Vestas Power Plant Solutions
Integrating Wind, Solar PV and Energy Storage

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Profile
Lennart Petersen

• M.Sc. Electrical Power Systems
• Industrial PhD student

• Working on Hybrid Solutions (Configuration, Control & Operation)
• Presentation about PhD work in Session 5B – System Design Aspects (Wed., 8.45)
Wind Integrated Hybrid Power Plant

Definitions

General definition of hybrid power plants with renewables:

This is a power system, using one renewable and one conventional energy source OR more than one renewable with or without conventional energy sources, that works in ‘stand-alone’ or ‘grid-connected’ mode.

Vestas definition of a grid-connected wind integrated hybrid power plant:

A wind integrated hybrid power plant, is a **sustainable energy solution** in which wind energy is complemented by solar energy and/or energy storage.

1. I. Lazarov, V. D., Notton, G., Zarkov, Z., Bochev, "Hybrid power systems with renewable energy sources types, structures, trends for research and development.," *Int. Conf. ELMA*, 2005
Wind Integrated Hybrid Power Plant

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On-Grid Hybrid Power Plant

- grid-integrated power plant unit

Off-Grid Hybrid Power Plant

- consumer-directed stand-alone unit (isolated microgrid)

1. I. Lazarov, V. D., Notton, G., Zarkov, Z., Bochev, "Hybrid power systems with renewable energy sources types, structures, trends for research and development.," Int. Conf. ELMA, 2005
Agenda

Value Proposition
• Combining Wind and Solar
• Combining Wind (& Solar) and Storage

System Topologies & Plant Control
• WTG-coupled vs. Co-Located
• Hybrid Power Plant Controller

Kennedy Energy Park (Australia)
• Operational use cases
• Weak grid connection
Shift in Energy / Power Sector

Maturity of renewable energy pushes governments to reduce and phase out incentives

Making control and predictability contribution towards the power & energy system can enable higher penetration of renewable energy!
Value Proposition – Wind + Solar + Storage

Potential for overall LCOE reduction

- Increased Annual Energy Production (AEP) and Capacity Factor (CF) per substation capacity
  → by complementarity of generation profiles
  → store excess power (curtailment reduction)

- CAPEX reduction
  → El. Infrastructure (“overplanting”)
  → Financing (higher P-value = lower project discount factor)

- OPEX reduction
  → Simultaneous maintenance
  → Share control & operation
  → deliver power despite shut-down WTG
Value Proposition – Wind (& Solar) + Storage

Grid services: License to operate in new markets, comply to country specific grid codes

Frequency Support

Power Oscillation Damping

Power Gradient Reduction (dP/dt)

Black Start

Value Proposition – Wind (& Solar) + Storage

Energy services: Enter into new markets, allow to capture additional revenue streams

Forecast Error Reduction

Energy Arbitrage

Load / Demand Following

Peak Shaving / Load Shifting


Hybrid Power Plant Topologies

**Small plants**
Low solar/wind ratio

**WTG-coupled**

- **3MW**
- 372kW
- DC or AC

- **Wind and PV**

- **Demonstrator in Spain**

**Large plants**
Hybrid Power Plant Controller (HPPC)

**Co-Located (sharing substation and infrastructure)**

- **24MW**
- 1MW

- **Wind and PV**

- **Louzes, Greece**

- **12MW**
- 1.2MW / 15min
- 0.4MW / 15min

- **Wind and storage**

- **Lem Kær, Denmark**

- **43MW**
- 15MW
- 2MW / 2h

- **Wind, PV and storage**

- **Kennedy, Australia**

**Vestas scope of work:** Full EPC & Service
Controlling the Hybrid Power Plant
Plant level control and optimisation of individual assets

Exemplary HPPC functionalities

1. Grid/Power services
   - Voltage Control (V / Pf / Q)
   - Frequency Control
   - Power Gradient Reduction
   - Power dispatch

2. Energy/Market services
   - Firming / Reduce forecasting error
   - Peak-shaving / Set schedule
   - Energy Arbitrage
   - Load/ Demand following
Kennedy Energy Park (Australia)
World’s first utility-scale hybrid power plant combining wind, solar & storage

15 MW<sub>AC</sub>  
6 x 2.5 MVA

43 MW  
12 x V136-3.6MW

2 MW / 4 MWh  
4 x 500 kW

SMA / Jinko Solar  
Vestas  
Tesla

50 MW Transfer Limit

**KEY BENEFITS**
- Increased Energy Production
- Improved Capacity factor
- Reduced cost
- Fulfillment of Grid Requirements & enable new earning opportunities

**KEY CHALLENGE**
- Controlling & operating the Hybrid Power Plant

**EPC* & Service**  
* Consortium with Quanta
Use Cases with Battery Energy Storage System
Complementing Wind and Solar Energy at Kennedy Energy Park

**Energy Arbitrage**
- Charge the battery at times of low energy prices (typically 8-11am)
- Discharge the battery at times of high energy prices (3-8pm depending on the month of year)

**Curtailment Reduction (“Store curtailed energy”)**
- Charge the battery at time when the available energy resource from wind and solar is above the allowed power transfer at the connection point (8-11am)

**Frequency Support (FCAS)**
- Contingency FCAS for the periods of time outside arbitrage and curtailment periods of operation.
Kennedy Energy Park
Complex Weak Grid Connection

- Normal SCR ~1.5
- N-1 SCR ~0.7
- 350km+ radial connection
Summary

• Hybrid power plants as **sustainable energy solutions** in which wind energy is complemented by solar energy and/or energy storage.

• Value proposition by:

  - **WTG-Coupled vs. Co-Located Hybrid power plant solution**
  - **Main challenges:** Right-sizing of assets & Hybrid power plant control
  - **Kennedy Energy Park** as world’s first utility-scale hybrid power plant combining wind, solar & storage
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