



# ABB goes offshore

## Products and solutions for offshore wind energy

# Effective and well proven integration of offshore wind energy into the grid

For network integration of Germany's offshore wind farm cluster "BorWin", around 130 km off the North Sea coast, ABB has supplied the BorWin1 transmission link, a well proven voltage source converter system also called HVDC Light®. For the first time, wind power generated on the high seas is being connected using high-voltage direct current transmission (HVDC). This link, being the first of its kind and rated 400 MW, constitutes the foundation for utilizing remote offshore wind power, thus making an important contribution to the German federal government's ambitious strive to increase the share of renewable energies in power generation.

In addition to the BorWin1 link, ABB is currently in the process of delivering the next large grid connection in Germany for renewables; a connection of three wind farms situated in the DoIWin cluster. The in total 800 MW from these wind farms will be transported by a state-of-the-art HVDC Light system, featuring ABB's latest developments within power transmission technology, such as cascaded two-level converters and 320 kV extruded polymer-based cables.

The DoIWin1 link will not only enable to further cut transmission losses utilizing new development of proven technology but also to integrate this eco-friendly power further inland than any other project, thereby reducing the network congestion in the near-shore grid.

The HVDC Light system is a self-commutated HVDC, based on power transistors (IGBT) and the use of lightweight, eco-friendly polymer cables. Compared to an AC link to connect the wind farm, this modern, eco-compatible technology, with its very low electromagnetic fields, oil-free cables and compactly dimensioned converter stations, cuts transmission losses by 25 %.



### Different sections of an HVDC Light converter station

- The AC power area includes the transformers, circuit-breakers and harmonic filters (if needed). The transformers for HVDC Light require only minor design modifications compared to standard power transformers of this size. The DoIWin1 link features parallel transformers, each with the ability to handle the full rated power in case of transformer malfunction.
- The converter reactors are used for filtering, and are also important in providing reactance for controlling the transmitted power.
- The alternating current is rectified using the HVDC Light valves. For each phase, valve halls are provided in which the IGBT valves, DC capacitors and the bushings are accommodated. The IGBT modules supply an easy-to-monitor output voltage, thanks to the sophisticated MACH2 protection and control system. The system features redundancy throughout, thus assuring a high level of availability. The valves used in the DoIWin1 link are of cascaded two-level type, meaning that the output voltage is build up by multiple voltage steps, thereby reducing the system losses as well as the overall stress of the nearby equipment.

- It is in the DC power area that the cables are linked; from here, marine cables and land cables connect up to the other HVDC Light converter station located onshore.
- The cooling system serves to ensure the correct operating temperature for the HVDC Light valves.
- The chopper resistor is used for fast active power reduction in the event of faults in the AC network.

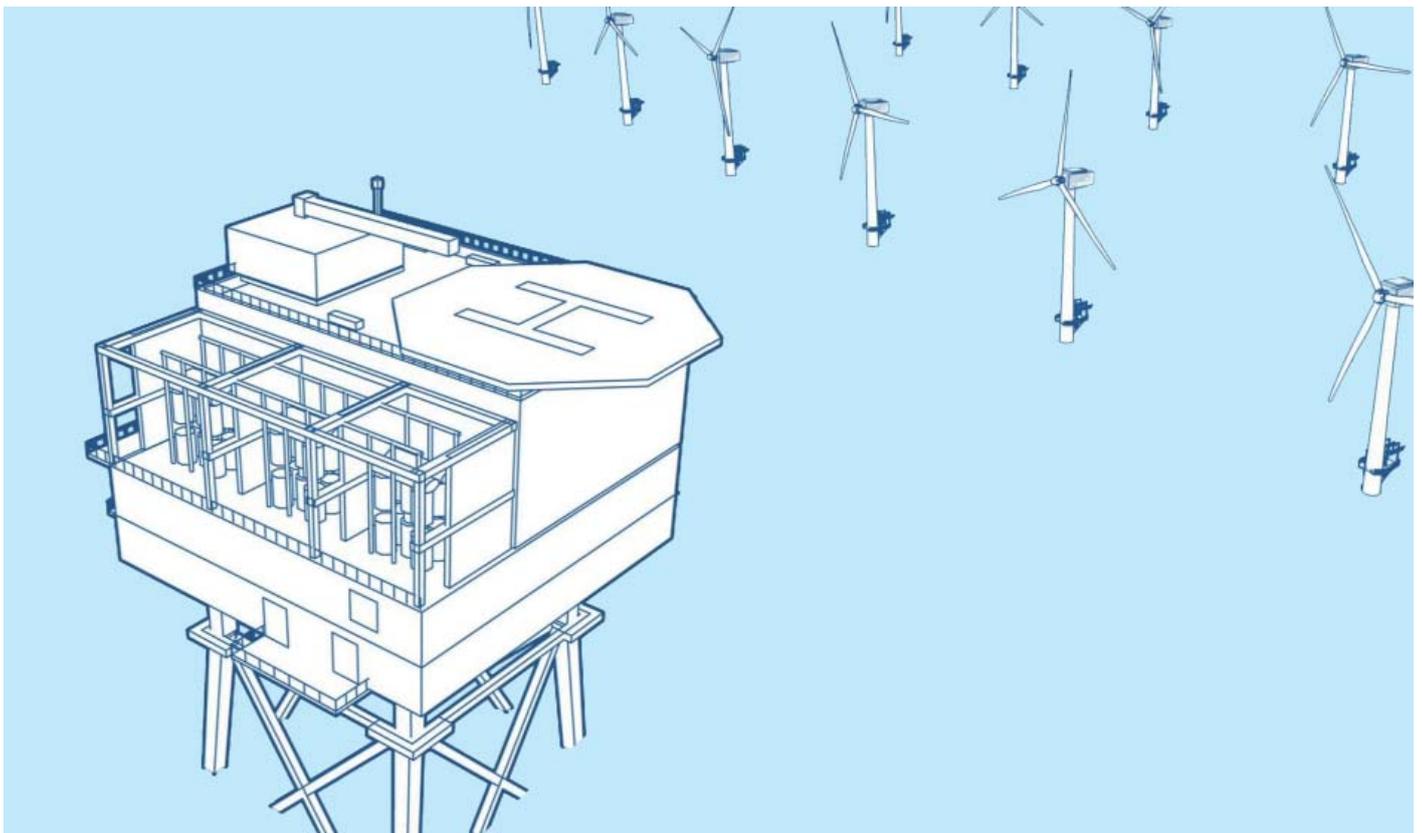
#### Main data BorWin1:

Commissioning:	2009
Power rating:	400 MW
AC Voltage:	155 kV (Offshore) 380 kV (UW Diele)
DC Voltage:	± 150 kV
Land cable length:	2 x 75 km
Sea cable length:	2 x 125 km

#### Main data DoIWin1:

Commissioning:	2013
Power rating:	800 MW
AC Voltage:	155 kV (Offshore) 380 kV (UW Dörpen-West)
DC Voltage:	± 320 kV
Land cable length:	2 x 90 km
Sea cable length:	2 x 75 km

BorWin1 – platform BorWin alpha



# Grid connection of offshore wind farms – using wind energy in an efficient and climate

## **ABB – the biggest supplier of electrical components, systems and services to the wind power industry**

Experience plays an important role when customers choose ABB for their products, systems and services. Over 100 years of experience and collaboration with power utilities, the process and automation industry and OEMs enables ABB to convert know-how and application understanding into products and solutions to benefit the wind power industry. Sustainable solutions, reliability and knowledge of industry-specifics, such as grid codes, have made ABB the leading partner for wind power. Profit from the know-how of a reliable partner and experience which products and systems can be applied in your projects.

## **Power Systems Consulting**

There are several boundary conditions that have to be given due consideration for costand energy-efficient network linkage of offshore wind farms. Capital investment and operating costs have to be minimized, as do transmission losses, while operational reliability has to be maximized. For this complex optimization job, ABB's globally deployed power systems consulting team of experts possess the comprehensively specialized knowledge required for putting together an optimally customized package.

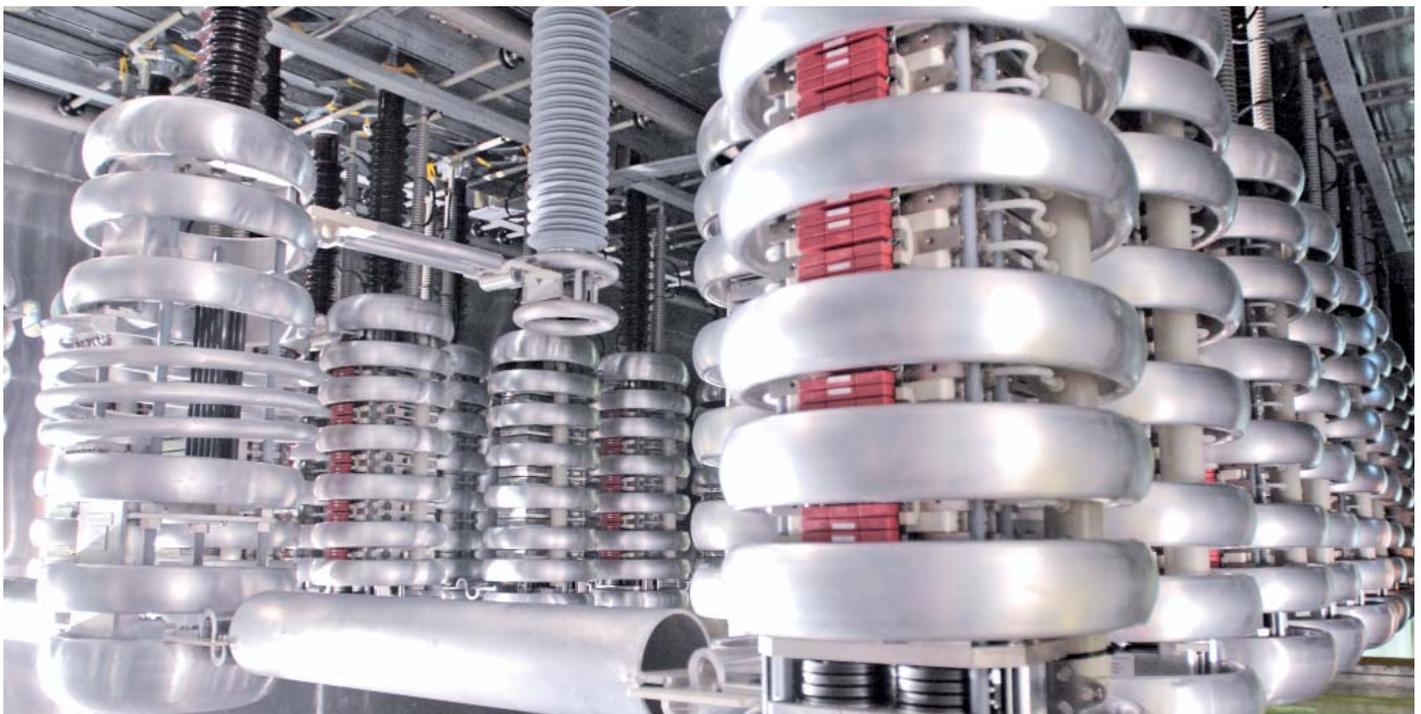
Multifaceted computations for determining the wind farm's internal cabling and network integration, covering points like:

- load flow,
- short-circuit current,
- harmonics,
- flicker and voltage dips,
- lightning-stroke and over voltages, and
- earthing system

ensure compliance with the grid code of the transmission network operators, and an optimized system design. Technical dimensioning of the wind farm's internal cabling for the individual wind energy installations, offer enormous potential for an optimized configuration.

Similar considerations apply for network linkage of an offshore wind farm, for which there are two basic alternatives:

- three-phase AC linkage – for relatively small offshore wind farms near the coast
- DC linkage – for sizeable offshore wind farms and installations a long way from the coast



# friendly way

## Network linkage of offshore wind farms

System-compatible integration of offshore wind farms can be provided using either High Voltage 3-phase AC links featuring XLPE-insulated cables or High Voltage DC links based on state of the art semiconductor technology.

The most cost-efficient solution when the location of the offshore wind farm is not too far from the coast is to use a High Voltage 3-phase AC transmission solution. When sizeable distances are involved, reactive power compensation may be required. ABB's modern SVC technology allows for cable compensation as well as fulfillment of demanding grid code requirements.

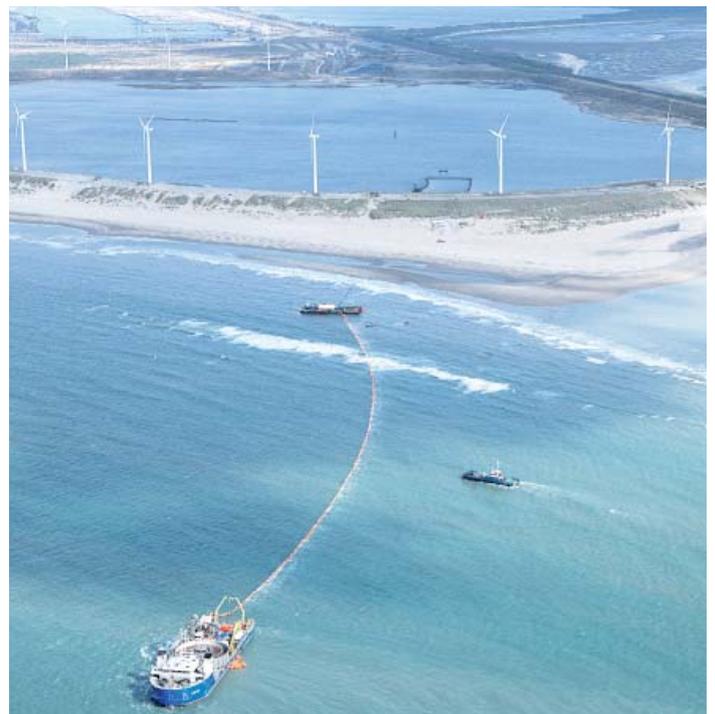
The ABB high voltage AC transmission links are characterized by:

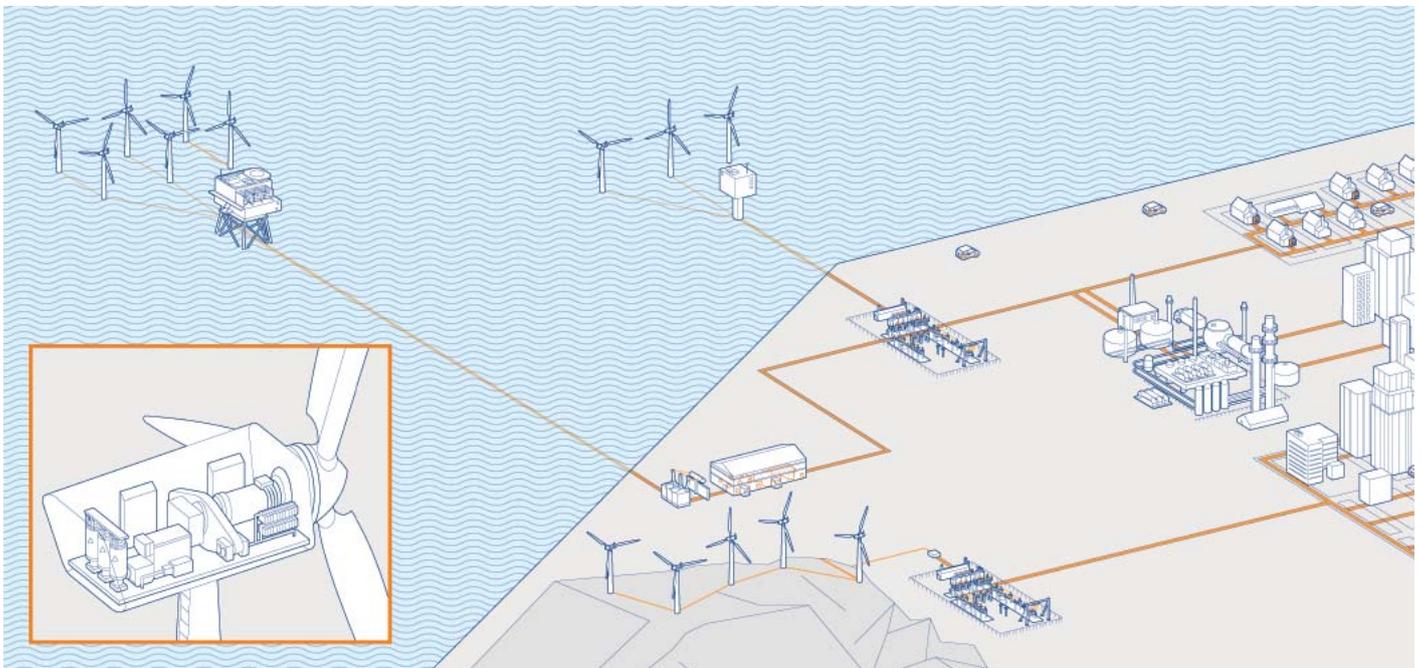
- modern XLPE insulated cable systems
- modern reactive power compensation technology
- future proof and grid code compliant solutions
- high quality and highly reliable component selection
- compact design
- state of the art control and monitoring systems

Depending on the rating of the offshore wind farm concerned, a high-voltage DC transmission option (HVDC) may be financially viable even for shorter distances. ABB's HVDC Light package is the most up-to-date system for power transmission under water and underground, and has been in use for more than 10 years.

Three characteristics make HVDC Light the ideal solution for linking up offshore wind farms:

- Unrestricted provision of reactive power  
This supports voltage stability at the connection point, enabling the high power levels of the offshore wind farms to be fed into the network without any deleterious effects on the system.
- Black-start capability  
The transmission system can be run up from a powerless state, e.g. if the wind has not blown at all.
- Decoupling of the networks  
With a DC transmission system, the wind farm's offshore network is decoupled from the power grid on the mainland by the DC link, which prevents resonances and instabilities. This solves some fundamental problems of offshore wind farms located a long way from the coast: firstly, for distances of more than 100 km, a link using three-phase marine cables is technically and financially counter-indicated, while secondly a conventional VDC option is not suitable for connection to weak or especially passive networks. In addition, HVDC Light excels in terms of simple-to-handle cable design and a modularized, factory-assembled construction of the HVDC converters. All this enables the network links required for the planned offshore wind farms to be completed with reassuring swiftness.





# Products for the wind energy industry

## Innovative and reliable solutions for all power ratings

### Generators

ABB supplies generators for both stall and pitch regulated wind turbines with outputs ranging up to 5 MW and higher. We offer all main concepts, from fixed speed and doubly fed to permanent magnet generators. Our traditional stall concept is the fixed speed generator, with the generator directly coupled to the grid. The doubly fed, semi-variable speed generator is a mainstream pitch concept where the rotor winding is also connected to the grid using a small converter to utilize wind gusts. Since the 1980's, ABB has delivered more than 15,000 wind turbine generators.

### Converters

ABB uses premium DTC technology, which provides reliable control for different types of wind power concepts. Wind power converters from ABB comply with the challenging conditions offshore. The mechanical construction, which is much easier to maintain, and the compact, spacesaving design as well as the corresponding high protection class of the cabinet are the features that stand out.

ABB can offer an optimized solution package for different types of wind turbine solutions. ABB's advanced design philosophy minimizes losses and does not rely on fuses, leading to reliable and highly efficient converters with low maintenance needs.

### Transformers

ABB offers the most complete range of transformers and associated products and services for wind power. Power transformers for substations have primary voltages up to 800 kV, liquid filled distribution transformers up to 72.5 kV, and dry transformers up to 52 kV. We have more than 6,000 transformer units operating reliably and efficiently in the wind power industry around the world.

## Switchgear

ABB develops, produces and delivers a full range of medium voltage solutions for wind power applications: switchgear for main substation – grid connection; switchgear with integrated switching and protection of the wind farm network, either located inside the tower and as a complete solution, or in a compact substation close to the tower; and other switchgear developed and adapted according to customer requirements. ABB's portfolio also includes gas insulated and air insulated solutions with a choice of gas or vacuum circuit breakers. The voltage is 1 - 40.5 kV and current ratings cover all possible technical combinations meeting IEC and ANSI requirements. ABB air and gas insulated switchgear with control, monitoring, protection and operation are designed to operate in harsh environments. The dimensions are reduced and plug and bolt technology is used for all medium voltage connections.

## Medium voltage products

ABB meets customer needs for reliable medium voltage products that include switchgear, apparatus, modular systems and distribution automation. The ABB product offering includes breakers and contactors, fuses and cutouts, reclosers, surge arresters and voltage indicators. Ranges of switches and disconnectors, instrument transformers and sensors are also available.

## Low voltage products

ABB offers a broad assortment of low voltage products for wind turbines. Generators, converters, soft starters and motors from ABB provide an efficient conversion of wind energy in electrical power. Low voltage circuit breakers, contactors and miniature circuit breakers support the safe distribution of energy. The wind turbine is controlled by its brain, a programmable logic controller from ABB. The essential personal safety is secured by fault current circuit breakers and emergency push-buttons. Control and detector units as well as operation units complete our portfolio.

## Cables

ABB is one of the world's largest land and submarine cable manufacturers. The knowledge acquired from cable installations over the years is beneficial for offshore wind farm installations. ABB can offer a complete range of services from design to commissioning, including complete project management; AC cables between the wind turbines, AC or DC cables from the wind farm to the shore station, cable accessories including installation, system site test, and cable laying.



# Offshore AC substations – collection platforms for offshore wind

More and larger wind farms are being located offshore. The capacity of these wind farms is of the order of several hundreds of MW. To minimize the electrical transmission losses and the cable costs, the turbines in such wind farms are electrically connected to an offshore substation provided with a step-up transformer. The transmission to shore is then achieved by an HV AC connection or an HVDC link.

With ABB as your partner, our extensive offshore experience will be implemented into the design of your substation with strong focus on safety and cost effective design all over the lifetime. The development and design of the substation is highly dependent on the actual location and the operation and maintenance philosophy for the substation and for the wind farm.

## Multi-discipline services

ABB provides multi-disciplinary engineering consultancy for all areas of the offshore substation:

- definition of design standards and codes
- general layout development with consideration of safety chemical handling, operation and maintenance
- implementation of electrical equipment such as power transformers, shunt reactors, gas-insulated switchgear, LV-switchgear, auxiliary power system, UPS system and control system
- substructure design including j-tubes for cables, boat landings and foundation
- specification of all auxiliary equipment such as cranes, emergency diesel systems and workshops
- accommodation facilities and helideck if required
- installation engineering for topside and substructure as well as cable pull-in planning

## Substructure design

The substructure design can be a simple steel mono pile, a larger jacket for deeper waters and higher topside loads or it can be a self installing type. ABB can adopt to both, the local requirements and the customer demands to provide a cost optimized solution for the total lifetime of the offshore wind farm. ABB has a track record on platforms with different substructure designs and can help the customers already during feasibility stage to select the best solution for their offshore wind project.

## Design codes

The designs can be performed according to any acknowledged standard e.g. DNV, Germanischer Lloyd, NORSOK or other international codes, as required to have the project certified by a Certifying Authority.



# Service for offshore facilities – commitment to ultra-stringent safety standards

Our service specialists are trained to ensure the most stringent of offshore safety standards. Quality stipulations, occupational health and safety, plus integrated management processes, are subjected to continual monitoring.

The avoidance of CO<sub>2</sub> is one of the paramount goals being targeted in this century. Worldwide, there are ambitious targets in place for this purpose: one option is increased utilization of renewable energies for generating the requisite energy. And one of the most promising energy sources available is offshore wind energy.

Operation and maintenance of offshore links or offshore substations require specialized service packages. We have synergized our corporate capabilities to create a full-coverage service package for offshore links, particularly for energy transmission based on HVDC technology from large wind farms.

In the offshore service operation, the platform and the building(s), the HVDC-converter/AC and DC cables are the direct responsibility of a Service Manager.

Maintenance work is carried out by offshore-qualified service technicians and engineers. Our capabilities cover operation, inspection, tele-monitoring, maintenance and repair work, all the way through to modernization and retrofit jobs on components and systems of the offshore link between the offshore wind farm and the onshore transformer substation.





### System service for offshore network links

For maintenance work on offshore network link systems and offshore substations, ABB offers individually tailored service packages responsively customized so as to ensure high dependability for the system concerned. The first step towards implementing an optimized maintenance strategy begins with itemizing and structuring the equipment concerned in a maintenance management system.

### Maintenance concept

ABB's maintenance concept is subdivided as follows to reflect the functions of the systems and components installed:

- Operationally relevant systems  
Systems and components that are directly necessary for the process concerned, such as the primary and secondary systems of the substations.
- Safety-relevant systems  
Systems and components that are important for the safety of the offshore substation and the personnel on board, such as fire protection and rescue systems.
- Structurally relevant components  
Components that are required for the stability of the offshore substation and for achieving the requisite useful lifetime.
- Amenities for personnel  
Amenities that ensure appropriate comfort for the personnel working at the offshore substation.

These modules are incorporated into a customized maintenance strategy. An optimized maintenance strategy is vital for maximized availability.

# Contact us

## **ABB AB**

### **Grid Systems - Offshore Wind Connections**

722 12 Västerås, Sweden

Phone: +46 21 32 50 00

[www.abb.com/windpower](http://www.abb.com/windpower)

#### **Note:**

We reserve the right to make technical changes or modify the contents of this document without prior notice. With regard to purchase orders, the agreed particulars shall prevail. ABB AG does not accept any responsibility whatsoever for potential errors or possible lack of information in this document.

We reserve all rights in this document and in the subject matter and illustrations contained therein. Any reproduction, disclosure to third parties or utilization of its contents - in whole or in parts - is forbidden without prior written consent of ABB AG.

Copyright© 2011 ABB

All rights reserved