# 12

# China's demand for energy

## A global perspective

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The surge in China's demand for energy in recent years raises some questions about the possible causes for the significant shift in the energy intensity of the Chinese economy at this stage of its industrialisation, as well as its long-term implications for future global supply of and demand for energy, and its potential impact on the environment. What has been the overall trend of world energy consumption in the past few decades? How does China's pattern of demand for energy fit into the normal pattern experienced by some other East Asian economies in the periods during which these economies were going through a similar stage of development? Has the increased energy intensity been driven primarily by China's ever increasing level of investment, which has reached an unprecedented scale in recent years? Or has it been caused by increases in domestic demand by households, resulting largely from rising per capita income propelled by reform and structural changes, including the unprecedented pace and scale of urbanisation?

Will China's pattern of energy consumption, which concentrates on coal, need to be changed radically in order for it to deal with its environmental issues while sustaining its economic growth in the long term? What kind of energy strategy does China need to adopt now in order to effectively reduce its current and future energy intensity to mitigate its impact on supply of world energy and prices as well as on the environment?[1] This chapter discusses these issues from a global perspective.

## World demands for energy: the long-term trend and structural change

With steady economic and population growth in most countries and regions, the global demand for energy has maintained a rapidly increasing trend during the past four decades. It increased from a total world demand of 3.9 billion tonnes of oil equivalent in 1965 to 10.6 billion tonnes of oil equivalent in 2005—an increase of 2.7 times for the period (Figure 12.1). The average annual growth rate of world energy demand climbed to 2.6 per cent over the last 5 years, and is likely to continue to grow strongly for at least the next 25 years (IEA 2006).

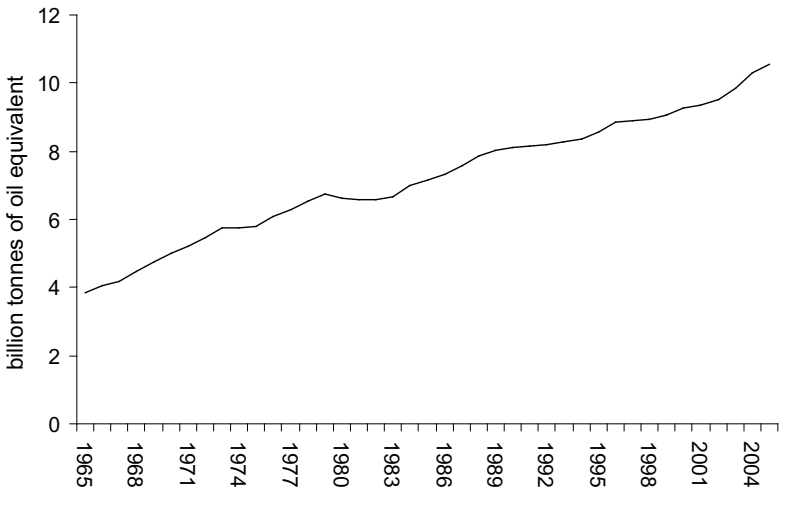
This firm increase in demand for energy has helped fuel global economic growth but has also placed considerable pressure on many issues of public concern such as sustainable energy supply, national development security in importing countries and global environmental protection. In particular, how to reduce the dependency of economic growth on energy usage and especially on carbon emission-intensive energy usage, has become the focus of public debate and government policies in industrialised and developing economies.

Current world energy consumption exhibits two significant patterns of change. One is that fossil fuels (including crude oil, natural gas and coal) continue to dominate world energy consumption, meeting about 88 per cent of total consumption (Figure 12.2). For example, crude oil, natural gas and coal accounted for 37, 23 and 28 per cent respectively of total world energy consumption in 2005, while other energy products—such as hydropower, nuclear power, biomass, geothermal, solar, wind and other renewable energy products—accounted for only 12 per cent.

The second feature is that energy demand in industrialised countries including the United States, the European Union, Japan, Australia, New Zealand and Russia still accounted for more than half of the total energy demand (54 per cent of total consumption). The United States was the largest (22 per cent), followed by the European Union (16 per cent), Russia (10 per cent), Japan (5 per cent) and Australia and New Zealand (1 per cent). The energy demand from developing economies—including South Korea, Association of South-East Asian Nations (ASEAN) members, China and India—has taken the remaining 46 per cent share. Among these, China ranked top (15 per cent), followed by India (4 per cent), ASEAN members (3 per cent), South Korea (2 per cent) and the rest of the world (21 per cent). China has become the second largest energy consuming country in the world (Figure 12.3).

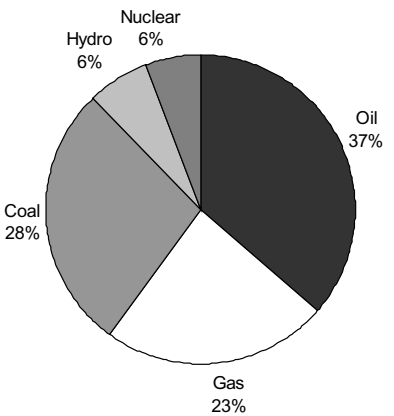
The rapid increase of energy demand and its increasing trend means the world faces two energy-related challenges: finding adequate and secure supplies of energy at prices that are consistent with economic stability; and environmental degradation caused by excessive fossil-fuel consumption.

Figure 12.1 **World primary energy consumption, 1965–2005** (billion tonnes of oil equivalent)




**Note:** Primary energy comprises commercially traded fuels only—excluded, therefore, are fuels such as wood, peat and animal waste.
**Source:** British Petroleum Global Limited (BP), 2006. *BP Statistical Review of World Energy*, 2006, British Petroleum Global Limited, London.

Figure 12.2 **World primary energy consumption structure, by product, 2005** (per cent)

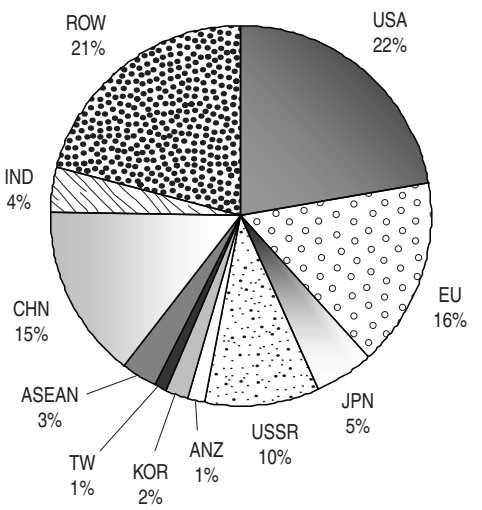



**Note:** Primary energy comprises commercially traded fuels only—excluded, therefore, are fuels such as wood, peat and animal waste.
**Source:** British Petroleum Global Limited (BP), 2006. *BP Statistical Review of World Energy*, 2006, British Petroleum Global Limited, London.

Against this background, the following characteristics of world energy demands can be observed.

First, global demand for cleaner energy products has been increasing more rapidly than that for traditional fossil-fuel products, suggesting that the pattern of global energy consumption is undergoing some environmentally favourable structural change. For example, in the period 1965–2005, the average annual growth rates of demand for natural gas, hydropower and nuclear power were 3.9, 3.2 and 108.1 per cent respectively (Figure 12.4). These growth rates were not only much higher than that of the average primary energy demand (2.7 per cent), they were higher than those for traditional fossil fuels such as crude oil and coal (2.5 per cent and 1.9 per cent respectively). In particular, the United States, the European Union, Japan and Russia have all significantly increased their use of natural gas and nuclear power while reducing their demand for coal. The structural change in favour of the use of cleaner energy products has been taking place mainly in industrialised countries.

Figure 12.3 **World primary energy consumption structure, by country, 2005** (per cent)

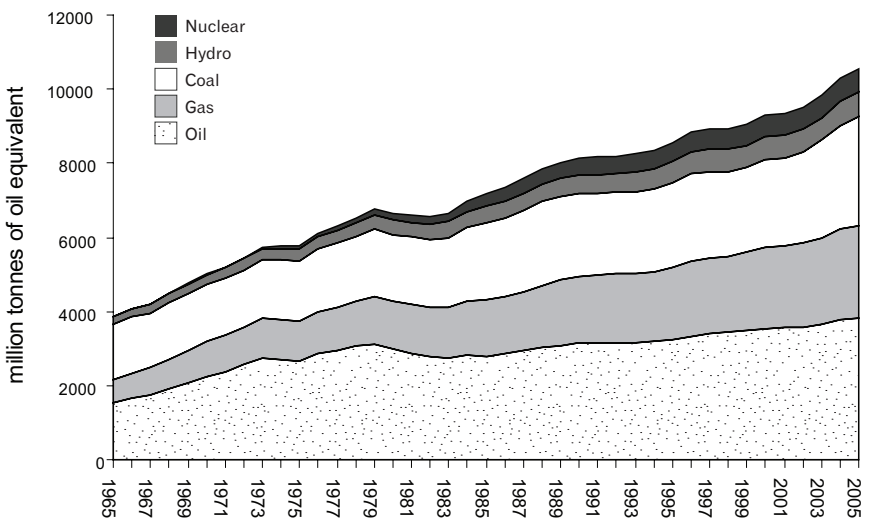



**Note:** Primary energy comprises commercially traded fuels only—excluded, therefore, are fuels such as wood, peat and animal waste.
**Source:** British Petroleum Global Limited (BP), 2006. BP Statistical Review of World Energy, 2006, British Petroleum Global Limited, London.

Second, developing economies—particularly the newly industrialised economies in East Asia—have shown a rapidly increasing trend of energy demand. In the period 1965–2005, the annual growth rate of energy demand in South Korea was 9.3 per cent, in Taiwan 7.2 per cent, among ASEAN members 7.3 per cent and in China 5.5 per cent—well above the world average annual growth rate of energy demand (2.5 per cent) during the same period (Figure 12.5). These rates were much higher than those in Japan (3.2 per cent), Australia and New Zealand (3 per cent), the European Union (1.5 per cent), the United States (1.4 per cent) and Russia (1.2 per cent).

Third, the newly increased demand from developing and newly industrialised economies focuses mainly on fossil fuels such as crude oil and coal. During the period 1965–2005, the annual growth rate of demand for crude oil in South Korea was 11.6 per cent, Taiwan 7.6 per cent, ASEAN members 5.8 per cent and China 8.8 per cent. The annual growth rate of demand for coal was 6.2 per cent in South Korea, 6.6 per cent in Taiwan, 16.7 per cent among ASEAN members

Figure 12.4 **World primary energy consumption structure, by product, 1965–2005** (million tonnes of oil equivalent)




**Note:** Primary energy comprises commercially traded fuels only—excluded, therefore, are fuels such as wood, peat and animal waste.
**Source:** British Petroleum Global Limited (BP), 2006. *BP Statistical Review of World Energy*, 2006, British Petroleum Global Limited, London.

and 4.8 per cent in China. These rates were much higher than the global average growth rates for crude oil (2.3 per cent) and coal (1.7 per cent).

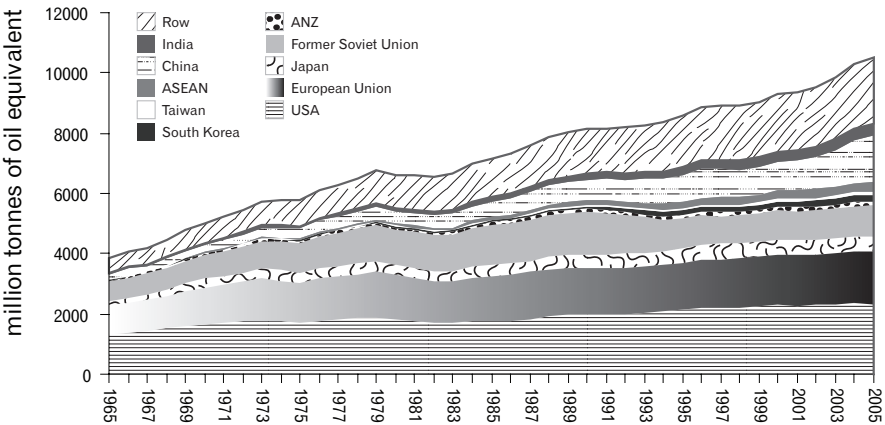
These trends provide evidence that the centre of gravity of global energy demand has been shifting from Organisation for Economic Co-operation and Development (OECD) countries—which were traditionally large consumers of fossil fuels—to East Asian developing economies. The developing economies in East Asia have had higher rates of economic and population growth than OECD countries. Underlying forces behind such a shift towards high energy intensity in these economies include rapid urbanisation, high investment shares of output and high and increasing export orientation. The same forces that worked for Japan, Korea and Taiwan in the past are now working for China; the only difference is the increasing absolute and relative size of the Chinese economy, which will magnify the impact on world markets beyond the high levels experienced in the recent past. For this reason, the strong growth in demand for energy in China is likely to continue through its period of rapid industrial transformation, which will be associated with strong economic growth, in the next two decades (Garnaut and Song 2006).

Due to the lack of domestic energy supplies and being in the catch-up phase of industrialisation, many economies in East Asia have had lower price and income elasticities for energy products than those in industrialised countries. As a result, they have become increasingly dependent on imports of energy from overseas, underlying changes in world energy prices. In fact, East Asian industrialisation was closely associated with two world oil price rises. One was in the 1970s—which occurred with rapid economic growth first in Japan, and then in Korea and Taiwan—and the other is the current one, to which China's growing economy has contributed (Figure 12.6). Another factor causing the price rise is that energy suppliers have been concentrating increasingly on certain countries or country groups such as Russia and the major Middle Eastern producers.

Compared with the price for oil, the surge in the price of natural gas has been more recent (Figure 12.7), reflecting the tendency of industrialised and developing economies to move towards cleaner energy options. World prices for coal were coming down from their peak in the 1970s, but started picking up again in this current resource boom (Figure 12.8). This trend is likely to continue, especially considering the fact that China—for the first time in recent decades—became a net importer of coal during the first quarter of 2007.

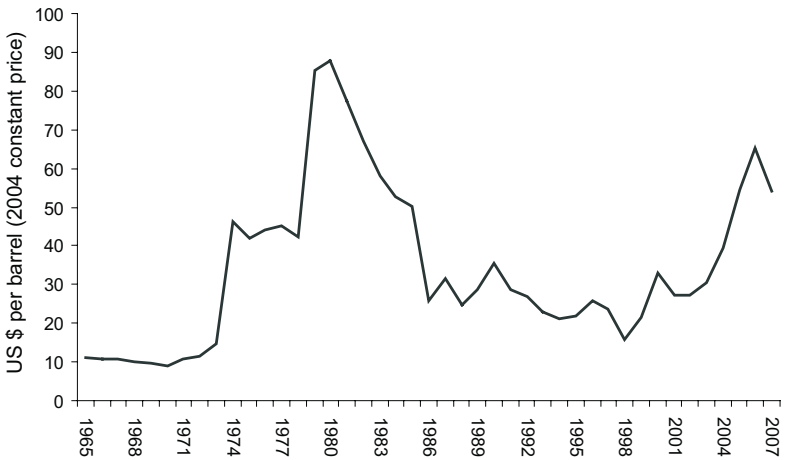
With the above trend of world energy demand identified, we can now have a close look at the changes of energy demand over time in China in order to explain its role in determining the changes in world energy demand and trade.

Figure 12.5 **World primary energy consumption structure, by country, 1965–2005** (million tonnes of oil equivalent)




**Note:** Primary energy comprises commercially traded fuels only—excluded, therefore, are fuels such as wood, peat and animal waste.
**Source:** British Petroleum Global Limited (BP), 2006. *BP Statistical Review of World Energy*, 2006, British Petroleum Global Limited, London.

Figure 12.6 **World real price of crude oil, 1965–2007** (US$ per barrel)



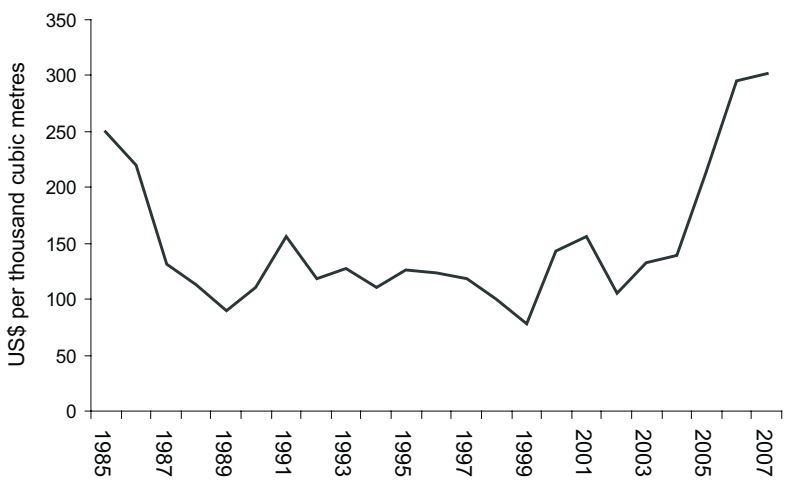

**Note:** The nominal price for the period 1965–83 is the US average and the nominal price for the period 1984–2007 is Brent dated.
**Sources**: British Petroleum Global Limited (BP), various issues. *BP Statistical Review of World Energy*, 1965–2005, British Petroleum Global Limited, London; International Monetary Fund (IMF), 2007. *International Financial Statistics*, 2006–07, International Monetary Fund, Washington, DC.

## China's primary energy demand, supply and trade

With an annual gross domestic product (GDP) growth rate of about 10 per cent, on average, China's total primary energy consumption increased by 36.3 per cent in the past decade, reaching 1.6 billion tonnes of oil equivalent in 2005. China has now become the second largest energy consumer in the world. The share of China's primary energy consumption in the world increased from 4.7 per cent in 1965 to 14.7 per cent in 2005. China's share of the increase in world primary energy consumption increased from 4.4 per cent in the period 1965–70 to 12.6 per cent during the period 2000–05. In the past few years, the growth rate of primary energy consumption in China has accelerated (Figure 12.9),[2] prompting the Chinese government to set a target for improving energy efficiency by 20 per cent in the period 2006–10.

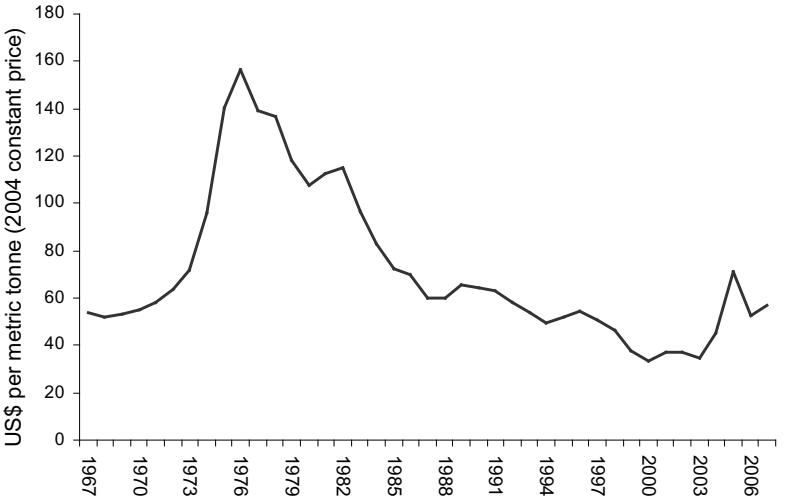
China's increasing demand for energy can be discussed by looking at the consumption pattern of different kinds of energy products. For example, its demand for coal has been driven by the need for electricity generation and industrial production, and China's rich endowment of coal means the product accounted for 70 per cent of total energy consumption growth during the period 1995–2005 (Figure 12.10).

Figure 12.7 **International real price of natural gas, 1985–2007**
(US$ per '000 cubic metres, 2004 constant prices)



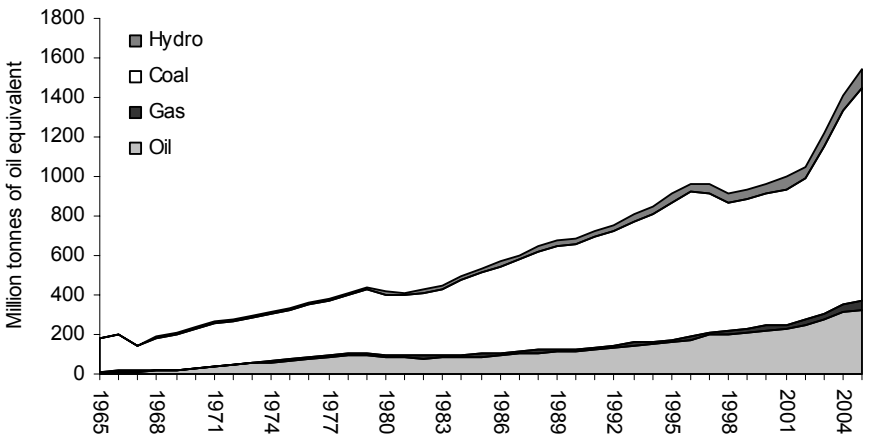

**Note:** The spot price of natural gas is the border price of Russian natural gas in Germany.
**Source:** International Monetary Fund (IMF), 2007. *International Financial Statistics, 2006–07*, International Monetary Fund, Washington, DC.

Figure 12.8 **Real prices of internationally traded thermal coal, 1967–2007** (US$ per metric tonne)




**Note:** The spot price of coal is the free-on-board (f.o.b.) price of Australian thermal coal—1,200 btu/pound, less than 1 per cent sulphur, 14 per cent ash—at Newcastle/Port Kembla.
**Source:** International Monetary Fund (IMF), 2007. *International Financial Statistics, 2006–07,* International Monetary Fund, Washington, DC.

Figure 12.9 **China's primary energy consumption structure, by product, 1965–2005** (million tonnes of oil equivalent)




**Source:** British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy*, 2006, British Petroleum Global Limited, London.

China's demand for oil is a result largely of the rapid increase in vehicle ownership and industrial development, with oil accounting for 17.7 per cent of the total energy consumption growth in the same period. Other energy products—such as natural gas, hydropower, nuclear power and so on—account for the remaining 11.7 per cent. In 2005, the consumption of major energy products over the total primary energy consumption reached 21.1 per cent for crude oil, 69.6 per cent for coal, 5.8 per cent for natural gas, 2.7 per cent for hydropower and 0.8 per cent for nuclear power.

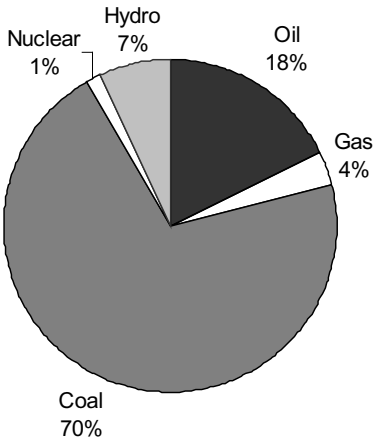
To meet its ever increasing demand for energy consumption, China has been intensifying production of all types of energy by increasing the total amount of investment in energy production. Figure 12.11 shows the share of investment in energy sectors over the total GDP in China during the period 1992–2004, in comparison with the world average shares during the same period.

The average ratio of investment in energy sectors to total GDP in China during the period 1992–2004 was 0.25 per cent—more than four times that of the world average, which was only 0.06 per cent during the same period. The highest ratio of investment in energy sectors in China reached a peak of 0.6 per cent in 1997. Although the East Asian financial crisis in 1997 had broken this trend by about 2000 and slowed the pace of investment in energy sectors, a new wave of investment in energy production in China seemed to accelerate after 2002.

As a consequence of the large-scale investment in energy, the production of various types of energy products in China increased significantly. Figure 12.12 shows the changes of the production of some major energy products in China during the past decade or so. With increased output from Western and offshore fields, crude oil production increased from 162 million tonnes of oil equivalent in 2000 to 181 million tonnes of oil equivalent in 2005. Coal production increased from 656 million tonnes of oil equivalent in 2000 to 1,107 million tonnes of oil equivalent in 2005. Natural gas production increased from 24.5 million tonnes of oil equivalent in 2000 to 45 million tonnes of oil equivalent in 2005, with an annual growth rate of more than 10 per cent—much higher than the average growth rate of 8.7 per cent during the previous three decades. With the Three Gorges Dam hydropower project completed—and other electricity-related construction in Guangdong and Guangxi Provinces—electricity generation has also increased, from 1,368 million tonnes of oil equivalent in 2000 to 2,474 million tonnes of oil equivalent in 2005. This trend of increasing capacity of electricity generation is continuing, with 60 gigawatts, or 2.5 per cent of established capacity, added annually.

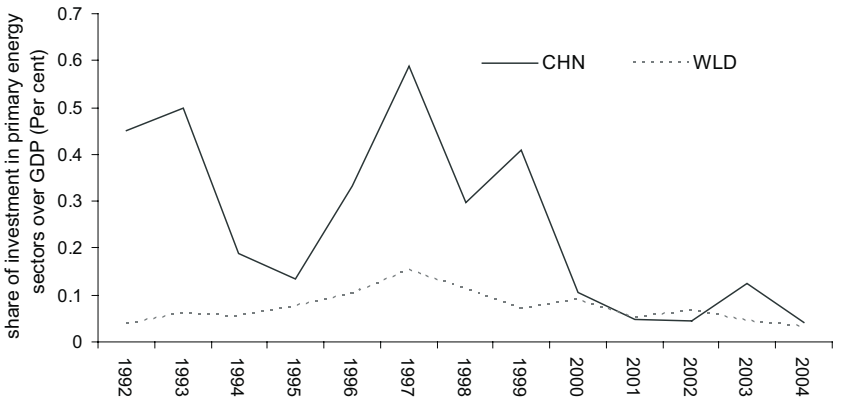
Despite the rapid increase of energy production in China, the gaps between domestic supply and demand have been increasing, especially for crude oil

Figure 12.10 **Share of primary energy consumption growth, by product, 2000–2005** (per cent)




**Source:** Authors' calculations with data from British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy,* 2006, British Petroleum Global Limited, London.

Figure 12.11 **Comparison of investment shares in primary energy sectors between China and the world average, 1992–2004** (per cent)




**Source:** World Bank, 2006. *World Development Indicators Online Database*, World Bank Group, Washington, DC.

and its products. These gaps will have to be met by imports. Between 1971 and 2003, China was a net energy exporting country. The situation has changed, however, since 1997, when the share of net imports of energy products of total energy consumption increased considerably—providing clear evidence that there has been an increasingly tight balance between energy demand and supply in China.

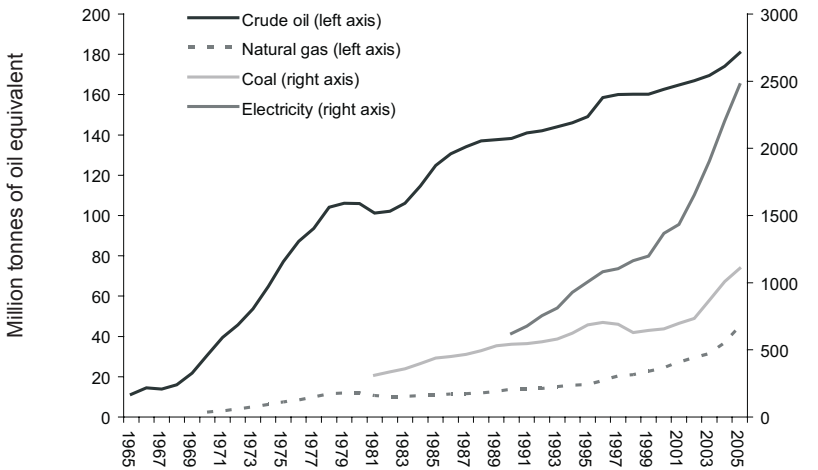
Figure 12.13 shows the net imports of crude oil, natural gas and coal, measured by the difference between their production and consumption during the past four decades. Since 1993, China has been a net importing country for crude oil and its related products and the average annual growth rate of net imports was 44 per cent, which was higher than that in any other country in the world in the same period. Although production of natural gas has exceeded its consumption in China since 1993, this gap has decreased significantly, with increased domestic demand after 2000. Coal is relatively more abundant than either crude oil or natural gas in China. With a significant increase in production of coal, it has almost met demands since 2000; however, owing to the substitution effect between coal and crude oil caused by rising oil prices in the world market, increases in demand for coal turned China into a net importer of coal by early 2007.

China is, therefore, becoming a new global centre of energy consumption—on par with the United States. Over time, a further increase in Chinese energy imports from the global market could add much more pressure to energy supplies and, consequently, prices—especially for fossil fuels—in China and the world. Thus, finding solutions to meet China's energy needs is not only important for China to sustain its long-term economic growth, it is critical to maintain market stability for energy products, which affects the global economy. These solutions are specified in China's eleventh Five-Year Plan on energy development, issued by the National Development and Reform Commission (NDRC) in April 2007. For these strategies to work effectively, it is useful to explore further how rising energy intensity in China at this phase of industrialisation has been determined.

## China's economic growth and demand for energy

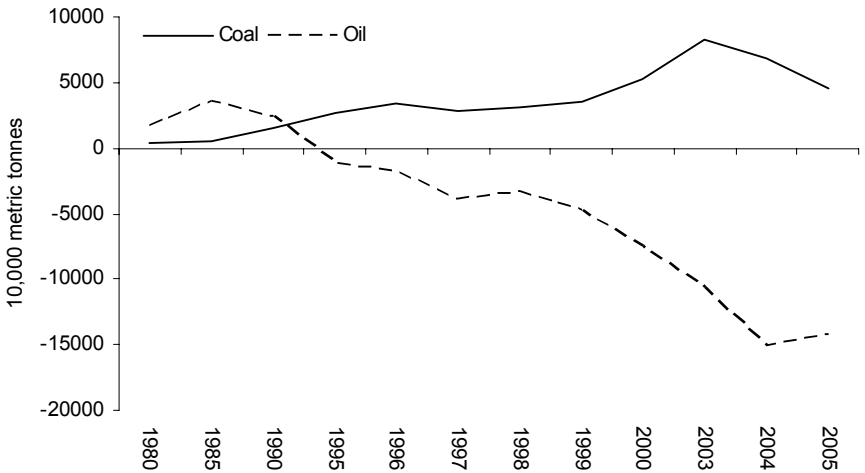
Economic growth impacts on the demand for energy in the following fashion. First, when economic growth increases GDP per capita in a country, the increased consumption per capita can generate additional demand for energy. For example, a rich country could consume more energy-intensive goods—such as appliances for cooling and heating, family automobiles, air transportation and so on—than less developed countries. The growth

Figure 12.12 **Production of crude oil, coal, natural gas and electricity in China, 1965–2005** (million tonnes of oil equivalent)




**Source:** British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy*, British Petroleum Global Limited, London.

Figure 12.13 **China's net imports of crude oil and coal, 1965–2005** (10,000 metric tonnes)




**Note:** Net imports are measured by the difference between consumption and production.
**Source:** British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy*, British Petroleum Global Limited, London.

pattern of this type of energy demand induced by economic growth is usually continuing and stable over time.

Second, when economic growth makes a country cross certain economic development stages, the adjustment in production technique and consumption pattern can lead to structural changes in energy demand. For example, when a country grows from a farming society into an industrialised society, it is expected that capital and energy-intensive industrial production will substitute for primary products or labour-intensive production and thereby generate a large demand for energy. This type of energy demand induced by economic structural changes usually takes place at an accelerated pace over certain periods of economic development. The two effects combined determine the level and scale of energy demand resulting from economic growth (or growth of GDP per capita) when population growth is controlled.

In linking changing patterns of energy demand to economic growth, most previous studies used the cross-country differences of consumption elasticity for energy (Fiebig et al. 1987; Churchill 1994; Brenton 1997; Garcia-Cerrutti 2000; Bernstein and Griffin 2005). The results obtained, however, vary and are hardly consistent. For example, Dahl (1992) argued that energy demand was price inelastic and slightly income elastic, but found no clear evidence that the developing world's energy demand was less price or more income elastic than for the industrial world. Churchill (1994) and Brenton (1997), using some cross-country estimations, found that the income elasticities of demand for energy products were higher in poorer countries than in wealthy countries. Such inconsistency in the previous studies leads us to think that this could be due to the different stages of economic development rather than country-specific characteristics that determine the changing pattern of energy consumption. To test this, we use the seven-country data for the period 1965–2005 to examine the impact of different economic development stages on primary energy consumption by using a demand function as specified below.

$$\ln C_{it}=\beta_0+\beta_1 \ln Y_{it}+\beta_2 \ln P_{it}+\beta_3 D_1+\beta_4 D_2+\beta_5 D_3+\beta_6 D_4+\beta_7 D_5+\beta_8 D_6 u_i+\varepsilon_{it} \quad (1)$$

where $C_{it}$ stands for primary energy consumption (tonnes of oil equivalent), $Y_{it}$ is GDP per capita with constant price (the 2000 US dollar price) and $P_{it}$ is the real price of primary energy (the real price of crude oil). $D_1$ - $D_2$ denote different economic development stages, measured by GDP per capita following the method from Chenery et al. (1986). That is, we define that the primary industrialisation stage, $D_1$, equals one if GDP per capita is between US$1,138 and US$2,275 (with the 2000 constant price); the medium industrialisation stage, $D_2$, equals one

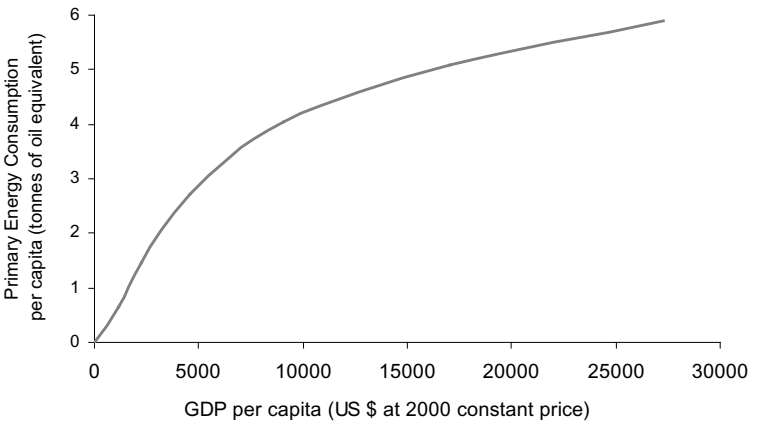
if GDP per capita is between US$2,275 and US$4,550 (with the 2000 constant price); the advanced industrialisation stage, $D_3$, equals one if GDP per capita is between US$4,550 and US$9,100 (with the 2000 constant price); the primary developed economic stage, $D_4$, equals one if GDP per capita is between US$9,100 and US$17,063 (with the 2000 constant price); the advanced developed economic stage, $D_5$, equals one if GDP per capita is between US$17,063 and US$27,300 (with the 2000 constant price); and the post-development economic stage, $D_6$, equals one if GDP per capita is more than US$27,300 (with the 2000 constant price).

Using the regression estimation results, Figure 12.14 plots the predicted relationships between energy consumption intensity (consumption of the primary energy per capita) and GDP per capita (in the 2000 constant US dollar price). It is shown that when GDP per capita in a country rises from US$2,500 to US$10,000 (in particular, from US$3,000 to US$5,000), there will be significant increases in energy consumption per capita. Beyond the US$5,000 level of per capita income, energy consumption intensity will continue to rise, but at a slower pace. After a country reaches per capita income of US$10,000, increases in energy consumption intensity become slower still.

This result is consistent with the changes of energy consumption intensities in East Asia during the period 1965–2005 (Figure 12.15). For example, Japan experienced a dramatic increase in per capita energy consumption in the 1960s, while South Korea and Taiwan experienced a similar increase in the 1980s. ASEAN countries demonstrated a similar trend in the 1990s and China entered a phase of rapidly increasing energy intensity after 2000. Interestingly, most of these significant changes in energy consumption intensity took place when the countries' GDP per capita was within the range of US$3,000 to US$5,000 (in the 2000 constant price)—except Japan. This could suggest that different stages of economic development generate structural changes, which underlie the changes in countries' energy intensities. This finding helps us to judge how China's energy intensity will relate to the level of its per capita income, and to predict the future trajectory that China is likely to follow in increasing its energy intensity.

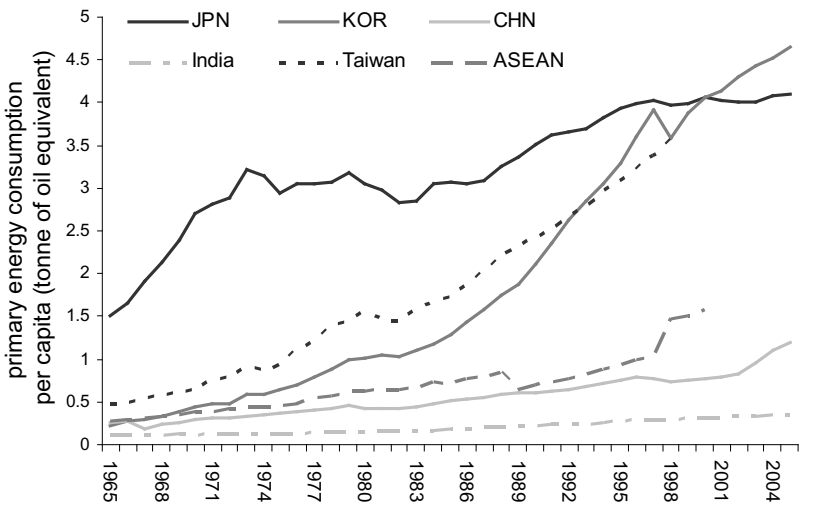
With per capita GDP of US$1,444 (in the 2000 constant price) in 2005, China entered a stage of development or industrialisation in which there would be a dramatic increase in its energy intensity in production. Following the estimates, we can predict that energy consumption will continue to accelerate at least until China reaches a per capita income level of US$5,000. Figure 12.16 compares energy consumption intensity in China with the world average of energy intensity during the period 1971–2005. The figure shows that a rapid increase in energy consumption intensity in China started to take place after 2000, driving Chinese energy consumption per capita above the one-tonne level.

Figure 12.14 **Estimated average primary energy consumption per capita across different stages of economic development** (per capita, tonnes of oil equivalent)




**Sources:** Authors' calculations using data from British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy*, British Petroleum Global Limited, London; Penn World Tables: Table 6.1.

Figure 12.15 **Primary energy consumption intensity in East Asia, 1965–2005** (per capita, tonnes of oil equivalent)

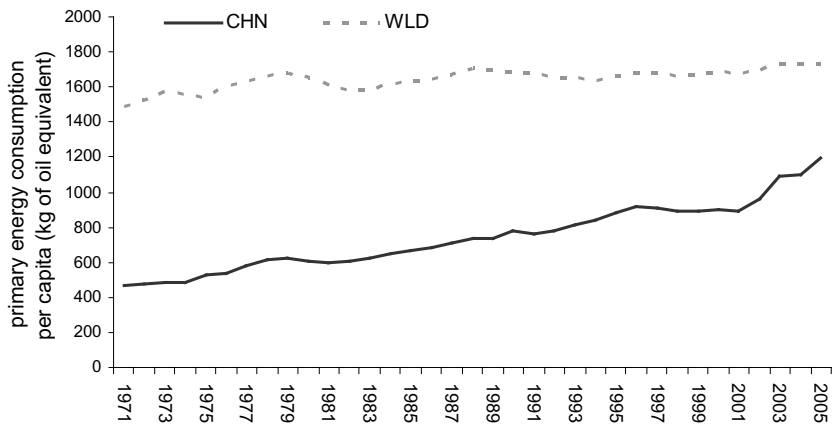



**Sources:** Authors' calculations using the data from British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy*, British Petroleum Global Limited, London; World Bank, 2006. *World Development Indicators Online Database*, World Bank Group, Washington, DC.

Moreover, a structural change analysis of energy consumption intensity, with the control of real income and price over time, can also be reflected using the accumulated CUSUM index (which ranges from zero to one).[3] The index is a set of procedures that can be used for testing for structural changes in the regression parameters. In applying this approach, emphasis is placed on graphical methods. A simple way of interpreting such a graph is to see whether the calculated indexes (the CUSUMS sequence) can cross the lines of given levels of significance. Such indexes are plotted in Figure 12.17, which shows that there is a breaking point at the turn of the new century, which indicates that China has entered a new phase of industrialisation in which structural changes with respect to its pattern of energy consumption intensity have been occurring. This breaking point in the changes in China's primary energy consumption is close to the time when its per capita income surpassed the mark of US$1,000—a clear signal that China has entered the new phase of industrialisation associated with increasing energy intensity.

Given the estimate of the International Energy Agency (IEA) of an annual growth rate in China of 6.4 per cent during the next 20 years, China's real GDP per capita could reach US$2,686 in 2015 and US$4,996 in 2025.[4] This essentially means—from what we have just described regarding the stages-of-development

Figure 12.16 **Comparison of primary energy consumption intensity between China and the world, 1971–2005**

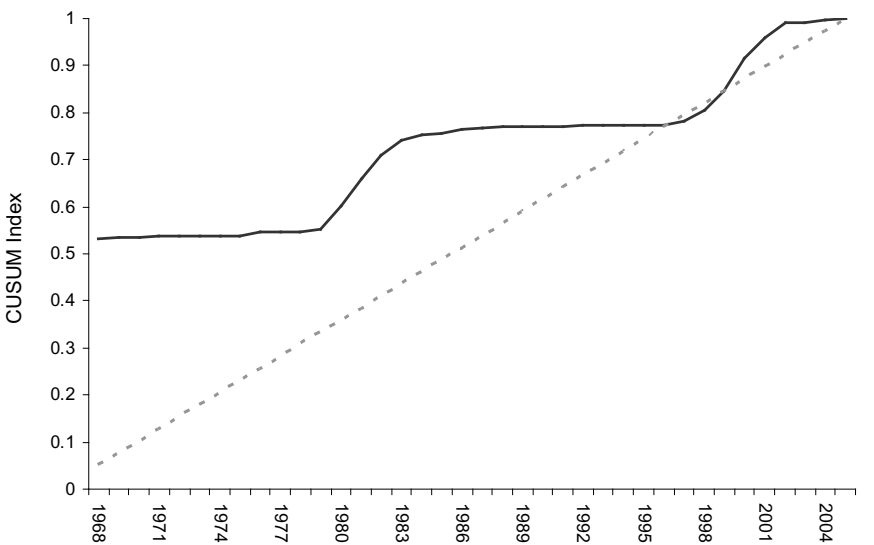



**Sources:** Authors' calculations using the data from British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy,* British Petroleum Global Limited, London; World Bank, 2006. *World Development Indicators Online Database*, World Bank Group, Washington, DC.

argument—that China's energy intensity will continue to rise at an accelerated pace in the next 15 to 20 years. This is largely because China has just entered a phase of industrialisation in which its industrial activities will concentrate mainly on those heavy industries that now consume about 54 per cent of China's total energy consumption—up from 39 per cent only five years ago (Rosen and Houser 2007). These conclusions would be even stronger if the IEA were to apply a higher, more realistic estimate of China's future growth rate.

Furthermore, with the rapid increase in per capita income, consumers' energy consumption has been increasing too, which has been boosted by household consumption such as for cooling and heating appliances and private vehicles and transportation. According to Rosen and Houser (2007), however, the commercial and transportation sectors won't surpass industry as energy demand drivers until a country reaches US$5,000 per capita GDP. By this criterion, the industrial sectors will continue to be the key drivers for energy

Figure 12.17 **Structural change of China's primary energy consumption (CUSUM index), 1968–2005**




**Sources:** Authors' calculations using the data from British Petroleum Global Limited (BP), 2006. *Statistical Review of World Energy*, British Petroleum Global Limited, London; World Bank, 2006. *World Development Indicators Online Database*, World Bank Group, Washington, DC.

consumption at least for the next 10–15 years. In that time frame, it is likely that the world will witness Chinese energy consumption per capita double—or more than triple if we think in terms of more realistic Chinese growth rates.

The environmental impact of the rising energy intensity in China will be enormous because the relatively high energy consumption intensities are associated closely with increases in greenhouse gas emissions. Such a prospect could be altered, of course, by improvements in technology, efficiency and the implementation of environmental policies and regulations that moderate growth in greenhouse gas emissions. One factor that makes it difficult for China to tackle its worsening environmental problems, however, is the composition of its energy consumption and production, which are dominated by coal. For example, according to China's eleventh Five-Year Plan on energy development (NDRC 2007), production of coal will continue to take the largest share (74.7 per cent) of China's total primary energy production by 2010, followed by oil (11.3 per cent), hydropower (7.5 per cent), natural gas (5 per cent) and nuclear power (1 per cent). By then, the share of coal production is forecast to drop only marginally, by 1.8 percentage points.

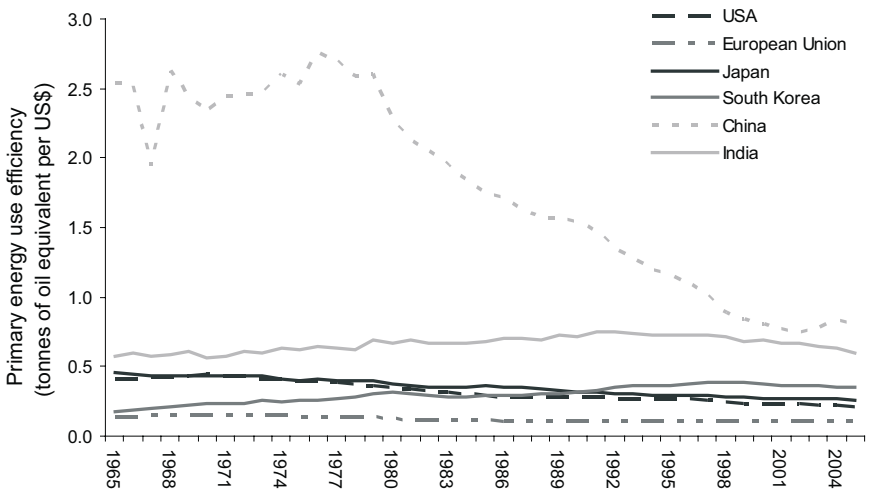
As a result, the IEA predicts that China will—from now until 2030—account for 40 per cent of the growth of global annual carbon dioxide emissions. These may turn out to be underestimates—bear in mind that this is based on estimates of Chinese economic growth that are only two thirds of those discussed in Chapter 1 as being relevant to the Platinum Age of economic growth.

The inefficient use of energy in China has worsened even further supply constraints and placed added pressure on the environment. China has made great progress in improving its energy efficiency, but there is considerable room for it to do more compared with the levels of energy efficiency in more advanced countries (Figure 12.18).

Given the rising energy demand and constraints on energy supply, China has made energy security the top priority of its energy policy goals. The eleventh Five-Year Plan delineates measures for the enhancement of energy security, with a strong emphasis on increasing investment in energy production and improving the efficiency of energy use.

To achieve the targets, a number of measures could be implemented (Bradley and Yang 2006). First, energy industries could by modernised by closing small and inefficient coal-mines and power plants and refineries with backward technology, while at the same time intensifying investment in the energy-production sector. Second, efficient technologies could be introduced into the process of energy consumption—from production and transportation to consumption. Small and inefficient iron and steel production plants could be closed. Third, sources of international energy supply could be diversified

Figure 12.18 **Primary energy consumption efficiency across countries, 1965–2005** (tonnes of oil equivalent per US$)




**Source:** World Bank, 2006. *World Development Indicators Online Database*, World Bank Group, Washington, DC.

Table 12.1 **Future growth of China's economy, energy consumption and CO2 emissions, 2000–2020 and 2020–2050** (per cent)

| | 2000–2020 | 2020–2050 |
|---|---|---|
| Annual growth rate of GDP (per cent) | 7.2 | 4.8 |
| Annual growth rate of energy consumption (per cent) | 4.3 | 1.7 |
| Elasticities of energy consumption[a] | 0.59 | 0.35 |
| Annual decreasing rate of energy intensity of GDP (per cent) | 2.8 | 3.0 |
| Annual growth rate of CO2 emissions (per cent) | 3.5 | 0.7 |
| Annual decreasing rate of CO2 emissions intensity of GDP (per cent) | 3.4 | 3.8 |

[a] Elasticities of energy consumption were calculated by dividing annual growth rate of energy consumption by annual growth rate of GDP.
**Source:** China, 2007. *National Assessment Report on Climate Change*, prepared by the Ministry of Science and Technology, China Meteorological Administration, and the Chinese Academy of Sciences, Scientific Publisher, Beijing:Table 22.3.

through multilateral and bilateral trade treaties. Fourth, current energy consumption could be diverted further from dirty, non-renewable fossil fuels to clean, sustainable energy—such as hydropower and nuclear power. Fifth, the energy price system could be reformed to enhance more efficient use of energy. Finally, new laws and regulations could be enacted to regulate exploration, production and consumption of energy, and their impact on the environment could be mitigated by designing and implementing an efficient, effective and fair pollution trading regime.

The adoption of these measures could pave the way for China to achieve its long-term objectives of economic growth, energy consumption and CO2 emissions (Table 12.1). According to this projection, China could reduce its emissions intensity of GDP by 42 per cent over the period 2006–20.

## Conclusions

China, together with other East Asian economies and India, will increasingly become the new centre of global primary energy consumption and a major source of environmental pollution in the next 20 years. Previous studies on energy seem to have underestimated the potential impact of China's economic growth on the balance of energy supply and demand. In particular, previous studies tended to neglect the incremental energy demand from China resulting from the shift from a lower economic development stage to a more advanced stage of industrialisation as well as understating likely economic growth rates. Increasing investment in energy production and improvements in energy efficiency could help to alleviate the pressure of balancing energy supply and demand in the short term. Seeking new sources of energy through technological innovations and international economic and technological cooperation would, however, be an important long-term solution to the dilemma of maintaining the sustainability of economic growth while protecting the environment.

## Notes

1 China is considering seriously such a strategy as it overtook the United States in carbon dioxide emissions by 8 per cent in 2006 according to a report released by the Netherlands Environmental Assessment Agency on 19 June 2007.

2 China's energy demand elasticity—which is the ratio of energy demand growth to GDP growth—increased from less than 0.5 between 1978 and 2000 to 1.5 between 2001 and 2006 (Rosen and Houser 2007).

3 See Brown et al. (1975) and Maskus (1983) for the technical details for applying this approach, and see Johnston (1984) for the statistical tests and interpretation of these indexes.

4 These are rather conservative estimates compared with most forecasts of 7–8 per cent annual growth rates in the Chinese economy during the next decade or so (see, for example, Maddison 2006).

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