Kaushik Das, DTU Wind Energy

Enhanced Features of Wind-Based Hybrid Power Plants

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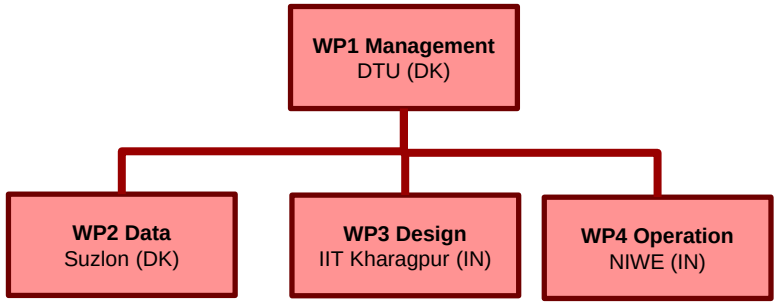
DTU Wind Energy

Work done as a part of Indo-Danish project
“HYBRIDize” funded by Innovationsfonden Denmark

HYBRIDize project

- 3 year Indo-Danish project
- Start date: 1st May 2019
- Funded by Innovationsfonden in Denmark and DST in India



Objective:

- minimize levelized cost of energy (LCOE) and levelized cost of storage (LCOS)
- maximize profit for HPP

Main Expected Outputs

- Weather based component sizing methodology (DTU)
- Electrical Infrastructure Design and Control (IIT, DTU)
- Assessment of grid code requirements for HPP (Suzlon)
- Development of Energy Storage Evaluator (HG-DK)
- HPP Forecasting System (DTU)
  - o Benchmarking with state-of-art forecasting (Suzlon, NIWE)
- HPP supervisory control to maximize profit from market (DTU)
- Development and validation of controls at a small NIWE facility (NIWE, IIT, DTU)

VRE based Hybrid Power Plant

- **<u>Utility-scale grid connected HPP</u>** are large power plants (hundreds of MW) operated to maximize profit from market while required to provide grid ancillary services similar to any large power plant.

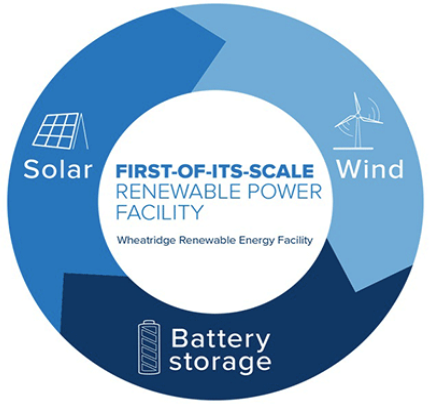
KENNEDY ENERGY PARK

Windlab and Vestas installed first utility-scale Kennedy Energy Park HPP in 2018 in Australia
43.2 MW of V136-3.6 MW WTs, 15 MW of PV and 2 MW/4 MWh Li-Ion battery storage
All managed by Vestas customised control system

Parc Cynog, UK
8.4 MW Wind and 5 MW solar PV

Wheatridge Renewable Energy Facility

North America's first major renewable energy facility combining wind, solar and battery storage in one location



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MNRE issues National Wind-solar Hybrid Policy

Solar

India to launch 2.5-GW wind-solar hybrid auction

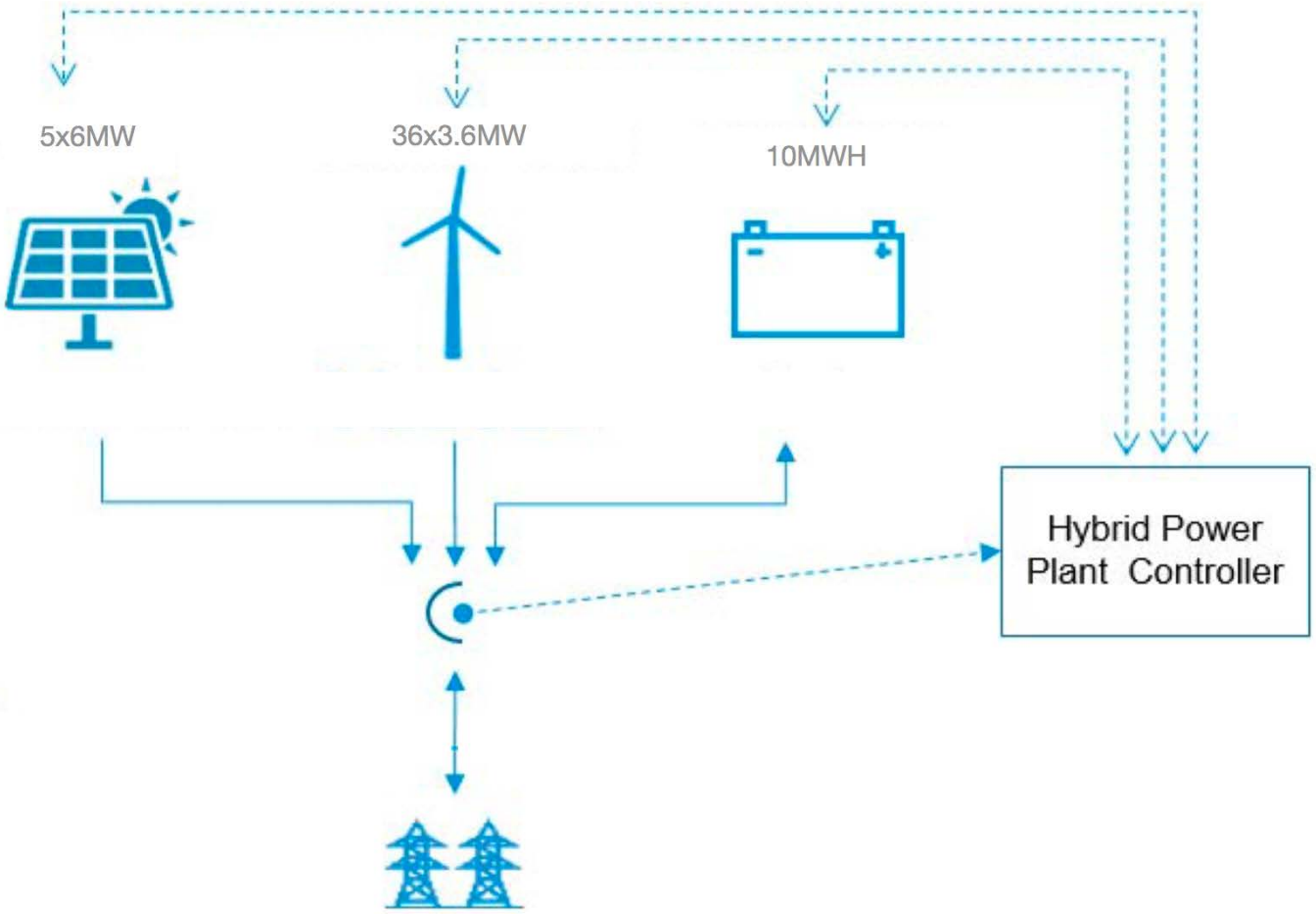
MEGAVIND

INCREASE THE SYSTEM VALUE OF WIND POWER

Today's wind turbines and wind farms are advanced electricity generation systems working in an increasingly integrated system that generates, stores, transmits and consumes energy. As described in the Megatrends, the build-out of the renewable energy capacity is moving towards technology-neutral tenders in which wind energy is competing head-to-head with other renewable technologies. Therefore, we are seeing companies moving towards delivering hybrid solutions consisting of e.g. wind, solar and storage facilities in order to best meet the demands for low cost, stable power generation and deliver reactive power and ancillary services.

The ability to fit into this new trend is a major innovation driver.

Hybrid Power Plant – Utility scale co-located grid connected

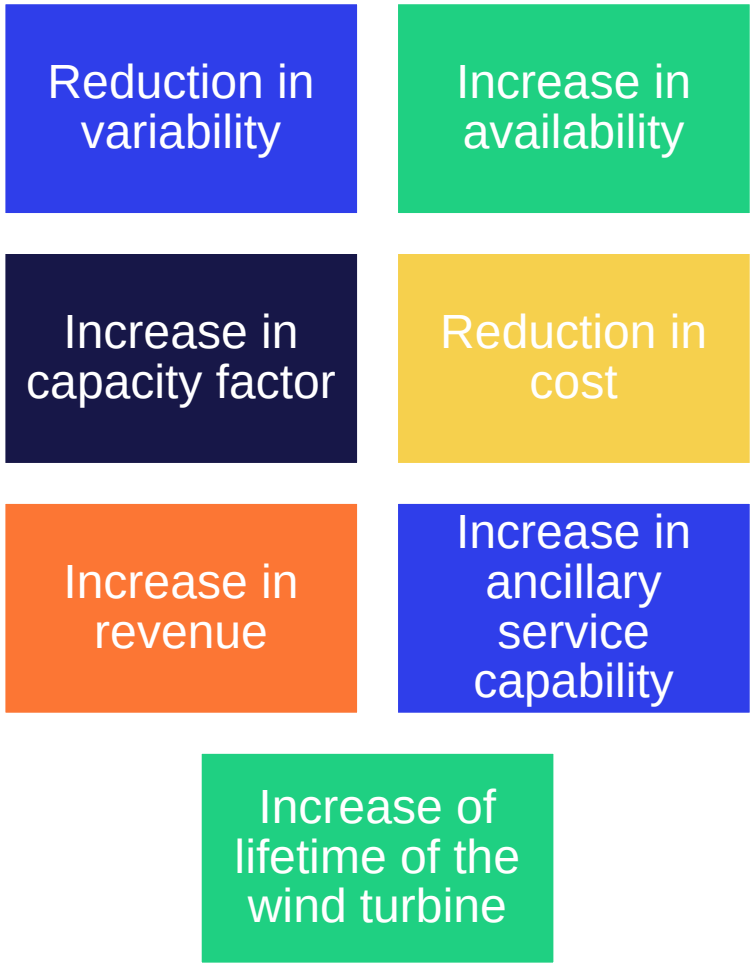


General Features:

- More than one generation sources involved
- All the assets are owned by same company so higher controllability
- Motivation is to reduce cost / maximize revenue from different energy markets
- Control of electrical load is not of concern of the power plant owner as compared to traditional Hybrid Power Systems
  - Sometime even provide near baseload generation
- Many stakeholders involved

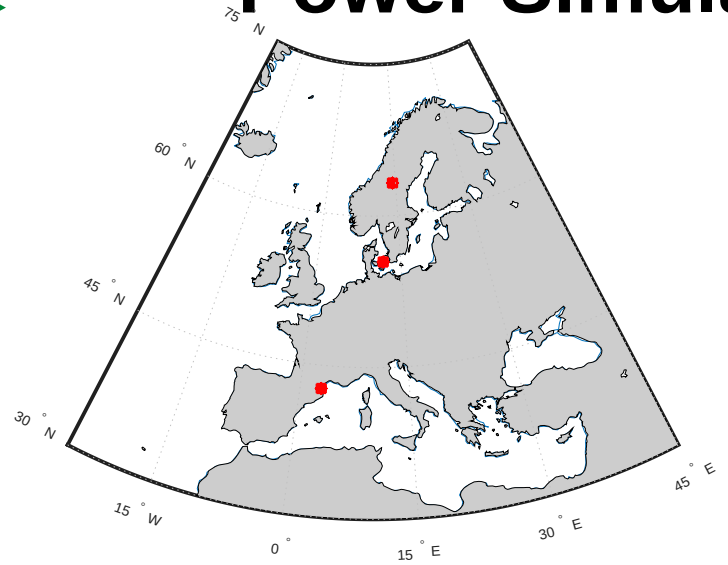
Advantages/Values of HPP

- **Cost reduction and Revenue increase**
  - Infrastructure
    - Reduction in land cost
    - Optimal use of electrical infrastructure and other infrastructure (e.g. access roads) saves costs
  - Project Development
    - Joint permitting process reduces risks and costs
    - Shared resources reduce internal costs
    - Joint site development reduces costs for e.g. soil investigations & weather measurements
  - Park Performance
    - Less fluctuating production increases electrical infrastructure utilization
    - Storage increases flexibility and number of accessible markets (Energy market, ancillary services market)
    - Reduction of forecast error using storage

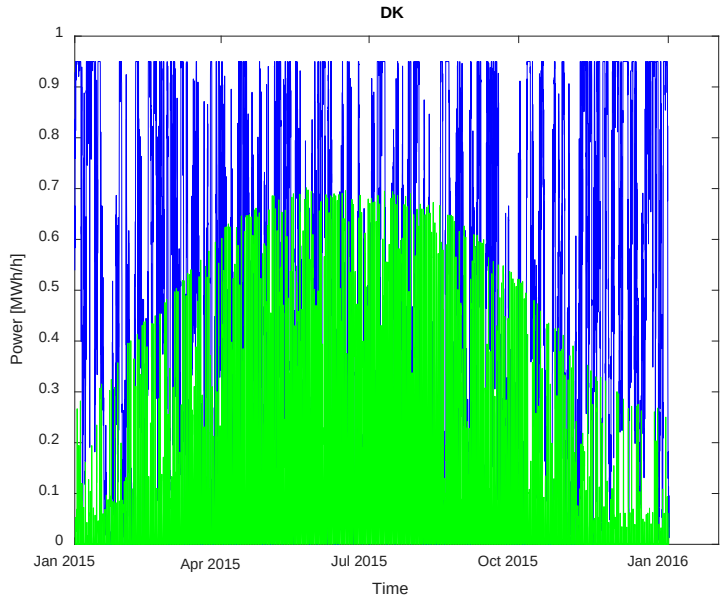


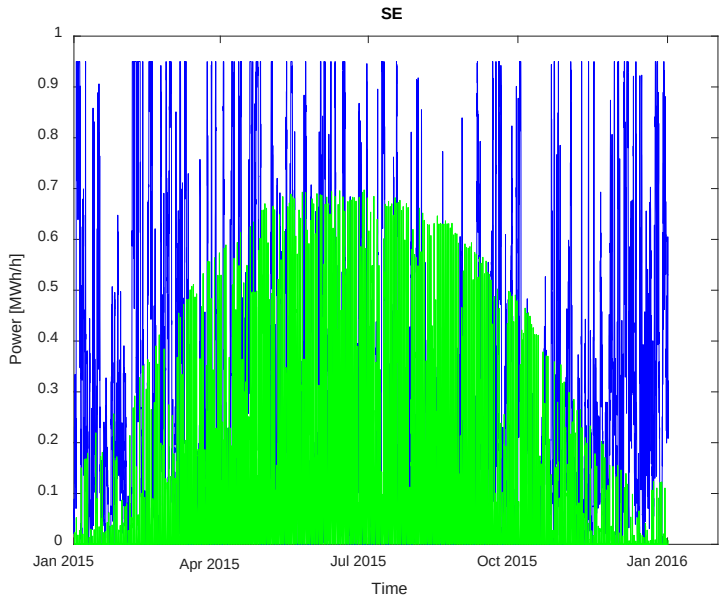
[1] Paulina Asbeck (Vattenfall), “Next-Gen Generation System: The symbiotic relationship of solar, wind & storage hybrid power plants”, 17th Wind Integration Workshop, 2018

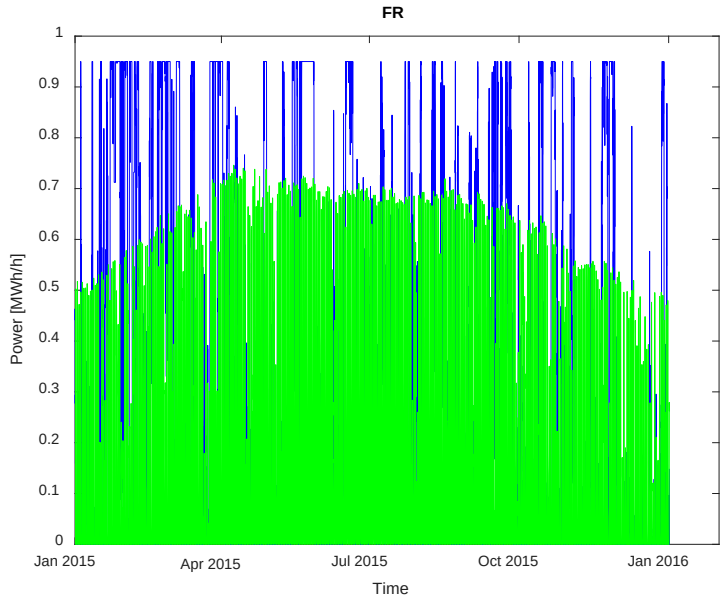
Power Simulation using CorRES



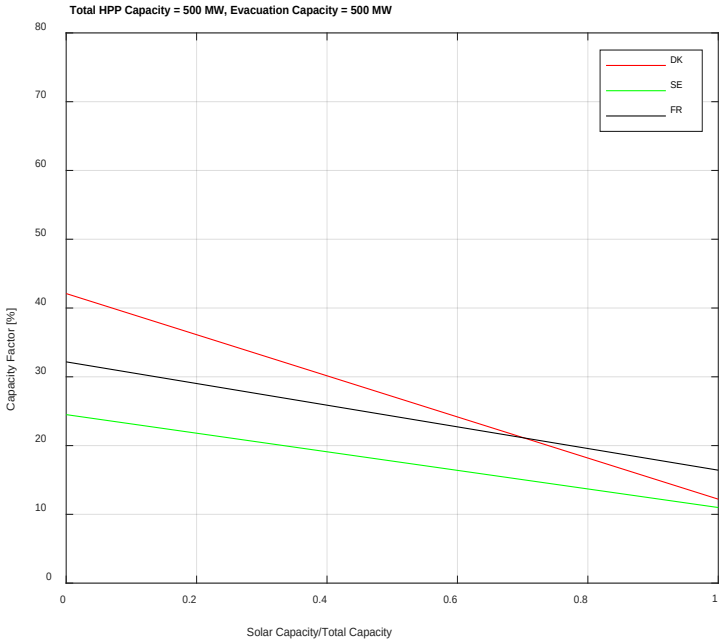
Location	Wind Power CF [%]	Solar power CF [%]	Correlation
Denmark (DK)	42	12	-0.1574
Sweden (SE)	24	10	-0.1206
France (FR)	32	16	0.0097







Increase in capacity factor



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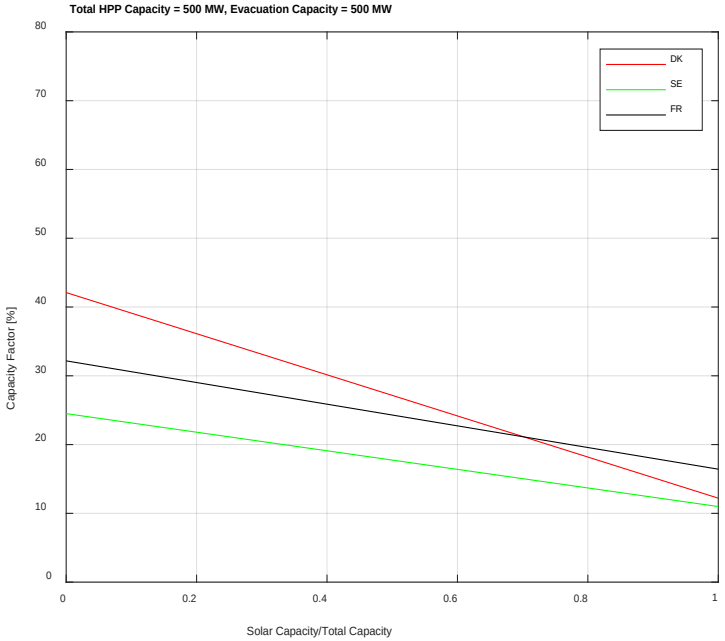

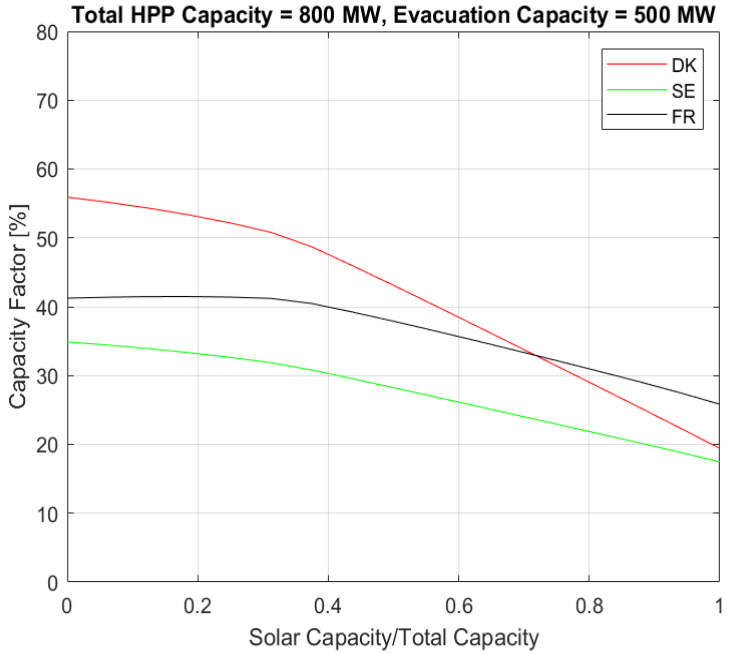

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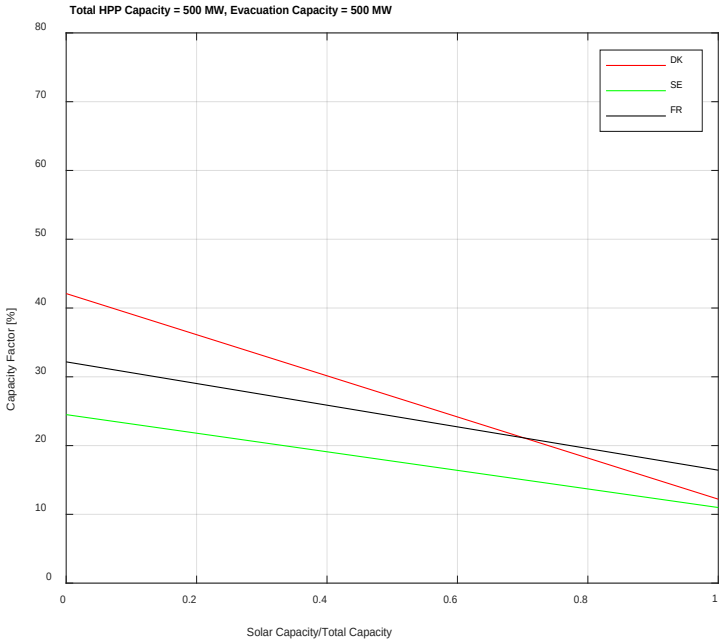
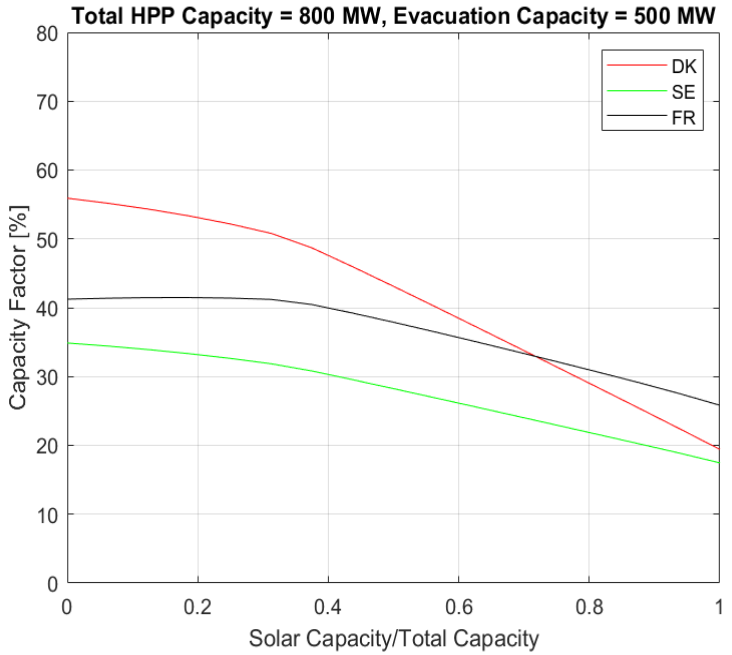
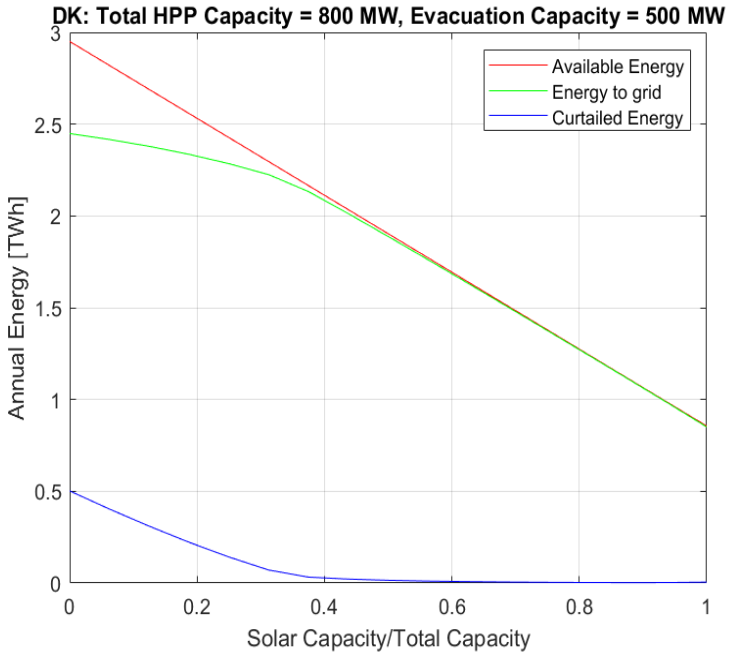
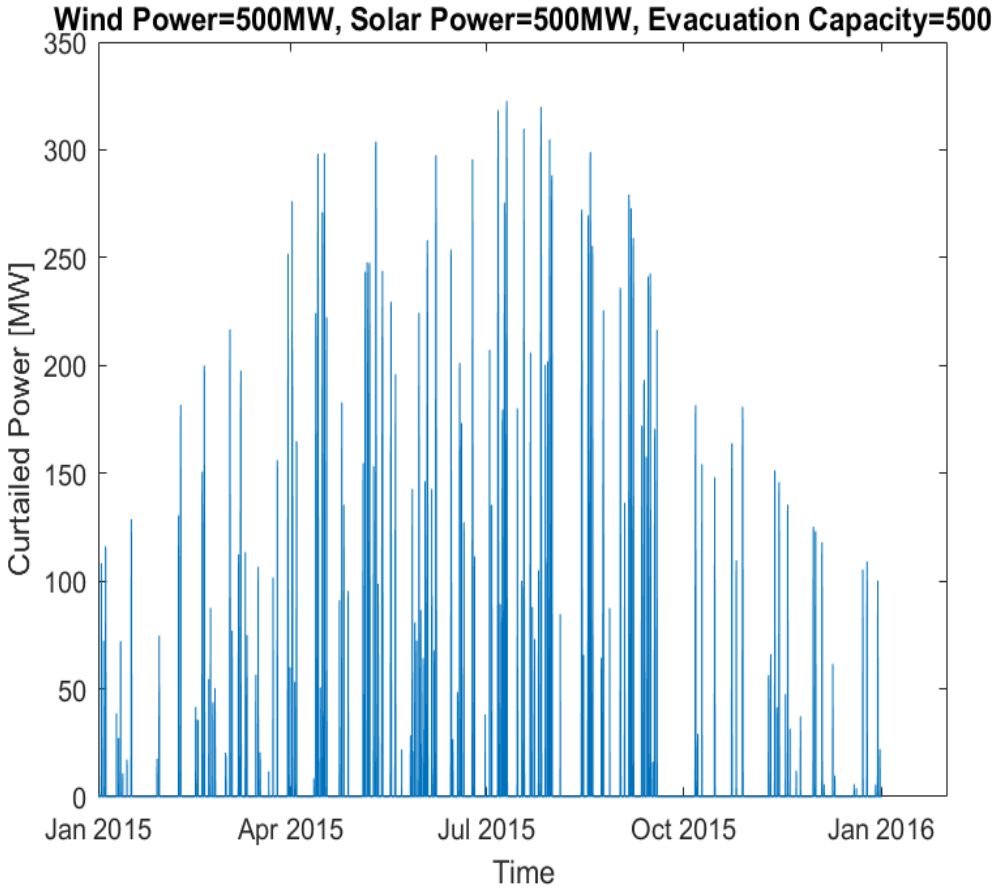
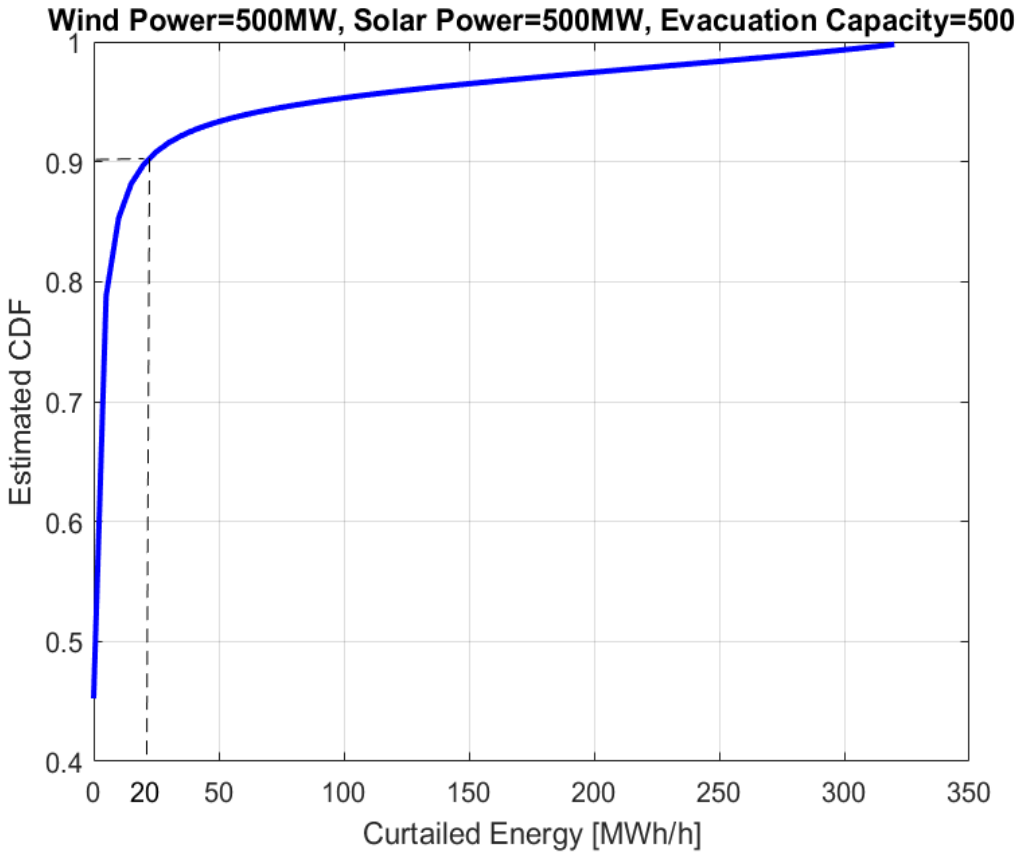






Increased dispatchability and flexibility using storage





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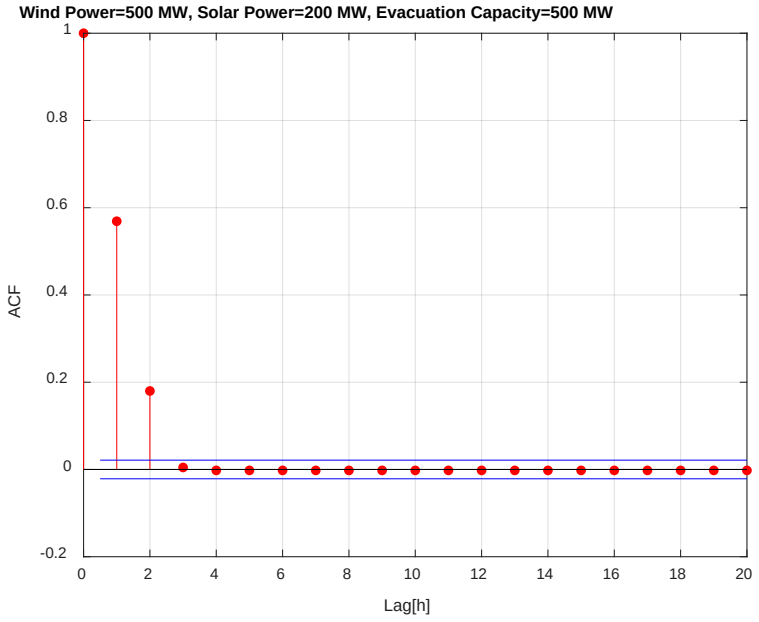

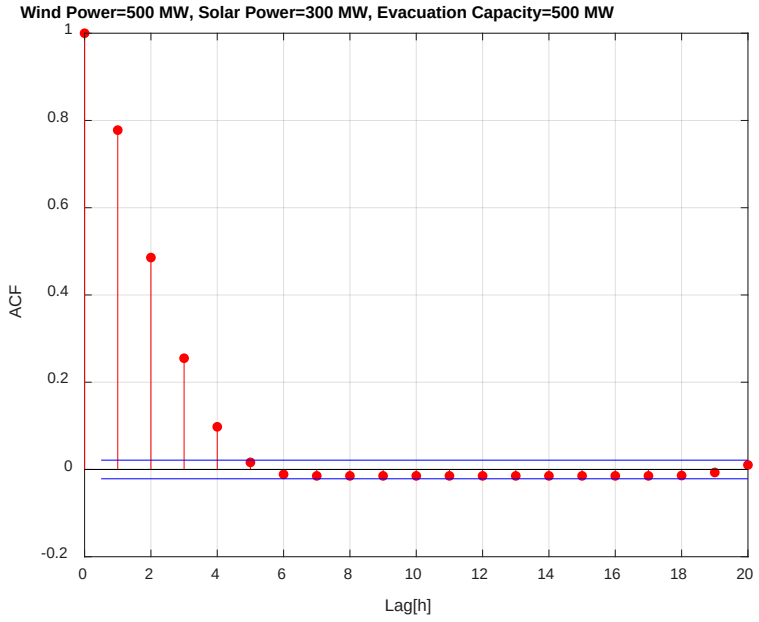

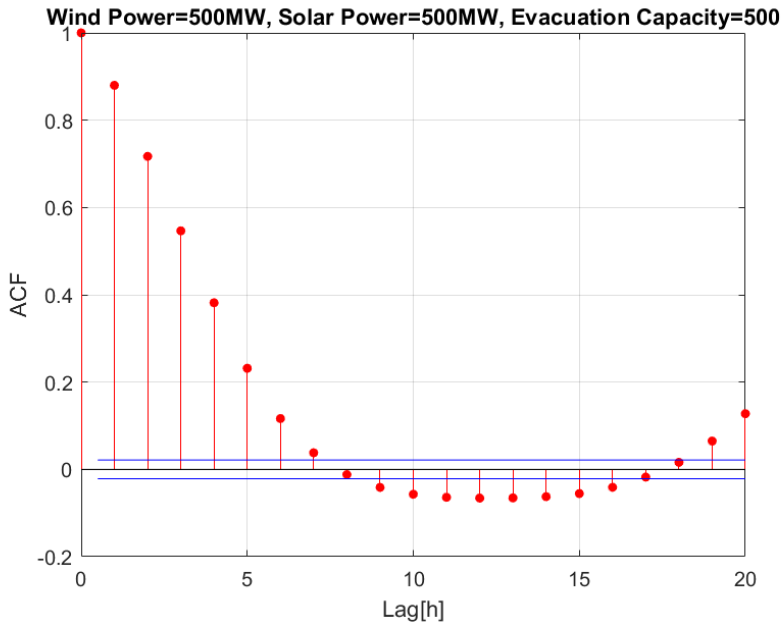

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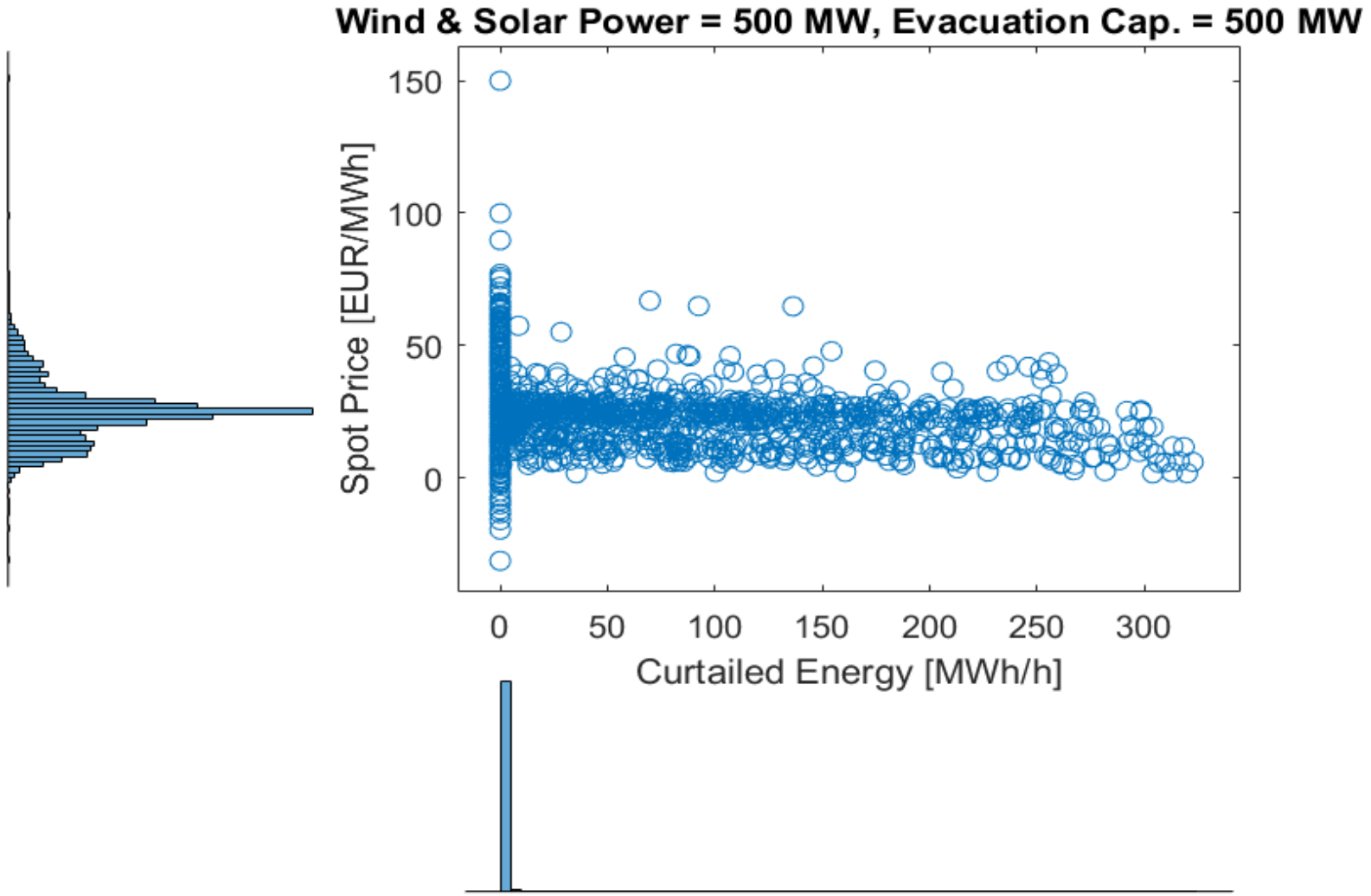
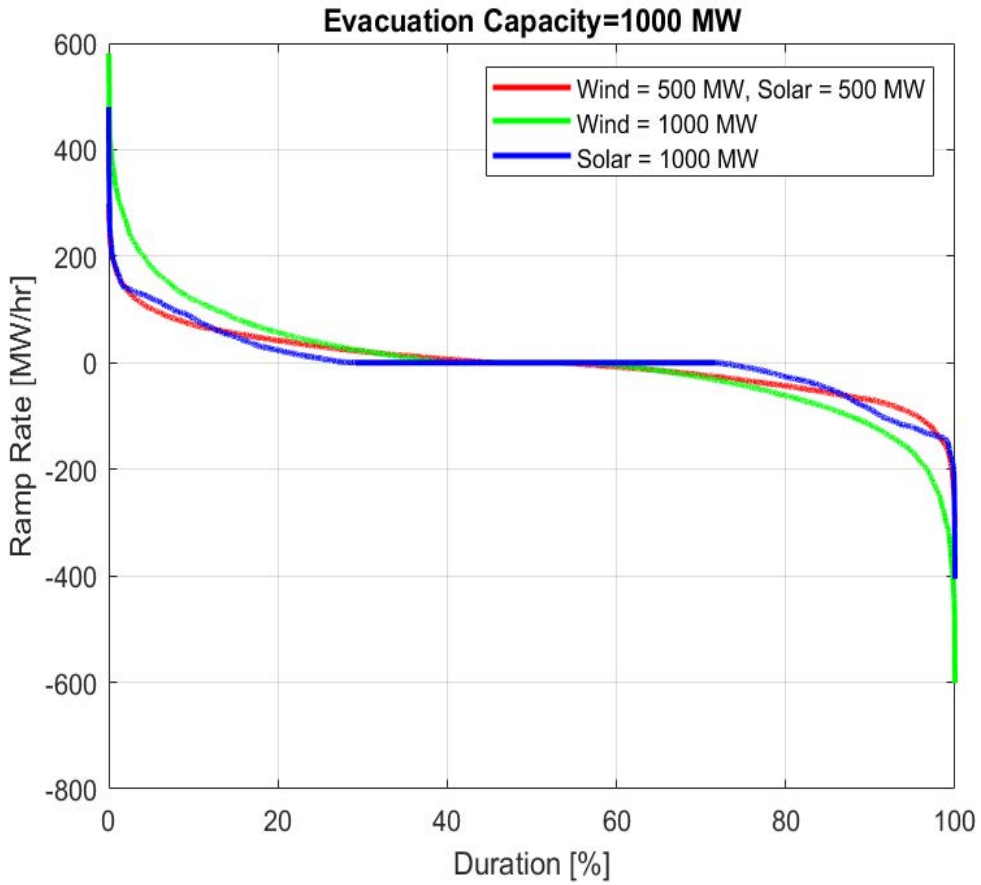
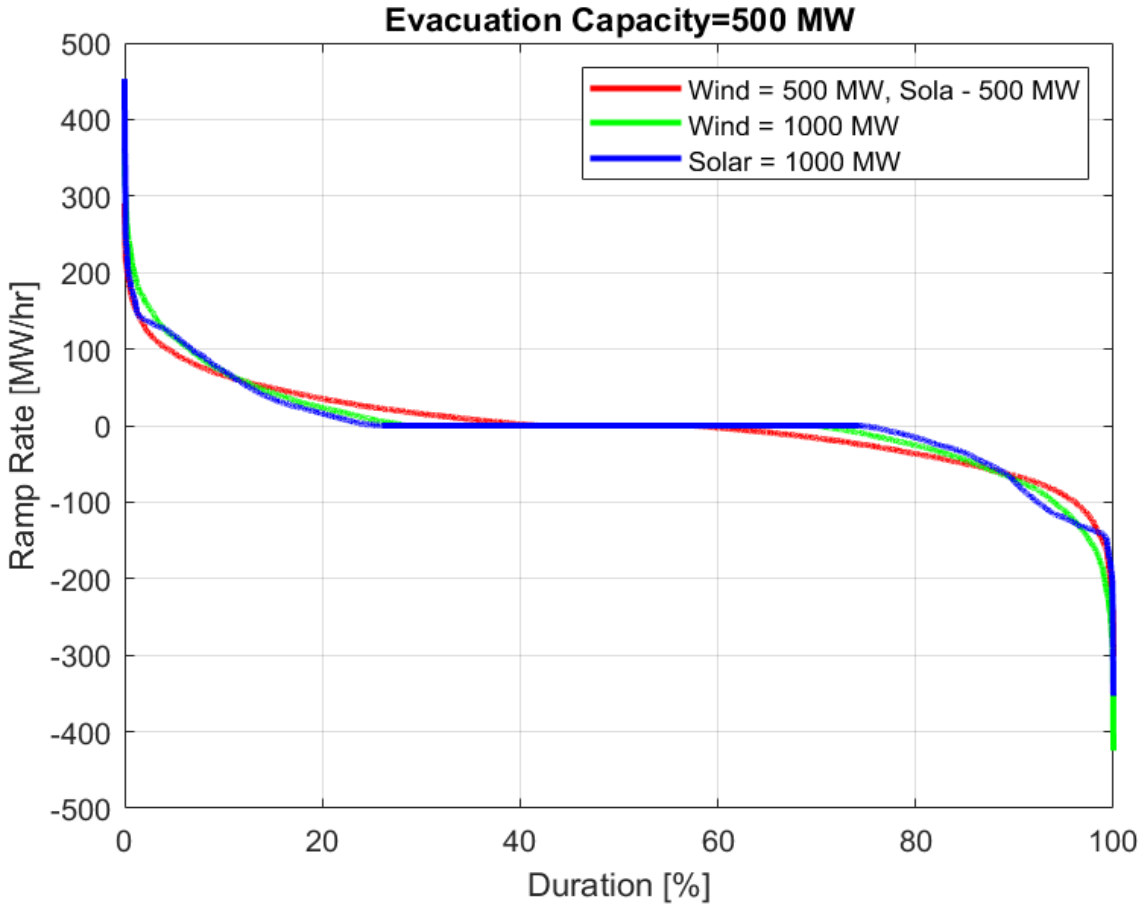


Reduction in variability






Research

Energy Management System

- Optimal operation on markets: energy markets, ancillary service markets and capacity markets considering uncertainties, component lifetime

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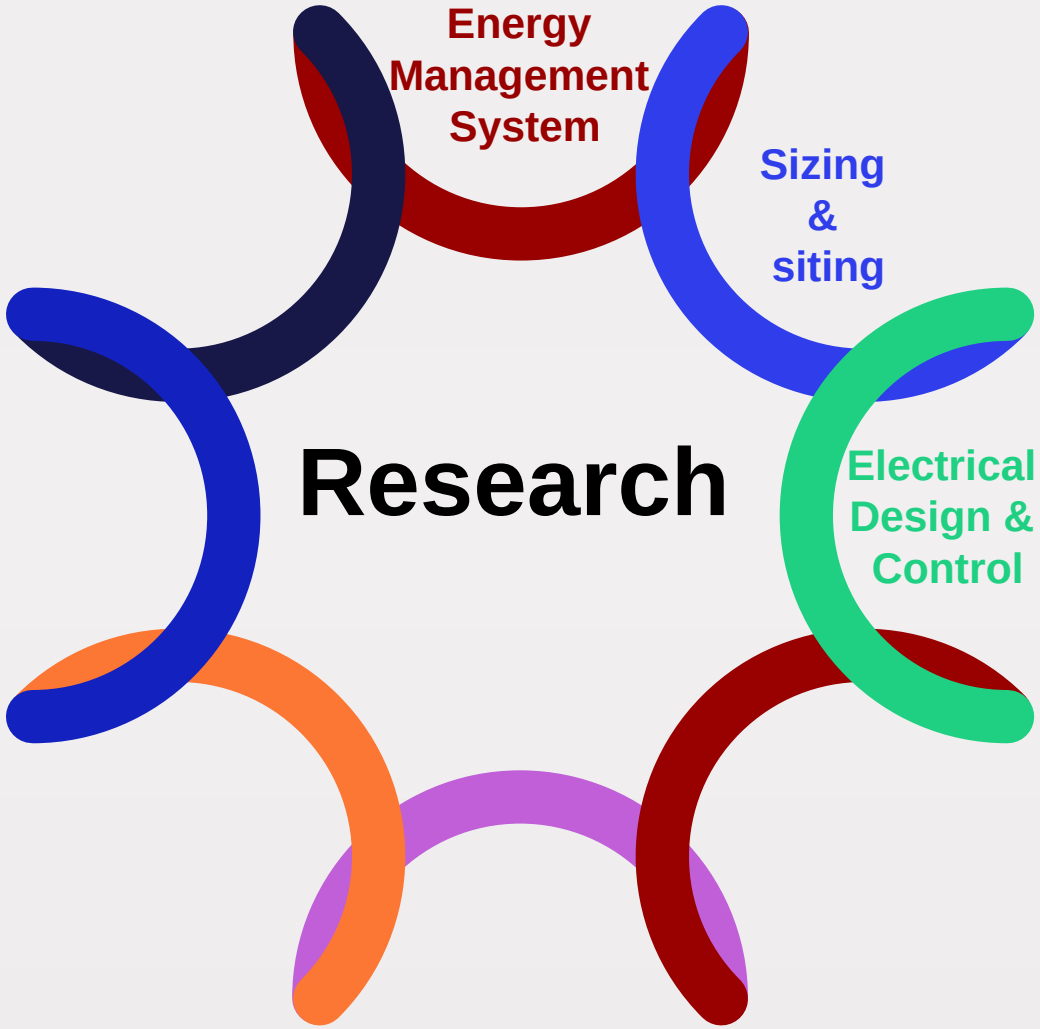
Sizing and siting

- Resource assessment
- Physical Design Optimization
- Choice of technologies
- Optimal sizing of components
- Hybridization of existing wind or solar plants



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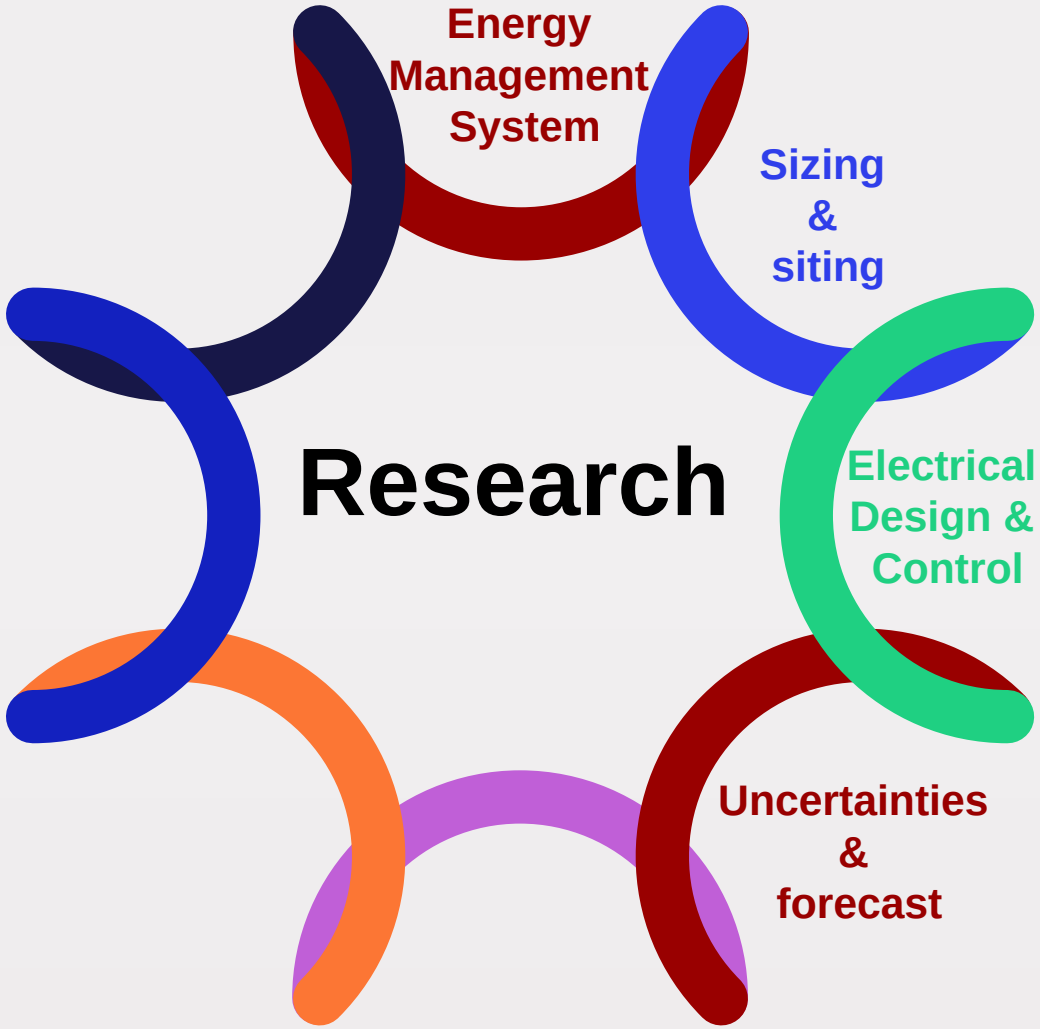

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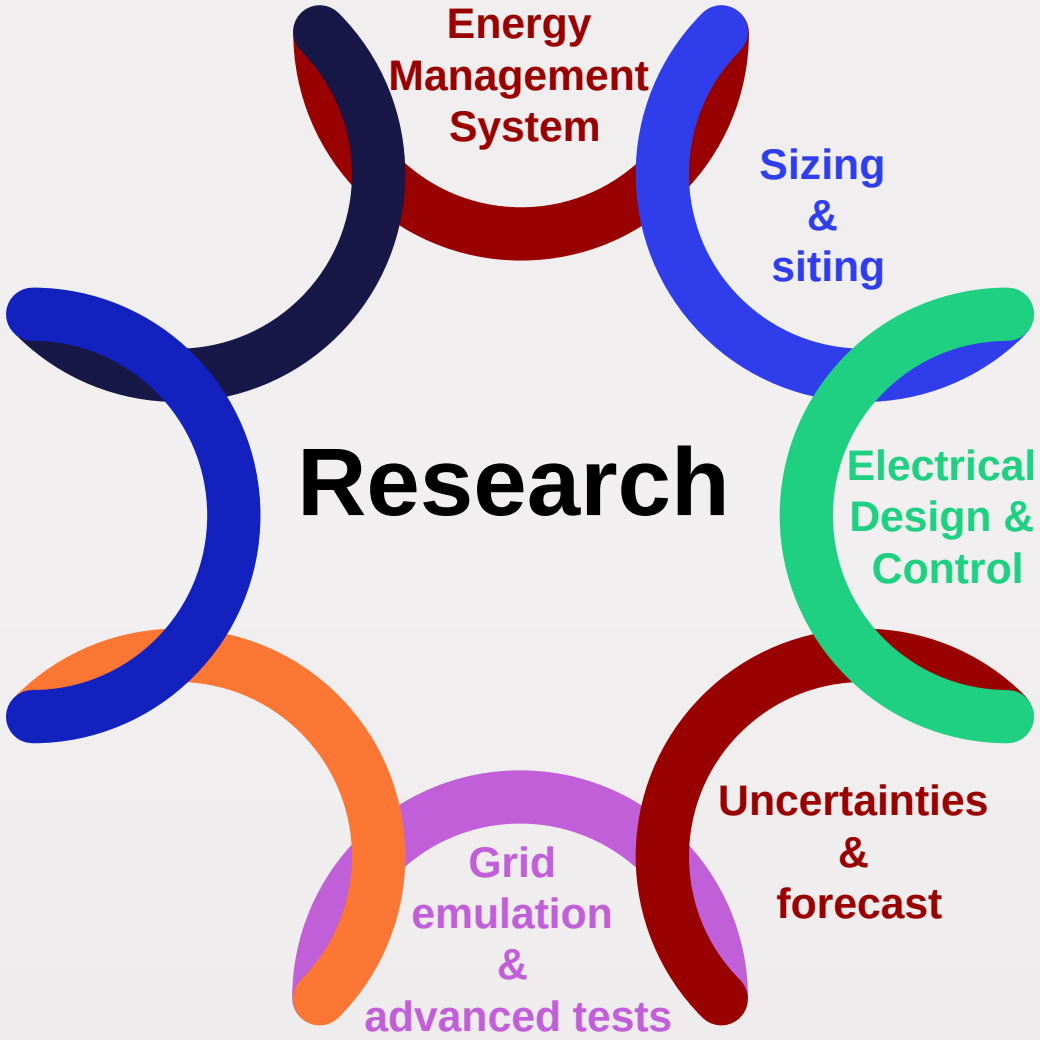
Uncertainties and forecast

- Variability for combined wind-solar-battery
- Market forecasts
- Hybrid power forecast
- Real time power simulation
- Assessment of flexibility & ancillary services



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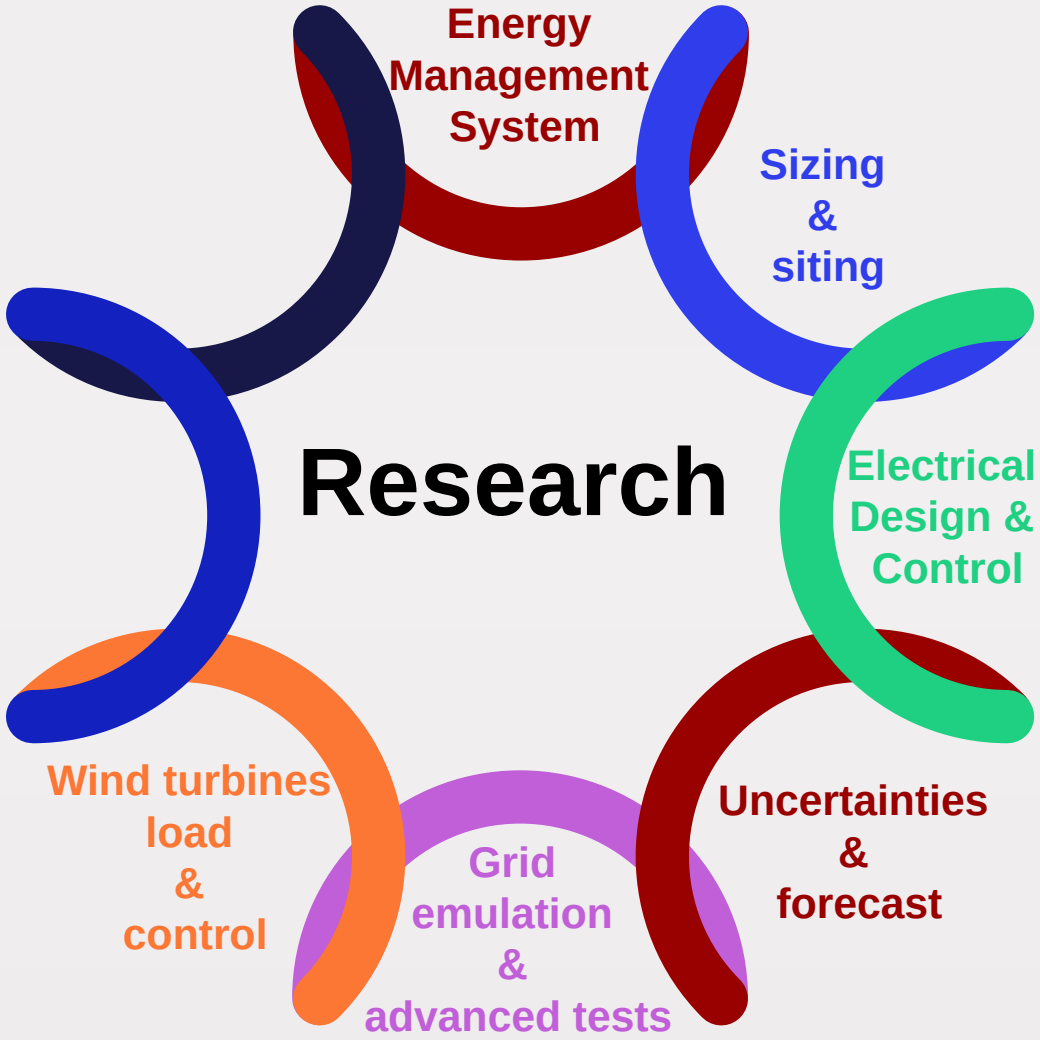
- Development of new test methods / grid codes
- Validation of models



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- Wake impact
- Load/fatigue minimization i.e. lifetime maximization
- Use of wind scanner in control

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- Optimization of wind farm output considering storage / solar
- Wake modeling/state estimation considering PV

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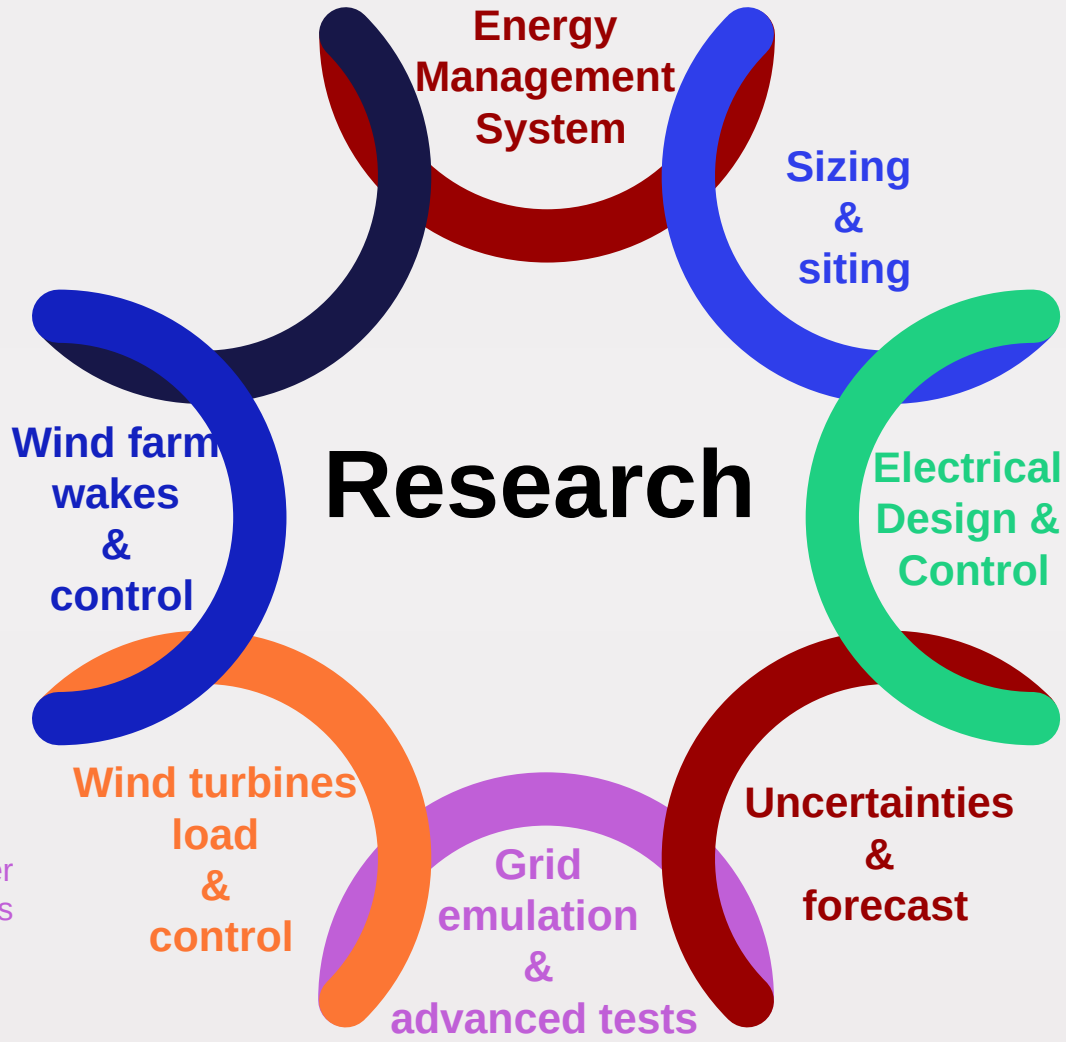

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Others

- Grid interaction and stability
- Improvement/adaptation of solar/storage technologies for HPP
- Offshore applications

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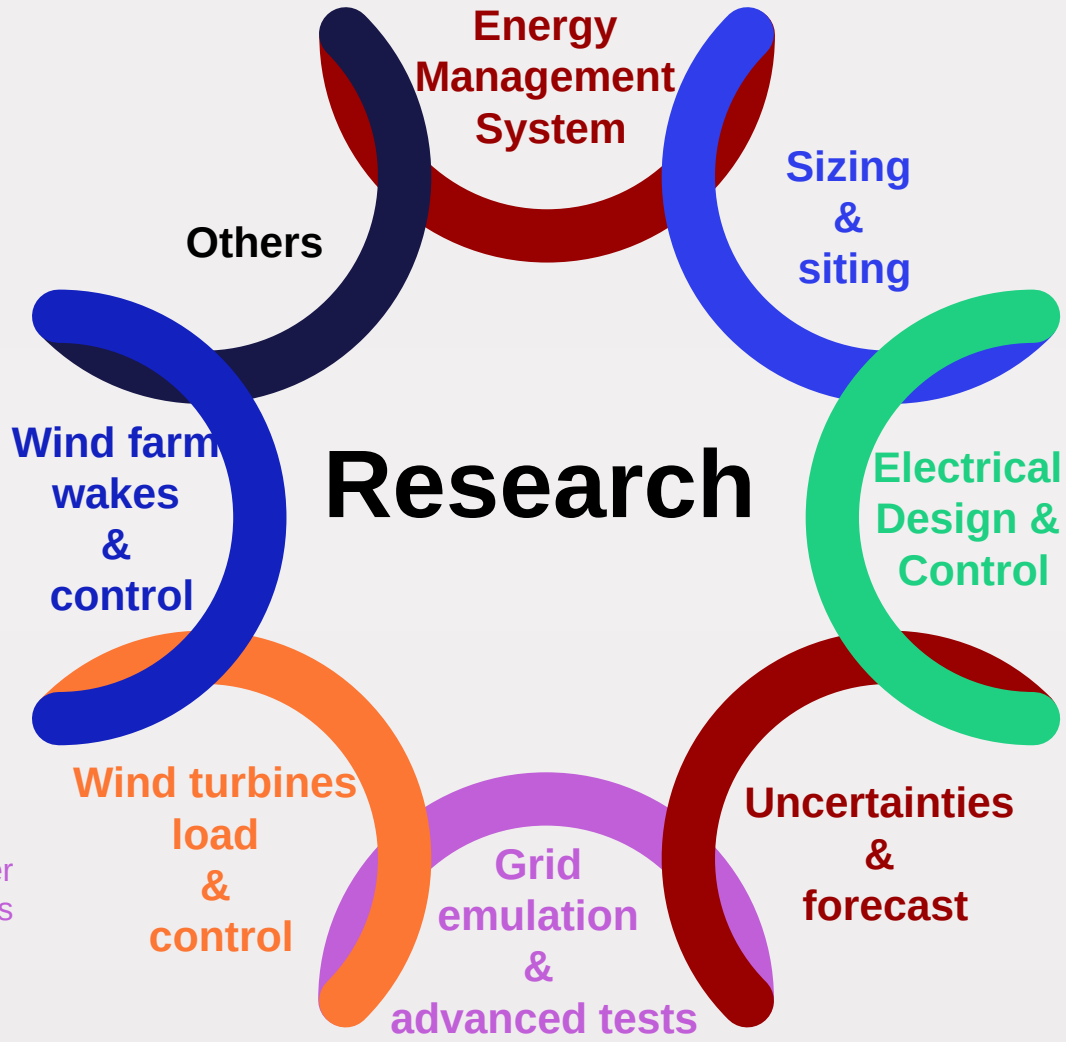

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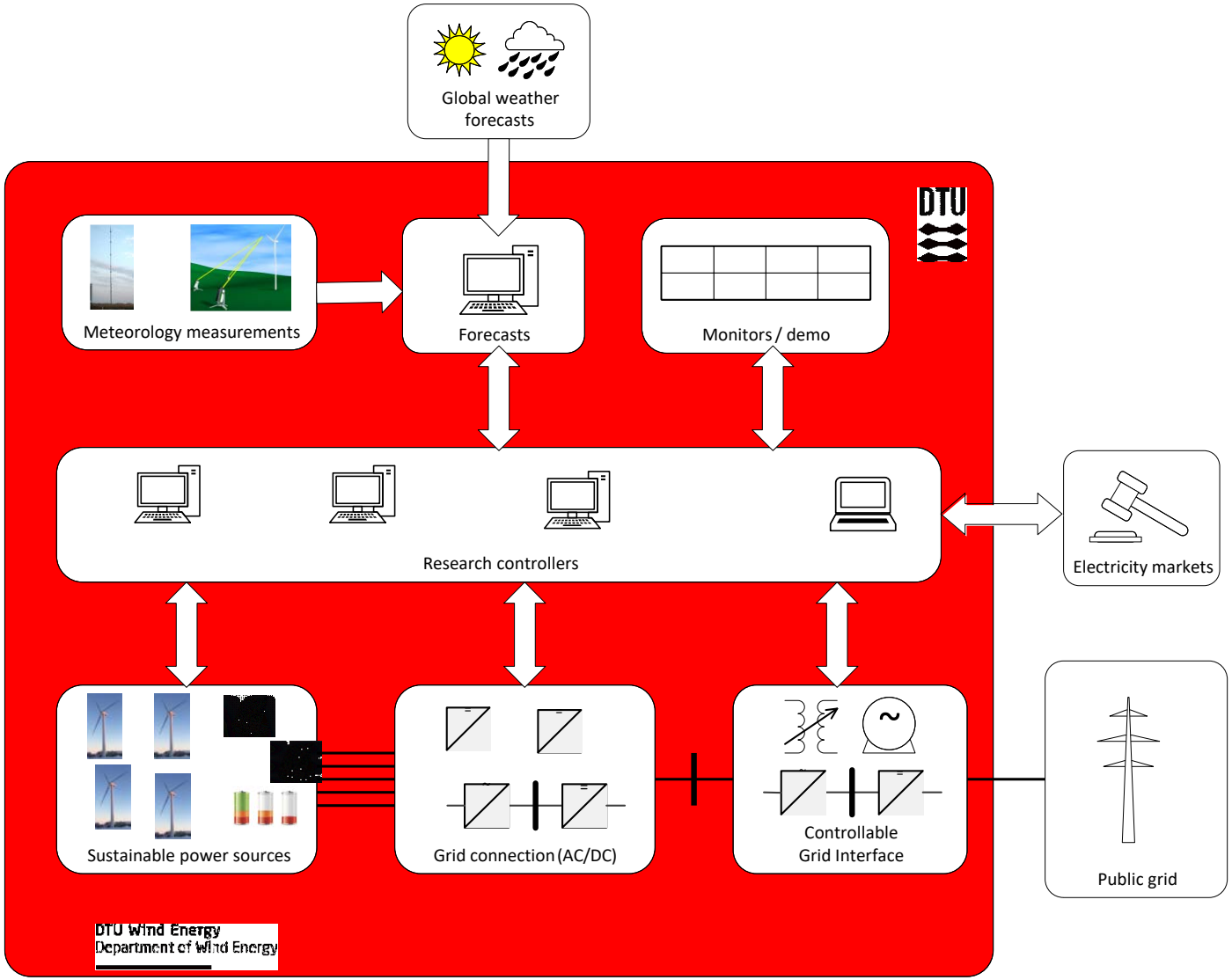
Wind-Hybrid Research Facility

- Grid connected wind-hybrid power plant (wind / solar / storage)
- Open research controllers
- AC and DC power collection (gird connection)
- Controllable grid interface
- Connection to external information (weather forecasts, markets)



Thank You