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Programs, Prices and Policies Towards Energy Conservation and Environmental Quality in China

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Abstract
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. This article focuses on China's efforts towards energy conservation and environmental quality. The article discusses a variety of programs, prices, market-based instruments, and other economic and industrial policies and measures targeted for energy saving and pollution cutting, and the associated implementation and reliability issues. The article ends with some concluding remarks and recommendations.

Keywords
Energy saving; Environmental quality; Low-carbon development; Power generation; Energy prices; Market-based instruments; Economic policies; Industrial policies; Resource taxes; Implementation and reliability; China

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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 (Ho and Nielsen, 2007; The World Bank, 2007; CAEP, 2013).

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 has since 2007 been the world's largest carbon emitter and its emissions have continued 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. The country is facing great pressure both inside and outside international climate negotiations to be more ambitious in combating global climate change.

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 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.

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. This is widely considered an important step towards building a 'harmonious society' through 'scientific development'. 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 in order to help reach an international climate change agreement at Copenhagen or beyond, and reaffirmed its plan to have alternative energy sources to meet 15 percent of the nation's energy requirements by 2020.

This article focuses on China's efforts towards energy conservation and environmental quality. The article discusses a variety of programs, prices, market-based instruments, and other economic and industrial policies and measures targeted for energy saving and pollution cutting, and the associated implementation and reliability issues. The article ends with some concluding remarks and recommendations.

2. Major programs and initiatives

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. This section highlights few major programs and initiatives to exemplify China's efforts towards energy conservation and emissions abatement.

2.1 The Top 1000 Enterprises Energy Conservation Action Program

Given that industry accounts for about 70% 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 33% of the national total and 47% of industrial energy consumption in 2004. The program aims to save 100 million tce cumulatively during the period 2006–10, thus making a significant contribution to China's overall goal of 20% energy intensity improvement (NDRC, 2006a).

In May 2006, the National Development and Reform Commission (NDRC), China's top economic planning agency, signed energy-saving responsibility agreements with governments of 31 provinces or their equivalent to allocate the overall energy-saving target of those Top 1000 enterprises to each province or equivalent. These governments in turn signed with those Top 1000 enterprises located in their regions. To ensure that the goal is met, achieving energy efficiency improvements has become a criterion for job performance evaluations of the heads of these enterprises. This will help them realize that they should take their jobs seriously because they have an important part to play in meeting energy-saving goals.

While there are areas that need further improvements (Price et al., 2010), this program goes very much as planned as far as the energy-saving goal is concerned. The first-year's results show that more than 95 percent of these enterprises appointed energy managers, and the program achieved the energy savings of 20 million tce in 2006 (NDRC and NBS, 2007). In 2007, the energy savings of 38.17 million tce were achieved, almost doubling the amount of energy savings in 2006 (NDRC, 2008c). In November 2009, NDRC (2009) reported that the Top-1000 Program had realized energy savings of 106.2 million tce by the end of 2008, two years ahead of schedule to achieve its cumulative goal for the program over the whole five-year period. 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, 2011b).

2.2 The 10,000 Enterprises Energy Conservation Low Carbon Action Program

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 Enterprises Energy Conservation Low Carbon Action Program. This enlarged program covered 16,078 enterprises. These enterprises include those industrial and transportation enterprises consuming energy of 10,000 million tce or more and other entities consuming energy of 5,000 tce in 2010. All together these enterprises consumed at least 60% of the national total in 2010. Shandong province is set to have the highest energy-saving targets of 25.3 million tce while Jiangsu province comes second with an energy-saving target of 22 million tce and has the maximum number of enterprises (1221 enterprises) under the program. The program aims to save 250 million tce cumulatively during the period 2011–15 (NDRC, 2012).

In December 2013, NDRC reported the performance results in 2012 of the 10,000 program. Of 14,542 enterprises examined, 3,760 enterprises exceeded their energy-saving targets, accounting for 25.9%; 7,327 enterprises fulfilled their energy-saving goals, accounting for 50.4%; and 2,078 enterprises basically fulfilled their energy-saving goals, accounting for 14.34%. While 1,377 enterprises, or 9.5% of the program's enterprises, failed to meet their targets, the program had achieved total energy savings of 170 million tce over 2011-12, meeting 69% of the total energy-saving goal during the 12th five-year plan period (NDRC, 2013e).

2.3 Low-carbon city development pilot program

The past three decades of economic reforms have witnessed a shift in the control over resources and decisionmaking to local governments. This devolution of decisionmaking to local governments has placed environmental stewardship in the hands of local officials and polluting enterprises who are more concerned with economic growth and profits than the environment. The ability of, and incentives for, lower-level governments to effectively implement energy-saving and pollution-cutting policies are therefore critical (Zhang, 2011a, 2012). With increasingly stringent energy-saving and carbon intensity goals, China started experimenting with low-carbon city development in the batch of five provinces and eight cities on 19 July 2010. This experiment is further expanded to the second batch of 29 provinces and cities on 5 December 2012 (Wang et al., 2013).

Globally as well as in China, cities have contributed to most of economic output and have accordingly given rise to most of CO_2 emissions. In China, cities are responsible for more than 60% of total energy consumption (CAS, 2009), and their contribution continues to increase given the expected urbanization rate of 65% in 2030 (Li, 2014). Clearly, given unprecedented urbanization, cities will play an even greater role in shaping energy demand and CO_2 emissions. Therefore, cities are the key to meeting China's proposed carbon intensity target in 2020 and whatever climate commitments beyond 2020 that China may take. The low-carbon city development experiment in these10 provinces and 32 cities in the context of government decentralization will serve as the test ground to see whether they can stand up to the challenges.

Wang et al. (2013) indentifies several problems and challenges for China's low-carbon city development, including the absence of sound carbon accounting systems, lack of low-carbon specific evaluation system, insufficient government-enterprise interactions, and excessive budget dependence on land concession. While these are areas that need further improvements, there are encouraging signs that this low-carbon pilot program moves in the right direction. The NDRC evaluation reveals that the ten pilot provinces cut their carbon intensity by 9.2% in 2012 relative to their 2010 level, much higher than the national average carbon intensity reduction of 6.6% (NDRC, 2014). In addition, while it is not mandated by the central government, all these pilot provinces and cities set CO_2 emissions peak in 2030 or early. 15 pilot provinces and cities even aim CO_2 emissions peak in 2020 or early, with Shanghai publicly announcing its peak year in 2020, Suzhou in 2020 and Ningbo in 2015, respectively (E. Wang, 2014). Zhang (2011a,b) argues from six angles that China could cap its greenhouse gas emissions in the year between 2025 and 2032, or around 2030. The practice and ambition of these piloted regions set the good examples of keeping their emissions under control, make the positive contribution to the overall low-carbon development in China, and thus could make China's carbon emissions peak occur even earlier than the aforementioned timeline.

2.4 Mandatory closures of small power plants while building larger, more efficient units

For power generation, coal-fired power plants dominate total electricity generation in China, accounting for about 75% of total capacity and more than 80% 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% 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 2008, China had closed small plants with a total capacity of 34.21 GW, relative to a total capacity of 8.3 GW decommissioned during the period 2001–5 (NDRC, 2008b). By the end of the first half year of 2009, the total capacity of decommissioned smaller and older units had increased to 54 GW, having met the 2010 target of decommissioned 50 GW one and half years ahead of schedule (*Sina Net*, 2009; 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), more than the entire current power capacity of the Great Britain and 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 2012, 75.6% of fossil fuel-fired units comprised units with the capacities of 300 MW and more, relative to 42.7% in 2000 (Zhu, 2010; NDRC, 2013c). The combined effect of shutting down small, less-efficient power plants and building larger, more-efficient plants led the average coal consumed per kWh of electricity generated to decline to 326 gce/kWh by 2012, or a 12.8% reduction relative to its 2005 levels of 374 gce/kWh (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. China now leads the world, having 54 USC plants of unit capacity of 1GW in operation by 2012 (NDRC, 2013c). With cost comparative advantages over other cleaner coal technologies, such as integrated gasification combined cycle (IGCC) and polygeneration technologies, SC and USC technologies will be developed and deployed in China.

3. Energy prices

Before the post-1978 economic reform, China's economic management structure was modeled principally on that of the former Soviet Union, an essential feature of which was the adoption of a united state pricing system. Under this pricing system, the state-set prices of goods, including those of energy, did not reflect neither the production costs nor the influence of market forces. The structure of state-set prices was also irrational: the same type of goods was set at the same prices regardless of their qualities, thus resulting in the underpricing and undersupply of goods of high quality. Over a very long period, this pricing system remained unchanged so that its inflexible and restrictive nature became increasingly apparent. Thus, the outdated pricing system had to be changed.

In 1984, the government required state-owned enterprises (SOEs) to sell up to a predetermined quota at state-set prices but allowed to sell above the quota or surplus at prices within a 20% range above the state-set prices. In February 1985, the 20% limit was removed and prices for surplus could be negotiated freely between buyers and sellers (Wu and Zhao, 1987). At that point, the dual pricing system was formally instituted. Such a pricing system introduced, among others, economic efficiency in the use of resources and was generally considered a positive, cautious step towards a full market price.[1]

Under this dual pricing system, SOEs still received allocation for part of their energy inputs at the state plan prices, which were kept much lower than their market prices. As a result, these enterprises have weak incentive for investment in energy conservation. Confronted with energy shortage and insufficient energy conservation investment, China has reformed its energy prices as part of sweeping price reforms initiated in 1993. While the overall trend of such energy pricing reform has been moving away from the pricing completely set by the central government in the centrally planned economy towards a more market-oriented pricing mechanism, the pace and scale of the reform differ across energy types.[2]

Coal pricing reform has been most extensively in terms of both pace and scope. The dual pricing system was introduced in 1984 where enterprises were required to sell up to a predetermined quota at state set prices but were allowed to sell above the quota at market prices. As part of sweeping price reforms initiated in 1993, coal price has since been set differently, depending on its use. Under a two track system for coal prices, the price of coal for non-utility use, the so-called “market coal”, has been determined by the market. But the price of coal for utility use, the so-called “power coal”, is based on “guiding price” that has been set by the NDRC substantially below market prices. In 2004, NDRC abolished its guiding price for power coal and set price bands for negotiations between coal producers and electricity generators. NDRC widened those bands in 2005, and scrapped them altogether in 2006 (Williams and Kahrl, 2008). NDRC proposed in May 2005 a coal-electricity price “co-movement” mechanism that would raise electricity tariffs if coal prices rose by 5% or more in no less than six months and allowed electricity generators to pass up to 70% of increased fuel costs on to grid companies. In December 2012, the State Council announced to abolish the two track system for coal prices, allowing the price of coal for utility use to be determined by the market just as the price of coal for non-utility use does. Moreover, it revises the coal-electricity price “co-

[1] See Wu and Zhao (1987) and Singh (1992) for general discussion on pros and cons of the dual pricing system and Albouy (1991) for its impact on coal.

[2] See Zhang (2014) for detailed discussion on the evolution of price reforms for coal, petroleum products, natural gas and electricity in China and some analysis of these energy price reforms.

movement" mechanism, allowing to adjust electricity tariffs if fluctuations in coal prices go beyond by 5% or more in 12 months and electricity generators to pass up to 90% of increased fuel costs on to grid companies instead of the existing 70% threshold (The State Council, 2012).

Similar to coal, a dual pricing system for crude oil was introduced in 1984, and was virtually eliminated in 1993. Since 1998 domestic crude oil prices have tracked international prices, but refined oil product prices have not. To address this disconnect, the government has implemented since May 2009 the pricing mechanism whereby domestic petroleum product prices would be adjusted upward if the moving average of international crude oil prices based on the composited crude oil price rose by more than 4% within 22 consecutive working days. To better reflect refiners' costs and adapt to fluctuations in global crude oil prices, NDRC launched in March 2013 an automatic petroleum product pricing mechanism, shortening the current 22-working-day adjustment period to 10-working-day and removing the 4 percent threshold. The composition of the basket of crudes to which oil prices are linked will also be adjusted (Liu, 2012; Zhu, 2013).

Reforms have been undergone for natural gas prices (Xinhua Net, 2013). A breakthrough in the reform area has been changing the existing cost-plus pricing to the "netback market value pricing" in Guangdong province and the Guangxi Zhuang Autonomous region. Under this new pricing mechanism, pricing benchmarks are selected and are pegged to prices of alternative fuels that are formed through market forces to establish price linkage mechanism between natural gas and its alternative fuels. Gas prices at various stages will then be adjusted accordingly on this basis (NDRC, 2011c). This new mechanism, which has been widely adopted in Europe, will better trace and reflect market demand and resource supplies, as well as guiding reasonable allocations. Until the Guangdong and Guangxi pilot reform program is implemented to the entire country, NDRC plans to lunch three-tier-tariffs for household use of natural gas across the whole country before the end of 2015 (China Economic Net, 2014). These price reforms and the pilot scheme in Guangdong and Guangxi help to establish a market-oriented natural gas pricing mechanism that fully reflects demand and supply conditions.

The government still retains control over electricity tariffs. But in order to encourage coal-fired power plants to install and operate flue gas desulfurization and denitrification facility the government offered since 2004 a price premium to electricity generated by coal-fired power plants with FGD facility installed (NDRC and SEPA, 2007) and since November 2011 a price premium for electricity generated by power plants with flue gas denitrification facility. The level and scope of the price premium were amended since their initial implementation in order to achieve the mandated emissions reductions (NDRC, 2013a,b). China also charged differentiated power tariffs for companies classified as 'eliminated types' or 'restrained types' in eight energy-guzzling industries from October 2006 onwards (NDRC, 2006b). NDRC implemented since July 2012 three-tier-tariffs for household electricity use, and since January 2014 expanded the three-tiered electrify pricing approach to the aluminum sector to phase out outdated production capacity and promote industrial restructuring more quickly (NDRC and MIIT, 2013; Gao, 2013). Similar tiered power pricing policy is expected to implement in other industries, such as cement, to force upgrades in the drive for sustained and healthy development.

4. 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 Yuan 200, and enterprises in the Central and Western part of the country Yuan 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 introduces market mechanism, developing energy management company (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, 2011a). The National Development Reform Commission and the Ministry of Finance of China award EMC Yuan 240 for every tce saved, with another compensation of no less than Yuan 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, 2011a). Moreover, with one-third of China's territory widely reported to be affected by acid rain, the formation of which SO_2, along with NO_2, contributes to, reducing SO_2 emissions has been the key environmental target in China. In its economic blueprint for 2006 to 2010, China incorporated for the first time the goal of reducing SO_2 emissions by 10% by 2010. With burning coal contributing 90% 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 Yuan/kW in the 1990s to the level of about 200 Yuan/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% 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% in 2011 of the total installed thermal capacity from 13.5% in 2005 (Sina Net, 2009; CEC and EDF, 2012). As a result, by the end of 2009, China had cut its SO_2 emissions by 13.14% relative to its 2005 levels (Xinhua Net, 2010), having met the 2010 target of a 10% cut one year ahead of schedule.

5. 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 and to save scarce energy and resources. This includes a 5% export tax on oil, coal and coke, a 10% tax on to non-ferrous metals, some minerals and 27 other iron and steel products, and a 15% tax charged on copper, nickel, aluminum and other metallurgical products. Simultaneously, imports tariffs on a range of items, including 26 energy and resource products such as oil, coal and aluminum, were cut from their current levels of 3-6% to 0-3%. 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 in December 2001. Among the affected items, which account for 37% 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. This policy will help to enhance energy efficiency and rationalize energy- and resource-intensive sectors as well as to control soaring exports and deflate the ballooning trade surplus. 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 Pearl River delta, a major manufacturing region in Southern China, Streets et al. (2006) found that 37% of the total SO_2 emissions in the region, 28% of NO_x, 24% of particulate matter (PM), and 8% of volatile organic compounds (VOCs) were caused by export-related activities. In the city of Shenzhen alone, the regional leader in industrial development and trade, 75% of VOCs, 71% of PM, 91% of NO_x, and 89% of SO_2 emissions from the industrial sector were released through the manufacture of exported goods. Effectively implemented, this policy will help polluting enterprises that export their products to pay attention to the environmental effects of their products and produce more environmentally friendly products.

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% for cars with engines of 1.0 liter or less, 8% for cars with engines of more than 4 liters, and 5% 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 decreases to 1%, whereas the rate for cars with engines of no less than 3 liters but no larger than 4 liters is set at 25%. Cars with engines of larger than 4 liters are now taxed at the highest rate of 40% (Sina Net, 2006; *People Net*, 2008; Zhang, 2010a).

6. 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. Many Asian countries have traditionally relied on rigid command-and-control (CAC) approaches. With the poor environmental performance of such approaches and the cost and complexity associated with their implementation, more and more countries in this region are transforming from current reliance on CAC regulations to market-based policy instruments. The added abatement costs will be imposed on polluting companies as part of production cost that can be reduced by cutting pollution. This is seen to increase not only cost-effectiveness but also flexibility in complying with the set environmental regulations.

With one-third of China's territory widely reported to be affected by acid rain, the formation of which SO_2, reducing SO_2 emissions has been the key environmental target in China. 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 Yuan 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 Yuan 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 Yuan 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 Yuan 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. Since 1999, Beijing levied charges of 1.2 Yuan per kilo of pollution equivalent for SO_2 emissions from coals of high sulfur content (SDPC et al., 2003). Jiangsu province raised charges for SO_2 emissions from the existing level of 0.6 to 1.2 Yuan per kilo of pollution equivalent from July 1, 2007 onwards, three years ahead of the national schedule (People Net, 2007;

Sina Net, 2007). China's Ministry of Finance, the State Administration of Taxation and the Ministry of Environmental Protection (MEP) have proposed levying environmental taxes to replace current charges for SO_2 emissions and chemical oxygen demand, a water pollution index. 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 running from 2011 to 2015. 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 plants that are inefficient and highly polluting, and to keep the frenzied expansion of offending industries under control, the 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 including cement, aluminum, iron and steel, and ferroalloy 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 goes 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, 2007a,b, 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, providing stronger incentives for provincial authorities to enforce the policy (Zhou et al, 2010). Partly for strengthening China's longstanding efforts to restructure its inefficient heavy industries, and partly faced with the prospect for the failure to meet the ambitious energy intensity target set for 2010, the NDRC and other five ministries and agencies jointly ordered utilities to stop offering preferential power tariffs to energy-intensive industries by June 10, 2010. Such industries will be charged with the punitive, differentiated tariffs. Those utilities that fail to implement the differentiated tariffs will have to pay a fine that is five times that of differentiated tariffs multiplied by the volume of sold electricity (J. Zhu, 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. Since the tax-sharing system was adopted in China in 1994, taxes are grouped into taxes collected by the central government, taxes collected by local governments and taxes shared between the central and local governments. All those taxes that have steady sources and broad bases and are easily collected, such as the consumption tax, tariffs and vehicle purchase tax, are assigned to the central government. VAT and income tax are split between the central and local governments, with 75 percent of VAT and 60 percent of income tax going to the central government. This led the share of the central government in the total government revenue to go up to 55.7 percent in 1994 from 22.0 percent in the previous year. In the meantime, the share of the central government in the total government expenditure just rose by 2 percent. By 2009, local governments only accounted for 47.6 percent of the total government revenue, but their expenditure accounted for 80.0 percent of the total government expenditure in China. To enable to pay their expenditure for culture and education, supporting agricultural production, social security subsidiary, and so on, local governments have little choice but to focus on local development and GDP. That will in turn enable them to enlarge their tax revenue by collecting urban maintenance and development tax, contract tax, arable land occupation tax, urban land use tax, and so on.

Alleviating the financial burden of local governments is one avenue to incentivize them not to focus on economic growth alone. Enlarging their tax revenue is the key to helping them cover a disproportional portion of the aforementioned government expenditure. In the tax-sharing system adopted in 1994, onshore resource taxes are assigned to local governments, while the central government is collecting revenues from resource taxes offshore. In 1984, resource taxes have been levied at Yuan 2–5 per ton of raw coal and Yuan 8 per ton of coking coal, with the weighted average of Yuan 3.5 per ton of coal. For crude oil, the corresponding tax is levied at Yuan 8–30 per ton. While the prices of coal and oil have significantly increased since 1984, 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 Yuan 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 that amounted to Yuan 193.4 billion 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.

Clearly, broadening the current coverage of resource taxation and significantly increasing the levied level also help to increase local government's revenues while conserving resources and preserving the environment. The Chinese central government started a pilot reform on resource taxation in Xinjiang, China's northwestern border area of abundant resources and numerous opportunities for growth and expansion. Since June 1, 2010, crude oil and natural gas are taxed by revenues rather than volume in Xinjiang. While it is enacted as part of a massive support package to help Xinjiang achieve leapfrog-like development, which is considered a strategic choice to deepen the country's Western Development Strategy and tap new sources of economic growth for China, this new resource tax will help to significantly increase the revenues for Xinjiang. It is estimated that the new resource tax levied at a rate of 5 percent will generate additional annual revenues of Yuan 4–5 billion for Xinjiang (Dai, 2010). This is a significant increase, in comparison with the total resource tax revenues of Yuan 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.

There have been intensified discussions on levying resource tax on coal by revenues. China is most likely to overhaul the current practice and levy on coal by revenues in 2014. Coal-rich provinces, like Shanxi and Inner Mongolia, have studied options to levy on coal by revenues. The tax rates are proposed to be 2-10%, depending on the extent to which current fees and charges are cut or abolished. Specifically, assuming coal price of Yuan 465 per ton, Shanxi proposes to levy at 2.2% if the charge for coal sustainable development fund (which charges Yuan 8-23 per ton, depending on the type of coal) remains; 7.4% if that charge is abolished. If coal price is assumed at Yuan 440 per ton, then Shanxi proposes to levy at 2.4% if the charge for coal sustainable development fund remains; 7.6% if that charge is abolished (Xing, 2013; Wang et al., 2014).

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 (chemical oxygen demand) 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.

Moreover, China had relied mostly on administrative means to achieve its 20% energy-saving goal for 2010. Qi (2011) shows that during the eleventh five-year plan period, the total amount of CO_2 reduction reached 1.25 billion tCO_2e through mandatory regulations and auxiliary financial stimuli, while only 0.035 billion tCO_2e were reduced as a result of market-based instruments. In the end, the country has had a limited success in meeting that goal. Learned from this lesson in the 11th five-year period and confronted with increasing difficulty in further cutting energy and carbon intensities in the future, China has realized that administrative measures are effective but not efficient. It is becoming increasingly crucial for China to harness market forces to reduce its energy consumption and cut carbon and other conventional pollutants and genuinely transit into a low-carbon economy. In the meantime, evidence suggests that environmental tax reforms and greenhouse gas emissions trading schemes in the OECD work (Andersen et al., 2007; Andersen and Ekins, 2009; Ellerman et al., 2000 and 2010).

To that end, China is experimenting with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities. Aligned with such an experiment, NDRC has approved seven pilot carbon trading schemes in the capital Beijing, the business hub of Shanghai, the sprawling industrial municipalities of Tianjin and Chongqing, the manufacturing center of Guangdong province on the southeast coast, Hubei province, home of Wuhan Iron and Steel, Shenzhen, the Chinese Special Economic Zone and across the border from Hong Kong. There are features in common in these pilot trading schemes. All the pilot schemes run from 2013 to 2015. During the pilot phase, banking is allowed, but allowances cannot be carried forward beyond 2015. Borrowing is not authorized to improve the liquidity of the carbon market. All regimes allow to a different degree the use of the Chinese Certified Emission Reductions (CCERs) that meet the requirements of China's national verification regulation. Of the seven pilot emissions trading cities, Shenzhen emissions trading scheme (ETS) includes the largest number of enterprises. Trading started on 18 June 2013 at about Yuan 28 per ton of CO_2. Allowances are currently traded at about Yuan 84 per ton, with prices peak at Yuan 140 per ton.As the country's first carbon trading scheme in operation, Shenzhen ETS is just a baby step when you look at the total amount of the regulated emissions compared to the country's total emissions of over 8 billion tons in 2012, but it is hailed as a landmark step for China in building nationwide carbon emissions trading scheme planned for later this decade. With 388 million tons of allowances set for 2013, Guangdong positions itself as the world's second largest carbon market behind the EU ETS. Trading started on 20 December 2013, with 0.12 million tons of allowances traded at Yuan 60-61 per ton. Based on these piloted schemes, China aims to establish a national carbon trading scheme, hopefully by 2016.

7. Implementation and reliability issues

It should be emphasized that enacting the aforementioned policies and measures targeted for energy saving and pollution cutting just signals a goodwill and determination of China's leaders. 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, except for the Mayor of Beijing municipality and the Governor of Shanxi province who stepped down for the mismanagement of the severe acute respiratory syndrome epidemic and ultra coal-mining accidents.

Another example is the enforcement of FGD operation to ensure that those units equipped 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% of those generation units with FGD facility did not use it" (Liu, 2006). Given that FGD costs are estimated to account for about 10% of the power generation cost (Peng, 2005), 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% of the installed FGD were running continuously and reliably (Xu et al., 2009).

This does not apply to power generation alone. MEP field inspections in early 2013 found 70% of the desulphurization facility installed in iron and steel plants in Herbei province, in which 7 of the ten most polluted cities in China locate, were not running continuously and reliably. Some plants stopped running the desulphurization facility at 8 clock in the evening and then started its operation at 8 clock in the morning, illegally discharging SO emissions in the evening (Wang and Wei, 2013). Even more alarming is that coal-fired plants were supposed to emit 1.44 million tons of SO_2 emissions in 2012 if they complied with the new emissions standards that took into effect in the beginning of 2012, but they actually emitted 8.83 million tons of SO_2 emissions, based on the data released from the Ministry of Environmental Protection (X. Zhang, 2014). With more than 90% of coal-fired generation capacity already equipped with FGD, 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% and 90% of total generation, and a penalty of 0.075 RMB/kWh for plants operating FGDs less than 80% 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). Based on its 2012 assessment of the total volume reduction of major pollutants in all provinces or equivalent and eight central state-owned enterprises, MEP issued the penalty on 15 enterprises involving improper operation of their desulfurization facilities and monitoring desulfurization data falsification. These enterprises were ordered not only to return the compensation for their desulphurization costs in proportion to the time when their desulfurization facilities were not in operation, but also had to pay a fine up to five times that the compensation amount they received (Qin and Qi, 2013).

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% 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% of their time conducting these inspections (Schreifels et al., 2012).

Implementation also raises concern about the reliability of energy data. This will be even a big issue at local levels because of the lack of reliable local energy statistics. The limited capacity and rampant data manipulation have turned the compilation of local energy statistics into a numbers game. NDRC reported that from 2011 to 2012, national energy intensity declined by 5.5% according to data from the National Bureau of Statistics. By contrast, national energy intensity declined by 7.7% based on aggregated local statistics during the same period (NDRC, 2013d). This differential in national energy intensity reductions suggests that local governments have overstated their achievement in energy conservation by 40%. Because of the mismatch between local and national statistics, even if each region claims to have met its energy saving goal, China would still fail to meet the national target. Local governments based on unreliable local energy statistics, perceive to have a better perspective for the attainment of their energy saving goals. Therefore, they do not feel the same level of urgency and pressure as the central government. This is seriously undermining the attainment of the national energy saving target.

8. 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 implemented and strengthened a variety of programs, prices, market-based instruments, and other economic and industrial policies and measures targeted for energy saving and pollution cutting. While these policies and measures are helpful in keeping China's energy demand and pollution under control, they fall short of the purposes of both preserving energy and resources and protecting the environment. It is fair to say that lack of strict implementation and coordination of these policies and measures, and lack of appropriated incentives to get local governments' cooperation are attributed to the undesired outcomes. But, in my view, this is mainly because China had relied most on costly administrative measures to meet its energy saving target in 2010. In the end, China missed that target.

Learned from this lesson in the 11th five-year period and confronted with increasing difficulty in further cutting energy and carbon intensities in the future, China has realized that administrative measures are effective but not efficient. It is becoming increasingly crucial for China to harness market forces to reduce its energy consumption and cut carbon and other conventional pollutants and genuinely transit into a low-carbon economy. The Chinese leadership is well aware of this necessity. This is clearly reflected by the key decision of the Third Plenum of the 18th Central Committee of Communist Party of China in November 2013 to assign the market a decisive role in allocating resources. However, to have the market to play that role, getting the energy prices right is crucial because it sends clear signals to both producers and consumers of energy. While the overall trend of China's energy pricing reform since 1984 has been moving away from the pricing completely set by the central government in the centrally planned economy towards a more market-oriented pricing mechanism, the pace and scale of the reform differ across energy types.

To date, the reform on electricity tariffs has lagged far behind, and accordingly the government still retains control over electricity tariffs. While China has been reforming electricity industry structure since 2002, transmission, distribution and sale of electricity are operated in integration by two main grid companies, State Grid and China Southern Power Grid, and several local grid companies, such as Inner Mongolia Grid, Shaanxi Grid. As the designated sole buyers of electricity from generators and distributors and sellers of electricity, they monopolize in their respective areas. Their monopoly power and thereby the lack of competition in the electricity market has been heavily criticized. However, in my view, separation of transmission and distribution is not a must option. The feasible approach should start reforming electricity sale side by setting up the electricity power trading market. In this regard, direct purchase for major electricity users, as piloted in Yunnan province, should be actively promoted. That will help to infer the cost of electricity transmission and distribution and help the government to set the appropriate level of the grid's transmission and distribution charges in future electricity power structure reform. While splitting grid is not a must option to achieve this goal, separating electricity sale from grid's transmission and distribution is a must to establish competitive electricity power market. Then the electricity sale side can be opened and electricity selling companies independent of grids can be set up in each region. As such, marketing trade will be performed on both electricity generation side and sale side and an open nationwide electricity power market will be established to create a market-based system for electricity pricing. These are considered as the more realistic option to move electricity power reforms forward. In the meantime, given that meeting the goal of cutting NOx emissions has been lagged far behind the government's set schedule as a result of high costs involved and thereby coal-fired power plants' reluctance to install and operate denitrification facility, the government could consider raising the current level of price premium for denitrification in order to encourage such plants to install and run denitrification facility continuously and reliably.

Even if the aforementioned energy price reform is undertaken, however, from a perspective of a whole value chain of resource extraction, production, use and disposal, energy prices still do not fully reflect the cost of production. Thus, combined with the pressing need to avoid wasteful extraction and use of resources, getting energy prices right calls for China to reform its current narrow coverage of resource taxation and to significantly increase the levied level. The resource tax levied on crude oil and natural gas by revenues rather than by existing extracted volume, which started in Xinjiang since June 1, 2010 and then was applied nationwide since November 1, 2011, is the first step in the right direction. China should broaden that reform to coal, overhauling the current practice and levy on coal by revenues. This will also help to increase local government's revenues and alleviate their financial burden of local governments to incentivize them not to focus on economic growth alone.

Right energy prices from a perspective of a whole energy value chain also need to include negative externalities. Clearly, the imposition of environmental taxes or carbon pricing can internalize externality costs into the market prices. Currently, China is experimenting with low-carbon provinces and low-carbon cities in six provinces and thirty-six cities. Aligned with such an experiment, the central government has approved seven pilot carbon trading schemes. The seven regions are given considerable leeway to design their own schemes, and these trading schemes that share some in common but have differing features have been put into operation since June 2013, respectively. Based on these piloted schemes, China aims to establish a national carbon trading scheme, hopefully 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 to disentangle China's additional efforts towards carbon abatement from those broad energy-saving and pollution-cutting ones.

Finally, it should be emphasized that implementation holds the key. This will be a decisive factor in determining the prospects for whether China will clean up its development act and meet its proposed carbon intensity target in 2020 and whatever climate commitments beyond 2020 that China may make. There are encouraging signs that the Chinese government is taking steps in this direction.

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