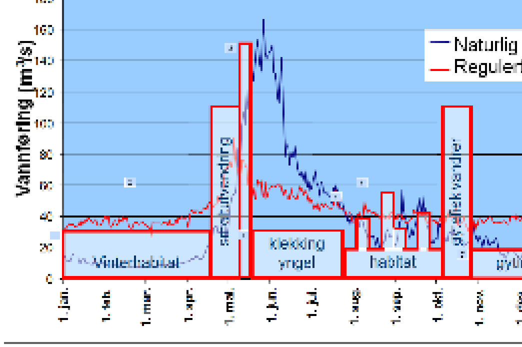
    

Energilagring

Oversikt over teknologier og nye innovasjoner

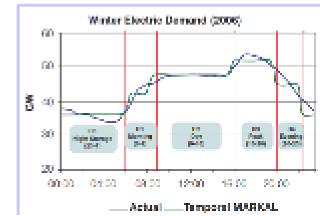
SINTEF
NTNU 100 skapende år
NINA
NATURHISTORISK MUSEUM UNIVERSITETET I OSLO
NIVA
uni Research

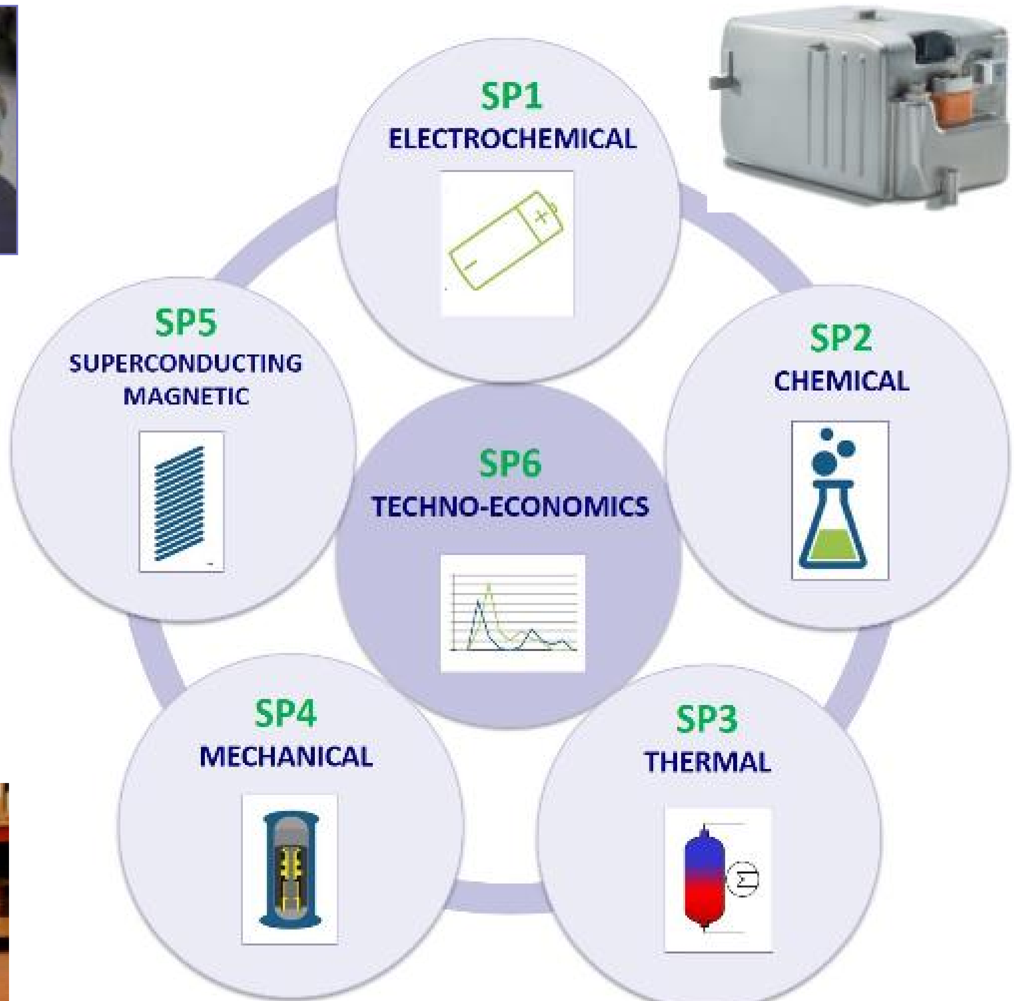
Atle Harby, SINTEF Energi,

Centre for environmental design of renewable energy - CEDREN

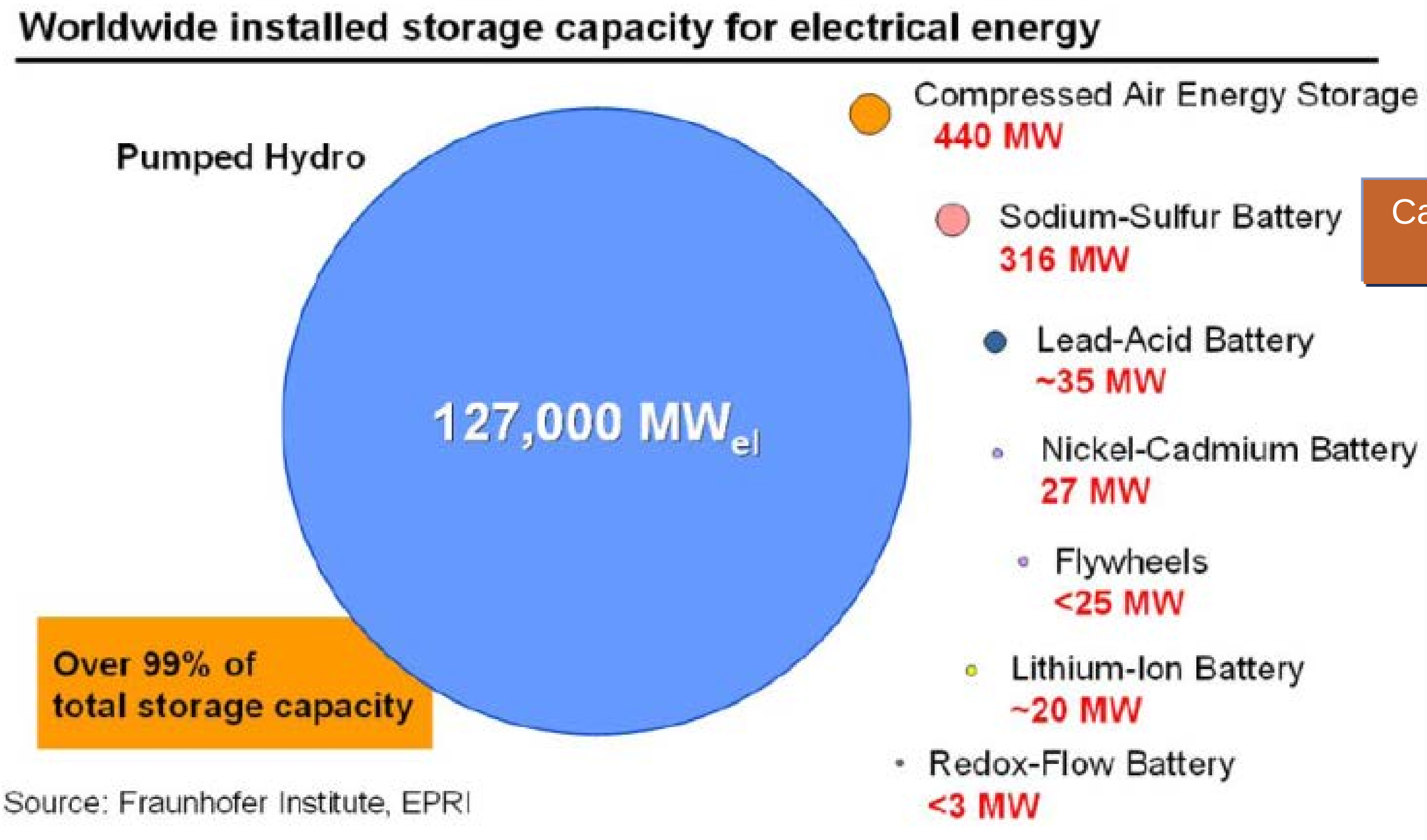
    

Energy Storage





Electrical Energy Storage capacity

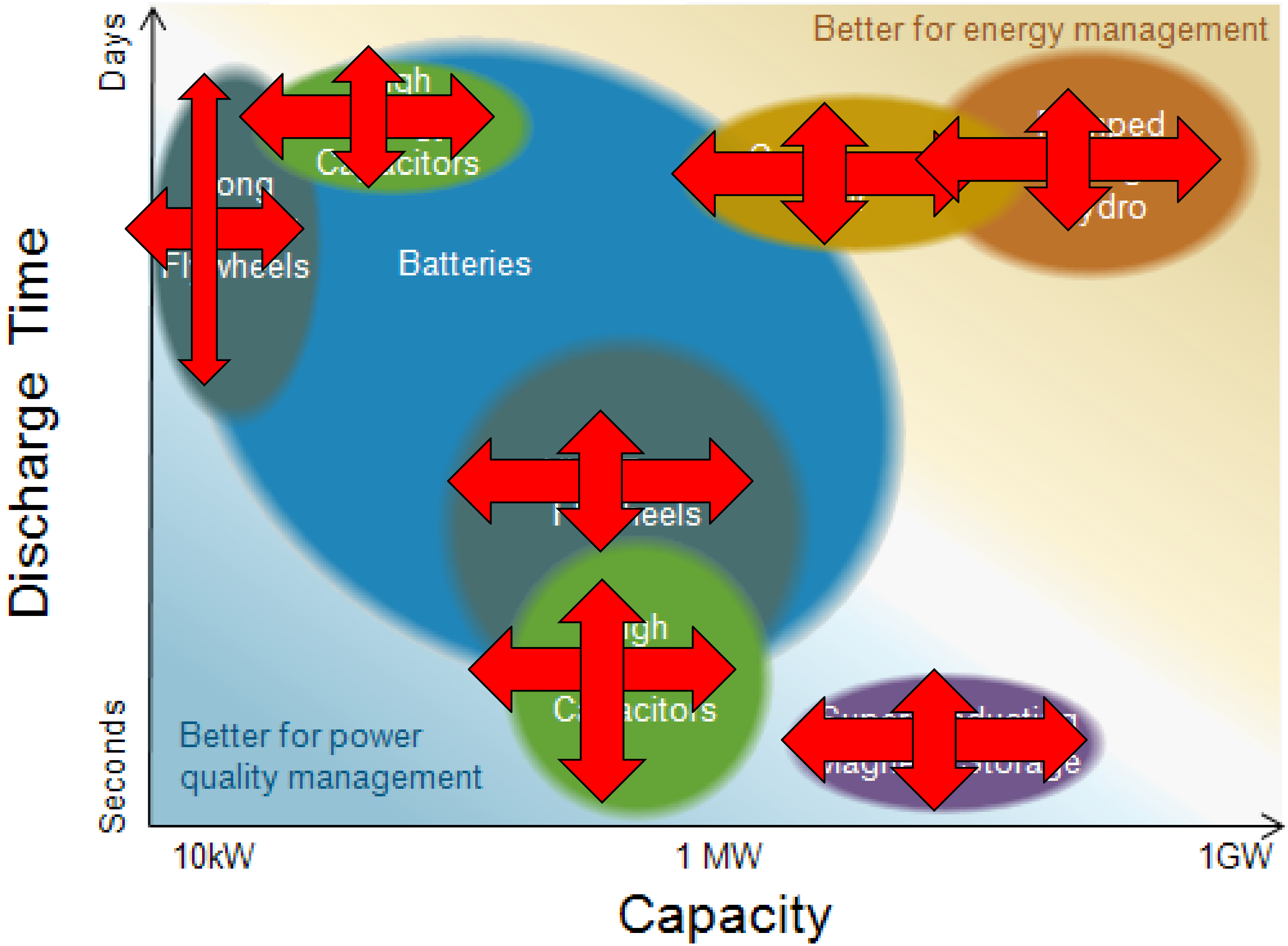


2 installations worldwide

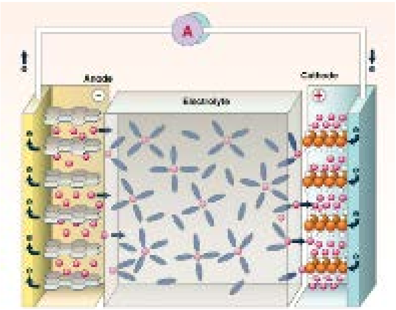
Ca 200 installations worldwide

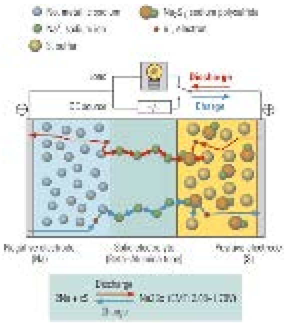
*Worldwide installed rated power of storage facilities for **electrical energy**. Such power level can be sustained for up to several hours or shorter*

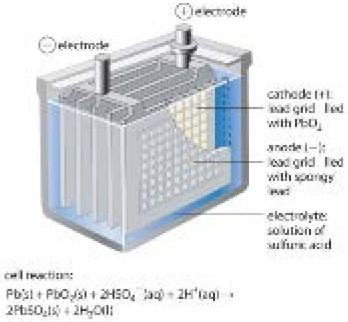
Electricity Storage Technologies

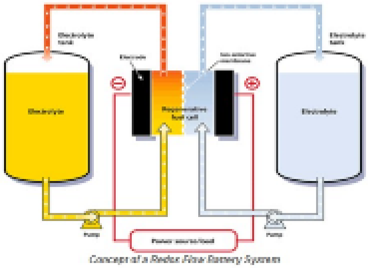


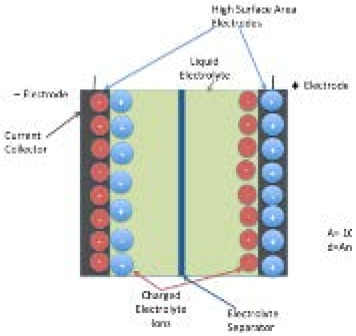
- Lithium-ion batteries
  - High cost, high density
- NaS batteries
  - High density, tolerates high T
- Lead-acid batteries
  - Low density, low costs
- Flow batteries
  - Many cycles, low density
- Super-capacitors
- Liquid metal batteries







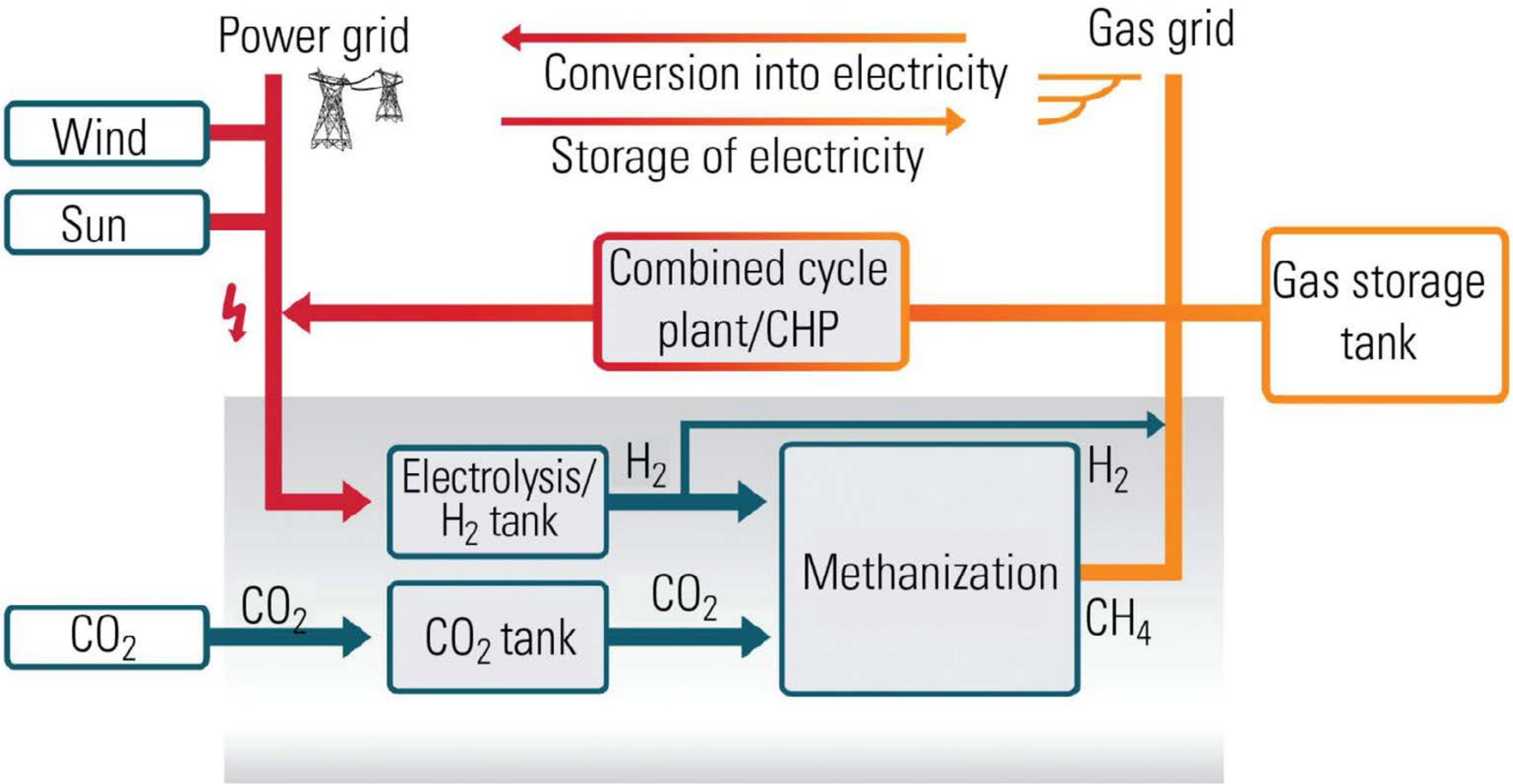




Duke Energy Notrees Wind Storage Demo Project, USA: 36 MW, 20 MWh

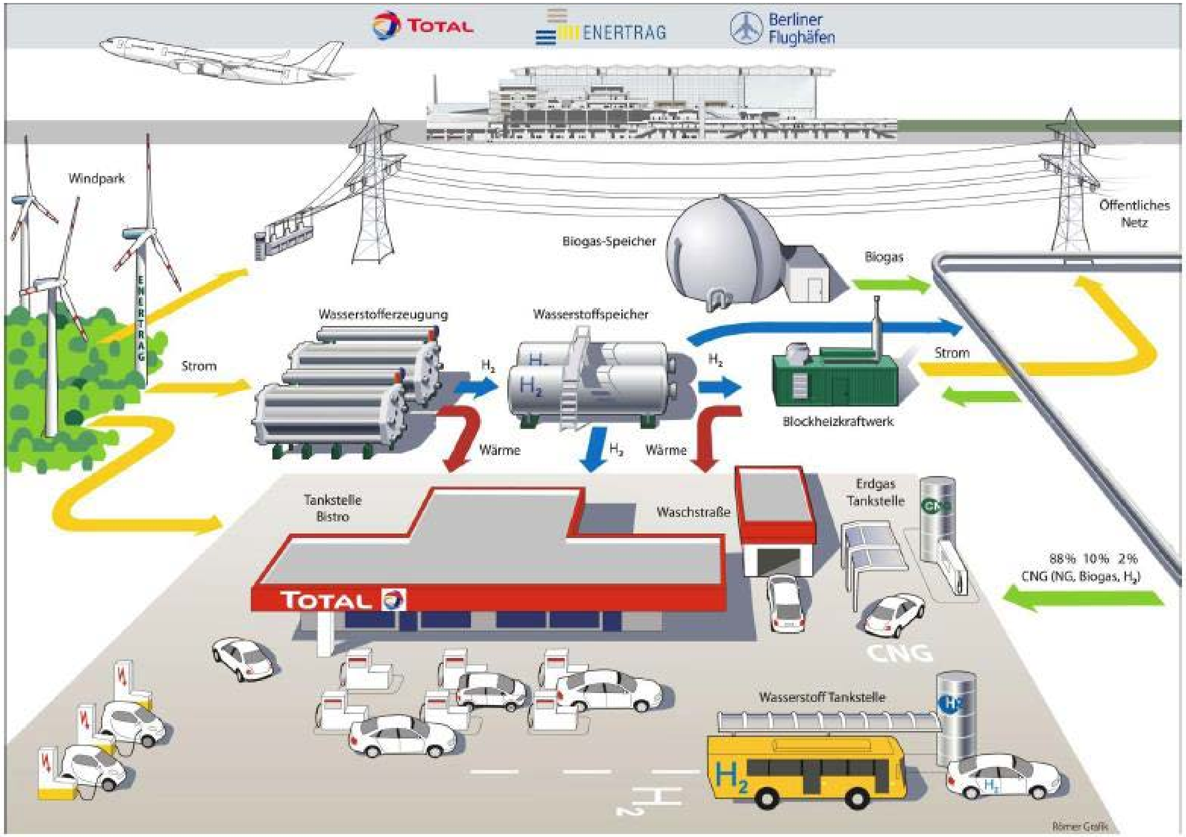
Flow batteries:
Gills Onions, California: 600kW, 3.6 MWh

Power to gas: Synthetic natural gas



Power to gas: Hydrogen

- Hydrogen as energy storage medium links stationary sector to transportation



Thermal Energy Storage

High temperature storage

District heating,
Theiß, Austria

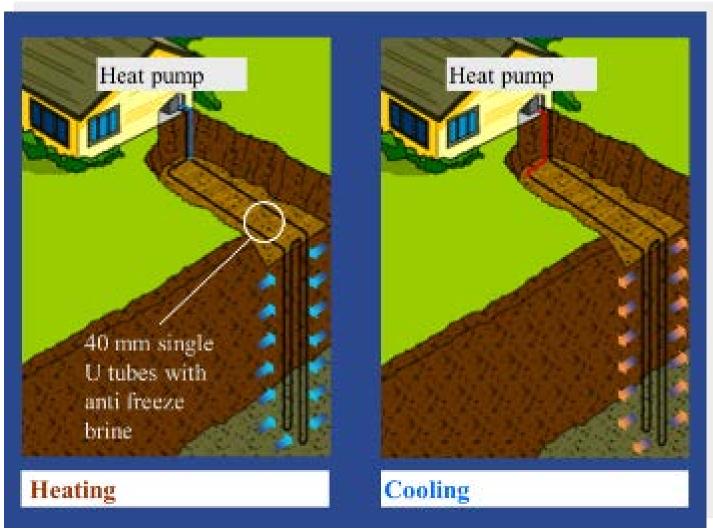
Steam accumulator,
Aerated concrete
manufacturing

Cowper storage,
blast furnace
industry >500 ºC

Molten salt storage,
Andasol power plant,
Spain: up to 400/565 ºC

Cold storage (ice)

Underground storage



Mechanical storage

Hydro

- Operates typically on weeks to hours
- Many applications for both energy and storage
- World-wide potential

Compressed air

- Operates typically on hours
- Two commercial energy storage plants
- Need for more research

Flywheels

- Operates typically on seconds to minutes
- Used a lot in many other sectors
- Few large-scale energy storage applications

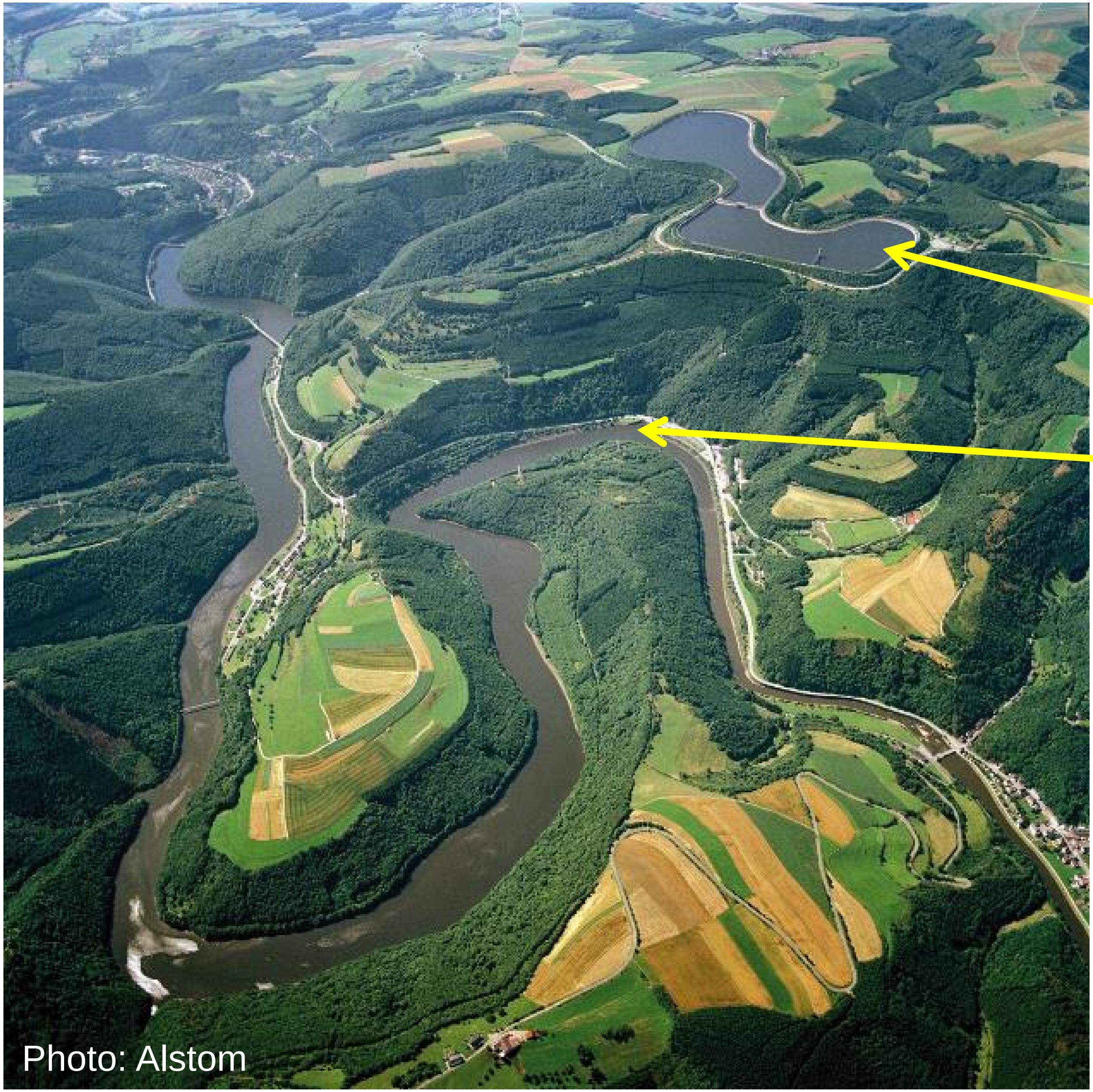
Limberg II, Austria

Grand Maison, France

1 800 MW turbine mode
1 275 MW in pump mode

Courtesy from Rioual, EdF

Vianden, Luxemburg



Upper reservoir

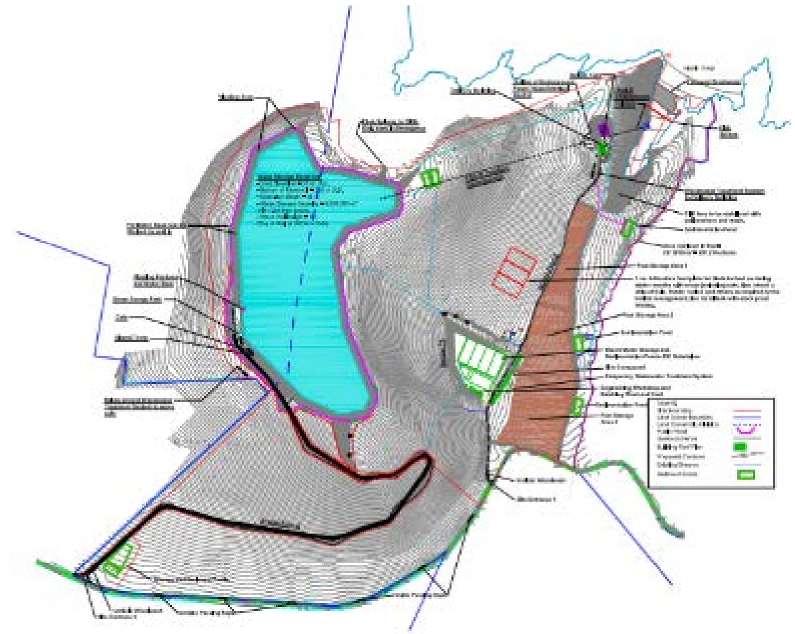
Lower reservoir:
The river

Compressed and liquid air energy storage

- Using caverns or tanks to store air
- Most applications use gas + air to run turbines
- R&D to use air expanders
- R&D to manage heat

New technologies – Sea water pumped storage

Okinawa PSP - Japan

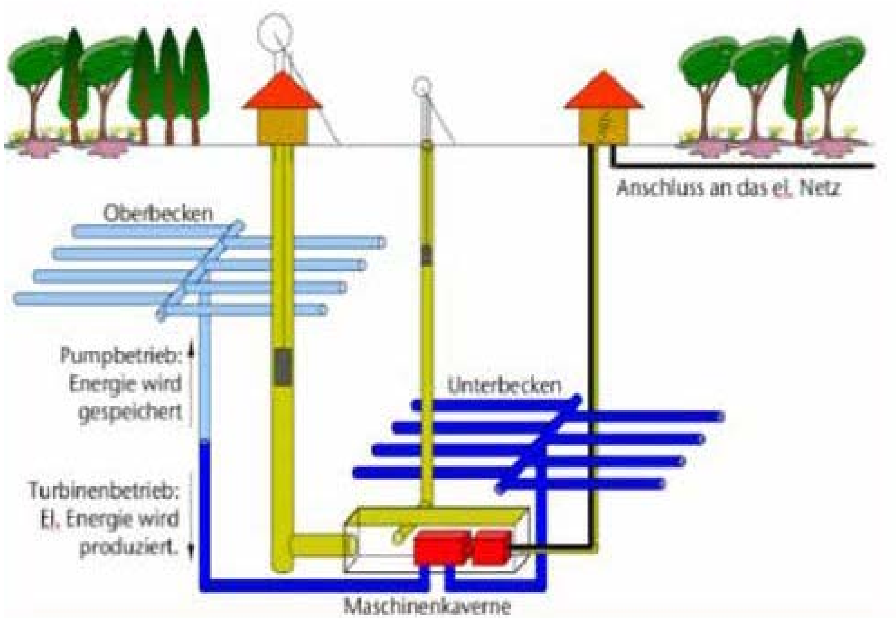


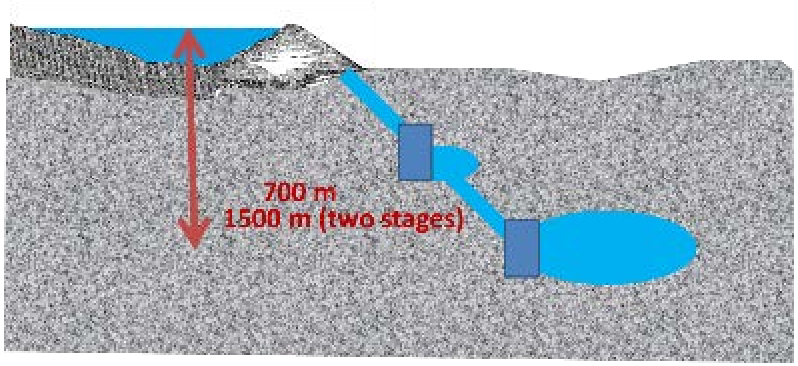
Proposed in Sardinia, Italy

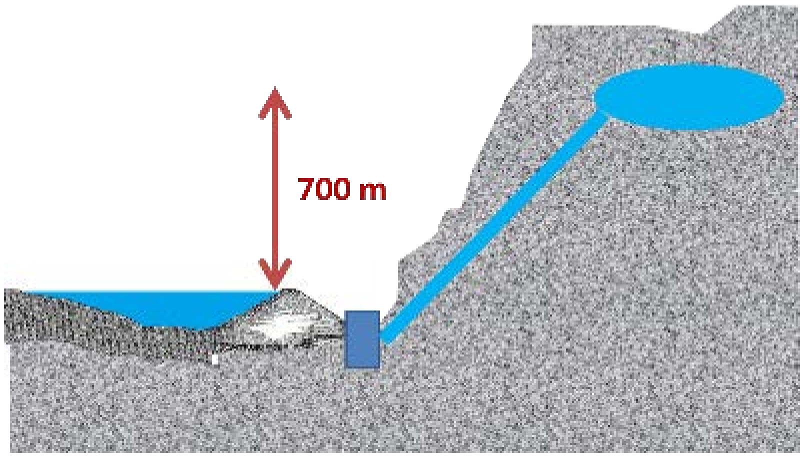
- No access to lakes
- Scarce water resources
- Isolated grids (islands)
- Extra maintenance (salt water)

- Proposed in several sites
- R&D required for equipment
- The potential is very large

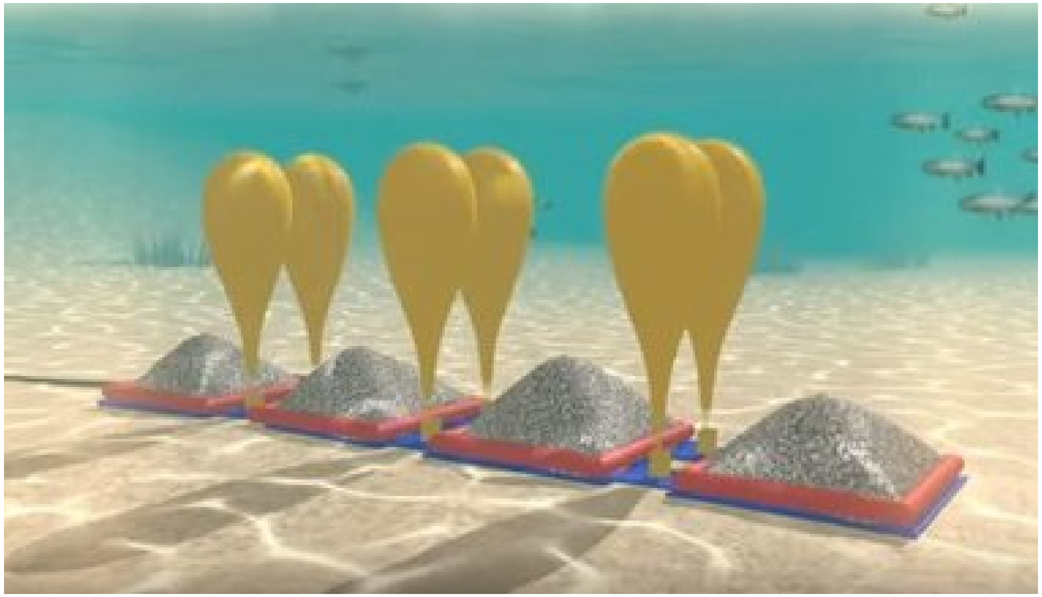
New technologies – Underground pumped storage



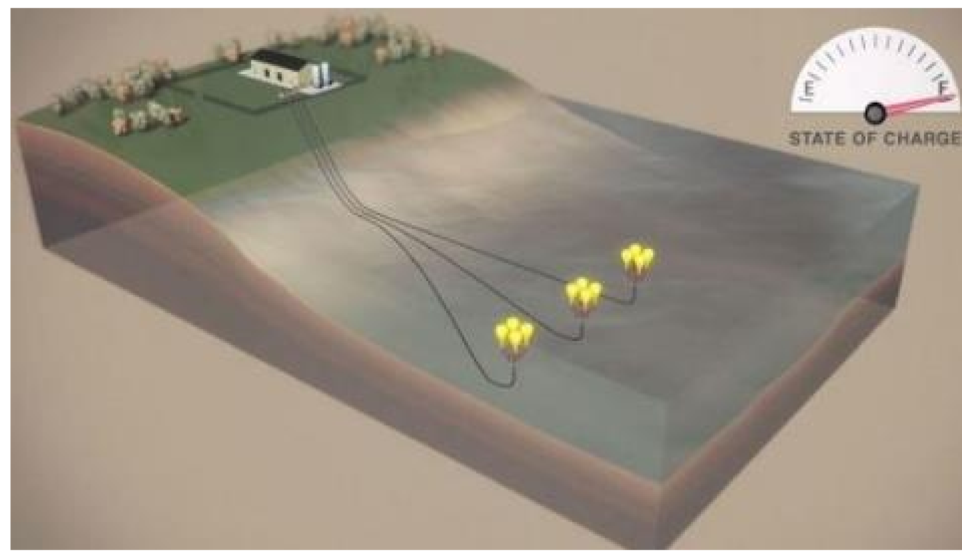




- Using existing mines
- Artificial caverns
- Conventional PSP technlogy



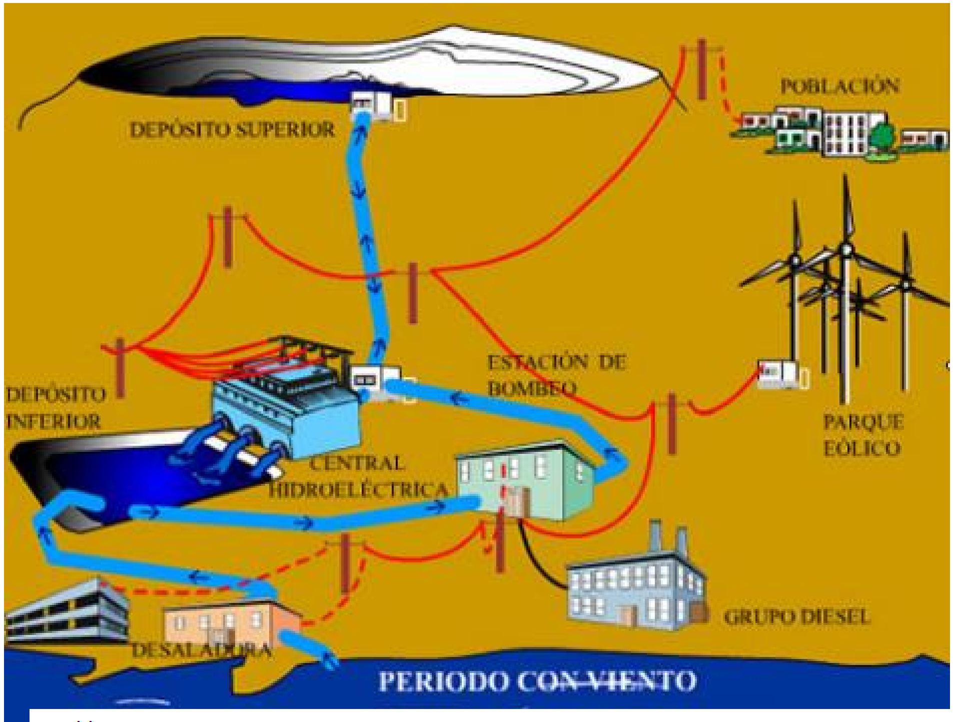

AEROSPACE


STATE OF CHARGE

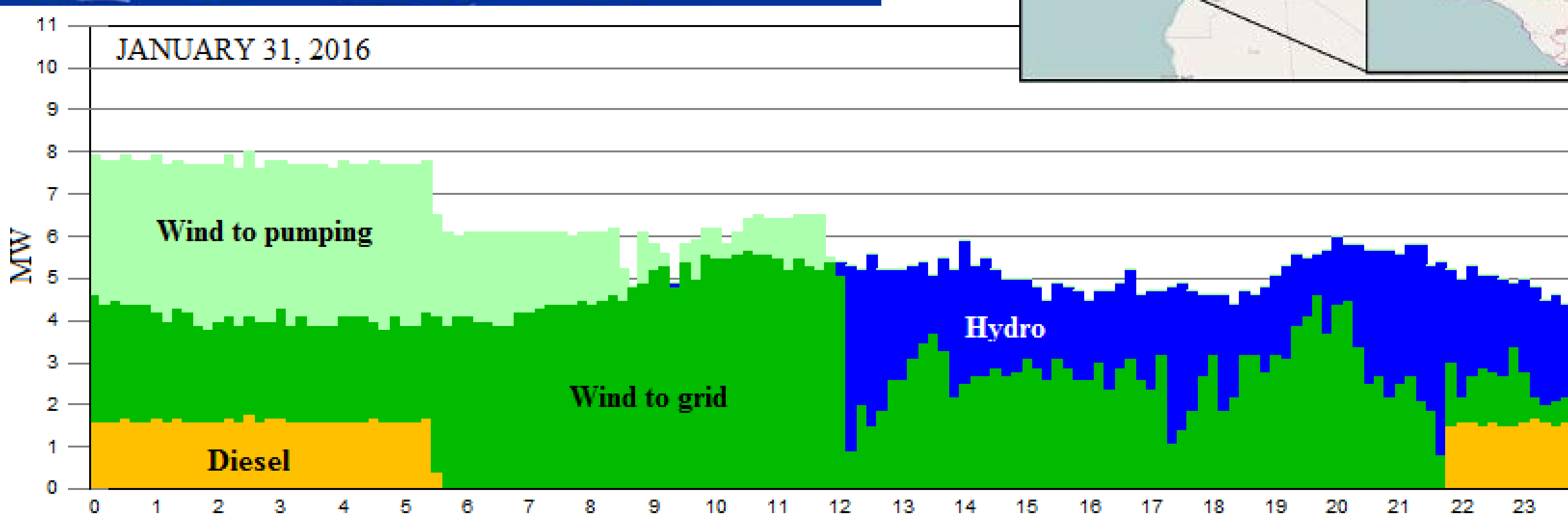
Hybrid systems – El Hierro island

Hybrid systems – El Hierro island

Hybrid systems – El Hierro island

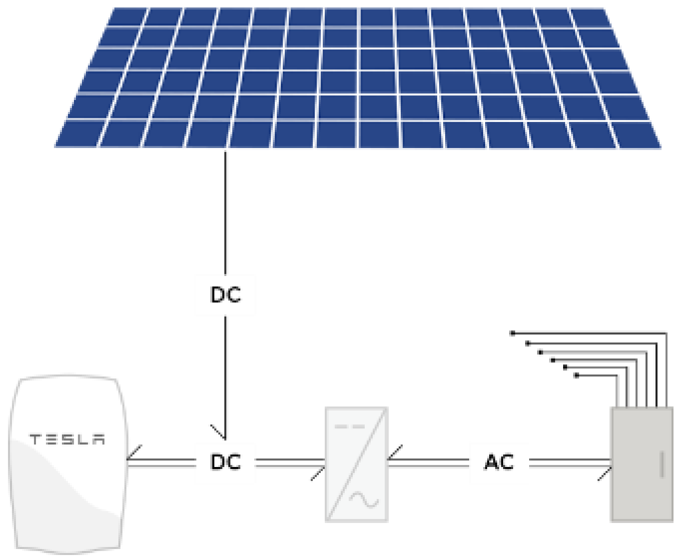


- Wind power
- Pumped hydro
- Daslination plant
- Diesel for back-up



Tesla PowerWall© - storage units for homes

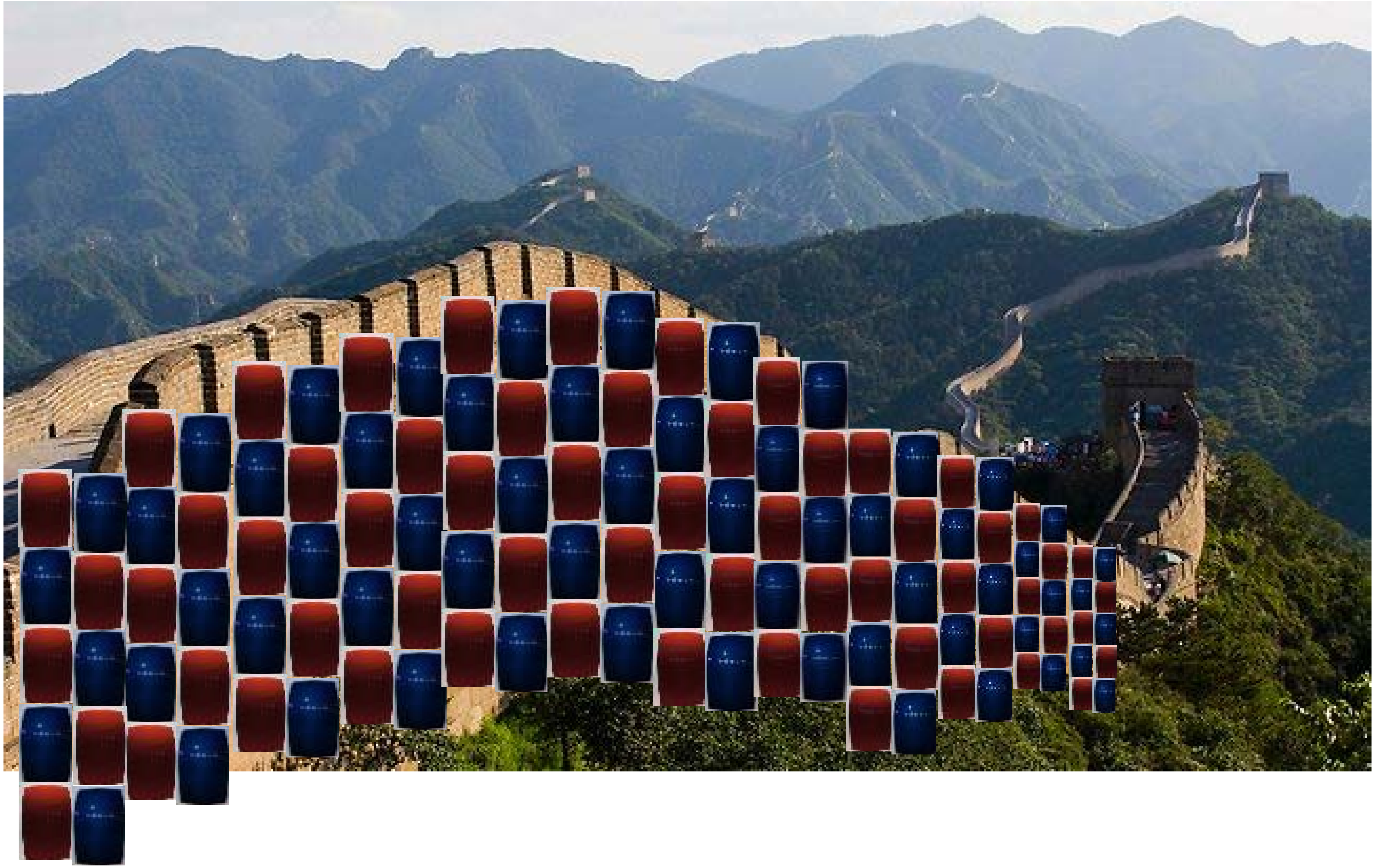
Roof-top solar panel or similar



PowerWall©

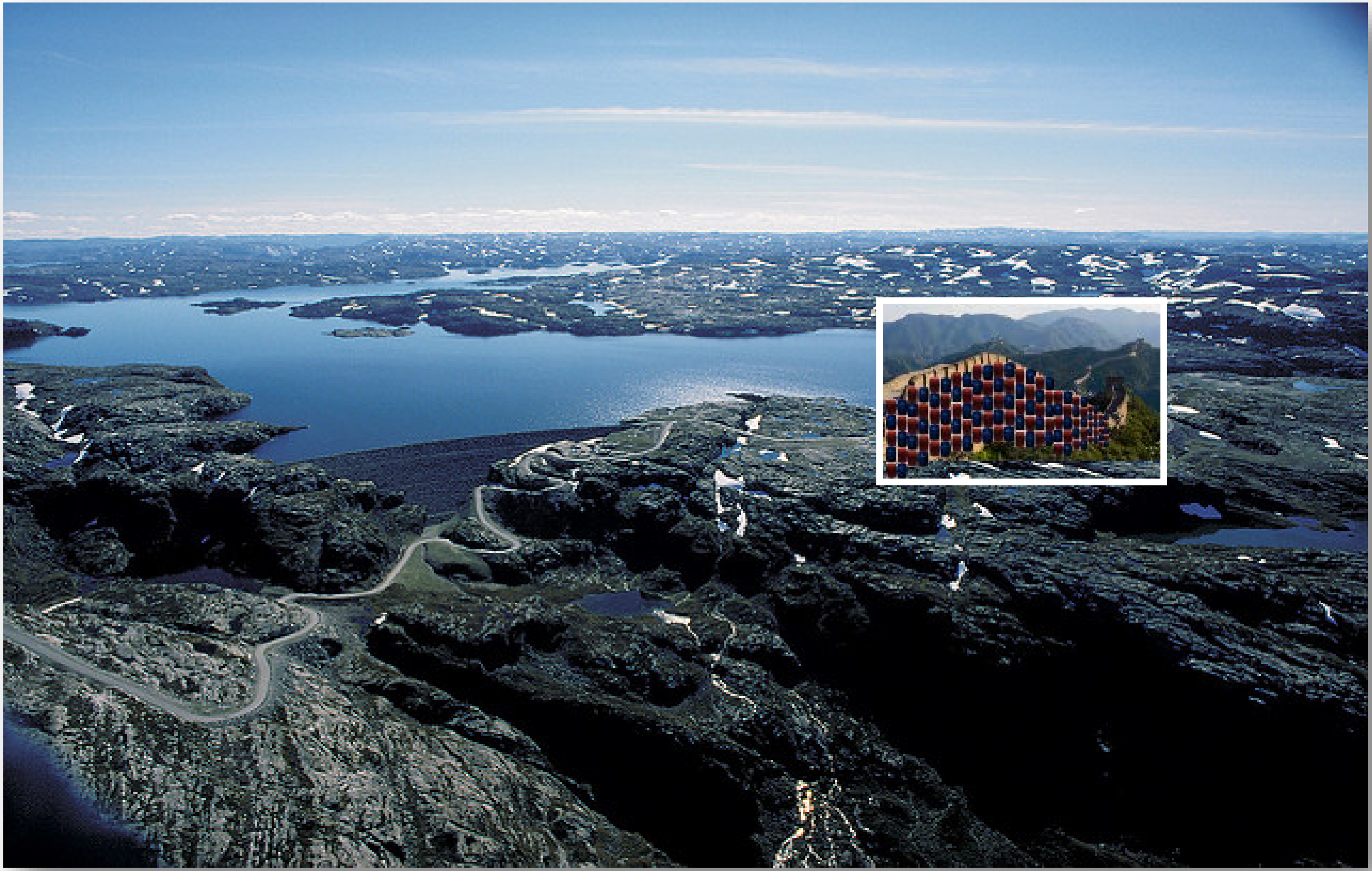
- Balancing solar energy
- Energy security
- Off-grid solutions

The Great Wall

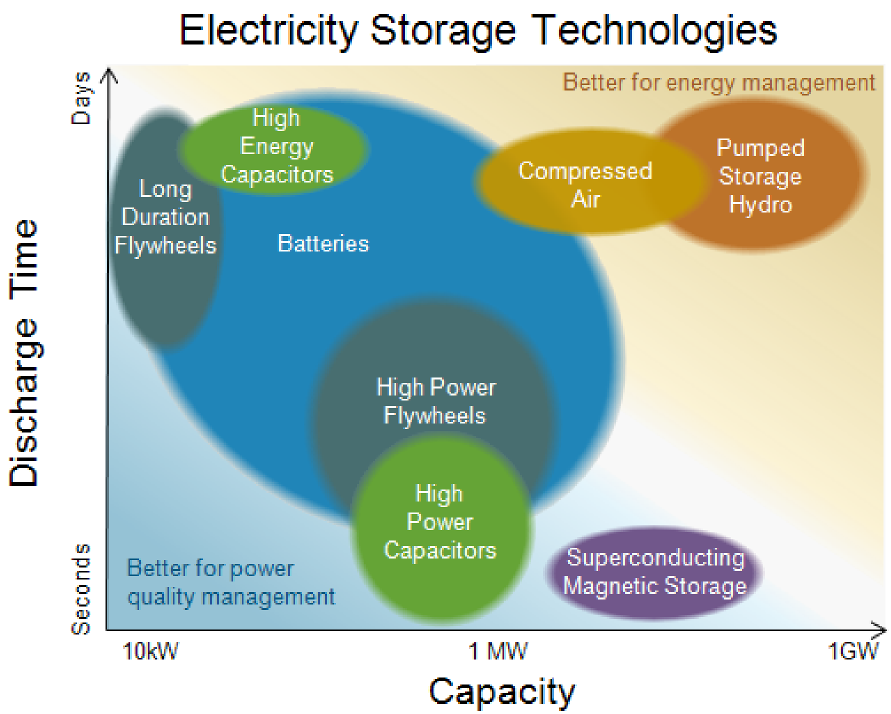


- Cover with Tesla PowerWall©

1,23 TWh = 15 % of Blåsjø



Conclusions



- We need more energy storage – better grid cannot solve all lack of storage
- We need all technologies for energy storage - plus some future ones
- Different technologies operate on different time scales with different volumes of storage
  → There is no "one size fits all"
- Use a combination of many storage options
- Norway can still be "first movers"
- We need markets and international collaboration to optimize storage solutions