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Contribution of Electric Power Technology to Greenhouse Gases Reduction

KUNIKO URASHIMA , TOSHINORI TOMA
Environment and Energy Research Unit

1 Introduction

World energy consumption has been increasing in recent years due to population growth, economic development, improved living standards, etc. Many countries are studying the introduction of biofuels to cope with the threat of oil depletion, rising oil prices, and similar problems. Since biomass-derived fuels are organic matter, they burn to produce CO_2. Because the carbon contained in the combustion gas derives from the CO_2 absorbed from the atmosphere by the biomass through photosynthesis during its growth process, burning of biofuels is considered to be carbon neutral. The latest research results, however, indicate that the amounts of CO_2 emissions are not always zero and that Greenhouse Gases (hereafter, GHGs) such as CH_4 generated by land reclamation activities for food production are increasing.[1] In countries with flourishing agriculture, like the developing countries, 2.5 billion people use firewood, charcoal, agricultural waste, and animal feces as cooking and heating fuels on a daily basis. These biomass resources account for more than 90% of total household energy consumption. Such use of biomass is inefficient, but more seriously, it causes damage to health and economic development. The results of a WHO (World Health Organization) survey suggest that indoor air pollution from burning biomass causes the deaths of as many as approximately 1.3 million people each year, most of whom are women and children.[2] Increasing competition for corn and sugar cane for fuel and food actually caused a rise in grain prices in 2007. In Japan, there are concerns about not only food issues but also problems such as a possible steep rise in the price of meat caused by the increased price of corn for animal feed produced in the United States.

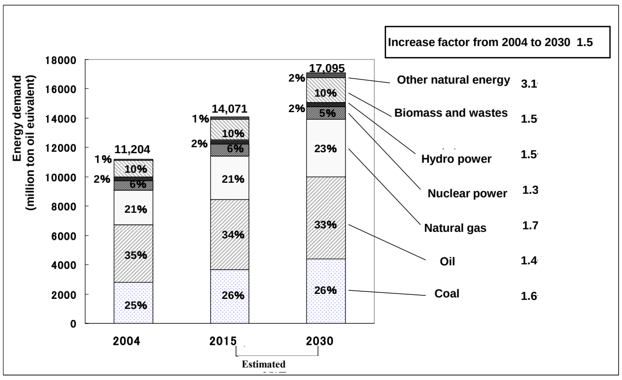
The consumption of coal an alternative to oil has also been increasing. Developing countries, in particular, are concerned that the problems of sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust causing acid rain, as well as CO_2, will become worse and develop into health hazards and cross-border pollution as a result of the increased use of coal and other fossil fuels. To deal with its environmental problems, which were most serious in the 1970s, Japan developed exhaust gas treatment technologies including electrostatic precipitators to remove soot and dust and desulfurization equipment and denitration equipment for SOx and NOx, which are now considered among the most advanced technologies of their type in the world. However, because few power plants in the developing countries are equipped with such environmental purification systems, Japan may face problems of cross-border pollution caused by pollutants from the developing countries.

In the above context, this article discusses the current situation and issues in the electric power industry and policies to contribute to global environmental problems.

2 Estimated energy demand and current problems of exhaust gas emissions

2-1 Estimated energy demand

Figure 1 shows future energy demand by fuel type and by area. World Energy Outlook 2006[3] estimates that world energy demand in the mid-21st century will increase to 1.5 to 2 times the present



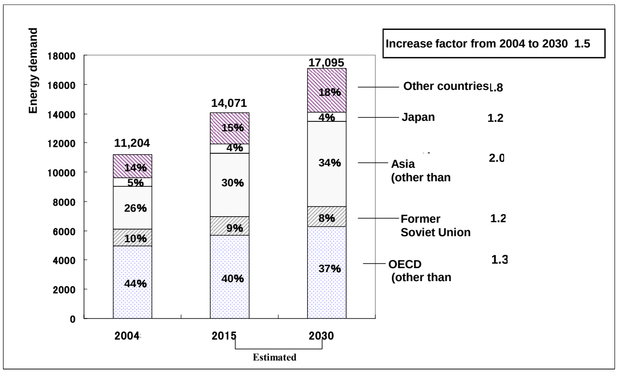


Figure 1 : Estimated world energy demand

Prepared by the STFC based on Reference[3]

level. Taking in account population growth and improvement in living standards in the developing countries, world energy consumption is tending to increase, particularly in Asia. Fossil fuels such as coal, oil, and natural gas will account for 83% of the total increase in energy demand by 2030, and their shares in world energy demand will remain virtually unchanged. The share of oil in fossil fuels will decrease, but will remain in the top position until 2030. The share of hydro power generation will increase slightly, but that of nuclear power generation will remain approximately the same. In the developing countries, the increase in modern commercial energy will offset the increase in biomass for biofuel production, power generation, and heat supply, resulting in a slight decrease in the share of biomass. The rate of increase of renewable energy other than hydro power (wind power, solar power, geothermal power, etc.) is highest, but the share will still be lower than that of fossil fuels in 2030.

The absolute energy consumption of coal will show the largest increase, and 80% of the increase in energy demand will come from China and India. The increased use of fossil fuels including coal and other resources may worsen the problems of sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust causing acid rain, as well as CO_2, resulting in health hazards and cross-border pollution. In China, which is called the “world’s workshop,” and other countries planning to build more electric power infrastructures, there is a concern that the increase in the emissions of sulfur fluoride (SF_6) and biomass-generated methane (CH_4) may generate a large amount of GHGs.

2-2 Current Greenhouse Gases emissions

The GHGs produced by power generation are mostly CO_2. According to Netherlands Environment Assessment Agency (MNP),[4] the country with the largest amount of CO_2 emissions in 2007 was China, followed by the United States. The shares of those two countries accounts for 47% of the world total. Neither country has signed the Kyoto Protocol. The emissions from the top five countries and regions including China, the United States, the European Union (EU), India, and Russia account for 71% of the world total. Effective reduction technologies and policies need to be introduced in the developing countries as well as in developed countries.

The Kyoto Protocol is intended to reduce the emissions of six types of GHGs, including CH_4, N_2O, hydrofluorocarbon (HFC), perfluorocarbon (PFC), and SF6, as well as CO_2. The Greenhouse Gases Inventory Office (GIO) of Center for Global Environmental Research, National Institute for Environmental Studies published GHGs emission trends for the period 1990-2006.[5] Figure 2 shows the amounts of GHGs emissions other than CO_2 from G8 countries in the year 2005. Even excluding CO_2, the United States is the largest GHGs emitting country. Countries with flourishing agriculture generally generate a large amount of CH_4 emissions. Since the non-CO_2 gases have a Global Warming Potential (GWP, the warming potential relative to that of CO_2, whose GWP is defined as 1) 310 to 20,000 times higher than that of CO_2, Japan cannot ignore the emissions of these gases (Table 1).

In 2006, China overtook the United States to become the world’s largest CO_2 emitting country, and in 2007, CO_2 emissions from India reached 8% of the world total. Development in other Asian countries is also likely to contribute greatly

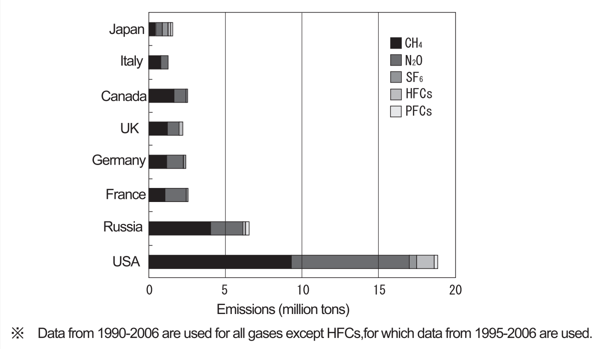


Figure 2 : Amounts of GHGs emissions other than CO_2 from G8 countries

Prepared by the STFC based on Reference[5]

to increased CO_2 emissions. The developing countries will account for more than 3/4 of the world increase in CO_2 emissions for the period 2004-2030. Their share of world CO_2 emissions may increase from 39% in 2004 to just over 50% in 2030. This increase is explained by the fact that the coal power utilization rate in these countries is higher than those of nuclear power and natural gas power.

2-3 Current problems of exhaust gas emissions and Japanese environmental technology

As described above, the increased use of coal for thermal power generation and other purposes in the developing countries has raised fears of the increase in emissions of air pollutants such as SOx, NOx, and soot and dust, in addition to CO_2. With its rapid economic growth in the 1950s, Japan took measures to solve the pollution problems, responding to damage to human health by air pollutants from factories. Power plants installed flue gas treatment systems for power generating equipment and improved combustion methods. Environment-friendly power generation is now the norm in Japan. As shown in Figure 3[6-7] the amounts of SOx and NOx emissions from thermal power plants in Japan are much lower than those in other major countries. This is the result of comprehensive promotion of coal use in harmony with the environment using Japan's advanced technologies for coal-fired power plants, i.e., clean coal technology.[8] The flue gas treatment technologies which Japan has developed in the past as measures against environmental problems, such as electrostatic precipitators to remove soot and dust and desulfurization equipment and denitration equipment for SOx and NOx, are the most advanced in the world. Thus, Japan can make an international contribution through the transfer of these technologies to developing countries.

3 World's top-level electric power technologies in Japan

3-1 Thermal efficiency of thermal power plants

Figure 4 compares the thermal efficiencies of thermal power plants by country.[5,9] The figure shows that Japanese power generation technology has realized the world highest thermal efficiency. Improving the thermal efficiencies of thermal power plants generally requires higher temperatures and pressures at the inlets of gas turbines and steam turbines. Gas turbines driven by high-temperature combustion gases operate in a temperature range which is limited by the turbine blade materials and the heat shield and cooling methods.

Early LNG combined cycle power generation (power generation system using a gas turbine in combination with a steam turbine) operated at a gas turbine inlet temperature of 1,100°C and a thermal

Table 1 : Greenhouse Gas emissions in Japan (total amount in million ton CO_2 equivalent)

	Emission source	GWP	Total amount for 1990-2006	Percentage to total amount
CO_2	Burning of fossil fuels, burning of biomass	1	20,881.9	93.7
CH_4	Rice paddies, exploitation of fossil fuels, landfill, waste/wastewater treatment, digestion activities of ruminants, nitrogen	21	485.4	2.2
N_2O	Burning, nitrogen fertilizers, agriculture and ranching, land improvement, sludge and sewage, etc.	310	511.7	2.3
HFCs	Aerosol propellants, refrigerants for car air-conditioners and refrigerators, insulation foaming agents, etc.	For example, HFC-134a: 1,300	181.3	0.8
PFCs	Manufacturing of semiconductors and parts, cleaning of electric parts, etc.	For example, PFC-14: 6,500	119.8	0.5
Sf_6	Insulation gas for transformers and others, manufacturing processes of semiconductors	23,900	107.8	0.5
		total	22,287.7	100

※ Data from 1996-2006 are used for PFC.

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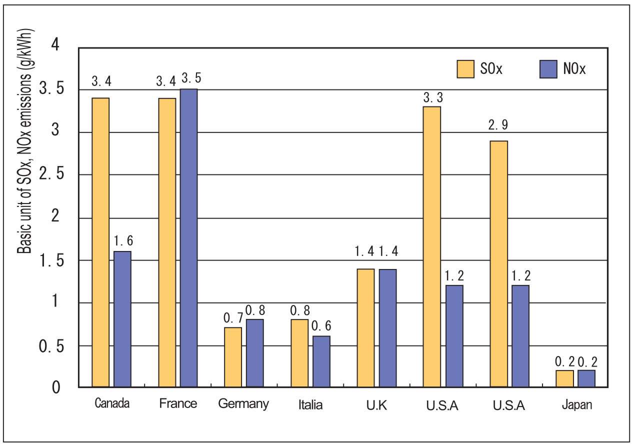

Figure 3 : Amounts of SOx and NOx emissions from thermal power generation in major countries

Prepared by the STFC based on Reference[6-7]

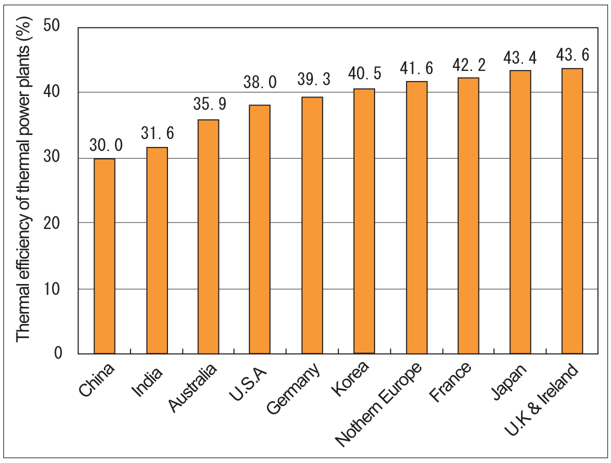

Figure 4 : Comparison of thermal efficiency of thermal power plants by country

Prepared by the STFC based on Reference[6,9]

efficiency of 47.2%. With the introduction of new materials and cooling methods, the latest systems achieve an increased inlet temperature of 1,500° C and a thermal efficiency of 59%. Tokyo Electric Power Company, for example, estimates that an increase of 1% in the average thermal efficiency of all power plants can reduce CO_2 emissions by 1.7 million tons.[10]

Higher temperature and pressure steam conditions at the steam turbine inlet have also been achieved in coal-fired power generation. The temperature has increased from 538°C in the early 1990s to 600°C at present. As a result, thermal efficiency also increased from about 42% to 45% or more. A demonstration test of coal gasification combined cycle power generation, as an application of combined cycle power generation technology, is underway using a 1,500°C class gas turbine with the objective of achieving a power generation efficiency of 48% or more.

Thus, improving the thermal efficiency of thermal power generation requires the development of turbine blades materials, heat shield materials, and cooling technology. Improvement of thermal efficiency is an important issue not only for cost reduction in power generation but also for control of GHGs emissions.

3-2 Technologies contributing to power generation infrastructures

Figure 5 shows the power transmission and distribution loss rates by country.[11] The loss rate in Japan is at the world's lowest due to improved transmission line materials and structures, higher transmission voltages, high-efficiency transmission and distribution equipment, improved transmission control technology, etc. Further improvement in the loss rate is required from the viewpoint of GHGs control. Improved equipment and materials, including amorphous transformers and superconducting transmission, for example, need to be developed for this purpose.

The sulfur fluoride (SF_6) used in the high-voltage breakers installed in transmission systems and other equipment has a warming factor approximately 24,000 times that of CO_2, and hence its discharge should be handled very carefully, even in small amounts. When these units are inspected or removed in Japan, SF_6 is recovered at a recovery rate of 98% or more and reused. In the future, the development of technology to further improve the recovery rate, research on alternative insulating materials to replace SF_6, and international transfer of the recovery technology are needed.

3-3 Power generation from wastes

A drastic increase in the amount of waste generation is expected in developing countries in the future due to mass consumption, hence, recycling and effective use of waste materials is desirable. One such measure is biomass power generation, which is the main method for generating power in developing countries,[12] as described above. Biomass fuels are classified into wastes and plants (cultivated crops). The main utilization methods include direct combustion and conversion into fuel through biochemical conversion such as

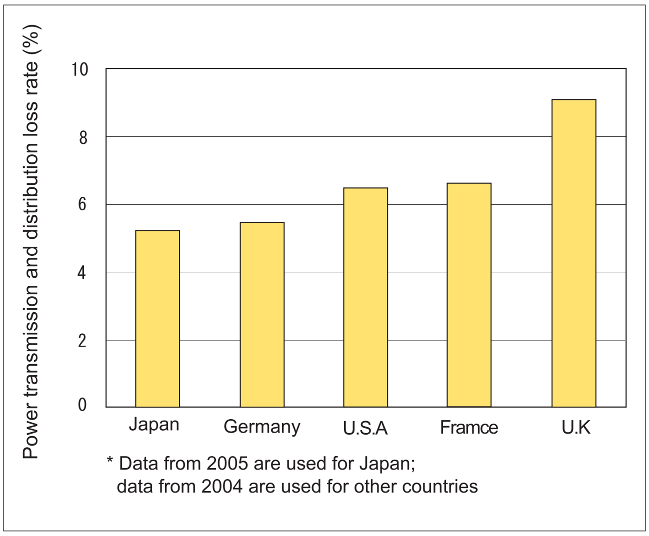

Figure 5 : Power transmission and distribution loss rate by country

Prepared by the STFC based on Reference[11]

CH_4 fermentation and thermochemical conversion by gasification and carbonization (Figure 6).[13] Power generation from waste incineration is the main use of biomass in Japan, which uses electric power or heat produced by burning the black liquor and waste chips generated in the manufacturing processes of paper and other products, the wood chips and bagasse (crushed sugar cane or similar plants after juice extraction process) produced in the processes of agriculture, forestry, and livestock farming, and garbage and trash from households and offices. Technologies which produce CH_4 gas from animal feces and food wastes have been established but are not yet widely used in Japan due to the problems of collection, transportation, and treatment of the residue after CH_4 fermentation. Collection and treatment systems have been established for sewage sludge, and facilities for converting the CH_4 gas generated at some sewage treatment plants into electric power or heat have been installed. This technology contributes to the reduction of N_2O.[14]

Plant (cultivated crop) biomass is used after converting plants such as sugar cane and rapeseed into fuels. Crop cultivation for energy use has hardly been developed in Japan because of problems of technology, the amount of cultivation required, land availability, and economy.

3-4 Heat pump technology contributing to energy saving

Measures to reduce electricity consumption are also important for GHGs control. The development and introduction of high-efficiency, energy-saving equipment are needed. Heat pumps are appropriate for cost reduction and load leveling in electric power systems (correction of the difference in power consumption between day and night) through energy-saving technology and late night power consumption. These systems can extract energy equivalent to 3 to 6 times the input electric energy from the atmosphere. Commercial ice thermal storage air conditioners (product name: Eco Ice) and domestic natural refrigerant heat pump

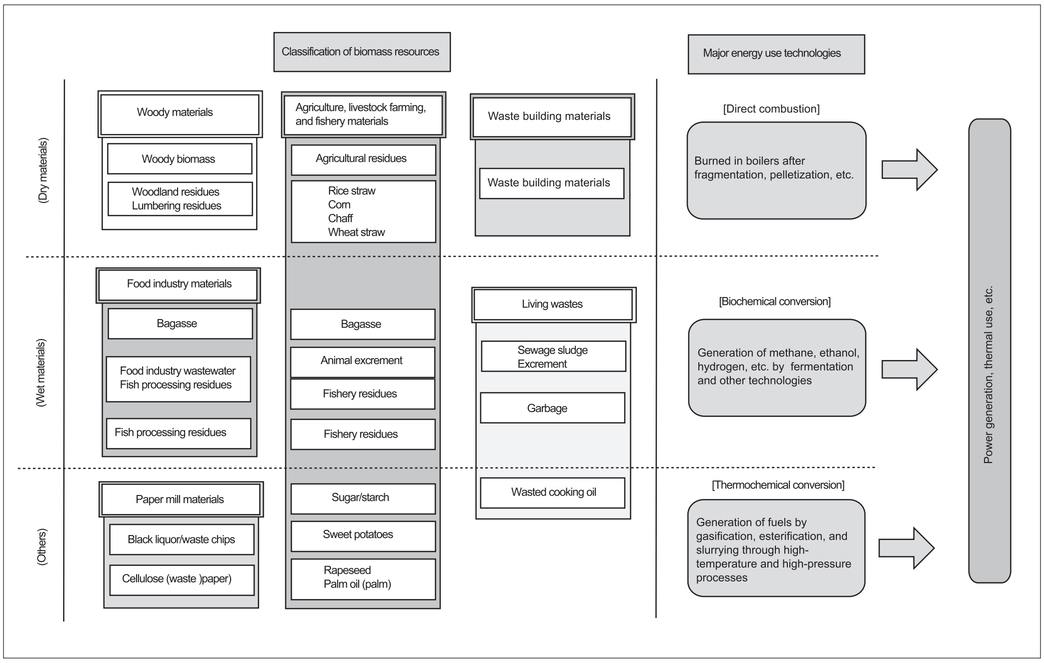

Figure 6 : Classification of biomass power generation and resources

Source : Reference[13]

water heaters (product name: Eco Cute) developed in Japan are being reviewed for introduction in the world as part of energy saving and total electrification. In particular, heaters can reduce the amount of CO_2 emissions to about 1/5 (compared to oil heaters) of those generated by systems that produce thermal energy by direct combustions of fossil fuels, and heat pump water heaters for cold areas can achieve a COP (coefficient of performance: ratio of produced energy to consumed power) exceeding 4. Hence, wider use of these technologies is desirable. The combination of thermal storage technologies, such as water thermal storage and ice thermal storage, and heat pump technology is effective not only for energy saving but also for load leveling. The heat pump air conditioning systems using low-temperature (10-20°C) geothermal energy shown in Figure 7[15] are expected to be widely used as measures for power demand peak cut, especially in summer. Some of the latest heat pumps use normally unused underground space for water thermal storage tanks (Figure 8).[16] Water in a thermal storage tank can also be used for fire-fighting or for emergency domestic purposes in time of disaster. From this viewpoint, this technology has potential value not only for earthquake-prone Japan, but also for the other Asian countries, which have suffered a series of natural disasters recently.

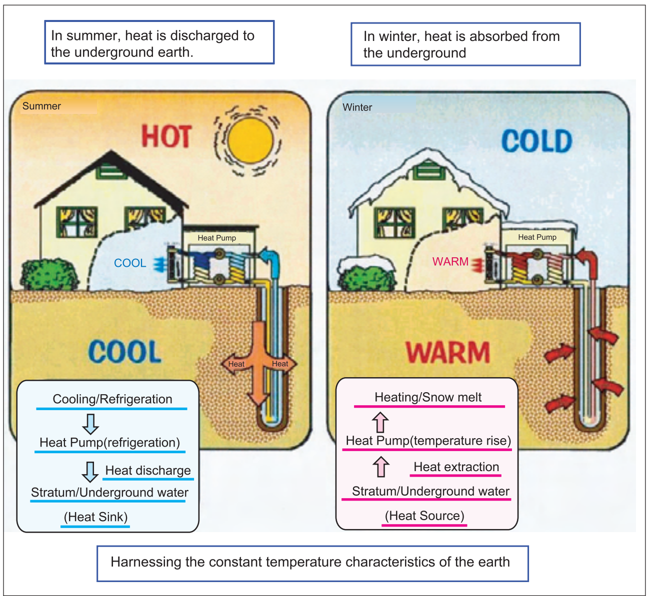

Figure 7 : Heat pump system using geothermal energy

Source : Reference[15]

4 Issues in the Japanese electric power industry from the viewpoint of Greenhouse Gases control

4-1 Improvement in the Energy Availability Factor of nuclear power plants

Nuclear power generation is vitally important in that it produces no GHGs emissions. It will play an important role in Japan in controlling global warming. Figure 9 shows the Energy Availability Factor of nuclear power generation plants by country.[17-18] France has a relatively low Energy Availability Factor due to load following operation, a technology in which output is changed in response to changes in power demand. Other major countries have high Energy Availability Factor of around 90%. Japan has a record low level of 60.7% because of the long-term shutdown caused by the Niigata Chuetsu-oki Earthquake and other factors. Improvement in the Energy Availability Factor is useful for controlling fossil fuel consumption, contributing to reductions in CO_2 emissions and power generation costs. In the case of Japan, a 1% improvement in the Energy Availability Factor results in a CO_2 emission reduction of about 3 million tons. Assuming that the rate increases

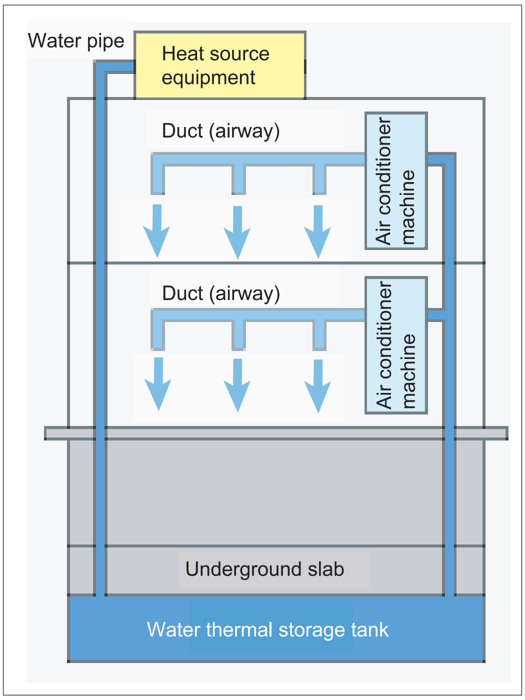

Figure 8 : Heat pump system equipped with underground water thermal storage tank

Source : Reference[16]

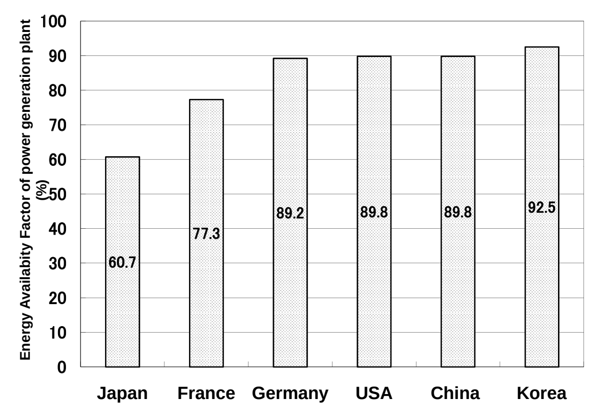

Figure 9 : Energy Availability Factor of nuclear power generation plants by country

Prepared by STFC based on Reference[17,18]

to 90%, as in other countries, a CO_2 emission reduction of about 88 million tons can be achieved (corresponding to about 6.9% of Japan's total CO_2 emissions in 2006). Improving the Energy Availability Factor requires assuring the safety of facilities, including appropriate measures against earthquakes, increasing transparency and openness, and gaining community trust. The requirements for this include wider use of constant rated thermal output operation (an operation method in which the thermal output generated from a nuclear reactor is held constant, unlike the conventional method of keeping electric output constant), extension of the continuous operation period through the adoption of online maintenance (carrying out maintenance and repair of spare machinery during plant operation) and monitored maintenance (monitoring the operation of equipment to determine its inspection dates), and increased rated output. Technologies for maintenance, inspection, and safety evaluation must be further improved for these purposes.

Studies on measures against aging, corrosion-resistant materials, high-level waste treatment, and human error are important for increasing the use of nuclear energy. Research on total efficiency improvement through the effective use of waste heat will also be important in the future.

4-2 Promotion of the use of natural energy

Figure 10 shows a comparison of CO_2 emissions by power source based on life cycle assessment (LCA).[19] Hydro power is apparently most appropriate from the viewpoint of CO_2 emissions. Japanese hydro power energy is all domestically produced, but about 70% of the country's potential output-based hydro power has already been developed. The remaining hydro power resources are located in up-country areas and are small in size, which makes it difficult to ensure economic efficiency. The effective use of low GHGs emitting hydro power energy under such conditions requires the development of small- and medium-scale hydro power generation plants using existing dams, agricultural irrigation channels, and water and sewage systems. Micro hydro power generation using small-capacity hydraulic power sources with a small head drop should be promoted in the future from the viewpoint of the compactification of cities. Application of the latest high-efficiency equipment such as water turbines and generators to existing large-scale hydro power plants is also effective. Research efforts to improve the efficiency of hydro power generation-related equipment need to be continued in the future. The Asian countries, on the other hand, have an abundance of undeveloped hydro power energy. Wide introduction of Japan's advanced hydro power generation technologies, such as hydraulic turbines and generators, is needed for stable energy supply and GHGs control in the Asian countries.

Figure 11 shows the amounts of geothermal resources and the capacities of power generation facilities[20] by country. Japan, one of most earthquake-prone countries in the world, has rich potential for geothermal energy, but it has a limited number of appropriate sites for building geothermal power plants due to restrictions on development in national parks and tourist spots. Enhanced geothermal power generation, from which

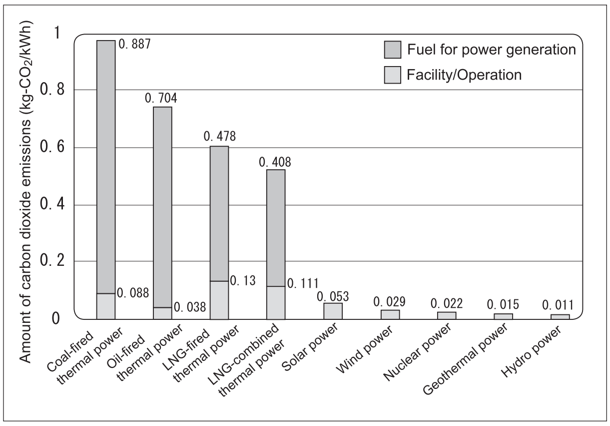

Figure 10 : Comparison of CO_2 emissions by power source type based on life cycle assessment

Prepared by STFC based on Reference[19]

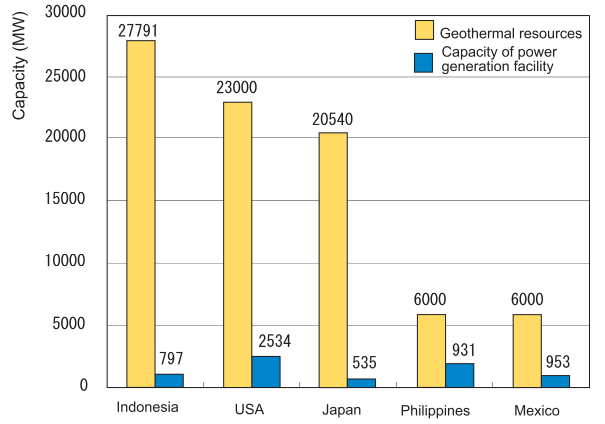

Figure 11 : Amounts of geothermal resources and the capacities of power generation facilities by country

Prepared by STFC based on Reference[20]

higher temperature and pressure steam can be produced, and currently unused binary cycle power generation, for which lower temperature steam and hot water (80-150°C) can be used, should therefore be developed for the effective use of geothermal energy. The air conditioning systems using low-level geothermal heat (10-20°C) described in Chapter 3 also need to be used more widely.

Solar power and wind power generation, on the other hand, are currently a focus of strong interest. These technologies have been introduced nationwide, and their further promotion should be encouraged. In the installation of generators, and wind power generators in particular, full consideration should be given to the environment and to measures against lightning strikes. Because these generators using natural energy can change output depending on weather conditions, concern about the effects of frequency and voltage variations on the electric system must be considered in case of large-scale introduction. Since stand-by operation of thermal power plants to balance out these effects is undesirable for GHGs control, the development of energy storage technologies such as storage batteries is essential. The use of solar thermal energy should also be encouraged.

4-3 Electric load leveling and power storage technologies

Figure 12 shows an example of the power generation configuration by power source when daily variations in power demand are considered.[21] Use of nuclear power with no power conditioning as base load is assumed, and in most cases, thermal power is used to adjust supply and demand. The gap between daytime and nighttime demand has recently been widening, mainly in summer. The need to cope with minimum nighttime demand makes further increases in the ratio of nuclear power generation difficult. Figure 13 shows the ratio of generated nuclear power and hydro power to total generated power. The basic unit of CO_2 emissions in France, which relies most heavily on nuclear power for electric power, is extremely low compared to those of the other major countries. Improving load leveling to correct the daytime-nighttime gap and increasing the ratio of nuclear power generation are effective for GHGs emission control in Japan. Since improved load leveling enables stable thermal power generation at high output, GHGs emission control can be expected as a result of the improvement in thermal power generation efficiency. Needless to say, the power source configuration must be optimized, comprehensively considering stable supply, economy, fuel procurement, and location, but efforts to provide better load leveling are crucial for GHGs emission control.

Load leveling technologies include peak shift technologies, such as the heat pumps described above, which shift power demand from day to night by using heat stored at night for daytime air-conditioning, bottom-up technologies, such as electric water heaters, which encourage nighttime power demand, and peak cut technologies, such as geothermal air conditioning systems, which control daytime power demand. Pumping-up hydro power is currently used as a peak shift technique for

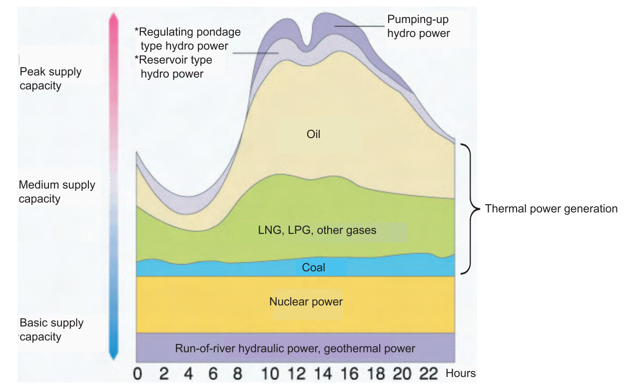

Figure 12 : Example of power generation configuration by power source considering daily variation in power demand

Prepared by STFC based on Reference[21]

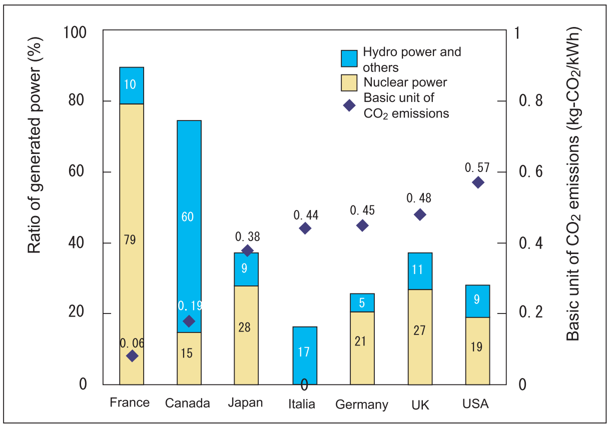

Figure 13 : Ratio of generated nuclear power and hydro power to total generated power and basic unit of CO_2 emissions

Prepared by STFC based on Reference[6]

storing power at night and using it during the day. As described above, however, no large increase in this type of power generation can be expected in the future. Cost reduction and wider use of power storage technologies using new types of storage batteries, such as sodium sulfur batteries and redox-flow batteries, both of which are in practical use, are needed. The early practical application of superconducting magnetic energy storage (SMES) technology, which is in the verification test stage, is also desirable. In particular, power storage technologies will be indispensable for the large-scale introduction of solar power generation and wind power generation.

5 Future approaches

Based on the above, the following discusses the future issues which Japan must address.

The increases in world population and energy demand will create many environmental problems, among which climate change should be actively addressed, as this will have a significant impact on human life and health and the living environment. For environmental problems such as regional air pollution and water pollution, Japan should provide other countries with technologies and information based on its experience.

5-1 Encouragement of CO_2 emission reduction through wider use of existing technologies

As clearly stated in Japan's Third Science and Technology Basic Plan, "integration of the environment and the economy" is the basic principle for building a sustainable society. The government of the United Kingdom published the Stern Review on the Economics of Climate Change[22] in 2006, which was based on reports by economists, scientists, policy makers, and participants from industry and NGOs who visited many major countries, including Brazil, Canada, China, EC, France, Germany, India, Japan, Mexico, Norway, Russia, South Africa, the United States, and international organizations to exchange information and opinions. At the Hokkaido Toyako G8 Summit held in July 2008, leaders discussed the environment and climate change as major subjects. The G8 countries agreed to "have a visionary objective of achieving at least a 50% reduction in world emissions by 2050 in common with all UNFCCC (United Nations Framework Convention on Climate Change) signatory countries, discuss the objective with them, and advise the UNFCCC to adopt it." The agreement includes a statement that developed countries need to accelerate the expansion of existing technologies and contribute to the world through the development and expansion of low-carbon technologies.[23] The "Action Plan for Building a Low-carbon Society" approved at a meeting of Japan's Cabinet in July 2008 set a long-term goal for this country. The plan intends to ensure that world emissions peak out in the next 10 to 20 years, and achieve a 60 to 80% reduction in Japanese emissions and a 50% reduction in world emissions by 2050.[24]

Japanese government ministries and agencies are studying various measures for GHGs reduction. Figure 14 shows a technical plan for GHGs emission reduction in which the Ministry of Trade, Economy and Industry (METI) is playing a leading role.[25] The plan intends to develop innovative technologies such as high-efficiency power generation and next-generation automobiles for reducing total CO_2 emissions by about 60%. A tentative calculation shows that existing technologies can contribute to a reduction of 40%.

The Environment and Energy Technology Innovation Plan prepared by the Council for Science and Technology Policy states : "Improving existing technologies greatly contributes to Greenhouse Gases emission reduction on a short-term basis. This approach has, however, limitations when aiming to reduce emissions drastically. On a medium- to long-term basis, the development of innovative technologies is essential to radically reduce emissions. Investment in research and development is made to improve existing technologies for a short period, but the focus of investment needs to be eventually shifted to innovative technology development."[26] On a short-term basis, therefore, Japan needs to put priority on transferring existing technologies to developing countries. These technologies include the world's most advanced technologies for high-efficiency power generation and transmission and distribution loss reduction, as well as technologies for energy-saving and pollutant removal. These activities will eventually help Japan mitigate environmental problems.

5-2 Encouragement of wider use of natural energy

The use of natural energy should be encouraged to reduce CO_2 emissions in the future. Solar power generation and wind power generation will be widely used in Japan. Because hydro power generation and geothermal generation can produce more stable outputs than solar and wind power generation, their importance should be emphasized. Hydro power, which is all domestically produced energy, produces a minimum amount of CO_2 emissions when generating energy. However, the effective use of unused hydro power energy resources will require a careful study of economic feasibility and appropriate locations. As for the maintenance of existing hydro power plants and water discharged from such plants, study and verification of their environmental condition and research and development on energy recovery are needed.

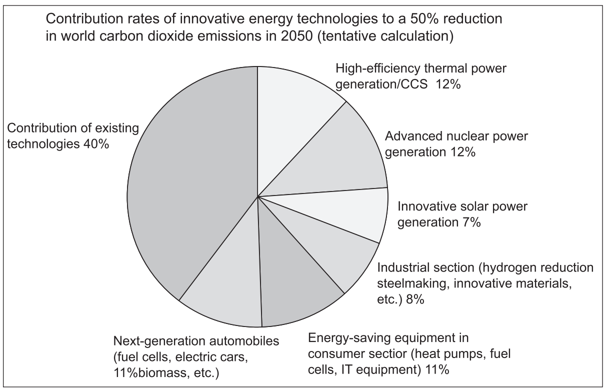

Figure 14 : Contribution rates of technologies to CO_2 emission reduction in 2050

Source : Reference[25]

Geothermal power and hydro power, produces only a small amount of CO_2 emissions when generating energy, and has a large resource potential in Japan. Many restrictions are also imposed on geothermal energy, these needs to be relaxed. Because the risk of the initial investment is a hurdle for geothermal power generation, support for the initial investment is necessary.

5-3 International contribution through transfer and implementation of technologies

As shown in Figure 4, the thermal efficiency of Chinese thermal power plants is lower than in the developed countries. As reasons for this, about 53% of China's thermal power facilities have a power generation capacity of 300,000 kW or less, and many existing small-scale power facilities with a power generation capacity of 100,000 kW or less have thermal efficiency in the 20% range.[27] In addition to technologies for modernizing these small-scale, low-efficiency facilities, transfer of technologies for plant operation, maintenance, and inspection to China is a significant international contribution. For example, a project to improve the thermal efficiency of aged coal-fired thermal power plants in China, which was carried out by Kyushu Electric Power Company in 2001, improved thermal efficiency by as much as 4.4% by introducing appropriate operation control, inspection, and maintenance practices. The thermal efficiency of these plants had been lowered by a reduction in the amount of transferred heat caused by coal ash deposits, increased pressure loss in air/flue ducts caused by ash deposits, and reduced efficiency caused by turbine blade wear and scale buildup on turbine blades. Thus, Japan's advanced plant control systems[28] and maintenance and inspection technologies, as well as power generation technologies, are highly valued in the world.

With increasing power demand, developing countries are building many power plants, and they need to improve their electric power systems. Transmission and distribution loss rates are extremely high in developing countries like India. Tokyo Electric Power Company and the Central Research Institute of Electric Power Industry, for example, concluded a technical cooperation agreement on 1 million volt transmission of electric power with China in 2005. Such international cooperation using Japanese advanced transmission and distribution technologies and SF_6 recovery technology to reduce transmission and distribution losses in developing countries is of great significance for global GHGs control.

As described above, Japan has the world's most advanced technologies for high-efficiency power generation and transmission, energy saving, power storage, and environmental measures. The use, establishment, and improvement of these existing technologies in this country are critically important for domestic GHGs emission reduction. Provision of knowledge, such as know-how on operation control, inspection, and maintenance, as well as Japan's high-efficiency equipment and other advanced hardware in the field of power technology, to technology-hungry developing countries is needed for regional environmental conservation and the reduction of total global GHGs emissions.

5-4 Better approaches and wider opportunities for consensus building

The implementation of energy and environmental policies requires not only technical development and infrastructure construction but also consensus building among the industrial, academic, public, and private sectors. In Japan, air pollution from smoke-emitting factories damaged human health during the high economic growth period of the 1950s. Administration, industries, and residents cooperated in tightening regulations, reviewing systems, developing technologies, and monitoring to overcome problems. These various efforts resulted in today's excellent environmental conditions in Japan.[29] Thus, cooperation between government agencies, industries, and the general public are essential to environmental improvement. Appropriate policies which expand platforms for consensus-building and widen opportunities for residents to actively participate by such platforms are necessary. Academic research through cooperation between the fields of social science and technology is important.

Building a vision of a desirable society in the future, such as an approach to climate change issues, for example, requires participation from many countries, a wide range of professional fields, and various viewpoints. In the case of the developing countries in particular, it is important for administration to play a central role in establishing platforms for consensus building among administration industries, and residents and increasing opportunities for discussion. These efforts are expected to lead to problem solving in individual countries. Referring to the example of other countries such as Germany, which are already actively grappling with consensus building processes, Japan should also introduce such processes into policy making more actively than it has in the past.

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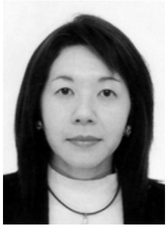

Kuniko URASHIMA
Senior Research Fellow, Environment and Energy Research Unit, Science and Technology Foresight Center
http://www.nistep.go.jp/index-j.html
D. Eng.
Dr. Urashima joined the Institute in 2003 after working in the fields of environmental pollutant treatment and removal technologies using plasma technology at electric manufacturers, universities, national institutes, and company in Japan, Canada, the United States, and France. She is mainly surveying general science and technology trends on the environment and energy in the world.

Toshinori TOMA
Research Fellow, Environment and Energy Research Unit, Science and Technology Foresight Center
http://www.nistep.go.jp/index-j.html
D. Eng.
Dr Toma was mainly involved in research and development of environmental technology and analysis technology at Tokyo Electric Power Company. He is interested in science and technology policy for realizing a low carbon society and is currently conducting survey work in the fields of the environment and energy.

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