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Energy and Environmental Issues and Policy in China

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Summary

China's rampant environmental pollution problems and rising greenhouse gas emissions and the resulting climate change are undermining its long-term economic growth. China, from its own perspective cannot afford to and, from an international perspective, is not meant to continue on the conventional path of encouraging economic growth at the expense of the environment. Instead, concerns about a range of environmental stresses from burning fossil fuels, energy security as a result of steeply rising oil imports and international pressure on it to exhibit greater ambition in fighting global climate change have sparked China's determination to improve energy efficiency and cut pollutants, and to increase the use of clean energy in order to help its transition to a low-carbon economy. This chapter focuses on China's efforts towards energy conservation, nuclear power and the use of renewable energy. The chapter examines a number of market-based instruments, economic and industrial policies and measures targeted for energy saving, pollution cutting, energy greening. To actually achieve the desired outcomes, however, requires strict implementation and coordination of these policies and measures. The chapter discusses a variety of implementation/compliance/reliability issues. The chapter ends with some concluding remarks and recommendations.

Keywords: Energy Saving, Renewable Energy, Power Generation, Nuclear Power, CCS, Market-Based Instruments, Economic and Industrial Policies, Carbon Intensity, Resource Taxes; Implementation, Compliance and Reliability, Financial Institutions

JEL Classification: Q42, Q43, Q48, Q52, Q54, Q55, Q56, Q58, R13, R15

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Abstract
China's rampant environmental pollution problems and rising greenhouse gas emissions and the resulting climate change are undermining its long-term economic growth. China, from its own perspective cannot afford to and, from an international perspective, is not meant to continue on the conventional path of encouraging economic growth at the expense of the environment. Instead, concerns about a range of environmental stresses from burning fossil fuels, energy security as a result of steeply rising oil imports and international pressure on it to exhibit greater ambition in fighting global climate change have sparked China's determination to improve energy efficiency and cut pollutants, and to increase the use of clean energy in order to help its transition to a low-carbon economy. This chapter focuses on China's efforts towards energy conservation, nuclear power and the use of renewable energy. The chapter examines a number of market-based instruments, economic and industrial policies and measures targeted for energy saving, pollution cutting, energy greening. To actually achieve the desired outcomes, however, requires strict implementation and coordination of these policies and measures. The chapter discusses a variety of implementation/compliance/reliability issues. The chapter ends with some concluding remarks and recommendations.

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1. Introduction

Since launching its open-door policy and economic reforms in late 1978, China has experienced spectacular economic growth, and hundreds of millions of the Chinese people have been raised out of poverty. In this course, China has been heavily dependent on dirty-burning coal to fuel its rapidly growing economy. Moreover, until recently, China had valued economic growth above environmental protection. A combination of these factors has given rise to unprecedented environmental pollution and health risks across the country (The World Bank, 2007; CAEP, 2013).

As a result, until 2009 urban air quality across the country still did not meet the air quality standards more than one-third of a year (MEP, 2010a, 2010b), and one-third of China's land is affected by acid rain. The deterioration of the environment has led to frequent pollution disputes across the country. In 2009, serious environmental risks had resulted in one sudden environmental incident every other day (MEP, 2010c). Along with corruption, income inequalities and soaring house prices, the environment is considered to be one of the leading causes of social unrest within the Chinese society.

The rising environmental degradation associated with China's rapid economic growth has led to significant economic costs. Existing estimates for such costs vary, depending on the comprehensiveness of the assessments. China's first official estimate for the economic costs of environmental pollution in 2004 put the figure at US$ 64 billion, or 3.05 percent of gross domestic product (GDP) (SEPA and NBS, 2006). This cost estimate was raised to about US$ 250 billion in 2010, or 3.5 percent of GDP (CAEP, 2013). This is a very conservative estimate; other estimates put the figure much higher. The World Bank (2007), for example, has estimated that the total cost of air and water pollution in China is about 5.8 percent of GDP.

While being confronted with rampant conventional environmental pollution problems, China became the world's largest carbon emitter in 2007 (IEA, 2007). The number one position put China in the spotlight, just at the time when the world's community started negotiating a post-Kyoto climate regime under the Bali roadmap. There were renewed interests and debates on China's role in combating global climate change. Given the fact that China's emissions are projected to rise rapidly in line with its industrialization and urbanization on the one hand, and the fact that China overtook Japan as the world's second largest economy on the other hand, China is seen to have greater capacity, capability and responsibility for taking on climate commitments. Clearly, China's rampant environmental pollution problems and rising greenhouse gas emissions and the resulting climate change are undermining its long-term economic growth. China, from its own perspective cannot afford to and, from an international perspective, is not meant to continue on the conventional path of encouraging economic growth at the expense of the environment. Instead, concerns about a range of environmental stresses and energy security as a result of steeply rising oil imports have sparked China's determination to green its economy.

To that end, China has incorporated for the first time in its five-year economic plan an input indicator as a constraint – requiring that energy use per unit of GDP be cut by 20 percent during the 11th five-year period running from 2006 to 2010. This five-year plan also incorporated the goal of reducing SO_2 emissions and chemical oxygen demand (COD) discharge by 10 percent by 2010, relative to their 2005 levels. Just prior to the Copenhagen Climate Change Summit, China further pledged to cut its carbon intensity by 40–45 percent by 2020 relative to its 2005 levels, and reaffirmed its plan to have alternative energy sources to meet 15 percent of the nation's energy requirements by 2020.

This chapter focuses on China's efforts towards energy conservation, nuclear power and the use of renewable energy. The chapter examines a number of economic policies and measures targeted for energy saving and pollution cutting. To actually achieve the desired outcomes, however, requires strict implementation and coordination of these policies and measures. The chapter discusses a variety of implementation/compliance/reliability issues. The chapter ends with some concluding remarks and recommendations.

2. China's efforts towards energy conservation

Given the inevitable trend that China's energy demand continues to rise over the next two decades and beyond, the key issue is how China can drive its future energy use and carbon emissions below the projected baseline levels to the extent possible. In this regard, improving energy efficiency is considered the cheapest, fastest and most effective way to keep energy growth under control and address environmental concerns. Indeed, China has taken considerable efforts to control the growth of its demand for energy.

Given that industry accounts for about 70 percent of the country's total energy consumption (Zhang, 2003), this sector is crucial for China to meet its own set goal. So the Chinese government has taken great efforts towards changing the current energy-inefficient and environmentally-unfriendly pattern of industrial growth. To that end, China is exploring industrial policies to encourage technical progress, strengthen pollution control, and to promote industrial upgrading and energy conservation. On the specific energy-saving front, China established the "Top 1000 Enterprises Energy

Conservation Action Program" in April 2006. This program covered 1008 enterprises in nine key energy supply and consuming industrial subsectors. These enterprises each consumed at least 0.18 million tons of coal equivalent (tce) in 2004, and all together consumed 47 percent of industrial energy consumption in 2004. The program aims to save 100 million tce cumulatively during the period 2006–10 (NDRC, 2006).
While there are areas that need further improvements, this program goes very much as planned as far as the energy-saving goal is concerned. In September 2011, NDRC reported that the Top-1000 Program had estimated to achieve total energy savings of 150 million tce during the 11th five-year plan period (NDRC, 2011c).

To help to meet the goals of energy-saving and carbon intensity reduction for the 12th five-year plan, NDRC and eleven other central government organizations (2011) in December 2011 announced the expansion of the Top-1000 Program to the 10,000 Program. This enlarged program covered about 17,000 enterprises. These enterprises include those industrial and transportation enterprises consuming energy of 0.10 million tce or more and other entities consuming energy of 0.05 million tce in 2010. Altogether these enterprises consumed at least 60percent of the national total in 2010. The program aims to save 250 million tce cumulatively during the period 2011–15 (NDRC, 2012).

For power generation, coal-fired power plants dominate total electricity generation in China, accounting for about 75 percent of total capacity and more than 80 percent of total power generation. China's total installed capacity of coal-fired power plants is more than the current total of the US, the United Kingdom and India combined. As the largest coal consumer, power and heat generation is consuming over half of the total coal use. This share is expected to rise to well above 60 percent in 2020, given the rapid development of coal-fired power generation. Thus, efficient coal combustion and power generation is of paramount importance to China's endeavor of energy-saving and pollution-cutting. To that end, China has adopted the policy of accelerating the closure of thousands of small, inefficient coal- and oil-fired power plants. The total combined capacity that needs to be decommissioned is set at 50 gigawatts (GW) during the period 2006–10.

In addition to mandatory closures at many small power plants, NDRC instituted a series of incentives for small, less-efficient power plants to shut down. Feed-in tariffs for small plants were lowered, power companies were given the option to build new capacity to replace retired capacity, and plants designated for closure were given electricity generation quotas which could be used to continue operation for a limited time or sold to larger plants (Williams and Kahrl, 2008; Schreifels et al., 2012). These incentive-based policies helped the government surpass the goal of closing 50 GW of small thermal power plants. By the end of the first half year of 2009, the total capacity of decommissioned smaller and older units amounted to 54 GW, having met the 2010 target one and half years ahead of schedule (Wang and Ye, 2009). By the end of 2010, the total capacity of decommissioned smaller and older unites had increased to 76.8 GW (*China News Net*, 2011), almost ten times the total capacity decommissioned during the period 2001–05.

The Chinese government's policy has concurrently focused on encouraging the construction of larger, more efficient and cleaner units. By the end of 2010, 72.7 percent of fossil fuel-fired units comprised units with the capacities of 300 MW and more, relative to 42.7 percent in 2000 (Zhu, 2010; CEC, 2011). The combined effect of shutting down small, less-efficient power plants and building larger, more-efficient plants led the average coal consumed per unit of electricity generated to decline by 12.8 percent by 2012 relative to its 2005 levels (CEC, 2011; CEC and EDF, 2012).

Due to higher thermal efficiency and relatively low unit investment costs, China's power industry has listed supercritical (SC) power generation technology as a key development focus. To date, this generation technology is the only advanced, well established and commercialized clean power generation technology in the world. As a result, an increasing number of newly built plants are more efficient supercritical or ultra-supercritical (USC) plants. With cost comparative advantages over other cleaner coal technologies, such as integrated gasification combined cycle and polygeneration technologies, SC and USC technologies will be developed and deployed in China.

With China dependent on coal to meet the bulk of its energy needs over the next decades, the commercialization and widespread deployment of carbon capture and storage technology is a crucial option for reducing both China's and global CO_2 emissions when meeting the country's energy needs. As a critical first step, IEA (2009b) recommends 20 large-scale CCS demonstration projects by 2020. This is of strategic importance to establishing CCS as a viable major carbon mitigation option. To that end, cooperation among countries will reduce both the costs and risks of CCS research and demonstration projects. To take advantage of the high level of manufacturing and low costs of manufacturing, labor and other factors in China, the US, the EU, Japan and other key players should cooperate with China in such a way to build more joint demonstration CCS projects in China based on their currently proven technologies to achieve economies of scale enough to bring down the cost. In the meantime, these countries should initiate a major new initiative to jointly develop more advanced and innovative CCS technologies with shared intellectual property rights. Until CCS projects are developed to the point of achieving economies of scale and bringing down the costs, China will not feel confident about committing to absolute greenhouse gas emissions caps. Given current trends, it is unlikely that this technology will find large-scale application either in China or elsewhere before 2030. This is one of the six reasons why expecting China to cap its greenhouse gas emissions well before 2030 is unlikely (Zhang, 2011b,c).

For residential buildings, China has tightened building efficiency standards over time. In 1986, the Chinese government issued the energy-saving design standard for heating in new residential buildings, requiring a 30 percent cut in energy use relative to typical Chinese residential buildings designed in 1980–81. This standard was revised in December 1995, requiring that new buildings be 50 percent more efficient by 2010 and 65 percent by 2020 (Zhang, 2008). In recent years, China has been enforcing the energy efficiency design standard more strictly, requiring that in the very cold area and cold area all new buildings in large and middle cities before 2001, in small cities before 2003 and nationwide since 2006 onwards comply with the energy efficiency standard of 50 percent (MOHURD, 2002, 2005). In northern and coastal developed areas, and in large cities, all the newly built buildings should meet the requirements of 65 percent local building energy efficiency standard (MOHURD, 2005).

In the transport sector, the excise tax for vehicles has been adjusted over time to incentivize the purchases of energy-efficient cars. The excise tax levied at the time of purchase was first introduced in 1994 when China reformed its taxing system, and the rate increases with the size of engines, set at 3 percent for cars with engines of 1.0 liter or less, 8 percent for cars with engines of more than 4 liters, and 5 percent for cars with engines in between. To further rein in the production and use of gas-guzzler cars and promote the production and use of energy-efficient small cars, from September 1, 2008, the rate for small cars with engines of 1.0 liter or less further decreased to 1 percent, whereas the rate for cars with engines of no less than 3 liters but no larger than 4 liters was set at 25 percent. Cars with engines of larger than 4 liters were taxed at the highest rate of 40 percent (Zhang, 2010a). China has set even more stringent fuel economy standards for its rapidly growing passenger vehicle fleet than those in Australia, Canada, California and the US, although they are less stringent than those in Japan and the EU. In the meantime, expanding Chinese cities are prioritizing public transport and are promoting efficient public transport systems (Zhang, 2010a).

3. Nuclear power

The expansion of nuclear power is inevitable in China to cope with its daunting energy security and environmental challenges. China has established a very ambitious plan for the development of nuclear power, and leads the world in the construction of nuclear power plants (CEC, 2011; Li, 2011; World Nuclear Association, 2011). The Fukushima accident will have no effect on China's stance on nuclear power, but will slightly affect the pace of its development. The likely target of 60-70 GW by 2020, instead of the more ambitious one of 86 GW planned prior to the Fukushima Daiichi nuclear power plant accident, still sets a pace that is unprecedented elsewhere. This, combined with great need for standardization of design, operational safety and ease of maintenance, suggests that China should give a careful consideration to the suitability of a foreign nuclear power technology for use in the country and avoid importing multiple examples of similar foreign nuclear technologies as China is currently doing. That will enhance China's ability to assimilate any particular nuclear technology, reduce the high cost and see it through to widespread deployment. This is the lesson that China should learn from importing coal gasification technologies from abroad. Chinese companies have imported more than twenty variants of such technologies. This has impaired China's ability to assimilate any particular technology (IEA, 2009a).

Moreover, given that nuclear power capacity is expected to increase significantly, securing the supply of uranium resources is seen crucial for achieving its upward revised nuclear goal. China needs to enhance cooperation with uranium-rich countries and establish its strategic reserves for uranium resources. Processing and storing nuclear wastes will become an issue as well. Thus, China also requires making parallel progress in the area of processing and storing nuclear wastes to match the significantly scaled-up development of nuclear power.

Furthermore, the Fukushima accident has raised safety concerns to an unprecedented level. No doubt, more advanced reactor designs and improved operation standards help to reduce the likelihood of risks for serious accidents. However, as the nuclear power construction program scales up, the probability of something going wrong increases. As illustrated in the radioactive leak, which occurred at the Daya Bay plant on May 23, 2010, an increased transparency and better communication to the public is of paramount importance for China to ensure the safe development of nuclear power. In a national business culture where quality and safety sometimes take a back seat, China particularly needs to keep a close eye on nuclear safeguards to ensure construction quality and operation safety of nuclear power plants. This will have a bearing on the public acceptance. The public acceptance exacerbates the already serious concerns about reactor safety, radioactive waste management and disposal, and the potential proliferation of nuclear weapons as well as the siting of related fuel cycle facilities in the US, Japan and the EU, even prior to the Fukushima accident. While such concerns and opposition are not publically expressed in China, this situation may change in the future as the development of nuclear power accelerates there.

4. The use of renewable energy

China has targeted alternative energy sources to meet 15 percent of its energy requirements by 2020. The Chinese government has also identified the development of the renewable energy industry as one of the seven strategic emerging industries.

On the specific front, China launched the so-called “Golden Sun” program to boost the solar sector. Through this program, the Chinese government will subsidize 50 percent of investment costs for more than 500 MW of solar power capacity up to 2011, with a maximum subsidy rate of 70 percent for independent solar power projects in remote areas. After years of simply taking advantage of overseas orders to drive down the cost of manufacturing solar panels, NDRC (2011a) enacted feed-in tariffs for solar power in July 2011 to form its own solar power market. As a result, project developers can sell electricity generated from solar power to utilities at the tariffs of RMB 1 per kilo-hour from August 1, 2011. With this first nationwide feed-in tariffs scheme for solar power, the government plans to have 50 GW of solar power by 2020 from 3 GW in 2011 (Guo, 2012; The State Council, 2012). To be more effective and to work to the full potential, the feed-in tariffs should be differentiated across regions according to the quality of solar energy resources and the conditions of engineering construction. With the economically exploitable hydropower potential estimated at 400 GW, the largest in the world, China has sped up the development of hydropower in recent years, planning to have the total capacity installed of 300 GW (including 75 GW small hydropower) in 2020 (NDRC, 2007). This target amounts to three-quarters of its economically exploitable potential. If the target is fulfilled, the economically exploitable potential of hydropower with favorable exploitation conditions will be fully developed by 2020 in China. Even so, China is still several percentage points away from its commitment to have alternative energy sources to meet 15 percent of its energy requirements by 2020.

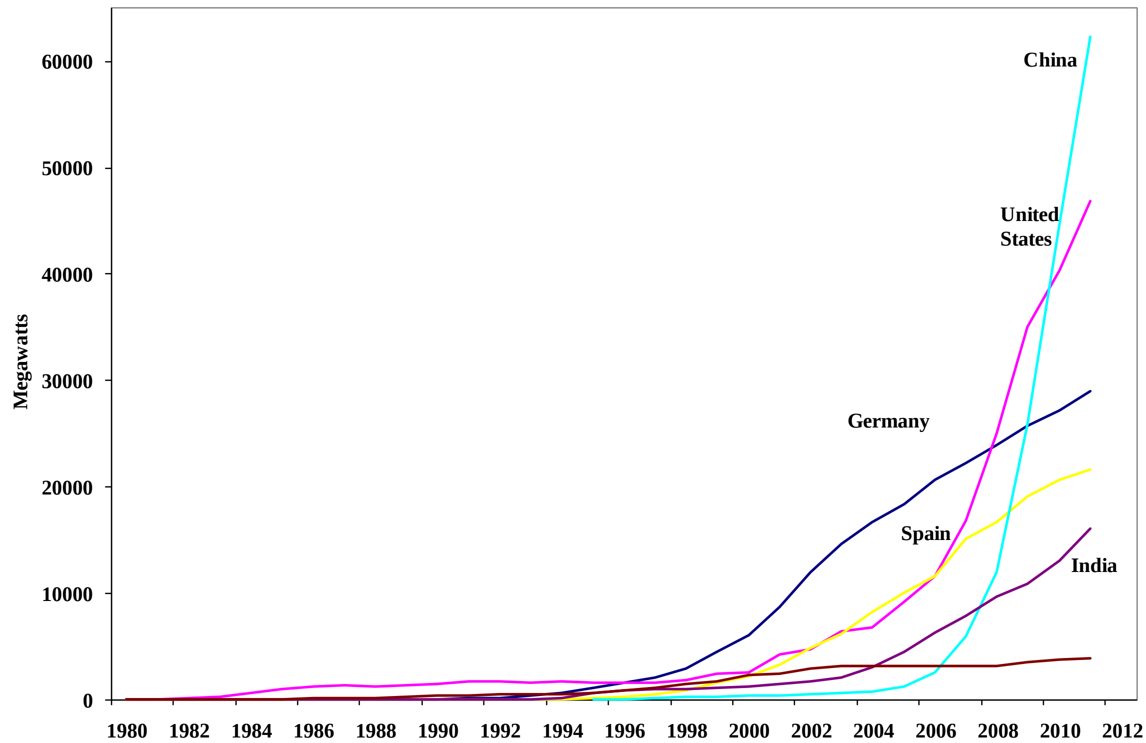

Figure 1 Cumulative installed wind power capacity by country, 1980–2011
Sources: drawn based on data from Global Wind Energy Council (2010 and 2012) and Earth Policy Institute (2008).

To fill this gap, China aims to increase its total installed capacity of wind power to 200 GW by 2020 (The State Council, 2012), almost seven times the 30 GW target as set as late as September 2007. In company with this, NDRC enacted feed-in tariffs for wind power, which took effect on August 1, 2009. According to the quality of wind energy resources and the conditions of engineering construction, four wind energy areas are classified throughout China, and on-grid tariffs are set accordingly as benchmarks for wind power projects across the nation, respectively (NDRC, 2009a). By letting investors know the expected rate of return on their projects through announcing on-grid tariffs upfront, the Chinese government aims to encourage the development of wind energy resources of good quality, thus supporting the development of wind power in proper order, thus promoting the healthy development of the whole wind industry in China. Moreover, given the significantly scaled-up wind power capacity planned for 2020, China should now place more emphasis on companies ensuring the actual flow of power to the grid rather than just meeting capacity. In this regard, improving the quality of increasingly used, domestically made turbines is seen as crucial for this endeavor (Zhang, 2010a and 2011b). While being less costly, domestic wind turbines in China breakdown more often, even collapse in the worst cases (China Environment News, 2010) and have overall capacity factors of several percentage points lower than foreign models. These few percentage points difference might not seem significant, but could well make a difference between a wind farm that is economically viable and one that is not.

5. Economic policies and engagement of the private sector

Having the right economic policies is crucial because it sends clear signals to these energy consumers, helping polluting enterprises to be held accountable for their environmental behavior as well as their profits and costs. Given the widespread use of fossil fuel subsidies in developing Asian region, removing these subsidies is essential to provide incentives for efficient fuel use and adoption of clean technologies that reduce emissions at sources. By definition, a subsidy lowers the cost of production, increases the price received by producers or lowers the price paid by consumers. By lowering the prices of fossil fuels, such fossil fuel subsidies not only are widely considered to distort international trade, but also increase the amount of such fuels consumed and thus the amount of harmful emissions (Zhang and Assunção, 2004). China, Indonesia and Malaysia are among the developing Asian countries that have since 2005 raised domestic energy prices to bring them more into line with international prices. This has led to a sharp fall in overall energy subsidies in these countries despite rising international prices. For example, China cut its total energy subsidies to around US$ 11 billion in 2006. This corresponds to a reduction of 58 percent compared to its 2005 level of around US$ 26 billion (IEA, 2006 and 2007). China has since raised its producer prices of gasoline and diesel several times. On June 1, 2010, China increased domestic producer price of natural gas by 25 percent (Wan, 2010). Since July 1, 2012 China has implemented tier-tariffs for household electricity use. The levels of such tier-tariffs are differentiated across provinces, and are set significantly higher for non-basic electricity use. Despite these long-awaited actions, removing such subsidies is but a first step in getting the energy prices right. Further steps to be taken include incorporating the costs of resources themselves to reflect their scarcity and internalizing the costs of externalities.

5.1 Market-based instruments

Market-based instruments, such as pollution charges, green taxes, tradeable permits, and penalties for the infringement of environmental regulations, are common ways to internalize externality costs into the market prices. With one-third of China's territory widely reported to be affected by acid rain, China has since 1996 started levying the charges for SO_2 emissions in the so-called Two Control Zones based on the total quantity of emissions and at the rate of 0.20 RMB per kilo of pollution equivalent (Yu, 2006). Since July 1, 2003, this charge was applied nationwide and the level of this charge was raised step by step. From July 1, 2005 onwards, the charge was applied at the level of 0.60 RMB per kilo of pollution equivalent. The pollutants that are subject to pollution charges are broadened to include NOx as well, which is charged at the rate of 0.60 RMB per kilo of pollution equivalent since July 1, 2004 (SDPC et al., 2003). To help to meet the energy saving and environmental control goals set for the 11th five-year economic plan, the Chinese government planned three steps to double the charges for SO_2 emissions from the existing level to 1.2 RMB per kilo of pollutant equivalent within the next three years (The State Council, 2007). Local governments are allowed to raise pollution charges above the national levels. Jiangsu province raised charges for SO_2 emissions from the existing level of 0.6 to 1.2 RMB per kilo of pollution equivalent from July 1, 2007 onwards, three years ahead of the national schedule (Sina Net, 2007). China's Ministry of Finance, the State Administration of Taxation and the MEP have proposed levying environmental taxes to replace current charges for SO_2 emissions and COD. This proposal is subject to the approval of the State Council. While their exact implementation date has not been set yet, it is generally expected to be introduced during the 12th five-year plan period. As experienced in environmental taxes in other countries (Zhang and Baranzini, 2004), such taxes will initially be levied with low rates and limited scope, but their levels will increase over time. Once implemented, the long-awaited environmental taxes will have far-reaching effects on technology upgrading, industrial restructuring and sustainable development in China.

To shut down inefficient and highly polluting plants, NDRC ordered provincial governments to implement the differentiated tariffs that charge more for companies classified as 'eliminated types' or 'restrained types' in eight energy-guzzling industries from October 1, 2006 onwards. While provinces like Shanxi charged even higher differentiated tariffs than the required levels by the central government (Zhang et al., 2011), some provinces and regions have been offering preferential power tariffs to struggling, local energy-intensive industries. The reason for this repeated violation is the lack of incentive for local governments to implement this policy, because all the revenue collected from these additional charges went to the central government. To provide incentives for local governments, this revenue should be assigned to local governments in the first place, but the central government requires local governments to use the revenue specifically for industrial upgrading, energy saving and emissions cutting (Zhang, 2007b, 2010). In the recognition of this flaw, the policy was adjusted in 2007 to allow local provincial authorities to retain revenue collected through the differentiated tariffs (Zhou et al, 2010).

To avoid wasteful extraction and use of resources while alleviating the financial burden of local governments, China needs to reform its current coverage of resource taxation and to significantly increase the levied level. In 1984, China started levying resource taxes for coal and oil. While the prices of coal and oil have since significantly increased, the levels of their resource taxes have remained unchanged over the past 25 years (Zhang, 2011b). As a result, the resource taxes raised amounted to only RMB 33.8 billion, accounting for about 0.57 percent of China’s total tax revenues and about 17.5 percent of the national government expenditure for environmental protection in 2009 (NBS, 2010). Therefore, to avoid wasteful extraction and use of resources while alleviating the financial burden of local governments, the way of levying taxes on resources in China should be changed. Such taxation should be levied based on revenues. In addition, current resource taxes are only levied on seven types of resources including coal, oil and natural gas. This coverage is too narrow, falling far short of the purposes of both preserving resources and protecting the environment. Thus, overhauling resource taxes also includes broadening their coverage so that more resources will be subject to resource taxation.

The Chinese central government started a pilot reform on resource taxation in Xinjiang since June 1, 2010. It is estimated that the new resource tax levied at a rate of 5 percent will generate additional annual revenues of RMB 4–5 billion for Xinjiang (Dai, 2010). This is a significant increase, in comparison with the total resource tax revenues of RMB 1.23 billion in 2009, inclusive of those from other resources than crude oil and natural gas (NBS, 2010). This will contribute to 17–21 percent of the total tax revenues for Xinjiang, in comparison with the contribution level of about 4.1 percent in 2009.

China has been experimenting with SO_2 emissions trading in Hubei, Hunan, Jiangsu, and Zhejiang provinces and Tianjin metropolitan city. Zhejiang province has implemented provincial wide trial SO_2 emissions quotas that can be purchased and traded since 2009. It as well as Jiangsu is experimenting with trading COD permits in Taihu Basin. In its Jinxing city, 890 enterprises were reported to participate in the paid use and trade of pollution quotas by mid-November 2009, representing rising trends of both volumes and prices of quotas transacted (CAEP, 2009). Even in Shanxi province, China’s coal and power base, power-generating plants sold SO_2 emissions quotas to the State Grid. The tradeable permits scheme thus entered the essentially operational stage in the province after years of preparation. China is experimenting with low-carbon provinces and low-carbon cities in five provinces and eight cities. Aligned with such an experiment, pilot carbon trading schemes are expected to be established in 2013. Based on these piloted schemes, China aims to establish a national carbon trading scheme by 2016.

However, these economic instruments do not work to their full potential, because the charges and fines are often set too low. The average charge for urban sewage treatment was reported to be RMB 0.7 per ton for 36 large and medium cities in China by the end of 2008, whereas the corresponding treatment cost is RMB 1.1 per ton (NDRC, 2009b; CAEP, 2009). Even for the aforementioned case of Jiangsu province, where the charges for SO_2 emissions at 1.2 RMB per kilo of pollution equivalent were levied from July 1, 2007 onwards, three years ahead of China's national schedule, this charge is still less than half of the real abatement cost, which is reported to be 3 RMB per kilo of pollution equivalent for abating SO_2 emissions from coal-fired power plants (Sina Net, 2007a). As a result, many polluting companies see their compliance costs higher than the fines, and accordingly choose to pay the fines rather than to reduce their pollution. To change this situation, pollution charges should be raised to reflect the cost of abating pollution, and the fines for offenders should be set higher than the abatement cost.

5.2 Supportive economic policies

The central government is also providing supportive economic policies to encourage technical progress and strengthen pollution control to meet the energy-saving and environmental control goals. To support the Ten Energy-saving Projects, China's Ministry of Finance and the NDRC (2007) award enterprises in East China RMB 200, and enterprises in the Central and Western part of the country RMB 250 for every tce saved per year since August 2007. Such payments are made to enterprises that have energy metering and measuring systems in place that can document proved energy savings of at least 10000 tce from energy-saving technical transformation projects. China also introducing energy management companies (EMC) to promote energy saving. China had only three EMCs in 1998 (*China News Net*, 2008). This number increased to over 80 by 2005 and further increased to over 800 in 2010 (NDRC, 2011b). NDRC and the Ministry of Finance of China award EMC RMB 240 for every tce saved, with another compensation of no less than RMB 60 for every tce saved from local governments (The State Council, 2010). As a result of an increasing number of EMC and award policy, the total annual energy saving by EMCs increased to 13 million tce in 2010 from 0.6 million tce in 2005 (NDRC, 2011b).

With burning coal contributing 90 percent of the national total SO_2 emissions and coal-fired power generation accounting for half of the national total, the Chinese central government has mandated that new coal-fired units must be synchronously equipped with a flue gas desulphurization (FGD) facility and that plants built after 1997 must have begun to be retrofitted with a FGD facility before 2010. And, policies favorable to FGD-equipped power plants are being implemented, e.g., the on-grid tariff incorporating desulphurization cost, priority given to be connected to grids, and being allowed to operate longer than those plants that do not install desulphurization capacity. Some provincial governments provide even more favorable policies, leading to priority dispatching of power from units with FGD in Shandong and Shanxi provinces. Moreover, the capital cost of FGD has fallen from 800 RMB/kW in the 1990s to the level of about 200 RMB/kW (Yu, 2006), thus making it less costly to install FGD facility. As a result, newly installed desulphurization capacity in 2006 was greater than the combined total over the past 10 years, accounting for 30 percent of the total installed thermal (mostly coal-fired) capacity. By 2011, the coal-fired units installed with FGD increased to 630 GW from 53 GW in 2005. Accordingly, the portion of coal-fired units with FGD rose to 90 percent in 2011 of the total installed thermal capacity from 13.5 percent in 2005 (Sina Net, 2009; CEC and EDF, 2012). As a result, by the end of 2009, China had reduced its SO_2 emissions by 13.14 percent relative to its 2005 levels (Xinhua Net, 2010), having met the 2010 target of a 10 percent cut one year ahead of schedule.

5.3 Industrial policies

In addition to supportive economic policies and market-based environmental instruments, governments are exploring industrial policies to promote industrial upgrading and energy conservation. With the surge in energy use in heavy industry, China's Ministry of Finance and the State Administration of Taxation started levying export taxes from November 2006 on a variety of energy and resource intensive products to discourage exports of those products that rely heavily on energy and resources. From July 1, 2007, China's Ministry of Finance and the State Administration of Taxation (2007) eliminated or cut export tax rebates for 2831 exported items. This is considered as the boldest move to rein in exports since China joined the World Trade Organization. Among the affected items, which account for 37 percent of all traded products, are 553 "highly energy-consuming, highly-polluting and resource-intensive products", such as cement, fertilizer and non-ferrous metals, whose export tax rebates were completely eliminated. From the point of view of leveling the carbon cost playing field, such export taxes increase the price at which energy-intensive products made in China, such as steel and aluminum, are traded in world markets. For the EU and U.S. producers, such export taxes imposed by their major trading partner on these products take out at least part, if not all, of the competitive pressure that is at the heart of the carbon leakage debates. Being converted into the implicit carbon costs, the estimated levels of CO_2 price embedded in the Chinese export taxes on steel and aluminium are very much in the same range as the average price of the EU allowances over the same period. Zhang (2009 and 2010b) have argued that there is a clear need within a climate regime to define comparable efforts towards climate mitigation and adaptation to discipline the use of unilateral trade measures at the international level. As exemplified by export tariffs that China applied on its own during 2006-08, defining the comparability of climate efforts can be to China's advantage (Zhang, 2010b).

China's Ministry of Commerce and the SEPA (2007) in October 2007 were in an unusual collaboration to jointly issue the antipollution circular. Targeted at its booming export industry, this new regulation would suspend the rights of those enterprises that do not meet their environmental obligations to engage in foreign trade for the period of more than one year and less than three years. A significant portion of China's air pollution can be traced directly to the production of goods that are exported. In the city of Shenzhen alone, the regional leader in industrial development and trade in the Pearl River delta, Streets et al. (2006) found that 75 percent of VOCs, 71 percent of PM, 91 percent of NO_x, and 89 percent of SO_2 emissions from the industrial sector were released through the manufacture of exported goods.

5.4 Environmental performance ratings and disclosure

The central government is also exploring other ways to enhance the efficacy of environmental monitoring and compliance. Naming and shaming polluters is one vehicle. In April 2010, China's MEP for the first time unveiled offending polluters and blacklisted state-owned enterprises. Out of 7,043 major polluting enterprises under the national environmental monitoring system, about 40 percent were found to have discharged substandard waste water or exhaust emissions in 2009. The offending polluters included the state-owned China Power Investment Corp, China Huaneng Group and China Guodian Corp, the three major national power-generating groups. This fact will help change the general public's perception that it is the small, private enterprises that are the country's main sources of pollution. The listing of some sewage treatment plants was another remarkable sign in the report as 47 percent of 1,587 monitored waste water facilities were found guilty of substandard discharges (Deng, 2010).

Governments can go beyond simple naming and shaming polluters by implementing environmental performance ratings and disclosure (PRD). The PRD relies on non-regulatory forces to create incentives for (mainly industrial) facilities to improve environmental performance. Such programs will motivate polluters to reduce emissions, even in developing countries where regulatory infrastructures are insufficiently developed or even absent or are subject to corruption, but where enough information can be reliably obtained to provide credible performance ratings (Dasgupta et al., 2006; World Bank, 2000). Modeled on Indonesia's successful Program for Pollution Control, Evaluation and Rating (PROPER), China introduced the Green Watch program in Zhengjiang, a relatively well-off city in Jiangsu province in June 1999, and Hohhot city, Inner Mongolia. This program developed color-coded systems to rate corporate environmental performance. The first Green Watch ratings were disclosed through the media in 1999. The program was extended from Zhenjiang city to all of Jiangsu province in 2001, and to eight other provinces in China during 2003-05. Nationwide implementation of the Green Watch program has been promoted since 2005. The companies under the Green Watch programs have dramatically changed their corporate environmental behavior. The Green Watch program in Jiangsu province indicates both increasing participation by firms and improvement in their compliance rates, with the number of rated firms increasing more than tenfold, from 1,059 in 2001 to 11,215 in 2006; and the percentage of firms with positive ratings (green, blue, and yellow) increasing from 83 percent in 2001 to 90 percent in 2006. Moreover, the Jiangsu case suggests that Green Watch ratings have stronger effects on firms with red ratings (moderate noncompliance) than those with black ratings (extreme noncompliance) (Legislative Affairs Office of the State Council, 2007; Jin et al., 2010).

5.5 Cooperation with financial institutions

The support of financial institutions is another avenue to promote improved corporate environmental performance. From April 1, 2007, China's SEPA has worked with the People's Bank of China on a new credit-evaluation system under which companies' environmental compliance records are incorporated into the bank's credit-evaluation system. This information will serve as a reference for commercial banks' consideration of whether or not to provide loans. The bank could turn down requests for loans from firms with poor environmental records (Zhang, 2007a). In mid-July 2007, SEPA announced the "green credit" policy jointly with the People's Bank of China and China Banking Regulation Commission. They will work together to enforce it, with the financial bodies denying loans to firms that SEPA identifies as failing to meet environmental standards. SEPA later posted on its web site and notified China's central bank and top banking regulatory commission of 30 offending companies that will be barred from receiving credits (Xinhua Net, 2007). Some bank branches go further. Jiangyin Branch of the

People's Bank of China in Jiangsu province issued the color-coded lending guidance, favoring those companies with superior environmental performance. For those green-rated companies, banks will enhance their lending scale and give priority to their financial needs. By contrast, the lending scale for those red-rated ones at best remains at its current level unless lending is requested for environment-improving equipments and technical transformation. Particularly strict lending conditions are attached to those black-rated companies. They cannot receive any new borrowing, and if they still fail to comply with the environmental regulations within a given period, banks will cut their borrowing and in the worst case can even ask them to return all their previous loans (Legislative Affairs Office of the State Council, 2007). Clearly, this concerted action by the central bank and SEPA is expected not only to reduce the risks borne by commercial banks, but also to encourage companies to think more about the environmental effect of their operation and self-discipline their environmental behavior. Aided by the International Finance Corporation, the finance arm of the World Bank Group, China is experimenting with the green credit policy in the steel industry in Sichuan province (CAEP, 2009). In August 2007, SEPA (2007b) also clearly stipulated that highly polluting enterprises are subject to auditing of their environmental records in case these enterprises want to list shares in the Chinese stock markets or get re-financed. China Securities Regulation Commission will incorporate information on their environmental auditing into its decision on whether or not to allow these enterprises to be listed or get refinanced. Moreover, investors in capital markets can be an important ally, reacting to the disclosure of environmental performance related to the companies that they invest in. The Shanghai Stock Exchange has disclosed environmental information since late 2009, in line with the rulesof the exchange to disclose corporate information (Ban, 2008). The reports from companies like PetroChina and Sinopec for example are still incomplete, because they have just released discharge data, but have not mentioned their records of violations and the subsequent penalties (Chung, 2010). With the so-called H-shares from companies incorporated in Mainland China traded on the Hong Kong Exchanges and Clearing, the Hong Kong exchange could amend its listing rules to require all those listed companies to disclose environmental information.

6. Implementation/compliance/reliability issues

6. 1 Implementation/compliance holds the key

To actually achieve the desired outcomes, however, requires strict implementation and coordination of these policies and measures. It has been stipulated that leaders of local governments and heads of key state-owned enterprises are held accountable for energy saving and pollution cutting in their regions, and that achieving the goals of energy efficiency improvements and pollution reductions has become a key component of their job performance evaluations. But no senior officials have ever been reported to take the responsibility for failing to meet the energy-saving and pollution-cutting targets to date, not to mention having been asked to step down from their positions on these grounds.

Another example is the enforcement of FGD operation to ensure that those generation units with FGD facility always use it. The government offered a 0.015 RMB/kWh premium for electricity generated by power plants with FGD facility installed to encourage the installation and operation of FGD facility at large coal-fired power plants. The premium was equivalent to the average estimated cost of operating the technology. However, this price premium was provided for FGD-equipped power plants regardless of FGD performance. This created an incentive for power plants to install low-cost, poor-quality FGDs in order to obtain the price premium, but not to operate the FGD (Schreifels et al., 2012). When NDRC conducted field inspections in July 2006, it found that "up to 40 percent of those generation units with FGD facility did not use it" (Liu, 2006). Given that FGD costs are estimated to account for about 10 percent of the power generation cost, combined with lack of trained staff in operating and maintaining the installed FGD facility and lack of government enforcement, this should not come as a surprise, unless there is adequate enforcement. Even if the installed FGD facilities were running, they do not run continuously and reliably. MEP field inspections in early 2007 found that less than 40 percent of the installed FGD were running continuously and reliably (Xu et al., 2009). With the portion of coal-fired generation capacity with FGD increasing, the government desulphurization policy should thus switch from mandating the installation of FGD to focusing on enforcing units with FGD to operate through on-line monitoring and control.

Clearly, implementation holds the key. This will be a decisive factor in determining the prospects for whether China will clean up its development act. There are encouraging signs that the Chinese government is taking steps in this direction. For example, given that the aforementioned price premium for FGD-equipped power plants was based on the installation of FGD facility, not its operation or performance. When requiring continuous emission monitoring systems (CEMS) at coal-fired power plants in May 2007, NDRC and MEP modified the price premium to address FGD performance, basing the electricity price premium on FGD operation and performance. The revised policy continued to provide a price premium of 0.015 RMB/kWh for power plants operating FGDs, but a penalty of 0.015 RMB/kWh is imposed for plants operating FGDs between 80 percent and 90 percent of total generation, and a penalty of 0.075 RMB/kWh for plants operating FGDs less than 80 percent of the time. Regardless of the duration of FGD operation, all plants were ordered to return the compensation for their desulphurization costs in proportion to the time when their FGD facilities were not in operation (NDRC and MEP, 2007; Xu, 2011). In its 2008 assessment of the total volume reduction of major pollutants, MEP found that FGD facilities of five coal-fired power plants were either in improper operation or their on-line monitoring and control data were false. These plants were ordered to return the compensation for their desulphurization costs in proportion to the time when their FGD facilities were not in operation and to make necessary adjustments in the specified period (K. Zhang, 2009).

The efficacy of basing policies on performance, not process suggests that the accuracy of SO_2 data is critical. Nowadays emission reports are verified by the central government. Prior to that, it was undertaken by the local environmental protection bureaus (EPBs), as MEP and NDRC mandated the installation of CEMS and the transfer of real-time data to EPBs in May 2007. This had led to nationwide underreporting of emission levels. While in the 11th Five-year Plan, MEP and EPBs collected SO_2 data from CEMS at most power plants, data quality concerns limited the use of the data (Zhang et al., 2011 and Zhang and Schreifels, 2011). To ensure the reliability of emission data, MEP instituted an inspection program for provinces, fuel suppliers, and major emitters. Based on the analyses of MEP inspectors, MEP rejected 30-50 percent of SO_2 reductions claimed by some provinces. This inspection system raised the level of accountability for plant owners and operators, but MEP's investment in the inspections in terms of both staff and financial resources was large. Staff at regional supervision centers spent up to 60 percent of their time conducting these inspections (Schreifels et al., 2012).

6. 2 Reliability issues

Take China's commitments to cut its carbon intensity by 40-45 percent by 2020 relative to its 2005 level as a case in point. China is not known for the reliability of its statistics (e.g., Rawski, 2001). As long as China's pledges are in the form of carbon intensity, the reliability of both emissions and GDP data matters.

Assuming the fixed CO_2 emissions coefficients that convert consumption of fossil fuels into CO_2 emissions, the reliability of emissions data depends very much on energy consumption data. Unlike the energy data in the industrial product tables in the *China Statistical Yearbook*, the statistics on primary energy production and consumption are usually revised in the year after their first appearance. The adjustments made to production statistics are far smaller than those made to consumption statistics, because it is easier to collect information on the relatively small number of energy producers than the large number of energy consumers. Figures 1 and 2 show the preliminary and final values for total primary energy consumption and coal consumption in China between 1990 and 2008, measured in million tons of coal equivalent (Mtce). Until 1996 revisions of total energy use figures were several times smaller than in the late 1990s and early 2000s. The preliminary figures for total energy use in 1999-2001 were revised upwards by 8-10 percent (shown in the right y-axis in Figure 2). In all three years, these adjustments were driven by upward revisions of 8-13 percent made to the coal consumption figures (shown in the right y-axis in Figure 3) to reflect the unreported coal production mainly from small, inefficient and highly polluting coal mines. These coal mines were ordered to shut down through a widely-publicized nationwide campaign beginning in 1998, although many had reopened because in many cases local governments had pushed back to preserve local jobs and generate tax revenues as well as personal payoffs. In recent years, preliminary figures for energy use are close to the final reported ones.

Similarly, China first releases its preliminary GDP figures and then revises them. These revised GDP figures for the years 2005-08 are further verified based on the second agricultural census released in February 2008 and the second nationwide economic census released in December 2009. With upward revisions of both GDP and the share of services, there is a big variation between the preliminary value for China's energy intensity and the final reported one. As shown in Table 1, such revisions lead to a differential between preliminary and final values as large as 123 percent for the energy intensity in 2006. With the government's continuing efforts to improve the quality of China's statistics, there is a downward trend of such a differential as a result of the revisions.

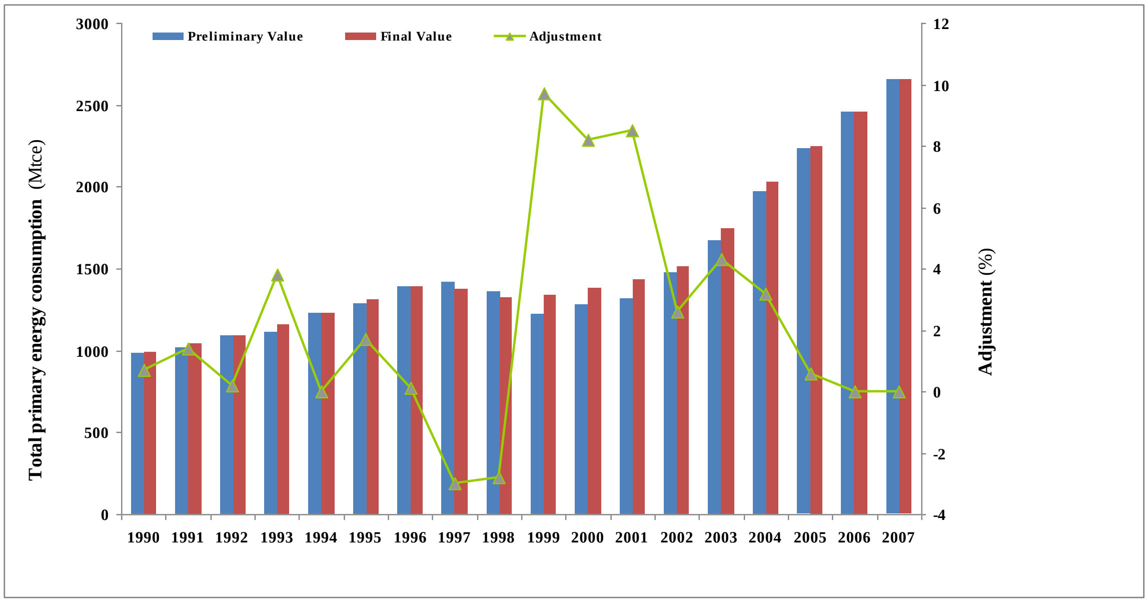

Fig. 2 Preliminary and final values for total primary energy consumption in China, 1990-2008

Source: Drawn based on *China Statistical Yearbook*, various years.

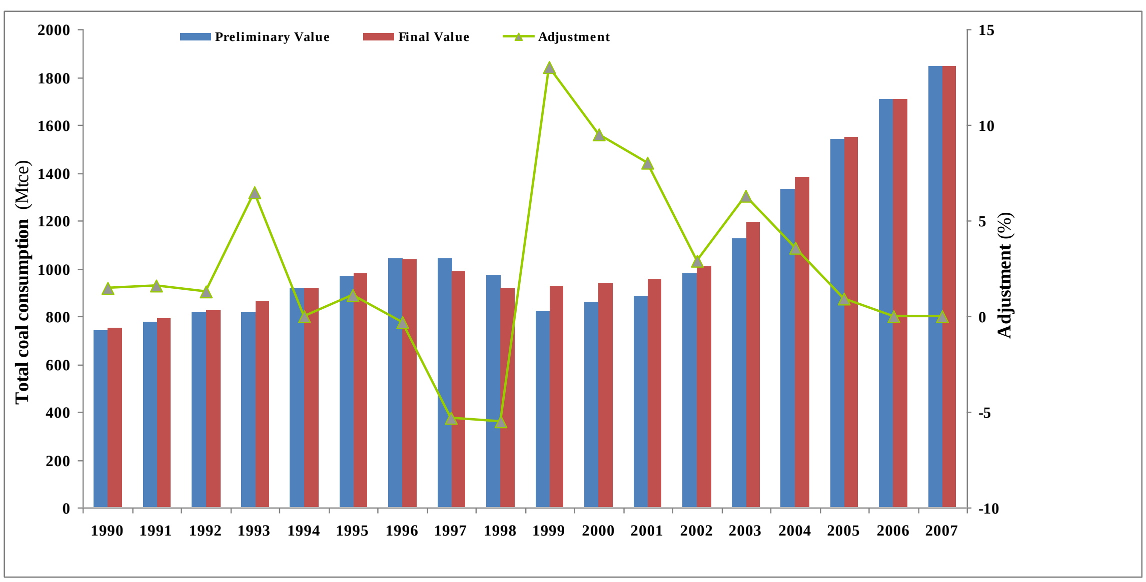

Fig. 3 Preliminary and final values for coal consumption in China, 1990-2008

Source: Drawn based on *China Statistical Yearbook*, various years.

Table 1 A reduction in China's energy intensity: preliminary value versus final value[a]

Year	Preliminary value (%)	Revised value (%)	Re-revised value (%)	Final value (%)	Differential between preliminary and final values (%)
2006	1.23 (March 2007)	1.33 (12 July 2007)	1.79 (14 July 2008)	2.74 (15 July 2010)	**122.8**
2007	3.27 (March 2008)	3.66 (14 July 2008)	4.04 (30 June 2009)	5.04 (15 July 2010)	**54.1**
2008	4.59 (30 June 2009)	5.20 (25 Dec. 2009)		5.20 (15 July 2010)	**13.3**
2009	3.98 (March 2010)	3.23 (15 July 2010)	3.61 (15 July 2010)		

Notes: [a] The dates when the corresponding data were released are in parentheses.
Source: Zhang (2011a).

From the preceding discussion, it follows that GDP figures are even more crucial to the impacts on the energy or carbon intensity than are energy consumption and emissions data. As long as China's commitments are in the form of carbon intensity, establishing a robust and transparent emissions and performance accounting framework is helpful, but not enough to remove international concern about the reliability of China's commitments. The aforementioned revisions of China's GDP figures reflect part of the government's continuing efforts to improve the accuracy and reliability of China's statistics on economic activity. Such revisions have huge implications for meeting China's energy-saving goal in 2010 and its proposed carbon intensity target in 2020.

7. Concluding remarks

China has gradually recognized that the conventional path of encouraging economic growth at the expense of the environment cannot be sustained. It has to be changed. To that end, China has strengthened existing policies and measures towards energy saving and pollution cutting, and the use of clean energy in order to address concerns about a range of environmental stresses and health risks from burning fossil fuels and energy security as a result of steeply rising oil imports, to honor its carbon intensity pledge in 2020 and to drive its future energy use and carbon emissions below the projected baseline levels to the extent possible.

In this course, the country has faced great difficulty ensuring that local governments act in accordance with centrally-directed policies, since the past three decades of economic reforms have witnessed a shift in the control over resources and decision making to local governments. This not only has led China to miss its energy-saving goal in 2010, but also has huge implications for meeting its proposed carbon intensity target in 2020 and whatever climate commitments beyond 2020 that China may make. Clearly, the central government needs to set appropriated incentives to get local governments' cooperation.

One way to ensure that local officials are held accountable for energy saving and pollution cutting in their regions is developing criteria that incorporate energy conservation and environmental performance into the overall evaluation of local officials' performances and applying those criteria consistently to ensure energy saving and pollution cutting are carried out in a rational way to avoid last-minute shutdown operations of factories across the country for meeting the energy-saving goals. Alleviating the financial burden of local governments is another avenue to incentivize them not to focus on economic growth alone. The central government really needs to cultivate steady and sizeable sources of revenues for local governments. Enacting property taxes or real estate taxes for local governments is urgently needed. Broadening the current coverage of resource taxation and significantly increasing the levied level also helps to increase local government's revenues while conserving resources and preserving the environment. The resource tax levied on crude oil and natural gas by revenues rather than by existing extracted volume, which was applied nationwide since November 1, 2011, is the first step in the right direction. However, the current coverage of resource taxes is too narrow, falling far short of the purposes of both preserving resources and protecting the environment. Thus, overhauling resource taxes includes broadening their coverage so that more resources will be subject to resource taxation.

Moreover, China mostly relied on administrative means to achieve its energy-saving goal for 2010. The country has had a limited success in meeting that goal, and continues to face rising energy demand and increasing difficulty in further cutting energy and carbon intensities. It is becoming increasingly crucial for China to harness market forces to reduce its energy consumption and cut carbon and other conventional pollutants. To that end, China is experimenting with low-carbon provinces and low-carbon cities, aiming to establish a national carbon trading scheme by 2016. However, in terms of timing, given that China has not levied environmental taxes yet, it is better to introduce environmental taxes first, not least because such a distinction will enable China to disentangle additional efforts towards carbon abatement from those broad energy-saving and pollution-cutting ones.

Also China needs to significantly scale up its efforts towards strengthening industrial restructuring to keep the frenzied expansion of highly energy-consuming, highly polluting and resource-intensive industries under control, and further transform the industrial structure and the development model towards a more energy-efficient, serviced-oriented economic structure. The decline in real energy intensity was the overwhelming contributor to the decline in China's industrial energy use over the past three decades and is expected to continue to play a major role, but structural change will become a crucial factor to determine whether China will meet its future energy-saving and carbon intensity goals (Zhang, 2003 and 2011b).

The Chinese government has also identified the development of the renewable energy industry as one of the seven strategic emerging industries. Now China aims to increase its total installed capacity of wind power to 200 GW by 2020. However, wind turbines often have to wait few months before they are hooked up to the power grid. Therefore, China needs to significantly improve its power grids and to coordinate the development of wind power with the planning and construction of power grids, including smart grids. New transmission lines will have to be constructed simultaneously as more wind power farms are built.

The expansion of nuclear power is inevitable in China to cope with its daunting energy security and environmental challenges. The Fukushima accident will have no effect on China's stance on nuclear power. However, China should give a careful consideration to the suitability of a foreign nuclear power technology for use and avoid importing multiple examples of similar foreign nuclear technologies. Moreover, securing the supply of uranium resources is seen as crucial for achieving its upward revised nuclear goal. China also requires making parallel progress in the area of processing and storing nuclear wastes to match the significantly scaled-up development of nuclear power. Furthermore, China particularly needs to keep a close eye on nuclear safeguards to ensure construction quality and operation safety of nuclear power plants.

Given continuous coal dominance in China's energy and power generation mix over the next two decades and beyond, China has adopted the policy of accelerating the closure of small, inefficient coal- and oil-fired power plants. Currently, China has set to decommission small, inefficient coal-fired power plants with a unit capacity of 50 MW or less. To benefit energy saving and the environment, China should consider doubling or even quadrupling that unit capacity to 100 MW or 200 MW below which inefficient coal-fired plants need to be decommissioned. The Chinese government's policy has concurrently focused on encouraging the construction of larger, more efficient and cleaner units. In the meantime, the country needs to accelerate the construction of large, more efficient, supercritical or ultra-supercritical coal-fired units. With China dependent on coal to meet the bulk of its energy needs over the next decades, the commercialization and widespread deployment of carbon capture and storage technology is a crucial option for reducing both China's and global CO_2 emissions when meeting the country's energy needs. Until CCS projects are developed to the point of achieving economies of scale and bringing down the costs, China will not feel confident about committing to absolute greenhouse gas emissions caps. Given current trends, it is unlikely that this technology will find large-scale application either in China or elsewhere before 2030. This to some extent indicates that expecting China to cap its greenhouse gas emissions well before 2030 is unlikely.

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