Present Status and Prospects for New Energy

Norio Kanie
Noriyuki Nakajima

1. Introduction

The situation regarding energy in Japan is changing dramatically. This change stems from efforts to protect the global environment beginning with the 3rd session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3), held in 1997 in Kyoto, Japan, and is also due to the liberalization of the electric power market in Japan.

Ever since the first and second oil crises, the research and use of alternative energy has been promoted in Japan. Examples of alternative energies include coal liquefaction, photovoltaic generation, utilization of solar heat, and geothermal power generation. A typical household had a solar-powered water heater installed on the house roof to supply hot water for a bathtub, for example. At one time, 800 thousand of these solar-powered water heaters were installed annually, contributing to a reduction in demand for crude oil. However, as the supply of crude oil stabilized, solar-powered water heaters gradually slipped from public awareness.

The subsequent deterioration of the global environment due to global warming, acid rain, ozone depletion, reduction of tropical forests, etc. has become critical issue for the international community. Sulfur oxides (SOx) and nitrogen oxides (NOx) emissions are regulated, and statutory regulations have mandated the discontinuation of carbofluorocarbon gas production. In order to combat global warming, we must reduce those substances that contribute to the warming problem. Carbon dioxide (CO_2), one of the substances contributing to global warming, is generated mainly by the combustion of fossil fuels, and therefore the usage of fossil fuels must be curtailed. The introduction of new alternative energy sources will lead to a reduction in CO_2 usage.

2. Present Status and Issues of New Energy

2.1 Definition

New energy is prescribed under the Special Law for Promoting New Energy Utilization as "resources for the production, creation and utilization of alternative energy, which are not yet in widespread use due to economic reasons, but are expected to contribute significantly to accelerating the adoption of alternative energy." The resources specifically mentioned include photovoltaic generation, wind power, utilization of solar heat, ocean thermal energy conversion, waste power generation, thermal utilization of waste, waste-derived fuel production, electric (and hybrid) powered vehicles, natural gas-fueled vehicles, methanol-fueled vehicles, natural gas cogeneration, and fuel cells. Figure 1 shows the technical levels of these new types of energy.

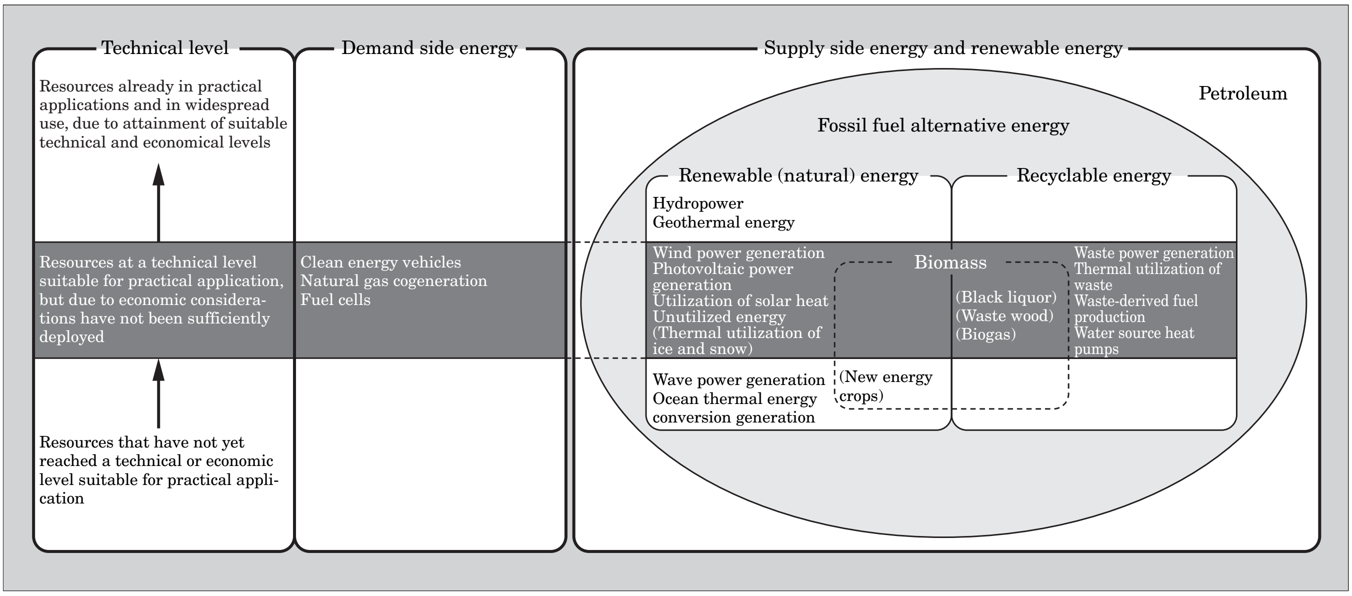
2.2 Present status

In December 1999, a New Energy Subcommittee was formed within the Ministry of International Trade and Industry's (presently the Ministry of Economy, Trade and Industry) Advisory Committee for Energy, and this subcommittee began studying the future course of Japan's energy policy. After a total of 18 meetings, the subcommittee released a written report in June 2001, the contents of which specified the quantity of new energy presently in use, the expected adoption and target levels for new energy by 2010 (see Table 1). New energy accounted for 1.2 % of the total supply of primary energy (equivalent to 6,930 ML of crude oil) in 1999, and 3 % of the total supply (equivalent to 19,100 ML of crude oil) is targeted by 2010.

The widespread adoption of new energy hinges upon the ability to achieve economic efficiency. Table 2 lists examples of estimated unit prices for power generation by various types of new energy resources.

Sufficient technical capability for practical application of new energy resources has been achieved and ongoing technical development is concentrating on finding ways to lower costs. Various measures are being studied in order to achieve the targets for 2010. One such measure under consideration is a bill requiring electric companies to provide a certain minimum quantity of power from new energy sources.

Fig.1 Technical level of new energy resources



2.3 Targeted adoption levels

Table 1 shows the targeted levels of new energy adoption by 2010, as set forth by the New Energy Subcommittee. The table shows both the case of continuation of the current policy and the target case, which implements additional measures. Policies aimed at the target cases were considered. New energy can be classified according to the supply-side and the demand-side. The supply-side includes photovoltaic generation, wind power generation and waste generation, and has a target value of the equivalent of 19.1 billion liters of crude oil. The demand-side includes clean energy vehicles, natural gas cogeneration, and fuel cells.

Renewable energy resources include new energy, hydropower (general waterpower) and geothermal energy, and as shown in Table 1 (b), the 2010 estimate and target is 40 billion liters, or approximately 7 % of the primary energy supply. This target value is 10 billion liters greater than the of 30 billion liters estimate according to existing policy, and that differential will be made up from new energy.

The target values in Table 1 are based upon values in the 1998 interim report by the Supply and Demand Subcommittee of the Advisory Committee on Energy, and significant differences between figures contained therein and 2010 target values are listed below.

(1) Wind power generation is increased from 300 MW to 3,000 MW
(2) Biomass power generation is added to the power generation field
(3) Unutilized energy is considered a group and includes the addition of ice energy
(4) Targeted capacity for cogeneration is halved from 10,020 MW to 4,640 MW.

The targeted adoption for all types of new energy is at the same level as approximately 3 % of the primary energy supply. Policy emphasizes solar power generation, power generation from waste, wind power generation and utilization of solar heat.

2.4 Issues

Issues concerning the adoption of new energy resources include economic efficiency, output stability and utilization factor. The resolution of these issues will accelerate the adoption of new energy.

(1) Economic efficiency

For each type of new energy resource, technical development is vigorously pursuing various techniques to reduce equipment cost. For example, wind power generation aims to reduce costs by increasing equipment capacity, and a 2,500 kW capacity windmill has been developed. Sixty percent of the cost of a photovoltaic power generation system is attributed to the expense of solar cell modules. To decrease the solar cell module cost, module efficiency is being enhanced, modules are being fabricated with larger surface area, and module production is being implemented on a large scale. However, at present, photovoltaic power generation remains approximately three times as expensive as the cost of residential use electricity.

With fuel cells, if waste heat is completely utilized, the power generation cost will approach the cost of commercially purchased electricity. However, battery cells have a lifespan of approximately 5 years (40,000 hours) and reduction of their replacement cost remains a challenge. Experimental studies are underway to extend the lifespan of existing cells, and in the near future, achievement of life spans on the order of 60,000 hours is expected.

Table 1 Share of new energy will grow to about 3 % by 2010

(a) Trends and targets of new energy (supply side)

Units: 1,000 kL (1,000 kW)

		1999 results		2010 estimate & target				2010/ 1999
				Estimate according to existing policy		Target		
		Crude oil equivalent	Equipment capacity	Crude oil equivalent	Equipment capacity	Crude oil equivalent	Equipment capacity	
		(10 ML)	(10 MW)	(10 ML)	(10 MW)	(10 ML)	(10 MW)	
Power generation field	Solar power generation	5.3	20.9	62	254	118	482	Approx. 23 times
	Wind power generation	3.5	8.3	32	78	134	300	Approx. 38 times
	Power generation from waste (resources)	115	90	208	175	552	417	Approx. 5 times
	Biomass power generation	5.4	8.0	13	16	34	33	Approx. 6 times
Heat utilization field	Solar heat	98	–	72	–	439	–	Approx. 4 times
	Unutilized energy (including ice energy)	4.1	–	9.3	–	58	–	Approx. 14 times
	Waste thermal energy	4.4	–	4.4	–	14	–	Approx. 3 times
	Biomass heat	–	–	–	–	67	–	–
	Black liquor, waste wood, etc. (∗1)	457	–	479	–	494	–	Approx. 1.1 times
Total for new energy (Percentage of the total supply of primary energy)		693 (1.2 %)	–	878 (1.4 %)	–	1,910 (approx. 3 %)	–	Approx. 3 times

(∗1): Grouped as one type of biomass. Includes portion used for power generation.

(b) Trends and targets of renewable energy

Units: 1,000 kL

	1999 results	2010 estimate & target		2010/1999
		Estimate according to existing policy	Target	
Total new energy supply	7	9	19	Approx. 2.7 times
Hydropower	21	20	20	Approx. 1 times
Geothermal energy	1	1	1	Approx. 1 times
Total renewable energy supply (Primary energy supply/ component percent)	29 (4.9 %)	30 (4.8 %)	40 (7 %)	Approx. 1.4 times
Primary energy supply	593	622	Approx. 602	

(c) Trends and targets of new energy (demand side)

	1999 results	2010 estimate & target		2010/1999
		Estimate according to existing policy	Target	
Clean energy vehicles (∗2)	65,000 vehicles	890,000 vehicles	3,480 M vehicles	Approx. 53.5 times
Natural gas cogeneration (∗3)	1,520 MW	3,440 MW	4,640 MW	Approx. 3.1 times
Fuel cells	12 MW	40 MW	2,200 MW	Approx. 183 times

(∗2): Includes the demand-side new energy vehicles of electric vehicles, fuel cell vehicles, hybrid inverter controlled motor and retarder vehicles, natural gas-power vehicles, methanol-power vehicles, and liquefied petroleum gas-powered vehicles.
(∗3): Includes fuel cell-derived power

(2) Output stability

Because wind power generation and photovoltaic power generation are dependent upon environmental conditions, their output is unstable. In Northern Europe, wind power is able to provide stable electric power because the average wind speed is large and the

Table 2 Comparison of new energy costs

Type of new energy		Energy cost	New energy/ comparative energy	Comparative energy cost
Solar power generation	Household use	Avg: 66 yen/kWh	Approx. 3.0 times Approx. 16.5 times	Household-use electric rate: 23.3 yen/kWh Equivalent fuel cost: 4.0 yen/kWh (*2)
		Max: 46 yen/kWh	Approx. 2.0 times Approx. 11.5 times	Household-use electric rate: 23.3 yen/kWh Equivalent fuel cost: 4.0 yen/kWh
	Non-household use	Avg: 73 yen/kWh	Approx. 3.5 times Approx. 18.3 times	Commercial electric rate: 20.0 yen/kWh Equivalent fuel cost: 4.0 yen/kWh
Wind power		Large-scale: 10 to 14 yen/kWh	Approx. 1.4 to 2 times Approx. 2.5 to 3.5 times	Rate for electricity from thermal power plant: 7.3 yen/kWh Equivalent fuel cost: 4.0 yen/kWh
		Small-scale: 18 to 24 yen/kWh	Approx. 2.5 to 3 times Approx. 4.5 to 6 times	Rate for electricity from thermal power plant: 7.3 yen/kWh Equivalent fuel cost: 4.0 yen/kWh
Waste power generation		Large-scale: 9 to 11 yen/kWh	Approx. 1.2 to 1.5 times	Rate for electricity from thermal power plant: 7.3 yen/kWh
		Small-scale: 11 to 12 yen/kWh	Approx. 1.5 times	Rate for electricity from thermal power plant: 7.3 yen/kWh
Phosphoric acid fuel cells		22 yen/kWh (*1)	Approx. 1.1 times	Commercial electric rate: 20.0 yen/kWh
Utilization of solar heat		28 yen/Mcal	Approx. 1 to 3 times	9.0 to 27.3 yen/Mcal (*3)
Water source heat pumps & Thermal utilization of waste		10 yen/MJ	Approx. 1.1 times	Heat supply cost (assuming use of city gas): 90 yen/MJ

(*1): Figure includes waste heat recovery
(*2): The equivalent fuel cost (4.0 yen/kWh) is set as a discretionary cost for the power company when installing solar power or wind power generation equipment, for which output will vary depending upon weather conditions.
(*3): The comparative energy cost for a solar heat system is the heat utilization unit price, which reflects the efficiency of a kerosene, city gas or LPG based hot-water supply. The respective energy costs are 9.0 yen/Mcal for kerosene, 18.5 yen/Mcal for city gas, and 27.3 yen/Mcal for LPG.
Note: These examples were computed using uniform assumptions and were chiefly based on the average cost of equipment for business operations introduced in 1999.

wind blows in a steady direction. In Japan, however, there are few places where the wind speed and direction are steady, and even if a steady wind could be obtained, because the electric power lines in many regions are weak, connecting wind power generation equipment to those lines would ultimately degrade electric power quality and negatively affect general household customers. When connecting wind power generation equipment to a weak electrical power system, equipment (such as a fly wheel system or storage battery system) capable of supplementing a fluctuating quantity of power generation must be installed on the wind power generation-side to ensure the electrical power quality.

(3) Utilization factor

Utilization factor is typically expressed as (actual annual electricity generated)/(standard capacity × 8,760 h) and is a value that represents the annual power generation of a facility operating at rated (standard) capacity. The utilization factor varies according to the location of the facility, but average values are 65 %, 22 % and 12 % for waste power generation, wind power generation and photovoltaic power generation, respectively. As can be seen from these figures, the utilization factor for new energy generating facilities is extremely low compared to that of conventional thermal power generating facilities. This low utilization factor is a major reason for the higher power generation cost of new energy resources. Photovoltaic power generation has an especially low value of 12 %. Of course, the utilization factor would improve if the facility were located at a site that received direct sunlight and had mostly clear weather conditions. Japan, unlike the desert regions of the Middle East, does not have any place where sunlight irradiation is excellent, and therefore it is not possible to improve this value to a large degree. Moreover, installing wind power facilities at sites where wind conditions are favorable can boost the utilization factor for wind power generation, but even in Europe's region of favorable wind conditions, the utilization factor is only about 35 %.

3. Fuji Electric's Approach to New Energy

Rather than considering each type of new energy as an individual power generation resource, Fuji Electric aims to provide comprehensive energy solutions that include conventional power generation from diesel and gas engines, as well as energy saving measures, and is proposing optimal energy supply systems to its customers. So as to be better equipped to provide total energy solutions to its customers, Fuji has established an energy solutions office and is expanding its energy solutions business.

In the field of energy savings, Fuji Electric-an early developer of high efficiency devices — is also providing energy saving devices such as inverters and energy saving equipment, in addition to energy saving systems such as heat storage system and cogeneration.

Fuji Electric has also entered the ESCO (Energy Service Company) business and performs equipment diagnosis and proposes energy saving measures. The establishment of a plan for energy savings requires detailed data about the power used by each facility. Should additional measurements be required, Fuji also supplies Ecopassion and Ecoarrow wireless measurement systems that simplify the task of wiring.

Fuji Electric, an early developer of technology for solar cells and fuel cells, has also been providing systems that utilize a wide range of renewable energy resources including geothermal, small-scale hydropower, wave power, and wind power resources. Details of Fuji's solar cells and fuel cells are described below.

3.1 Photovoltaic power generation

Leveraging its core technology of inverters, Fuji Electric has standardized power conditioners (inverters for photovoltaic power generation use) and is selling photovoltaic power systems.

At present, the majority of solar cells used worldwide for power generation are crystalline-type solar cells. Fuji Electric is working to develop amorphous (non-crystalline) solar cells. Although amorphous solar cells are less efficient than crystalline solar cells, there is no need to be concerned about the limited supply of crystalline silicon material, and amorphous solar cells can be mass-produced, leading to lower costs. Moreover, the solar cells being developed by Fuji Electric are deposited on plastic film instead of a conventional glass substrate, and since a roll-to-roll process is utilized in which film that had been wound on a roll is rewound onto another roll after the solar cell film deposition, and this process is believed to lead to lower costs. Presently, Fuji Electric is concentrating on verifying reliability and lowering costs of these amorphous solar cells. Fuji Electric is also promoting the development of integrated roofing material that leverages the characteristics of Fuji Electric's amorphous solar cells, and is working to make this material commercial feasible.

3.2 Fuel cells

Many various types of fuel cells have been developed. Fuji Electric began developing phosphoric acid fuel cells in 1973, after performing collaborative research with electric power companies and gas companies and implementing field-testing to ensure reliability and performance, has been shipping commercial devices since 1998. Presently, Fuji is concentrating on expanding sales of phosphoric acid fuel cells and on developing polymer electrolyte fuel cells. The main use for phosphoric acid fuel cells has been in cogeneration systems that use town gas (13A, natural gas) as fuel to generate electricity or to pre-heat feed water. Recently, Fuji has also delivered fuel cells that use biogas, having methane gas as its main component and created as a byproduct from the decomposition of raw garbage or sewage sludge, as fuel for the purpose of generating electricity or heating fermentation processes. By generating energy from energy resources that were previously incinerated or otherwise unused, these types of systems will contribute to the preservation of the environment.

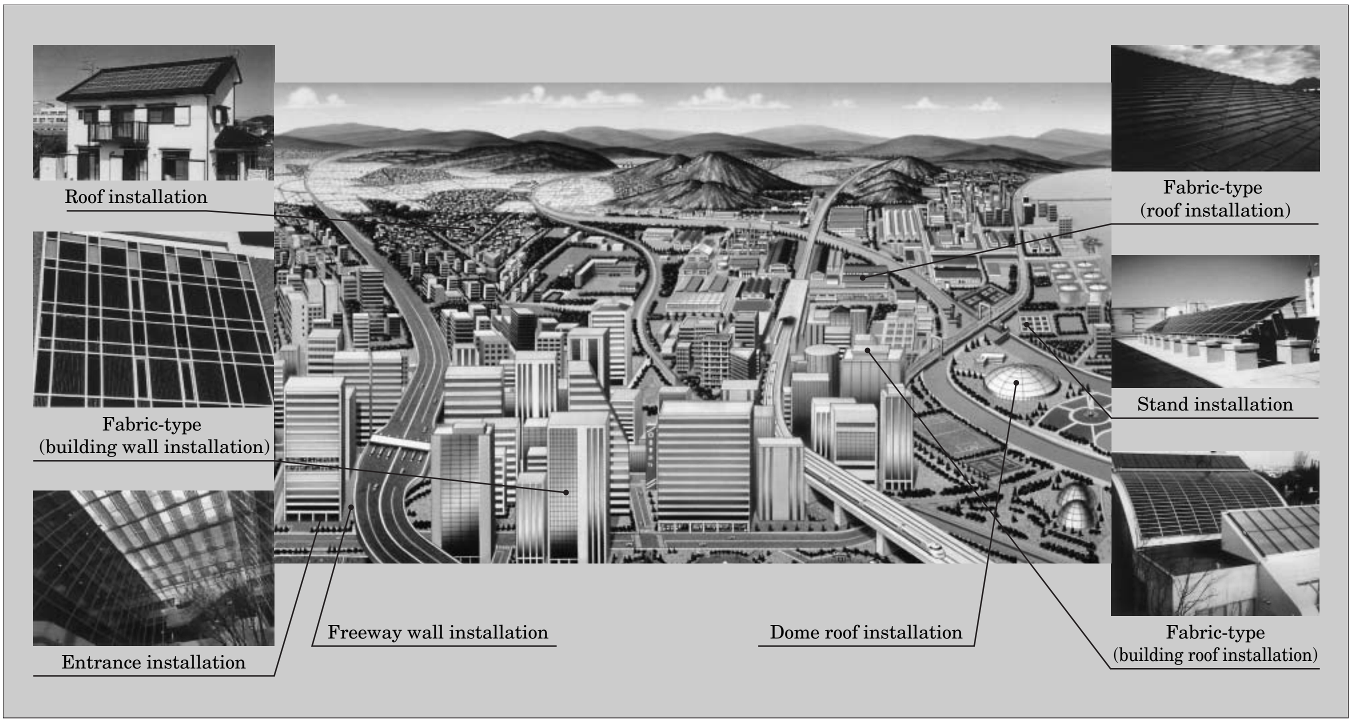
4. Future Prospects

The year 2010 targets outlined by the New Energy Subcommittee form the guidelines for promoting the adoption and widespread usage of new energy. New facilities will be brought online for photovoltaic power generation, waste power generation, and wind power generation, with the largest new capacity for photovoltaic power generation, followed by waste power generation, and wind power generation. In terms of the equivalent quantity of crude oil, however, this order becomes inverted as 5,520 ML for waste power generation, 1,340 ML for wind power generation and 1,180 ML for photovoltaic power generation. This discrepancy is due to differing values of the utilization factor as described above. Waste power generation is more efficient and is therefore a more economical means for generating electricity. If the cost of electricity generation is the most important factor affecting the adoption and widespread use of new energy, then we should concentrate efforts on promoting waste power generation.

Some people have the opinion that wind power generation is ill suited for Japan, where unlike Northern Europe there are few places favored by a steady wind speed and direction. However, relatively stable wind can be obtained at sea, and the introduction of offshore wind power generation — which has also begun in Northern Europe — is believed to be the key to achieving targeted adoption levels in Japan. Wind power generation will be advanced as small-scale power generation facilities having capacities of less than 2,000 kW and large-scale power generation facilities such as a wind farm having capacities of several tens of megawatts.

The major disadvantages of photovoltaic power generation are that the sunlight which reaches the earth has a low energy density and that the utilization factor is small. Its advantage, however, is that photovoltaic power generation equipment of large or small capacity can be installed in any suitably sized area that receives sunlight, and this makes it possible for even an individual to contribute to clean power generation according to his or her own finances. Other types of new energies do not have this advantage. Figure 2 illustrates example installations of photovoltaic power generation systems in a city. The opportunities for installation are limitless and include conventional roof installations, stand mounted installations, integration with building material (roof, wall, and window installations), and installations in the sound

Fig.2 Photovoltaic power generation example for city use



barriers along freeways. The cost of photovoltaic power generation is predicted with near certainty to drop to the same level as that of residential use electricity by 2010. Due to impending environmental issues, applications of photovoltaic power generation are expected to increase dramatically and become more widespread. The amorphous solar cells being developed by Fuji Electric have an approximately 10 % higher annual power output than crystalline solar cells. This is because photovoltaic power modules reach elevated temperatures during the summer months and amorphous solar cells, compared to crystalline solar cells, only exhibit slight degradation of efficiency due to high temperatures. Consequently amorphous solar cells are able to achieve higher efficiency. By leveraging this advantage, Fuji Electric plans to make significant contributions to photovoltaic power generation.

To lower the cost of fuel cells, polymer electrolyte fuel cells are expected to become the mainstream, and applications are predicted to center on fuel cells for automobiles and stationary fuel cells for home use. If the application of fuel cells to automobiles becomes practical, mass production will be necessary and subsequent cost reductions are anticipated. To promote the widespread usage of fuel cells, a fuel supply infrastructure must be built out and supporting maintenance work will also be necessary. Meanwhile, phosphoric acid fuel cells, which have a high operating temperature, are well suited for use in cogeneration systems that utilize exhaust heat. In the future, applications for phosphoric acid fuel cells will be segregated from those for polymer electrolyte fuel cells.

5. Conclusion

Separate from but concurrent with the New Energy Subcommittee, the Ministry of Economy, Trade and Industry organized an Energy-Saving Subcommittee to study Japan's future policy regarding energy saving. According to the report issued by this Energy-Saving Subcommittee, the target for year 2010 is the equivalent of 57 billion liters of crude oil, which is approximately three times the total new energy target. Based on these figures, to curtail CO_2 emissions and protect the environment it is important to reduce consumption of existing energy resources and also to incorporate a well-balanced percentage of new energy.

Fuji Electric will continue to contribute to society by providing energy solutions that include new energy resources as well as energy saving measures.

Reference

(1) NEDO Activities to Promote the Introduction of New Energy.