



## Storage Systems for Large Wind Turbines

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# Storage Systems for Large Wind Turbines

## Challenges

## Objectives

- 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.

- 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.

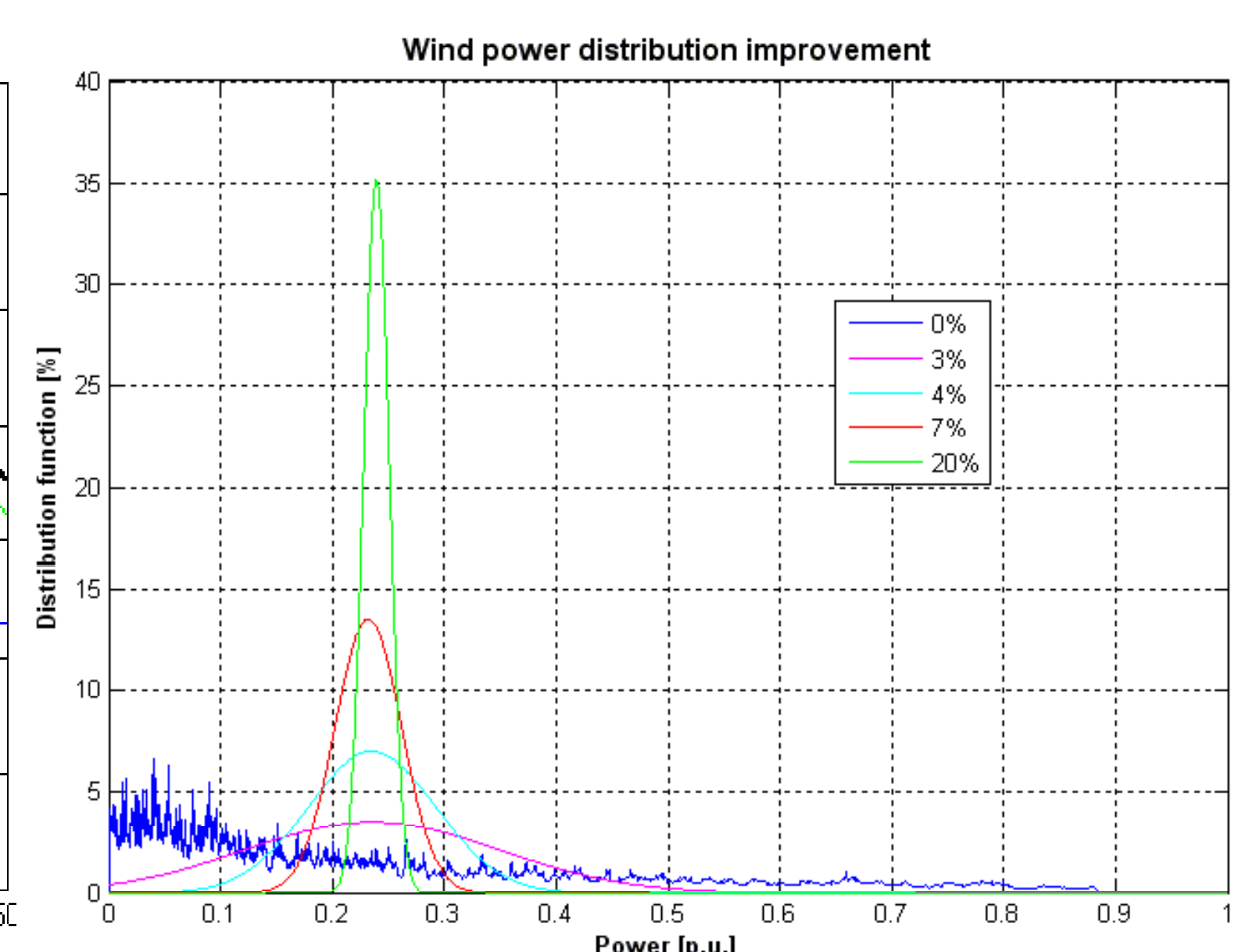
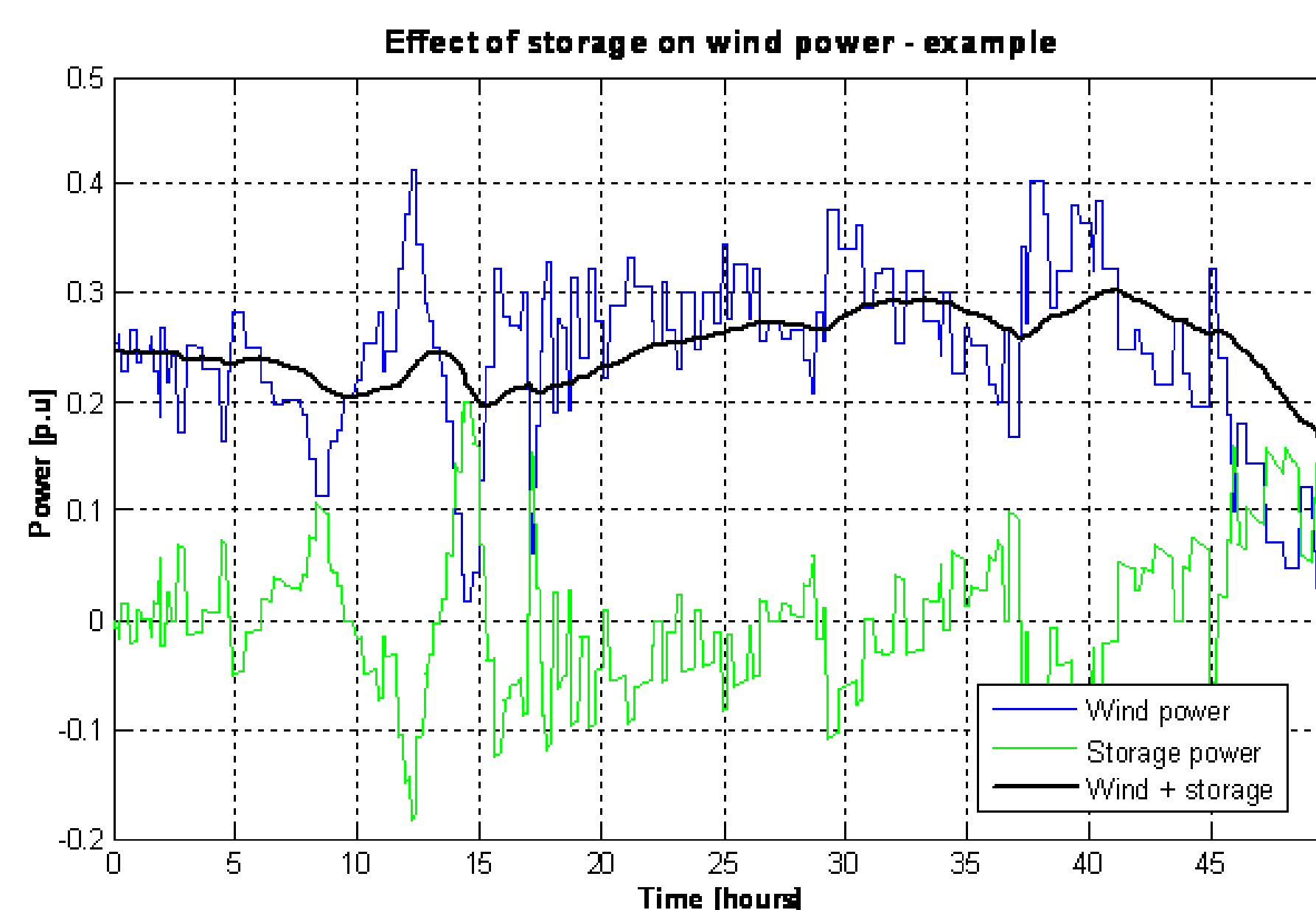
## Main Services that can be offered by ES

### 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:

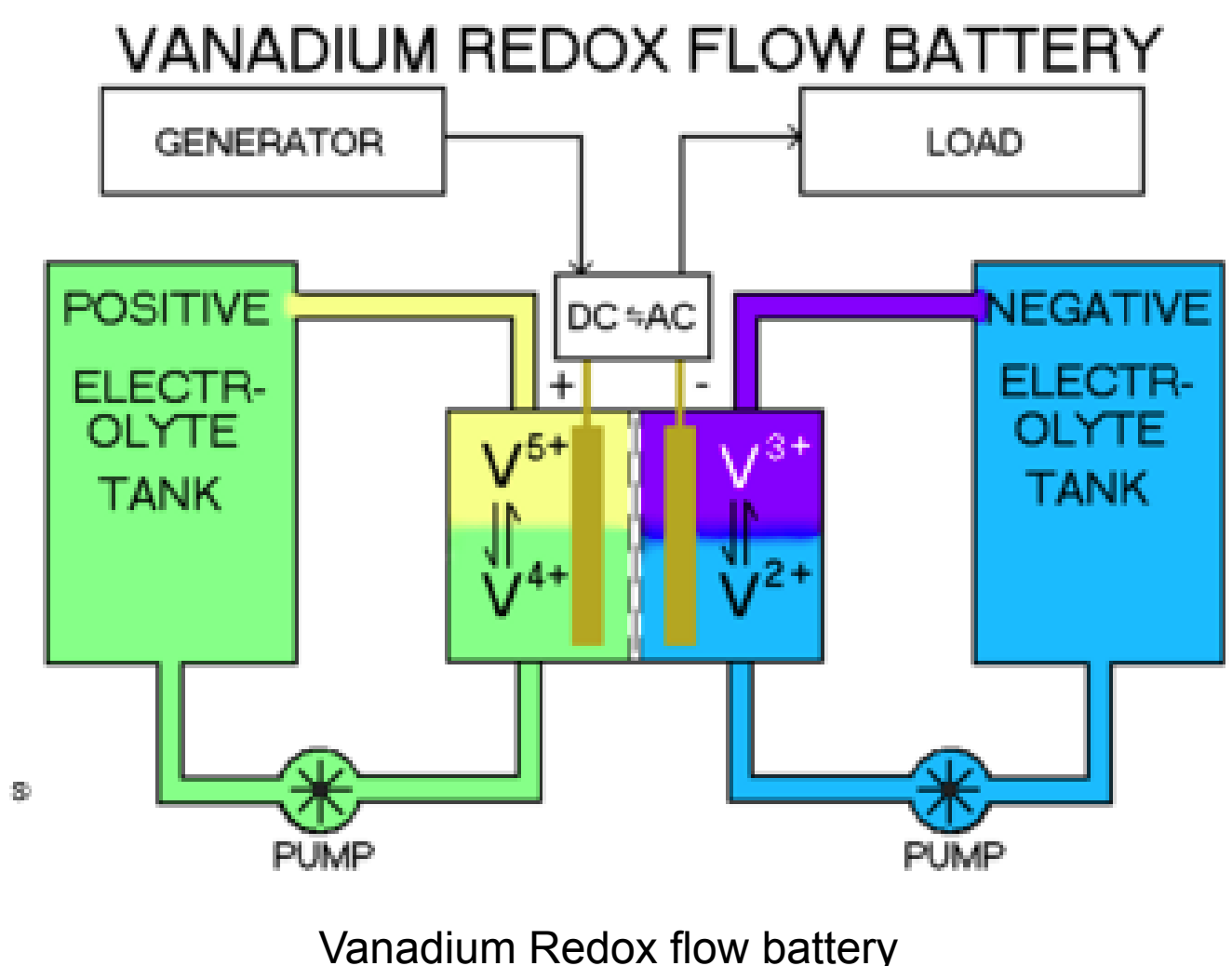
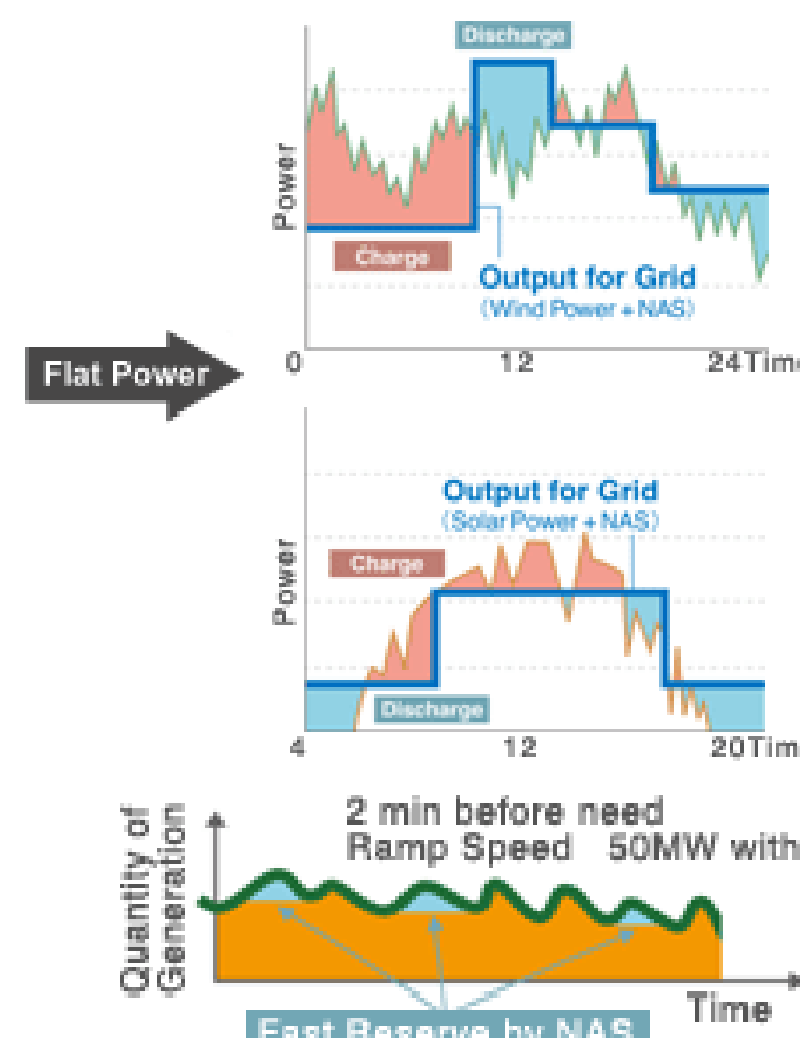
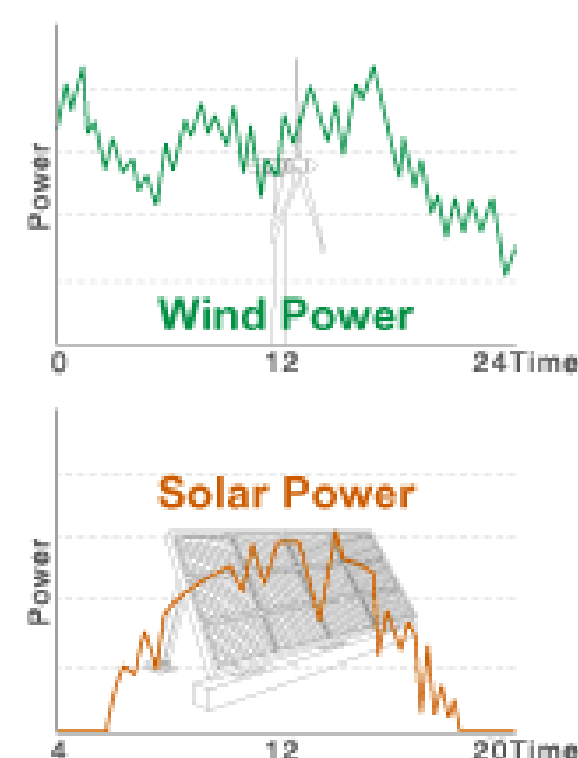
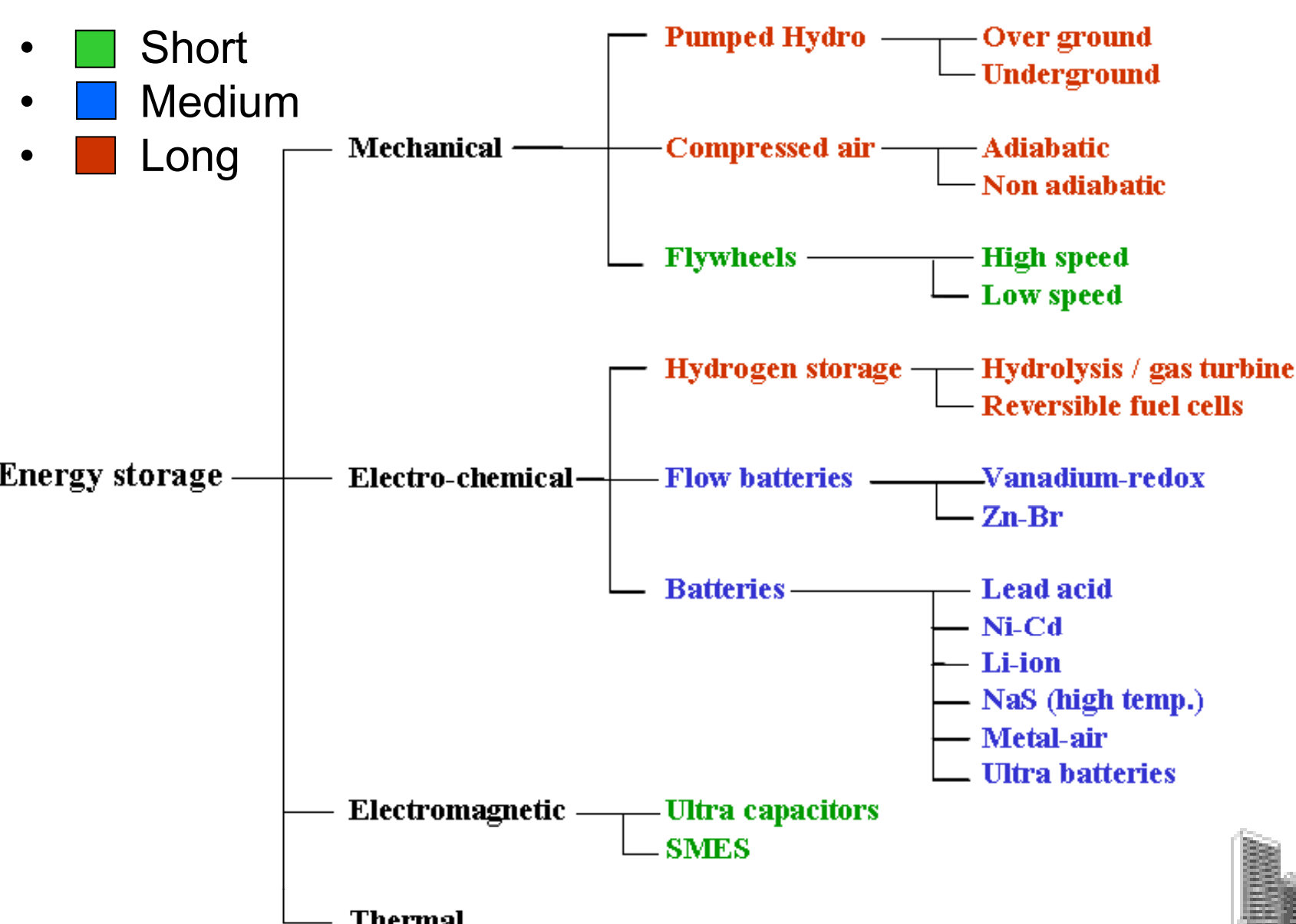
- frequency control
- regulating reserves
- spinning reserve
- voltage control
- soft stop



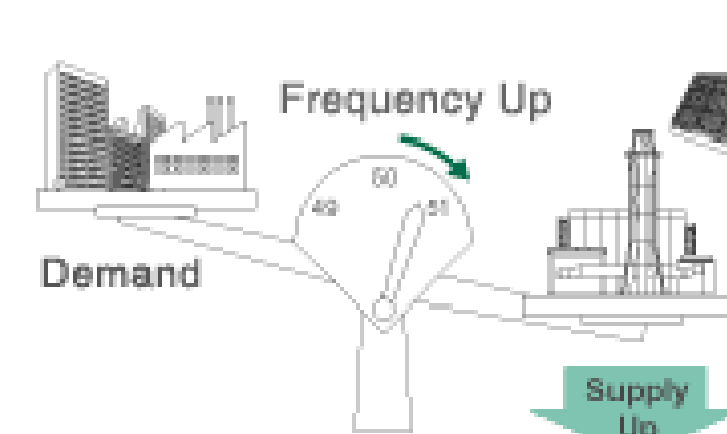
Source: Improving wind power quality with energy storage, C. Rasmussen

## Some significant technologies

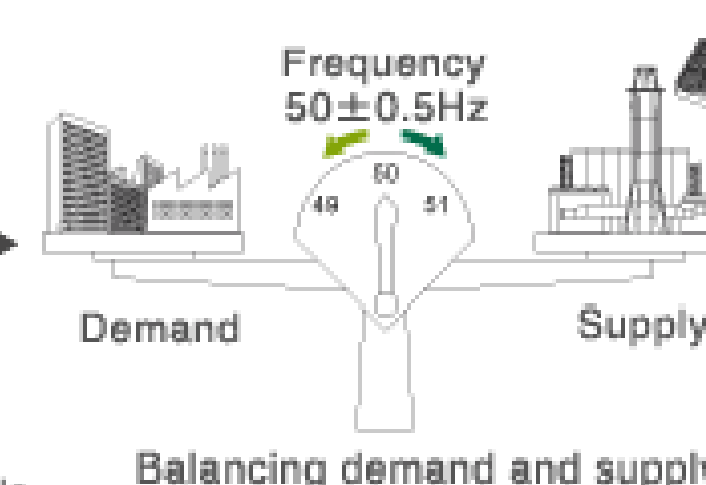
### Time scale: Energy storage – technology overview



### Unstable Network

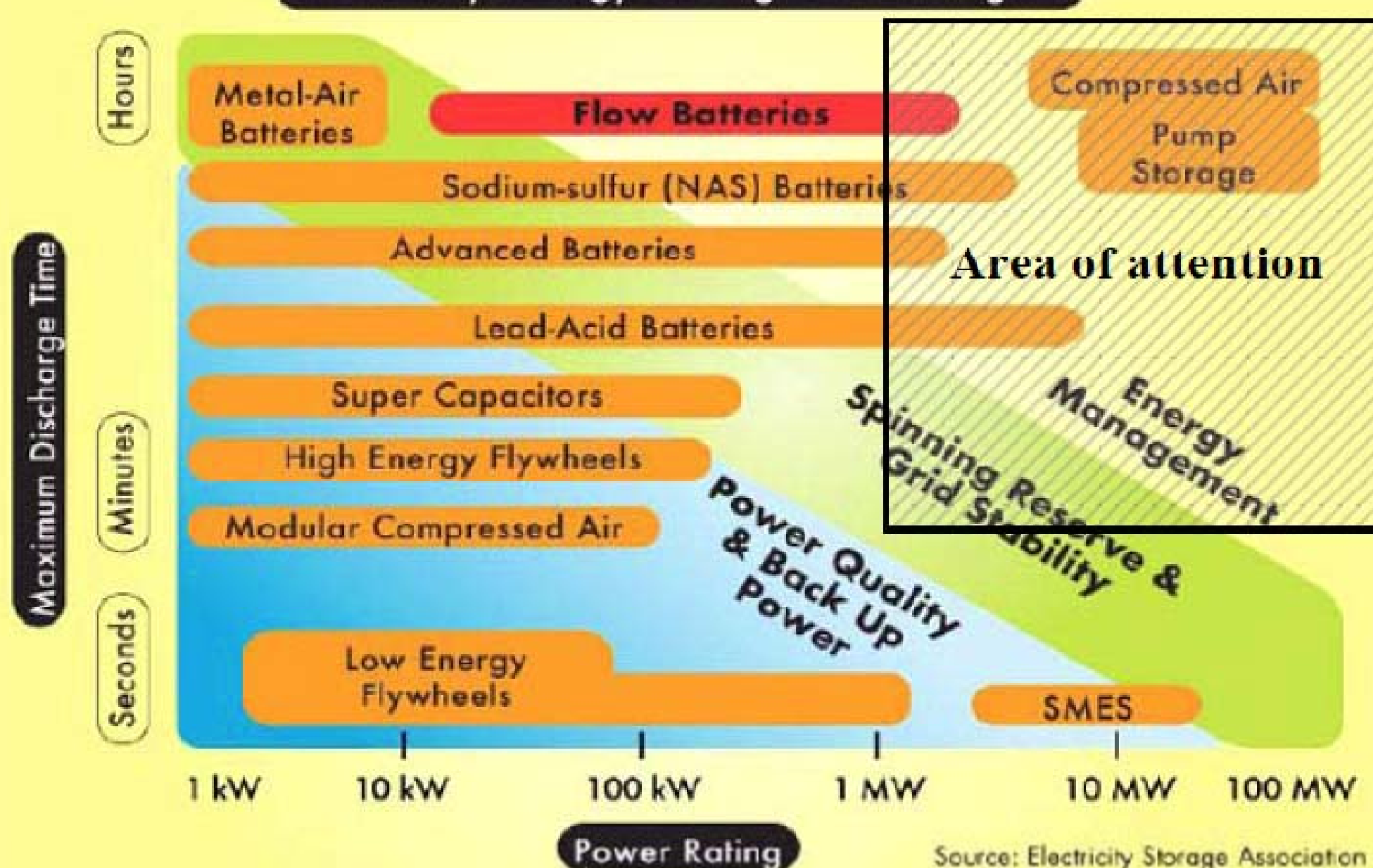


### Stable Network



Ultracapacitor 75V, 94F, Source: Maxwell Technologies

### Electricity Energy Storage 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:

