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Trends and Prospects for Japan-China Technical Assistance in Energy and the Environment
— From the Viewpoint of Global Environmental Problems and Energy Security —

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1 Introduction

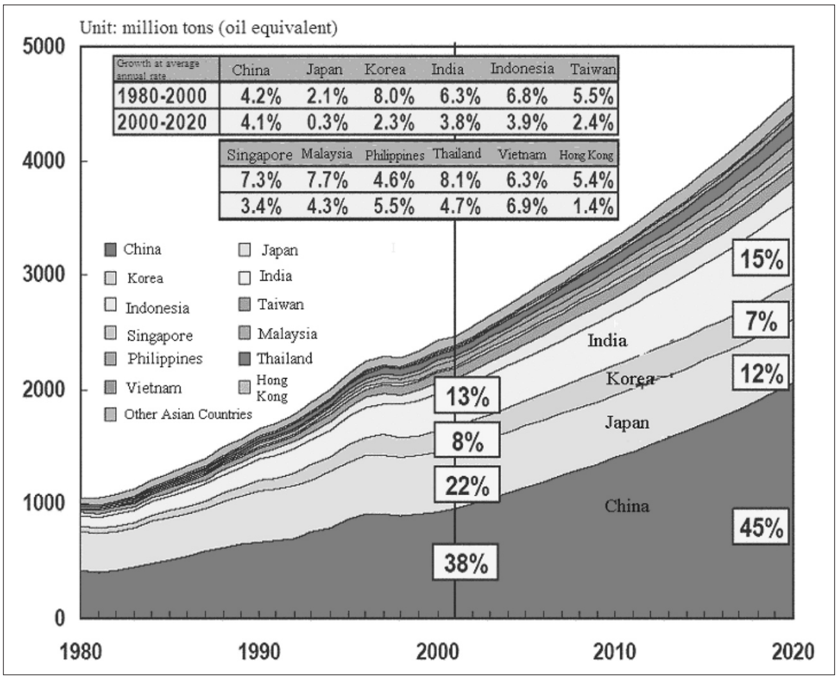
Achieving 3E - Energy security, Environmental preservation and sustainable Economic growth - is the biggest challenge to be faced by the international community in the 21st century. While the world economy has globalized rapidly in the post-Cold War period with the progress of IT, the Asian "tigers" (countries that have achieved high economic growth) are beginning to exert a considerable impact on the world's energy market. With these countries expected to continue rapid growth and consuming more energy, the Asian region is the most likely to place a huge burden on the global environment in coming years. In particular, it is estimated that China's primary energy consumption will account for some 45% of Asia's total consumption and 50% of its CO_2 emissions in 2020[1]. Worse still, air pollution involving sulfur and nitrogen oxides, etc. in China will probably have serious effects on neighboring countries, including Japan. It is thus critical that Japan work together with China in addressing the 3E issue by securing energy supply and tackling energy-related environmental problems.

In the meantime, China's remarkable economic growth, a product of the government's reform and liberalization policy, is resulting in power shortages, depletion of natural resources and serious environmental disruption. Alarmed at the present situation, since these problems represent a potentially serious undermining of national economic and social development, the Chinese government is beginning to reorient itself to a "recycling economy," considering a revision of the current economic development model as part of its strategy for sustainable development. The international community has been insisting on the need to create such an economy in China in view of global environmental conservation, placing high expectations on technical assistance from Japan, which has been striving to develop environmental conservation technologies.

Japan has been offering technical assistance to China through the ODA (Official Development Assistance) in the fields of energy and the environment. Major independent administrative agencies engaged in international technical assistance include the Japan International Cooperation Agency (JICA), the Japan External Trade Organization (JETRO) and the New Energy and Industrial Technology Development Organization (NEDO), all of which are making substantial contributions to China in their respective fields. However, considerable recent problems have surfaced such as inappropriate technology transfer and a shortage of local maintenance engineers.

This article provides an overview of the 3E issue, based on the present situation in China and Japan. It also summarizes trends and prospects for Japan-China technical assistance from the perspective of a cooperative framework, coal exploitation, clean coal technology, environmental conservation technology and the utilization of natural gas, and nuclear and renewable energy, thereby providing some suggestions as to how Japan and China should

Figure 1: Asia's primary energy consumption by region



Source: The Institute of Energy Economics, Japan[1]

cooperate with each other in addressing the 3E issue.

2 Status in Japan and China concerning energy, the environment and economy

2-1 Status in China

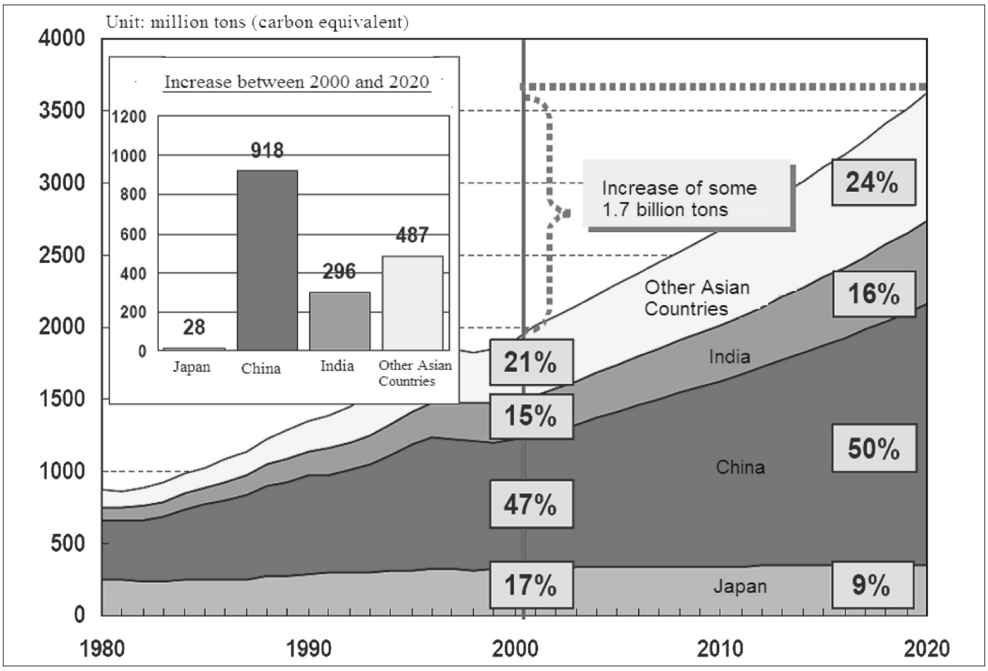
The Chinese economy, which expanded dramatically in the 1990s thanks to robust domestic demand, has experienced 7-9% annual growth since accession to WTO in 2001. Despite uncertainties associated with internal economic disparities, ongoing reforms of state-owned companies, unemployment and non-performing loans, the economy is expected to continue growth at an average annual rate of 7.2% provided the current macro-economic policy remains in place[1].

Energy demand in China, meanwhile, has increased dramatically due to the rapid economic growth and advancing motorization. Indeed, China is now the world's second largest consumer of primary energy and is expected to consume an amount equivalent to 2.06 billion tons[1] of oil in 2020 (or 1.7 billion tons, according to the World Energy Outlook 2002 of IEA). It is estimated that China's consumption of primary energy will account for some 15% of total global consumption, or as much as 45% of Asia's total 2020 consumption (as compared to 38% in 2000), as shown in Figure 1[1].

Coal and oil account for about 70% and 20%, of the primary energy in China respectively - a situation attributable to the country's abundant coal resources, ensuring a stable supply of low-cost coal. Coal continues to be a major energy source in China, though its share of the energy mix is expected to decrease to 56% in 2020 due to increasing dependence on natural gas and nuclear energy. Coal is also an essential energy source for power generation: coal-fired power generation made up 78% of the total in 2000; hydraulic power generation, 16%; oil-fired power generation, 3.4%; and nuclear power generation, 1.2%[1,5]. The share of coal-fired power generation is estimated to be 70% for 2020[1].

On the other hand, some estimates predict global CO_2 emissions to increase from 6.5 billion tons in 2000 to 9.9 billion tons in 2020 (both on a carbon equivalent basis) and emissions from Asian countries are expected to account for about half of the increase. In particular, those from China are estimated at 1.8 billion tons (carbon equivalent) [1] for 2020 (or 1.5 billion tons, according to reference[2]), second only to the U.S.A. As shown in Figure 2, the proportion

Figure 2 : Trends in Asia's CO_2 emissions



Source: The Institute of Energy Economics, Japan[1]

of China's emissions as part of Asia's total will increase from 47% in 2000 to 50% in 2020. Asia's total emissions, meanwhile, are expected to increase by 1.7 billion tons (carbon equivalent) between 2000 and 2020, about 53% of which will come from China. Major emission sources in China are the power generation and industrial sectors, while emissions from the transport sector are increasing due to motorization. Increased CO_2 emissions from China will likely have a substantial impact on global warming.

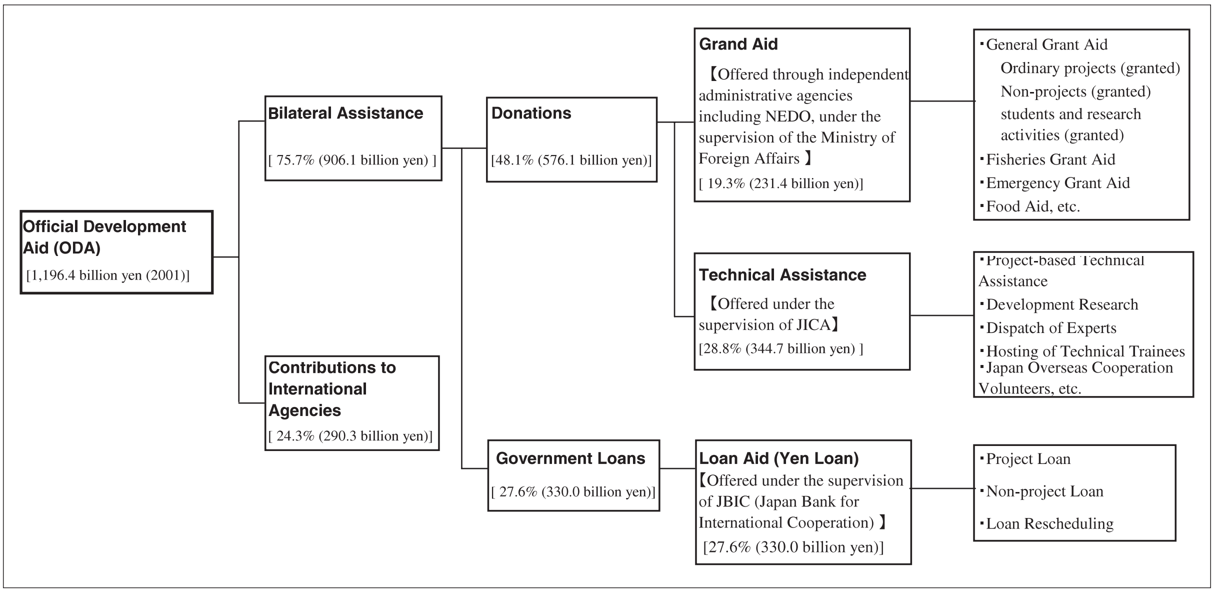
In contrast, emissions of sulfur oxides, which experienced an upward trend in the 1980s and the first half of the 1990s, peaked in 1996-1997 and have since been decreasing due to altered industrial structure, improved energy efficiency and tightened environmental regulations[2]. Nevertheless, seven cities in China were ranked among the world's 10 most seriously polluted cities, according to a survey conducted by WHO in 1998. Air pollution continues to be a major concern in China, while its antipollution measures have yet to prove effective. As mentioned earlier, moreover, the country is experiencing rapid motorization and the serious air pollution resulting from such economic growth may have a substantial impact on neighboring countries, including Japan[17].

2-2 Status in Japan

Because of the policy prioritizing energy security above all, a fuel shift (from oil to nuclear energy, natural gas and coal) and energy-saving measures (adopted primarily by the industrial sector) have made dramatic headway over the past three decades. As a result, the proportion of oil in the total energy mix has decreased from 77% to 49%. With the economy growing modestly (at an average annual rate of 1.3%), and a declining population due to a falling birthrate and an aging population as well as progressive energy-saving measures progressing, Japan's energy consumption is expected to level off or decrease in the future. Accordingly, its predicted share of Asia's primary energy consumption will decrease from 22% in 2000 to 12% in 2020 (see Figure 1).

While the prevention of global warming has become a key issue, Japan seems unable to reduce its greenhouse gas emissions by 6% (from the 1990 levels, taken from a five-year average) between 2008 and 2012 in accordance with the Guideline of Measures to Prevent Global Warming (the Kyoto Protocol). As shown in Figure 2, however, the proportion of Japan's CO_2 emissions as part of Asia's total is expected to decrease from 17% in 2000 to 9% in 2020. By contrast, China's

Figure 3 : Framework of Japan's ODA



Source: Prepared by the author, based on the website of ODA : http://www.mofa.go.jp/mofaj/gaiko/oda/

emissions will increase, as mentioned in Chapter 2-1. In addition to reducing domestic emissions, therefore, Japan should work together with Asian countries (particularly China) to curb the regional greenhouse gas emissions.

Specifically, it is essential that Japan offer its advanced technologies in terms of coal utilization and clean coal technologies, environmental conservation technologies, and technologies for utilizing natural gas and nuclear and renewable energy to these countries.

3 Trends and challenges in Japan-China technical assistance

3-1 Previous trends in Japan-China technical assistance

This chapter addresses trends in Japan-China technical assistance from the viewpoints of economic assistance, research cooperation and private investment.

(1) Economic assistance

Japan has been offering technical assistance to China through ODA (Official Development Assistance) in the fields of energy and the environment[10]. As shown in Figure 3, Japan's ODA is comprised of bilateral assistance (direct assistance to developing countries) and multilateral assistance (assistance through international agencies). The former includes donations (grant aid and technical assistance) and bilateral loan (loan aid or yen loan). Figure 3 shows the total amount of assistance in 2001 and the proportion of each assistance program in the total; grant aid and technical assistance, when combined, account for around half the total amount.

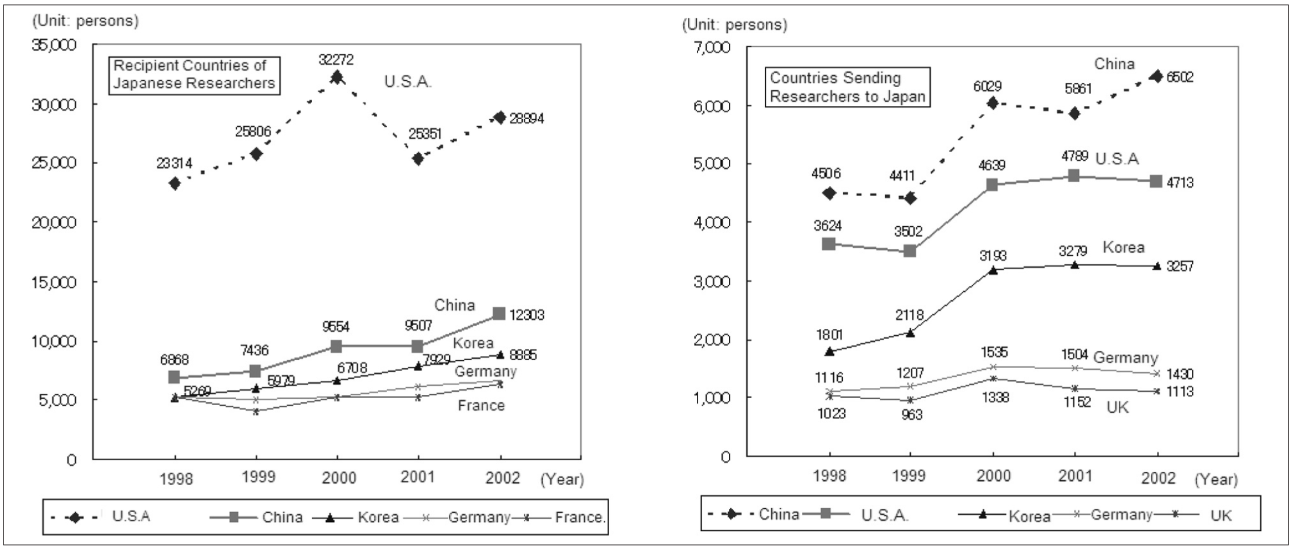
Table 1, meanwhile, shows examples of ODA-based technical assistance to China in the fields of energy and the environment. In the energy field, NEDO plays a leading role in offering technical assistance in the effective use of coal, natural gas and hydraulic power. Specifically, programs for the effective utilization of coal, China's major energy source, have commenced with the introduction of circulating fluidized bed boilers and desulfurizing agent-added CWM (Coal Water Mixture) systems. In the environment field, meanwhile, a variety of environmental conservation measures are in place under the initiative of the Ministry of Environment and JICA to tackle air pollution, acid rain, water treatment, domestic waste disposal, chemical substance management, environmental management policies, etc. Citing the transfer of desulfurization technology as an example, however, the ongoing assistance programs are designed to set up pilot plants rather than commence commercial runs - a situation that makes it difficult to quantify the achievements of Japan's technical assistance[2].

Table 1 : Examples of ODA-based technical assistance to China in the fields of energy and the environment[*1]

Field		Project Name	Organizations Involved		Loan or Grant	Period
			Japan	China		
Energy	Eco-friendly coal utilization	• Introduction of circulating fluidized bed boilers	NEDO	Fangshan Garments Group Co.,Ltd., etc.	Grant	1993-1998, 2002-2004
		• Demonstration of desulfurizing agent-added CWM (Coal Water Mixture) systems	NEDO	Beijing Yanshan Petrochemical Co.	Grant	1998-2002
	Natural gas utilization	• Construction of natural gas distribution facilities (Henan air environment improvement project)	JBIC[*2]	Henan Provincial Government (the Finance Agency)	Loan	2002
		• Construction of natural gas distribution facilities (Anhui air environment improvement project)	JBIC	The State Development Planning Committee	Loan	2002
	Hydraulic power utilization	• Hubei small-scale hydropower plant	JBIC	Huber Provincial Government (the Finance Agency)	Loan	2000
		• Gansu small-scale hydropower plant	JBIC	Gansu Provincial Government (the Finance Agency)	Loan	2000
	Power network	• Harbin power network extension	JBIC	The State Power Corporation of China	Loan	1999
	Effective energy use	• Coke dry quench model project (AIJ)[*3]	NEDO	The State Development Planning Committee	Grant	1996-2000
		• Energy-efficient ferroalloy electric furnace model (AIJ)	NEDO	The State Development Planning Committee	Grant	1997-2000
Environment	Air pollution	• Development of manuals for measures to prevent air pollution from fixed sources	JICA, The Ministry of the Environment	The State Environmental Protection Administration	Grant	1996-1997
		• Measures to alleviate regional air pollution (including acid rain, yellow sand and particle contaminants)	JICA	The State Environmental Protection Administration	Grant	2002-2006
	Acid rain	• Development of model strategies and plans for acid rain monitoring networks	JICA, The Ministry of the Environment	The State Environmental Protection Administration	Grant	1996-1999
		• Development of measures to reduce emissions of pollutants causing acid rain in East Asia and research into assessments of its environmental impact	JICA	The State Environmental Protection Administration	Grant	1998-1999
	Urban	• Measurement and calculation of auto-emission coefficients in relation to Dalian environmental model city surveys	JICA	The State Environmental Protection Administration	Grant	1997
		• Japan-China environmental development model cities plan	The Ministry of Foreign Affairs	The State Environmental Protection Administration	Grant	1998-1999
	Water treatment	• Research cooperation in coal mine wastewater biotreatment	NEDO	The State Development Planning Committee	Grant	1993-1998
		• Suzhou water environment conservation plan	JBIC	Suzhou Provincial Government	Loan	1999
	Domestic waste disposal	• Joint research on domestic waste disposal in Beijing City	JICA	The State Environmental Protection Administration	Grant	1998-2000
	Chemical substance management	• Management of new hazardous chemical substances such as dioxins and EDCs	JICA	The State Environmental Protection Administration	Grant	2002-2006
	Environmental management policies	• Improvement of environmental information networks	The Ministry of Foreign Affairs, JICA	The State Environmental Protection Administration	Grant	1998-1999
		• Improvement of environmental management standards (measures to promote ISO 14000, trial introduction of a pollution control manager system	JICA	The State Environmental Protection Administration	Grant	2002-2006

*1: Prepared by the author, based on the websites of ODA http://www.mofa.go.jp/mofaj/gaiko/oda/, New Energy Development Organization (NEDO) http://www.nedo.go.jp/kankobutsu/nenshi/3color/1999_2000/kokusai/01tojyou.html and the Sino-Japan Friendship Center for Environmental Protection Project (Japan International Cooperation Agency) http://www.zhb.gov.cn/japan/fulezu2syoukai.html
*2: Japan Bank for International Cooperation
*3: A joint implementation project in accordance with UNFCCC (U.N. Framework Convention on Climate Change)

Figure 4 : Top five countries in international research cooperation (universities, research institutes, etc.)



Universities include national universities, inter-university research institutes, national junior colleges, national technical colleges, public universities and private universities. Research institutes refer to national research institutes, independent administrative agencies and government-affiliated research institutes. Public and private universities, and national junior colleges were included in the survey as from 1997; national technical colleges, national research institutes and government-affiliated research institutes, as from 2000.

Source: Prepared by the autohr, based on Reference[19]

(2) Research cooperation

A survey was conducted on the number of exchange programs agreed between Japanese and overseas universities (as of October 1, 2002, covering technical fields including energy and the environment) to keep track of research cooperation between universities and research institutes in Japan and China[19]. Japanese universities primarily cooperate in research activities with counterparts in Asia, Europe and North America. In particular, Chinese universities account for some 44% of the Asian universities currently in partnership with Japanese counterparts.

Since the conclusion of the “Science and Technology Cooperation Agreement” in May 1980, the Japanese and Chinese governments have held regular meetings of the Joint Science and Technology Cooperation Joint Committee. The latest gathering took place in February 2003 to exchange views in four priority fields including energy and the environment; producing an agreement concerning cooperation in research on “science and technology to conserve the environment and create an eco-friendly society.”

Another survey was conducted on the number of Japanese researchers sent overseas and foreign researchers accepted (by country), with the aim of clarifying the extent of international research cooperation among Japanese universities and research institutes. Figure 4 shows recent trends in the top five countries. Japan has accepted the largest number of researchers from China, which itself is second in terms of the destination of Japanese researchers sent overseas (about 40% of those are sent to the U.S).

(3) Private investment in China

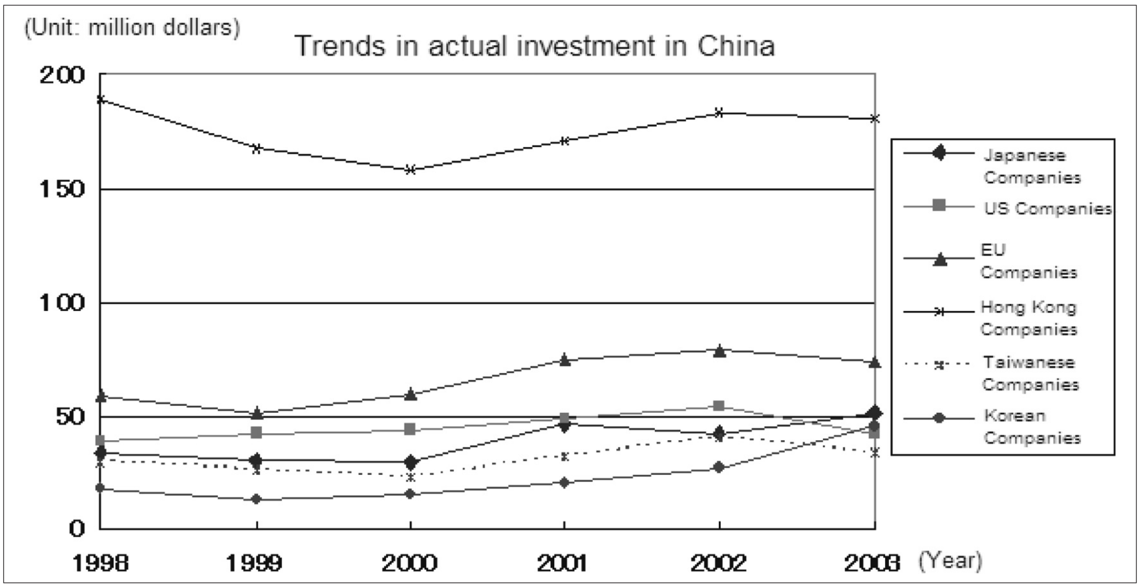
A survey was conducted to monitor Japanese companies’ investment in China (in comparison with EU, US and Asian companies). Figure 5 shows trends in actual investment in China in all technical fields including energy and the environment. Japanese companies have been less aggressive than those in Hong Kong and EU countries. Jin Jianmin, a chief researcher at Fujitsu Research Institute who summarized an interview survey conducted in China, suggests that this is attributable to resources in information gathering, sales and distribution -which tend to be lacking in Japanese companies as compared to their EU rivals[11].

3-2 Challenges and measures for cooperation between Japan and China

A closer look at trends in Japan-China technical assistance from the viewpoints of economic assistance, research cooperation and private investment reveals progress in a variety of fields including energy and the environment. As shown in Table 2, however, there have been challenges posed to both the public and private sectors to further advances in cooperation[2,3]. One is the transfer of appropriate technology and the other is the training of maintenance engineers. The former involves discrepancies between Japan's cooperation programs and the present situation in China. Specifically, (i) China's infrastructure has yet to be fully developed due to financial and institutional constraints and (ii) the dwindling resources of Japanese companies in terms of information gathering, sales and distribution are resulting in inappropriate technology transfer. The latter concerns Chinese engineers and researchers working on site, to whom techniques and expertise have yet to be passed on. Specific problems include (i) insufficient training programs due to a shortage of experts sent from Japanese companies and universities and (ii) a lack of training facilities.

An energy and environmental technology center should thus be established and promoted, based on a Sino-Japanese governmental agreement. Accordingly, it is recommended that training institutes be set up all over the country, each of which will serve as a base to demonstrate the specialties and products of Japanese companies and universities, offering training programs in energy (including energy-saving measures) and environmental management respectively. Middle-ranking on-site engineers are expected to develop expertise (which will then be passed on to workers) through such institutes. On the other hand, it may also be advisable for Japanese companies to conduct field trips to gather first-hand information to ascertain what is really needed. The center will also function

Figure 5 : Private investment in China



Source: Prepared by the author, based on statistical data of Japan-China Investment Promotion Organization (http://www.jcipo.org/)

Table 2 : Challenges and measures for cooperation between Japan and China

<table>
<tr><th>Subject</th><th>Challenges</th><th>Measures</th></tr>
<tr><td>Transfer of appropriate technology</td><td>• Japan's cooperation programs (technology transfer) do not correspond to the present situation in China.
◦ Inefficient infrastructure due to financial and institutional constraints
◦ The dwindling resources of Japanese companies in terms of information gathering, sales and distribution</td><td rowspan="2">• Establishment of an energy and environmental technology center to:
◦ Demonstrate the specialties and products of Japanese companies and universities
◦ Offer training programs in energy management and environmental management
◦ Conduct field trips to gather first-hand information on site (ambient surroundings, basic requirements, etc.)
◦ Work with the Chinese government to protect the intellectual property rights of commercialization technology to be transferred and to improve the investment climate for the transfer</td></tr>
<tr><td>Training of engineers</td><td>• Techniques and expertise have yet to be passed on to Chinese engineers and researchers working on site.
◦ Both the number of Japanese experts and the frequency of their dispatch have been insufficient.
◦ There are not many training facilities in the country.</td></tr>
</table>

as a hub to protect the intellectual property rights of Japan's commercialized technologies and to improve the investment climate for future technology transfer.

While both the Japanese and Chinese governments should address global environmental problems and energy security from a broad perspective, it is critical that Japan's proprietary expertise in coal utilization, clean coal technology, environmental conservation technology and the utilization of natural gas and nuclear and renewable energy be promoted through the center.

4 Japan's advanced clean energy and environmental technologies to be offered

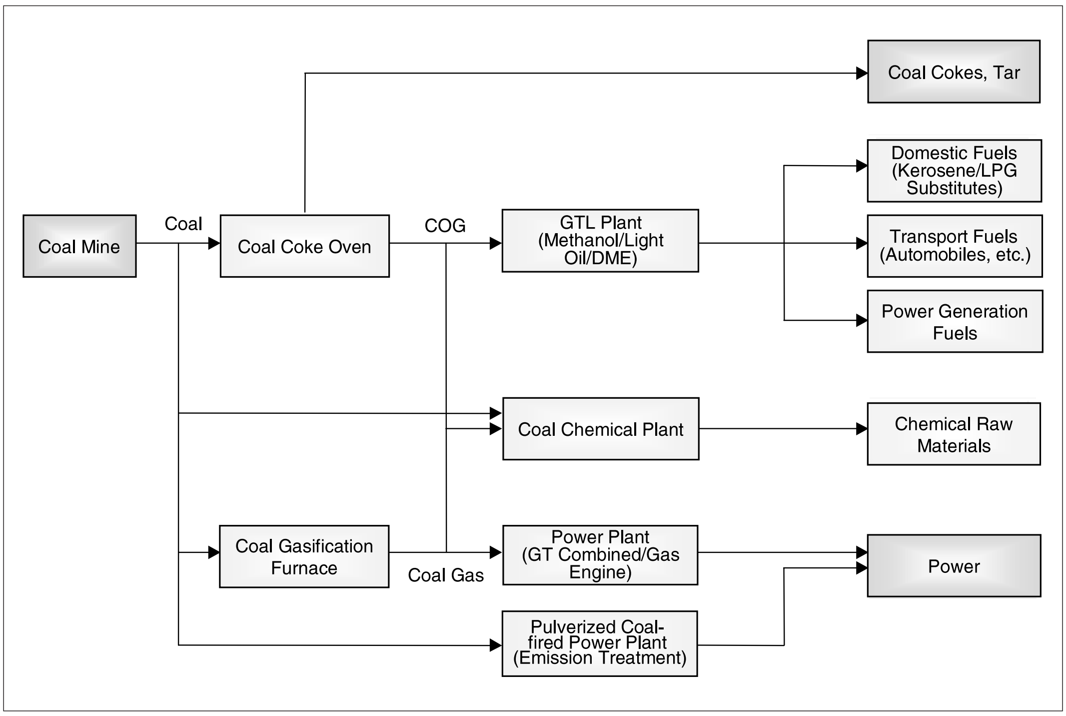
The following are Japan's advanced clean energy and environmental technologies that can be offered to China to solve the country's energy and environmental problems.

4-1 Coal utilization and clean coal technologies

Clean coal technologies are essential to China, which continues to depend on coal for its power supply[7]. These particular technologies include (i) thermal-efficiency improving technology (ii) desulfurization and denitration technologies (iii) coal treatment technology (coal liquefaction, gasification and slurrying) and (iv) coal ash utilization technology. As for technologies relating to (i) and (ii), "supercritical pressure pulverized coal-fired power generation" has already been in practical use in Japan, while "ultra supercritical pressure pulverized coal-fired power generation" and "pressurized fluidized bed combustion combined-cycle systems" are nearing commercialization. In addition, "integrated coal gasification combined-cycle systems" are scheduled for commercialization around 2010, and "coal gasification fuel cell systems," by 2020[2].

High value-added items (methanol, ammonia, activated carbon, etc.), liquid auto fuels, domestic fuels (light oil, kerosene, LPG substitutes such as dimethyl ether, etc.) can be produced through coal treatment technology. Coupled with thermal-efficiency improving technology, moreover, it can create an energy/chemical chain that is based on coal utilization (see Figure 6). With coal gasification plants producing 0.8-1.2 million t/y of liquid methanol operating in Japan,

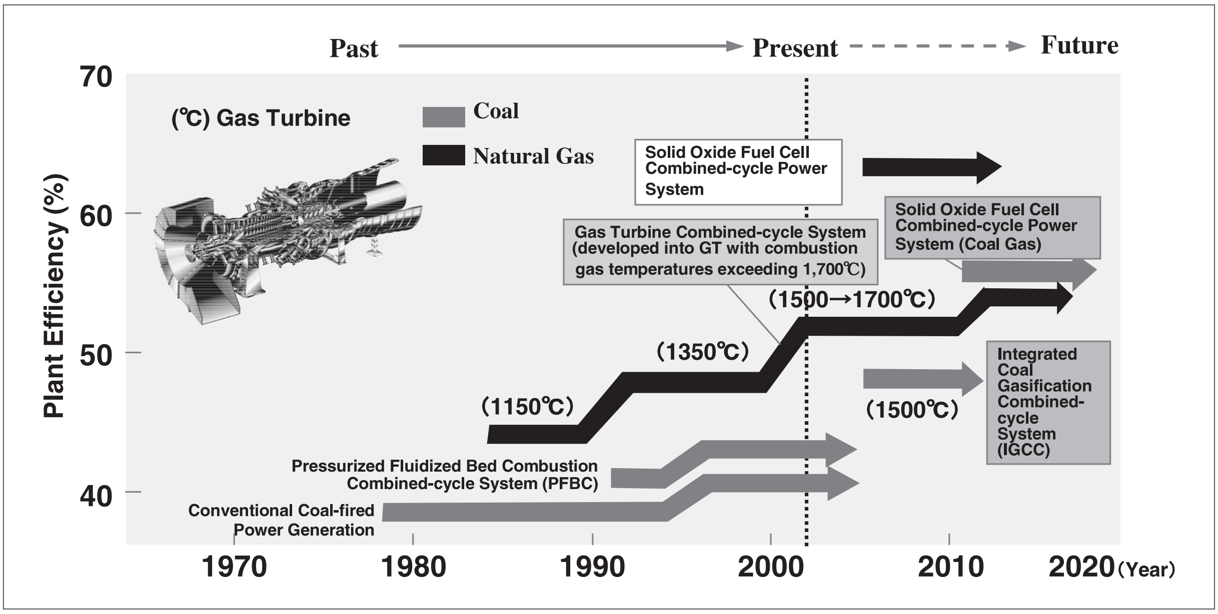
Figure 6 : Coal-based energy/chemical chain



COG: Coke-oven Gas, GTL: Gas to Liquid, GT: Gas Turbine, DME: Dimethyl Ether

Source: Prepared by the author, based on Reference[8]

Figure 7 : Efficiency of natural gas-fired and coal-fired power generation systems



Source: Reference[15]

its expertise in constructing 0.4-0.6 million-t/y methanol plants can be offered to China.

Specific plans are underway in China to develop high value-added industries based on new applications of coal other than those for fuel. Clean coal technology is expected to gain in importance in China.

4-2 Natural gas utilization technologies

Though demand for natural gas constituted a mere 2.7% of overall primary energy consumption in China as of 2002, the government's energy security policy emphasizes the promotion of natural gas as a substitute for oil[4]. It is yet to be seen whether the use of this energy source will expand as dramatically as expected, but natural gas-fired power generation is expected to grow in the country, with power rates in coastal areas stabilizing and environmental regulations tightening[5].

As domestic technologies for natural gas power generation are not available, there is every chance that China will be dependent on overseas technologies. Thus lies the opportunity for Japan to contribute substantially to the construction of natural gas-fired power plants in China, offering its gas turbine technology including gas turbine combined-cycle systems with dramatically improved power generation efficiency, with the temperatures of combustion gas at the inlet of a gas turbine increasing. The third-generation gas turbine combined-cycle systems, for instance, maintain an efficiency level exceeding 50%, with the temperatures of their combustion gas ranging from 1,450 to 1,500 degrees Celsius. At the same time, research is underway to develop a gas turbine with combustion gas temperatures exceeding 1,700 degrees Celsius. Figure 7 shows the power generation efficiency of natural gas-fired power generation, compared with that of coal-fired power generation.

Other categories relevant to natural gas utilization include air conditioning, transportation and distributed power sources such as fuel cells. Japan has the potential to contribute in these categories as well.

4-3 Nuclear energy utilization technology

The National Development and Reform Commission (founded in March 2003) specifies nuclear power generation as one of the principles in developing China's power industry, aiming to set up about 31 nuclear power plants by 2020 to generate 4% (or 36 million kW) of the country's total power supply[6,12]. With domestic technologies for nuclear reactors unavailable, China continues to depend on overseas technologies, as in the case of the aforementioned natural gas utilization technologies. Japan, meanwhile, began to operate light-water reactors (LWR) in 1970, the total output of which account for some 15% of the country's primary energy production, or as much as one third of its total power supply. Japan is thus capable of contributing to China's nuclear power generation through its LWR technology.

The Chinese government decided to sign the London Guidelines[*1](an international framework for the nonproliferation of nuclear technology, controlling imports and exports of nuclear power facilities) in 2004, which will enable Japan to export its nuclear power technology and products to China. With the EU and U.S.A. also poised to offer their expertise, however, full support of the Japanese government is critical to beat the competition.

4-4 Renewable energy utilization technologies

Despite its low energy density, the significance of introducing extremely eco-friendly renewable energy is widely acknowledged. In fact, China began to address renewable power generation technologies in 2000, focusing on solar energy, wind power and biomass[9]. Japan is still taking the lead in this particular area with its commercialized technologies[14], and hence great potential remains to contribute to China's environmental conservation efforts.

With small- to medium-scale systems constituting a major part of renewable energy power generation, they can be installed individually or collectively at a variety of locations, from dwellings to medium-scale power plants - a feature that diversifies the cooperation frameworks and broadens the scope of potential recipients. Japanese companies and trading houses engaged in energy and environmental businesses are thus shifting their focus from the sluggish domestic market to the promising Chinese market. There is every chance that small-scale renewable energy projects involving minimal business risks and considerable flexibility will serve as their means to gain a foothold in China[2].

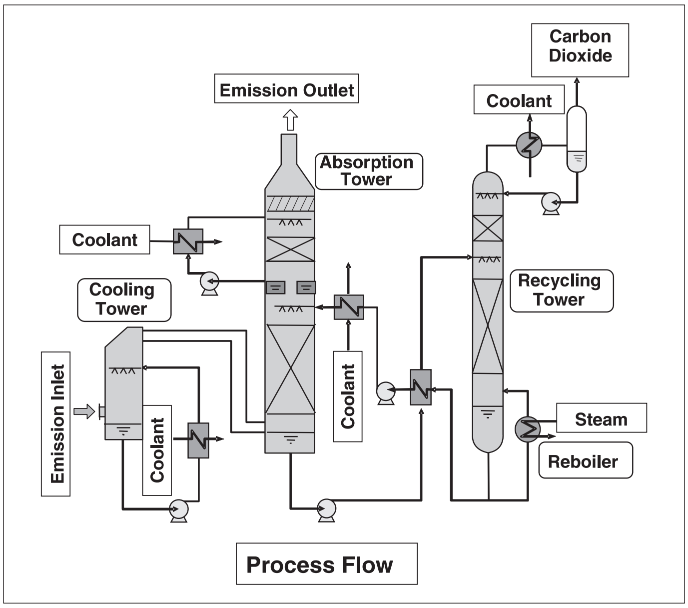
4-5 Environmental conservation technologies

This chapter addresses desulfurization/denitration technologies to reduce the levels of sulfur and nitrogen oxides (major air pollutants in China), and CO_2 separation technologies applicable to thermal power plants. Japan began to develop environmental conservation technologies more than 20 years ago, ahead of Western industrialized countries, and is continuing to take the lead in this area.

Desulfurization technologies[13] can be broadly categorized into (i) pre desulfurization technology, (ii) furnace desulfurization technology, and (iii) flue-gas desulfurization technology, which includes wet and dry methods. The wet method using limestone slurry, a commonly used process in Japan, is the most efficient desulfurization technique. Likewise, denitration technologies can be broadly categorized into (i) low-NOx combustion technology, (ii) furnace denitration technology, and (iii) flue-gas denitration technology. As in the case of flue gas desulfurization technology, flue-gas denitration technology comprises wet and dry methods, while the selective catalyst method combining low-NOx combustion technology and catalysts is currently the mainstay of the denitration process. When transferring Japan's desulfurization and denitration technologies to China, techniques best suited to the present situation in China should be selected.

Japan is also heading the field in CO_2 separation technologies using alkanolamine, a liquid that readily absorbs CO_2[16]. Figure 8 shows the flow of CO_2 separation technologies applicable to thermal power plants: flue gas (from a thermal power plant or boilers) is cooled down to 45 degrees Celsius through a cooling tower; amines in an absorption tower absorb CO_2; and a recycling tower heats the amines containing CO_2 up to 130 degrees Celsius to recover the gas. An enhanced oil recovery process using CO_2 injection appears to be a promising application of recovered CO_2. CO_2 separation technology is of interest to both Japan and China since it contributes to reducing CO_2 emissions in China.

Figure 8 : CO_2 separation technology for thermal power plants



Source: Reference[15]

5 Recommendations on policies

As mentioned at the outset, achieving 3E - Energy security, Environmental preservation and sustainable Economic growth - is the biggest challenge to be faced by the international community in the 21st century. It is critical that this issue be addressed in the Asian region, where energy demand and the resulting environmental load are expected to increase. In particular, comprehensive and cooperative approaches should be adopted for China. This chapter provides an overview of the 3E issue, based on the present situation in China and Japan, summarizing trends and prospects for Japan-China technical assistance from the viewpoint of a cooperative framework, coal utilization and clean coal technologies, environmental conservation technologies and the utilization of natural gas and nuclear and renewable energy.

- It is estimated that global CO_2 emissions will increase from 6.5 billion tons in 2000 to 9.9 billion tons in 2020, with as much as half of this 50% increase coming from Asian countries. A mere 2% of the increase is attributable to Japan, with modest predicted economic growth but as much as 53% to China, with a rocketing economy.
- In addition to reducing domestic emissions, Japan should collaborate with Asian countries (particularly China) to curb regional greenhouse gas emissions. It is also essential that Japan make the most of its commercialized technologies in the fields of coal utilization (including clean coal utilization), natural gas, nuclear power, renewable energy and environmental conservation to assist China and other Asian countries.
- Japan has been offering technical assistance to China through ODA (Official Development Assistance) in the fields of energy and the environment, emphasizing coal utilization technologies and measures to guard against air pollution. However, there have been considerable recent problems: (i) discrepancies between Japan's cooperation programs and the present situation in China, and (ii) techniques and expertise that have yet to be passed on to Chinese engineers and researchers working on site.

In view of the abovementioned trends and challenges present in Japan-China technical assistance, the following four approaches are recommended to solve the 3E issue of Japan and China: (i)Transfer of Japan's commercialized technologies; (ii) Creation of a bilateral framework for reducing greenhouse gas emissions; (iii) Development of strategic joint research and development projects; (iv) Development of human resources on a medium- to long-term basis

These approaches are designed to transform the conventional "cooperation," from unilateral "assistance" into bilateral "collaboration," which benefits both Japan and China.

(i) Transfer of Japan's commercialized technologies

To solve China's 3E issue, it is recommended that Japan's commercialized technologies in the fields of energy and the environment - coal utilization and clean coal technologies (high-efficiency coal-based power generation, coal gasification, coal liquefaction, etc.), environmental conservation technologies and technologies for utilizing natural gas, nuclear energy and renewable energy - be transferred to China. While investment funds are financed primarily by the private sector, public funds (Development Bank of Japan, Japan Bank for International Cooperation, etc.) should be used for projects involving high risks. To facilitate technology transfer and training of maintenance engineers, moreover, Japanese experts should be dispatched on a long-term basis, based on a bilateral agreement, to establish and promote an energy and environmental technology center through which technical training would be offered and first-hand information exchanged. This center would be a base in China allowing a sufficient number of nationwide training institutes to be subsequently set up. It would also function as a hub to protect the intellectual property rights of Japan's commercialized technologies when transferred, and to improve the investment climate for future technology transfer.

(ii) Creation of a bilateral framework for reducing greenhouse gas emissions

A system based on Clean Development Mechanism (CDM)[*2] should be created and managed between Japan and China, where Japan earns CO_2 emission credits from emissions reduced in China through the aforementioned technology transfer. Such a system requires a framework in which CO_2 emissions reduced by technological transfer are quantified and certified. The Japanese and Chinese governments should establish this framework based on mutual political cooperation and agreement.

(iii) Development of strategic joint research and development projects

Strategic joint research and development projects in the fields of energy and the environment should be promoted between Japan and China, based on cooperation between industry, academia and government. Specific projects may include research into air pollutants such as SOx and NOx in East Asia (a survey of emission sources and their distribution through aerial observations)[18], and development of advanced technologies with clear objectives (high-efficiency coal gasification combined power generation, clean coal technology including coal ash utilization, etc.). Achievements of the projects shall be protected as intellectual property rights, based on a mutual bi-lateral agreement.

(iv) Development of human resources on a medium- to long-term basis

A program to exchange students in the fields of science and technology should be promoted between universities and graduate schools in Japan and China to develop human resources sufficiently aware of the 3E issue. Specifically, it is recommended that the Japanese and Chinese governments create independent scholarships for students of their partner countries.

Through the recommendations mentioned above, China's coal resources will be exploited domestically to their fullest potential by taking advantage of Japan's commercialized technologies and technologies to be developed jointly by Japan and China. The 3E will also be achievable in Japan and China alike through the implementation of antipollution measures and the reducing of CO_2 emissions in China. Benefits for China include (i) diversification of power supply, (ii) development of inland areas including coal-producing regions and (iii) exploitation and proliferation of advanced technology. Those for Japan, meanwhile, will be (i) effective reductions in CO_2 emissions and (ii) maintenance or improvement of industrial competitiveness. Moreover, the two countries will benefit from (i) environmental conservation and (ii) sustainable economic growth.

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Glossary

*1 The London Guidelines

With nuclear weapons testing in India as a turning point, seven countries including Japan, the U.S. and the former Soviet Union met together in London in 1975 to discuss measures to prevent nuclear materials from being diverted into weapons. This international meeting later expanded to include a total of 15 countries, mapping out guidelines for the export of nuclear-related items to non-nuclear weapon countries - i.e., the London Guidelines, which were officially announced by IAEA in 1978 (with 27 countries currently taking part). The guidelines are designed to: (i) secure a commitment from countries importing nuclear materials not to divert them into weapons, (ii) apply IAEA safeguards against any misapplication of nuclear materials, (iii) implement appropriate measures to protect nuclear materials, (iv) regulate the transfer of enrichment and reprocessing technologies, and (v) regulate the retransfer of nuclear materials. The disclosure of Iraq's clandestine nuclear program resulted in the tightening of export regulations. The revised version of these guidelines was agreed on and enforced in Warsaw in 1992

*2 Clean Development Mechanism (CDM)

A system through which the parties to the Kyoto Protocol implement greenhouse gas reduction projects in host countries (not participating in the protocol) to earn emission credits. This system is considered to be of interest to host counties since investment by the parties to the Kyoto Protocol is expected to promote environmental conservation measures and technology transfer.

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