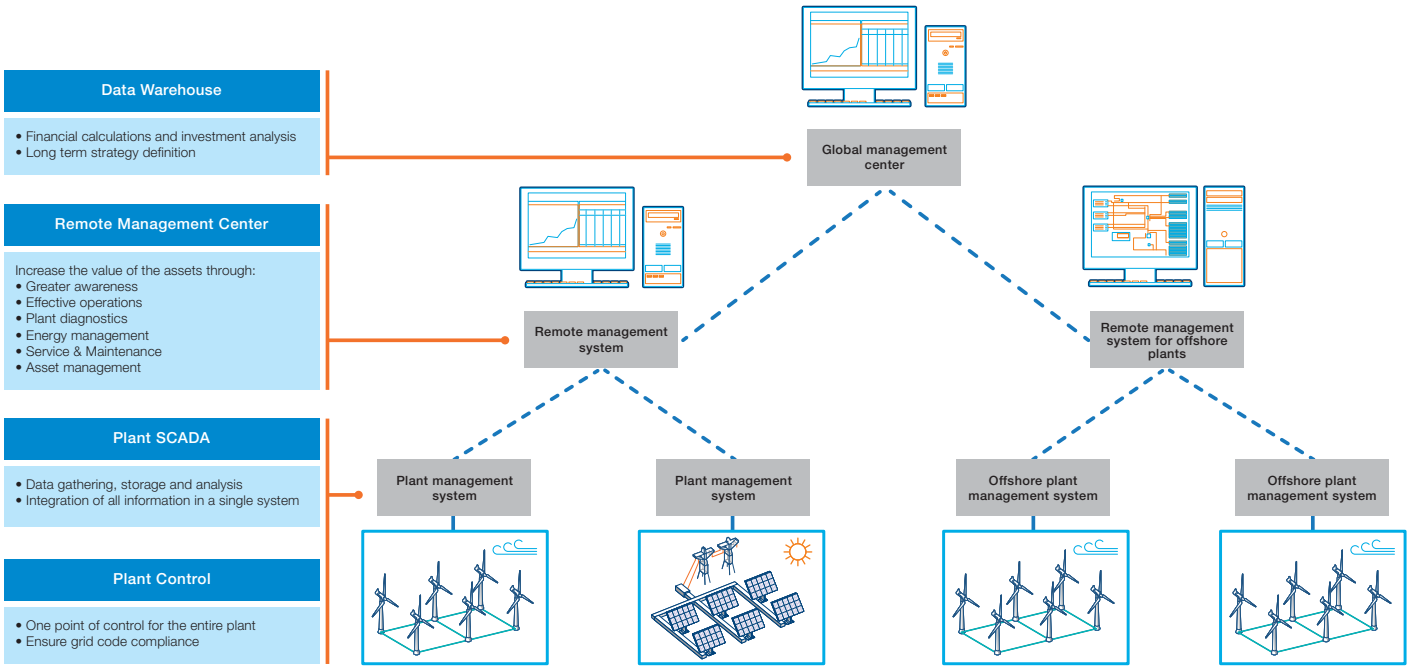
# Symphony Plus for wind
## Tailored automation for wind generation

Power and productivity
for a better world™

## Versatile control for wind power plants

A wind power plant and a traditional coal- or gas-fired turbine power plant both make electricity, but their generating processes are fundamentally different, which means the requirements of their control and automation systems are also very different.

# Scalable automation for wind generation




**Solution Architecture**

A traditional power plant has full control over input fuel (coal, gas, water), and uses relatively few process components, such as steam or gas turbines, to convert fuel into electricity. Staff are generally present to run the operation.

By contrast, a wind power plant has no direct control over the input fuel, which is wind. There are many process components involved (wind turbines), and the generating plant is usually located in remote areas, typically unmanned.

Since the wind does not always blow when electricity is needed, the input fuel is variable, more difficult to predict and this can have significant impacts on optimum power flow, transmission congestion, power quality, system stability, load dispatch, and economic analysis.

Utility grid operation is impacted by the uncertain future production of wind power plants, as well as the variability of current production and how active and reactive power exchange with the grid is controlled. Therefore, accurate production forecasting is another major hurdle for power system operators.

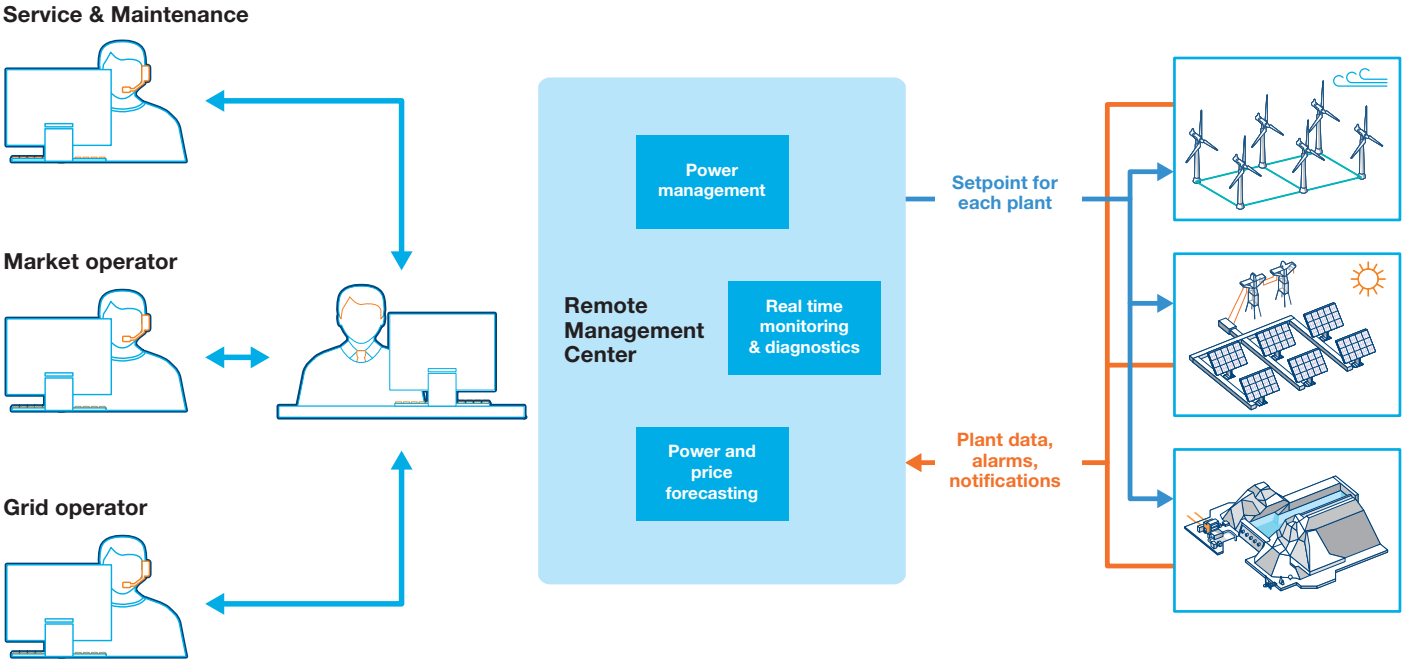
Wind turbines are grouped to form a single power infeed to the grid, so control of these process components must be coordinated in such a way that they behave as a single generating unit, while grid code requirements call for wind power plants to behave like conventional power plants in terms of power dispatching, voltage and frequency control and power system stability.

Technology is available now to provide versatile control of wind power plants, and further improvements will eventually bring wind power to grid parity. To enable wind plants to coordinate turbine operations and behave like conventional power plants and meet specific grid requirements, advanced control systems are common at the point of interconnection (POI). Each turbine also requires advanced control components to safely and reliably regulate individual operation. Advanced control and communications systems, such as Supervisory Control and Data Acquisition (SCADA) products, Intelligent Electronic Devices (IEDs) and plant safety systems are essential to optimize the performance, financial return, and meet the contractual obligations and grid requirements of wind power plants.

## ABB automation for wind power plants

Effective automation of renewable power plants relies on remote control centers due to the size of the plants and their geographical dispersion. The ABB solution architecture for wind power includes:

- **Remote Management Center**, to help increase asset value through greater awareness and plant diagnostics, effective operations, service and maintenance, asset and energy management.
- **Plant Monitoring and Control system**, where plant data is gathered and stored in a SCADA system according to a consistent data model to provide real-time status and support the analysis of all the connected generation units. This is also the single point of control where grid code compliance is ensured for the entire plant fleet.




Solution overview and relevant function and interfaces to the plants and other systems.

## Remote Management Center

This hierarchical control architecture includes plant level and remote center systems, and standardized protocols to connect all relevant assets into a single system. Interfaces with other systems ensure the effective operation of renewable plants.

Key features of this system include:

- The capacity to monitor and provide diagnostics of the generation fleet through dedicated applications
- Forecasting of power production and energy prices
- A power management function to turn renewable plants into reliable generation and to optimize power production based on diagnostics and forecasting

### Plant diagnostics

The diagnostics functionality spans all aspects of plant operations, from high-level Key Performance Indicators (KPI) providing fast and easy assessments of asset status to Symphony® Plus's Condition Monitoring and performance assessment software. The Symphony Plus online information system uses detailed data to identify problems and provide maintenance suggestions by establishing the actual status of plant health.

A wide range of standardized or customer-specific KPIs provide immediate information about plant performance and the efficiency of every single wind turbine, including capacity factor, power curve and much additional relevant information.

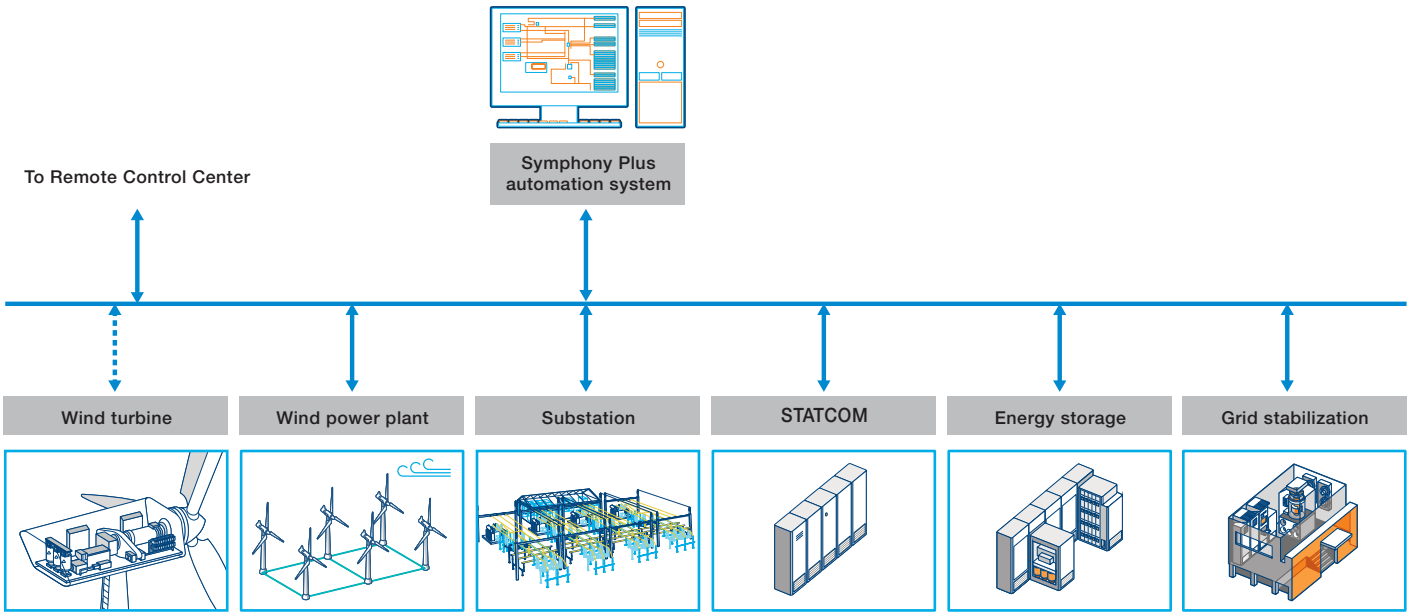
Analyst, Symphony Plus's Condition Monitoring software for rotatory machines, provides the user with:

- deep analysis of vibration, temperature and other relevant turbine data to determine equipment health
- reference values correlated to the working point under several conditions in order to define warning or danger thresholds according to the actual plant asset
- time left to reach a defined threshold in order to schedule the maintenance plan according to actual plant status, allowing for plant stops (e.g. at low-wind days) to avoid unnecessary/unplanned outages
- ability to identify possible damage in order to save maintenance time and repair only what is necessary

### Power and price forecasting

ABB's forecasting tools for wind and other renewable assets not only forecast a plant`s power production, but also the prices in the plant`s energy marketplace. Production forecast horizons can be a few minutes to a few days ahead. This provides operators and maintenance planners with the valuable information needed to maximize asset uptime and the efficiency of every turbine, while also supporting and ensuring educated decision making.

# Tailored automation for wind generation




**Architecture of the plant level system**

To ensure high quality forecasts, sensitivity analysis and comprehensive statistics are done to track changes in data that will provide a better understanding of relevant inputs to the forecasting tools, and capture more accurately the forecast peaks and valleys.

### Power Management

OPTIMAX PowerFit provides real time optimization of the generation fleet with a new system layout and online optimization connected directly to automation networks. This system enables power and price forecasting for intraday optimization, and mathematical optimization runs in control loops with simple engineering.

OPTIMAX PowerFit increases the flexibility of power production, including secondary control, minute reserve, and direct trading, and operates on the ABB Dynamic Optimization platform.

The benefits of OPTIMAX PowerFit include an operation that is always run at the economic best point, maximizing plant and fleet efficiency. It enables operator participation in secondary and tertiary control, intraday optimization and direct trading of renewable power. It supports the planned production of generation assets, enabling human operators to take a supervisory role. Moreover, OPTIMAX PowerFit helps integrate renewable generation into power systems, transforming them into a flexible and dispatchable source of energy.

### Plant monitoring and control system

Symphony Plus SCADA architecture and S+ Operations HMI provide data acquisition from wind turbines and/or wind power plant SCADA systems through various protocols. Data acquisition from the substation SCADA and/or Remote Teminal Units (RTU) or direct connection to the IEDs is through the IEC 61850 standard for electrical substation automation. This system supports connections to any other device or system, such as STATCOM (static synchronous compensator), capacitor banks, power and energy storage. It also supports a broad range of communication protocols, such as IEC 60870-5-101/104, DNP3, OPC, Modbus, IEC 61850, as well as a large number of I/Os for measurement acquisition, for example, power, current, wind speed, wind direction and temperature.

The Symphony Plus control system helps integrate the operations of generation and electrical equipment into a single system. It provides one point of control for the entire plant, and one point of connection with the upper level systems (plant and grid operators). It 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. It dispatches the individual wind turbines in case the wind power plant controller is missing, or not desired.

# Customer benefits

## Symphony Plus for Wind

More than 6,500 systems installed – two thirds in the power and water sectors – and more than three decades of service makes ABB`s Symphony family one of the world`s largest installed bases of distributed control systems (DCS).

The Symphony Plus control system is designed to meet a wide range of plant configurations with a flexibility and scalability that enables it to serve small and server-less applications as well as large multi-system, multi-server architectures. It supports the seamless integration of field devices, process and turbine automation systems, electrical and SCADA solutions as well as business and maintenance systems, providing a secure and reliable control environment.

Recent additions to the portfolio include new features and functionalities for geographically distributed applications like wind and photovoltaic plants, hydropower stations and water distribution networks. The new capabilities address the challenge of incorporating large numbers of small modular units such as wind turbines, solar trackers, remote terminal units or pipeline sensors into a common operations hierarchy, while providing better visibility and control of the entire plant or network.

Symphony Plus is a reaffirmation of ABB's commitment to continue investing in this platform based on an 'evolution without obsolescence' approach of introducing new technology with enhanced benefits, while protecting the long-term investment of customers by ensuring full compatibility with existing installations. This helps to balance customer objectives like asset availability, operational reliability and production efficiency with asset life extension, carbon reduction and regulatory compliance.

## Same system, different plants

ABB systems enable plant operators to easily manage both traditional and renewable generation power plants with a variety of Symphony Plus control solutions. As many utilities shift their new capacity additions to the renewable sector, it is important to use the same automation system found in traditional generation plants to also manage added renewable assets. Training costs for operators and/or new hires can then be drastically reduced.

A number of innovations set ABB's control offering for wind power plants apart, including improvements that enhance wind power plant efficiency with new sensing technologies.

| S+ Operations: greater awareness, faster response, better decisions | |
|---|---|
| **Greater awareness** | - Intuitive HMI to visualize all relevant process data from the plant, grid connection and weather stations<br>- Visualization of critical data in a high level display based on Geographic Information System (GIS)<br>- Effective navigation from the GIS displays to the plant operational displays and vice versa |
| **Effective operations** | - Alarm management system for greater awareness and faster response<br>- EEMUA191-compliant alarm analysis tools help users categorize alarms with focus on effectiveness and safety operation |
| **Data analysis and reporting** | - Wind turbine power curve and power coefficient analysis<br>- Energy production and production loss<br>- Standardized key performance indicators based on the IEC 61400-12<br>- Customer specific performance indicators |
| **Remote management** | - Commands to remotely or locally controlled plant and/or substation equipment<br>- Remote setpoint settings such as active and reactive power or power factor angle set-point to the power plant<br>- Remote diagnostic and handling of errors, alerts, or alarms |

Symphony Plus applications provide wind power plant operators with numerous advantages, including greater awareness of conditions in operations, more effective operations, the capacity for remote management, and data analysis and reporting.

## Increase revenues by improving wind plant efficiency

Besides standardized and customer specific performance indicators, the diagnostic functions present in Symphony Plus for Wind make use of advance technology to determine more accurately the potential improvement of asset efficiency. Using Spinner Anemometer and/or LiDAR (Light Detection and Ranging), Symphony Plus for Wind is able to accurately measure wind speed and hence identify yaw misalignment errors and the associated energy losses. Additionally, a more realistic power curve (efficiency) of the wind turbine can be determined and compared to the one observed from normal SCADA measurements.

## Minimize costs by operating at the economic best point

With OPTIMAX PowerFit, finding the economic best point that maximizes plant and fleet efficiency is assured at all times during plant operations. Moreover, this solution enables participation in secondary and tertiary control, intraday optimization and direct trading of renewable power. It supports the planned production of generation assets, enabling human operators to take a supervisory role. Overall.

# Microgrids and isolated systems

ABB defines the ‘Microgrid’ as an integrated energy system consisting of distributed energy resources and multiple electrical loads operating as a single, autonomous grid – either in ‘grid-connected’ or ‘islanded’ mode, depending on the existing utility power grid. A Microgrid is similar to a traditional power grid, but on a smaller scale and with a smaller total power rating.

## Integrating wind

The easiest way to generate electricity in areas not serviced by electrical networks is with a generator that burns fossil fuels, such as diesel, gas and heavy fuel oil. However, many remote places are also rich in renewable energy sources such as wind, which could all be harvested as a cost-effective and environmental-friendly means to provide power in these areas.

ABB’s quest to assist Microgrid communities reduce their reliance on fossil fuels has driven the development of a number of technologies designed to integrate, manage and control renewable generation, specifically wind in isolated or weakly connected grids.

Already, these technologies have increased the production and integration of renewable energy into a number of power generation systems across the world that previously relied solely on fossil fuels.

### Hybrid power plant - Greenfield

ABB’s hybrid power plant is made up of a minimum of one fuel-based generator and one renewable energy generator.

A full turnkey solution including consultation (technological and economical feasibility), plant design, installation, commissioning and service support has been designed for areas with no access to quality power.Integrated wind power plant - Brownfield

Our engineered solution for integrating wind into an existing fuel-based generation microgrid has been designed to upgrade existing power systems with renewable energy generation, thereby reducing their reliance on fossil fuel and improving the security of supply.

### Optimized microgrid integration

ABB’s engineered Microgrid stabilization and energy flow optimization solution is designed for customers who have an existing hybrid power plant but are experiencing stability issues and want to improve security of supply. This solution has the ability to optimize the operations of existing power stations with existing renewable energy generators.

## Technologies

### Microgrid Plus System

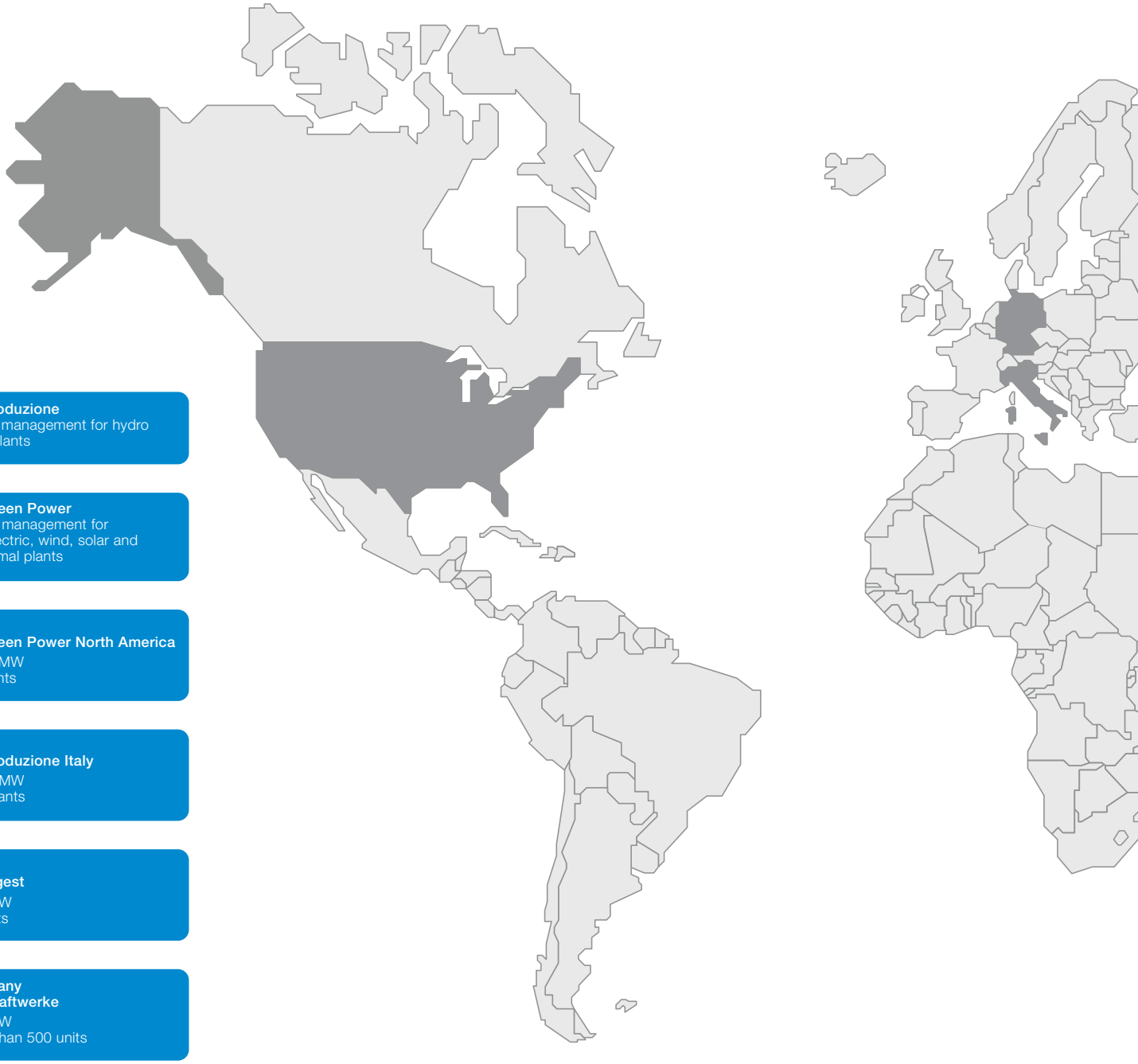
The Microgrid Plus System is a specially-designed networked control system. It is a key technology responsible for coordinating the operation of hybrid power stations and successfully stabilizing and integrating renewables such as wind into microgrids.

The unit manages the energy flow within a power network to ensure there is enough spinning reserve, step load capability and balance between supply and demand in the power grid. It also optimizes the average use of renewable energy, even when sources are intermittent.

### PowerStore

A PowerStore™ is a flywheel or battery-based grid stabilizing system that enables intermittent renewable energy to be integrated in to the grid. State-of-the-art ABB inverters can be used either to support the grid, or act as a Virtual Generator. PowerStore is extremely beneficial in Microgrids where it offers real and reactive power support to remote and island communities, remote research centres, industrial and commercial areas, defence bases, and institutions and campuses where fuel costs and production schedules are critically important.

# Reference projects



**Enel Produzione**
Remote management for hydro power plants

**Enel Green Power**
Remote management for hydroelectric, wind, solar and geothermal plants

**1 USA**
**Enel Green Power North America**
- 1,673 MW
- 93 plants

**2 Italy**
**Enel Produzione Italy**
- 3,068 MW
- 403 plants

**3 Italy**
**Veronagest**
- 289 MW
- 7 plants

**4 Germany**
**Next Kraftwerke**
- 570 MW
- More than 500 units

1. **USA – remote renewable management system for hydroelectric, wind, solar photovoltaic, biomass and geothermal plants**
   Customer: Enel Green Power North America
   Monitored capacity: 1,673 MW, 93 plants
   Generation mix: wind, solar, hydro, biomass and geothermal plants
   System: Symphony Plus-based plant automation system and remote management system based on Network Manager with power management and production forecasting applications

2. **Italy – remote renewable management system for hydroelectric, wind, photovoltaic and geothermal plants**
   Customer: Enel Produzione/Enel Green Power Italy
   Monitored capacity: 3,068 MW, 403 plants
   Generation mix: hydro, wind, solar and geothermal plants
   System: Symphony Plus-based, with six remote control centers and a disaster recovery control center ready to take over from any of the six remote centers in the event of faults or malfunctions

**GDF Suez Renewable**
Remote management of wind power plants

**Veronagest**
Remote management of wind power plants

**SECI Energia**
Remote management of wind power plants

**Vattenfall**
Internal optimization of multi-unit conventional power plants

**Next Kraftwerke**
Large-scale virtual power plant for secondary control and minute reserve

**Falk Renewables**
Hosted management of renewable plants

**Fera**
Hosted management of renewable plants

**Andromeda Wind**
Hosted management of renewable plants

**SW Trier**
Intraday optimization of municipal power, including e-mobility

**3. Italy – remote renewable management system for wind plants**
Customer: Veronagest
Monitored capacity: 289 MW, 7 plants
Generation mix: wind
System: Symphony Plus plant automation systems and one remote control center

**4. Germany – virtual power plant for secondary frequency and minute reserve control**
Customer: Next Kraftwerke
Monitored capacity: 570 MW, more than 500 units
Generation mix: biogas, biomass, CHP, hydro, wind, solar, as well as industrial processes
System: Symphony Plus-based with OPTIMAX PowerFit for power management

# Case studies

One of Enel Green Power plants being monitored in Italy

Project: Renewable control center and plant automation
Location: more than 20 wind power plants in Italy, including six control centers and a disaster recovery center
Direct customer: Enel Produzione
End customer: Enel Green Power
Completion: 2006 -2008

## Customer need

- Integration of all wind power plants into a single control and monitoring system
- Operation and maintenance support
- TSO data exchange and dispatching order execution
- Monitoring and performance indicators for entire fleet of wind turbines

## ABB's response

- Control center SCADA solution based on S+ Operations
- Plant level gateways to integrate the process data (wind plant) and electrical data (substations) for transmission to the control center, and to implement plant automation
- Disaster recovery architecture to ensure redundancy and no loss of data

## Delivered benefits

- Ability to monitor and control wind power plant from a single, remote location
- Single and uniform HMI for generation control and grid connection management
- Consolidated reports of plant performance for the entire fleet of wind power plants

## Why ABB was awarded the project

- ABB can provide an integrated control system to help manage, monitor and diagnose power plants in real time, as well as analyze performance and support maintenance activities

**Next Krafwerke large-scale virtual power plant**

Project: Large-scale virtual power plant for secondary control and minute reserve
Location: Germany, serving all four of the country`s transmission grid operators
Direct customer: Next Kraftwerke
End customer: Next Kraftwerke
Completion: 2012 – 2013

## Customer need

- Control system for large-scale virtual power plant
- Managing pools of distributed generation assets, such as biogas, biomass, CHP, hydro, wind, solar, industrial processes
- Highly scalable for fast-growing business (hundreds of units totaling 570 MW in 2013)

## ABB's response

- Control system running in the cloud 24/7
- Remote protocols to grid operators and generation units
- Redundant real-time optimization for multiple pools
- Simple supervision, alarm management, including SMS, e-mail
- Information management with open interfaces to trading

## Delivered benefits

- Provide balancing power to multiple grid areas with one system
- Simple control engineering
- Redundant PC-based runtime exploiting dynamic optimization
- Based on Symphony Plus

## Why ABB was awarded the project

- References (customer projects and scientific publications)
- Responsiveness to customer needs
- Fast project execution and delivery

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