State of New Energy Sources

By Kidahashi Tsutomu

The two oil shocks that hit Japan in the 1970s exposed the fragility of an energy system that relied on imports for the majority of its supply. Since then, Japan has devoted major efforts to developing and introducing energy resources that provide alternatives to oil. The Sunshine Project, launched in 1974, promotes technological development of new energy sources, and the Moonlight Project, initiated in 1978, promotes the technological development of energy conservation. These plans have furthered technological developments in the fields of photovoltaic power generation and fuel cells.

In addition, the Law Concerning the Promotion of the Development and Introduction of Oil-Alternative Energy Sources was passed in 1980. A special account system was set up to provide the financial basis for the law and the New Energy Development Organization (NEDO) was founded to serve as its central promotional body.

Japan's reliance on oil fell from 77.4% in 1973 to 58.2% in 1992 due to the introduction of such oil-alternative energies as nuclear power, coal and natural gas. Reliance on non-fossil fuels grew from 5.6% to 15.1% over the same period. Even with the many positive technological developments coming out of the work on new energy, these resources still account for a mere 1% to 2% of Japan's primary energy supply.

In the past, the primary impetus for the development and introduction of new energy sources was the issue of energy security, but the increasing severity of global environmental problems has created another role for new energy sources: reducing CO_2 emissions. A 1990 opinion poll found that photovoltaic energy is approaching nuclear power as the public's energy of choice for the next decade, a finding that suggests great expectations for new energy.

In the government's long-term energy supply and demand outlook, which was revised this year, the estimate for new energy (including geothermal energy) in the year 2010 was hiked from the previous figure of 2.3% of total energy supply to 3.6%. The government has erected two mechanisms to achieve this goal:

Classification of New Energy Sources

Technology Classification	Energy Classification	Form of Energy	Example of Energy Use
Technologies related to reusable energy	Solar	Light energy Heat energy	Photovoltaic power Solar system
	Wind	Kinetic energy	Wind power generation
	Geothermal	Heat energy	Geothermal power generation
	Biomass (use of organic matter)	Chemical energy	Alcohol fuel Use of biomass
	Ocean	Kinetic energy (waves) Potential energy (tides) Heat energy (heat differentials)	Wave power generation* Tide power generation* Ocean heat differential power generation*
Advanced energy use technology	Fuel cells	Chemical energy	Phosphoric acid fuel cell Molten carbonate fuel cell Solid oxide fuel cell
	Unutilized	Heat energy	Urban waste heat Systems for use of heat differentials in rivers,etc.
	Use of waste products	Heat energy	Garbage incineration power generation
Fuel form	Coal use	Chemical energy	Coal liquefaction and coal gasification
	Hydrogen use	Chemical energy	Hydrogen power generation Transportable fuels

Note: NEDO is not involved in the technological development of those items marked with an asterisk (*).

the New Sunshine Project, a composite of the Sunshine and Moonlight projects created in 1993 with research and development funds of ¥1.55 trillion for the period 1993 to 2020, and a number of subsidy measures for the promotion of new energy implementation. The greatest possible efforts are now being devoted to this end.

New energy technologies can be roughly divided into renewable energy technologies such as solar, geothermal and wind power; advanced energy use technologies such as fuel cells and the utilization of unexploited energy sources; and fuel conversion technologies such as coal liquefaction and gasification and hydrogen fuel (see table). Let us outline the state of development of each of these new energy sources.

Solar energy

The sun produces an enormous amount of energy. The amount of solar energy that reaches the earth in a single hour is equivalent to approximately twice the amount of energy used by all of mankind in one year. Furthermore, solar energy is non-polluting and quiet. It does have some major drawbacks, however. Energy output fluctuates with variations in the amount of sunshine reaching the earth, for example. The cost of gathering solar energy is also rather high since solar energy is a low-density form of energy.

One form in which solar energy can be utilized is photovoltaic power generation. Photovoltaic cells manufactured today generally have conversion efficiencies no greater than around 15%. A conversion efficiency of 15% means that a solar collecting device one square meter generates 150 watts of electrical energy. It is generally held that for photovoltaic energy to be truly viable, a conversion efficiency of at least 20% is necessary. Other issues that still need addressing are technological developments that will cut the cost of photovoltaic energy and the large-scale generation of photovoltaic energy.

Photovoltaic energy is currently being used as an independent and dispersed type power source for isolated islands and mountain cabins. A cut in the cost of 1 kilowatt/hour of photovoltaic energy to ¥20 to ¥30 (approximately 1/7th of current costs) would allow practical application of photovoltaic power generation in individual homes and public facilities.

Wind energy

The wind has long been harnessed as an energy source and wind power generation has been aggressively pursued, mainly in Europe and the United States. Since it is an effective technology when the direction and speed of wind is fixed and large areas can be utilized, it has proven most appropriate on the U.S. West Coast and on the western seaboard of Europe, both of which are exposed to prevailing westerlies.

Japan, on the other hand, is a mountainous country with turbulent air masses above it, making conditions for wind power less than ideal. Potential sites are also limited. Consequently, current wind power only produces 4,500 kilowatts of power in Japan. A nationwide survey of wind conditions is now under way to find sites with stable wind conditions. Development of large-scale wind power generation systems in the 500-kilowatt class is being pushed forward with the goal of reducing costs and using land space more efficiently. The aim is to increase wind power generation in the future.

Geothermal energy

Geothermal energy is an abundant form of natural energy in a country with great volcanic activity like Japan. It is also a form of energy whose utilization places little burden on the environment. Consequently, there are great hopes for the exploitation of geothermal energy, which currently generates 300 megawatts of electricity. There is a program to increase this output to 550 megawatts over the next two to three years. A number of issues must be overcome before there is further development of this energy source, however. They include reduction of risks associated with exploration, exploitation of currently unused geothermal resources and coexistence with natural scenery and hot water springs.

Consequently, NEDO is conducting a nationwide survey to elucidate where geothermal resources are located, how much potential energy is available, and what effects development of the resources would have on the environment. A survey of deep-seated geothermal resources, those located over 3,000 meters beneath the earth's surface, is also being conducted. Development of systems to produce electricity from high-temperature water and hot dry rock located several thousand meters below the surface are also being pursued. In the hot dry rock system, water is applied to hot rock and the resulting steam is channeled to the surface and captured to produce electricity.

Fuel cells

Hydrogen and oxygen are produced in the electrolysis of water. A fuel cell produces electricity through the opposite of this reaction, producing water by combining hydrogen from a fuel such as natural gas, methanol, or coal gas with an electrolyte such as oxygen in the air. Fuel cells are a highly efficient energy source since they can produce energy in the forms of electricity and heat simultaneously. They also have many environmental advantages, including the fact that they produce few air pollutants.

Fuel cells are classified according to the type of electrolyte used. There are phosphoric acid fuel cells, molten carbonate fuel cells and solid oxide fuel cells. Phosphoric acid fuel cells are expected to be the first to be put to practical use, and it is estimated that they will have a thermal efficiency of 40%, with 80% total efficiency (a function of electricity and heat output). Currently, these fuel cells are undergoing rigorous laboratory trials. If the capabilities of fuel cells can be hiked up another level and if their costs can be reduced, they should be able to compete with other forms of commercial power, and rapid adoption of fuel cells as small-scale dispersed type and demand site equipment type power sources may be possible.

Molten carbonate and solid oxide fuel cells have a high reaction temperature

which translates into a correspondingly high thermal efficiency, so they are being developed as the next-generation fuel cell technology.

Unutilized energy

Unutilized energy refers to energy sources that traditionally have not been exploited to any significant degree. Examples include urban waste heat in the exhaust from buildings and subways as well as heat differentials in rivers, seawater and waste water. These untapped energy sources represent a vast quantity of heat energy. However, in most cases, urban waste heat is under 50°C and most heat differential energy is under 30°C, making for a low-density energy source. Consequently, these energy sources are not being adequately utilized.

NEDO is involved in the development of a super heat pump energy accumulation system that effectively recovers and accumulates unutilized waste heat, which by its nature is low-temperature and has a variable output. NEDO also initiated the Broad Area Energy Utilization Network System in 1993, a project whose aim is to erect a network system that can efficiently recover untapped low-temperature waste heat from factories and other sources and transport it long distances with little heat loss to urban-dwelling consumers.

Waste power generation

Of the approximately 2,000 waste incinerators in Japan, around 110 generate energy, producing around 360,000 kilowatts of power. However, the energy efficiency of the waste incinerators/power generating facilities is only around 15% because the facilities, due to the presence of metal-corrosive gases such as hydrogen chloride in the incinerators' emissions, must be operated at low steam temperatures and low pressures.

A boiler for power generation constructed of highly corrosion-resistant materials is now being developed to overcome this hurdle. With the new boiler, the goal is to increase energy efficiency to 30%.

Hydrogen energy

Hydrogen has a high heat generation capacity per unit—about three times that of oil. It is also a clean energy that produces neither smoke nor CO_2 when burned. Unfortunately, problems have delayed the implementation of hydrogen energy, such as the ability to produce large volumes of hydrogen at low costs.

In 1993, NEDO initiated the International Clean Energy Network Using Hydrogen Conversion (World Energy Network) to resolve these issues. The aim of the project is to build a network for converting energy from clean, reusable energy sources abundant in developing nations, such as water and solar power to hydrogen, which can then be transported to places in need of energy around the world. This plan is one of the hallmarks of the New Sunshine Project.

Toward future implementation

Some new energy technologies are now moving toward the implementation stage. Whether or not they will be implemented is a crucial issue.

The key will be the creation and expansion of funding measures aimed at encouraging the introduction of new energy sources. Under one of these funding measures initiated in 1992 as a test, the government subsidizes two-thirds of the cost for businesses to install photovoltaic power facilities and one-third the cost for fuel cell facilities. In 1994 another system was implemented whereby the government covers half the cost of erecting a photovoltaic power system for individual homes (target of 700 homes).

Secondly, conditions surrounding the current energy system must be developed to foster the implementation of new energy sources. The ability of new energy power generators to link into the electric power system of conventional power companies will be key to the advancement of new energy. To discover what problems will arise when that time comes, NEDO has erected an experiment on Rokko Island, off Kobe, where solar energy, fuel cells and wind power generators are tied into the electric power grid. The electric power companies recently announced the unit price and other conditions for purchasing excess energy produced by new energy sources. This will be a great boost for the introduction of new energy sources.

Thirdly, it is important to promote prior investments in cutting-edge new energy technology to the public organizations that create national infrastructures. Therefore, it is necessary to aggressively move forward in installing new energy facilities in government and local administration public facilities to serve as demonstrations and to introduce new energy technologies through regional development projects.

Finally, conditions are such that it is quite difficult for the average potential user of new energy to obtain adequate information on the technology or economic viability of new energy sources. Consequently, NEDO and other bodies must attempt to disseminate related information and increase their consulting functions to respond appropriately to the needs of users. Furthermore, commendation and recognition systems and demonstration projects should be established to spread and heighten awareness and understanding of new energy technologies. At the same time, a long-term focus on new energy should be fostered through the public education system.

As we have seen, Japan, with NEDO in the lead, is grappling with the development of new energy on a wide range of fronts. Now that a response to global environmental problems is being pursued, expectations placed on new sources of energy have been heightened another notch. NEDO, too, plans to heighten its push for technological developments and the introduction and spread of new energy sources to respond to the increased demands of the nation. JJTI

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