East Asia's Energy and Environment Problems

by

Yoshiki OGAWA

March 2003

Economic and Social Research Institute

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1. Global Energy Supply-Demand Outlook and Characteristics of Steadily Expanding East Asia

(1) Long-term global energy supply-demand outlook and characteristics

After crude oil prices plunged in 1986, global energy demand has increased steadily until the mid-1990s helped by high economic growth, mainly in Asia. The Asian economic crisis triggered by the crash of the Thai baht took on a serious look beyond expectations and growth of global energy demand temporarily slowed down. Although it made a rapid recovery in the second half of the 1990s, the growth of energy demand again slackened due to economic stagnation caused by the collapse of IT bubbles, mainly in the United States.

Table 1 Long-Term Outlook of Energy Demand by the IEA

(Unit: 1 million tons of oil equivalent)

	History		Projections			Percentage change	
	1971	2000	2010	2020	2030	2000/1971	2030/2000
Asian developing countries	766	2,288	3,014	3,841	4,720	3.8%	2.4%
Composition ratio (%)	(13.7)	(22.7)	(24.9)	(27.1)	(29.0)		
China	404	1,162	1,514	1,913	2,326	3.7%	2.3%
East Asia	149	531	735	953	1,178	4.5%	2.7%
South Asia	213	595	765	975	1,216	3.6%	2.4%
Other developing countries	452	1,334	1,727	2,195	2,786	3.8%	2.5%
Composition ratio (%)	(8.1)	(13.2)	(14.3)	(15.5)	(17.1)		
OECD advanced countries	3,485	5,432	6,145	6,768	7,293	1.5%	1.0%
Composition ratio (%)	(62.3)	(53.8)	(50.7)	(47.7)	(44.7)		
Former Soviet and East Europe	889	1,034	1,231	1,385	1,501	0.5%	1.3%
Composition ratio (%)	(15.9)	(10.2)	(10.2)	(9.8)	(9.2)		
Coal	1,449	2,355	2,702	3,128	3,606	1.7%	1.4%
Composition ratio (%)	(25.9)	(23.3)	(22.3)	(22.0)	(22.1)		
Oil	2,450	3,604	4,272	5,003	5,769	1.3%	1.6%
Composition ratio (%)	(43.8)	(35.7)	(35.3)	(35.3)	(35.4)		
Natural gas	895	2,085	2,794	3,531	4,203	3.0%	2.4%
Composition ratio (%)	(16.0)	(20.7)	(23.1)	(24.9)	(25.8)		
Atomic energy	29	674	753	719	703	11.5%	0.1%
Composition ratio (%)	(0.5)	(6.7)	(6.2)	(5.1)	(4.3)		
Hydraulic power	769	1,370	1,596	1,808	2,019	2.0%	1.3%
Composition ratio (%)	(13.8)	(13.6)	(13.2)	(12.7)	(12.4)		
World total	5,592	10,088	12,117	14,189	16,300	2.1%	1.6%
Composition ratio (%)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)		

(Source) IEA, “World Energy Outlook 2002,” October 2002

Amid the prolonged global economic recession, the International Energy Agency announced the latest world energy supply-demand outlook in October 2002 [1]. Table 1

shows a general outline of the global energy demand outlook. The stagnation and slowdown of energy demand caused by the Asian economic crisis and the collapse of IT bubble is temporary, and the IEA forecasts that energy demand will inevitably increase, mainly in Asia and other developing countries over the medium and long term of 2010, 2020, and 2030. The energy outlook [2] published by the U.S. Department of Energy (DOE) in March 2002 also forecast a similar increase in energy demand.

Global energy demand, which stood at 5.6 billion tons of oil equivalent in 1971, reached 10.1 billion tons of oil equivalent in 2000, posting an average annual growth rate of 2.1% during the 30 years. IEA forecasts that global energy demand will increase to 12.1 billion tons of oil equivalent in 2010, 14.2 billion tons of oil equivalent in 2020, and 16.3 billion tons of oil equivalent in 2030. DOE's forecast put global energy demand at 12.4 billion tons of oil equivalent in 2010 and 15.4 billion tons of oil equivalent in 2020, or slight higher than the IEA forecast.

The DOE estimates the average growth rate of energy demand from 2000 to 2002 at a 2.1%, while the IEA estimates an average annual growth rate of 1.6% from 2000 to 2030. It suggests that the IEA takes the impact of the global recession since 2000 and responds to long-term environment problems more seriously than the DOE. But they share the view that the world as a whole will have to depend greatly on fossil fuels, such as coal, oil, and natural gas, in 2020 and even in 2030.

What can be pointed out is that the component ratio of Asia's developing countries in global energy demand will further increase in the years to come (Table 1). According the IEA outlook, the component ratio of Asia's developing countries will increase from 23% in 2000 to 25% in 2010, 27% in 2020, and to 29% in 2030, posting a 6 point-increase in 30 years. By contrast, the component ratio of OECD developing countries will decrease. Asia's developing region will gain importance in future energy demand.

Table 1 also shows the global energy supply outlook up to 2030 based on IEA estimates. We can tell from the table that fossil fuels, such as oil, coal and natural gas, account for around 85% of energy supply up to 2030. This suggests that there will be no major change in the world energy structure, which basically depends on fossil fuels and will continue to do so even in 2030.

One of the characteristics that can be seen in the IEA energy supply outlook is that the component ratio of natural gas is forecast to increase in the world as a whole up to 2030 (Table 1). The ratio is forecast to increase from 20.7% in 2000 to 25.8% in 2030, posting a 5-point increase. By contrast, the component ratio of atomic energy is forecast to post the steepest decrease up to 2030. Although the supply of atomic energy in

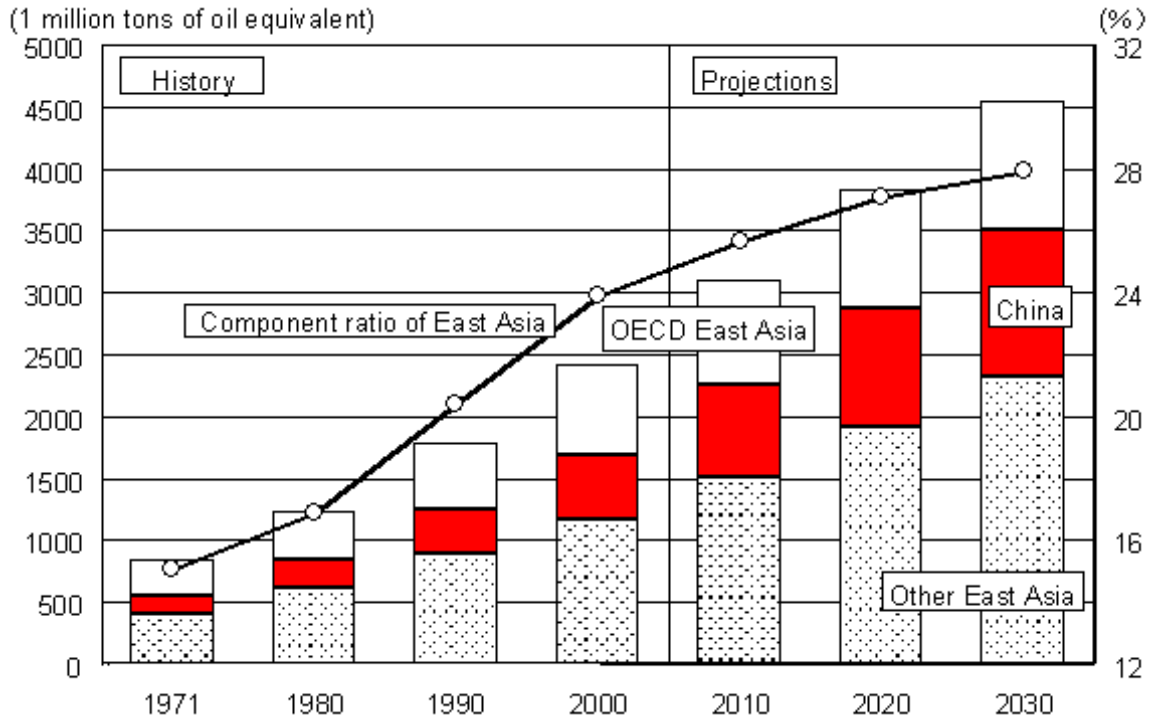
absolute volume will increase up to 2030, it is forecast to decrease thereafter.

What is characteristic about the component ratios of coal and oil is they will remain almost unchanged up to 2030. According to the IEA outlook, the component ratio of oil is expected to decrease only slightly from 35.7% in 2000 to 35.4% in 2030, and the component ratio of coal is expected to decrease only by about 1 point from 23.3% in 2000 to 22.1% in 2030. The position of oil as the largest component of energy supply will remain almost unchanged at least until 2030.

(2) Steadily expanding energy demand in East Asia and its characteristics

A detailed study of the history and projections of energy demand (IEA2002) in East Asia (including Japan) shows that energy demand in the region rose sharply in the 1980s (Figure 1). The IEA outlook takes into account the temporary slowdown in demand caused by the Asian economic crisis and economic stagnation triggered by the collapse of IT bubbles. Still, it projects a steady growth of energy demand in East Asia up to 2020, a projection shared by various other outlooks.

Figure 1 Energy Demand Outlook in East Asia



(Source) IEA, "World Energy Outlook 2002," October 2002

The IEA projects East Asian energy demand at 3.1 billion tons of oil equivalent in 2010, 3.8 billion tons of oil equivalent in 2020, and 4.5 billion tons of oil equivalent in 2030 (Figure 1, Table 2). It projects the average annual growth rate of energy demand from 2000 to 2030 at about 2.1%. In view of the fact that the growth rate of energy demand in the past 30 years was about 3.7%, the projection shows a slight slowdown, but the increase in absolute volume is large. However, if the economic growth of East Asian developing countries accelerates again and if the increase in energy demand in China and ASEAN countries picks up stream, energy demand would increase rapidly in and after 2010.

Table 2 Long-Term Outlook for Energy Demand in East Asia by IEA

(Unit: 100 million tons of oil equivalent)

	History		Projections			Percentage change	
	1971	2000	2010	2020	2030	2000/1971	2030/2000
Coal	283	909	1,190	1,472	1,774	4.1%	2.3%
Composition ratio (%)	(33.7)	(37.7)	(38.3)	(38.4)	(39.0)		
Oil	302	817	1,013	1,256	1,464	3.5%	2.0%
Composition ratio (%)	(35.9)	(33.9)	(32.6)	(32.7)	(32.2)		
Natural gas	8	184	302	425	548	11.4%	3.7%
Composition ratio (%)	(1.0)	(7.6)	(9.7)	(11.1)	(12.1)		
Atomic energy	2	126	188	245	292	15.4%	2.8%
Composition ratio (%)	(0.2)	(5.2)	(6.1)	(6.4)	(6.4)		
Hydraulic power	245	376	412	440	467	1.5%	0.7%
Composition ratio (%)	(29.2)	(15.6)	(13.3)	(11.5)	(10.3)		
Total of primary energy	840	2,412	3,106	3,838	4,545	3.7%	2.1%
Composition ratio (%)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)		
East Asian share in the world (%)	(15.0)	(23.9)	(25.6)	(27.1)	(27.9)		

(Source) IEA, “World Energy Outlook 2002,” October 2002

Fossil fuels, such as oil, coal and natural gas, also will account for about 85% of energy supply in East Asia up to 2030. What characterizes East Asia in terms of its energy supply source composition is that the component ratio of natural gas is extremely low and that the component ratio of coal is considerably high. The component ratio of natural gas in East Asia is forecast to rise by about 4-5 points from 7.6% in 2000 to 12.1% in 2030. The component ratio of coal, which stood highest at 37.7% in 2000, is expected to maintain its high level registering around 38-39% in 2030. This indicates that coal is an extremely important energy for East Asia.

Atomic energy is expected to move horizontal at around 6.5%, after increasing up to 2020 both in terms of absolute volume and component ratio. East Asia differs from the rest of the world on this issue, as the component of atomic energy is expected to

decrease. This indicates that for East Asia, where energy demand has been steadily increasing, atomic energy is an important supply option in the long run.

The component ratio of oil in East Asia is more or less the same as in the rest of the world and is expected to show no major fluctuation up to 2030. The component ratio of oil in East Asia is forecast to decrease only 1-2 points from 33.9% in 2000 to 32.2% in 2030. The importance of oil with the second largest component ratio next to coal is expected to remain almost unchanged, at least up to 2030.

In any case, energy demand in East Asia, as a whole, is expected to continue its steady increase in absolute volume over the long term. For this reason, there is concern that various problems may occur in connection with energy supply and demand, making it necessary to take measures in various fields. Next, I would like to point out some of the characteristics of energy demand in Asia.

(3) Factors behind expanding energy demand: electrification and motorization

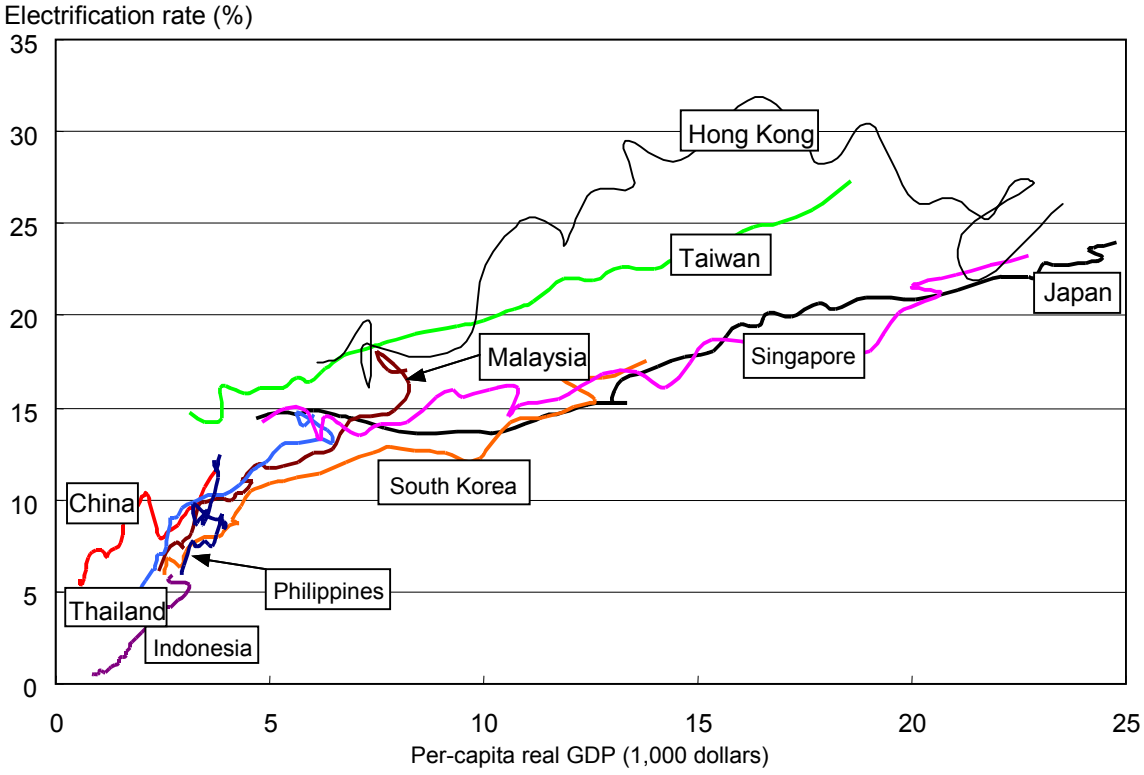
As of 2000 the total energy demand breakdown in Japan was as follows: the power generation sector accounted for 34%, the industry sector for 28%, the civilian sector 20%, and the transportation sector for 18%. On the other hand, in East Asian developing countries, the power generation sector accounted for 31%, the industry sector for 28%, the civilian sector for 29%, and the transportation sector for 11%. Although the share of the industry sector in energy demand still remains large in East Asian developing countries, their demand pattern is expected to shift to patterns similar to advanced countries like Japan in the future.

One of the conceivable directions is that the share of the power generation sector will increase in line with the progress of electrification. Another direction is that the share of the transportation sector will increase in line with the expansion of industrial activities and a rise with income levels. Since electrification in Asian developing countries has been expanding at an earlier stage than in advanced countries, the power generation sector will become the most important sector in energy demand in the future. Energy demand in the transportation sector is also expected to increase in line with the growth and expansion of industrial activities. As will be described later, the share of the civilian sector, in which consumption of energy for non-commercial purposes accounts for a large proportion, will decrease.

The electrification rate (the ratio of electricity consumption to final energy consumption) in East Asian countries varies depending on the economic level of each country (Figure 2). In a low-income country, electricity consumption begins with lighting, as the country believes liberating people from darkness is the first step toward

the civilized world. When industrialization begins, it will lead to large consumption of electricity by the industry sector, and large-scale electricity sources and main transmission networks will be established. When the electrification advances further as a result of the progress in industrialization, power transmission networks reaching households will be established. When the country reaches the level of advanced countries, the power consumption in the civilian sector increases, as people seek a comfortable standard of living equipped with air conditioners and other home electric appliances.

Figure 2 Relations between Income Level and Electrification Rate



(Source) IEA, "Energy Balances in OECD and Non-OECD Countries," 2002

What characterizes East Asian electrification is that developing countries with lower income levels begin electrification earlier. One of the big reasons for this is that the governments of Asian developing countries attach important to electric power in energy supply to the civilian sector and strive to ensure the electric power supply. For forest resource-poor developing countries, electric power is all the more important as the energy source for the civilian sector. The sharp increase in electricity demand for air conditioners in developing countries is also expected to become an important issue in

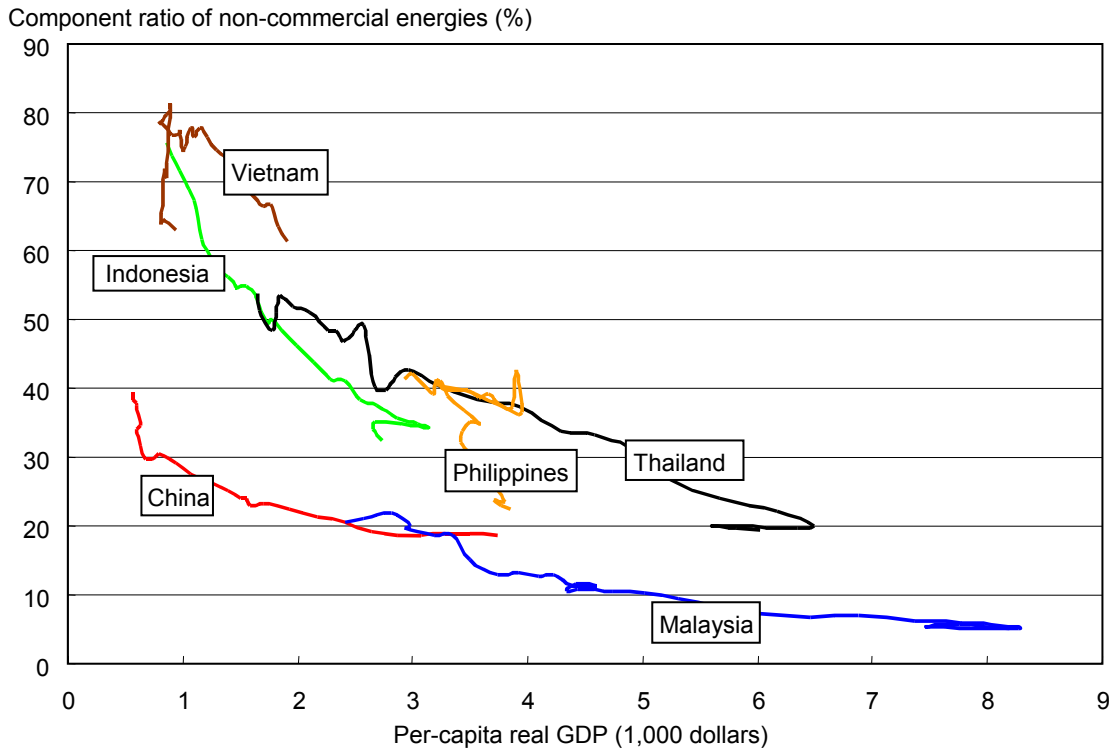
the years to come.

In East Asian developing countries, the share of the civilian sector in energy consumption is closely linked to the change in economic standard. For example, the share of the civilian sector stands at around 50% or higher in countries like Vietnam and Indonesia. When industrialization advances, the share of the industry sector in energy consumption rises, as the weight of energy-intensive industries increases, and the share of the civilian sector declines.

It is because countries generally follow this path that the share of the civilian sector in NIEs is lower than in ASEAN, and in ASEAN than in South Asia. If a country reaches the level of advanced countries like Japan, the shares of the civilian and transportation sectors increase, as the weight of less energy-consuming tertiary industry rises in the country and people begin to seek a comfortable life of high unit energy consumption.

In addition to such commercial energies as oil, gas, and coal, East Asian developing countries also consume non-commercial energies (plant fuels), such as firewood, bagasse, and cowclap. The component ratio of plant energies in primary energy demand in these countries has been decreasing due to a shift mainly to fossil fuels in line with the advancement of their economic growth (Figure 3). In some of the countries, though the component ratio has been decreasing, the absolute volume of consumption has been increasing. Plant fuels are mainly used at household kitchens, and in some countries, for heating rooms. Use of firewood tends to encourage unrestrained logging, contributing to the destruction of forests. In countries like China, the component ratio of plant fuels is low for their low level of economic standard, as firewood is no longer available in the neighborhood due to past destructive lumbering.

Figure 3 Relations between Income Level and Non-Commercial Energy Ratio in East Asian Developing Countries



(Source) IEA, "Energy Balances in OECD and Non-OECD Countries," 2002

In East Asian developing countries, demand for petroleum products increased sharply in the past 20 years and the oil demand, mainly for transportation fuels, has increasingly shifted to so-called white oil, such as gasoline and diesel oil. Motorization, centering on passenger cars, has yet to start in full scale in these countries. If motorization gets into full swing, it would further increase demand for petroleum products, mainly for diesel oil, and accelerate the shift to white oil. In the future, a steady increase in oil demand brought about by the progress in motorization would become one of the important factors characterizing energy consumption in East Asian developing countries.

(4) Inefficient energy consumption in East Asian developing countries

A study of the past 20 years' of per-GDP energy consumption (unit energy consumption: this is a energy performance indicator as seen from the macro-economy including changes in industrial structure) in East Asian developing countries shows that the unit energy consumption of Hong Kong, a city state based on the service industry

and tourism, is at a low level, while those of South Korea and Taiwan are at the level of heavy industry.

Behind these NIEs are semi-advanced countries and less-developed countries, and the values of their unit energy consumption are proportionately higher. The reason why the unit energy consumption of countries with lower economic standards is higher is that their consumption of non-commercial energies is larger. The unit energy consumption in many of the Asian developing countries is 2-4 times higher than that of Japan. China's unit energy consumption is much higher than in other countries in the region.

The fact that the value of unit energy consumption is high means that Asian developing countries' energy consumption for economic activities is inefficient. Improvement of energy efficiency and energy saving are important options when promoting harmony of economic growth, energy supply-demand, and environmental conservation.

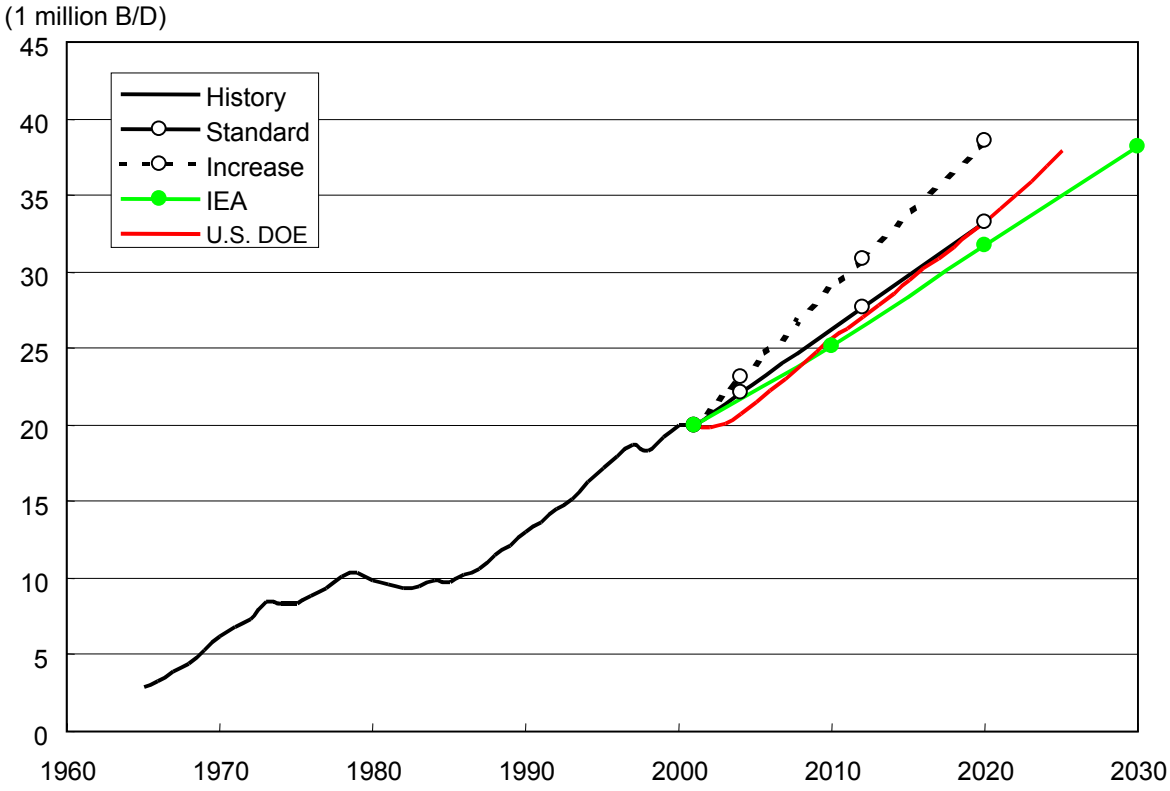
2. Increased Dependence on the Middle East for Oil Supply in Asia

(1) Outlook for oil demand increase in Asia and its characteristics

Oil demand had been held down at an average annual growth rate of around 1% for 15 years up to 1985 due to the steep rise of crude oil prices triggered by two times of oil crisis. However, it began to pick up due to lower energy prices and posted an average annual growth rate of around 2% for the next 15 years. The increase was particularly strong in Asian developing countries, the growth center of the world. Though the increase was mostly accounted for by transportation fuels such as gasoline and diesel oil that cannot be easily substituted by other fuels, demand for fuels for generation of electricity, for petrochemical materials and for industrial use also increased.

Energy demand and oil demand temporarily slowed down due to economic stagnation caused by the economic crisis in Asia and the collapse of the IT bubble. But, these adverse factors are not likely to leave any big impacts. On the contrary, energy demand and oil demand in Asia are expected to increase steadily over the long term. Figure 4 shows changes in oil demand in Asia and its long-term outlook.

Figure 4 Trend of Oil Demand in Asia and Outlook



(Source) BP "BP Statistical Review of World Energy 2002"; IEA, U.S. DOE, Institute of Energy Economics

Since the standard case [4] of the Institute of Energy Economics is based on the outlooks made by the governments of Asian countries, it heavily takes into account the governments' objectives of switching to alternative energy sources, such as coal and natural gas. On the other hand, it is generally believed that the long-term trend of crude oil prices up to 2020 will move horizontally at around 20-25 dollars per barrel. Therefore, the component ratio of oil may not decrease as planned or may increase in some countries, as was the case in the 1990. For this reason, an oil-demand increase case vis-à-vis the standard case is also assumed. As Figure 4 shows, oil demand in Asia is expected to reach 33.19 million B/D in 2020, about 1.7 times as much as in 2001, when the demand stood at 19.94 million B/D. The forecasts made by the IEA and the U.S. DOE follow almost the same trend as that of the standard case.

How to deal with the increase in oil demand from the supply side will become a big problem in the years to come. In fact, India, China and ASEAN increased imports of petroleum products in response to the oil demand increase in the second half of the 1980s. However, since there's a limit to imports of petroleum products, countries like

South Korea, Thailand, China and India stepped up efforts to expand oil refineries in the 1990s. The refineries expanded by the Asian developing countries, however, are mostly toppers, and full-scale secondary systems, such as hydrocracking facilities, were not introduced. If we set our sights on 2020, it will become important to establish secondary facilities to increase crude refining capacity. In view of the fact that Asian oil demand is heavily concentrated in middle distillates, it will become specifically necessary to beef up secondary facilities, such as the hydrocracking system to produce good-quality middle distillate by cracking heavy oil and the environment-friendly hydrorefining system to obtain high-quality middle distillate.

(2) Slowdown of crude oil production in East Asia and increase of imports from outside the region

Next, let's examine the future trend of crude oil production in Asia. Asian crude is known for containing low sulfur. Crude production in Asia, as compared with other regions, has been on a decreasing trend since the beginning of 1990. Although there are some oil fields that are expected to increase production, such as Tarim Basin in China, South China Sea and Far East Russia, there are many more fields that are expected to see their production decrease. In fact, many oil fields in Asia are barely able to maintain the current level of production or can increase slightly at best. In the case of Indonesia, production is expected to decrease moderately from 2000 to 2005.

Crude oil production in Asia has been on a slightly upward trend from about 6.09 million B/D in 1990 to about 6.74 million B/D in 1995 and to 7.21 million B/D in 2001. However, according to the IEA's long-term outlook [1], production is expected to decrease from 6.2 million B/D in 2010 to 5.7 million B/D in 2020 and to 4.8 million B/D in 2030. Given such a decrease in crude oil production within the region, it is clear that the countries in the region will be unable to catch up with the increase in oil demand. Moreover, it is generally believed that China, Indonesia and other oil-producing countries in the region will see their capacity to export low-sulfur crude decrease considerably as a result of the expansion of their domestic demand. For Asian oil-producing countries, whether to use domestically produced oil to meet domestic demand, or to import Middle East oil for domestic demand will become an important issue. Depending on which option is chosen, the availability of low-sulfur oil from oil-producing countries will change greatly.

Although the supply-demand balance of oil products may remain tight in Asia, the supply-demand balance of crude oil is not likely to become tight due to the existence of the Middle East, the large supplier of crude. However, when it comes to low-sulfur

crude, of which Asian countries are main producers, its supply-demand balance may become tight. Depending on which option the low-sulfur crude producing countries choose, there may arise problems with regard to supply-demand and prices of low-sulfur crude.

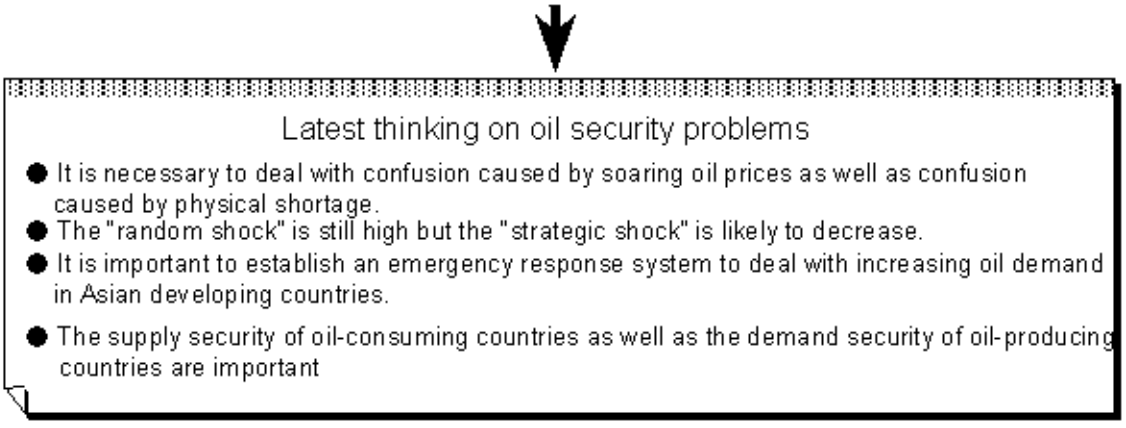
(3) Experiences of past oil crises and awareness of security in Western countries and East Asia

After experiencing three oil chocks of the first oil crisis (1973-1974), the second oil crisis (1978-1979: Iranian revolution, 1980-1981: Iran-Iraq War) and the Gulf War (1990-1991), countries, mainly advanced countries, have beefed up public stockpiles of oil and enhanced oil market functions. As a result, their approach to oil security has changed greatly.

Figure 5 Experiences of Oil Crises and Points of Recent Oil Security

	1st oil crisis (October 1973)	2nd oil crisis (December 1978)	2nd oil crisis (October 1980)	Gulf crisis (August 1990)
Factors behind the crisis	● Fourth Mideast War ● Export ban by Arab oil-producing countries	●Iranian revolution ●Sudden production decline in Iranian oil	● Iran-Iraq War	● Iraqi invasion of Kuwait
Supply decreasing period	● About 6 months	●About 4 months	●Abut 5 months	●About 7 months
Size of supply decrease	●4.3-4.5 million B/D (February) ● 2.2-2.6 million B/D (February)	● 5.3-5.6 million B/D (February) ● 3.8 million B/D (February)	●3.7-4.1 million B/D (February) ●2,5-3.0 million B/D (March)	● 5.0-5.3 million B/D (February) ● 4.0-4.7 million B/D (March)
Surplus production capacity	●About 3.75 million B/D	●About 4.55 million B/D	●Abut 6.7 million B/D	●About 6.2 million B/D
Oil stockpiles (OECD average)	●Private 70 days, Public --	●Private 65 days, Public 7 days	●Private 77 days, Public 9 days	●Private 61 days, Public 25 days
Oil market structure	●Major posted price system ●Long-term contracts of major-held crude	●Government selling price system of oil-producing countries ●Long-term contracts with oil-producing countries		●Market-linked pricing system ●Development of oil futures market ●Term contracts with oil-producing countries and expansion of spot transactions

(Note) In the case of the Gulf, even after the end of the Gulf War, the decrease of crude supply continued until production by Kuwait recovered.



(Source) Institute of Energy Economics

Specifically, the idea that future oil-supply security problems will be caused by random events (random shock), such as wars, is gaining more popularity than the idea that such problems will be caused intentionally (strategic shock) by oil-producing

countries. Also, fewer people hold the view that oil-consuming nations will fall short of oil supply at a time of oil supply disruption. Rather, people are more concerned about macro-economic damage by soaring oil prices at the time of supply disruption.

In contrast to this Western recognition of the situation, Asian countries, including Japan, feel uneasy about supply security and are still concerned about the availability of oil. Asian countries' uneasiness about supply security differs widely from one country to another due mainly to their different development stage their respective economy's and depending on the availability of oil resources. To be more precise, Japan, South Korea, and Taiwan, the three large oil-importing countries or area with large economies, take the supply security problem seriously, but oil-producing China and Indonesia do not take the problem very seriously. The degree of uneasiness also differs among government organizations, state-run oil companies, and private oil companies.

It is highly likely that Asia's uneasiness about supply security will further heighten, if Asian countries' imports of oil from countries outside the region increase or if imports of oil by oil-producing countries in the region increase or if they become net importers of oil in the future. Since Asian countries are concerned about supply disruption caused by a random event and physical availability of oil, when considering policy options, it is necessary to give extra consideration to strengthening the capacity to deal with supply disruption and respond to the problem of availability.

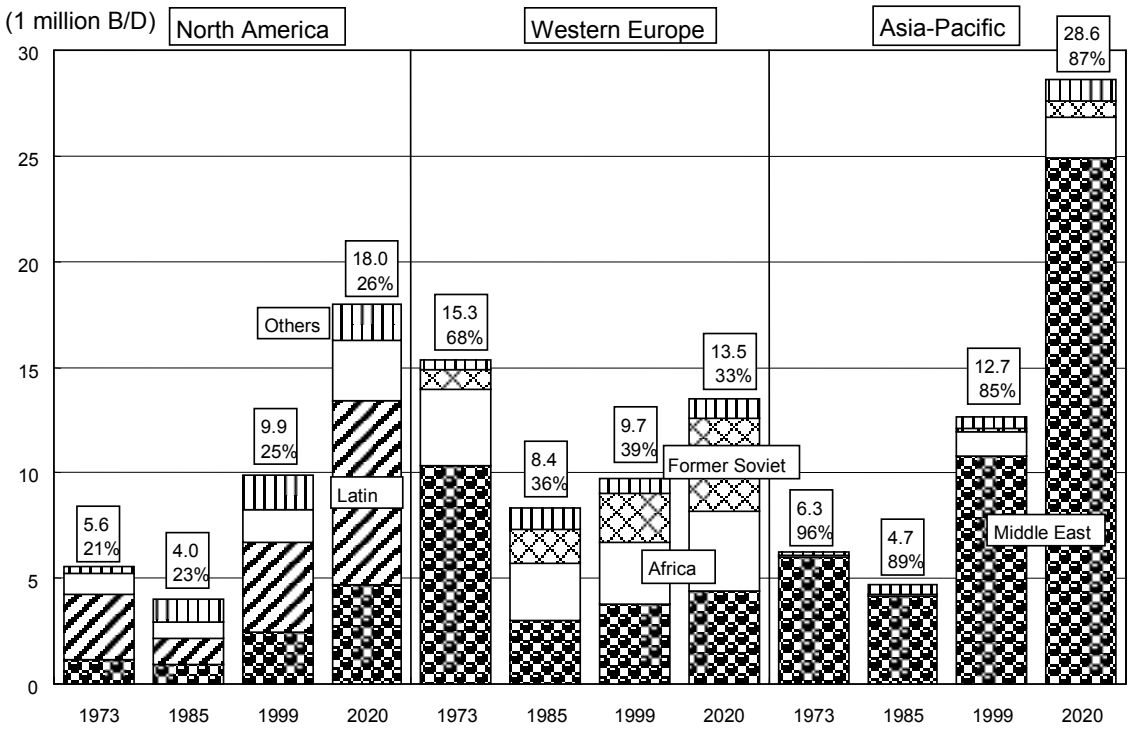
Asia's increased dependence on Middle East oil resulting from their increased energy and, in particular, oil demand is the major factor causing Asia's concern about supply security, but for the Middle East oil-producing countries, Asia is very important in terms of securing marketing outlets. In view of the fact that oil countries' revenues fluctuated wildly due to erratic movements of crude oil prices during the oil crises, Asia should be an indispensable market for the oil-producing countries. Stated another way, just as Asian oil-consuming countries are concerned about supply security, Middle East oil-producing countries are concerned about demand security.

(4) Response to Asia's increased dependence on Middle East oil – preparations of emergency measures

If the crude oil price remained stable at around 20 dollars per barrel up to 2020, what oil supply-demand problem would it cause? The biggest problem would be that Asia-Pacific region's dependence on Middle East oil will increase drastically, as oil demand in Asian developing countries is expected to increase sharply. In fact, according to U.S. DOE's outlook, Asia-Pacific region's oil imports from the Middle East, which stood at 11 million B/D in 1998, are expected to more than double to 25 million B/D in

2020, as illustrated in Figure 6. Although the dependence on the Middle East will remain almost unchanged at 85%, the problem is that the absolute volume of oil imports from the Middle East increases drastically.

Figure 6 Quantitative Increase in Dependence on Middle East Oil in Asia-Pacific Region



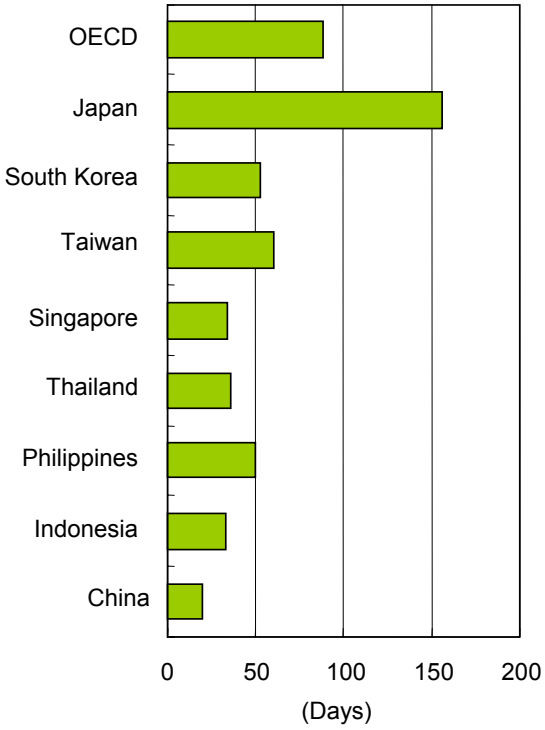
(Source) "BP Amoco Statistical Review of World Energy," US DOE/IEA, "International Energy Outlook 2001"

By contrast, North America OECD region's dependence on Middle East oil from 1973 to 1997 stood at 21-25%. The region's oil imports are expected to increase to 18 million B/D in 2020, but its dependence on Middle East oil will not change much at 26%. Europe's dependence on Middle East oil stood at 68% in 1973, when the first oil crisis broke out, but its dependence has been held below 40% since around 1985 thanks to the improvement of oil supply environments, such as development of North Sea oil. Europe's oil imports are expected to come to 13.5 million B/D in 2020 and its dependence on Middle East oil is expected to drop to 33%. What is characteristic about European and U.S. imports of oil is that their dependence on the Middle East does not rise much and that the absolute volume of Middle East oil does not increase much.

Given Gulf oil-producing countries' abundant oil resources, even if Asia-Pacific region's oil imports from the Middle East increased, it would not lead to a shortage of peacetime oil supply.

The problem is how to respond to the emergency of oil supply disruption caused by random events. As Figure 7 shows, since Asian developing countries do not have sufficient oil stockpiles and as their memories of firsthand experiences of past oil crises become remote, many of the developing countries that have increased their economic power may get panicky in an emergency.

Figure 7 Recent Moves to Build Up Oil Stockpiles by Asian Oil-Consuming Countries



Asia's recent moves concerning oil stockpile

- The Chinese government began a study on the creation of a state oil stockpile system. It targets building up oil reserves of 110 million barrels (25 days of demand) by 2010.
- Taiwan is also studying creating a state oil stockpile system, in addition to requiring oil companies to keep reserves equal to 60 days of demand.
- Thailand, which eased mandatory oil company stockpiles, is also studying creating a state oil stockpile system in three stages.
- International discussions on oil stockpiles in Asia animated.
  - Proposal of joint stockpile scheme at APEC
  - Study on East Asia (mainly Japan, China, and South Korea) oil stockpile scheme

(Source) Findings of field surveys [5] conducted by the Institute of Energy Economics

In order to prevent this, it is necessary to establish emergency response measures, such as oil stockpiles, and strive to construct an energy supply-demand structure that does not depend too much on oil. In any event, it is necessary for Asia, whose energy demand is expected to increase drastically over the long term, to study using other energy sources other than oil, such as natural gas, coal and atomic power.

When we consider oil-supply security, an important problem is the supply route from the Middle East to East Asia. Middle East countries are politically unstable and the

sea lane to East Asia is narrowly constricted by the Malacca Strait and the Lombok Strait. The area around the Spratly Islands is beset by territorial disputes over oil resources. If East Asia's imports of Middle East oil increase, the problem of secure sea lane for the oil supply route will become important. We will have to think about security problems focused on East Asia's oil supply as a whole.

Since their coastlines are shallow with continental shelves, China and India, who are to become big oil consumption regions in the future, do not have good harbors equipped with port facilities for big tankers to make transportation of Middle East oil economically viable. It is necessary to construct appropriate oil supply systems in the whole of Asia by fully taking into account not only problems in an emergency but also problems in peacetime.

An increase in oil demand means a further increase in the Asian region's dependence on the Middle East. How to ensure oil-supply security in Asia, where there are still many developing countries that have yet to have enough oil stockpiles for an emergency, is an extremely important issue. Specific problems that have to be addressed are promotion of development of oil and gas resources within the region, diversification of oil importing sources, strengthening the relationship of interdependence with Middle East oil-producing countries, and beefing up oil stockpile systems.

3. Development of Alternative Energies in East Asia

(1) Increased demand for natural gas in East Asia and its characteristics

In many of the East Asian developing countries, there was a major change in the composition of fossil fuels through two oil crises. In Indonesia and Malaysia, for instance, the composition ratio of natural gas increased in place of oil. In South Korea, Taiwan, Hong Kong, China and Vietnam, coal increased its composition ratio. It can be said that there were two major flows in Asian developing countries – from oil to natural gas and from oil to coal.

Countries blessed with natural gas and whose production districts are close to consumption regions have been able to promote greater use of natural gas. In the case of Japan, though it required massive investment, Japan promoted imports of natural gas in the form of LNG from remote areas in the Asia-Pacific region. In the 1990s, NIEs, such as South Korea and Taiwan, promoted the use of environment-friendly LNG by investing heavily. Recently, countries like China and India are making preparations to give shape to their LNG introduction plans.

Asia's component ratio in global natural gas demand is still low. However, its natural gas demand posted an extremely high annual growth rate of 11.4% during the

period from 1971 to 2000, while the comparable figure for the world, as a whole, was 3.0%. One of the big characteristics in terms of demand for natural gas in Asia is that since domestic gas pipeline networks have yet to be established sufficiently, the electric power sector accounts for the major proportion of natural gas consumption.

In terms of supply, one of the characteristics is that natural gas is liquefied and shipped in the form of LNG to countries with relatively high economic standards, such as Japan, South Korea and Taiwan, unlike in Europe and the United States where gas supply through pipelines has prevailed. Pipeline gas is used in such countries as Malaysia, Thailand, Indonesia and China, but not on a large scale.

In the Asia-Oceania region, the use of natural gas is still small relative to its reserves, the reserve-production ratio is relatively long at 37.5 years as compared to that of oil reserves (16.3 years). There are also abundant natural gas resources in the Middle East, Far East Russia, and Alaska, which can be shipped to Japan. According to CEDIGAZ data, proved recoverable natural gas reserves in the Asia-Oceania region, which stood at zero in 1960, increased sharply in the 1970s and stood at 500 tcf as of 1998.

One of the big characteristics of natural gas reserves in Asia is that natural gas reserves beneath the seabed increased significantly. The undersea ratio of natural gas resources in the Asia-Oceania region has stood at over 60% since the middle of the 1990s. The high ratio of undersea natural gas generally means an extra cost for the construction of transportation infrastructure when it is to be domestically used.

In view of the increase in natural gas resources in Asia and the fact that they are not yet used on a large scale, expanding the use of natural gas in Asia raises hopes in various aspects.

(2) Supply-demand outlook of LNG bound for East Asia and dependence on countries outside the region

Table 3 shows LNG demand outlooks made by three resource development companies and Wood Mackenzie as of 2002. According to their forecasts, LNG demand will come to 117-135 million tons in 2010 and to about 140 million tons in 2015. Unfortunately, there is no published forecast for LNG demand in 2020. But we can estimate the growth of natural gas demand based on the long-term outlook of energy demand announced by the U.S. Department of Energy and the International Energy Agency.

The three resource development companies and Wood Mackenzie say in their respective outlook that LNG demand in Asia will be greatly affected by such factors as when the recovery of investment can be expected, what environmental measures are

taken mainly by advanced countries, if Japan's nuclear energy development makes progress as planned by the government, and if IPP construction in Taiwan goes smoothly.

Table 3 Outlook of LNG Demand in Asia

	2001	2010					2015	
		Company A		Company B		Wood Mack	Company C	Wood Mack
		High case	Low case	High case	Low case			
Japan, South Korea, Taiwan	75.1	104	92	102	92	101.1	120	103
India, China, Others	0.0	31	17	26	15	20.0	20	36
Total	75.1	135	117	126	117	121.1	140	139

(Unit: 1 million tons)

(Source) "Natural Gas Situations and LNG Supply-Demand Trend in Asia-Pacific Region," "Asia Gas Report 1999 March edition"

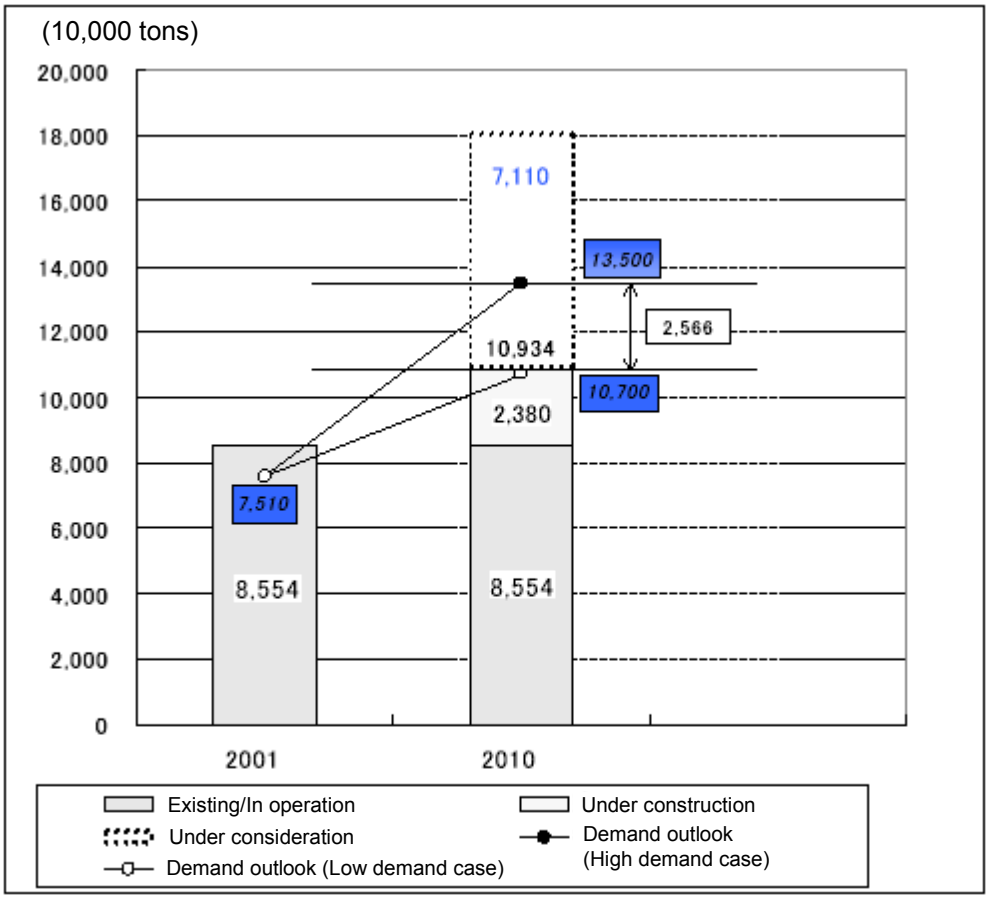
Next, let's take a look at the supply potential of LNG for the Asian market. As of the end of 2001, LNG liquefaction plants with a total liquefaction capacity of 85.54 million tons were in operation for exports to Asia [6]. Reflecting heightened interest in environmental problems, many LNG projects were announced mainly by major companies for exports to Asia throughout the 1990s.

LNG projects now under construction or in preparation for construction amount to 23.8 million tons. If these plants are included, total LNG liquefaction capacity in 2010 is estimated to come to 109 million tons, an amount that can meet a major portion of Asian LNG demand estimated for 2010. Many other projects are expected to follow suit. Among them are Yemen, Australia Gorgon, and Sakhalin 2. They are now confirming the amount of reserves and conducting market surveys. The nominal value of the liquefaction capacity of projects under consideration totals 71.11 million tons. If the capacity of existing projects now in operation is included, the supply potential of LNG liquefaction capacity in 2010 comes to 180.44 million tons. Some of the projects remain suspended or have been put off, apparently due to a delay in investment, such as Canada's Pac-Rim project that has remained stalled, and the Bayu-Undan joint project involving Australia and Indonesia that has been postponed indefinitely.

Although there are super-giant gas fields with more than 30 tcf, such as Qatar's 250 tcf and Turkmenistan's 140 tcf, it can be said that giant gas fields with proven reserves of more than 3 tcf are LNG candidates.

From the viewpoint of oil substitute and environment problems, how natural gas is positioned is drawing attention. Since major oil companies are bent on developing LNG projects with an eye on the Asian market, and a big supply potential of LNG can be expected from 2000 to 2010.

Figure 8 Surplus of Supply Potential of LNG for Asian Market in 2010



(Note) Of the projects under consideration, those that met conditions are to be started. It does not mean that all the projects under consideration are realized.
(Source) "Natural Gas Situations and LNG Supply-Demand Trend in Asia-Pacific Region," 2003.

As Figure 8 illustrates, if you put Asia's LNG demand in 2010 and LNG supply potential together, it shows that natural gas resources that are to be turned into LNG are in a state of excess-supply. This oversupply condition is likely to remain unchanged over a long period of time until 2020. This means that there will inevitably be a move to

utilize the natural gas resources in question for purposes not in conflict with LNG.

If the supply potential of natural gas is ensured, it can be said in the medium- and long-term that the main customer is Asian developing countries whose energy demand is expected to grow steadily for years to come. If they increase oil demand sharply, Asian countries may suffer from an unstable supply in an emergency due to increased dependence on Middle East oil and if they depend on domestic coal resources, they will be pressed not only by the problem of global warming but also by immediate environment problems, such as air pollution and acid rain. In this sense, Asian developing countries inevitably crave natural gas as an important energy source.

A study of gas fields by size in the Asia-Oceania region shows that small (0.3~1 tcf) and medium-sized (1~3 tcf) gas fields account for more than 40% of the total. If gas fields with 3~10 tcf are included, they account for 80%. This shows that effective use of small and medium-sized gas fields is important for the Asia-Oceania region. In the Middle East and former Soviet Union, super-giant gas fields with more than 30 tcf account for about 60%. For Asia, the existence of abundant natural gas resources outside the region, such as the Middle East and Far East Russia, is important. It will become an important issue that we study various ways to utilize the vast amount of the natural gas resources.

In view of the fact that gas fields with at least 5 tcf are suitable for LNG, there does not exist abundant natural gas resources for LNG within Asia. Therefore, if demand for LNG increases, Asia will have to eventually depend on natural gas resources in the Middle East or Russia. In that sense, it is necessary to study problems of energy-supply security, as in the case of oil. If LNG becomes a major energy source, with its proportion in total primary energy demand exceeding a certain level, then it will become necessary to build up a certain amount of LNG stockpiles as an emergency response measure, as in the case of oil.

(3) Natural gas pipeline projects for East Asia and supply security problem

With regard to the future of Asian developing countries, what we have to take note of is that many of these countries that are expected to post further economic growth and increase energy demand are located deep inside the Eurasia continent. By contrast, Japan, South Korea and Taiwan, or countries or region that have achieved economic development, are island nation or close to the sea. Therefore, for the developing countries on the continent, pipelines are essential infrastructure to transport energy. For this reason, various international natural gas pipeline construction projects are now under way in many parts of Asia, as is shown in Table 4.

Table 4 Major International Natural Gas Pipeline Construction Projects in Asian

	Countries (outline of route)		Length of pipeline	Supply amount	Note
SPA, MOU already signed	Malaysia-Thailand waters -> Malaysia, Thailand	JDA (Thailand-Malaysia joint development zone) ->Thailand, Malaysia	About 350km	5.0-8.7 BCM/year	Malaysia takes the first phase portion of gas. Scheduled for completion in June 2002.
	Indonesia ->Singapore	South Sumatra ->Singapore	477km	2003~, 3.4 BCM/year	Pertamina and PowerGas signed sales contract in February 2001
	Indonesia ->Malaysia	South Natuna Sea Block -> PGU II (Southeaster part of the country)	97km	1.0-2.6 BCM/year	Gas supply to PGU II (Malay Peninsula main pipeline)
	Qatar ->UAE ->Oman ->Pakistan (Dolphin project)	Qatar ->UAE (First phase)	350km	2BCFD	Screening of companies participating in FEED contract concerning equipment is now under way.
	Qatar-Kuwait				Details on project and amount of gas supply now under discussion.
At the stage of FS implementation	Sakhalin->Japan	Korsakov->Ishikari	About 450km	Under production plan, Exxon's production capacity is 1BCFD.	Exxon and Japan Petroleum Exploration began pipeline laying FS in 1998.
		Ishikari->Niigata	884km		
		Aomori->Kanto	860km		
	Turkmenistan->China	Turkmenistan->Shanghai	About 5,730km	18-20 BCM/year	Route (Lianyungang->Shanghai) changed and the economic feasibility under review.
	Irkutsk->China	Irkutsk->Beijing	About 3,500km	30 BDM/year	Russia, China and South Korea began FS in 2002.
Planning stage	Iran->India		About 2,200km	18-20 BCM/Year	Laying undersea P/L that does not go through Pakistan now under study.
	Bangladesh->India	Bangladesh->Orissa	N.A.	N.A.	Making little headway due to domestic political problems in Bangladesh.
	Turkmenistan->Pakistan (TPA project)		1,440km	20 BCM/Year	Unocal withdrew from the project.
Project postponed or cancelled	Indonesia->Thai	Natuna gas field-> Thailand	About 1,538km	500 MMCFD from 2005 and 1,000MMCFD from 2007	Postponed until at least 2007 due to currency crisis and slowdown of gas demand in Thailand.
	Oman->India		About 1,150km	20 BCM/Year	Cancellation of the project reported in October 1996.

	Iran->Pakistan	About 1,600km	About10 BCM/Year	Postponed until 2005

(Note) In addition to the above, a Yakutsk (Russia)->China pipeline project was reported (FS implementation agreed in 1999), but details about pipeline route are not available.

(Source) "Natural Gas Situations and LNG Supply-Demand Trend in Asia-Pacific Region," 2003

The leader in the field of international natural gas pipeline network is Europe. A study of how the current European pipeline network came into being shows that, after the discovery of a large gas field in the Netherlands, a pipeline network was created for export to neighboring countries and, after the pipeline network expanded in Europe, it was extended to large natural gas resources outside the region, such as Russia and Algeria. Later, North Sea natural gas joined the network. The fact that a local network was connected extensively to natural gas resources outside the region has provided gas-supply security.

If a similar network has to be established in East Asia, perhaps it is critically important to develop a natural gas pipeline network in China. In fact, China has been expanding its east-west natural gas pipeline for its local natural gas resources. The West-East Gas Pipeline Project to supply natural gas in the Tarim Basin to Shanghai is about to be completed. If new natural gas resources are developed and the cross-country pipeline network is expanded in China, it would become easy to link the network to natural resources outside the country, such as Irkutsk and Turkmenistan. For the future use of natural gas, it is important to study how the infrastructure for natural gas should be developed consistent with the economic rationality of Asian developing countries.

(4) Increasing use of coal in East Asia and its problems

Demand for coal in East Asia increased from 265 million tons of oil equivalent in 1971 to 559 million tons in 1986 and to 879 million tons in 2000. By use, while the component ratio of the use for steel production decreased from 20% in 1971 to 16% in 2000, demand for coal for electricity generation increased sharply from 47 million tons of oil equivalent in 1971 to 134 million tons in 1986 and to 430 million tons in 2000. The ratio of the demand for coal for civilian use or other purposes (general industrial use, etc.) dropped to 35%, or 307 million tons of oil equivalent, in 2000 after hitting a peak of 62%, or 165 million tons in 1971.

It can be said that the increased use of coal in the electric power sector is the biggest factor behind the increase in coal demand in East Asia. This trend is seen in the whole Asian region. Be that as it may, since China accounts for more than 70% of coal demand

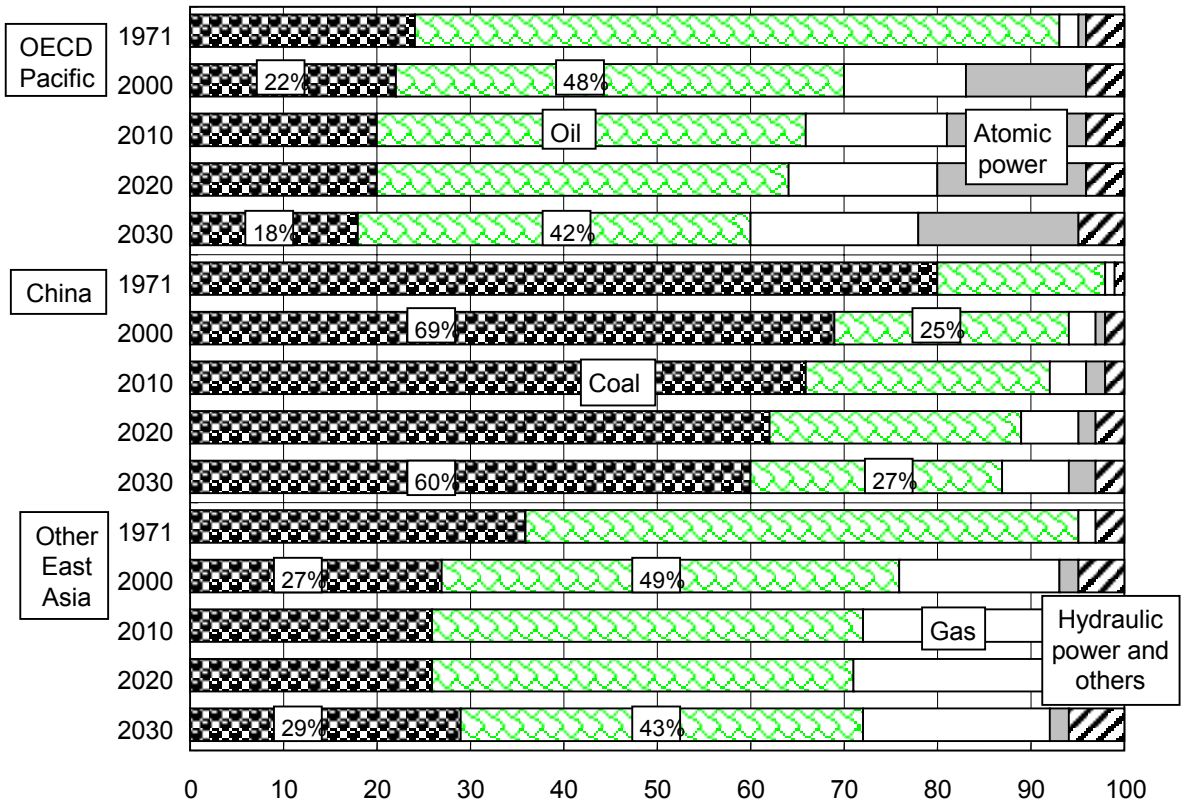
in East Asia as a whole, it is no exaggeration to say that the increase in the use of coal and its problems are a China problem.

Coal production in East Asia in 2000 stood at 779 million tons of oil equivalent, accounting for 34.1% of total coal production in the world. On the other hand, East Asia's consumption of coal in the same year came to 879 million tons of oil equivalent, accounting for 37.7% of total coal consumption in the world. East Asia's coal production is lower than its coal consumption. China accounts for nearly 90% of coal production in East Asia. Recently, the growth of coal production by Indonesia has been conspicuous, and the country is now the second largest coal exporting country in East Asia next to China. This is one of the characteristics in terms of coal supply in the region.

Major coal-exporting countries to East Asia from outside the region are Australia, the United States, Canada, South Africa and Columbia. Major coal-exporting countries in Asia are China, Indonesia and Vietnam. East Asia depends greatly on the Middle East and former Russia for oil and natural gas, but it depends on completely different countries for coal. This is another characteristic. The fact that East Asia has a major coal supply source in its close geographical proximity (Australia) means much in terms of securing a stable supply of coal.

According to the IEA global energy supply-demand outlook, East Asia's coal demand is expected to increase over the long term and nearly double by 2030. In particular, China is expected to account for 72% of all increases in coal demand, amounting to 620 million tons of oil equivalent. The IEA outlook for coal demand increase in China, mainly in the electric power sector, takes into account environmental constraining factors, such as air pollution.

Figure 9 Energy Supply in Increasingly Coal-Dependent East Asia



(Note) This energy supply composition does not include non-commercial use energy.
(Source) IEA, "World Energy Outlook 2002," September 2002

The biggest characteristic of energy supply and demand in Asia is that coal occupies an important place in supply (Figure 9). Even now, China depends on coal for two-thirds of its energy needs. Recently, oil-producing countries, such as Indonesia and Malaysia, have also increase their use of coal, mainly in the power generation sector. In consideration of worsening environment problems, these countries want to reduce their dependence on coal, but are unable to do so. Therefore, they are now thinking of reducing pollutants as much as possible with clean coal technology in order to effectively utilize coal.

In developing countries, low-quality coal is often burned directly for civilian use. Small industries also burn coal directly without removing pollutants from coal. When using coal, it is important to convert coal into clean secondary energy by removing pollutants efficiently and intensively at, for instance, a large power-generation plant. In any case, it is important for Asia's dependence on coal to promote development of clean coal technology aimed at enhancing the efficient use of coal and removing pollutants from a long-term viewpoint.

Whether developing countries increase dependence on natural gas or coal is an important issue. However, many of the countries that have so far increased the use of local natural gas are planning to increase their use of coal, especially in the power generation sector.

(5) Atomic energy option that will become necessary in East Asia in the long run

In OECD Asia, Taiwan, and ASEAN, energy supply is largely accounted for by oil, while the use of natural gas is increasing. For these countries and areas, developing infrastructure, such as pipelines, to increase the use of natural gas is an important issue. In the longer term, where East Asia will position atomic power will become an important issue. Japan first introduced atomic power before the first oil crisis and since then has developed atomic power as the pillar of domestically produced energy and alternative energy resource to oil. South Korea and Taiwan have drastically increased atomic power since the beginning of the 1980s. China activated its first atomic power plant early in the 1990s and has been promoting the construction of more plants.

In addition, Indonesia and Thailand are considering introducing atomic power in around 2010. For instance, in the case of Thailand, though domestically produced brown coal is currently one of the main fuels for power generation, it is expected to become necessary for the country to introduce atomic power in around 2010, after increasing imports of coal from around 2000 to meet growing electric power demand.

For East Asian developing countries that are expected to show fast economic growth and a sharp increase in energy consumption, atomic power is certainly an important source for electric power generation. However, in order to use the giant technology safely, above all, it is important to develop and establish a solid infrastructure, including engineers and social structure. There are strong oppositions against atomic power in Western countries. However, given the long-term increase in Asia's energy demand, it is vital that Asia keeps the atomic power option.

4. Response to Regional Environmental Issues in East Asia and Problems

(1) Response to worsening immediate problem of environment – air pollution by fixed sources

Due to accelerated increase in energy consumption in the 1990s, immediate environment problems, centering on air pollution, have deteriorated in East Asia. The seriousness of the environment problem differs from one country to another depending on the country's economic standard and on the kind of energy it uses. The problem is a national issue in South Korea and Taiwan, while it remains an urban issue in Thailand