Renewable Energy in the National Energy Plan of Japan

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ABSTRACT

Japan has few indigenous energy supplies, and imports the bulk of its energy, so it is hardly surprising that, following the oil crises of the mid 1970's, it has taken renewable energy seriously. Moreover, increasing constraints on energy and the environment, especially the global environmental consequences of energy use, are causing a rising concern world wide, giving a warning that such constraints may limits to sustaining our future development.

This paper, at first, introduce prospects of energy demand and supply in Japan. Then, the implementation of new/renewable energy policy measures are explained. Finally, the author look over the present state of new/renewable energy introduction in Japan and its outlook.

1. INTRODUCTION

Japan depends on imports for more than 80% of its energy needs, and its energy supply structure is particularly fragile among developed countries. For instance, the import dependence of Germany and the USA are only 61% and 26%, respectively.

Oil accounts for 52% of Japan's total energy supply, and at 99%, Japan's import dependence for oil is extreme. Besides, 86% of Japan's oil imports come from the Middle East. Amid growing energy demand worldwide, the world energy supply-demand situation is likely to tighten in the future, centering on oil. If the current energy demand increases substantially, depletion of energy resources will accelerate at a geometric resources will become essential for the future attempts to secure energy supplies.

The United Nations Framework Convention on Climate Change(UNFCCC), which was adopted at the Earth Summit held in Rio de Janeiro in 1992, took effect in March 1993. Japan ratified it in May 1993 to tackle domestic CO_2 and other greenhouse gas emissions as part of coordinated international efforts.

The second report of the Intergovernmental Panel on Climate Change(IPCC) was compiled in 1994 at the request of the UNFCCC and it concluded that CO_2 and other greenhouse gases released into the atmosphere as a result of the combustion of fossil

Table1. Long-Term Demand & Supply Outlook of Energy (2

Final Energy Consumption Outlook

(Unit?F billion liter crude oil equiv

FY / Item	1990		1999		2010			
					New BAU?s case		New policy case	
	Amount	?“	Amount	?“	Amount	?“	Amount ?iapprox?D)	?“ ?iapprox?
Industry	183	52.5	197	49.0	187	45.8	185	46
Consumer	85	24.4	105	26.1	126	30.8	120	30
?@Home	46	13.3	55	13.8	60	14.7	58	14
?@Business	39	11.2	50	12.3	66	16.1	63	16
Transport	80	23.0	100	24.9	96	23.4	94	24
?@Automobile	39	11.0	53	13.2	51	12.5	50	12
?@Truck and others	42	12.0	47	11.7	45	10.9	45	11
Total	349	100	402	100	409	100	400	100

?sBAU=Business as Usual

Primary Energy Supply Outloo

(Unit?F billion liter crude oil equiv

FY / Item	1990		1999		2010			
					New BAU case		New policy case	
	Amount	?“	Amount	?“	Amount	?“	Amount	?“ (approx.
Oil	307	58.3	308	52.0	280	45.0	approx.271	45
Coal	87	16.6	103	17.4	136	21.9	approx.114	19
Natural Gas	53	10.1	75	12.7	82	13.2	approx.83	14
Nuclear	49	9.4	77	13.0	93	15.0	93	15
New&renewable energy	29	5.6	29	4.9	30	4.8	40	7
?@Hydro	22	4.2	21	3.6	20	3.2	20	3
?@Geothermal	1	0.1	1	0.2	1	0.2	1	0.2
?@New energy	7	1.3	7	1.1	10	1.6	20	3
Total	526		593		622		602	

Outlook of Energy Related CO_2 Emission

(Unit?F billion liter crude oil equiv

FY / Item	1990	1999	2010	
			New BAU case	New policy case (approx.)
CO_2 emission (Growth ratio from FY 1990)	287	313 (8.9?“)	307 (6.9?“)	287

fuels and other activities would rise its temperature by 2_ and push up the sea level by 50cm in the next 100 years. For this reason, future attempts to secure energy supplies must be accompanied by considerable efforts to reduce the share of fossil fuels.__

At the first conference of the parties to the UNFCCC(COP1), held in March 1995 in Berlin, a decision aimed at establishing a process to introduce a protocol that would set a framework for appropriate action for the period beyond 2000(Berlin Mandate), was adopted. This led to the adoption of a protocol specifying quantified greenhouse gas emissions reduction targets and related measures(Kyoto Protocol) at COP3, which was held in December 1997 in Kyoto. As part of this process, Japan pledged to reduce CO_2 and other greenhouse gas emissions by 6% from 1990 levels by around 2010.

2. IMPLEMENTATION OF NEW/RENEWABLE ENERGY POLICY MEASURES

Table2. Outlook of Japanese New Energy Supply for FY

Supply Side New Energy Outlook

	FY1999 Actual result		FY2010 prospect/Target				2010?1999 (approx
			New BAU case		New policy case		
	Crude oil equivalen (million lit.)	Generatio capacity (MW)	Crude oil equivalen (million lit.)	Generatior capacity (MW)	Crude oil equivalent (million lit.)	Generatio capacity (MW)	
Power Generation							
?@PV power generation	53	209	620	2,540	1,180	4,820	23?I
?@Wind power generation	35	83	320	780	1,340	3,000	38?I
?@Waste power generation	1,150	900	2,080	1,750	5,520	4,170	5?F
?@Biomass	54	80	130	160	340	330	6?F
Heat Utilization							
?@Solar heat	980	?|	720	?|	4,390	?|	4?F
?@Untapped energy ?@(including glacial energy)	41	?|	93	?|	580	?|	14?I
?@Waste	44	?|	44	?|	140	?|	3?F
?@Biomass	?|	?|	?|	?|	670	?|	?|
?@Black liquor&waste materials ?s	4,570	?|	4,790	?|	4,940	?|	1.1?
Total supply of new energy (Share in TPES ?s?s)	6,930 (1.2%)	?|	8,780 (1.4%)	?|	19,100 ?iapprox.3?"?i	?|	3:1

?s Adjusted as a part of Biomass and some of them are used for the generatio

?s?s TPES=Total Primary Energy Supply

Demand-Side New Energy Outlook

	FY1999	FY2010 Prospect/Target		2010?F1
	Actual result	New BAU case	New policy case	(approx.)
Clean energy vehicle ?s	65,000 units	890,000 units	3.48 million units	53.5?
Natural gas cogeneration ?s?s	1,520MW	3,440MW	4,640MW	3.1?I
Fuel cell	12MW	40MW	2,220MW	183?

?s Including the vehicles powered by electricity, fuel cell, hybrid, methanol and LP

?s?s Including cogeneration using fuel cells.

Source?FNew Energy Subcommittee, Advisory Committee for Resources and Ener

2-1 Basic Guideline for New/Renewable Energy Introduction

In December 1994, Japan adopted Basic Guideline for New Energy Introduction as a cabinet decision, laying out the Government's approach to tackling new and renewable energy for the first time. The Basic Guideline calls for the mobilization of government-wide efforts to introduce new and renewable energy at the national level, the invigoration of local level efforts by local governments, and understanding and co-operation by private

businesses and the general public.

The Guideline sets the following numerical target for the introduction of new and renewable energy for FY2010: 19.1 billion liter oil equivalent(loe) or 3% new and renewable energy share of the total primary energy supply.

2-2 Action Plan for Economic Structure Reform__

In May 1997, Japan adopted a program for the "Development of an Environment Favorable to New Business Activities" as a cabinet decision as part of a government action plan running up to around 2010 which was based on the coordinated implementation of policy measures by ministries and agencies. The program included the new/renewable energy industry as one of the 15 new industries to be promoted, paving the way for the development of a one-stop fast-track system aimed at addressing problems encountered in the course of the commercialization of new/renewable energy sources. The program envisages the basic policy directions of new and renewable energy. The implementation of the program is expected to lead to an expansion in the size of new energy related employment and market.

2-3 The Law on Special Measures for Promotion of the Utilization of New Energy

In June 1997, a law was enacted to facilitate the introduction of new and renewable energy. The basic standpoint of this law is that "any person involved in energy has an obligation to strive for the introduction of new and renewable energy," and on that basis the Government has been implementing policy measures geared towards accelerating the introduction and popularization of new and renewable energy.

The law paved the way for the introduction of various policy measures aimed at developing an environment favorable for the introduction and popularization of new and renewable energy, such as low-interest loans for the establishment of new businesses, subsidies, loan guarantees and supply of information/know-how. New Energy Foundation (NEF) shares the task of implementing these measures.

3. PRESENT STATE OF NEW/RENEWABLE ENERGY INTRODUCTION IN JAPAN AND ITS OUTLOOK

3.1 Photovoltaic Power Generation

__Photovoltaic Power generation energy that helps alleviate pressure on the power system during peak hours as it generates electricity during the day, when power demand is high. With its resource potential estimated at 8.5 billion kl (as converted to oil equivalent) in Japan, it holds great promise for the future.

The cost of solar cell modules has halved over the last 10 years, and is currently at the 500yen/W (4.5US$/W) level. Nevertheless, its power price is still several times higher than commercial power price, and R&D efforts aimed at further improving conversion efficiency and reducing manufacturing costs are under way to cut the cost to the 200yen/W(1.6US$/W) level by around 2005.

A range of demand stimulation measures has been introduced. A typical example is a national government subsidy for the installation of a home power generation system designed for interconnection with an electric utility's power grid with dual-direction power flow, which is administered by the NEF. The subsidy covers about from 1/2 to 1/3 of equipment and other costs (present subsidy is 120,000 yen/kW or 1,000US$/kW).

And any excess electricity generated by the system during the day can be sold off to the electric utility at the same price as electricity supplied by it based on the excess electricity purchase system introduced by electric utilities by utilizing time-dependent variable-rate power supply contracts. The scheme, introduced in FY 1994, was given a major funding boost in FY 1997, with a view to guiding the photovoltaic power generation market into self-sustainability by around FY 2002.

Subsidies are available for photovoltaic power generation system for homes, businesses, public facilities, etc. Of these, those relating to homes, which are administered by the NEF, amounted to about 69 billion yen(575 million UD$) in value from FY 1994 to 2000, covering 57,000 systems with a total power output of 210MW(as of FY2000 end). Subsidies relating

to businesses, public facilities, etc., which are administered by NEDO, amounted to about 16.8 billion yen(140 million US$) in value from FY1992 to 2000, covering 495 systems with a total power output of 13.5MW.

The cumulative output of photovoltaic power generation systems introduced by the end of 2000 is about 321MW, and the numerical target for introduction by FY2010 is 4,820MW(1.18 billion loe).

Table3 Outline of Subsidy Program for Residential PV Systems

	Number of approvals	Total installed capacity (MW)	Subsidy ratio in the total installation cost	Upper limit of subsidy (yen/kW)	Max system capacity to be subsidized (kW)	Budget (billion yen
1994	539	1.9	1/2	900,000	5	2
1995	1,065	3.9	1/2	850,000	5	3.27
1996	1,986	7.5	1/2	500,000	4	4.06
1997	5,654	19.5	1/3	340,000	4	11.11
1998	6,352	24.1	1/3	340,000	10	14.7
1999	17,396	64.3	1/3	329,000	10	16.07
2000	25,741	95.8	-	-	-	17.8
2001 1st period	13,401	-	-	120,000	10	23.5
2nd period	-	-	-	120,000	10	

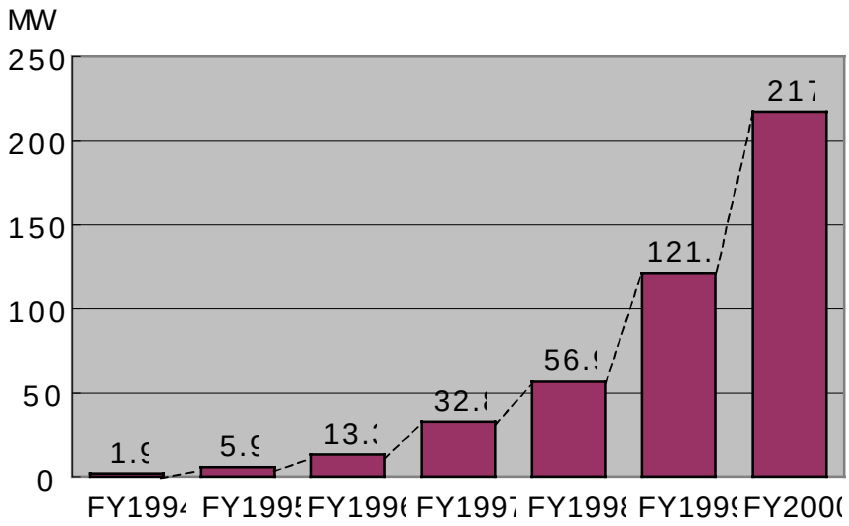


Fig.1 Cumulative Installed Capacity of PV Systems

Table4. Recent Installation Cost of Residential PV System

(unit:1000yen/kW

	Crystal	Monocrystal	Multicrystal	Amorphous
Average of installation c	769	809	762	818
(1)PV Cell	484	526	477	540
(2)BOS	197	200	196	189
(3)Installation work	88	83	89	89
Highest installation cost	1349	1295	1349	1327
Lowest installation cost	470	511	470	509

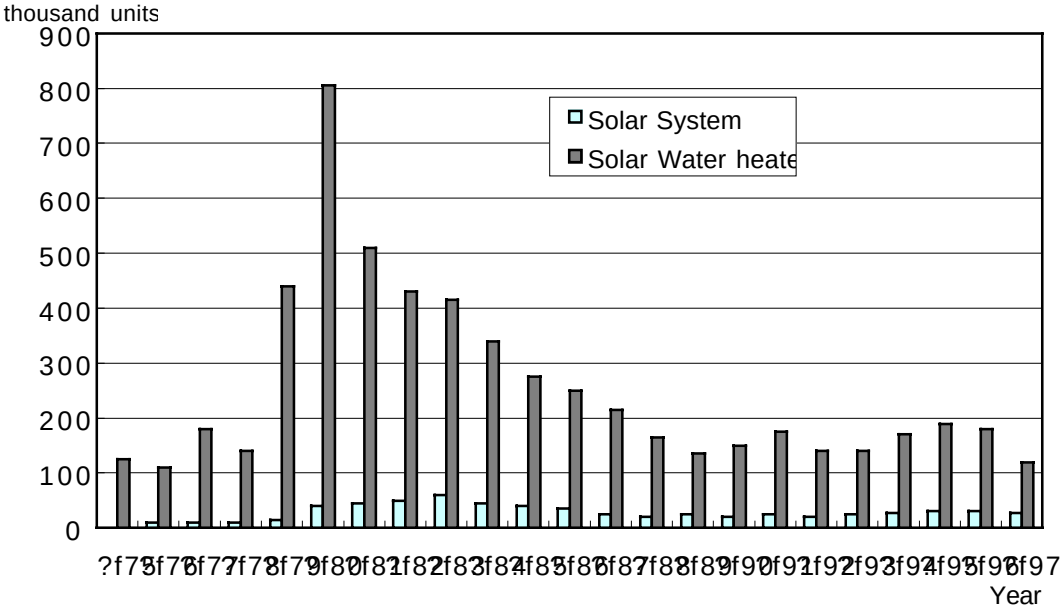
The date are calculated based on 1314 systems installed between November 1
December 12, 2001 under the subsidy program.
(Monocrystal:189; Multicrystal:1112; Amorphous;13)
Tax is not included.

3.2_Solar Heat Utilization

The use of solar heat soared in the 1980's, shortly after the second oil crisis. So far, the solar thermal industry has shipped more than four million solar system. Now, the systems disused outnumber the systems installed. The number of new installations is decreasing and the number of the systems disused is increasing. The decrease in new installations comes from the high costs. While the solar heat costs remain high, the cost of the conventional energies, such as gas and kerosene, stay low. Solar thermal systems for non-residential use require a large initial investment. These systems pay only when there is great demand for heat. Most of the systems are installed in hospitals and public institutions.

New technologies are expected to help increase the use of solar heat. Now, the solar thermal industry is developing new technologies and seeking new applications. The new technologies include solar thermal systems integrated into roofs and other building materials, and hybrid systems combining solar thermal technology and PV technology.

3.3 Wind Power Generation



Soure: Solar System Development Association

Fig.2?@Transition of Installation of Solar Water Heater an Circulation Type Solar System

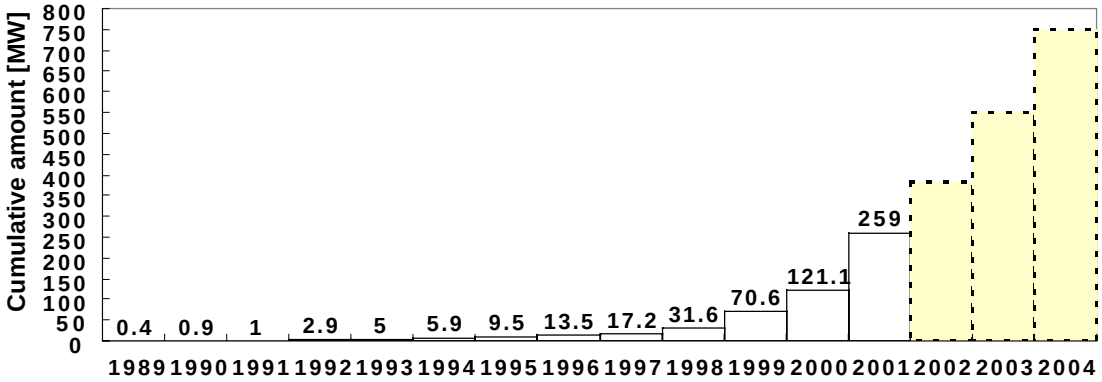
Wind power generation enjoys relatively wide use among natural new energy sources, centering on Europe and North America. This is largely attribute to the fact that wind power generation is closest among new/renewable energy sources to commercial power generation in terms of cost where conditions are favorable.

In recent years, wind power generation has made significant progress in Japan as well, with about 284 units built by September 2001 with a total installed capacity of about 160 MW. By the end of 2002, the figure is expected to increase to 300 MW, which was former Japan's target for installation by 2010. The installation target for 2010 has been revised to 3,000 MW(1,340,000 kloe)

Lately, wind power generation systems have been increasing in size. At present, more than fifty 1,000 kW class units (up to 1,650kW per unit) are either under construction or in the pipeline in Japan. Apart from the scaling up of mechanical design, R&D efforts are focusing on, among other things, the adoption of blade design aimed at lowering the cut-in wind speed to utilize weak winds, improvement of aerodynamics design to reduce noise and computerized real-time operation control. R&D is also under way for a 100 kW class wind power generator for islands with difficult wind conditions.

3.4 Thermal Energy Utilization(Untapped Energy and Cogeneration)

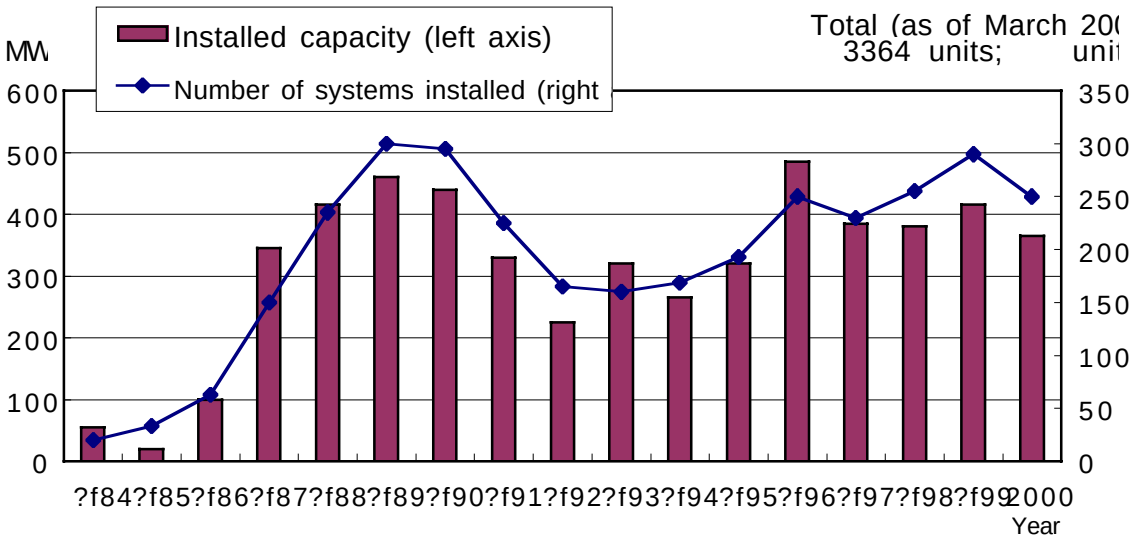
District Heating and Cooling(DHC) system provide a certain volume of heat(more than 5 Gcal/h according to the Heat Supply Businesses Law) to specific districts and office buildings. As of end of August 1996, 77 businesses have obtained licenses for 127 sites.



Figre3 Trend of Wind Power Generation Introductic

The resource potential of untapped source of energy, including thermal energy conversion using seawater, river water, etc. and waste heat utilization of refuse incineration, is estimated at 3.4 billion loe, and there have so far been 37 schemes geared towards utilizing such energy. Recently, glacial energy has been included. In the Hokkaido and Tohoku districts, which have heavy snowfalls, ice and snow stored in winter has been used to store agricultural products in summer for many years. Some municipal governments are developing the technology of using ice and snow as a cooling source for air conditioning in summer. As estimate shows that the annual supply of glacial energy can be 0.5 million kl (converted into crude oil) in heavy snow districts for air conditioning. The numerical target for the introduction of untapped energy utilization by FY2010 has been set to 580 million loe.

_The resource potential of cogeneration (including fuel cell systems), which utilizes heat from a power generation system, is estimated at 23 billion loe. As of the end of FY2000, there were 5,603 cogeneration plants with a combined power output of 5,480 MW (2.4% of



overall power generation output). The numerical target for the introduction of cogeneration (excluding steam turbine system) by FY2010 has been set to 10,020 MW (6.62 billion loe).

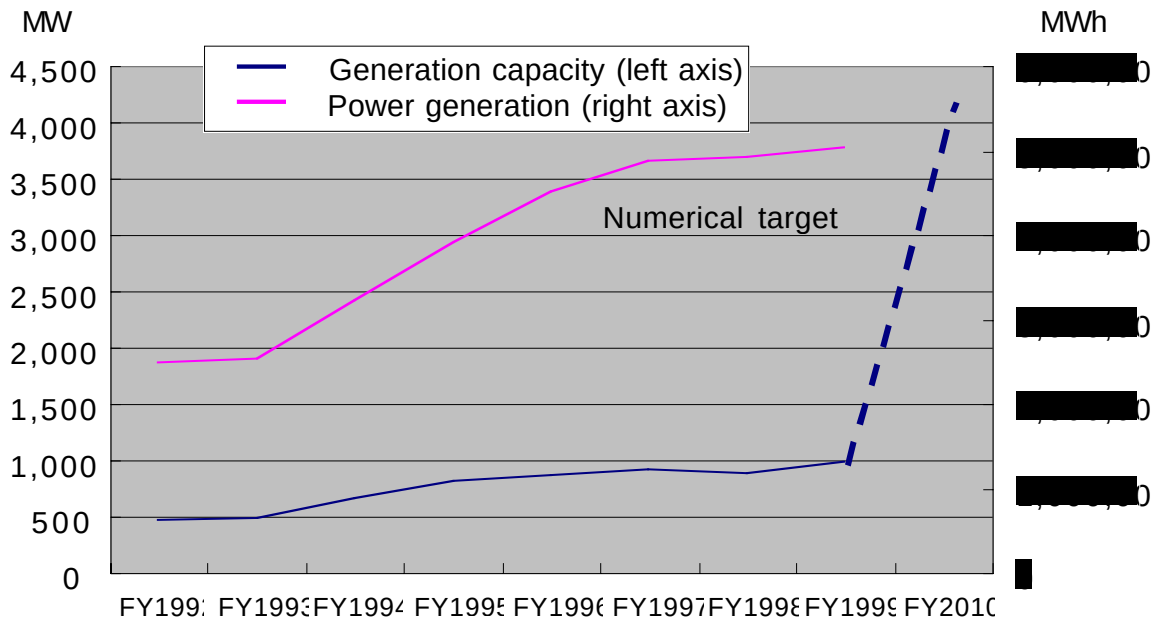
3.5 Waste Incineration Power Generation

In 1998, 51.6 million tons of municipal solid waste was generated(1.1kg/person/day), and 77% of them was incinerated, 7.5% taken to a landfill site and 12.1% recycled. Industrial waste generation, on the other hand, was 408 million tons, and there had been little change since 1990. As of the end of FY 1999, there were more than 1900 municipal solid waste incineration facilities, and 189 had power generation equipment attached to them. The combined power output was 843 MW. The number of industrial waste incineration plants featuring power generation equipment, on the other hand, stood at 53 as of the end of FY 1999 with a combined power output of 136 MW. Altogether, there were 242 waste incineration plants with power generation equipment, and their combined installed capacity was 979 MW. The numerical target for the introduction of waste incineration power generation by FY 2010 has been set to 4,170 MW (5.52 billion loe).

However, low-temperature combustion during refuse incineration has become a major social problem as a cause of dioxin generation, with 90% of overall dioxin emissions attributed to waste incineration. To cope with this, Japanese Government has set the dioxin control target that is to cut the overall dioxin emissions from nation-wide waste incineration plants by about 90% from 1997 levels over four years. This requires the introduction of high-temperature combustion incineration plants (e.g. gasification melting furnaces), and boost plants to build high-efficiency refuse incineration power generation system in the future.

3.6 Biomass Energy

It is regarded that the Japanese estimated biomass resources and its potential capacity will be equal to 19.1 billion loe, the current new energy introduction target for



Source: Natural Resources & Energy Agenc

Fig.5?@Waste Power Generation in Japa

2010. The use of biomass energy has been promoted in Japan as well as other countries. The methane gas, which is extracted from organic waste, is used for power generation. Also, methane gas extracted from sewage sludge is applied fro city gas. Also biomass

energy has low impact on the environment, a stable amount of introduction is expected. However, at present, a matter of economy, such as cost of transportation and collection of biomass energy, hinder the expansion.

For further utilization of untapped biomass resources, integrating measures are required for their collection, transportation, preliminary treatment, energy conversion and the infrastructure system.

3.7 Clean Energy Vehicles

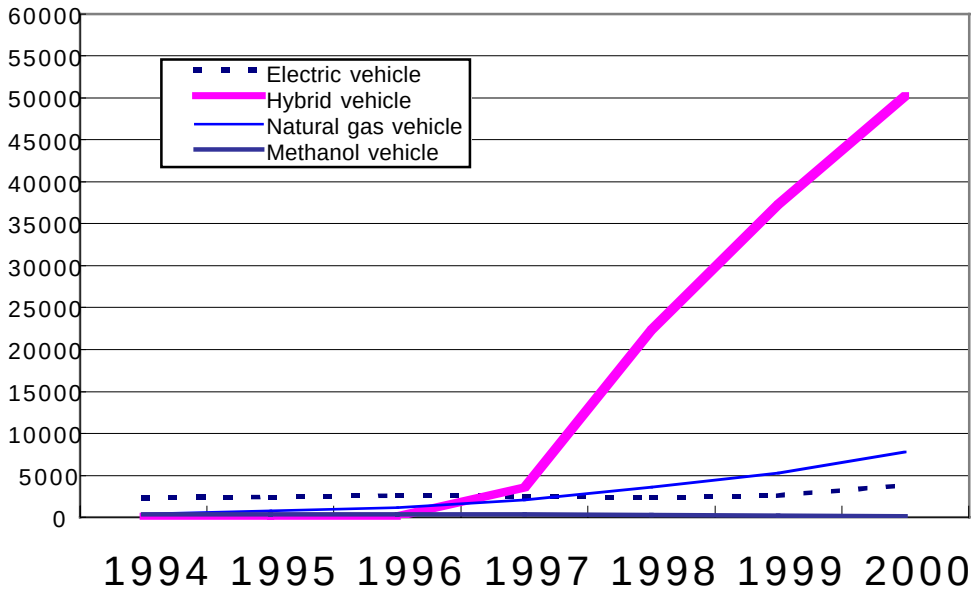
Table 5?@Reserves and Recoverable Reserves of Biomass Energy in FY2010(estimation)

Type of biomass		Fy1999 Result of introduction	FY2010 Reserves	Recoverable reserve
Agricultural waste	(1)Rice husk	6.1	800	223
	(2)Rice straw	0	3,709	197
	(3)Rapeseed	0	?\	?\
	(4)Bagasse	860	166	154
Livestock waste	(5)Dung of cattle and pig	NA	(1,279)2s overlap(18)	
	(6)Fowl droppings(broiler only)	NA	293	19
Forestry resources	(7)Thinnings	0	1,302	374
	(8)Forest residues	0	139	40
	Branches and tops	0	720	720
	Total of forest residues	0	859	760
Industrial waste	(9)Wood waste	[473]2s(50,000kW)	2,229	602
	(10)Architectural waste	NA	2,063	1,978
	(11)Sludge(organic liquor waste)	NA	3,530	2,312
	(12)Sludge(sewage)	(1998) 87	2,613	2,613
	(13)Black Liquor	(1998) 4,360	5,450	5,450
General waste	(14)Garbage(refuse)	NA	(650)2s overlap(18)	?\
	(15)Cooking oil waste	NA		
Others	(16)Human waste	(1997) 21	(88)2s overlap(18)	?\
	(17)Landfill gas	1.3(3,395,000)3Nm	226	226
	(18)Mixed intensive treatment	NA (Yagi Town 140kW)	4,841	?\
	(19)Fuel wood	67	300	
Total	All	5,665	28,792	Sum is not figured o
	Except (13) (19)	1,238	23,042	because of overlaps
cf.?@ Waste power generation and waste heat utilization of incinelation plant		?\	6,760	?\

NOx pollution in cities has been escalating, and CO_2 is causing a global environmental protection problem. From the view point of environmental protection, therefore, high hopes are attached to the introduction of clean energy vehicles (CEV) because of their superior NOx and CO_2 emission performance.

Importantly, electric cars have undergone considerable improvements in mileage between charges, traveling speed, etc. Nevertheless, more R&D efforts are needed to, among other things, improve batteries in terms of longer service lives and greater energy densities, long with further price reduction efforts through mass production. The use of fuel-efficient hybrid cars, which are driven by a fuel gasoline engine and an electric motor, have started to increase.

Major car manufacturers released their hybrid car models in 2000. As of the end of FY 2000, a total of 62,032 CEVs had been introduced in Japan (3,815 electric vehicles, 50,272 hybrid cars, 7,811 natural gas vehicles and 134 methanol vehicles). To cater for these vehicles, 54 battery charging stations, 556 natural gas fuelling stations and 38 methanol fuelling stations have been set up. The numerical target for the introduction of clean energy vehicles by FY 2010 has been set to 3.48 million units.



	1994	1995	1996	1997	1998	1999	2000
Electric vehicle	2300	2429	2558	2509	2390	2579	3815
Hybrid vehicle	100	120	145	3596	22340	37260	50272
Natural gas vehicle	421	759	1211	2093	3640	5252	7811
Methanol vehicle	310	311	314	300	279	192	134

Fig.6 Trend of Clean Energy Vehicles Introduction in Ja

3.8 Fuel Cell

From the operating principle of the fuel cell, there are hardly any CO2 or NOx emissions. Other advantages of fuel cell include low noise, wide choice of fuels, small size and flexibility with the installation locations. At present, phosphoric acid fuel cells (PAFCs) are in the early stages of commercialization.

As end of March 2001, a total of 69 on-site PAFC systems with a combined power output of 11.6 MW had been introduced by gas companies in Japan. Reliability, which was a problem in the past, has improved to a practically acceptable level. The numerical target for the introduction of fuel cells by FY2010 has been set to 2,200 MW.

_In terms of future potential, the polymer electrolyte fuel cell (PEFC) is the focus of attention. PEFCs, which use a fluorine compound electrolytic membrane, are suitable for automotive and home uses. However, there are still problems with cost, weight and fuel processing, and further R&D efforts will be needed to overcome them. In March 2001, the Fuel Cell Commercialization Conference of Japan (FCCJ) was established to pave the way for the development of fuel cell.

3.9 Hydropower

Hydropower accounts for around 20% of the total output of power generation

facilities. According to Electric Power Development Coordination Council, in FY1997, total output of hydropower facilities was 46,320 MW. Of which 44,850 MW was consumed by private facilities. In Japan, already 65% of technologically and economically feasible hydropower resources have been developed. The remaining 35% can provide about 12,0000 MW output according to the 5th Hydroelectric Power Generation Potential Survey. In the future, hydropower locations will become smaller in scale and more remote in area, and development costs are expected to increase.

3.10 Geothermal

Japan is one of the most distinguished volcanic countries in the world, and geothermal energy is its precious domestic energy. And as it emits very little CO2, it is also regarded

Table6?@Potential Hydropower Resources and Its Development Condition(As of M

	Number of sites	Total output(MW)	Average output(MW)
Developed	1810	21502	11.9
Under construcion	57	597	10.5
Undeveloped	2716	12124	4.5
Total	4583	34222	-

Table7?@Potential Hydropower Considered Technically and Economically Feasib
(5th Hydroelectric Power Generation Potential Survey)

Generation type	Number of sites	Output(MW)	Possible annual generated power(
Run-of-river	365	2460	10320
Pondage	58	1169	4558
Reservoir	42	583	1840
Total	465	4211	16718

as an effective means to deal with global warming issues as well as wind and small- to-medium scale hydroelectric power. However, geothermal energy has some difficult tasks. The initial investment cost is huge, and some measures are indispensable for preservation of natural scenery around the development site, and guarantee of the hot-spring utilization without any influence.

In Japan, actual survey for geothermal energy resources has begun around 1950, and the first geothermal power station started its operation in 1966. After 35 years, 16 geothermal power plants in the 14 geothermal power station sites (excluding small power generation facilities for household use) are currently operating in Japan. Total authorized rated output reaches 530 MW, or 0.2% of the whole Japanese power capacity of 250 GW. Actual power output of the geothermal power for FY 1999 was 3,440GWh, and this is account for 0.3% of 1,000TWh, the whole power output in Japan.

4. CONCLUSION

Today we are faced with big transition of basic resources as essential as food. This is the transition of energy system from hunting fossil fuels and nuclear materials in the ground to harnessing energy poured from the sun to the earth. In energy production, energy cultivation means to have their own energy production systems in distributed, relatively small scale areas to sustain their activities.

Though, Japan is vulnerable in energy supply, and has a big population in a small land area, the domestic renewable energy resources are fairly large, but unexploited. Renewable energy technologies are easy to understand and practice, benign to environment, and need only small capital built when local materials are used. In transition from an energy hunting to an energy cultivating civilization, Japan, as one of the industrialized countries, could provide an important model for the development of many countries which like Japan, do not have domestic fossil fuels.

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