Developing and Constructing Wind Energy

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Introduction

WIND ENERGY

We Energies is undertaking several efforts to generate more energy from renewable resources. In May 2008, the Blue Sky Green Field Wind Energy Center began operating. The site is home to 88 wind turbines in the towns of Marshfield and Calumet in northeast Fond du Lac County. Blue Sky Green Field is designed to generate 145 megawatts of electricity, and is capable of powering more than 36,000 residential homes.

We are currently pursuing additional wind energy to meet customer demand and to meet the state of Wisconsin’s Renewable Portfolio Standard.

Our customers are demanding more renewable energy through our Energy for Tomorrow program, which allows customers – residential, commercial and industrial – to purchase all or a portion of their energy from renewable sources. Additionally, the state’s Renewable Portfolio Standard requires Wisconsin utilities to generate 10 percent of their energy from renewable sources by 2015. Currently, We Energies’ supply portfolio includes approximately 3 percent from renewable energy.

Throughout history, people have connected with the wind. Wind power was used to grind grain and pump water before electrification of farming in the Midwest. In the early 1970s, oil shortages created more demand for alternative energy sources, thus increasing the popularity of wind turbines to generate electricity.

A wind turbine uses moving air to create electricity. Steady winds turn the blades, which drive a generator that produces electricity. Electricity generated by utility-scale wind turbines is sent to the electric distribution network, where it replaces electricity that would otherwise have been generated by more traditional sources such as coal, oil, nuclear and natural gas.

*The contents of this book are a representation of construction activities at our Blue Sky Green Field site. Some aspects of construction may vary from one development to another.
Clearing and building a gravel access road

One of the first steps in the construction process is site clearing and building the gravel access roads. Access roads are constructed from existing public roadways to each turbine site to provide access for equipment necessary for construction, and to facilitate access to the turbine for ongoing operation and maintenance. Temporary access roads are constructed within a corridor approximately 40 feet wide.
Before gravel is installed topsoil is stockpiled, subsoil is compacted, and a geotextile matting is placed. Upon completion of construction, temporary access roads are converted to smaller, permanent roads approximately 16 feet wide. The portion being removed is cleared of gravel and fabric, decompacted, and topsoil restored.
A culvert can range in length from 150 – 175 feet. This is necessary for the large component deliveries.
Access road completed for construction

**SITE PREPARATION**

The width of the gravel road is approximately 16 feet for the primary travel path, but may be up to 40 feet wide during the construction phase to allow for the large cranes needed for turbine erection. All access roads are restored to the 16 foot width after construction is completed.
To erect the turbine, two different cranes are needed. A smaller crane is used to install the turbine’s control system and base and lower mid-tower sections. It is also used to assemble the rotor. A larger crane is used to install the upper mid-tower and top-tower sections, nacelle and rotor. Due to the size, weight and slow speed of this large crane, it cannot drive along public roads; therefore, it is necessary to create cross-country paths. The path used is determined by several factors including looking for the shortest distance between turbines, use of land already participating in the project, significant changes in grade, and avoiding woodlands, wetlands and waterways.
A completed crane path

SITE PREPARATION

Topsoil is cleared and stockpiled, and the subsoils are compacted. The crane path area is restored once the turbines are standing. Landowners are compensated for lost crop opportunities in the area used for the crane path.
The collector system is a series of underground electric cables that run from each turbine to the electrical substation. Typically, a series of turbines will be interconnected to create a "circuit"—rather than having a direct cable from each turbine to the substation. At our Blue Sky Green Field wind farm there are a total of eight circuits. This is a drawing of a circuit that connects 11 turbines and sends the electrical output to the substation via one underground cable system.
Installing cable for the collector system

**COLLECTOR SYSTEM**

In this photo, there is a single circuit being installed in a two-foot-wide trench. When multiple circuits are installed in adjacent trenches, there must be a five-foot-wide separation between each circuit. The minimum buried depth is four feet.
Removing and stockpiling soils

The first steps in constructing the foundation is to remove and stockpile topsoil and subsoils. These soils are stockpiled separately. Upon completion of foundation construction, the soils are replaced in the proper strata.
Foundations are constructed by excavating a hole, placing reinforcing steel and pouring approximately 325 yards of concrete into the excavation. Each foundation is approximately 55 feet wide and 8 feet deep in the center.
Topsoil and subsoil from the excavation is stockpiled in a semicircle around the foundation. The next step is to replace the subsoil and then the topsoil over the concrete foundation. Only the very center of the foundation remains above the soil surface when grading is complete.
A backfilled foundation prior to topsoil replacement and crane pad installation.
After the foundation construction is complete and the area backfilled, a crane pad is constructed to allow for turbine erection. The area is approximately 55 x 80 feet and will remain after construction for routine maintenance activities.
There are four main parts of a wind turbine: the foundation (base), the tower, the nacelle, and the rotor (hub and blades assembly). The rotor converts the energy of the wind into rotational motion. The nacelle contains the electric generator and other components that convert the mechanical rotation of the rotor into electricity. The tower supports the nacelle and rotor, and the foundation acts as an anchor that supports the entire assembly.
For the Blue Sky Green Field site, the tower sections were off-loaded at the Port of Green Bay and transported by truck to the site. Each truck transported one tower section - approximately 74 feet long.
Erecting the tower

The first components delivered and erected are the base and mid-section of the tower. When completed, each turbine consists of four tower sections.
Setting the base-section on the turbine foundation

TURBINE CONSTRUCTION

It takes approximately seven hours to set the first two tower sections.
The base and mid-section, as seen here, stand approximately 105 feet. The total height of the turbines at Blue Sky Green Field from the base to the tip of the blade is 397 feet.
Looking up inside a turbine
The nacelle is the enclosure at the top of the tower that contains the drive shaft, gearbox, generator, electronic controls and associated equipment. The nacelle is reached by a ladder that runs inside the tower so technicians can access the turbine components for maintenance and repair.
Inside the nacelle
Yaw deck inside the nacelle

The yaw deck allows the rotor and nacelle to align with the wind.
The yaw deck is able to turn three complete revolutions before locking to ensure the cables are not twisted. It will then reset itself.
The blades are connected to a central cone called the hub, which is connected to a shaft that passes into the nacelle.
Turbine blades have aerodynamic wings that create lift and rotation of the rotor as the wind blows across them. Each turbine blade at Blue Sky Green Field measures 134 feet. The rotor assembly weighs approximately 47 tons.
Flying the blade assembly
Restored site after construction
The area around the turbine is returned to the landowner for planting. We ask that a distance of 15 feet be maintained from the foundation of the towers to protect the equipment. Directly under this area, only 18-24 inches below the surface, are the concrete foundations and grounding cables for the turbines. For safety, gravel is placed in this area as a reminder of the underground infrastructure.
Blue Sky Green Field Wind Energy Center