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ZhongXiang Zhang
College of Management and Economics, Tianjin University

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Keywords:
Low-carbon economy; carbon emissions peaks; coal consumption; carbon pricing; energy prices; resource tax reform; renewable energy; China

JEL Classification:
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Address for Correspondence:
ZhongXiang Zhang
Distinguished University Professor
College of Management and Economics
Tianjin University
Tianjin 300072
China
Tel: +86 22 87370560
Email: ZhangZX@tju.edu.cn

Making China the transition to a low-carbon economy: Key challenges and responses

ZhongXiang Zhang
张中祥 天津大学管理与经济学部“千人计划”特聘教授
Distinguished University Professor, College of Management and Economics, Tianjin University, Tianjin 300072, China. *Email:* ZhangZX@tju.edu.cn

Abstract
China has realized that for its own sake and from the international community's perspective, it cannot afford to continue along the conventional path of encouraging economic growth at the expense of the environment. Accordingly, the country has placed ecological goals at the same level of priority as policies on economic, political, cultural and social development. Specifically, to meet the grand goal involves not only capping China's nationwide coal consumption to let it peak before 2020 and carbon emissions peak around 2030, but also putting in place a variety of flagship programs and initiatives, prices and policies. This paper argues that the 2030 carbon emissions peak goal is ambitious but achievable and concludes by arguing why China's anti-pollution outcomes this time might be different from the previous ones.

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ZhongXiang Zhang
Distinguished University Professor
College of Management and Economics
Tianjin University
Tianjin 300072
China
Tel: +86 22 87370560
E-mail address: ZhangZX@tju.edu.cn

1. Introduction

Following three decades of rapid economic growth, China is facing a variety of daunting challenges. On environmental side, domestically, dense smog and haze, which frequently hit in Beijing and other places in China, and steeply rising oil imports raise great concern about a range of environmental problems and health risks and energy security. Internationally, given that China is already the world's largest energy consumer and carbon emitter and that its energy use and carbon emissions continue to rise rapidly as it is rapidly approaching to be the largest economy in the next one to two decades, China is facing great pressure both inside and outside international climate negotiations to be more ambitious in combating global climate change. Thus, China, for its own sake and from the international community's perspective, cannot afford to continue along the conventional path of encouraging economic growth at the expense of the environment.

The Chinese leaders are fully aware of these challenges the country faces. In response, the 18th Conference of the Central Committee of the Communist Party of China adopted a general policy of Ecological Civilization, placed ecological goals at the same level of priority as existing policies on economic, political, cultural and social development, and emphasized that Ecological Civilization would be fully implemented in all aspects of economic development.

With the grand vision of Ecological Civilization, the issue is then how China explores concrete, constructive and realistic solutions in the 13th five-year (2016-20) plan (FYP) and beyond in order to be successful in making its transition to a low-carbon, green economy.

This paper is organized as follows. Section 2 discusses that China's key energy-related environmental challenges lie in capping nationwide coal consumption to let it peak in the 13th FYP and carbon emissions peak around 2030. Section 3 discusses flagship programs and initiatives, prices and policies that are put in place in response to these challenges in order for China to genuinely transform into a low-carbon economy. Section 4 concludes by arguing why the outcomes this time might be different from the previous ones.

2. Cap coal consumption by 2020 and carbon emissions by 2030

Burning coal contributes to the overwhelming majority of national total sulfur dioxide emissions, dust, nitrogen oxide emissions and CO_2 emissions in China, and has given rise to unprecedented environmental pollution and health risks across the country (Zhang, 2007 and 2011a; CCCCPPRP, 2014). Moreover, given that China's energy mix is coal-dominated, cutting China's carbon intensity to meet its climate commitments by 2020 is in fact cutting its energy intensity, and abating CO_2 emissions in China is closely linked to rein in its energy consumption in general and its coal consumption in particular. Clearly, when China's coal peak is crucial to determine when China's carbon emissions would peak and to materialize ecological civilization goal.

2.1 Cap nationwide coal consumption to enable its peak in the 13th FYP
Both China and India rely heavily on coal to fuel their economies, but coal accounts for a much larger share in China's energy mix than that of India. As the world's largest coal producer and consumer, China produces and consumes about twice as much coal as the U.S., the world's second largest producer and consumer. Coal has accounted for over two-thirds of China's primary energy consumption for several decades. Coal-fired power plants dominate total electricity generation in China, consuming over half of the total coal use. As a result, China's total installed capacity of coal-fired power plants is more than the current total of the U.S., the United Kingdom and India combined.

China's National Energy Adminstration initially proposed to cap total national energy consumption in mapping out the 12th five-year (2010-15) plan, but that national cap was not included in the plan for a variety of reasons (Zhang, 2011a). Dense smog and haze that frequently hit in Beijing and other places in China, which is the combined effect of heavy airborne pollution and meteorological conditions, has sparked China's determination to cap coal consumption and combat air pollution, in an effort to ease mounting public concern over air quality. The so-called Atmospheric Pollution Prevention Action Plan released by the State Council (2013) aims to scale back coal's proportion of energy consumption to 65 percent by 2017 in order for the concentration of hazardous particles, including PM 2.5, to drop by ten percent in all cities compared with 2012.

In physical terms, on average, coal production in China increased yearly by 200 million tons over the past 10 years, but increased by 50 million tons in 2013; in percentage terms, coal use increased yearly by 9 percent over the past 10 years, but increased by 2.6 percent in 2013. The key challenge for China in the 13th FYP is to let coal consumption to peak in 2016-2020 by undertaking strict measures. This would lead the resulting CO_2 emissions to be estimated to peak in 2025-2030, and coal's share in the total energy mix to be estimated to be below 50 percent in 2030 (Wang, 2014; Zhang, 2014a).

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A1. Energy conservation and carbon mitigation in key energy-consuming industries
Given that industry accounts for about 70% of China's total primary energy consumption, few key energy-consuming sectors are crucial for China to meet its own set energy-saving and carbon mitigation goals. So the Chinese government has taken great efforts towards changing the current energy-inefficient and environmentally-unfriendly pattern of industrial growth. During the 13th FYP, China needs to further explore and enhance industrial policies to encourage technical progress, strengthen pollution control, and to promote industrial upgrading and energy conservation in key

industries in order to meet the increasingly stringent energy-saving and emissions-cutting commitments.

Indeed, a sectoral approach can serve as the first step under a prospective international climate treaty. Wang et al. (2015) argue that the cement, steel, aluminum sectors in China can be among the first group to be covered under the sectoral approach. This recommendation is very in line with the proposal made in Zhang (2000) that a combination of a targeted carbon intensity level with an emissions cap at a sector level is the most stringent commitment that China can make around or beyond 2020.

A2. Cut coal consumption in absolute terms in severely polluted regions

Capping coal consumption not only requires enhanced efforts in key energy-consuming sectors, but also unprecedented, coordinated regional efforts, in particular in more developed and severely polluted regions. The Atmospheric Pollution Prevention Action Plan (The State Council, 2013) sets more stringent concentration targets for hazardous particles for more-developed areas, with the Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl River Delta required to cut levels by 25 percent, 20 percent and 15 percent respectively. To that end, coal consumption in these more advanced and severely air polluted regions should not increase, and be further cut in absolute terms in the 13th FYP.

2.2 Capping carbon emissions around 2030

2.2.1 Why around 2030 for timing China's absolute emissions caps?

Many factors need to be taken into consideration in determining the timing for China to take on absolute carbon emissions caps. Zhang (2010 and 2011a,b) argue from the following six angles that China could cap its greenhouse gas emissions around 2030.

First, the fourth assessment report of the IPCC recommends that global greenhouse gas emissions should peak by 2020 at the latest and then turn downward, to avoid dangerous climate change consequences. With China already the world's largest carbon emitter, the earlier China takes on emissions caps, the more likely that goal can be achieved. However, given China's relatively low development stage and its rapidly growing economy fueled by coal, its carbon emissions are still on the climbing trajectories beyond 2030, even if some energy saving policies and measures have been factored into such projections. All the integrated assessment models examined by the European Commission-funded LIMITS (Low climate IMpact scenarios and the Implications of required Tight emission control Strategies) project foresee that China's carbon emissions under the baseline scenario would peak in the second half of this century, with 2080 as the median year across models (Tavoni et al., 2015). A recent joint Tsinghua-MIT study suggests that in the so-called continued effort scenario under which China will maintain its Copenhagen pledge momentum and achieve a carbon intensity reduction rate of approximately 3% per year from 2016 through 2050,[1] China's carbon emissions would not peak until 2040, while China's

[1] At the Copenhagen climate change summit, China pledged to cut its carbon

carbon emissions under the baseline scenario would not peak until 2050 (Zhang et al., 2014).

Second, before legally binding commitments become applicable to Annex I (industrialized) countries, they have a grace period of 16 years starting from the Earth Summit in June 1992 when Annex I countries promised to individually or jointly stabilize greenhouse gases emissions at their 1990 levels by the end of the past century to the beginning of the first commitment period in 2008. This precedent points to a first binding commitment period for China starting around 2030.

Third, with China still dependent on coal to meet the bulk of its energy needs for the next several decades, the commercialization and widespread deployment of carbon capture and storage (CCS) is a crucial option for reducing both China's and global CO_2 emissions. Thus far, CCS has not been commercialized anywhere in the world, and it is unlikely, given current trends, that this technology will find large-scale application either in China or elsewhere before 2030. China's report of the Deep Decarburization Pathways Project and the aforementioned joint Tsinghua-MIT study share this view. Both of them project no CCS facilities on power plants by 2030, and CCS facilities on about 90% of coal-fired power plants and 80% of natural gas fired power plants by 2050 assuming that CCS technology will become commercialized after 2030 (Teng et al., 2014; Zhang et al., 2014). 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 emissions caps.

Fourth, developing countries need reasonable time to develop and operate national climate policies and measures. This is understood by knowledgeable U.S. politicians, such as Reps. Henry Waxman (D-CA) and Edward Markey (D-MA), the sponsors of the American Clean Energy and Security Act of 2009. Indeed, the Waxman-Markey bill gives China, India and other major developing nations time to enact climate-friendly measures. While the bill called for a "carbon tariff" on imports, it very much framed that measures as a last resort that a U.S. president could impose at his or her discretion not until 1 January 2025 regarding border adjustments or tariffs, although in the middle of the night before the vote on 26 June 2009, a compromise was made to further bring forward the imposition of carbon tariffs.

Fifth, another timing indicator is a lag between the date that a treaty is signed and the starting date of the budget period. With the Kyoto Protocol signing in December 1997 and the first budget period staring 2008, the earliest date to expect China to introduce binding commitments would not be before 2020. Even without this precedent for Annex I countries, China's demand is by no means without foundation. For example, the Montreal Protocol on Substances that Deplete the Ozone Layer grants developing countries a grace period of 10 years (Zhang, 2000). Given that the scope of economic activities affected by a climate regime is several orders of magnitude larger than those covered by the Montreal Protocol, it is arguable that

intensity by 40-45% by 2020 relative to its 2005 levels. This raises the issue of whether such a pledge is ambitious or just represents business as usual. See Zhang (2011a,c) for detailed discussion on stringency and credibility issues related to China's carbon intensity commitment and their implications.

developing countries should have a grace period much longer than 10 years, after mandatory emission targets for Annex I countries took effect in 2008.

Sixth, while it is not unreasonable to grant China a grace period before taking on emissions caps, it would hardly be acceptable to delay the timing beyond 2030. China is already the world's largest carbon emitter and, in 2010 it overtook Japan as the world's second largest economy, although its per capita income and emissions are still very low. After another twenty years of rapid development, China's economy will overtake that of the world's second-largest emitter (the U.S.) in size, whereas China's absolute emissions are well above those of number two. Its baseline carbon emissions in 2030 are projected to reach 12.0 billion tons of carbon dioxide, relative to 5.3 billion tons for the U.S. and 3.7 billion tons for India (IEA, 2013), the world's most populous country at that time. This gap with the U.S. could be even bigger, provided that the U.S. would cut its emissions to the levels proposed by the Obama administration and under the American Clean Energy and Security Act of 2009. By then, China's per capita income will reach a very reasonable level, whereas its per capita emissions of more than 8.0 tons of carbon dioxide are projected to be well above the world's average and about 3.3 times that of India (IEA, 2013). While the country is still on the climbing trajectory of carbon emissions under the business as usual scenario, China will have lost ground by not taking on emissions caps when the world is facing ever alarming climate change threats and developed countries will have achieved significant emissions reductions by then.

2.2.2 Peaking around 2030 is ambitious but achievable

A recent joint Tsinghua-MIT study suggests that in the so-called continued effort scenario under which China will maintain its Copenhagen pledge momentum and achieve a carbon intensity reduction rate of approximately 3% per year from 2016 through 2050,[2] China's carbon emissions would not peak until 2040, while China's carbon emissions under the baseline scenario would not peak until 2050 (Zhang et al., 2014). This means that China would bring the peaking year forward to 2030, at least ten years earlier than under the so-called continued effort scenario, when it commits to cap its carbon emissions around 2030. Therefore, from this perspective, this commitment is ambitious.

Measured in other ways, however, the story differs. One way is to examine whether emissions peak in 2030 is consistent with the 2°C target. The LIMITS models project that China's emissions should peak in 2020 under both 450 parts per million (ppm) and 500 ppm scenarios in order to achieve the 2°C target by the end of 2100 (Tavoni et al., 2015).[3] Other studies in Figure 1 by the Energy Modeling Forum and SSP suggest that China's emissions should peak in 2020-25 in order to achieve the

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[2] At the Copenhagen climate change summit, China pledged to cut its carbon intensity by 40-45% by 2020 relative to its 2005 levels. This raises the issue of whether such a pledge is ambitious or just represents business as usual. See Zhang (2011a,c) for detailed discussion on stringency and credibility issues related to China's carbon intensity commitment and their implications.

[3] This does not say the issue of who pays. Tavoni et al. (2015) show that, with a per capita allocation China would get a higher allocation of emissions allowances than with the equal cost allocation.

same 2°C target. Clearly, China's commitment to let GHG emissions peak in 2030 does not seem to be consistent with the 2°C target in any of the three scenarios. Moreover, as shown by Figure 1, China's GHG emissions must decrease very quickly for the 2°C target to be achieved. This suggests that even were China to be successful in reaching this target, the necessary emissions reductions after the peak year are unlikely to be achieved (Carraro, 2015).

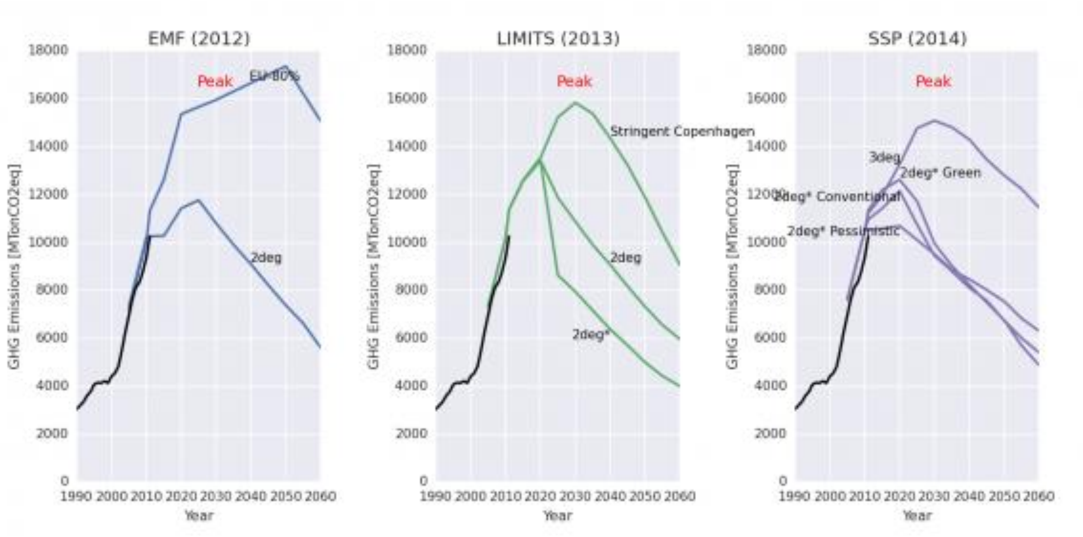

Figure 1 China's GHG emissions from 1990 to 2100
Source: Carraro (2015).

Another angle is to look at what costs the emissions peak would be achieved. The *China and the New Climate Economy* report suggests that under the moderate growth scenario, capping China's carbon emissions around 2030 would cost 0.02% and 0.06% of China's GDP in 2020 and 2030, respectively, without consideration of other benefits of carbon abatement (He et al., 2014). The European Union's commitments to cut its GHG emissions by 30% relative to 1990 levels are widely considered less stringent, partly because the European Commission analysis found that a 30% internal reduction would cost 0.2 to 0.3% of GDP in 2020. If a 30% reduction were part of an international agreement, GDP impacts vary between -0.6% to 0.6% in 2020 (Klaassen et al, 2012). In percentage terms, the estimate of China's loss is very small, and is one magnitude of order less than that of the EU. While China is not expected to to exhibit greater ambition than the EU, the latter being seen to have greater capacity, capability and responsibility, the small loss projected for China could be interpreted as meaning either that China's commitments of peaking level would be less stringent or that the peaking year could be further brought forward.

But it is achievable based on the model projections and on the action ground. The LIMITS models project that China's emissions would peak slightly later than 2030, based on the commitments that China made prior to the joint China-U.S. climate statement in November 2014 (Tavoni et al., 2015). If China's commitments to have non-fossil fuels to meet its 20% of energy demand by 2030 in that joint climate statement (The White House, 2014) is factored in, then China's commitments to cap emissions by 2030 are in line with what the LIMITS models foresee in the pledge scenario (Tavoni et al., 2015). On the action ground, as discussed in Section 3.2 on low-carbon city, with increasingly stringent energy-saving and carbon intensity goals, China began experimenting with low-carbon city development in 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). All the pilot provinces and cities under the low-carbon city or region development program set CO_2 emissions peaks in 2030 or earlier although it is not mandated by the central government.15 pilot provinces and cities even aim for a CO_2 emissions peaks in 2020 or earlier, with Shanghai publicly announcing 2020 as its peak year, 2020 for Suzhou and 2015 for Ningbo (Zhang, 2015). In 2015, NDRC plans to select 10 model cities of varying kinds from these 42 pilots to further explore and support the implementation measures aimed at the emissions peaking in these selected cities before 2030, thus leading the whole country to the emissions peaking (21SO, 2014). Clearly, the practices and ambitions of the pilot regions have set good examples for keeping emissions under control, making positive contributions to overall low-carbon development in China, and thus possibly contributing to making its carbon emissions peak occurring even sooner than the aforementioned timeline.

2.2.3 At what level that peak would be?

Under the joint China-U.S. climate statement by the Presidents of China and the U.S. on 11 November 2014 in Beijing, China has pledged to cap carbon emissions by 2030 or earlier (The White House, 2014). However, how China's carbon emissions are likely to develop or at what level they will finally peak is still an open question. The peaking level is of great interest and concern, not only for China but also for other countries.

In theory, purely from the perspective of climate commitments, China could let its emissions peak at a high level around 2030, and then cut emissions from that high level. That would ensure that China would meet its international commitments. The counterargument is that China cannot afford to do that because dense smog and haze has become a major issue and triggers mounting public complaints. The anti-pollution policies and measures taken help get emissions down.

Just like estimates of peaking time differ, estimates of peaking level also differ significantly across studies. Jiang et al. (2013) suggest that China's carbon emissions would peak at 9 Gt CO_2 in 2030 under low-carbon scenario. The peaking level could go down to 8.5 Gt CO_2 under enhanced low-carbon scenario. These estimates might be too optimistic, assuming widespread adoption of more advanced low or zero carbon technologies without factoring in adoption costs and behavior changes. Teng and Jotzo (2014) suggest China's carbon emissions peaking during the 2020s, returning to a level below the 2020 level by 2030, and backing to around current levels by 2040. With CO_2 emissions in 2013 estimated to be 9.1 Gt CO_2 based on the revised energy statistics released in February 2015 by the National Bureau of Statistics of China (2015), which adjusts upward coal consumption in 2013 by 589 million tons, this suggests the peaking level of 10.6 Gt CO_2 in 2030. The aforementioned Tsinghua-MIT study suggests that China's carbon emissions would peak at 12.1 Gt CO_2 around 2040 in the so-called continued effort scenario and 10.2 Gt CO_2 around 2030 in the so-called accelerated effort scenario (Zhang et al., 2014). Taken these estimates together, my educated estimate is that China is most unlikely to reveal its peaking emissions level in 2030, and if China would do, it would not be lower than 10 Gt CO_2 in 2030.[4]

China's peak level is of importance to other countries as well because it will affect the carbon space left for others in order to keep temperature rise below 2°C degree. India's Council on Energy, Environment and Water (2015) shows that, given the available global carbon space and China's dominance, India would have very little carbon space left if China decides to level off its carbon emissions at 12 Gt CO_2 as the continued effort scenario in the aforementioned Tsinghua-MIT study suggests.

3 Programs, prices and policies towards the transition to a low-carbon economy in China

3.1 Strengthening and expanding flagship programs and initiatives and supportive economic policies

China has implemented a variety of programs and initiatives, and supporting economic and industrial policies and measures targeted for energy saving and pollution cutting in the 11th and 12th FYPs (Zhang, 2015). Flagship initiatives of significant nature include, but are limited to, the Top 1000 Enterprises Energy Conservation Action Program, the 10,000 Enterprises Energy Conservation Low Carbon Action Program, and mandatory closures of small power plants while building larger, more efficient units.

Supportive economic policies are also implemented to encourage technical progress and strengthen pollution control to meet the energy-saving and environmental control goals. To support energy-saving projects, since August 2007 the Ministry of Finance and NDRC (2007) has been awarding enterprises in the east RMB 200, and those in the central and western parts of the country RMB 250 for every ton of coal equivalent (tce) saved each year. Such payments are made to enterprises that have energy metering and measuring systems in place that can document energy savings of at least 10000 tce from energy-saving technical transformation projects. Since July 2011, such awards are increased to RMB 240 for enterprises in the east, and RMB 300 for those in the central and western parts of the country for every tce saved each year and at the same time, the minimum requirements for total energy savings from energy-saving technical transformation projects are lowered to 5000 tce from the previously required amount of 10000 tce (Ministry of Finance and NDRC, 2011). The government also introduced energy

[4] Indeed, China does not reveal its carbon peaking emissions level in 2030 when submitting its intended nationally determined contributions to the United Nations Framework Convention on Climate Change on 30 June 2015, which details its commitments to climate change mitigation and adaptation in the post-2020 period.

management companies (EMC) to promote energy saving. The central government awards EMCs RMB 240 for every tce saved, with another compensation of no less than RMB 60 for every tce saved by local governments. Taxes are used to promote the purchase of smaller cars. The excise tax on a car with an engine less than one liter is 1% of its value, whereas a four-liter engine is taxed at 40% of the car's value. Renewable vehicles, like electric, hybrids and fuel-cell cars, are exempt from purchase taxes until the end of 2017. Policies favorable to flue gas desulphurization (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 without desulphurization capacity. Some provincial governments have even more favorable policies, such as priority dispatching (Teng et., 2014) of power from units with FGD in Shandong and Shanxi provinces. The government has offered power price premium for denitrification, and has charged differentiated power tariffs and tiered power tariffs (Zhang, 2014a).

China needs to further strengthen and expand these programs and initiatives and supporting policies to keep China's energy demand and pollution under control and to meet the purposes of both conserving energy and resources and mitigating climate change and protecting the environment.

3.2 Enhancing scope and level of the low-carbon city development in the context of government decentralization and unprecedented urbanization

Globally, including in China, cities have contributed to the most to economic output and have accordingly given rise to the majority of CO_2 emissions. In China, cities are responsible for more than 60% of total energy consumption, and their contribution continues to increase given the expected urbanization rate of 65% by 2030 (Li, 2014). Clearly, given such unprecedented urbanization, cities will play an even greater role in shaping energy demand and CO_2 emissions in the 13th FYP and beyond. 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 these 10 provinces and 32 cities (see Figure 2) in the context of government decentralization will test whether they can meet the challenge.

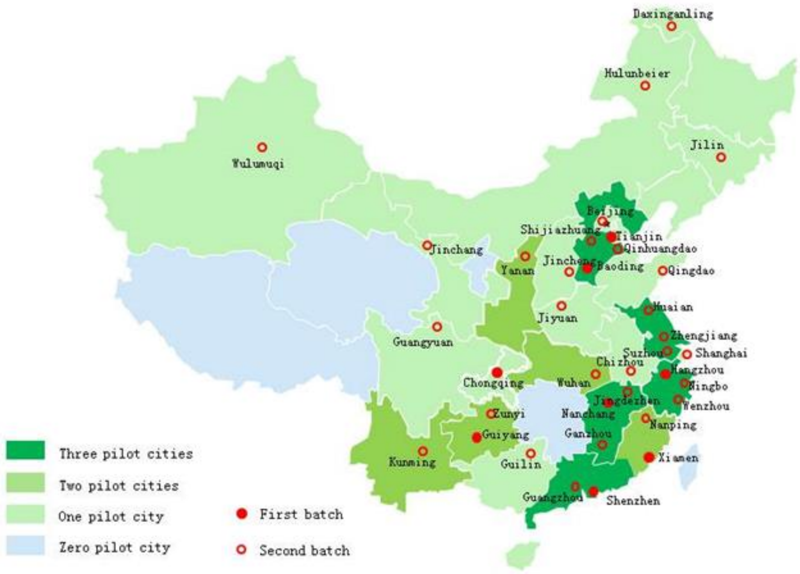

Figure 2 Two batches of low-carbon pilot cities in China
Source: Y. Wang et al. (2015).

However, the past three decades of economic reforms have witnessed a shift in the control over resources and decision-making to local governments. This devolution 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 began experimenting with low-carbon city development in five provinces and eight cities on 19 July 2010. The experiment was further expanded to a second batch of 29 provinces and cities on 5 December 2012 (Wang et al., 2013). Relative to the first batch of low-carbon pilots, the application process of the second batch of low-carbon pilots is much more transparent. The NDRC Department of Climate Change issued in April 2012 a Circular on Organization and Recommendation of Applications for the Second Batch of Pilot Low-carbon Provinces and Cities (NDRC, 2012). This Circular lays out the four conditions on which provinces or cities are eligible for applications. First, leaders of governments who attempt to bid under this low-carbon development pilot call attach great importance to green, low-carbon development. Second, such potentially hopeful regions should have set the specified targets for low-carbon development, such as their carbon intensity, the share of non-fossil fuels in the total primary energy mix, and carbon sinks and forest coverage rates in the 12th five-year plan period. Third, they should play an exemplary role in promoting green, low-carbon development and in developing innovative low-carbon development way that would be of great value to other regions. Fourth, they should compile, put forward and submit their preliminary implementation plan of low-carbon pilots (NDRC, 2012). This fourth condition is the key difference between the application of the second batch of low-carbon pilots and that of the first batch. In the application of the first batch of low-carbon pilots, the applicants only need to submit the application materials, and would not require to submit their implementation plan of low-carbon pilots until they are selected to be the pilot regions (Wang, 2012). Based on the overall assessment of the submitted materials, field visits and the experts' evaluation, 29 provinces and cities are selected of over 40 applicants in the second batch. Clearly, the low-carbon city development experiment in these selected 10 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.

All these pilot provinces and cities are making efforts towards strengthening industrial restructuring and technological upgrading, improving energy mix and energy efficiency, prioritizing public transport and promoting efficient public transport systems, and optimizing urban form. In this process, however, Wang et al. (2013) found that these provinces and cities have confronted with a variety of problems and challenges. They include, but are not limited to, 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. Moreover, the central government does not provide any preferential policies and financial support to the pilot provinces and cities, which may serve as one of their real motives for applying for the low-carbon pilots. These pilots may be given priority if low-carbon development special fund is establshed and provided in the future. But no low-carbon development special fund in place now may restrict these pilots to achieve their full potential and meet with the expectations of why these pilots are established in the first place.

While these are areas that need further improvements, there are encouraging signs that this low-carbon pilot program moves in the right direction. An NDRC evaluation revealed that the ten pilot provinces cut their carbon intensity by 9.2% in 2012 relative to their 2010 level, a rate much higher than the national average of 6.6% (NDRC, 2014a). In addition, all these pilot provinces and cities set CO_2 emissions peaks in 2030 or earlier, with 15 pilot provinces and cities even aiming for CO_2 emissions peaks in 2020 or earlier (Zhang, 2015).

3.3 Increasing the widespread use of renewable energy

From a long-term perspective, widespread use of renewable energy is a real solution. Increasing the share of renewable energies in the total primary energy supply not only enhances energy security, but also is environmentally friendly and conducive to good health. This has created a new impetus for encouraging the use of renewables worldwide. China has targeted alternative energy sources to meet 15% and 20% of its energy requirements by 2020 and 2030, respectively. The Chinese government has also identified the development of the renewable energy industry as one of the seven strategic emerging industries.

Not only is China setting extremely ambitious renewable energy goals, more importantly, China is taking dramatic efforts to meet these goals. Solar energy had been supported initially with investment subsidies through so-called “Golden Sun” program. After years of simply taking advantage of overseas orders to drive down the cost of manufacturing solar panels, feed-in tariffs for solar power were enacted in July 2011 to form its own solar power market. Wind power had benefited from the bidding-based tariffs since 2003. Since August 2009, this supportive policy for wind power was replaced by feed-in tariffs. Under this new policy, four wind energy areas are classified throughout China, based on the quality of wind energy resources and the conditions of engineering construction, and on-grid tariffs are set accordingly as benchmarks for wind power projects across the nation, respectively. With an installed capacity of 103.4 GW, China overtook the US for the first time to lead the world’s total renewable energy capacity in 2010, pushing the US to a distant second in total installed capacity of 58 GW (Pew Charitable Trusts, 2011).

However, for solar PV, the domestic solar power market is still in the initial stage of development. Both the key technology and the demand, namely, the solar PV industry, relies heavily on the overseas market. For wind power, the converter, gearbox, bearing and generator are still dominated by foreign companies or imports (Yu, 2013). So the key challenge for China in the renewable energy area is how to build from its success in the installation in the 12th FYP to further improve technology levels, in particular for those key components and parts of renewable technologies that China has still relied on foreign advanced technologies and to further enhance pace and scale of installation and use in the 13th FYP.

3.4 Harnessing the market forces to genuinely transform into a low-carbon economy

China needs to complement administrative measures with market-based approaches and tools in the 13th FYP. To date, China has relied mostly on administrative means to achieve its set energy-saving goal for 2010. Qi (2011) shows that during the eleventh five-year plan period, total CO_2 reductions 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, China has had limited success in meeting its goal. Learning from this and confronted with increasing difficulty in further cutting energy and carbon intensities, going forward, China has realized that administrative measures are effective but not efficient. It is becoming increasingly crucial that it harness market forces to reduce energy consumption and cut carbon and other conventional pollutants and genuinely transform into a low-carbon, green economy during the 13th FYP.

The Chinese leadership is well aware of this necessity. This is clearly reflected in November 2013 by the key decision of the Third Plenum of the 18th Central Committee of the Communist Party of China to assign the market a decisive role in allocating resources. This will serve as the overcharging guidance on mapping out the 13th FYP.

3.4.1. Getting the energy prices right

To have the market to play that role, however, requires getting the energy prices right 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 to move away from pricing entirely set by the central government in the centrally planned economy and towards a more market-oriented pricing mechanism, the pace and scale of the reform differ across energy products (Zhang, 2014a).

To date, the reform on electricity tariffs has lagged far behind, and accordingly the government still retains control over electricity tariffs. This complicates implementing the pilot carbon trading schemes in the power sectors in China. The latter creates a new impetus for power pricing reforms to allow the pass-through of carbon costs in the electricity sector as a result of implementing carbon trading. Thus power pricing reforms will be the key area for reform in the 13th FYP.

Natural gas prices are also the pressing area for further reform. Given coal-dominated energy mix in China, increasing a share of cleaner fuel, like natural gas, has been considered as the key option to meet the twin goal of meeting energy needs while improving environmental quality. However, natural gas price has long been set below the producers' production costs, and does not reflect the relationship between its supply and demand, or alternative fuel prices. This has not only led Chinese domestic gas producers to be reluctant to increase investments in production, but also has constrained the imports of more costly natural gas from abroad. The government has changed the existing cost-plus pricing to the "netback market value pricing" in Guangdong province and the Guangxi Zhuang Autonomous region (NDRC, 2011). 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. The pilot schemes in Guangdong and Guangxi provide the right direction to establish a market-oriented natural gas pricing mechanism. China needs to take lessons learned from the two pilot schemes and examine what kinds of adjustments and improvements are needed regarding the choice of alternative fuels, the selection of the pricing reference point and the creation of netback market value pricing formula in order to implement the Guangdong and Guangxi pilot reform program to the entire country in the 13th FYP (Gao et al., 2013; Zhang, 2014a).

3.4.2 Resource tax reform

Even if the 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 the 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 (Zhang, 2014a and 2015). The resource tax levied on crude oil and natural gas by revenue rather than existing extracted volume, which began in

Xinjiang 1 June 2010 and was then applied nationwide beginning 1 November 2011, is the first step in the right direction. China have further broadened that reform to coal, overhauling the current practice and levy on coal based on revenue beginning 1 December 2014. The Task Force on Green Transition in China of the CCICED (2014) recommends that a higher resource tax should be imposed on fossil fuels, with tax rates raised to at least 10% preferably 15% for domestic and imported coal, and to 10-15% for domestic and imported oil by 2025. This will also help to increase local government's revenues and alleviate their financial burden in order to incentivize them not to focus on economic growth alone (Zhang, 2010 and 2011a).

3.4.3 Imposing environmental taxes or carbon pricing

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. These market-based instruments, if established, will serve as a cost-effective supplement to costly administrative means on which China has mainly relied to meet its current energy saving goal.

The introduction of environmental taxes to replace current charges for SO_2 emissions and discharged chemical oxygen demand has been discussed in both academic and policy circles in China for quite some time. Draft tax law on environmental protection was released in June 2015 for public comments (Legislative Affairs Office of the State Council, 2015), but the timing of its revision and eventual passage of Chinese legislature as a law is unknown and accordingly its exact implementation date has not been set yet; the sooner environmental taxes are imposed in the 13th FYP, the better, but it should not be later than 2020. As experienced in environmental taxes in other countries, such taxes will initially be levied with low rates and limited scope, but their levels will increase over time. Moreover, environmental taxes should be shared taxes, with the majority of the revenue going to local governments.[5] However, in terms of timing, given that China has not levied environmental taxes yet, it is better to introduce environmental taxes first in the 13th FYP, 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.

The whole legislation process of amending the existing environmental law and promulgating environmental tax law takes time, and until it is completed, there is no legal basis to authorize the levy of these taxes. In the meantime, there is the pressing

[5] The central government intends to replace existing environmental fee and charge by an environmental tax. But 90% of the revenue for the environmental fee and charge goes to the local governments (Tian and Xu, 2012). That means that if environmental tax at the beginning is charged at a level that could replace the existing environmental charge and fee, the majority of that revenue should be local in order to respect current distribution of the revenue between central and local governments.

need to meet with the energy and emissions targets in a cost-effective way. I believe that a combination of these considerations motivates China to go for emissions trading. In late October 2011, National Development and Reform Commission (NDRC) (2011) approved seven pilot carbon trading schemes in Beijing, the business hub of Shanghai, the sprawling industrial municipalities of Tianjin and Chongqing, the manufacturing center of Guangdong province, Hubei province (home of Wuhan Iron and Steel, Shenzhen), the special economic zone across the border from Hong Kong.

There are features in common in these pilot trading schemes. These pilot trading schemes all run from 2013 to 2015 and, except for the Chongqing pilot where multiple gases are considered, all other pilots cover only CO_2 emissions. The pilots cover emission sources at enterprise levels, which is different from the EU and Californian emissions trading schemes which cover emissions of installations or facilities. Moreover, unlike the EU ETS, indirect emissions from both electricity generation within the pilot region and generated from the amount of imported electricity from outside pilot regions are covered in all the pilot schemes. All carbon trading pilots in China have incorporated some mechanism to address supply-demand imbalance and the resulting price uncertainty. During the pilot phase, banking is allowed, but allowances cannot be carried forward beyond 2015, which is the ending date of the pilot period. Borrowing is not authorized to improve the liquidity of the carbon market. As shown in Table 1, all pilots allow to a different degree the use of the China Certified Emission Reductions (CCERs), ranging from 5% of their CO_2 compliance obligation in Beijing and Shanghai to 10% in Guangdong, Shenzhen and Tianjin.

Table 1 The allowable use of CCERs in the seven carbon trading pilots

	Maximum allowable use as percentages of the caps (%)	Local origin requirements
Beijing	5	50%
Chongqing	8	No
Guangdong	10	70%
Hubei	10	100%
Shanghai	5	No
Shenzhen	10	No
Tianjin	10	No
CCERs have to meet the requirements of China's national monitoring, reporting and verification (MRV) regulation		

The seven pilot regions are given considerable leeway to design their own schemes. The pilot schemes have different coverage of sectors, ranging from four sectors in Guangdong to 26 sectors in Shenzhen. The threshold to determine whether an emissions source is covered differs across pilots, ranging from 5000 tCO_2 equivalent per year in Shenzhen from 2013-15 to 60000 tons of coal equivalent in Hubei. A combination of the two factors leads the number of covered entities to differ significantly, from 114 in Tianjin to 635 in Shenzhen. Consequently, the share of covered emissions in the total emissions in each pilot region varies significantly, ranging from 36% in Hubei and 38% in Shenzhen to 57% in Shanghai. Regimes differ regarding the origin of CCERs. Shenzhen specifies that all CCERs have to be generated inside China but outside the city, but Hubei requires that all have to come from inside the province (see Table 1).

Ways to allocating allowances differ across pilots. While all pilots allocate all or the majority of allowances for free, such allocations are based on grandfathering, benchmarking or in both. Even if allowances are grandfathered on a historical basis, Chongqing is based on the highest emissions in any of the years from 2008 to 2012 to reduce the effect of whipping the fast ox to the extent possible, while other pilots are based on the average emissions levels over the period 2009-12. In one given pilot, for some sectors grandfathering is based on their historical emissions, while for other sectors it is based on their historical emissions intensities.

Pilots also differ when coming to compliance. While Beijing opts out the auction to provide the last opportunity for those enterprises of shortfall allowances to meet their compliance obligations, some pilots like Shanghai and Shenzhen auction additional allowances for enterprises of shortfall allowances at the end of that trading day to comply their obligations for 2013. Even if Shanghai and Shenzhen opt for the last auction for enterprises of shortfall allowances, they reason and accordingly set their reserve price differently. While all pilots impose a fine on non-complying entities, compliance rules vary across pilots, ranging from deducting a certain amount of shortfall allowances from the amount to be allocated to non-complying enterprises in the following year to charging the non-complying entities at 3-5 times the prevailing average market prices for each shortfall allowance. Non-complying entities in the Hubei pilot face both fines and deduction of shortfall allowances. They are charged at 1-3 times the yearly average market prices for each shortfall allowance, with the amount of penalty imposed on them capped at Yuan 150000, and two times the amount of their shortfall allowances are deducted from the amount to be allocated in the following year.

Since Shenzhen launched its first trading on 18 June 2013, Shanghai, Beijing Guangdong, and Tianjin, in turn, launched their first trading prior to the end of 2013. These five pilots have to comply with their emissions obligations for the year 2013 before the first compliance deadlines, which are set in the end of the first half of 2014. As shown in Table 2, the first-year performance of the five pilots examined is generally good. The better than expected performance of the pilots encourages other regions to develop carbon trading. Meantime, there are significant variations in the MRV and the prices of allowances across the seven pilots. On top of these facts, ensuring China's commitment to cap its carbon emissions around 2030 to be met adds the urgency to further develop emissions trading scheme to complement with administrative means on which China has relied mostly to achieve its increasingly stringent energy-saving and carbon intensity goals (DCCNDRC, 2015). This raises the issue of future development of carbon trading in China.

Table 2 Five carbon trading pilots' compliance rate in the first compliance year

	Measured against enterprises (%)	Measured against allowances (%)
Beijing	97.1	Not available
Guangdong	98.9	99.97
Shanghai	100	100
Shenzhen	99.4	99.7
Tianjin	96.5	Not available

There are two ways for China to establish a national carbon market. One is to establish a nationwide emissions trading scheme (ETS) by linking those existing pilot carbon trading schemes that meet all the qualification conditions to be integrated into a national linked system. Another way is that, based on experience and lessons learned in the pilots, China establishes a national ETS, and until a full-fledged national ETS is established and works, regional ETS continues to function in parallel, but those entities covered in the existing regional carbon trading pilots will be unconditionally integrated into a nationwide ETS scheme if they meet the threshold set by a nationwide regime, which is expected to be much higher than ones set in most of the existing regional carbon trading pilots. Each of the options has its own pros and cons in China's context, and needs weighted against a variety of criteria including administrative costs.

It seems that China has opted for the second option, and that the central government will determine the coverage of greenhouse gases and scope of sectors included. One senior NDRC official announced in February 2015 that China plans to initially include six sectors in its national ETS: power generation, metallurgy and nonferrous metals, building materials, chemicals, and aviation. The threshold for an emissions source to be covered will be set at 26000 tons of CO_2 equivalent per year, giving China's carbon market estimated at three to four billion tons of CO_2 emissions (Lin, 2015). This would establish China's ETS as the world's largest scheme, twice the size of the EU ETS, the current world's largest ETS. With a three-year pilot phase, such a nationwide carbon market will become fully functional after 2019 (DCCNDRC, 2015; Lin, 2015).

However, no matter which option takes in the end, it is important to ensure that all the emissions data are properly measured, reported and verified in an aim to make each unit of emissions reduction reliable and comparable across regions. This is a prerequisite to link fragmented regional carbon markets and trade allowances across regions, and thus to ensure that a nationwide carbon emissions trading scheme functions properly in China. To that end, a national ETS legislation needs to be established to authorize emission trading at the national level, providing united guidelines and methodologies on ETS design and operation and enforcement of MRV and penalties for non-compliance at the minimum, ascribing allowances as financial assets and defining their valid duration in an aim to generate economically valuable and environmentally-credible reductions and to provide a solid basis for building a sound national ETS. The recently released interim measures for carbon emissions trading (NDRC, 2014b) moves in the right direction, but that is not enough. Not only more specific details of such interim measures need to be worked out, but more importantly the provisions governing emissions trading across regions in the form of interim measures are needed to be elevated to a level of the greater legal strength, ideally to national law. Given that process may take much time, they are needed to be elevated at least to the State Council's regulation. The necessity is at least because dispute could become more intensive and frequent as the carbon market expands beyond the institutional jurisdiction of administrative regions.

4 Concluding remarks: why might the outcomes this time be different from the previous ones?

Concerns about a range of environmental stresses, along with worries over 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, green economy. This is clearly reflected by the key decisions of the Third Plenum of the 18th Central Committee of Communist Party of China to assign the market a decisive role in allocating resources and to build ecological civilization systems and mechanisms.

This outlook is not completely new. Indeed, President Hu Jintao and Prime Minister Wen Jiabao had recognized the seriousness of environmental degradation in China, and accordingly insisted that the conventional Chinese path of encouraging economic growth at the expense of the environment has to be changed. As a first but most important step to clean up the country's development act, Messrs. Hu and Wen incorporated for the first time energy-saving and environmental goals into the national five-year economic blueprint for China. This change was a double-edged sword. It distinguished their vision of China's development from that of their predecessors, but also created a test of their leadership. Overall, China had limited success on the environmental front during their tenure.

Given that environmental compliance costs would be higher now than before and are increasing as emissions targets become increasingly stringent on the one hand and that dodging of environmental regulations is widespread and common in China on the other hand, why might the outcomes this time be different from the previous ones?

First, maintaining social harmony and stability has been the top priority in China, and the environment issue, reflected by pollution disputes and sudden environment incidents,[6] has been one of the leading causes of social unrest in the Chinese society (Zhang, 2007). If not addressed appropriately, widespread dissatisfaction and disputes could challenge the authority and legitimacy of China's Communist Party's ruling.

Second, the need for improved environmental quality has been raised to unprecedented importance. In March 2014, Chinese Premier Li Keqiang said to about 3000 delegates to China's legislature that China will "declare war against pollution as we declared war against poverty" after nearly every Chinese city monitored for pollution failed to meet state standards in 2013. If China's accomplishment and worldwide recognition of eradiating poverty could be considered as some kind of predictor, this would provide some credibility of winning anti-pollution. In line with this public acknowledgement at the highest level that China is facing an environmental crisis, as discussed in the paper, China is attempting to cap coal consumption, and is making unprecedented efforts toward upgrading the economy, eliminating outdated energy producers and industrial plants, tackling the perennial problem of overcapacity, and promoting clean and green technology.

Third, dense smog and haze has become a major issue that affects Chinese people's lives. A combination of mounting public complaints about smog and the growing standards of living not only makes people feel the necessity for more anti-pollution measures, but also increases public support for these policies and measures.

Fourth, the governments at all levels take broad approaches to tackling environmental issues. While having relied mostly on administrative means to date, China has realized that administrative measures are effective but not efficient. China is increasingly harnessing market forces to reduce its energy consumption and cut carbon and other conventional pollutants and genuinely transit to a low-carbon, green economy. Such market-based instruments include, but are not limited to, moving away from the energy pricing entirely by the central government in the centrally planned economy towards a more market-oriented pricing mechanism, reforming its current narrow coverage of resource taxation and the resource tax levied by revenue rather than existing extracted volume, experimenting with seven pilot carbon trading schemes, and implementing a system for chargeable use of resources and a system for ecological compensation. Moreover, given many environmental issues of a cross-border nature, the neighboring regions, such as the Beijing-Tianjin-Hebei region, Yangtze River Delta and Pearl River Delta, now increasingly act collectively rather than on their own. These collective and coordinated efforts significantly increase their effectiveness in combating the pollution.

Fifth, implementation holds the key to actually achieving the desired outcomes, and there are encouraging signs that the Chinese government is strengthening existing efforts and is taking additional steps in this direction. Indeed, enacting the 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,

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[6] 712 sudden environment incidents broke out in 2013 in China. While the number of such incidents was reduced to 471 in 2014, this record still means nine incidents every seven days (MEP, 2014 and 2015).

however, requires strict implementation and coordination of these policies and measures. This will be a decisive factor in determining the prospects for whether China will clean up its development act and meet its carbon intensity target in 2020 and honor its commitments to cap its carbon emissions around 2030.

Based on these facts and observations, I am cautiously optimistic that China will be able to accomplish a great deal on the environmental front. It is in China's interest to not only sustain its economic growth, but to also ensure its standing in the world community to be seen as a positive force in addressing environmental problems. If President Xi Jinping and Prime Minister Li Keqiang can make China "green," history will record their contribution as equal to Mao Zedong's achieving China's independence, and Deng Xiaoping's creation of a more prosperous country.

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