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Energiewende – Gut vernetzt?
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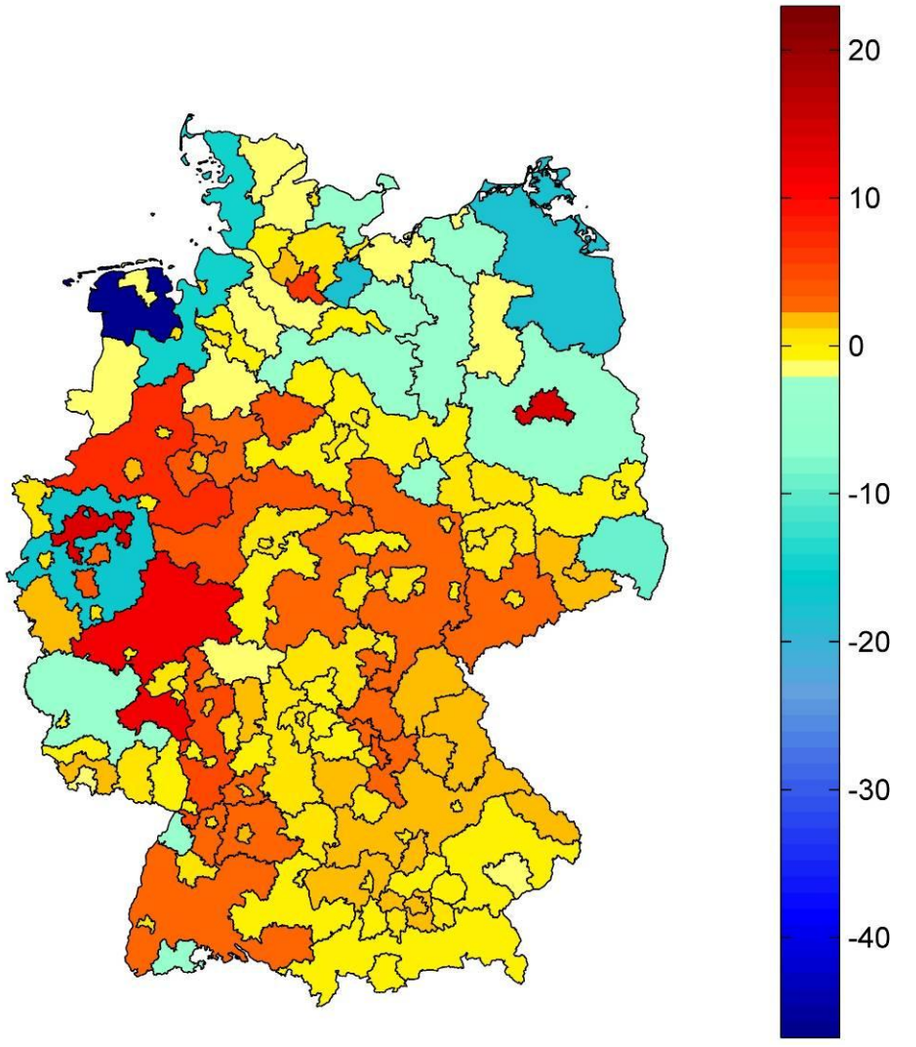
Future Energy Storage/Balancing Demand

Dr. Christian Doetsch

Fraunhofer UMSICHT
Germany



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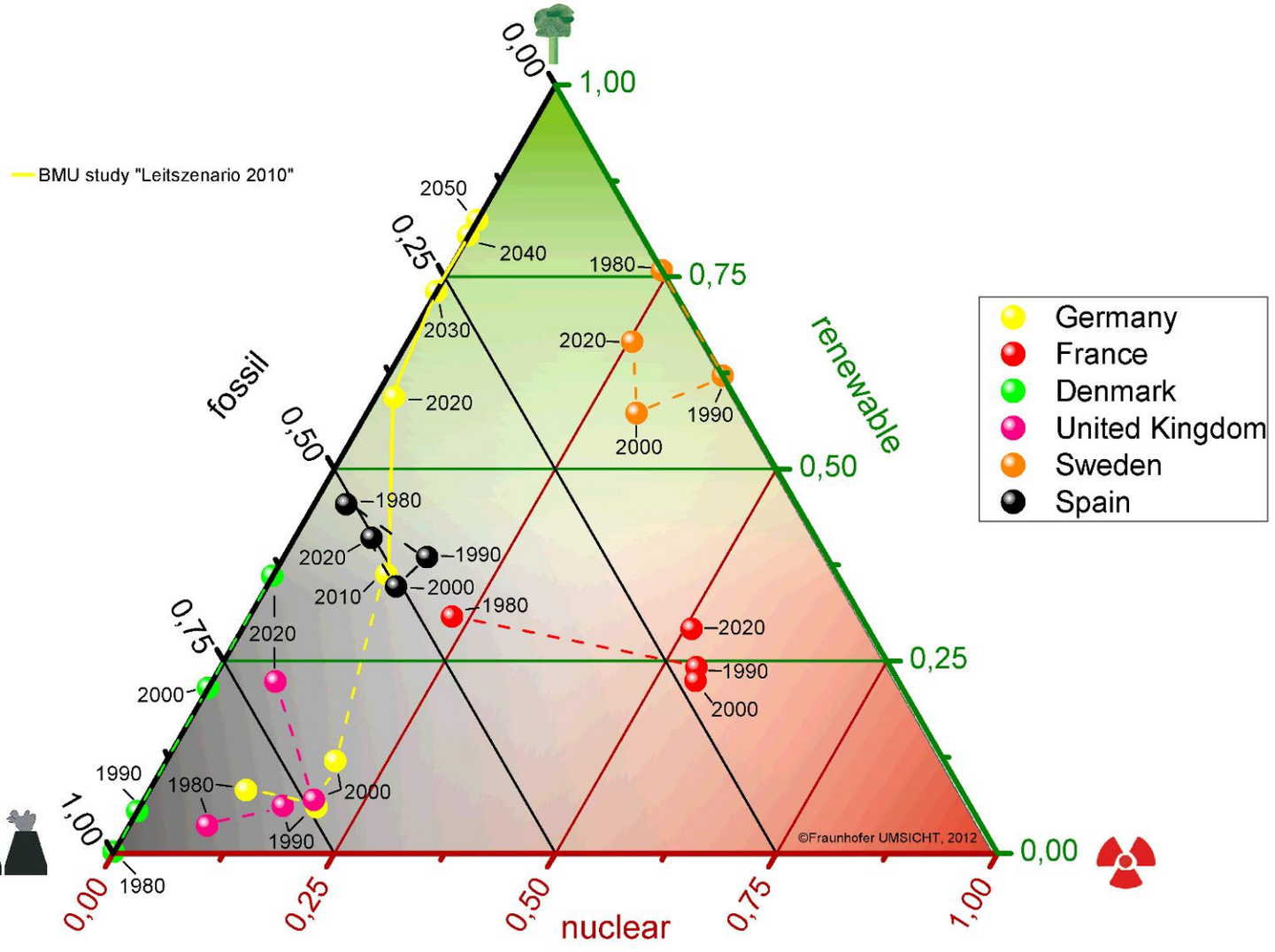
Change of the electric energy system

- **Energy System**
  - change to renewable energies
  - much more fluctuations
  - less base load power plants
- **Challenges**
  - balancing the grid at each time
  - managing the temporary surplus or lack of energy

Need of energy balancing devices

Installed electricity generation power in different european countries



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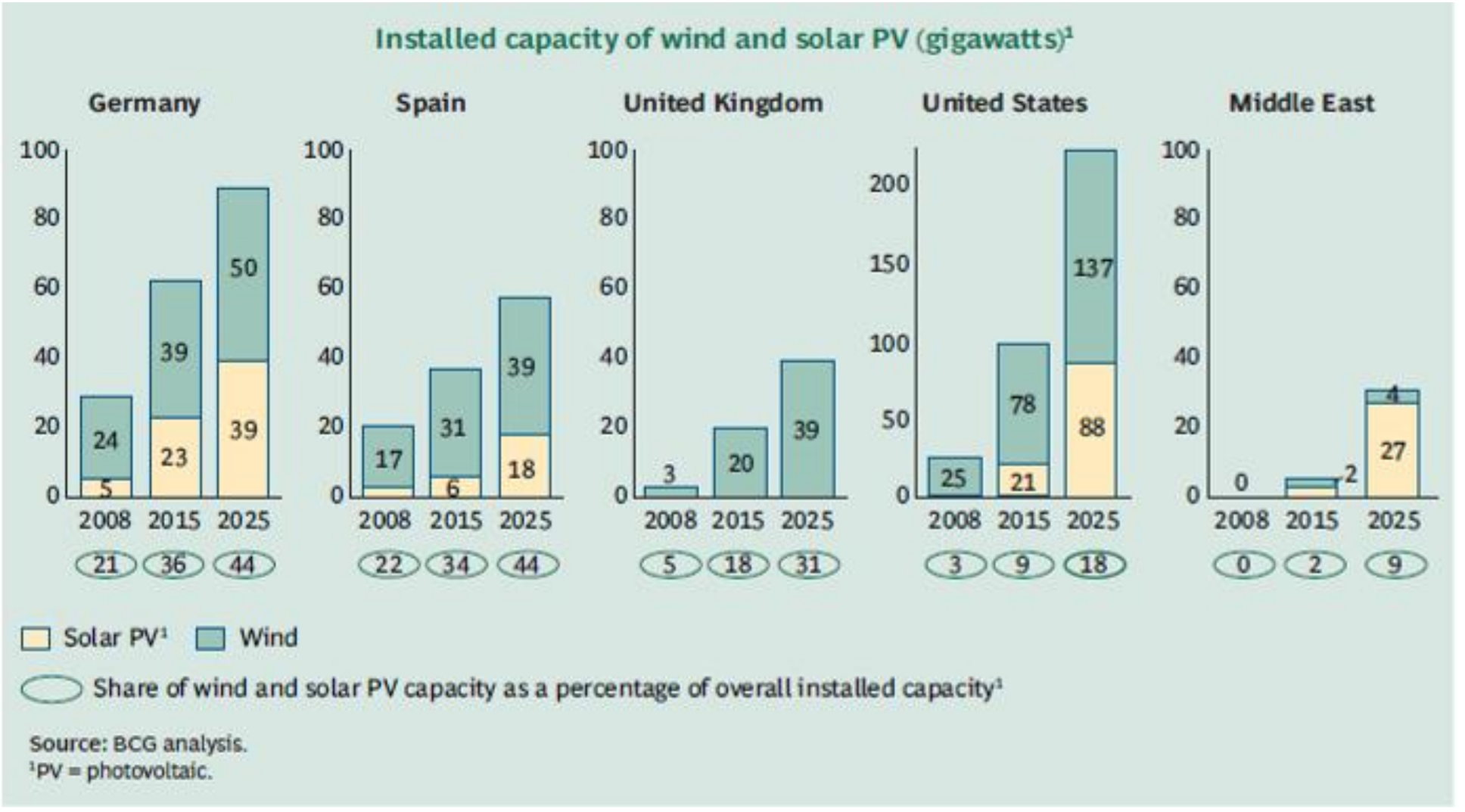
Growth in Demand for Wind and Solar PV Will Likely Be Strong Across All Major Regions Through 2025



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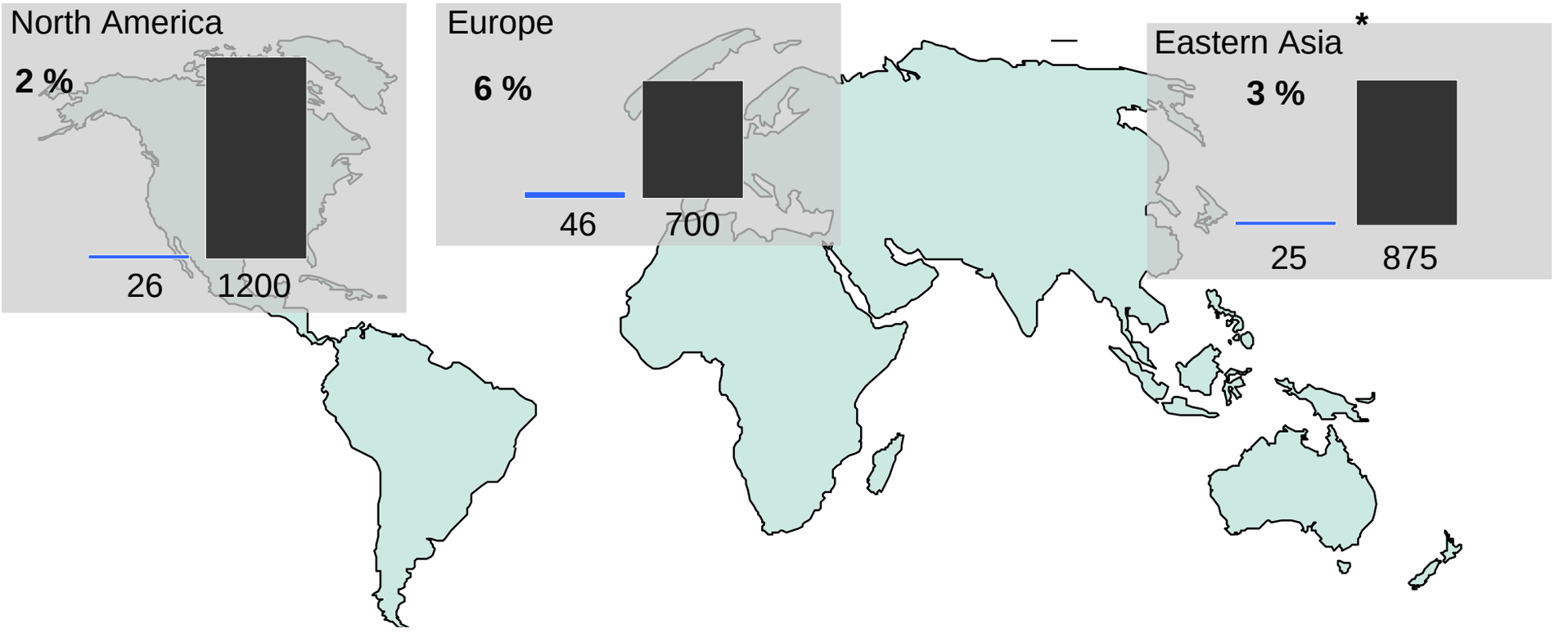
Installed energy storage system vs. installed generation capacity



*** Japan, China, Korea, Taiwan**

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Worldwide installed storage capacity for electrical energy (2010)

CAES	**477 MW_{el}**	Compressed Air Energy Storage
NaS	**302 MW_{el}**	Sodium-Sulphur Battery
LA	**125 MW_{el}**	Lead-Acid Battery
Redox	**38 MW_{el}**	Redox-Flow Battery
NiCd	**26 MW_{el}**	Nickel-Cadmium Battery

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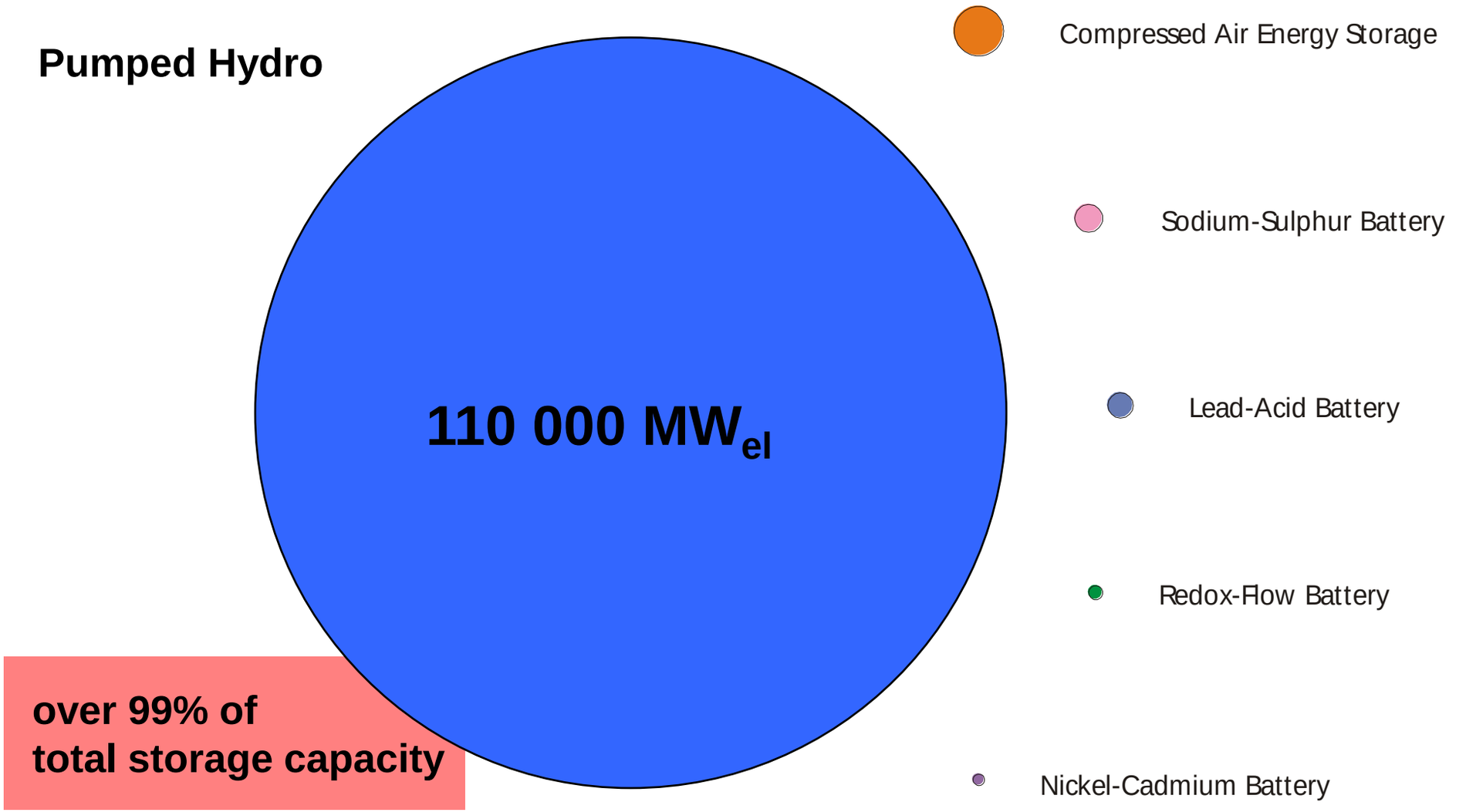
Worldwide installed storage capacity for electrical energy



over 99% of total storage capacity

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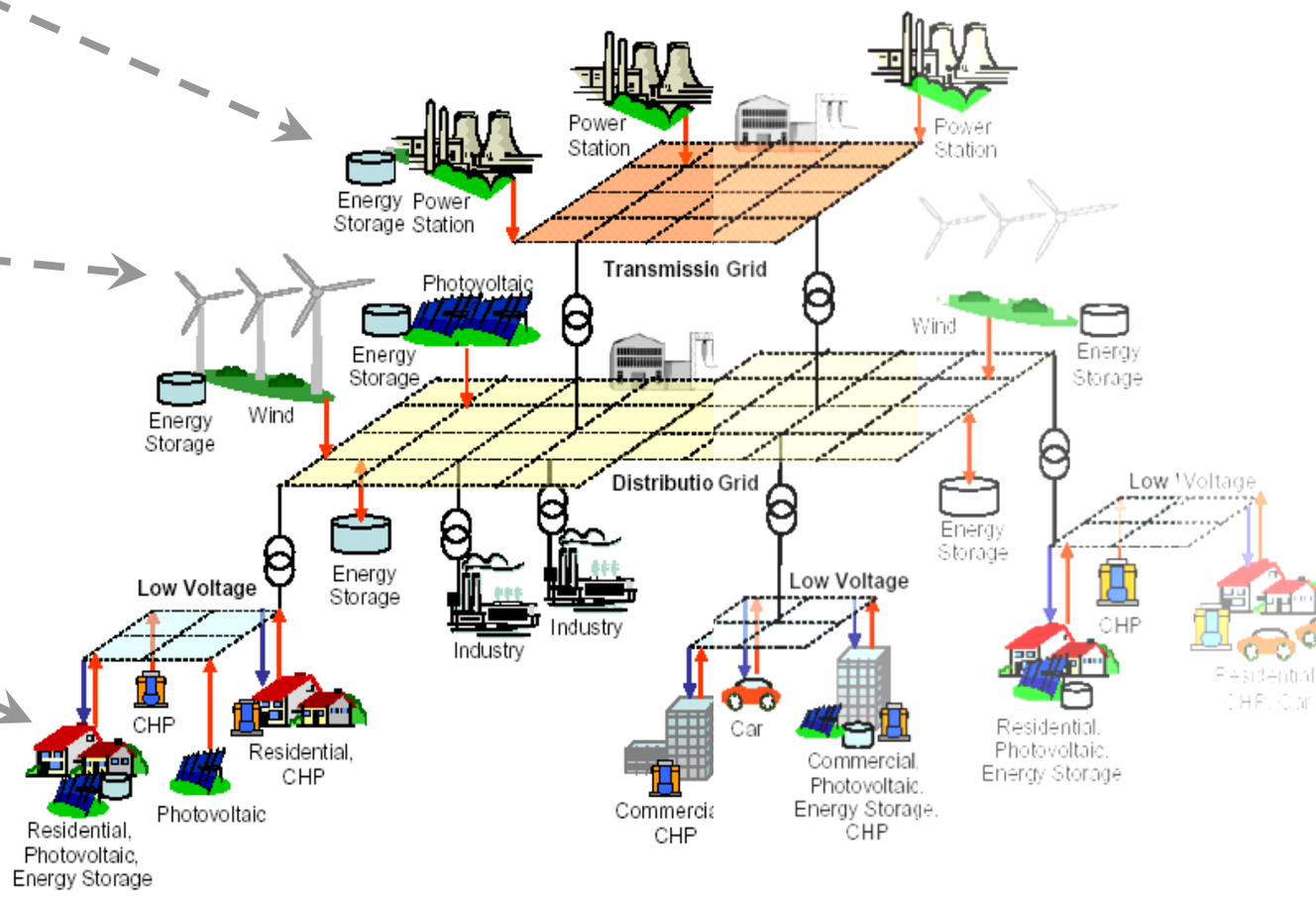
Where (grid-level) could this systems be located ?

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



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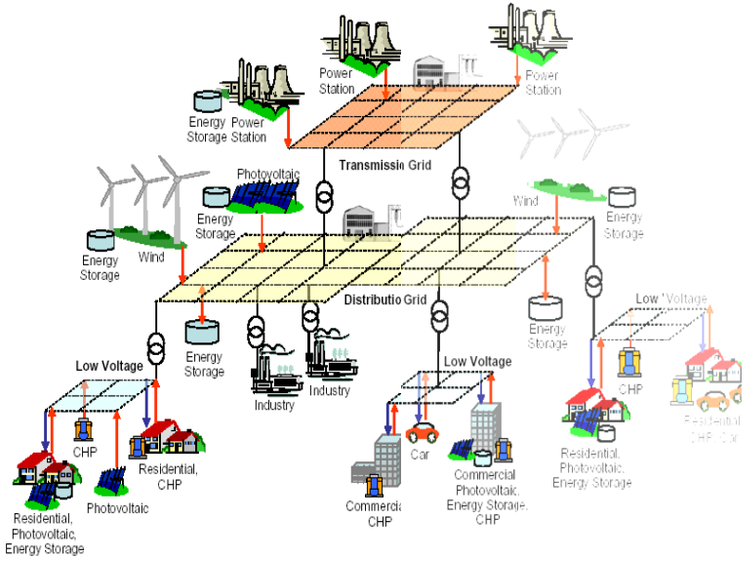
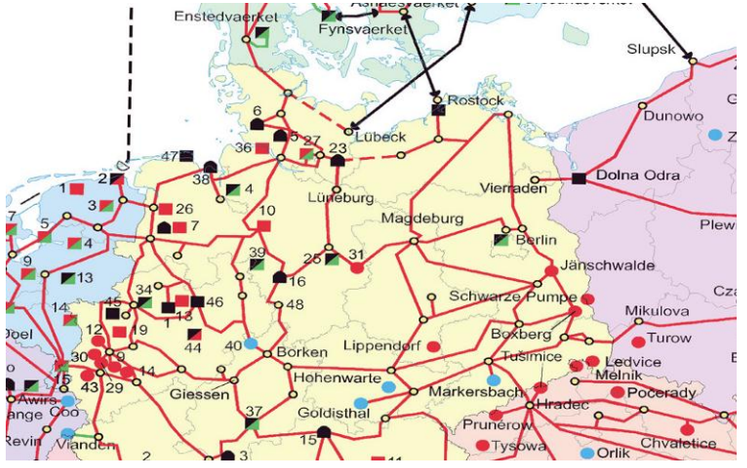
Basic technical framework



- **there is always a real grid no ideal grid**
  - fluctuations are local (e.g. PV) or central (e.g. wind)
  - demand fluctuations are local (household) or central (industry)
  - storages, DSM etc. are always local or central options



- **Germany was, is and will be no island**
  - grid connections to European neighbors
  - embedded to the European grid
  - important for 100% renewable energy scenario

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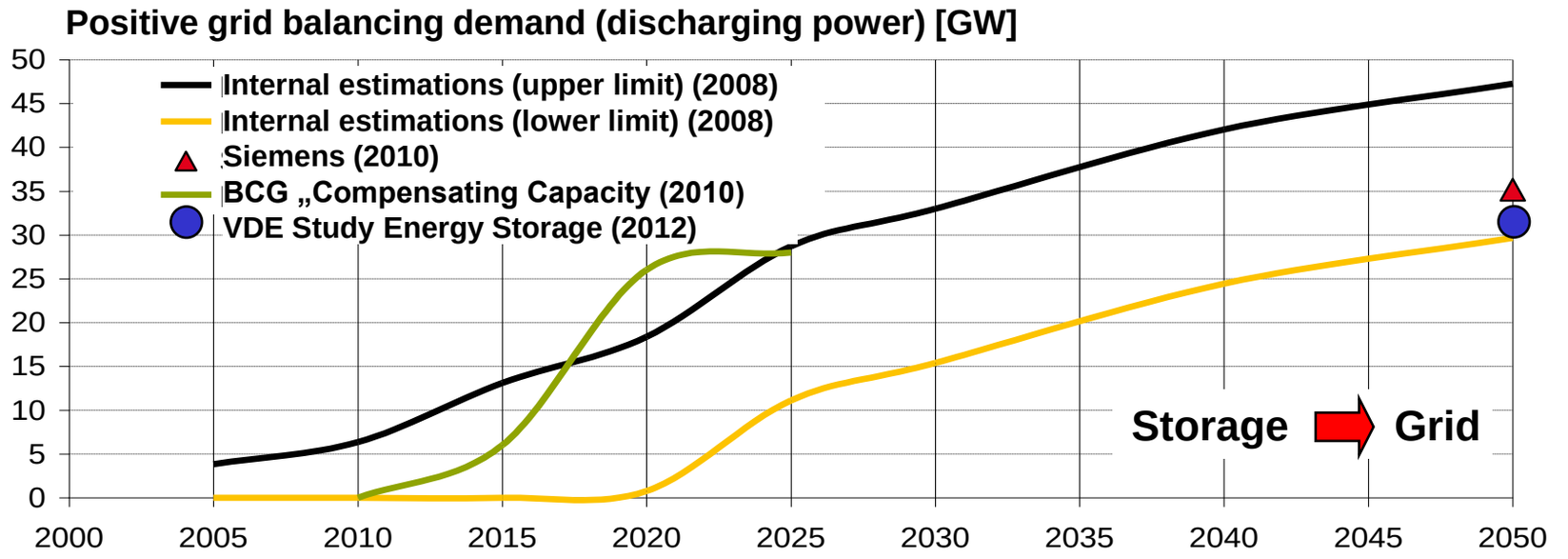
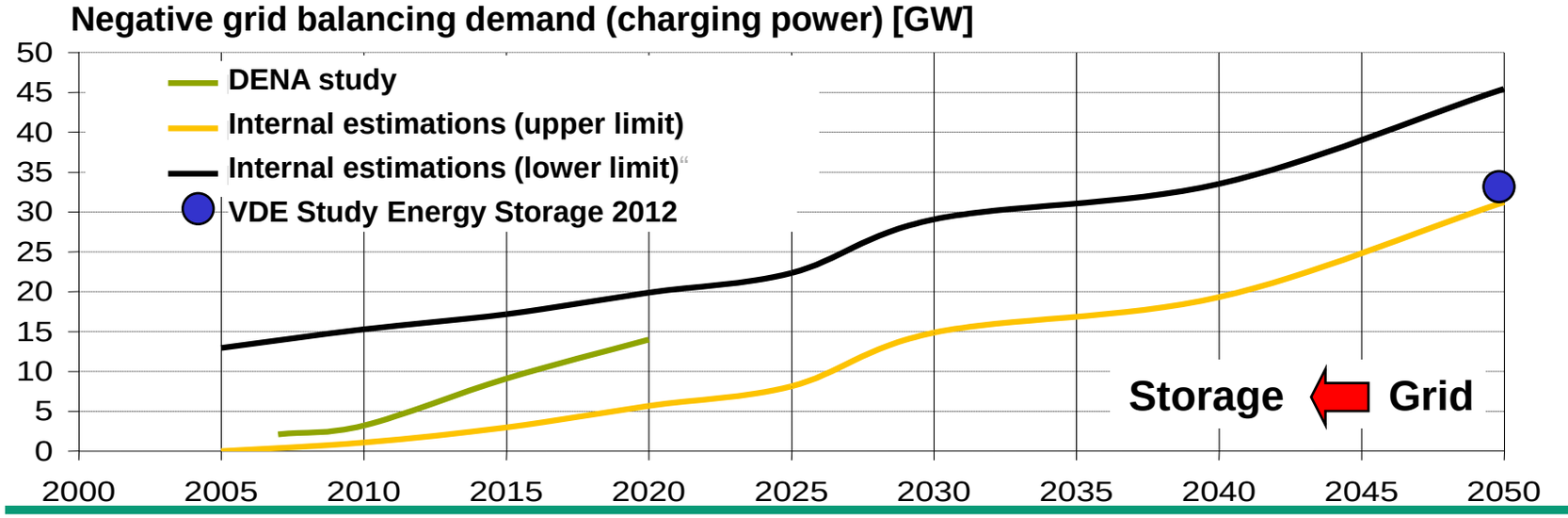
Estimations for Grid Balancing Demand (Germany, Peak Load 90 GW)





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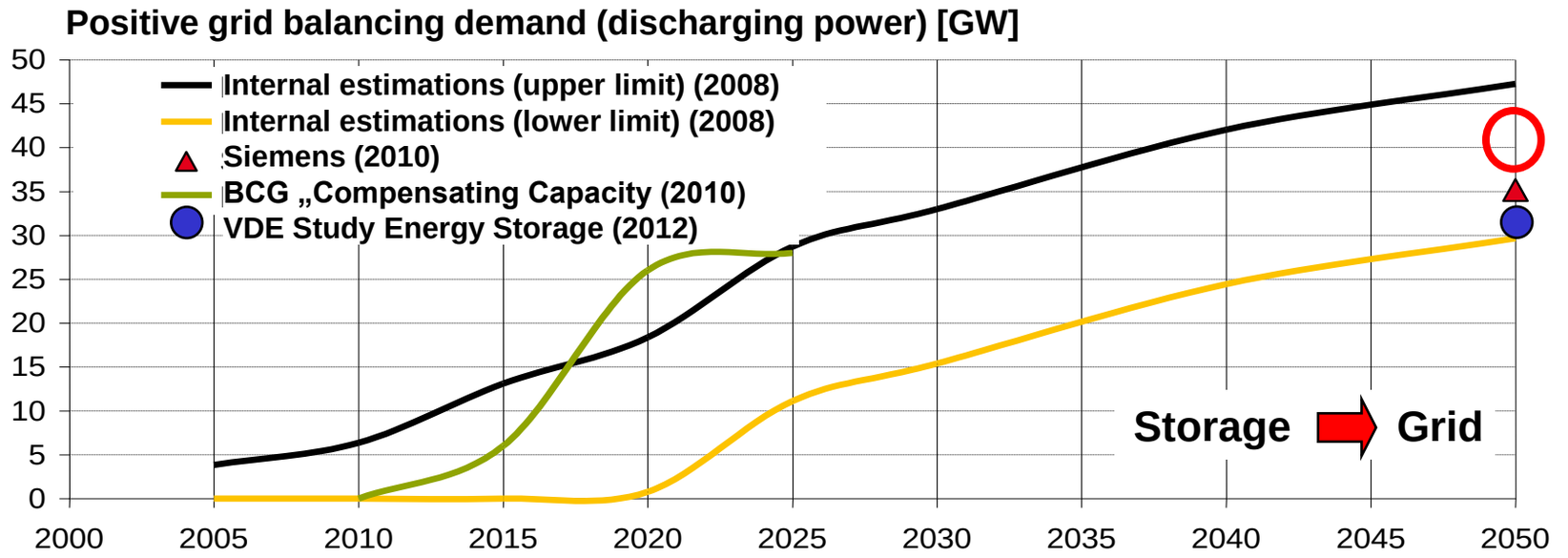
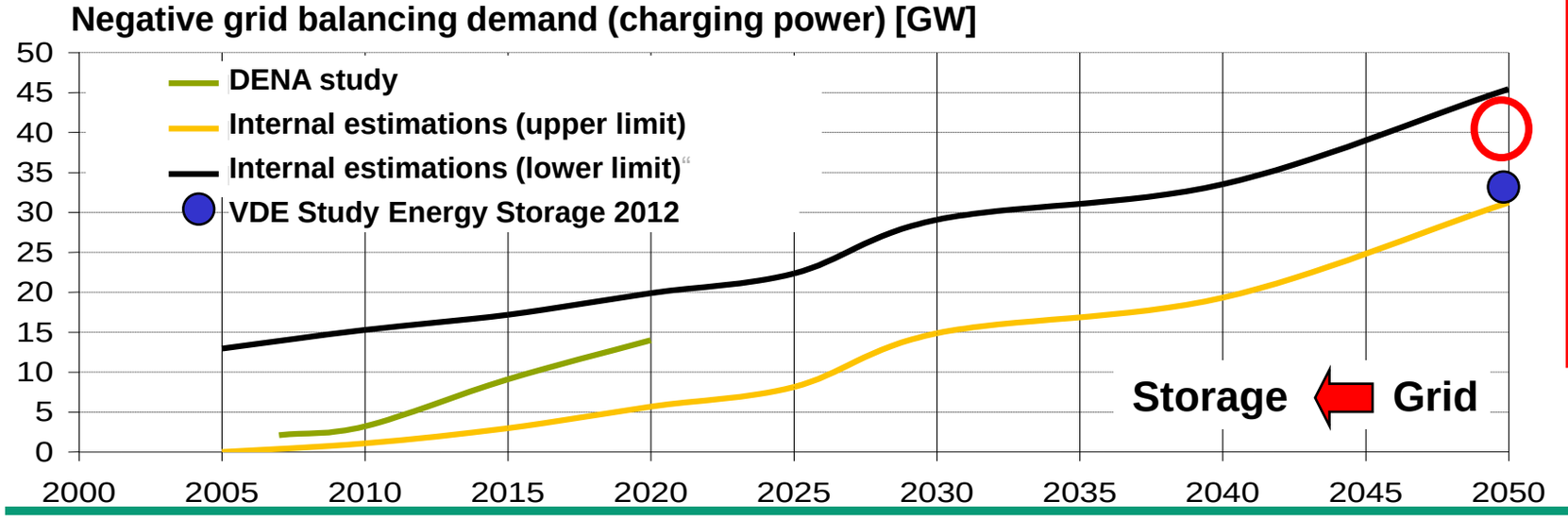
Grid Balancing Demand: Power [GW] vs. Stored Energy [GWh/a]





Example:

Grid Balancing Demand 2050

positive: approx. 40 GW

negative: approx. 40 GW

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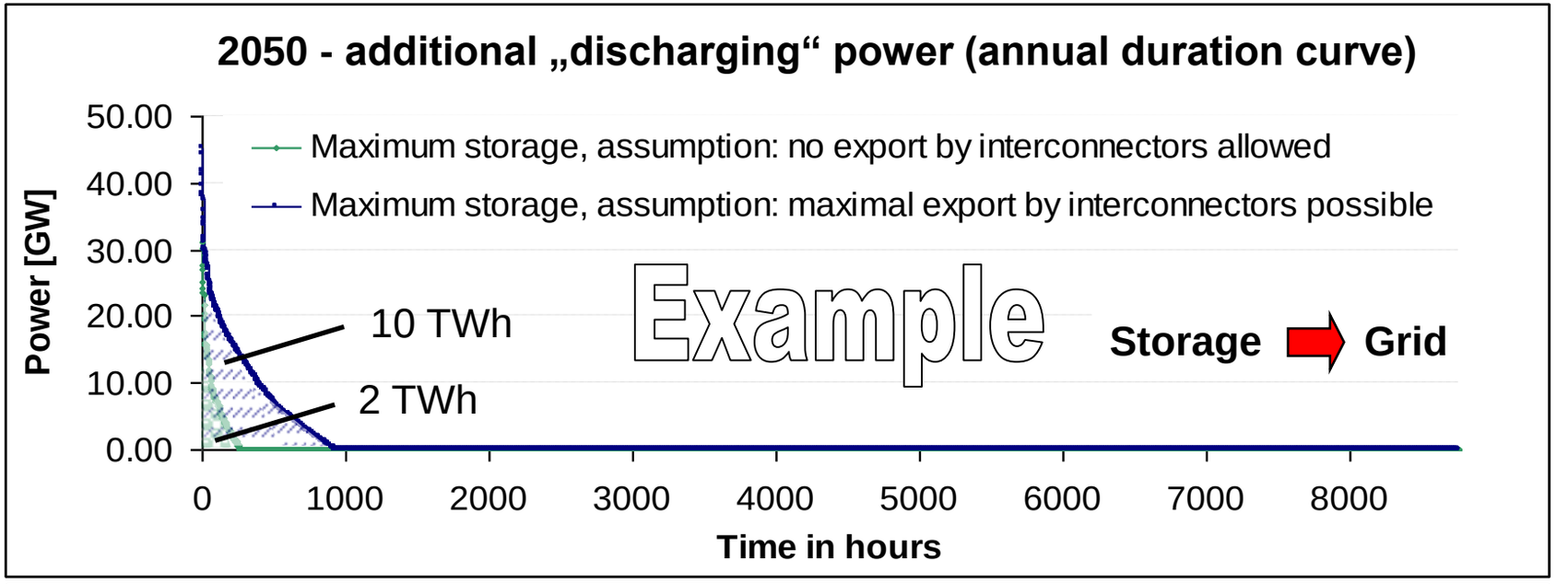
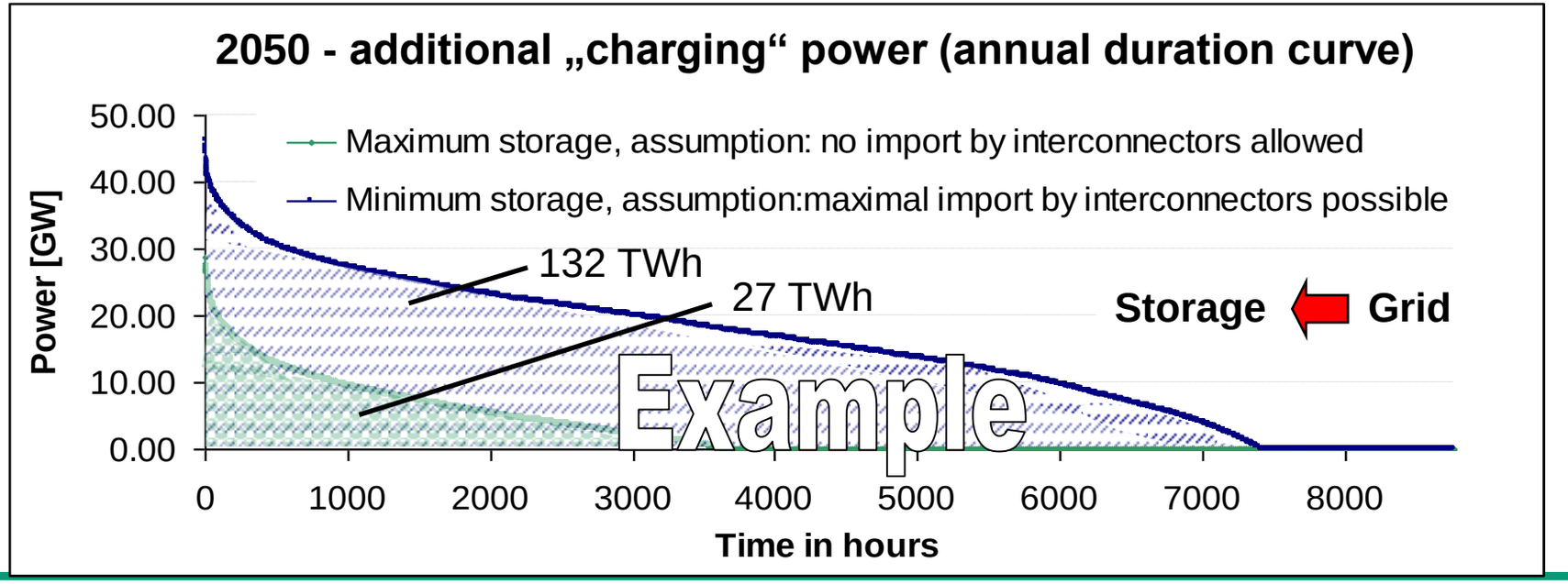
Grid Balancing Demand Analysis: Power vs. Yearly Stored Energy





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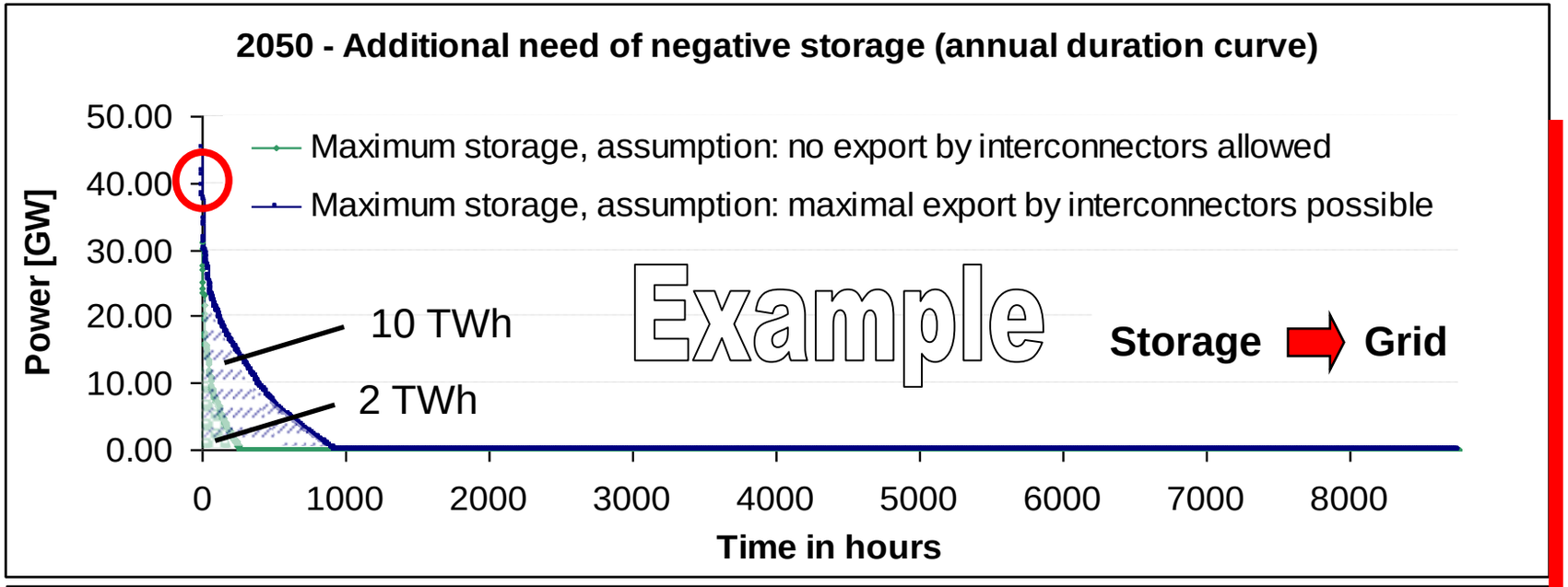
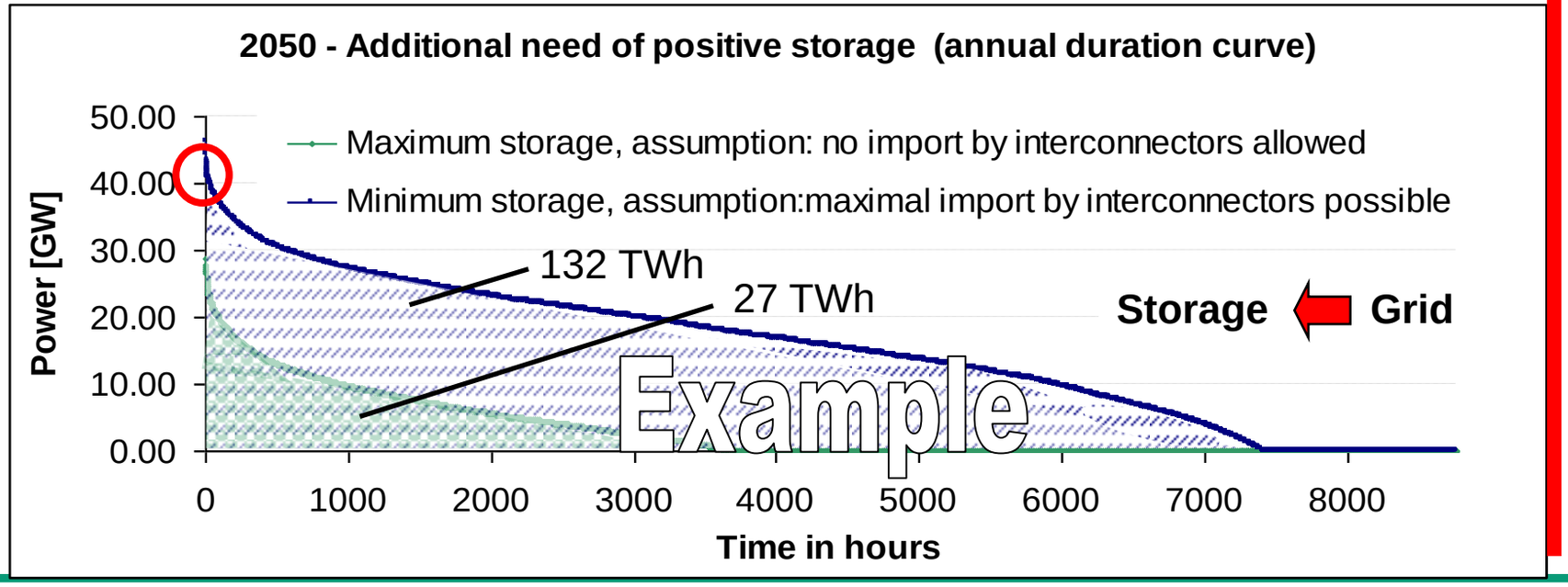
Grid Balancing Demand Analysis: Power vs. Yearly Stored Energy





Example:

Grid Balancing Demand 2050

Discharging: 2-10 TWh

Charging: 27-132 TWh

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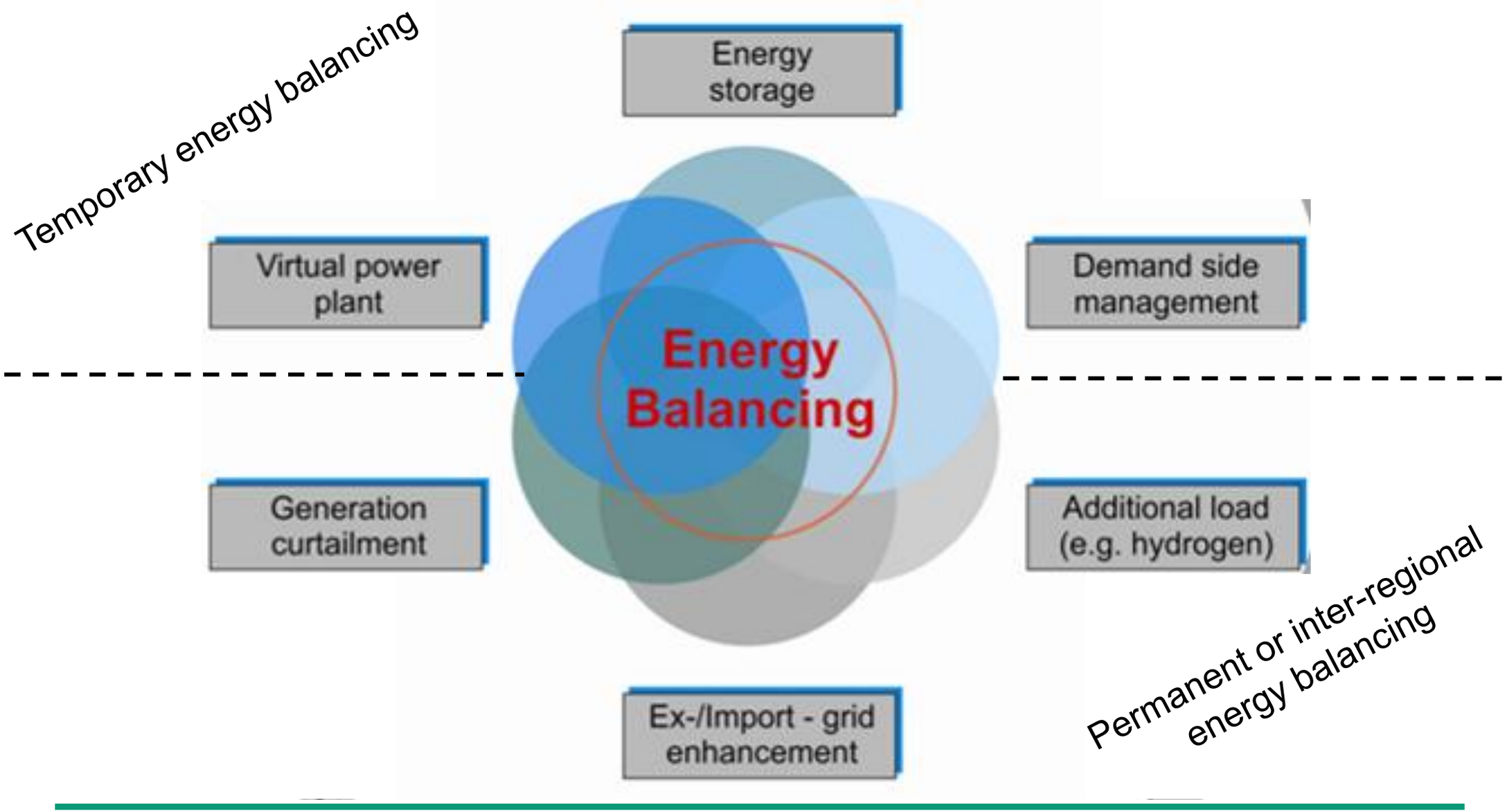
Measurements for “Grid-Balancing”



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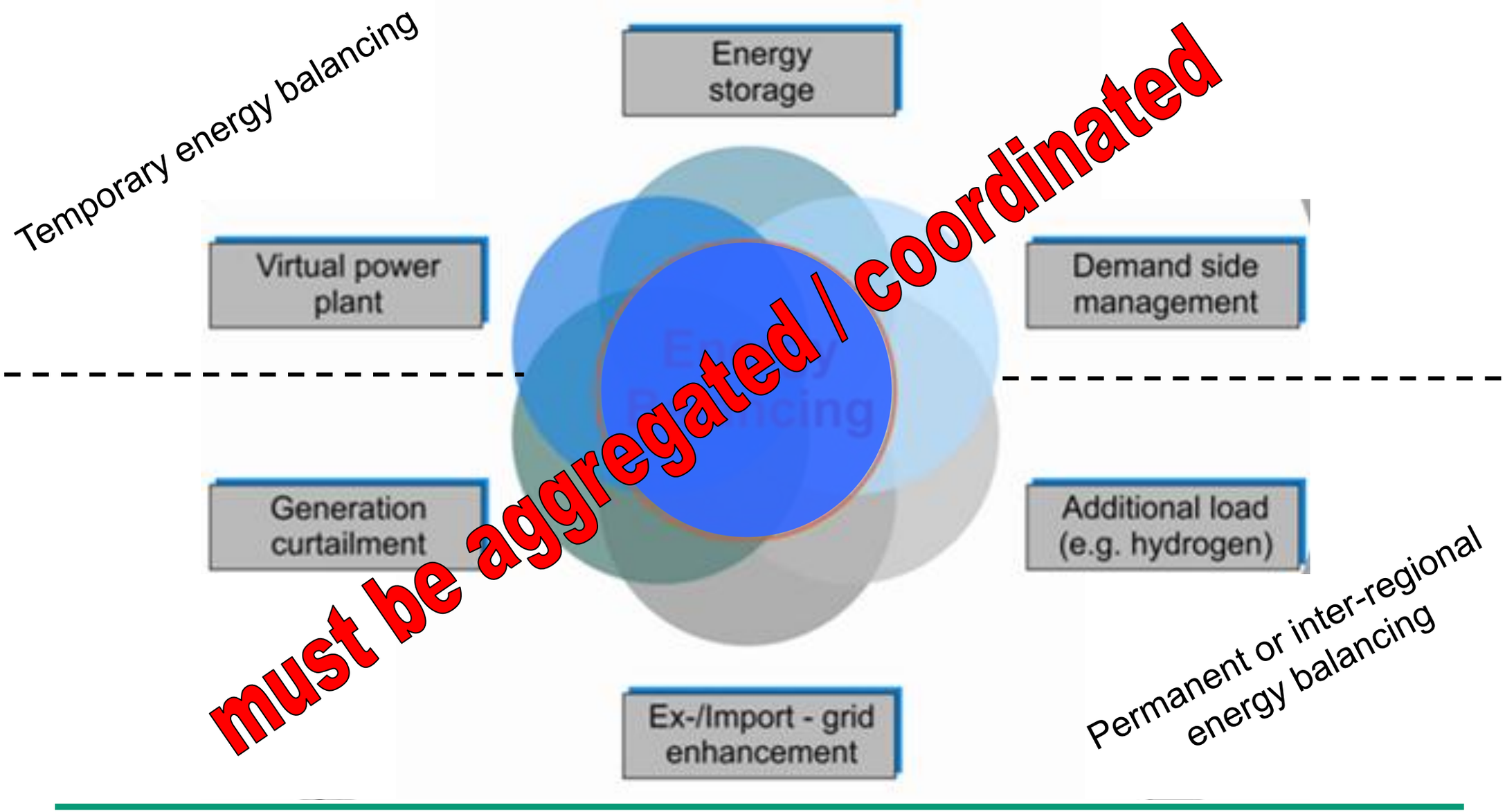
Measurements for “Grid-Balancing”



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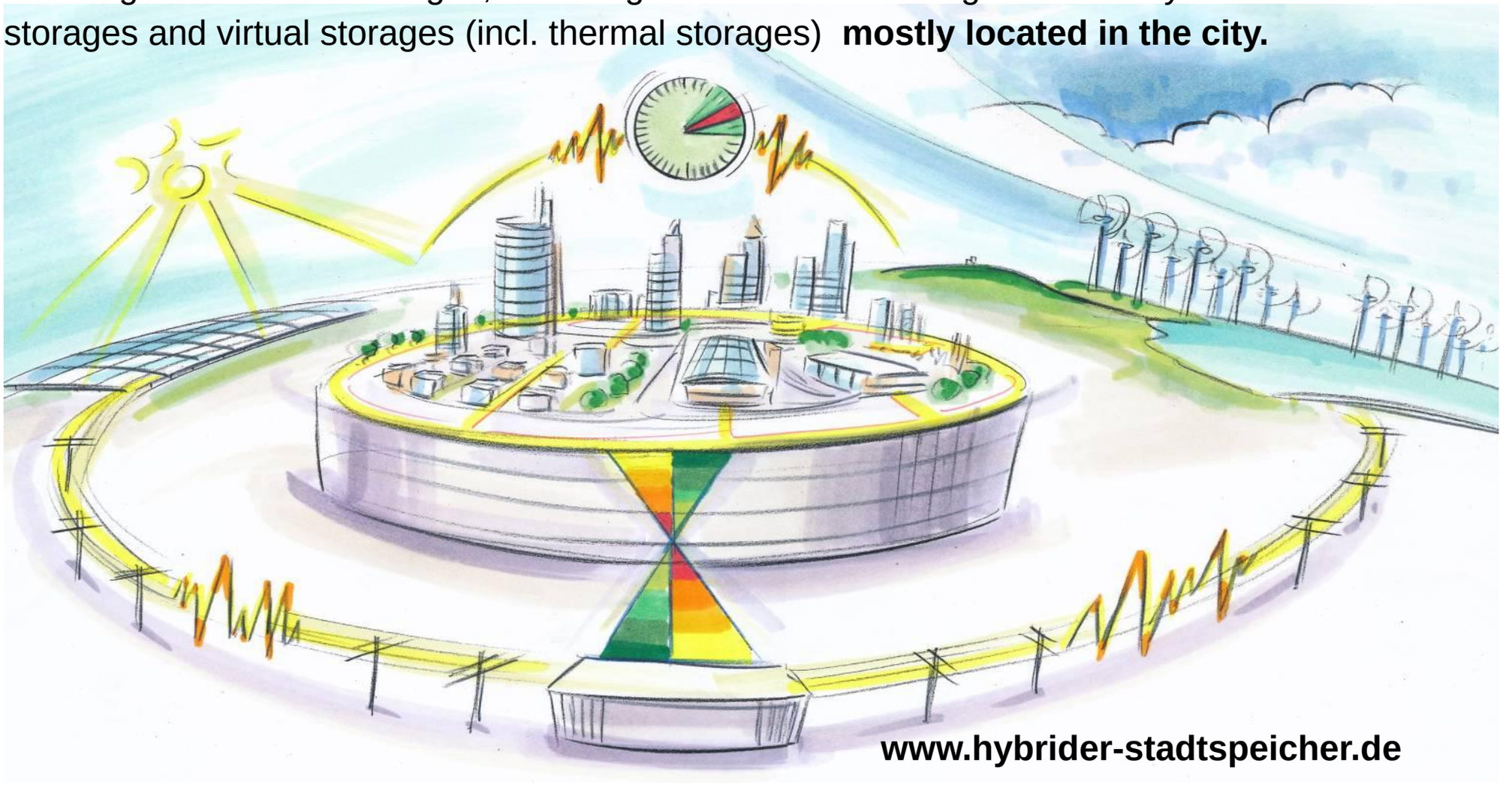
Vision » hybrid urban energy storage «

Realization of high shares of renewable energies by a smart combination of different storages: Few huge centralized storages, some big decentralized storages and many small decentralized storages and virtual storages (incl. thermal storages) **mostly located in the city.**



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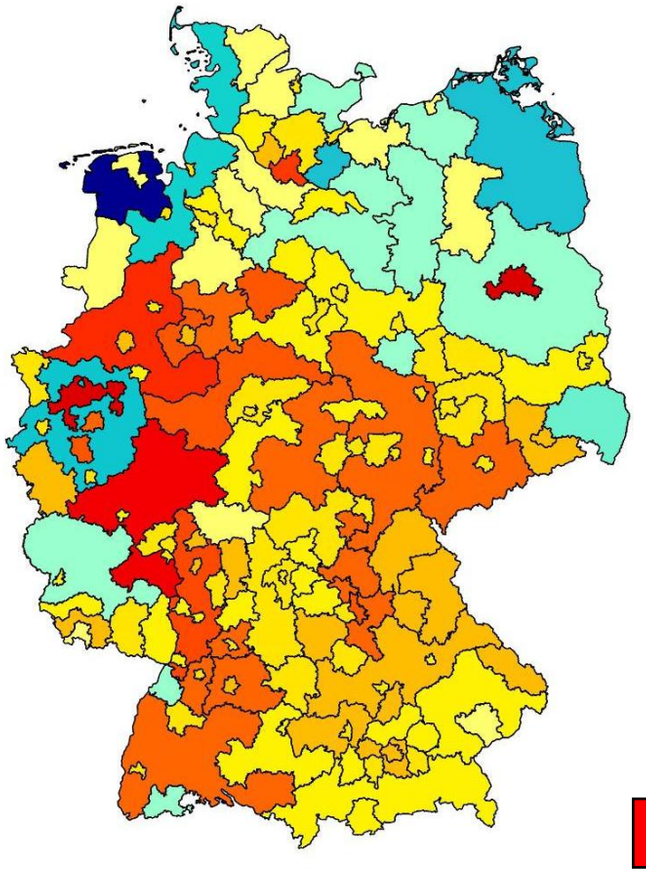
Conclusions



- energy balancing demand will increase due to higher penetration of fluctuating renewable energies
- different storage technologies will be located at different points of the grid and will solve different problems
- Germany has a good but no ideal grid (restrictions) but is embedded in the European grid
- energy balancing demand ≠ energy storage demand
- many different measurements for grid balancing, virtual (e.g. DSM) and real storages must be aggregated and operated in a coordinated way
- economical regulations must support these operations modes

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www.hybrider-stadtspeicher.de

Dr. Christian Doetsch
Tel.: +49 208 8598 1195
christian.doetsch@umsicht.fraunhofer.de