Introduction to Energy storage

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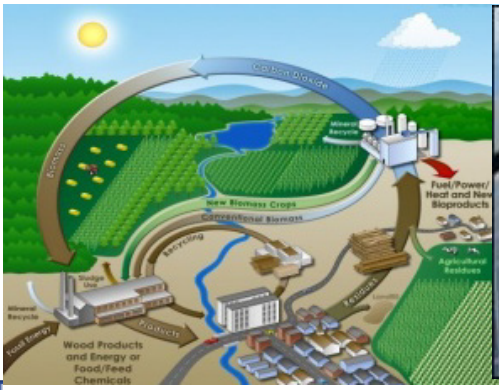


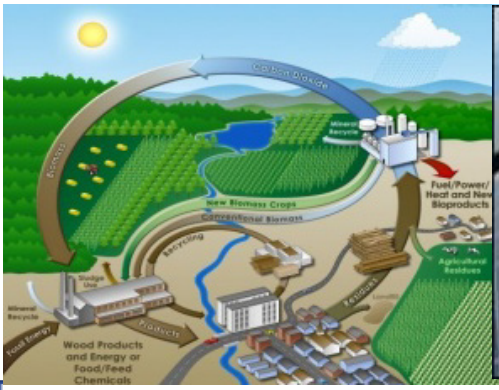


CEDREN
The Research Council of Norway
EERA
European Energy Research Alliance
CenSES
Centre for Sustainable Energy Studies

Challenges for a sustainable energy system

- Sustainable economic growth
- Energy security
- Environmental impact
- Climate and emissions

- What role will energy storage play?





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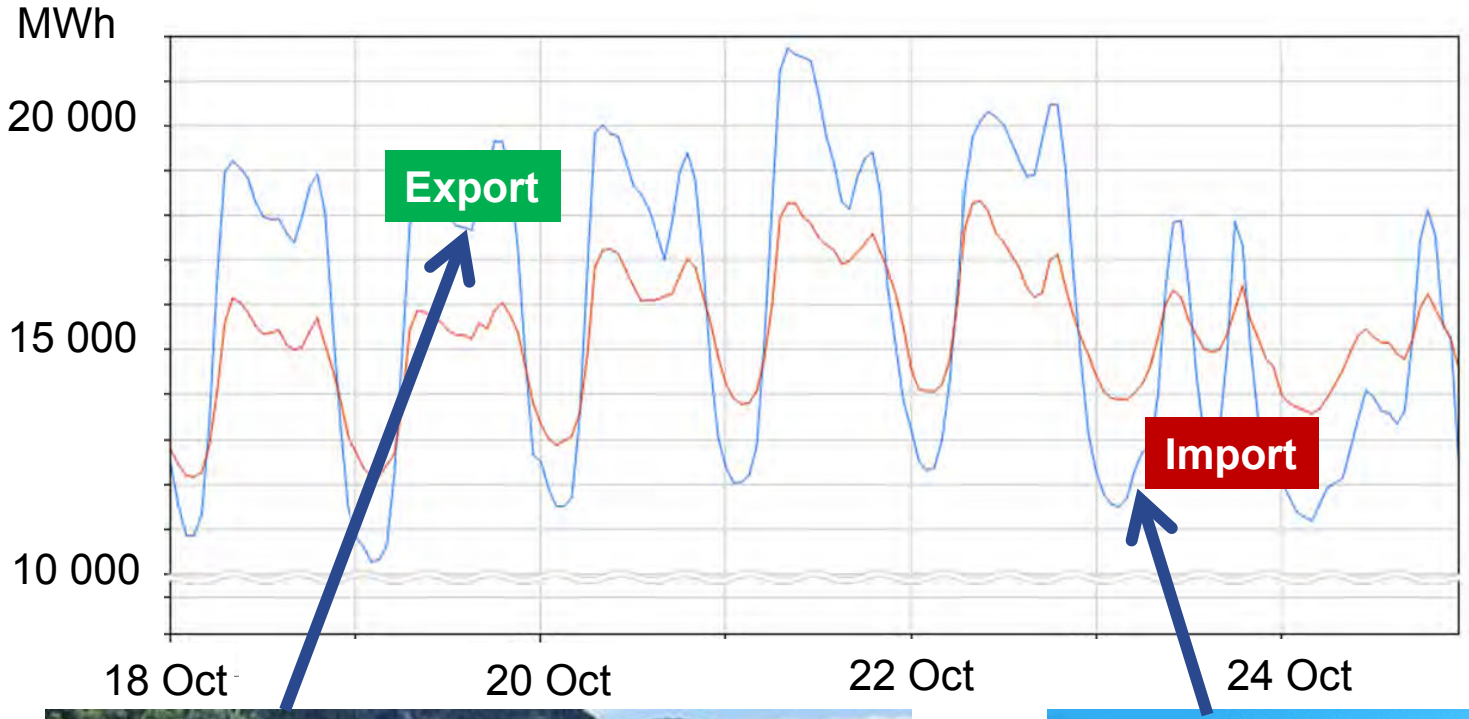
Energy scenarios

- Transmission and distribution infrastructure
- Energy storage technologies
- Demand side management
- Renewable energy
- Electrification and fuel switching
- CCS

Norwegian hydro and Danish wind

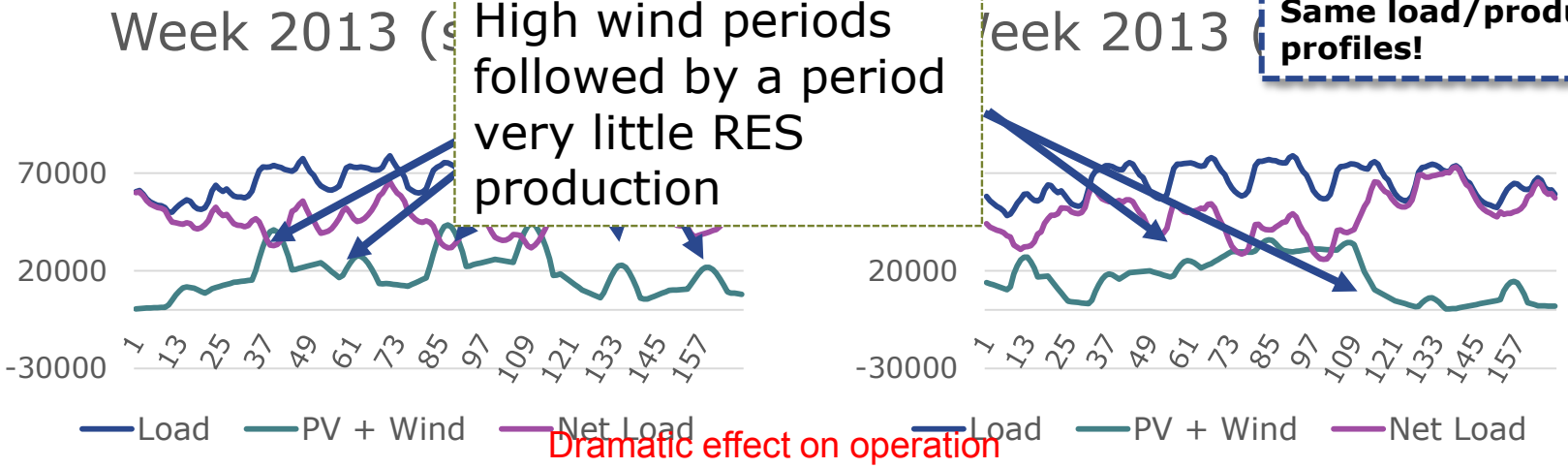


Danish wind cover underproduction

Germany power scenarios 2013/2030

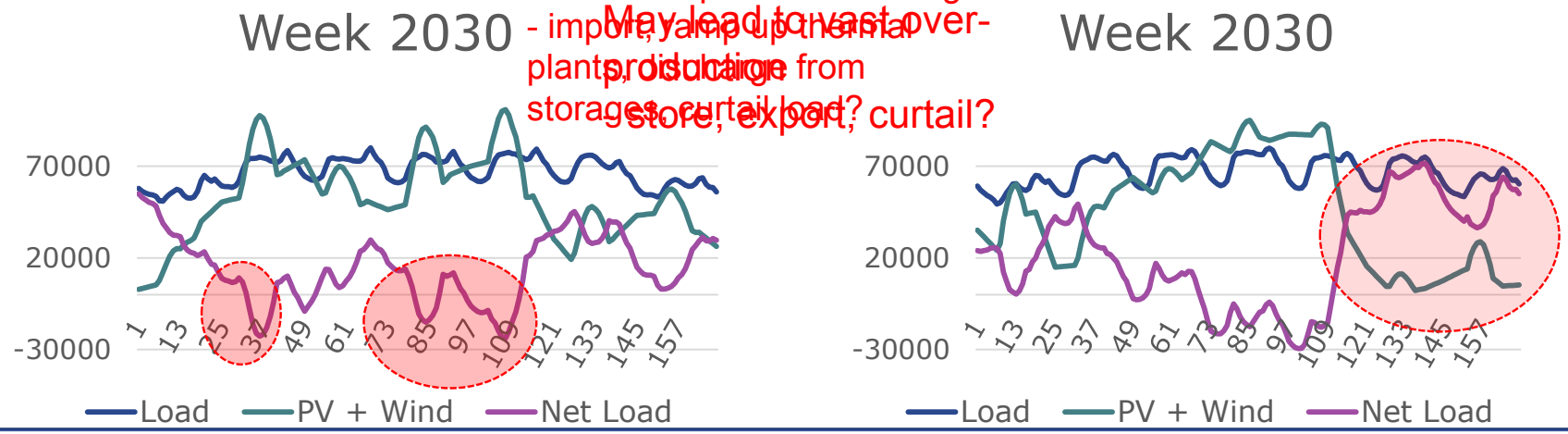
Assumptions:
Demand 2013: 531 TWh
Demand 2030: 541 TWh
Installed wind + PV 2013: 70 GW
Installed wind + PV 2030: 157 GW
Same load/production profiles!

High wind periods followed by a period very little RES production



Dramatic effect on operation when RES penetration is high
- import, ramp up thermal plants, discharge storages, curtail load?

May lead to vast over-production
store, export, curtail?



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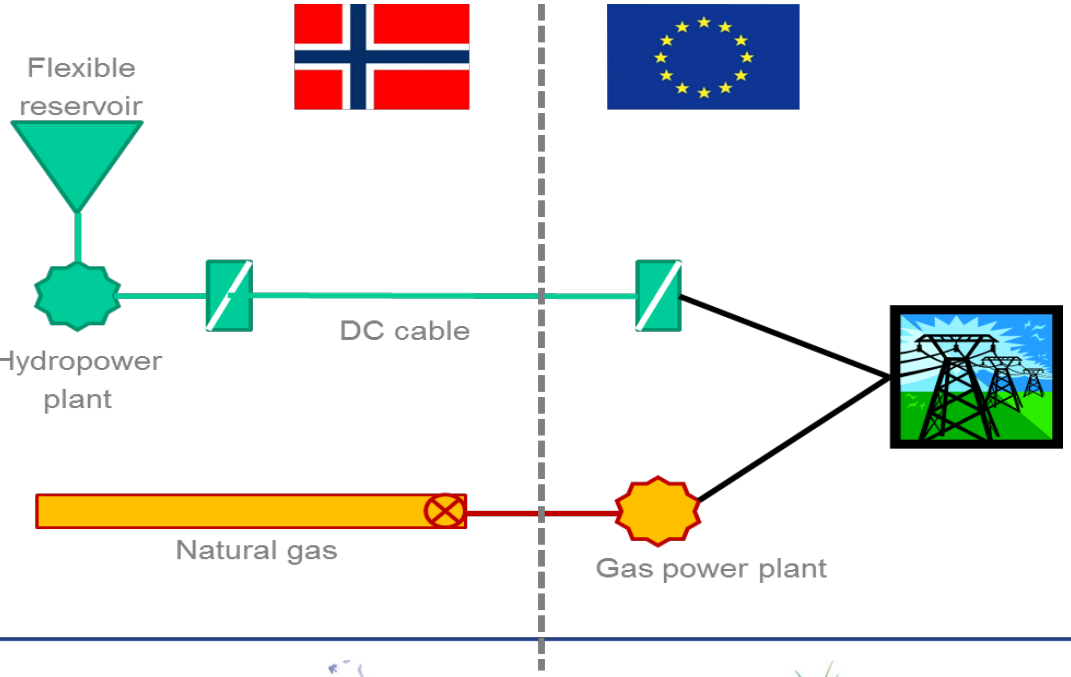
Joint CenSES/Cedren position paper



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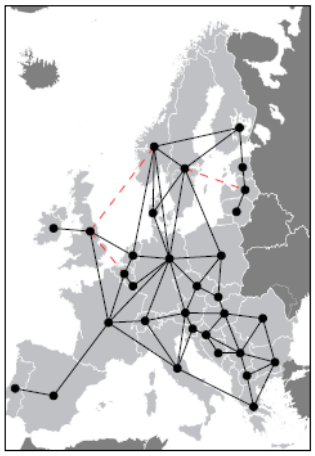
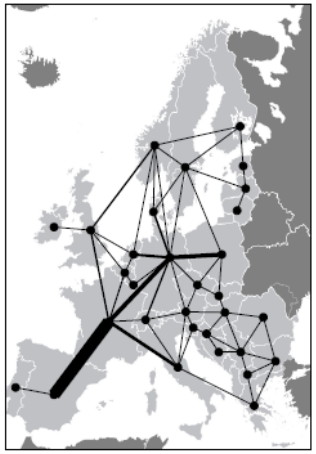
New infrastructure

2010 2050

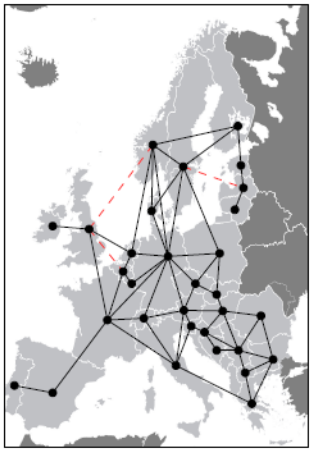
Global 202020



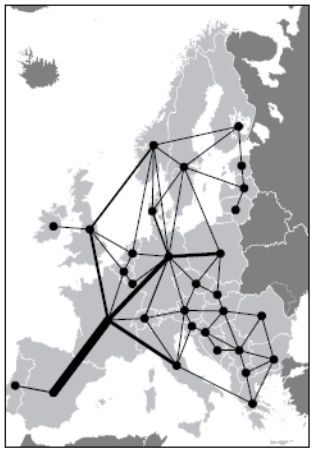
Global 202020



450 ppm



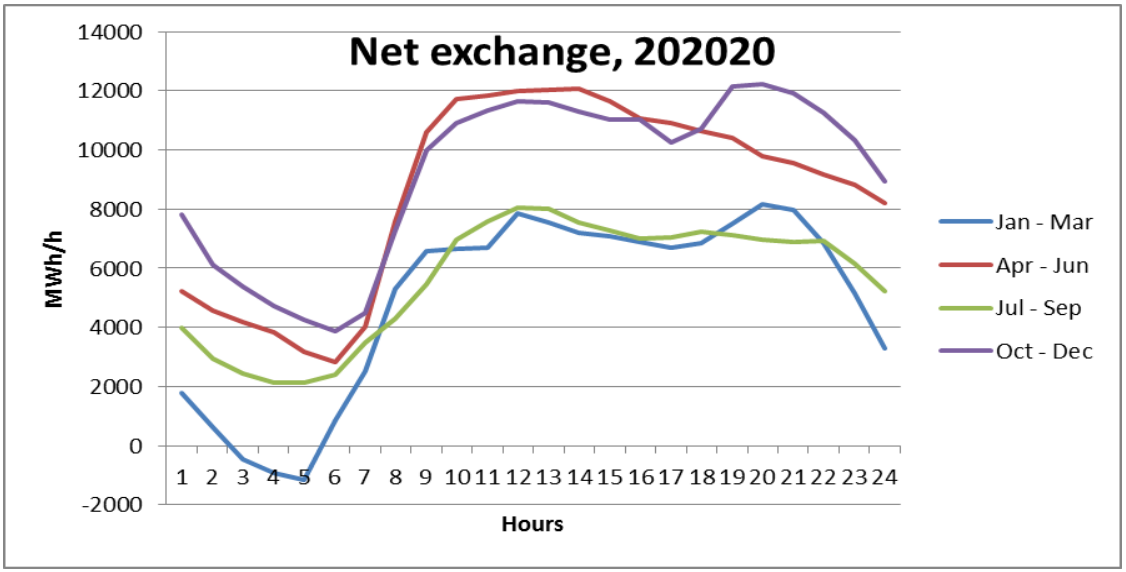
450 ppm



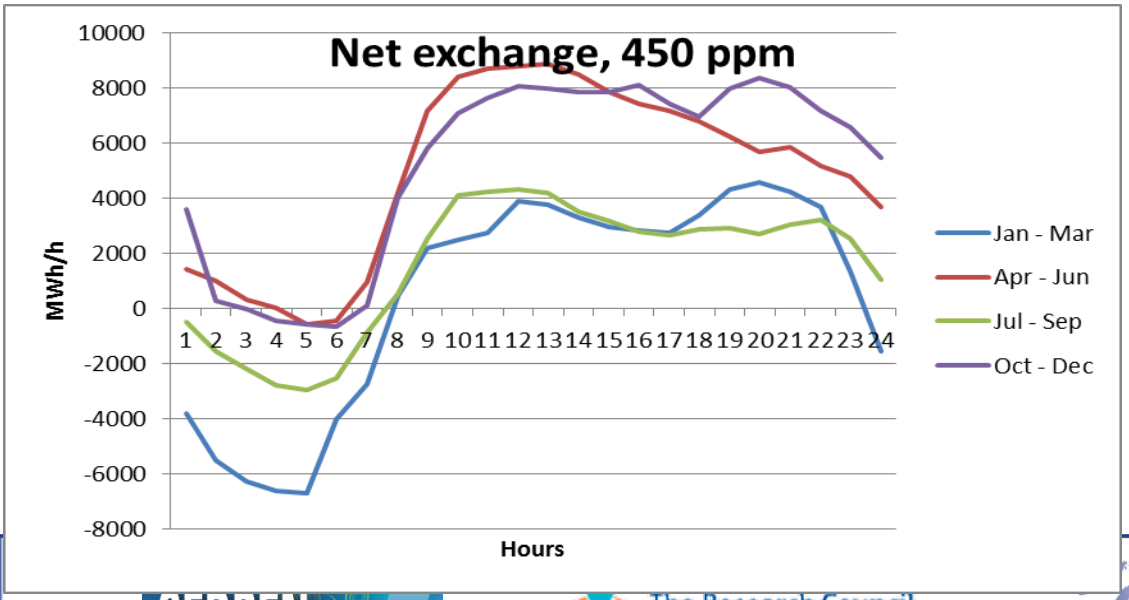
No invest 0.5 GW 1 GW 2 GW
5 GW 10 GW 20 GW 30 GW

Will this picture change with the development of new storage technologies?

Example: Power exchange (from Norway)

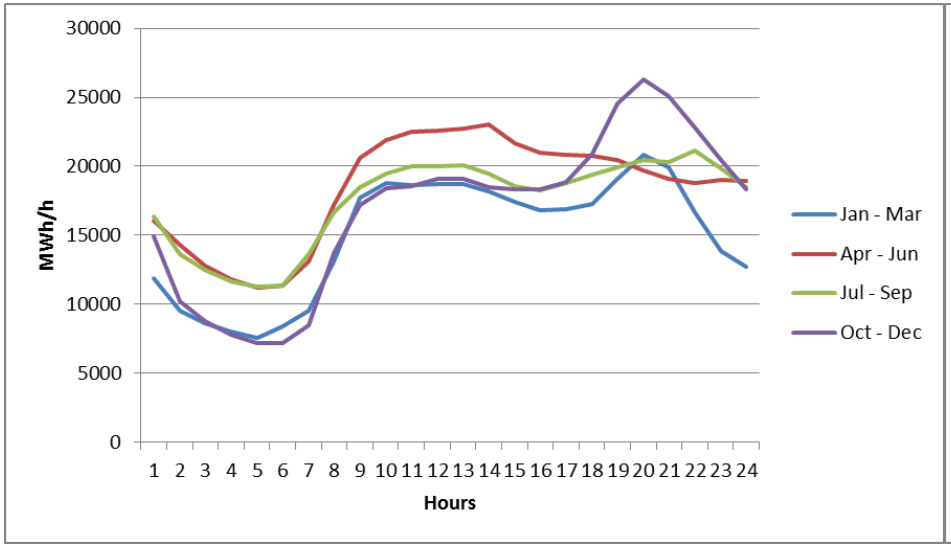


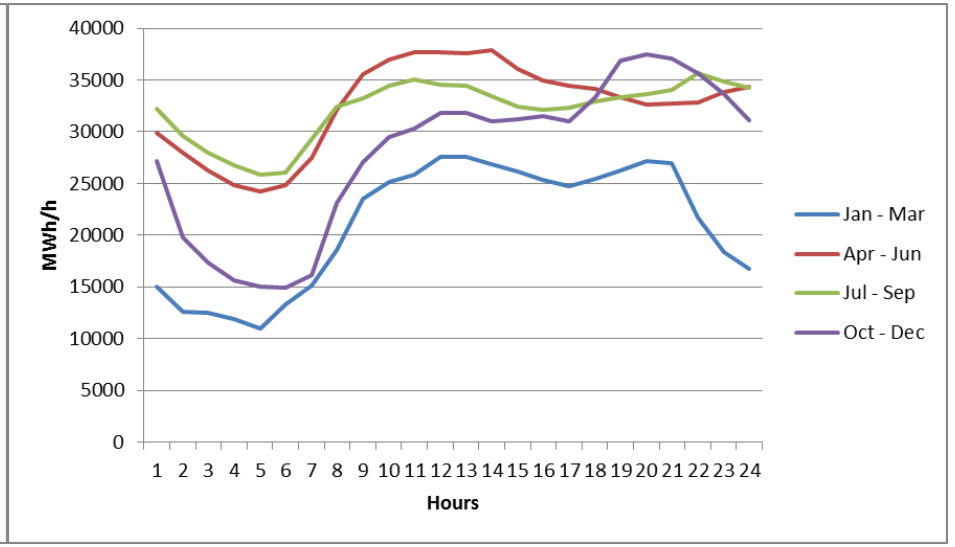
European demand 4594 TWh
Norwegian demand 162 TWh
New Norwegian cap. 22.7 GW
Net export 62 TWh



European demand 5520 TWh
Norwegian demand 197 TWh
New Norwegian cap. 22.7 GW
Net export 27 TWh

Example: Natural gas exchange





The possible inventory changes in the export pipelines are close to handling these variations.

Energy storage technologies

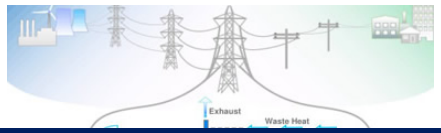
1) **Electrochemical Storage**
Batteries, Super Capacitors

2) **Chemical Storage**
Hydrogen, Methanol, Ammonia

3) **Thermal and Geothermal Storage**
Heat, Advanced Fluids, PCM,

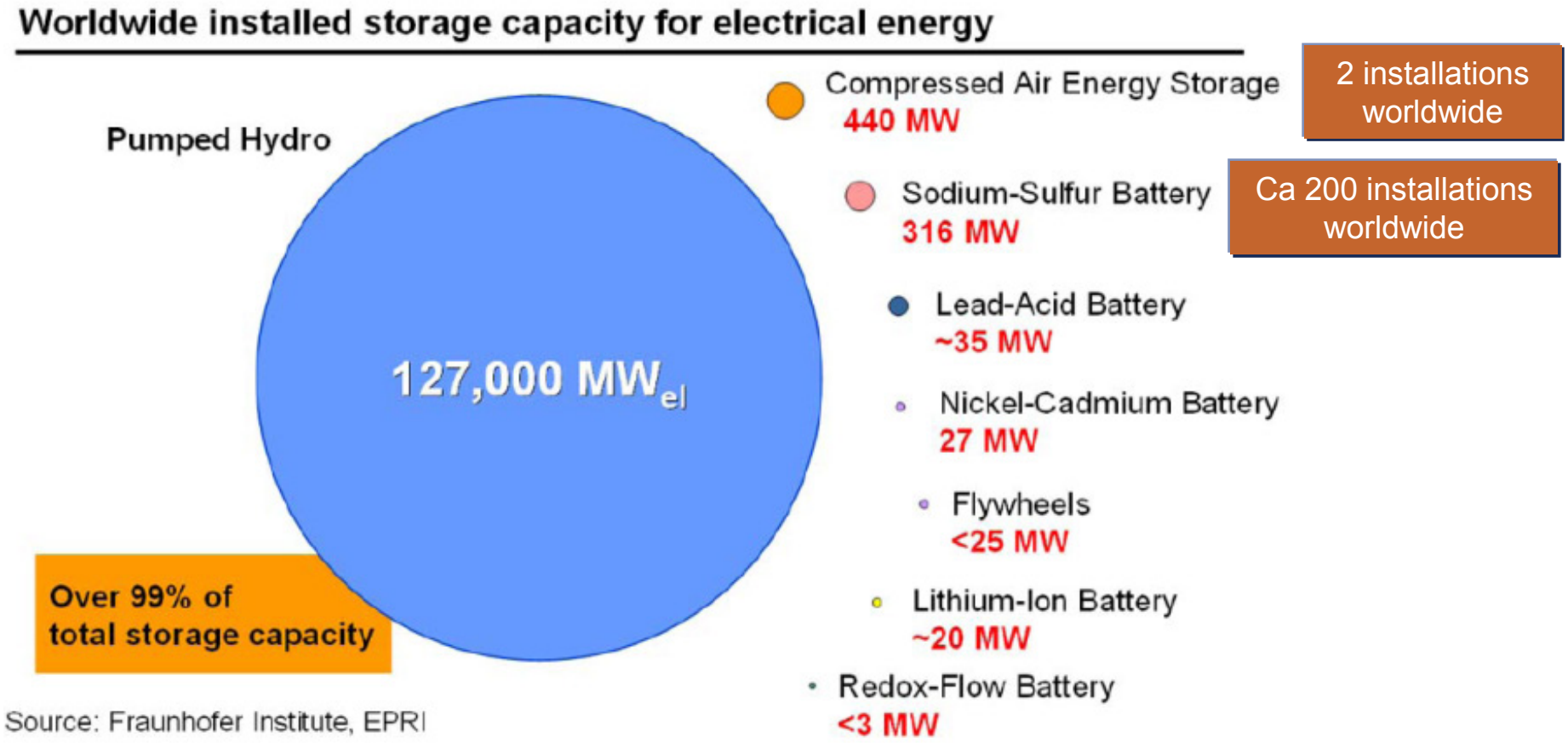
4) **Mechanical Storage**
Hydro, Flywheels, Compressed Air

5) **Superconducting Magnetic Energy Storage**



Maybe as much as 340 TWh of storage volume and 150 GW of balancing capacity needed in Europe by 2050

Installed Energy Storage capacity



*Worldwide installed rated power of storage facilities for **electrical energy**. Such power level can be sustained for up to several hours or shorter*