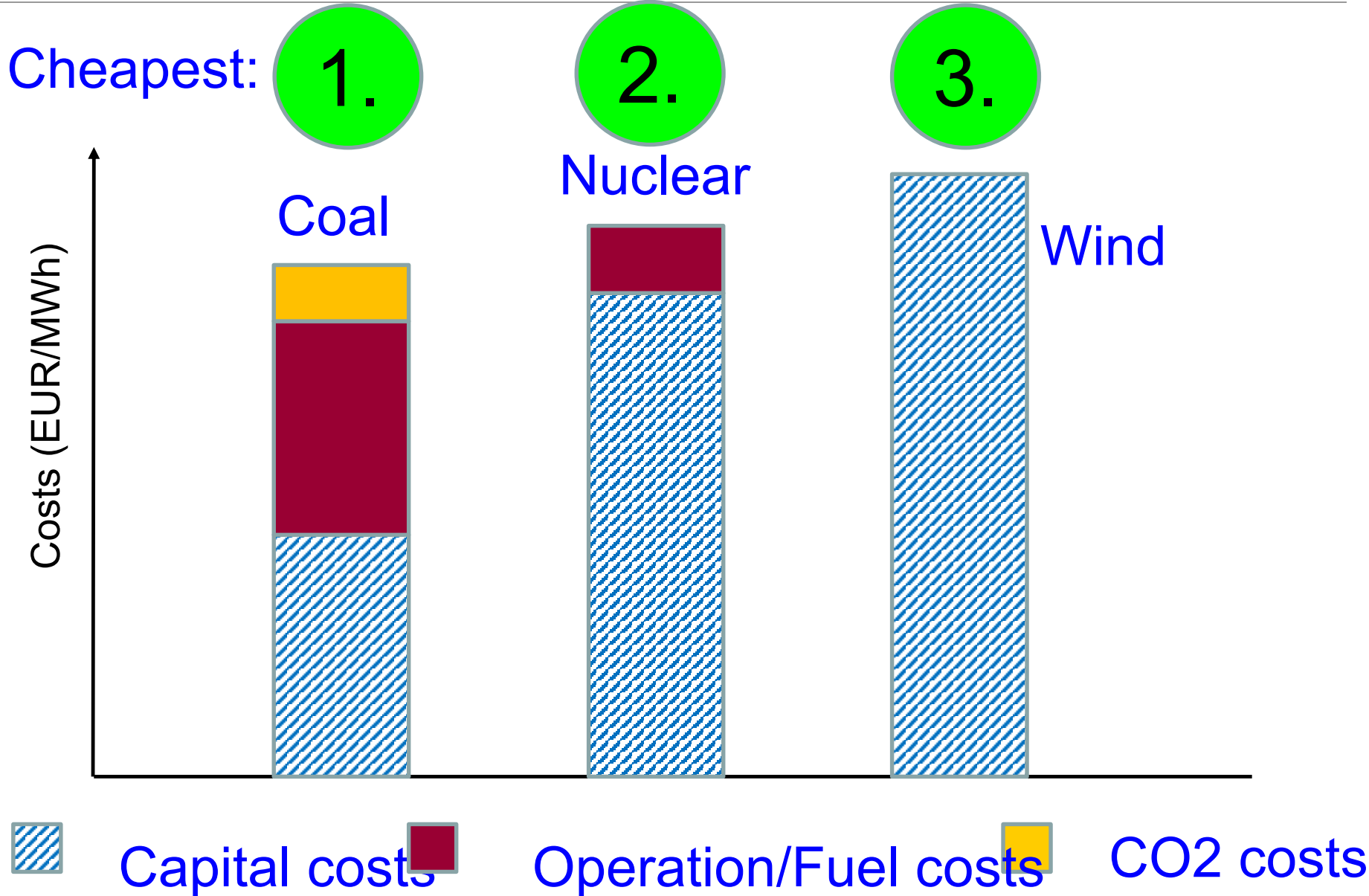
$$STMC = \text{Fuel costs} + \text{CO}_2 \text{ costs}$$

Long-term marginal costs (LTMC):

$$LTMC = STMC + \text{Capital costs} + \text{O\&M costs}$$



LONG-TERM MARGINAL COSTS



SHORT-TERM MARGINAL COSTS

Cheapest:

3.

2.

1.

Coal

Nuclear

Wind

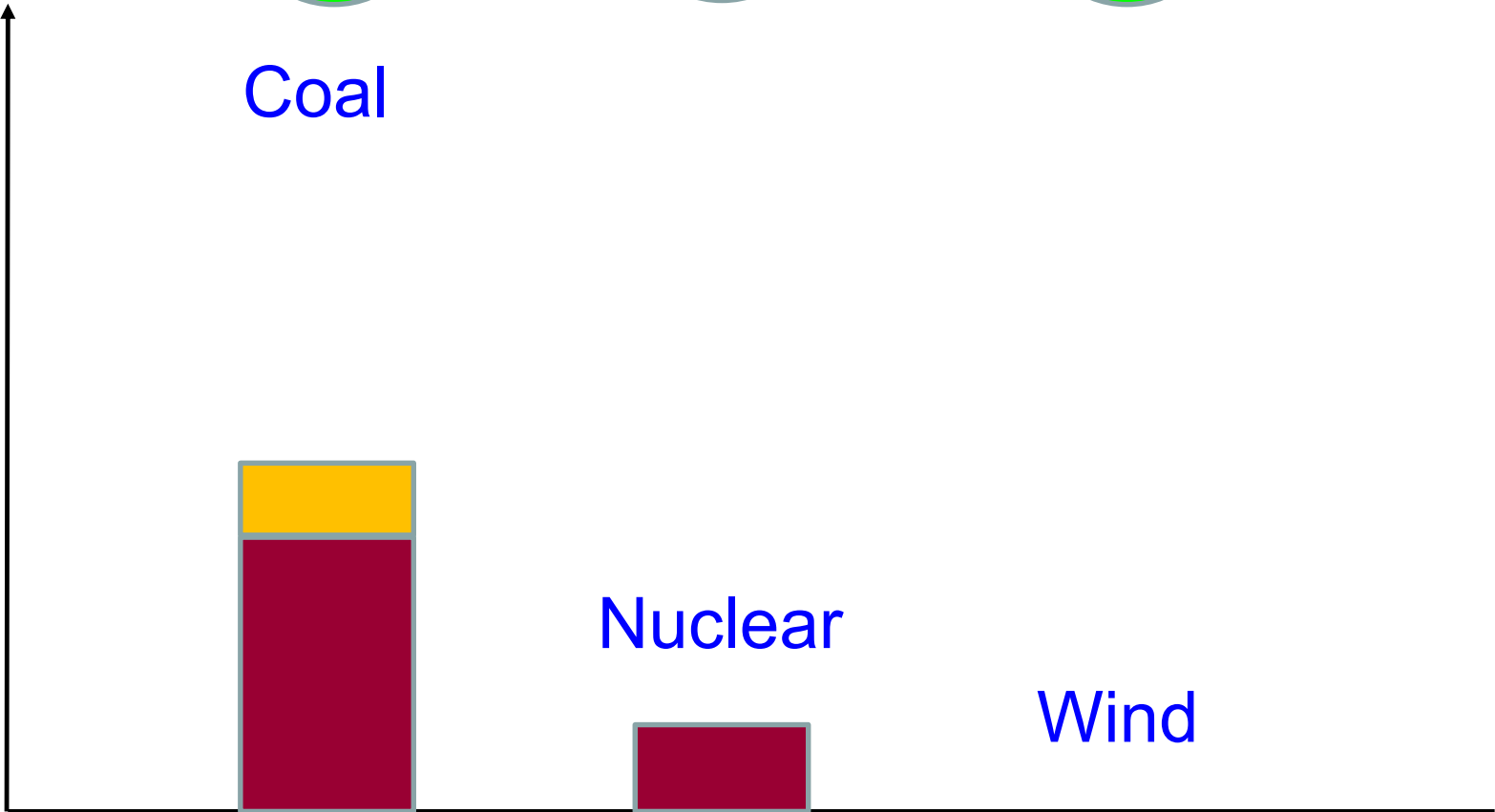
Costs (EUR/MWh)



Operation/Fuel costs



CO2 costs



Expectation of:

prices = Short-term marginal costs:

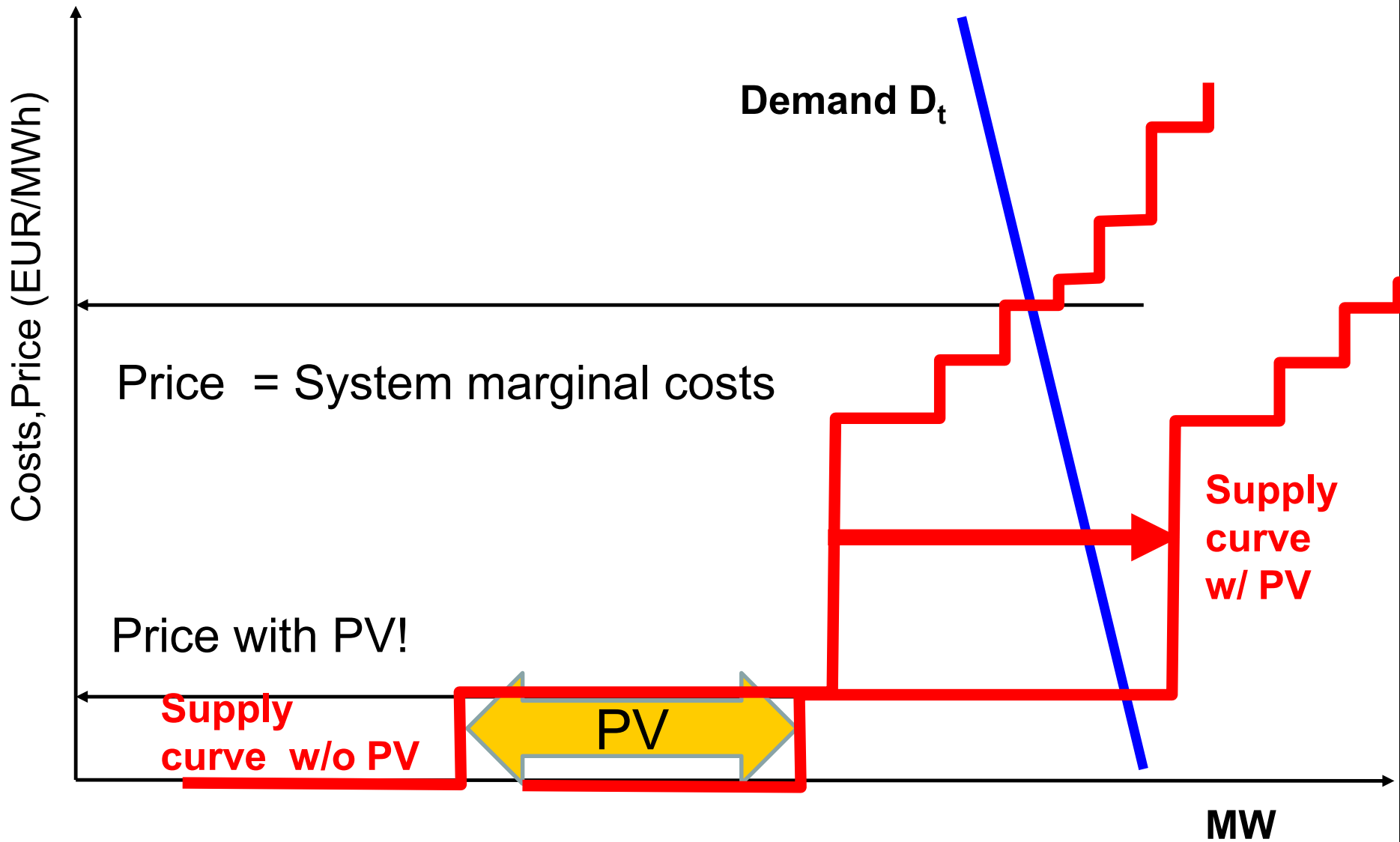
(Short-term marginal costs = fuel costs)

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

3 HOW VARIABLE RENEWABLES IMPACT PRICES IN ELECTRICITY MARKETS



PRICES WITHOUT AND WITH PV



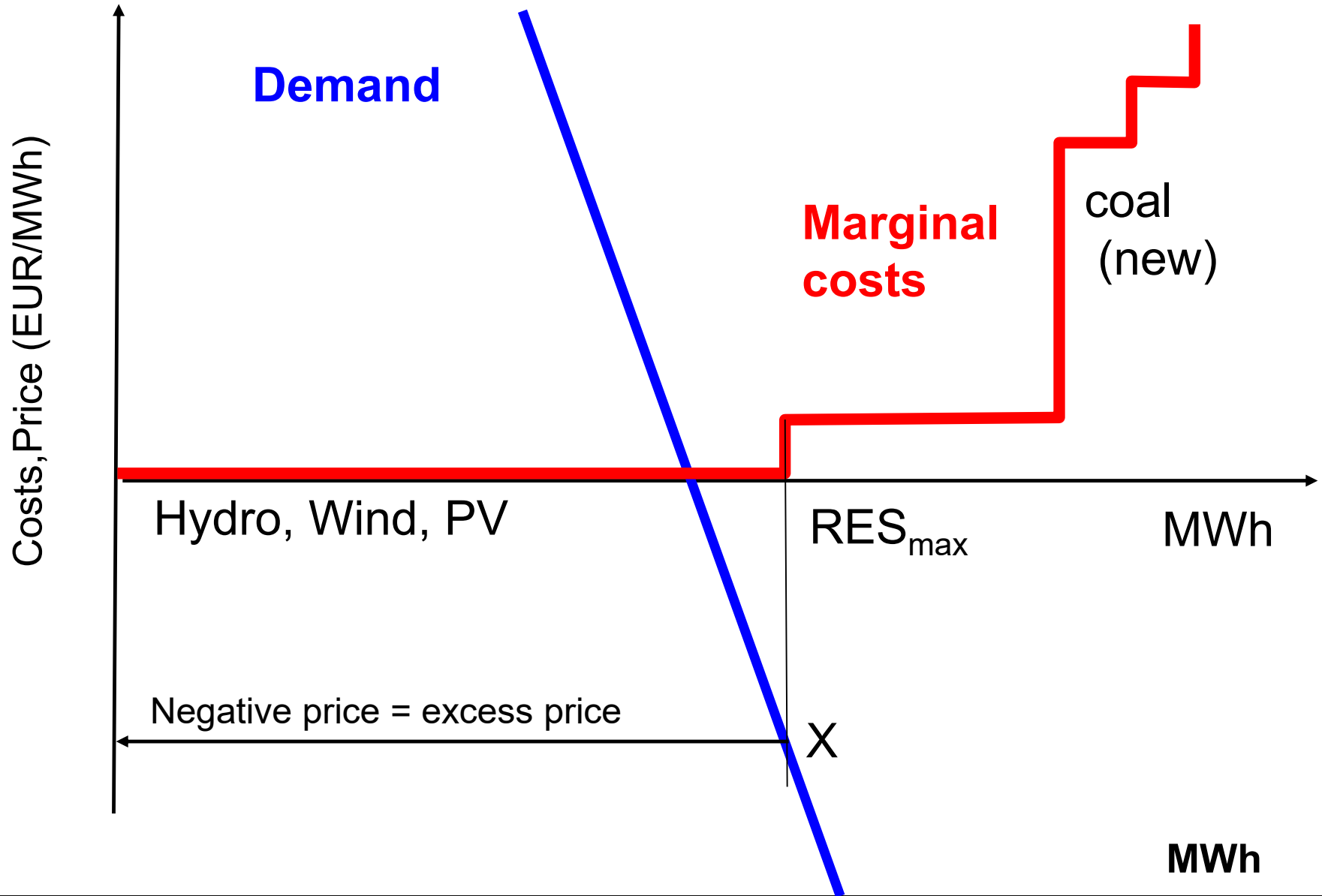


CATEGORIES OF „PROBLEMS“:



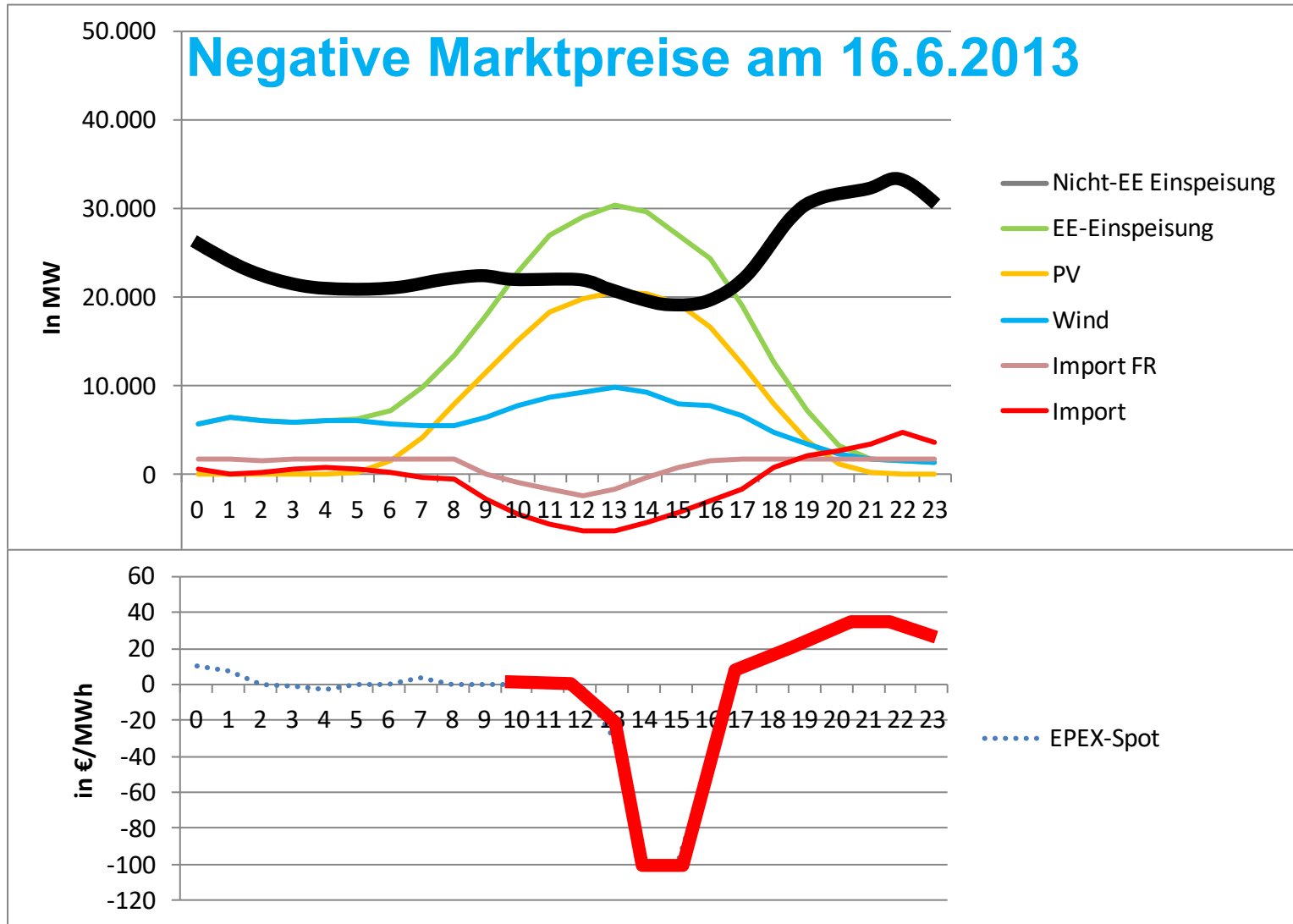
- 1. Prices decrease to Zero (or below) at a number of days;**
- 2. Lacking contribution margin to fixed costs**
- 3. On how many days will we face high and on how many days low prices?**

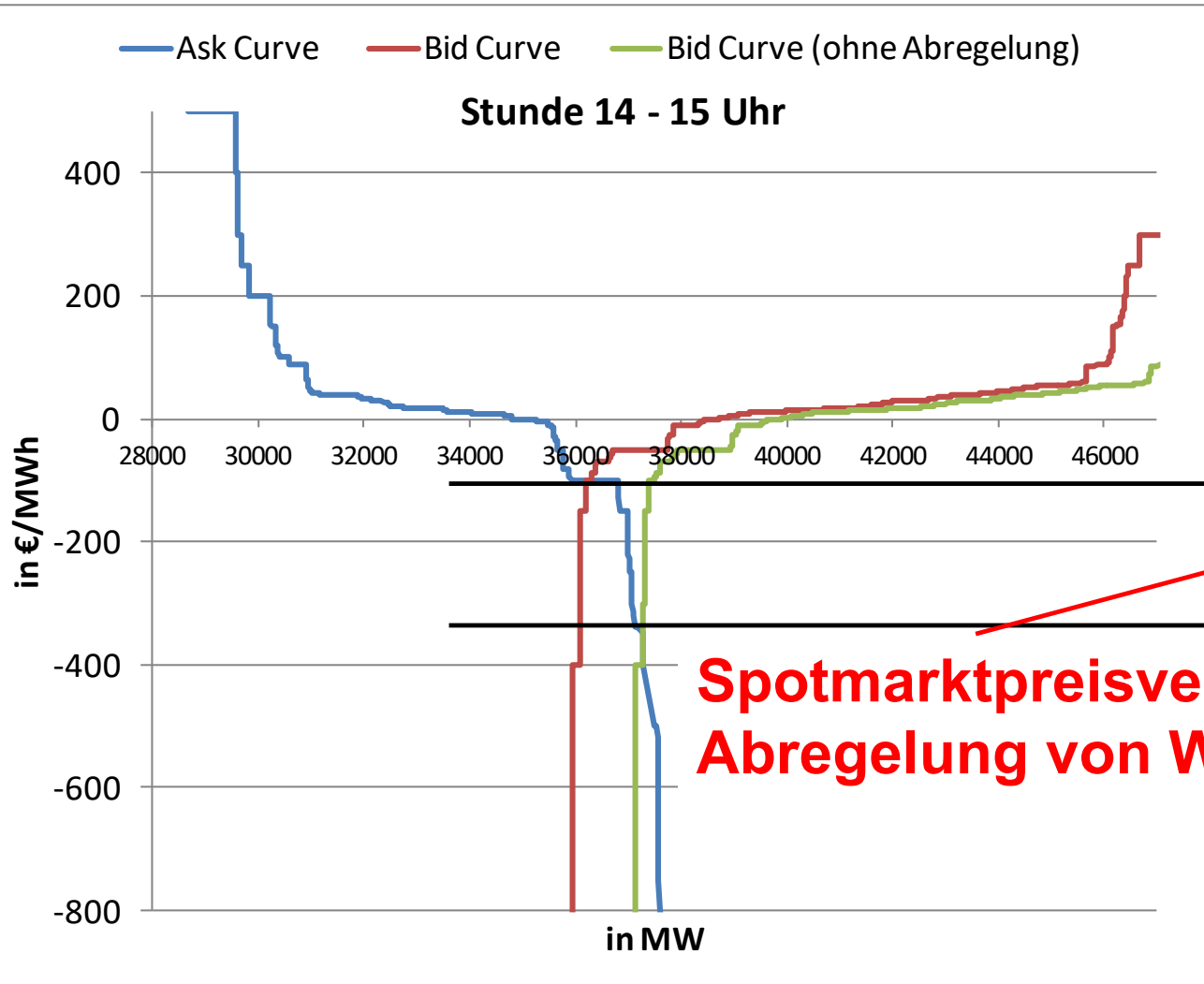
PRICE SETTING UNDER EXCESS CAPACITY





PROBLEM: EINFLUSS TEMPORÄR GROSSER MENGEN EET (?) AUF SPOTMARKTPREISE





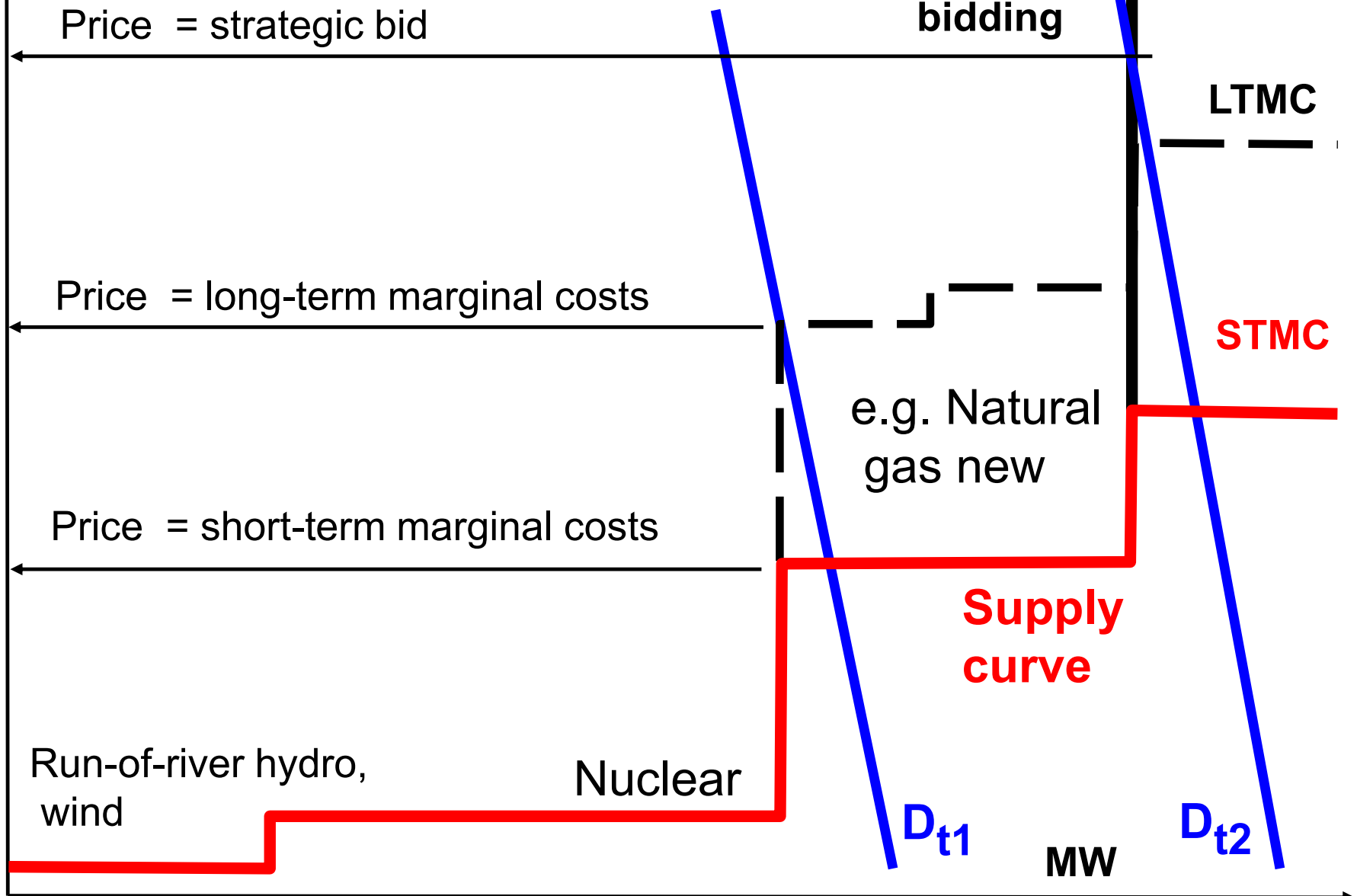
**Spotmarktpreisveränderung durch
Abregelung von Windkraftanlagen**



Prices under scarce capacities



Costs, Price (EUR/MWh)



Price = strategic bid

Strategic bidding

LTMC

Price = long-term marginal costs

e.g. Natural gas new

STMC

Price = short-term marginal costs

Supply curve

Run-of-river hydro, wind

Nuclear

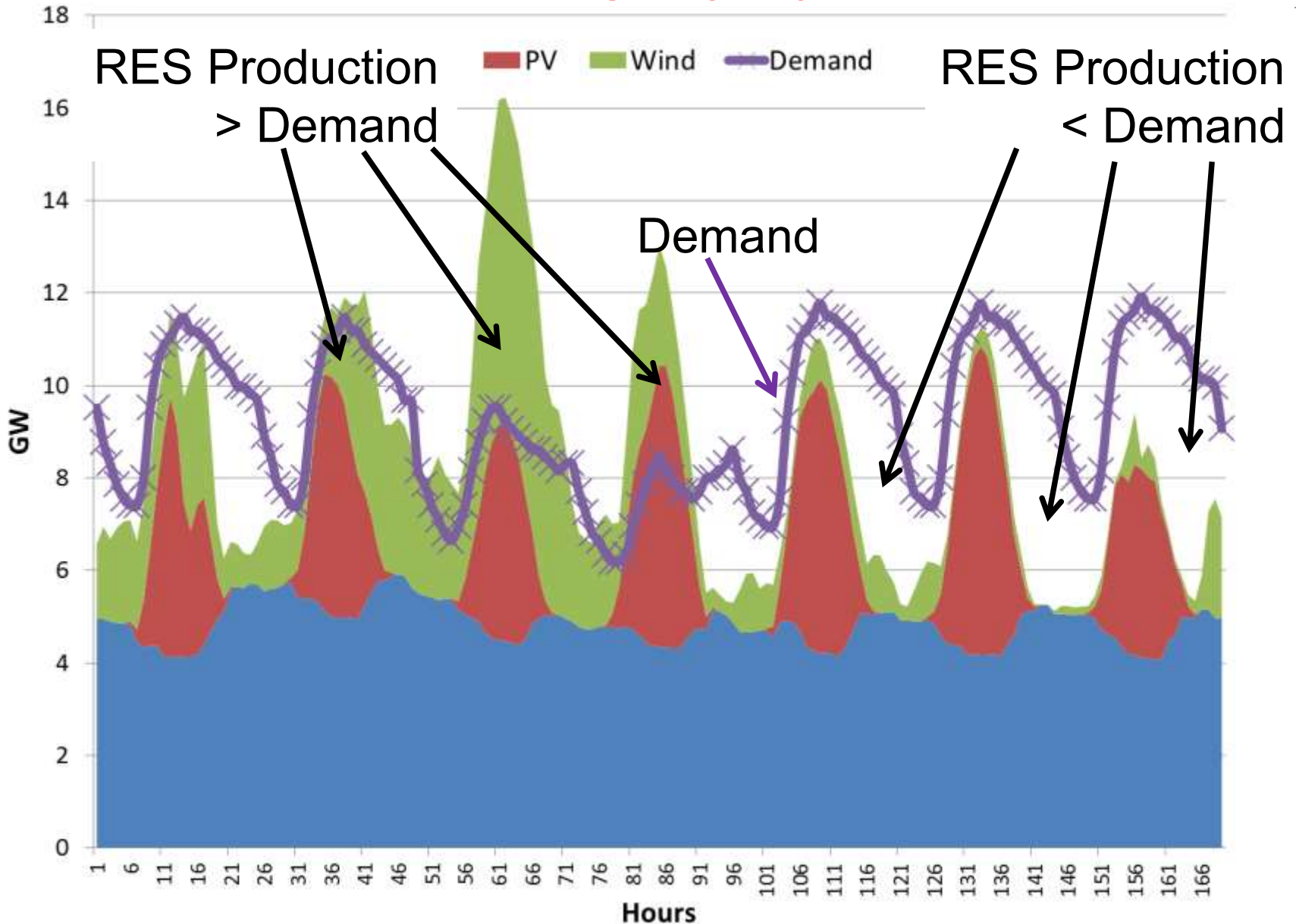
D_{t1}

MW

D_{t2}



Example: Supply and Demand

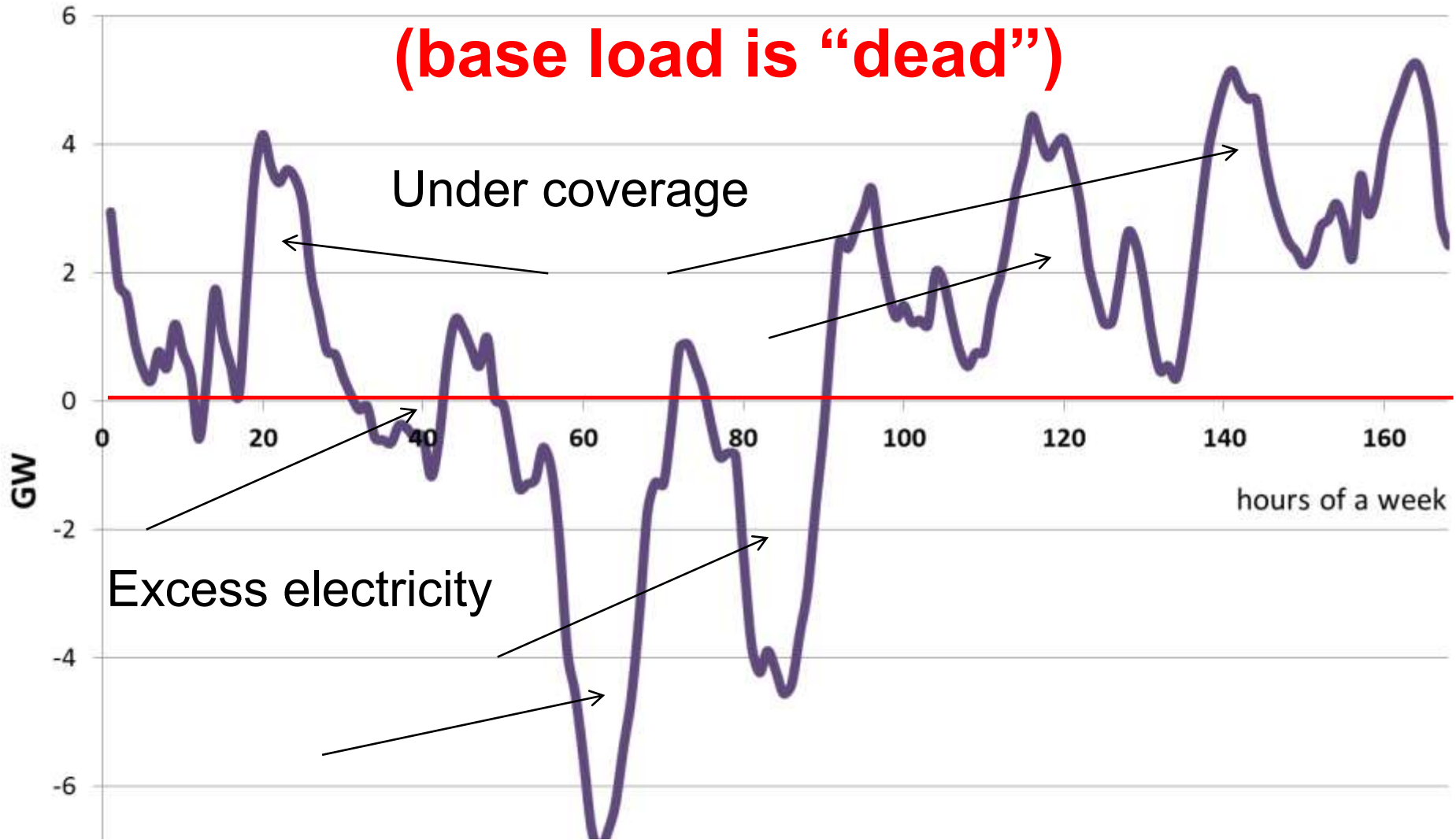




Key term of the future: Residual load

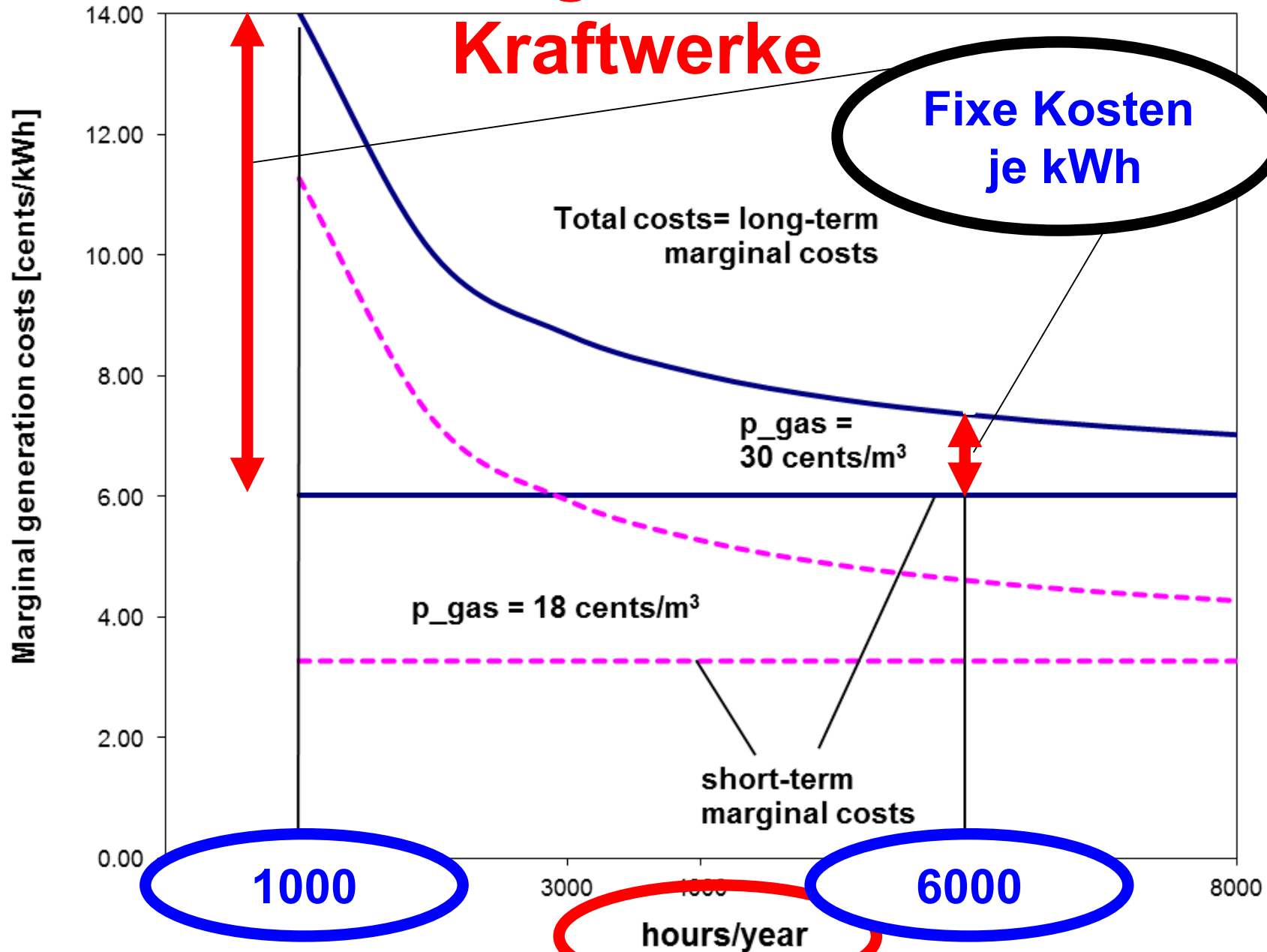


(base load is “dead”)

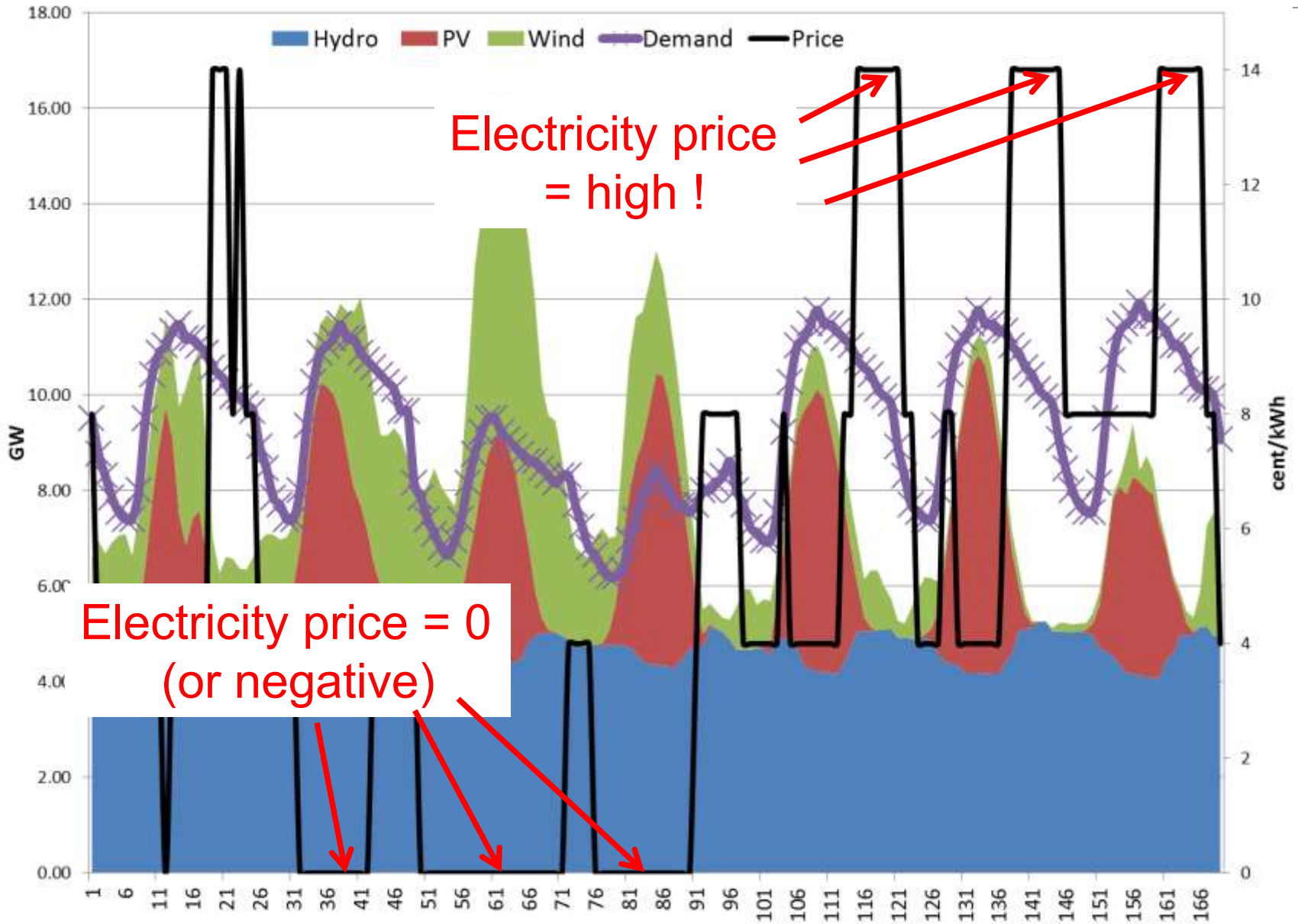


Residual load = Load – non-flexible generation

Auswirkungen auf GUD- Kraftwerke

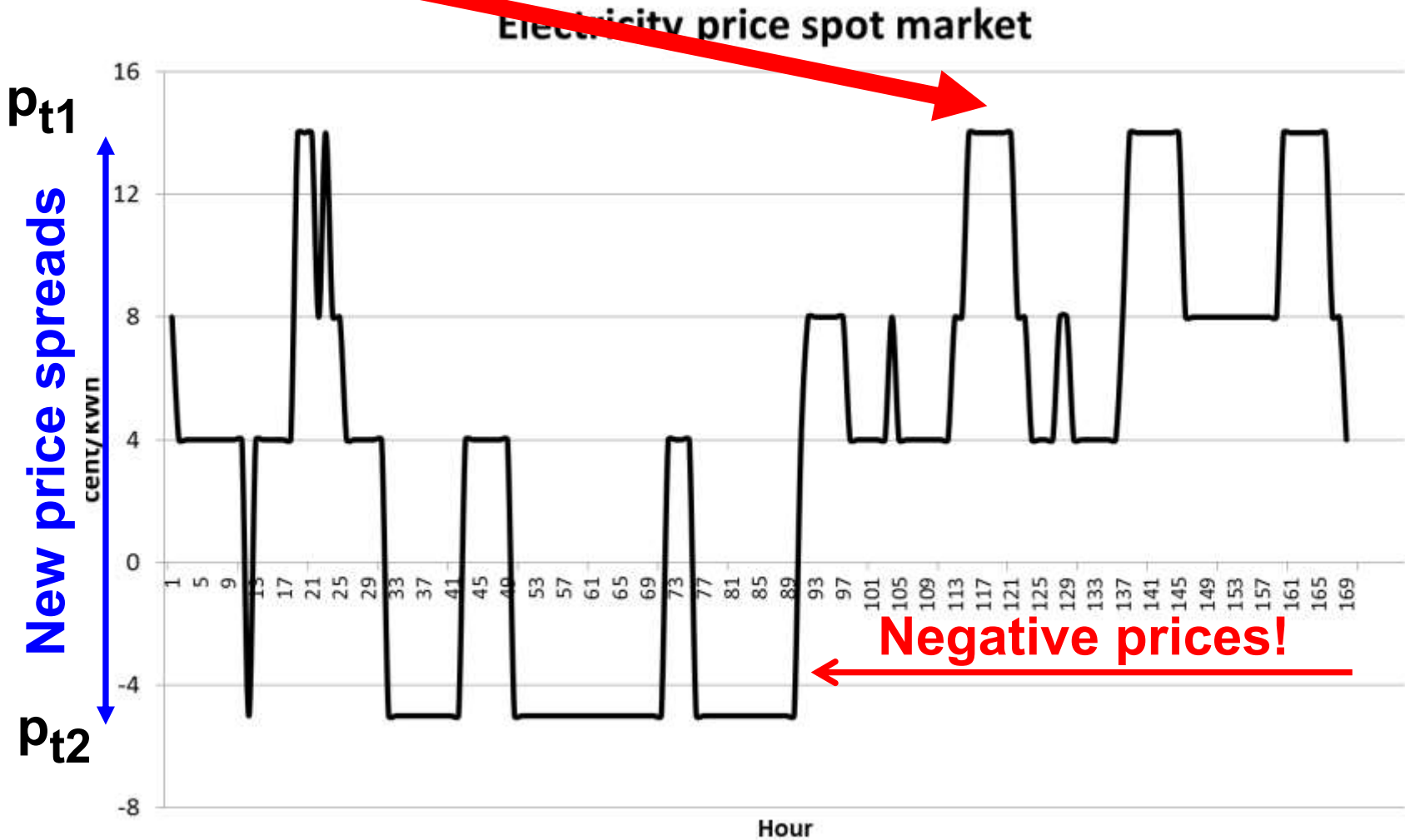


Temporarily high prices





Are these prices TOO HIGH?



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

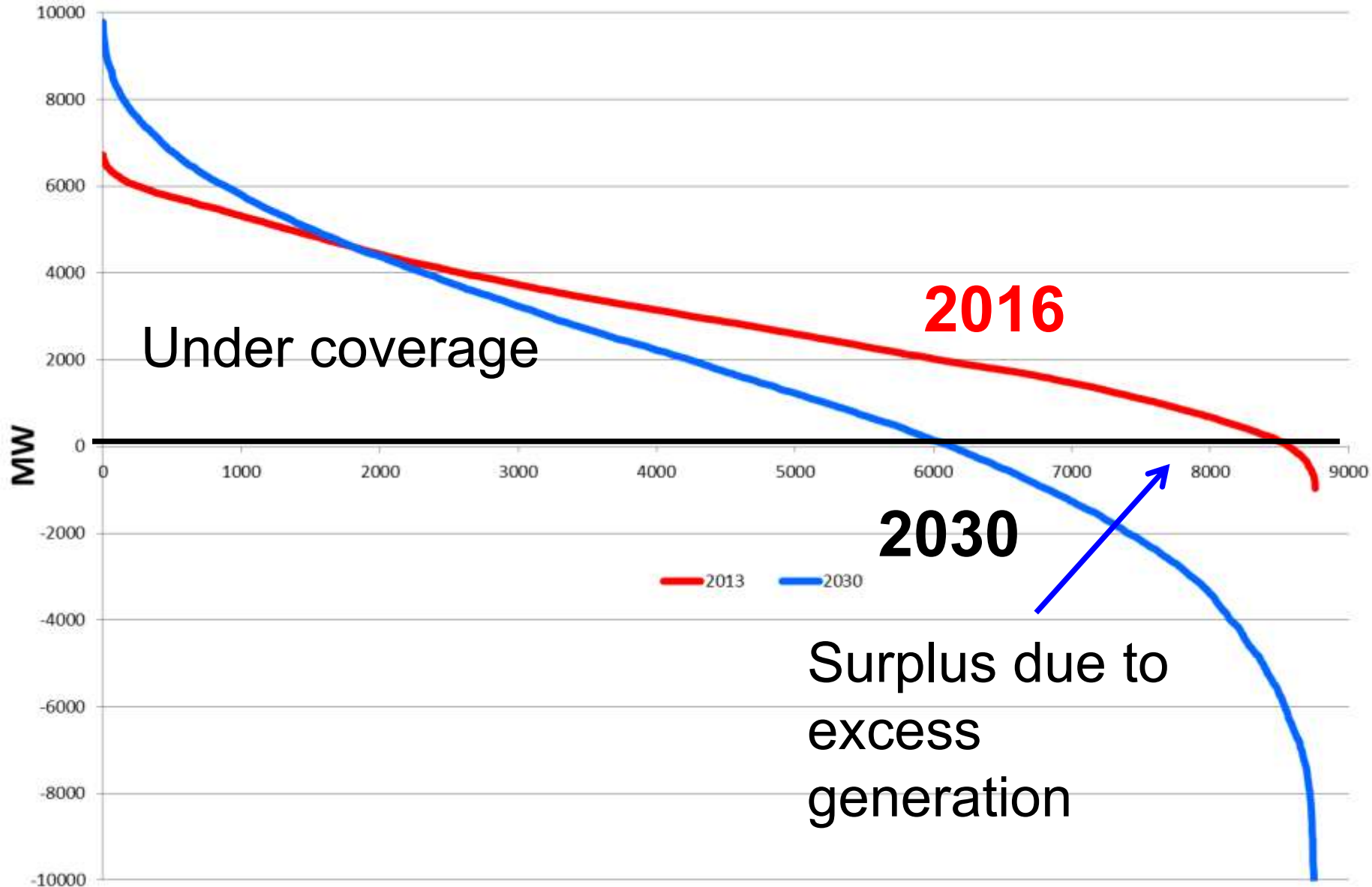


6. NEED FOR NEW MARKET MODELS





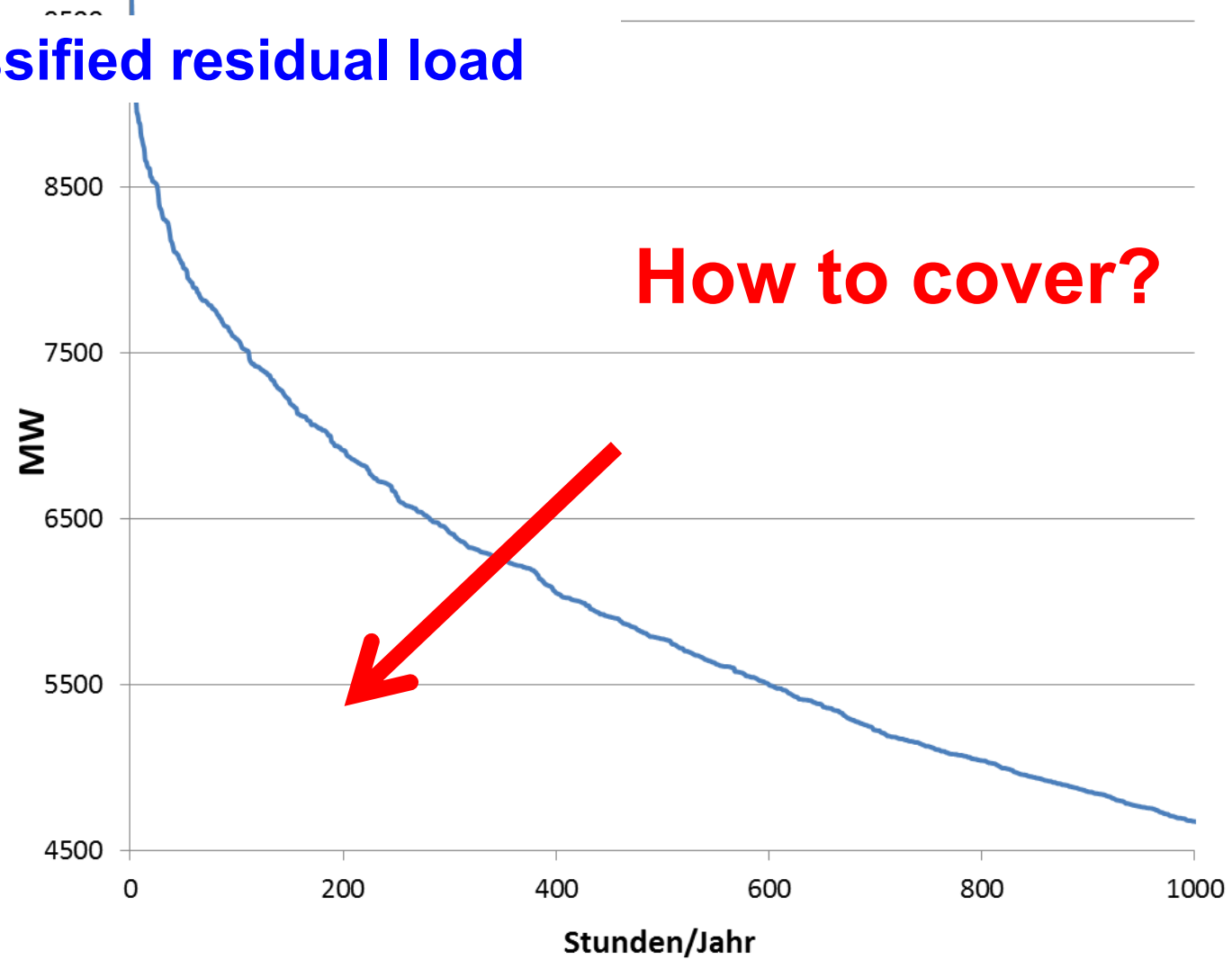
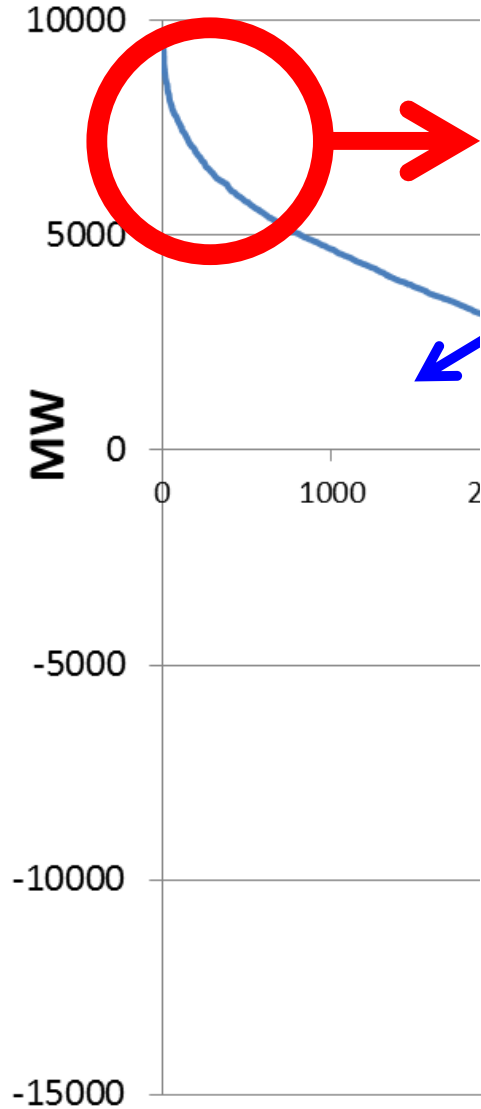
Classified residual load



Geordnete Residuallast



Classified residual load



How to cover?

1

By a regulated capacity „market“ ?
or

**By competition between supply-side
and demand-side technologies (incl.
storages and grid)?**



4 THE CORE PROBLEMS OF CAPACITY PAYMENTS



All regulatory capacity payments for power plants distort 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

The higher the excess capacities, the lower is the share of RES

strive to retain system resource adequacy by correct price signals



DIMENSIONS OF ELECTRICITY MARKETS



SUPPLY

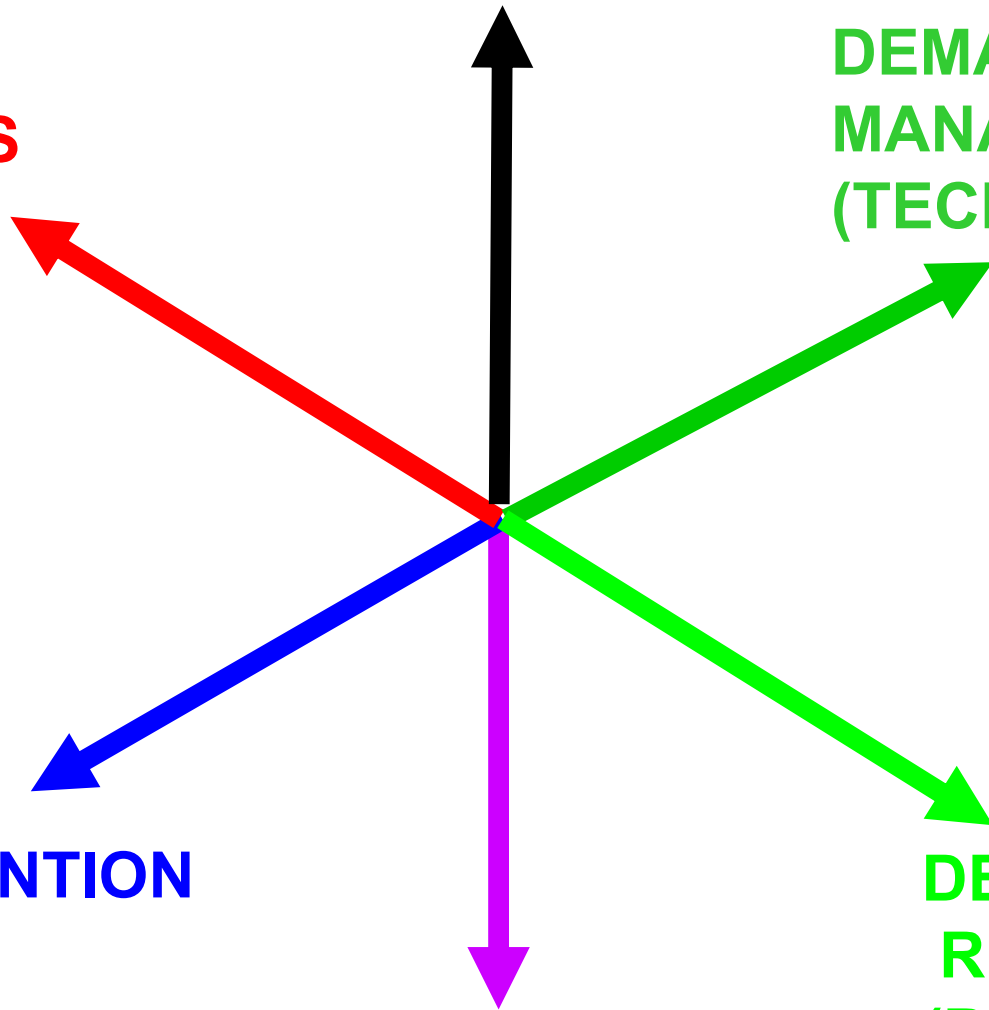
STORAGES

**DEMAND-SIDE
MANAGEMENT
(TECHNICAL)**

GRID EXTENTION

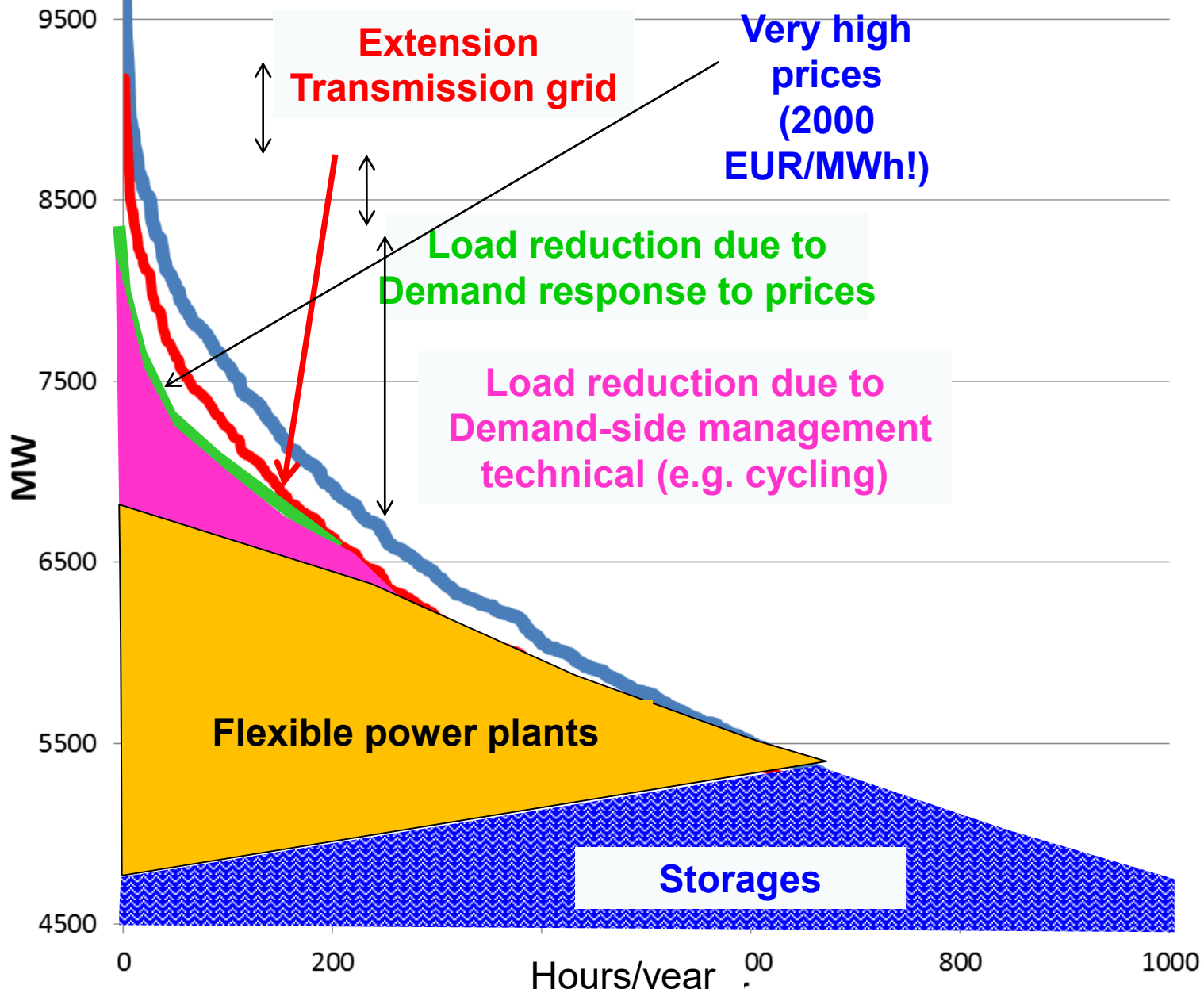
**DEMAND
RESPONSE
(PRICE SIGNALS)**

SMART GRIDS

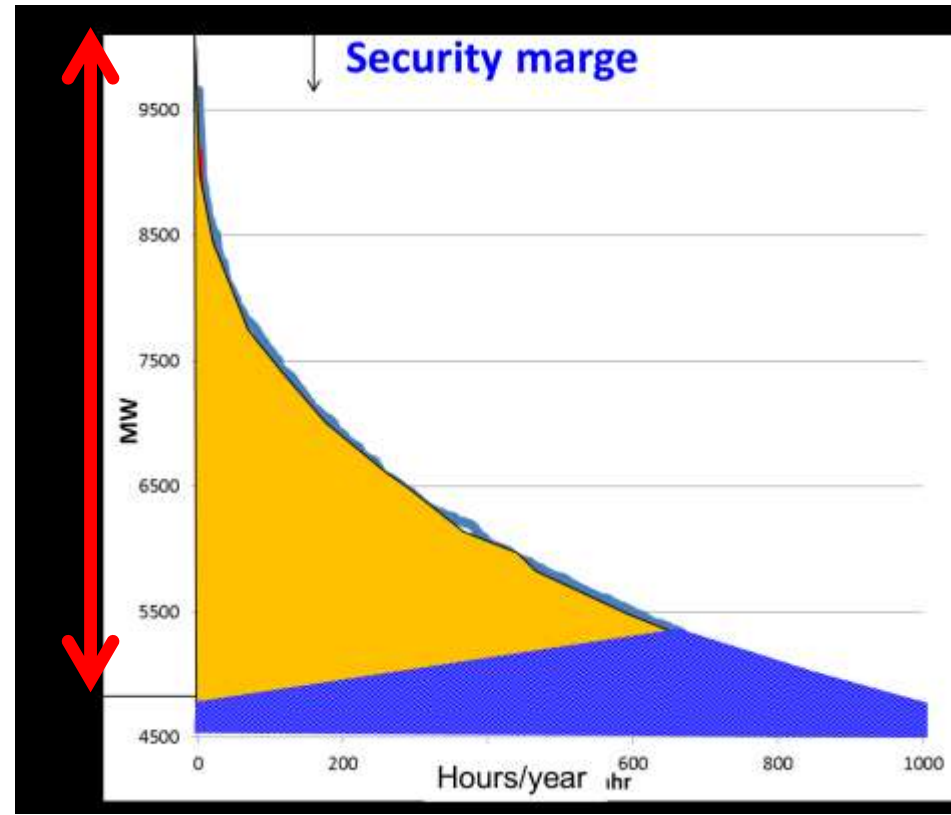
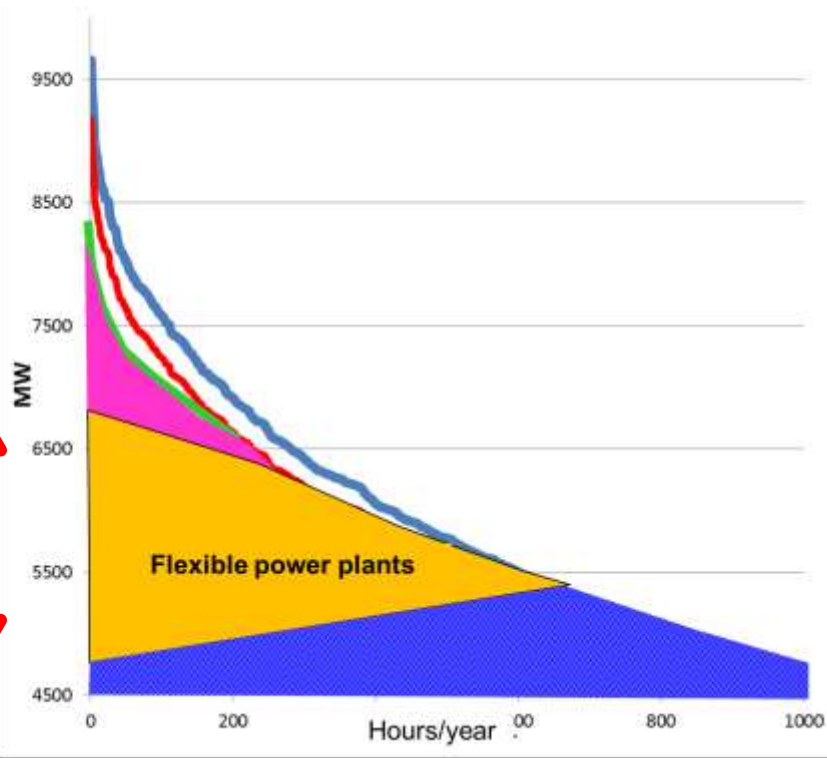




5 Flexible coverage of residual load

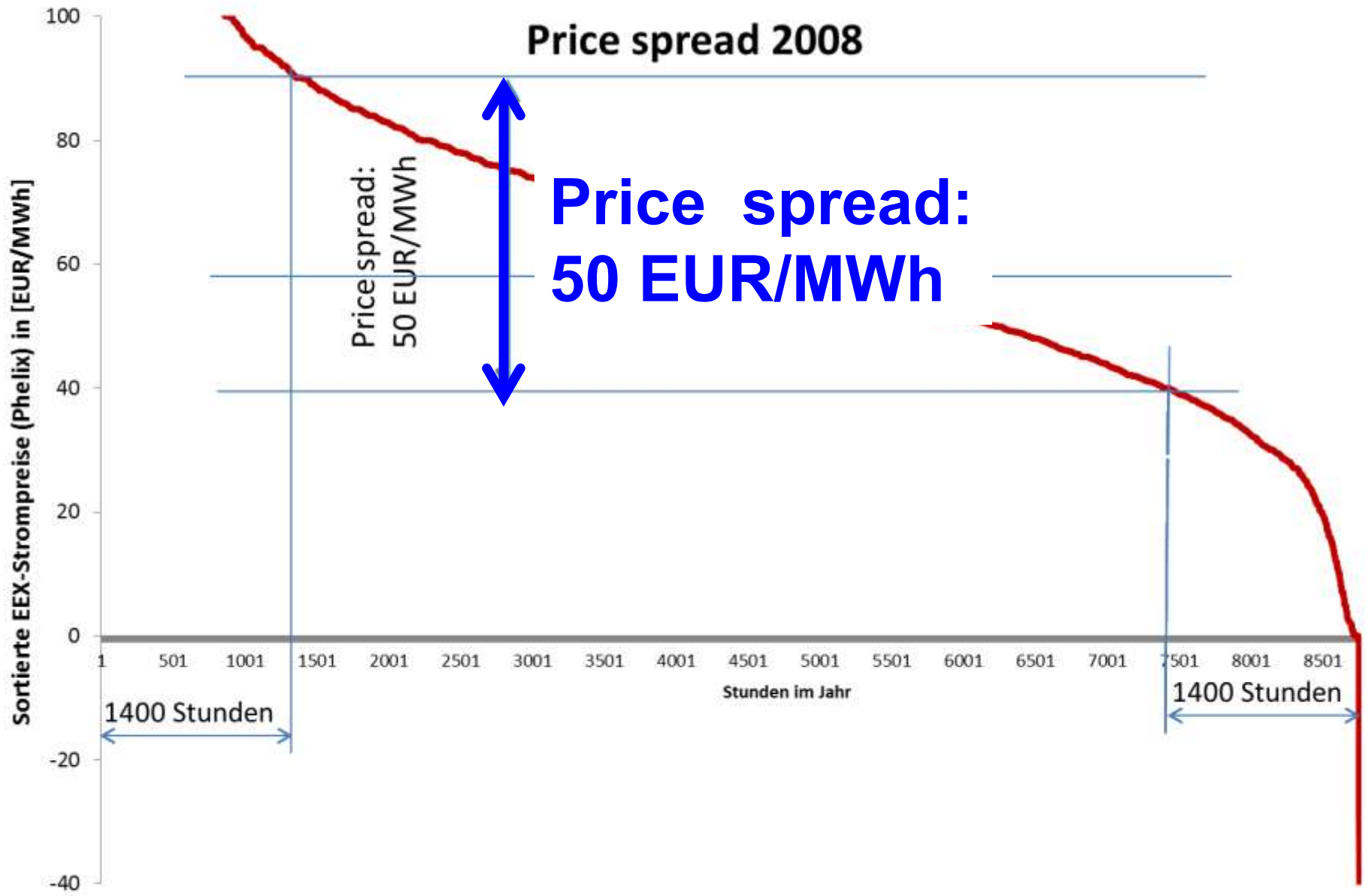


Comparison

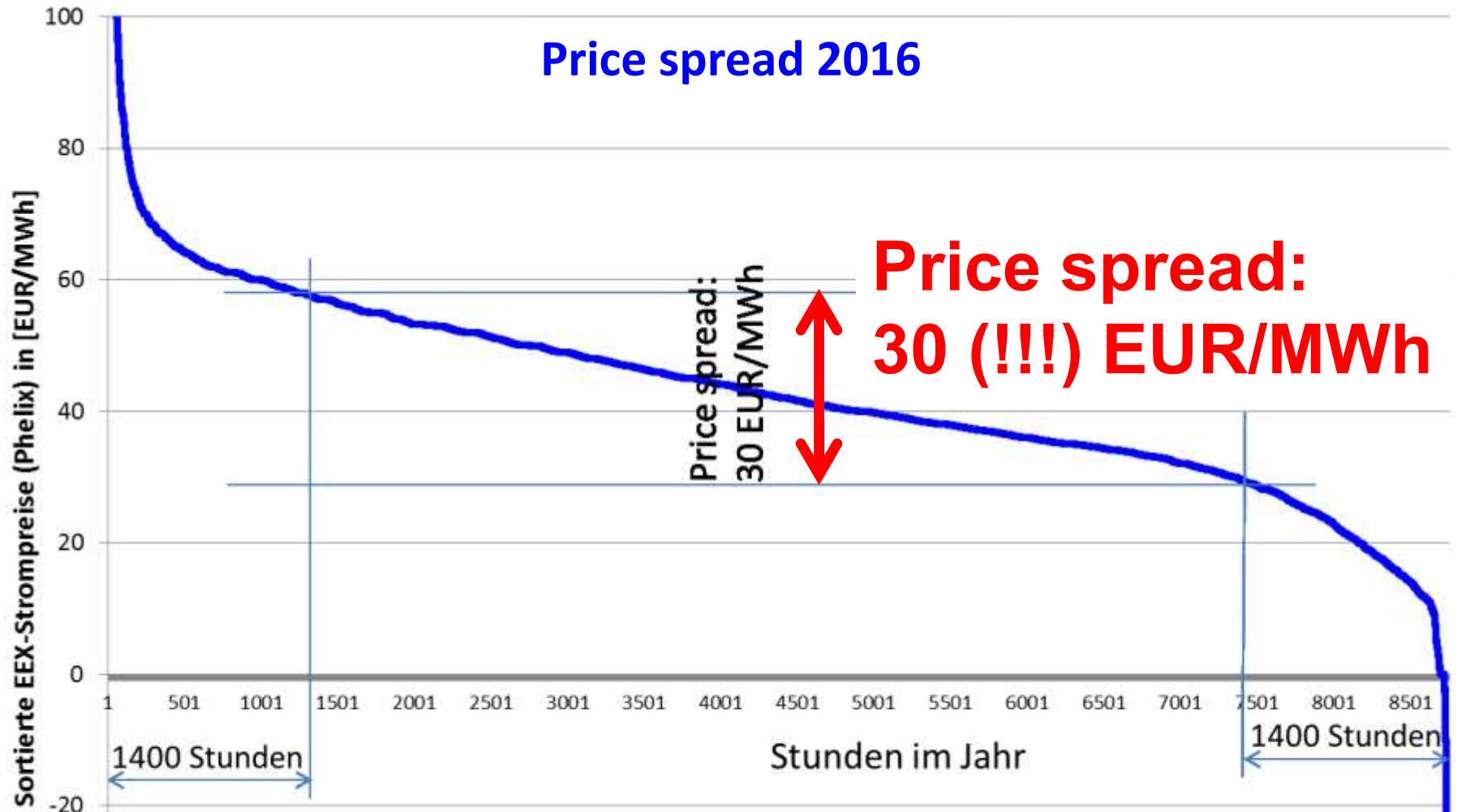




ECONOMIC INCENTIVES



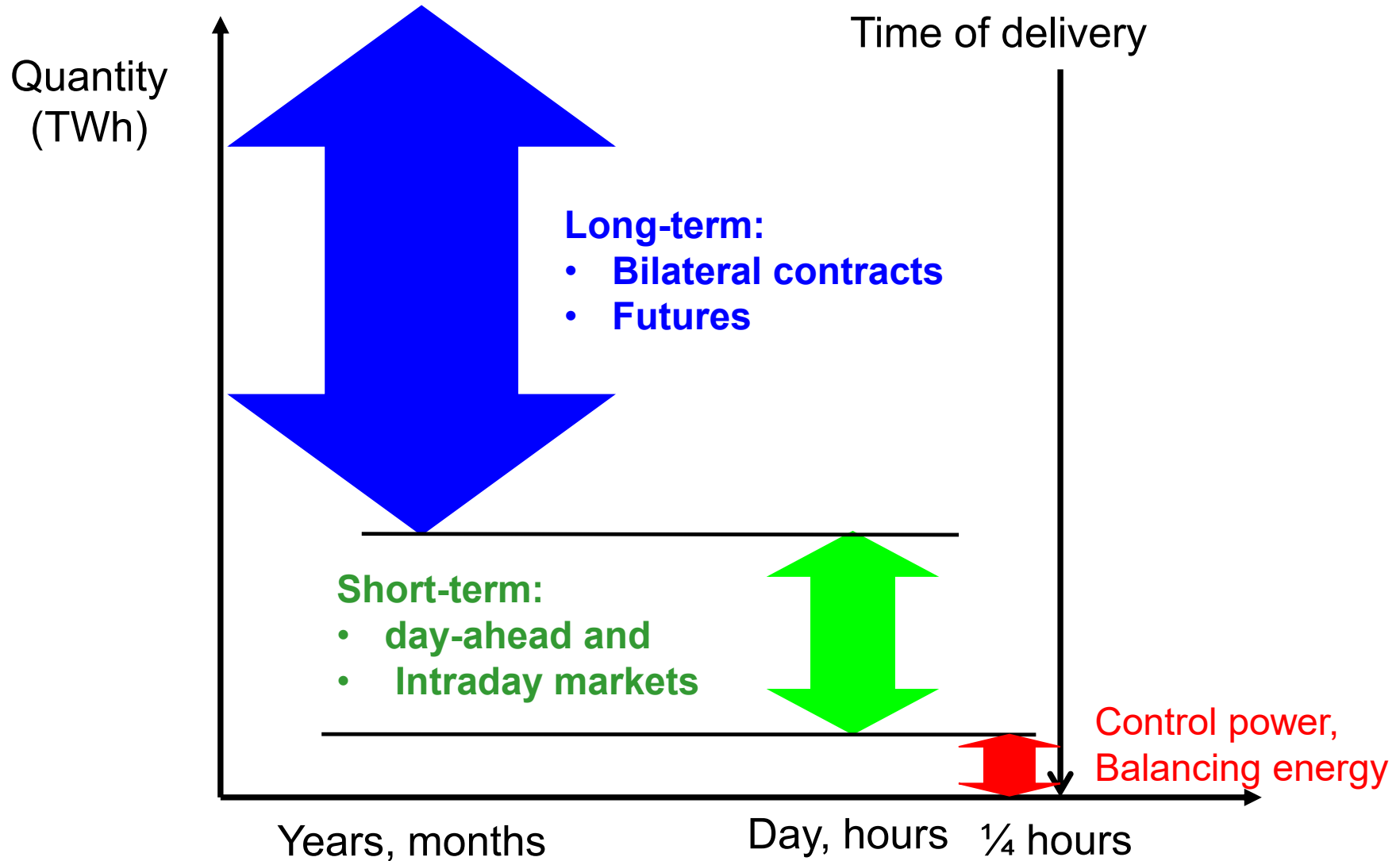
Price spread 2016

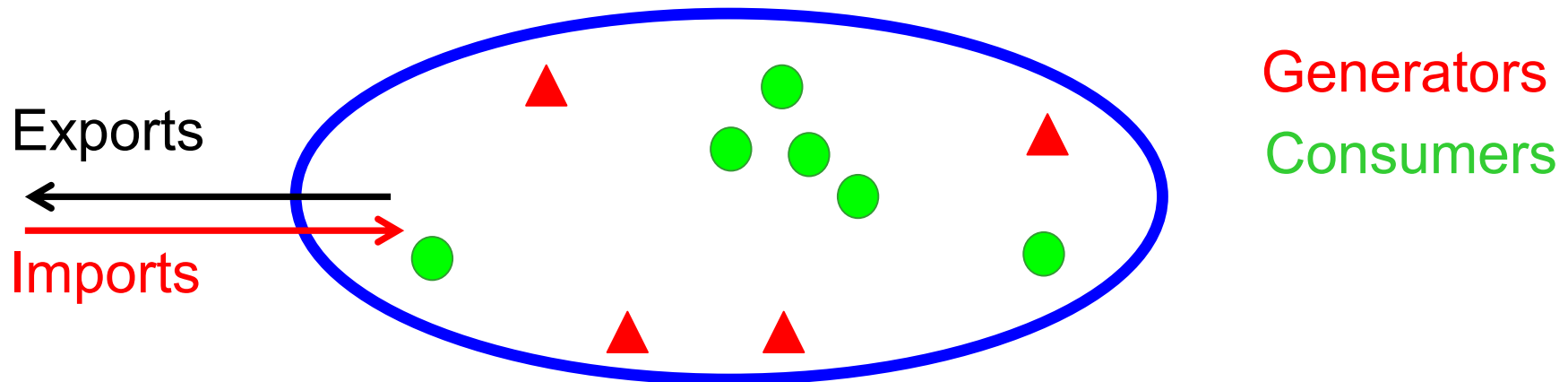


→ There is no incentive today to launch flexibility measures (except in the control power market)!

6. THE CORE ROLE AND RESPONSIBILITY OF BALANCING GROUPS

Elements of electricity markets



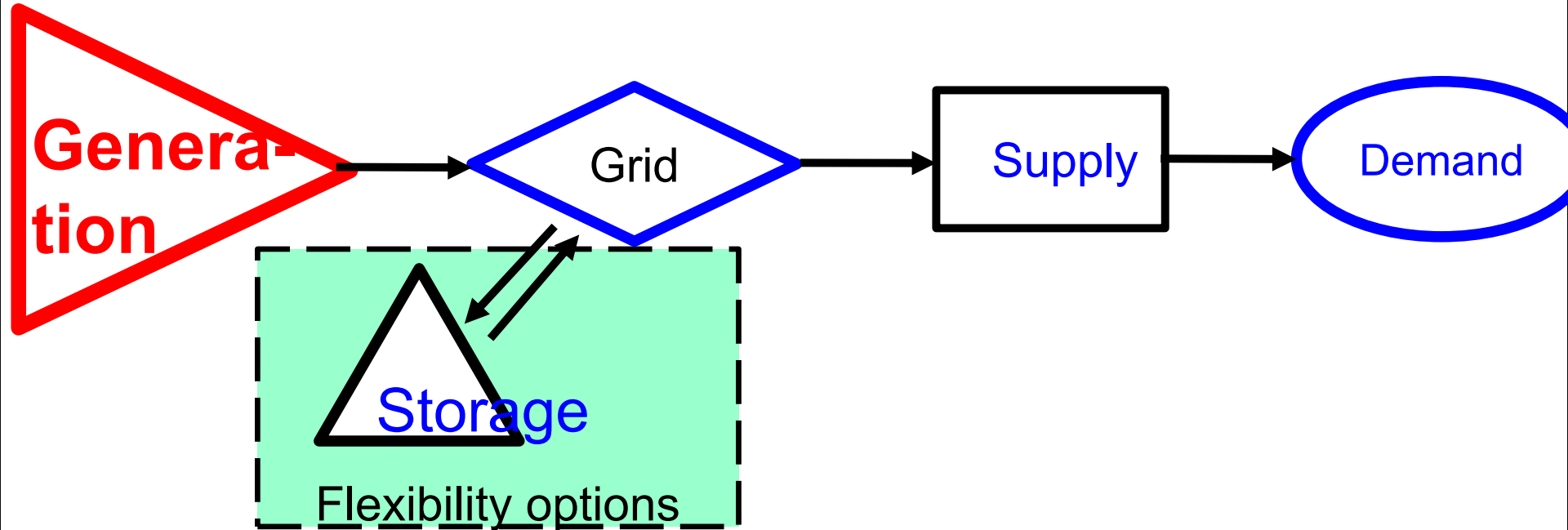


Balancing group: entity in a control area of an electricity system; it has to ensure that at every moment demand and supply is balanced

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

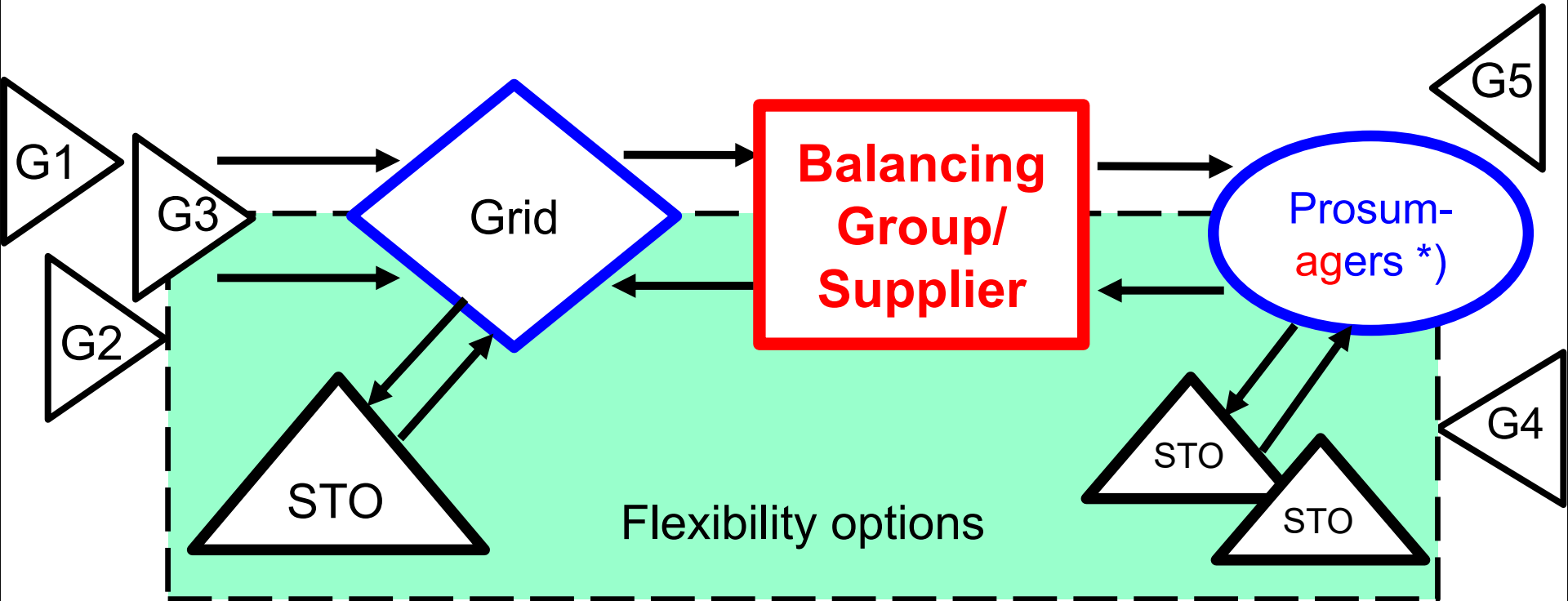
**To meet this target: own generation , storage, flexibility,
Trading in long-term, day-ahead and intraday market**

Every difference → high costs!





New Thinking: Making the electricity system more democratic



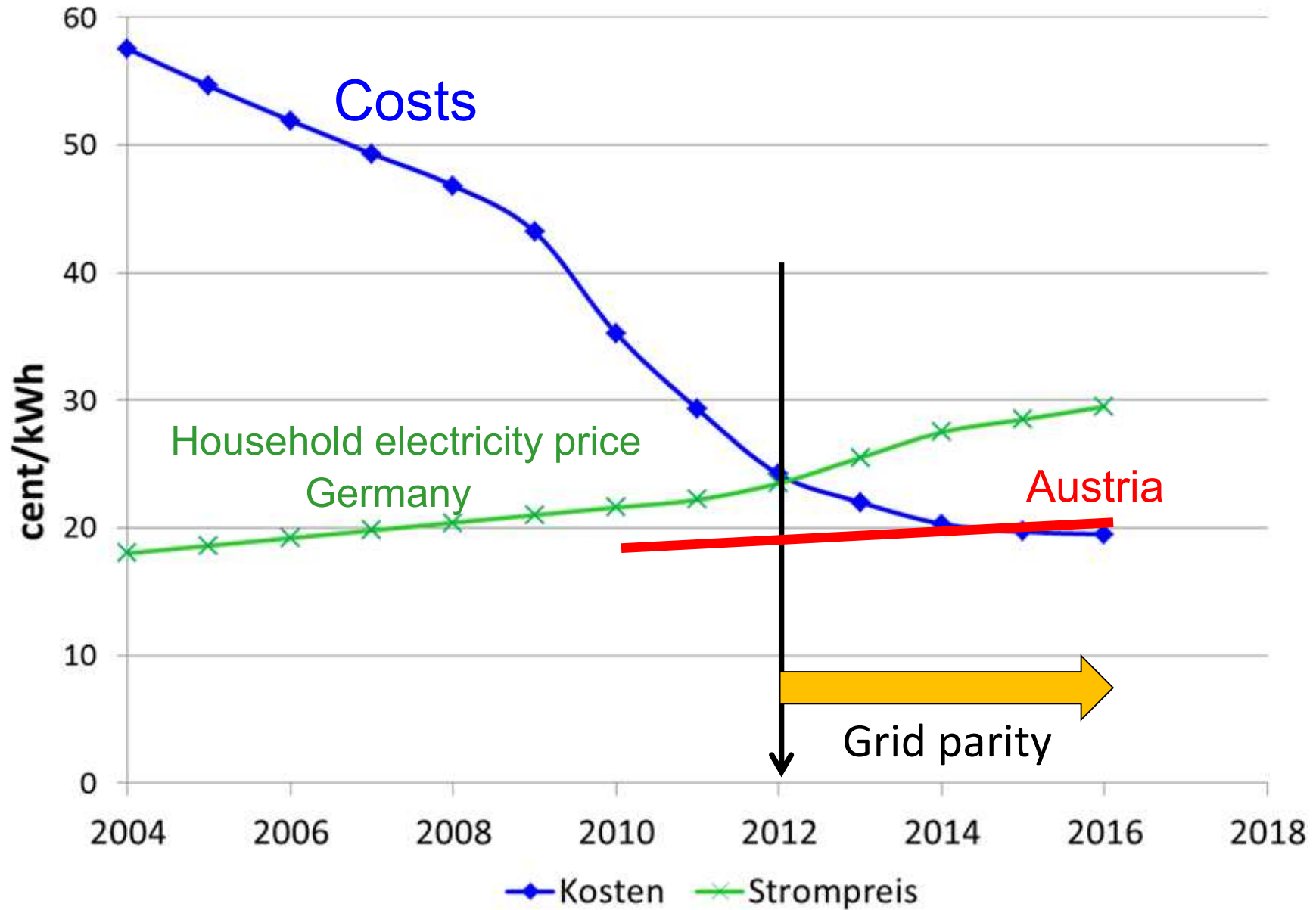
*) R. Green

7. IS THE TIME FOR SUBSIDIZING RENEWABLES OVER ?

As long there is no price on CO₂



Grid parity: PV-costs and household electricity prices



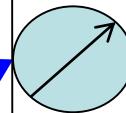


Tenant electricity model and Blockchain

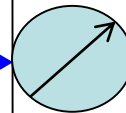
PV-System on the roof

Tenant electricity model:
Contracted PV-electricity

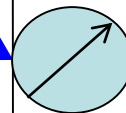
**Balancing
Group/
Supplier**



Customer 1



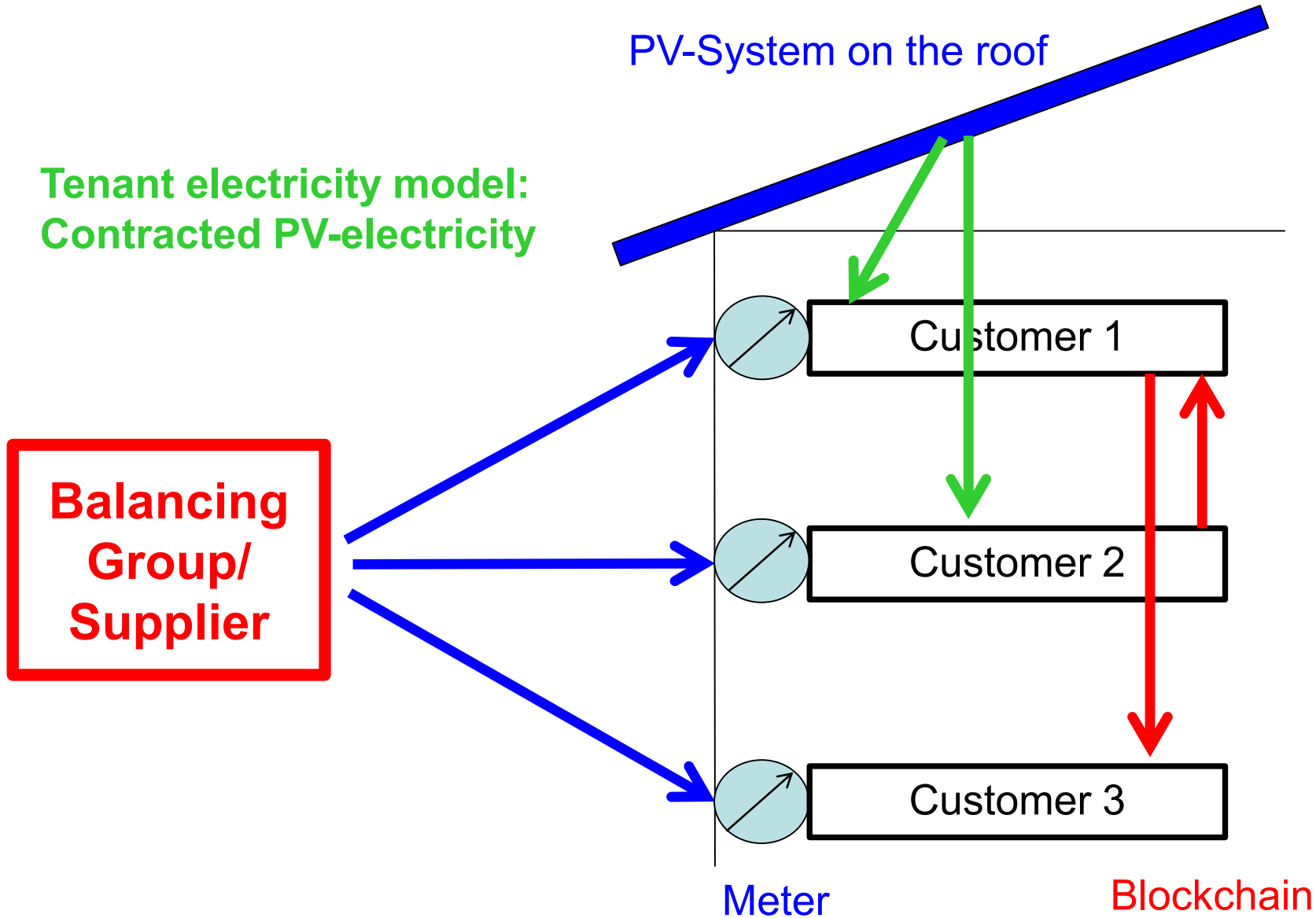
Customer 2



Customer 3

Meter

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



APP. A: CAPACITY MARKET MODELS



	P= STMC	P= LTMC	DS contracts	Exist. cap.	New cap.
EOM classic	X				
EOM revised		X			
EOM + DCM		X	X		
Compreh. CCP	X				X
Focused CCP	X			X	X

EOM...Energy-only market

CCP...Centralized capacity payments

DCM...Demand-side capacity market



OPEN QUESTIONS REGARDING CCP:



Which quantity of capacity where?

How to split in existing and new capacity?

How to tune with grid extension?

Who plans? On national or international level?

**E.G. CCP in DE influence operation of
Austrian and Swiss hydro storages**

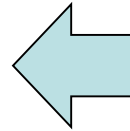
Capacity MARKETS??? How should
competition take place in a specific
region with one supplier?

Or in France???



THE PLANNING SPIRAL

**Financing
inter-
national?**



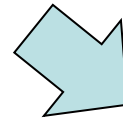
**CCP Inter-
national**



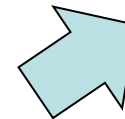
**Grid
extention
Nat./Int.**



**CCP
National**



**Storage
Internat.**



**Central
European
planning
commission
!**

**Conclusion: Increasing
planning!**



Regional decentral capacity „MARKETS“ ???



Capacity problems on regional level!

Statement EWI Cologne, in favour of CCP:

“If we introduce capacity markets they must ensure full supply security. That is to say the capacities we need must at least to some extent be higher than expected demand, including a security margin”
(Energy&Management, March 2013)

Now imagine which excess capacity comes about if all European REGIONS do this on there level...

→ Huge additional costs!

APP. B: THE ROLE OF STORAGES



Residual load = Load – non-flexible production



2. The costs of storage

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

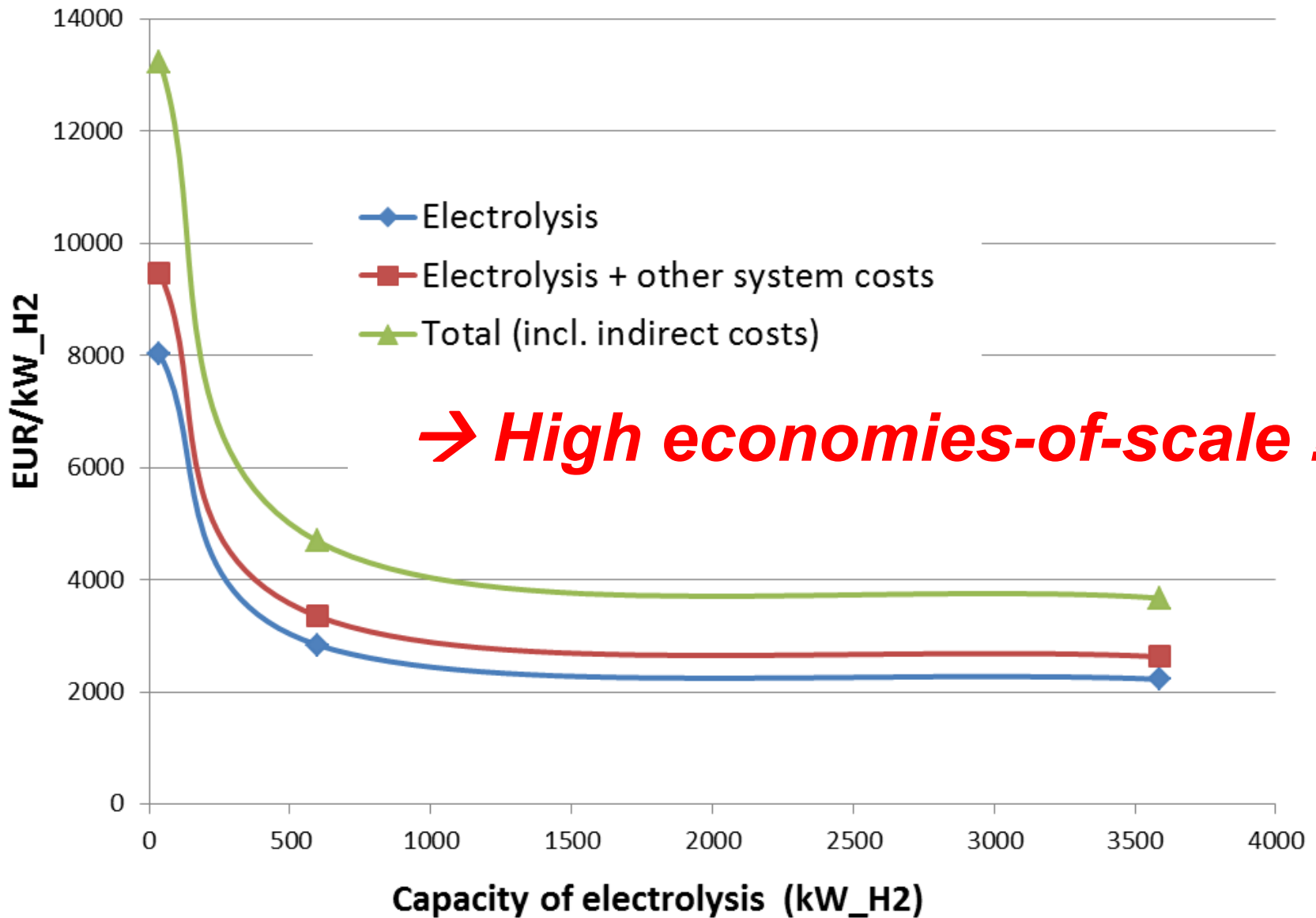
- C ... Storage costs (EUR per kWh)
C_E ... Energy costs (EUR per kWh)
C_{OM} ... O&M costs (cent per kWh)
IC ... Investment costs (EUR/kW)
α ... Capital Recovery factor
T ... Fullloadhours (hours per year)
η_{SP} ... Efficiency of storage

Key factors:

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



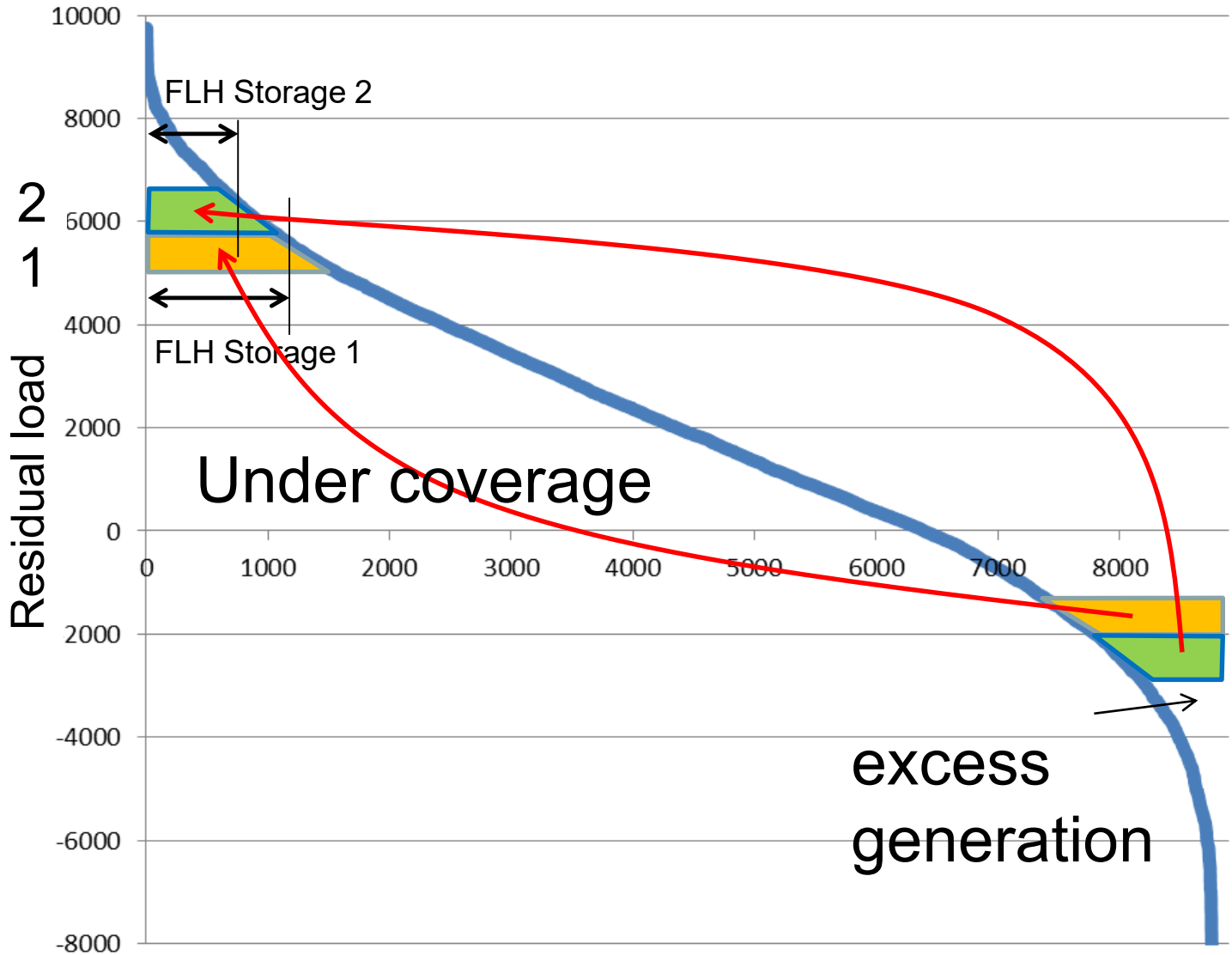
Investment costs of hydrogen production 2014





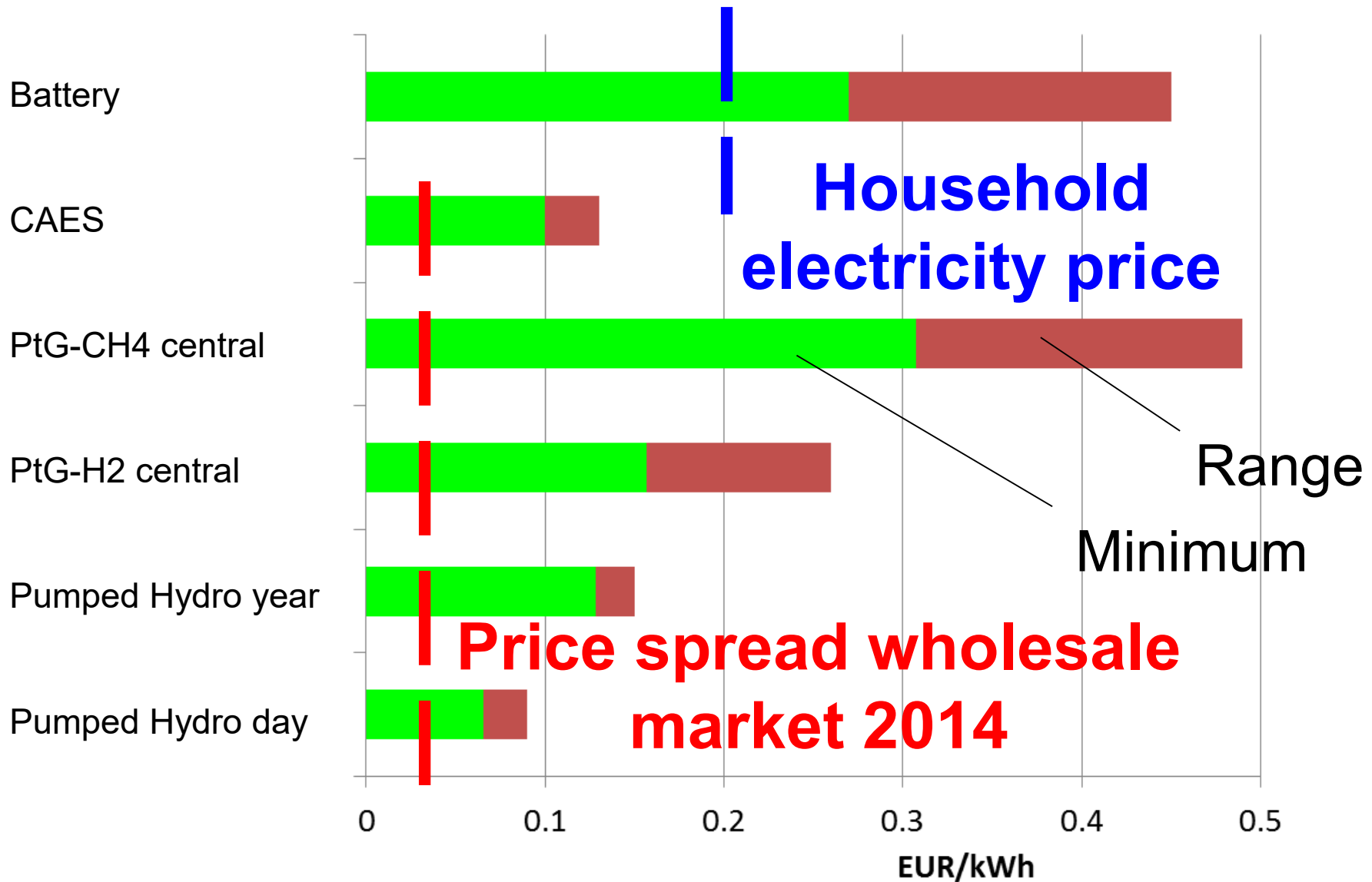
Decreasing full-load hours of storages

Storage 2
Storage 1



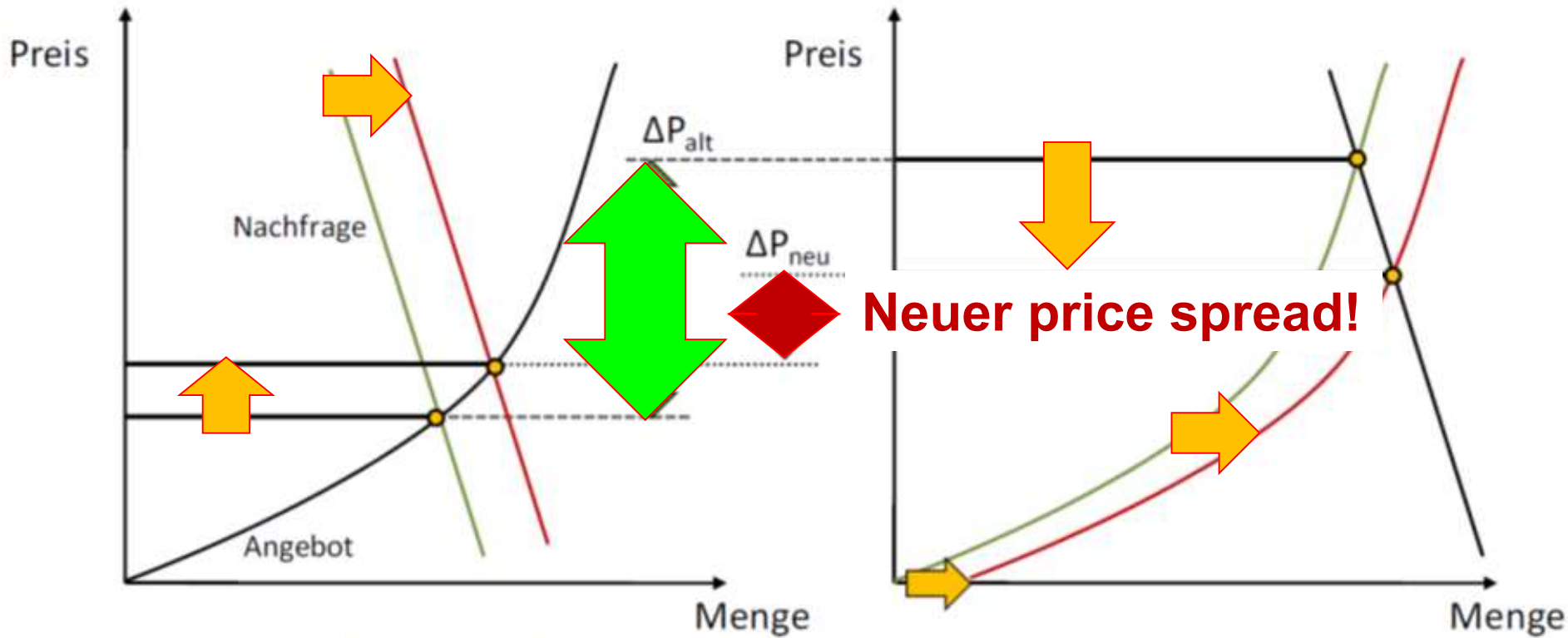


Range of costs 2015





The impact of new storage on price spreads



Stunde 1: Einspeichern

Stunde 2: Ausspeichern

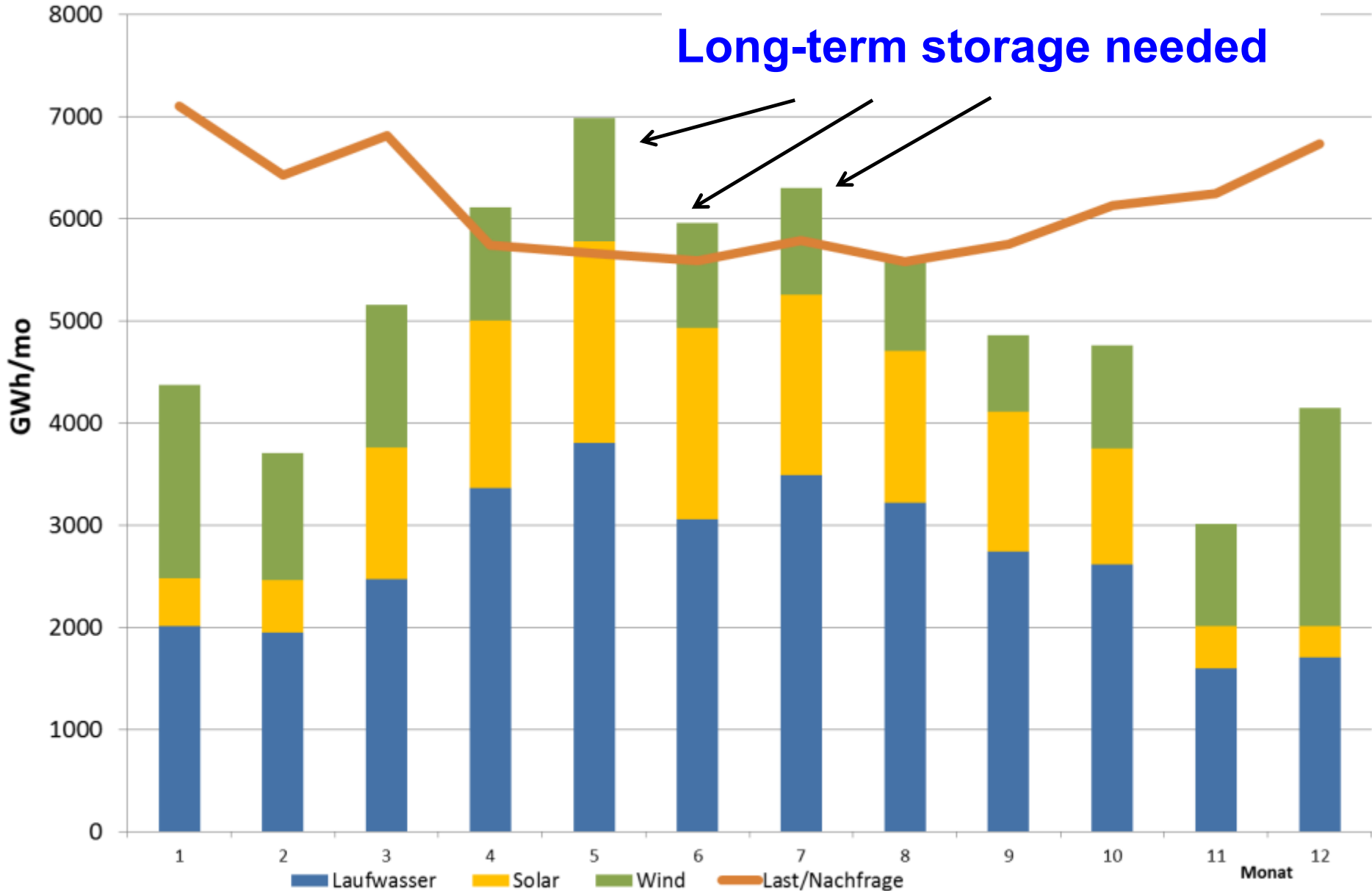


Sector coupling / Sector integration

Demand for long-term storage



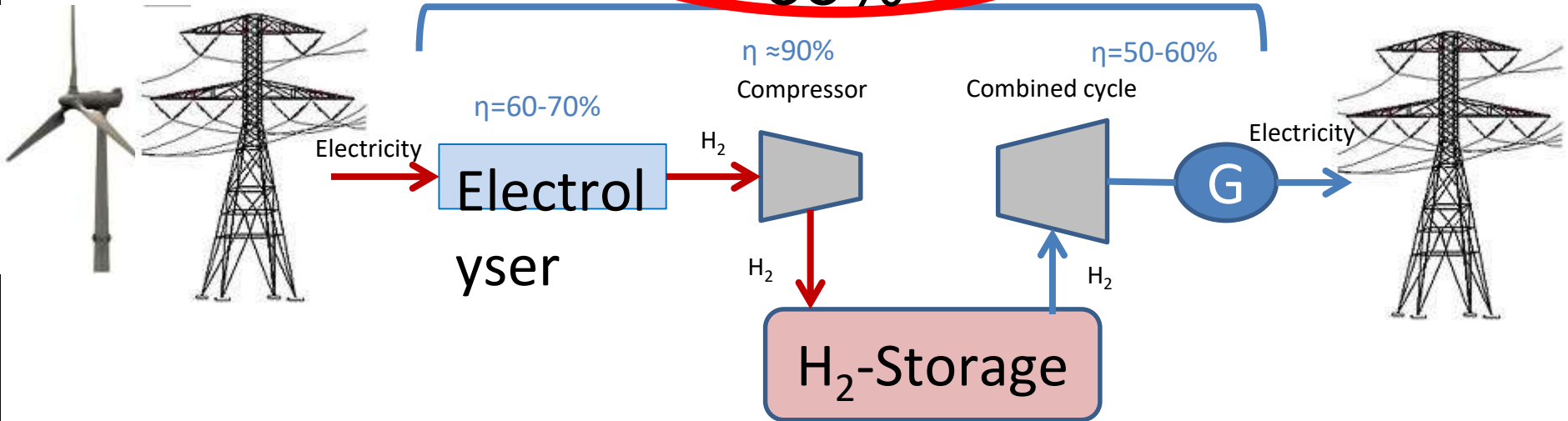
Long-term storage needed



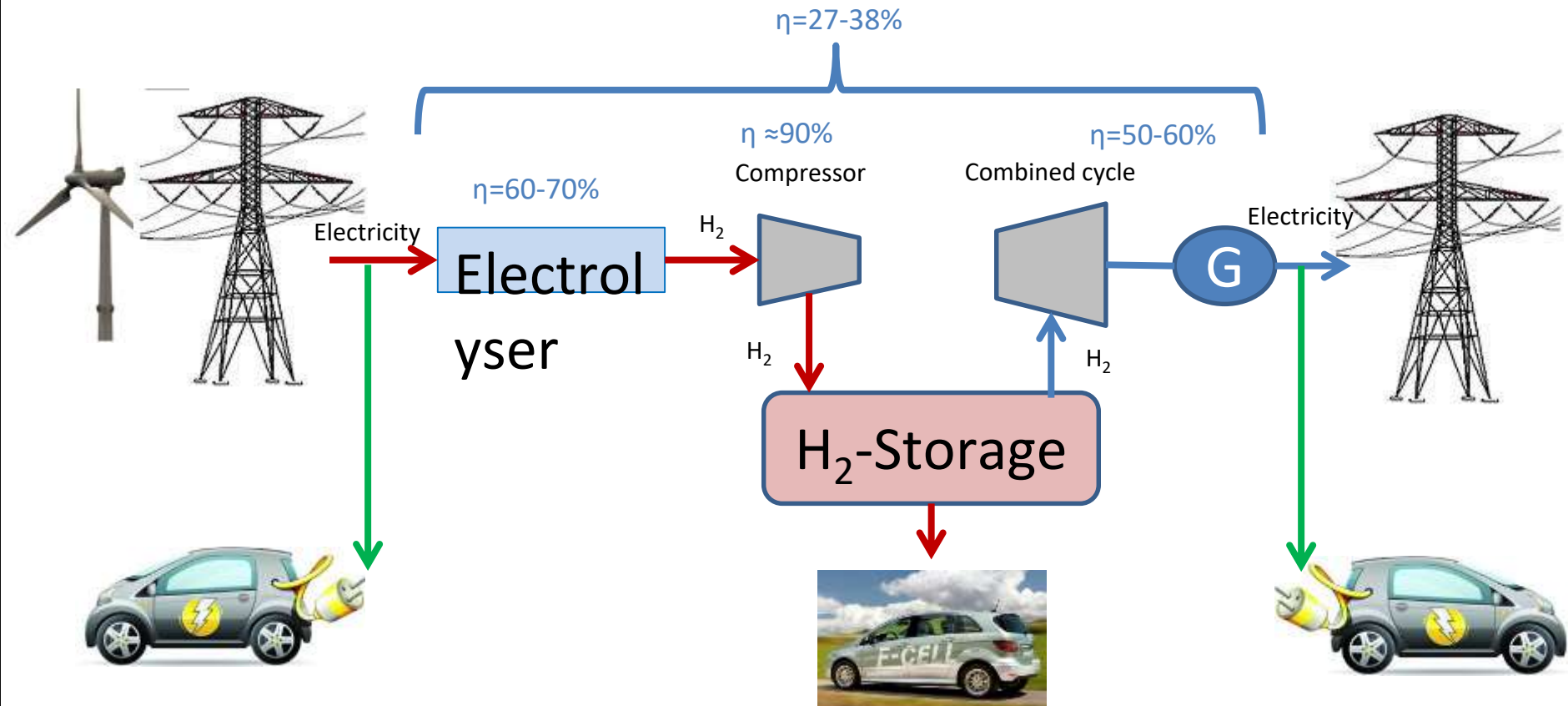
Hydrogen: storage and roundtrip use for electricity generation

Very low roundtrip efficiency for electricity!

$\eta = 27\text{-}35\%$



Using hydrogen and methane in transport



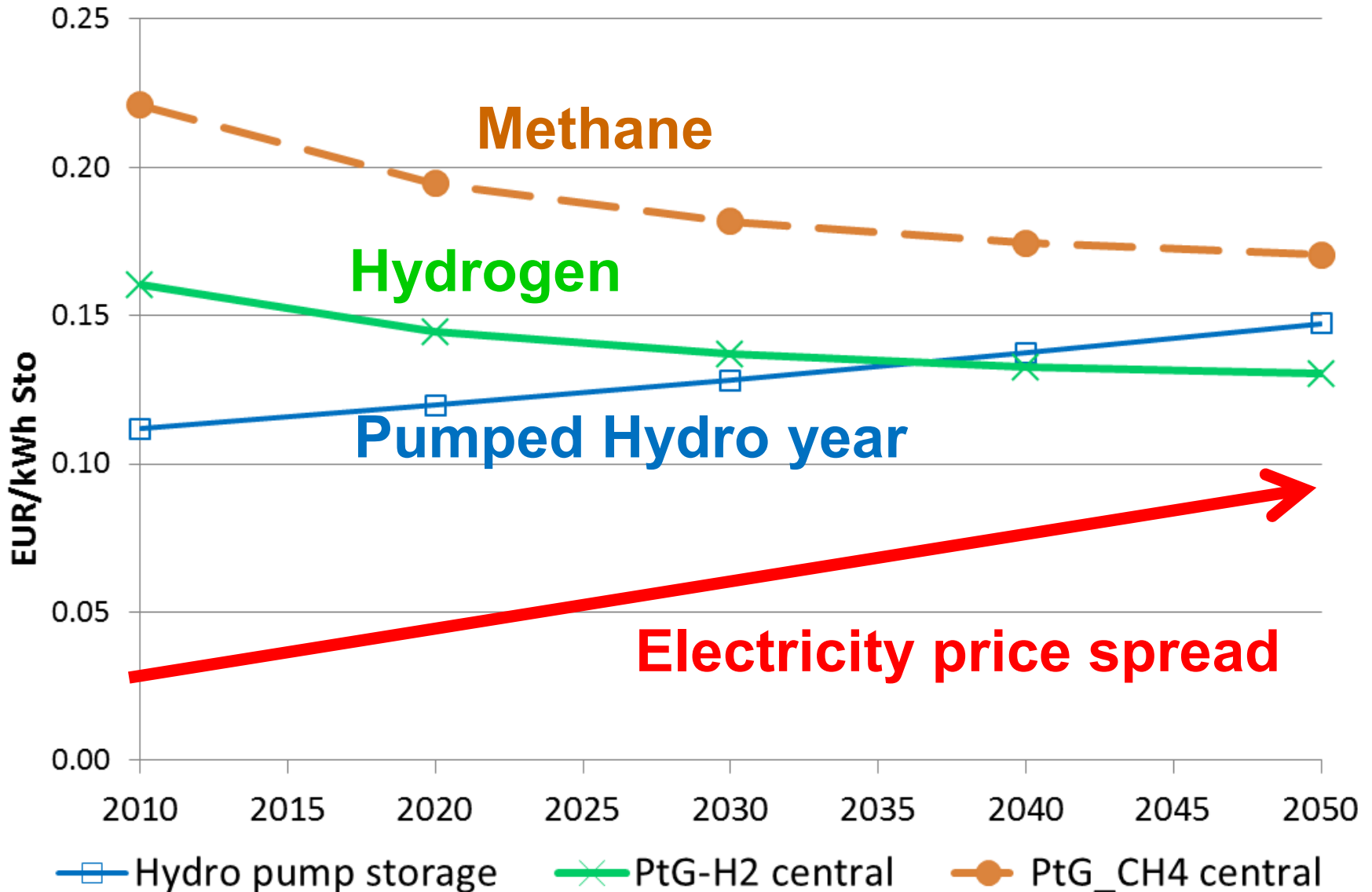
Energy supply chains: Storage and/or use of R

Costs scenarios for long-term storage technologies



Storage costs optimistic 2010 - 2050

(Electricity costs = 0, T=1800 hours/year)





ANNEX: SUPPLY SECURITY AND DIMENSIONS

Historical (anachronistic) definition:

At every point-of-time every demand has to be met regardless of the costs!

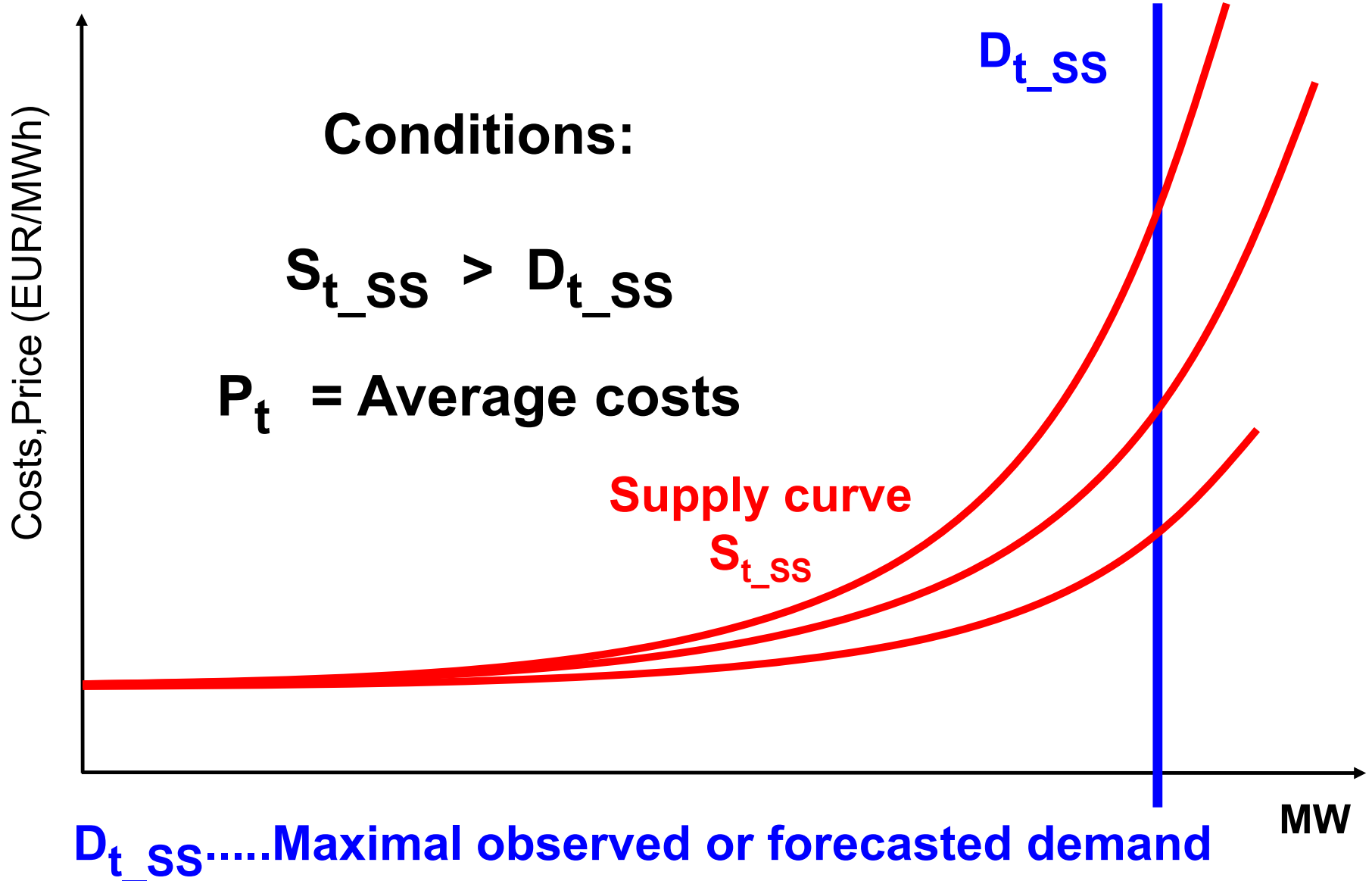
(Note:

Supply security is an energy economic term!

Supply security \neq system reliability!)



HISTORICAL SUPPLY SECURITY



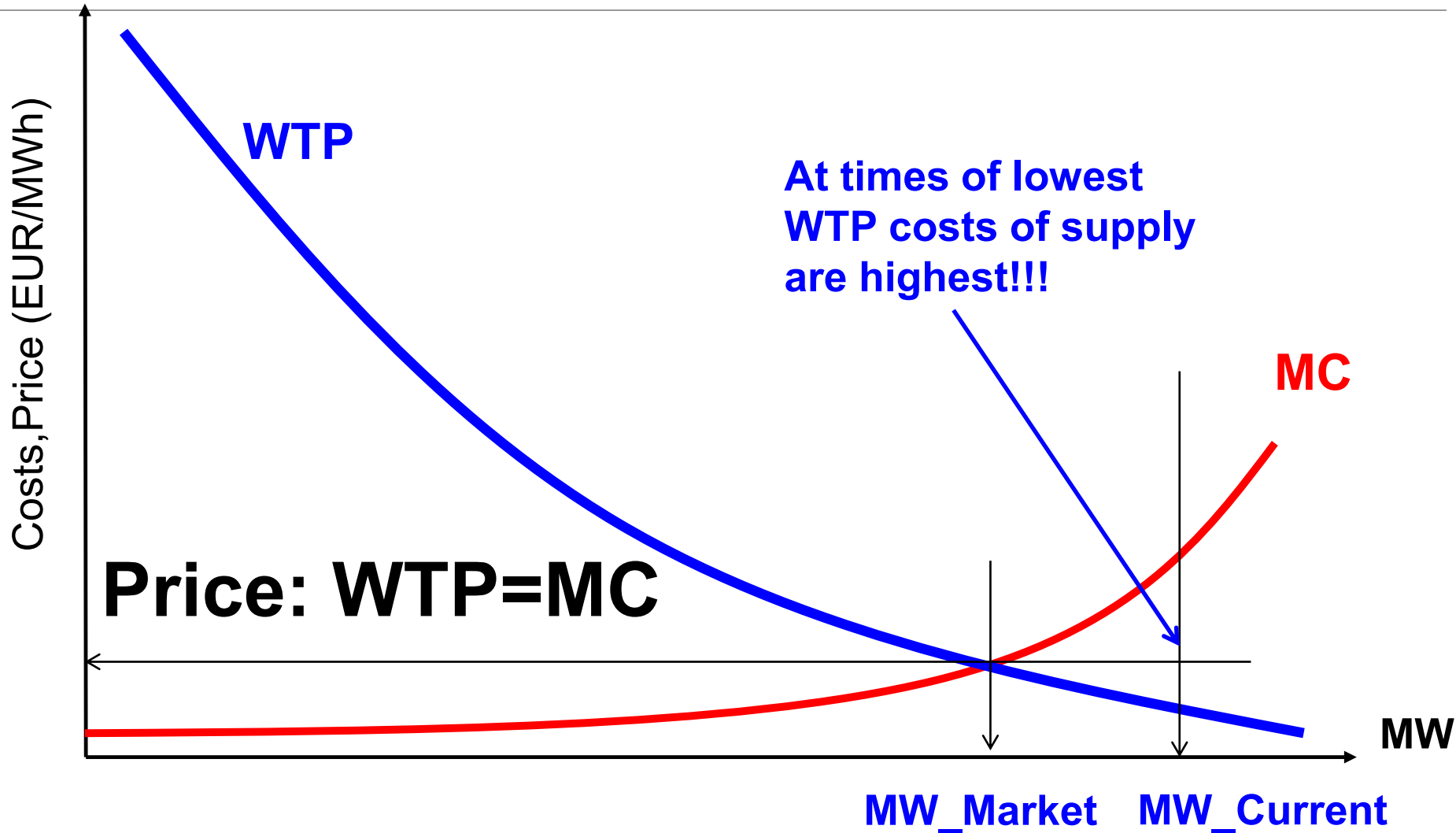
**Historical SS + Centralized Capacity
Payments (CCP)**

=

New market DESIGN!
(=planned economy)



A MARKET DESIGN



PhD thesis Praktijnjo: A wide range of WTP on the demand-side!