WIND TURBINE PAPER

Written by the
AIMU Technical Services Committee

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Wind Turbine Paper

Background

A wind turbine is a device that converts the kinetic energy of the wind into mechanical energy. This mechanical energy can be used for specific tasks (such as grinding grain or pumping water) or for driving a generator that converts the mechanical energy into electricity that is supplied to the power grid or individual users.

The earliest recorded (traditional) windmill dates from the year 1191 in Suffolk, England. The popularity of the windmill grew as a replacement for animal power for grinding grain. With the introduction of iron components in the 19th century, the traditional windmill reached its summit and was a common sight in towns and villages.

The first use of a windmill to generate electricity was by Charles F. Brush in Cleveland, Ohio in 1888 and by 1908 there were over 70 in operation with capacities ranging from 5 to 25 KW. By the 1930s, windmills with capacities as high as 100 KW were in use as a source of electricity, particularly in remote areas where centralized distribution systems had not yet been installed.

More recently, due to technological development combined with the rise of fossil fuel price and concerns over ecological change, the turbine capacity has roughly doubled every five years:

	Typical Capacity	Typical Blade Length	Typical Technology
Mid 1990s	400 – 500 KW	15 – 25 m	Fixed rotational speed and fixed blade pitch angle
2000	1,000 KW	25 – 35 m	Dual rotational speed and fixed blade pitch angle
Present	2,000 – 3,000 KW	35 – 45 m	Variable rotational speed and variable blade pitch angle
Next 5 years (predicted)	3,000 – 7,000 KW	45 – 60 m	

Global wind turbine installations have been rapidly rising, due to the maturation of wind turbine technology and the proliferation of government policies that support the development of wind energy. Installations increased from 11,531 megawatts (MW) per year in 2005 to 37,466 MW per year in 2009, with a total of 157,899 MW capacity installed at the end of 2009. The wind turbine market is diversifying geographically. In the 1990s and early 2000s, it generally centered on Europe, but in 2009 installations in Asia and North America exceeded installations in Europe. In 2009, installations in Asia were 14,639 MW; in North America, 10,872 MW; and in Europe, 10,526 MW. Although the upward trend of new projects has recently declined, due to the global financial situation, wind turbines are still seen as the best developed form of renewable energy and many governments have aggressive long term goals for their development.

The traditionally large domestic market is one of the key reasons for the strong position of Europe-based original equipment manufacturers (OEMs) in the wind turbine industry. In 2009, at least two were among the top three suppliers of wind turbines in eight of the ten largest markets. Vestas (based in Denmark) and Enercon (Germany) supplied wind turbines to the largest number of markets. U.S.-based General Electric Co. (GE) was the world's second largest supplier in 2009, primarily due to its strong presence in the U.S. market (an estimated 84 percent of turbines supplied by GE were to the U.S. market). However, GE and many European OEMs lost global market share in 2009 as a result of the rapid growth in China and the dominant position of China-based manufacturers in that market. Two of the five leading wind turbine suppliers in 2009 were China-based OEMs and five of the fifteen leading suppliers were based there.

U.S. wind turbine installations increased every year from 2005 to 2009, and the United States was the largest wind turbine market in the world in terms of annual wind turbine installations from 2005 to 2008. (In 2009, China surpassed the U.S. in annual installations.) However, record 2009 installations masked significant instability in the market. The financial crisis and recession contributed to a slowdown in project development starting in the fall of 2008. As a result, there were high installations in the first quarter of 2009 as projects started in the previous year reached completion and high installations in the fourth quarter after provisions in the American Recovery and Reinvestment Act of 2009 (Stimulus Bill) were finalized. There continue to be challenges and U.S. installations are projected to decrease.

The United States is likely to continue to be one of the largest global markets. The challenging market conditions in 2009 did not appear to have halted the trend toward increased U.S. production by OEMs. U.S.-based OEMs, which accounted for 46 percent of U.S. wind turbine installations in 2009, have a significant domestic presence in nacelle production but they do not produce blades in-house. GE has three U.S. plants that assemble nacelles and is the largest U.S. producer of nacelles. U.S.-based Clipper Windpower began production of nacelles in 2006 and was the 13th largest global wind turbine supplier in 2009.

Investment in the U.S. market by foreign-based OEMs has significantly increased as there are currently seven (7) companies operating a total of ten plants producing blades, nacelles, and towers. Five additional foreign-based OEMs are planning to manufacture in the United States with another eight plants scheduled. Foreign OEMs are localizing production in the United States in order not only to take advantage of the growing market but also to reduce transportation costs, minimize the risks associated with currency fluctuations, ease logistical challenges associated with exporting large nacelles and components, and avoid import duties.

Three U.S.-based suppliers (Knight and Carver, Molded Fiberglass, and TPI Composites) and Denmark-based supplier LM Glasfiber, which is the largest independent blade supplier globally, produce blades in the United States. Others have announced plans to open manufacturing plants here.

Tower manufacturing in the United States has also expanded significantly with companies announcing new manufacturing plants. The number of plants in the US increased from six in 2004 to 20 in 2009. Only one overseas OEM, Vestas, currently has a tower manufacturing facility in the United States.

In summary, cargo underwriters and surveyors should continue to see a number of wind turbine projects in both the short and long term. This paper addresses the safe and efficient transport of utility-scale (>1000 kilowatts) wind turbines. It will review the risks involved, and best practices utilized, in wind turbine projects.

U.S. Import Trends

U.S. wind turbine imports substantially increased after 2005, peaking in 2008 but declining slightly thereafter. The leading producers of wind turbine components to the United States are:

- Denmark, accounting for 34.5 percent of imports
- Japan, 25.5 percent
- Spain, 13.3 percent
- India, 10.7 percent, and
- Germany, 8.9 percent

U.S. Exports

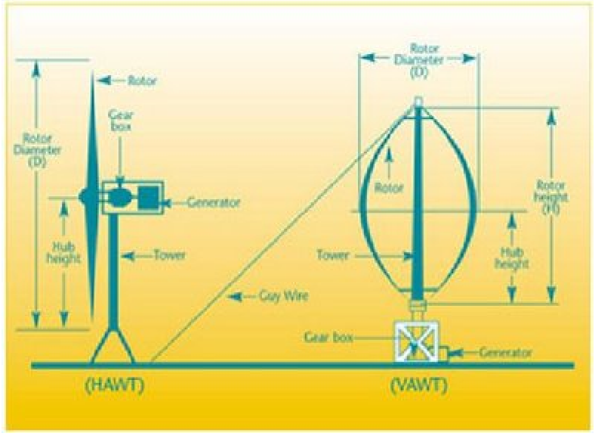
The value of U.S. wind-powered equipment exports rose from just $3.6 million in 2005 to $117.0 million in 2009 due to increasing shipments to Canada, Mexico, and South America. In 2009, Canada accounted for 66 percent of exports, Chile 16 percent, and Mexico 15 percent. However, exports have been limited due to the lack of U.S. production capacity, high demand within the U.S. market, and the fact that the largest U.S. producer, GE, already has plants in many of the key foreign markets.

Wind Turbine Major Design Components

Types of Wind Turbines

Modern wind turbines fall into 2 basic groups:

a. Vertical Axis Wind Turbine (VAWT)
b. Horizontal Axis Wind Turbine (HAWT)

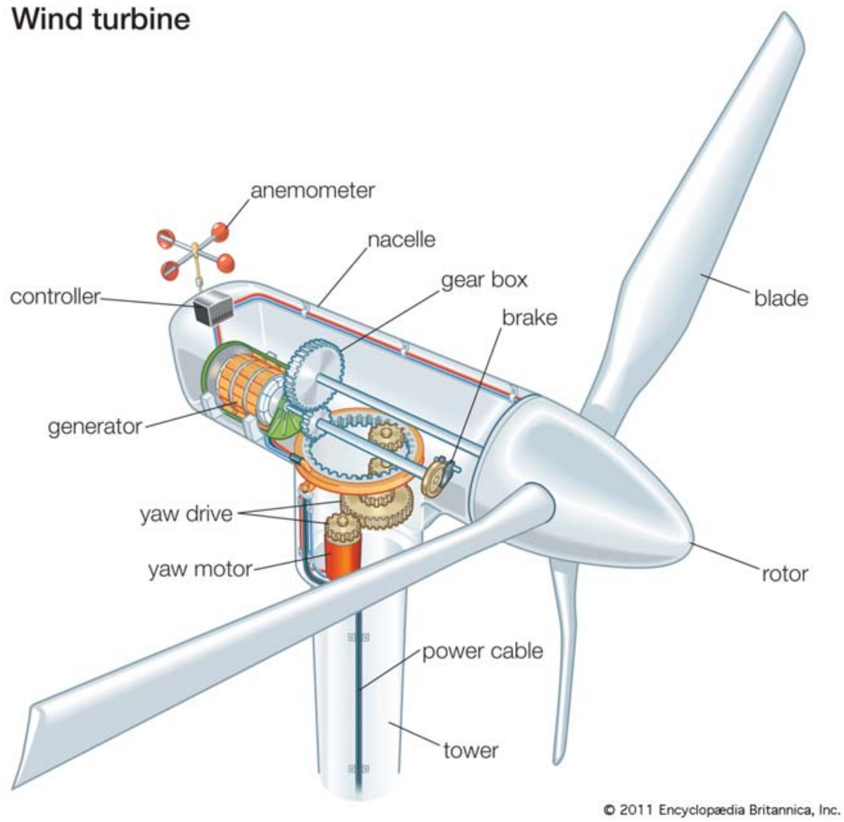


In a VAWT, the shaft is mounted on a vertical axis perpendicular to the ground – like an eggbeater. VAWT's are always aligned with the winds; as such adjustment is not necessary when the wind direction changes. Some of the disadvantages of the VAWT are that it cannot start moving by itself, it needs a boost from its electrical system to get started. Also, instead of a tower, it typically uses guy wires for support, so rotor elevation is lower. Lower elevation means slower wind due to ground interference, which contributes to lower efficiency. All equipment is at ground level for easy installation and servicing; but that means a larger footprint for the turbine, which is a big negative in farming areas. This design is rarely used in large wind farms.

In a HAWT, the shaft is mounted horizontally, parallel to the ground. HAWTs need to constantly align themselves with the direction of the wind. This type of turbine uses a tower as a base and the components are at an optimum elevation for wind speed. As such, each tower takes up very little space since almost all of the components are up in the air. Most large modern wind turbines are horizontal-axis turbines.

Wind TURBINE Major COMPONENTS

The horizontal-axis, 3-blade turbine on a free-standing tubular tower is the predominant configuration for large grid-connected wind turbines. A wind turbine is comprised of four major components: Rotor, Nacelle, Tower and Blades.



Wind Turbine Components

While wind turbines can vary considerably, as to height, blade length and generating capacity, they all have the same basic design. The following are the main components of a wind turbine that must be shipped.

Rotor: Sometimes called the hub, this is used to connect the blades to the gear box and power generation train within the nacelle.

Nacelle: an enclosure which contains the electrical and mechanical components, namely the gear box, the brake, the speed and direction monitor, the yaw mechanism and the generator.

i) Gearbox: Many turbines have a gearbox that increases the rotational speed of the shaft to match the required rotation speed of the generator/alternator. Some smaller turbines (under 10 KW) use direct drive generators that do not require a gearbox.

ii) Generator: Wind turbines typically have an AC generator (housed in the nacelle) that converts the mechanical energy from the wind turbine's rotation into electrical energy. Synchronous generators require less rotational speed than asynchronous ones and thus are often operated without gearbox even in bigger wind turbines.

Tower: Towers are usually tubular steel structures (about 80 m/260 feet high) which support the rotor and nacelle. It also raises the rotor high in the air where the blades are exposed to stronger winds. They consist of several sections of varying heights. The tower sits on a reinforced concrete foundation, so that it is well fixed onto the ground.

Blades: The modern rotor blades are made of composite materials, making them light but durable. Blades are often made of fiberglass, reinforced with polyester or wood-epoxy. Vacuum resin infusion is a new material which is gaining popularity among manufacturers. Most wind turbines have three blades. Blades are generally 30 to 50 meters (100 to 165 feet) long, with the most common size around 40 meters (130 feet). Blades typically represent approximately 22% of the value of a wind turbine.

Transformer: The electricity generated by wind turbines must be delivered to the electrical grid. In order to do this, the voltage needs to be stepped up for energy transmission. There is usually, at least, one large transformer that is shipped with a wind turbine project and is considered a critical component especially for DSU and operational BI.

Ocean Carriage:

Because of the multimodal nature of most wind turbine shipments, control over the process is important. Shippers, consignees, and transportation and logistics partners are all engaged in the planning and routing. It is critical that transportation concerns are an integral part of project planning from its earliest stages. For instance some blade design engineers are looking for designs to minimize transportation costs. A shortened maximum chord reduces shipping package height, while an increased root thickness translates to structural weight reduction. This will allow the shipping of two, 2.4 MW 40-meter Flatback wind blades per truck without exceeding weight restrictions.

Blade designers should be tasked with developing dedicated shipping cradles for the blades that they manufacture. These cradle designs need to take into consideration all modes of transportation and securing of cargo for ocean, barge, rail, truck and air. In addition, various lifting arrangements, including single point, twin lift and forklifting, need be considered as well as connection points for expandable blade trailers.

Blades in custom cradles, stacked 3 tiers high, and stowed atop the ship's hatch covers.

Also deck loading criteria, transport and racking stresses need to be reviewed. The final cradle should have lifting and lashing points clearly marked as well as the center of gravity. Also, the cradle under the blade tip must be placed at a specific distance from the root, to avoid possible deflection of the blade, when lifted or transported. The location of the tip cradle should be marked on the blade.

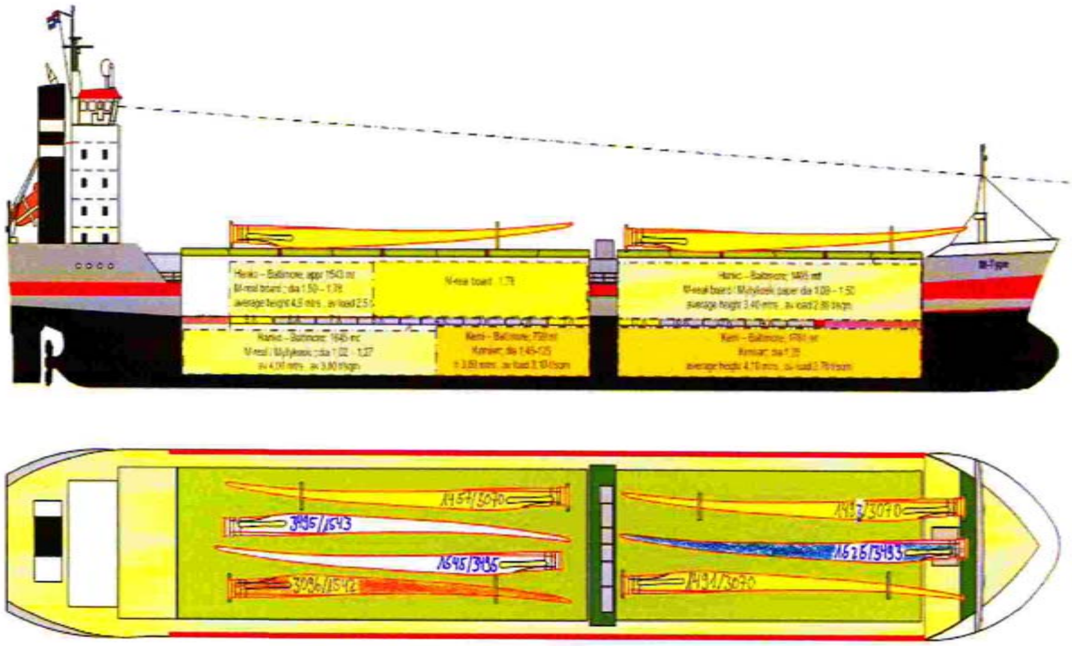
Example of blades shipped individually with a fixed frame on the root and a movable frame placed under the tip. Placement of the cradle along the tip is critical.

Nacelles can be shipped break bulk. This one is shrink wrapped and secured to a mafi trailer aboard a Ro-Ro

Coverage for this type of cargo will often start once the equipment leaves the manufacturer’s facility and extend until the cargo is delivered at the job site. However, this can vary with the terms of sale (Incoterms). Foreign manufactures will often provide the transport from the factory to the port of export (Free Alongside-FSA).

Tower section, shipped in a custom cradle, set atop trailer by two shore cranes, working in tandem. Below two power train & gear units are secured on mafi trailers for transport aboard a RoRo. Well marked lifting points are needed, as well as protection against the elements.

Example of a stow plan for carriage of wind turbine project cargo.



Nordex turbine blades in frames , 7 pcs , appr 90 mt in total.
4 pcs framed blades stowed on extreme port and sb, conventional framed blades stowed in between
Framed blades need 24 iso plates, 24 pcs TL/BLL. If vessel has no tl/bll lash frames as on last Oranjeborg (see att picture)
Vessel has all lashing material on board ex last Nordex voyage
Use stamped dunnage under frames (stock Esbjerg), leave sufficient space between blades.

Stowplan Missouriborg
7 pcs "Nordex" Wind turbine blades ;
Esbjerg – Baltimore

The preparation of the vessel to properly load/stow and secure the cargo is important. The booking note should contain information in respect to the weight, the manner of packaging, dimensions of the blades and maximum allowable stowage height. The proposed stow location should be agreed upon in advance, for example on deck, below deck or Ro-Ro with loading via stern or side ramp.

If Ro-Ro loading is proposed the turning radius for both loading and discharge operations must be carefully reviewed. Berthing assignments at either loading or discharge ports can cause problems due to sufficient turning radius not being available.

Vessel stability and lashing calculations should be made prior to the commencement of loading, based on the vessel's relevant characteristics (such as length, speed, metacentric height or GM and stowage location on board), the cargo (dimensions and weight) and the lashing material to be used (wire rope, chains, shackles-rings-pad eyes, steel bands, etc. etc.). The units have to be handled with extreme care as strong winds during loading/discharging create difficulties when lifting the oversized loads. Another concern is the proper determination of the structure lifting points and the center of gravity; special attention should be given to the lifting points and the center of gravity on the lift needs to be verified. All components should be clearly marked on sides and top of lift to highlight lifting and lashing points, as well as centers of gravity.

The vessel's Cargo Securing Manual should be approved by the relevant Flag State Authority or directly by the relevant Class Society, if such authority for approval has been transferred to the Class Society by the Flag State Authority. As wind blades are not mentioned in the list of cargoes under section 5.3 for non-standardized stowage and securing in The Code of Safe Practice for Cargo Stowage and Securing, 2003 edition, an annex describing the general nature for the stowage and securing should be worked out and approved by the relevant Flag State Authority or Class Society. The surveyor should ensure that stowage/lashings and securing of the cargo is in compliance with the applicable annex.

Ensure that the proposed loading, discharge and transshipment ports have made adequate investments in their infrastructure to ensure they have the appropriate on-dock equipment, sufficient land for staging and storage, a trained labor force and logistics teams, as well as a railhead, or rail service loop track, for railcars, or berthing arrangements for barges, capable of moving wind-energy cargo.

Look for a port equipped with mobile harbor cranes such as the Port of Vancouver, WA, USA which has two 140-metric ton Liebherr mobile harbor cranes. When used in tandem, these can lift up to 280 metric tons. Vancouver's heavy-lift capability makes it possible to lift increasingly heavy and large nacelles from the offshore side of a vessel, saving time and eliminating the expense of turning the vessel.

Rotors are transported as break bulk cargo and can be carried within ship's holds or transported on mafi trailers, aboard Ro-Ro ships.

Barge transportation has many of the same concerns as ship movements; however it avoids many of the road and bridge strength restrictions and varying state-to-state regulations that can complicate planning, permitting, and execution of road shipments. This is utilized either for coastal service or as part of a feeder ship operation. Concerns to be addressed for barge shipments include verifying the suitability of the barge to ensure that deck loading criteria thresholds are not exceeded. The physical condition of the barges and the cargo securing should be verified with an on-hire inspection and a load and stow survey. During the loading of the barge, ensure that proper trim is maintained for good handling. Also due to the high windage nature of many turbine components the lashing calculations need to take this into consideration; this should also be considered when selecting the horsepower requirements of the tug.

Handling:

Tower stacking frames, wind turbine hub carriers, vacuum blade lifters, lifting yokes for blades, spreader beam for tower sections, lifting yokes for hubs and transport frames for tower sections are just some of the specialized equipment available for the safe and efficient handling of wind turbine components. The original equipment manufacturer should be consulted on the proper lifting of their items. All lifting equipment that is put in use requires current test certificates. In addition, pre-use and periodic inspection protocols are to be put in place and adhered to.

Shrink wrap and custom fit covers are an alternative to heavy, expensive custom tarps or conventional hand wrapping for various wind-power applications. Transhield is one manufacturer that produces covers made from a shrinkable plastic fabric. These covers consist of three layers: an outer layer that is UV-resistant and also reduces condensation, a middle adhesive layer, and a soft inner layer. The covers install easily and shrinking the cover makes for a tight fit, resulting in quality protection from factory to field for tower sections, root ends, blades, and other products. Other manufacturers are making similar products that can be used to protect components during shipment.

85 ton transformer is lifted from the ship's hold by the terminal shore crane and placed directly on a heavy haul trailer for transport to job site.

Storage

Having adequate lay down and staging areas are critical along the proposed transportation route, not just at the final destination. A large wind farm may consist of several hundred individual wind turbines, and cover an extended area of hundreds of square miles. Roscoe Wind Farm in Roscoe, Texas, owned and operated by E.ON Climate & Renewables is the world's largest capacity wind farm with 627 wind turbines. It spans parts of four counties and covers nearly 100,000 acres, several times the size of Manhattan.

The size and number of components required for construction of an economically viable wind farm can overstress the capabilities of many storage locations. Important aspects of storage site selection include access to various transportation modes; railheads, barge landings and improved roads. The physical footprint of the location must also be considered- is there adequate paved and fenced storage capacity to handle projected throughput? What will be the peak requirements and will there be sufficient crane capacity? Another major criterion for a storage location is the availability of a trained labor pool and facilities to accommodate their needs.

If cargo is to be stored at the port, then a heavy weather or hurricane contingency plan should be developed, especially for the blades. This may require placing temporary lashings on the blades to keep them from being blown about.

Normal wear and tear of any surface is expected over time, but whenever there is extensive pressure and constant flow of traffic, road damage becomes inevitable. A suitable storage site must have the infrastructure to support and maintain its paved surfaces.

Over the Road Transport

Intermodal transport is a necessary part of the U.S. wind industry's continued growth. But as with any aspect of domestic transportation and logistics, trucking remains the go-to mode for managing first- and last-mile deliveries, especially in remote areas. For an entire 150 MW project, transportation requirements have been as much as 689 truckloads, 140 railcars and 8 vessels to the United States. And, many projects today are much larger; the largest operating project is currently 736 MW with others in excess of 4,000 MWs in the early stages of development.

U.S. Motor carriers overall do a good job transporting oversized, heavy cargo from point A to point B, but need to fully take advantage of technology to improve the overall performance of the supply chain. This will allow better planning and asset allocation at the final construction site or intermediate transshipment points.

At present in the United States there are over 20 trucking companies with expertise in the wind energy business, including ATS Specialized, Daily Express, Landstar Carrier Services and Mammoet USA. One of the most critical pieces to the over the road transport equation is the experience and training of the drivers. Ensure that the proposed trucker has an adequate supply of qualified drivers to support the trucking schedule. Transport companies face many challenges with a wind turbine shipment because each state has different rules, and approved routes are subject to change. Ensure that the trucker has the ability to work with federal, state, and local governmental agencies to find the best solutions to the route adjustments that will be required to complete the shipment of the cargo.

Specialized equipment for road transport includes prime movers, expandable blade trailers, Schnabel trailer sets and multiple axle combinations for Nacelle transport.

Telescoping trailer used for carrying blades. The rear trailer is steerable and controlled from a trail vehicle.

Over the last few years, a 1.5 MW wind turbine has been the prevalent size on U.S. roads and wind farms. It is about the largest and heaviest that transports easily on most U.S. roads. But turbine design is trending to larger units; hence, 2.5 and 3 MW units will soon be more frequently encountered.

Seven truck rigs are usually needed to deliver each commercial-size turbine, which includes three tower sections; a nacelle containing a turbine's generator, gear box and electrical apparatus; and three long blades. These vehicles constitute a specialty for all involved - manufacturers, logistics providers and haulers. Each turbine blade is 120 to 130 feet long but weighs only about 20,000 pounds, translating into the use of extendible trailers over multiple axles and there is still a lot of overhang of the blade.

A tower base is much shorter but more stout, generally with a length from 60 to 70 feet, diameter of 16 feet and weight of 75 tons. A two-part Schnabel holds each end of a cylindrical base or center section and carries it low to the pavement so overhead obstructions can be cleared. A lighter tower top section goes on a double-dolly rig with steerable rear axles. The generator nacelle, generally weighing 40 to 45 tons, goes on a 55-ton lowboy with a multi-axle jeep. A rig carrying a nacelle or lower tower section can weigh between 120,000 to 180,000 pounds that is spread over 13 axles.

Motor carriers should have an in-house staff dedicated to studying the proposed routes for height and width clearances, weight limits, turning radii, obtaining permits from multiple jurisdictions and other project planning. This includes obtaining escorts where needed. The rigs can run then only during specified hours and days.

One of the major challenges for the transportation of larger wind equipment components is the wind itself. Components are bigger, heavier, and therefore more challenging for the trucking industry. Wind pressure on heavy loads requires experienced drivers who are specially trained to transport wind power components.

Rail Transport

Given the unwieldy and oversized nature of many wind turbine component shipments, the railroad is a likely mode for transporting this type of cargo to and from ports and between U.S. manufacturing and installation locations. In an ideal world, a railroad would bring turbine components to within a few miles of a wind farm. According to data from CSX Railroad, railroads are about three times more efficient than trucks for moving heavy equipment. But railroads have challenges as well with clearances for the large parts of a wind turbine. For instance, many tunnels are too small for the largest components. A cargo width of 12.5 ft. is about maximum and in some areas the tunnels are too narrow to accommodate passage.

Site Discharge

The final mile can be the toughest segment of the total transit; places where the wind blows are not the easiest to access. Final site discharge can be expedited by having the proper equipment staged, with plans for the lifting arrangements in the hands of the personnel conducting the discharge and staging. Having an adequate lay down and staging area is critical; the known patterns as well as the vagaries of the weather must be taken into account. The site location was chosen due to its steady winds, but those same conditions will adversely impact discharge of the project's components.

Remote project sites with difficult access present unique logistical challenges. A hillside project in Italy used the services of Erickson S-64F air crane helicopter to transport turbine blades the final 9 miles due to road restrictions. Boeing is presently working on developing the JHL-40 Jess Heavy Lifter; this is a hybrid airship that would provide heavy-lift services for project logistics moves. Technology continues to evolve and adapt to meet the changing needs of customers.

Nacelle and blades discharged and on site; the risk typically transferred from Cargo or CAR or EAR underwriter.

For wind turbine components from some countries like India the supply chain is extended and the total time can be lengthy; it can take several months to order and schedule factory production, plus another 30 days at sea, followed by inland transportation to the site. Any type of cargo damage can have serious consequences on a project, including delay in start up. The step-up transformer is a bottleneck item for all the electricity produced in a wind farm and thus is most critical for DSU and BI aspects.

An often overlooked protocol is having a cargo inspection program at the job site. Equipment should be inspected carefully for damage, upon receipt, and all parties notified if damages are found. Unfortunately, the tendency is to let cargo sit at the job site, until it is needed, and only then might damage be discovered.

Offshore Wind Turbine Projects

Offshore wind turbines are less obtrusive than turbines on land, as their size and noise is mitigated by distance. Because water has less surface roughness than land, the average wind speed is usually considerably higher over open water. Consequentially, capacity factors are higher than at the onshore locations.

Europe is the leader in offshore wind energy. As of 2010, there were 39 offshore wind farms off Belgium, Denmark, Finland, Germany, Ireland, the Netherlands, Norway, Sweden, and the United Kingdom with a combined operating capacity of 2396 MW. Proposed installations by the European Wind Energy Association include a set of 40GW installations (100,000MW) by 2020 and 150GW by 2030. The largest wind farm as of

November 2010 was the Thanet Offshore Wind Project in the UK rated at 300 MW, followed by the Horns Rev II farm in Denmark rated at 209 MW.

Ontario, Canada is pursuing several locations in the Great Lakes including the suspended Trillium Power I, approximately 20 KM from shore and over 400 MW in capacity.

As of today there are no offshore wind farms in the US. There are projects however that are under discussion for the East Coast, Great Lakes and the Pacific Coast. The first planned offshore wind farm, Cape Wind, is near Block Island, Rhode Island.

Particular attention for these projects should be given to defining where the coverage will transfer from Cargo to the CAR or EAR underwriter. The demarkation can vary considerably with the individual project. Projects can be basically "stick built," where the components are transported offshore on deck barges to be assembled (piece by piece) or the assembled wind turbine may be transported offshore by a custom made vessel and then set in place.

In the U.S., the offshore wind turbine industry is still in its infancy, as most of the projects have been on shore or inland wind farms. The construction and transport for the offshore segment, is still an evolving industry.

Other Issues

Delay in Start-Up (DSU) coverage is often required for energy projects, as these projects often involve substantial penalties, if the start-up date is not met. This can also take the form of Advanced Loss of Profits (ALOP), Business Interruption (BI) and Consequential Financial Loss. DSU provides the insured with coverage for the loss of *Profits*, (generally defined as loss of gross revenue – variable costs saved), or additional expenses incurred, including penalty fees, for the project not being completed by the project's designated start-up date, due to physical loss or damage to the machinery or equipment in transit, from a covered peril. Machinery or equipment whose loss or damage might delay the start up of the entire project is called *Critical Cargo*, and is generally declared by the insured at the start of the project. For wind turbine projects, the major components of the turbines (including the blades) are often considered Critical Cargo, esp. the step up transformer.

If DSU coverage is requested, underwriters should obtain information about the time required to replace damaged or lost equipment. Often, the project contractor will have this information developed and estimates for time to replace critical cargo will be included in the application. It should be noted that DSU indemnity period is measured by the time the completion of the project is delayed and usually contains a deductible, typical 30 or 60 day, depending on the project contract requirements.

Damages and subsequent claims reporting procedures should be established early in the project, especially if DSU coverage is in play. One of the first questions is to determine if the damaged equipment can be repaired on site, or if it needs to be returned to the manufacturer. Often, a manufacturer's representative will need to make a field inspection of the damaged equipment to make this determination. It would not be unusual that this representative would have to travel from his/her home base to the site at some expense.

The turbine blades are the components most at risk to handling damage. However, the blades are often of fiberglass construction and smaller chips, gouges and fractures can be repaired on site or by local manufacturer-authorized repairers. The blades are also subject to manufacturer's quality assurance inspection, prior to being installed at the job site. Other wind turbine components are also subject to damage in transit, particularly the nacelles and transformers. Nacelles have a light fiberglass shell and can easily be damaged. Transformers can sustain damage to their internal components or active parts from vibrations and/ or impacts, during handling and transportation, especially if dropped or subjected to an impact beyond the design limits (esp. acceleration force). Manufactures will typically place impact recorders on transformers that can record the magnitude of the impact, as well as the date and time.

Since wind turbine projects generally involve multiple shipments over a period of time, lost or damaged critical cargo in the early phases of the project, often can be replaced with subsequent shipments, which would minimize the cost of a potential DSU claim. Major wind turbine manufacturers have reported back orders of 1 – 2 years, but sometimes a project using the same components can encounter major delays (due to, for example, environmental permit problems or financing problems), which can lead to surplus equipment available that could be used to replace lost or damaged equipment. Today, wind turbines are bought and sold, as virtually a global commodity and sometimes replacements for damaged components can be found available on the market. Most critical run terms of lead time is are bigger step up transformers with a capacity of several hundreds of MW.

DSU claims should always be handled by adjusters that are familiar with time element claims and, sometimes, forensic accountants are contracted to assist in the evaluation.

To identify deviations from the time schedule of a project, DSU cover requires a thorough project survey, which enables the insurer to determine delays caused by insured losses in cargo or construction from other uninsured delays, e.g. caused by bad planning.

Project synergies with Inland Marine coverages

Inland Marine Builder's Risk coverage, or Construction All Risks (CAR) or Engineering All Risk (EAR) are different types of Inland Marine & Property coverage that can be obtained for the property coverage of the wind turbines, or wind farms, as they are being erected. The Cargo coverage will apply while machinery and equipment is in transit, but after the discharge at the job site, the coverage will transition to Inland Marine Builder's Risk or CAR or EAR. The question is at what point will this transition actually occur?

Similarly, manufacturers will sell and deliver their wind turbines with different selling conditions. Some manufacturers will provide the over the road transit from their factory to the port of export and the ownership of the cargo may actually change hands at the port, while at other times, the sale is made “Ex Works,” where the buyer is responsible for transporting the machinery and equipment to the port.

It is important for the underwriter to define where the Cargo coverage will attach and where it will cease even if both the Cargo coverage and the Builder’s Risk covers are written by the same insurer.

Offshore projects, where blades or other components are delivered offshore on deck barges, are often considered part of the CAR or EAR coverage, once the cargo has been delivered to the offshore construction site. But what happens when heavy weather develops and the material barges (holding the components) are then towed inside to protected waters, and then towed back out to the job site, after the weather conditions have improved? Would the coverage revert back to a Cargo cover, or stay on the CAR or EAR coverage?

Loss Examples

The following are examples of the type of losses that have been experienced in the transport of wind turbines.

a) The most common damage is to the blades, mostly from handling damage. Blades are constructed of synthetic resin composites and are light structures that can be blown about by winds, during loading, resulting in striking against hatch coamings or other structures. Blades are also prone to damage, while being transported by truck and/or telescoping trailers, which have independent steerage on the rear unit. Experienced driving teams have caused damage within the port, simply moving the blades from alongside the ship to the storage area on the pier, by clipping fences or warehouse corners. Fortunately, these types of physical damages can often be easily repaired on site. Due to their construction (essentially a plastic composite), there have also been reports of blades damaged by hot work for welding of pad eyes or securing stops, due to poor hot work procedures and protection.

b) There have also been reports of collapse of stow and/ or heavier components loaded below deck that have shifted, due to heavy weather. One incident known involved a shipment from Italy to Denmark where approximately $4 million in damages were incurred. Heavy, break bulk equipment is often secured with welded steel plates or stops, which can fail if the welding is of poor quality and/or an insufficient number of stops utilized. We have also heard similar reports of shifting and/or collapse of stow for blades carried in 40-foot ISO frames that are often stowed several tiers high. Securing aboard ship should be in compliance with the Cargo Securing Code, Annex 13, for Non-Standardized Cargo. Also, if securing is accomplished by stops, the quality of the welds is important and non-destructive testing should be considered, especially if the welding is done by the ship’s crew.

c) A large loss occurred in Sicily, where a large number of blades were discharged on to the quay and stored in stacks, adjacent to a warehouse, because the wind farm was not ready to receive the blades. About a month later, the warehouse was destroyed in a major fire, with arson suspected. Fire damage to the blades was reported at over 5 million Euros. Underwriters should be aware of any extended storage of wind turbine components and consider any necessary changes in coverage terms and conditions that might be appropriate.

d) Transformers can be damaged during shipment, particularly if they are dropped or subject to a sudden impact. Damage may occur to the internal components of the transformer that are not designed to withstand this type of G (acceleration) force. Manufacturers will typically provide impact recorders for shipment, but these are passive and will only record the event. It is important to determine if any impact recorders, or any other concealed damage indicators, are provided by the manufacturer and their fragility setting.

Since transformers are shipped with the oil drained, manufacturers will typically provide an inert gas atmosphere within the transformer, to prevent corrosion from setting up. Pressure gauges and make up bottles are typically provided for transport. It is important that these gauge readings be recorded, at each hand-off or transshipment point.

Summary

When considering providing cargo coverage for wind turbine projects, underwriters should first determine the insured's needs and whether or not DSU coverage may be needed. Transport information should be developed to conduct a risk assessment and to determine the appropriate terms and conditions of coverage, as well as values and exposures. Typically, survey warranties would be placed in the policy, requiring a marine surveyor to approve the load, stow and securing at each leg or hand-off point for the shipment of the major components or any Critical Cargo. For inland wind turbine projects, this would include:

- Over-the-road transport from the manufacturer's factory to the port, depending on Incoterms.
- Unloading and pier storage at the port of loading
- Loading, stow and securing aboard ship
- Discharge and pier storage at port of import and determination of how long the equipment will be exposed on the pier.
- Truck or rail loading surveys for transport to the job site
- Discharge survey at the job site and receipt inspection

These types of projects can be very survey intensive, although some underwriters may waive inspections of repetitive shipments that are sourced from the same manufacturer, shipped through the same terminals, and transported by the same ocean and inland carriers. Nonetheless, loss control costs for these projects can be considerable.

Although 2010 saw the number of new wind turbines installed drop nearly 50% from 2009, according to the WEA, the average annual growth for the wind turbine industry in the U.S. has been 35% per year, over the past 5 years. Also, three major wind turbine manufacturers opened manufacturing plants in the U.S. in 2010. Current tax credits for any contracted wind turbine energy projects are scheduled to expire at year end of 2012. The current high prices for carbon based fuels and the projected long term energy needs by booming countries like China and India make it likely that forms exploitation of renewable energy, such as wind turbines, will continue to be part of the world's energy strategy.

With federal mandates for states to meet specific targeted percentage of energy produced by renewable sources, it is certain that despite the current economic conditions, underwriters will continue to see these types of risks presented.

References:

- American Wind Energy Assoc. (www.awe.org)
- AWE Offshore Wind Conference & Expo 2012 (www.offshorewindexpo.org)