CHAPTER TWO

The Environmental Context of Energy

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Air pollution hangs over an industrial area in Kawasaki, Japan. Policymakers in the Asia-Pacific region must search for a balance between environmental concerns and the economic aspirations of their people. © Michael S. Yamashita/Corbis

Along with growing dependence on imported oil and natural gas, environmental concerns associated with increased energy use are at the heart of the Asia-Pacific energy-security dilemma. How will societies in the region balance concerns about air, water, and land pollution with the economic aspirations of their people? And as the environmental impact of energy use transcends national—and even regional—boundaries, how will countries in the region and around the world devise and enforce international agreements to make sure that economic development in one country does not come at the expense of environmental problems somewhere else?

Even efforts to reduce dependence on imported energy involve environmental tradeoffs. Countries can slow down their consumption of imported oil and natural gas by generating electricity with coal, the only fossil fuel that is abundant in the region. Yet coal combustion causes air pollution at local and regional levels and produces greenhouse gases that contribute to global warming. Several countries in the region could also reduce their dependence on imported energy by switching to nuclear power for electricity generation, but the use of nuclear power raises concerns related to accidents, the safe disposal of radioactive wastes, and the possibility of nuclear-weapons proliferation.

All energy sources have some impact on the environment, and every decision about energy use and economic growth has environmental implications. Among energy sources, coal, oil, and biomass (trees, shrubs, and agricultural and animal wastes) cause the highest levels of air pollution (Table 2.1), while coal and biomass produce the most greenhouse gases for the same amount of energy generated (Siddiqi 2000). With growing energy use in Asia and the Pacific, air pollution is becoming an increasingly important problem, particularly in urban areas, and greenhouse gases from the region are making a significant contribution to global climate change.

More efficient use of energy, whatever its source, can lower consumption and thus contribute to achieving environmental goals. Technological improvements can make energy use less harmful. And switching away from coal or oil to natural gas, hydropower, nuclear power, or wind or solar energy can help reduce problems of air quality, acid rain, and global climate change.

Air quality

The largest sources of air pollution are smoke and exhaust from burning fossil fuels and biomass. Outdoor air pollution is particularly critical in the cities of

Table 2.1. Major environmental impacts of energy sources

Impact	Energy source							
	Fuel-wood	Coal	Petroleum products	Natural gas	Hydro-power	Nuclear	Solar	Wind
Air pollution	H	H	H	L	L	L	L	L
Acid rain	H	H	H	L	L	L	L	L
Greenhouse gas emissions	H	H	M	L	L	L	L	L
Impact on oceans	L	L	M	L	M	L	L	L
Impact on inland waters	L	L	M	L	H	L	L	L
Impact on land	H	M	L	L	H	L	L	L
Disturbance to ecosystems	H	M	M	M	H	H	L	L
Solid wastes	L	H	L	L	L	H	L	L
Noise	L	M	M	L	L	L	L	H
Visual	H	H	H	M	L	L	M	M
Disaster potential	M	M	H	M	H	H	L	L

Source: Estimated by author.
Note: H = high impact; M = medium impact; L = low impact.

the Asia-Pacific region, while indoor air pollution, largely from cooking and heating with biomass fuels, tends to be more important in rural areas.

Air pollution in cities stems primarily from motor-vehicle exhaust and smoke from coal used in power plants and factories and for domestic heating. Small particles released by the combustion of coal and petroleum products can cause a wide range of health problems, including respiratory diseases, lung cancer, and heart disease. Air pollutants from fuel combustion also include sulfur dioxide (SO_2), which contributes to acid rain and can cause health problems, particularly among children and the elderly. Another important air pollutant, nitrogen dioxide (NO_2), is a poisonous gas. When combined with hydrocarbons and sunlight, NO_2 produces photochemical reactions and smog. Unhealthy levels of these pollutants are found in the ambient air of many cities in the region (Table 2.2).

The World Health Organization (WHO) has recommended guidelines for maximum concentrations of SO_2 and nitrogen oxides (NO_x) in the ambient atmosphere, as given in Table 2.2. WHO has not yet recommended a guideline for small particles, so the table includes the U.S. Environmental Protection Agency (EPA) air-quality standard for particulate matter (PM_{10}).

Out of 29 cities that had particulate-matter counts above the EPA standard in 1999, 27 were in the Asia-Pacific region (World Bank 2005). They included, among others, Beijing, Chongqing, Shanghai, and Tianjin in China; Delhi, Kolkata (formerly Calcutta), and Mumbai (formerly Bombay) in India; Jakarta in Indonesia; and Bangkok in Thailand.

Table 2.2. Air pollution in selected cities of Asia and the Pacific

Country	City	Urban population (millions, 2005)	Particulate matter[ab] (1999)	SO_2[ac] (1995–2001[d])	NO_2[ac] (1995–2001[d])
Australia	Sydney	4.39	22	28	81
China	Beijing	10.85	106	90	122
	Chongqing	4.98	147	340	70
	Shanghai	12.67	87	53	73
	Tianjin	9.35	149	82	50
India	Delhi	15.33	187	24	41
	Hyderabad	6.15	51	12	17
	Kolkata	14.30	153	49	34
	Mumbai	18.34	79	33	39
Indonesia	Jakarta	13.19	103	NA	NA
Japan	Tokyo	35.33	43	18	68
	Yokohama	3.37	32	100	13
Malaysia	Kuala Lumpur	1.39	24	24	NA
New Zealand	Auckland	1.15	15	3	20
Philippines	Manila	10.43	60[e]	33	NA
Republic of Korea	Pusan	3.53	43	60	51
	Seoul	9.59	45	44	60
Singapore	Singapore	4.37	41	20	30
Thailand	Bangkok	6.60	82	11	23
WHO recommended guidelines			—	50	40
EPA standards			65–75	—	—

Sources: World Bank (2005); WHO (2000); EPA (2005).
[a] Micrograms per cubic meter.
[b] Average annual concentrations in residential areas of particulates smaller than 10 microns.
[c] Average annual concentrations.
[d] Data are for the most recent year available.
[e] Data are for 2000.
NA = not available.

Among the cities with ambient concentrations of SO_2 exceeding WHO guidelines are Beijing, Chongqing (the highest level among the cities shown), Shanghai, and Tianjin in China, Kolkata (estimated for 2005) in India, Yokohama in Japan, and Pusan in the Republic of Korea (South Korea). Cities with NO_2 levels exceeding WHO guidelines include the same four cities in China, Delhi in India, Tokyo in Japan, and Pusan and Seoul in South Korea.

Air pollution in other cities of the region, such as Karachi and Lahore, may well exceed the WHO/EPA standards. For many cities, however, reliable data on SO_2 and NO_2 concentrations and on particulate-matter levels and are not available.

As if the current situation were not serious enough, air pollution is expected to worsen in many of these cities, as well as in several smaller cities of the region. Much of the increase in air pollution in Asian and Pacific cities stems from the growing number of motor vehicles. Between 1990 and 1999–2001, the number of motor vehicles per capita more than doubled in South Korea, the Philippines, India, and China (Table 2.3). The total number of motor vehicles increased at an even faster pace because populations were also growing during this period. Between 2004 and 2015, the number of motor vehicles is projected to more than double in most Asian countries. Increased traffic congestion, which results in more emissions per distance traveled, will also add to air pollution.

The use of coal for electricity generation and industry contributes significantly to urban air pollution. Since 1980, coal use has grown in nearly every major country of the region, and it is expected to continue growing (see Appendix Table 2.1). In many cases, the rising use of coal will cause higher levels of air pollution, acid rain, and greenhouse-gas emissions.

Although most outdoor air pollution originates in the region's major cities, it extends—in the form of acid rain (more accurately referred to as acid precipitation)—far beyond urban boundaries and national borders. Acid rain results primarily from emissions of SO_2 and NO_x produced from the burning of coal. When released into the atmosphere, these gases react with water, oxygen, and other chemicals to form a solution of sulfuric and nitric acid, which can be carried over long distances by prevailing winds before returning to earth in rain, snow, fog, or dust. Acid rain can damage forests and soils, fish and other animals, building materials, and human health.

Acid rain is a growing concern in the region, particularly in East Asia. The highest levels have been measured in southern China where a great deal of high-sulfur coal is burned (Figure 2.1). Prevailing winds can spread acid rain from this region as far as South Korea and Japan.

Forest fires also cause widespread haze in Southeast Asia. In 2005, fires on the Indonesian island of Sumatra caused Malaysia to declare a state of emergency in the two coastal cities of Kuala Selangor and Port Klang, where the residents were advised to stay indoors. Schools were closed in the central state of Selangor and in Kuala Lumpur, the capital city.

Droughts and the illegal burning of rain forests by farmers and loggers are blamed for the periodic episodes of haze. The prolonged and extensive haze over Malaysia, Singapore, and Indonesia during 1997 caused several billion dollars in economic loss due to a decline in tourism and agricultural production (Arnold 2005), in addition to harmful effects on human health. Although forest fires are not strictly an energy issue, energy-related air pollution adds to pollution from fires, resulting in a much greater health impact.

Table 2.3. Growth in per-capita number of motor vehicles in selected Asia-Pacific countries, 1990 to 1999–2001: Number of vehicles per 1,000 population and percent increase

Country	Number of vehicles per 1,000 population		Percent increase
	1990	1999–2001	
China	5	12	140
India	4	10	150
Indonesia	16	25	56
Japan	469	572	22
New Zealand	524	696	33
Pakistan	6	9	50
Philippines	10	32	220
Republic of Korea	79	255	223
Singapore	130	168	29

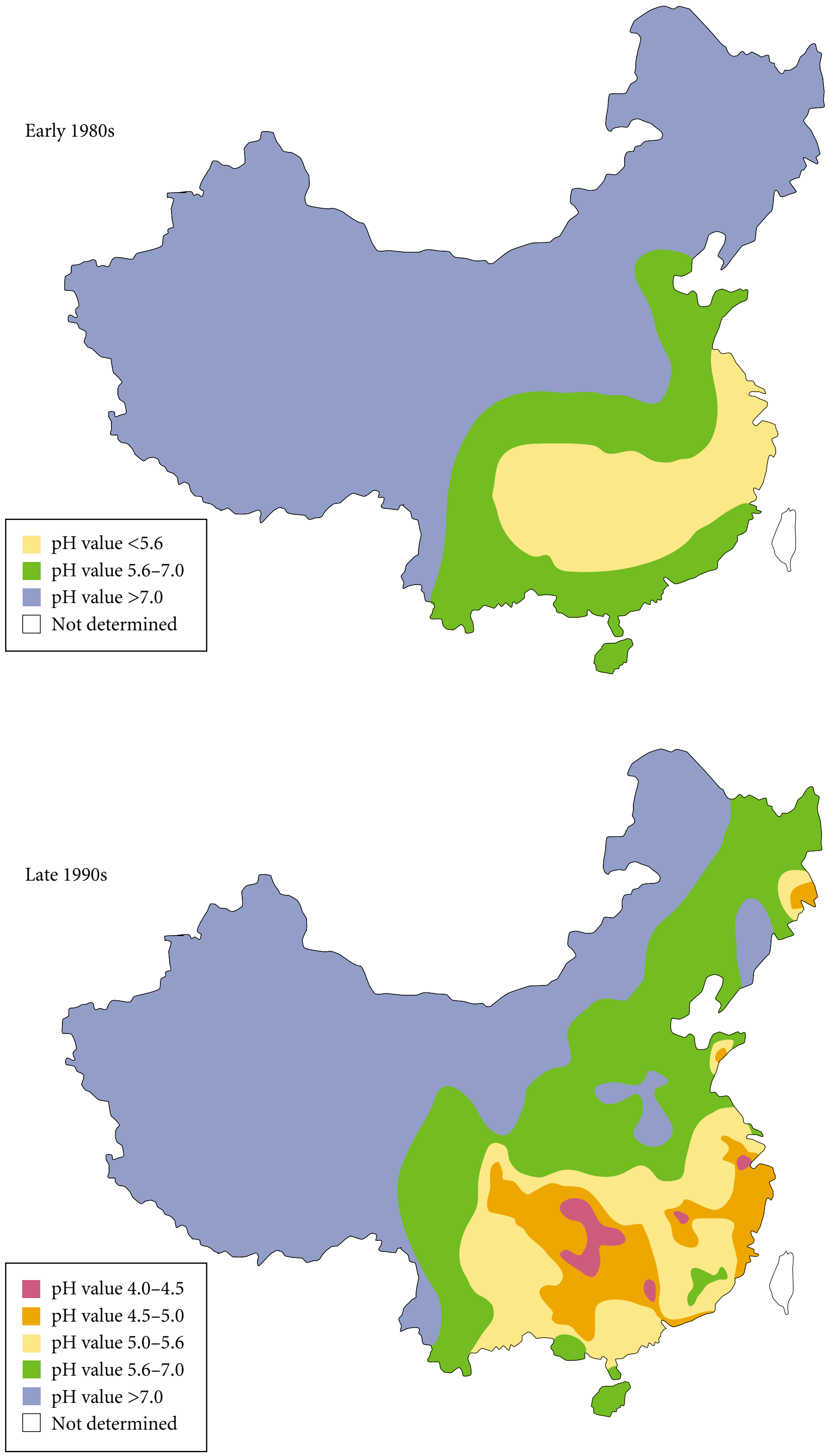
Source: World Bank (2004).

Several of the region's largest cities have managed to reduce at least some air pollutants. The decline in lead concentrations in Bangkok is one example. In Seoul, concentrations of SO_2 have fallen dramatically—from 0.094 parts per million (ppm) in 1980 to less than 0.001 ppm in 2000. Concentrations of nitrous oxide (N_2O), particulates, and ozone (O_3) have increased, however (Jeon 2001). Most of this increase is due to the city's rapidly growing number of vehicles—from about 130,000 in 1970 to more than 2 million in 2000. To counter this trend, the Korean government is promoting the use of compressed natural gas (CNG) in buses. While only 77 such buses were in operation in 2000, the number has been increasing rapidly and is expected to reach 20,000 by 2007.

Overall, air quality is improving in a few major cities of the region, holding steady in some, and deteriorating in others, depending on the growing numbers of motor vehicles, the energy sources used for industry and power generation, and government measures to curb emissions (Huizenga, Haq, and Schwela 2003). Air-pollution levels are low and decreasing in Tokyo and Osaka; they are moderate to high but decreasing in Pusan, Hong Kong, Delhi, and Seoul; and they are high but stabilizing in Bangkok, Beijing, Chongqing, Kolkata, Metro Manila, Mumbai, and Shanghai. In most other cities of the region, air pollution is getting worse.

While combustion of fossil fuels is the major source of air pollution in urban areas, burning fuelwood and agricultural and animal wastes is the largest source of air pollution in the countryside. Exposure to pollutants from biomass combustion is particularly harmful to women who use biomass fuels to cook under conditions of poor ventilation. It is also harmful to young children who are often nearby while their mothers are cooking.

Figure 2.1. Increase in acidity (lower pH values) of precipitation in China, early 1980s to late 1990s



Source: Based on He, Huo, and Zhang (2002). Reprinted with permission from the publisher.

WHO estimates that indoor air pollution causes 1.6 million deaths per year in developing countries. About 550,000 of these deaths occur in India alone (Walsh 2004). Rural women and their children are often exposed to many times higher levels of harmful pollutants than are urban dwellers. A recent survey on indoor air pollution in Bangladesh (Dasgupta et al. 2004) found that women and children were exposed to twice the level of pollutants as men. The authors estimated that the exposure of children could be reduced by half with two simple measures: increasing their time outdoors from three to five or six hours a day and concentrating their outdoor time during peak cooking periods.

Global climate change

There is general scientific consensus, documented in the reports of the Intergovernmental Panel on Climate Change (IPCC), that emission of greenhouse gases is the most important human activity contributing to global climate change (WMO and UNEP 2001). The gases that contribute most to climate change are carbon dioxide (CO_2), methane (CH_4), N_2O, halocarbons, and tropospheric ozone. Slightly more than one-half of the total effect is due to CO_2, and about two-thirds of the CO_2 is produced from energy conversion, primarily from the combustion of coal, oil, natural gas, and biomass. Natural gas is mainly composed of methane, and methane leaks from producing areas and from pipelines also contribute to global climate change.

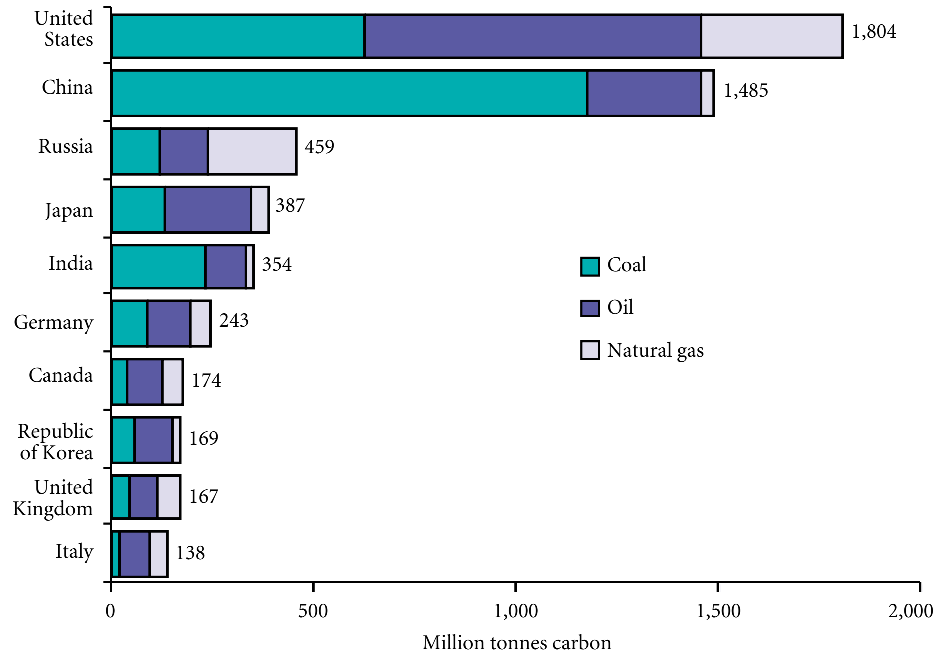
Greenhouse-gas emissions from developing countries in Asia are increasing due to growing populations and rapid industrialization. Among the 10 countries in the world with the highest CO_2 emissions from fossil-fuel use, China ranks second (after the United States) and India fifth (Figure 2.2). Two of Asia's developed countries also rank in the top 10—Japan (fourth) and South Korea (eighth). In China and India, coal makes the largest contribution to total CO_2 emissions; in Japan and South Korea, the largest contributor is oil.

Although high in absolute terms, greenhouse-gas emissions from the large developing countries of Asia are much lower on a per-capita basis than emissions from the world's industrialized nations. In terms of CO_2 emissions, one person in the United States has a greater negative effect on the environment than more than six people in China or nearly 21 people in India (Figure 2.3).

This contrast in per-capita CO_2 emissions has been a major issue obstructing international agreements on global climate change. Although still comparatively low, per-capita emissions in many developing countries are increasing rapidly. China, for example, is expected to become the world's largest emitter of CO_2 by 2009. Policymakers in Washington and representatives of energy-intensive industries have argued that limiting emissions in the United States will have serious economic consequences if no limits are placed on the larger developing countries such as China and India (see, for example, Victor 2004).

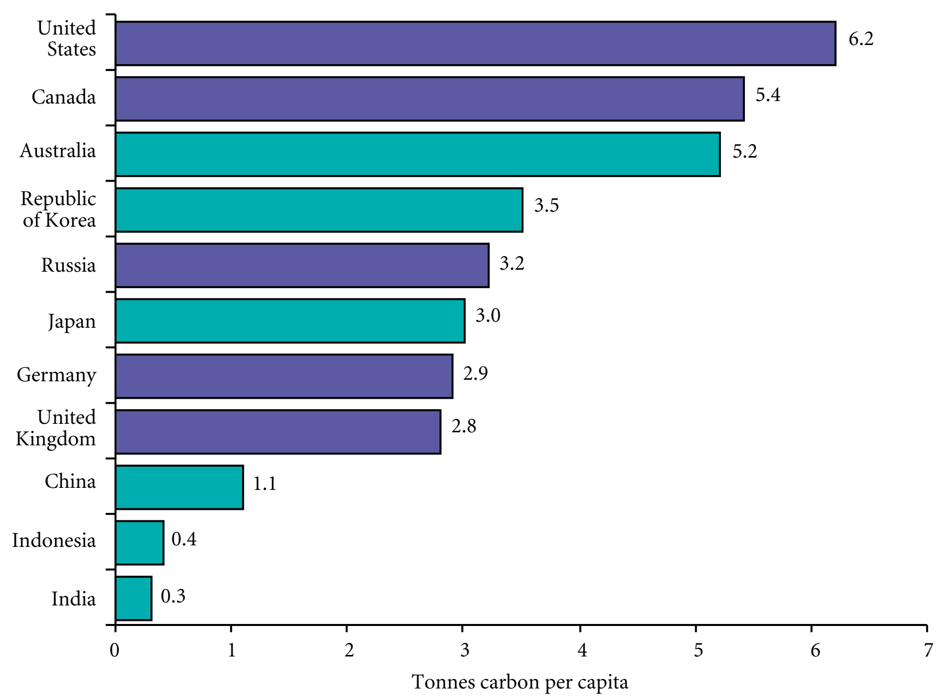
Meanwhile, representatives from almost all developing countries, including

Figure 2.2. Annual total CO_2 emissions (million tonnes of carbon) from major emitting countries due to combustion of coal, oil, and natural gas, 2005



Source: Calculated by the author from BP (2005).

Figure 2.3. Annual per-capita CO_2 emissions (tonnes of carbon) from all fossil-fuel combustion in selected large countries of the world, 2005



Source: Calculated by the author from BP (2005).
Note: Countries/economies in the Asia-Pacific region are shown in green.

The United Nations Framework Convention on Climate Change (UNFCCC) was signed at the World Summit in Rio de Janeiro in 1992. The Kyoto Protocol, which spells out the actions to be taken under the Convention, was opened for signatures in 1998. After ratification by the Russian Federation in November 2004, the Protocol came into force in February 2005. The effectiveness of the Protocol is substantially hampered, however, because the United States (along with Australia and a few smaller countries) has not ratified it.

A major reason given by the United States for not ratifying the Kyoto Protocol is that it requires that industrialized nations as a whole reduce greenhouse-gas emissions to about 5 percent below 1990 levels over a five-year period from 2008 to 2012. Developing countries are not required to reduce their emission levels. Because the United States has continued to increase emissions since the Kyoto Protocol was formulated, it would now need to reduce current levels by about 30 percent to meet the Kyoto targets.

Most reductions would have to come from a decrease in CO_2 emissions associated with the use of fossil fuels, primarily coal and petroleum products. In the United States, where 51 percent of electricity is generated from coal (EIA 2004), there has been strong opposition to building nuclear power plants, and most of the economically feasible hydropower capacity is already being utilized. Thus reductions in energy-related emissions would have to come from improvements in energy efficiency and greater use of natural gas, wind, and solar energy. U.S. policymakers feel that complying with these requirements would hurt the competitive position of the United States with respect to large developing countries such as China and India, which are not required to reduce their emissions.

The Kyoto Protocol also includes provisions such as emissions trading and the Clean Development Mechanism (CDM). Emissions trading allows one country to meet some of its obligations under the treaty by obtaining “emission-reduction credits” from another country. For example, an industrialized country might obtain emission-reduction credits by providing economic assistance to a developing country in return for a pledge that the developing country would retain a certain area under forests. The CDM provides guidelines for joint projects in which an industrialized country receives emission-reduction credits when it funds a project in a developing country where emissions are reduced. There have been some limited applications of these provisions on a bilateral basis and through multilateral organizations such as the World Bank.

The Kyoto Protocol, by itself, will not stabilize greenhouse-gas emissions. The national emission targets set by the Protocol for 2008–2012 need to be followed by successive rounds of targets, to be negotiated on a rolling basis. It may also be necessary, as a recent study for the Pew Center on Global Climate Change (Aldy et al. 2003) suggested, to place more emphasis on complementary or alternative approaches that go beyond quantified emission reductions. Such policies might focus on technology standards and accelerated research and development.

The Asia-Pacific Partnership on Clean Development and Climate represents a complementary approach. The United States launched the Partnership with Australia, China, India, Japan, and South Korea in 2005 (U.S. Department of State 2005). Among other initiatives, the Partnership will:

- Collaborate to promote the development and diffusion of existing and emerging technologies and practices that are cost effective and reduce stress on the environment. Areas of cooperation include energy efficiency, clean technologies for the use of coal, increased use of liquefied natural gas (LNG), carbon capture and storage, methane capture and use, non-military nuclear power, rural/village energy systems, and renewable energy technologies
- Cooperate on the development and diffusion of longer-term transformational technologies that will promote economic growth while enabling significant reductions in greenhouse-gas intensities. Areas for mid- to long-term collaboration include hydrogen, next-generation nuclear fission, and nuclear fusion
- Help build human and institutional capacity to strengthen cooperative efforts, seeking opportunities to engage the private sector

The vision statement of the Partnership mentions that its goals are consistent with those of the UNFCCC. No mention is made of the Kyoto Protocol, however, since the Partnership is meant to provide a supplementary approach. In this context, Japan’s role in the Partnership is especially noteworthy, since Japan has a strong commitment to reduce its emissions as specified under Kyoto.

ASSIGNING A COST TO AIR POLLUTION

The World Bank (1992) has estimated that 2 to 5 percent of all deaths in urban areas in the developing world are due to exposure to high levels of airborne particulates. SO_2, NO_x, volatile organic compounds, lead, and carbon monoxide (CO) also have significant adverse effects on human health.

There have been a number of attempts to estimate the economic cost of pollution-related health problems. The Asian Development Bank (1999) estimated annual economic losses due to death and illness caused by airborne particulates and lead at US$2.1 billion in Jakarta and US$2.5–6.3 billion in Bangkok.

The elimination of lead from gasoline in Bangkok, fully implemented in 1995, is one of the best-known success stories of improving air quality in the Asia-Pacific region. The average level of lead in blood samples taken from traffic policemen declined from 22.3 milligrams per deciliter (mg/dl) in 1995 to 5.5 mg/dl in 2000 (Wangwongwatana 2002). The proportion of school children with lead concentrations of more than 10 mg/dl dropped from 26 percent in 1993 to 2 percent in 2000. The economic benefit of reducing lead pollution in 2000 alone was estimated at US$175 million.

China and India, point to the gap in current per-capita emissions levels. They maintain that most accumulated greenhouse gases in the atmosphere today have come from the industrialized nations and these nations should reduce their emissions before asking the developing nations to do so. If the goal is to reduce the effects of human activities on climate change, the concerns of both developing and industrialized nations will need to be addressed.

In the period up to 2015, CO_2 emissions are expected to continue increasing in most of the countries of the Asia-Pacific region (Table 2.4). Factors that will affect the rate of increase include the overall economic growth rate, the energy intensiveness of national economies, and the choice of energy sources. Countries that rely heavily on coal, such as China, India, and Australia, will find it more difficult to slow down increases in CO_2 emissions than countries that put more emphasis on natural gas or hydropower, such as Bangladesh, Pakistan, Malaysia, and New Zealand.

Table 2.4. Projected growth in CO_2 emissions from fossil fuels in selected Asia-Pacific economies, 2005 actual and 2015 projected: Million tonnes of carbon and percent change

Country/economy	Million tonnes of carbon 2005	Million tonnes of carbon 2015	Percent change[a]
Australia	106	126	19
Bangladesh	11	19	76
China	1,485	2,310	56
China, Hong Kong SAR[b]	21	25	19
India	354	481	36
Indonesia	96	122	27
Japan	387	389[c]	1
Malaysia	41	52	27
New Zealand	11	11[c]	5
Pakistan	36	54	50
Philippines	21	29	38
Republic of Korea	168	229	36
Singapore	40	53	33
Taiwan	85	115	35
Thailand	67	92	37
Vietnam	19	41	116

Sources: Calculated by the author from BP (2006) and FACTS Global Energy (2006) for 2005 and from FACTS Global Energy (2006) for 2015.
[a] Calculated from more exact values than shown in preceding two columns.
[b] Special Administrative Region.
[c] Projections for 2015 will need to be reduced to meet Kyoto-Protocol requirements.

Hydropower and nuclear energy: Advantages and disadvantages

Hydropower. Water has been used on a small scale as a source of energy for centuries. The rapid growth in the use of electricity in the early 20th century increased the demand for hydropower, and thousands of small and large dams were constructed for power generation. Hydropower as a source of electricity has a high initial capital cost, but a low operating cost. On a small scale, it is generally considered to be a clean and environmentally friendly energy source.

The potential for using hydropower to generate electricity depends on the configuration of flowing water and the distance from centers of demand (World Commission on Dams 2000). Not surprisingly, the most promising sites were developed first. Today, more difficult and controversial sites are being examined for development.

During 2005, the Asia-Pacific region produced roughly 25 percent of the world's total hydropower for electricity generation, equivalent to about 3.4 million barrels of oil per day (boe/d) (BP 2006). China produced more than one-half of Asia's total electricity from hydropower, at 1.8 million boe/d. Japan, India, Pakistan, New Zealand, and Australia also generated significant amounts of hydro-electricity.

There is usually no opposition to the development of small-scale hydropower plants that can supply electricity to hundreds or a few thousand households. By contrast, the construction of large dams for hydropower frequently inundates vast areas of agricultural land, disrupts natural ecosystems, and displaces entire communities. During recent years, there has been strong opposition to such projects, including the Sardar Sarovar Dam on the Narmada River in India and the Three Gorges Dam on the Yangtze River in China.

Choosing between energy sources always involves tradeoffs, and hydropower is no exception. The Three Gorges Dam, for example, will be the largest hydropower project in the world, generating about 16,000 megawatts (MW) of electricity. If this same amount of electricity were to be generated using coal, it would result in the emission of about 140 million metric tons (tonnes) of CO_2 a year. In addition, the emission of particulates, SO_2, and other gases would have substantial negative effects on human health.

China already suffers from electricity shortages, and demand is certain to increase. There is no question that the Three Gorges project will contribute to economic growth, and the dam will help to control floods on the Yangtze River. Nevertheless, the project has entailed the relocation of almost one million people and the loss of valuable ecosystems and agricultural lands. In 2003, the government of China's Sichuan Province decided to drop plans to build a dam on the Min River, one of the main tributaries of the Yangtze, due to public and media opposition (Economy 2004).

Nuclear energy. Like hydropower, nuclear energy is used primarily to generate electricity. In 2005, Asia and the Pacific accounted for about 20 percent of the world's total electricity generated from nuclear power. More than one-half of this was in Japan and another one-fourth in South Korea (BP 2006). The rest was in China, India, Pakistan, and Taiwan.

The nuclear-power sector is growing particularly quickly in China and India. Output in China increased by about 74 percent in 2003 and by another 14 percent in 2004, making China the third largest producer of nuclear energy in the region. As of mid-2005, China's nuclear power capacity stood at 7,916 MW. This capacity is expected to triple by 2020, over a period of 15 years. The nuclear-power capacity of India is projected to increase from 2,770 MW in 2005 to 6,730 MW in 2008, with a target of 20,000 MW by 2020 (JAIF 2005). Pakistan has two relatively small nuclear power plants in operation, and a third is under construction with assistance from China.

High initial costs, combined with problems related to storing radioactive wastes, concerns about accidents, and pressure to adhere to nuclear non-proliferation treaties, deter most countries in the region from using nuclear energy. New Zealand, for example, passed legislation in 1987 that excluded the use of nuclear power for any purpose. Australia's large reserves of high-quality coal have made it unnecessary to rely on nuclear power to generate electricity. To be economically viable, nuclear power plants must be large, making them unsuitable for countries with small populations and low total electricity demand.

Well-publicized nuclear accidents such as at Three Mile Island in the United States and Chernobyl in the former Soviet Union have led to a re-examination of the role of nuclear power in the energy supply of developing countries. Radiation from the Chernobyl accident spread to many countries in Europe and beyond. Thousands of people were evacuated, animals that grazed in the area could not be used for food, and millions of acres of agricultural land could not be used for years.

In August 2004, Japan suffered its worst nuclear accident, with four workers killed and another seven injured. This took place at a power plant west of Tokyo. Fortunately, there was no radiation leak, but such an accident is still cause for concern. Japan obtains about 30 percent of its electricity from nuclear energy, and even a temporary closure of nuclear plants could cause substantial disruption throughout most of the country.

In October 2000, anti-nuclear groups in Taiwan were able to halt construction of a nuclear power plant on the northeastern coast. According to the Taiwan Environmental Action Network, multinational corporations such as General Electric, Hitachi, Mitsubishi, and Toshiba have large stakes in the construction of the US$5.6 billion project and are exerting pressure on the government to keep the project alive.

Nuclear energy presents a classic example of the tradeoffs involved in decision-making on energy and the environment. In routine operation, nuclear power has much less environmental impact than fossil fuels. The probability of an accident is low, but should one occur, the implications could be significant for millions of people both within and beyond national borders. Another critical issue is the secure disposal of radioactive wastes for hundreds or thousands of years, including making sure that they do not fall into the hands of terrorists. Nuclear energy could play a major role in reducing global climate change, but in helping to solve one problem it could create others.

Alternative energy sources

When the price of oil and other fossil fuels shot up during the 1970s, there was renewed interest in alternative energy sources such as photovoltaic (PV) solar cells, wind turbines, and geothermal energy. When fuel prices went down in the 1980s, research and development funds for alternative energy sources also declined.

More recently, the revival of interest in renewable and other alternative energy sources stems from concern about air pollution and global climate change. The UNFCCC and the Kyoto Protocol have been major catalysts for the development of more reliable and efficient wind turbines, PV systems, and solar thermal panels. The rise in oil and natural-gas prices since 2004 has given added impetus to the development of alternate energy sources.

Until just a few years ago, the common perception was that renewable energy might play a significant role in energy supply one day. That day seems to be approaching much faster than many people thought.

The annual worldwide investment in renewable energy reached US$38 billion during 2005, an increase of US$8 billion from a year earlier (REN21 2006). Germany and China were the largest investors, contributing about US$7 billion each. The United States invested about one-half of this amount, or US$3.5 billion, followed by Spain and Japan with more than US$2 billion each, and then India. These numbers include investments in small, but not large, hydropower facilities. Investments in large hydropower plants totaled roughly US$15–20 billion in 2005.

Another indication of the rapid growth of renewable energy is the expansion of installed capacity, particularly for generating electricity. Total global installed capacity for wind power in 2005 was 59,000 MW (REN21 2006), the equivalent of about 60 average-sized nuclear-power plants. Among Asian countries, India's wind-power capacity of 4,200 MW is the fourth largest in the world, after Germany, Spain, and the United States (CECL 2006). At the end of 2005, China had a total installed wind-power capacity of 1,260 MW (Li et al. 2006), mainly in small projects. Japan had a slightly smaller capacity, at 1,230 MW.

Stand-alone electricity systems are particularly important for the millions of people in Asia and the Pacific who still lack electricity for lighting and other basic uses, particularly in remote rural areas that are not connected to national grids. In China, where about 30 million people have no access to electricity (Ku, Lew, and Ma 2003), the government completed a Township Electrification Program in 2005 that provides electricity from PV systems, small hydropower facilities, and small wind turbines to about 200,000 households in 1,000 townships (REN21 2006). The next phase of the program is projected to provide electricity from renewable sources to 3.5 million rural households in 10,000 villages by 2010. Full rural electrification is planned by 2015. The ongoing rural electrification program in Thailand has already provided solar home systems to almost 200,000 households. In Sri Lanka, about 20,000 homes were provided with PV solar systems, and 900 received small hydropower systems during 2005 alone.

Over the past few years, many countries, including several in Asia and the Pacific, have established policy targets for the share of total energy or total electricity to be supplied by renewable sources. China has announced a revised target of 16 percent of total primary energy to be provided by renewable sources (including large hydropower projects) by 2020, up from 7.5 percent in 2005. China's 2020 targets for specific sources include 300,000 MW from hydropower, 30,000 MW from wind power, 30,000 MW from biomass, 1,800 MW from PV systems, and smaller quantities from geothermal and solar thermal power (REN21 2006). If these goals are achieved, China will be the clear leader in almost all forms of renewable energy.

As a short-term target, India plans to use renewable sources for 10 percent of additional electrical capacity. This includes cogeneration of power in sugar production and other industries that use energy from biomass. Although not yet established formally as targets, several long-term goals have also been proposed by the Indian government. These include using renewable sources to supply 15 percent of all electricity and switching 10 percent of current oil consumption to biofuels, synthetic fuels, and hydrogen by 2032 (REN21 2006). Pakistan has announced targets of supplying 5 percent of all electricity from renewable sources by 2030 and installing 1,100 MW of wind power much sooner.

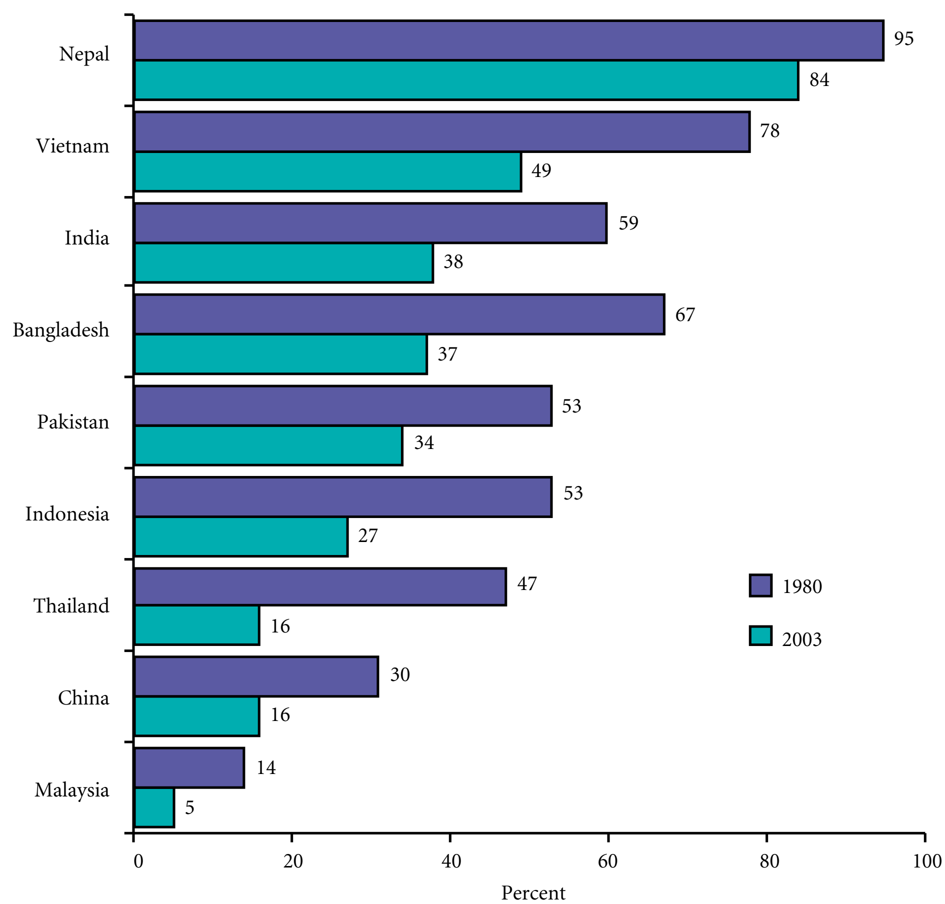
Several countries have introduced a mixture of incentives, including tax breaks and guaranteed prices, to help increase the use of renewable energy. For example, the boom in the construction of Indian wind-power facilities during the 1990s was driven by tax incentives that enabled developers to recover the full investment costs of wind farms in the first year of operation (Martinot et al. 2002). Six Indian states have guaranteed prices for renewable energy that supplies existing power grids. The Australian government provides a subsidy of US$3.15 per watt of installed PV capacity.

Although not strictly renewable, geothermal power shares many features with wind and solar power. This is because geothermal resources are generally expected to last for centuries, and the environmental impact of exploiting them is usually small. Geothermal projects often discharge superheated water and dissolved solids into streams or lakes, however, with adverse effects on aquatic ecosystems. Four of the world's largest users of geothermal energy are in the Asia-Pacific region—the Philippines (second highest capacity in the world), Indonesia (fourth highest), Japan, and New Zealand. Over the next 10 years, the use of geothermal energy for electricity generation is expected to increase globally by more than 6 percent a year, and much of this growth will be in the Asia-Pacific region.

Traditional biomass sources of renewable energy, such as fuelwood and agricultural and animal wastes, still supply about 7–11 percent of primary energy in the world as a whole (Martinot et al. 2002). The contribution of energy from these sources is much higher in many developing countries of Asia and the Pacific. In 2003, more than one-third of the total primary energy used in Bangladesh, India, Myanmar, Nepal, Pakistan, Sri Lanka, and Vietnam came from traditional biomass.

In the region as a whole, consumption of traditional biomass energy sources increased by 41 percent between 1980 and 2003 (Appendix Table 2.2), despite the fact that fuelwood is generally becoming more scarce. The share of energy consumption from biomass sources went down in most countries (Figure 2.4),

Figure 2.4. Share of total energy supplied by combustible biomass and wastes, selected Asia-Pacific countries, 1980 and 2003



Sources: OECD/IEA (2005a; 2005b).

however, because the use of fossil fuels increased even more quickly. In New Zealand, the share of biomass energy sources increased slightly between 1990 and 2003 because tree plantations were developed for energy production.

The environmental impact of burning traditional biomass fuels is similar to the harmful impact of burning coal, both in terms of local air pollution and global climate change. "Cleaner" technologies can reduce local air pollutants, but not CO_2, the main contributor to climate change. To decrease CO_2 emissions, development plans in rural areas will need to include provision of alternative energy sources where feasible, so that communities can become less dependent on biomass.

More efficient energy use

One important way to reduce the adverse environmental impact of energy use is to improve energy efficiency—that is, to consume less energy while maintaining the same output of goods and services. Industrialized countries all over the world improved energy efficiency when oil prices shot up during the 1970s. Concerns that reductions in energy use might slow down economic growth have generally not been borne out. In fact, the countries that were first to develop energy-efficient technologies were able to increase exports to other countries and thus actually benefited economically.

Japan, in particular, was able to achieve significant efficiency improvements in several sectors. During the 1980s, Japanese manufacturers introduced automobiles that gave better mileage per gallon than earlier models. With these energy-efficient models, they captured a sizable share of the automobile market in the United States and in many Asia-Pacific countries. The same scenario appears to be playing out again following the oil price hikes of 2004 and 2005.

Improvements in energy efficiency and structural changes in the economy—shifting from heavy industry toward more emphasis on the information sector—have helped China achieve high rates of economic growth with relatively small increases in energy consumption (Zhang 2003). India's increasing focus on the information industry is also leading to a decline in energy use per unit of gross domestic product (GDP). Similar trends are beginning to emerge in several other developing countries of the region.

Policy considerations

Over the past 30 years, policymakers concerned with the energy sector have begun to place more emphasis on environmental issues. This shift began in the industrialized countries, where environmental problems associated with energy use had been evident for some time. During recent years, serious health effects from air pollution have also led developing countries to consider environmental factors in formulating their energy policies.

In the Asia-Pacific region, Japan was the first country to modify its energy policy to reduce dependence on coal and make greater use of LNG and nuclear power, even though these energy sources were more expensive. South Korea has taken similar steps since the 1980s.

China and India both depend on domestically produced coal for more than one-half of their energy supply, and neither country is in a good position to cut back on the use of coal. Rather, these countries have emphasized improvements in energy efficiency to slow down the expansion of coal use, and they have moved some of the most polluting industries to less-populous areas where fewer people are affected. New installations frequently use improved technologies that make coal combustion less polluting, but it is difficult to shut down and retrofit existing plants given high costs and tight production schedules.

At the local level, perhaps the most important energy-related environmental issue is air pollution in the region's major cities. Unless strong environmental measures are formulated and implemented, expanding populations, industrial development, and growing numbers of motor vehicles are likely to exacerbate air pollution with accompanying effects on human health. Almost all Asia-Pacific countries have air-quality goals and emission standards, but strict, consistent implementation is rare.

Apart from steps taken by individual countries, the need for concerted action at the regional and global level is becoming increasingly apparent. Large-scale issues include haze and acid rain in much of Asia, as well as the region's contribution to global climate change. Progress in addressing these regional and global issues has been slow, partly due to resource scarcity and partly due to politics.

In assessing the outlook up to 2015, there will likely be considerable pressure on the larger countries of the region, including China and India, to address issues of global climate change. The pressure on these countries will increase if the major holdout industrialized countries—the United States and Australia—ratify the Kyoto Protocol or other follow-up agreements designed to reduce future emissions of greenhouse gases.