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Traffic near the cooling towers of a nuclear power plant in Baotou, Nei Mongol Autonomous Region, China. Between 2005 and 2015, China's primary commercial energy consumption, which includes oil, natural gas, coal, nuclear power, and hydropower, is projected to increase by 5 percent a year. © Michael S. Yamashita/Corbis

The Asia-Pacific region plays a critical role in today's global energy markets. Asian and Pacific countries are large and growing consumers of oil and increasingly important consumers of natural gas. As major importers from the Middle East and other regions, their participation in global oil and gas markets affects the availability and cost of energy everywhere in the world. And their growing dependence on imports is at the heart of concerns about energy security in the region.

In addition to oil and natural gas, coal is a particularly important energy source in China, India, the Democratic People's Republic of Korea (North Korea), and other countries of the region. Given the low levels of technology currently in use, heavy dependence on coal in some Asia-Pacific countries raises concerns about harmful air pollution and global warming.

Regional information presented in this book is largely based on data from 44 countries and economies. Information on individual countries and economies focuses on the major energy producers and consumers in the region: Bangladesh, India, Nepal, Pakistan, and Sri Lanka in South Asia; Brunei Darussalam, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam in Southeast Asia; China, North Korea, Hong Kong Special Administrative Region (SAR), Japan, the Republic of Korea (South Korea), and Taiwan in East Asia; and Australia and New Zealand in the Pacific (Figure 1.1).

Sources of energy include fossil fuels (oil, natural gas, and coal), traditional biomass fuels (trees, shrubs, and agricultural and animal wastes), renewable energy sources (hydropower, solar, geothermal, and wind), and nuclear power. Several countries in the region—including China, India, Bangladesh, Pakistan, Indonesia, and Vietnam—still make considerable use of traditional biomass sources of energy. It is difficult, however, to estimate total energy use in situations where fuel is not traded in the marketplace. For this reason, the discussion focuses mainly on primary commercial energy, which is defined to include oil, natural gas, coal, nuclear power, and hydropower. Traditional biomass fuels, as well as geothermal, solar, and wind energy, will be included in the discussion where relevant data are available.

Energy consumption: World's fastest growth ---

Energy consumption is growing more quickly in Asia and the Pacific than in any other region of the world. Between 1965 and 2005, primary commercial energy consumption in the region increased sixfold (Figure 1.2). And the rate



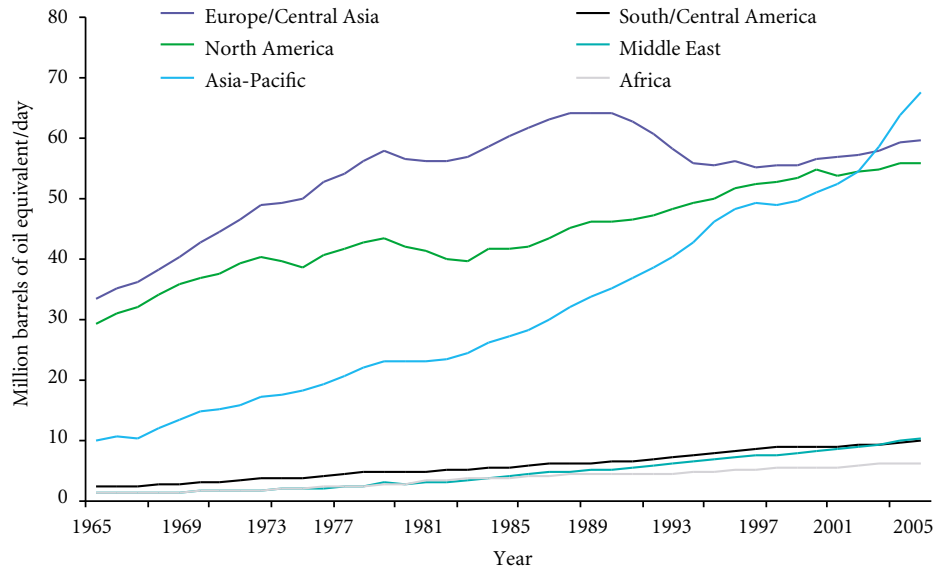
Figure 1.1. Map of the Asia-Pacific region
Source: East-West Center.

Notes: Major energy producers and consumers in the region are: Bangladesh, India, Nepal, Pakistan, and Sri Lanka in South Asia; Brunei Darussalam, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam in Southeast Asia; China, the Democratic People's Republic of Korea (North Korea), Hong Kong Special Administrative Region (SAR), Japan, the Republic of Korea (South Korea), and Taiwan in East Asia; and Australia and New Zealand (not shown) in the Pacific.

Other countries/economies included in regional totals are: Afghanistan and Maldives in South Asia; Cambodia, Timor-Leste, and Lao People's Democratic Republic in Southeast Asia; Macao SAR and Mongolia in East Asia; and the Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu in the Pacific.

Boundaries represented in the map are not necessarily authoritative.

Figure 1.2. Trends in total annual energy consumption (million barrels of oil equivalent/day) in major regions of the world, 1965–2005



Sources: BP (2006); FACTS Global Energy (2006).

Notes: Primary energy is limited to commercially traded fuels. Excluded are traditional biomass fuels such as wood, peat, and agricultural and animal waste, which, although important in many countries, are unreliably documented in consumption statistics.

of growth is accelerating. In 1995, Asia and the Pacific accounted for 27 percent of global primary commercial energy consumption. By 2005, this share had increased to 32 percent (Appendix Table 1.1). In 2015, the region will account for a projected 38 percent of the world's energy consumption.

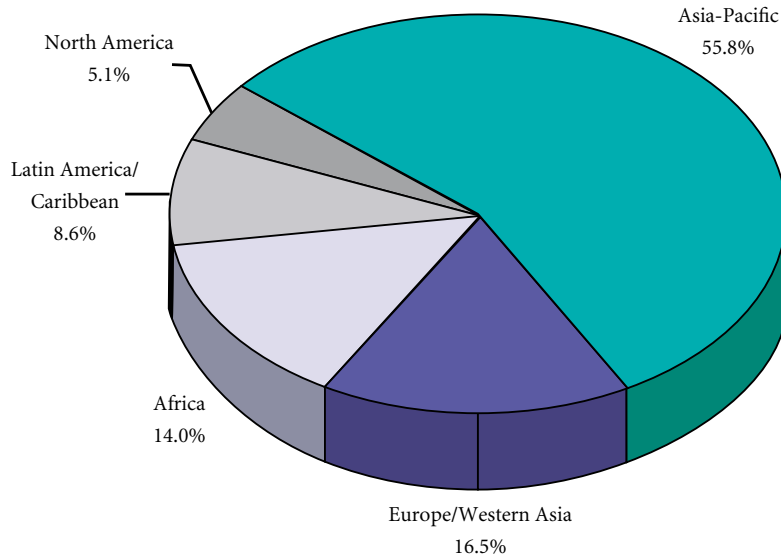
Population alone would suggest that the Asia-Pacific region is an important player in world energy markets. In mid-2005, the region accounted for 56 percent of world population, well over twice the size of any other region (Figure 1.3 and Appendix Table 1.2). Fertility is projected to decline somewhat in Asia and the Pacific, but the region will still account for more than one-half of global population in 2050 (PRB 2005).

Although total energy use is large because of the region's large population, citizens of Asia and the Pacific use relatively little energy per capita (Figure 1.4 and Appendix Table 1.3). On average, 10 people in the Asia-Pacific region use about as much energy as two people in Europe or one person in the United States. This current low use of energy per capita points to enormous potential for consumption growth in the future. Will governments in the region be able to meet the future energy demands of their citizens? And at what cost?

Energy consumption and economic growth. Rapid growth in energy consumption will stem largely from the Asia-Pacific region's unprecedented economic growth. In fact, trends in the region offer a textbook illustration of how economic growth and primary energy consumption usually go hand in hand.

Over a quarter century from 1980 to 2005, annual economic growth in Asia

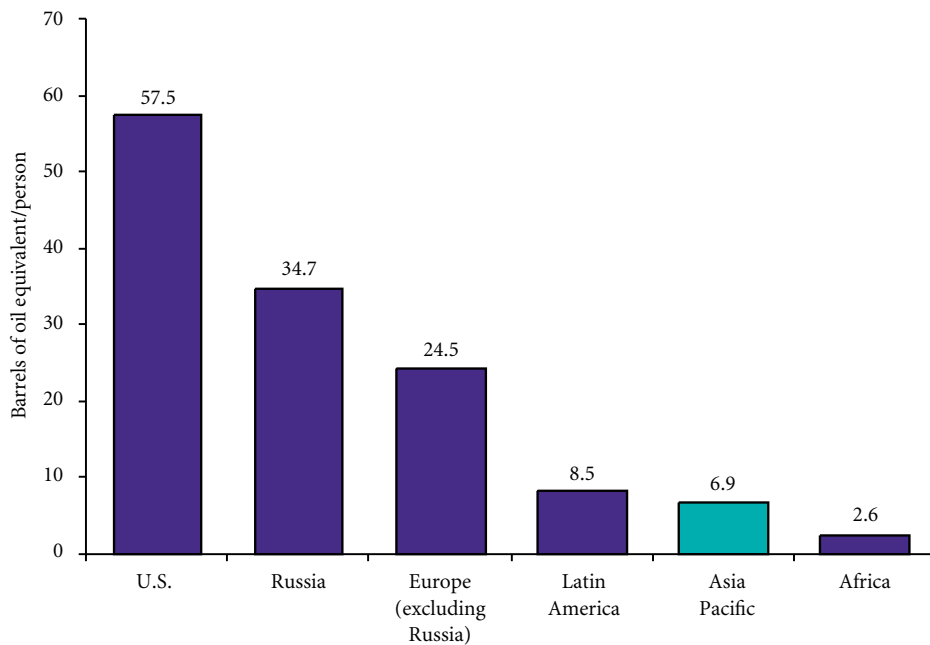
Figure 1.3. Proportion of total global population in major regions, mid-2005



Source: PRB (2005).

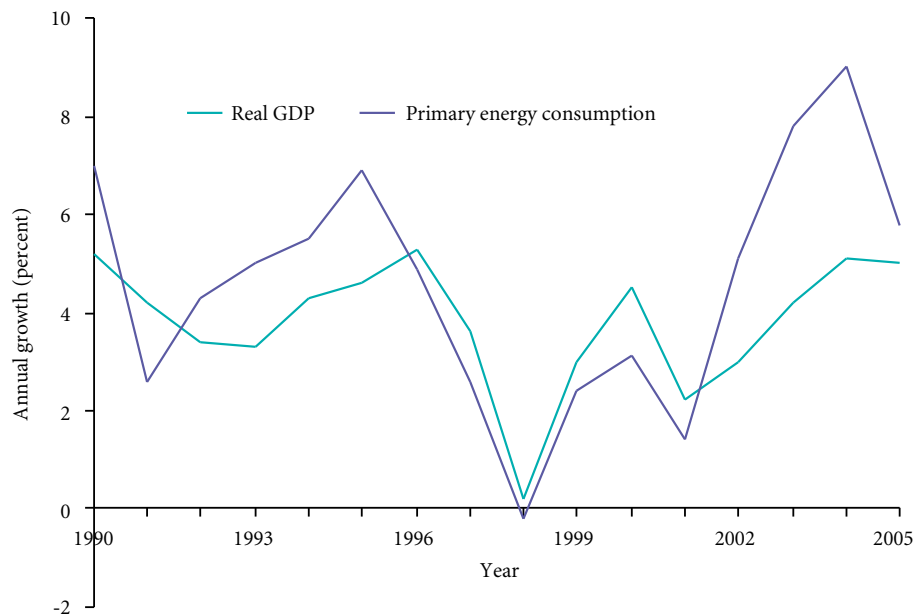
Note: Proportions in figure are not exactly the same as in Appendix Table 1.2 due to rounding.

Figure 1.4. Per-capita annual primary commercial energy consumption (barrels of oil equivalent) in the United States, Russia, and major regions of the world, 2005



Sources: BP (2006); PRB (2005); FACTS Global Energy (2006).

Figure 1.5. Primary energy consumption and real gross domestic product (GDP) in the Asia-Pacific region: Annual growth rates 1990–2005



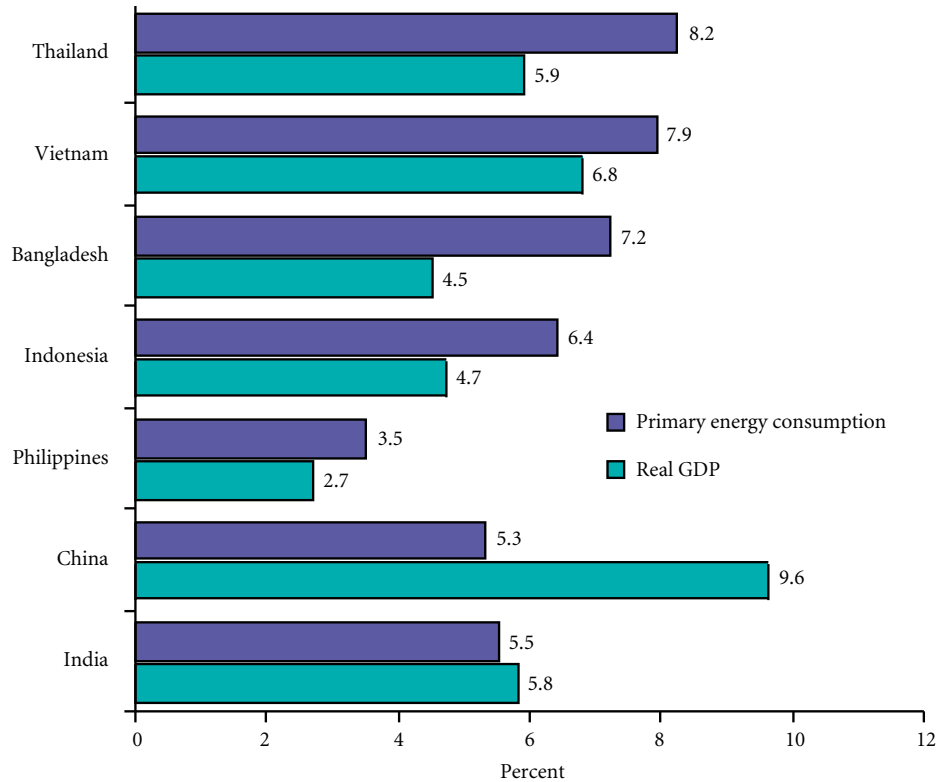
Sources: IMF (2006); BP (2006); OECD/IEA (2006); FACTS Global Energy (2006).

and the Pacific averaged 4.2 percent, while annual growth in primary energy consumption averaged 4.4 percent (Appendix Table 1.4). During the economic boom years of 1990–1996, growth in energy consumption accelerated (Figure 1.5). The economic crisis of 1997–1998 slowed both regional economic growth and growth in energy consumption dramatically, but both recovered and began climbing steeply again.

While the precise relationship between energy consumption and economic growth is a matter of academic debate, rapid economic growth tends to be associated with large increases in energy consumption at early stages of industrialization. Growth rates for energy consumption and real gross domestic product (GDP) in several developing countries of Asia and the Pacific illustrate this link (Figure 1.6 and Appendix Table 1.4). As economies mature, economic growth typically becomes less energy intensive, and the linkage between economic growth and energy consumption weakens.

Two countries at early stages of industrial development stand out as exceptions to this pattern—China and, to a lesser extent, India. Why has growth in energy consumption in these two countries lagged behind economic growth, particularly in China? There could be several possible reasons. First, both economies have experienced some degree of structural change, with light industry and the service sector growing faster than the more energy-intensive heavy industrial sector. Second, the introduction of energy-saving measures and the importation of energy-saving machinery have helped both economies move toward greater energy efficiency. A third reason relates to rising energy prices. A policy shift from substantial energy price subsidies to a more market-oriented approach—

Figure 1.6. Primary energy consumption and real gross domestic product (GDP) in selected developing economies of the Asia-Pacific region: Average annual growth rates, 1980–2005 (percent)



Sources: IMF (2006); BP (2006); OECD/IEA (2006); FACTS Global Energy (2006).

with prices increasingly determined by supply and demand—has helped both China and India reduce excessive energy use.

Despite improvements in efficiency, China and India rank, along with Japan and South Korea, as by far the largest energy consumers in the region. Looking ahead to 2015, China is projected to increase energy consumption by 5 percent a year—from 31.1 million barrels of oil equivalent per day (boe/d) in 2005 to 50.8 million boe/d in 2015 (Appendix Table 1.1). Among other Asian and Pacific countries, Bangladesh, Brunei, Myanmar, Nepal, Pakistan, Sri Lanka, and Vietnam are all expected to increase energy consumption by more than 4 percent a year over the same 10-year period (Appendix Table 1.1). In 2015, China alone will account for a projected 51 percent of total primary energy consumption in the Asia-Pacific region, up from 45 percent in 2005.

Energy sources. Among specific energy sources, the Asia-Pacific region uses more coal than the world as a whole and less natural gas (Figure 1.7). Totals for the region are dominated by China and India, however, and both countries are particularly dependent on coal. Without China and India, the energy mix in the rest of the region is dominated by oil. In fact, the Asia-Pacific region, excluding China and India, is more dependent on oil than the world as a whole.

Between 1995 and 2005, oil consumption in Asia and the Pacific increased

HOW IS ENERGY MEASURED?



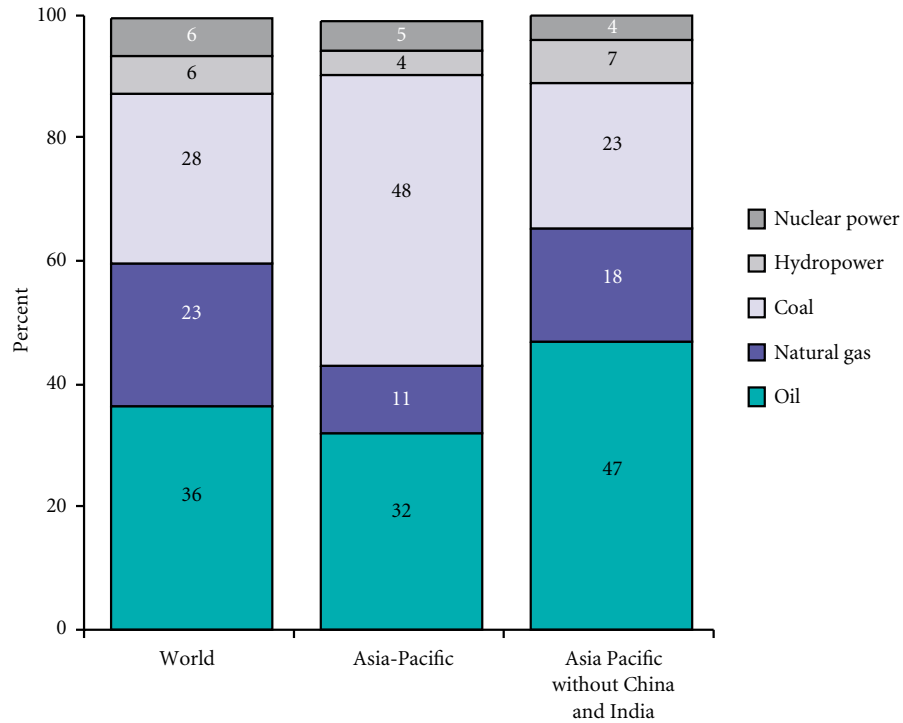
Storage area for oil barrels in Shanghai, China. In 2005, nearly one-half (44 percent) of the oil consumed in China was imported.
© REUTERS/Aly Song/Landov

It is difficult to compare the amount of energy produced or consumed from different sources because different types of energy are measured in different ways. Crude oil and petroleum products are generally measured in terms of barrels, with one barrel equivalent to about 159 liters or 42 U.S. gallons. Coal is measured in metric tons (tonnes), equal to 1,000 kilograms. Natural gas is measured in terms of volume as cubic meters (m^3) or standard cubic feet (scf) or in terms of heat as British thermal units (Btu). Liquefied natural gas (LNG) is measured in tonnes. Hydropower and nuclear power, used to generate electricity, are measured in watt hours.

All of these energy sources can be compared in terms of barrels of oil equivalent (boe) as a common unit, using the following conversion factors (BP 2006). One boe is approximately equal to:

- Coal: 0.205 tonnes of hard coal or 0.410 tonnes of lignite
- Natural gas: 5,370 standard cubic feet (scf)
- LNG: 0.110 tonnes
- Heat: 5.479 million British thermal units (Btu)
- Electricity: 1.644 megawatt hours. For hydropower and nuclear power, the conversion is based on thermal equivalence assuming 38-percent conversion efficiency in a modern thermal power station

Figure 1.7. Share of oil, natural gas, coal, hydropower, and nuclear power in total primary energy consumption in the world, the Asia-Pacific region, and the Asia-Pacific region without China and India, 2005



Sources: BP (2006); FACTS Global Energy (2006).

Note: Estimates of primary energy consumption include only commercially traded fuels.

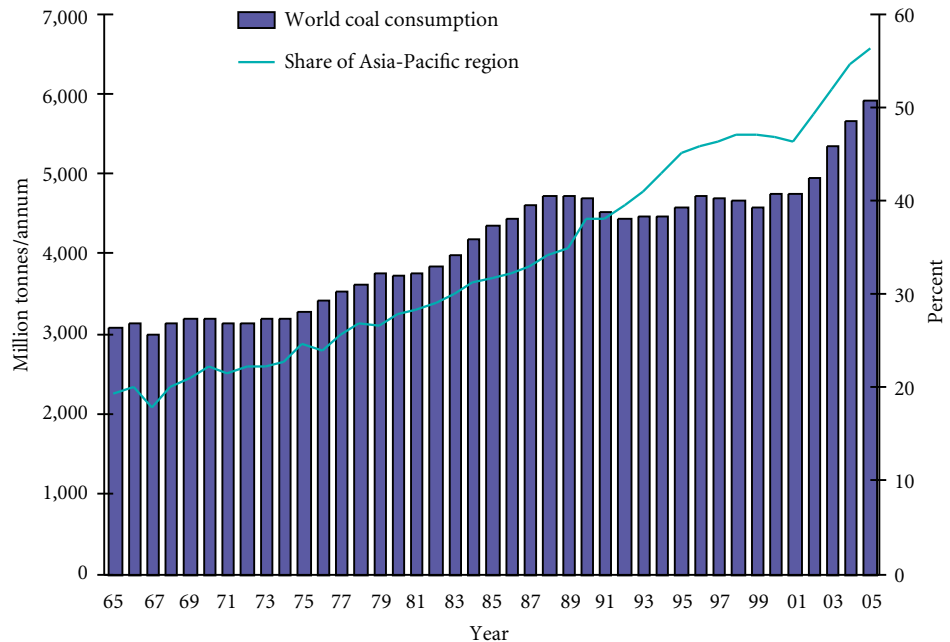
by nearly one-third, or 32 percent (FACTS Global Energy 2006). Over the same 10-year period, global oil consumption also increased, but more slowly—by 18 percent (BP 2006). As a result, the Asia-Pacific region’s share in global oil consumption rose from 26 to 29 percent. By 2015, the region will account for a projected 33 percent of global oil consumption.

Among major countries/economies in the region, oil is the most important source of commercial energy consumption in Japan, South Korea, Taiwan, Indonesia, Singapore, Malaysia, Vietnam, Thailand, the Philippines, and New Zealand (Appendix Table 1.5). Although coal is more important than oil in China’s overall energy mix, the Chinese use more oil than any other country in the region (Appendix Table 1.1). And oil consumption is growing fastest in China, more than doubling—from 3.2 to 6.5 million barrels per day (b/d)—between 1995 and 2005 (FACTS Global Energy 2006).

Although starting from a much smaller base, natural-gas consumption in Asia and the Pacific is growing even faster than the consumption of oil—increasing by 82 percent between 1995 and 2005 (FACTS Global Energy 2006). Over the same 10 years, world consumption of natural gas went up by only 28 percent (BP 2006). As a result, the region’s share in global consumption rose from 10 to 14 percent. Over the next 10 years, natural-gas consumption is projected to continue growing faster in Asia and the Pacific than in the world as a whole.

Natural gas is the most important source of commercial energy in Bangla-

Figure 1.8. World coal consumption (million tonnes per annum) and share of the Asia-Pacific region (percent), 1965–2005



Sources: BP (2006); FACTS Global Energy (2006); OECD/IEA (2006).

desh, Brunei, and Pakistan (Appendix Table 1.5). Japan is the largest consumer of natural gas in the region, however, followed by China, Indonesia, Malaysia, Taiwan, and India (Appendix Table 1.1).

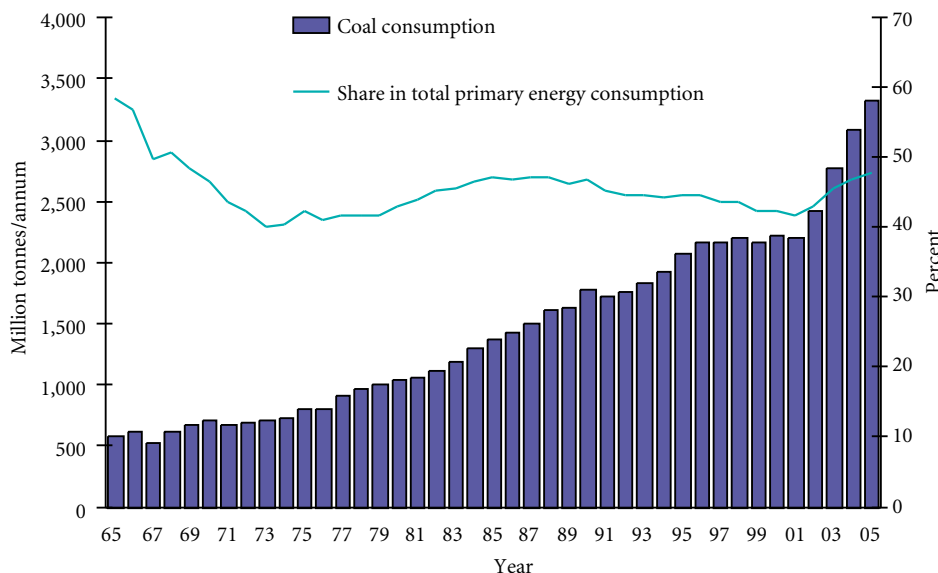
Except for one period of leveling off during the 1990s, world coal consumption has increased steadily over the past 40 years (Figure 1.8). Annual increases in global consumption have been particularly steep since 2000, primarily because of a surge in coal use in China. Within the Asia-Pacific region, coal is the most important energy source in China, India, Australia, and North Korea (Appendix Table 1.5).

Between 1965 and 1995—and, more recently, since 2000—nearly all of the incremental growth in global coal consumption has come from the Asia-Pacific region. As a result, the region’s share in global consumption increased from 19 percent in 1965 to a whopping 56 percent in 2005.

While the absolute amount of coal consumed has gone up fairly steadily, the share of coal in regional energy consumption has fluctuated and declined, partly in response to changes in oil prices (Figure 1.9). Persistent increases in international oil prices in 1973–1985 and again since 2001 prompted some degree of fuel switching from oil to coal, mainly for power generation. In 2001, the share of coal in the region’s primary commercial energy consumption reached its lowest point, at 42 percent—down from 58 percent in 1965. By 2005, the share had risen again, to 47 percent, mainly because of double-digit growth in coal consumption in China.

In 2005, the Asia-Pacific region generated and used 740 terawatt hours

Figure 1.9. Coal consumption in the Asia-Pacific region (million tonnes per annum) and share of coal in the region's total primary commercial energy consumption (percent), 1965–2005



Sources: BP (2006); FACTS Global Energy (2006); OECD/IEA (2006).

Note: Estimates of primary energy consumption include only commercially traded fuels.

(TWh) of hydroelectric power, equivalent to 3.4 million boe/d (see Appendix Table 1.1). In the region as a whole, hydropower accounted for 5 percent of primary commercial energy consumption (Appendix Table 1.5). China was by far the biggest consumer, using over one-half of the regional total, followed by India and Japan (Appendix Table 1.1).

Despite growing environmental concerns focusing on huge hydroelectricity projects, the use of hydropower is increasing more quickly in Asia and the Pacific than anywhere else in the world. The regional share of the world total grew by five percentage points over 10 years—from 20 percent in 1995 to 25 percent in 2005 (BP 2006). And regional growth of hydropower is expected to continue to outpace the global average in the years ahead. The majority of new hydropower projects in the region will be in China.

In 2005, Asia and the Pacific generated and used 553 TWh of nuclear power, equivalent to 2.5 million boe/d (see Appendix Table 1.1). This was 20 percent of the global total, up slightly from 18 percent in 1995. Only six countries/economies in the region use nuclear power—Japan (consuming more than one-half of the regional total), South Korea, China, Taiwan, India, and Pakistan (Appendix Tables 1.1 and 1.5).

Energy production and resource constraints

Although energy consumption is growing faster in Asia and the Pacific than anywhere else in the world, growth of energy production has been sluggish. Production growth is restricted by the region's limited domestic supplies of oil and natural gas.

Production of specific types of energy varies widely among countries and economies in the region (Appendix Tables 1.6 and 1.7). Natural gas accounts for more than one-half of domestic energy production in Bangladesh, Brunei, Malaysia, Pakistan, and Thailand. Coal accounts for more than one-half of energy production in Australia, China, and India. In Japan, South Korea, and Taiwan, where a large proportion of the energy consumed is supplied by imports, considerably more than one-half of the energy produced domestically is from nuclear power.

No country in the region obtains as much as one-half of its domestic primary energy production from oil, although Brunei, Malaysia, and Vietnam come close. Domestic oil production is constrained by the region's limited reserves. Indeed, Asia and the Pacific have the smallest proven oil reserves of any major region in the world. At the beginning of 2006, the region had an estimated 40 billion barrels of oil reserves, or slightly more than 3 percent of the world total (BP 2006). Within the region, China has by far the largest oil reserves (Appendix Table 1.8), followed by India, Indonesia, Malaysia, and Vietnam.

The internationally accepted definition of proven energy reserves is "those quantities which geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions" (BP 2006). Individual countries may use their own definitions, however. In China, for example, the government and state corporations usually report larger oil, natural-gas, and coal reserves than the levels recognized (or "certified") internationally.

In 2005, Asia and the Pacific produced 7.5 million b/d of oil. Production was by far the highest in China, followed by Indonesia, Malaysia, and India (Appendix Table 1.6). A reserve-to-production (R/P) ratio can be calculated as the oil reserves remaining at the end of 2005 divided by production over the year (Appendix Table 1.8). The result is an estimated number of years that existing reserves can be expected to last if production continues at the same rate and no new reserves are discovered. Given these assumptions, it is estimated that oil reserves in the Asia-Pacific region will last another 14 years—or until 2019.

Predictions of future energy supplies based on reserve-to-production ratios are only indicative, however. As exploration continues, new sources may be identified, and as extraction technologies improve, more oil may be obtained from existing fields. Yet no matter which standards are applied, there is little doubt that today's proven oil reserves in Asia and the Pacific are inadequate to meet the region's current and future energy needs.

The situation is more favorable for natural gas. The Asia-Pacific region has an estimated 8 percent of global natural-gas reserves (BP 2006). In 2005, the region produced 6.0 million boe/d of natural gas, or 12 percent of global production. The largest natural-gas reserves in the region are in Indonesia (Appendix Table 1.8), followed—in order of size—by Australia, Malaysia, and China. The R/P ratio for natural gas is more encouraging than for oil, suggesting that

existing natural-gas reserves in the region will last for nearly 41 years if production remains at 2005 levels.

In 2005, Indonesia was the largest producer of natural gas in the region, followed by Malaysia, China, and Australia. China's natural-gas production was geared toward the large domestic market, while Indonesia, Malaysia, Australia, and Brunei were large natural-gas exporters, in the form of liquefied natural gas (LNG).

Coal resources are relatively abundant in Asia and the Pacific. At the beginning of 2006, the region held nearly one-third of the world's estimated 909 billion metric tons (tonnes) of proven coal reserves (Appendix Table 1.8) and accounted for 55 percent of global coal production.

Despite rapidly increasing consumption in recent years, the region as a whole still manages to produce as much coal as it consumes. With ample domestic reserves in many countries, including China and India, R/P ratios suggest that existing coal reserves will last for nearly 100 years, assuming that production continues at 2005 levels. Thus security concerns related to coal focus more on environmental problems than on potential supply limitations.

Growing dependence: The Asia-Pacific energy dilemma

In 2005, the Asia-Pacific region accounted for 33 percent of global energy consumption but only 24 percent of global energy production (Figure 1.10). Combining oil, natural gas, coal, nuclear power, and hydropower, countries in the region consumed 68.2 million boe/d of primary commercial energy but produced only 52.4 million boe/d (Appendix Tables 1.1 and 1.6). The balance of 15.8 million boe/d—nearly one-fourth of total consumption—was filled by imports.

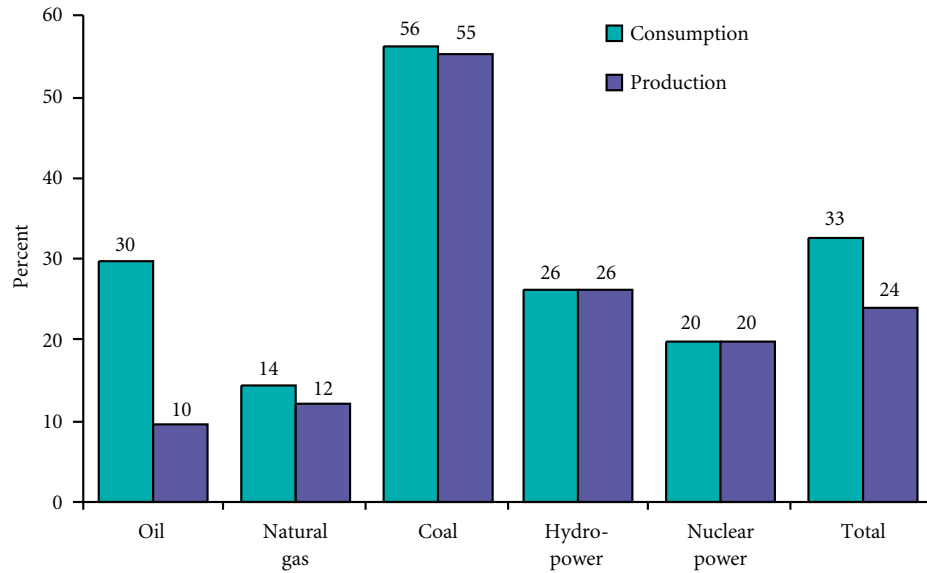
The region as a whole produced almost as much natural gas as it consumed and exported slightly more coal than it imported. Regional consumption of crude oil, however, at 30 percent of the global total, was much larger than the regional share of production, at 10 percent (Figure 1.10).

The result of escalating consumption and stagnating production will be a large and growing dependence on imports, particularly of oil. More than 10 years ago, in the early 1990s, Asia and the Pacific became the largest oil-importing region in the world. With oil consumption projected to increase by nearly one-third between 2005 and 2015 (Appendix Table 1.1), the trend toward greater dependence on imports appears inevitable (see Energy Insecurity Index).

Natural-gas consumption is still relatively low in the region, but it is expected to increase even more quickly than oil consumption, nearly doubling by 2015. Rising natural-gas consumption combined with limited production potential will exacerbate overall dependence on imports from the Middle East.

Because of their dependence on imported oil, many economies in Asia and the Pacific are particularly vulnerable to fluctuations in oil prices. This vulnerability is even greater because regional price formulas for natural gas are often

Figure 1.10. Share of the Asia-Pacific region in global consumption and production of oil, natural gas, coal, hydropower, and nuclear power, 2005 (percent)



Sources: BP (2006); FACTS Global Energy (2006).

Note: Estimates of primary energy consumption and production include only commercially traded fuels.

linked to crude-oil prices. When oil prices go up, natural-gas prices go up as well. This is particularly true for prices of spot cargos (natural gas purchased for immediate delivery). Spot prices are largely based on current prices at Henry Hub (natural-gas pipeline hub in Louisiana), and these, in turn, are strongly influenced by oil prices. Although some existing LNG contracts have built-in price ceilings, in the long term the prices for new natural-gas contracts and contract renewals will also fluctuate with oil prices.

A spike in oil prices can affect a country's economic performance in several ways. Higher oil prices trigger a direct transfer of income from oil-importing countries to oil-exporting countries. Japan, for example, has no oil resources of its own and consumes about 5 million b/d of oil. If oil prices increase by US\$10 per barrel, this amounts to an additional income transfer of US\$50 million per day from Japan to the countries that supply its oil. It adds up to more than US\$18 billion over the course of a year.

In addition to this direct transfer of income, higher oil prices increase the cost of industrial production, which reduces output and contributes to inflationary pressure. Consumers feel the pinch as higher prices for petroleum products and a variety of other goods. The cumulative effect is a deterioration in living standards, a slowdown in economic growth, and, ultimately, an increase in unemployment. The impact obviously varies among countries, but overall, the Asia-Pacific region is a major net oil importer, and most economies in the region suffer when oil prices are high.

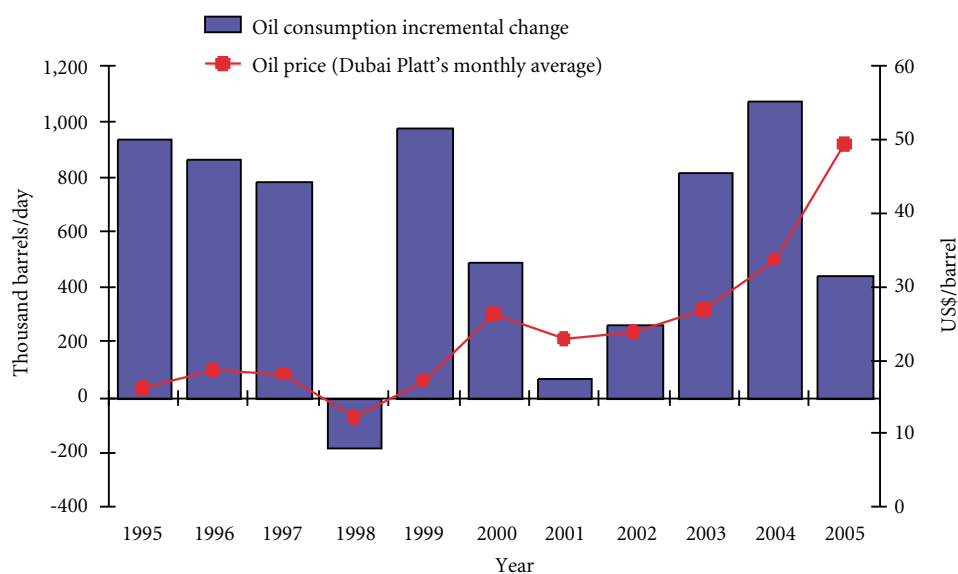
Market observers and researchers have closely watched the impact of oil prices on economic growth since the oil price shocks of the 1970s. A study by

Table 1.1. Hypothetical impact of an oil price increase of US\$10 per barrel on selected Asian economies, second quarter 2004 through fourth quarter 2005 (percent)

Country/economy	Impact of oil price increase (percent)	
	Consumer prices	Gross Domestic Product (GDP)
China	+0.5	-0.8
India	+1.7	-0.8
Indonesia	+1.3	+0.1
Japan	+0.7	-0.5
Malaysia	+1.4	-0.9
Philippines	+1.4	-1.9
Republic of Korea	+0.8	-0.6
Singapore	+1.3	-1.7
Taiwan	+0.3	-0.4
Thailand	+1.5	-2.2

Source: Park (2004).

Figure 1.11. Annual incremental change in oil consumption in the Asia-Pacific region and global oil prices, 1995–2005



Source: FACTS Global Energy (2006).

the Asian Development Bank (Park 2004) examines the impact of a US\$10-per-barrel increase in the price of oil extending from the second quarter of 2004 through the fourth quarter of 2005. As might be expected, developing economies that are heavily dependent on oil imports (such as Singapore, the Philippines, and Thailand) are most affected (Table 1.1). More-mature economies (such as Japan and South Korea) and those that are oil exporters (such as Indonesia and to some extent Malaysia) experience a smaller impact. In South, Southeast, and East Asia as a whole, a US\$10-per-barrel rise in oil prices would raise consumer prices for all goods by an estimated 1 percent and reduce GDP growth by 0.6 percent. In Thailand—the country worst affected in this hypothetical scenario—GDP growth would be reduced by more than 2 percent.

Because even small changes in consumption or production can trigger large swings in energy prices, the Asia-Pacific region has also come to play a critical role in global energy markets, particularly in the market for oil. When oil consumption increases in Asia and the Pacific, global prices generally rise (Figure 1.11). Conversely, when oil consumption levels off in the region, global prices generally stagnate, as seen during the 1997–1998 Asian economic crisis.

Since 2003, the dual impact of global supply uncertainty and an enormous increase in Chinese consumption, as well as consumption in the United States and the Middle East, has contributed to a sharp rise in oil prices everywhere in the world. Thus, the Asia-Pacific region's growing dependence on imported energy has helped cause an energy-security dilemma of global proportions.