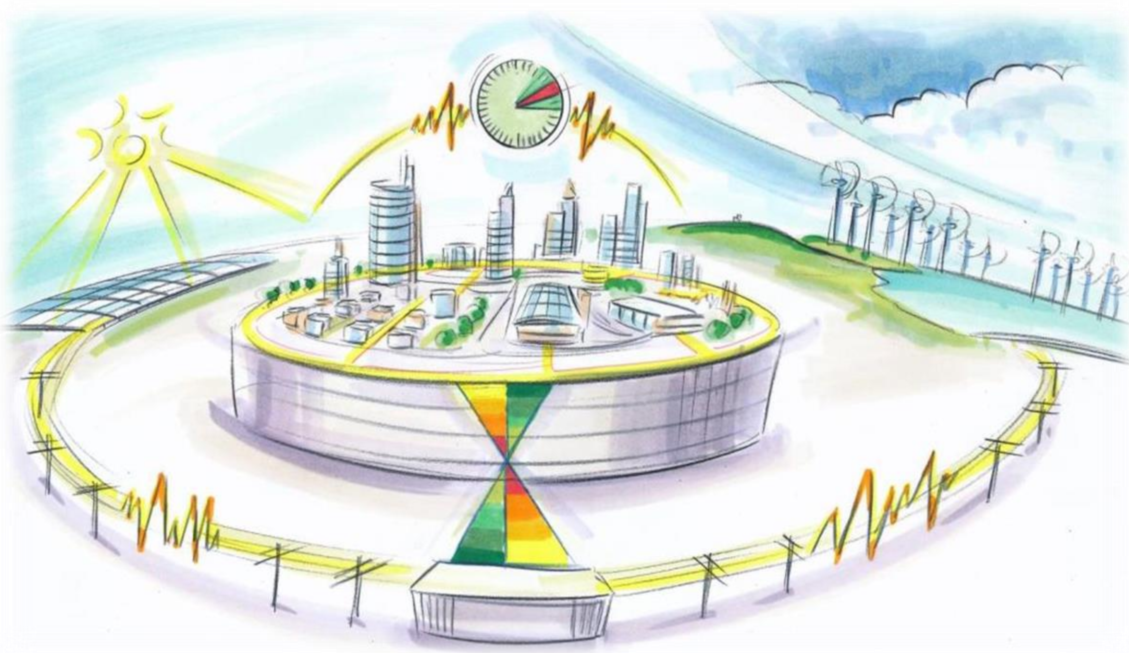
21. Fachgespräch der EEG-Clearingstelle - Speicherbetrieb unter dem EEG 2014

»Energiespeicher: Technologien, systemischer Bedarf, Anwendungen sowie Markt und Hemmnisse«

Prof. Dr. Christian Doetsch
Fraunhofer UMSICHT



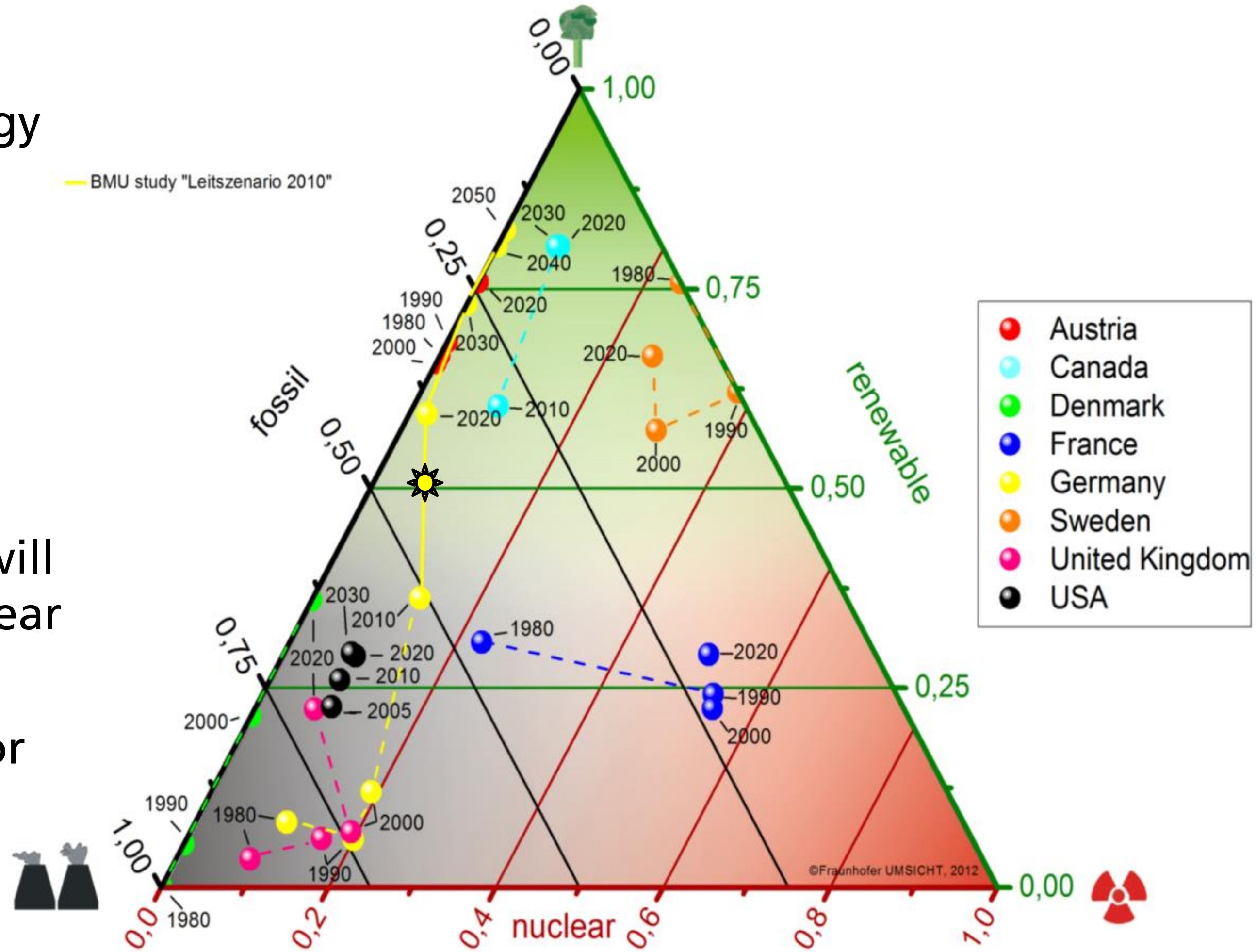
Mit **neuer** Energie

Berlin,
Montag, 8. Juni 2015

Fraunhofer UMSICHT

Share of installed electricity generation in Germany and other OECD countries – and their development

- Germany, 2013:
  25% renewable energy
- But this means:
  85 GW renewable capacity
  90 GW conventional capacity approx. 50% share
- Future: Renewables will increase rapidly, nuclear energy will fade out
- Increasing demand for energy balancing measurements



Source: Fraunhofer UMSICHT

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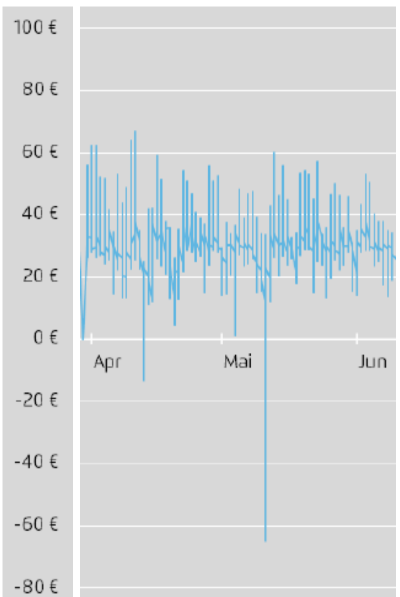
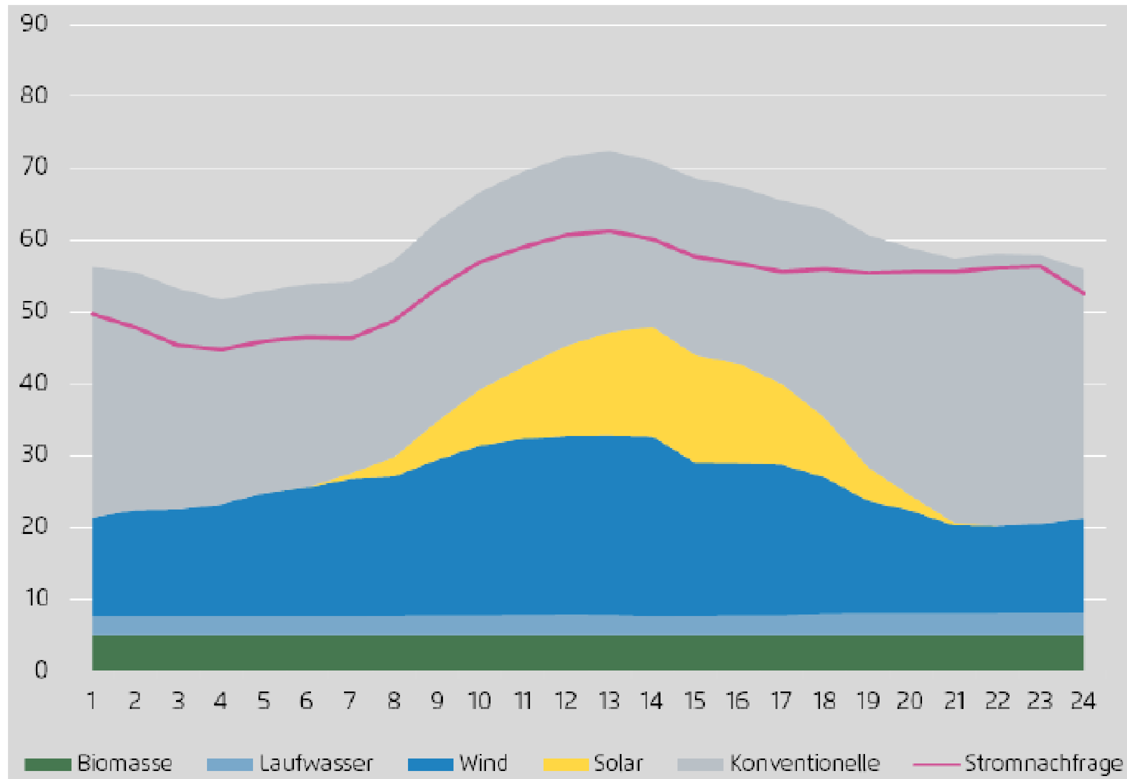
Peak RE share 2014, Germany: 80% Renewable Energies

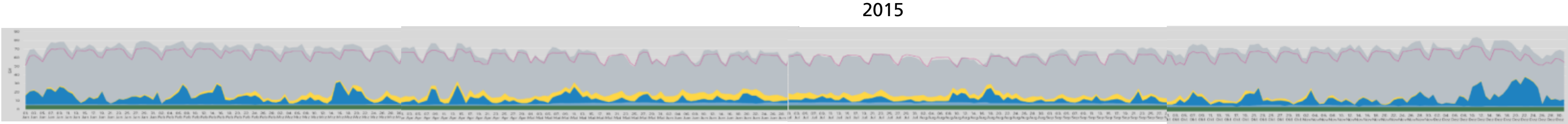
(Saturday, May 11, 2014)

- Surplus of energy leads to negative day-ahead prices





Source: AGORA, „Die Energiewende im Stromsektor: Stand der Dinge 2014 ", 2015



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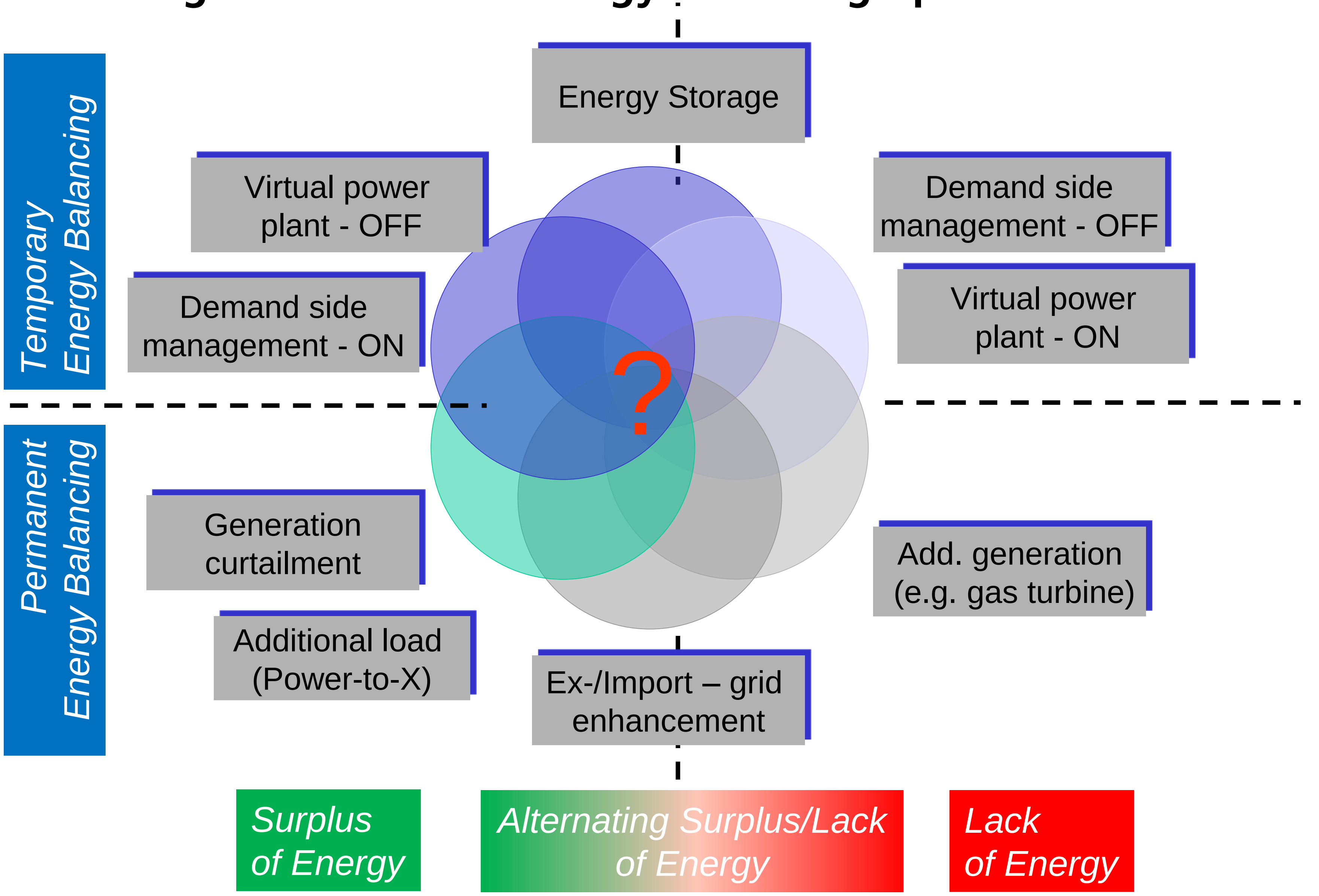
System integration: Electric energy balancing options



System integration: Electric energy balancing options

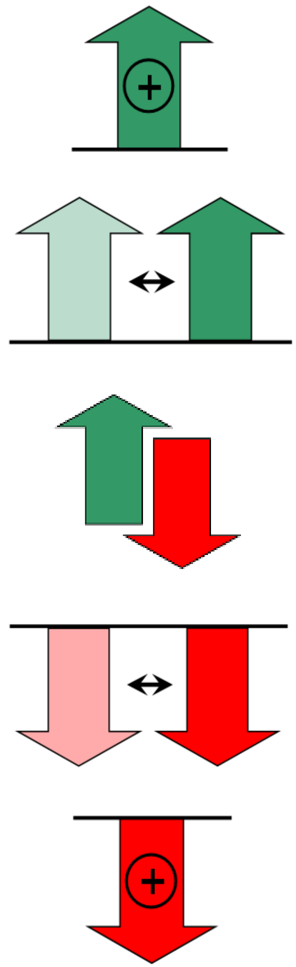
Add. generation (e.g. gas turbine)

Virtual power plant

Energy Storage

Demand side management

Additional load (Power-to-X)



Additive Generation
- rare short-term peak loads

Dispatchable Generation
- frequent and high short-term peak loads

Energy Storage
- daily balancing of power demand and generation

Dispatchable Load
- frequent and high short-term generation peaks

Additive Load
- rare generation peaks

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System integration: A functional electric energy storage

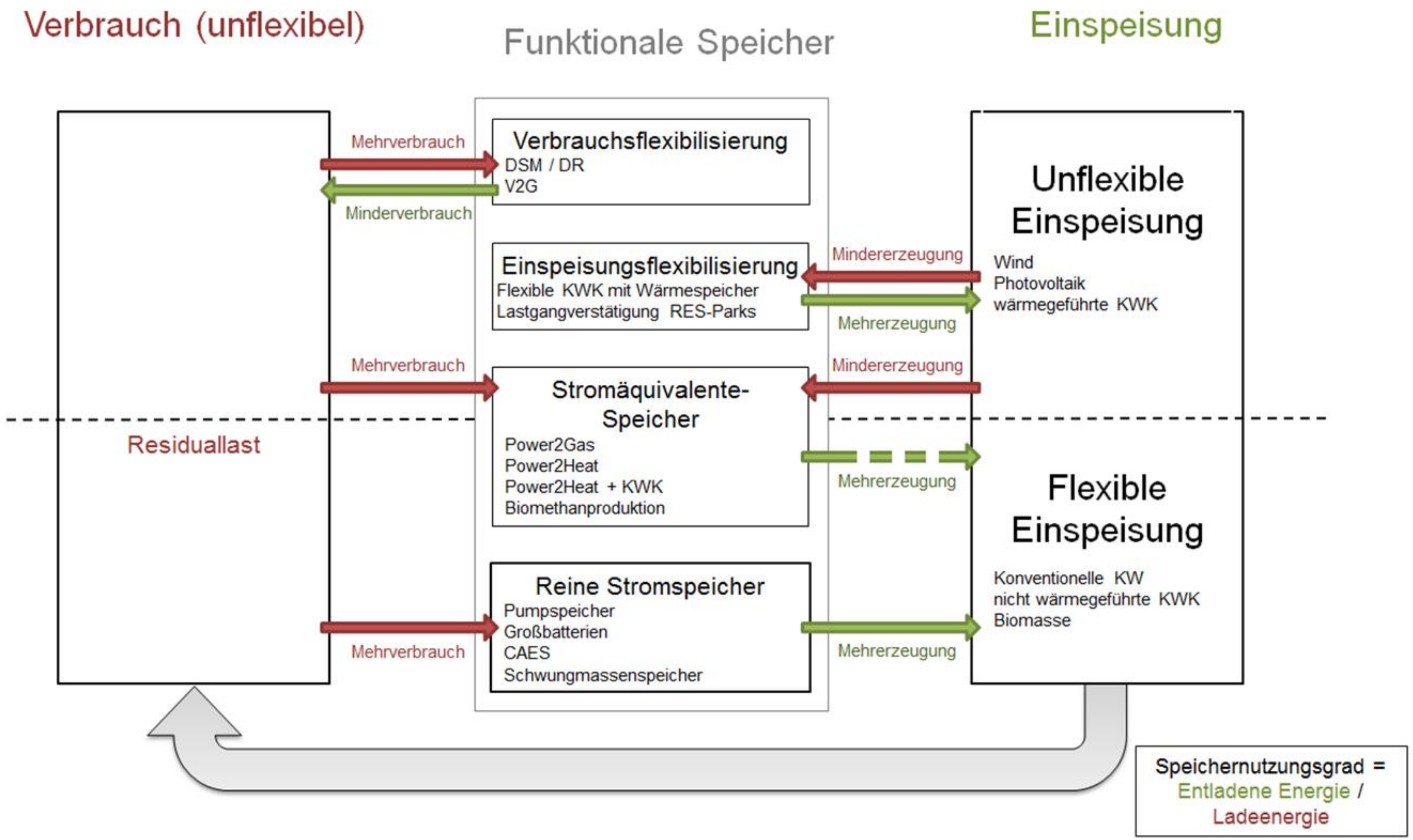
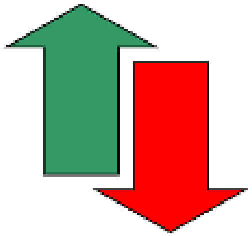


Fig: © FFE , https://www.ffe.de/publikationen/fachartikel/417-funktionale-stromspeicher

Energy Storage Technologies for system integration

Electric energy storages

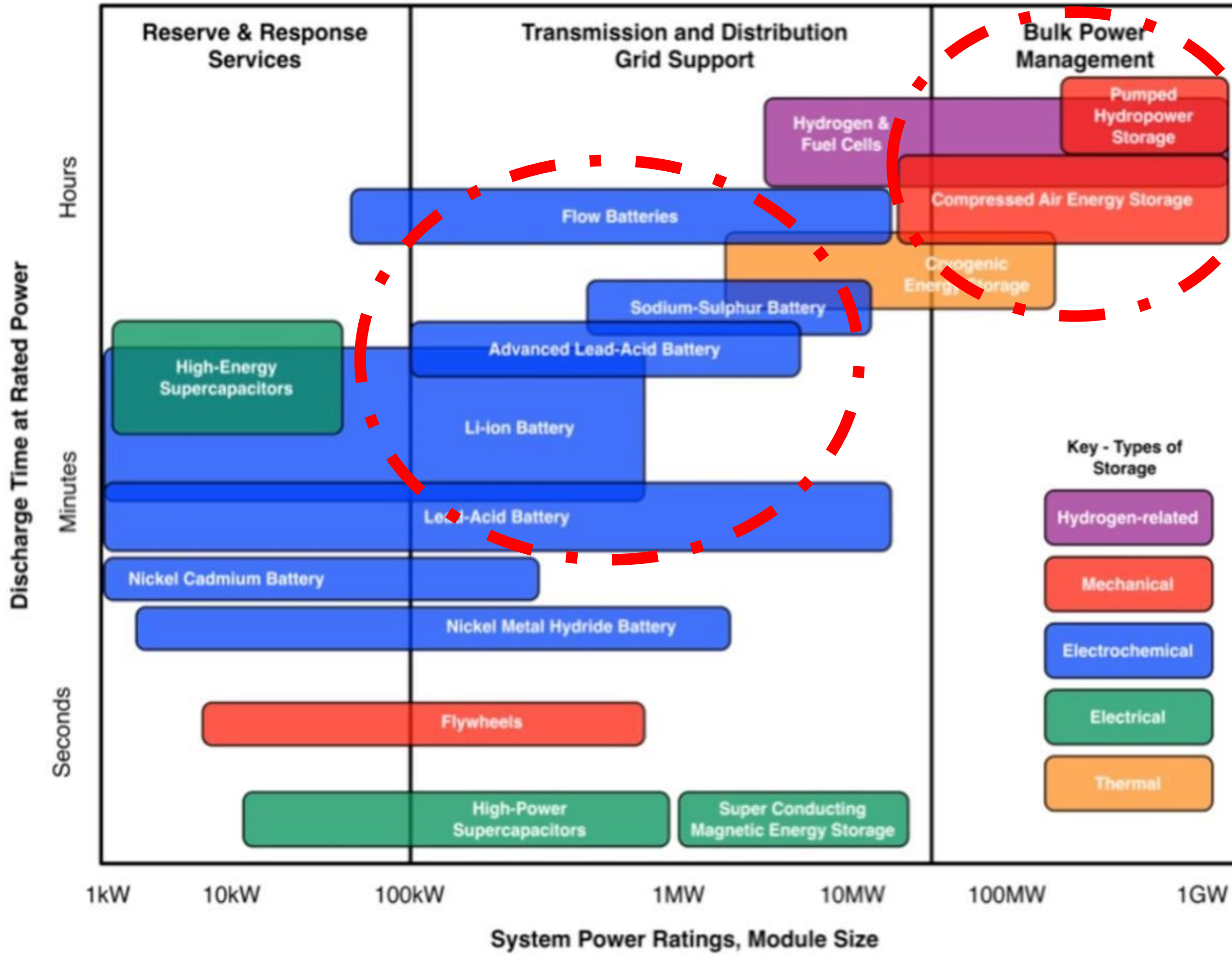


Batteries

- lead acid
- lithium-ion
- redox-flow

Mechanical storages

- CAES
- pumped hydro



http://reneweconomy.com.au/2013/the-missing-link-why-australia-needs-energy-storage-46236

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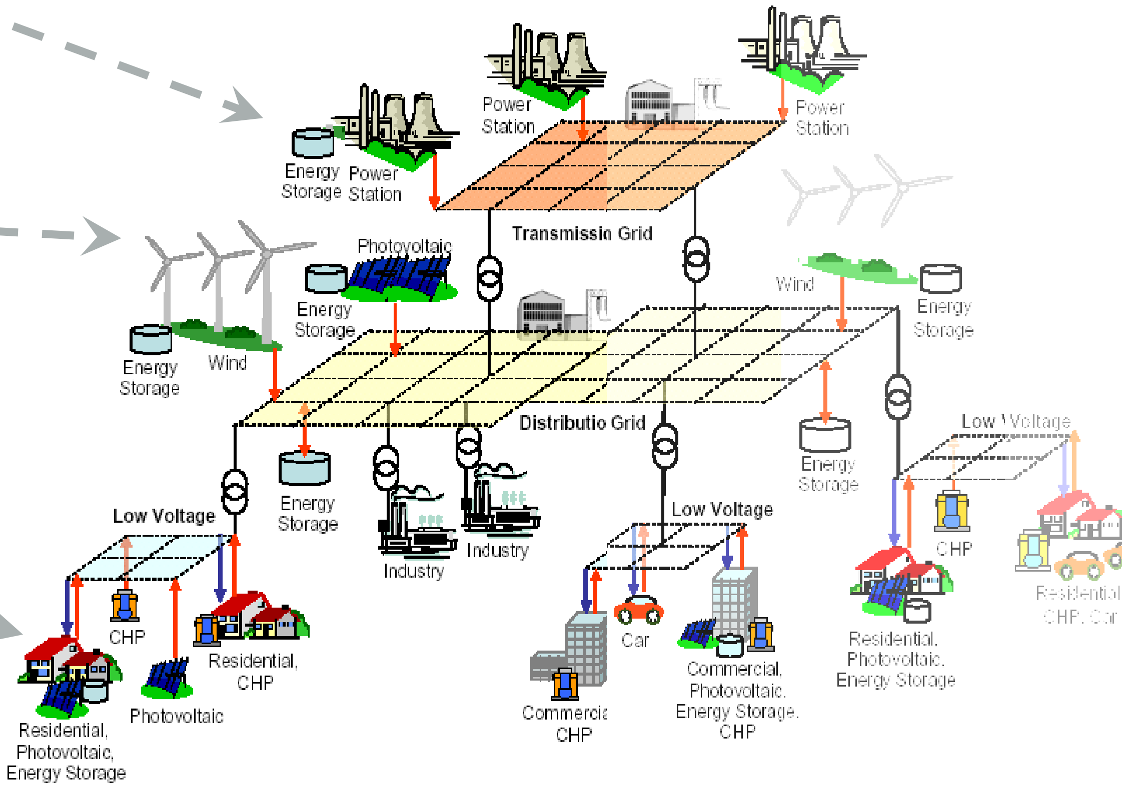
Energy Storage Technologies for system integration

Where (grid-level) could this systems be located ?

- **central electric storages**
  - pumped hydro
  - hydrogen generation
  - compressed air energy storage
- **decentralized huge batteries**
  - lithium-ion batteries
  - lead acid batteries
  - NaS batteries
  - Redox-Flow batteries
- **local batteries**
  - lithium-ion batteries
  - lead acid batteries
- **virtual storages**
  - HP + thermal storage
  - µCHP + thermal storage



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Prediction: Surplus vs. lack of energy

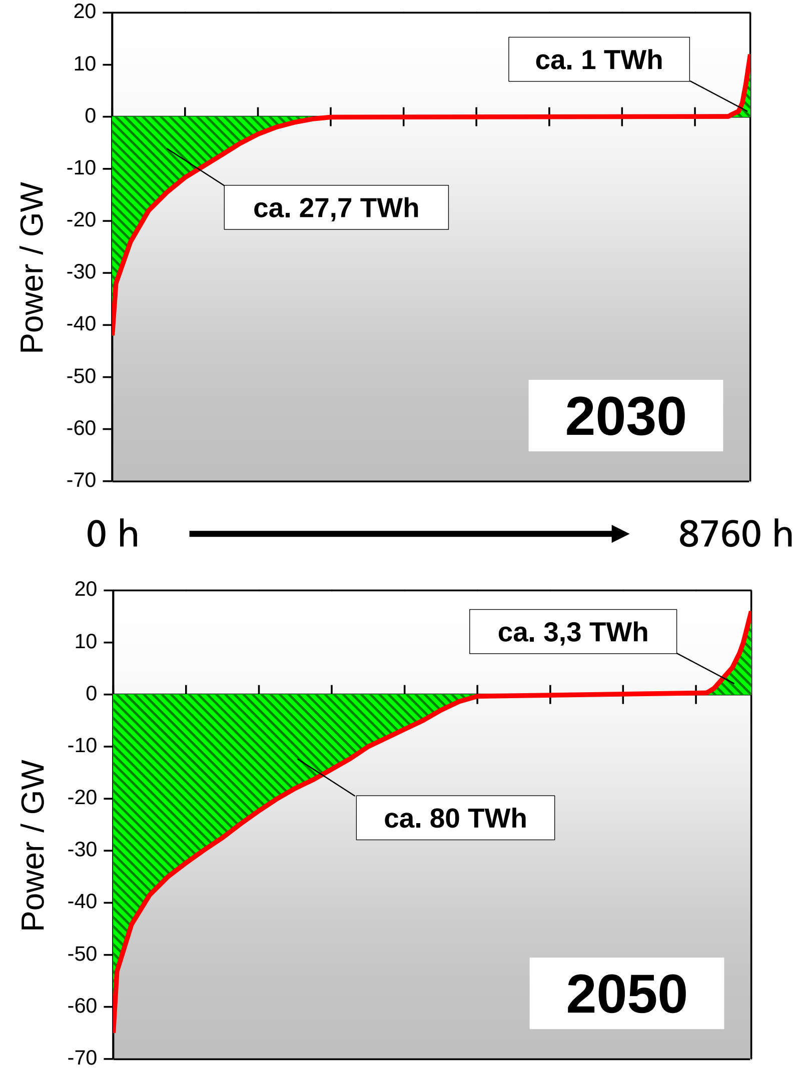
sorted annual curve

- **2030**
  - Surplus:
    - approx. 2500 h/a
    - approx. 28 TWh
  - Lack:
    - approx. 300 h/a
    - approx. 1 TWh

mismatch

- **2050**
  - Surplus:
    - approx. 5000 h/a
    - approx. 80 TWh
  - Lack:
    - approx. 300 h/a
    - approx. 3.3 TWh

mismatch



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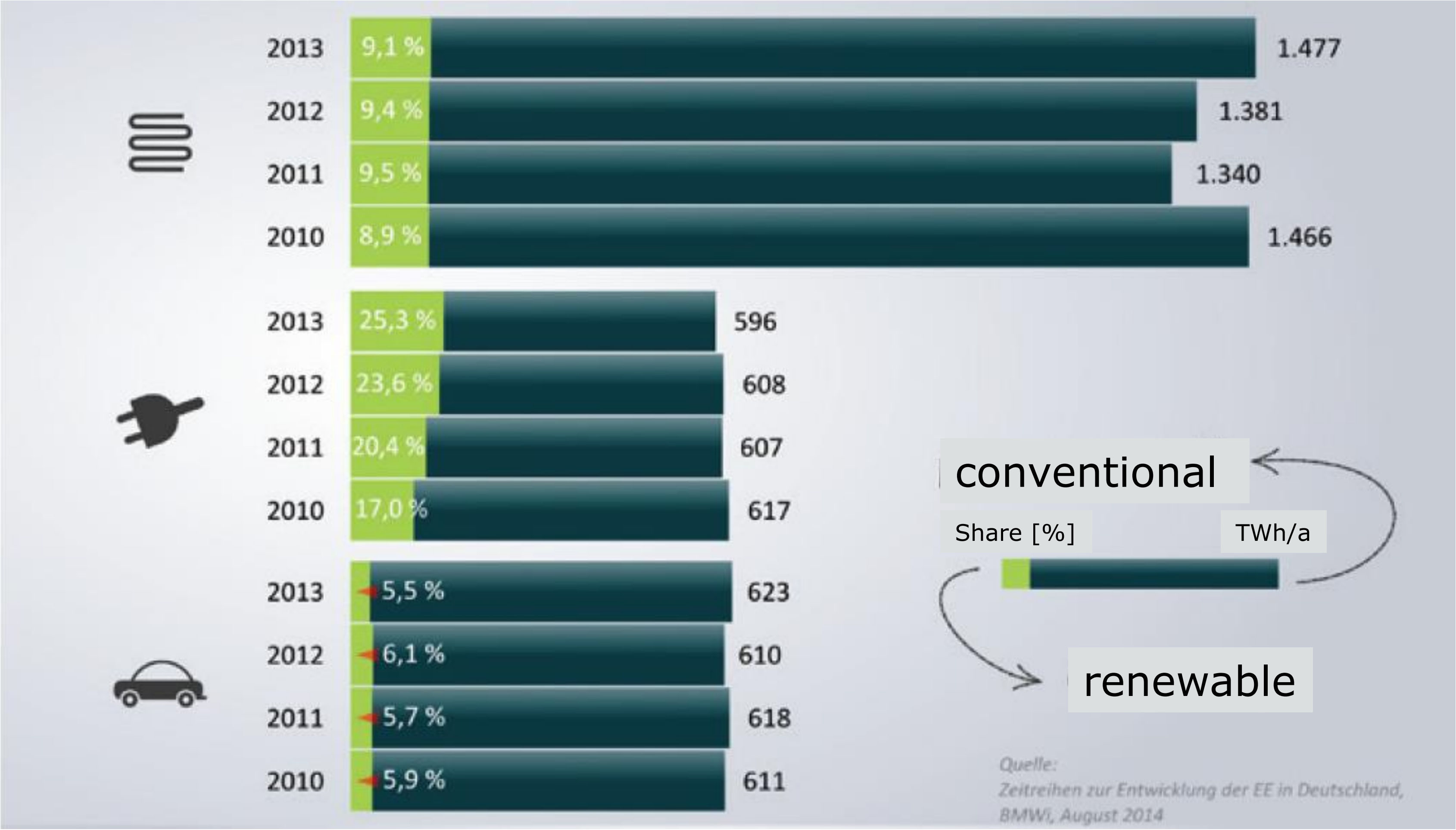
Development of Renewable Energy Share
(Process) Heat / Electricity / Mobility



Source: FFE, BMWI, in ENERGY 2.0; http://www.energy20.net/media/energy20/energ2.0week.html

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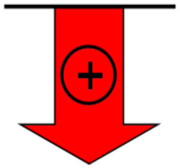
Power-to-X: „You are leaving the electrical sector“

Power-to-heat



Potential

- Private heat demand about 650 TWh
- Domestic hot water >3 TWh/month

Technology

- State-of-the-art technology
- low-cost, high flexibility, 100% efficiency

Economic assessment

- Only 1/3 of total cost (house-hold) are generation cost
- Business case for decentral application?
- Business case for central (district heating) application ?

Durchschnittliche Strompreiszusammensetzung 2013

	Prozentualer Anteil	Anteil für Privatkunden	
Stromerzeugung	32,3%	8,85 ct/kWh	Markt
Netznutzung	18,8%	5,15 ct/kWh	Regulatorischer Anteil
§19 Umlage	0,5%	0,15 ct/kWh	
Mehrwertsteuer	15,0%	4,12 ct/kWh	
Konzessionsabgabe	6,6%	1,80 ct/kWh	
Öko-/Stromsteuer	7,5%	2,06 ct/kWh	
EEG-Umlage	19,3%	5,28 ct/kWh	

Quelle: BDEW

„Power 2 Heat“ ist aufgrund der Höhe des Strompreises aktuell wirtschaftlich nicht darstellbar.

© MVV, Daten BDEW

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Power-to-X: „You are leaving the electrical sector“

Power-to-gas / Power-to-product

Power-to-gas

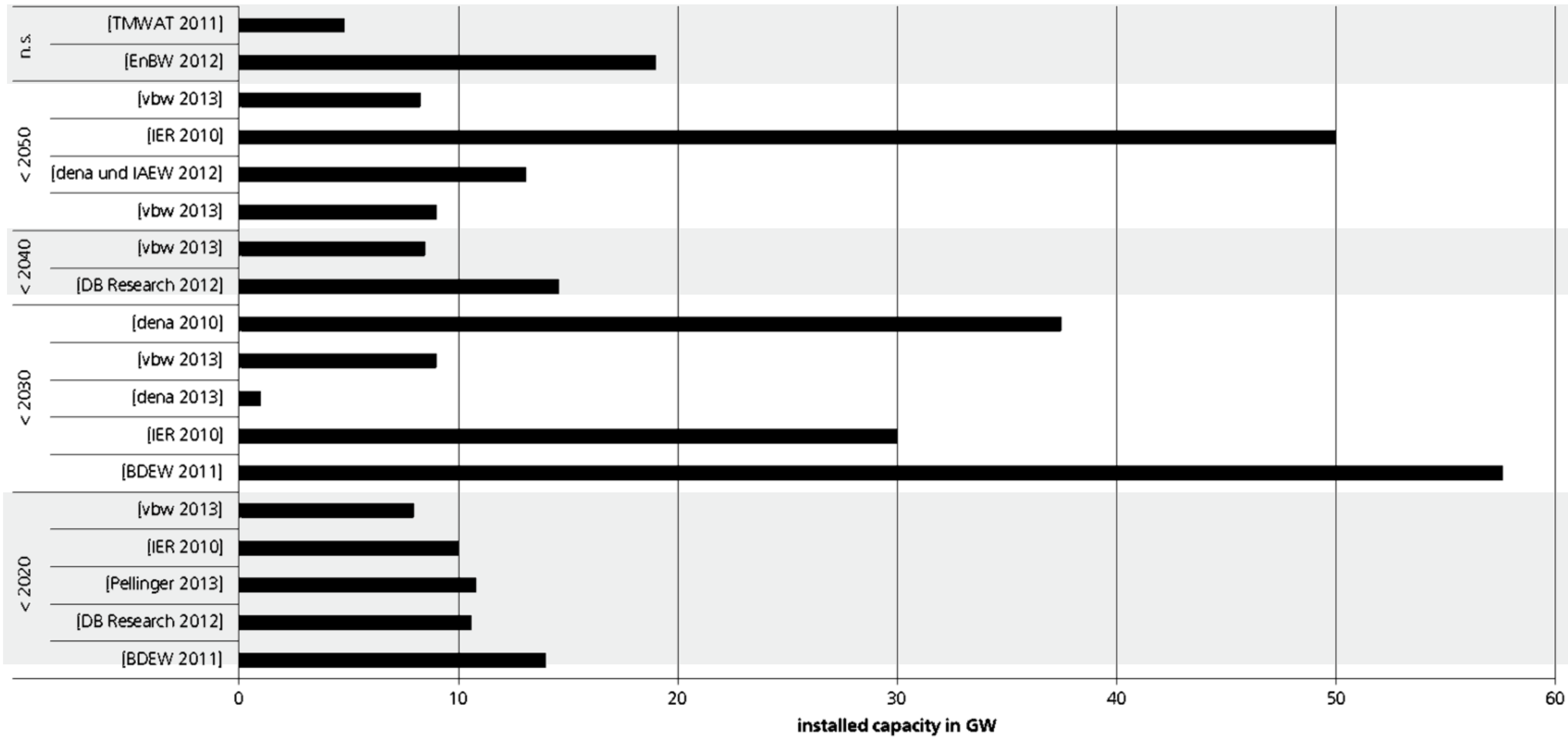
- available technology
- high-cost, efficiency approx. 55 %, less flexible (e.g. Hydrogenics / EON Falkenhagen)

http://www.hydrogenics.com/about-the-company/news-updates/2013/08/29/e.on-and-swissgas-begin-commercial-operations-at-power-to-gas-facility-in-germany-using-hydrogenics-technology

Power-to-product (liquid, chemistry, …)

- Research and development e.g. acetylene, formic acid, high pressure direct methanol
- very high cost, efficiency ?

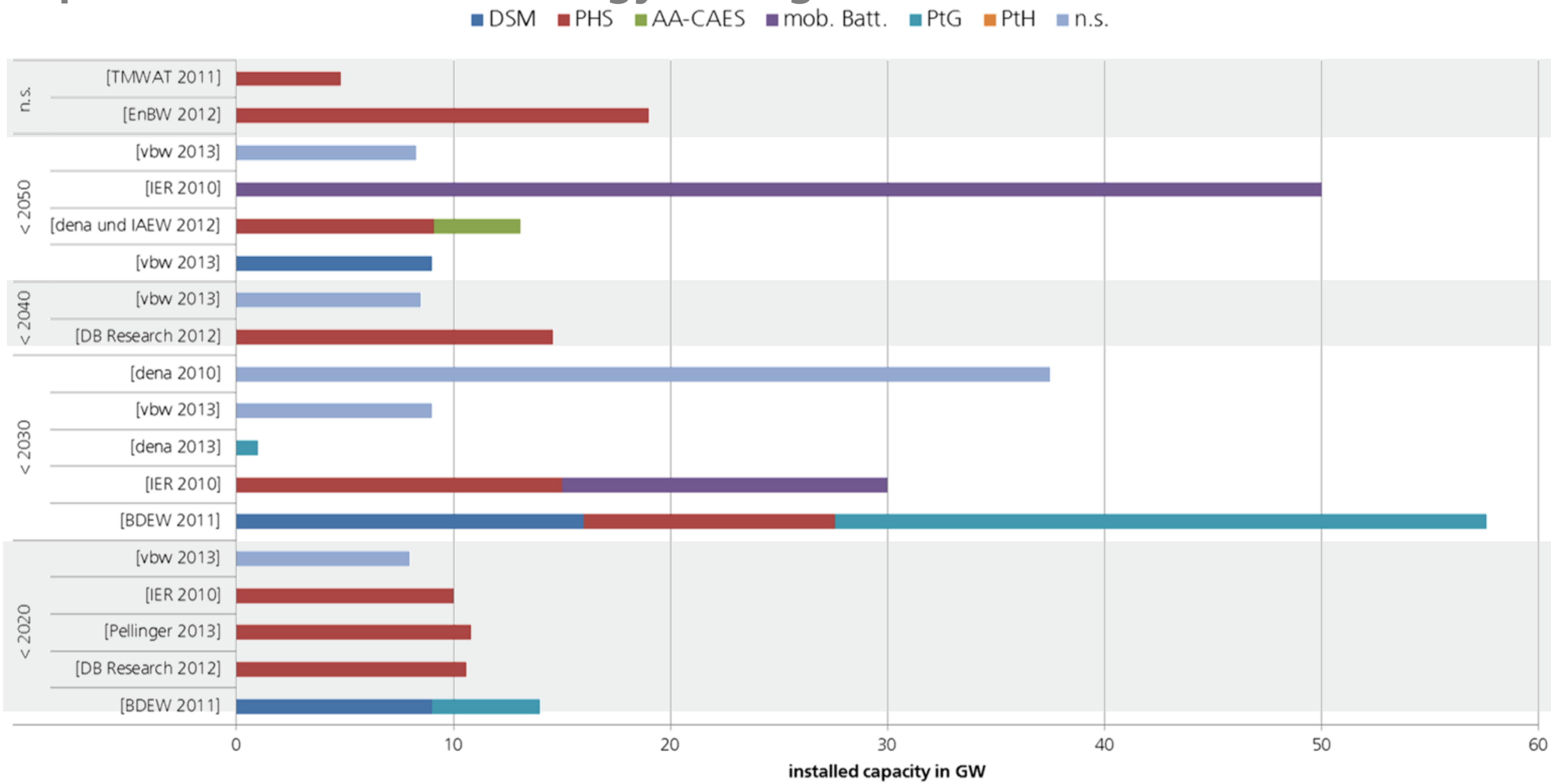
Exemplary Results of the Metastudy Energy Storage
Expansion Potential of Energy Storage



- Very heterogeneous results (capacity)

Exemplary Results of the Metastudy Energy Storage

Expansion Potential of Energy Storage



- Very heterogeneous results (capacity and technical solutions)
- Expansion of storage capacity expected from 2025 due to less conventional power plants and increasing share of renewables.

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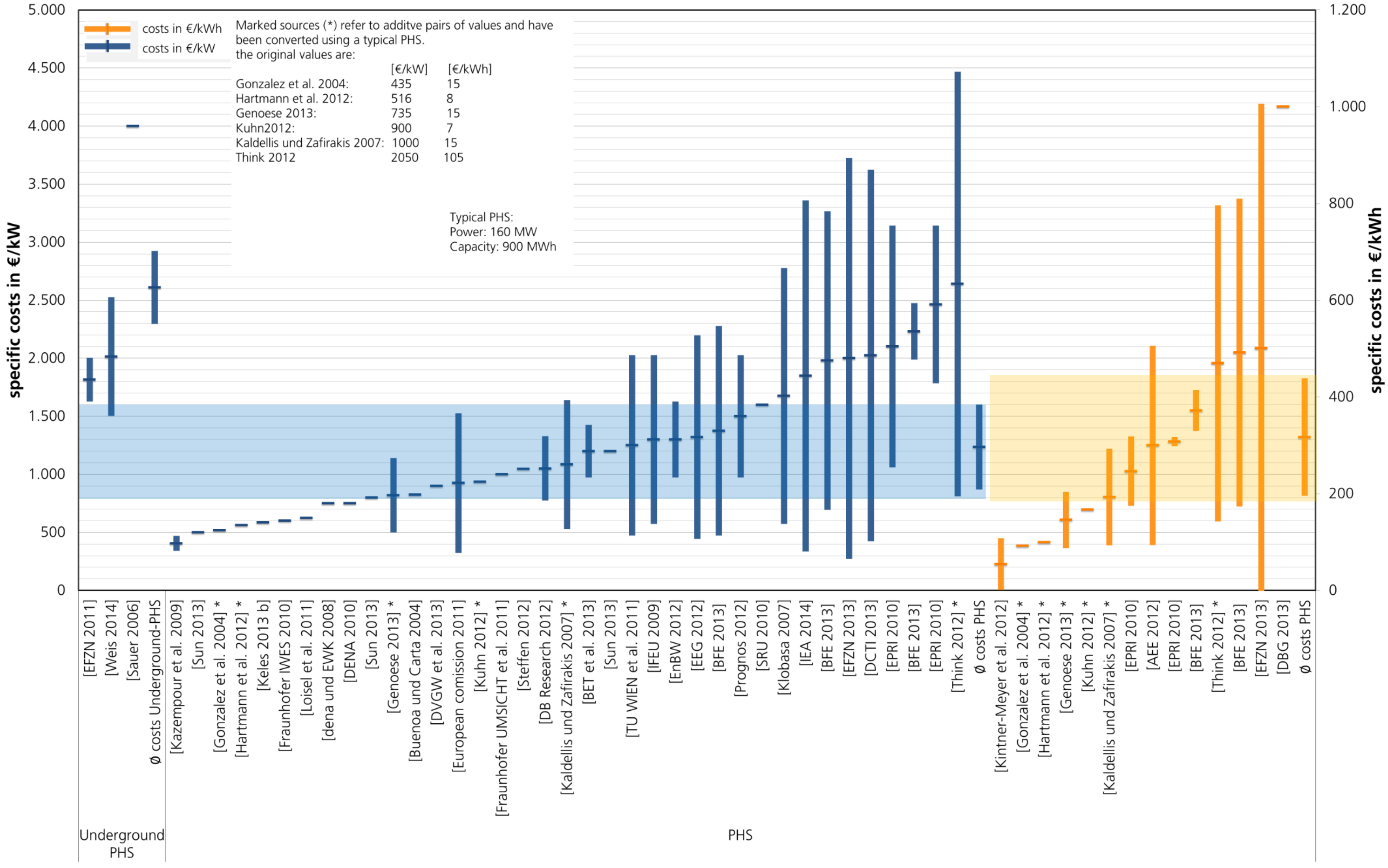
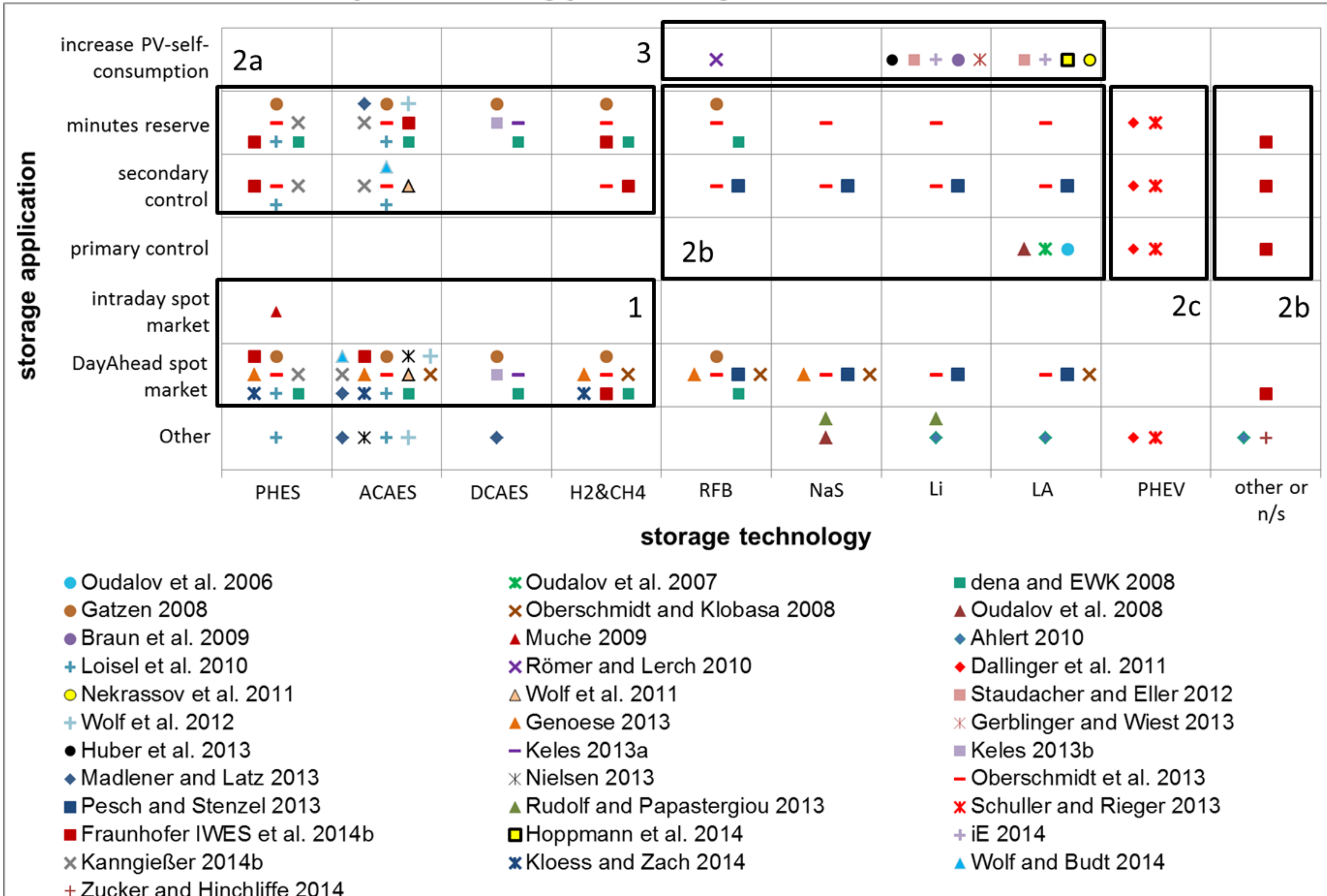
Exemplary Results of the Metastudy Energy Storage

Investment Costs – Example PHES



Exemplary Results of the Metastudy Energy Storage

Economic Efficiency of Energy Storage – Cluster Overview



PHES = Pumped Hydro Energy Storage, A/DCAES = Adiabatic/Diabatic Compressed Air Energy Storage, RFB = Redox-Flow-Battery, PHEV = Plug-in-Hybrid-Vehicle, LA= Lead Acid battery

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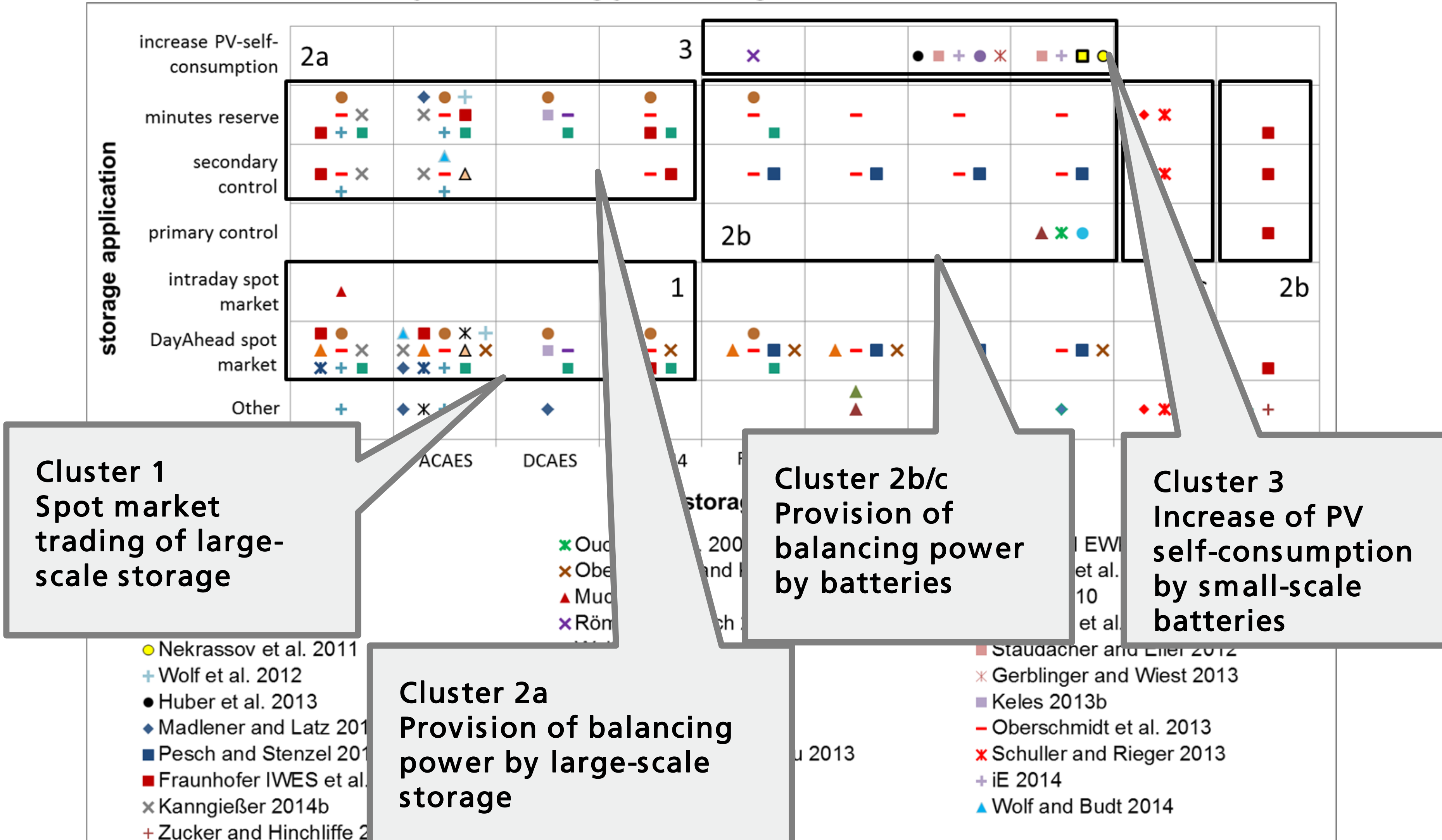
Exemplary Results of the Metastudy Energy Storage

Economic Efficiency of Energy Storage – Cluster Overview



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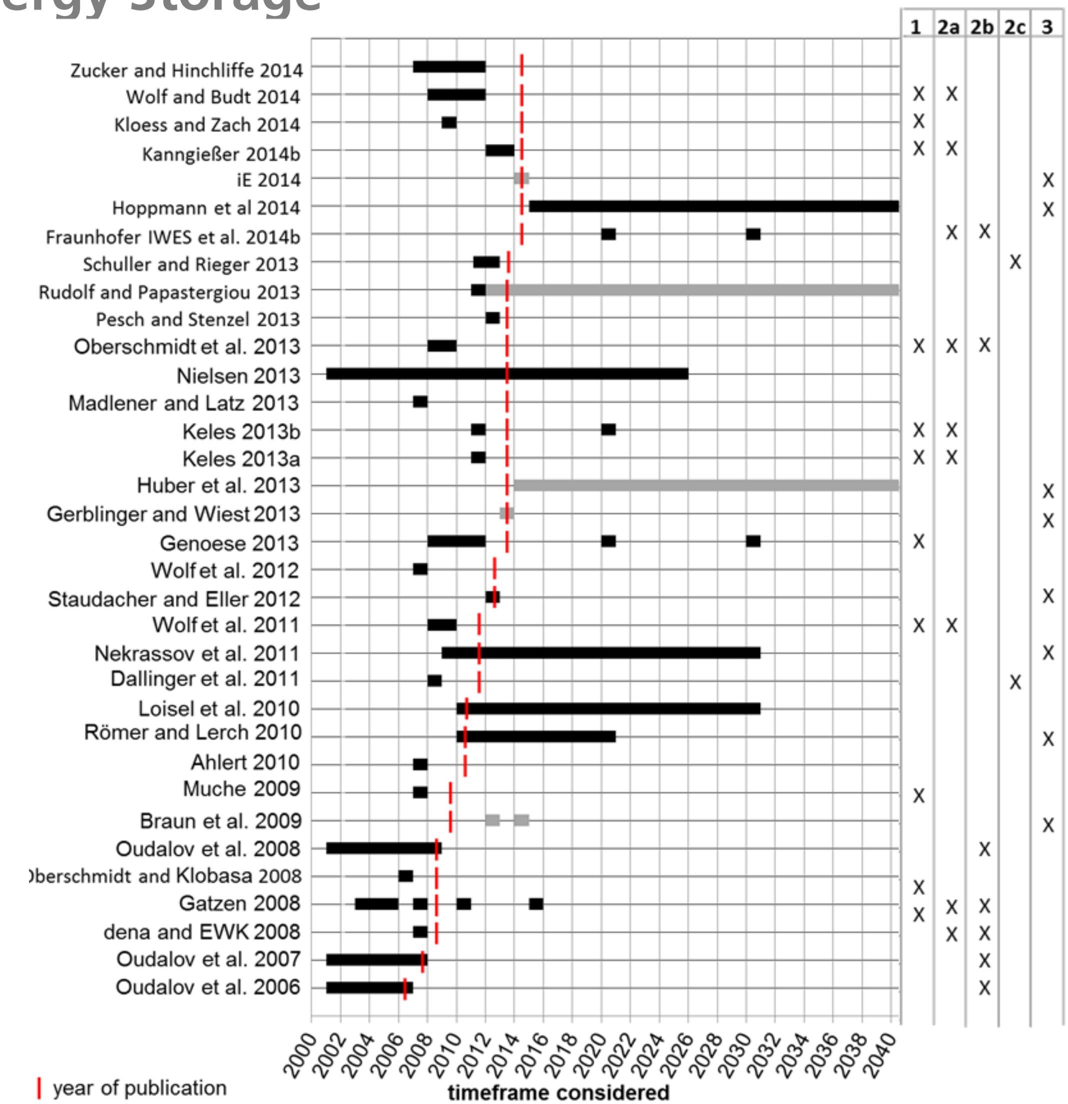
Exemplary Results of the Metastudy Energy Storage

Economic Efficiency of Energy Storage

- Most of the studies calculate the economic efficiency based on historical time series.
- Approx. one third delivers forecasts for future years.



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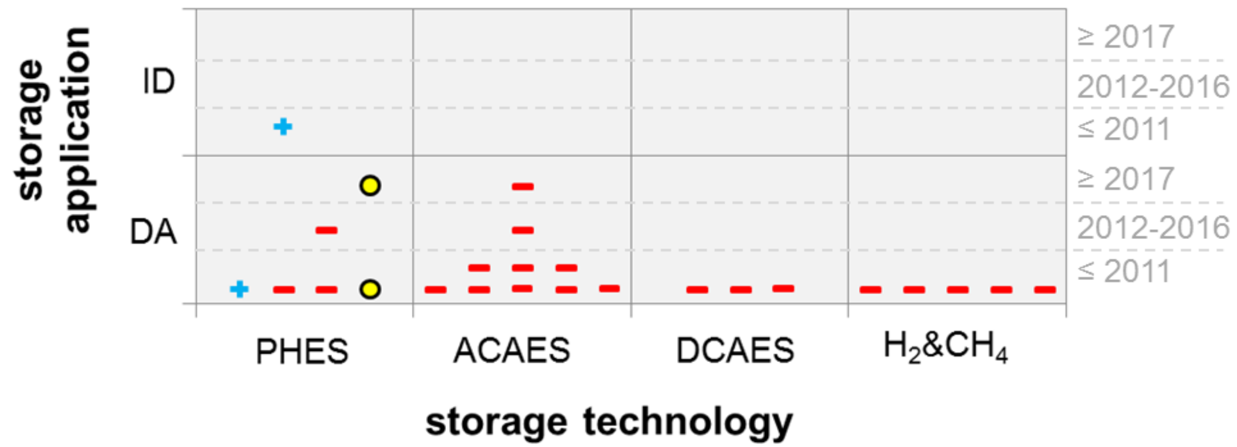
Exemplary Results of the Metastudy Energy Storage

Economic Efficiency of Energy Storage – Cluster 1

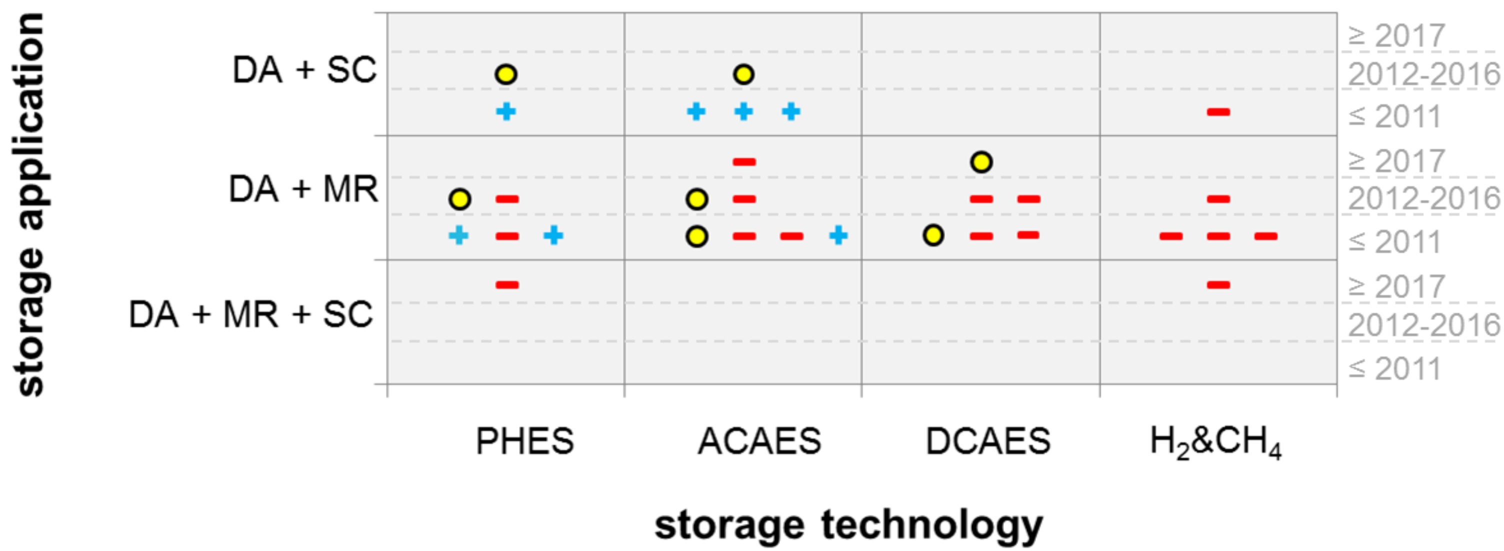
- Spot market trading of large-scale storage



PHES = Pumped Hydro Energy Storage, A/DCAES = Adiabatic/Diabatic Compressed Air Energy Storage, ID = intraday spot market, DA =DayAhead spot market

Exemplary Results of the Metastudy Energy Storage
Economic Efficiency of Energy Storage – Cluster 2a

- Provision of balancing power by large-scale storages



PHES = Pumped Hydro Energy Storage, A/DCAES = Adiabatic/Diabatic Compressed Air Energy Storage, DA =DayAhead spot market, SC = secondary control, MR = minutes reserve

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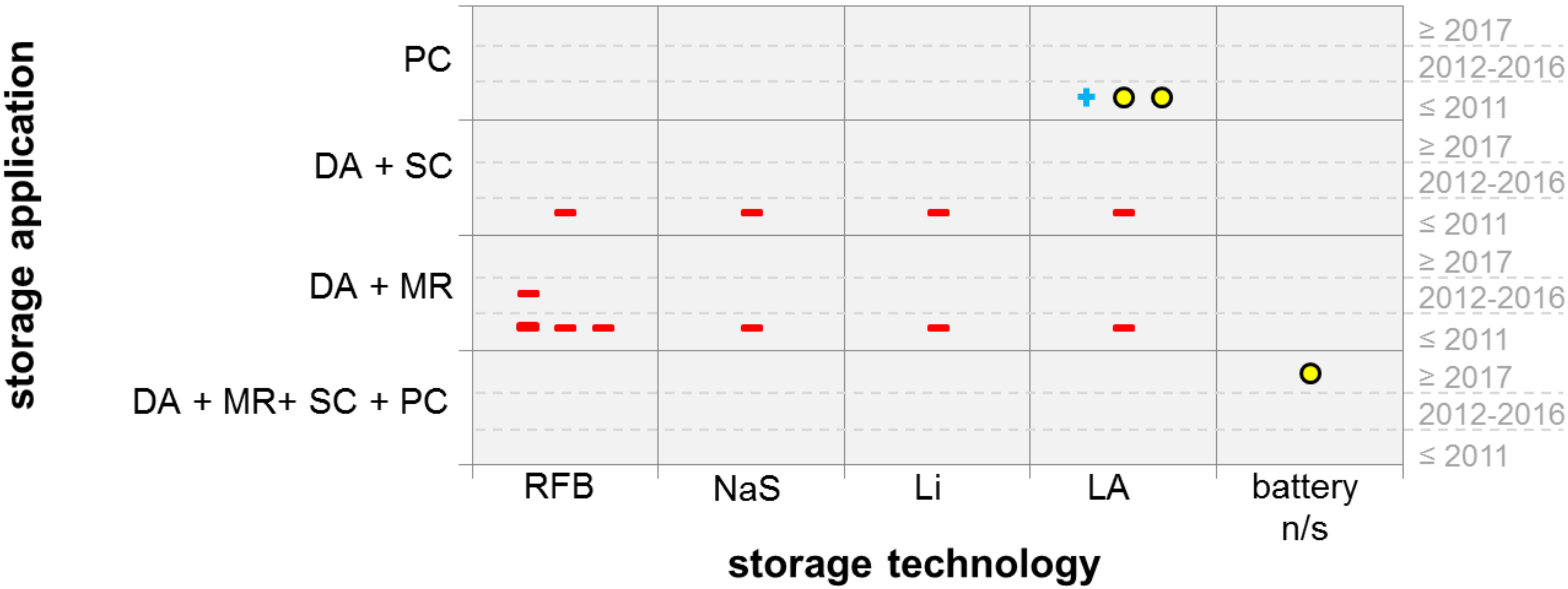
Exemplary Results of the Metastudy Energy Storage
Economic Efficiency of Energy Storage – Cluster 2b/2c

- Provision of balancing power by stationary batteries
- Provision of balancing power by mobile batteries (PHEV) (only two sources in total stating economic efficiency)



RFB = Redox-Flow-Battery, LA = Lead Acid battery, DA =DayAhead spot market, SC = secondary control, MR = minutes reserve , PC = primary control

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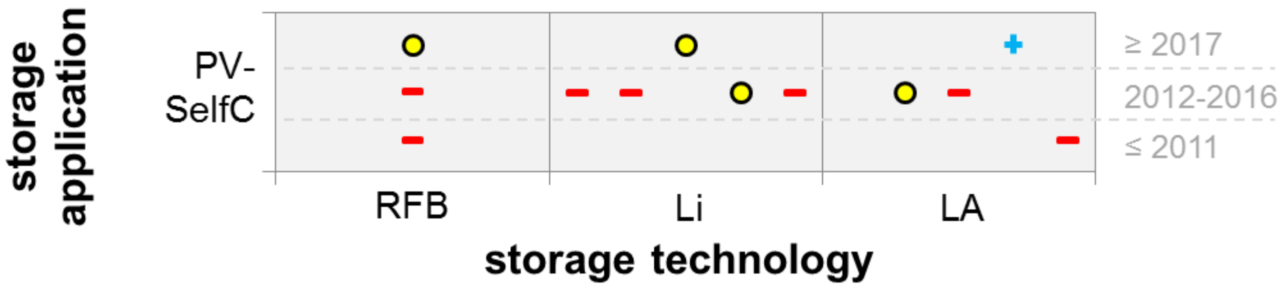
Exemplary Results of the Metastudy Energy Storage
Economic Efficiency of Energy Storage – Cluster 3

- Increase of PV-self-consumption by small-scale batteries



RFB = Redox-Flow-Battery, LA = Lead Acid battery, PV-SelfC = PV-Self-Consumption

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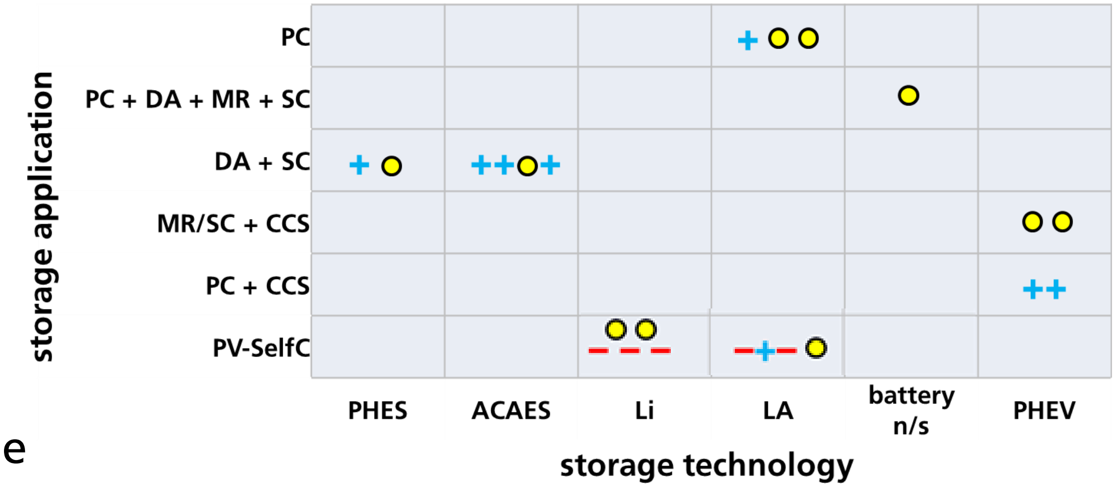
Exemplary Results of the Metastudy Energy Storage

Economic Efficiency of Energy Storage – Conclusion

- Only few studies on primary control, but consistently showing economic efficiency for batteries providing primary control.
- For mobile batteries economic efficiency can be reached with primary control, secondary control (negative) as well as minutes reserve (negative).
- In the future, the combination of PV-self-consumption and small-scale batteries could be economically feasible.

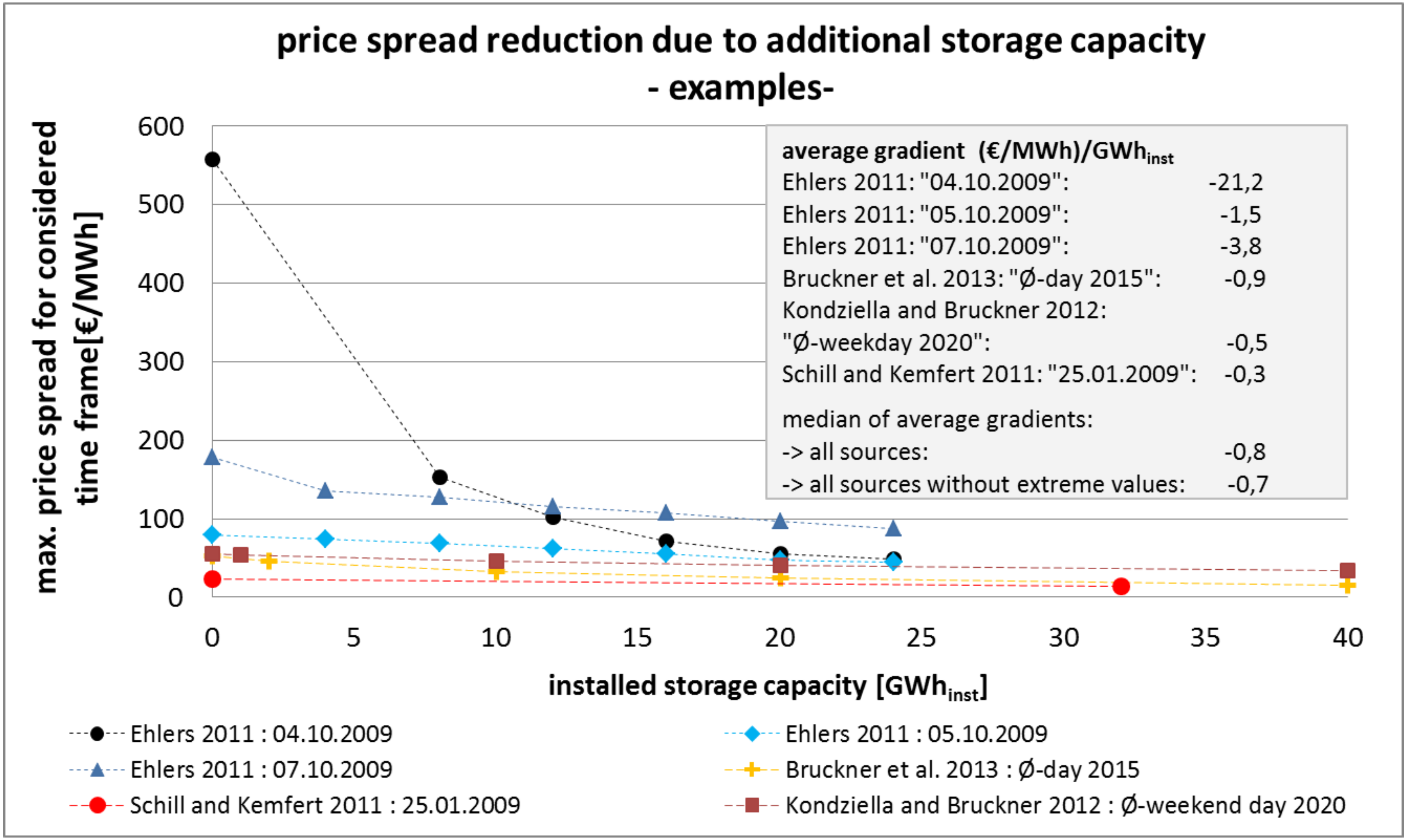


- In the past, the combination of large-scale storage and secondary control (negative) could be economically operated.
- Due to lack of data predictions on the future economic efficiency of all other applications are difficult to be derived.

PHES = Pumped Hydro Energy Storage, ACAES = Adiabatic/Diabatic Compressed Air Energy Storage, PHEV = Plug-in-Hybrid-Vehicle, LA= Lead Acid battery, PC = primary control, DA =DayAhead spot market, SC = secondary control, MR = minutes reserve , CCS = Charging Current Substitution, PV-SElfC = PV-Self-Consumption

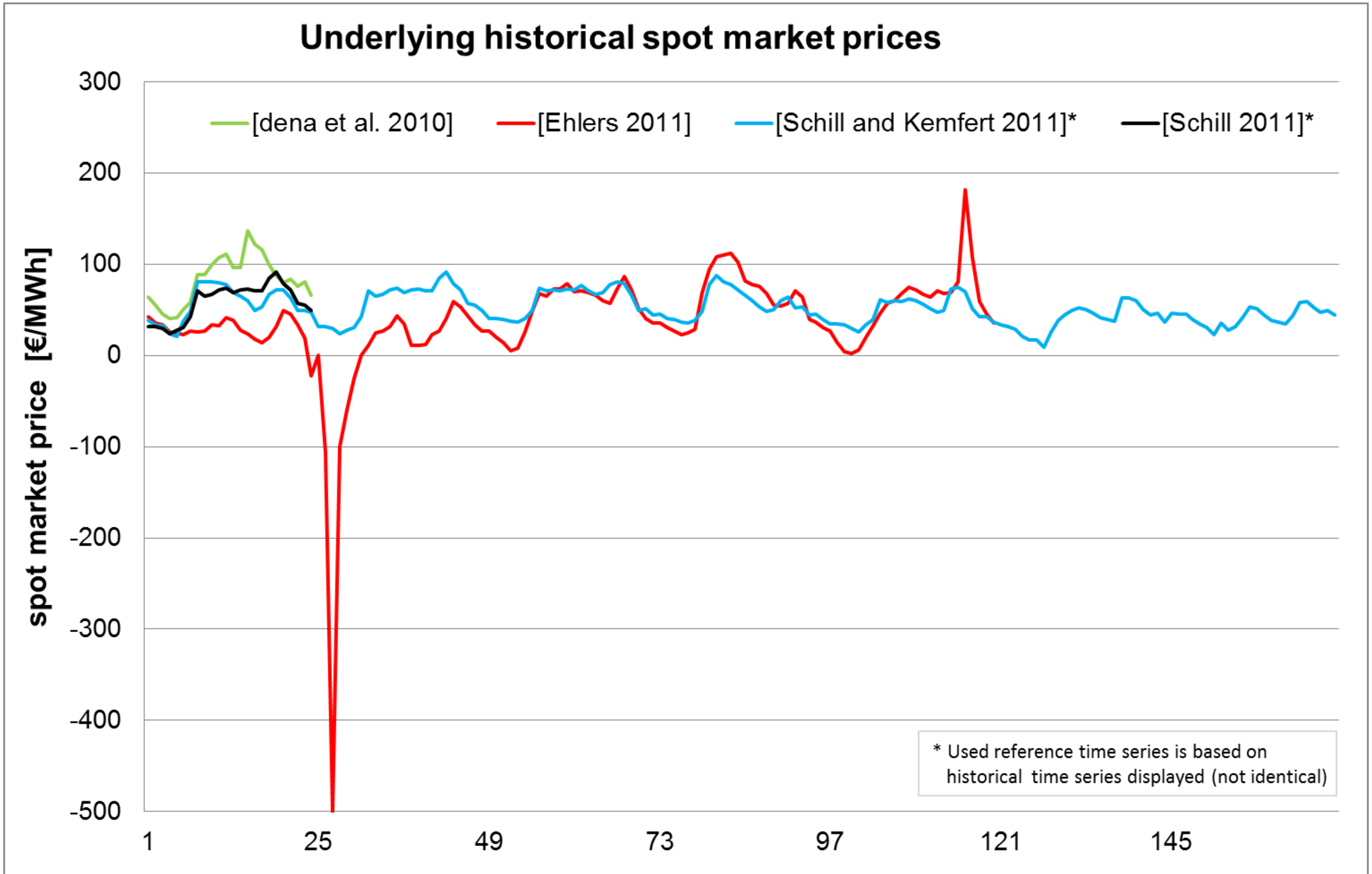
Exemplary Results of the Metastudy Energy Storage

Impact of Energy Storage on the Energy Market



Exemplary Results of the Metastudy Energy Storage

Impact of Energy Storage on the Energy Market



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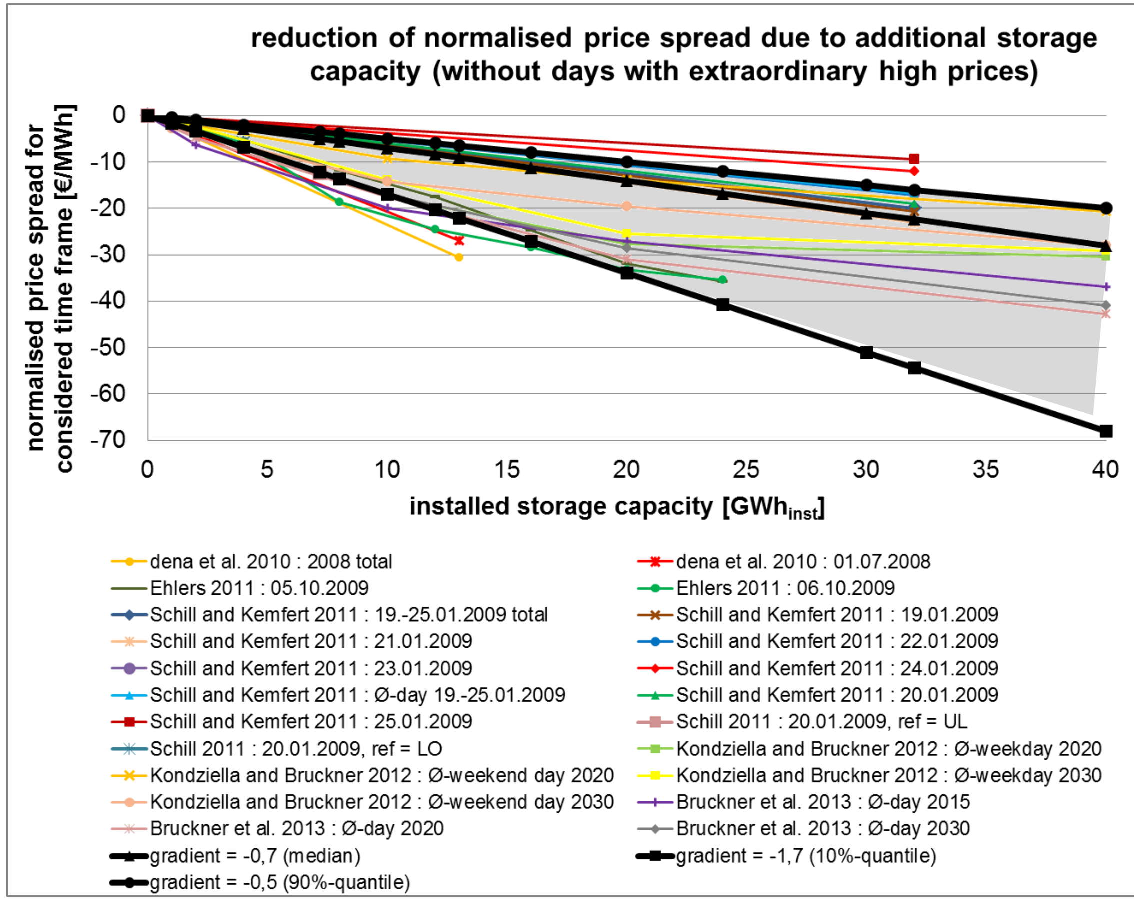
Exemplary Results of the Metastudy Energy Storage

Impact of Energy Storage on the Energy Market - Conclusion

- Main effect: smoothing of market price due to load shifting operation
- Price spread is reduced on average by 0.5-1.7 €/MWh per GWh storage capacity (median: -0.7 (€/MWh)/GWh_{inst}).
- Reduction is strongly depending on the chosen time series and not linear but reaching a threshold.



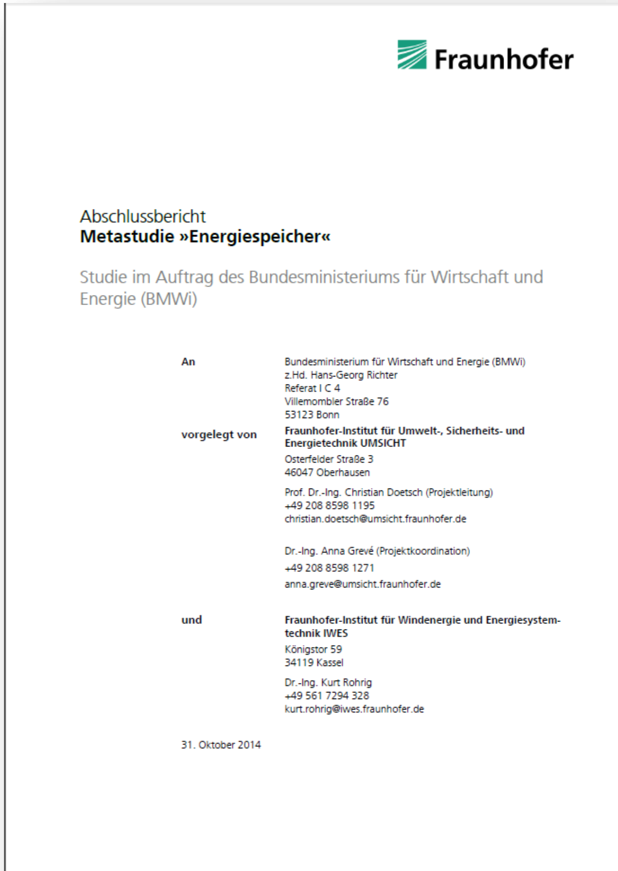
Summary / Conclusion

- Energy balancing demand is driven by high share of variable renewable energies
- There is a bunch of different electric energy storage applications with individual advantages and disadvantages (PHES, CAES, Batteries etc.)
- CAPEX are mostly high (but PHES), but decreasing due to development
- There are more balancing / flexibility opportunities: e.g. "functional energy storages" like Demand-Side-Management, virtual power plants etc.
- Future energy balancing ("storage") demand depends on both economic / technical framework and balancing options/technologies
- Currently there are no/less market driven energy storage business cases, but in the near future the self consumption of electricity from PV (<10kW)

Conclusion

- "Storage" demand is forecasted, business cases are not existing
  => market design has to be improved

Metastudy Energy Storage (2015)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Abschlussbericht
Metastudie »Energiespeicher«

Studie im Auftrag des Bundesministeriums für Wirtschaft und Energie (BMWi)

An	Bundesministerium für Wirtschaft und Energie (BMWi) z.Hd. Hans-Georg Richter Referat I C 4 Villemombler Straße 76 53123 Bonn
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31. Oktober 2014

- Published by Fraunhofer UMSICHT and Fraunhofer IWES, 2015, May
- Funded by BMWi
- More than 800 sources to 20 key questions in 7 work packages were investigated
- Approx. 400 studies were evaluated
- 271 pages
- Free download available (PDF)
- Summary (Short version) will be available soon

www.umsicht.fraunhofer.de/de/presse-medien/2015/metastudie-energiespeicher.html

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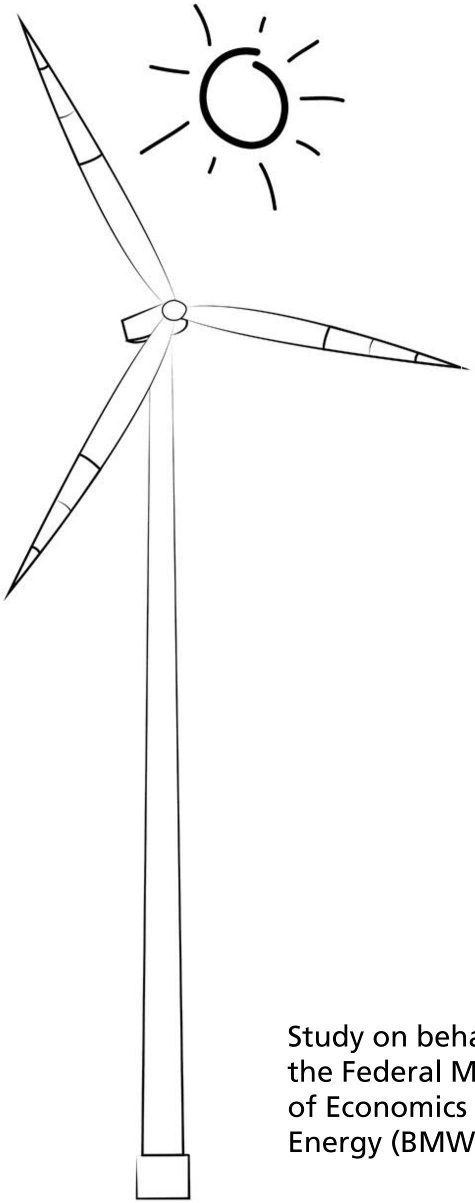

Study on behalf of
the Federal Ministry
of Economics and
Energy (BMWi)

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