Introduction
Wind Market
Onshore stable, Offshore expected to grow

Onshore Wind Capacity Outlook  CAGR 2013-2023: 5.8%

Offshore Wind Market Outlook  CAGR 2013-20: 20.6%

- Traditionally strong Onshore markets forecast to have a moderate growth
- Favorable Onshore sites drying up
- Europe sustained by RES policies in UK and Germany
- China challenged by overcapacity and grid access

- Offshore market forecast to grow at 20% CAGR from 2013 to 2023
- Offshore presents increasingly attractive opportunity
- UK and Denmark pose largest global markets; Europe accounts for 72% of installations and 89% of pipeline
- China forecast to pick up with resolution of regulatory and infrastructure complications

Source: Make Consulting Q1 2014 Wind Power Market Outlook
## Wind Market Challenges, Situation, Trends

<table>
<thead>
<tr>
<th><strong>Challenges</strong></th>
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<tbody>
<tr>
<td>General trend to reduce or eliminate the subsidies for renewable energies across the globe</td>
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<tr>
<td>Cost of renewables to reach grid parity</td>
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<table>
<thead>
<tr>
<th><strong>Situation</strong></th>
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<tbody>
<tr>
<td>Slowdown in new installed capacity – economic challenges for some of the WT OEMs</td>
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<tr>
<td>Market consolidation on ownerships side - larger utilities acquire projects and assets from smaller owners</td>
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<table>
<thead>
<tr>
<th><strong>Trends</strong></th>
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<tbody>
<tr>
<td>Operations and maintenance in focus - make assets more profitable</td>
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<tr>
<td>Offshore sector asks for improved remote management and better reaction to field problems</td>
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</tbody>
</table>
ABB delivers from A to Z into wind industry
Wind Power Generation, Transmission, Integration & Control

EMS: Energy Management System
GMS: Generation Management System
HVAC: High-voltage Alternating Current
HVDC: High-voltage Direct Current
PLC: Programmable Logic Controller
SCADA: Supervisory Control And Data Acquisition
Value Proposition
Customer Value Proposition

Why ABB?

Trusted partner

ABB is a leading provider of automation and power solutions to the wind industry, covering all areas from wind turbines, to farms to grid connection and operation of assets.

ABB is a strong technology leader committed to long term developments for bringing wind power on par with other generation technologies.

Reliable & proven solution

Symphony Plus, ABB’s leading automation system for power & water industry, provides the necessary flexibility and scalability demanded by wind farms to large fleets.

Focus on customer values

Symphony Plus Wind specific applications improve control, operations and diagnostics of wind power plants, increasing the efficiency and uptime of turbines, and therefore maximizing owner’s benefits.
Wind Automation
Customer Benefits

Reduce Costs, Improve Efficiency

- Effective operations of fleet of plants with scalable and versatile remote control center solutions
- Improved efficiency of the wind turbines based on a range of diagnostic solutions, from high level KPIs to detailed Condition Monitoring analysis of relevant components
- Reduced costs of operations using a single automation system to manage all assets

Sustainable Business, Trusted Partner

- ABB’s wind automation system helps our customers expand their business in the renewable sector
- Highly competitive solutions and strong partners needed for successful renewable business in the long run
- ABB’s vast experience and expertise in wind industry helps our customers to always stay on top of their business
Solution Overview
Wind Automation
Solution Architecture

Automation of renewables relies on remote control centers due to plant sizes and their geographical dispersion.
## Wind Automation
### Key Offerings from ABB Power Generation

<table>
<thead>
<tr>
<th>Provide automation solutions for the wind sector</th>
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<tbody>
<tr>
<td><strong>Monitor and diagnose the wind farms</strong></td>
</tr>
<tr>
<td>Provide automation solutions for wind farms (at farm and at remote levels) using Symphony Plus platform</td>
</tr>
<tr>
<td>- S+ Operation as SCADA solution for the remote control center</td>
</tr>
<tr>
<td>- S+ Operations and PLC for SCADA and control system at the farm level</td>
</tr>
<tr>
<td>Monitor relevant signals and diagnose the wind farms to minimize downtime of turbines and improve their efficiency</td>
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<table>
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<th>Provide software solutions to increase the value of renewables</th>
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<td><strong>Turn renewables into a reliable generation source</strong></td>
</tr>
<tr>
<td>Provide control capabilities and aggregation in (larger) virtual power plants to facilitate the integration of renewables into the power system planning and operations through flexible control and forecasting of power production</td>
</tr>
<tr>
<td>Provide optimized control, predictive service and maintenance solutions to reduce the cost of renewable energy</td>
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</table>
Solution Overview
Focus on Awareness, Effectiveness & Optimization

Architecture and Interfaces
- Hierarchical architecture with Plant Level and Remote Center Systems using the same technology (S+ Operations)
- Standardized protocols to connect all relevant assets into a single system
- Interfaces with other systems for effective operations of renewable plants

Key Features
- Monitoring and diagnostics of the generation fleet through dedicated applications
- Power Management function to turn renewable plants into reliable generation
- Forecasting of power production and energy prices
- Optimization power production based on diagnostics and forecasting
### Plant Level System

**Single Point for Monitoring & Control**

**SCADA Functionality**
- Data acquisition from Wind Turbines and/or Wind Farms SCADA systems through various protocols
- Data acquisition from the Substation SCADA and/or RTU or direct connection to the IEDs through 61850
- Supports connection to any other device/system, e.g. STATCOM, Capacitor Banks, Energy Storage
- Supports a broad ranges of communication protocols, e.g. IEC 60870-5-101/104, DNP3, OPC, Modbus, IEC 61850
- Measurements acquisition (e.g. power, current, wind speed/direction, temperatures)

**Control Functionality**
- Integrates the operations of generation and electrical equipment into a single system
- One point of control for the entire plant, one point of connection with the upper level systems (plant and grid operators)
- Coordinates the control of active and reactive power at the plant level, integrating reactive power compensation devices and/or energy storage into the control logics of the plant
- Dispatches the individual wind turbines in case the wind farm SCADA controller is missing or not desired
Remote Control Center
Monitoring & Diagnostics

![Image](image.png)

<table>
<thead>
<tr>
<th>Greater Awareness</th>
<th>Effective Operations</th>
<th>Remote Management</th>
<th>Data Analysis and Reporting</th>
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<tr>
<td>• Intuitive HMI to visualize all relevant process data from the plant, grid connection and/or weather stations</td>
<td>• Alarm Management system for greater awareness and faster response</td>
<td>• Commands to remotely or locally control the substation equipment</td>
<td>• Wind Turbine Power curve and Power coefficient analysis</td>
</tr>
<tr>
<td>• Visualization of critical data in a high level displays based on GIS</td>
<td>• EEMUA191-compliant alarm analysis tools help users categorize occurring alarms with focus on effectiveness and safety operation</td>
<td>• Remote set-point settings to the power plant such as active and reactive power or power factor angle set-point</td>
<td>• Energy Production and production loss</td>
</tr>
<tr>
<td>• Effective navigation from the GIS displays to the plant and vice-versa</td>
<td></td>
<td>• Remote diagnostic and handling of errors, alerts, or alarms</td>
<td>• Standardized Key Performance Indicators based on the IEC 61400-12</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Customer specific Performance Indicators</td>
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Remote Control Center
Power Management

Features of OPTIMAX PowerFit

- Real Time Optimization of generation fleet due to new system layout with online optimization connected directly to automation networks (either physically or through VPN)
- Use of power and price forecasting for intraday optimization
- Mathematical optimization running in control loops with simple engineering
- Increase flexibility of power production, including: secondary control, minute reserve, direct trading
- Running on ABB Dynamic Optimization platform

Benefits of OPTIMAX PowerFit

- Always run at economic best point, the plant and fleet efficiency is maximized
- Provides capability for the operator to participate in the secondary and tertiary control
- Intraday optimization
- Direct trading of renewable power
- Planned production of generation assets
- Human operators take supervisory role
Remote Control Center
Power Production & Energy Prices Forecasting

Features

• Neural Network Technology – which recognizes relationships and applies this knowledge to produce accurate daily and hourly demand and price forecasts.

• Rules-based Error Handling – to identify, cleanse, and manage data in a way that can still produce accurate forecasts.

• Error by Time-Frame – can indicate outlying months, days, or hours, as well as isolate where adjustments need to occur.

• A Scatter Plot – of actual data versus forecasts can depict outer points immediately

Capabilities

• Flexible Data Integration – for creating a customized model set-up, forecast execution, and results processing.

• Profile Manager – for creating, adjusting and maintaining similar models to allow for easier use.

• Sensitivity Analysis & Comprehensive Statistics – to track changes in data for a better understanding of relevant inputs and more accurate capture of forecast peaks and valleys.

• Customized Reports/Graphs – which analyze specific data areas and present them in Excel, Access, and/or HTML using the Ventyx Report Agent.
Condition Monitoring for Wind Turbines
### Why?

- Breakdown of critical assets affects negatively the uptime of the turbines and their capacity factor.
- Understand the condition of the assets and better plan maintenance and service activities, particularly for offshore projects.
- Reduce costs and risks associated with breakdown of components.

### How?

- Condition Monitoring System to monitor critical components such as gearbox, main bearing, main shaft, generator shaft.
- Dedicated algorithms for asset condition estimation to support the decision making of operations and maintenance personnel.
Diagnostics of Wind Farms
Solution for vibration & temperature monitoring

**Predictive Maintenance**
- Uses Analyst results and other relevant process data to estimate the remaining life of the components

**Analyst**
- Software solution that monitors and analyses MCM data along with other relevant process variables necessary to determine the condition of the equipment
- Provides Key Vibration Indicators (KVI), Key Diagnostics Indicators (KDI) and Key Performance Indicators

**Machine Condition Monitoring (MCM800)**
- Hardware & software platform to acquire and process vibration and temperature data from relevant sensors (ABB and non ABB)
- Used in thermal and hydro generation, marine and other applications where large machines are involved
Customer Benefits
Customer Benefits
Reduce Investment due to Strategy Shift

Same operators can easily manage renewable plants

Operator

Renewable Plants Control Center Symphony Plus

Thermal Power Plant Control Symphony Plus

Hydro Power Plant Control Symphony Plus

Solar Plants
Wind Plants
Small Hydro Plants
Thermal Plants
Large Hydro Plants
Customer Benefits
More Value from the Assets

Maximize benefits with optimal power dispatching

- Real time control loops optimize the setpoints for each plant considering customer objectives and asset constraints
- Intraday optimal planning taking in consideration the forecasts of power production and energy prices
- Diagnostic results are accounted for in the optimization

Historical and Real Time Asset Data

Power forecasts

Optimal Power Dispatching

Real Time Operation & Control

Intraday Operation & Planning
Customer Benefits
Increase Efficiency with Newer Technologies

Improve the efficiency of wind farms

Spinner Anemometer (from ROMO Wind)

- Accurate wind speed measurements using sonic sensors placed on the spinner of each wind turbine
- Possibility to accurately determine the power curve (efficiency) of the wind turbine by correlating wind speed and produced power
- Identify the reasons for efficiency loss (e.g. yaw misalignment) and correct it

LiDAR Technology (from Pentalum)

- Accurate wind speed measurements using LiDAR (Light Detection and Ranging) sensors placed on the ground, in front of each wind turbine
- Possibility to accurately determine the power curve (efficiency) of the wind turbine by correlating wind speed and produced power
- Identify the reasons for efficiency loss (e.g. yaw misalignment) and correct it
Know and understand the process
Wind flow analysis and influence on WF performance

Technology

- LiDAR* technology to sense the wind speed and direction within and around the wind farm
- Accurate measurements at different high levels across the wind turbine rotor plane

Strengths

- More precise wind speed and direction measurements as compared to the traditional nacelle anemometry (anemometer cups and wind vanes)
- Cost effective technology based on Spidar from Pentalum
- Easy to handle, mount and monitor due to its minimalistic requirements to setup
- Sensor data can be wirelessly transferred to the control center or can be integrated in the existing wind farm communication infrastructure

Added Value

- Independent measuring devices to be used as alternative to existing nacelle anemometry
- Wind flows in the wind farm and its surroundings can be better understood
- Wind turbine performance and loads can be calculated in a more accurate way

*LIDAR = Light Detection and Ranging
Remote Renewable Management System
Example of Installation in Italy

- 6 Remote Control Centers distributed on regional and macro-regional basis (PGP based)
- 1 Disaster Recovery Control Center ready to take over any of the 6 in case of faults or malfunctions
- The Remote Control Centers manage all wind, solar and hydro plants in the region
- 1 dedicated Control Center for managing the geothermal power plants

![Map of Italy with control centers marked](image)

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<tr>
<td>Total 3068 MW</td>
<td>Total plants 403</td>
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<tr>
<td>1512 MW</td>
<td>723 MW</td>
<td>112 MW</td>
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<tr>
<td>720 MW</td>
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93 renewable energy plants of multiple types: Wind, Solar, Hydro, Biomass and Geothermal

PSPG provides Plant Level Automation Systems

- S+ Operations
- Ventyx provides the Remote Management System
  - AGC for Power Management and coordination with SPP and other ISOs
  - Nostradamus for Production Forecasting
## Customer Value Proposition

### Key Points to Take Away

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