How to Manage the Chinese Coal Value Chain

by Kevin Jianjun Tu

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Executive Summary

Coal is the backbone of China's energy sector, and accounts for 95 percent of the country's proven fossil fuel reserves. In 2012, China produced 3.66 billion tonnes of coal, near half of global total. Railway is the most important mode of coal transport in China, but bottleneck of transport infrastructure has continuously been a deterrent for sector growth. China consumes near half of global coal, and the electricity industry currently accounts for half of national coal consumption in China. China first became a net coal importer in 2009, and surpassed Japan as the world's largest coal importer in 2011. In 2007, China surpassed the United States as the world's largest carbon emitter. As a result, how to appropriately regulate the Chinese coal value chain, from mining to transport to end use, lies at the heart of any solution to not only improve sustainability of China's energy sector, but also prevent global climate change.

Based on two high level coal value chain exchanges, a careful examination of the Chinese coal industry, interview of governmental officials, solicitation of expert opinions, policy debates amongst leading analysts, and field trips to different coal mining regions in China, this study identified the following policy recommendations:

- Develop a medium- to long-term national energy & climate strategy that aims to accelerate the peaking of both national coal consumption and greenhouse gas emissions.
- China should first fundamentally improve the governance of the energy sector before the country can promote the National Energy Administrative as the Ministry of Energy.
- Act immediately to improve coal statistical distortion.
- Redesign the pilot carbon pricing mechanism and make it compatible with China's national circumstances. Ideally, a nationwide revenue-neutral carbon tax should be levied by the Ministry of Finance by 2015.
- Actively encourage energy imports from demonstrably more environmentally benign sources, especially natural gas.
- Abandon national guidelines on coal production and consumption caps, and impose legally binding coal consumption caps in coastal China, and legally binding coal intensity targets in inland China.
- Simultaneously control coal-fired air pollutants and carbon emissions, especially in the electricity industry.
- To actively participate in global energy governance reform, and proactively initiate a Major Coal Economies' Forum.
An Illustrative Map of China

Note: The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by either the author or the Carnegie Endowment.
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1. Introduction

Coal is the backbone of China's energy sector, and accounts for 95 percent of the country's proven fossil fuel reserves.\textsuperscript{1} Not surprisingly, it has played a key role in the country’s economic growth especially since the Chinese late paramount leader Deng Xiaoping opened the Chinese economy to the outside world in 1978. When the People's Republic of China was founded in 1949, the Middle Kingdom’s annual coal production was only 32 million tonnes, by 1978 it had reached 618 Mt. Throughout the next three and half decades, coal production generally accelerated until 2012 when it reached the unprecedented output level of 3.66 billion tonnes, making China the world’s largest coal producer at near half of global total output.\textsuperscript{ii}

Historically, China has been a net coal exporter because of a large reserve base, low labour costs, attractive export prices, and government tax incentives. In 2003, China’s coal exports peaked at 94 million tonnes (Mt) with net coal exports at 83 Mt. Though coal prices in China has been deregulated by the central government, the pricing of retail power has long been tightly regulated by the National Development and Reform Commission. In 2009, Chinese major coal mining companies were unwilling to make concession to help Chinese utilities reduce the latter's heavy losses partly caused by high prices of thermal coal, and a prolonged dispute over contract thermal coal prices between China’s major coal enterprises and power companies and the geographic proximity between China’s coastal provinces and major regional coal export countries turned China into a net coal importer. Since then, China's coal imports grew rapidly and surpassed Japan as the world's largest coal importer in 2011. Last year, Chinese coal imports grew by 59 percent and reached 290 Mt.\textsuperscript{iii}

Since China alone is projected to account for more than 70 percent of global coal consumption growth by 2017, the shifting of China’s coal production/consumption/imports balance has the potential not only to significantly disrupt the international coal trade, but also to substantially impact global climate trajectory.\textsuperscript{iv} According to the International Energy Agency, the volume of the entire world seaborne coal trade is less than one third of China’s annual coal production/consumption. In 2012, coal-fired carbon emissions in China were 27 percent higher than national carbon dioxide emissions in the United States.

Facing both international pressure to slow its spiking carbon emissions and domestic demand to improve deteriorating local environments such as air quality and water scarcity, Beijing
understands the importance of accelerating the peaking of national coal consumption in order to meet its own energy conservation and emissions reduction goals. As a result, how to appropriately regulate the Chinese coal value chain, from mining to transport to end use, lies at the heart of any solution to not only improve sustainability of China's energy sector, but also prevent global climate change. Given the rising importance of the Chinese economy as a whole and China's energy sector in particular, Chinese decision makers are expected to pay increasingly higher attention to global governance issues especially climate change.

In the last 18 months, the Energy & Climate Program at the Carnegie Endowment has conducted an in-depth study of the Chinese coal value chain. Two high level US-China coal conferences was convened, with the first one in Beijing on October 24, 2012, and the second one in Washington DC on March 7, 2013.

The objectives of this study are to 1) comprehensively review the Chinese coal value chain, 2) identify problems and policy challenges in the Chinese coal industry, and 3) make politically plausible and environmentally sound policy recommendations that may be utilized by Chinese decision makers at the National Development and Reform Commission (NDRC) including the National Energy Administration (NEA), Ministry of Environmental Protection, State Council and other relevant departments to better regulate the Chinese coal value chain, with emphasis on moving both domestic and global climate agenda forward. Furthermore, policy recommendations in this study were made with simultaneous consideration of China's often conflicting needs of economic development, national security interests and how the nation should respond to climate change.

Based on a careful examination of the Chinese coal industry, interview of governmental officials, solicitation of expert opinions, policy debates amongst leading analysts, and field trips to different coal mining regions in China, the author is able to present an overview of the linkages between the Chinese economy and coal in section one, a comprehensive review of the Chinese coal value chain in section two, and an assessment of the policy challenges throughout the Chinese coal industry in section three. In section four, three criteria are utilized to make politically plausible and environmentally sound policy recommendations in order to better regulate the Chinese coal value chain: 1) appropriate tradeoff amongst different policy targets; 2) value added discussion to current policy debate in China; and 3) political plausibility.

While insights and feedback gained from many experts have been extremely helpful for the author to finalize the report, opinions expressed in this study nevertheless do not necessarily
represent views of either those experts or the Carnegie Endowment for International Peace, and responsibility for any errors in this study remains the author's own.

1.1 China: A Hybrid Economy at Crossroad

Since Deng Xiaoping opened the Chinese economy to the outside world in 1978, China's nominal GDP has grown at an astonishing 12.2 percent annually, reaching $5.93 trillion and surpassed Japan as the world's second largest economy in 2010.

In absolute terms, China is a big economy. Measured in purchasing power parity, the size of the Chinese economy was only 25 percent smaller than that of the United States in 2011, and the International Monetary Fund projected that China will overtake the United States as the world's largest economy as early as 2016.\(^1\) However, other forecasts compare the gross domestic products and current exchange rates of the United States and China in arguing that it will be many years before these two countries trade places.

Even so, Figure 1 shows that the size of the Chinese economy is expected to be at least comparable with that of the United States by 2035. Given that China has already overtaken the United States as the world's largest energy consumer and carbon dioxide emitter, and is expected to surpass the United States as the world's largest oil importer in 2014,\(^2\) it is increasingly difficult for China to be treated as a developing country in traditional terms especially from the perspective of industrialized nations.

Nevertheless, despite its mighty image in absolute terms, China is certainly not a developed country yet, once the country's per capita indicators are examined. In 2010, China's per capita GDP (current US$) were less than half of world average and one tenth of the Unites States, and it is projected to be still lower than world average and only one quarter of the U.S. level by 2035.

Difficult to be regarded as a developing country, but not yet to achieve the status of a developed nation, China, a hybrid economy caught between developing countries and developed nations, faces a dilemma that whether economic development should be continuously regarded as the highest political priority in years to come.

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In October 2002, the Chinese government established the ambitious goal of expanding China’s economy fourfold by 2020. One decade later, this target was rephrased by the former Chinese president Hu Jintao as securing the goal of completing the building of a moderately prosperous society in all respects by 2020.\(^3\) Although China's economic growth has been impressive so far, Beijing has to face daunting energy and environment challenges along with the country's continuous need for poverty reduction as below.

- **Energy security.** With its relatively limited domestic petroleum resources, China needs to import more oil and gas to achieve its projected development goal. With 284 Mt of net oil imports, China's dependency on foreign oil reached 58 percent in 2012. While China did not start to import gas until 2006, Chinese gas imports reached 42.8 billion cubic meters in 2012, the equivalent of 29 percent dependency rate on foreign gas.\(^4\)

To make matters worse, Figure 2 shows that China relied on politically unstable Middle East for more than 50 percent of its crude imports, about 80 percent of China's crude oil imports are transported through the strategically vulnerable Strait of Malacca. Not surprisingly, the

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\(^4\) [http://www.gov.cn/jrzg/2013-01/30/content_2323461.htm](http://www.gov.cn/jrzg/2013-01/30/content_2323461.htm)
focus of China's energy security anxiety is the vulnerability of seaborne energy imports. At present, China lacks the naval power necessary to protect its sea lanes of communication. Beijing fears that during a national security crisis ships carrying energy resources could be interdicted by hostile naval forces.

Figure 2: Routes of China’s Oil Imports

Note: The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by either the author or the Carnegie Endowment.
Source: China Customs, 2011 data.

- Environmental degradation. The heavy reliance on coal causes severe environmental impacts in China. According to a joint study funded by Greenpeace, Energy Foundation and the World Wildlife Fund, even an non-inclusive accounting indicates that coal-related environmental, social and economic externalities account for 7.1 percent losses of China's GDP.\textsuperscript{vi} Coal combustion accounted for 75 percent of sulphur dioxide, 85 percent of nitrogen,
Coal mining is water-consuming. The enormous amount of water consumed during coal mining activities lead to vegetation degradation, water loss, soil impoverishment and erosion. Amongst China's key coal mining districts, 71 percent is short of water resources, and 40 percent encounters severe shortage of water. Coal can lead to severe soil contamination. Trace metals such as mercury contained in coal can result in serious soil pollution.

Because of the over-reliance on carbon-intensive coal, China surpassed the United States as the world's largest carbon emitter in 2007. According to the author's estimation and U.S. EIA, coal-fired carbon emissions in China were 27 percent higher than national carbon dioxide emissions in the United States in 2012. As a developing country, China was exempted from emission reductions in the Kyoto Protocol in 1997. Nevertheless, under the Durban Platform for Enhanced Action, all parties of conference, no matter their stage of development, have agreed to reach a legally binding climate treaty by 2015 in order to be implemented from 2020. China is thus facing increasing higher pressure from the international community to retard its spiking carbon emissions.

- Poverty reduction. Since the start of China's open-door policy in 1978, sustained GDP growth has fueled a remarkable increase in per capita income and a decline in the poverty rate from 85 percent in 1981 to 13.1 percent in 2008. During this period, China lifted 662 million people out of poverty. Given coal's importance in China's energy sector, the availability of abundant and affordable domestic coal has certainly played an important role in poverty reduction. Meanwhile, it is worthwhile to emphasize that income disparities in China have widened. The growing income inequality is illustrated most clearly by the differences in living standards between the urban, coastal areas and the rural, inland regions. Exact statistics are disputed, and China's GINI coefficient in 2010 ranges from 0.481 released by the National Bureau of Statistics and 0.61 estimated by the Chinese Family Financial Investigation and Research Center. In 2008, 13 percent (173 million people) of China's population still lived below the $1.25/day poverty line defined by World Bank, and poverty reduction is expected to continuously be an important consideration that underlies China's national energy policy.

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5 Poverty is defined as the number of people living on < $1.25/day. Source: http://siteresources.worldbank.org/INTPOVCALNET/Resources/Global_Poverty_Update_2012_02-29-12.pdf

6 http://www.nfcmag.com/article/3919.html
2. The Chinese Coal Value Chain

The value chain is the sequential value-adding activities that convert inputs into outputs. At the industrial level, it is consisted of the different steps that are involved in producing goods/services, starting with feedstock and ending with final product/service. In this study, coal value chain is a chain of activities in the coal and related industries, from mining, transport, to end-use. Values are added to coal and coal products primarily through the following activities:

- Coal production—raw coal is extracted from coal seams at various mines.

- Coal preparation and washing (optional)—depending on the specific end-use requirement, coal preparation or washing may be needed to produce better quality coal, which results in substantially lower air emissions and less ash formation during combustion.

- Transportation—this is an essential link between coal suppliers and end users. Different transport modes including railways, seaborne vessels, inland waterway shipping, and trucking have been utilized by the industry to move coal between suppliers and end users.

- Coal end-use—steam coal is primarily consumed at power plants, industrial boilers, and residential and commercial buildings. Coking coal with higher retail values is fed into different iron and steel mills. Unlike the rest of world, coal is also an important feedstock for the Chinese chemical industry.

In the last decade, progress made throughout the Chinese coal value chain has been impressive. the Chinese Ministry of Land and Resources and the coal industry have spent significant efforts to survey and collect geological data on coal resources. While Shenhua owns and operates the world's most efficient coal mine, some of China's dedicated coal railways such as the Daqin Line are considered as the best coal railway infrastructure in the world, and more and more state-of-art coal-fired power plants are commissioned across the country. Nevertheless, although China has made significant progress to reduce its coal consumption intensity per unit GDP, rapid growth in absolute terms and wide discrepancy in terms of performance and standards have been witnessed throughout the Chinese coal value chain, leading to significant energy and environmental challenges for Chinese decision makers.
2.1 Coal Resources and Reserves

China’s coal resources cover a land area of 600,000 square kilometers (km²), encompassing 6 percent of the country’s 9.6 million km² area. The China Geological Survey reported that China’s inferred coal resources—both known and unknown reserves—total 5,555 Gt. More than 90 percent of identified coal reserves in China are in less-developed, arid areas that are environmentally vulnerable. vii

Figure 3: Chinese Coal Resource Distribution Map

Note on geological time scale: C2-P1 represents the Upper Carboniferous to Lower Permian Periods; P2, the Upper Permian; J1-2, the Lower and Middle Jurassic; K1, the Lower Cretaceous.

Source: Chinese Ministry of Land and Resources.

There are five major coal-endowment districts in China: northeast, north China, south China, northwest, and Tibet & Yunnan. As illustrated in Figure 3, 89 percent of China’s gross coal resources are located in the seven provinces of Gansu, Guizhou, Qinghai, Shanxi, Shaanxi, Sichuan, and Yunnan, the four autonomous regions of Inner Mongolia, Ningxia, Tibet, and
Xinjiang, and the municipality of Chongqing lying to the west of the Daxing’anling, Taihangshan, and Xuefengshan mountain ranges. Coal resources to the east of these mountain ranges account for a mere 11 percent of China’s gross coal resources. Similarly, 93.6 percent of gross coal reserves are located in eighteen provincial-level divisions to the north of the Kunlunshan-Qinling-Dabieshan series of mountain ranges, which include—in addition to the aforementioned Shanxi, Shaanxi, Inner Mongolia, Ningxia, Gansu, Qinghai, and Xinjiang—Beijing, Tianjin, Hebei, Liaoning, Jilin, Heilongjiang, Shandong, Jiangsu, Anhui, Shanghai, and Henan. Only 6.4 percent of gross coal reserves lie to the south of these mountain ranges. The unbalanced resource distribution largely determines the pattern of coal transportation in China, which generally follows north to south and west to east routes. 

In 2008, the Ministry of Land and Resources reported that China’s total coal reserves—its known resources—across the country’s 8,672 mining districts amounted to 1,246 Gt, which includes 326 Gt of “basic reserves” (those that are suitable for resource extraction in the near future) and 920 Gt of “prognostic reserves”. The Ministry of Land and Resources reports China’s “proven reserves” to be 170 Gt, a figure that is significantly higher than British Petroleum’s estimate of 114.5 Gt, which has not been updated for years.

In terms of coal resource distribution by type of coal, lignite accounts for 13.5 percent of China’s coal resource. Inner Mongolia and Yunnan alone possess 76.5 percent and 13.8 percent of China’s lignite resources, respectively. Low-rank bituminous coals primarily concentrate on coalfields in the Erdos Basin, Datong, south Liaoning, and Xinjiang. Coking coals are primarily produced in Shanxi, Hebei, Shandong, north Jiangsu, north Anhui, Heilongjiang, Liaoning, Xinjiang, Guizhou, Sichuan, Hunan, and Jiangxi, and Shanxi alone accounts for 55 percent of China’s proven coking coal reserves. Meager coal and anthracite are produced in Shanxi, Guizhou, Yunnan, south Hunan, west Beijing, Fujian, Jiangxi, Guangxi, Yunnan and Ningxia. Currently, quality deterioration of average Chinese coal has become an increasingly serious concern for coal consumers in China.

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7 Basic reserves are based on relatively extensive geological exploration activities. They are suitable for resource extraction in the near future or longer term. The proven coal reserves are the portion of basic reserves that can be economically recovered in the near future. Prognostic reserves are primarily based on geological inferring and modeling instead of extensive exploration activities. Total Reserves = Basic Reserves + Prognostic Reserves.

2.2 Coal Production

There are only 13 major coal mining districts or coalfields in China that are suitable for surface mining operations, and coal suitable for surface mining represents only 4.1 percent of China’s ensured reserves\(^{\text{x}}\). In the mid-1990s, surface mining accounted for only about 3 percent of national coal production\(^{\text{xi}}\). This ratio increased slightly to 4 percent in 2001 and about 5 percent to 8 percent in recent years\(^{\text{xi}}\). Though the Chinese government encourages the development of large-scale surface mines, coal output from surface mines are unlikely to exceed 10 percent of national production in the near future due to resource constraints.

Figure 4: China’s Coal Production by Type of Enterprise, 1950–2010

![Graph showing coal production by type of enterprise from 1950 to 2010](image)

Note: Underreporting represents coal statistical revisions made by the National Bureau of Statistics of China in 2006 and 2010, which has not been disaggregated by the National Bureau of Statistics of China in terms of type of coal enterprise.


There are three types of coal mines in China (see Figure 4 for a breakdown of China’s coal production according to type of enterprise). First are key state-owned enterprises, which were once supervised by the former Ministry of Coal Industry. Today, except for the Shenhua Group, the largest state-owned coal company in China, and the China Coal Energy Company, all key state-owned coal enterprises are supervised by provincial governments. State-owned mines accounted for half of national coal output in 2010. The Shenhua Group’s coal production and
sales reached 352 Mt and 441 Mt in 2010.\textsuperscript{xiv} In comparison, Peabody Energy Corporation, the world’s largest private-owned coal mining company, produced only 174 Mt of coal in the same year.\textsuperscript{xv} Moreover, Shenhua’s fatality rate was 0.025 deaths/Mt of coal in 2010, significantly lower than national average at 0.75 deaths/Mt of coal in the same year. Not surprisingly, the Chinese government is trying to promote the Shenhua model.\textsuperscript{xvi}

The second group is made up of the numerous township and village enterprises in the Chinese coal industry. Agricultural collective economic organizations or peasants invest in these mines (most are private and small) and control them. They pose a number of regulatory challenges, such as environmental degradation, tax evasion, and mining accidents, and are often blamed as the primary reason behind China's widespread coal statistical distortion, which will be discussed in detail in section 3.3.

In 1991, there were over 100,000 TVE mines in China, and the central government tried to reduce the number of operating township and village mines to 10,000 by 2010.\textsuperscript{xvii} Beijing’s national campaign to close these mines was hampered by conflicts of interests between local and central governments due to the vested interests of many local officials, making Beijing’s regulatory effort largely unsuccessful. Township and village mines accounted for about 35 percent of national coal output in 2010.

Finally, local state-owned mines are owned and supervised by local governments instead of the central government; their market share generally shows a declining trend in recent years. In 2010, local state-owned mines accounted for only 15 percent of national coal output.

Though the Chinese government has a very strong political desire to keep national coal output at around 3.9 Gt/year by the end of the 12th Five-Year Plan period in 2015, coal output in China may be significantly higher than the reference trajectory if two scenarios prove real: sizeable coal gray markets exist in China, and the official coal output statistics in recent years have been seriously underreported. Further, the Chinese government’s ambitious planning targets could prove unable to effectively prevent a domestic coal consumption spike. This happened during the 11th Five-Year Plan period (2006–2010), with the original 2010 coal production control target of 2.6 Gt/year far exceeded by an actual coal output level of 3.24 Gt/year. Fragmented governance of coal, which is discussed in detail in section 3.5, has contributed to formation of a sizable grey coal market in China.
2.3 Coal Transport

With China’s coal reserves and production largely concentrated in the north, northwest, and southwest parts of the country, major coal-consuming centers in the east and south coastal regions have only limited coal endowments, but relatively high coal-consumption levels. The long distances between China’s coal-production regions in the hinterland and consuming centers in the coastal areas make transportation one of the most important issues in the Chinese coal industry.

Rail has traditionally been the most important transport mode for moving coal within China. According to the National Bureau of Statistics, the amount of coal and coke transported by China’s national rail network increased steadily from 417 Mt in 1978 to 1,655 Mt in 2010—an average 4.4 percent increase annually. As national coal output has grown, railway infrastructure, operating at close to full capacity, has become increasingly capacity constrained, leading to bottlenecks. Currently, bottleneck of railway infrastructure has become an important driving force underlying China's rising coal imports, which is discussed in detail in section 3.4.

Railway is an ideal transport mode for hauling coal over long distance. In 2006, 37 percent of coal transported by rail moved less than 500 km, 45 percent moved between 500 and 800 km, 13 percent moved between 800 and 1,200 km, and only about 5 percent of coal transported by rail moved beyond 1,200 km in China. As a result, 1200 km is deemed as the threshold of moving coal economically in China by rail. In addition, the average coal transport distance by national railways increased steadily from 358 km in 1978 to 642 km in 2010, which further aggravated the burdens on China’s congested rail infrastructure. The share of China’s coal output transported by the national rail network has declined continuously, from 65 percent in 1978 to 46 percent in 2010, and local and joint venture railways play an increasingly important but still marginal role in China’s rail transportation sector.

Figure 5 shows China’s inter-regional coal flow by rail. In 2010, China’s inter-provincial coal flow by rail reached 1.56 Gt. Shanxi, Shaanxi, Inner Mongolia (especially the western part), and Ningxia (especially the eastern part) are primary coal supply and delivery centers in China. This

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8 Before March 2013, the National Railway Network were owned and operated by the former Ministry of Railway. Since then, it was operated by the newly established China Railway Corporation. Local railways are managed by local governments. Joint venture railways are jointly invested by the former Ministry of Railway and local governments (or enterprises or other investors).
Central south, east China, and northeast China are the primary coal recipient regions in China. In 2010, east China received 165 Mt of coal by rail, and sent 15 Mt of coal to central south China. Central south China received 124 Mt of coal by rail and sent 18 Mt to east China in the same year. In 2010, northeast China received 136 Mt of coal by rail.

Figure 5: China’s Inter-Regional Coal Flow by Rail in 2010

Since the late 1990s, rapid capacity expansion of major ports across the country increased the total cargo throughput (including coal) processed by major coastal ports from 347 Mt in 1997 to
5,484 Mt in 2010, the equivalent of 24 percent annual growth. Coal and coal products handled by major coastal ports increased from 86 Mt in 1997 to 1,163 Mt in 2010 (see Figure 6)—more than twelvefold spike or 22 percent per year. During the same period, coal production grew from 1,373 Mt to 3,235 Mt, the equivalent of an average of 6.8 percent per year. The capacity expansion of seaports thus seems to have proceeded at a rate much faster than national coal production.

**Figure 6: China’s Cargo Throughput by Major Coastal Ports, 1984–2010**

Transportation on inland waterways is another important element of the domestic coal-distribution system, carrying 484 Mt of coal in 2010 and accounting for approximately 12 percent of China’s coal output that year. Currently, coal represents an important share of shipping on the inland waterways, making up approximately 18 percent of total cargo tonnage. Inland waterway transport is expected to remain cost competitive in moving large quantities of coal along long-distance transport corridors in China. Geographic suitability and availability of port facilities, rather than freight costs, are expected to be the primary constraint to growth of inland waterway coal transport.**xx**

More and more severe capacity constraints on China’s railway infrastructure has resulted in an increased reliance on road transportation. Still, transporting coal by roadway is considered to be only supplemental to transport by rail and waterways due to the latter two modes’ economies of scale. Roads are most likely to be an intermediate mode along the supply chain, as coal travels from producers on railways to ports where it is then transported to users in coastal locations.
In addition, long-distance trucking of coal is both economically unattractive and environmentally undesirable. Transporting coal by road is not only less fuel-efficient and thus more polluting, it is also more expensive than rail transport. Road transport is generally suitable only for coal deliveries between coal-producing and coal-consuming regions that are a short distance from each other; distances that coal is transported by truck normally remain below a 500 km threshold. Nevertheless, in rare circumstances (for example, Datong to Qinhuangdao, a route that is 638 km long), this limit can be higher if a highway connection is available and other modes of transport are capacity constrained.

2.4 Coal Consumption

With limited domestic petroleum and natural gas endowments, coal has accounted for the majority of China’s primary energy consumption. In 1949, for instance, coal accounted for 96.3 percent of China’s primary energy consumption. By 1980, that number had dropped to 72.2 percent and by 2010 to 68 percent. Overly rapid growth of coal consumption has been and is expected to continuously be a primary policy challenge for Chinese decision makers, which is discussed in detail in section 3.1. In addition, the unprecedented production, transport and utilization of coal has led to numerous social and environmental impacts, which is discussed in detail in section 3.2.

Figure 7 depicts coal consumption by sector between 1980 and 2010. In 1980, power generation accounted for 21 percent of national coal consumption. The electricity industry’s share of national coal consumption increased steadily, reaching 48 percent in 2010, and is expected to keep rising in the coming decades. Other transformation industries (for example, coking, heating, coal washing) made up 16 percent of national coal consumption in 1980, and the industries’ share of national coal consumption increased to 23 percent in 2010, which is primarily driven by rising coke and heating demand. While coal chemical development may improve China’s energy security, but an overheating of this sector could lead to severe environment impacts, which is discussed in detail in section 3.6.

Industrial end use accounted for 35 percent of national coal consumption in 1980. In particular, the iron and steel industry’s share has been around 10 percent since 1980. In comparison, the share of national coal consumption going to the chemicals industry has fluctuated over time and declined moderately from 8.0 percent in 1980 to 5.7 percent in 2010. Further, nonmetal minerals’
The share of national coal consumption has also fluctuated over time and increased slightly from 7.5 percent in 1980 to 7.9 percent in 2010.

The residential sector’s share of national coal consumption dropped from 19 percent in 1980 to 3.0 percent in 2010. This development was primarily driven by increasingly stringent environmental regulation, rising environmental awareness, and access to cleaner fuel such as liquefied petroleum gas and natural gas. Finally, other end user’s share of national coal consumption shows a declining trend over time, dropping sharply from 32 percent in 1980 to 20 percent in 2010.


With large-scale installation of advanced Greenfield9 power generation plants and the accelerated retirement of small, inefficient units, thermal electricity generation efficiency in China has improved significantly in recent years. During the 11th Five-Year Plan period, the government’s mandate of lowering national energy intensity per unit GDP by 20 percent between 2005 and 2010 has encouraged the installation of supercritical and ultra-supercritical technology—currently the most efficient coal-fired electricity-generation technology—in the

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9 Relating to or denoting previously undeveloped sites for commercial development or exploitation.
power sector. Nevertheless, compared to international best practices, there is still sufficient room for China to further improve the efficiency level of its generation fleet.

Since 1978, China’s rapid economic development has propelled its power demand, growing at 9 percent annually. Due to coal’s dominance in China’s energy sector, the thermal power sector has grown at an almost identical pace as the power industry as a whole. Thermal power’s share of national electricity generation has been maintained around 80 percent between 1978 and 2010. In the Chinese context, the dominance of coal, the high cost of oil, and lack of available gas make coal-fired generation the vast majority of all thermal power.

Since 1978, coal consumption for power generation in China has increased at 7.5 percent annually, reaching 1.51 Gt in 2010. In comparison, thermal power increased at 9.0 percent annually during the same period. The lower growth rate of coal consumption can be largely explained by energy efficiency gains achieved by the power industry. For instance, average coal-fired generation efficiency in China has increased from 26 percent in 1978 to 37 percent in 2010, the equivalent of 41 percent improvement.

Industrial statistics show that the rate of electricity distribution loss was lowered from 9.64 percent in 1978 to 8.06 percent in 1990 and then from 7.81 percent in 2000 to 6.49 percent in 2010, the equivalent of a 33 percent improvement on energy efficiency during the study period. If the Chinese power sector was still operating at the 1978 efficiency level, additional coal amounting to 614 Mt would have been wasted in 2010. As a result, energy conservation is expected to continuously be the top priority in the Chinese electricity industry in years to come.

2.5 The Chinese Coal Value Chain in an International Context

Chinese coal's importance in the international context can be illustrated with ratios as below:

- China’s “proven coal reserves” were 170 Gt, representing 18.5 percent of global total and ranking the second in the world after the United States.
- In 2011, China's coal output of 3520 Mt accounted for 45.7 percent of global total, ranking No. 1 in the world.

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10 China classifies both coal and natural gas-fired power generation as thermal power.
- In 2011, the length of China's railway stood at 85292 km, ranking the second in the world after the United States.\textsuperscript{11} Coal transported by Chinese railways rank No. 1 in the world.

- In 2011, China's coal consumption accounted for 40.4 percent of global total, ranking No. 1 in the world.

- In 2010, China's coal-fired carbon emissions accounted for 46.3 percent of global total, ranking No. 1 in the world.

Though the Chinese coal value chain dominates the global stage, from proven coal resources to environmental impacts, the unprecedented exploitation and utilization of coal also lead to numerous policy challenges. Section three reviews the most pressing issues identified in this study.

\textsuperscript{11} Source: World Development Indicators online.
3. Policy Challenges

Decision makers are facing numerous policy challenges throughout the Chinese coal value chain. In this study, based on an in-depth literature review and extensive expert interview, a careful examination is conducted to select the most pressing challenges that may lead to significant impacts on not only long-term sustainability of China's energy sector but also global climate integrity. In order of its priority, with the most important one first, seven pressing policy challenges are identified as below:

- Rising coal demand and constraints of alternatives;
- Severe environmental impacts throughout the coal value chain;
- Problematic statistical reporting;
- China's rising coal imports;
- Fragmented governance of coal; and
- Dilemma of coal chemical development.

3.1 Rising Coal Demand and Constraints of Alternatives

Since 1990, the baseline year of Kyoto Protocol, the Chinese economy has grown at an astonishing 10.1 percent annually. In comparison, the country's energy consumption increased at a much slower pace of 5.2 percent annually. While the implied energy intensity gain of the Chinese economy has been impressive, China nevertheless accounts for 39 percent of global energy demand spike between 1990 and 2010. Because of China's heavy reliance on coal, the country's share of global incremental carbon emissions was 53 percent during the same period, and coal-fired carbon emissions in China alone represents 44 percent of global incremental carbon emissions.

Although the Chinese economy is projected to grow at a slower pace in the coming decades, Figure 8 shows that China is expected to still account for 36 percent of global energy demand growth and 43 percent of global carbon emissions increase. Not surprisingly, with Chinese coal alone representing 17.3 percent of the world's incremental energy consumption and 29 percent of the world's increment carbon emissions by 2030, how to accelerate the peaking of national coal consumption in China has become a legitimate question that deserves serious policy elaboration.
According to the Energy Research Institute at the NDRC, China's national coal consumption is projected not to peak until 2040 under the reference scenario.\textsuperscript{xxv} Nevertheless, with sufficient policy incentives, both the ERI and the IEA concluded that the Chinese government can accelerate the peaking of China's national coal consumption as early as 2020. To substitute coal use at scale and reduce coal-fired carbon emissions, nuclear, natural gas and renewables have all been identified by various modeling teams as promising candidates.

The magnitude 9.0 earthquake and subsequent tsunami that hit the Fukushima Daiichi Nuclear power plant in March 2011, and the severity of Fukushima accident fortunately prompted Beijing to halt approvals of new nuclear power plants pending changes to safety standards. As a result, the Chinese government has significantly tightened the country's nuclear safety standards when the State Council approved the resumption of nuclear power plant construction in October 2012. Nevertheless, the Chinese government plans to restrict the number of new nuclear reactor approvals to a "small amount" by 2015, and will only allow them to be build in coastal region instead of inland China. All inland nuclear power projects have been suspended. China's 2020 nuclear target is widely expected to fall to 60 to 70 gigawatts (GW), and the country needs to overcome numerous technical and safety barriers before further increasing its nuclear capacity.

Natural gas is often seen as an ideal option to optimize China's unsustainable energy mix. Gas could improve the country's environment because of its lower air pollution and carbon emissions.
With only 1.5 percent proven gas reserves in the world, China needs to significantly ramp up its gas imports or look for alternative resources. Given the energy security concern, exploring alternative resources domestically is apparently more attractive from the perspective of Chinese decision makers. According to the U.S. Energy Information Administration, China has more technologically recoverable shale gas than any other country in the world, but there are many barriers that will prevent China from duplicating America's success. The difficult geology in China, lack of technical expertise, China's inability to attract investment from smaller players from either China or foreign countries, the legal vacuum for shale gas development (including licensing, exploration and production), a lack of intellectual property rights protection for technology, relatively low gas prices in China, a dearth of easily recoverable fields for new entrants and environmental impacts of hydraulic fracturing all are deterring investment.

Renewable development in China has been very impressive in the past decade, with wind as China’s third-largest energy source, behind coal and hydropower. Nevertheless, 20 percent of China's wind capacity currently remains unconnected to the grid. Beijing needs to resolve this issue before wind development can be sustained in the future. While China has the world's largest solar panel manufacturing capacity, Chinese companies have long relied on overseas market for capacity expansion. Overcapacity and heated competition results in not only prolonged price drop but also a dangerous capacity utilization rate at less than 60 percent, which are further aggravated by anti-dumping and anti-subsidy investigations targeting China's PV manufacturers in both US and EU. While the Chinese government plans to increase the country's installed solar capacity to at least 36 GW by 2015, how to resolve the severe overcapacity issue across the solar manufacturing industry and the similar grid connection obstacle that retards China's wind potential are expected to be difficult.

Finally, though China's 12th Five Year Plan for the Energy Sector aims to actively push forward with large hydro development in the Nu (Salween), Lancang (Mekong) and Yalongzangbu (Brahmaputra) river basins. All the prospect development are located in ecologically sensitive and seismically active regions of Yunnan province and Tibet, and all along internationally shared rivers. Not surprisingly, opposition against large dam construction from China's southeast Asian neighboring economies are expected to continuously retard China's hydro ambitions in the years to come.

12 http://business.sohu.com/20130104/n362282621.shtml
3.2 Severe Environmental Impacts throughout the Coal Value Chain

China has long been the world's largest coal producer and consumer, however, the unprecedented exploitation and utilization of coal has also created many environmental and social challenges. First of all, China's heavy reliance on carbon-intensive coal has made the country surpassed the United States as the lead in carbon emissions in 2007. Figure 9 shows that China's carbon emissions have grown steadily over time especially after 2000. In 2012, coal-fired carbon emissions in China alone were 27 percent higher than national carbon dioxide emissions in the United States, and China's absolute carbon emissions are expected to rise substantially by 2020. As a result, how to accelerate the peaking of China's national coal consumption lies in the heart of any climate strategy for not only China but also the rest of the world, which is the primary environmental impact address in this study.

Figure 9: Fuel Combustion Carbon Emissions: China vs. U.S., 1949-2012


Other major coal-related social and environmental impacts that are not directly tackled in this study include:

- The physical disturbances: There are only 13 major coal mining districts or coalfields in China that are suitable for surface mining operations, and coal suitable for surface mining represents only 4.1 percent of China’s ensured reserves. As a result, the physical disturbances of coal mining activities in China have been minimized by the dominance of underground
coal mining. Nevertheless, given the scale of China's coal industry, the impacts should be alleviated by improved mining practices.

- **Subsidence and settlement**: Underground coal mining subsidence has plagued many coal mining districts in China. Existing statistics indicate that mining subsidence area is around $6 \times 10^5$ hm$^2$ in China and half of the annual increase of land supplement is caused by mining activities. Meanwhile, there are 15000 hm$^2$ farmland which was occupied by gangue hills and the increasing speed of gangue is 0.15 - 0.2 billion tons annually. Currently, many scholars indicated that mining subsidence, villages relocation, solid waste accumulation are the main reasons of land occupation and destruction in mining areas.xxvi

- **Water-related issues** are of great importance to China’s coal supply chain. At present, many areas in China are suffering from water scarcity, as well as fragile ecosystems. Especially in Northwest China, enormous coal reserves will be exploited in the near future, and a large number of large-scale coal industries are on the agenda, while water shortage remains a severe problem. Further, waste water discharged by the coal industry pollutes the local environment and damages the water system. By 2030, coal-fired power generation will still account for the largest part of water use in the coal supply chain.xxvii

- **Coal fires**: It is estimated that about 20 Mt of coal are being burnt in uncontrolled coal fires in China each year. Beyond the huge economic losses resulting from uncontrolled combustion of high-quality coal deposits, another problem is the enormous environmental stress that results from coal fires. Large amounts of toxic pollutants and greenhouse gases are emitted from the fires polluting the atmosphere. Chinese coal fires alone are estimated, to emit a yearly amount of about 66 Mt of carbon dioxide equivalent.xxviii

- **Fugitive methane**: In 2007, CMM emissions in China reached 19.3 billions of cubic meters, most of which contributed by the state-owned mines with high-gas content. Although the total amount of coal mine methane (CMM) emissions in China is great, about six times of that in the U.S., its contribution to global warming is relatively small, about 5 percent, when compared with CO$_2$ emitted from the fossil fuel consumption in China. Ventilation air methane accounts for 65-70 percent of the total CMM emissions in China.xxix

- **Coal mine safety**: Since the inception of the People's Republic of China in 1949, more than 250,000 miners have died in China’s numerous coal mine accidents. However, the coal mine safety record in China is full of controversy. Guo et al. (2006) reported that annual fatalities
were as high as 70,000, and independent estimations suggest that annual coal mine fatalities were about 40,000 in 1980s, 20,000 in 1990s and 10,000 at the beginning of this millennium.

- **Bottleneck of transport infrastructure and related impacts:** The requirements of moving increasingly higher amount of coal between coal producers in North China and coal consumers in coastal provinces have imposed high toll on China's transportation infrastructure, and bottleneck of the railway infrastructure has long been a serious policy concern. During coal transportation process, dust emissions are probably the most common nuisance or disturbance issues, and road damage can result from the transportation of coal from mines and coal processing facilities.

- **Deteriorating air quality in many urban centers and adjacent regions:** Airborne emissions of gaseous or solid oxides are one of the principle environmental concerns with coal combustion. Air pollution in China is alarming much of the time, but in early 2013 the problem became so acute that it made international headlines. Fine particulate especially PM2.5, pollutant particles smaller than 2.5 microns in diameter -- PM 2.5, is a critical air pollutant of concern for human health because it is small enough to reach the lung's most sensitive tissues, where it can facilitate infections and induce cancers. A report prepared by Deutsche Bank Market Research indicates that coal combustion accounts for 40 percent of China's national PM2.5 emissions.

- **Discharge of solid byproducts:** Coal ash is China's largest source of solid waste. With over 1400 coal-fired power plants scattered across the country, China produces at least 375 Mt of coal ash annually. Unfortunately, the Chinese government significantly underestimates the quantity of coal ash in the environment, largely because the rate of coal-ash recycling has been vastly exaggerated to 60%. According to testing conducted by Greenpeace, coal ash from the 14 power plants contains more than 20 kinds of heavy metals and chemical compounds. In testing samples of surface water and well water from near disposal sites, Greenpeace found that concentrations of various harmful substances exceeded standards for drinking and irrigation water by multiple times.

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3.3 Problematic Statistical Reporting

China’s energy statistical collection system was initially developed—and functioned well—under a planned economy, with the assumption that all units producing, transforming, delivering and consuming commercial energy would provide complete and accurate reports. As China quickly moved toward a market economy, however, the energy activities outside of the state-owned enterprises grew rapidly. For instance, the percentage of coal produced by township and village coal mines increased from 18% in 1980 to 49% in 1995. Yet no reliable mechanisms were in place to collect the coal statistics from small, non state-owned mines, so the quality of China’s coal statistics deteriorated over time.

With the intention of alleviating environmental degradation and improving the safety record of the coal mining industry, the Chinese government launched a campaign to close small, non state-owned coalmines in 1997, imposing a stringent national production cap on the coal mining industry. As the aged state-owned coalmines became increasingly unable to keep pace with the demand spike fueled by the booming economy, however, many of the small coalmines that were ordered to be shut down during the campaign managed to survive. Allured by the tax revenue, local governments in coal mining regions were unwilling to comply with the central government’s production cap and simply underreported the coal supply and demand within their geographic boundaries.

Inflicted by serious staffing shortages, the NBS headquarters struggled to compile the country’s energy balance tables, let alone conduct investigations for suspicious claims. As doubts were raised about the accuracy and reliability of the coal statistics, the NBS resorted to dependence upon spokespersons defending their numbers and quoting various explanations such as efficiency gains, economic structural changes and fuel substitution. Eventually, pressure on energy demand prompted NBS officials to revise historical coal statistics in 2006. Since both the extent and coverage of the 2006 statistical revisions were considered to be insufficient, the NBS revised China’s coal supply statistics in 2010 and is expected to keep doing so in the future. Nevertheless, the revision methodology and procedure have not yet been transparent to outside parties.

Figure 10 compares the most recent national coal output reported by the central government with provincial summation of coal production in China. Before 1995, national coal production in China generally equals to the summation of coal output in all Chinese provinces. Since then, underreporting of coal output became increasingly rampant across the country. In 2000, the
revised national coal output was 43.3 percent higher than summation of coal output at the provincial level. While the aforementioned discrepancy became less a concern around 2005, coal statistical distortion has moved towards a reversed direction during the 12th Five Year plan period. In 2011, national coal production reported by the central government were 10 percent lower than summation of coal output in provincial level.

**Figure 10: Comparison of Coal Output: Provincial Summation vs. National Reporting**

Note: Percent of discrepancy is based on the ratio between the sum of 2006 and 2010 revisions and original coal production statistics.

Source: NBS (various years-b).

Similarly, the summation of coal consumption in all Chinese provinces and autonomous regions is significantly higher than aggregate coal consumption data at national level reported by the NBS in recent years. Taking coal imports/exports, storage change and losses in coal washing and dressing into consideration, unexplainable amounts of coal consumption at the provincial level have increased rapidly since 1990 and first peaked at 561 Mt in 2001, when underreporting of coal statistics was officially recognized as one of the most serious years. Since then, the grey picture of coal statistical distortion in China has only improved marginally by 2005 and rebounded sharply thereafter, reaching 512 Mt in 2008.xxxii

Even reporting of national coal imports cannot be exempted from statistical distortion. Indonesia has been China's largest sources of coal imports in recent years. According to China Customs, China imported 64.7 Mt of coal from Indonesia in 2011. In comparison, BPS Statistics of
Indonesia reported Indonesia exported 104 Mt of coal to China in the same year, 61 percent higher than the level reported by China. While the aforementioned discrepancy is likely to be caused by China Customs' questionable practice of ignoring coal imports with heating content below certain threshold, the sharp contrast again suggests the accuracy of China’s coal statistics as a whole is problematic.

### 3.4 China’s Rising Coal Imports

Historically, China has been a net coal exporter. In 2003, China’s coal exports peaked at 94 Mt with coal imports at 11 Mt. Since China produced 1,835 Mt of coal and consumed a similar amount in the same year, imports had very little impact on China’s overall coal balance at the time. Just a few years later, in 2008, China’s coal situation would markedly change when China’s imports and exports equalized. In 2009, China imported 126 Mt of coal and became a net coal importer for the first time. In 2011, China surpassed Japan as the world's largest coal importer. In 2012, China's coal imports increased by near 60 percent on a year over year basis, reaching 290 Mt. While this paled in comparison to the country’s total coal production of 3,660 Mt in 2012, China has nevertheless become the most dominant player in global coal market.

![Figure 11: China's Coal Imports by Country vs. Coal Exports](source: China Customs.)
As the amount of China’s coal imports has drastically increased, so too has the number of its coal trade partners (Figure 11). Currently, Indonesia and Australia are the two largest overseas coal suppliers to China. Since 2008, these two countries accounted for near half of China’s total coal imports. But there is a difference in the mixture of products coming from each of the two suppliers. Indonesian exports to China are dominated by steam coal, which is suitable for producing steam and mainly used in power generation. In comparison, coking coal, which is primarily used for industrial processes like iron and steel production represent the majority of Australian coal exports to China.

Once a largely isolated coal market, China now plays an increasingly important role in shaping global trade flows and increasing price fluctuations in world coal markets. Understanding the key forces driving Chinese coal imports is necessary for assessing the global implications of China’s international coal trade. There are several factors that could be influencing China’s coal-importing decisions.

- **Transportation bottleneck**: the majority of China’s coal resources are located in western and northern inland provinces. In contrast, many major coal-consuming centers are located along China’s heavily populated eastern and southern coastline, where less than 5 percent of China’s proven coal reserves are located. This unbalanced coal resource distribution and consumption pattern means that coal must be transported long distances via railways, roads, or waterways (both inland river and coastal marine transport) from the west to the east and from the north to the south, and integrated railway and coastal marine shipping is the most important mode of coal transport in China. Since China’s Ministry of Railways is both the regulator and the monopoly operator of China’s national railway network, a lack of competition has led to insufficient investment in coal rail lines thus far, and railway has long been the weakest link of the Chinese coal transport systems. From the perspective of the Chinese government, rising coal imports might be encouraged as a way to ease China’s deteriorating transportation bottlenecks.

- **Environmental and safety considerations**: the environment could also play a part in China’s coal-importing decisions. Importing coal from overseas markets might enable the Chinese central government to close down many small and inefficient mines and prevent similar mines from being opened up, thereby protecting local environments. China could view importing coal rather than mining it domestically as one possible strategy for reducing its coal-related carbon footprint. This, however, would merely shift the burden of coal production–related carbon emissions to other nations whose coal China imports, doing no
good to stop rising global greenhouse gas emissions. Coal mining can be an unhealthy and
dangerous profession if it is not regulated appropriately. Since the creation of the People’s
Republic of China in 1949, official statistics put the number of Chinese coal miners killed by
mining accidents at more than 250,000. Rising coal imports should make it easier for China
to continuously close or consolidate small and unsafe mines, leading to improved safety
performance in the coal industry.

- **Market factors and coal supply**: based on Chinese buyers’ behavior in the past, prices will
likely be a significant factor for future coal imports. Squeezed by regulated electricity prices
and looking to minimize costs, many Chinese buyers may import heavily when international
prices are relatively low and rely on domestic coal when international prices are relatively
high.

- **National cap on coal production**: during the 12th Five Year Plan period, the Chinese
government plans to cap national coal production around 3.9 billion tonnes by 2015. Given
the fact that national coal output has already reached 3.66 billion tonnes in 2012, the
disparity between government production quotas and national coal demand is expected to
stimulate China's coal imports over time.

- **Coking coal resource constraint**: China is rich in coal, but not all types. Coking coal,
compared to steam coal, is a relatively scarce resource as it only represents about one-quarter
of China’s total coal reserves. According to the National Administration of Coal Mine Safety,
China’s total coking coal reserves, 55 percent of which are located in Shanxi, account for 13
percent of the global total. Faced with specific coal resource constraints, the Chinese
government might prefer importing coking coal to buttress supplies and protect domestic
coking coal reserves from depletion.

- **Domestic coal trade pattern**: unlike the United States where coal miners and utilities are
comfortable with long-term contracting of thermal coal, Chinese coal enterprises and major
utilities need to meet annually to negotiate contract prices of thermal coal. Even if a contract
is signed, execution of the contract is not guaranteed once price fluctuation is considered as
too substantial by either party. In addition, Chinese utilities often source a significant portion
of their coal input from the spot market, and there generally lacks hedging mechanisms in
China for either coal producers or utilities to minimize price-related risks. Bottlenecked with
transport infrastructure, coal shipped from inland China often become less competitive than
coal produced in other part of the world.
Quality deterioration of domestic coal: As low sulphur coal is mined first in China, average sulphur content of Chinese coal is expected to rise over time. Further, China only has a low proportion of high-quality coal reserves, that are depleted at very fast pace. As a result, the average heat content of Chinese coal declined from 21.1 GJ/tonne in 2005 to 20.7 GJ/tonne in 2010, the equivalent of a two percent quality deterioration during the 11th Five Year Plan period. Declining coal quality will lead to intensified mining activities, and will further strain coal production and transport capacity in China. Finally, transporting more coal to consumers will translate into higher volume of electricity and fuel use across different transportation modes.

3.5 Fragmented Governance of Coal

Since 1949, the governance structure of the Chinese coal industry has witnessed continual change. The former Ministry of Coal Industry (MCI) has been created and abolished, several times. Since 1978, state-owned coal mines became encumbered by heavy welfare obligations to their bloated workforces and millions of retired workers. Unable to meet the burgeoning demand for domestic coal, Beijing had to encourage private investment in the coal industry. As a result, the share of coal production by township and village enterprises (TVE) grew from 15.4 percent in 1978 to 46.2 percent in 1995. In 1998, the MCI was finally abolished.

With the emergence of the NEA under the NDRC in 2008, the era of the centralized governance for the Chinese coal industry has been permanently ended. In 2010, the creation of the National Energy Commission is another attempt by Beijing to nationally coordinate China’s energy sector. In 2013, the Electricity Regulatory Commission was merged with the NEA under the NDRC. Nevertheless, the management responsibility of the Chinese coal industry is still fragmented among many governmental agencies. See Table 1 below for more detail.

Broadly speaking, there are five stakeholder groups in the Chinese coal industry:

- The government group is the most powerful stakeholder in the Chinese coal industry. Nevertheless, it is not uniform since viewpoints may differ at national, regional and local levels. Coal-producing regions often have different interests than those that use coal or suffer the consequences of coal use, and local administrations may emphasize different goals from those from the central government.
The industrial group, typically represented by managers and owners, covers upstream and downstream sectors, and includes industry associations, as well as coal transporters and traders.

Experts and research institutes, whether serving one of the other groups or behaving independently, play an important role in developing and deploying new technologies and policies, and in shaping ideas about what is desirable and possible.

Labor is considered as a separate stakeholder group since, historically and currently, the interests of ordinary workers and management have not always coincided.

The group of ordinary citizens can only exert minimum influence on the development of the Chinese coal industry though non-governmental organizations and individuals have become increasingly vocal in China.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Group</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Department of the NEA at the NDRC</td>
<td>Central Government</td>
<td>Prepares national plans for the coal industry, sets policy and approves new mines.</td>
</tr>
<tr>
<td>Coal Division of the Economic Operations Bureau at the NDRC</td>
<td>Central Government</td>
<td>Responsible for day-to-day management of the industry. It formulates annual production plans, guides coal transport plans and issues production licenses. It is also responsible for CDM projects under the Kyoto Protocol.</td>
</tr>
<tr>
<td>State Administration of Coal Mine Safety</td>
<td>Central Government</td>
<td>The SACMS under the State Administration of Work Safety (SAWS) oversees safety at coal mines across the country.</td>
</tr>
<tr>
<td>Ministry of Land Resources</td>
<td>Central Government</td>
<td>The MLR is responsible for coal resource management. The Geological Prospecting Division examines, approves and issues prospecting licences. The Mineral Development and Administration Division issues mining licences;</td>
</tr>
<tr>
<td>State-Owned Assets Supervision and Administration Commission</td>
<td>Central Government</td>
<td>The SASAC owns key state coal enterprises, but is supposedly not to directly intervene daily operations of those coal enterprises. Nevertheless, the SASAC is concerned with operation efficiency, and is authorised to close or declare bankrupt of those mines that are not economically viable;</td>
</tr>
<tr>
<td>Ministry of Environmental Protection</td>
<td>Central Government</td>
<td>The MEP is responsible for approving environmental impact assessments for new mines, submitted during the feasibility stage, and monitors coal mining operations for any breaches of pollution control regulations.</td>
</tr>
<tr>
<td>State Administration for Industry and Commerce</td>
<td>Central Government</td>
<td>The SAIC issues and updates business licences and conducts field inspections.</td>
</tr>
<tr>
<td>Ministry of Industry and Information Technology</td>
<td>Central Government</td>
<td>MIIT is responsible for clean production, industry management and information technology in coal-related sectors.</td>
</tr>
<tr>
<td>Ministry of Commerce</td>
<td>Central Government</td>
<td>The Foreign Trade Division of MOFCOM issues coal import and</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Group</td>
<td>Responsibility</td>
</tr>
<tr>
<td>--------------------------------------</td>
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</tr>
<tr>
<td>Ministry of Railway</td>
<td>Central Government</td>
<td>The MOR is both the regulator of China’s rail transport industry, and the operator of the majority of the country’s railway network.</td>
</tr>
<tr>
<td>Ministry of Science and Technology</td>
<td>Central Government</td>
<td>The MOST funds coal-related R&amp;D projects.</td>
</tr>
<tr>
<td>Provincial Coal Management Authorities</td>
<td>Provincial Government</td>
<td>Either provincial Administration of Coal Industry, or Bureau of Coal Industry, or provincial commission of Development and Reform, or other relevant agencies.</td>
</tr>
<tr>
<td>Bureau of Coal Mine Safety</td>
<td>Provincial Government</td>
<td>Under direct supervision of the SACMS to oversee safety of local coal mines.</td>
</tr>
<tr>
<td>China National Coal Association</td>
<td>Industrial Group</td>
<td>CNCA is a non-profit organization funded by membership fees from coal mining enterprises. It serves as a bridge between enterprises and government and in practice also complements the NDRC for outsourced work such as the preparation of drafts of industrial policies, and the collection of coal statistics.</td>
</tr>
<tr>
<td>China Coal Transport and Distribution Association</td>
<td>Industrial Group</td>
<td>CCTD is one of the subsidiary industrial associations under the CNCA, it primarily focuses on the transportation and marketing components of the coal value chain.</td>
</tr>
<tr>
<td>Key State-owned Enterprises</td>
<td>Industrial Group</td>
<td>Under China’s past central planning system, centralised-allocation mines were directly managed by the central government; since 1993, they have been renamed as key state-owned mines. After the Ministry of Coal Industry was demolished in 1998, authority over key state-owned mines was devolved to local governments.</td>
</tr>
<tr>
<td>Local State-owned Enterprises</td>
<td>Industrial Group</td>
<td>Local state-owned mines were managed by provincial or county-level governments. The ownership of local SOE mines has been increasingly blurred by the investment from both key SOE mines and private sector.</td>
</tr>
<tr>
<td>Township and Village Enterprises</td>
<td>Industrial Group</td>
<td>TVE mines were managed by township or village governments. In reality, they are often private mines owned by individuals.</td>
</tr>
<tr>
<td>Utilities</td>
<td>Industrial Group</td>
<td>Big Five including Guodian, Datang, Huaneng, Huidian and China Power Investment Corporation are China’s leading electricity producers. Other important players in this segment include Sinohydro, Gezhouba, State Grid, provincial and local generators. Major utilities are still struggling to establish long term supply agreements with major coal mining enterprises to avoid dispute on contract thermal coal prices in the future or enter the coal mining business by themselves.</td>
</tr>
<tr>
<td>Other Major End Users</td>
<td>Industrial Group</td>
<td>Other major coal end users in China include iron and steel mills, cement and other building material producers, and coal chemical plants. These coal users are currently paying higher prices for coal than utilities in China.</td>
</tr>
<tr>
<td>Coal Experts</td>
<td>Expert and Research Institute Group</td>
<td>Some serve one of the other groups, and some may be considered as independent. Their influence in China’s coal industry is highly dependent on personal connection with other groups.</td>
</tr>
<tr>
<td>China Coal Information Institute</td>
<td>Expert and Research Institute Group</td>
<td>CCII is a leading coal research institutes under the leadership of its President, Prof. Shengchu Huang. It currently focuses on coal mine safety, coal bed methane utilization, carbon capture and storage, and annual outlook of the Chinese and world coal markets.</td>
</tr>
<tr>
<td>Employees of State-owned Mines</td>
<td>Labour Group</td>
<td>Salary and work conditions of this sub-group are above industrial average.</td>
</tr>
<tr>
<td>Migrant Peasants</td>
<td>Labour Group</td>
<td>The most powerless social group in China, they have minimal</td>
</tr>
</tbody>
</table>
### Stakeholders Group Responsibility

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Group</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>workers in Coal Mines</td>
<td></td>
<td>influence on the development of the Chinese coal mining industry.</td>
</tr>
<tr>
<td>Citizens in neighbouring communities of coal mines</td>
<td>Citizen Group</td>
<td>They are often forced to confront coal mining enterprises due to social and environmental impacts on their neighbourhood by coal mine development.</td>
</tr>
<tr>
<td>Other Chinese Citizens</td>
<td>Citizen Group</td>
<td>They are increasingly vocal to express their concerns on mine safety, environmental degradation and other coal-related pressing issues.</td>
</tr>
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</table>

Source: International Energy Agency and expert interview.

#### 3.6 Dilemma of Coal Chemical Development

Unlike most parts of the world, coal has long been used as a dominant fuel and feedstock in the Chinese chemical industry due to resource constraints. The aggregate energy consumption in the Chinese chemical industry has increased by 95 percent since 2000, reaching 361 Mtce in 2010. During the same period, coal and coke inputs have increased by 55 percent and 54 percent, reaching 169 Mt and 18 Mt in 2010. As a result, coal and coke’s share in the energy mixture of the Chinese chemical industry has been lowered from 48 percent in 2000 to 38 percent in 2010. Nevertheless, considering the looming potential of coal-to-liquids (CTL) and other coal chemical development across the country, the Chinese chemical industry’s reliance on coal may rebound in the future.

Coal chemical industry is the process that uses coal as raw material to produce gases, liquids and solids, which are then used to synthesize a series of chemicals. Traditional coal chemical industry generally refers to gasification, liquefaction, coking, processing of coke and coal tar, calcium carbide industry and uses of coal as raw material to produce coal-based derivatives through oxidation- and solvent extraction processes. The new coal chemical industry is based on C1 chemistry knowledge to synthesize coal-derived fuels and chemicals from syngas through large scale coal gasification (Xie 2005). Currently, major end products of the Chinese coal chemical industry can be categorized under the following five technological routes: coking, coal gasification, coal liquefaction, coal to chemical products and Coal to calcium carbide.

In this study, coal liquefaction is used as an example to demonstrate the complexity of regulating coal chemical development in China. In early 2000s, over 80 potential coal-to-liquid (CTL) projects have been announced in China. After Beijing realized that the sector was at risk of growing too quickly, the NDRC announced in 2006 that it would not approve the construction of any further CTL projects before the technology has been successfully demonstrated. In August
2008, the NDRC put a halt on all new CTL project approvals until these technologies can be proven by ongoing industrial scale experiments. Table 2 lists major existing coal chemical facilities in China including three coal to liquids projects as below:

- Shenhua began the installation of the world’s first commercial scale direct coal liquefaction plant in Inner Mongolia in August 2004. With an annual capacity of 1.08 Mt of oil output per year, the first phase of this project has a price tag at $12.3 billion RMB. A trial operation of the plant in December 2008 achieved continuous operation of 303 hours.

- In February 2007, Luan Group started the construction of its 160 kt / annum indirect CTL demonstration plant in Shanxi. The total investment of the project is $3.5 billion yuan. In December 2008, Luan’s demonstration plant produced China’s first barrel of coal-based synthetic oil.

- In May 2006, Yitai Group, China’s largest private coal mining enterprise, began the construction of its 160 kt / annum indirect CTL plant. The total investment of the project is $2.5 billion yuan. On March 23, 2009, Yitai announced that the trial operation of its demonstration plant was successful with its diesel product meeting the Euro IV standard.

<table>
<thead>
<tr>
<th>Table 2: Major Coal Chemical Facilities in China</th>
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<tr>
<td><strong>Type</strong></td>
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<td>Coal to Liquids</td>
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<td>Coal to Gas</td>
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<tr>
<td>Coal to Olefins</td>
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<tr>
<td>Region</td>
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</tbody>
</table>
| Shenhua in Ningdong | 600 kt   | 2011 | Capacity factor of gasifier and MTP reactor reached 75% and 105%, recovery rate of propylene reached 29.05%.
| Datang in Duolun  | 460 kt   |      | Capacity factor reached 70%.                       |

Source: Changjiang Securities.

Given the contrast between China’s relatively limited petroleum endowment and its abundant coal resources, the successful commercialization of both direct and indirect coal liquefaction techniques can prepare China well in case of a potential oil supply disruption or long term oil price hike in the international market. Nevertheless, there are some important negative aspects of CTL that offset the advantages it appears to bring, namely that CTL has: 1) intensive water requirements: 3-4 tonnes of water per tonne of products for direct CTL, and 4.5-5.5 tonnes of water for indirect CTL; 2) impacts on local air quality; 3) coal-combustion related carbon emission and process GHG emissions; 4) substantial energy efficiency losses in the coal-to-oil conversion process, which contradicts with China’s 16 percent energy intensity reduction goal set by the 12th Five Year Plan: 3-4 tonnes of coal per tonne of products for direct CTL, and 4.5 to 5.5 tonnes of coal per tonne of products for indirect CTL; and 5) significant financial risks associated with the wide fluctuation in world oil prices. As a result, developing technologies to produce biofuels on the basis of lignocelluloses, introduction of electrical vehicles or relying on natural gas for more transport fuel use may represent a better alternative to reduce China’s dependence on oil.

At the beginning of the 12th Five Year Plan period, there are increasingly higher pressure from local governments in China's coal production districts to kick off coal chemical development to attract large sum of investment, move up value chain from low value-added raw coal to higher value-added chemical products. In March 2013, the NDRC approved 10 new coal chemical projects in China, including one coal liquefaction project, 5 coal to gas plants and 4 coal to olefins facilities. If similar approval are issued by the central government in the future, the implication on China's carbon emissions trajectory is expected to be quite significant.
4. Policy Recommendations

China's impressive economic growth since 1978 and its unique success in lifting millions of Chinese out of poverty - fuelled primarily by abundant and affordable domestic coal - has drastically changed the perception how the country is viewed by the outside world. Although the Middle Kingdom is no longer regarded by many as a developing country in traditional terms, the country still has a long road ahead before it can achieve the status of a developed nation. As a hybrid economy at a crossroad caught between developing countries and developed nations, China faces many energy policy challenges including how to simultaneously sustain social and economic growth, ensure energy security and improve environmental integrity, and it is extremely difficult to design policy instruments for China that address all the aforementioned challenges without making difficult trade-offs.

The complexities of the trade-offs involved can be best illustrated in how to regulate the Chinese coal value chain, from mining to transport to end use. On the one hand, coal is the backbone of China's phenomenal social and economic rise in the past, and it is expected to be continuously relied upon to sustain the country's economic development including poverty reduction in the years to come.

China’s heavy dependence on indigenous coal brings benefits in terms of energy security. The conversion of coal to chemicals, liquid fuels, and synthetic natural gas can allow an even greater reliance on its domestic resources than possible in many other countries. Recently, the Chinese government has encouraged state-owned energy companies to invest in coal mines outside of China to secure external coal supplies that would further enhance China’s energy security. It is worthwhile to emphasize that strengthening China's energy security with coal may often be incompatible with the country's efforts to improve environmental integrity.

The unprecedented exploitation and utilization of coal in China has caused serious damage to local ecology and environment, and also resulted in increasingly substantial carbon emissions. According to the International Energy Agency, around 80 percent of total energy-related carbon emissions permissible by 2035 to limit warming below two centigrade have already been locked by existing power plants, buildings and factories, leaving little room for more consumption of fossil fuel especially coal.\(^\text{16}\)

\(^{16}\) http://www.reuters.com/article/2012/05/16/us-energy-summit-iea-idUSBRE84F0Z820120516
Under a carbon-constrained world where developed countries have not made serious efforts to reduce consumption of carbon-intensive products, carbon embedded throughout the Chinese coal value chain is expected to become ever more important. If the Chinese coal value chain cannot be better regulated to conserve energy and allow fuel substitution at scale, there is little hope for the international community to control global temperature rise below two centigrade.

In the last 18 months, the Energy & Climate Program at the Carnegie Endowment has conducted an in-depth study of the Chinese coal value chain. Two high level U.S.-China coal conferences were convened, with the first one in Beijing on October 24, 2012, and the second one in Washington, D.C. on March 7, 2013. Based on a careful examination of the Chinese coal industry, interview of governmental officials, solicitation of expert opinions, policy debates amongst leading analysts, and field trips to different coal mining regions in China, the author developed an extensive list of potential policy recommendations, crafted to address and balance China's most pressing but often conflicting needs of economic development, energy security and environmental integrity. Furthermore, the following screening process has been utilized to finalize list of policy recommendations in this study:

- **Appropriate tradeoff amongst different policy targets**: before the selection of any specific policy recommendation, difficult tradeoff may need to be made to appropriately address often conflict targets including economic development, energy security and environmental integrity. Meanwhile, special considerations have been incorporated into the analysis in order to address the facts: 1) the marginal return on social utility from economic development is expected to diminish as average Chinese become increasingly wealthy over time; 2) China can improve its energy security with non-coal solutions such as the building up of a sizable strategic oil reserves, contributing to the international energy governance regime, and protect its access of overseas energy resources by leveraging its rising economic and military strengths; and 3) Average Chinese's willingness to pay for higher environmental quality will rise over time.

- **The Chinese economy should not be severely impacted by any selected policy recommendation that may endanger China's social stability.** How China can sustain the continuous expansion of its economy will be one of the most important policy priorities for Chinese decision makers in years to come. While it is reasonable to slow down a rapidly growing economy to safeguard a country's environmental integrity, a severe impact on
economic growth, with significant negative impact on poverty alleviation, is deemed as politically unacceptable as it may endanger China's social satiability.

- **National energy security should not be severely endangered by any selected policy recommendation that may result in abrupt rise of energy prices in international markets.** In 2012, China's dependency rates on coal, oil and gas were 8 percent, 58 percent, 29 percent, respectively. Given the importance of Chinese coal and China's impressive presence in global energy markets, a overly rapid phase out of Chinese coal is deemed undesirable as it implies either a hard landing of the Chinese economy or unacceptable amounts of imported energy, which can be translated to volatile price fluctuations in the international energy market.

- **Climate implications of any selected policy recommendation should be substantial.** In this study, greenhouse gas emissions reduction potential is selected as the primary indicator of environmental integrity. Any selected policy recommendation should either have the potential to be translated into substantial greenhouse gas emissions reduction or serve as the supporting regulatory environment that favors positive climate outcomes.

Once a policy recommendation passes the compatibility test with the aforementioned criteria, it is then evaluated against the following questions:

- **Does the policy recommendation add value to the current policy debate in China?** As coal is the most dominant fuel in China, it is not a surprise that coal-related policy issues have been extensively studied. As the average performance of the Chinese coal value chain still lags behind international best practices, energy conservation potential is widely recognized as substantial. Nevertheless, the necessity and approaches of energy conservation are well understood and accepted by the Chinese government, which is evidenced by the adoption of national energy intensity reduction targets in two consecutive Five Year Plan periods. Further, as China has encountered great difficulty to fully meet its national energy intensity target in the 11th Five Year Plan with command and control policy instruments, no policy recommendation on energy conservation is made in this report, instead, more emphasis was given to market-based policy instruments such as carbon pricing.

- **Is a policy recommendation political plausible?** Given the enormous regulatory constraints in China, political plausibility is arguably the most important criterion in terms of policy recommendation selection. To retard China's rising carbon emissions, aggressively deploying CCS can be effective. Nevertheless, given China's national circumstances as an emerging
economy with sizable population in poverty, Chinese decision makers are unlikely to accept such type of environmental initiatives without witnessing their adaptation in other parts of the world especially developed countries.

After the above steps, the author relies on his own judgment and feedback from the expert team to prioritize the list of policy recommendations. Special consideration is also given to make sure all segments of the Chinese coal value chain are covered by at least one recommendation. While the policy recommendations are intended to serve as a reference for Chinese decision makers especially those at the NDRC including the NEA, Ministry of Environmental Protection and State Council, they should also be useful for the international community to better understand the Chinese coal value chain.

1. Develop a medium- to long-term national energy & climate strategy that aims to accelerate the peaking of both national coal consumption and greenhouse gas emissions.

Various plans are regularly developed by the Chinese government to set goals for economic development and environmental conservation, but they are often short-term in nature, with five year plan as the most common format. To address China's rising energy and climate challenges, Beijing is in an urgent need to develop a medium- to long-term national energy and climate strategy. Accelerating the peaking of national coal consumption and greenhouse gas emissions should become the overarching policy goals for such a plan. Ideally, the proposed medium- to long-term strategy should be updated by each administration in China at a five year interval.

In April 2013, Mr. Xie Zhenhua, deputy director at the NDRC, announced that China will develop a Long-term Low Carbon Roadmap to 2030 and 2050, that aims to: 1) strengthen the macro-level design of low carbon development in China; 2) accelerate the promotion of low carbon development research at strategic level; 3) identify milestone targets in the future and assess pathways / technical measurements. In the end, the Roadmap will be used as the basis to develop the 13th Five Year Plan and medium- to long-term national strategy for social development, energy and environmental planning. Finally, the most important component of the roadmap is to assess when China's GHG emissions will peak.17

While the recent announcement made by the NDRC is certainly a wise move made by the Chinese government in the right direction, energy efficiency, expansion of nuclear capacity,  

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renewable development, industrial restructuring and demand side management are all recommended to be further strengthened. In addition, Beijing should also take the following issues into consideration when the proposed long-term national energy and climate strategy is formulated:

- While energy-economy model\(^1\) is one effective tool used extensively in the past to evaluate energy and climate policies, significant barriers exist in China to prevent the buildup of sufficient domestic capacity to undertake energy and climate policy assessments. Chinese energy policymakers even used the discrepancy between existing forecasts and statistics as an excuse to raise suspicion on the usefulness of energy-economy models. Nevertheless, in order to develop sound long-term national energy and climate strategies, Beijing should consider to provide more resources and strengthen capacity of its domestic modeling community, and best practices used in other part of the world should be adopted as appropriate. For instance, the crucial step of a modeling analysis, the establishment of baseline forecast, is a tricky business in China. To improve the capacity of its modeling community, many countries including the United States, Australia, Germany and Japan set a good example by regularly examining performance of forecasts in past studies, similar efforts should also be made in China.

- Contrary to the perception of the outside world, there only exist a few options for the Chinese central government to effectively retard spiking domestic coal mining activities. Railway is by far the most important coal transport mode in China. Chinese railways had long been monopolized by the Ministry of Railway, which was finally disbanded in March 2013. The Ministry of Transportation has taken over administration and regulation of the railway industry, and a state-owned company, the China Railway Corporation, is running the commercial operations. Nevertheless, even after the deregulation of the railway industry, the central government should continuously restrict the expansion of China's dedicated coal rail capacity. If so, the retail coal prices in the coastal provinces can be sustained to retard coal consumption growth and encourage coal imports. Though the restriction of dedicated coal railway expansion may lead to undesirable increase of long distance trucking of coal, the

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\(^1\) An energy-economy model is a mathematic simplification of the energy sector and its linkages with the economy, and includes only the aspects that the model developer regards as important for the purpose of the model's application. The following six dimensions may be utilized to classify energy models, including 1) top-down vs. bottom-up, 2) time horizon, 3) sectoral coverage, 4) optimization vs. simulation techniques, 5) level of aggregation, and finally 6) geographic coverage, trade, and leakage.
overall benefits of coal mining and consumption suppression should still outweigh the negative impacts of higher traffic of coal trucks.

Another policy instrument is for Beijing to consolidate the coal industry with increasingly stringent environmental and safety standards. While many of the country's small mines are expected to be phased out, Beijing should also restrict permitting of Greenfield coal mine capacity in order to retard unsustainable domestic mining activities and encourage coal imports in the years to come. Though restricting capacity expansion of either dedicated coal railways or Greenfield coal mines serve can prevent the formation of an overly sizable coal industry once China's coal consumption peaks, the central government should nevertheless be prepared to overcome fierce opposition from the coal mining industry.

2. The next round of energy sector reform in China should focus on how to improve governance of the energy sector instead of government restructuring. If the country's weakness on energy and environmental governance can be satisfactorily improved by 2015, China will be in a much better position to promote the NEA as the Ministry of Energy.

The governance of China's energy sector, especially the coal value chain, has long been fragmented amongst many governmental agencies. This has lead to widespread deficiencies such as lack of inter-governmental coordination and over-competition for administrative power. Not surprisingly, there exists a misperception within China's energy policy community that the creation of a super Ministry of Energy may resolve many of the fundamental deficiencies that have plagued China's energy sector.

During the Seventh Central Government Administration between 1988 and 1993, China once had its own Ministry of Energy, which aimed to comprehensively manage coal, electricity, petroleum and nuclear industry. However, the fierce opposition from other governmental agencies and the Ministry's inability to regulate China's overly powerful state-owned energy companies made the trial unsuccessful, and the Ministry of Energy was disbanded in 1993.

Since then, numerous attempts were made to improve governance of China's energy sector, with mixed outcomes. Although the NEA was merged with the ministerial level Electricity Regulatory Commission during the most recent round of administrative system reform in March 2013, the NEA remained a deputy ministerial level agency under the NDRC. As a result, the aforementioned government restructuring was widely regarded by many as a transitional step to move towards a more effective energy governance structure in China.
Nevertheless, given the importance of energy to any economy, governance of the energy sector including the coal value chain is difficult to be managed by just one super ministry in not only China but also other parts of the world. For instance, the U.S. DOE is a cabinet-level department of the United States government with responsibilities that cover the nation's nuclear program, energy conservation, energy-related research, and domestic energy production. Since regulatory authorities of energy resources largely belong to state governments, the role of U.S. DOE is heavily oriented to energy research, which explains why U.S. DOE's counterpart in China is often the Ministry of Technology and Science instead of the NEA during U.S.-China energy collaboration.

At the federal government level, U.S. Department of the Interior primarily regulates the coal mining industry and the Mine Safety and Health Administration at the U.S. Department of Labor oversees the safety of coal mining. Coal transport is largely regulated by U.S. Department of Transportation. In terms of coal-fired generation that accounts for about 93 percent of U.S. annual coal use, U.S. DOE has the broadest responsibilities in regulating power generation and electric transmission, distribution, and retailing in the United States, additional regulatory bodies include the Federal Energy Regulatory Commission, which has designated the North American Electric Reliability Corporation to oversee bulk electric generation and transmission. While U.S. EPA have a broad range of regulatory authorities to oversee environment-related issues throughout the coal value chain, U.S. DOE also covers coal technology research and development. In sum, there does not exist a super ministry in the United States with regulatory power throughout the coal value chain.

As a result, during the next round of China's energy sector reform, the Chinese government may consider to focus on resolving the existing deficiencies throughout the Chinese coal value chain:

- **Conflicts between the coal mining industry and the power sector:** currently, the pricing of coal in China is entirely subject to supply and demand balance, but electricity retail prices are still tightly regulated by the central government. In the past, both encouraging the formation of integrated coal mining and power generation companies and the Coal-Electricity Price Linkage Mechanism have not been able to satisfactorily resolve conflicts between the upstream and downstream coal sectors. In theory, the mechanism of long-term contract of thermal coal for power generation in the United States is a model that deserves serious policy elaboration by Chinese decision makers, as such a market-based approach can free the Chinese central government from overly excessive intervention of the energy market.
- **Relationship between government and enterprises**: to better regulate the Chinese coal value chain, two issues need to be resolved between the government and enterprises - first, key state-owned energy companies are very powerful players in China. Many of the top executives at key state-owned companies are either minister- or deputy minister-level officials within China's political hierarchy. Since the NEA is only a deputy ministerial level agency, it is difficult for state-owned energy companies to be appropriately regulated in China. In addition, without comprehensive protection of properties rights in the energy sector, the private coal miners lack incentives to invest sufficiently to fully comply with environmental and safety standards, which makes them a natural target for various governmental crackdown initiatives. Nevertheless, according to experience in industrialized nations, private enterprises can be socially and environmentally responsible especially when they are regulated according to the rule of law.

- **Relationship between central and local governments**: the path to better regulatory control of energy sector in China has proven to be elusive, with a sizable "enforcement gap" - the disparity that persists between laws on the books and actual compliance. China's political system is based on a top-down model. In theory, the central government sets standards and regulations that should always be strictly enforced by local governments. Nevertheless, there exist many places in China where "the mountains are high, and the emperor in Beijing is far away." Put another way, China’s historic and chronic difficulty of compelling local officials to obey central policies remains as elusive as ever. The sharp contrast between Beijing’s increasingly stringent measures to tightly regulate the coal industry and the rampant corruption especially at local levels suggests that the perceived probability of governmental officials and other decision makers of being caught in corruption-related case is still pretty low. To eliminate the aforementioned contrast, the establishment of the rule of law is considered as the key remedy. Further, with Beijing grabbing too much of China's overall tax revenue, local governments are forced to be protective of small coal mines and inefficient local plants that are important to local economy.

- **Government's preference for administrative orders instead of the Rule of Law**: with its prolonged history of imperial dynasties, China has long been a country that is ruled by human leaders. In comparison, at its most basic, Rule of Law refers to a system in which law is able to impose meaningful restraints on the state and individual members of the ruling elite, as captured in the rhetorically powerful if overly simplistic notions of a government of laws, the supremacy of the law, and equality of all before the law. Although the insufficient
presence of Rule of Law in China does not mean the absence of rules by which Beijing enforces its will at the local level. Nevertheless, the over reliance on administrative orders and the lack of Rule of Law have made rental seeking increasingly rampant amongst government officials especially at local level.

If the aforementioned weaknesses can be satisfactorily improved by 2015, Beijing is in a much better position to promote the National Energy Administrative as the Ministry of Energy during the 13th Five-Year Plan period.

3. **Act immediately to improve coal statistical distortion throughout the Chinese coal value chain.**

Reliable national statistics are fundamental for appropriate administration of a country's energy sector, as well as for global climate negotiations about future emission targets and the allocation of responsibilities. China, the world’s largest energy consumer and carbon emitter, has frequently been questioned about its data transparency and accuracy of energy and emission statistics. In the past, Beijing has become increasingly reliant on stringent standards and regulations to tame the Chinese coal value chain. Nevertheless, as one of the largest country in the world with diverse regional circumstances, coal statistical distortion has become a chronic administrative difficulty in many parts of China, which leads to serious impacts on global climate change science as well as international climate negotiation.

As the world largest carbon dioxide emitter, China does not officially publish annual estimates of carbon dioxide emissions, though it has submitted national GHG emissions inventory in 1994 and 2005 to the UNFCCC. In a study published by Nature Climate Change in 2012, a group of researchers estimated China’s national carbon dioxide emissions and aggregated all of the provinces’ emissions between 1997 to 2010, based on two different official and publicly available energy data sources. While the researchers’ estimation of the national total carbon dioxide emissions is based on the energy statistics from the National Bureau of Statistics of China (NBS), the provincial summation is based on data from 30 provincial statistics offices, excluding Tibet, Hong Kong, Macao and Taiwan. Despite the fact that both sources are “official”, the carbon dioxide emission based on the data differ by 1.4 gigatonnes for year 19

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19 The NBS annually publishes both national and provincial energy statistics.
Differences in reported coal consumption in coal washing and manufacturing are identified as the main contributors to the discrepancy in official energy statistics.\textsuperscript{xxxiv} Without in-depth investigation, it’s still premature to tell whether statistical double counting alone might be sufficient to explain wide discrepancy of China's various coal indicators. While almost all Chinese provinces are reported to grow their economies at above national average levels in recent years (raising doubts on the legitimacy of China’s reported GDP growth rates), some local governments might need to exaggerate coal consumption within their administrative boundaries as supporting evidence for their inflated economic expansion. Further, to meet national energy intensity targets, there might exist incentive at the central government level to suppress national coal consumption. Finally, if Chinese coal production data are still seriously underreported at both national and local government levels, it is natural for national coal consumption to be scaled down accordingly for the sake of statistical consistency.

Since statistical distortion is not a unique phenomenon that limits to the coal industry, resolving this challenge should rely on policy instruments that: 1) make local statistical bureaus more independent from local government intervention (i.e., directly allocating funding from central governmental, the National Bureau of Statistics should have more control on appointment of officials at local statistical bureau level); and 2) make local governors accountable for any statistical distortion, the “one ballot veto” rule should be strictly applied in cases of violations.

4. Redesign the pilot carbon pricing mechanism and make it compatible with China's national circumstances. Ideally, a nationwide revenue-neutral carbon tax should be levied by the Ministry of Finance by 2015.

Currently, the NDRC has initiated carbon trade pilot programs in two Chinese provinces and five cities. Given the ongoing statistical distortion that has plagued most part of China, the above policy experiment is expected to convince Chinese decision makers of the urgency to improve the country's statistical reporting system.

Progressing in parallel with China’s carbon market experimentation is a lesser-noticed commitment to explore carbon taxes in the country, as either a complementary or substitute environmental policy tool. In early 2012, it was reported that a hypothetical carbon tax system

\begin{itemize}
\item The figure is equivalent to Japan’s annual carbon dioxide emissions, the world’s fourth largest emitter, with 5 percent of the global total.
\end{itemize}
had already been drafted by the Ministry of Finance’s Financial Science Research Institute and submitted to Ministry officials for review. The scheme was said to focus on companies with high fossil fuel consumption, with a tax rate beginning at 10 yuan (~$1.60) per ton of CO2, with a progressively increasing scale for companies with large annual emissions. The Ministry of Environment has also submitted its own preference for a tax of 20 yuan (~$3.20), rising to 50 yuan (~$8.00) by 2020. Such a tax, although two-times the one proposed by the Ministry of Finance, would only add around $1.75 to the price of a ton of coal (trading at ~$100/ton) and around $2.75 to the price of a barrel of oil (trading at ~$110/bbl).

In mid-February 2013, the head of the tax policy division at the Ministry of Finance announced that a new environmental taxation regime was to be implemented, with carbon taxes indicated to be amongst the set of taxes under consideration. In the same announcement, a resource tax on water and a reform of coal taxes – basing fees on price instead of sales volume – were also suggested. No tax rates or further specifics have yet been officially divulged. The significance of the announcement has since been intensely debated, with many seeing it as a landmark in Chinese environmental policy and others far more sanguine on the novelty and eventual impact of any tax reform.

While the government specifically mentioned the possible taxation of energy-intensive products and luxury vehicles without public-transport uses, some have suggested that the nomenclature of “carbon tax” is misplaced and that it is instead a re-labeling of an existing “pollution discharge fee” that is often left unenforced by local governments seeking to woo industry and investment. The conversion of an “administrative fee” to a statutory tax offers new legal force, and the tax is to be collected by local taxation authorities that have traditionally been closely supervised by the central tax institutions. The reform will supposedly allow for a sufficient level of provincial authority in tax collection, leaving the credibility and consistency of enforcement an open question.

Furthermore, it remains unclear how the tax was to interact with regional emission trading schemes (ETS) pilots or an eventual national carbon market, or with the country’s stated desire to cap annual coal consumption and production at around 3.9 billion tons by 2015. The Ministry of Environmental Protection also scored a coup with the lesser-publicized, yet hardly trivial, decision by the Chinese state council to make new low-sulphur standards for automotive diesel mandatory by the end of 2014, with stricter standards taking effect in 2017. The standards had been originally designed years earlier and were sitting on the shelf while an internal battle was waged between the Ministry of Environmental Protection and the major NOCs. Although
sulphur regulations have no direct relationship to carbon taxation in China, they were given the
green light largely as a response to the recent outcry over air quality in Chinese cities, and it is
not inconceivable that climate policy could similarly benefit from Beijing’s need to be seen as
being proactive on environmental protection given the complementarities amongst emission
controls for various pollutants.

Given China's national circumstances, carbon tax should also be adopted by the Chinese
government to slow the country's rising coal consumption and carbon emissions. The proposed
carbon tax can start at a relatively moderate level (e.g. 10 yuan/ tCO2), with the goal of
increasing it over time if other major carbon emitting economies follow suit. Ideally, the
proposed carbon tax should be revenue-neutral, with a significant portion of the revenue spent to
encourage research, development and utilization of cleaner and low-carbon energy.

5. Actively encourage energy imports from demonstrably more environmentally benign
sources, especially natural gas, in order to suppress more environmentally harmful
domestic mining activity, the long-distance transport of coal, and coal consumption across
the country.

Natural gas is composed primarily of methane, the main products of the combustion of natural
gas are carbon dioxide and water vapor. When combusted, coal releases much higher levels of
harmful emissions, including a higher ratio of carbon emissions, nitrogen oxides (NOx), sulfur
dioxide (SO2) and particular matters than natural gas. Not surprisingly, natural gas is often seen
as an ideal option to substitute coal at scale in order to optimize China's unsustainable energy
mix.

While demand for gas in China is planned to grow to 260 billion cubic meters by 2015, up from
108 in 2010, an astonishing annual growth rate of almost 20 percent. But since gas production in
China increased by only 14 percent a year between 2006 and 2010, China needs to either quickly
ramp up its domestic gas supply or increase its gas imports.

Though China is endowed with the largest technologically shale gas resources in the world, lack
of technical expertise, difficult geology, institutional and regulatory deficiencies, water
availability and risks of contamination all mandate that American shale success cannot be easily
duplicated in China. In order to substitute coal at scale, the Chinese government should
encourage a drastic increase of imports of pipeline gas from central Asia and Russia and
liquefied natural gas from other part of the world. The timely reform of natural gas pricing mechanism is key for China to attract more and more gas imports in the years to come.

Historically, China has been a net coal exporter. In 2003, China’s coal exports peaked at 94 Mt with coal imports at 11 Mt. Since China produced 1,835 Mt of coal and consumed a similar amount in the same year, imports had very little impact on China’s overall coal balance at the time. Just a few years later, in 2008, China’s coal situation would markedly change when China’s imports and exports equalized. In 2009, China imported 126 Mt of coal and became a net coal importer for the first time. In 2011, China surpassed Japan as the world's largest coal importer. In 2012, China's coal imports increased by nearly 60 percent on an annual basis, reaching 290 Mt. While this paled in comparison to the country’s total coal production of 3,660 Mt in 2012, China has become the most dominant player in global coal market.

While China's rising coal imports can certainly alleviate environmental impacts of widespread coal mining activities and long-distance transport of domestic coal, they can also prepare China with a better position to regulate its coal value chain once national coal consumption peaks. Nevertheless, the international ENGO community has long been concerned with one particular issue whether China's rising coal imports really suppress the country's domestic coal mining activities or simply make more affordable coal available to Chinese consumers and encourage coal consumption. To address such policy concern, it is important for the Chinese central government to impose province-specific coal consumption cap in coastal China as detailed in recommendation 6.

From overseas coal producers' perspective, it is worthwhile to notice the high uncertainty associated with China's future coal imports levels. IHS CERA predicts that Chinese coal imports will peak by decade’s end and enter a prolonged period of decline through 2035. The combination of moderating demand and increased domestic production will reduce the need for China to import coal. IHS believes China's coal imports have already peaked in 2012. Overall coal demand in China will peak around 2025 at about 5.1 billion metric tons. IHS suggests the Chinese import boom that has supplied much of enthusiasm for U.S. coal producers will be short-lived.\footnote{http://investorplace.com/2013/02/dont-count-on-china-to-buy-americas-coal/}

Finally, the recent slowdown of the Chinese economy has severe impacts on the profit margin of Chinese domestic miners. In response to the Chinese coal mining industry's lobbying activities,
the NEA issued a draft of the coal regulation calling for a halt to imports of coal with a calorific value lower than 4,544 kilocalories per kilogram, sulfur content higher than 1% and 25% ash on a net-as-received basis.22 Currently, the Chinese electricity is lobbying the central government not to impose such a coal imports restriction. From the perspective of energy conservation and air pollutant emissions reduction, it may make sense for the Chinese government to introduce such a regulation. The NEA nevertheless should resist pressure from the coal mining industry unless the similar coal quality standard can be also applied to domestic coal production.

6. China should impose legally binding coal consumption caps in coastal China, and legally binding coal intensity targets in inland China. In certain metropolitan cities such as Beijing, Tianjin and Shanghai, coal use should be gradually phased out in order to improve air quality.

As illustrated by the simplified map of China in the beginning of the report, the People's Republic of China is administratively divided into 22 provinces, 5 autonomous regions, 4 municipalities under the direct control of the central government - Beijing, Tianjin, Shanghai, and Chongqing. Although the political hierarchy of these 31 administrative zones are considered equal, their economic status and energy circumstances differ drastically with each other.

Many Chinese provinces could count as outright “countries” in terms of their population or economic output, let alone land area. Shandong, Henan and Guangdong are China's most populous provinces with populations of around 95 million people each – more than 10 million more than Germany. Xinjiang, Tibet and Inner Mongolia all have land areas of more than 1 million square km, comparable to South Africa or Colombia.xxxv When comparing provincial GDP numbers, the top three, namely Guangdong, Shandong and Jiangsu, are all coastal provinces, they together accounts for 28.3 percent of national GDP in 2011. In terms of per capita GDP, China is a diverse country with large income disparity. In 2011, per capita GDP in Tianjin was more than 400 percent higher than that of Guizhou, one of the poorest province in inland China.

To explore region-specific coal policy initiatives, China is divided into two parts in this study: coastal provinces and inland China. China’s coastline covers approximately 14,500 km from the Bohai gulf on the north to the Gulf of Tonkin on the south, and coastal provinces in China includes Beijing, Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian,

22 http://online.wsj.com/article/SB10001424127887323844804578526750491368748.html
Guangdong and Guangxi. Table 3 shows that the coastal provinces' relative share of national GDP, coal and energy consumption have already peaked around 2000, no matter whether measured with absolute or per capita term. As a result, while the less developed inland China should be spared with additional room for economic growth, more stringent regulations may be adopted in coastal provinces to achieve national energy conservation and emissions reduction goals.

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<tr>
<td>Per capita</td>
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<td>GDP</td>
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<td>207.1</td>
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<td>102.9</td>
<td>103.8</td>
<td>101.8</td>
<td>94.9</td>
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In 2010, summation of provincial coal consumption in China were 22 percent higher than national coal consumption. As a result, though the Chinese government aims to cap national coal consumption around 3.9 billion tonnes by 2015, it is rather difficult to disaggregate national coal consumption cap to provincial levels. In addition, the strict enforcement of a national coal cap at provincial level may further stimulate coal statistical distortion in certain parts of the country.

Compared with those inland province, coastal China is more economically developed with better capacity to improve their statistical collection mechanism, the Chinese government may consider to impose province-specific coal consumption caps in coastal China. Based on social economic development status of each coastal provinces, the central government should set province-specific coal consumption cap. A stringent set of coal caps in coastal China can ensure China's rising coal imports will substitute domestic coal mining activities instead of encouraging national coal consumption. To allow inland China additional room for economic growth, only legally binding coal intensity targets should be imposed in inland China. Finally, in metropolitan centers such as Beijing, Tianjin and Shanghai where air pollution is a particular concern, coal use should be gradually phased out with natural gas and alternative cleaner fuels over time.23

23 Deutsche Bank Research estimated that coal accounts for 45 percent of PM2.5 emissions in China, and the Beijing municipal government reported that coal accounts for 16.7 percent of PM2.5 within the city's
In the longer term, once China resolves its coal statistical distortion and also becomes a more wealthy nation, Beijing may consider to impose a national cap on carbon emissions. With more stringent emissions reduction targets set for coastal provinces, the proposed policy mechanism is expected to stimulate a national carbon trade market, with substantial transfer of wealth to encourage economic development in inland China.

7. Simultaneously control coal-fired air pollutants and carbon emissions, especially in the electricity industry. The inter-departmental coordination between the NDRC and the Ministry of Environmental Protection is the key.

To promote energy saving and emission reduction, the Chinese government established a set of targets in the Outline of the 12th Five-Year Plan for National Economy and Social Development. These targets include reducing energy and carbon emissions intensity per unit GDP by 16 percent and 17 percent, respectively, as well as decreasing the total emissions of primary air pollutants (SO2 and NOx) by eight and ten percent, respectively. According to the lessons drawn during the 11th Five-Year Plan period, when a pure end-of-pipe pollution control measure reduces the emission of a specific pollutant, an increase in emissions of other pollutants often occurs as a side-effect. For example, in order to reduce 1 kg of SO2, a flue gas desulphurization unit consumes electric power at about 3.67 kWh, which can be translated into emitting more CO2 (5.43 kg) and NOx (0.016 kg). The target for NOx reduction is also very difficult to attain. Lack of mature technologies and exorbitant costs are the major barriers to effective pollution control under a pure end-of-pipe approach.

Fulfilling multiple energy saving targets necessitates the “co-benefits” of carbon dioxide abatement and local air pollutant (e.g. SO2 and NOx) reduction. As about half of Chinese coal is consumed by the power sector, simultaneous control of coal-fired air pollutants and carbon emissions are especially relevant to meet energy conservation and emissions reduction in this important coal transformation industry. In a pilot study, front-end and in-the-process control measures are identified with higher priority than end-of-pipe control measures for the pollutant reduction technology selection. Combined with the targets of total pollutant control and cost limitations, single pollutant or multi-pollutant (APeq) abatement routes can be drawn to help administrative boundary. Coal combustion in small heating boilers during the winter season is particular a environmental concerns for urban centers in north China.
decision makers formulate appropriate emission reduction plans. A large co-control potential for technical and structure-adjustment measures characterizes the power industry.

To reflect the multi-pollutant co-control effectiveness of various technologies for SO2, NOx, and CO2 control, air pollutant equivalent (APeq) is quantified with weights inferred from pollutant charge in China. The understanding of decision makers regarding the relative importance of local and global pollutants can be well-reflected by the application of APeq when choosing varied weight values for different pollutants. The weight values change in accordance with variations in pollutant price, or are associated with the scientific, political, and even psychological recognition of the relative importance of local pollutants and GHG emissions. Sensitivity analysis of unit abatement costs can be performed for the priority order. For example, when the relative weight of CO2 increases at a higher level relative to those of SO2 and NOx, the priority of CCS in terms of UPRC also increases. Thus, the selection of multi-pollutant mitigation technologies is not only a scientific issue but also an economic and political one.

Currently, the Ministry of Environmental Protection and the NDRC regulate air pollutant and greenhouse gas emissions, respectively. Nevertheless, the lack of inter-governmental coordination and the separation of the governance of emissions from the same sources (e.g. coal combustion) have negative impacts on the effectiveness of China's air pollution control and greenhouse gas reduction programs. Co-control of coal-fired air pollutants and carbon emissions is proposed as a technologically sound mechanism for the Chinese government to better improve environmental performance of coal combustion especially for coal-fired power generation.

8. Actively participate in global energy governance reform, and proactively pursue advance coal technologies, environmental best practices and know-how through international collaboration such as the formation of a Major Coal Economies' Forum.

China is now the world's largest energy consumer and carbon dioxide emitter. Since 1990, China accounts for 39 percent of global energy demand growth. Because of China's heavy reliance on coal, the country's share of global incremental carbon emissions was 53 percent during the same period, and coal-fired carbon emissions in China alone represents 44 percent of global incremental carbon emissions. In addition, China is expected to account for 17.3 percent of the world's incremental energy consumption and 29 percent of the world's increment carbon emissions by 2030. While China's increasingly dominance in the global energy scene has profound impacts not only international energy trade but also global climate change, the
institutions which oversee international energy trade that is worth about $2.3 trillion per year – or 16 percent of all international trade – belong to another era.

For instance, the International Energy Agency, an intergovernmental organization created in the wake of the 1973 oil crisis in order to coordinate energy policy amongst major energy consumers, does not have China, the world's largest energy consumer, as a member, with institutional rules and structures standing in the way of any change.

In April 2013, the International Energy Agency announced that it will invite China and other emerging economies to take part in key strategic talks. The initiative to form an "association" between the IEA, combining 28 industrialized economies, and non-members is aiming to create a closer alliance on energy security, environmental sustainability and data sharing.

Given China's rising dominance as a major energy consumers and importer, a closer ties between China and the IEA is expected to serve the best interest of both parties, Beijing should respond positively to the IEA's initiative in support of its own effort to make global energy trade more transparent and its own national statistical reporting more reliable.

To deal with coal-fired carbon emissions and tackle with global climate challenge, China and the United States, the largest two coal economies, are essential. Nevertheless, it also makes sense to bring both the European Union and Russia into the fold. Combining nearly 60 percent of the world’s GDP and accounting for a similar percentage of global carbon emissions, the CURE economies—China, the United States, Russia, and European Union—are the ideal platform for multilateral collaboration on energy and climate solutions. These countries’ aggregate economic output, energy consumption, and carbon emissions are expected to continuously represent more than half of the global total in the decades to come. Hope for combating global climate change rests on creating synergy among these four economies first.

And all four will benefit from collaboration on energy and climate solutions. China can advance its cooperation with the United States and Europe especially in area of cleaner coal technology and increase its own energy security through closer ties with Russia. The United States will face less pressure from the developing world to pay the full cost of adaptation and mitigation. Russia will improve its miserable energy-efficiency record. And Europe will have greater success in

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24 The International Energy Agency will invite China and other emerging economies to take part in key strategic talks, so
transferring its experience with climate legislation and carbon trading to these countries, while exploring specific opportunities with Russia and the United States to internally develop and import more natural gas as a substitute for coal.

Above all, cooperation between a few key players should be much easier than consensus building among 194 countries. For instance, a CURE dialogue on climate solutions may be initiated to promote collective actions on emissions abatement, and a CURE agreement could be just what’s needed to then reach a global deal. The world is urgently running out of time to contain the global temperature rise below two degrees Celsius, and the UN framework for climate negotiations is unlikely to quickly produce robust results. So it is time for China to propose its own initiative to move the global climate agenda forward by exploring alternative platforms for collaboration. The group of CURE economies may be the answer for the Chinese government.

Finally, compared with oil and gas, coal resources are more evenly distributed in the world. Even so, the world's top 10 coal producing countries, namely China, United States, India, Australia, Russia, Indonesia, South Africa, Germany, Poland and Kazakhstan, accounted for 89 percent of global coal output. In addition, the top 10 coal consuming economies, namely China, United States, India, Japan, South Africa, Russia, South Korea, Germany, Poland and Australia, represented 86 percent of global coal consumption. In comparison, top 9 destinations of China's coal imports, namely Indonesia, Indonesia, Australia, Mongolia, Russia, Vietnam, South Africa, North Korea, United States and Canada accounted for 98 percent of China's coal imports. In order to promote cleaner coal technology collaboration and address the profound environmental implications of China's rising coal imports, the Chinese government should consider to initiate a Major Coal Economies' Forum, with the selected countries from the aforementioned three lists. To make the Forum more easily to be kicked off, it can be initiated as a task force under either the G20 or the Major Economies Forum on Energy and Climate.
5. References


ii National Bureau of Statistics.

iii China Customs.


v Detail of these two conferences are available at Carnegie Endowment's website.


viii Conference proceedings, Third Working Meeting of the CCICED Task Force on Sustainable Use of Coal (Beijing, 2009).


x Editorial Board of CEIYB (various years). China Electricity Industry Yearbook. China Electric Power Press, Beijing. Classification of coals in China (GB/T 5751-2009 Chinese Classification of Coals) is not consistent with the international standards. For instance, ASTM D 388-2005 Standard Classification of Coals by Rank classifies coals as meta-anthracite, anthracite, semianthracite, low volatile bituminous, medium volatile bituminous, high volatile (A, B, C) bituminous, sub-bituminous (A, B, C), and lignite (A, B). In comparison, ISO 11760:2005 – Classification of Coals categorizes coals as anthracite (A, B, C), bituminous (A, B, C, D), sub-bituminous (A), and lignite/brown coal (B, C).

xi http://kbs.cnki.net/forums/50150/ShowThread.aspx [July 1, 2009].


xiv The difference can be largely explained by coal bought by Shenhua from other producers (for example, township and village mines) primarily due to the latter’s lack of access to a rail transport network.


xvi For discussion of Chinese coal sector consolidation policy and the “Shenhua Model,” see the working paper “Remaking the World’s Greatest Coal Market: the Quest to Develop Large Coal Power Bases in China,” by
Huaichuan Rui, Richard Morse, and Gang He drafted for the Program on Energy and Sustainable Development at Stanford University.

xvii China Coal Information Institute, *China Coal Industry Yearbook* (Beijing: China Coal Information Institute, various years); Chinese National Development and Reform Commission. 11th Five Year Plan for the Chinese Coal Industry.

xviii The amount of coal transported by rail in China include throughput handled by 1) the national railway network controlled by the Ministry of Railways of China; 2) the local railway network controlled by various local governments and other entities; and 3) several dedicated coal rail lines controlled by the Shenhua Group. Historical statistics are only available for coal transported by the national railway network, which accounts for the majority but a diminishing share of coal transported in China. In 2010, coal transported by the national rail network was 1.7 Gt. In comparison, the total amount of coal transported by rail in China was 2.0 Gt in the same year. Source: National Bureau of Statistics, China Statistical Yearbook (Beijing: China Statistics Press, various years)


xxiv China Electricity Council and National Bureau of Statistics.


