Online Optimisation and Control for Renewable Hybrid Power Plants

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Vattenfall in Brief

Key Facts / Figures

- One of Europe’s leading energy companies
- 100% owned by the Swedish state
- Main products: electricity, heat, gas, energy services
- Main markets: Sweden, Germany, the Netherlands, the UK, Denmark and Finland
- Net Sales 2018: 156,8 MSEK

6.5 million
Electricity customers

2.1 million
Heat customers

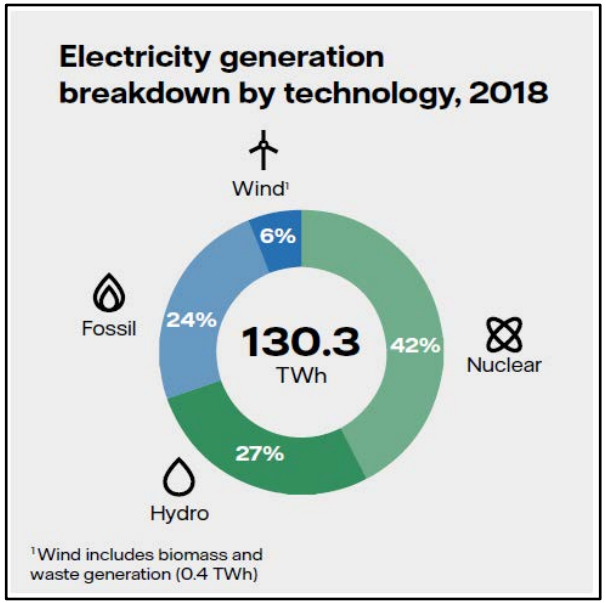
3.3 million
Electricity network customers

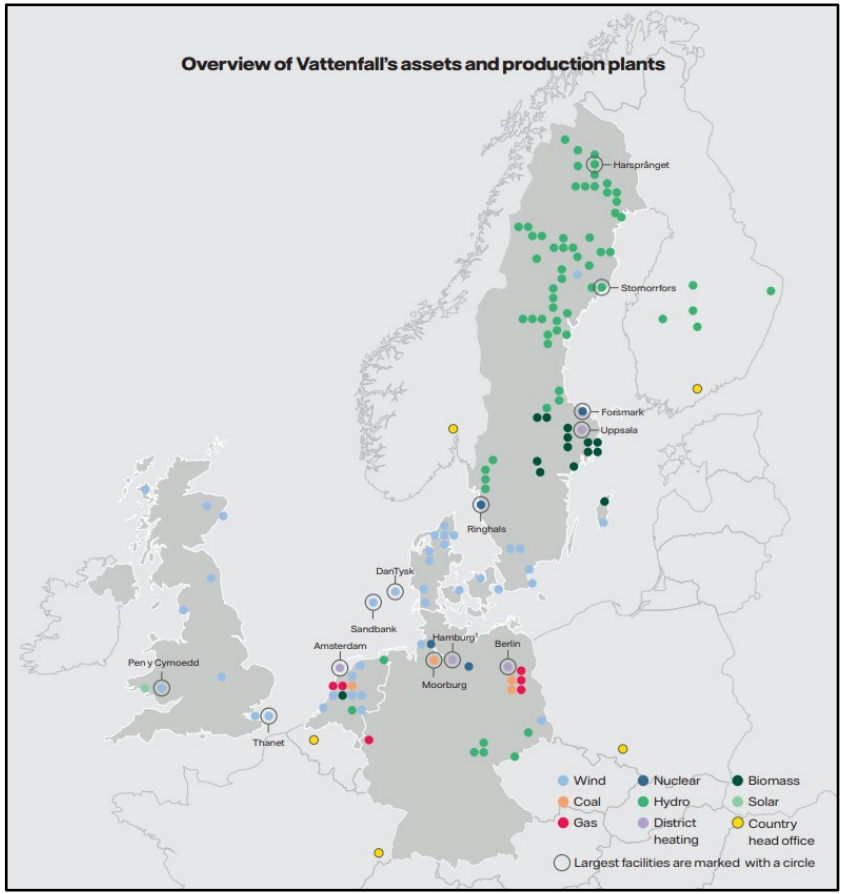
2.4 million
Gas customers

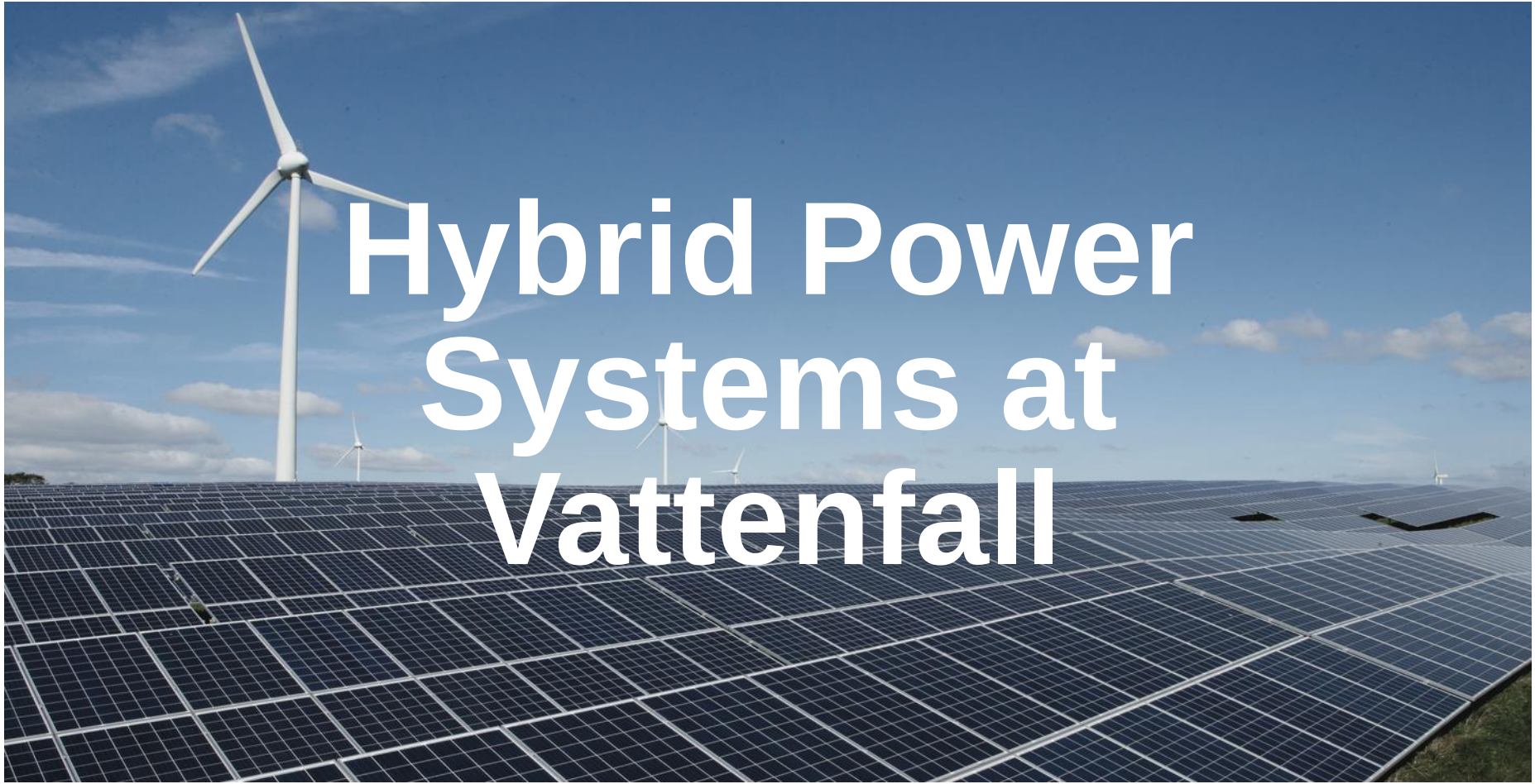
19,910
Employees

Electricity Generation and Asset Map

VATTENFALL







Hybrid Power Systems at Vattenfall

Background

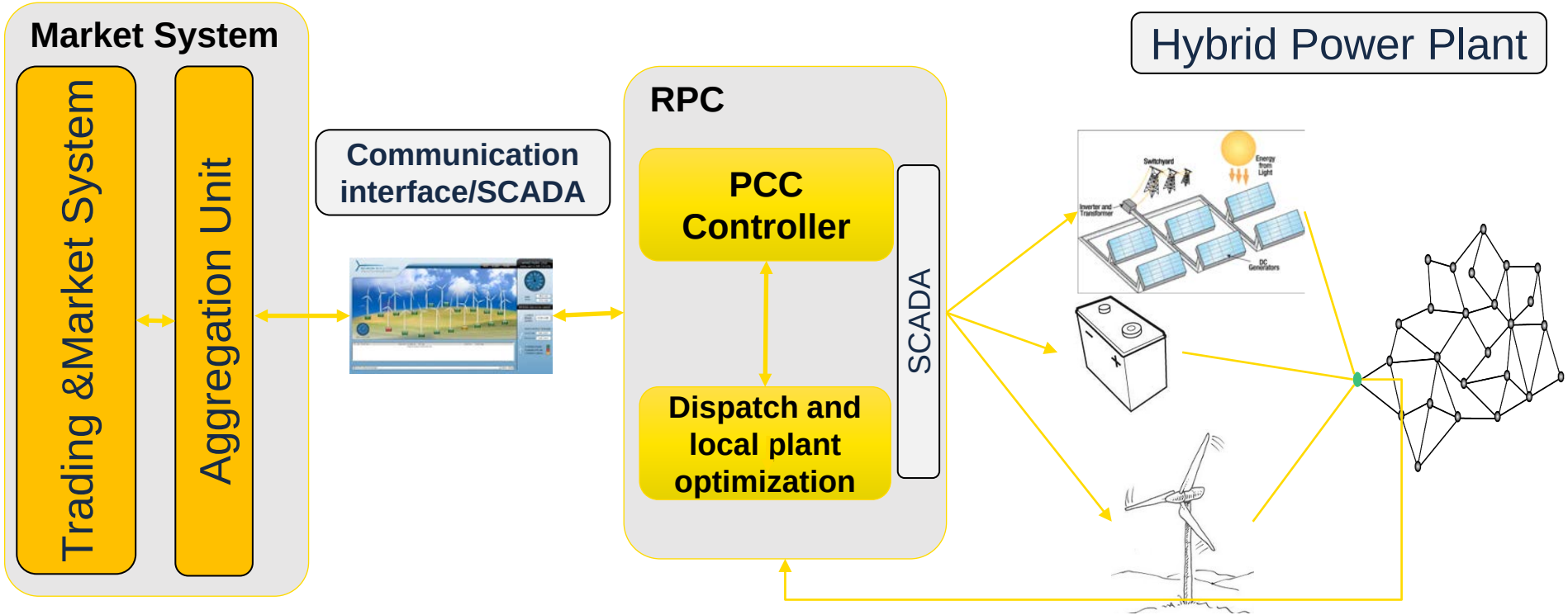
- Vattenfall aims to be fossil-free within one generation
- Sweden commited by law to be carbon-neutral by 2045
- Result: Increased focus in wind, hydro, storage and flexibility
- Issue: Integration of the different technologies

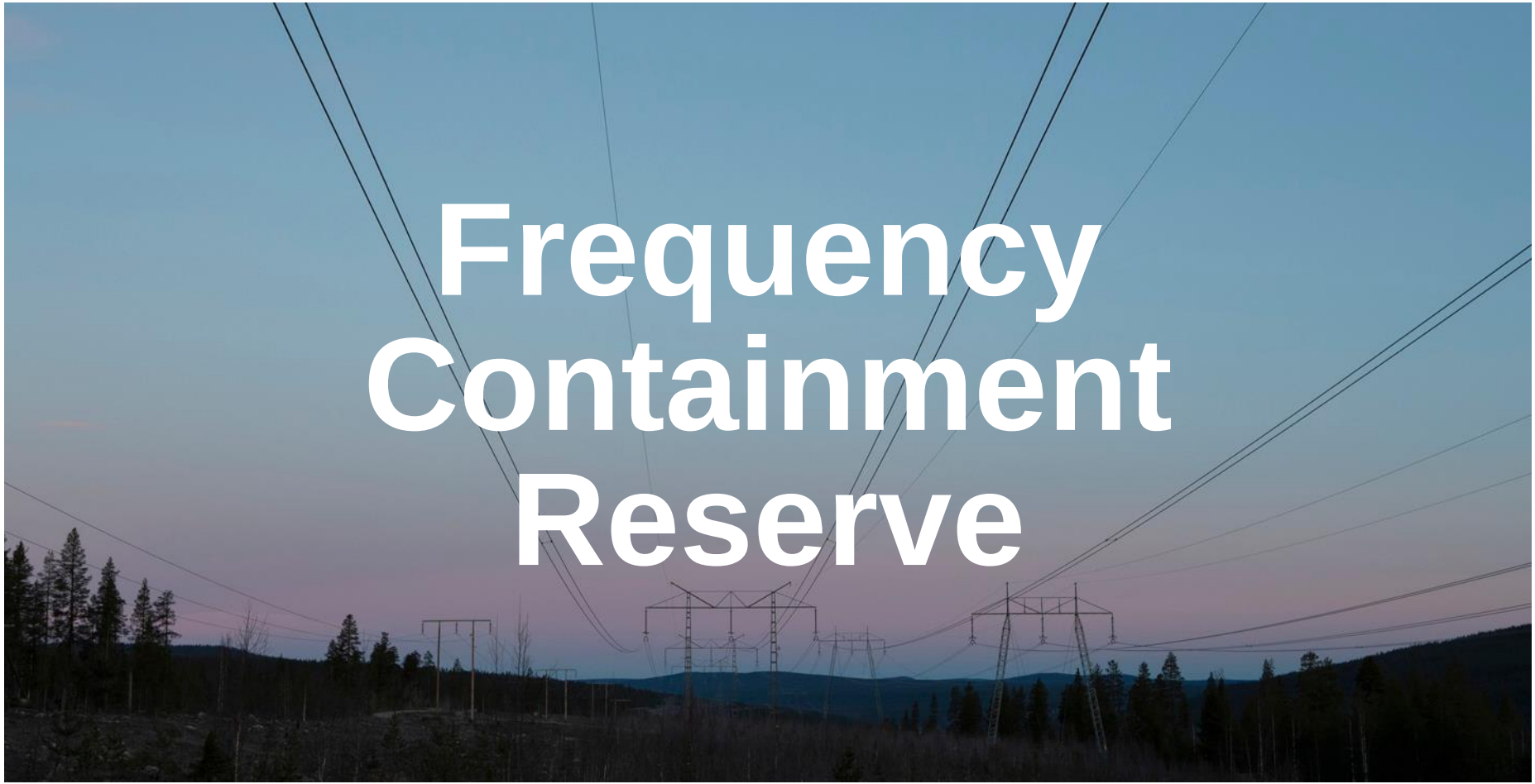
Hybrid at Vattenfall

- Trend for adding batteries and solar installations to existing onshore wind farms
- Better utilisation and flexibility
- Solar Farm installed at a Wind Farm in Wales, UK
- Batteries installed at Wind Farms in the Netherlands and the UK
- New hybrid (wind-solar-battery) plant planned for the Netherlands (2020)

Battery storage at the Pen y Cymoedd Wind Farm in the UK, source: Vattenfall

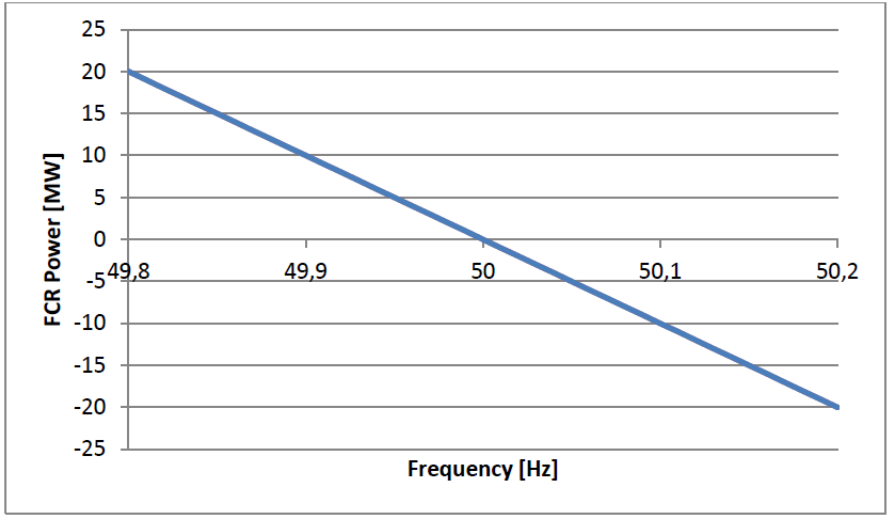
Need for a Hybrid Power Plant Controller



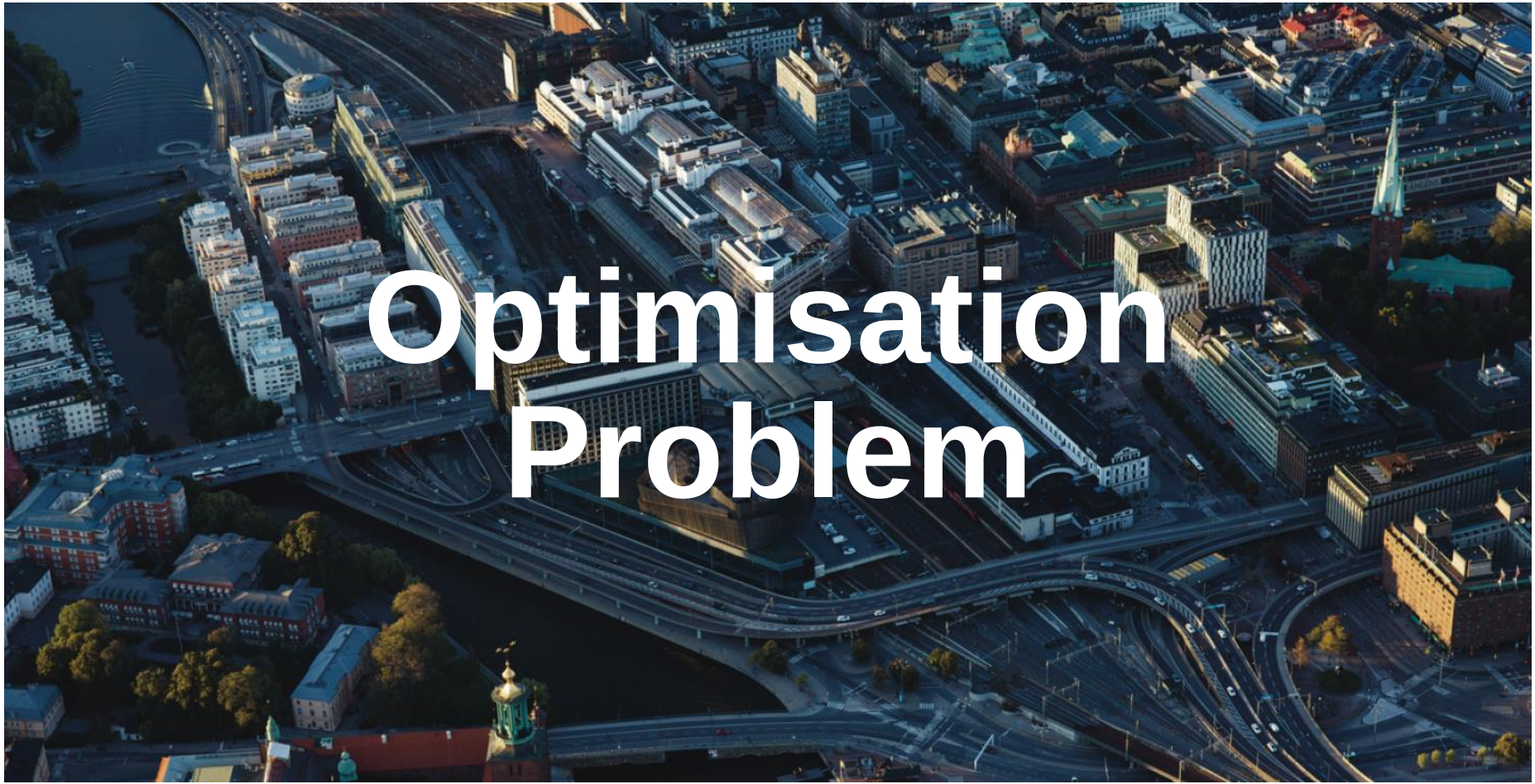

Frequency
Containment
Reserve

FCR for the Netherlands

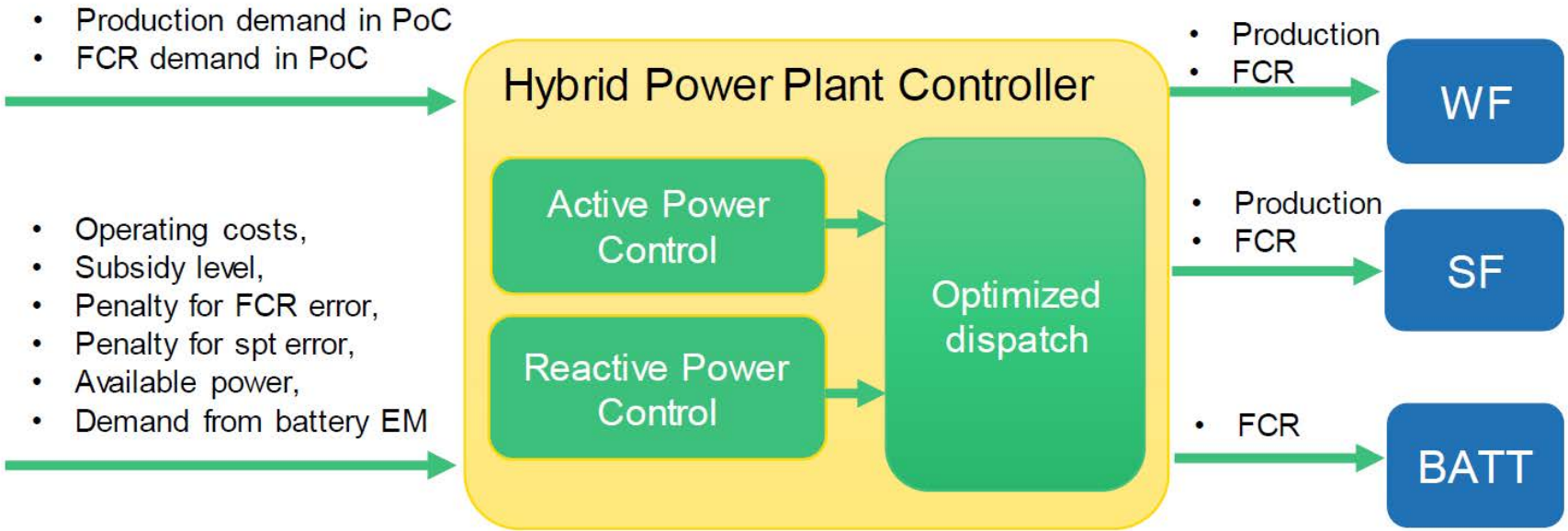
- Responding to frequency deviations by increasing / decreasing production
- Participation through an auction scheme (weekly bids)
- Reserve Providing Units (RPUs) or Reserve Providing Groups (RPGs)
- Requirements for Prequalification proven with tests



FCR response example, source: TenneT


Optimisation
Problem

Optimisation in Hybrid Power Plant Controller



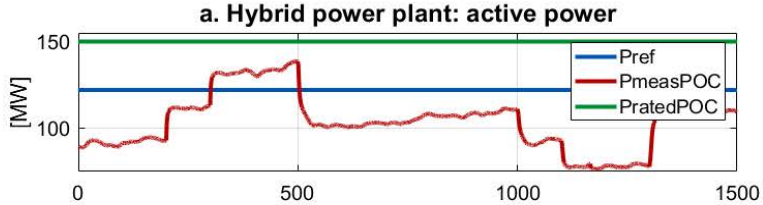

Test Cases

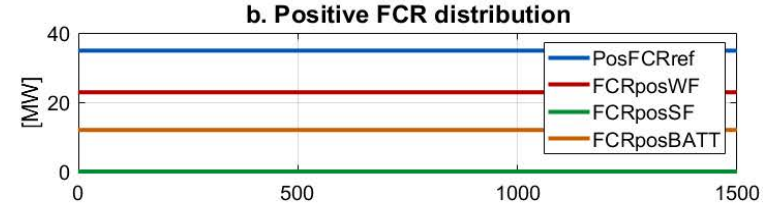
Simulation Data

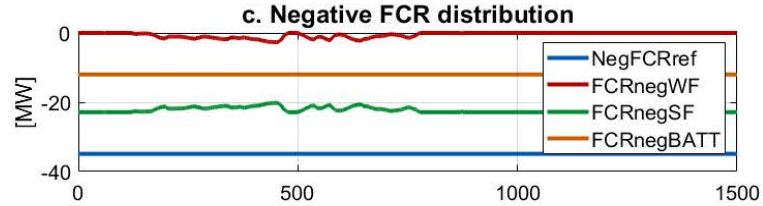
- Hybrid Power Plant comprising a Wind Farm, a Solar Farm and a Battery
- Assumptions:
  - All plants are certified to deliver FCR
  - The HPP is treated as a single power unit
  - The possible power for the wind and solar farm can be estimated accurately
  - Quantification of operating costs

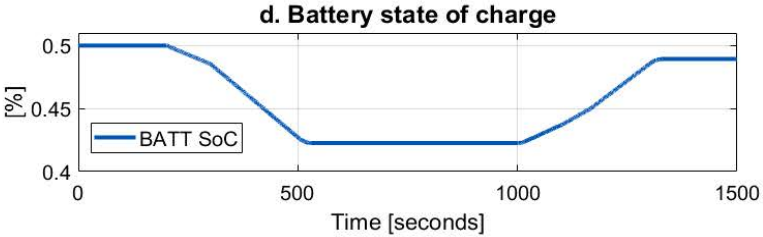
Component	Size	Unit
POC limit	150	MW
WF rating	122.4	MW
SF rating	40	MW
BATT rating	12	MW/MWh
r_{spot}	50	€/MWh
r_{sub}^{WF}	17	€/MWh
c_{op}^{WF}	7	€/MW
r_{sub}^{SF}	17	€/MWh
c_{op}^{SF}	5	€/MW

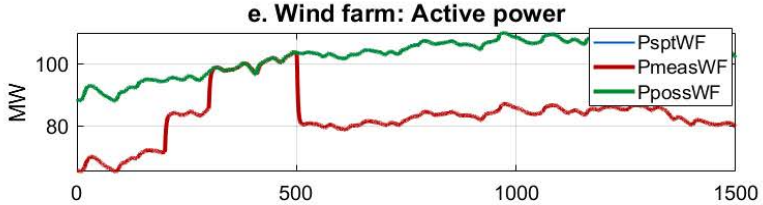
Test Case 1: FCR demand with varying possible power and frequency

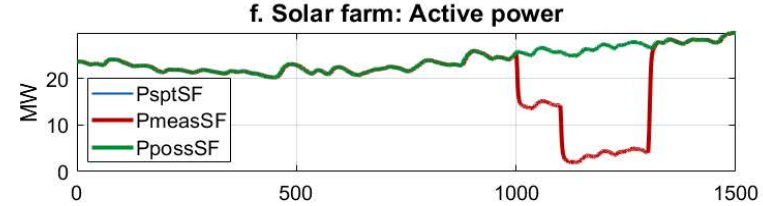


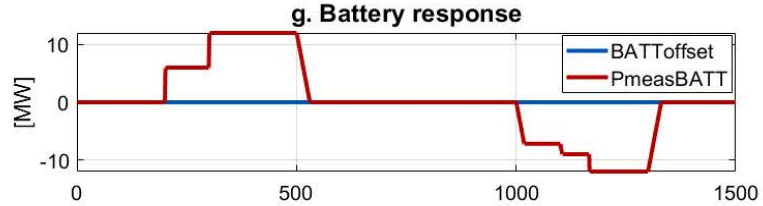


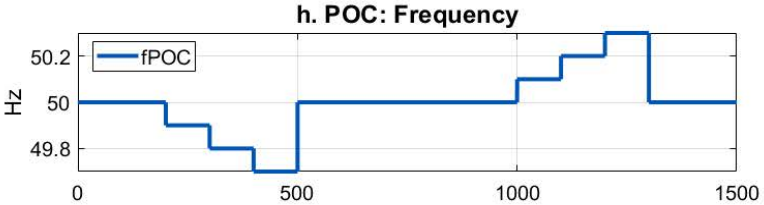




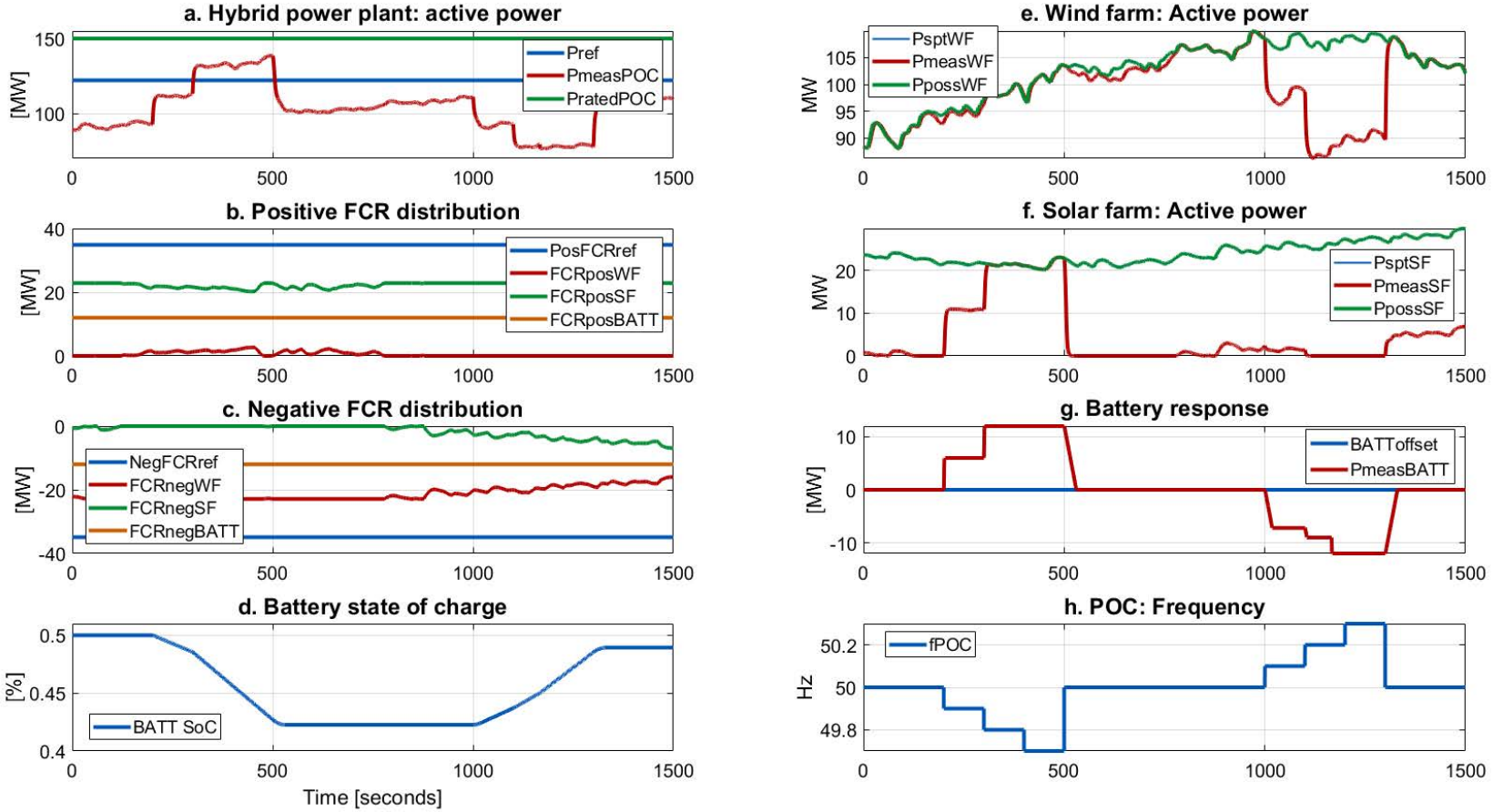








Test Case 2: Wind Farm subsidy higher than the Solar Farm subsidy




Conclusions

Conclusions

- Combining wind farms with solar farm and/or batteries comes with benefits but challenges as well
- Results show that there is room for optimising the FCR provision from a Hybrid Power Plant
- The exact gain from such an optimisation have to be compared to a prespecified distribution of FCR
- The operation costs and subsidy levels are the main factors affecting the distribution of FCR between the different generation units
- Any kind of optimisation has to take into account the technical constraints and grid limitations
- Optimal steering of Hybrid Power Plants enables a power system with high shares of wind and solar production


Thank you for
your attention!