Largest Domestically-developed Wind Turbines MWT92/2.4 Begin Commercial Operations in the Hills of the Noto Peninsula

Power Systems

Responding to the increased use of renewable energy sources throughout the world, Mitsubishi Heavy Industries, Ltd. (MHI) has developed the MWT92/2.4, a large wind turbine featuring effective operation, utilizing wind turbine design and manufacturing technologies that we have established over the past 20 years. These products have been manufactured and distributed throughout the world since 2007. The Fukura Wind Farm (Shika-machi, Hakui-gun, Ishikawa Prefecture), which is equipped with nine of the MWT92/2.4 wind turbines, was completed and began commercial operations in January of 2011. The characteristics of the MWT92/2.4 wind turbine and a description of the Fukura Wind Farm are presented below.

1. Wind Turbine Structure

A wind turbine is composed of a nacelle (which holds the blades that catch wind and convert the wind into rotational energy, together with the devices that convert the rotational energy into electric power, including a gear box, generator, hydraulic system, cooling system, and control system) and a tower that supports the blades and nacelle at an elevated level. To capture continually fluctuating wind energy in a safe and effective manner, wind turbines must be structurally strong enough to resist all possible conditions, feature sophisticated control technologies, and incorporate reliable components.

Wind turbines are designed according to the available wind, and wind is classified by strength according to the IEC standard. Turbines are designed based on the frequency distribution of wind speed occurrence for each class. Therefore, turbines of the same model can be used in areas belonging to the same wind-speed class, making it possible to design and manufacture mass-production models without designing turbines specific to each location.

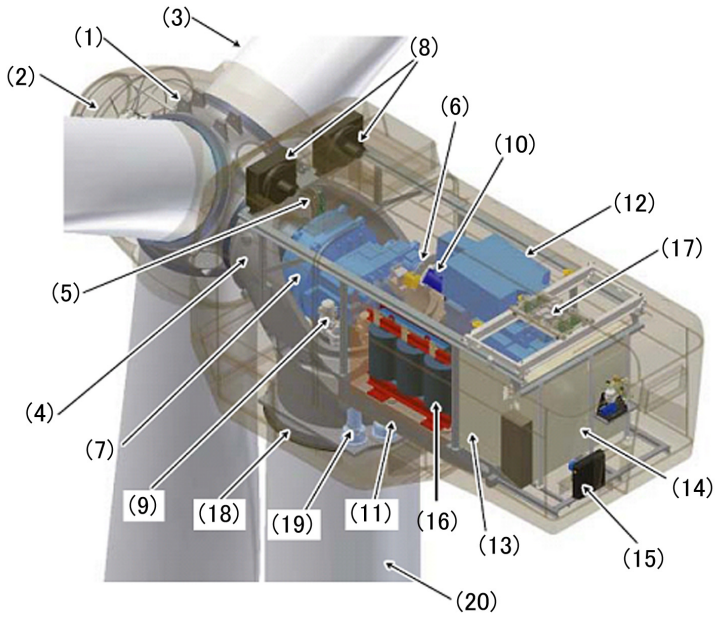
2. Characteristics of the MWT92/2.4 Wind Turbine

The specifications of the wind turbine are listed in **Table 1**, and its internal structure is shown in **Figure 1**.

The characteristics are as follows.

Table 1 Specifications of the MWT92/2.4

Wind turbine model	Horizontal axis propeller type pitch control wind turbine	Cut-in	3.0 m/s
Rated output	2,400 kW	Cut-out	25.0 m/s
Rotor diameter	92 m	Cut-out/reset	20 m/s
Hub height	70 m	Rotational speed (interval)	9.0 – 16.9 rpm
Output control method	Individual pitch control, variable speed control	Rotational speed (rated)	15.0 rpm
Yaw control	During power generation: upwind During stoppage due to strong wind : downwind	Transformer	690 V/22 kV or 34.5 kV, 2,700 kVA
Wind class	IEC Class IIA Maximum wind speed: 70 m/s	Generator	Doubly-fed asynchronous three-phase induction 2,520 kW, 690 V
Rated wind speed	12.5 m/s	Frequency	60 Hz (50 Hz)



(1)	Hub
(2)	Hub capsule
(3)	Blade
(4)	Nacelle bed plate
(5)	Main bearing
(6)	Main shaft brake
(7)	Gear box
(8)	Oil cooler
(9)	Oil pump
(10)	High-speed coupling
(11)	Rear frame
(12)	Generator
(13)	Nacelle control panel
(14)	Inverter
(15)	Cooler for inverter
(16)	Transformer
(17)	Service winch
(18)	Yaw bearing
(19)	Yaw gear
(20)	Tower

Figure 1 Structure of the MWT92/2.4

- The construction and operating costs have been reduced by designing the turbine to be the largest onshore wind turbine.

  If the output per wind turbine is increased, fewer turbines are required to produce a given output, thereby reducing the construction and operating costs, including maintenance costs and operational supervision costs. However, the long blades and large nacelle may violate transportation regulations. Because of this, it is generally believed that the maximum rated output of an onshore wind turbine should be set between 2 and 3 MW/unit. MHI has led the competition in developing and commercializing the 2.4-MW product.
- MHI has maintained an advantage in terms of transportation and installation by dividing the nacelle into three modules.

  As mentioned above, increasing the size of a wind turbine can conflict with transportation regulations. However, this issue has been circumvented by dividing the nacelle into three modules (**Figure 2**), making it possible to install the MHI wind turbine on sites where comparable turbines manufactured by competitors cannot be installed due to transportation regulations. Furthermore, the division into three modules enables more flexible designs for the nacelle, since it is freed from weight and dimensional limits, allowing a component layout with sufficient space for easy maintenance, and a strong structure featuring high rigidity.

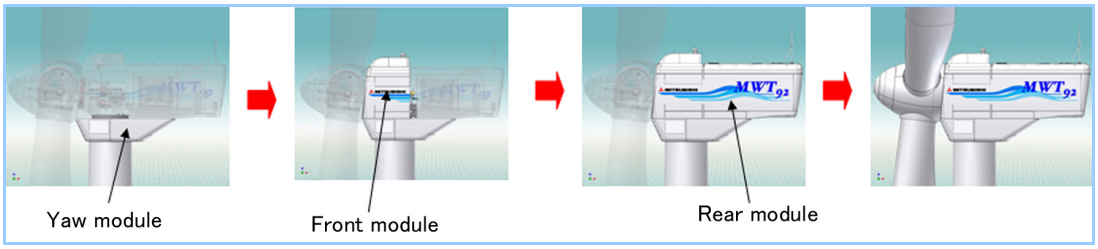


Figure 2 Division of the nacelle into three modules

- The model is intended for low to medium wind speed areas, but it is designed to resist wind speeds of up to 70 m/s.

  This wind turbine is intended for medium wind speed areas, which belong to Class 2 of the IEC standard. The capacity to resist wind speeds of up to 70 m/s is necessary because the wind speed is generally low but the maximum wind speed is high due to typhoons in the majority of regions in Japan.

- By incorporating a doubly-fed asynchronous generator + IGBT converter, output fluctuations are leveled to realize power generation with a limited load on the system.

  When an induction generator is directly connected to the system (as is typically the case in conventional wind turbines), significant output fluctuations occur due to changes of wind speed. These fluctuations are one of the factors that degrade the power quality of the system. Following the adoption of the new system, variable-speed operation at 9 to 16.9 rpm became possible, enabling the absorption of an instantaneous increase in wind speed as kinetic energy, and thereby reducing the load fluctuations.
- Reliability of blade pitch control has been improved by controlling the pitches of the three blades individually.

  The pitch angles of wind turbines are controlled so that the amount of generated power is maintained within a rated output. When the wind speed exceeds the operable range, the wind is released by adjusting the pitch angles. Because the pitches of the three blades of our wind turbine are controlled individually, if control of one blade fails, the other two blades can still be controlled, allowing the turbine to be stopped safely.

  MWT92/2.4 is extremely reliable because we have improved this model constantly while manufacturing more than 600 units.

3. Fukura Wind Farm

The Fukura Wind Farm, which recently began commercial operations, is the result of a project initiated in 2006 by the Hokuriku Electric Power Group as a part of its preventive measures against global warming. The project was developed by the Nihonkai Power Generating Company (100% funded by the Hokuriku Electric Power Company), construction was provided by the Kajima Corporation, and manufacturing, delivery and test operation of the wind turbines were handled by MHI. The power plant generates approximately 41 million kWh of electricity per year, which is the amount consumed by 11,000 households. Following the revision of the Building Standards Act in 2007, approval of the Minister of Land, Infrastructure, Transport, and Tourism (which was already required for high-rise building designs) became mandatory for turbine foundation and tower structure designs. The MWT92/2.4 was the first large wind turbine of 2 or more MW to receive the approval of the minister.

This power plant is located along a prefectural road that stretches toward the north on the western side of the Noto Peninsula. The large wind turbines that come into view along the road are overwhelming. We hope that you will visit the area to experience this spectacular sight (**Figure 3**).

Figure 3 Fukuura Wind Power Plant

4. Future Prospects

The MWT92/2.4 lineup includes 95 m models and 102 m models featuring higher performance. We have also developed a cold climate version of the turbine, which is resistant to temperatures as low as –40°C. The cold climate version is already in operation. We will continue to improve this series of products by incorporating the results of actual operation and customer comments, so that the next series will feature even higher performance and convenience.