SIEMENS

Oceans of opportunities

Complete solutions for the entire life cycle of offshore wind farms

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Answers for energy.

Sustainable profit

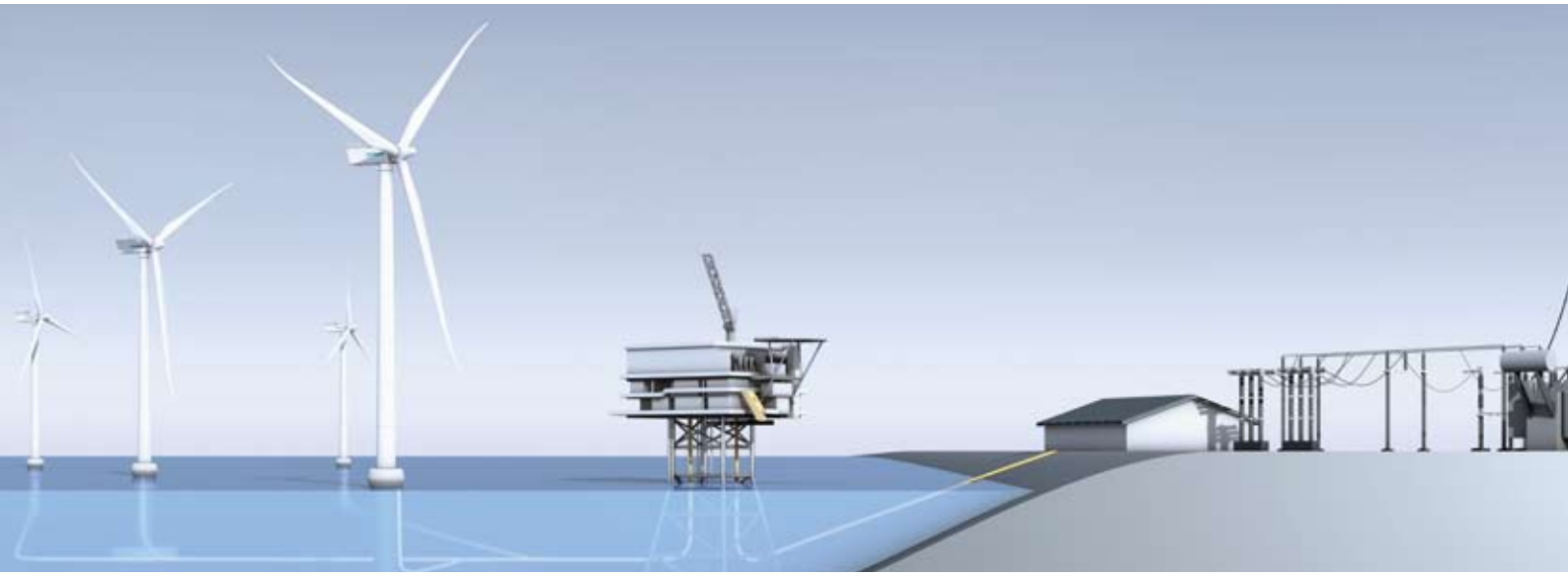
Offshore wind power – firmly established as a viable source of renewable energy

Due to higher, more consistent wind speeds at sea, offshore wind turbines can generate substantially more energy than onshore wind turbines. Offshore wind farms may reach capacity factors in the range of 50%. Even considering the planning constraints relating to shipping lanes, fishing, bird migration, and the like, the world has abundant space for offshore projects.

Offshore wind power has its challenges, however. Conditions during installation, operation, and maintenance may be harsh, and the product requirements are high. It takes a special supplier to provide stable, long-term offshore partnerships.

When it comes to offshore wind power, no supplier can match Siemens in terms of experience and reliability. Siemens has a proven track record for delivering offshore projects on budget. From the world's first offshore wind farm more than 20 years ago to today's largest offshore wind farms, all projects have been delivered on time and on budget. All projects operate with high availability.

Optimized processes across the complete project life cycle make Siemens a stable, reliable, and trustworthy business partner.



Siemens offers integrated solutions and services that perfectly meet the high demands along the entire wind energy conversion chain

Number one in offshore

Grown from experience

Siemens has developed a broad realm of experience and excellent skills in delivering offshore projects.

From the outset Siemens has played a key role in founding the offshore wind industry by installing the world's first offshore wind farm in Vindeby, Denmark, in 1991. The 11 turbines installed in this pioneering project are still in excellent condition. The turbines have consistently operated at high availability, reflecting the unique combination of product quality and dedicated offshore modifications.

Now, amidst the current boom in offshore projects, Siemens still leads the world in offshore technology. With an installed offshore capacity of more than 2 GW and a high order intake, the company remains the preferred supplier of wind turbines to offshore projects.

Furthermore, unlike any other offshore wind turbine supplier, Siemens offers equipment for the entire energy value chain, from the wind turbine to net conversion, efficient feed-in to smart energy grids, and power distribution.

Making history, over and over again
The trend in offshore wind farms is towards larger and more complex projects, located further from shore, in deeper waters, which are exposed to severe sea and wind conditions.

Utilizing the knowledge gained from more than two decades of experience in the offshore environment, Siemens is equipped to handle the challenges of this unique environment.

Siemens has not only supplied the world's first, but also the world's largest offshore projects. For several years, the 165-MW Nysted offshore wind farm held the record as the largest offshore project. In September 2009, that record was broken by the 200-MW Horns Rev II project. The 500-MW Greater Gabbard project, currently under installation, will raise the bar again. And the world's first 1-GW project, London Array, will represent yet another stride towards large-scale, green energy supply.

All record projects – and all feature Siemens wind turbines.

Siemens can also supply turnkey grid connections for wind farms, including construction of the offshore transformer station

Delivering on a promise
Delivering projects on time and within budget is one of Siemens' major strengths. Since the offshore industry was established in 1991, and despite the logistical challenges associated with offshore installation works, every Siemens offshore project has been completed within budget and on time.

This unique track record was not established by chance. It requires deep respect for the challenging conditions, detailed planning, and superior and consistent project management skills required during the execution phase. All of which are key elements of the Siemens offshore model.

The Siemens offshore model has been proven to deliver results. Everywhere, every time.

Providing the best technology
When access conditions are difficult and when high wind resources make every hour count, reliability is the key to profitability.

Over the years, Siemens turbines have set the standard for robustness and reliability. Designed with offshore applications in mind, the turbines have a rugged, conservative structural design, automatic lubrication systems with ample supplies, climate control of the internal environment, and a simple generator system without slip rings. These and many other high-quality design features provide exceptional reliability with long service intervals.

Siemens turbines are built to last.

Maximized potential across the board

A well-proven and robust installation process

Components delivery to port
Siemens transports all components, parts and equipment to a harbor site close to the proposed wind farm. The site serves as the assembly and embarkation station for the project.

Pre-assembly of components
Once all necessary components have been delivered, pre-assembly commences. Siemens designs, plans, and executes all work processes to minimize the amount of work required offshore.

Storage of rotor blades
Specialists place rotor blades in the storage area, ready for shipment to the site. The blades are stored in special transport fixtures used on the installation vessel. In some cases, blades are shipped as completed rotors.

Load out
Service technicians load all components onto the transport vessel in accordance with the project plan. Siemens' proprietary fixtures and sea fastenings are used for safe transport and working procedures.

Experience counts in installation
Drawing on more than two decades of experience in successfully delivering offshore projects on time and within budget, Siemens knows exactly what it takes.

Over the years, a large number of aspects of installation methodology have been tested and analyzed. Gradually, best practices have been established, and even though the process often needs to be adjusted to fit project-specific requirements, the fundamental approach remains the same.

By thoroughly understanding the complexity and challenges associated with implementing an offshore project, and by establishing optimized installation processes, Siemens maximizes the value of each link in the chain, providing minimum costs and optimum predictability in project delivery.

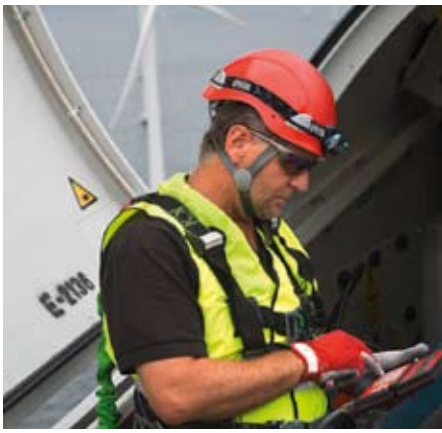
Installation scope
The Siemens installation scope is tailored to the needs of individual customers. One classical approach is an all-in equipment supply where Siemens provides the installation vessels. In another approach, the customer provides the installation vessels and Siemens carries out the work. Further alternatives are possible, depending on the customer's skills and objectives and a joint evaluation of the most optimal solutions.

Irrespective of the installation scope, Siemens' customers will always benefit from the reliability and robustness of a proven installation process.

Transport
A transportation vessel takes the components to the site. Transportation time can vary from site to site based on many factors, including the vessel type, the distance from the port of origin to the site, and weather conditions.

Installation
The transport vessel arrives on-site. The tower is lifted onto the foundation. Service technicians then lift the nacelle onto the tower and the rotor is mounted on the nacelle, either as a completed unit or in single-blade installation.

Commissioning
Once the turbine is mechanically completed and energized, it is thoroughly tested for commissioning. Some tests are automatically performed by the turbine computer controller, while others are performed by the service crew.



Service and maintenance
Siemens provides service and maintenance during the warranty period. Long-term service and maintenance contracts are also available from Siemens to ensure years of trouble-free operation.

Blades on a service vessel before mounting

The inside of an SWT-3.6

Simply the best

The fundamental pillars – the best turbines and the best service

Turbine types offered
Two Siemens turbine types are offered for offshore projects, the SWT-2.3 and the SWT-3.6. Both types offer the same key features.

Rotor
The rotor blades for Siemens' offshore turbines are made of fiberglass-reinforced epoxy, manufactured using the proprietary Siemens IntegralBlade® process.

Unlike conventional wind turbine blades, the IntegralBlades® are cast in one piece in a closed process. This process leaves no weak points at glue joints and provides optimum quality. The aerodynamic design represents state-of-the-art wind turbine technology, offering maximum energy extraction from any available wind resource, and the structural design lives up to the usual Siemens safety factors in addition to all industry codes and standards.

The blades are mounted on double-row pitch bearings fitted to a large rotor hub. The pitch actuation system is hydraulic, offering maximum robustness and safety.

Like the turbine itself, the blades are designed to last.

Nacelle
The nacelles of the Siemens' offshore turbine types are ideally suited for severe offshore operating conditions.

Major components such as the main shaft, the gearbox, and the yaw system are all of particularly heavy dimensions. The automatic lubrication systems have redundant lubricant reserves to enable continued operation even if scheduled maintenance is severely delayed by weather. The nacelle canopy is metallic to provide optimum lightning and fire protection. All safety systems are fail-safe and have layers of redundancy. Fully integrated climate control and comprehensive offshore-grade surface protection contribute to long service life.

Overall performance is well-proven and all details are designed using market-leading engineering practices.

Tower
Siemens offshore turbines are normally mounted on tubular steel towers fitted with internal personnel hoists.

A prefabricated power module is located at the bottom of the tower and provides the platform for the power converter, the turbine transformer, and the medium-voltage switchgear.

Blades being transported before mounting

Service technicians at work on an SWT-2.3-93

Grid performance
Grid stability requirements grow as more wind power is fed into the grid. Siemens also sets the standard in the field of grid compliance.

Power conversion is implemented with Siemens' unique NetConverter® system. This system uses full conversion of the power generated, efficiently decoupling generator and turbine dynamics from the grid. The NetConverter® system offers maximum flexibility in the turbine response to voltage and frequency control, fault ride-through, and output adjustment. As a result, Siemens turbines comply with all relevant grid codes.

Service and maintenance
Reliable and competent service and maintenance is almost as important for profitable offshore wind power projects as selecting the right turbine equipment. Due to sea and wind conditions, access may be restricted for long periods, and the losses resulting from trivial errors could be substantial.

Siemens is known as the most experienced and reliable offshore service provider, with an unmatched track record for maintaining optimum availability. Central demand planning, excellent diagnostics capabilities, and competent field service teams offer fast response times and well-planned service operations.

The service offering can be adjusted to match the owner's skill sets, objectives, and interest in participation. Irrespective of the service scope, Siemens' support enables owners to maximize revenue and earnings throughout the project lifetime.

Monitoring
Siemens offshore turbines are equipped with the unique Siemens WebWPS SCADA system. This system offers remote control and a variety of status views and useful reports from a standard Internet browser. The status views present information such as electrical and mechanical data, operation and fault status, meteorological data, and grid station data.

Voltage and frequency control, and other grid-related adjustments, can be implemented by the integrated park pilot utility in the WebWPS SCADA system.

In addition to this WebWPS SCADA system, the turbine is equipped with a web-based turbine condition monitoring (TCM®) system. The TCM® system continuously carries out precise condition diagnostics on main turbine components and gives early warning of possible component problems in real time. Based on the TCM® system, Siemens can detect and correct any problems at the earliest possible stage, thereby reducing maintenance costs, optimizing availability, and maximizing energy output.

New turbine technology
Siemens has installed the first prototype of its next generation offshore wind turbine at the Høvsøre test site in Denmark and has initiated the first trial operation. The new SWT-6.0-120 wind turbine, with a power rating of 6.0 megawatts and a rotor diameter of 121 meters, uses Siemens' innovative direct drive technology and the well-proven B58 blade. The wind turbine will also be available with a rotor diameter larger than 150 meters. Serial production is planned for 2014.

Offshore projects and references

More than 20 years of experience and over two gigawatts of installed capacity

Vindeby, Denmark
1991

Location:	Baltic Sea
Rated capacity:	4.95 MW
Scope of supply:	11 x 450 KW
Distance to shore:	1.5 km
Water depth:	1–5 m
Operator:	DONG Energy

Middelgrunden, Denmark
2000

Location:	Öresund, Baltic Sea
Rated capacity:	40 MW
Scope of supply:	20 x 2.0 MW
Distance to shore:	3.5 km
Water depth:	2–6 m
Operator:	DONG Energy, Middelgrundens Vindmøllelaug

Samsø, Denmark
2002

Location:	Baltic Sea
Rated capacity:	23 MW
Scope of supply:	10 x SWT-2.3-82
Distance to shore:	3.5 km
Water depth:	20 m
Operator:	Samsø Havvind A/S

World's first offshore wind farm
Siemens was the first wind turbine manufacturer to venture out to sea. In 1991, 11 turbines of 450 kW were installed at Vindeby, off the southern islands of Denmark.

The turbines, which are still running efficiently today, gave Siemens a head start in offshore projects and provided a testing ground for offshore modifications. These modifications are now thoroughly proven and form the basis of today's turbine technology.

The mega farms of tomorrow have their roots in this humble installation.

Offshore wind turbines are growing
Not only are offshore wind farms increasing in size, but so is the equipment.

In 2004, Siemens introduced the SWT-3.6-107 wind turbine. Eight times larger than the first offshore turbines, the 3.6-MW turbine type is now considered the de facto standard for offshore projects. In 2007, the first 25 SWT-3.6-107 wind turbines were installed at Burbo Banks and currently, this machine is the world's most popular offshore wind turbine.

Rødsand (Nysted), Denmark
2003

Location:	Baltic Sea
Rated capacity:	165.6 MW
Scope of supply:	72 x SWT-2.3-82
Distance to shore:	6–10 km
Water depth:	6–9.5 m
Operator:	DONG Energy, E.ON Sweden

Burbo Banks, Great Britain
2007

Location:	Irish Sea
Rated capacity:	90 MW
Scope of supply:	25 x SWT-3.6-107
Distance to shore:	7–12 km
Water depth:	7–12 m
Operator:	DONG Energy

Lillgrund, Sweden
2007

Location:	Öresund, Baltic Sea
Rated capacity:	110 MW
Scope of supply:	48 x SWT-2.3-93
Distance to shore:	6–7 km
Water depth:	4–13 m
Operator:	Vattenfall

Based on the proven technology of the SWT-3.6-107, the SWT-3.6-120 wind turbine featuring a 120-meter rotor was released in 2010. With this turbine, Siemens has produced a machine that can generate more power than its predecessor could at similar wind speeds.

Basically, the main difference between the two machines' core components is the rotor. The SWT-3.6-120 is equipped with 58.5-meter long rotor blades, giving it a swept area of 11,300 m^2 or the equivalent to nearly two football fields.

Tests indicate that the new machine will generate approximately 10 percent more electricity in comparison to similar wind turbines.

In 2011, Siemens introduced the new SWT-6.0-120 wind turbine with a power rating of 6.0 megawatts and a rotor diameter of 121 meters. It uses Siemens' innovative direct drive technology and well-proven B58 blade. The wind turbine will also be available with a rotor diameter larger than 150 meters. Serial production is planned for 2014.

Lynn/Inner Dowsing, Great Britain
2008

Location:	Greater Wash, North Sea
Rated capacity:	194.4 MW
Scope of supply:	54 x SWT-3.6-107
Distance to shore:	5–6 km
Water depth:	6–13 m
Operator:	Centrica

Baltic I, Germany
2010

Location:	Mecklenburger Bucht/ Baltic Sea
Rated capacity:	48.3 MW
Scope of supply:	21 x SWT-2.3-93
Distance to shore:	16 km
Water depth:	16–19 m
Operator:	EnBW

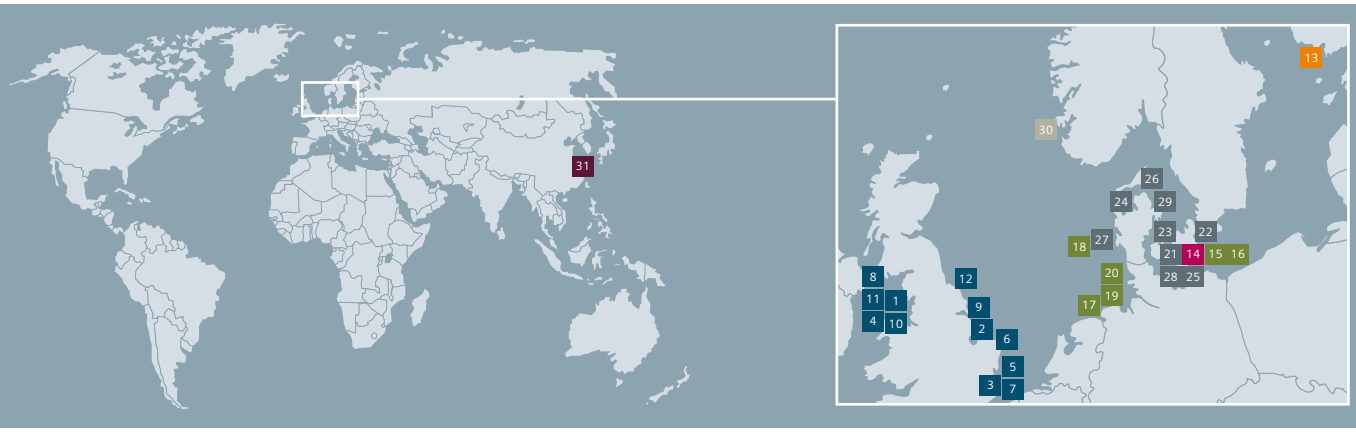
London Array, Great Britain
2011

Location:	Thames Esturay, North Sea
Rated capacity:	630 MW
Scope of supply:	175 x SWT-3.6-120
Distance to shore:	35 km
Water depth:	21–28 m
Operator:	DONG Energy

MW = megawatt, KW = kilowatt

1 **Burbo Banks, UK, 2007** 25 x SWT-3.6-107	9 **Lincs, UK**[1] 69 x SWT-3.6-120	17 **Borkum Riffgat, DE**[1] 30 x SWT-3.6-107	25 **Rødsand I/Nysted, DK, 2003** 72 x SWT-2.3-82
2 **Lynn/Inner Dowsing, UK, 2008** 54 x SWT-3.6-107	10 **Gwynt y Môr, UK**[1] 160 x SWT-3.6-107	18 **Dan-Tysk, DE**[1] 80 x SWT-3.6-120	26 **Frederikshavn, DK, 2003** 1 x SWT-2.3-82
3 **Gunfleet Sands, UK, 2009** 48 x SWT-3.6-107	11 **West of Duddon Sands, UK**[1] 108 x SWT-3.6-120	19 **Borkum Riffgrund I, DE**[1] 77 x SWT-3.6-120	27 **Horns Rev II, DK, 2009** 91 x SWT-2.3-93
4 **Rhyl Flats, UK, 2009** 25 x SWT-3.6-107	12 **Teesside, UK**[1] 27 x SWT-2.3-93	20 **Meerwind Sud Ost, DE**[1] 80 x SWT-3.6-120	28 **Rødsand II, DK, 2010** 90 x SWT-2.3-93
5 **Greater Gabbard, UK**[1] 140 x SWT-3.6-107	13 **Pori, FIN, 2010**[2] 1 x SWT-2.3-101	21 **Vindeby, DK, 1991** 11 x 0.45 MW	29 **Anholt, DK**[1] 111 x SWT-3.6-120
6 **Sheringham Shoal, UK**[1] 88 x SWT-3.6-107	14 **Lillgrund, SE, 2007** 48 x SWT-2.3-93	22 **Middelgrunden, DK, 2000** 20 x SWT-2.0-76	30 **Hywind, NO, 2009** 1 x SWT-2.3-82
7 **London Array, UK**[1] 175 x SWT-3.6-120	15 **Baltic I, DE, 2010** 21 x SWT-2.3-93	23 **Samsø, DK, 2002** 10 x SWT-2.3-82	31 **Rudong Intertidal, CHN**[1] 21 x SWT-2.3-101
8 **Walney, UK**[1] 51 x SWT-3.6-107, 51 x SWT-3.6-107	16 **Baltic II, DE**[1] 80 x SWT-3.6-120	24 **Rønland, DK, 2002** 4 x SWT-2.3-93	

[1] in progress [2] designed for arctic conditions



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