Storage Systems for Large Wind Turbines

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Storage Systems for Large Wind Turbines

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♠ Vestas No.1 in Modern Energy

Challenges

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- Make the wind power plant to appear and behave like conventional power plant.
- Move the wind power plant to the sector where it can be considered as more reliable and controllable source of energy.
- Better correlation between actual market energy price and actual wind power generation.
- Offer various services to the power system.

Objectives

- Energy storage for Wind Power System – state of the art, especially present situation and trends.
- Services that energy storage technologies can provide to the WPP and power system.
- Modeling of wind and the most relevant storage technologies and their services.
- Evaluation of obtained results.
- Laboratory validation of different storage techniques and storage managements.

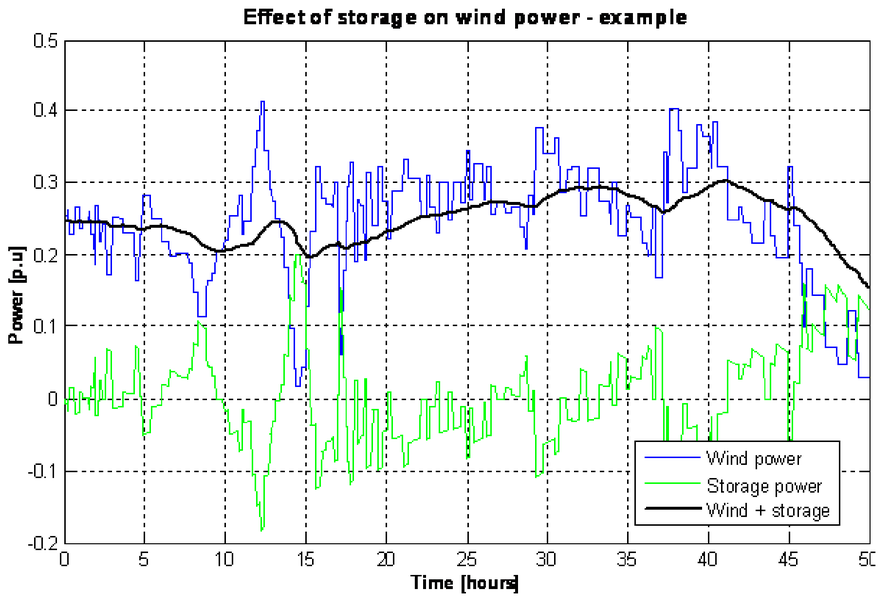
Main Services that can be offered by ES

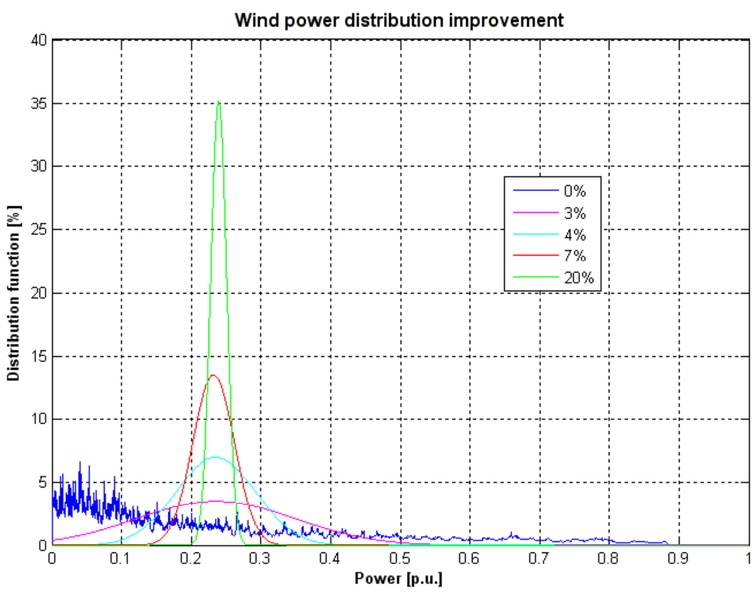
Services that can be offered to WPP:

- higher availability, predictability and smaller variability
- black start without assistance from a grid
- energy arbitrage
- peak shaving
- production leveling

Services that can be offered to the grid:

- frequency control
- regulating reserves
- spinning reserve
- voltage control
- soft stop





Source: *Improving wind power quality with energy storage, C. Rasmussen*

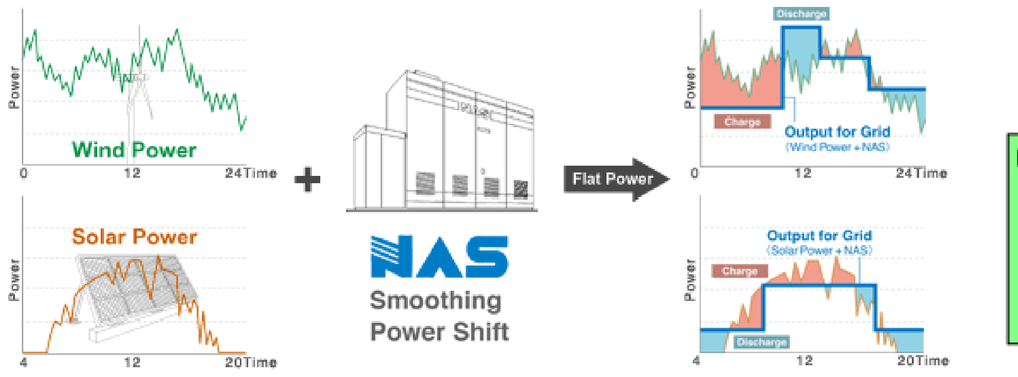
Some significant technologies

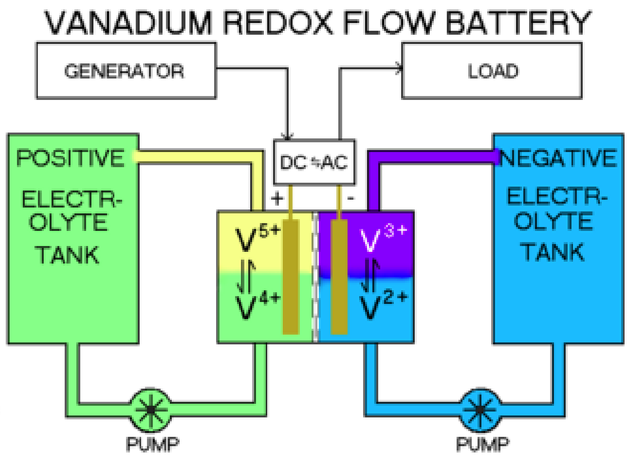
Time scale:

- Short
- Medium
- Long

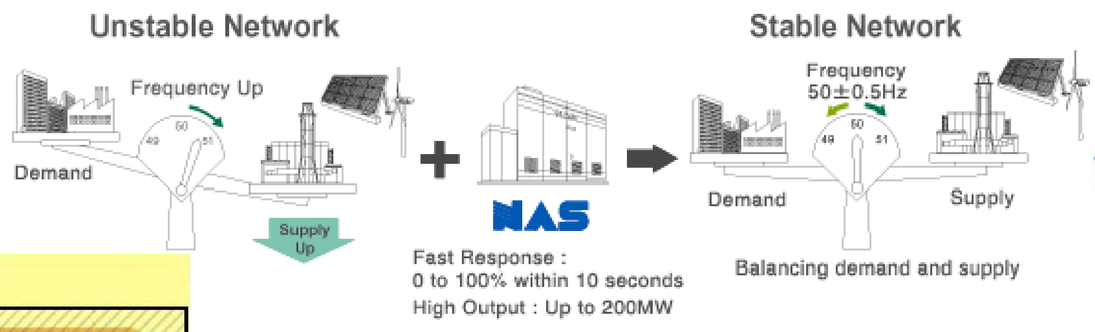
Energy storage – technology overview

- Energy storage
  - Mechanical
    - Pumped Hydro — Over ground / Underground
    - Compressed air — Adiabatic / Non adiabatic
    - Flywheels — High speed / Low speed
  - Electro-chemical
    - Hydrogen storage — Hydrolysis / gas turbine / Reversible fuel cells
    - Flow batteries — Vanadium-redox / Zn-Br
    - Batteries — Lead acid / Ni-Cd / Li-ion / NaS (high temp.) / Metal-air / Ultra batteries
  - Electromagnetic — Ultra capacitors / SMES
  - Thermal

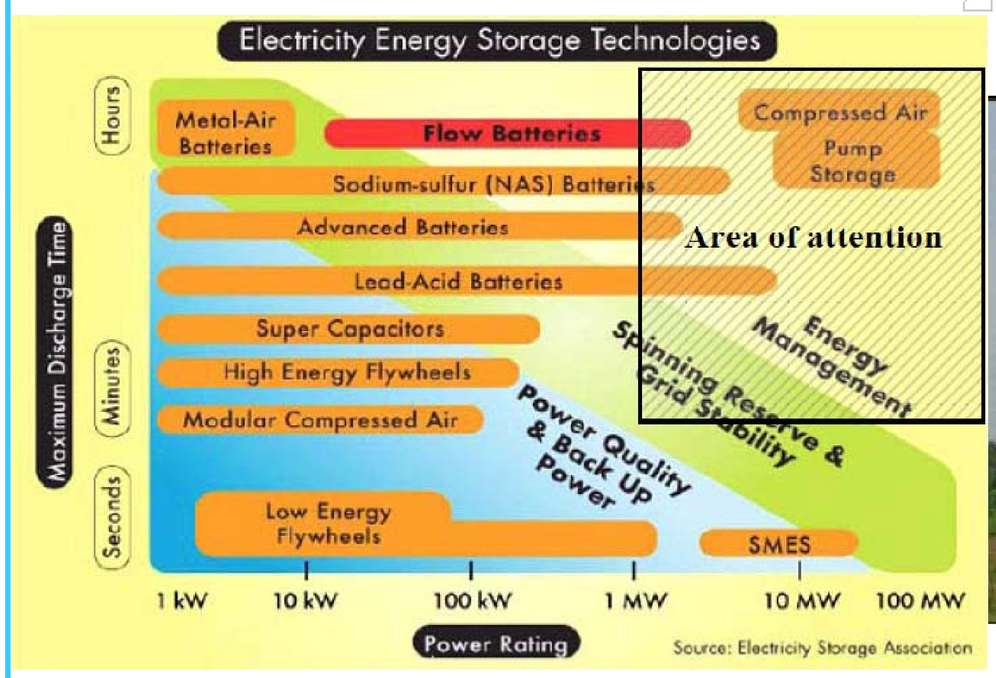


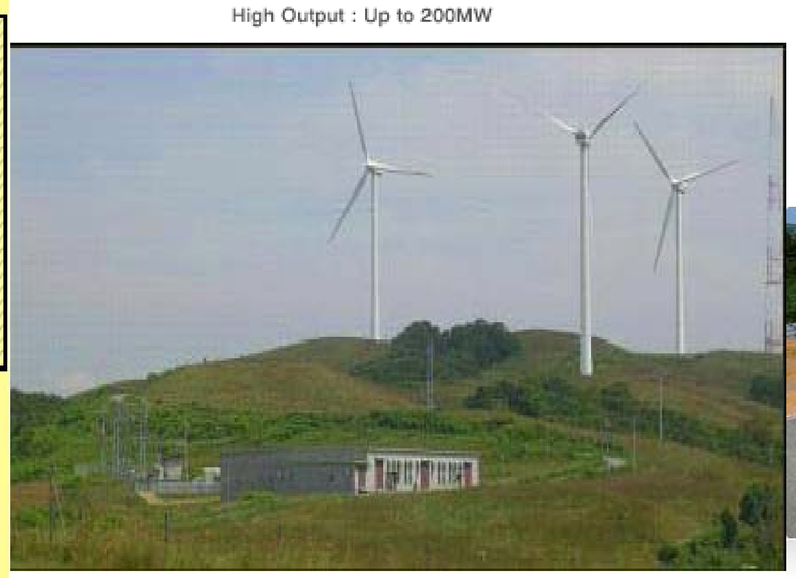


Vanadium Redox flow battery



Ultracapacitor 75V, 94F, **Source:** *Maxwell Technologies*





4 MW (6 MW pulse) x 1.5 hour VRB-ESS Grid-Coupled, Sapporo, Japan

34MW NAS storage, Japan

PhD Preliminary Goals:

- State of the art and provisional study plan
- Modeling of relevant storage technologies and services
- Test case studies of services offered by Energy Storage
- Laboratory validation of energy management strategies

Future work: