Chapter 12
Japan

12.1 INTRODUCTION

At the end of 2003, the total wind-power capacity in Japan was 506 MW, which corresponds to one-sixth of the national target for wind-power capacity by 2010. Japan's wind power was severely impacted in September 2003 when a huge typhoon attacked Miyako Island. All seven wind turbines on the island were heavily damaged.

2.2 NATIONAL POLICY

Strategy

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 for 2010 from 300 MW to 3,000 MW in the latest Primary Energy Supply Plan.

Progress Towards National Targets

In 1995, the government and the New Energy and Industrial Technology Development Organization (NEDO) started a promotional policy with subsidy-programs. In June 1997, the *Law on Special Measures for Promotion of Utilization of New Energy (New Energy Law)* was enacted, which encouraged wind-generation businesses in Japan. As a result, some large-scale commercial wind farms ranging from 20 MW to 30 MW were developed, and a rapid increase in wind-power capacity in Japan was recorded in the last three years.

In April 2002, 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 1.1% of their total electricity supply from renewables by 2010.

12.3 COMMERCIAL IMPLEMENTATION

Installed Capacity

Japan's cumulative wind-power capacity was 506 MW at the end of 2003. Figure 12.1 shows the history of wind turbine development in Japan. Every value of capacity was taken at the end of the year.

Rates and Trends in Deployment

At the beginning of 2004, the increase in cumulative wind-power capacity was recorded as 7.5 times that at the beginning of 2000. The average increase late in this period was 71.3%. Many commercial wind farms have been developed with support from government promotional subsidy programs. However, wind capacity has had limitations due to some regional utilities' grid problems.

Contribution to National Energy Demand

Wind power generation from April 2002 to March 2003 was 569.4 GWh. The national energy demand in the same period was 841.4 TWh, and the contribution of wind power counts for 0.068%.

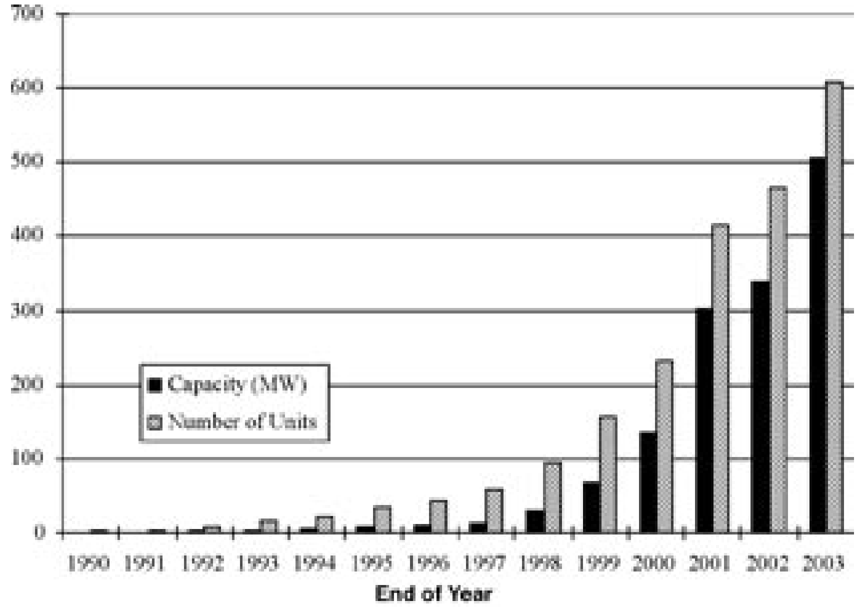

Figure 12.1 History of installed wind capacity in Japan
Data source: NEDO

12.4 MARKET DEVELOPMENT AND STIMULATION

Main Support Initiatives and Market Stimulation Incentives

NEDO has been conducting the following three subsidy programs as part of the Ministry of Economic, Trade, and Industry's (METI's) introduction and dissemination program. These programs play an important role for local governments' and private companies' wind-power developments.

1. Field test program for developing wind turbine generating systems

This program started in 1995 to stimulate the introduction of wind-energy plants into Japan. NEDO subsidizes local governments and private companies at 100% for one year of wind measurements and 50% for facility construction and operation.

2. Regional New Energy Introduction Program

This program has supported new energy projects developed by forefront developers or public sectors since1998. NEDO subsidizes up to 50% for the design and construction of each wind-power plant with a capacity of more than 1,500 kW.

3. New Energy Business Support Program

This program is for the private wind farm developers, and NEDO subsidizes up to one-third for each facility design and construction.

Unit Cost Reduction

More than 90% of installed wind turbines in Japan are imported from Europe and the United States. Therefore, the unit cost itself is considered to be the same as in Europe or the United States. However, some other factors – such as transportation cost and the additional cost to stabilize the power for grid connection – require a higher total plant cost.

12.5 DEPLOYMENT AND CONSTRAINTS

Wind Turbines Deployed

Commercial wind farm deployment increased in 2003. Table 12.1 lists the 20 largest wind farms. These large wind farms are located primarily in the northern part of Japan – 49% of the total capacity listed in Table 12.1 comes from wind farms in the Tohoku area, and 37% comes from wind farms in the Hokkaido area.

Most of the wind turbines in Japan are imported from Europe and the United States. There are, however, a few national manufacturers such as Mitsubishi Heavy Industries (MHI), Ltd. for large-scale wind turbines and Fuji Heavy Industries (FHI), Ltd. for small-scale wind turbines. The share in capacity of the national manufacturers is only 7.3%, as shown in Figure 12.2.

Operational Experience

In Japan, the outstanding technical issues related to wind power are power quality, the risk of typhoon attacks and lightening strikes, and high turbulence at hilly sites. Many turbines have been hit by lightning, and winter lightning poses a specific threat due to its intense power and electric current that is much higher than the world average.

In September 2003, a huge typhoon attacked Miyako Island. All seven wind turbines on the island were severely damaged: three fell down, three lost blades, and one had its nacelle cover broken. The destroyed turbines were all imported from Denmark or Germany. The maximum (extreme) wind speed recorded was 74.1 m/s, which means the typhoon is the seventh largest in the history of observation.

In principle, the typhoon accident is considered a natural calamity because the wind-gust speed at hub height was likely more than 90 m/s. Typhoons are not uncommon on Miyako Island – the first, third, fifth, and seventh highest wind speeds have been recorded there. The Japanese government recently set up a committee of investigation to explore typhoons incidents on the island.

Main Constraints on Market Development

Grid capacity, or power quality, has become one of the most important issues in Japan. The regional utility has limited available capacity for wind generation to 250 MW in the Hokkaido area and 150 MW in the Tohoku area. Even without these limits, the national target by 2010 will be difficult to attain.

Complex terrain affects mechanical strength and electrical quality due to gusty and turbulent wind. It also increases the cost of transportation, erection, and grid-connection. NEDO conducted a demonstration program on a power stabilization technique using battery-back-up.

12.6 ECONOMICS

As large-scale, commercial wind-power plants ranging from 20 MW to 30 MW are developed, the economics are getting more competitive. The cost of energy (COE) is 9.00 yen/kWh to 11.00 yen/kWh for medium-scale wind turbines with capacities between 500 kW and 1,000 kW. The COE is 7.00 yen/kWh to 9.00 yen/kWh for large-scale wind farms comprised of wind turbines with capacities of more than 1,000 kW.

No.	Location	Plant capacity (kW)	Turbine capacity (kW)	Number of units	Manufacturer
1	Rokaksho-mura, Aomori-ken	33,000	1,500	22	NEG-Micon
2	Higashidouri-mura, Hokkaido	32,500	1,300	25	BONUS
3	Higashidouri-mura, Hokkaido	27,000	1,500	18	NEG-Micon
4	Nikaho, Akita-ken	24,750	1,650	15	Vestas
5	Tomamae, Hokkaido	23,100	1,650	14	Vestas
6	Horonobe, Hokkaido	21,000	750	28	Lagerwey
7	Esashi, Hokkaido	21,000	750	28	Lagerwey
8	Kuzumaki, Iwate-ken	21,000	1,750	12	Vestas
9	Tomamae, Hokkaido	20,000	1,000	20	BONUS
10	Oyamada-mura, Mie-ken	15,000	750	20	NKK-Lagerwey
11	Kitakyuushuushi, Fukuoka-ken	15,000	1,500	10	GE Wind Energy
12	Wakkanai, Hokkaido	14,850	1,650	9	Vestas
13	Noshiro, Akita-ken	14,400	600	24	Hitachi-Enercon
14	Nejima-machi, Kagoshima-ken	13,000	1,300	10	IHI-NORDEX
15	Seto-cho, Ehime-ken	11,000	1,000	11	MHI
16	Kazuno, Akita-ken	7,650	850	9	Vestas
17	Tomamae, Hokkaido	7,500	1,500	5	Hitachi-Enercon
18	Akita, Akita-ken	6,000	750	8	NEG-Micon
19	Shimamaki, Hokkaido	4,500	750	6	NEG-Micon
20	Ine-machi, Kyoto-fu	4,500	750	6	Lagerwey

Table 12.1 Japan's 20 largest wind farms

Trends in Investment

As shown in Table 12.1, nine wind farms with capacities of more than 20 MW have been developed. The current wind turbine cost is approximately 100,000.00 yen. The installation cost is decreasing as large-scale wind power plants increase. The cost differs depending on wind condition, grid condition, and plant size.

Plant cost is 130,000.00 yen/kW to 200,000.00 yen/kW for medium-scale wind turbines with capacities between 500 kW and 1,000 kW. Plant cost is 110,000.00 yen/kW to 150,000.00 yen/kW for large-scale wind farms comprised of wind turbines with capacities of more than 1,000 kW.

Trends in Unit Costs of Generation and Buy-Back Prices

The average electricity purchase price is about 18.00 yen/kWh. The wind-generated electricity purchase price has been as low as 11.50 yen/kWh, according to the utilities' purchase menus. However, since RPS

Vestas	21.4%
NEG-Micon	21.3%
Lagerwey	17.1%
BONUS	11.9%
Mitsubishi	7.0%
Hitachi-Enercon	6.2%
IHI-NORDEX	4.7%
GE Wind Energy	4.1%
TACKE	2.6%
Fuhrlander	1.1%
Etc	1.0%
DeWind	0.6%
Repower SystemAG	0.4%
Fuji	0.3%
WindWorld	0.1%
Kenetech	0.1%
Yamaha	0.1%

Figure 12.2 Manufacturer share of turbine capacity (MW)]

began, the price is often decided through tender, which results in a price reduction of up to 4.00 yen/kWh to 5.00 yen/kWh. The subsidy could keep the economic balance.

12.7 INDUSTRY

Manufacturing

MHI is the only national manufacture that supplies medium-to-large wind turbines. MHI has recently developed variable-speed, synchronous wind turbines with capacities of 300 kW, 600 kW, and 2,000 kW.

FHI is a relatively new wind turbine manufacturer. Under a national project, FHI developed a 40-kW Subaru wind turbine and a 100-kW wind turbine as a result of its 20-kW class rotor development in cooperation with the Mechanical Engineering Laboratory (MEL).

Industry Development and Structure

As shown in Figure 12.2, Vestas, Neg-Micon, and Lagerway are Japan's three largest manufacturers in terms of capacity, with a cumulative share of about 20%. MHI's share is 7%.

MHI is a national manufacturer that provides large wind turbines. The largest 2-MW wind turbines are horizontal axis, variable-pitch control, variable-speed control, and gearless, with a permanent magnet synchronous generator. MHI conducts business all over the world, in countries such as Germany, India, Mexico, Portugal, the United Kingdom, and the United States.

FHI is another national manufacturer that provides small-to-medium wind turbines with capacities of 40 kW and 100 kW.

Since 1 November 2000, Japan Natural Energy Company, Ltd., has provided power generation services mainly to corporate customers using natural energy sources such as wind power with *Certification of Green Power*. In addition, nearly 100 companies in the wind industry founded the Japan Wind Power Association in 2002.

12.8 GOVERNMENT-SPONSORED R,D&D

Priorities

Government-sponsored R&D was closed in fiscal year 2002 (March 2003) based on the judgment that wind turbine technology has become mature enough.

Since 1978, the Japanese government – formerly the Ministry of International Trade and Industry (MITI), now METI – aims its wind energy R&D program at energy security after the oil crises. This is one part of the general R&D program for renewable

Figure 12.3 The aftermath of typhoon attack on Miyako Island
Source: Asahi-Shinbun Website

energy called the New Sunshine Project and has been directed by the New Sunshine Program Promotion (NSS) Headquarters, MITI.

After global warming was recognized, the objective of the New Sunshine Project was set to develop innovative technology to create sustainable growth while solving both energy and environmental issues.

Table 12.2 summarizes Japan's national wind energy activities, which are described in more detail as follows:

A. New Sunshine Project: R,D&D

In 1999, Japan started new R&D,D programs on new wind technologies for remote islands.

B. Technical demonstration programs on wind power stabilization

In 2000 and 2001, two new demonstration programs were undertaken by NEDO to develop techniques to stabilize wind output power.

C. Promotion of introduction with subsidies

NEDO's field test programs, the New Energy Local Introduction Supporting Program, and the New Energy Business Supporting Program, have played an important role in promoting the introduction of wind turbines among private sectors as well as local governments.

D. Integration of Japanese Industrial Standards (JIS) and International Electrotechnical Commission (IEC) standards

The national programs include co-operation in IEC standard activities in the wind energy category. METI is also promoting the policy in order to keep international consistency. In 1999, two JIS that keep conformity with IEC 61400 standards were published, and in 2001, JIS had three more standards introduced.

In fiscal year 2003, the Japan Electrical Manufacturers' Association (JEMA), and the National Institute of Advanced Industrial Science and Technology (AIST) started a new wind measurement program. The purpose of the program is to catch typical Japanese wind characteristics, such as turbulent intensity and gust, by observation with high-sampling time and then provide J-class wind models that can be used as design standards for wind turbines built in Japan.

Figure 12.4 A large wind farm in Japan

D. IEA Wind R&D

NEDO, AIST (MEL), Mie University (MU), and JEMA have started IEA international co-operations in Tasks XI, XV, XVII, and XVIII by presenting technical data.

NSS R,D&D and Demonstration Programs

Since 1999, METI has conducted two new R&D programs in order to meet the national target of 300 MW of wind power by 2010. Programs are needed partly because Japan has many severe external conditions such as typhoon attacks, high turbulence intensity, weak grids in remote areas and islands, and poor accessibility at hilly sites and islands. These two programs are as follows:

1. Advanced Wind Turbine Generating Systems for Remote Islands

Japan consists of hundreds of islands where electric power depends on expensive diesel power; however, Japan has plenty of wind resources. Since 1999, NEDO has been conducting a national R&D project titled, Development of Advanced Wind Turbine Systems for Remote Islands.

METI and NEDO developed a prototype, 100-kW turbine for remote islands where there may be severe external conditions such as typhoon attacks, high gusts, poor accessibility, lack of large cranes, and weak grids.

The following targets of this project were successfully achieved:

- Among small islands, the COE of wind can be cheaper than that of diesel, amounting to 30.00 yen/kWh to 100.00 yen/kWh

National Activities	Period	Organization/Institute
A. New sunshine project (R, D&D):	**1978-**	**METI (NSS-HQ, MITI)**
(1) Wind resources measurement	**1990-1994**	**NEDO**
(2) R&D of LS-WTGS (500kw) on tappi cape	**1990-1997**	**NEDO/MHI/Tohoku EPC**
(3) Demonstration of a mw-class wind farm on miyako island	**1991-1998**	**NEDO/Okinawa EPC**
(4) Generic, innovative R&D	**1978-**	**AIST (MEL)**
(5) Advanced WTGSS for remote islands	**1999-2003**	**NEDO**
(6) Local area wind energy prediction model	**1999-2003**	**NEDO**
B. Demonstration programs		
(1) Research on stabilization of output power from WTGSS.	**2000-2001**	**NEDO**
(2) Research on stabilization of output power from a WTGSS with storage batteries	**2000-2001**	**NEDO**
(3) Research on stabilization of output power from wind farm with storage batteries	**2003-**	**NEDO**
C. Promotion of introduction:	**1992-**	**METI (MITI)/NEDO**
(1) Field test program		
(2) New energy business support		
D. Standard: IEC, ISO, JIS	**1988-**	**METI/JEMA/AIST/ Industries**
E. IEA Wind R&D	**1978-**	**METI, AIST, MU, JEMA**

Table 12.2 National wind energy activities

- Demonstrations show that design power quality can be maintained at a maximum of 40%
- On islands where large cranes are not available, turbines can be easily constructed using a 16-ton crane and a gin pole unit
- Turbines are designed to be safe for up to 80 m/s of extreme wind speed under typhoon attacks

2. Local Area Wind Energy Prediction Model (LAWEPS)

This computational fluid dynamics (CFD) model is applied to Japanese complex terrain with high accuracy in predicting local wind flows. Figure 12.5 shows the nesting structure employed by the CFD model, and the wind atlas from the first to the third nesting stage can be seen publicly on NEDO's website. The final fifth stage has a 10-m mesh resolution, and the CFD solutions for the fourth and fifth nesting stages can be obtained by running LAWEPS code, which is also publicly available.

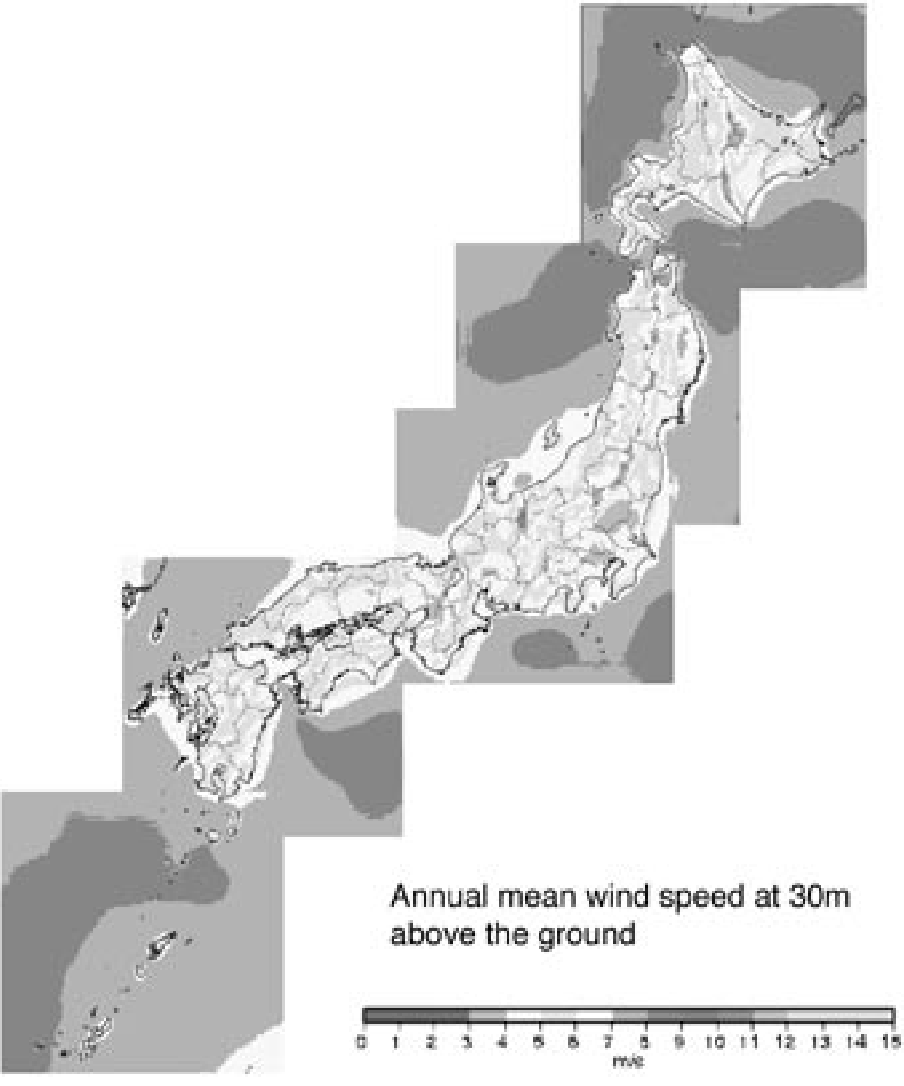

Figure 12.5 Annual mean wind speed at 30 m above ground level (first nesting level: 500-m mesh)

Figure 12.6 shows the results of a comparison between measured annual mean wind speed and those predicted by CFD models at a height of 30 m above ground level. LAWEPS gives the highest prediction.

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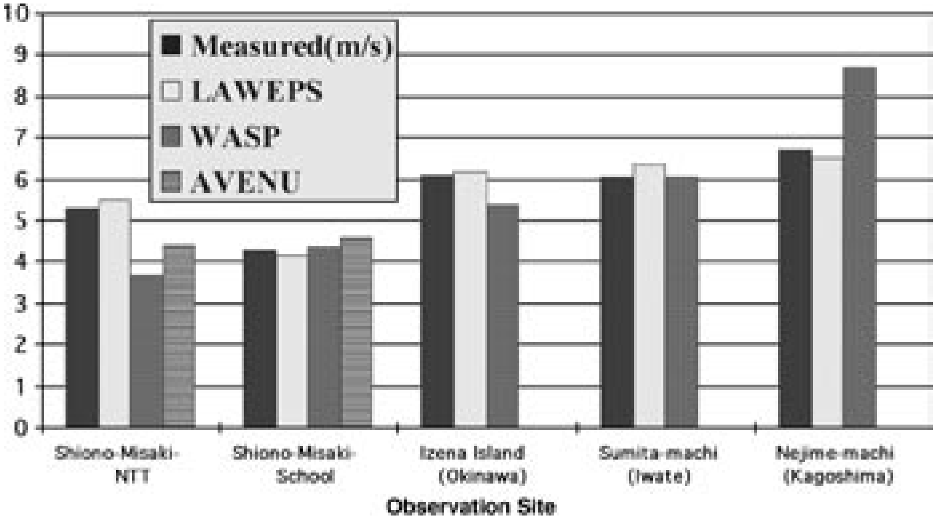

Figure 12.6 Comparison between measured annual mean wind speed and those predicted by CFD models at 30 m above ground level