ICEE 2017

29|30 June 2017

3rd International Conference on Energy and Environment: bringing together Economics and Engineering

Faculty of Economics of Porto / Portugal

ICEE Conference

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Keynote Speakers

HENRIK LUND

M.Sc.Eng, PhD, Dr.Techn. Henrik Lund is Professor in Energy Planning at Aalborg University in Denmark and Editor-in-Chief of Elsevier international journal ENERGY. Prof. Lund was head of department from 1996 to 2002 and has served as head of several large research projects in Denmark as well as in Europe. Prof. Lund holds a PhD in "Implementation of sustainable energy systems" (1990) and a senior doctoral degree in "Choice Awareness and Renewable Energy Systems" (2009). Prof. Lund has more than 25 years of research experience and involvement in Danish Energy Planning and Policy making. Among others, Prof. Lund has been involved in the making of the Danish Society of Engineers', proposal for a future 100% Renewable Energy Plan for Denmark. Prof. Lund was awarded a gold medal by the International Energy Foundation (IEF) for "Best Research Paper Award" within the area "Energy Policies & Economics" in 1998. And Prof. Lund is the main developer of the energy system analysis model EnergyPLAN, which is used by various researchers and energy planners around the world. Prof. Lund has contributed to more than 200 books and articles and is the author of the book "Renewable Energy Systems - The Choice and Modeling of 100% Renewable Solutions." (Academic Press, Elsevier 2014).

LUC HENS

Graduated as a biologist and received his Ph. D. in Biology from the Vrije Universiteit Brussel (VUB), Belgium. Until 2010 He was a professor and Chair of the human ecology department. He also lectures at the Technical University in Sofia (Bulgaria), at the National and Kapodistrian University of Athens (Greece), and at Lisbon University (Portugal). He was a senior scientific adviser at the "Vlaamse Instelling voor Technologisch Onderzoek" (VITO), which is Belgium's biggest environmental research organization. He is currently retired as an emeritus professor. Professor Hens' specific area of research concerns the elucidation of interdisciplinary instruments for sustainable development. In this framework, he acted as the promoter of over 10 research projects on environmental management in ports in Vietnam and Cambodia. Luc Hens acts as an expert in environmental policy on several councils in Belgium. He is the European editor for the "International Journal of Environment, Development and Sustainability".

U.PORTO FEP ECONOMICS AND MANAGEMENT

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Cef.Up has been financed by Portuguese Public Funds through FCT (Fundação

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University of Minho
School of Engineering

CENTROALGORITMI

Sustainability".

JORGE VASCONCELOS

Chairman of NEWES, New Energy Solutions. Consultant to several international organizations and national authorities. Invited Professor at the Technical University of Lisbon, MIT/Portugal Program. Chairman of APEEN (Associação Portuguesa de Economia da Energia - IAEE Affiliate).

First chairman of the Portuguese Energy Regulatory Authority. Founder and first chairman of the Council of European Energy Regulators. Co-founder of the Ibero-American Association of Energy Regulatory Authorities (ARIAE). Founder and member of the Executive Committee of the Florence School of Regulation. Prior to the regulatory experience, he worked in industry and at several European universities. Among many other functions, member of the European Commission Advisory Group on the Energy Roadmap 2050 and Chairman of the Green Tax Reform Commission set up by the Portuguese Government in 2014.

Author and editor of several books and articles. Graduated in power systems from Porto University and got the Dr.-Ing. degree from the University of Erlangen-Nuremberg.

REINHARD HAAS

Energy Economics Group, Institute of Energy Systems and Electric Drives, Vienna University of Technology

Reinhard Haas is university professor of Energy Economics at Vienna University of Technology in Austria. He teaches Energy Economics, Regulation and Competition in Energy markets, and Energy Modelling.

His current research focus is on (i) evaluation and modelling of dissemination strategies for renewables; (ii) modelling paths towards sustainable energy systems; (iii) liberalisation vs regulation of energy markets; (iv) energy policy strategies.

He works in these fields since more than 20 years and has published more than 60 papers in reviewed international journals. Moreover, he has coordinated and coordinates projects for Austrian institutions as well as the European Commission and the International Energy Agency.

This conference is supported by:

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

Reinhard HAAS

Energy Economics Group, TU Wien

Porto, 30 June 2017

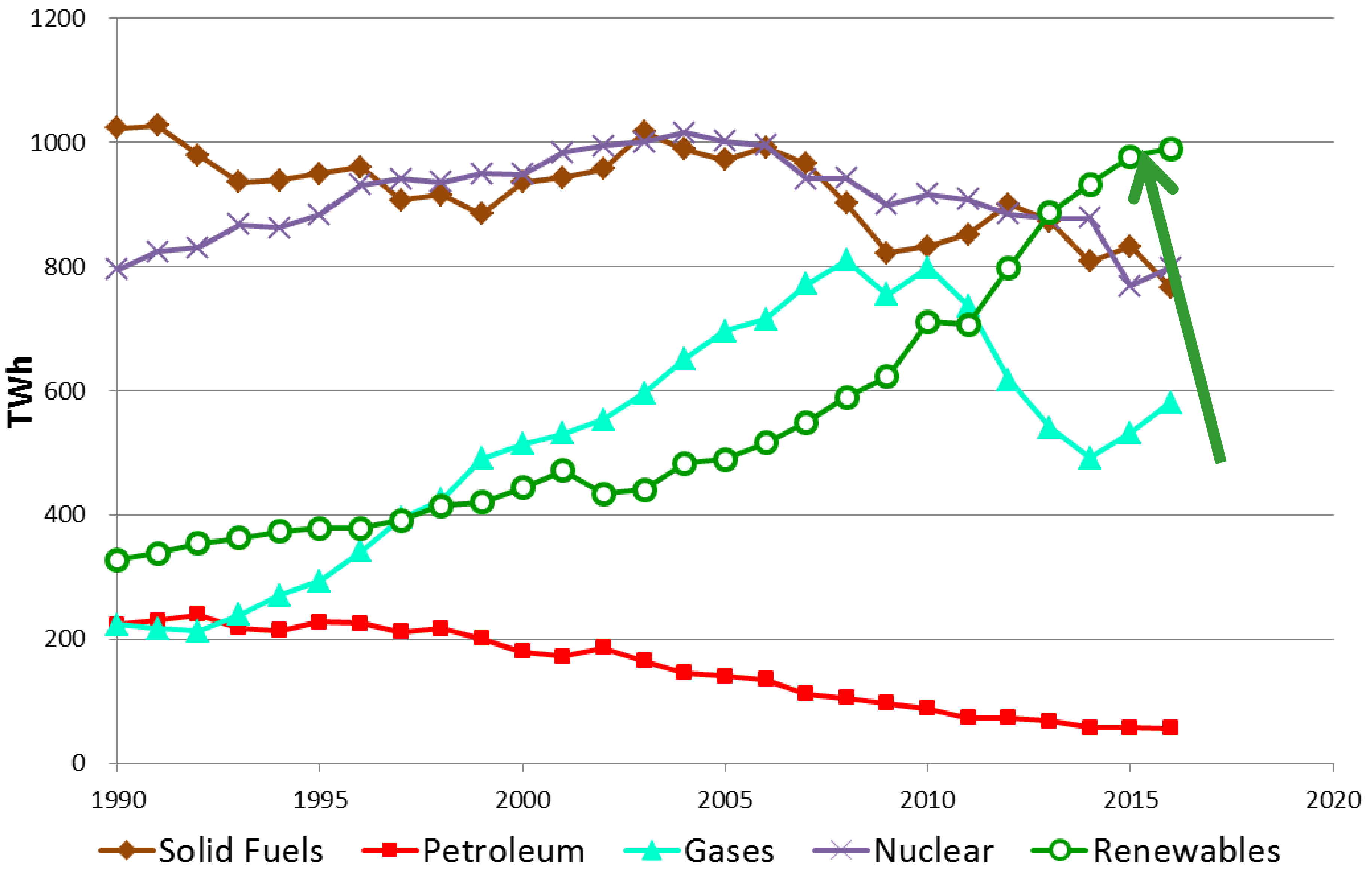
CONTENT:

1. INTRODUCTION

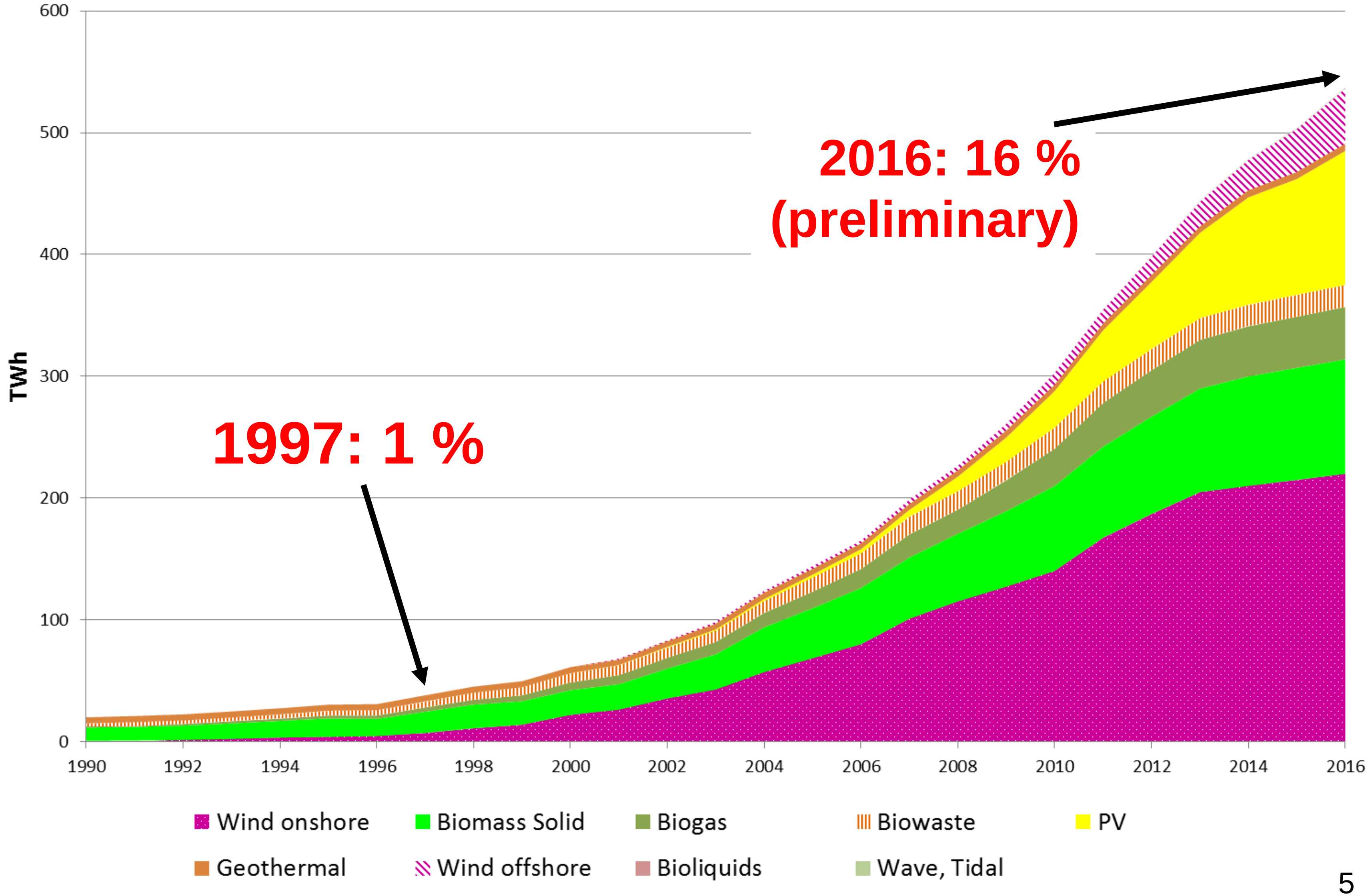
Motivation:

* 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 central planning approaches

Introduction: Electricity generation EU-28



EU-28: Electricity generation from „new“ RES



Source: EUROSTAT, own estimations

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

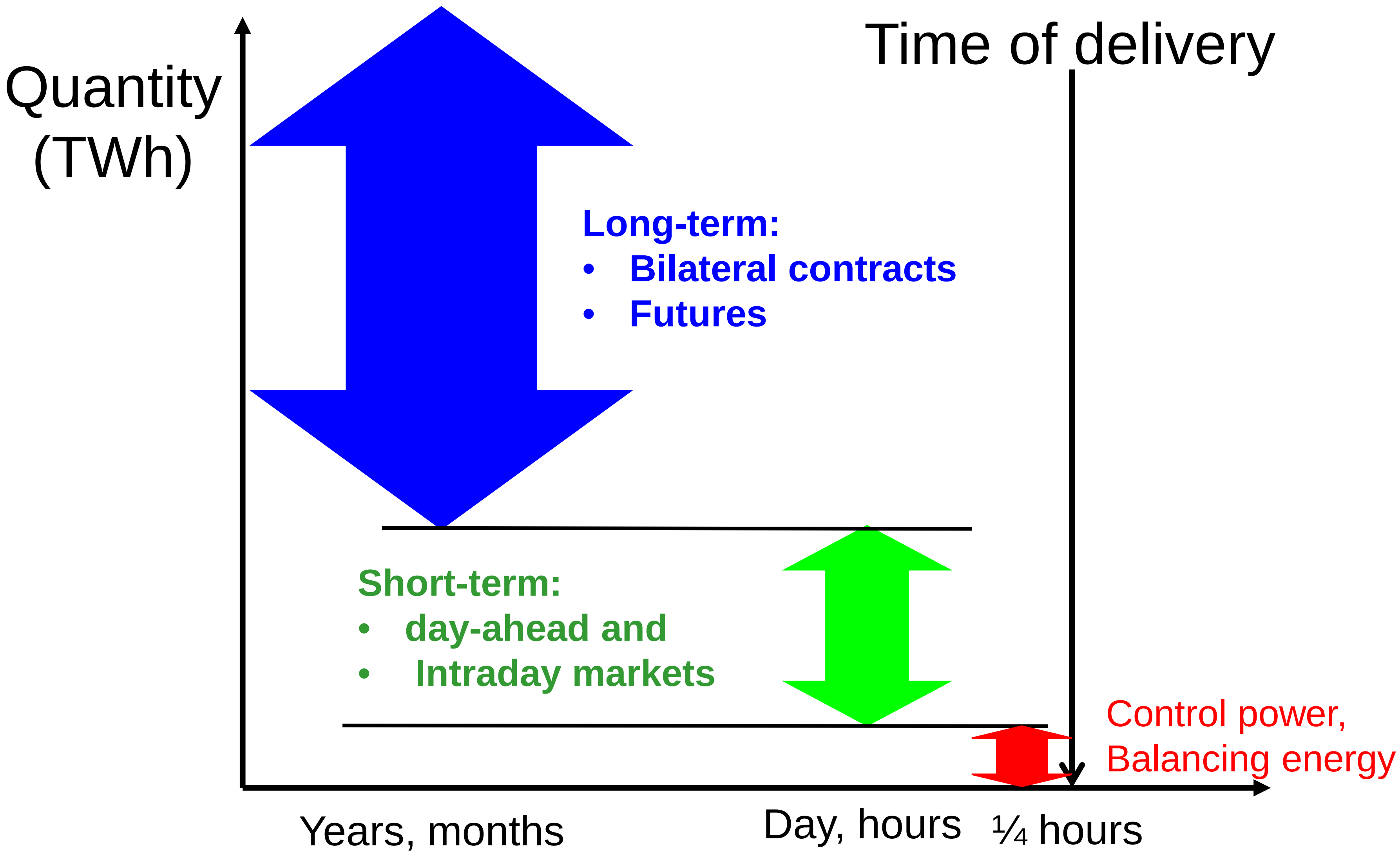
2. METHOD OF APPROACH

- 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;

Elements of electricity markets



Day-ahead electricity markets

Expectation of

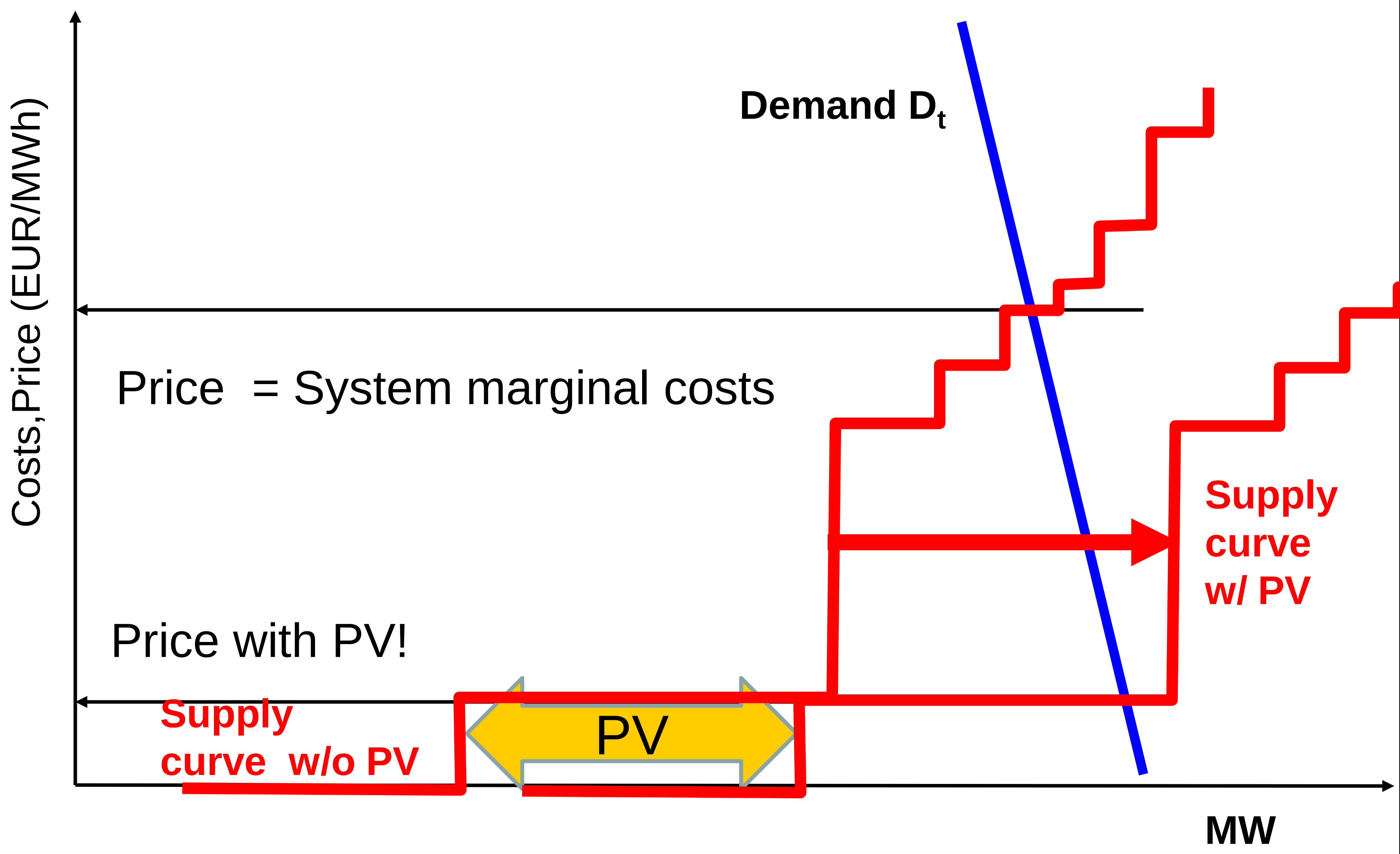
prices = <u>Short</u>-term marginal costs

(Short-term marginal costs = fuel costs)

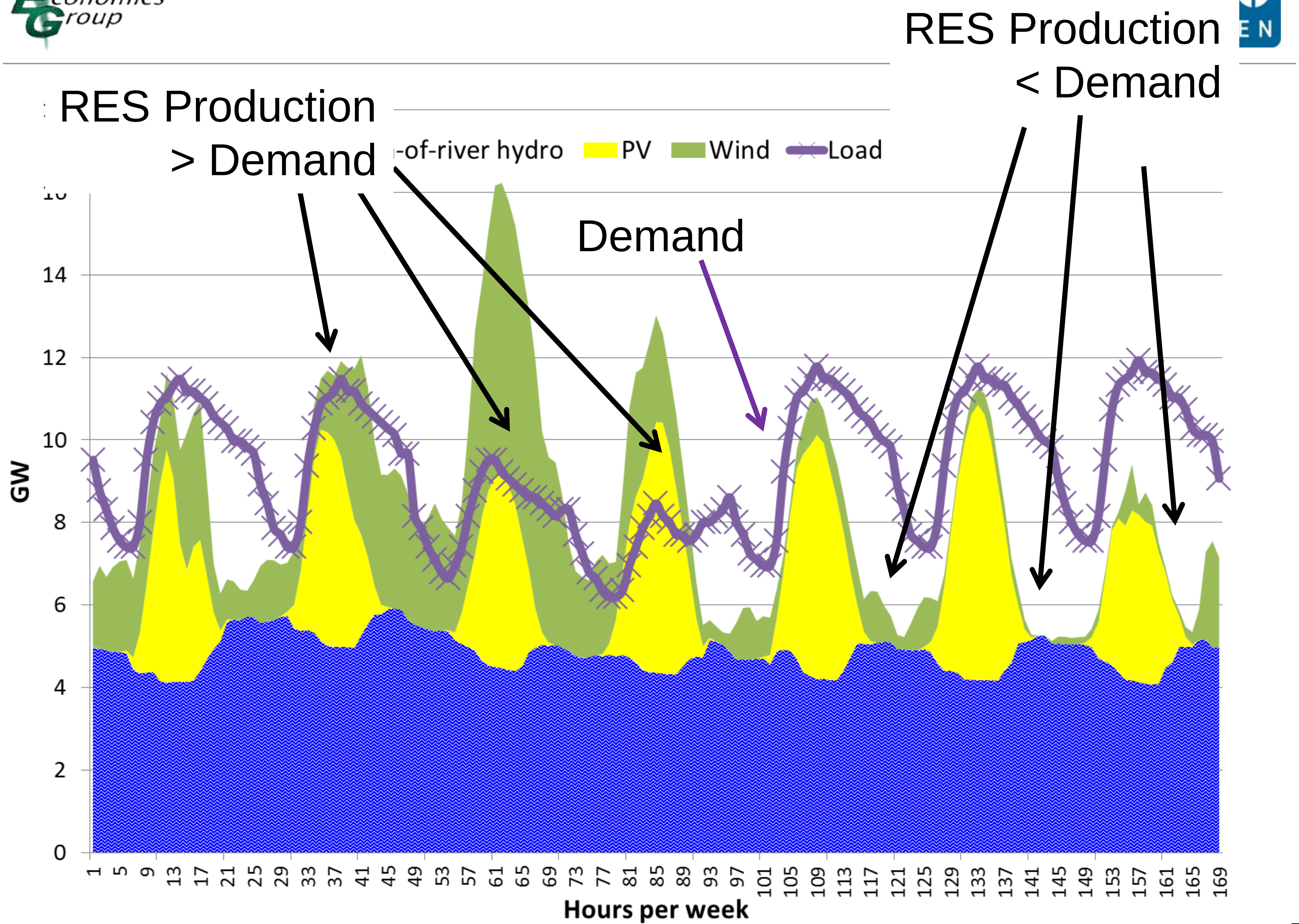
due to huge depreciated excess capacities at the beginning of liberalisation!

3 HOW VARIABLE RENEWABLES IMPACT PRICES IN ELECTRICITY MARKETS

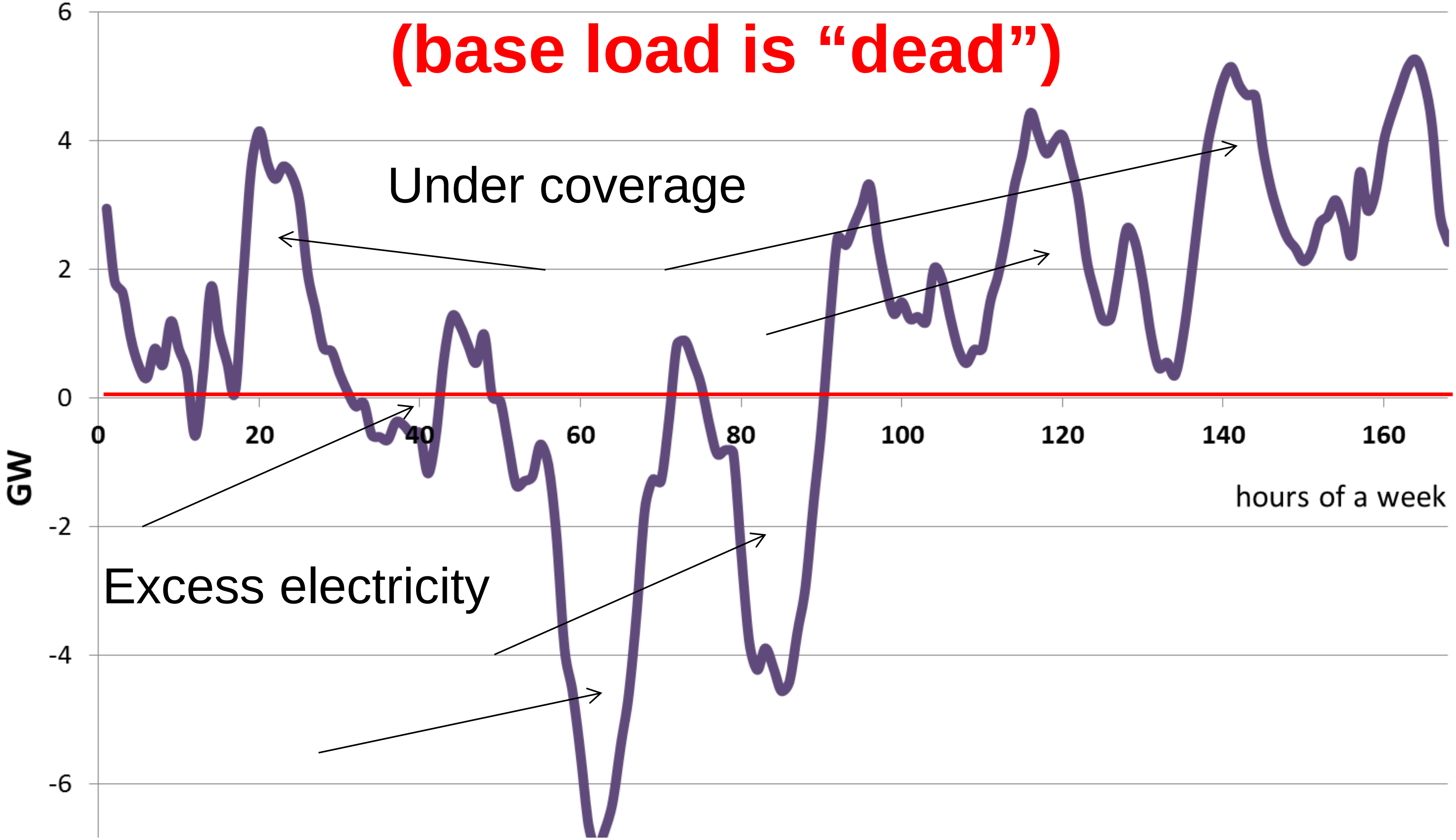
Example: prices without and with PV



Supply and Demand

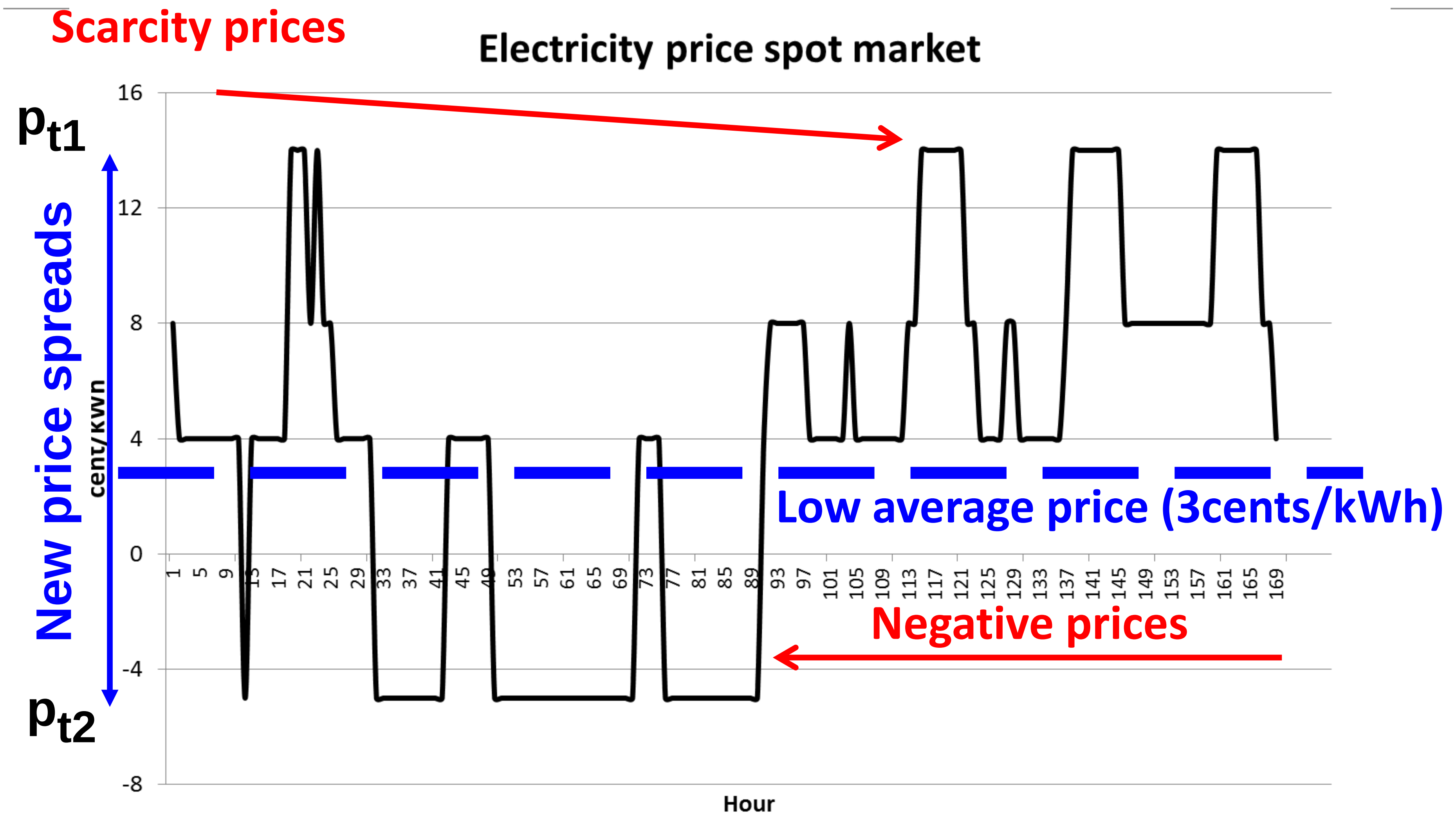


Key term of the future: Residual load (base load is “dead”)



Residual load = Load – non-flexible generation

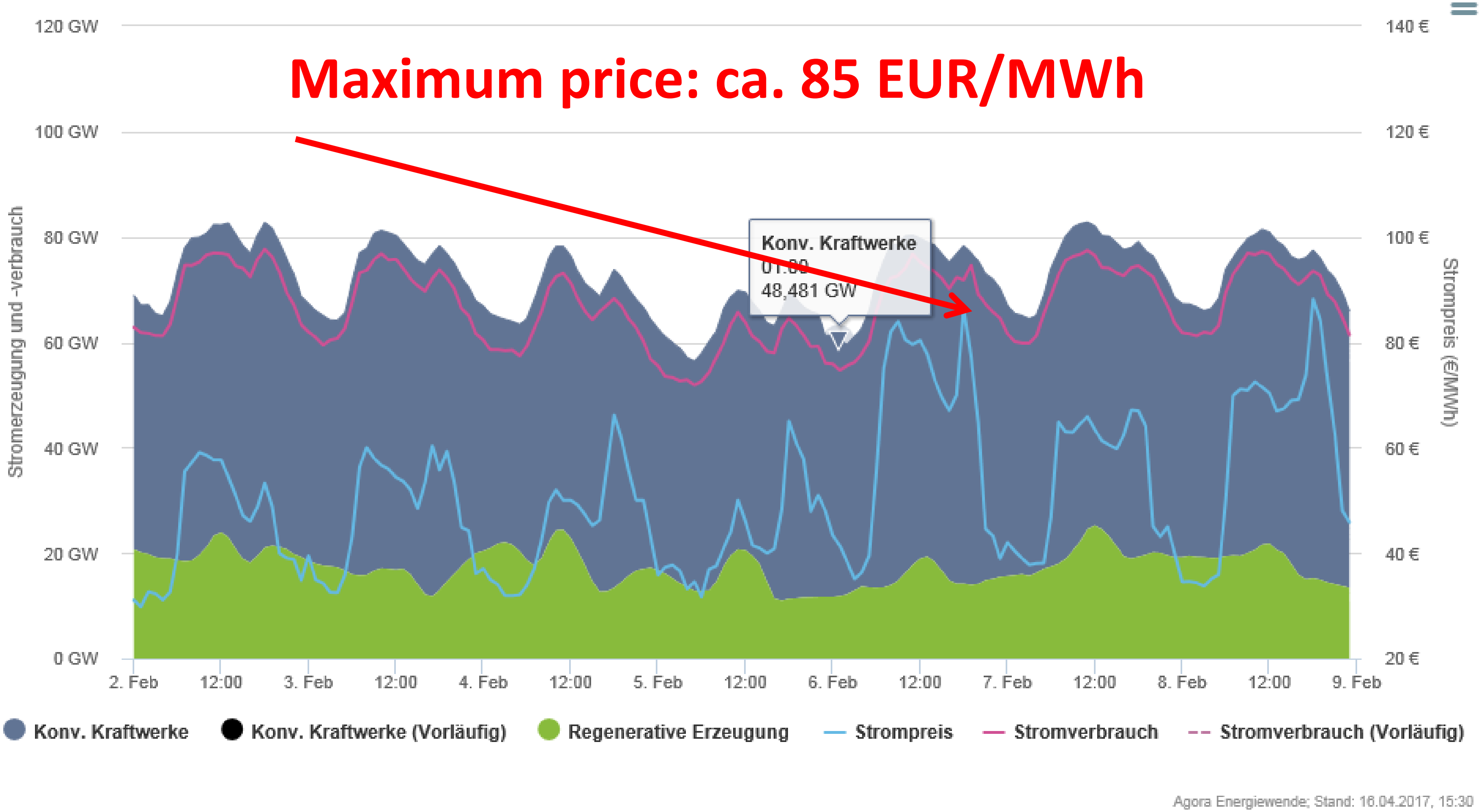
Deviation from STMC-pricing in spot markets



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

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

Maximum price: ca. 85 EUR/MWh

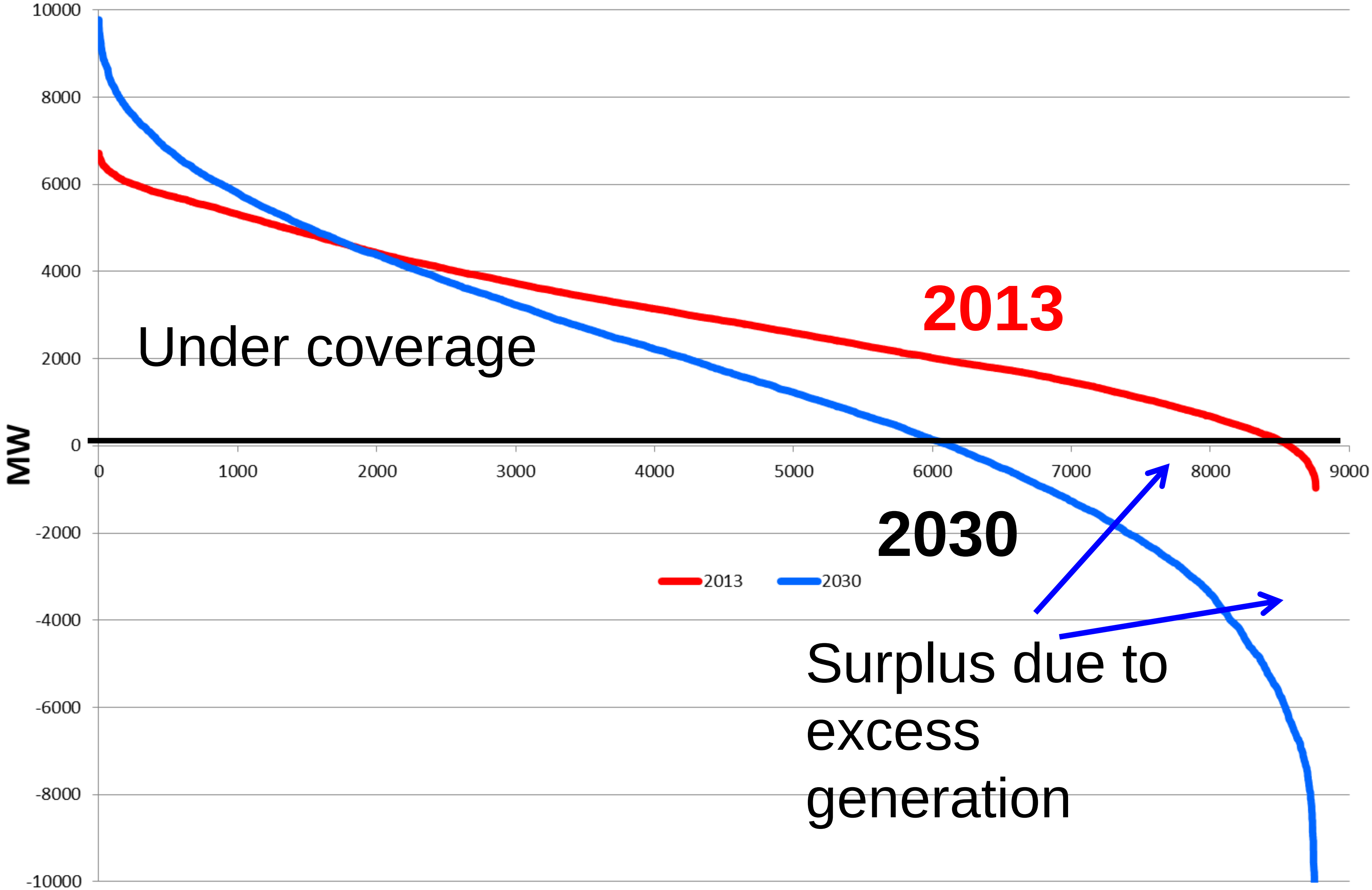


Given a price pattern, showing excess and scarcity prices it would be attractive for a sufficient number of flexible power plant operators to stay in the market!

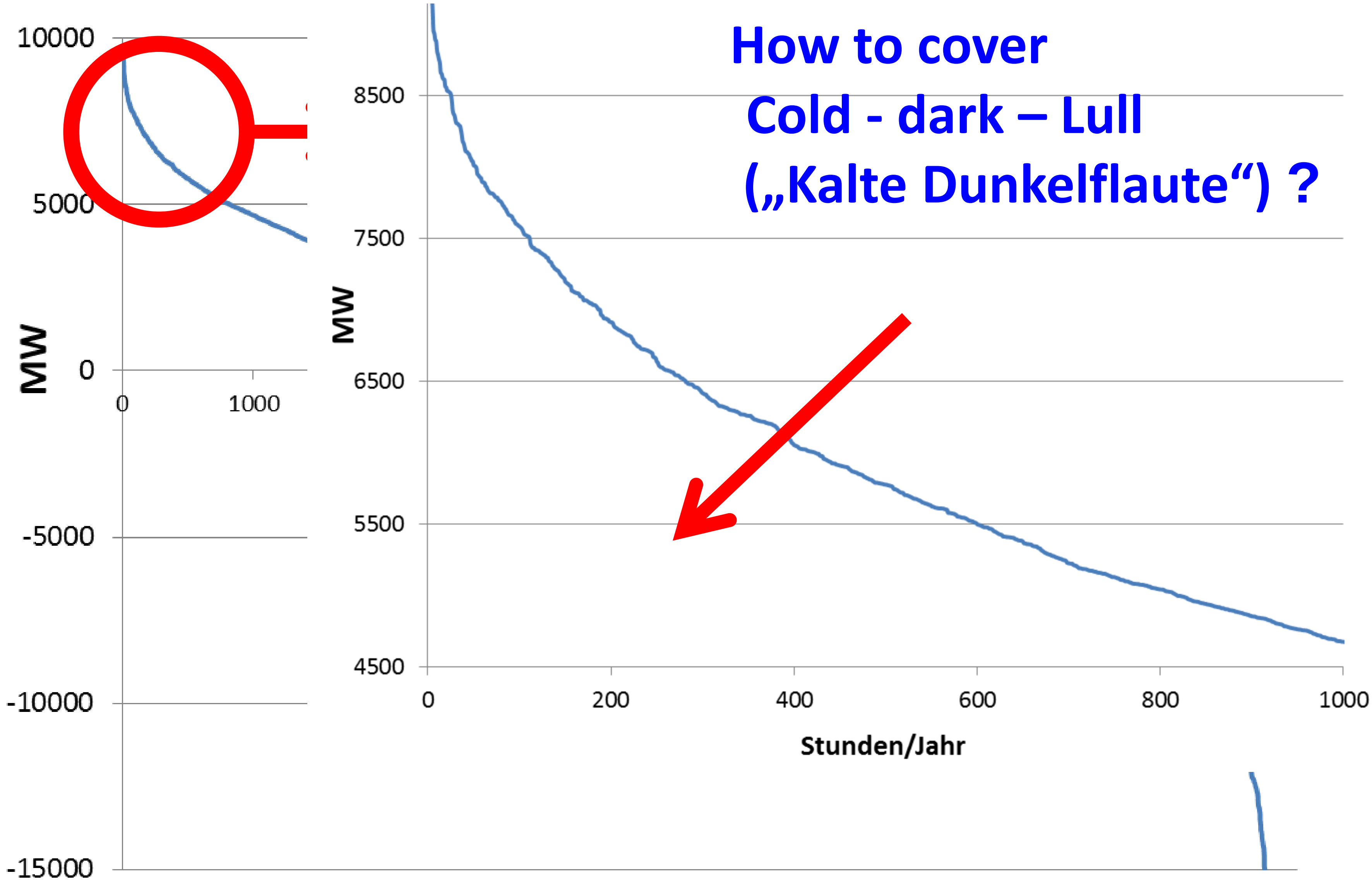
→

REVISED ENERGY-ONLY MARKET

Classified residual load



Classified residual load



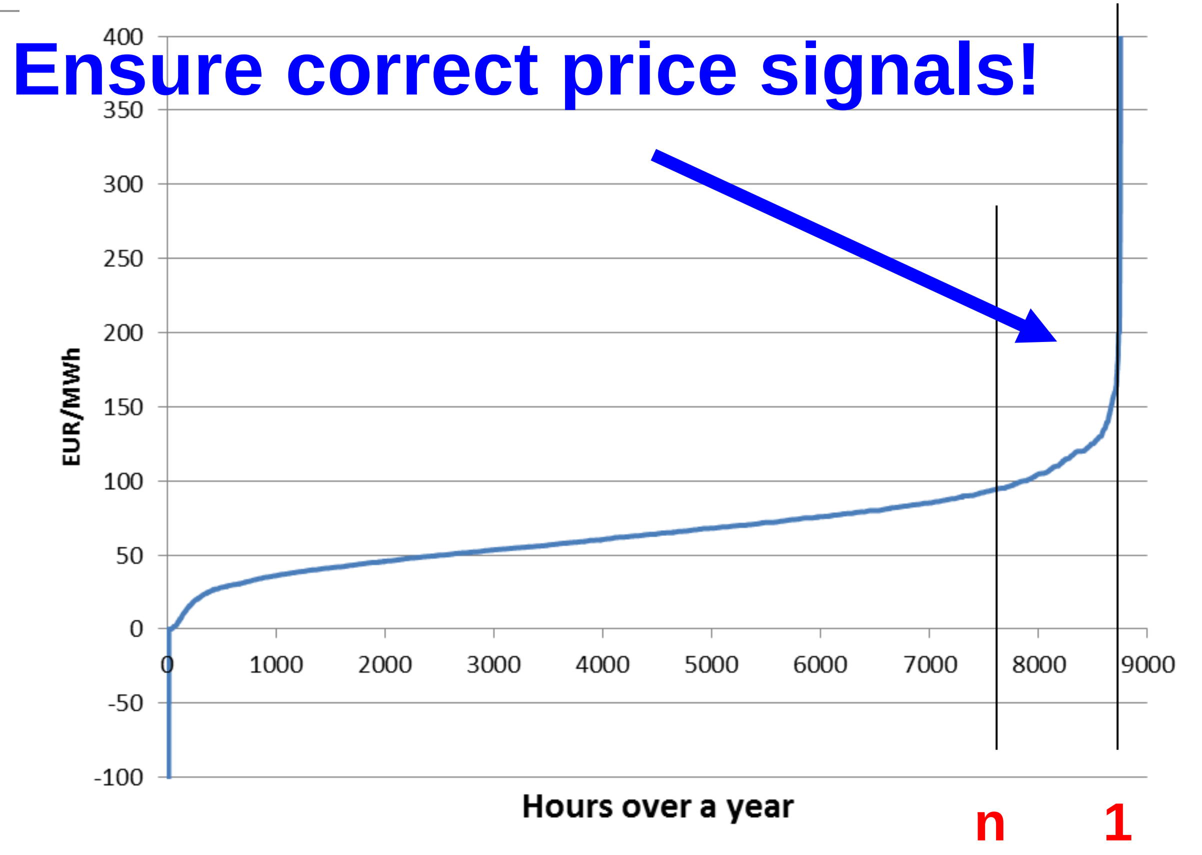
There are two extreme positions:

By Planning including a regulated capacity „market“ with STMC pricing?

or

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

Cost duration curve



Generators stay in the market if:

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

4 CORE PROBLEMS OF CAPACITY PAYMENTS

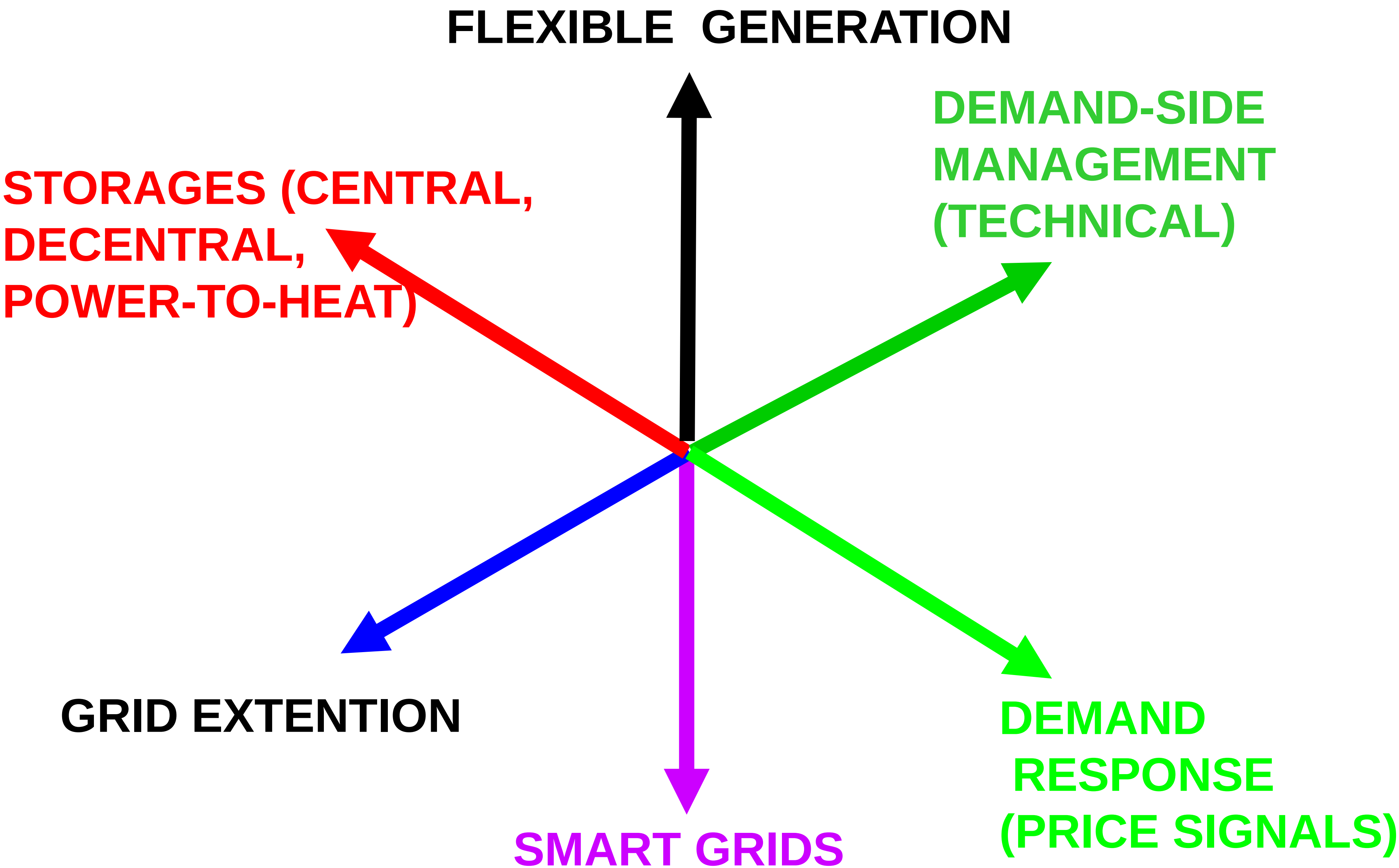
All regulatory capacity payments for power plants destort the EOM and lead to wrong price signals for all other options

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

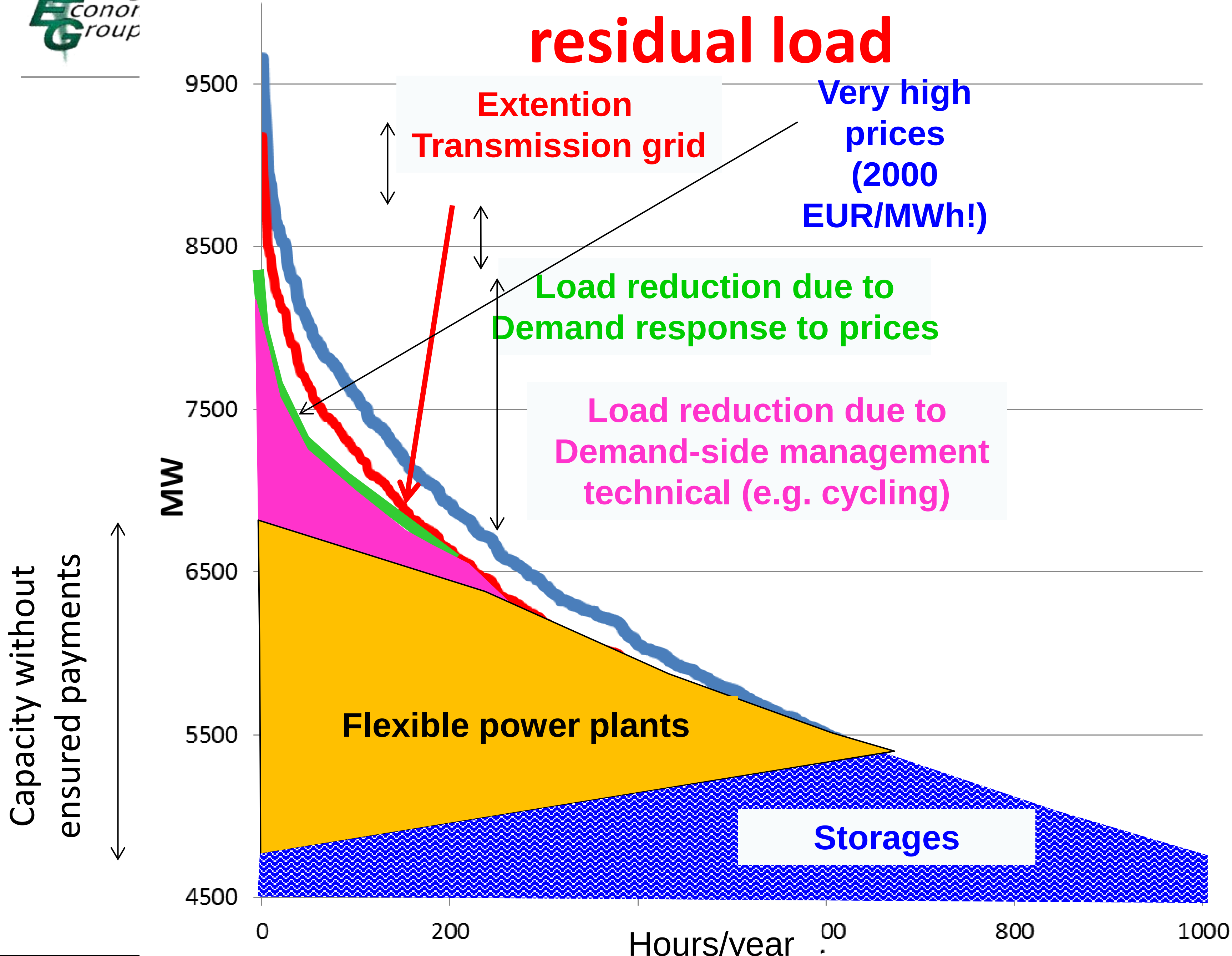
Capacity payments lead to a rebound: Due to these lower price signals → higher capacity demanded than needed under correct price signals!

Capacity payments → lower quantity of flexibility → lower share of variable RES

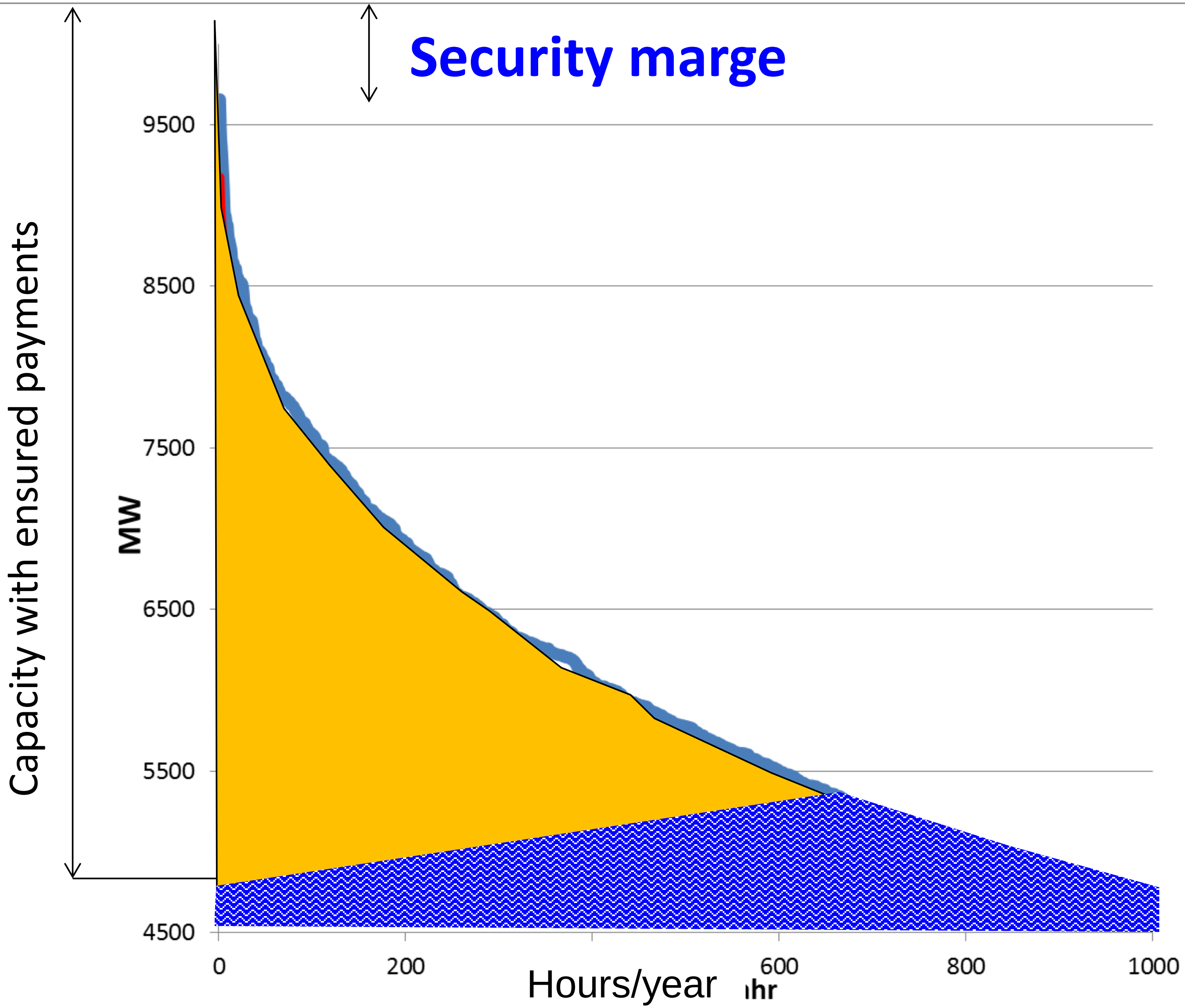
5 THE ROLE OF FLEXIBILITY AND SECTOR COUPLING



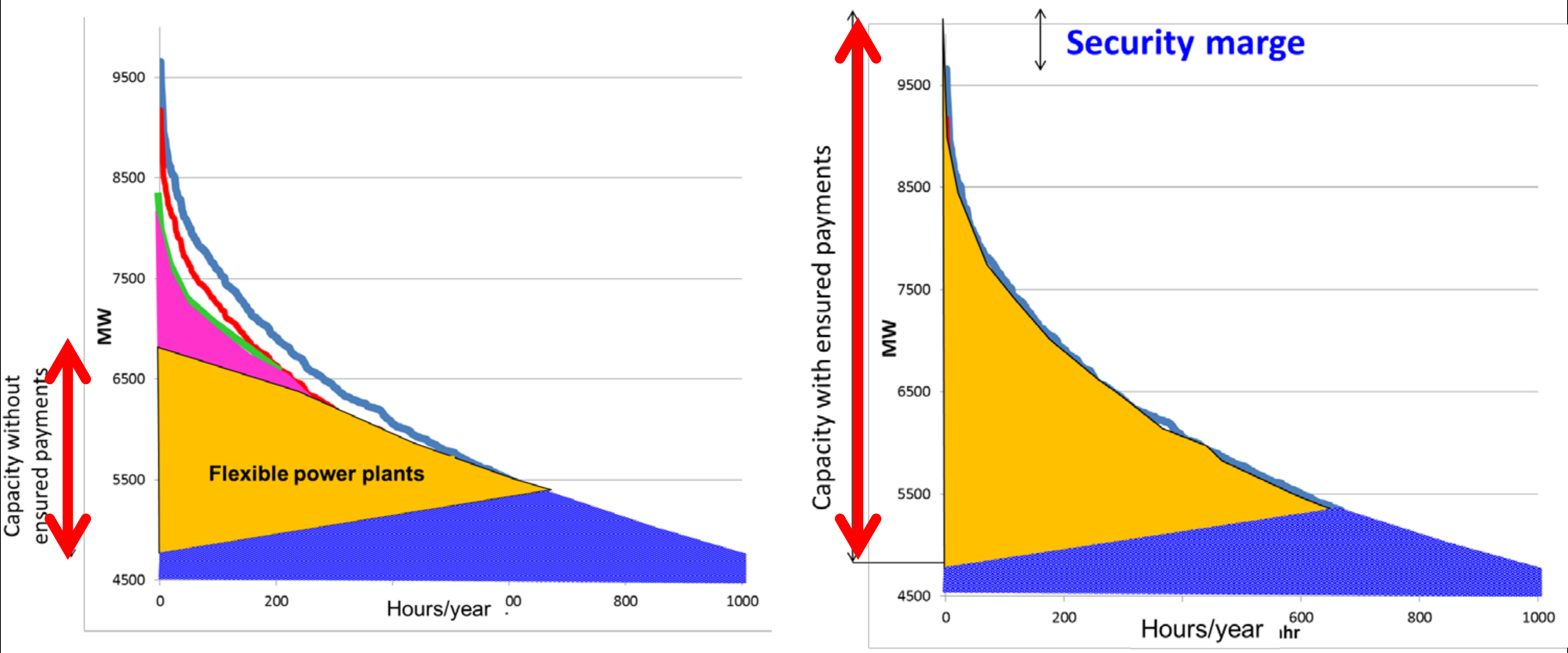
Market-based coverage of residual load



Capacity payments for residual load

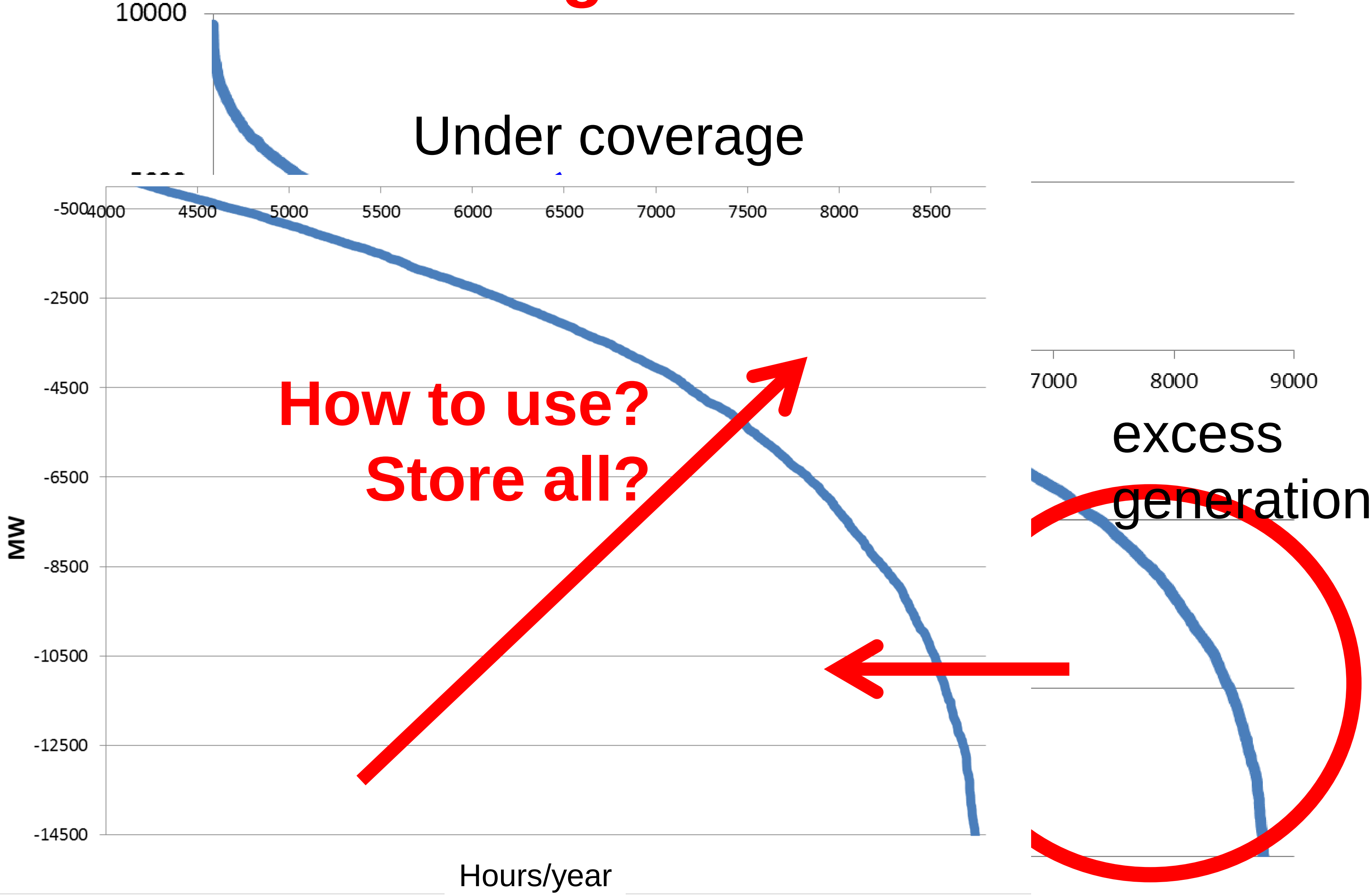


Comparison

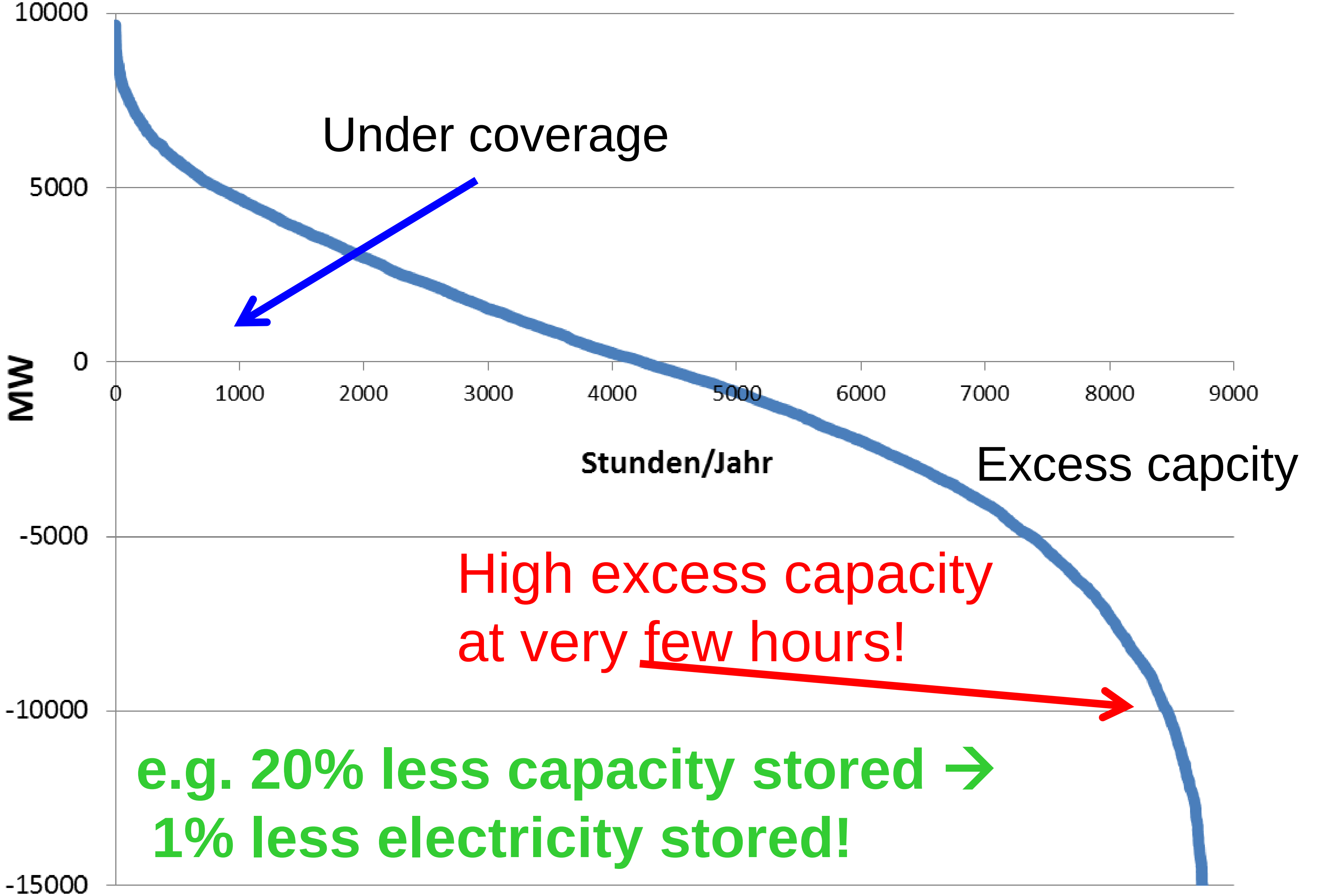


Security marge
9500
8500
7500
6500
5500
4500
MW
Flexible power plants
Capacity without ensured payments
Capacity with ensured payments
0
200
800
1000
600
Hours/year

Specific question: How much storage do we need?

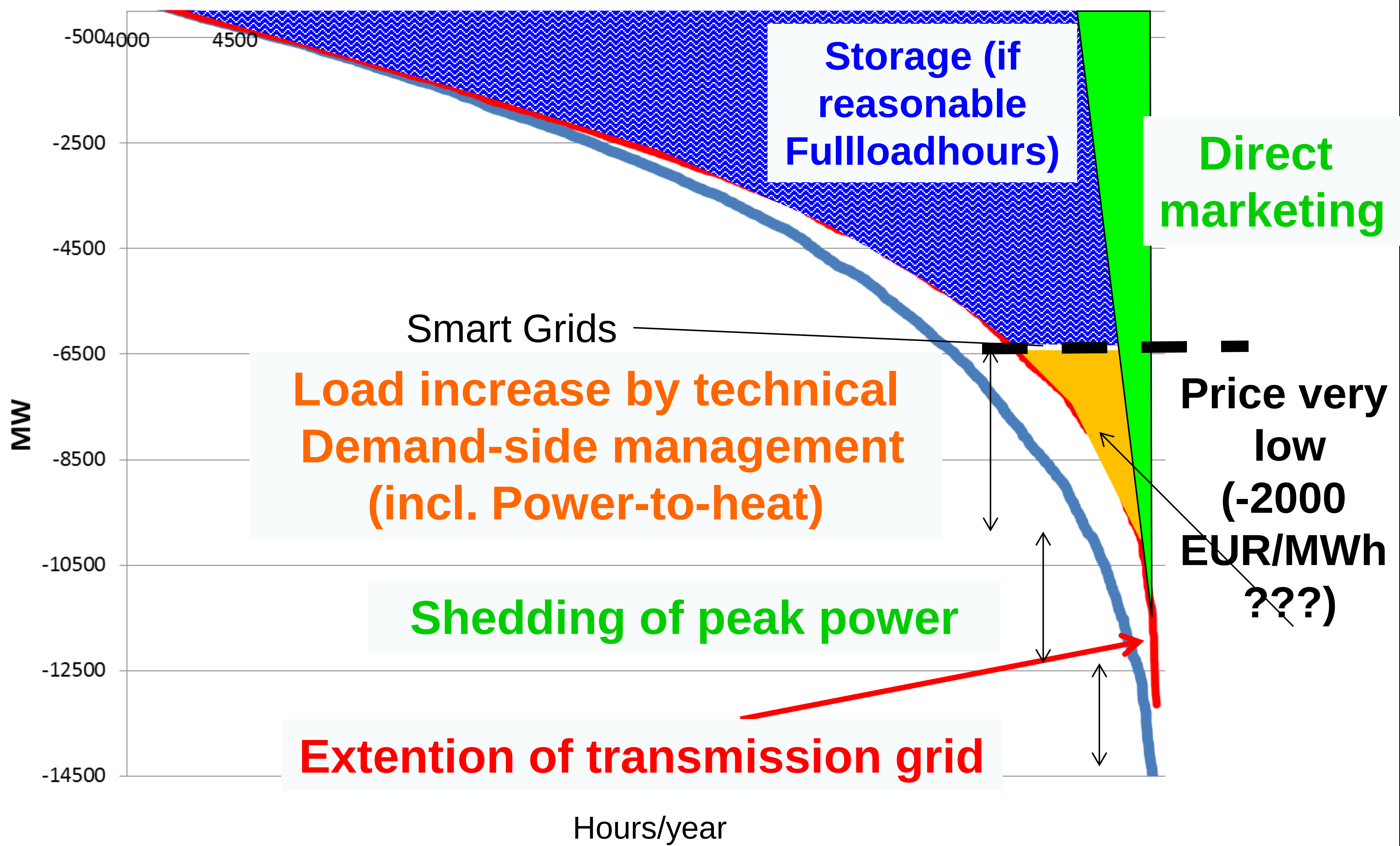


Storing every peak?

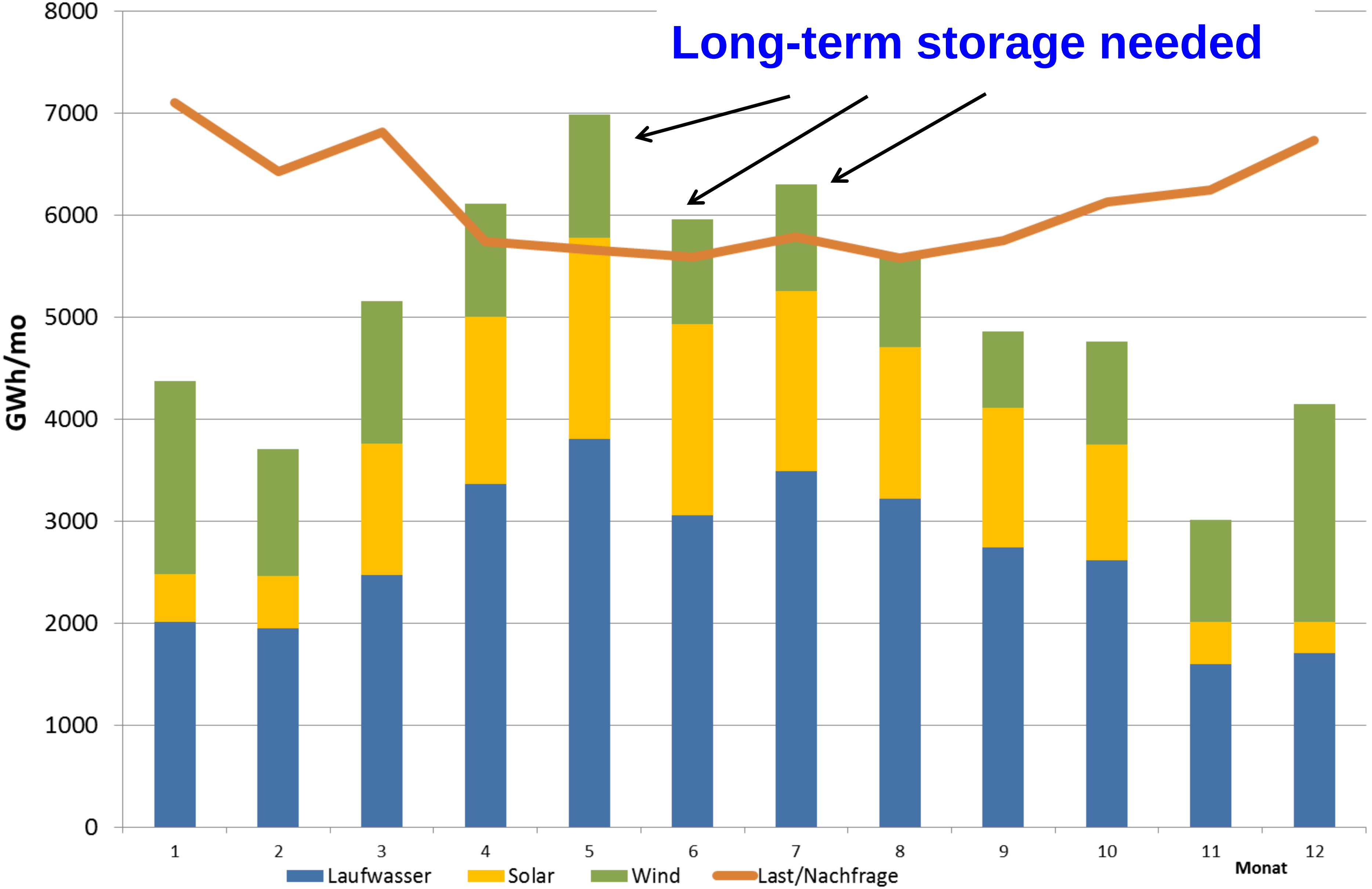


e.g. 20% less capacity stored → 1% less electricity stored!

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

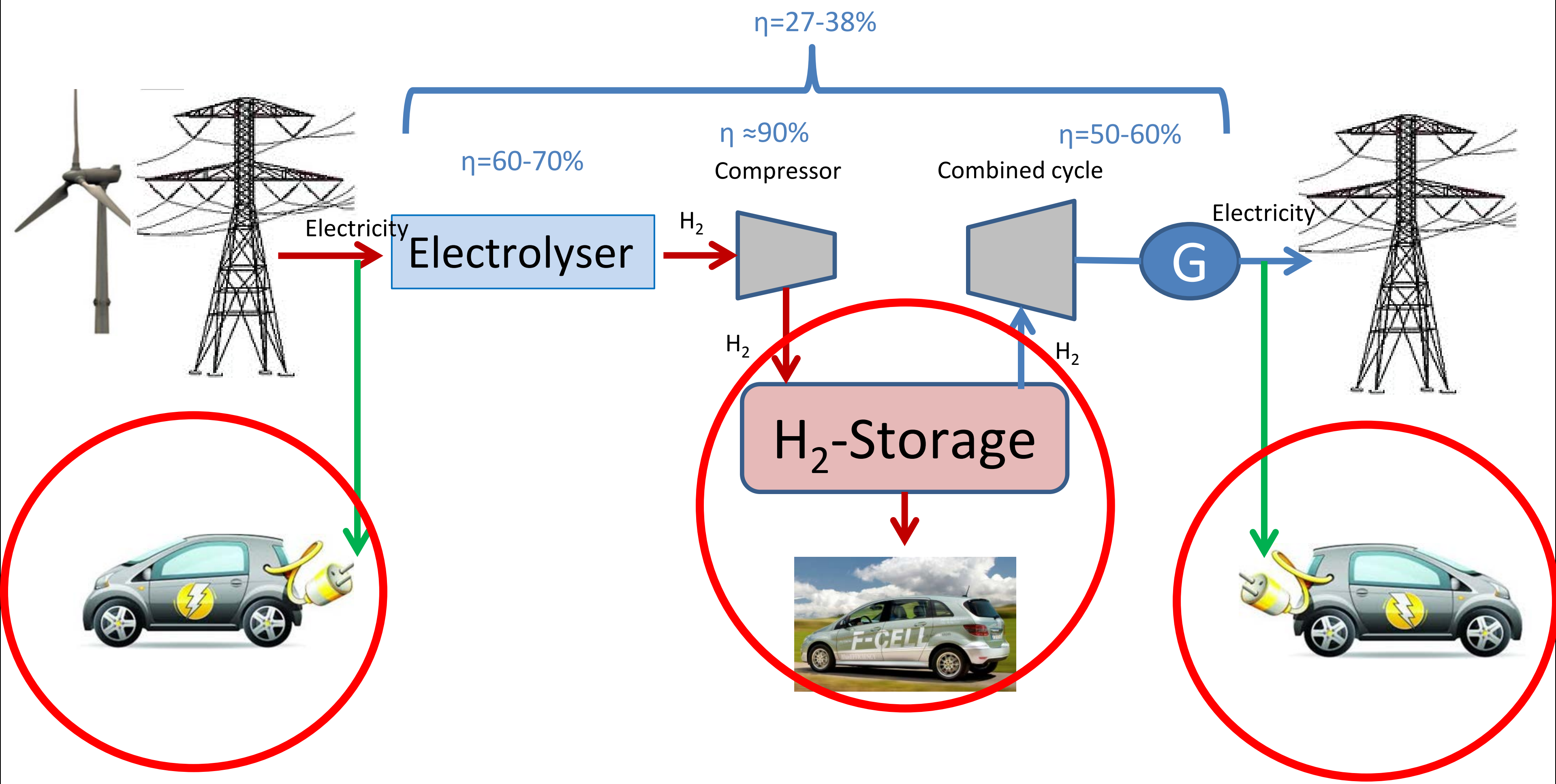
Transport

* Vague simplified suggestions, no convincing long-term solutions

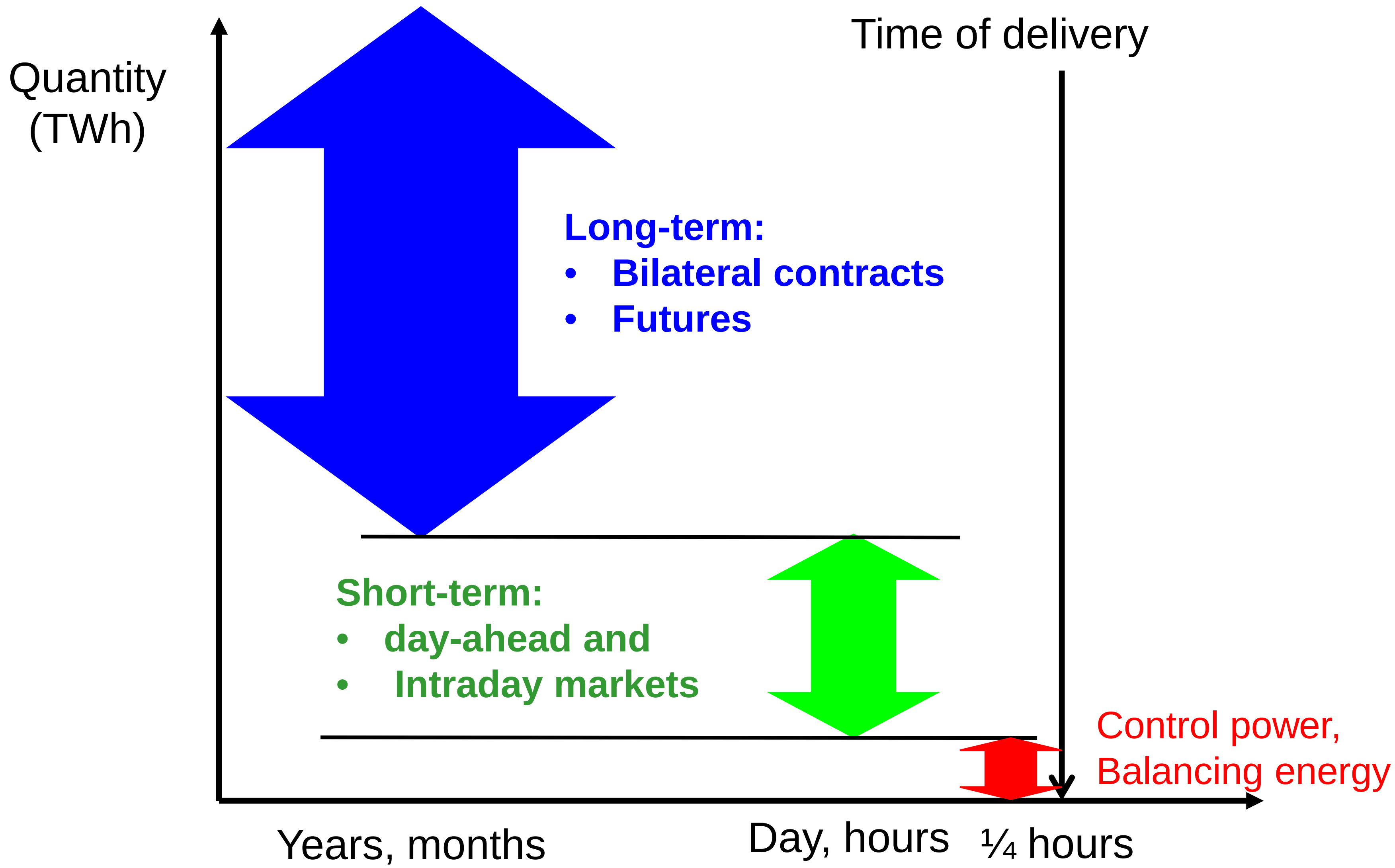
* Central (Ptx approaches, e.g. H2) vs decentral (end user level, E.g. Evs, heat pumps for heating) applications

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

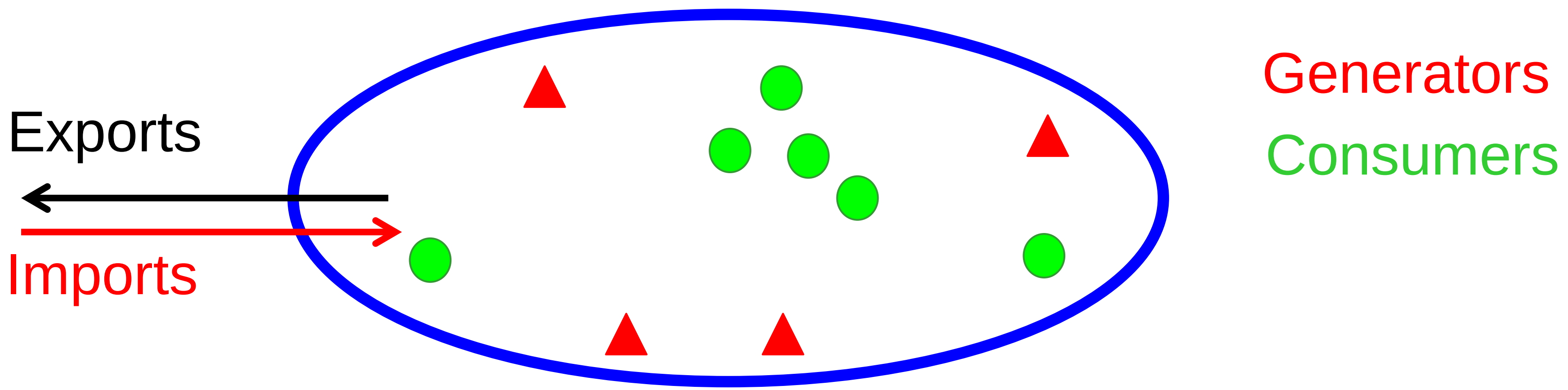
Sector coupling hydrogen: Storage and fuel in transport?



Elements of electricity markets



6. THE CORE ROLE AND RESPONSIBILITY OF BALANCING GROUPS



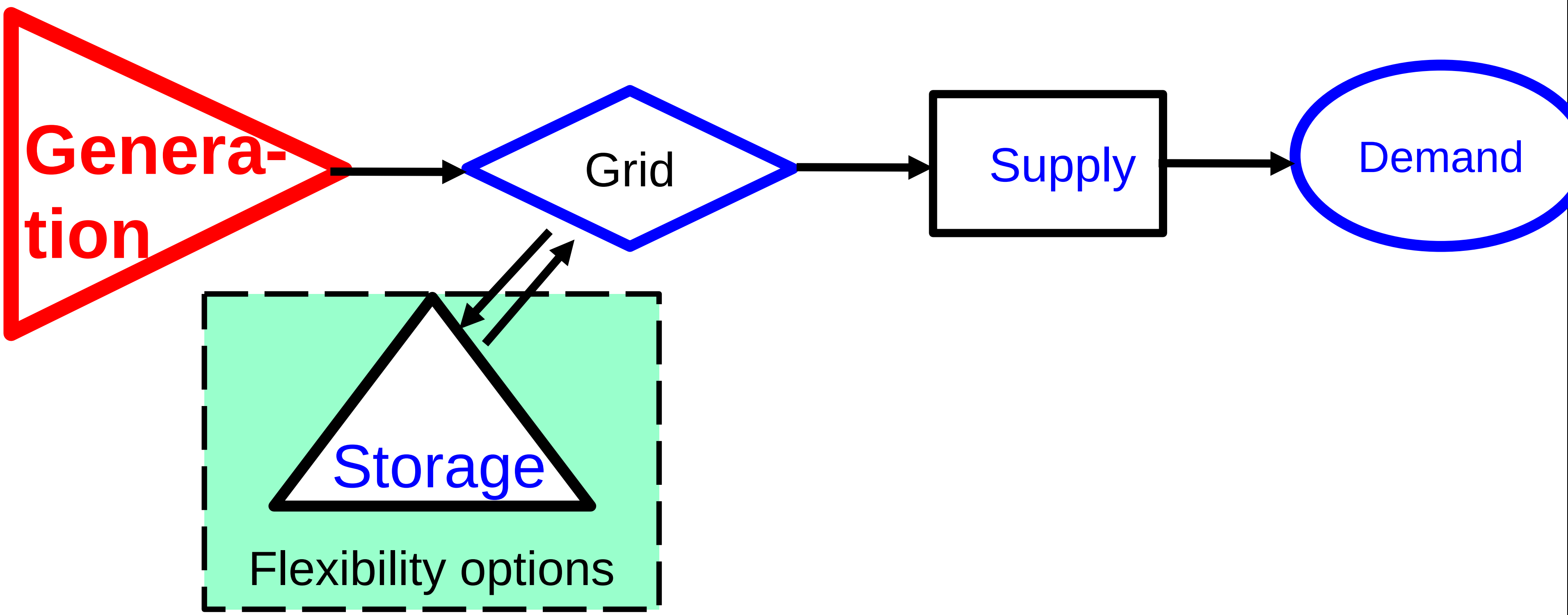
Balancing group: entity in a control area of an electricity system; it has to ensure that at every moment demand and supply is balanced

E.g. municipal utility of Porto, Vienna, Copenhagen

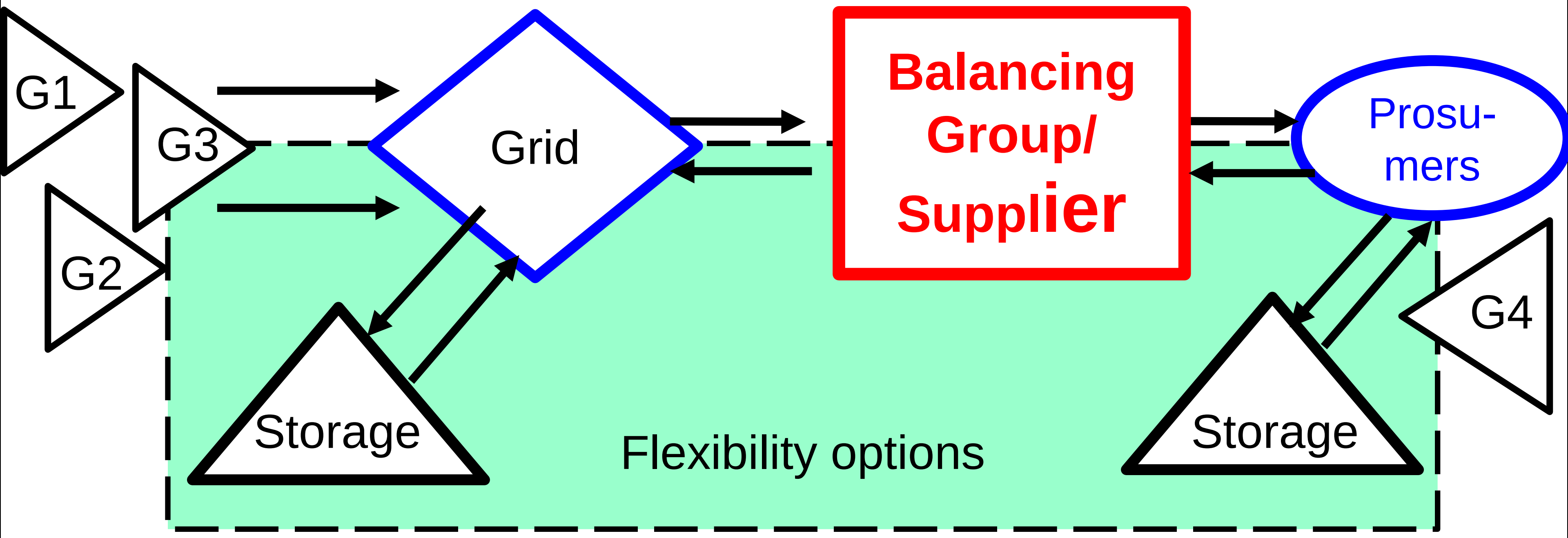
To meet this target: own generation , storage, flexibility, Trading in long-term, day-ahead and intraday market

Every difference → high costs!

Old thinking

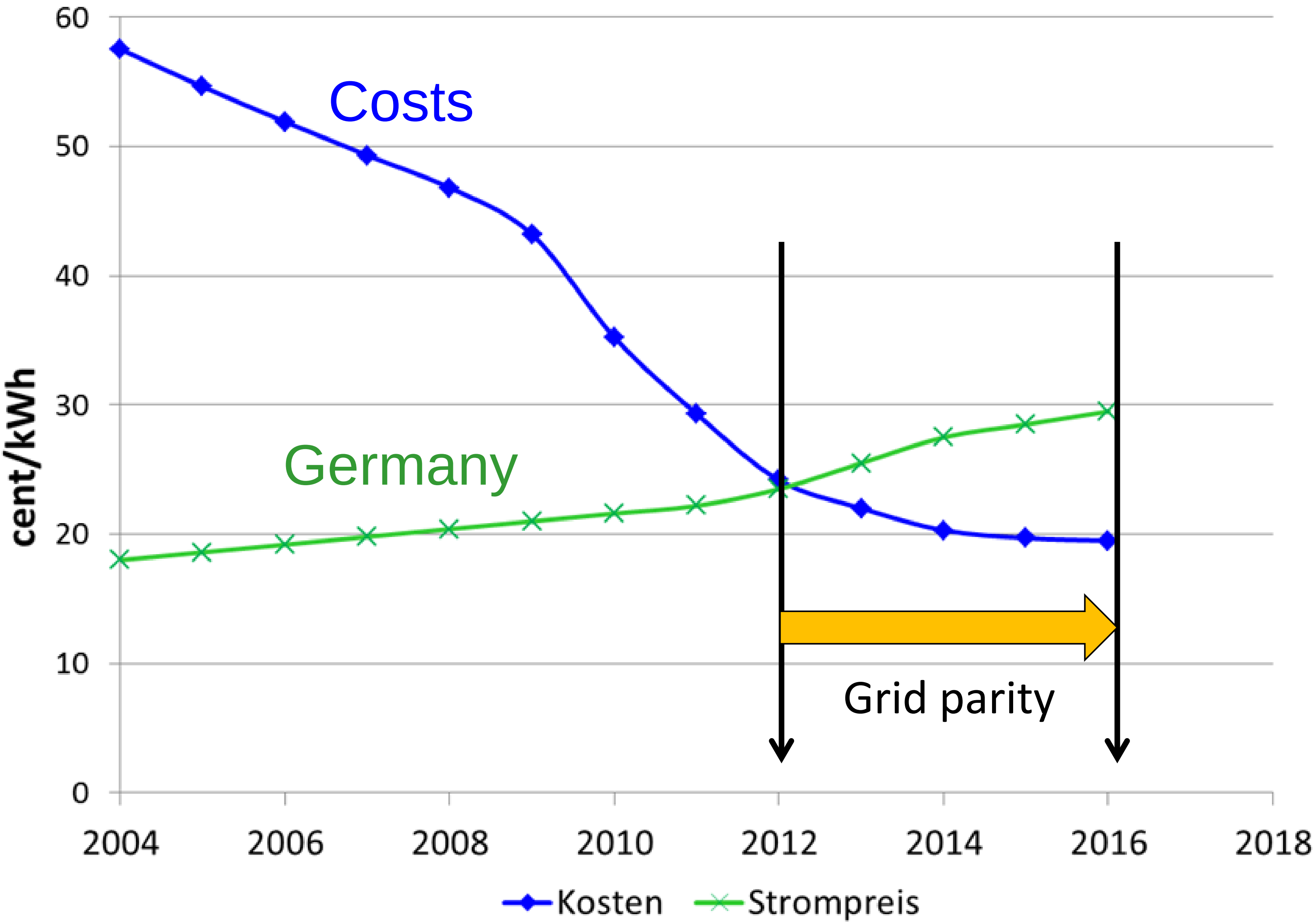


New Thinking: Making the electricity system more democratic



7. IS THE TIME FOR SUBSIDIZING RENEWABLES OVER ?

Grid parity: PV-costs and household electricity prices



Assessment of Grid Parity

Savings/revenues

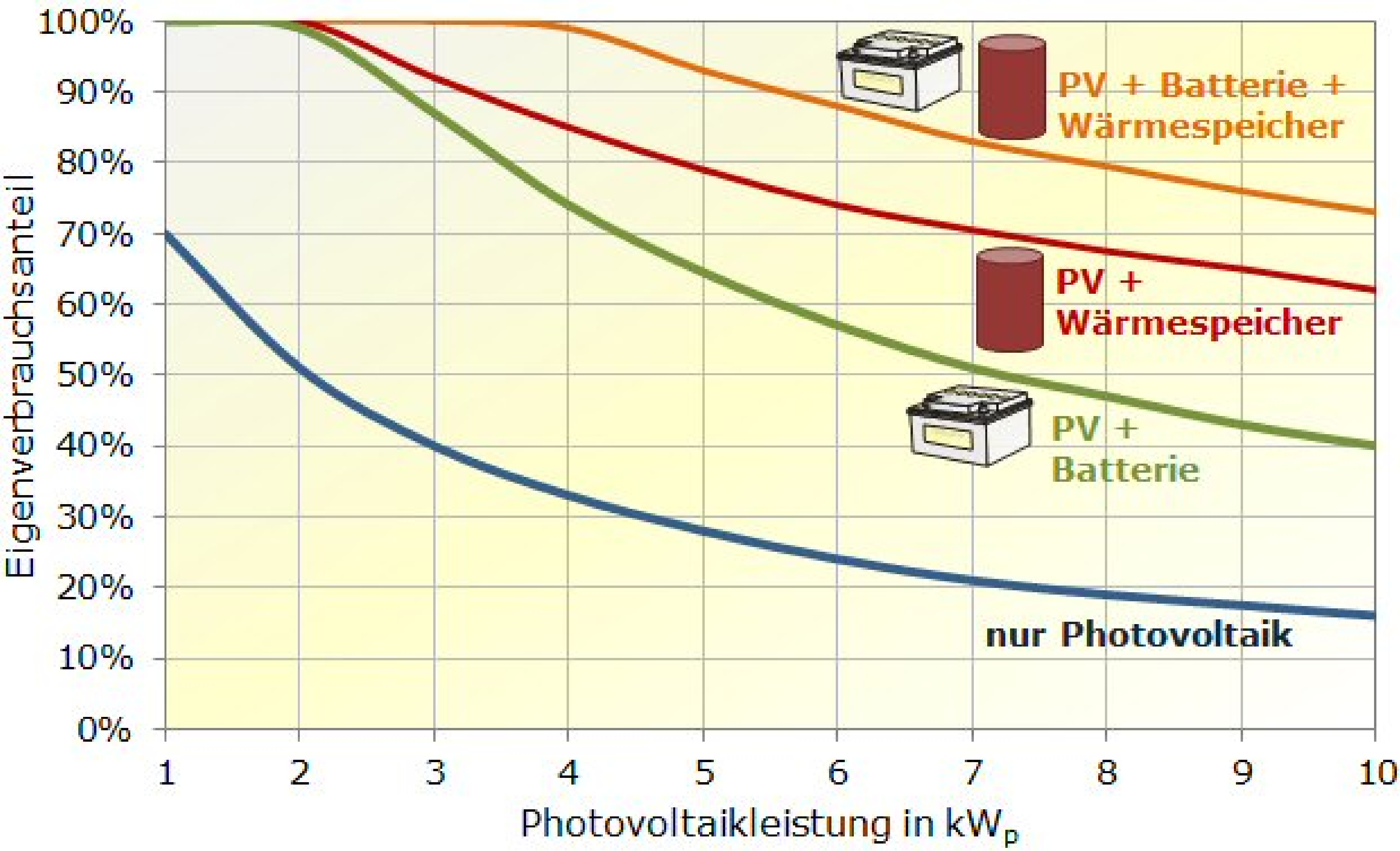
Costs

$$E_{Own} * P_{HH} + E_{Feed\text{-}in} * P_{feed\text{-}in} > \text{Annuity}$$

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!
- New key player: Balancing group (Supplier), no more the generator

8. CONCLUSIONS

- **Capacity payments: Any CP will distort the system towards more conv. and less RES capacity**
- **calls for capacity markets: a last try of the old generation-focused system to survive**
- **a pragmatic solution: Strategic reserves which go along with very high penalties (higher than maximum price would be in the EOM) for those suppliers (balancing groups) who make use of them (or to be seen as insurance suppliers can pay)**