Markets for New Energy Storage Technologies

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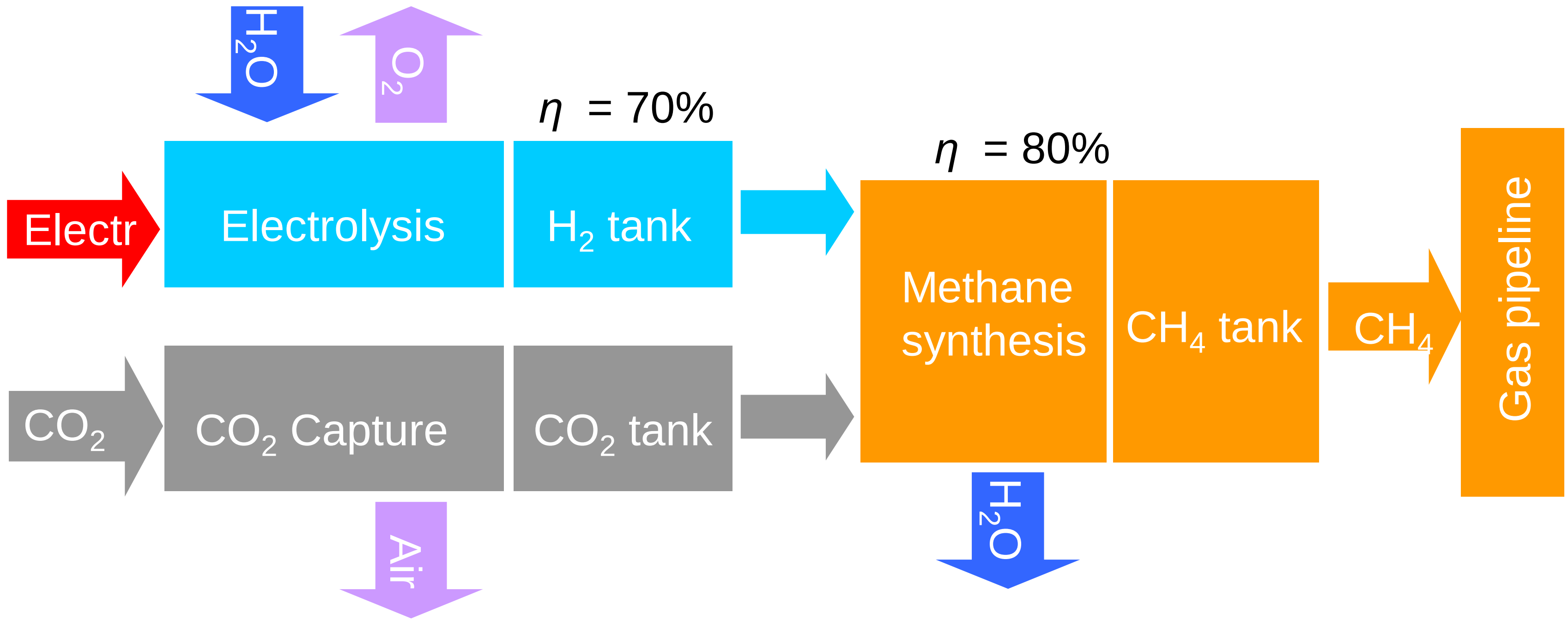
Energy Storage Systems in the Narrow Sense

[Source: FVEE 2018, p. 25]

Storage technology	Capacity [kWh/t]	Load [MW]	Efficiency	Range
Pumped Hydropower		1 - 500	80%	day - month
Air pressure	2 kWh/m³	10 - 300	40% - 70%	hour - ½ day
Lead acid	40		85%	day - month
Li-Ion	**~160**	**0.002 - 20**	**>95%**	**¼ hour - days**
Na-Ion	20 - 30	0.002 - 200	80% - 90%	¼ hour - days
NaS	110	> 0,05	85%	day
Redox-Flow	25	0.01 - 10	75%	day - month
Water	10 - 50	0.001 -10	50% - 90%	day - year
High temperature (liquid salt, …)	50 - 150	5 - 300	>95%	hour - day
Latent heat storage	50 - 75	0.3 - 6	90% - 95%	hour – weeks
Thermochemical	120 - 250	0.01 - 1	100%	hour - months
Hydrogen / methane	**>10'000**	**0.001 - 100**	**25% - 65%**	**day - years**

Power to Gas (Synthetic Gas; Wind Gas)



Chain efficiency electricity to gas < 60 percent

Investments create an economic pressure towards base-load electricity

Levelized Cost of Batteries [Example]

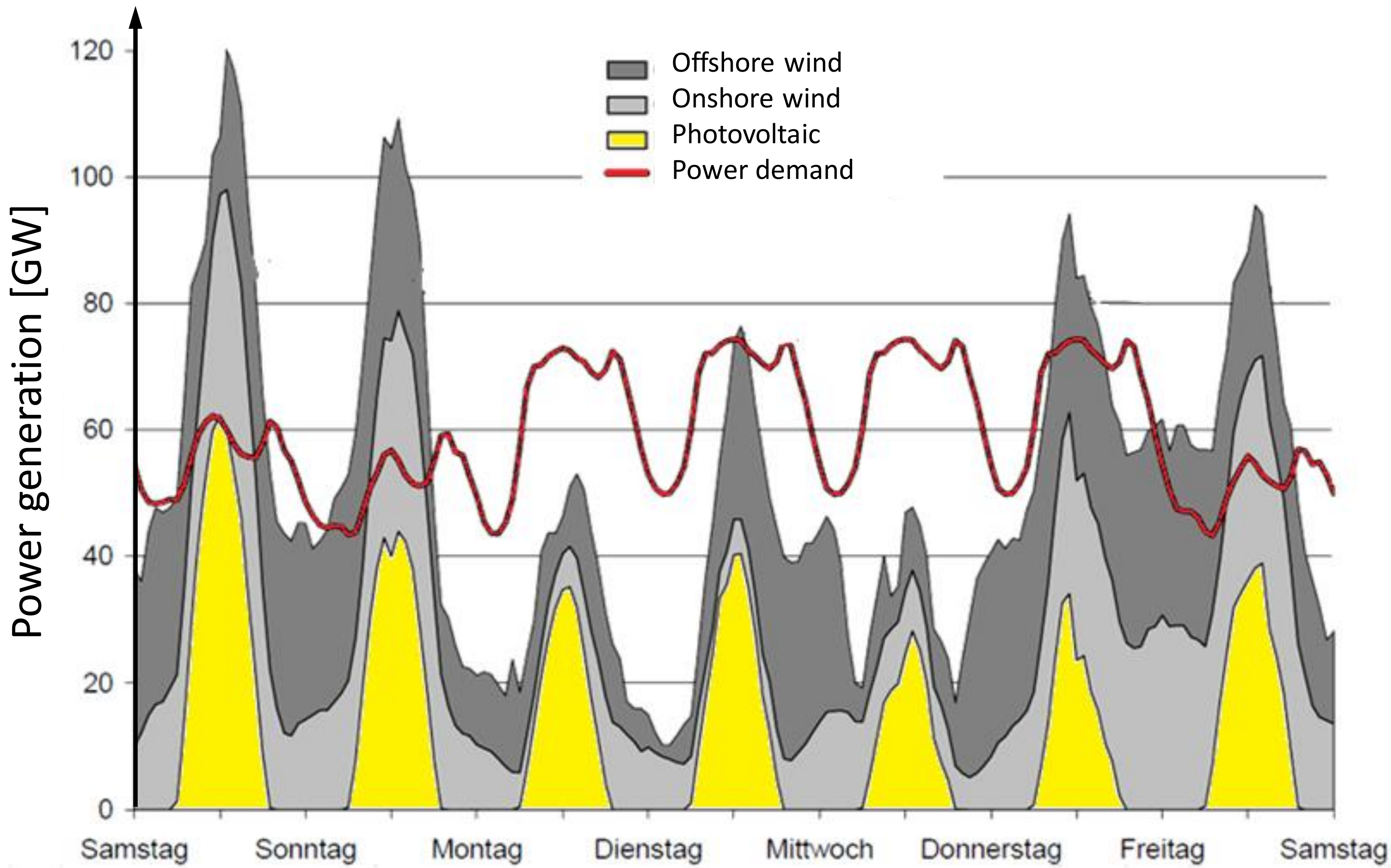
Assumed cost of the storage system	6‘000 €
Rated size of the storage system	10 kWh
Depth of discharge (incl. average degradation over lifetime)	80%
Number of storage cycles over lifetime	7‘000
Energy efficiency of storage system	95%

Levelized Cost Of Storage (LCOS): The case of electric batteries

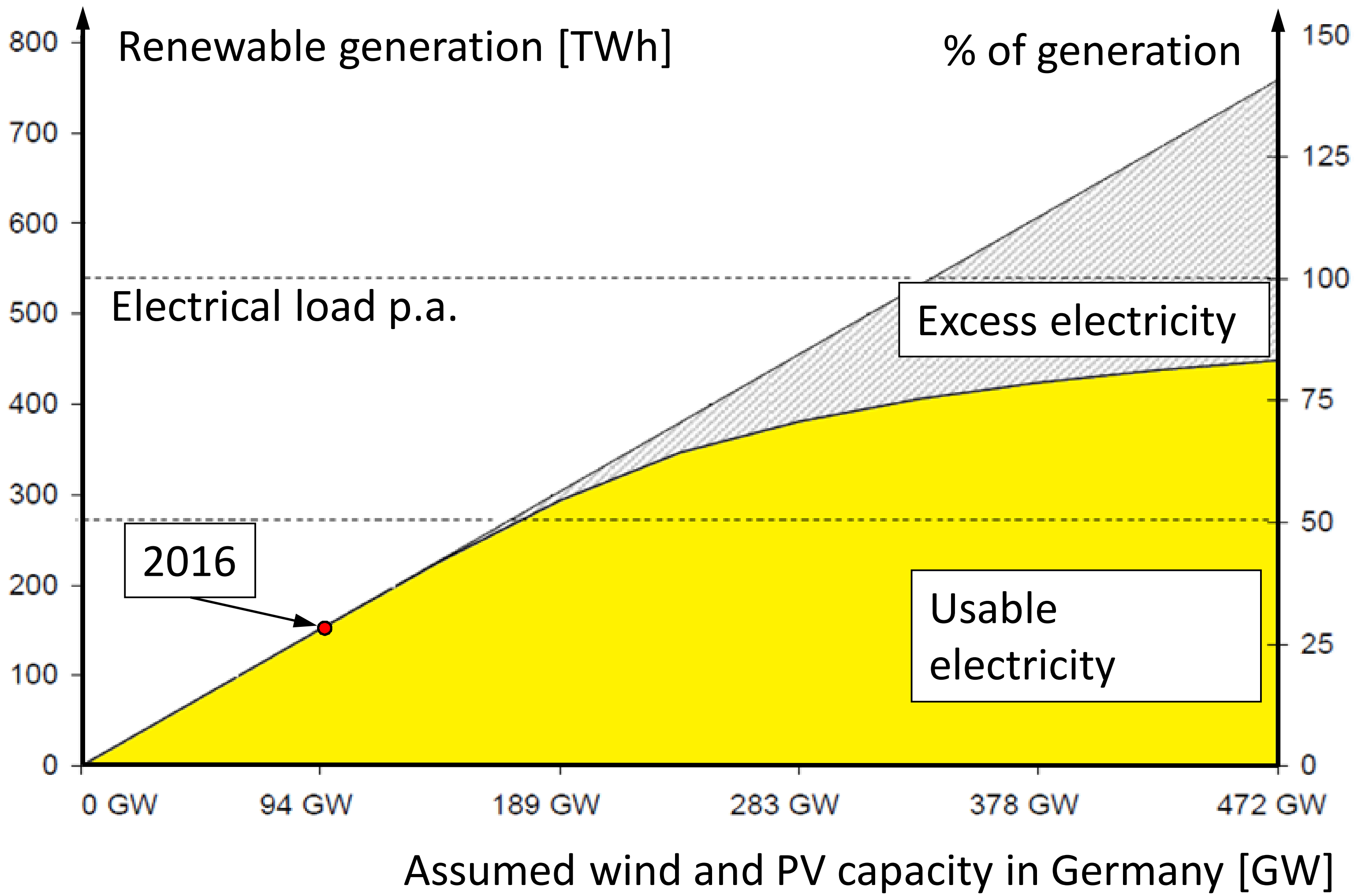
6.000 € / (10 kWh * 0.8 depth * 7’000 cycles * 0.95 efficiency) = 11.28 Ct/kWh or 113 €/MWh

Scenario "High Renewable Electricity"

[Sample week in summer; source: Grosse Böckmann 2010]



Excess Electricity *[Source: from Grosse Böckmann 2010]*



Negative Day-ahead Prices

[Germany; own calculations from EPEX data]

Year	Number of hours with price ≤ 0	Minimal price [Euro/MWh]
2010	12	-20.45
2011	16	-38.82
[illegible]	56	-221.99
[illegible]	64	-100.93
[illegible]	63	-65.03
[illegible]	126	-79.94
2016	97	-130.09
2017	104	-83.06
2018	119	-76.01
2019 (till 21.08.)	126	-80.69

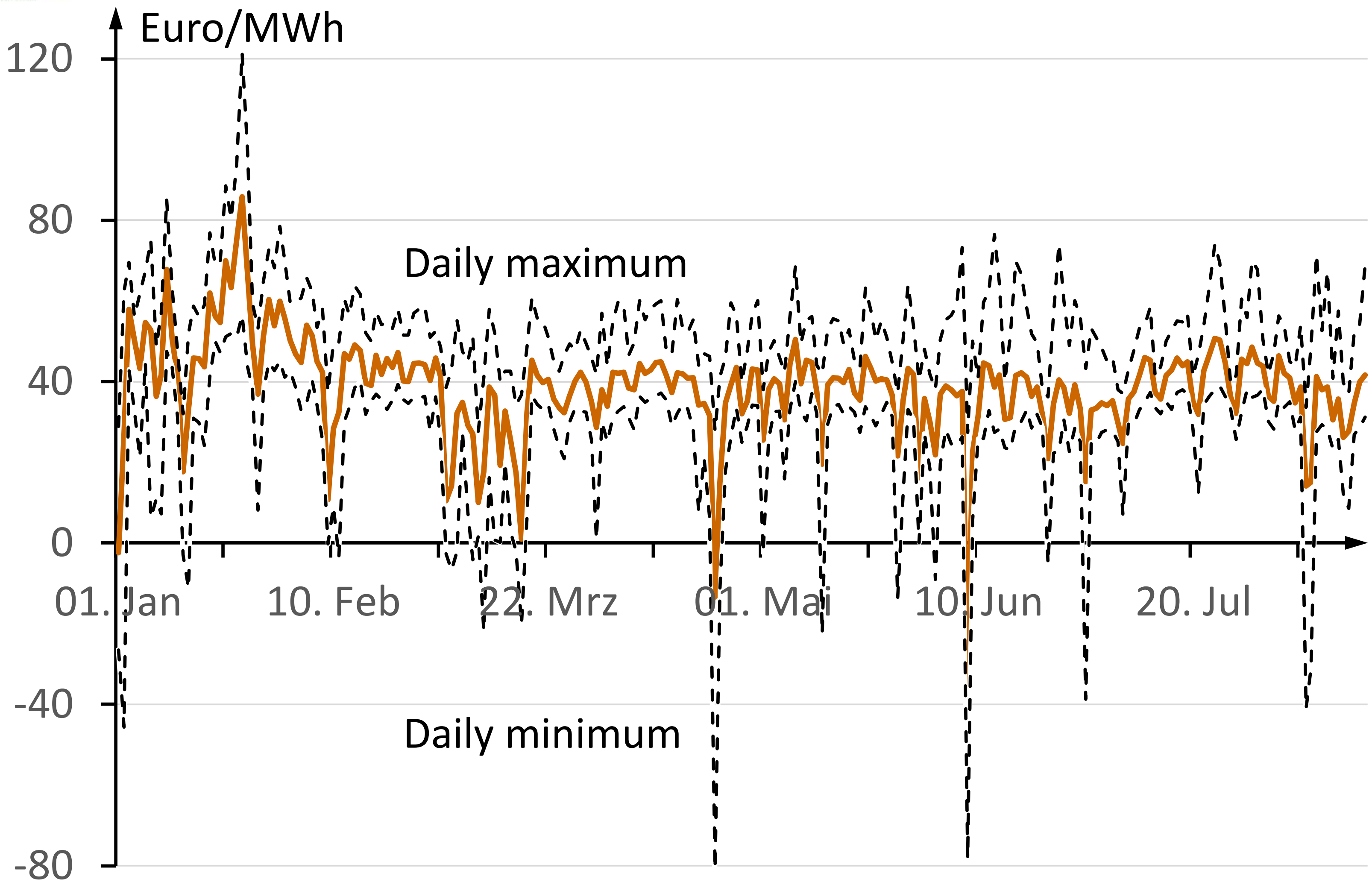
Unanticipated regulation could eliminate negative wholesale prices

Economics of Energy Storage Investments

- On energy only power markets, merchant investments into energy storage systems rely on the (expected) daily price spreads, cumulated over a year
- Different power markets must be considered (forward, day-ahead; intraday, …)

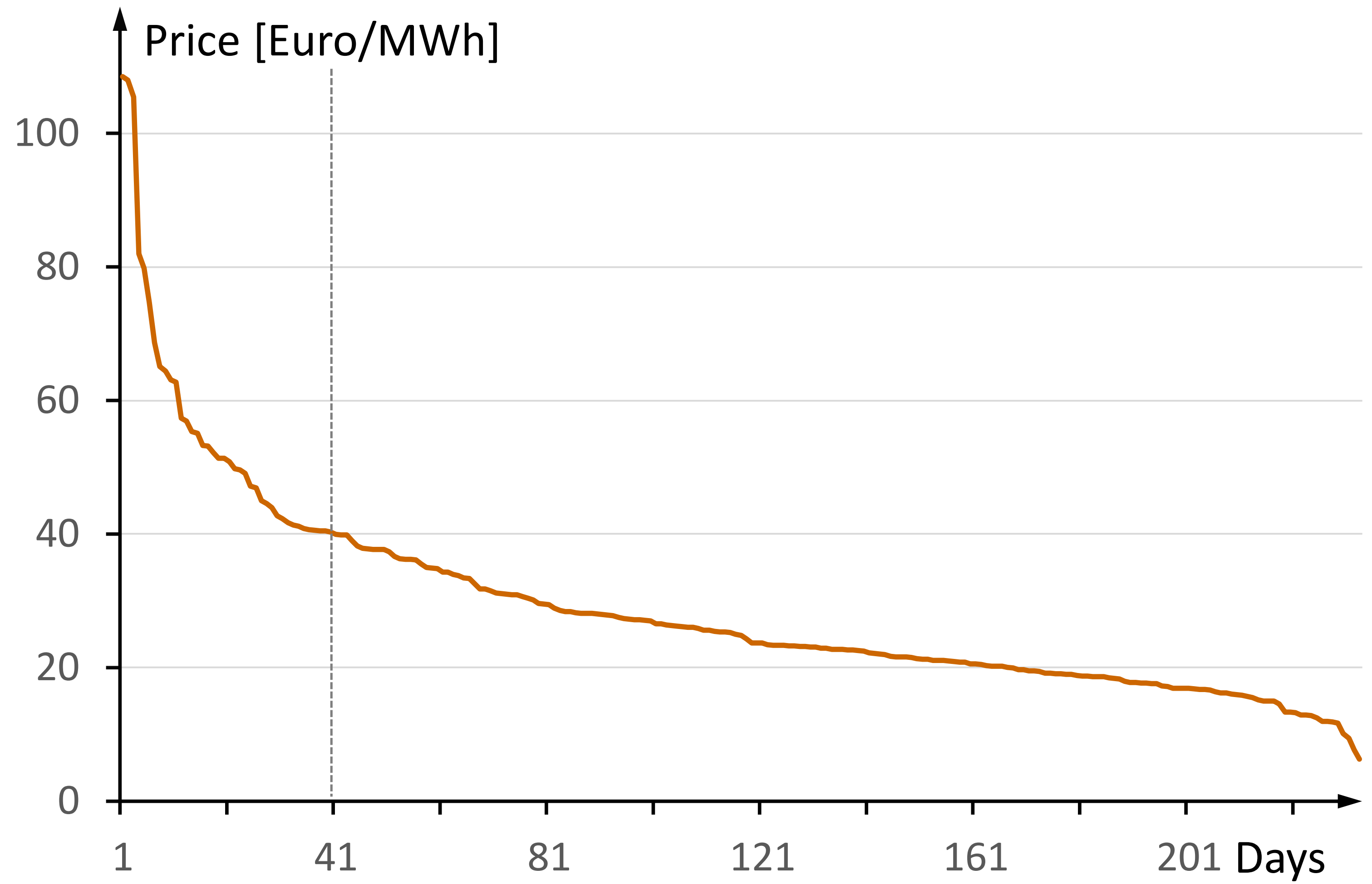
Day-ahead Power Price Spreads 2019

[Germany, January-August; own calculations from EPEX data]



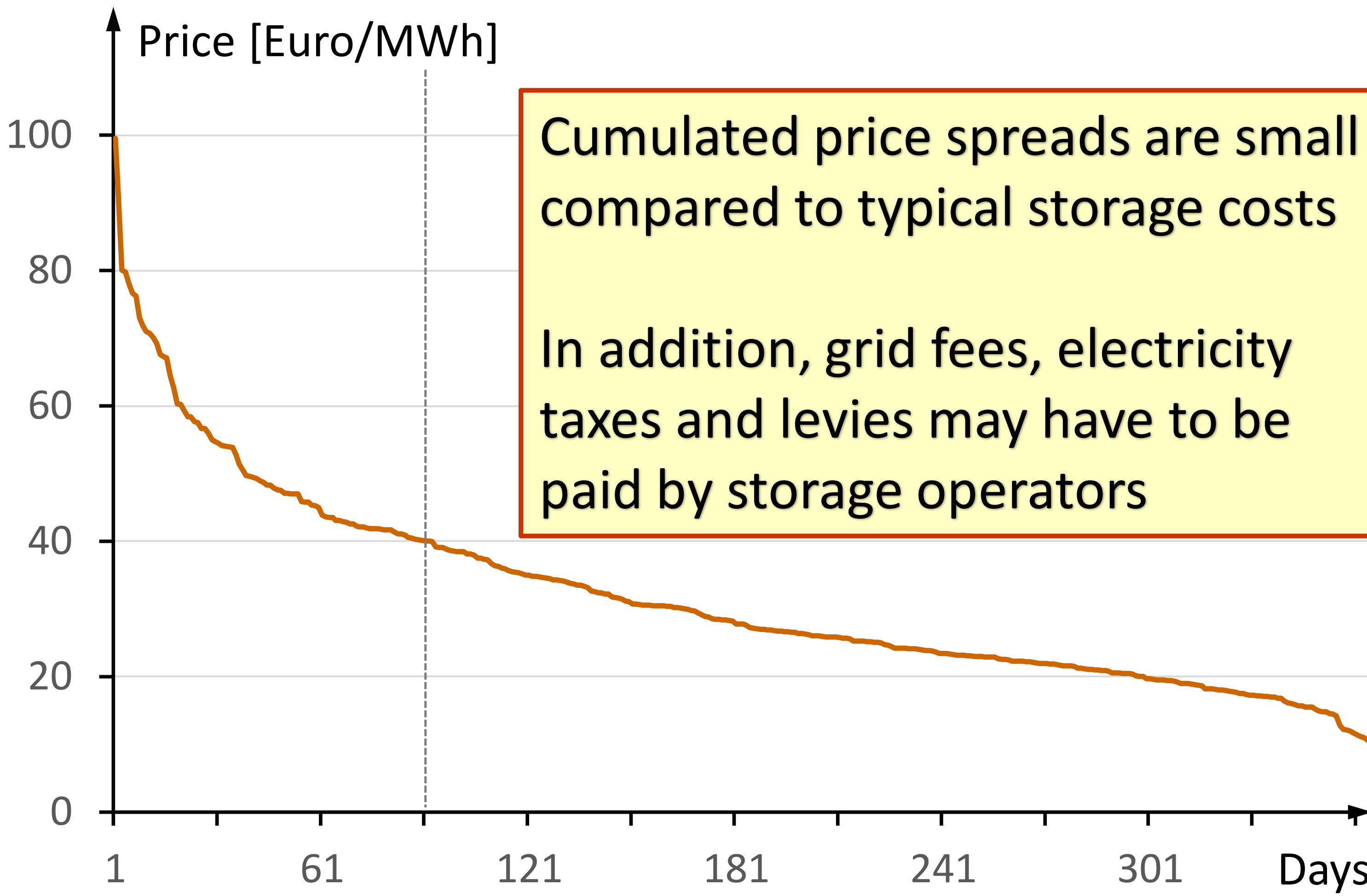
Ordered Daily Price Spreads 2019

[Germany January-August 2019; own calculations from EPEX data]



Ordered Daily Price Spreads 2018

[Germany; own calculations from EPEX data]



Cumulated price spreads are small compared to typical storage costs

In addition, grid fees, electricity taxes and levies may have to be paid by storage operators

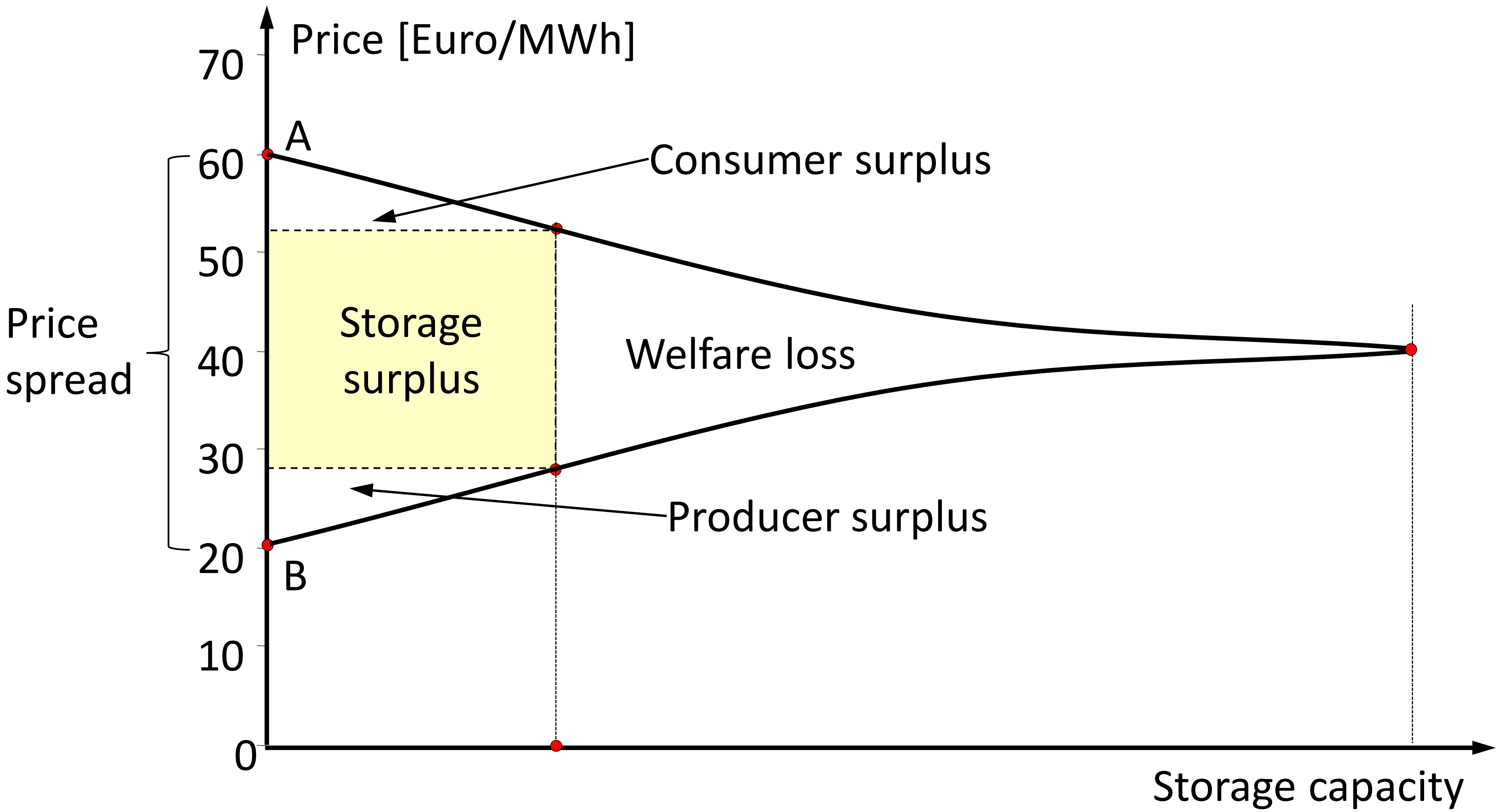
Example for Electricity Price Components

Germany 2016	Power purchase from the grid	Auto generation	Power purchase in „local context“
		Euro/MWh	
Grid fee	18.00 – 30.00		18.00 – 30.00
REN levy	63.54	22.24	
Electricity tax	20.50		
Concession fee	1.1 – 23.90		1.1 – 23.90
CHP levy	4.45		4.45
§ 19 StromNEV	3.78		3.78
Offshore levy	0.40		0.40
Total	86.77 – 121.57	22.24 – 42.74	23.73 – 83.03

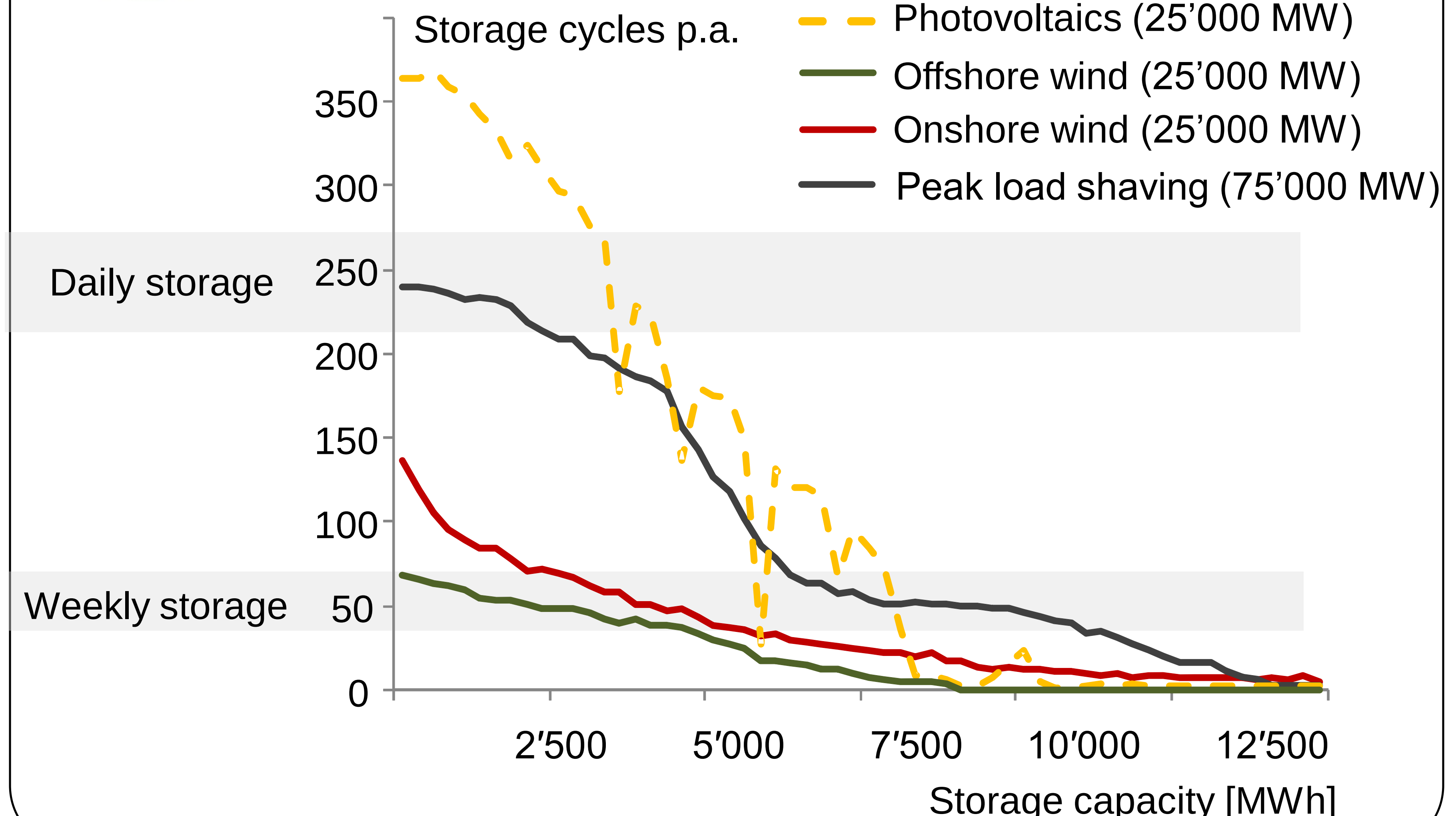
Strategies for Solving the Storage Problem

- Solution 1: Selective exemptions from electricity fees, levies and taxes for certain storage applications → high regulatory complexity
- Solution 2: Shift from energy related grid fees to load related grid fees (eventually including levies) → new regulatory approach, but not sufficient
- Solution 3: Replacing the (remaining) electricity levies through CO_2 taxes (This would imply in Germany additional 40 Euro/t CO_2, if all domestic CO_2 emissions would be included) → politically difficult
- Solution 4: Companies in a monopolistic position may convince regulators to transfer storage system costs to their customers → storage systems as grid asset

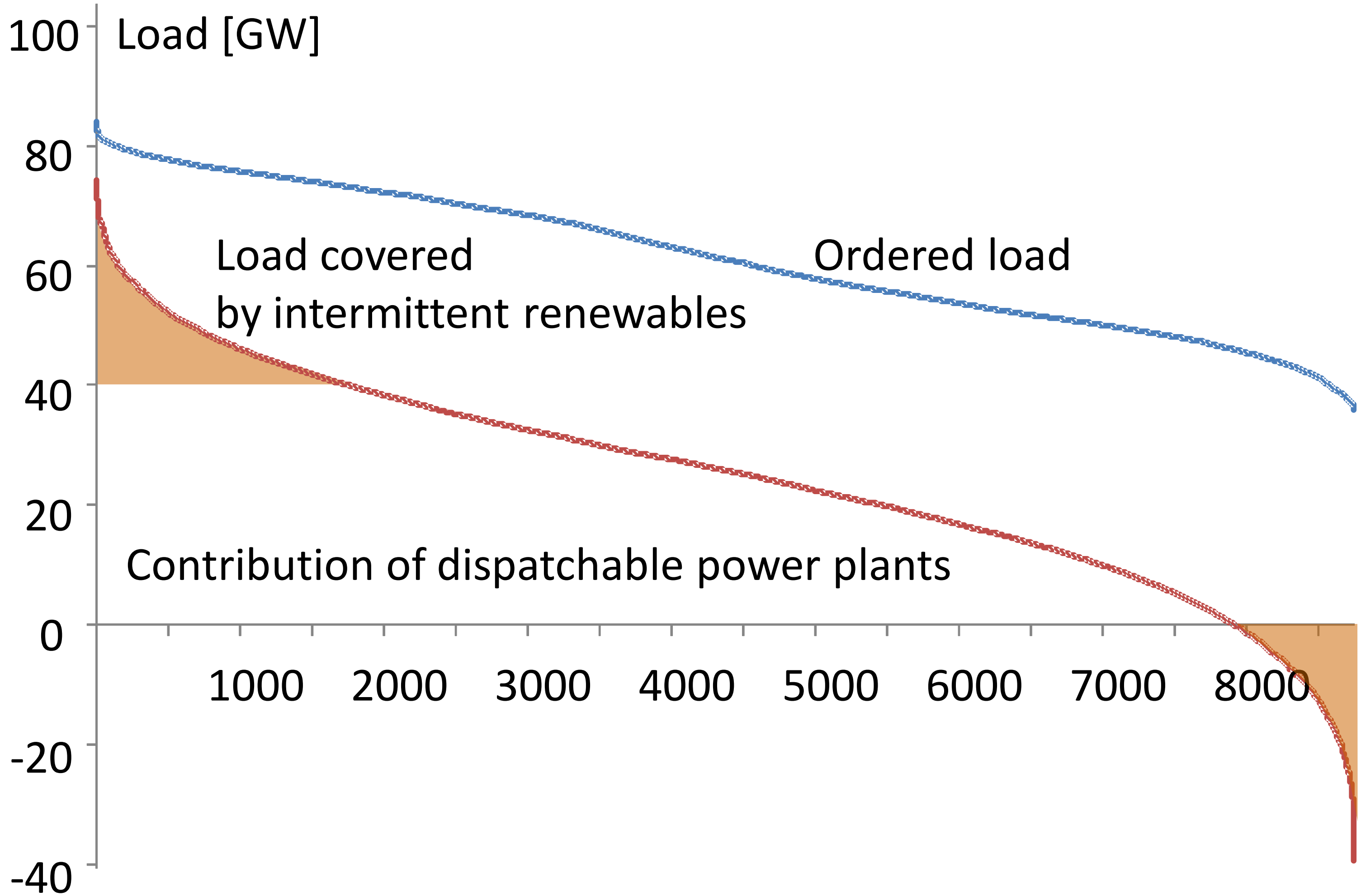
Cannibalization of Storage Investments



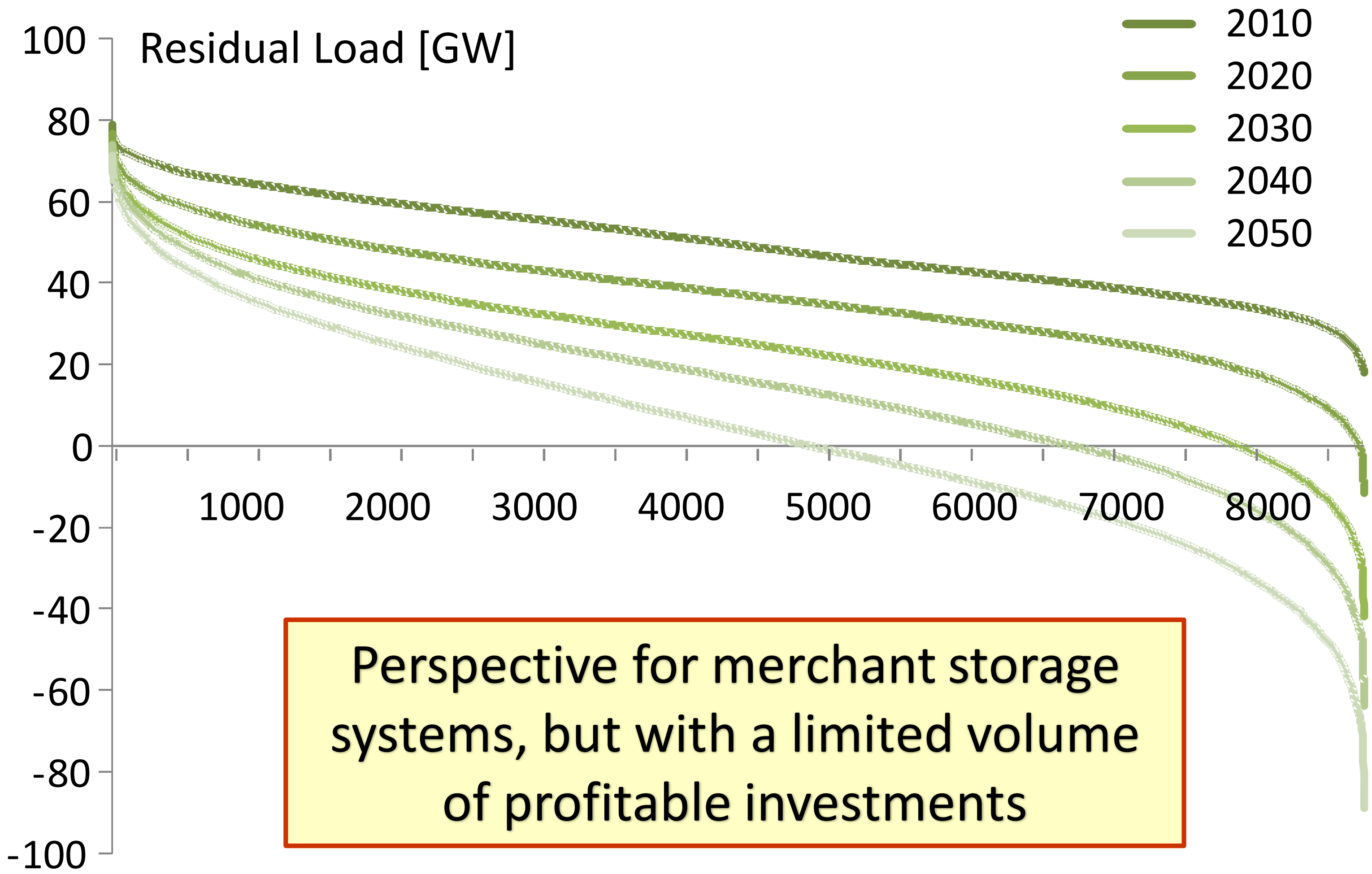
Number of Storage Cycles *[Source: Ehlers 2011]*



Residual Load and Electricity Storage



Expected Development of Residual Load

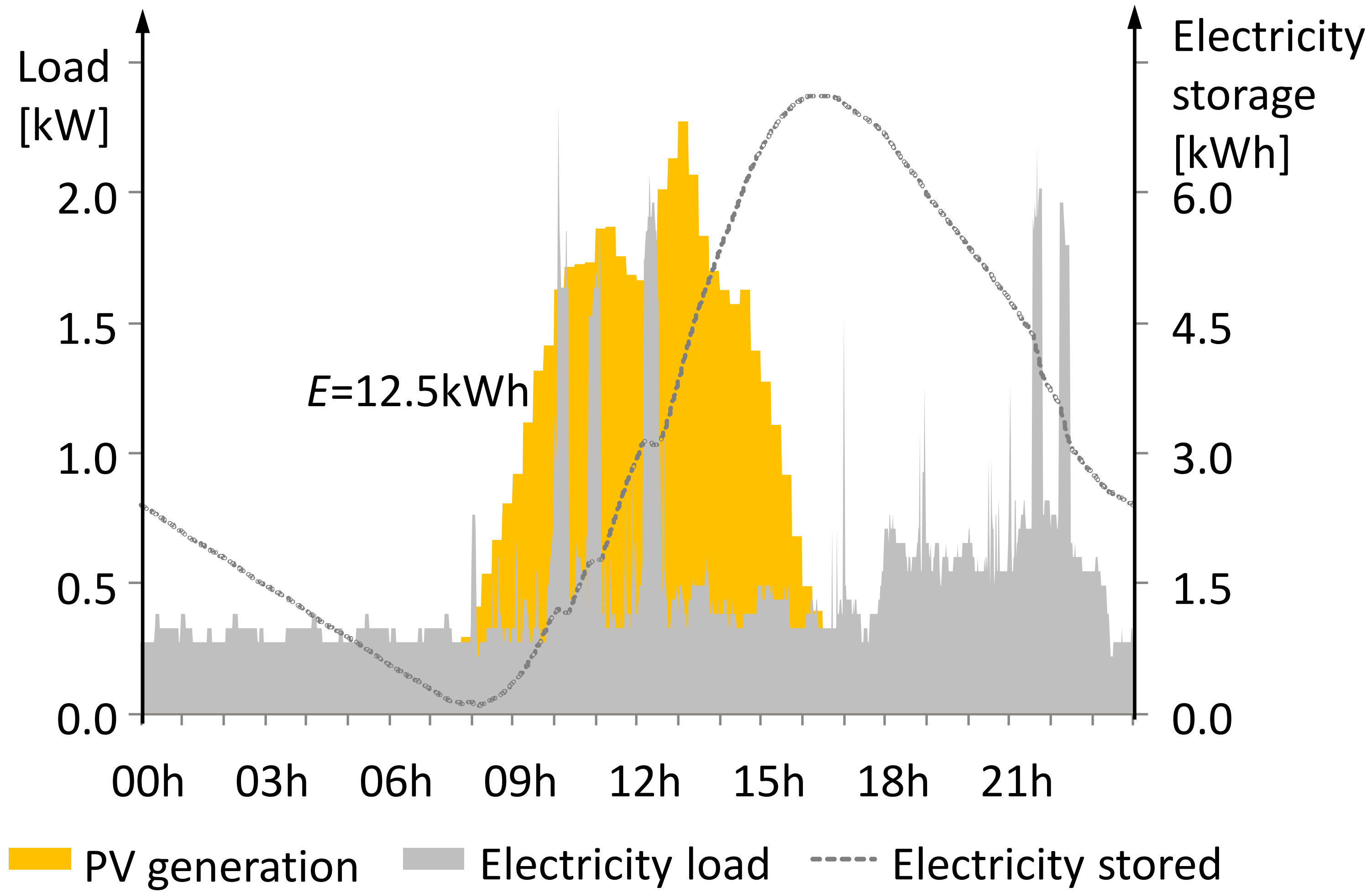


Perspective for merchant storage systems, but with a limited volume of profitable investments

Promising Strategies for Storage Investments

- Storage systems with low investment expenditures (or with major components already in place: Power-to-Heat; fleet of electric vehicles; Demand-side-Management, …)
- Operate storage systems beyond the wholesale electricity market (decentralized installations at final consumers, …)
- Introducing capacity payments for (certain) wholesale storage systems?
- Financing storage systems through monopolistic companies (grid operators)

Simulation of a Single Family House



Problems of Decentralized Storage Systems

- How should Balancing Responsible Parties (BRPs) reflect retail customers with significant storage capacities?
- Should electricity be provided to these customers through a synthetic profile (as today)?
- Management of decentralized storage systems in the interest of grid stability (Remark: certainly not with area wide power prices)
- What are the managing costs?
- At what conditions a customer may accept external interventions into its own storage system?

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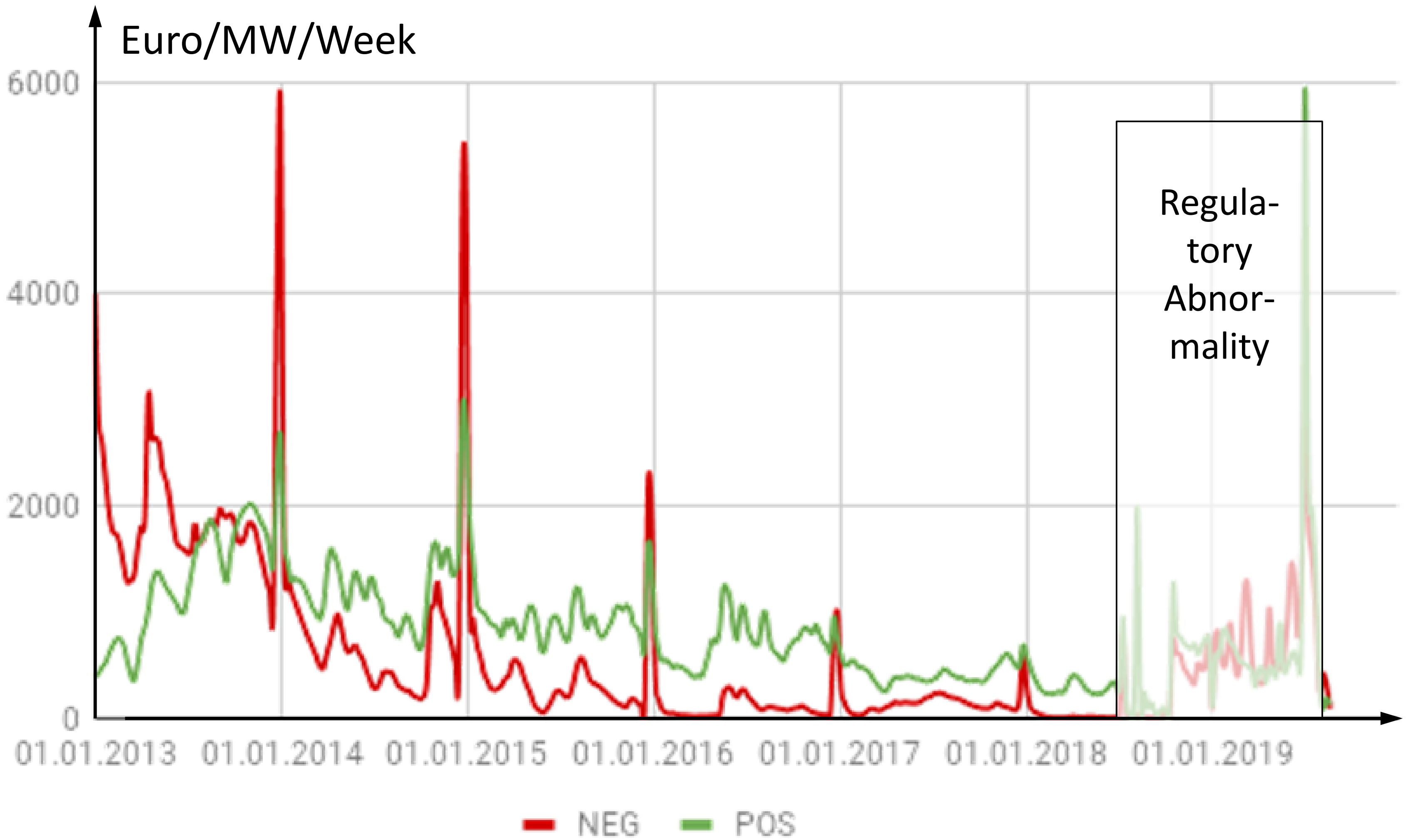
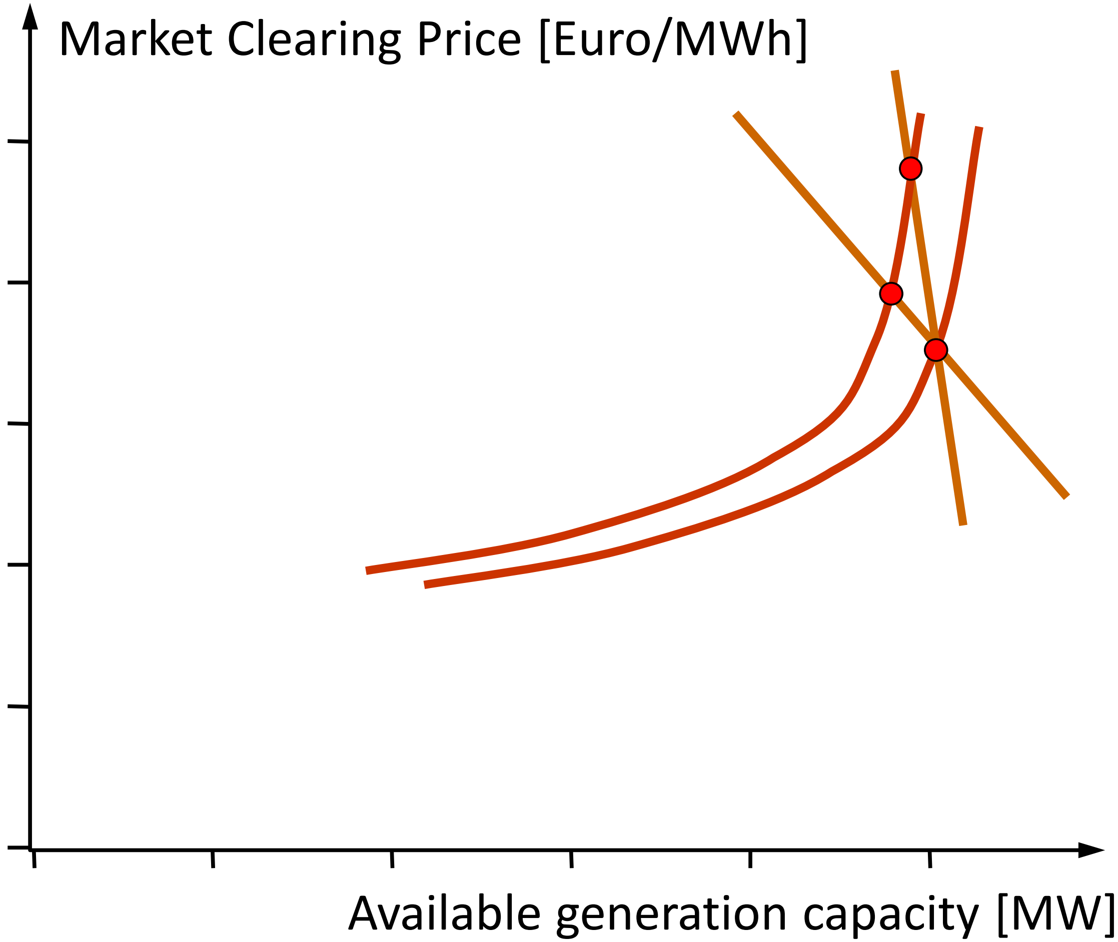
Capacity Prices of Secondary Control Power

[Germany; Source: regelleistung-online.de]



The Ultimate Challenge to Storage Investments: Price Elasticity of Demand



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Conclusions of my Presentation

- It is rather challenging to develop promising business cases for electric storage systems
  - High investment costs
  - Cannibalization effects
  - Central dispatch of decentralized storage
- Capacity markets are no sustainable solution …
- … but the monopolistic position of grid industries
- Attention: Capital intensive storage systems (such as Power-to-Gas) cause an economic pressure towards base-load electricity generation

Thank You

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