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Wen Zhao (2010) 'Analysis on potentials of China's agricultural growth after Lewis turning point', unpublished working paper.
Ying Hu (2009) 'Estimation of China's urban and rural economically active population size in the years 2000–2008', *Chinese Population Science*, 6: 14–22.

5 Climate change mitigation

A defining challenge for China

Stephen Howes[1]

INTRODUCTION

Reducing greenhouse gas emissions is a defining challenge for China in two senses. First, it is required to avert dangerous and potentially catastrophic climate change. And, second, an effective response to climate change requires fundamental economic reforms and poses critical questions for China's emergence on the international stage as a superpower. Success on the mitigation front will be a good indicator of overall domestic reform progress and of China's peaceful and responsible global rise.

The next section presents a summary of China's historical and projected emissions trajectory, an assessment of its mitigation target, and an analysis of its objectives in relation to energy and the environment. The third section examines the desirability and feasibility of carbon pricing as an instrument to achieve these objectives, while the fourth section analyzes the importance of energy-sector and broader economic reform for mitigation. The fifth section of the chapter, which considers the very difficult international environment for mitigation, and proposes some strategies for China, is followed by a concluding section.

The analysis is in terms of carbon dioxide (CO_2) from fossil fuels, with a particular focus on the electricity sector. This is partly for tractability, partly because of the growing importance of CO_2 emissions from fossil fuels and partly because they are separately targeted by China. The next three sections draw on World Bank (2010a), which I co-authored with Leo Dobes. This report was written for the Asia Pacific Economic Cooperation (APEC) forum economies, and so has an Asia–Pacific focus which is a natural lens through which to analyze China's efforts and challenges.

CHINA'S CLIMATE CHANGE MITIGATION CHALLENGE AND OBJECTIVES

China's emissions trajectory

China's rise to industrial superpower status – illustrated by comparative steel production volumes in Figure 5.1 – has accelerated global emissions growth. China is now the largest emitter of CO_2 (from fossil fuels), with 25 per cent

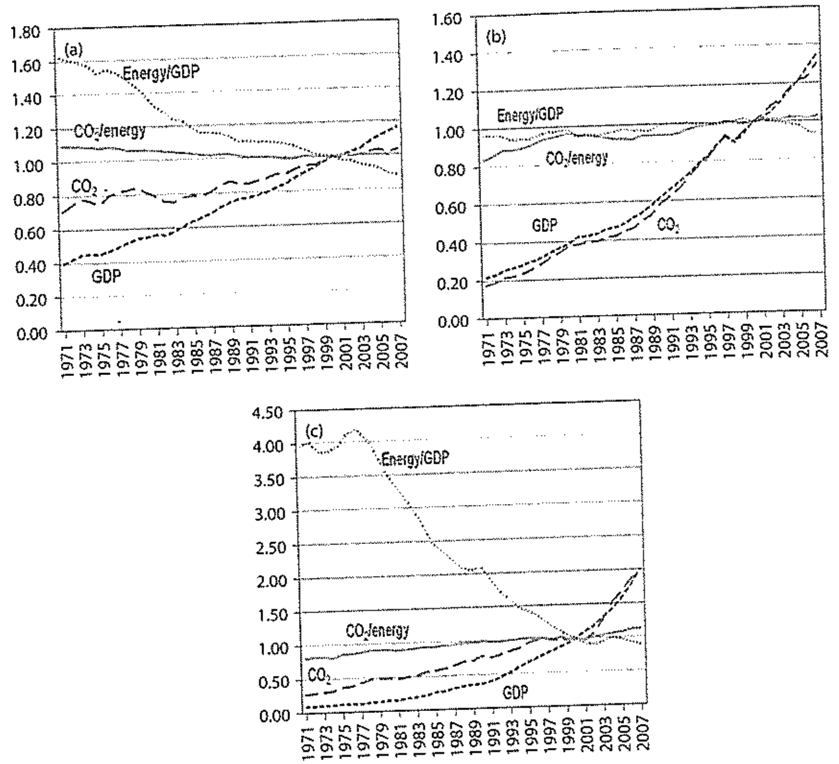

Figure 5.2 CO_2, GDP, emissions intensity of energy, and energy intensity of GDP for three groups of APEC economies, 1971–2007 (2000 = 1): (a) mature developed economies, (b) developing and newly developed economies excluding China and Russia, and (c) China. In most developing economies, but not in China (until recently), CO_2 emissions track GDP. Notes: Mature developed economies are Australia, Canada, Japan, New Zealand and USA. Developing and newly developed are all others apart from China and Russia. Data for Papua New Guinea are missing. GDP is measured in billions of constant year (2000) US dollars, using purchasing power parities (PPPs) to convert from local currency. Energy is measured in Mtoe (million tonnes of oil equivalent), and CO_2 is measured in millions of tonnes. Source: IEA (2009a).

and to promote energy-efficient lighting and more efficient buildings, and so on. These projects have been backed by high levels of government spending, expected to exceed US$10 billion by the central government alone in the last year. Several fiscal policies have also been used. Energy-intensive industries have been subjected to higher electricity prices and reduced export rebates.

The success which China has had in achieving its objective of a 20 per cent reduction in energy intensity is unclear. Official statistics suggested an ini-

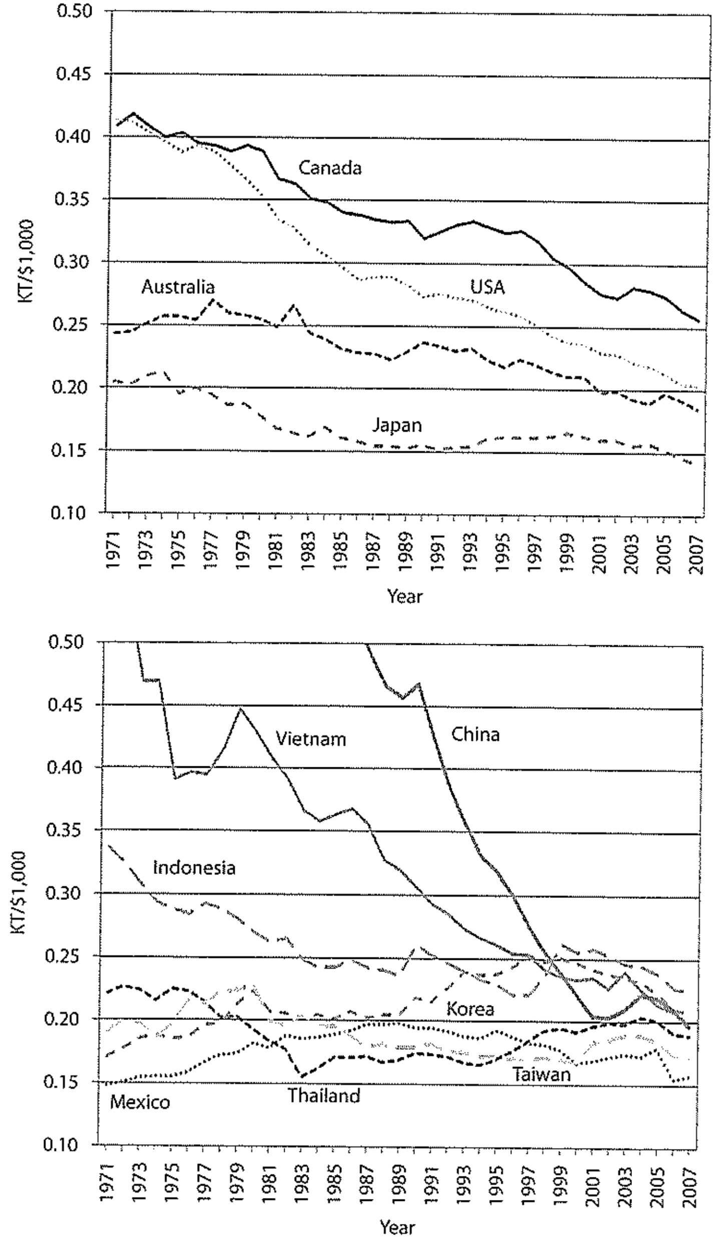

Figure 5.3 The ratio of energy consumption to GDP for selected APEC economies, 1971–2007. China's energy intensity used to be extraordinarily high, but now looks average. Note: See notes to Figure 5.2. Source: IEA (2009a).

The Chinese emissions target is an ambitious one which will not be met without considerable policy effort. Figure 5.5 illustrates this point by comparing national targets relative to estimates for 'business as usual' derived largely from Garnaut *et al.* (2009) for a range of APEC economies. China's target comes in as at least as ambitious as those of several other much richer economies, including Korea, Canada and the United States. Achieving it would require 30 per cent lower emissions than China would experience under business as usual. If China's target is achieved, its absolute and per-capita emissions would still increase, but by much less than would otherwise be the case. Its per-capita emissions at the end of the decade would be 7 rather than 10 tonnes, still up from almost 5 tonnes today, but representing a total savings in emissions of about 4 billion tonnes of CO_2 (more than 10 per cent of current annual global emissions of CO_2 from fossil fuels).

Why has China adopted both an emissions target and a renewables target? There are four objectives driving action in the energy–environment space.

First, the risks of unmitigated climate change are clearly a factor, as is China's perceived need to be seen to be contributing to solving this global problem.

Second, China is seeking to tackle national environmental problems. China has 13 of the world's 20 most polluted cities, 30 per cent of its land is damaged by acid rain as a result of sulphur emitted from coal, and health damages from air pollution are expected to reach 13 per cent of GDP in 2020 (see, for example, Zissis and Bajoria (2008)). Millions face serious indoor as

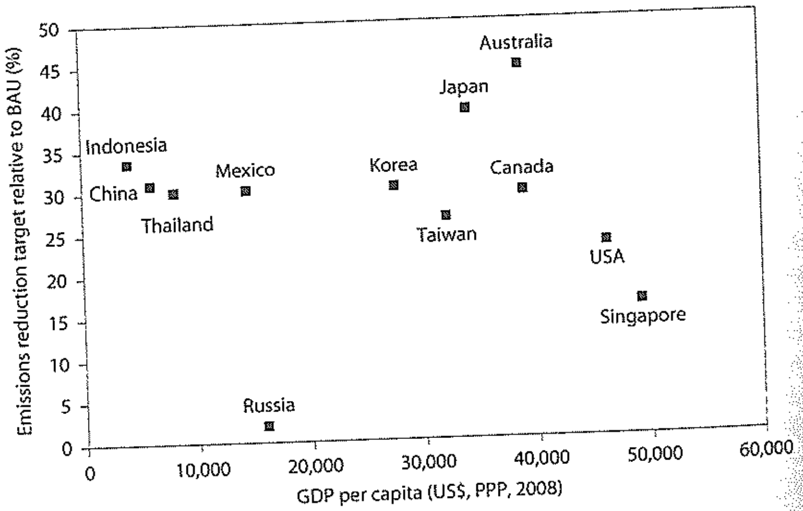

Figure 5.5 2020 APEC emission control targets expressed as a reduction relative to business as usual (BAU). China's emissions reduction target is ambitious.
Notes: National targets as recorded in the Copenhagen Accord or other statements. Where a target range has been committed to, the mid-point of that range is selected. Source: World Bank (2010a).

well as outdoor air pollution problems. A meta-analysis of epidemiological studies concluded that 'indoor air pollution from solid fuel use in China is responsible for approximately 420,000 premature deaths annually, more than the approximately 300,000 attributed to urban outdoor air pollution in the country' (Zhang and Smith 2007: 848).

Third, energy security is a growing concern. China has long been reliant on oil imports, and has just recently become a significant coal importer (Figure 5.6). At present production rates, China's currently proven coal reserves will last only another 41 years (World Bank 2010a). That said, energy security concerns will continue to revolve around oil more than coal. China already imports almost 60 per cent of its oil needs, but in 2010 will import less than 10 per cent of its coal. Worldwide, there is a lot of coal left. Garnaut (2008: Table 3.3) reports that, at 2007 production rates, the world has 139 years of coal left in its reserve base, as against only 60 years of gas and 40 years of oil. Also, unlike oil, much of that coal is in secure locations, such as Australia. The volatility and overall upward trend in world energy prices over the last decade (Figure 5.7) have also heightened energy security concerns.

Fourth, China is seeking technological advantage. China, like a number of economies around the world, increasingly views clean energy and, more broadly, low-carbon technology as a future major source of innovation, the 'next big thing'. China seeks to become a leading global supplier and eventually developer of these new technologies. Dechezleprêtre *et al.* (2008) measure technological innovation in respect of climate change mitigation using patent filings. Japan alone is responsible for 37 per cent of the world's climate change mitigation inventions (Table 5.1). The United States is in second position with 11 per cent, and China is in fourth with 8 per cent. China's 2007 Medium and Long-term Development Plan for Renewable Energy explicitly identifies the deployment of Chinese intellectual property domestically as a policy objective.

All four of these objectives are important for China's policy-makers. Together, they make up what is now called the 'green growth' agenda, most famously embraced by Korea. There are of course synergies between the four objectives. By pushing down global energy prices, global action on climate change would improve the terms of trade for economies such as China, and thus improve energy security. But there are also trade-offs. An emissions reduction target on its own might undermine energy security goals. Carbon capture and storage (CCS) is an example. CCS will help reduce emissions, but will also worsen local air pollution and weaken energy security, since it will significantly reduce the efficiency of coal plants. Likewise, some measures to improve energy security can increase emissions. Coal-to-liquid conversion (currently under consideration and/or development in several Asia Pacific economies, including China) will reduce reliance on oil imports, but will increase emissions.

This mix of objectives, and the possibility of trade-offs between them, demands a mix of instruments. This is certainly what we see in China, where a whole raft of instruments, from the command and control and regulatory approaches discussed earlier, to a range of feed-in tariffs and special tax and

Table 5.1 Top 12 inventors in climate change mitigation technologies, with average percentage of total global inventions across different mitigation technologies

Country	*Rank*	*Average % of world's inventions*
Japan	1	37.1
USA	2	11.8
Germany	3	10.9
China	4	8.1
South Korea	5	6.4
Russia	6	2.8
Australia	7	2.5
France	8	2.5
UK	9	2.0
Canada	10	1.7
Brazil	11	1.2
Netherlands	12	1.1
Total		87.2

Source: Dechezleprêtre *et al.* (2008).

Notes: Inventions are measured based on patent count data. The percentages shown average over 13 different climate change mitigation technology areas. These include not only renewable energies, but also relevant inventions in the areas of building, lighting, carbon capture and storage, and cement.

Nordhaus (2008: 22) writes: 'Whether someone is serious about tackling the global-warming problem can be readily gauged by listening to what he or she says about the carbon price.' In Nordhaus's view '[t]o a first approximation, raising the price of carbon is a necessary and sufficient step for tackling global warming'. This section considers whether carbon pricing would be desirable for China, and whether it would be feasible.

Carbon pricing would not suffice as a policy to promote climate change mitigation for China (or other developing economies). Complementary policies would be needed in three areas. First, so-called technology policies, such as research and development subsidies and feed-in tariffs, would be needed to promote technological leadership. Views on the wisdom both of an activist industrial policy objective and of individual instruments to achieve them are mixed, but, taking the objective as given, a more targeted approach to technological innovation and dissemination is needed than is provided by carbon pricing. Second, there is a risk that carbon pricing on its own would lead to substitution from emissions-intensive coal to less-emissions-intensive oil, thus reducing emissions but worsening energy security. This would need to be avoided by complementary policies to tax oil, or again promote renewables, so that the substitution is not from coal to oil but away from fossil fuels altogether (gas is already being promoted but is supply-constrained). Third, there are still several hundred million households reliant on biomass for cooking and heating in China, with

serious negative health consequences. A carbon price, as a tax on modern energy, could conceivably make it harder for these households to escape the traditional energy sector. However, the empirical evidence (summarized in Wadhwa *et al.* (2003)) suggests, in fact, that exit from traditional energy is not price sensitive, and that what is more important are complementary policies either to reduce the health costs of using traditional energy sources, or to extend access to the modern sector.

Although not sufficient on its own, carbon pricing would seem to be an essential part of an effective policy response to the mitigation challenge. There is no doubt that if China wants to achieve an ambitious emissions objective, such as the one that it has just adopted, it will have to increase the price of energy. Figure 5.8 summarizes the challenge facing China. It compares China (and Taiwan and Korea) to two sets of developed economies: the USA and Canada on the one hand, and the European Union (EU) and Japan on the other. The USA and Canada have cheap energy (low electricity and petroleum prices) and a high energy/GDP ratio. By comparison, the EU and Japan have expensive energy and a low energy/GDP ratio. China, with relatively low energy prices and high energy intensity, currently looks much more similar to the USA and Canada than it does to Europe and Japan. But China's mitigation objective requires that it ends up looking more like

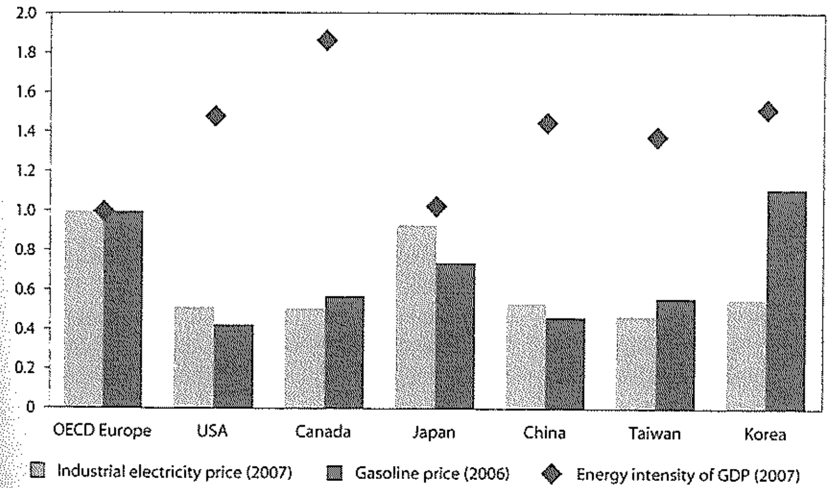

Figure 5.8 Electricity prices, gasoline prices and energy intensity (ratio of energy use to GDP) for USA, Canada and Japan relative to the OECD member economies of Europe. China's future: low energy prices or high energy efficiency? Notes: Energy prices measured in current US$, using market exchange rates; energy intensities measured using PPPs. For energy intensity definitions, see Figure 5.2. Energy efficiency is defined as the inverse of energy intensity. All OECD Europe values are normalized to one. Sources: IEA (2009a, 2010).

carbon prices, and this political constraint to carbon pricing for developing economies will weaken.

Whatever the level at which it is set, would a carbon price have an impact? We now turn to this question of the economic feasibility of carbon pricing. Clearly, a carbon price on coal would send a strong signal to commercial consumers of coal, such as steel manufacturers. But much of the energy sector in China is regulated, and here matters are more complex. For concreteness, we focus below mainly on the impact of a carbon price in the electricity sector.

A carbon price will, in an otherwise well-functioning market, push up the relative price of emissions-intensive goods, and thereby reduce emissions in four ways. First, it will push consumer demand in the direction of goods which are less emissions intensive (for example, to wear extra clothing and turn down the heating). Second, it will induce suppliers to make their goods less emissions intensive (for example, to make electricity with gas instead of coal). Third, it will lead investors to invest in projects that are less emissions intensive (for example, to build an aluminium smelter that runs on hydro rather than thermal power).[4] And, fourth, carbon pricing will give a financial incentive for innovators to develop new products which are less emissions intensive (for example, to invent a hydrogen or electric car).

The effectiveness of the fourth channel of induced innovation will depend on the extent to which the other three channels are effective. In the case of the electricity sector in China, as I show below, each of the first three channels might in fact be blocked.

Impact of carbon pricing on demand

For a carbon price to have an impact on demand, it clearly needs to be passed on to final consumers. But recent experience suggests that there is no guarantee this will happen. Coal is the dominant fuel for electricity in China. In recent years, the price of coal in China has risen sharply, as illustrated by Figure 5.10, which plots the spot or market price for coal.[5] A lot of coal (about 70 per cent) is sold under long-term contract but, in 2007, price controls for long-term contracts were removed (Rosen and Houser 2007). Contract prices are significantly lower than market prices, but should over time follow the latter upwards. Market coal prices spiked in the middle of 2008, with some prices exceeding 1,000 yuan per tonne. At this point, the Chinese Government capped the market price at 800 yuan.

Through a series of electricity tariff increases, China greatly reduced electricity subsidies over the 1990s. However, China has found it difficult to pass on the increase in coal costs it has recently experienced. China has a formula in place for adjusting the electricity price every 6 months if the coal price changes by more than 5 per cent. However, since the end of 2004, when the formula was introduced, although this condition has been met 10 out of 12 times (in relation to coal market prices), the price of electricity has been changed only thrice, and by much less than the formula mandated. In nominal terms, coal prices rose 40 per cent between the first half of 2006 and 2010, but electricity prices by only about 15 per cent. In fact, over the past few years, electricity selling prices have not even kept pace with inflation, as Figure 5.11 shows.

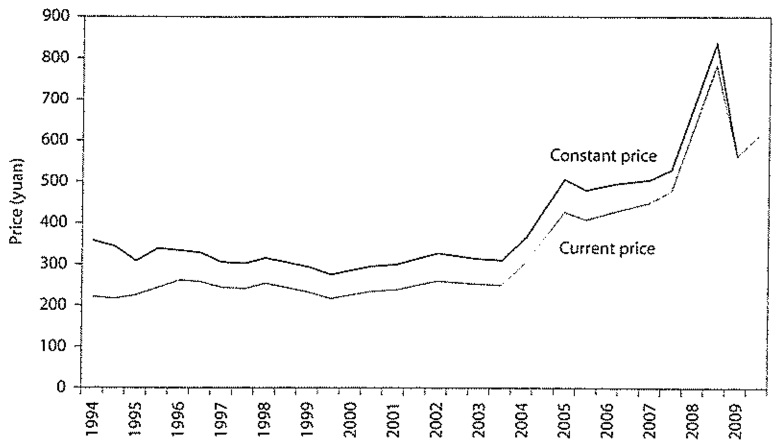

Figure 5.10 Current and constant spot market prices of coal, 1994–2010. The era of cheap coal in China is over. Notes: 6-month average FOB prices per tonne (1,000 kg) of coal at the Qinghaungdo Port for three types of coal (where available): Datong Premium Mix 6k, Shanxi Premium Mix 5.5k, and Shanxi and Datong Mix 5k. The CPI deflator is used to obtain the constant price series, using 2009 as the base. Sources: NBS (2010) and national Chinese coal data.

The result has been a squeeze on margins in the electricity sector, as seen in Figure 5.12. In 2003, coal costs were less than half of the price at which grid companies purchased power from generators. In 2008, they were over 100 per cent and, despite some relief from falling coal prices, at the end of 2009 coal costs still consumed over 70 per cent of coal-fired generator revenue. How is the sector managing to survive? Much coal is still sold under contract, and contract prices would lag spot prices, given the doubling of the latter since middle of the last decade. Generator profits are also being squeezed, and the margin between the final selling price and the wholesale power purchase (generation) price has also fallen. Morse *et al.* (2009) report that Chinese power companies lost an estimated 70 billion yuan in 2008.

Similar problems with cost pass-through have occurred in the petroleum sector, as Figure 5.13 illustrates. China announced it was moving to market-based pricing for petrol in December 2008 but, in May 2009, the government announced that it would set prices to protect consumers when world oil prices exceeded US$80 a barrel (Kojima 2009).

many power plants to build, where to site them, what fuel they should tap and what prices they will charge. As a result, instead of partially withdrawing from business, the government merely switched its role from directly controlling the power industry via repatriation of all revenues and direction by ministerial fiat to indirectly controlling utility state-owned enterprises' (SOEs') access to financial markets and project approval. SOEs in the power sector are not substantially more independent than they were before the reform in terms of power project development.

Price signals are crucial for getting decentralized agents to adjust their actions to meet national targets. However, central planners can directly incorporate national targets into their decision-making, without any price signal at all. The Chinese Government already has capacity targets for all major generation types. Figures that are both official and up-to-date are hard to come by, but form part of the Twelfth Five-Year Plan approved in April 2011. Figure 5.14 presents estimates of what China's 2020 expansion targets are or will be, both for total generation capacity, and for different fuel types. They imply not only a rapid aggregate expansion, but significant continued diversification away from coal to gas, nuclear and wind.

Would planners move further away from coal if they were told to use a carbon price? A precise answer to this would depend on the calculation of the implicit carbon price that would give the outcome shown in Figure 5.14.

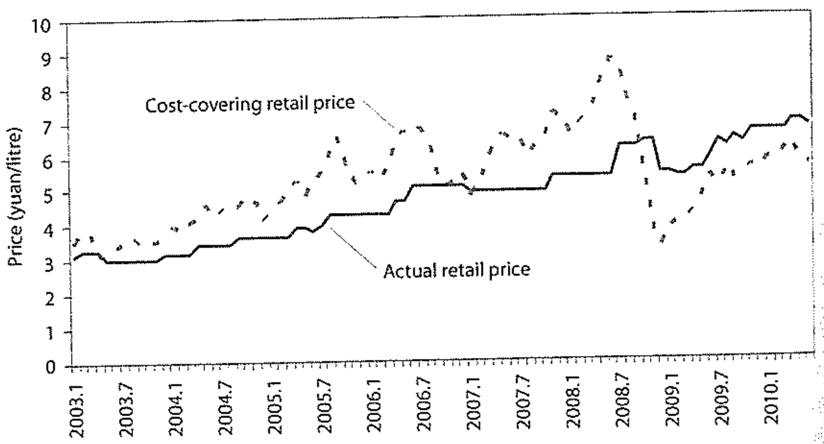

Figure 5.13 Actual retail prices for petrol in China, and what they would need to be to cover costs given world prices for crude. Petrol prices in China follow world prices except when world prices are very high. Notes: Cost-covering retail prices are based on the world price for crude and include margins for refining and distribution. In January 2009, China increased the fuel tax from 0.2 yuan/litre to 1.0 yuan/litre. The cost-covering retail price does not include taxes. The price is for Beijing, and for 93-octane gasoline. Source: Li (2010), updated.

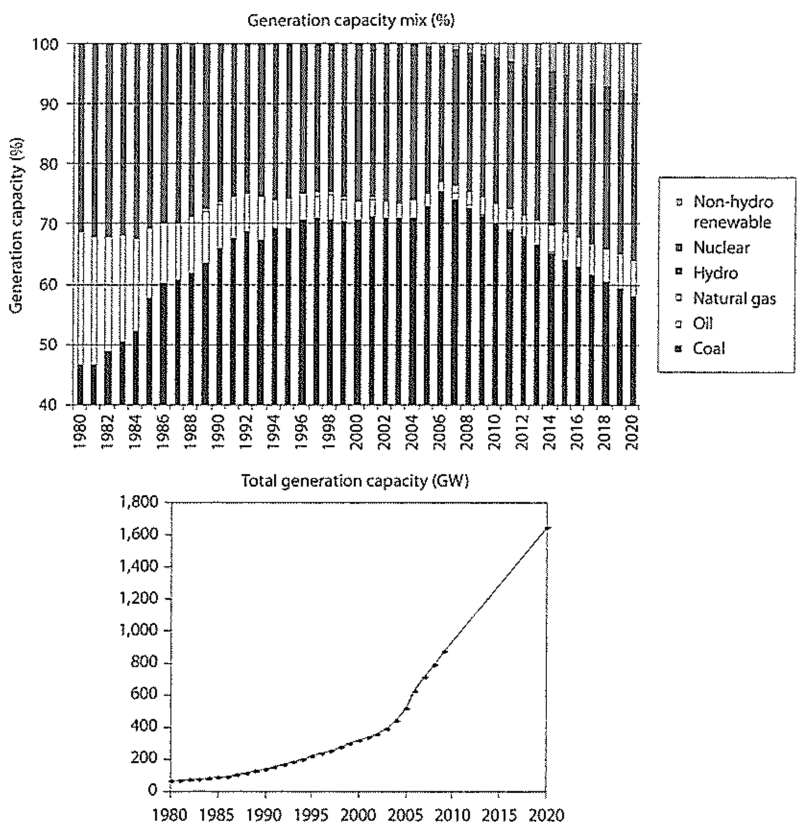

Figure 5.14 Electricity generation capacity by fuel type (%) in China, historical (1980–2009) and projected (2020). China's 2020 generation targets aim to reduce the dominance of coal-fired generation, while doubling total capacity. Notes and sources: Target year is 2020; last year of historical data is 2009; for intermediate years, linear interpolation used. Historical capacity data come from EIA (2010). However, this source doesn't distinguish between coal, oil and gas capacity. The subdivision of thermal capacity into these three types is done using electricity generation data from IEA (2009b) up to 2006 and own sources for 2009 (2007 and 2008 are interpolated). Note vertical axis truncated from below at 40% to magnify the changes envisaged. At the time of writing, there was no public, up-to-date and comprehensive generation expansion plan. Targets were therefore compiled from various public sources. (The Twelfth Five-Year Plan, approved by the Chinese Government in April 2011, contains an updated generation expansion plan.)

However, since China's expansion plans already embody a significant move away from coal, there can certainly be no presumption that the introduction of a carbon price would influence the generation mix, unless the carbon price was itself very high.

The search for what Rosen and Houser call 'the root causes of (China's) structural over-allocation into energy-intensive industry' (Rosen and Houser 2007: 37) must extend beyond the energy sector. As they argue: 'the pervasive revealed comparative advantage of heavy industry manufactured goods from China is generally rooted in distortions other than energy inputs' (ibid: 38).

China is characterized by both an exceptionally high investment rate and by a high share of industry in value-added, as Figure 5.15, from He and Kuijs (2007), shows. The reasons for this are complex, but include, as argued by Huang, Y. (2010), limited liberalization of China's factor markets. Low interest rates, high reinvestment rates by state-owned enterprises and low land prices in particular have all encouraged capital-intensive industrial production.

Whatever the causes, one of China's main economic policy objectives is rebalancing of the economy. This rebalancing has multiple dimensions: from savings to consumption, from production for foreign markets to production for domestic markets, and from the industrial to the service sector. Rebalancing the economy should not only be good for short-term economic welfare, but should also reduce emissions. Table 5.2 illustrates this point by comparing the share of GDP for China's different sectors with their share of energy use. Industry (the secondary sector) is responsible for 49 per cent of China's GDP, but 84 per cent of China's energy use. A 10 percentage point switch in GDP composition away from industry towards services (the tertiary sector) would, everything else being equal, result in a 14 per cent reduction in energy intensity.

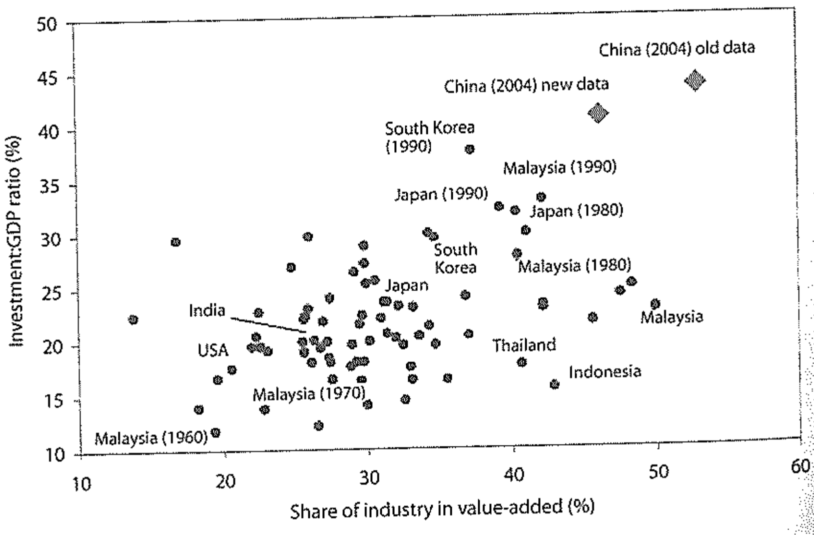

Figure 5.15 China has exceptionally high investment rate and industry/GDP share. Source: He and Kuijs (2007).

Table 5.2 A switch away from industry to services would help reduce China's energy intensity. Notes: The year is 2007. Construction is included with industry in the secondary sector. Household energy use (about 11% of the total) is included in the secondary share of energy use. Source: NBS (2010).

Sector	*Share of GDP (%)*	*Share of energy (%)*	*Energy intensity index*
Primary (agriculture)	11	3	0.3
Secondary (industry and construction)	49	83	1.5
Tertiary (services)	40	14	0.3
Total	100	100	1

Slower economic growth would also of course help reduce the growth in China's emissions. If China grows at 10 per cent in 2010, as its initial estimates suggest, then its average GDP growth according to the latest figures, between 2005 and 2010 will be just over 11 per cent. This is not only well above the 7.5 per cent target embodied in the 2006–10 Eleventh Five-Year Plan. It will also be China's highest 5-year average growth since the reforms began, which is a remarkable result considering that the period encompasses the global financial crisis. It seems heretical to suggest that China would do better by growing more slowly, but it is possible that slower growth would actually improve welfare. For example, a switch in government spending from infrastructure to health could reduce growth but still be welfare-enhancing as well as emissions-reducing.

As with energy reform, rebalancing will not be undertaken to reduce emissions. But emissions reductions efforts will not succeed unless rebalancing occurs. It is this link between mitigation and rebalancing which, more than any other domestic issue, makes climate change a defining challenge for China. The international challenges China faces in relation to climate change, to which we now turn, are no less daunting.

INTERNATIONAL DIMENSIONS

Recent developments

In 2009, I wrote a chapter in the annual Australian National University 'China update' (Howes 2009a) answering in the affirmative the question of whether China could save the Copenhagen negotiations and deliver a global deal. While some accused the Chinese of wrecking the negotiations, Copenhagen, with Chinese support, in fact delivered all three of the ingredients I argued would be critical for obtaining a global deal.

First, in the run-up to Copenhagen, the Chinese Government announced its domestic emissions target, the 40–45 per cent target discussed above.

proponent of the view that China and other major developing countries should take on business as usual targets, so that it could make a profit (via the sale of excess emissions permits) from any mitigation effort (Frankel 2007). Such a view is supported by a literal interpretation of the United Nations Framework Convention on Climate Change, Article 4.3 of which famously guarantees developing countries that the 'incremental costs' of their mitigation efforts will be covered by others.

China's commitment is not only unconditional on funding support from other countries. It is also unconditional on the commitments made by other countries. Several developed countries or regions, such as Japan and the EU, have put forward targets that are conditional on the efforts of others. Others, such as the USA and Australia have yet to put forward definitive targets. China's target by contrast is already firm and operational.

What else might be expected from China?

Three additional steps can be considered. First, the biggest contribution China could make would be to make clear progress to its 2020 target. This would not only make a significant contribution to the task of global mitigation, but would also have a significant encouragement effect on other countries. Since the USA cannot be persuaded to lead, perhaps our only chance is that it can be forced to follow. The onus for putting such a strategy in place must fall on other developed countries, but cannot be successfully executed by them alone. China has a critical role to play, as its stance, more than that of any other country, will influence Washington.

The second area where more could be expected from China is in the area of transparency. It is not clear to the outside observer why, even if in a regime honouring the central UNFCCC tenet of 'common but differentiated responsibilities', different reporting standards should apply to different countries. China could be given a grace period to give it time to do the technical work needed to meet global reporting standards. But it is hard to see why, once this period is over, the world's biggest emitter should not be required to meet the world's best standards for reporting and verification. China's low per-capita income and relatively low per-capita emissions require strong differentiation of its target from those of developed countries (for example, China should be allowed to grow its emissions in the immediate future, albeit at a slower rate than in the past), but it is hard to see how these factors should lead to the country being made subject to different verification standards. As discussed earlier, it is not possible to verify from published data China's claim to be on-track to achieving its target of a 20 per cent reduction in energy intensity by 2010 relative to 2005. This undermines the credibility of China's mitigation effort, and inevitably leads to suspicion that China is exaggerating its progress. China can and must do better in terms of international reporting and transparency.

Third, should China adopt a more flexible position in the international negotiations, and drop its insistence on a second Kyoto Protocol commitment period? This would certainly be helpful for overcoming the current

stalemate, but may be too much to ask. Geopolitical realities demand that China would need to get something in return for this concession. One could imagine a grand bargain in which China dropped its insistence on a second commitment period for Kyoto in return for the US Senate adopting legislation on climate change. Unfortunately, due to US Senate intransigence, such a bargain is not on the table.

CONCLUSION

Climate change mitigation poses important domestic and international challenges for China. On the domestic front, China has put forward an ambitious emissions reduction target. Achieving it will not be easy. The chapter has highlighted three critical challenges that will need to be addressed if this target is to be achieved.

First, successful mitigation will require that energy prices rise significantly, whether through the introduction of a carbon price or other means. This is not an easy task for any country, and particularly not for one such as China, which still faces significant development challenges. But it is critical not only for reducing emissions, but also for other important policy goals, in particular energy security.

Second, if carbon prices are to fulfil their potential as a mitigation instrument, reform of the energy sector will be required to allow cost pass-through. Reforms to allow a merit-order for generation dispatch, so that environmental as well as economic considerations can be taken into account, will also be important.

Third, to slow energy growth, mitigation will also require a rebalancing of the Chinese economy, away from industry towards services.

Other measures will of course be needed (such as support for research and development, and other regulatory measures), but the three highlighted above will be the most difficult and have the most far-reaching consequences.

On the international front, the failure of the USA to provide leadership on the climate change issue makes for a bleak outlook. The fundamental international question facing China in relation to climate change mitigation is: is it willing to provide leadership on an issue on which the world's superpower is inadequately engaged? Looking forward, as China becomes more and more powerful, increasingly the world will look to it for leadership on important global issues. Climate change will be an important test case of whether China is prepared to rise to the challenge, even when the USA is lagging.

It is unrealistic to think that an international agreement can be reached without greater effort by the USA. But China also needs to do more to show global leadership. The most important contribution it can provide is to make serious progress towards its 2020 target. It also needs to improve the transparency around its official energy and emissions figures, with a view to eventually adhering to the same reporting rules as other major global powers.

IEA (International Energy Agency) (2006) *China's Power Sector Reforms: Where to Next?*, Paris: IEA.

—— (2008) *World Energy Outlook 2008*, Paris: IEA.

—— (2009a) CO_2 *Emissions from Fuel Combustion*, 2009 edition, release 01, available at http://oberon.sourceoecd.org/vl=15178979/cl=15/nw=1/rpsv/statistic/s26_about.htm?jnlissn=16834291.

—— (2009b) *Energy Balances of Non-OECD Member Countries – Extended Balances*, 2009 edition, release 01, Paris: IEA.

—— 2010, *Energy Prices and Taxes – Energy End-use Prices, (US/toe, PPP/unit)*, vol. 2010, release 02, available at http://puck.sourceoecd.org/vl=16663138/cl=15/nw=1/rpsv/statistic/s29_about.htm?jnlissn=1683626x.

Johansson, A., Heady, C., Arnold, J., Brys, B. and Vartia, L. (2008) 'Tax and economic growth', *OECD Economics Department Working Paper*, No. 620, Paris: Organisation for Economic Co-operation and Development, available at http://www.oecd.org/officialdocuments/displaydocumentpdf/?cote=ECO/WKP(2008)28&doclanguage=en.

Kojima, M. (2009) 'Government response to oil price volatility', *Extractive Industries for Development Series*, No. 10, Washington, DC: World Bank.

Lee, H. (2010) 'Regional mitigation costs from EMF22 models', Canberra: Australian National University (mimeo).

Li, J. (2010) 'The economic effect of raising petrol product prices – application of SIC-GE', paper presented to the International Conference on the SIC-GE Model and Policy Simulation, 15–16 April, Beijing.

Liuxiahzaihui (2010) *In the Name of Carbon: The Global Game behind the Scene of Low-carbon Conspiracy*, Beijing: China Development Press.

Mao, Y., Sheng H. and Yang, F. (2008) *The True Cost of Coal*, Greenpeace, the Energy Foundation and WWF, available at http://www.eu-china.net/web/cms/upload/pdf/materialien/TCOC-Final-EN-08_10-28.pdf.

Mercados EMI (Mercados Energy Markets International) (2010) *China Power Dispatch Efficiency Improvement: Final Technical Report*, prepared for Energy Sector Management Assistance Program, Washington, DC: World Bank.

Morse, R.K., Rai, V. and He, G. (2009) 'Real drivers of carbon capture and storage in China and implications for climate policy', *Program on Energy and Sustainable Development, Working Paper*, No. 88, Stanford, CA: Stanford University.

NBS (National Bureau of Statistics of China) (2010) *2009 China Statistical Yearbook*, Beijing: China Statistics Press.

Nordhaus, W. (2008) *A Question of Balance: Weighing the Options on Global Warming Policies*, New Haven, CT: Yale University Press.

Outlook Economics (2010) *China Energy Graphs*, Canberra: Outlook Economics.

Pahle, M. (2010) 'Germany's dash for coal: exploring drivers and factors', *Energy Policy*, 38(7): 3431–3442.

PBL (Netherlands Environmental Assessment Agency) (2010) Database associated with J. Olivier and J. Peters 'No growth in total global CO_2 emissions in 2009', Bithoven, The Netherlands: Netherlands Environmental Assessment Agency, available at http://www.pbl.nl/en/publications/2010/No-growth-in-total-global-CO_2-emissions-in-2009.html.

Rosen, D.H. and Houser, T. (2007) *China Energy: A Guide for the Perplexed*, Washington, DC: Center for Strategic and International Studies, and Peterson Institute for International Economics.

Rosenzweig, M.B., Voll, S.P. and Pabon-Agudelo, C. (2004) 'Power sector reform: experiences from the road', *The Electricity Journal*, 16–18, available at doi:/10.1016/j.tej.2004.10.002.

SERC (State Electricity Regulatory Commission) (2006) *Electricity Regulation Report 2006 [Dianli jianguan baogao (2006)]*, Beijing: SERC.

—— (2007) *Electricity Regulation Report 2007 [Dianli jianguan baogao (2007)]*, Beijing: SERC.

—— (2008) *Electricity Regulation Report 2008 [Dianli jianguan baogao (2008)]*, Beijing: SERC.

—— (2009) *Electricity Regulation Report 2009 [Dianli jianguan baogao (2009)]*, Beijing: SERC.

Sheehan, P. (2008) 'The new global growth path: implications for climate change analysis and policy', *Climatic Change*, 91(3–4): 211–231.

Stern, D. and Lambie, R. (2010) 'Where is it cheapest to cut carbon emissions?', *Environmental Economics Research Hub Research Reports*, No. 1063, Canberra: Crawford School, Australian National University.

UNDP (United Nations Development Programme) (2010) *China and a Sustainable Future: Towards a Low Carbon Economy and Society*, China Human Development Report 2009/10, Beijing: China Publishing Group Corporation.

UNFCCC (United Nations Framework Convention for Climate Change) (2010) *Copenhagen Accord*, FCCC/CP/2009/L.7, 18 December.

Wadhwa, W., Gangopadhyay, S., Bacon, R., Kumar, P., Kojima, M., Lvovsky, K. and Ramaswamy, B. (2003) *India: Access of the Poor to Clean Household Fuels*, UNDP and World Bank Energy Sector Management Assistance Programme, available at http://vle.worldbank.org/bnpp/en/publications/energy-water/india-access-poor-clean-household-fuels.

World Bank (2010a) *Climate Change and Fiscal Policy: A Report for APEC*, Washington, DC: World Bank.

—— (2010b) *Winds of Change: East Asia's Sustainable Energy Future*, Washington, DC: World Bank East Asia and Pacific Region, East Asia Infrastructure Unit.

Wu, F.F., Wen, F. and Duan, G. (2004) 'Generation planning and investment under deregulated environment: comparison of USA and China', *IEEE Power & Energy Society General Meeting*, 2004, 2: 1324–1328.

Zhang, C. and Heller, T.C. (2004) 'Reform of the Chinese electric power market: economics and institutions', *Program on Energy and Sustainable Development, Working Paper*, No. 3, Stanford, CA: Stanford University.

Zhang, J. and Smith, K.R. (2007) 'Household air pollution from coal and biomass fuels in China: measurements, health impacts, and interventions', *Environmental Health Perspectives*, 115(6): 848–855.

Zhao, L. (2008) 'Research on issue of electrovalent composing in China', Masters' dissertation (in Chinese), Dongbei University of Finance and Economics.

Zhou, N., Levine, M. and Price, L. (2010) 'Overview of current energy efficiency policies in China', *Energy Policy*, 38(11): 6439–6452.

Zissis, C. and Bajoria, J. (2008) 'China's environmental crisis', Council on Foreign Relations, available at http://www.cfr.org/publication/12608/chinas_environmental_crisis.html.