

Small Wind Turbines in Sustainable Urban Environment

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ABSTRACT

In recent years, the importance of renewable energy such as solar, wind, biomass, small hydro, etc., has been increasing because of the need to prevent global warming and to reduce harmful substances in environment.

Especially, a cumulative capacity of large scale wind power plants are more than 5×10^4 MW (equivalent to 50 units of nuclear power plants!) in the world and 10^3 MW in Japan. These wind turbines are installed mainly in strong wind areas. However, small wind turbines from 100W to 10kW classes are installed mainly in urban areas where wind blows not so strong. These small wind turbines are naturally entered into the urban environment as the symbol of "environmental era". There are more than six thousands systems operating in Japan. Moreover, to utilize complementary effect between solar and wind energy, many of these small wind turbines are used as hybrid power systems combined with wind turbines and PV panels. As the ultimate hybrid plant, even the triple hybrid system consist of solar, wind, and biomass is installed at Ashikaga Institute of Technology.

Our goal, a real sustainable society in future will be assured depending on real sustainable and proven energy, namely renewable energy. The small wind turbines are just fit in sustainable urban environment.

Introduction

At the end of FY 2004 (March 2005), the total installed wind power capacity in Japan was estimated to be 940 MW with 930 units of wind turbine. This value corresponds to one-third of the national target for wind power introduction by 2010. After some wind turbines experienced severe damage from typhoons or lightning strikes, several activities have been organized to promote sound development of wind technology under governmental initiatives. As for the small scale wind turbines, there are more than six thousands systems operating in Japan.

National Policy

At the United Nations (UN) Climate Change Conference in Kyoto in December 1997, The Japanese government agreed to reduce the output of greenhouse gases by 6% by

2010, compared to the 1990 level. To attain this target, the government has changed the target of wind power in the latest Primary Energy Supply Plan for 2010 from 300MW to 3,000MW. The government also set another target to develop wind energy to supply as much as 6,020MW by 2030.

In April the Japanese government passed legislation for a Renewables Portfolio Standard(RPS) in order to realize the national target for renewables by 2010. The contribution of renewables to the total primary energy resources is expected to be 3% in 2010, up from 1.2% in 1999. Under the RPS, Japan's utilities are obligated to source 1.35% of total electricity supply from renewables by 2010.

Commercial Implementation

Japan's cumulative wind power capacity was 684MW in September 2004 and will be 936MW at the end of fiscal year 2004(March 2005). Figure 1 shows the history of wind turbine development in Japan. Every value of the capacity was taken at the end of each fiscal year(March).

The average annual increase late in the period of latest five years is as rapid as 170%. Most commercial wind farms have been developed with governmental promotional subsidy programs. Wind power generation from April 2003 to March 2004 was 987.8GWh. The national energy demand in the same period was 834.3TWh, so the contribution of wind power counts for only 0.118%.

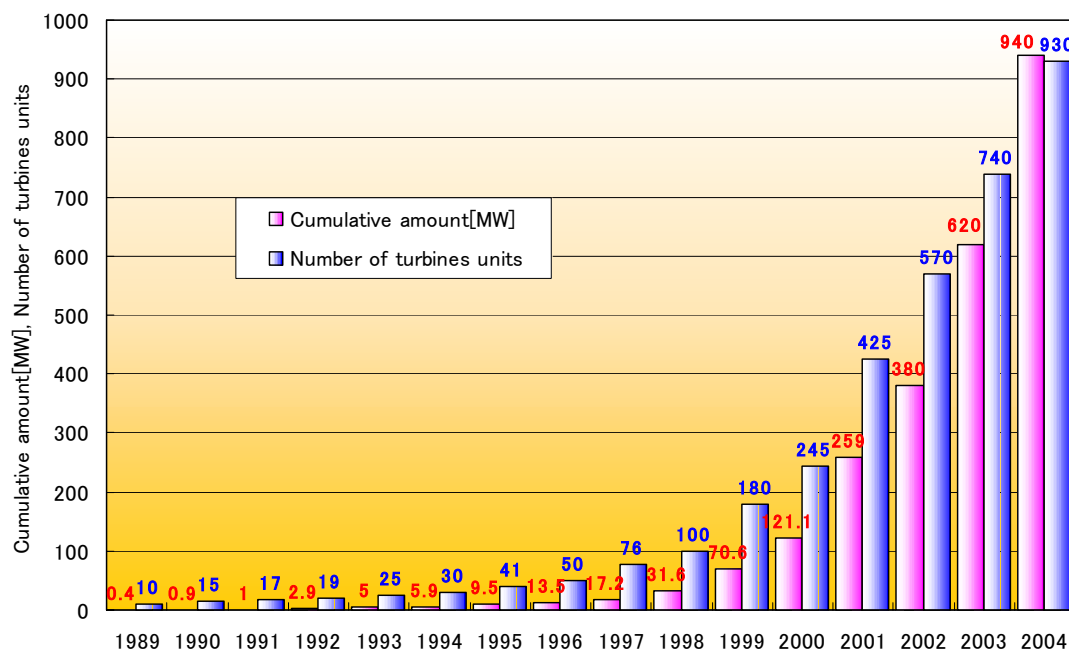


Figure 1 History of wind turbine development in Japan (Data source : NEDO)

Market Development and Stimulation Incentives

The Ministry of Economic, Trade, and Industry's (METI's) and the New Energy and Industrial Technology Development Organization (NEDO) have been conducting several subsidy programs to promote wind energy market development since 1995. The programs cover wind measurements (Field Test Program), initial investment (New Energy Business Support Program) and a few other subsidies. Actually, these programs have stimulated the markets and realized the rapid development of wind power generation in Japan. The subsidy rate ranges from 1/3 to 1/2, and reaches 100% for field testing. The contribution of the subsidy is evaluated through cost of energy (COE). For example, although depending on wind speed, the COE was 10 Yen/kWh without subsidy but 8 Yen/kWh with subsidy in 1999.

Since most wind turbines are imported mainly from Europe, unit cost itself is considered to be the same as in Europe or the United States. However, some other factors such as foundation cost, transportation cost and the additional cost to stabilize the power for grid connection require additional plant cost.

Deployment and Constraints

There have been installed several commercial wind farms during fiscal year 2004. The largest two are 57MW plant built in Wakkani, Hokkaido developed by Urus Energy Co. and 42MW plant built in Kamaishi, Tohoku area also developed by Urus Energy Co. Figure 2 shows regional distribution of wind power plants and capacity. The Tohoku area has the highest density, followed by Hokkaido and Kyushu areas.

In Japan, the outstanding technical issues related to wind power are power quality, typhoon attacks, lightning strikes, and high turbulence at hilly sites. In September 2003, a huge typhoon attacked Miyako Island in Okinawa. All seven wind turbines on the island were severely damaged: three were struck down, three lost blades, and one had its nacelle cover broken. The destroyed turbines were all imported from Denmark or Germany. The maximum wind speed was 74.1m/s which means the typhoon was the seventh largest in history. However, typhoons are not uncommon in Miyako island—the first, third, fifth, and seventh highest wind speeds have been recorded there during past half century. The government set up a committee to explore typhoons incidents on the island.

Lightning, especially in winter season at Japan Sea side, is also a difficult issue in Japan. Many turbines have been hit by lightning and winter lightning posed a specific threat due to its intense power and electric current that are much higher than the world average.

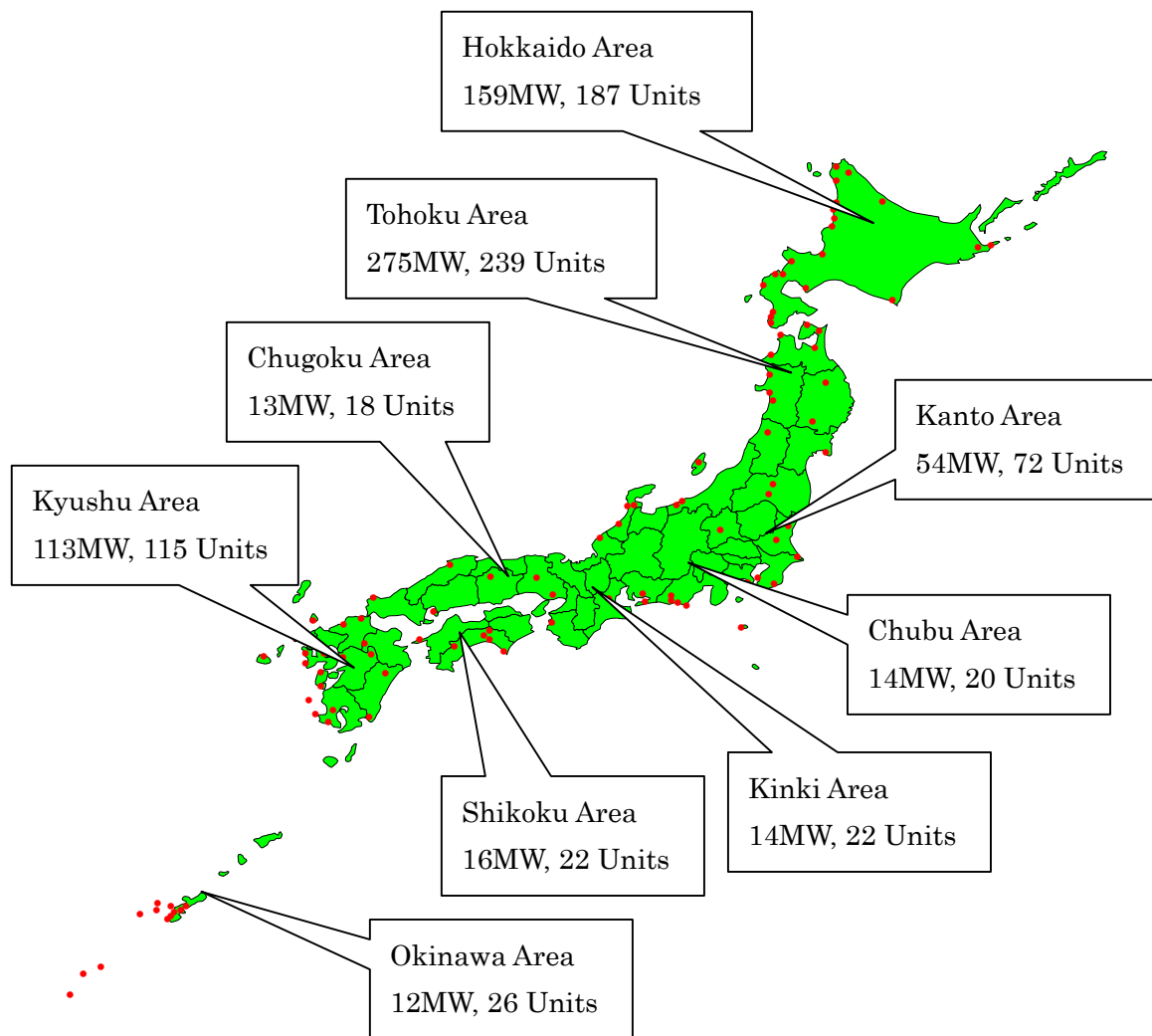


Figure 2 Regional distribution of wind power plants

Power quality and grid capacity issues are very important on a small island with weak grid like Japan compared with European countries with strong grid.

Main Constraints on Market Development

Grid capacity, or power quality, has become one of the most important issue in Japan. The regional utility has limited available capacity for wind generation to 250MW in Hokkaido area and 450MW in Tohoku area. The limits would vary as experience is gained; however, these limits are the greatest barrier to achieving the national target by 2010. RPS was expected to accelerate wind power development, however, since the introduction of new energy is an obligation for electric power companies, contracts have been awarded to cheaper waste based biomass generation.

Economics of Wind Energy

According to model estimation for a 25MW wind farm discussed at a national committee, the COE is 10.2 Yen/kWh with subsidy. Today, the COE is from 9.00 to 11.00Yen/kWh for medium scale wind turbines and is 7.00 to 9.00 Yen/kWh for large scale wind farms comprised of wind turbines with capacities of more than 1,000kW.

The current wind turbine cost is approximately 100,000Yen/kW. The installation cost is decreasing as large-scale wind power plants increase. The cost differs depending on wind conditions, grid condition, and plant size. According to NEDO's experience in 1999, initial cost was ranging from 250,000 Yen/kW to 30,000Yen/kW for medium wind farms, while about 200,000Yen/kW for large wind farms (20MW).

Wind Turbine Manufacturers

Mitsubishi Heavy Industries Ltd.(MHI) and Fuji Heavy Industries Ltd.(FHI) are the two national manufacture that supplies medium-to-large wind turbines. Last year, MHI started development of a 2.4MW (Rotor dia. 92m) wind turbine MWT92. After component testing, a system will be built and tested in Yokohama. FHI developed down-wind type 2MW (Rotor dia. 80m) and installed at Hasaki in Ibakraki prefecture as shown in Figure 3.



Figure 3 2MW Down-wind machine by FHI

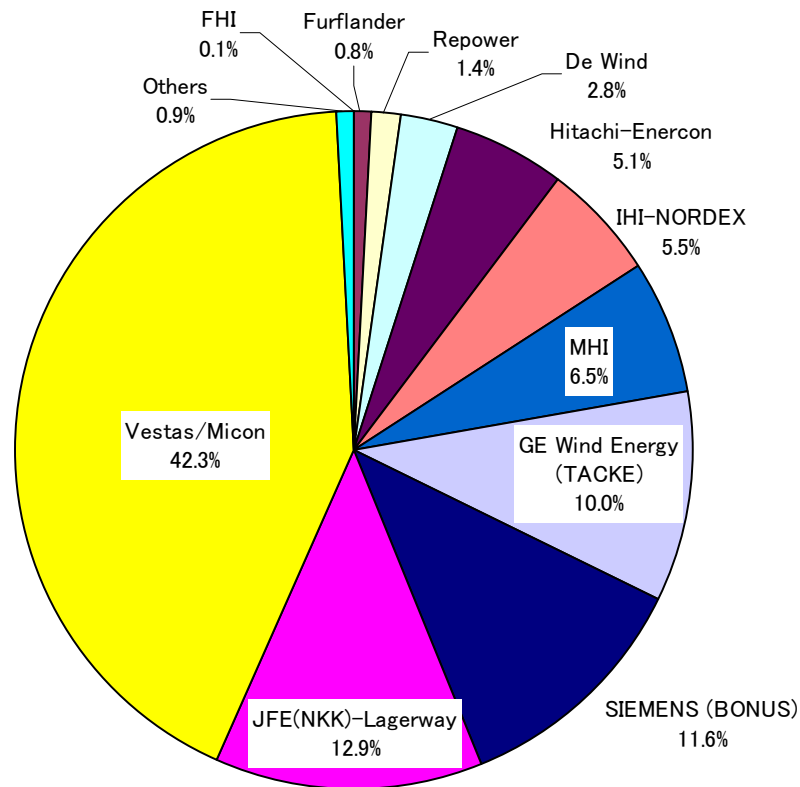


Figure 4 Japanese market share of manufacturers

Last year, a new subsidy scheme for small wind turbines was created that stimulated the industry. The industry includes MHI and several other manufactures that provide small wind turbines.

Market share among manufactures is shown in Figure 4. Vestas/Micon turbines have 42% of the market for wind generation in Japan. MHI's contribution is 6.5%. In 2002, the wind industry organized the Japan Wind Power Association to develop the wind industry.

Government Sponsored R&D

The main governmental support tools for wind energy are subsidies. The total budget for the main three programs, Field Test Program, New Energy Local Introduction Supporting Program, and New Energy Business Supporting Program, was 40,990 million Yen in FY 2003. The Government ended support for wind energy R&D programs (Sunshine Program) in fiscal year 2002 (march 2003). However, some demonstration programs are being conducted. They are focused on grid performance or power quality. Two of these are developed by NEDO: "Techniques for Grid

Stabilization” and “Battery-Supported Wind Farms.”

In 2003 and again in 2004, a significant number of wind turbines were damaged by typhoon attacks from south to north in Japan. Considering these accidents, the government set up the following committees.

- Committee of Wind Turbine Availability Improvement
- Committee of Numerical Wind Power Prediction
- Committee of Design Methods against Extreme Winds
- Committee of Lightning Protection
- Technical Committee of Grid Connection.

Improving the integration of IEC standards and Japanese Industrial Standards (JIS) is an important task, because Japanese external conditions differ from those in IEC Standards in several respects. Typhoon and lightning are the main topics. Japan Electrical Manufacturer’s Association (JEMA) supports this task under METI’s initiative in order to develop J(=Japanese)-class wind models with which any manufacturer can design a turbine at any place in Japan. To derive models, wind measurements with high sampling speed are undertaken.

Japan has huge energy potential on offshore. Therefore, offshore technology is necessary in Japan. However, no big projects or research programs have been initiated. This is because the Japanese water, even in the near-shore area, is not shallow as in North Sea or Baltic Sea.

Small Wind Turbines in Urban Environment

There have been installed more than six thousand units of small wind turbines in Japan. These small wind turbines are used in many areas; mountain cottage, educational items, hobby, battery charger of weather station at remote site, symbol of environmental activity, and grid connection and so on. Figure 5 to 8 show such typical example of small wind turbine system.

The most important requirement of these small wind turbine are as follows;

- Safety first
- Noise free
- Visually acceptable
- High Performance
- Maintenance free

On this context, said JEMA is preparing Safety Manual for Small Wind Turbine Users. Nowadays, as the typical trend of these small wind turbines shown are hybrid system. Since, most small wind turbines are installed urban environment with not so strong

wind condition. Therefore, if you want to have stable electricity, it is necessary to combine wind turbine with PV panels or other renewable energy sources.



Figure 5 “Air Dolphin-1kW” by Zephyr



Figure 6 Nikko Co., NWG-4K



Figure 7 “Soyokage”
by Shinko Elec. Co,



Figure 8 “WIND FLOWER”
by Toshiba Engg. Co.,

As the ultimate hybrid plant, even the triple hybrid system consist of solar, wind, and biomass is installed at author's Ashikaga Institute of Technology as shown in Figure 9.

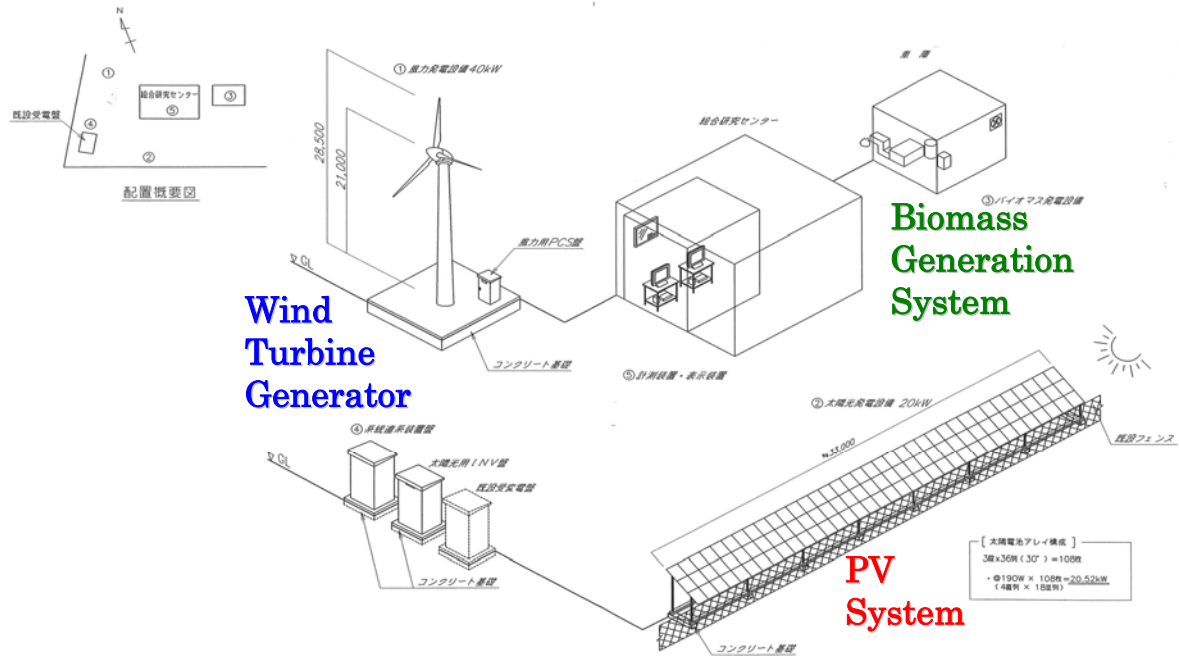


Figure 9 Overview of Triple Hybrid Renewable Energy Generation System at A.I.T

Conclusion

Our goal, a real sustainable society in future will be assured depending on real sustainable and proven energy, namely renewable energy. The small wind turbines are just fit in sustainable urban environment.

Reference:

H. Matsumiya, National Activities in Japan, IEA Wind Energy Annual Report 2004, IEA, June 2005, pp.147-153