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Storage Systems for Large Wind Turbines

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**Challenges**

- 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
- peak shaving
- production leveling

Services that can be offered to the grid:

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

**Some significant technologies**

**Time scale:**  
- Short
- Medium
- Long

**Energy storage – technology overview**

- Flow batteries
- Vanadium Redox Flow Battery
- Ultracapacitor
- Sodium-sulfur (NAS) batteries
- Lead-acid batteries
- Supercapacitors
- High Energy Flywheels
- Compressed Air

**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:**