

Haringvliet The first Utility Scale Hybrid Power Plant

Hybrid Power System Workshop

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Presentation Content

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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, UK, Denmark and Finland
- Electricity Production 2020: 112.8 TWh
- Net Sales 2020: 158,8 MSEK



6.8 million
Electricity customers



1.8 million
Heat customers



3.3 million
Electricity network customers



2.3 million
Gas customers



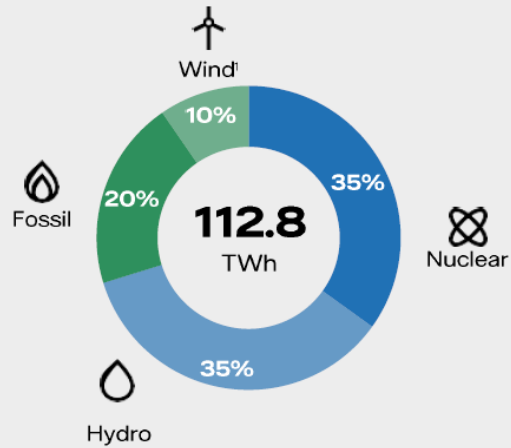
19,859
Employees



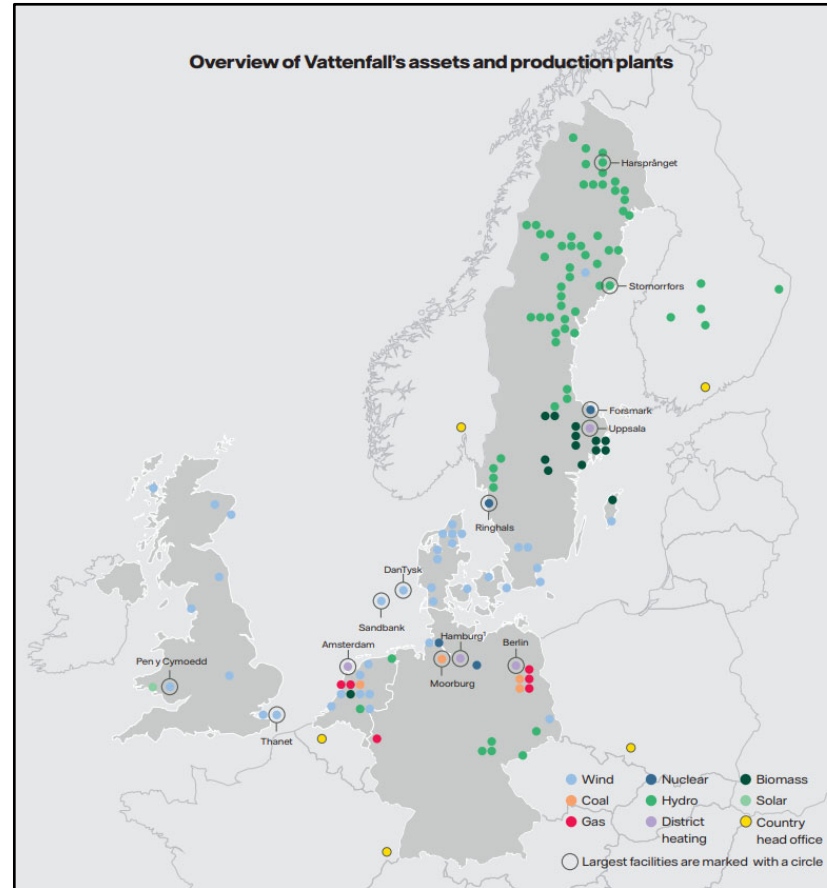
Electricity Generation and Asset Map

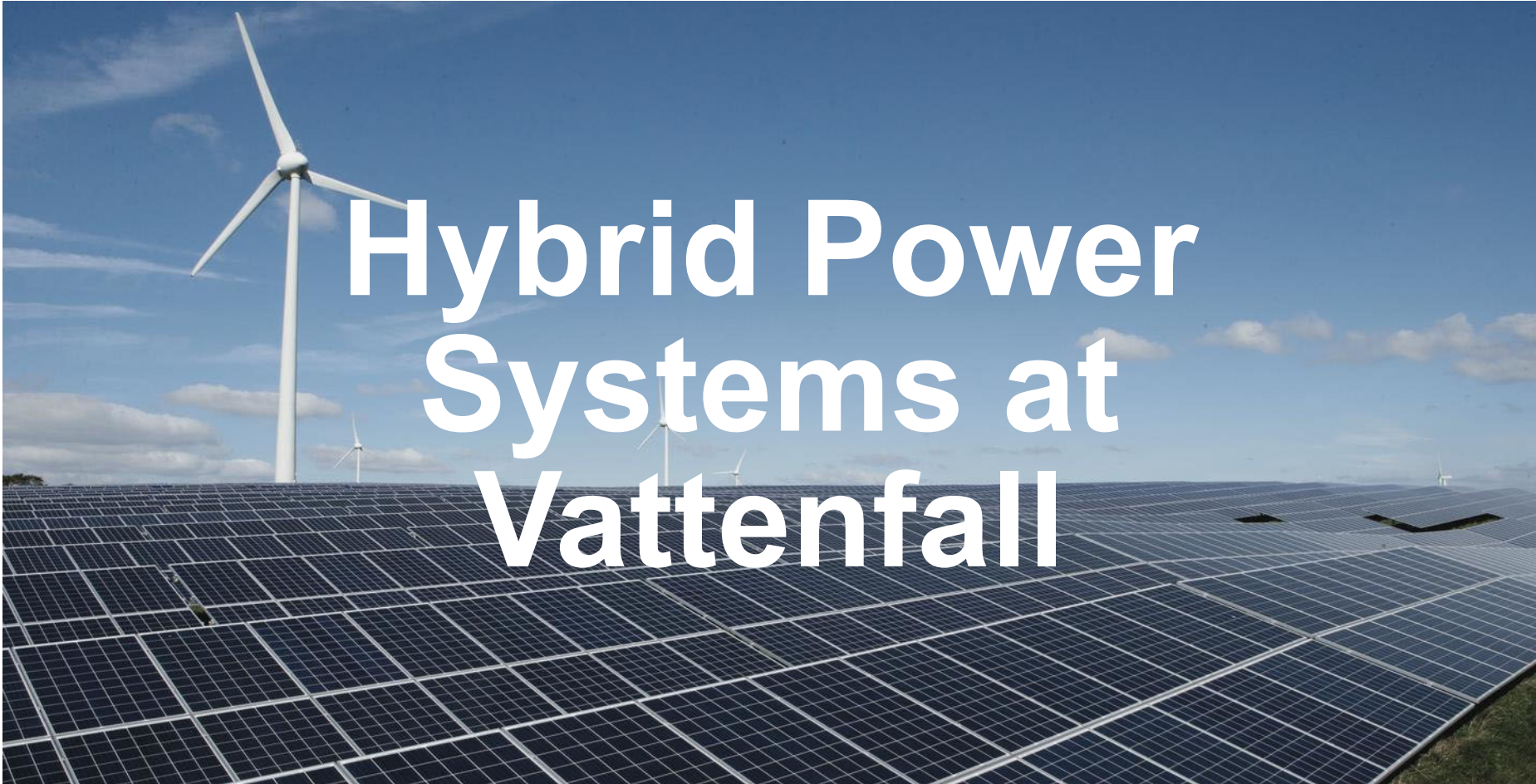


Electricity generation breakdown by technology, 2020



¹Wind includes biomass and waste generation (0,3 TWh)





Hybrid Power Systems at Vattenfall

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Background

- Vattenfall aims to be fossil-free within one generation
- Sweden committed by law to be carbon-neutral by 2045
- Result: Increased focus in renewables energy sources (Wind & Solar)
 - Investigating different storage and flexibility opportunities
- Challenges: 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
- Haringvliet (wind-solar-battery) Hybrid Power Plant soon to be in full operation



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

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Hybrid wind and solar installation come with advantages

Hypothesis

Infrastructure

- Joint usage of land reduces costs and contributes to local support
- Joint usage of grid and infrastructure saves costs

Project Development

- Joint permitting process reduces risks and costs
- Shared resources reduce internal and external costs
- Joint site development reduces costs for e.g. soil investigations

Park Performance

- More stable production curve increases utilization of the grid
- Batteries increase flexibility and accessible markets
- Forecasting errors can be buffered by batteries

COST REDUCTIONS, REVENUE INCREASE, DESIGN OPTIMIZATION

De-risking and diversifying: increase value

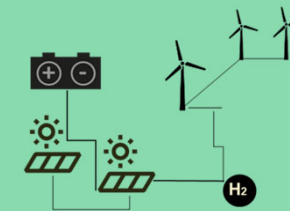
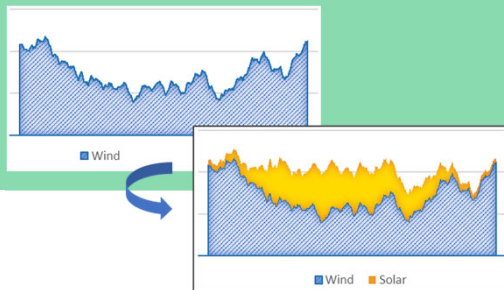
- Diversifying revenue streams: such as ancillary services and hydrogen sales
- Reduce volatility of power signal
- Reduced exposure to merchant commodity market



Pipeline enabler: hybrid sells!

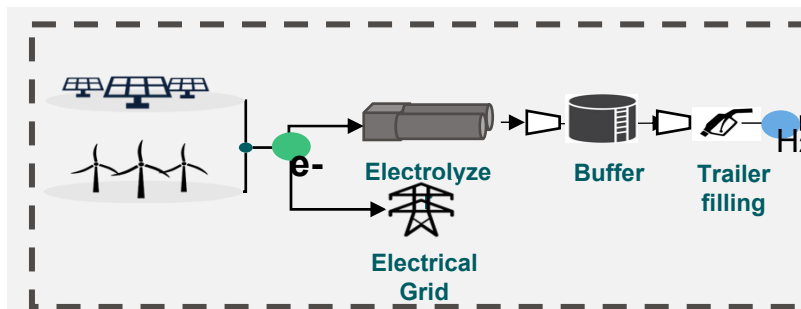
- Hybrid can provide tender and subsidy opportunities
- Hybridization can increase the chances on obtaining permits
- MW installed capacity per km² increased (clustering our efforts)

Renewable Hybrid Parks: The energy plant of the future



System integration

- Utilize grid capacity to full potential due to complementarity
- Support efficient grid built out



Improved business case

- Cost synergies to be achieved
- H2 + wind and solar provides access to cheaper electrons
- Reduce curtailment cost by incorporating H2 plant

Challenges and potential within Renewable Power Plants

- Challenges
 - Power Limitations in the Point of Common Connection: Increase the utilization of the grid connection point while securing against overloading
 - Unclear grid codes and certification processes for Hybrid Power Plants
 - Coordination of the Ancillary Services provided by different generation sources
 - Flexibility in operating different generation and/or storage units
 - Multiple systems from various suppliers to service and maintain
- Potential
 - LCoE Reduction: Increased utilization of the shared grid connection/agreements and lower costs due to own park controller
 - LRoE Improvement: Approaching subsidy-free market enables participation in different grid services markets to enhance additional revenues
 - Hybrid Power Plants: Wind+Solar+Storage connected on a common Point of Common Connection, increased power generation flexibility
 - Vattenfall in control with different smart optimization algorithms based on the weather conditions and spot price forecasted
 - Maximize yield (revenue) while providing grid support function and minimizing fatigue loads
 - Easier Operation
 - Increased Flexibility



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Haringvliet Hybrid Power Plant

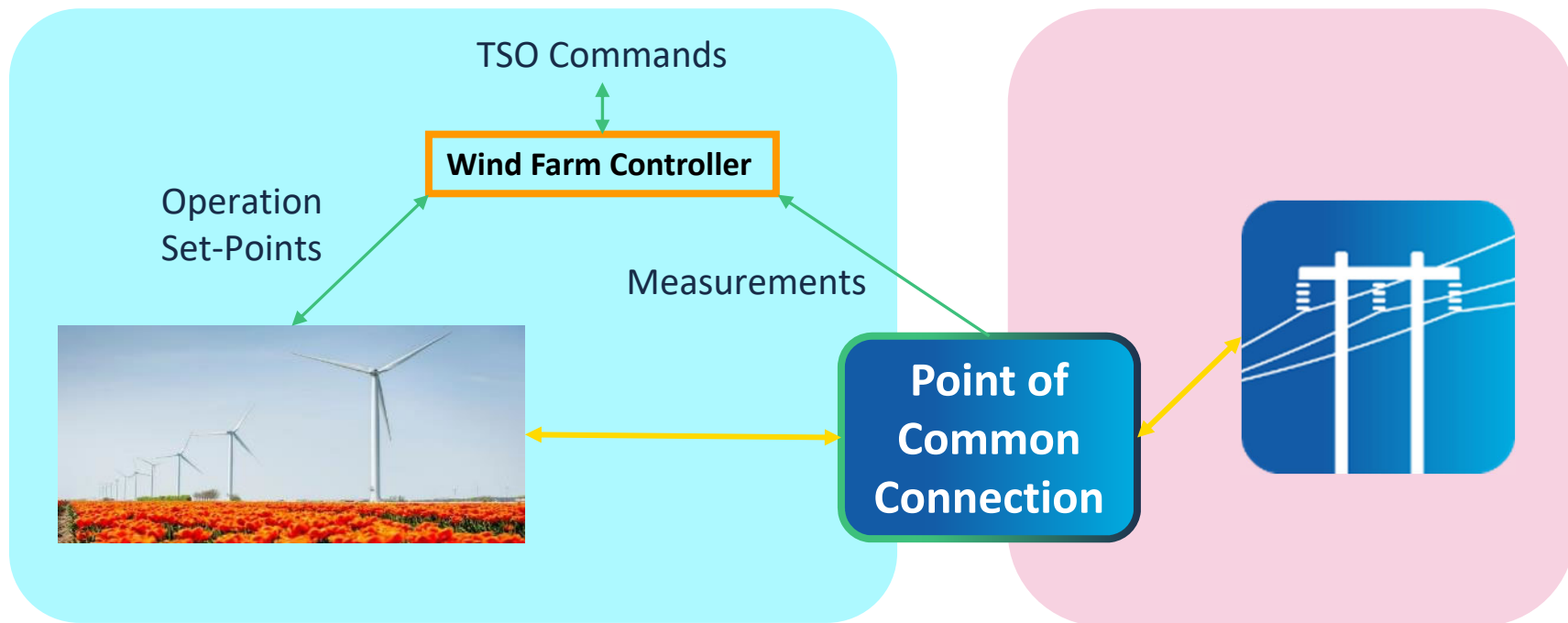


- Wind farm: 22 MW
- Number of turbines: 6
- Maximum height: 150 m
- Solar farm: 36 MWp
- Number of solar panels: 124.000
- Battery capacity: 12MW / 12 MWh
- In operation: Q3 2021

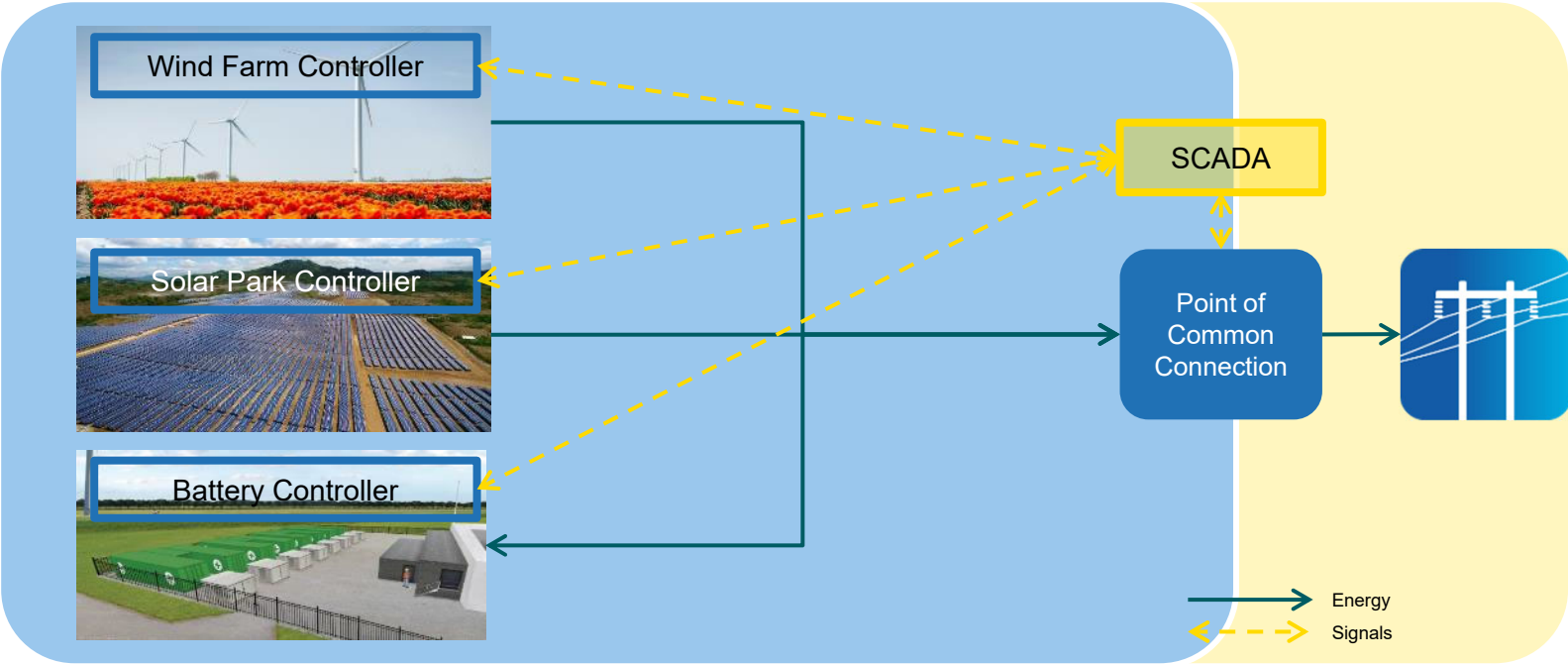
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C4 – Strictly confidential, C3 – Restricted, C2 – Internal, C1 – Public
Confidentiality: C2 - Internal

Today's onshore wind farms layout

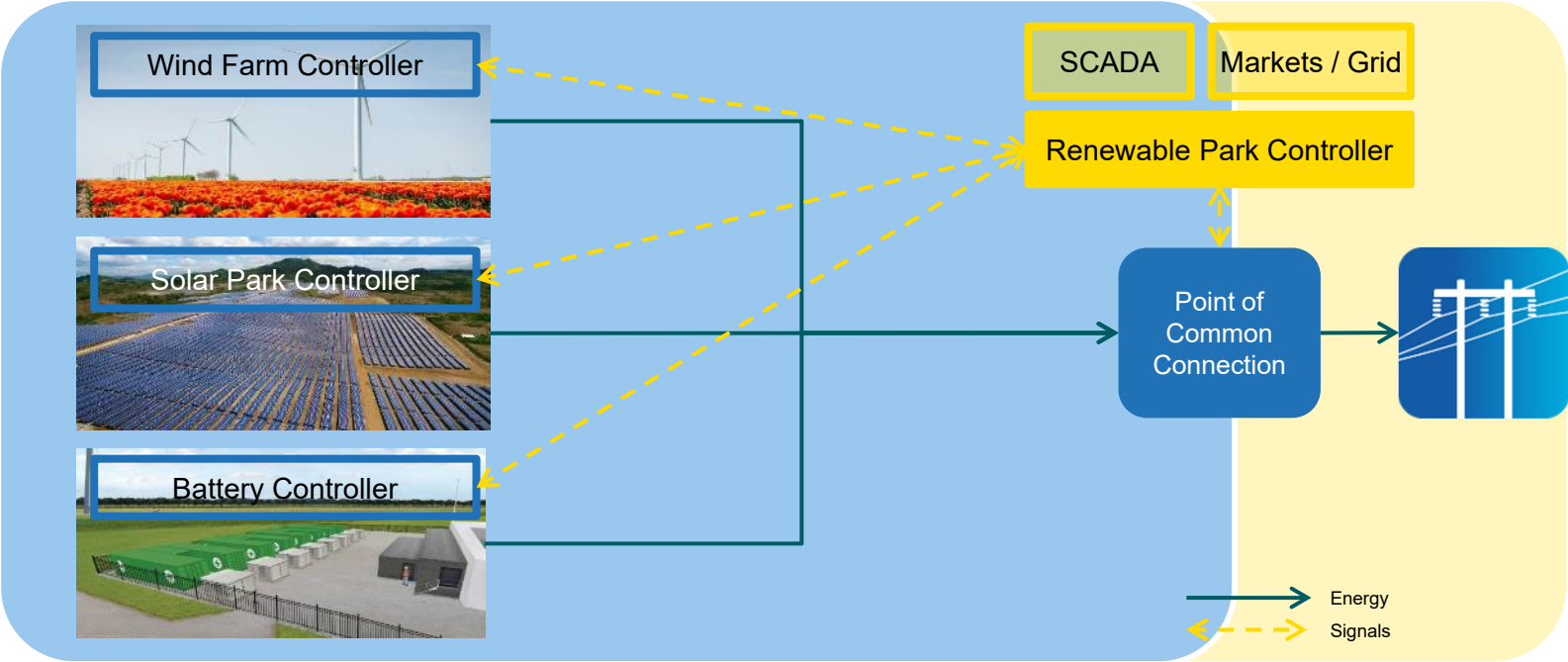


Renewable Power Plants

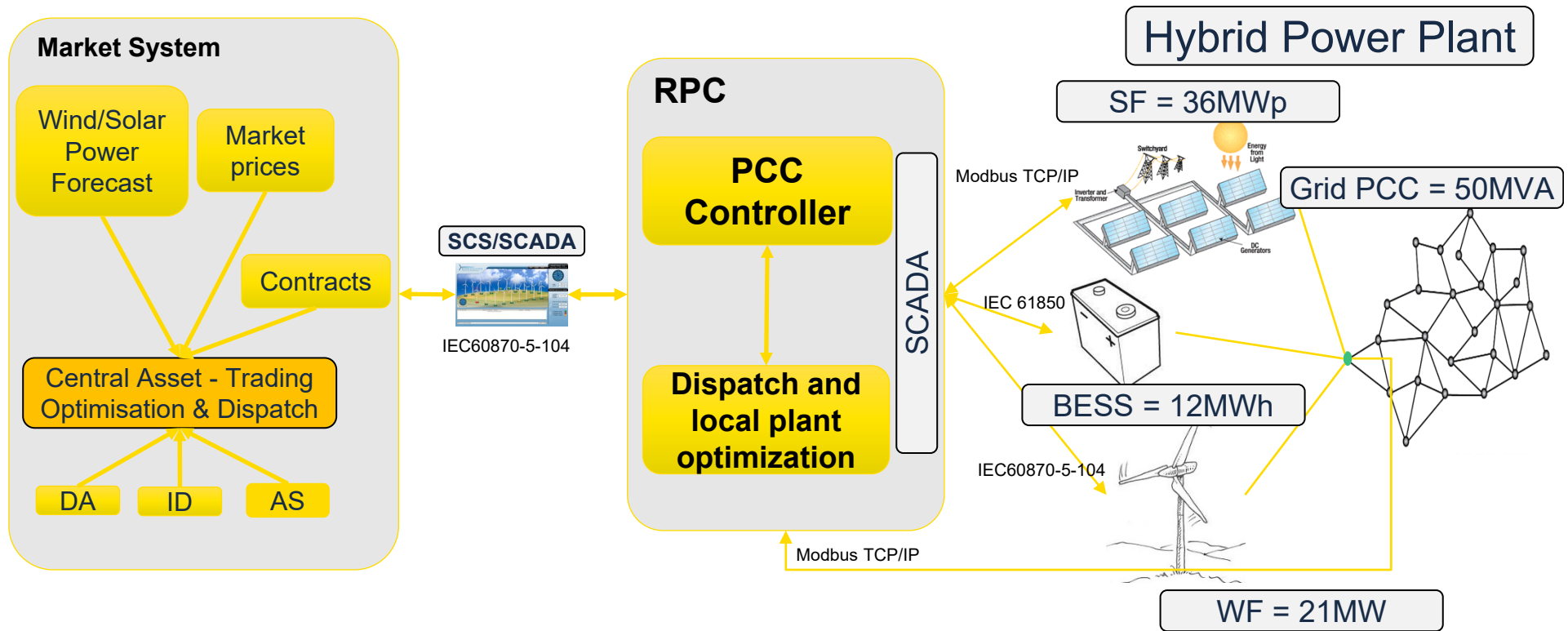


Solution: Renewable Park Controller

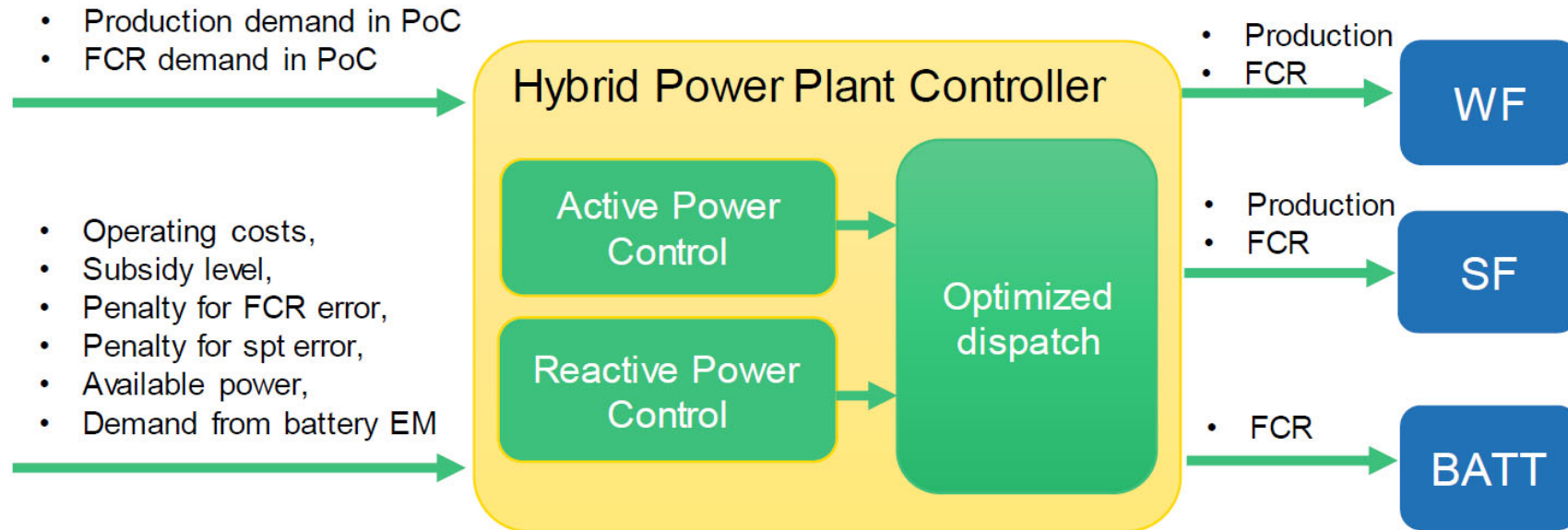
Vattenfall's Renewable Park Controller - Enhanced optimization functions based on Energy market spot prices, Weather Forecast & Grid demands



Haringvliet - RPC Architectural Diagram



Optimisation in Hybrid Power Plant Controller



Conclusions

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Conclusions

- Combining wind farms with solar farm and/or batteries comes with benefits but challenges as well
- Any kind of optimization must 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!

