CHINA 13TH FIVE-YEAR PLAN (2016-2020)

COAL CONSUMPTION CAP PLAN AND RESEARCH REPORT

EXECUTIVE SUMMARY

CHINA COAL CAP PLAN AND POLICY RESEARCH PROJECT

JANUARY 2016

About the China Coal Cap Plan and Policy Research Project (China Coal Cap Project)

China is the world's largest producer and consumer of coal. While coal is the main energy source for China's economic development, it has also caused serious damage to the environment and public health. Especially since 2012, large areas of China have experienced frequent and severe air pollution in the form of thick smog that poses a grave threat to public health. In order to address climate change, protect the environment and reduce air pollution, the China Coal Consumption Cap Project was launched in October 2013, bringing together over 20 leading Chinese stakeholders, including government think tanks, research institutes, and industry associations, to develop a comprehensive roadmap and policy package for establishing and implementing a national coal consumption cap. Accelerating the replacement of coal with energy efficiency and cleaner energy sources will fundamentally help China achieve its long-term economic, environmental, and climate goals.

To learn more, please go to: www.nrdc.cn/coalcap/index.php/English/index.

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INTRODUCTION

Since September 2013, China's State Council has released a series of documents and policies that support a coal consumption cap, particularly the Air Pollution Prevention and Reduction Action Plan ("Air Pollution Action Plan") and the Energy Development Strategy Action Plan (2014-2020). The "Air Pollution Action Plan" made a clear requirement to "establish long-term coal cap targets at the national level, and to assign supervisory responsibilities for these targets." The newly revised Air Pollution Prevention and Control Law, which became effective January 1, 2016, includes requirements to adjust China's energy structure, optimize coal use, promote the clean and efficient use of coal, and gradually lower the proportion of coal used for primary energy. Based on the available data, close to 20 provinces and autonomous regions and more than 30 cities in China have currently set some form of target for coal consumption reduction. With this foundation, it is imperative that China design and implement coal consumption caps at the national and local levels, as well as in coal-intensive sectors.

In the 13th Five Year Plan (FYP) period, China's economic development has entered a "new normal." For China's energy sector, this period provides a golden opportunity for strategic reforms. The coal consumption cap plan should embody and implement the "Four Revolutions and One Cooperation" concept that President Xi Jinping proposed for the energy system. This would place emphasis on establishing a modern economy that is green, low-carbon, and circular. China should increase the share of its energy from green sources and make a series of high-level strategic design decisions on energy use and overall deployment. The core focus of controlling China's energy use should be to control coal.

For over a year, the China Coal Consumption Cap Plan and Policy Research Project ("China Coal Cap Project") has been conducting research to develop original analyses. Using scientific methodology, it has investigated ecological, environmental, and resource-driven "red line" restrictions on coal use,and analyzed and researched 13th Five Year Plan coal cap targets, policies and measures, in order to assist with China's energy transition and provide policy-makers with advice and suggestions for developing and implementing a 13th Five Year coal cap plan.

1 GOAL FOR THE COAL CONSUMPTION CAP PLAN

Coal mining and use damages the environment and public health. Coal accounted for 84.4% of direct and indirect mercury emissions nationally in 2012, as well as 93% of sulfur dioxide, 70% of nitrogen oxides, and 67% of particulate matter emissions. Coal use and combustion also contributed to 63% of primary $PM_{2.5}$ emissions and 51-61% (with an an average rate of 56%) of the pollutants serving as chemical precursors for secondary $PM_{2.5}$ in different regions. Coal combustion and utilization is closely associated with the occurrence of smog over large areas, as well as the emission of industrial waste gas.

Coal consumption is responsible for about 80% of the CO_2 emissions from the energy sector, and over 64% of the greenhouse gas emissions. Additionally, 83% of methane emissions are coal related, and coal combustion produces 86% of black carbon emissions. Waste water from coal extraction and use makes up 43% of the industrial sector's waste water emissions, as well as 72% of the sector's solid waste. Coal mining produces over 2 billion tons of coal gangue – enough to occupy 20,000 hectares – and has caused over 1,300,000 hectares to be lost to land subsidence. Coal contains arsenic, antimony, boron, cadmium, chromium, and heavy metals. Coal mining is a relatively dangerous industry, with the worker death rate higher than most other industries. Lung disease from coal dust also accounts for over 50% of all professional illness.

As estimated by the China Coal Cap Project's report on The True Cost of Coal in 2012, the environmental and public health costs caused by coal mining, transportation, combustion, and utilization were 303 RMB per ton in 2012. In addition, the loss and damage from CO_2 emissions from coal were estimated at 160 RMB/ton, for a total cost of 463 RMB/ton. In 2012, total coal production and consumption reached 3.945 and 4.117 billion tons respectively, with total external costs up to 1.9079 trillion RMB, making up 3.7% of GDP that year (see Appendix 1). Controlling coal consumption and production can promote the sustainable development of the coal industry, allowing green, safe, and efficient coal production capacity to make up 74% of total coal output. Increasing the scientific production capacity of the coal industry can substantially reduce environmental damage, mining deaths, and threats to public health.

The goal of the coal consumption cap plan is to adhere to the restraints set by red lines for environmental resources (air, water, land, climate change, etc.) at the national, local, and sectoral level, and to design coal consumption cap targets for the 13th Five-Year Plan period. The plan will also actively promote and implement the reduction, substitution, and cleaning up of coal utilization, adopt both market mechanisms and government policies to achieve coal cap targets during the 13th Five-Year Plan period, and place priority on mechanisms and policy tools that simultaneously address multiple targets connected to protecting the environment, safeguarding the public's health, conserving energy and resources, and controlling the temperature rise from climate change. Through the coal cap, the share of coal in energy consumption will decrease from 64% in 2015 to to below 55% by 2020, improving the environment efficiently and at low cost, protecting public health, conserving resources and helping to control climate change to no more than a 2°C increase in temperature.

2 OVERALL NEEDS AND GUIDING PRINCIPLES OF THE COAL CAP PLAN

The 13th Five-Year Plan period is a critical stage in China's social and economic development, and it will be important to address new challenges and take advantage of new opportunities facing Chinese society and the nation's economy. The coal cap plan for the 13th Five-Year Plan period will reflect the central government's guiding concept for administrating China. This guiding concept has a number of elements, including an emphasis on human-oriented practices and an effort to advance China's "four comprehensives" strategy. Its central goal is to build a well-off society in a comprehensive and holistic manner. The 13th Five-Year Plan period is a complete five-year cycle for the new generation of leaders to propose, determine, and implement this new governance philosophy. The economic development of China has entered a "new normal," providing a valuable opportunity for a comprehensive reform and transition of the energy sector.

The strategy for the coal consumption cap plan will reflect and embody the energy system's concept of "Four Revolutions and One Cooperation," highlight the development of a low-carbon, green, and circular economy as an important goal in China's efforts to modernize, significantly decrease the environmental footprint of China's energy use, establish a series of top-level policy arrangements, and emphasize a transformation in how energy is used and exploited. The strategy will also build an industrial structure and mode of production that is high-tech and low-impact (both in terms of resource use and pollutant emissions), accelerate the development of energy-saving, environmentally-friendly industries, new energy, and other green industries, and form new points of growth for economic and social development.

A coal cap is the cornerstone of China's efficient, low-carbon, clean, and safe development. It is a critical measure for resource conservation efforts and other development goals like transitioning the economic structure and increasing efficiency in the energy sector, all of which are predicated on a reduction in coal use. The coal cap will strictly adhere to environmental emission standards and clean up the production and use of coal. Implementing a coal cap will also promote the development of clean energy. Replacing coal in the energy mix will expand clean energy and guide the transition to a new energy system. Capping coal production can also help with the implementation of a coal consumption cap, an important consideration as the coal industry works to solve overcapacity issues. The measures and strategies employed to cap coal will also assist in advancing China's ongoing energy transition.

3 PRINCIPLES AND METHODS FOR ESTABLISHING A COAL CAP

During the 13th Five-Year Plan period, China should establish a system of coal consumption caps at three levels: national, local and sectoral. These different caps should support and promote each other so as to achieve the overall coal cap objectives.

3.1 RED LINE RESTRICTIONS

China is facing severe challenges to its resources, environment, ecology, and climate safety. The nation's continuing environmental degradation must be checked in the 13th Five Year period, and there must be a clear, overall improvement. The coal consumption cap targets must meet strict "red line" restrictions for land resources, water resources, air quality, public health, and climate change. The coal consumption cap targets at the national, regional, provincial (including municipalities and autonomous regions) and city level must meet each level's restrictive conditions. These restrictive conditions should not only grow stricter over time, but be differentiated by region. The sectoral coal consumption cap targets must not only meet the requirements for resource conservation, emission reduction, and carbon reduction formulated at the national level, but must also respect the different environmental, ecological, and resource-driven red line restrictions (hereby referred to as "red lines") in the areas where the enterprises are located. In regions where several of these red lines exist, the most powerful restriction will be the bottom line for setting the target, i.e. the most restrictive limitation will be the one used to determine policy.

3.2 INTEGRATING COAL CAP MODELS

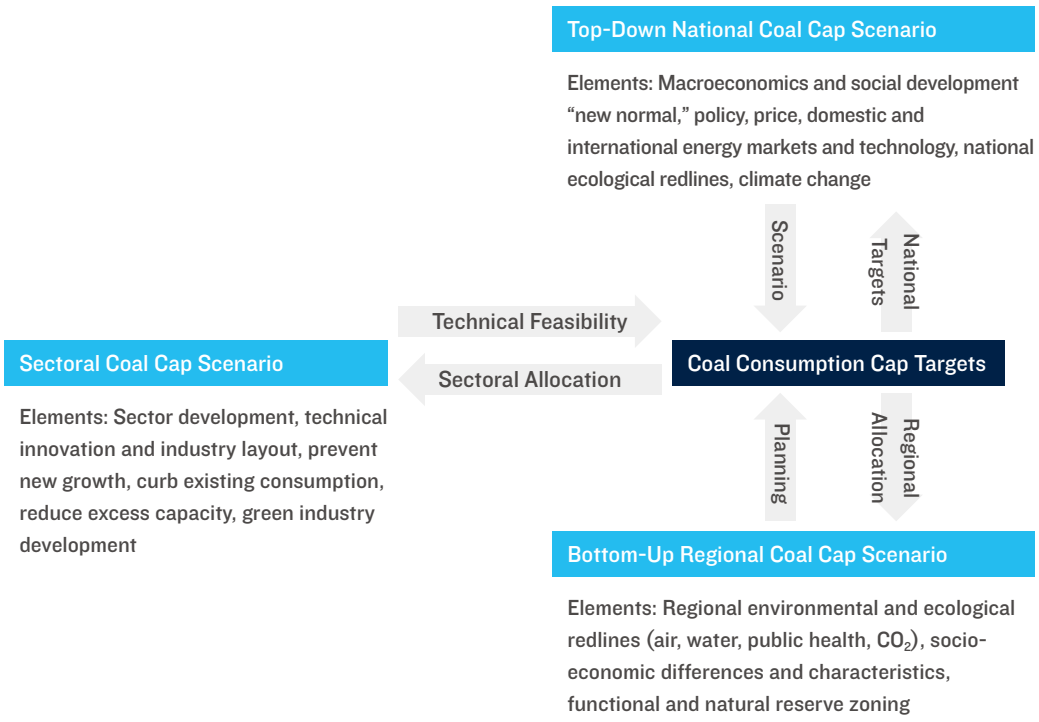
The process for setting coal consumption cap targets incorporates a top-down macro-economic model, a bottom-up regional differentiation model, and a sectoral analysis technology differentiation model. After adjusting and integrating the models multiple times, a scenario analysis with several unique advantages was developed. First, it was effective under a range of restrictive red line conditions; second, it was capable of meeting multiple red lines at once, which is difficult to do using a conventional scenario analysis model. It was also able to account for the influence of China's "new economic normal." This new solution is the integrated model, shown graphically in Figure 1.

In the initial step, the integrated model first analyzes the economic impact of adhering to the particular red lines in various localities and sectors. Next, it sets different red line requirements and economic changes resulting from China's "new normal" for the national, local, and sectoral models. After several rounds of

coupling and adjustment, whichever model is able to meet the most stringent red line requirements and produce the lowest levels of coal consumption would also satisfy the red lines for the other two models.

In the second step, the national coal cap analysis uses the coal consumption target that satisfied the most stringent red line requirements and disaggregates it to the local and sectoral levels. The first step of the local and sectoral scenario analysis sets a foundation for top-down target allocation, allowing the target to meet local and sectoral red lines and incorporate the influence of China's "new economic normal."

Figure I: Integrated Model for Coal Cap Target Analysis



4 ANALYSIS OF 2020 COAL DEMAND

Based on analysis of the most recent energy data from China's National Statistics Bureau, coal consumption peaked in 2013 at 4.244 billion tons of raw coal. Coal consumption in 2014 dropped to 4.116 billion tons, a decrease of 3.02%. In 2015, coal consumption fell by another 3.7% to 3.963 billion tons. The Coal Cap Project has analyzed energy and coal demand for 2015-2050. Figure 2 shows coal demand for four scenarios, titled the "reference," "energy-saving," "2°C" and "coal cap" scenarios (all for 2015-2020). The coal cap scenario follows the energy-saving scenario up to 2030 and is able to satisfy various red line restrictions. After 2030, as a result of climate change's strict 2°C ceiling for temperature rise, the coal cap adopts stricter restrictions, "jumping" from the energy saving scenario to meet the 2°C scenario pathway. The space for coal demand becomes more compressed, in order to achieve a level of 2-3 tons of CO_2 emissions per capita by 2050.

For the analysis of coal demand, determining the 2020 red lines is the first priority (see Table 1)

Figure 2: Coal Demand under Reference, Energy-Saving, 2°C Climate Mitigation and Coal Cap Scenarios

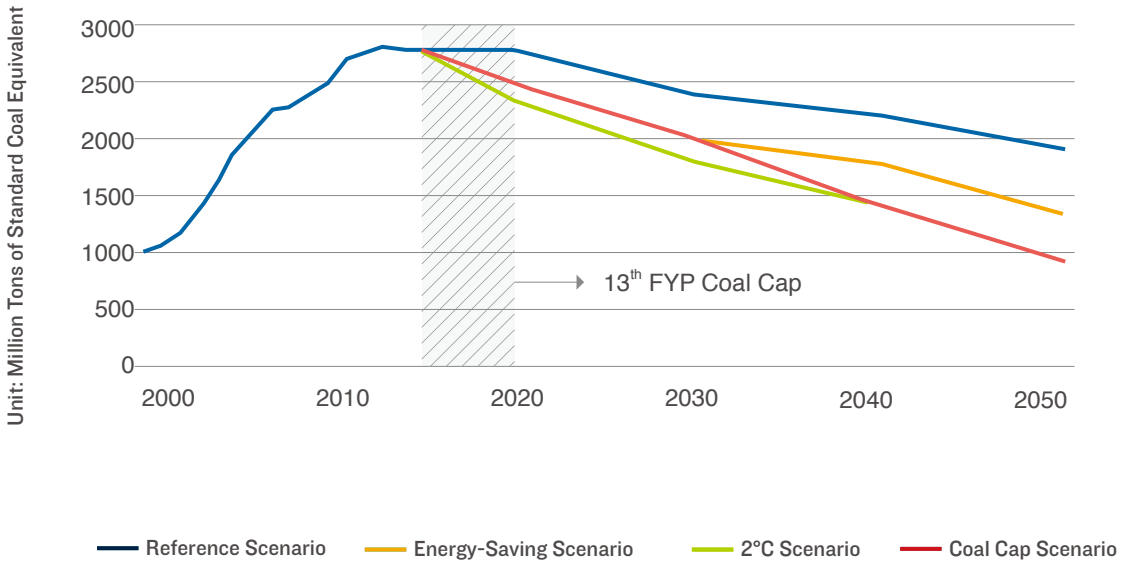


Table I: Resource, Ecology, Enviroment and Climate Red Lines for Coal Demand

	Environmental Restrictions	Restrictions on Coal Consumption Demand
CO_2 emissions	Decrease carbon emissions intensity by 50% by 2020 Peak carbon emissions before 2025	4 billion tons or less in 2020 3.5 billion tons or less in 2025
Air Quality	Average $PM_{2.5}$ emissions should be around 45 μg/m^3 by 2020 and 35μg/m3 by 2025	3.9 billion tons or less in 2020 3.4 billion tons or less in 2025
Water Resources	By 2020, cap water use in coal mining and consumption at 74.7 billion m^3. In northern China, particularly the northwestern regions, water restrictions for coal mining and use should be especially strict.	3.8 billion tons or less in 2020
Land	In regions where coal development is forbidden, coal mining and use should not be allowed	
Public Health	In 2012, the number of premature deaths attributed to coal-related air pollution was about 700,000 people. By 2020, the number of deaths attributed to air pollution should be reduced to 590,000	Improve air quality by reducing, replacing, and cleaning up coal use

Based on the progress of efforts in emission reduction and the trends in coal demand, especially public attention to air quality, the task for attaining the air quality targets will be realized in two stages within 10 years. By 2020, air quality will have significantly improved, with the annual average $PM_{2.5}$ level reaching around 45 μg/m^3 in cities at the prefecture level and higher. In addition, the percentage of level two Blue Sky Days each year should surpass 85% in the 74 municipalities recognized as "key cities." By 2025, air quality will reach the level 1 interim target value prescribed by the World Health Organization, with the annual average $PM_{2.5}$ level decreasing to around 35 μg/m^3. Based on the restrictions that the risk of climate change places on carbon emissions, coal consumption in 2020 and 2030 should be lower than 4 billion tons and 3.5 billion tons respectively. In addition, restrictions on water resources are severe. In 2020, water use from coal production and consumption should be limited to no more than 74.7 billion cubic meters, which means that coal consumption should be less than 3.8 billion tons. In 2030, quotas for water consumption will have to become even stricter in order to maintain a balance with existing water resources.

Forecasts for China's economic and energy development situation from 1990 to 2020 are shown in Appendix 2. The coal cap macroeconomic model parameters used for the 13th Five Year period are as follows: a GDP growth rate of 6.7%, urbanization level of 61%, and population of 1.37 billion. In the GDP parameter, tertiary and secondary industry account for 57% and 36% of the economy, respectively. The consumption rate was set at 56.9%, the investment rate at 42.1%, and the export rate at 22.6% (net exports of 1%). Energy-intensive industries accounted for 30.6% of the economy, and the growth rate of energy demand is between 1.3 and 2.2%. In this scenario, natural gas and renewable energy grow rapidly, oil rises slowly, and coal consumption is in a period of gradual decline.

The major outcomes of the coal consumption scenario analysis show that the coal cap targets in 2020 (the energy-saving scenario) will be 2.51 billion tonnes of coal equivalent (tce) (equivalent to 3.5 billion physical tons of coal), meeting the carbon emissions restriction from climate change (4 billion tons of coal), the air quality restriction of approximately 45μg/m^3 (3.9 billion tons of coal), the water resource restriction of 74.7 billion m^3 (3.8 billion tons of coal) and land use restriction (no coal exploitation or utilization in prohibited areas). The reference, energy-saving, and 2°C scenarios are shown in Table 2.

Table 2: Coal Demand Scenario Analysis in 2020

Scenario	Reference Scenario	Coal Cap Scenario (Energy-Saving)	2°C Scenario
Coal (billion tce)	2.81	2.51	2.35
Oil (billion tce)	0.88	0.87	0.817
Natural gas (billion tce)	0.34	0.479	0.55
Non-fossil (billion tce)	0.71	0.72	0.836
Total energy (billion tce)	4.8	4.58	4.55
CO_2 emission (billion tons)	9.75	9.09	8.62
GDP (trillion, 2010 RMB)	82.6	82.6	82.6
GDP (trillion, 2015 RMB)	9.36	9.36	9.36
Energy consumption per unit GDP (ton standard coal/1,000 RMB)	0.580	0.55	0.55
Reduction of energy intensity (%)	19.3	23	23.4
Proportion of coal (%)	58.5	54.8	51.6
Proportion of non-fossil fuel energy (%)	14.8	15.7	18.4

In the coal cap scenario (i.e. energy saving), the consumption of coal, oil, natural gas, and non-fossil energy in 2020 will account for 54.8%, 19%, 10.5% and 15.7% of total energy consumption respectively. Compared with the reference scenario, the proportion of coal and natural gas change significantly: coal consumption will reduce by 300 million tce, and natural gas consumption will increase by 79 million tce. The energy structure of the coal cap scenario will tend to be more low carbon, and CO_2 emissions will reach 9.09 billion tons. The CO_2 emissions caused by coal use would be restricted to 7.5 billion tons in 2020. It will be possible for energy intensity and carbon intensity to drop by more than 18% and 21% based on 2015 levels. The coal cap scenario has coal demand that is 160 million tce higher than the 2°C scenario. Due to the 3.7% decrease in coal consumption from 2014 to 2015, CO_2 emissions in 2015 are estimated to have been around 1% lower than in 2014, which were estimated to be 9.4 billion tons. In the reference scenario, coal consumption will have plateaued, and CO_2 emissions will peak in 2020 and then begin to decline. Under the coal cap scenario, emissions in 2020 will be 5.7% lower than their peak in 2014, and the coal cap policy will lead China's CO_2 emissions to peak in 2014. As climate restrictions become stricter, the coal cap scenario shifts to follow the the 2°C scenario after 2030 so that CO_2 emissions can be kept within levels that will allow the world to meet its target of no more than 2°C temperature rise.

The bottom-up regional coal consumption scenario analysis offers several advantages. It meets various environmental and water resource red lines in different regions, considers the technological progress and cost of coal consumption and emissions reductions for various pollutants, and sets coal cap targets for several regions. This model has solved the problem of regional differentiation and provided a foundation for production structure, investment policy, decision-making, and the development of a carbon and emissions trading market.

In the sectoral scenario analysis, the production of iron and steel, cement and the majority of other coal-intensive industries will have peaked in 2014. The 13th FYP will accelerate efforts to change China's industrial structure through deleveraging, reducing inventory, reducing costs, and strengthening areas of weakness, all of which will have a large impact on coal-intensive sectors and promote a substantial decrease in coal consumption. However, China's manufacturing

industry will still maintain production capacity at a fairly high level. In the building sector, the government should cap the country's total floor area at 70 billion square meters. In the power sector, the installed capacity of coal power should be held to 960 GW before 2020. Future development in the coal chemical industry is still a source of uncertainty.

Based on this analysis, the coal cap plan during the 13th Five Year period will adopt an 18% energy intensity reduction target and a 21% carbon intensity reduction target. During the 13th Five Year Plan, China will establish a national carbon trading market. Coal is the largest contributor to CO_2 emissions, and the six large industries that will be part of the national carbon trading program (power, building materials, iron and steel, building energy efficiency, paper, and non-ferrous metals) are all high coal-consuming sectors. China's energy and carbon saving targets have already been in place for many years, providing a wealth of experience. During the 13th Five Year Plan period, total energy savings should reach 700 million tce, reducing CO_2 emissions by 1.8 billion tons.

5 NATIONAL COAL CAP TARGETS, TASKS, AND IMPLEMENTATION PATHWAY

The national coal cap target is established according to red lines, as well as an analysis of coal demand. A coal cap is a mandatory target that corresponds to red lines and targets for energy intensity, carbon intensity, and renewable energy. China can achieve the national coal cap target through the reduction, clean utilization, and replacement of coal, and the use of dual controls in coal consumption and production.

5.1 TARGETS

National coal cap target for 2020:	2.51 billion tce (3.5 billion tons of coal)
Total energy consumption:	4.58 billion tce
Coal's share of primary energy consumption:	54.8%
Oil share:	19%
Natural gas share:	10.5%
Non-fossil energy share:	15.7%
Coal reduction target:	300 million tce (420 million tons of coal)
Coal production cap target:	3.4 billion tons of coal

5.2 MAIN TASKS

(1) Make adjustments to the economy, industry, and manufacturing sector. Alleviate overcapacity. Adjust the policies governing exports of energy-intensive products.

(2) Allocate the national coal cap target to provinces, autonomous regions, and municipalities based on the economic, technical, financial, and natural conditions in each area. Provinces and autonomous regions should then allocate the coal cap target to the city level. The government should implement coal cap targets at four levels: national, regional, provincial and city. Coal cap targets will be included in government responsibility and performance assessment indices at each level of government, along with other criteria.

(3) Allocate the national coal cap target to the energy-intensive power generation, manufacturing, and building sectors in accordance with the characteristics of each sector. This will be used to design a coal cap plan for each sector. The manufacturing industry includes iron and steel, cement, building materials, the chemical industry, the coal chemical industry, the paper industry, and the ceramics industry.

(4) Implement a coal production cap of 3.4 billion tce.

(5) Strengthen and promote the establishment of an ecological civilization in the 13th Five Year Plan, building on the foundation developed by the 12th Five Year Plan. Establish co-control, co-management, and coordinated plans to achieve coal caps at each level and sector. A comparison of the key energy and environmental targets in the 12th Five Year Plan and the China Coal Cap Project's 13th Five Year Plan Recommendations is shown in Appendix 3. Capping coal consumption and protecting public health are closely connected, and air quality should improve markedly during the 13th FYP period. Reductions in major pollutant emissions are outlined in Table 3

(6) Propose a guarantee plan for the coal cap that includes reforms in the energy system and technology, as well as in sources of energy supply and levels of demand. Outline market mechanisms and measures and establish an international energy regulatory agency that can help advance a coal cap.

5.3 IMPLEMENTATION

The coal reduction targets will not be achieved by adjusting coal use alone. It is also necessary to coordinate and harmonize with other targets that can also support reductions in coal use. The primary strategy for coal reduction has three components: reducing coal use, clean utilization of coal, and replacing coal in the energy mix.

5.3.1 COAL REDUCTION AND EFFICIENT UTILIZATION

Coal reduction and efficient utilization methods should reduce the country's coal consumption by 218.25 million tce, accounting for 72.9% of total coal reductions under the coal cap.

Coordinated targets:

Energy intensity (energy used per unit of GDP) in 2020 is reduced by 18% from 2015 levels

Carbon intensity (carbon emitted per unit of GDP) is reduced by 21% from 2015 levels

Energy consumption per unit of industrial added value (for enterprises above the designated size) is reduced by around 23% from 2015 levels

Total CO_2 emissions from coal consumption: 7.5 billion tons

Other resource targets for 2020:

Current national water resource use: 670 billion cubic meters

Coal-related water use: 74.7 billion cubic meters

Water consumption per 10,000 RMB of industrial added value is reduced by more than 30% from 2013 levels

Water consumption per 10,000 RMB GDP is reduced by more than 35% from 2013 levels

Forest coverage rate: 24%

Forest coverage area increases by 40 million hectares from 2005 levels

Forest stock increases by 3 billion cubic meters from 2005 levels

Remediance of coal mining-related subsidence: 85%

There are two primary components of coal reduction. One is improving efficiency and increasing the utilization rate of existing equipment. A second aspect is indirect energy savings, such as those achieved through rebalancing the economic and industrial structure, shutting down outdated production capacity, solving overcapacity issues, concentrating manufacturing enterprises, and greening manufacturing. Our analysis indicates that more efficient coal use technologies can reduce coal consumption by 86.01 million tce, 39.3% of the possible reduction in coal, while indirect energy savings can reduce coal consumption by 132.74 million tce, 60.7% of the possible reduction in coal. Contributions from indirect coal reduction are about 20% higher than those from more efficient use of coal. Reducing coal use will also reduce overall air pollutant emissions: reducing coal consumption by 218 million tons will reduce SO_2, NOx, and particulate matter emissions by 1.411, 1.558, and 0.823 million tons respectively.

5.3.2 CLEAN UTILIZATION OF COAL

Reduction Targets: 29.6 million tce, 9.9% of potential coal reductions

Related environmental targets:

Air quality: Annual average $PM_{2.5}$ concentration of approximately 45μg/m^3 (decrease of 40%-50% in key areas and decrease of 20% in other areas)

Days of level 2 air quality:	>85%
Decrease of SO_2 from 2015 levels:	17%
Decrease of NOx from 2015 levels:	21%
Decrease of particulate matter from 2015 levels:	25%
Decrease of volatile organic compounds (VOC) from 2015 levels:	18%
Decrease of atmospheric ammonia nitrogen from 2015 levels:	16%

Clean coal technology targets:

Raw coal washing and selection percentage:	80%
Fly ash utilization percentage:	75%
Establish a regional coal blending center	
Substantially increase the re-filling rate for coal gangue	

The total pollutant emission reduction system is an important means to promote the improvement of environmental quality. The various emission reduction targets of the 13th Five-Year Plan period will more than double those of the 12th Five-Year Plan period. The starting point for setting total emission reduction targets for newly-added pollutants such as particulate matter, volatile

organic compounds (VOCs) and atmospheric ammonia nitrogen is high, set at 25%, 18% and 16%, respectively. The emission reductions targets of five air pollutants in the 13th Five Year Plan are shown in Table 5. On January 1, 2015, the most rigorous Environmental Protection Law in China's history came into force, and the implementation of the Air Pollution Action Plan has been implemented fairly quickly. The Law on Prevention of Air Pollution came into effect on January 1, 2016, accompanied by focused supporting policies and measures, and there has been active public participation for addressing air pollution. These factors together promote the clean utilization of coal.

Table 3: Reduction Targets and Emission Reductions of Five Atmospheric Pollutants in the 13th Five-Year Plan Period

Type of pollutant	SO_2	NOx	Primary $PM_{2.5}$	NH_3	VOC
2020 Reduction Targets (%)	17	21	25	16	18
2020 Reduction Amount (million tons) (based on 2015 levels)	3.28	4.23	2.56	1.45	3.94

Efforts will be made to strengthen coordination in pollutant control and to promote the application of clean coal technology. The goal is to have the raw coal washing rate reach 70% in 2017 and 80% in 2020. Coal quality processing should be expanded overall. This includes the use of cleaning technology at the point of production, such as coal washing, coal shaping, coal blending, and coal slurry. Washing coal can get rid of 50-70% of fly ash and 60-70% of inorganic sulfur. A coal blending center for regions and large cities could reduce sulfur content to under 1% and fly ash to under 12%. Regions and large cities with particularly severe pollution should reduce sulfur content to less than 0.8% and fly ash to under 10%, or even lower. Shaped coal and other clean coal technologies should also be expanded. Altogether, these measures can increase the efficiency of coal use by 5%. Assuming coal production is 3.4 billion tons in 2020, the above clean coal technologies can reduce coal consumption by 29.6 million tce, 9.9% of potential coal reductions. This reduction in coal use will in turn reduce SO_2 emissions by 191,000 tons, NO_x emissions by 211,000 tons, and particulate matter by 111,000 tons. Coal washing can remove 3.49 million tons of SO_2 emissions. Increasing the coal washing rate by 10% in the 13th FYP period can reduce SO_2 emissions by 349,000 tons compared to 2012.

Control of emissions at the source will be coordinated with end-of-pipe pollution treatment, and oversight will be more intensive. The setting of special emission standards for 25 key sectors as required under the Air Pollution Action Plan has been finished, so that air pollutant emission standards have been basically completed. Efforts need to be made to improve the environmental regulatory system, establish a robust environmental protection management system for all pollutants, establish and improve on an emissions permit system, and ban emissions without a permit, as well as emissions in excess of emissions standards and total emission control limits.

5.3.3 COAL REPLACEMENT

Coal reduction target: 51.65 million tce, representing 17.2% of potential reductions

Replacement targets:

Consumption of natural gas:	468 million tce (360 billion cubic meters)
• Rate of coal mine gas extraction:	65%
• Rate of coal mine gas utilization:	60%
Consumption of renewable energy:	720 million tce
Electricity used in place of coal:	80 TWh/year

In terms of replacing coal, the coal cap project recommends achieving a goal of obtaining 15.7% of primary energy from non-fossil fuel sources by 2020. In order to do this, renewable energy should account for 37.5% of total installed capacity and account for 26.9% of total power generation during the 13th Five Year Plan period. 15% of all building heating should come from renewable energy. The government should establish a renewable energy generation quota for each province or implement quota requirements for utilities, and renewable energy targets for building heating should be set according to local conditions.

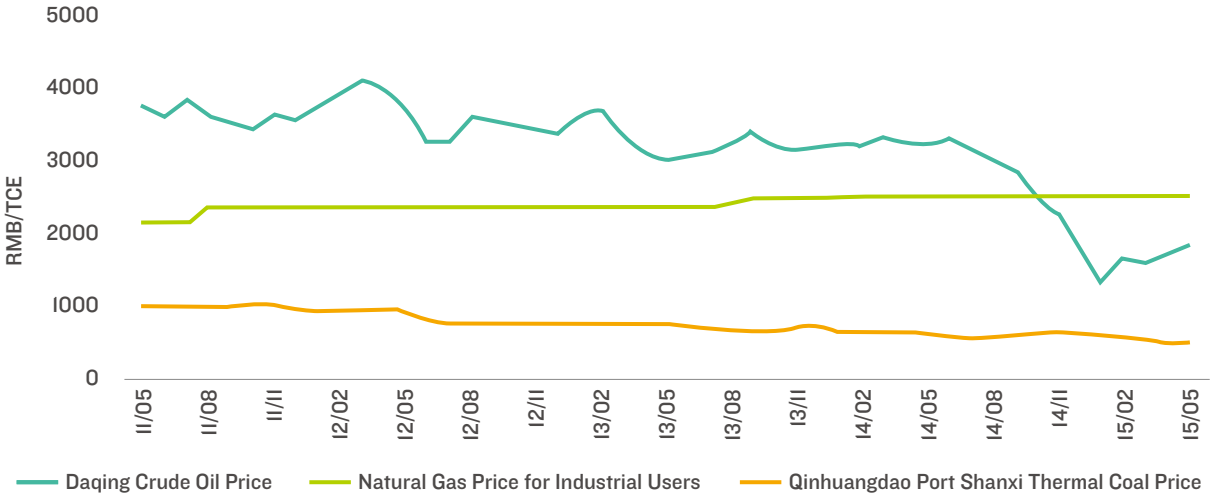
Replacing coal with electricity should become more widespread. In large cities and megacities, due to air quality requirements, only electricity or natural gas should be used in central areas or in areas where coal is banned. During the 13th Five Year Plan period, the State Grid Corporation should generate 65 to 70 TWh of electricity from non-coal alternative sources every year. Besides the State Grid Corporation, other programs replacing coal with electricity should total 10-15 TWh. The equivalent of about 6.7 GW of coal fired power capacity will be sufficient to replace coal used for direct burning. Utilization hours for alternative energy sources should also be increased.

At this time, natural gas is the most realistic choice to replace coal. Raising the proportion of natural gas in the fuel mix will also help improve energy system efficiency. Assuming no other conditions change, using more natural gas under the coal cap scenario would improve energy system efficiency by several percentage points (based on global models for energy consumption structures). Coal cap policies can increase the share of natural gas in the energy mix and consequently increase the efficiency of China's energy system to 38.5% by 2020, a 2.4% increase over the 2012 energy system efficiency of 36.1%. In 2014, natural gas accounted for 5.7% of total energy consumption. By the end of the 13th Five-Year Plan period, the supply of natural gas should reach 360 billion cubic meters, making up 10% of total energy consumption.

The supply of this 360 billion cubic meters of natural gas resources is relatively certain, so the key obstacle to natural gas replacing coal is price. As shown in Figure 3, although the price of oil per tce has dropped more rapidly than that of coal, the price gap between natural gas and coal is widening. Presently, demand for natural gas is growing slowly. If the price of natural gas is not adjusted downward and the demand for natural gas is not increased, it will be difficult for the consumption of natural gas to reach 360 billion cubic meters by 2020, affecting the ability for natural gas to serve as a substitute for coal. The Chinese

government did introduce changes in the second half of 2015, reducing the retail price of natural gas by 0.7 RMB per cubic meter in order to encourage consumption. However, further reforms need to be made to the supply and demand of gas and relevant market mechanisms in order to increase natural gas's proportion in the energy mix.

Figure 3. Coal, Oil, and Natural Gas Price Trends in China, May 2011 – May 2015



(Unit: RMB/ton standard coal)

For pollutant emissions avoided by replacing coal, see Table 4.

Table 4: Pollutant Emissions Avoided By Replacing Coal (Unit: 1,000 tons)

		Particulate Matter	SO_2	NOx
Power Sector	Replacement with gas-fired electricity	1.1	5	6.9
	Replacement with renewable energy	7	30.0	42.1
	Replacement with electric boilers	36.6	193.3	168.1
Other Sectors	Replacement with natural gas-fired boilers and renewable energy heating	29.5	149.3	145.4
	Total	74.2	377.6	362.5

Note: 1) In 2020, the power sector will replace a total of 36 million tce coal; 2) Other sectors will replace 15.65 million tce coal

In short, by using just three coal reduction measures, supplementary targets, and clean coal technologies, coal consumption can be reduced by 300 million tce (420 million tons). This will in turn reduce SO_2 emissions by 2.328 million tons, NO_x by 2.132 million tons, and particulate matter emissions by 1.008 million tons. This represents 71%, 50%, and 39% of the total reductions in SO_2, NO_x, and particulate matter in 2020 respectively. In addition, by using end-use reduction technology like ultra-low emission coal plants, the 13th FYP pollution reduction targets can be achieved.

5.4 IMPLEMENTING SCIENTIFIC COAL PRODUCTION CAPACITY AND A COAL PRODUCTION CAP

Coal production cap target:	3.4 billion tons
Scientific production capacity target:	2.75 billion tons

A coal production cap is a way for the coal industry to address its challenges and develop in a more sustainable way. It will also help the industry solve issues with overcapacity and stabilize coal prices. Through a coal cap, energy-intensive industries – which up to now have taken advantage of low-cost coal to fuel irrational expansion – will be pushed to optimize their industrial structure. The goal of a coal production cap is to establish a coal development strategy that develops a green, safe, and efficient scientific production capacity. In 2020, coal production capacity will be reduced, and the proportion of production capacity that is scientific will have risen to 74% ("scientific production capacity" follows 10 different indicators, such as safety, efficiency, and environmental friendliness). By 2030, the proportion should reach 100%.

In China's 13th Five Year Plan period, provinces in the eastern and central regions that produce more than 50 million tons of coal (Shandong, Hebei, Liaoning, Heilongjiang, Shanxi, Anhui, Henan) and provinces in the western region that are major sites for coal production (Inner Mongolia, Shaanxi, Guizhou, Xinjiang, Yunnan) should have their coal production restricted to a collective total of 3.387 billion tons (Table 5).

Table 5: Coal Production Cap Targets for Key Provinces in 2020

Unit: Million Tons

Eastern Region				Central Region			Western Region				
Hebei	Liaoning	Heilongjiang	Shandong	Shanxi	Anhui	Henan	Inner Mongolia	Shaanxi	Guizhou	Xinjiang	Yunnan
73	41	62	113	943	137	114	950	481	181	210	82

The indicators for scientific production capacity were derived from development challenges that the coal industry faces from the natural world, such as those posed by environmental, safety, and resource-driven restrictions. The scientific production targets for the five largest coal producing regions during the 13th Five Year Plan period are shown in Table 6.

Table 6: Scientific Production Capacity Targets in the Five Largest Coal Producing Regions Under a Coal Cap Scenario

Unit: Billion tons

Region	2016		2017		2018		2019		2020	
	Scientific production capacity	Proportion (%)	Scientific production capacity	Proportion (%)	Scientific production capacity	Proportion (%)	Scientific production capacity	Proportion (%)	Scientific production capacity	Proportion (%)
Shanxi, Shaanxi, Inner Mongolia, Ningxia, Gansu	1.455	59.14	1.531	61.75	1.612	64.51	1.697	67.39	1.786	70.37
East China	0.401	81.07	0.414	85.31	0.427	89.71	0.440	94.24	0.454	99.13
South China	0.053	13.79	0.076	20.51	0.107	29.93	0.153	44.36	0.217	65.24
Xinjiang Qinghai	0.087	44.48	0.109	51.80	0.136	60.10	0.170	69.83	0.212	80.96
Northeast China	0.071	46.15	0.073	49.31	0.076	53.34	0.079	57.62	0.082	62.07

Other development objectives:

Concentrate coal production: The production capacity in the large coal bases should account for about 95% of production capacity nationwide. Large-scale coal mines should produce 300,000 tons of coal per year, or 70% of total production. Small-scale coal mines (defined as mines with a production capacity less than 300,000) should have a collective production capacity of 300 million tons per year, or 7% of national production capacity. Through mergers & acquisitions and measures to retire outdated production capacity, the entire coal mining industry should be reduced from the 6,390 companies existing in 2015 to 3,000 or fewer companies by 2020.

Increase the share of processed coal: By 2020, China's raw coal selection rate should reach 80%. Scientific production capacity at coal mines should achieve a raw coal selection percentage of 100%. The level of safety in the coal mining profession should also be increased. Changes to the country's fundamental production system alone should decrease the percentage of occupational death in coal mining (i.e. deaths per 1 million tons mined) to 0.15%. Scientific production capacity would further decrease the percentage of occupational deaths to 0.1%, as well as reducing the percentage of deaths from occupational pneumoconiosis to 0.2%

Increase the comprehensive utilization rate of coal and decrease environmental and ecological damage: The percentage of coal gangue that is used should be more than 75%; the percent remediation for land subsidence from coal mines should reach higher than 80%. Over 90% of coal gangue sites and open-pit mines' discharge fields should be reclaimed. Coalbed methane (coal mine gas) production should reach around 40 billion cubic meters. This includes 20 billion cubic meters of surface production (basically all of which should be used) and 20 billion cubic meters of gas collected from underground mines (60% or more of which should be used). Scientific production capacity can increase the percent of coal waste that is re-used to 80% or higher, the percent of coalbed methane (coal mine gas) that is used to 65% or more, the percent land subsidence areas that are remediated to 85% or more, and the percent of coal gangue and open-pit discharge fields that are remediated to 95% or more.

5.5 CO-BENEFITS OF A COAL CAP

A coal cap will produce a number of economic and societal co-benefits. The implementation of a coal cap plan will have a substantial impact on water resource conservation and protection, point source air pollution reduction, and protection of public health. The three primary implementation methods of the coal cap, combined with the results of a coal production cap, will lead to significant improvements in China's environment (see Table 7).

Reducing coal use will help with water saving and conservation efforts. Without a coal cap, coal mining and utilization will exceed the limits set by the water resource red line by 2020, using 21.8 billion cubic meters more water than the red line (which is set at 74.7 billion cubic meters) would allow. With a coal cap plan and additional water-saving measures and technologies, water consumption in 2020 can be kept under 72.1 billion cubic meters. According to analysis, source reductions from a coal cap can reduce $PM_{2.5}$ levels in the Beijing-Tianjin-Hebei region (commonly referred to as Jing-Jin-Ji) by 14%. Reducing emission rates at the source of pollution is more cost effective than reducing them at the end point. Furthermore, by lowering the risk to public health from air pollution, a coal cap will reduce the number of premature deaths by 71,000

persons in 2020, compared to the reference scenario.

The coal cap will create around 1.86 million new positions in the energy saving and green power sector. The coal mining industry, due to weakening economic growth and mechanization of mining, will shed around 1.1 million jobs; of this, job losses from a coal cap will be around 310,000 people. Following transitions to the energy structure, the number of new jobs in coal-fired power generation will be reduced by about 37,000 people. However, due to the development of clean energy, the power sector will experience a shift in employment, and by 2030 this downward trend in job creation will have reversed. Overall, the coal cap will not have a significant impact on the unemployment level, and in the long term it will create even more new jobs in the green sector.

Table 7: Summary of Co-Benefits of a Coal Cap

Program	Co-benefits	2020
Coal	Coal Reduction (million tons)	420
Water Resources	Reduction of coal mine drainage (million m^3)	770
	Reduction in the area of coal mine land subsidence (km^2)	67.0
	Reduction in soil erosion (km^2)	79.6
	Reduction in wastewater from coal washing (million m^3)	190
	Amount of water conserved (million m^3)	5,210
Air Quality	SO_2 emission reductions (million tons)	2.33
	NOx emission reductions (million tons)	2.13
	Particulate emission reductions (million tons)	1.01
Public Health	Reduction in premature deaths (1000 persons)	71
	Reduction in mining deaths (persons)	32
	Reduction in occupational pneumoconiosis (cases)	844
Energy System Transition	Avoided investment (billion RMB)	1.55
	Reduction in system costs (billion RMB)	85.89
Impact on Unemployment	Coal mining and washing industry jobs (1000 persons)	-310
	Power Sector jobs (1000 persons)	-37
	Energy saving and green power services industry (1000 people)	1,860
Greenhouse gas emissions	CO_2 emissions reductions (million tons)	850

6 LOCAL COAL CAPS

China should establish local coal caps based on red lines at the regional, provincial, and city level, with the provincial level being the key area. At the regional level, these red lines can establish a better production system centered around coal-saving and emission reduction regulations – particularly for electricity generators, steel factories, cement factories, and highly polluting industries. At the provincial level, coal cap plans will push for comprehensive, balanced, and sustainable economic and societal development. At the city level, coal cap plans will be people-focused and will emphasize pragmatic, actionable measures that respect all relevant red lines. Based on available statistics, currently almost 20 provinces and more than 30 cities have established local coal cap plans based on the Air Pollution Action Plan (see Appendix 4). A national level coal cap can push all areas in China to implement coal cap plans.

6.1 TARGETS

Table 8: 13th Five Year Plan Coal Cap and Coal-Saving Targets by Region

Region	Coal Consumption in Reference Scenario (million tons)	Coal Consumption Targets in Coal Cap Scenario (million tons)	Total Coal Saved (million tons)
Jing-Jin-Ji and Surrounding Regions (Shanxi, Henan, Shandong)	1,356.1	1,279.7	76.4
Only Jing-Jin-Ji	314.3	290.9	23.4
Yangtze River Delta and Surrounding Regions	686.5	611.5	75
Only Pearl River Delta	488.1	435.7	52.4
Sichuan-Chongqing-Guizhou and Surrounding Regions (Hunnan, Hebei)	747.6	697.7	49.9
Only Sichuan-Chongqing-Guizhou	402	372.1	29.9
Northwest (Inner Mongolia, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang)	1,225.9	1,066.2	159.7
Northeast (Heilongjiang, Jilin, Liaoning)	476.6	427.1	49.5
Southeast (Fujian, Jiangxi, Guangdong, Guangxi, Hainan)	463.3	454.3	9
Southwest (Yunnan, Tibet)	122.3	112	10.3
Total	5,078.3	4,648.5	429.8

Note: Local and national statistics differ. However, the 427.3 million tons saved based on local statistics and the 420 million tons (300 million tce) saved based on national statistics are close enough that we treat them as roughly the same value.

6.2 MAIN TASKS

(1) Allocate the national air quality, water resource, coal-related CO_2 emission, and coal cap targets to the provincial level and above.

(2) Allocate total emissions control targets for air pollutants (sulfur dioxide, nitric oxygen, particulate, ammonia nitrogen, and volatile organic compounds) to the provincial level and above.

(3) Allocate the national energy intensity and carbon intensity targets to the provincial level. Establish provincial-level renewable energy quotas and renewable energy heating (and air conditioning) targets.

(4) Allocate the above targets to the municipal level according to the characteristics of the provinces.

(5) Establish effective coal cap measures in accordance with the different red lines (environmental, ecological, and resource-driven). Establish effective regional, provincial, and city-level coal cap measures.

(6) Governments agencies at regional, provincial and municipal levels should coordinate and work together, emphasizing key measures in key locations, on-the-ground implementation, and effectiveness.

(7) Establish market mechanisms and learn from international experience promoting coal caps at the city level.

6.3 IMPLEMENTATION

6.3.1 INDUSTRIAL LAYOUT AND REGIONAL COAL CAP PLANNING

(1) Establish regional coal cap planning with air quality restrictions as the primary consideration

There are two regions in which coal consumption intensity has been continuously high. One of these regions is composed of Beijing, Tianjin, Shandong, Shanxi, Hebei, Henan, Shanghai, Jiangsu, Zhejiang and Anhui; the other spans Hubei, Hunan, Chongqing, Sichuan and Guizhou. This is the foundation for the regional "joint prevention and control" of air quality. According to the national target for annual PM2.5 concentration (about 45μg/m3 in 2020), the working group has established air quality targets, water consumption targets, and coal cap targets for these regions, which are shown in Table 9.

Table 9: Air Quality, Coal Cap and Total Water Use Red Line Targets

Region	Air quality targets (μg/m³)		Total water consumption red line (billion cubic meters)	Coal cap (million tons)
	2013	2020	2020	2020
Beijing, Tianjin, Hebei	106	50 (-55%)	30.6	257.8
Shanxi, Henan, Shandong, Hubei, Anhui	86	47 (-45%)	128.8	1,196.5
Yangtze River Delta	67	40 (-40%)	89.8	386.5
Sichuan, Chongqing, Guizhou	67	43 (-36%)	55.3	328.0
Pearl River Delta	47	35 (-26%)	45.6	160.0
National	73	45 (-38%)	670.0	4,114.0

In 2020, the provincial coal caps targets should total to 4.14 billion tons of coal, corresponding to a national target of 3.5 billion tons. [1] The coal cap target in the Beijing, Tianjin and Hebei region in 2020 will amount to a reduction of over 163 million tons from 2012 levels, and that in the Yangtze River Delta will amount to a reduction of over 88 million tons. 2020 coal consumption in the air quality joint prevention and control regions will be lower than consumption levels in 2012. The 2020 coal consumption in other regions may be slightly higher than 2012 levels. To guarantee that air quality will not decrease, other regions will increase their use of coal cleaning and end-of-pipe controls so as to ensure that the air quality across the country can achieve the 2020 targets.

Water resources in Beijing, Tianjin, Hebei, Shanxi, Henan, Shandong, Hubei, Anhui, Shanghai, Jiangsu and Zhejiang will be given special attention, especially considering the shortage of water in Beijing, Tianjin, Hebei, Shanxi, Shandong, Henan, Shanghai, and Jiangsu. Industries must factor water resource availability into their production plans, and municipalities and the agricultural sector should pay close attention to water use efficiency.

The Jing-Jin-Ji region and neighboring Henan and Shanxi provinces should add a maximum 19.34 GW of new coal-fired power capacity by 2020, with total installed coal-fired power generating units in the region capped at 298 GW. The Yangtze River Delta region and neighboring Anhui and Zhejiang provinces should add a maximum 28.71 GW, with coal-fired power generating units in the region capped at 209 GW. The newly added coal-fired power generating units in Sichuan, Chongqing, Guizhou and Hunan regions should only reach 26.28 GW, with the main additions in Guizhou and Hubei; here, coal-fired power generating units should be capped at 128 GW. The newly added coal-fired power generating units in the Pearl River Delta and surrounding regions should reach more than 1 GW. No new coal-fired power plants should be built in the Pearl River Delta itself, with coal-fired power

1.Based on China's statistical data, provincial coal cap data cannot be simply added up to reach the national coal consumption figure, so during the formulation of the provincial coal cap targets, the provincial coal consumption data in national statistical yearbooks is taken as the basis to reach the combined local coal cap target of 4.114 billion tons of coal by 2020, equivalent to a national coal cap target of 3.5 billion tons.

generating units capped at 60 GW.

The existing production capacity of crude steel in the Jing-Jin-Ji region is around 370 million tons. From this starting level, Hebei Province has targeted a reduction of 60 million tons. The Yangtze River Delta should relocate part of its production capacity and manufacturers to the southern coastal area. By 2020, it is expected that Sichuan and Guizhou will reduce capacity and adjust the distribution of steel manufacturers, set production based on market size and iron ore costs, eliminate outdated production capacity and avoid constructing new factories. In 2020, the cement clinker output in the Jing-Jin-Ji region should be pressed to reduce to 65 million tons or less, less than it was in 2014.

For air pollution and water pollution caps, joint prevention and control across different regions is a promising solution. The US experience with sulfur dioxide control and the European experience with water pollution control in the Danube Valley indicates that regional joint prevention and control is an effective measure to achieve the most cost-effective results. In the last few years, both central and local governments have made a great effort to control air pollution in the "three regions" (Jing-Jin-Ji, the Yangtze River Delta, and the Pearl River Delta) and achieved notable results. Joint prevention and control needs to be implemented over a broader area, covering the entire Jing-Jin-Ji region and surrounding areas (Shanxi, Henan, Shandong), Yangtze River Delta and surrounding areas (Jiangsu, Shanghai, Zhejiang, Anhui), as well as Chengdu, Chongqing, Guizhou and Hunan. The Ministry of Environmental Protection should set up a new office to coordinate the prevention and control of air pollution across this sizeable area.

The coal consumption for winter heating in the north is substantially higher than the southern regions without heating in winter, so solving the problem of coal combustion in the heating season is a key issue for coal control. In the northern cities, efforts will be made to reduce coal consumption for heating, introduce power and heating co-generation, centralize heat production, and adopt gas-fired and electric boilers for heat and hot water supply. For those areas in which centralized heating cannot be supplied, low-cost alternatives can be chosen. Certain cities can also provide heat to the surrounding areas by using the waste heat supplied by large-scale enterprises.

China should establish and improve clean coal distribution centers and ban the sale of bulk coal with ash content higher than 12% and sulfur content higher than 1% in cities. It should also accelerate the construction of natural gas infrastructure in the surrounding areas of cities and towns and promote the use of gas in place of coal. For rural areas, we encourage the use of various alternative energies such as distributed solar energy and biogas, as well as the implementation of a preferential policy on natural gas prices to push rural residents to change their coal use habits. For some cities and towns in the north, residents can make use of wind energy in the winter for heating.

(2) Establish a regional coal cap plan focused on water resource restrictions.

The northwestern six provinces and autonomous regions, which includes Xinjiang, Gansu, Ningxia, Qinghai, Shaanxi and Inner Mongolia, are vast but sparsely populated. Despite its large landmass, air pollution in the cities in this region is serious, and water resources are an important red lines for its development.

The development of the coal industry in the northwestern region is being accelerated. This new expansion has reached 650 million tons per year, accounting for 87% of the nation's total. Among 14 recently constructed coal bases with 100 million tons capacity, 6 bases are in the western region. The annual output of coal in Xinjiang will make up more than 20% of the nation's total by 2020. However, there is a general scarcity of water resources in the western region, which the development of the coal

industry has further exacerbated. The imbalance between supply and demand of water resources is very conspicuous, especially in Shanxi, Shaanxi, Inner Mongolia, Ningxia, and Gansu. The output of raw coal in the region amounts to 60% or more of the nation's total, while its share of water resources is only 4.8% of the nation's total. In the Ningdong base, the existing water use for coal consumption has already exceeded the red line for 2015. In the Xinjiang base, there is still space between total water use for coal consumption and the red line, but the coal base still has a serious shortage of water. The coal-fired power stations in Inner Mongolia, Shaanxi, and Xinjiang are the largest in the country, reaching 27.48 GW, 25.22 GW and 23.25 GW, respectively. In addition, the projects that are being built, planned, and approved – a total of 224.55 GW in six provinces and autonomous regions throughout the northwestern region – will be launched soon, with an installed capacity equivalent to one-fourth of the installed capacity for existing coal-fired power in the country. Coal exploitation has also pushed forward the development of local coal-fired power and the modern coal chemical industry. According to available statistics, there are currently at least 115 coal chemical industry projects slated to move forward in the future. Quite a few coal chemical projects feature large coal consumption, high pollutant emissions, high carbon dioxide emissions, large water consumption, and difficulties with sewage treatment. In this context, the Coal Cap Project predicts that the coal consumption in the western region may have significant growth, with coal consumption in the six provinces and autonomous regions in the northwest forecasted to grow by 68% by 2020 (according to 2012 levels). This cannot help but be a cause for concern.

Table 10 shows the restrictions and coal cap targets for water resource conservation and air quality in the northwestern region. By 2020, the national air quality requirements in 2020 should be stricter than the national level in 2012. With the strict restrictions on coal consumption set by the water resource red line, the 2020 coal cap target should be 940.5 million tons, a reduction of 14.58% over the baseline coal demand. Under water resource and other red line restrictions, the construction of new coal mines, coal-fired power plants, and coal-to-gas projects in China's northwest regions should be strictly re-evaluated. Projects that ought to be delayed should be delayed, projects that ought to be paused should be paused, and projects that ought to be canceled should be canceled. In 2020, the northwestern provinces of Xinjiang, Inner Mongolia, Ningxia, Gansu, and Shaanxi should limit their installed coal-fired capacity to 40.79, 90.43, 20.78, 20.36 and 32.15 GW respectively.

Table 10: Water Use Red Line, Air Quality Targets, and Coal Cap Targets in the Northwestern Region in 2020

Province/Municipality	Water use red line (billion cubic meters)	Air quality target (μg/m^3)	Coal Cap (million tons)
Inner Mongolia	21.2	38	353.5
Shaanxi	11.3	47	176
Gansu	11.4	38	84
Qinghai	3.8	40	26
Ningxia	7.3	38	97
Xinjiang	51.6	38	204
Total	106.6	Average 40	940.5

(3) Establish a regional coal cap plan focused on environment improvements

A regional coal cap plan centered around ecological improvement should include China's northeast, southeast, and southwest regions, specifically Heilongjiang, Jilin, Liaoning, Fujian, Jiangxi, Guangdong, Guangxi, Hainan, Yunnan, and Tibet.

Currently, these provinces/regions have relatively low air or water resource constraints compared with the regions discussed in the above two sections, but they still need to make significant effort to not only maintain current levels of environmental quality, but also to improve in order to meet their environment, ecology, and resource targets in 2020 and 2030. Therefore, these provinces also need a coal cap plan, striving to improve their environmental quality and lead the country in achieving its 2020 environmental targets.

In particular, the northeast region should improve efficiency and adopt clean utilization technologies and clean energy alternatives for their winter heating and industrial coal consumption. Though endowed with rich coal resources, Yunnan province, under a coal cap, should prevent excessive coal development or utilization. The supply and demand for energy in these regions is growing. They should endeavor to meet this demand with energy efficiency, renewable energy, nuclear energy, and natural gas in order to control and reduce their current coal consumption levels.

6.3.2 PROVINCIAL-LEVEL COAL CAPS BASED ON ECOLOGICAL PROTECTION

China should establish provincial-level coal cap plans in 30 of its provinces. The governments of provinces, municipalities and autonomous regions should design integrated provincial-level coal control plans that take into account regional differences. The sub-national coal caps should meet local red line constraints, and governments should formulate provincial-level targets for coal reduction, clean use, and fuel switching. Policy differentiation does not mean selective implementation of a coal cap. Rather, all provinces should adopt coal cap policies, with the strength and specific targets of these policies adjusted based on local conditions.

(1) Establish provincial red lines

Provincial, municipal and autonomous regional governments should map out ecological function areas and develop economic and urban development plans in strict accordance with the region's key functions and land planning requirements. The China Coal Cap Project has established $PM_{2.5}$ control targets for 30 provinces, municipalities, and autonomous regions across the country (see Appendix 5). These are based on the existing provincial PM2.5 emission concentrations, the national and key regional $PM_{2.5}$ emission targets, and the coal control targets for 2020. Based on these targets, the $PM_{2.5}$ concentration in Beijing, Tianjin, Hebei and surrounding Shandong, Henan, and Shanxi provinces needs to have the largest reduction by 2020. The Yangtze River Delta, Sichuan, Chongqing, Guizhou, and the three northeastern provinces need to achieve the second largest reduction. When these targets are achieved in 2020, the excess deaths caused by coal-related $PM_{2.5}$ pollution would drop to approximately 590,000, from 708,000 in 2012.

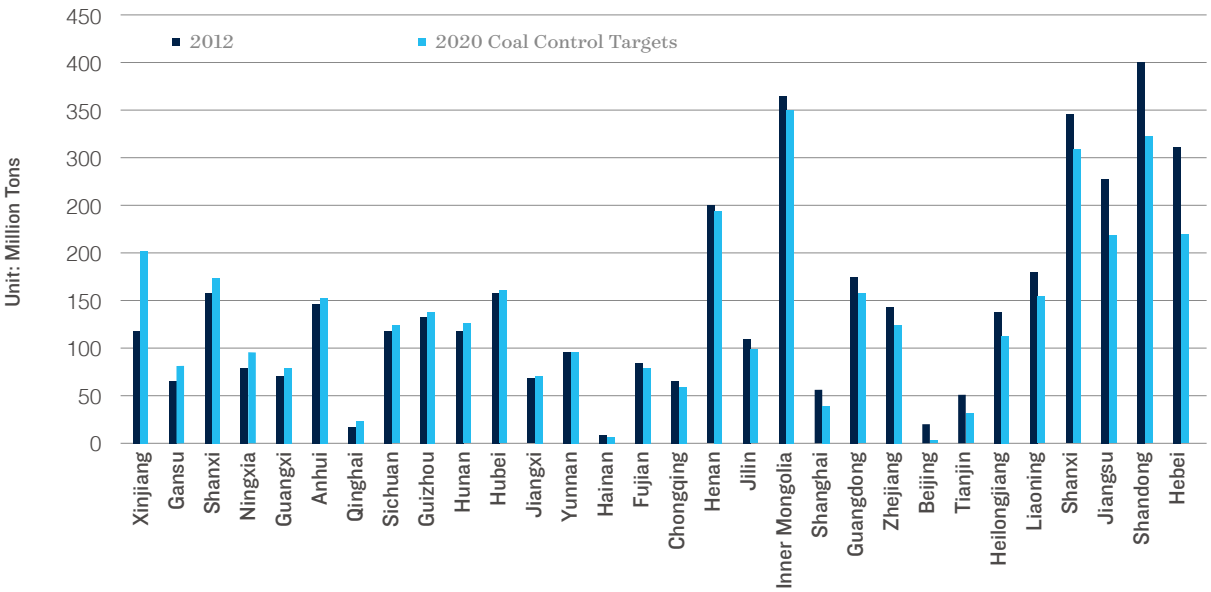
The Measures on Assessment for Implementing the Most Rigorous Water Resource Management System, issued by the State Council, set out the total water consumption red-line limits for all provinces in

2020 and 2030 (see Appendix 5). The limits for cities have also gradually been released. Under the coal cap scenario, CO_2 emissions from coal consumption will reach 7.5 billion tons by 2020. Targets for carbon emissions from coal are then allocated to each province so as to create a mandatory limit for increases in coal consumption (see Appendix 5).

(2) Provincial-level coal cap targets

Following the State Council's Air Pollution Action Plan, over 20 provinces, cities and autonomous regions have set coal cap targets, coal consumption limits, or $PM_{2.5}$ concentration goals. Using environmental cost-benefits analysis with set limits on air quality targets and coal-related carbon emissions, the China Coal Cap Project has set the 2020 coal cap targets for all 30 provinces (see Figure 4). Compared to the baseline scenario for 2020, a coal cap would require every province except Guangdong to reduce their coal consumption, with collective reductions totaling 430 million tons. Currently, the only statistics available for provincial coal consumption are from 2012. Based on this 2012 data, in order for the coal cap scenario for 2020 to be realized, Hebei, Jiangsu, and Shandong will need to reduce their coal consumption by 50 million tons or more; Shanxi, Tianjin, Liaoning, Heilongjiang, and Zhejiang will need to reduce their consumption by around 20 million tons; Anhui, Jiangxi, Hunan, Hubei, Guangxi, Sichuan, Chongqing, and Qinghai will have slight increases; Shaanxi, Gansu, and Ningxia can increase their consumption by 10 million tons or more; and coal consumption in Xinjiang can increase by 80 million tons or more.

Figure 4. Provincial Coal Cap Targets Under Red Line Constraints



(3) Provincial targets for energy intensity and carbon intensity

The national 13th FYP includes energy and carbon intensity targets of 15% and 18% respectively. Based on its research, the Coal Cap Project recommends targets of 18% for energy intensity reduction and 21% for carbon intensity reduction.

Allocating the 18% national-level energy intensity reduction target. In order to allocate this among the provinces, the Coal Cap Project learned from the goals and experience of the past two Five Year Plans. With China's economic "new normal," the relationship between energy consumption and GDP has changed dramatically. China is transitioning into a development path that generates high GDP with low energy input. If the country continues to adopt energy intensity targets similar to those in the 12th Five Year Plan period, the targets will likely be ineffective and easily achieved. Therefore, for the 13th Five Year Plan period we divided the provinces into six categories and designed a diverse set of targets (see Appendix 6). Since meeting its target for the 12th Five Year Plan has proven to be difficult, the western autonomous region of Xinjiang has an energy intensity reduction target of only 5%, with an annual reduction rate at 1%.

Allocating the 21% carbon intensity reduction target. We allocated the 21% carbon intensity reduction target among the provinces using a similar type of categorization (see Appendix 6). The sum of provincial energy and carbon intensity targets will be slightly higher than the national targets.

In addition, China has announced plans to establish a national cap and trade market in 2017. China should learn from the lessons in the European carbon market, i.e. that low carbon reduction targets will lead to carbon market failure.

(4) Provincial air pollution emission reduction targets

The report recommends that, by the end of the 13th Five Year Plan period, the average $PM_{2.5}$ concentration nationwide for prefecture level and above cities should reach approximately 45μg/m^3. In the 13th Five Year Plan, primary $PM_{2.5}$ (particulate matter), atmospheric ammonia nitrogen and volatile organic compounds (VOCs) should be included as general emission reduction targets (see Appendix 7). SO_2, NOX and primary $PM_{2.5}$ have a direct link to coal combustion and utilization. While atmospheric ammonia nitrogen and VOCs have less relevance to coal, these five gaseous pollutants contribute significantly to secondary $PM_{2.5}$. Although the 13th FYP only set targets for $PM_{2.5}$ reduction, many provinces and cities have enacted measures to control and reduce VOCs and atmospheric ammonia nitrogen.

(5) Coal replacement based on local conditions

See Table 11 for our recommended renewable energy targets (including installation and generation) in the 13th Five Year Plan. The share of electricity generated from renewable energy provides the best indicator for the level of optimization in the energy structure. By 2020, the share of renewable energy in power generation (not including large hydro) should reach 13.8%. If large hydro is included, renewables should reach 26.9% of China's power generation. Many nations, including China, have tried a host of methods – from auctions, feed-in tariffs, to a quota system – to encourage renewable energy development. The feed-in tariff has been particularly effective, spurring the development of renewables in China.

Now China's distributed renewable energy is facing bottlenecks and obstacles to its development and attempts to reduce costs. A renewable energy quota system, which has long been a subject of discussion, should be a good solution for developing a high penetration of renewable energy

while simultaneously reducing subsidies. To establish a quota system, the country should adopt a 13.8% target for renewable energy's share in electricity generation, and allocate quotas to each province. The quota system can encourage local renewable energy development and reduce long-distance renewable power transmission. It should also include a market mechanism to allow quota trading. For each province's renewable energy quota recommendation, please see Appendix 6.

Table 11: 13th Five Year Plan Renewable Energy Installation and Generation Targets

	Installed capacity (GW)	Power generation (TWh)
Wind power	235	470
Solar PV	110	176
CSP	10	35
Biomass energy	14	63
Large hydro	270	959
Small hydro	80	266
Subtotal of renewable energy	719 (including large hydro)	1,969 (including large hydro)
	449	1,010
Total Electricity System	1,917.6	7,317.6
Share of renewable energies	37.5% (including large hydro)	26.9% (including large hydro)
	23.4%	13.8%

In 2016, the National Energy Administration established targets for non-hydro renewable energy, i.e., the market quotas for renewable energy which it had been discussing for several years. China has many mountainous and hilly areas, and it's a leader in small hydro construction and technology. These small hydro projects make a sizeable contribution to the economic development of mountainous regions. Small hydro still has large potential for future development, so renewable energy development targets or quotas should include small hydro.

In the northern regions, winter heating uses a large amount of energy. However, geothermal energy, hot springs, solar energy, and heat pumps can provide clean alternatives to coal for winter heating. Renewable energy especially can be a key player in building heating. The Ministy of Housing and Urban Rural Development has set a target of 15% renewable energy use for building heating. For renewable energy heating targets for the Yangtze River Delta's hot summer/cold winter region and southern regions' hot summer/warm winter regions, see Appendix 6.

In large cities and megacities, efforts will be made to eliminate coal consumption in core urban areas, replace coal-fired boilers with ones based on gas or electricity, convert or retire coal-fired heating boilers larger than 20 steam tons in size to boilers based on clean energy, and popularize the application of gas-fired boilers and heat storage electric boilers. The coal consumption in various for-profit service sectors should be replaced by electricity, natural gas, and other clean energies. Inter-provincial power sourcing should be increased, the cooperation and development of outside-of-province power sources should be enhanced, and stable bases for these external electricity sources should be established.

6.3.3 CITY COAL CAP PLANNING BASED ON A HUMAN-CENTERED APPROACH AND RED LINES

Cities are the key to implementing coal cap plans. There are 74 key cities, 293 prefecture-level cities, and 361 county-level cities across the country. China is continuing to urbanize rapidly; by 2020 the urban population is expected to make up 61% of the total population, and city sizes will have further expanded.

(1) Establish and allocate city-level red lines

The Ministry of Water Resources has allocated national red lines for total water consumption to prefecture-level cites and counties. The China Coal Cap Project has also allocated city-level air quality and carbon emission restrictions.

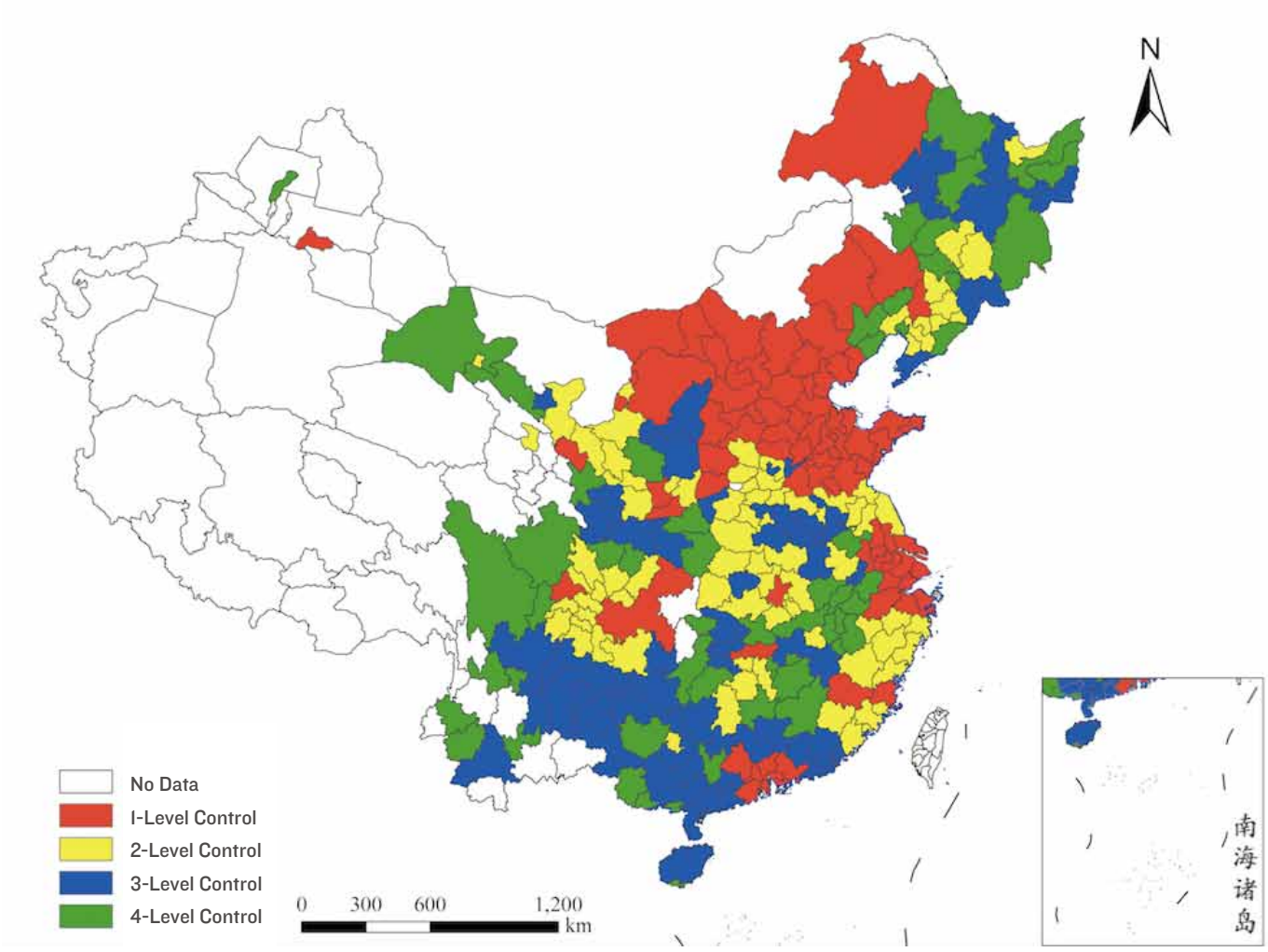
(2) The classification of city coal caps and allocation of total coal cap targets

The Coal Cap Project has divided the 293 prefecture-level cities into thirteen categories according to their size and coal consumption intensity (see Appendix 8). In addition, taking into account urban air quality and coal consumption intensity, air pollution restrictions in these 293 cities have also been divided into four levels. Out of the 83 cities designated in the “Class I” restriction, 47 were key pollution control cities specified in national atmospheric pollution prevention and control legislation, while the additional 36 cities were those in the Jing-Jin-Ji region and surrounding areas that had the most severe atmospheric pollution. Most cities with a high level of development and poor air quality have been given Class I and Class II restrictions. These cities’ advanced economic developments means they are capable of stronger air pollution restrictions, and also that it is essential to strictly control their coal consumption and improve their air pollution.

Under the coal control scenario, total coal consumption for the 13 categories of cities, which in 2015 was around 3.12 billion tce (4.37 billion tons raw coal), [2] will drop to 2.91 billion tce (around 4.08 billion tons) in 2020 (the predicted peaking periods for various cities are shown in Appendix 8). When selecting coal cap policies and measures for different types of cities, it‘s necessary to consider local conditions, taking into account different stages of economic development, resource endowment, and comparative advantages. It’s also important to make use of complemantary policies and employ the emission reduction measures with the smallest marginal cost. Provincial coal caps should be broken down into city-level targets based on city classification.

2.There are 334 prefecture-level regions in China, including 293 prefecture-level cities. The 4.32 billion tons of coal consumption is only the coal consumption of the 293 prefecture-level cities, and the coal consumption of other prefecture-level regions is not included. The coal consumption of the 293 prefecture-level cities is calculated based on the coal consumption of provinces.

Figure 5: City Categories for Air Pollution Control



From 2010 to 2020, the coal consumption in the 13 categories of cities will follow a pattern of growth, peaking and decline. Coal consumption increased quickly in the previous ten years (2003-2013), with national coal consumption peaking in 2013 and city coal coal consumption around 3.12 billion tce. After this, coal consumption began a gradual decline.

According to available statistics, the coal cap scenario's 2020 coal consumption would be close to 300 million tce less than the reference scenario, showing that coal cap policies will have a noticeable impact. After 2020, the coal cap scenario's coal consumption will continue its gradual decrease.

The more coal-intensive cities are focused in Shanxi, Shaanxi, Henan, Hebei, Ningxia, Inner Mongolia, and Guizhou, with eastern coal cities generally less intensive than central-western cities. Urumqi, Taiyuan, and Tangshan are the most coal-intensive cities among the megacities. Of the large cities, there are 11 cities that can be considered coal-intensive, including Pingding, Laiwu, Baotou, Datong, Handan, and Yinchuan. Of the medium-size cities, there are 32 designated as coal-intensive, including Wuhai, Linfen, Shizuishan, Yuncheng, and Liupanshui. There are 16 coal-intensive cities among the small cities group, including Wuzhong, Zhongwei, Jiaguguan, and Luliang.

(3) Giving top priority to air pollution control in key cities and primary city groups

The 74 key air pollution cities are characterized by large populations, high density, strong economic development, and severe air pollution that has a substantial impact on public health. Therefore, these cities should be given top priority for air pollution control. In 2013, among the 74 key cities across the country, the annual average $PM_{2.5}$ concentration was 72 μg/m^3; only 3 cities reached the national standard. In 2014, the average $PM_{2.5}$ concentration in the 74 key cities was 62.4μg/m^3. In 2015, the average $PM_{2.5}$ concentration in the 74 key cities was 55 μg/m^3 , down by 12% and 23.6% over 2014 and 2013. Of these 74 cities, 11 cities have now reached the national standard. The air quality in most of the cities has seen marked improvements, as shown in Figure 6. The decrease in $PM_{2.5}$ levels and reduction in coal consumption are closely related.

Among the 74 key cities, the ten with the highest $PM_{2.5}$ concentration in the first half of 2015 were Baoding, Zhengzhou, Xingtai, Handan, Shijiazhuang, Hengshui, Tangshan, Jinan, Langfang, and Wuhan. In order to tackle air pollution in these 10 cities, we should prioritize reducing their coal consumption and changing their energy structure. This will allow us to bring their air pollution under control within a relatively short time frame. For cities at the bottom of this list, the MEP should implement measures like in-person meetings to oversee and urge city-level government officials to adopt stricter measures to improve air quality.

During the 12th Five-Year Plan period, the Ministry of Environmental Protection has put forward air pollution control objectives for the "three regions and ten groups" facing severe air pollution problems. Table 12 has included the Henan Central Plains city cluster. Judging from the values in 2013, with the exception of the western costal cities where average $PM_{2.5}$ concentration value is equal to or less than 35μg /m^3, the $PM_{2.5}$ concentration of each city group is either very high or relatively high.

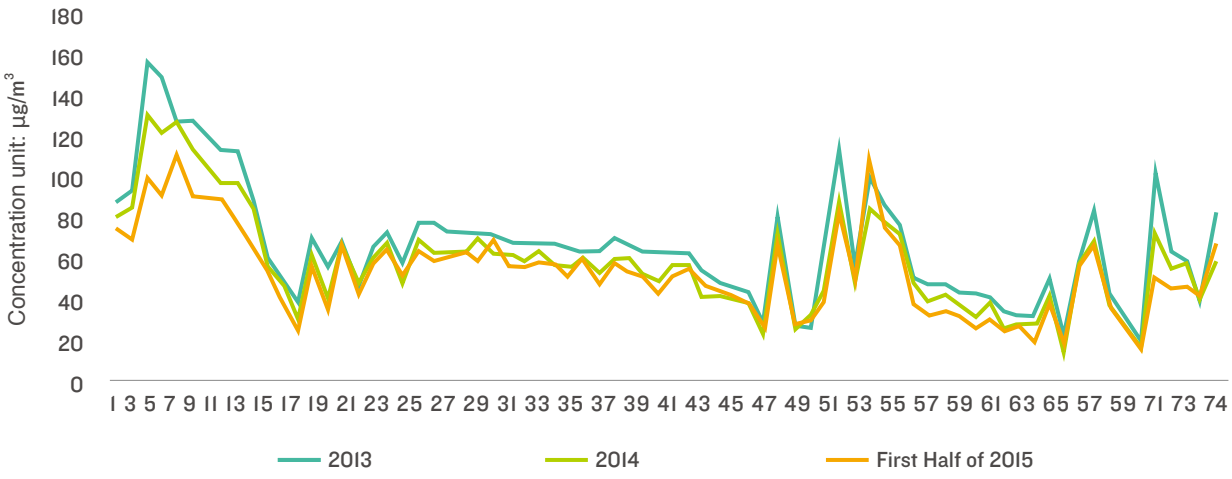
The average $PM_{2.5}$ concentration of the Henan Central Plains city cluster was worse in the first half of 2015 than it was in 2014. The air pollution in the Henan Central Plains city cluster also jumped to second place nationally, behind the Jing-Jin-Ji city cluster. Based on this change, national-level policies for governing these city clusters should adjust their scope. The city clusters in the western coastal area and the Pearl River Delta region should have "graduated" from this administrative oversight. The air pollution in the Henan Central Plains city

cluster and the whole province should be placed under close supervision. Urumqi, the central part of Liaoning, and city clusters in the central and northern part of Shanxi should be under intensified guidance. The national city groups should be transformed from "three regions and eleven groups" into "two regions and ten groups".

Emphasis should be placed on air pollution control in key city clusters, and adjustment should be made every two years. Local governments should play the key role in implementing differentiated policy and financial support from the central level to bolster areas that need urgent support. Table 12 has listed the target value for annual average $PM_{2.5}$ concentration in 2020, as well as the annual average value of $PM_{2.5}$ concentration in the "three regions and eleven groups" by 2020. The annual average $PM_{2.5}$ concentration in these key city groups and regions should be 45.2μg/m^3. Factoring in the relatively good air quality in various medium and small cities, it should be possible to reach the annual PM2.5 concentration target of 45μg/m^3 by 2020.

Joint management and control of air pollution by cities should be able to more effectively address the air pollution within cities, especially when megacities are the focus. The central government should coordinate air pollution policies in inter-provincial city clusters, the provinces should coordinate policies in intra-provincial city clusters, and large cities should support surrounding small cities. Collective policies will create collective momentum, accelerating improvement in urban air quality.

Figure 6: $PM_{2.5}$ Concentration Trends in 74 Major Cities, 2013 through First Half of 2015



Note: 1. Beijing 2. Tianjing 3. Xingtai 4. Shijiazhuang 5. Baoding 6. Handan 7. Hengshui 8. Taishan 9. Langfang 10. Cangzhou 11. Qinhuangdao 12. Chengde 13. Zhangjiakou 14. Taiyuan 15. Hohhot 16. Shenyang 17. Dalian 18. Changchun 19. Harbin 20. Shanghai 21. Taizhou 22. Huai'an 23. Wuxi 24. Changzhou 25. Nanjing 26. Xuzhou 27. Zhenjiang 28. Yangzhou 29. Suqian 30. Nantong 31. Lianyuangang 32. Suzhou 33. Yancheng 34. Huzhou 35. Jinhua 36. Jiaxing 37. Quzhou 38. Shaoxing 39. Hangzhou 40. Wenzhou 41. Taizhou 42. Ningbo 43. Lishui 44. Zhoushan 45. Hefei 46. Fuzhou 47. Xiamen 48. Nanchang 49. Jinan 50. Qingdao 51. Zhengzhou 52. Wuhan 53. Changsha 54. Zhaoqing 55. Foshan 56. Guangzhou 57. Jiangmen 58. Zhongshan 59. Dongguan 60. Shenzhen 61. Zhuhai 62. Huizhou 63. Nanning 64. Haikou 65. Chongqing 66. Chengdu 67. Guiyang 68. Kunming 69. Lasa 70. Xi'an 71. Lanzhou 72. Xining 73. Yinchuan 74. Ürümqi

Table 12: Statistics of $PM_{2.5}$ concentration ($\mu g/m^3$) in key City Clusters Between 2013 and the First Half of 2015

	$PM_{2.5}$ average value in city groups					2015	2015	2020
City clusters	2013 full year	2014 first half	2014 full year	2015 first half	# of cities	Max. value	Min. value	Target value
Henan Central Plains city cluster	102.4	93.5	82.6	86.4	17	109.8	65.8	58
Shandong Peninsula	87.9	81.9	76.0	71.2	5	86.5	52.4	52
Beijing, Tianjin and Hebei	113.9	110.2	101.5	87.7	11	112.3	58	50
Urumqi, Xinjiang	85.2	69.3	62.9	70.6	1	70.6	70.6	50
Wuhan and surrounding areas	88.7	96.0	79.5	79.3	6	82.6	61.2	48
Central part of Liaoning	72.7	62.4	63.3	72.2	6	72.2	51.8	48
Central and northern part of Shanxi	74.2	64.2	59.7	60.1	7	60.1	49.6	46
Changsha, Zhuzhou, Xiangtan	79.1	83.4	72.7	68.2	3	68.2	62	44
Guanzhong, Shaanxi	104.2	90.5	71.5	55.7	5	58	53	44
Chengdu, Chongqing	75.1	78.9	67.8	66.7	2	70.2	63.1	43
Gansu, Ningxia	55.4	53.9	52.1	48.3	5	52.4	46.5	42
Yangtze River Delta	69.4	69.6	62.1	60.4	14	66.9	45.7	40
Pearl River Delta	46.2	42.3	41.1	35.1	9	42.3	32.5	35
Western Straits	32.3	35.4	33.1	34.7	6	38.1	31.6	34

6.4 REGIONS, PROVINCES, AND CITIES SHOULD RESPECT RED LINES AND EMPHASIZE COORDINATED MANAGEMENT AND CONTROL

6.4.1 KEY MEASURES FOR LOCAL COAL CONTROL

The central government, regional coordination authorities, provincial governments, and municipal governments should set up coordination and management groups to strengthen the communication and coordination among various departments and various levels of government on coal control tasks. There is currently a lack of government organizations working on coal control at the regional level, so management and and supervision is weak. Management of coal involves energy, land, water conservation, environmental protection, and other departments, which need to be better coordinated. the government should establish a mechanism to facilitate discussion on coordination for air pollution control and water resource protection across departments, regions, and river basins. This will bolster the role of regional water resource protection agencies and regional air pollution controlsupervision and inspection agencies. the government should also establish mechanisms to coordinate pollution prevention and control in order to carry out regular consultation, joint monitoring, joint enforcement, joint emergency response, and information sharing. Finally, the government should establish a performance assessment and accountability system for ministries and regional offices related to industrial policy. Governments agencies at regional, provincial and municipal levels should coordinate and work together, focusing on key measures, on-the-ground implementation, and effectiveness.

Currently, mechanisms for joint prevention and control of regional air pollution are discussed often but rarely acted on. Other than the Jing-Jin-Ji and Yantze River Delta regions, both of which have joint committee meetings, most regions have difficulty coordinating their pollution reduction policies. This is an important issue to resolve because without the active assistance of neighboring provinces, the Jing-Jin-Ji and Yantgze River regions will also have difficulty accomplishing their goals. Therefore, a key question is how to establish a national-level agency that has the responsibility, authority, and accountability to ensure strong regional control of air pollution and water resources.

Provinces should play the key role in environmental oversight and ensure active participation by local governments. We should integrate red lines into provincial-level regulations as guiding restrictions, work out an overall plan for the construction of an ecological civilization in each province, and include adherence to red linesthroughout the planning process. The provincial governments should be responsible for establishing coal control plans and relevant environmental red-line restrictions. The provincial-level governments' regulatory agencies should mobilize the province's resources to coordinate with and provide mutual assistance to agencies at all levels, both inside and outside the province. The provincial governments should develop methods and standards for assessment, establish an environmental and ecological monitoring network, and ensure the accuracy and authoritativeness of data collection. Coal cap planning will take environmental and ecological protection as the top priority and promote a harmonious development of the economy and socity .

City governments stand at the frontline of development policymaking and are directly responsible for designing and implementing economic and industrial policies. In the early stages of China's development, local governments focused solely on economic development, a decision that allowed them to achieve outstanding economic growth. However, this development model is

unsustainable, and eventually it will run up against the natural limits of China's environmental and resource endowments. This will require a re-adherence to the Chinese saying, "Blue water and skies are the real source of wealth." Practically speaking, this means that governments at all levels must strictly adhere to red lines and develop their economies in a way that promotes "smart," low-carbon, and livable cities. In this way, they'll be able to develop holistic societies that don't sacrifice environmental health for economic gain.

6.4.2 USE MARKET MECHANISMS TO DEEPEN THE RESULTS OF LOCAL COAL CAPSS

Market mechanisms and similar economic measures are invaluable tools for addressing resource and environmental challenges. Examples include cap-and-trade systems for energy and water use, or for pollutant and carbon emissions. These types of market measures should be designed to complement other command-control measures in a way that facilitates the implementation of coal cap plans and makes coal cap targets easier to achieve.

The China Coal Cap Project has already designed a city-level cap-and-trade system for coal consumption, a mechanism that we believe can be a foundation for the development of a coal cap-and-trade system on a larger scale. Such a system, if developed, should connect efforts to establish markets for carbon, pollutant emissions, and water use rights. Saving coal should be connected with saving water, reducing emissions, and reducing carbon. Steps are already being taken in this direction, with China planning to establish a national carbon cap-and-trade program by 2017. Given that coal is the main source of carbon emissions, reducing coal use will be key to reducing carbon.

The expansion of China's emissions trading pilots from the provincial and city-wide to national level showcase the country's goal of developing a society where environmental resources are properly valued. This will in turn promote the adjustment of China's industrial structure to one that has a smaller environmental footprint. Targets for emissions control of key pollutants will be more easily achieved, environmental regulations will be stronger and easier to enforce, and the overall quality of the country's environment will improve. Currently, the only pollutants subject to mandatory emissions controls by the central government are SO_2, NOx, COD, and ammonia (coal is a key contributer to emissions of the first two). However, local governments can – and should – develop pilot projects to reduce other pollutants that are harmful to their local environments.

The establishment and implementation of a water rights trading market is another key measure that can help achieve the optimal allocation of water resources. Local governments and water resource management agencies should work together to develop a local water resource plan that establishes a market for water rights trading, promoting the development of an economy that protects water resources. Currently, water resources are undervalued in China; a water rights trading market would go a long way in changing this. The mining and use of coal uses a particularly substantial amount of water, so reducing coal use will help save a significiant amount of this resource. However, caution should be exercised about including the agriculture industry in these water rights trading markets, especially in the less mature northeast regions. Water rights trading in the agriculture and coal sectors should be kept separate for now.

A city-level cap-and-trade system for coal consumption is unique in its ability to connect these different types of market mechanisms. As markets for carbon, pollutant emissions, and water trading mature, a cap-and-trade system for coal consumption can connect with and support these markets to deepen the economic incentive for reducing coal use. Markets for carbon, pollutant emissions, and water use operate relatively independent of each other, but because coal has links to all three of these markets, it can bridge the gap between them. As such, China should work to develop a city-level cap-and-trade system for coal consumption as soon as possible. Better coal data will also be critical for the success of these different market mechanisms.

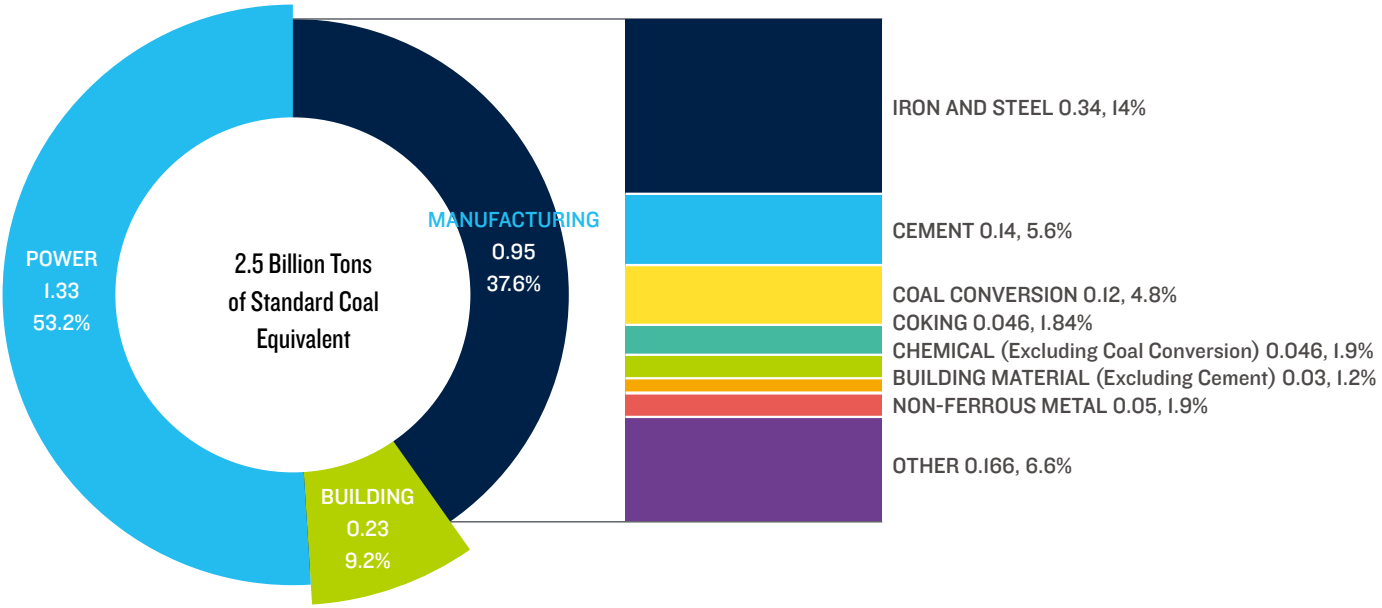
7 SECTORAL COAL CAPS

In the 13th Five-Year Plan period, Chinese industry is entering a transitional stage. The production output of many energy-intensive industries either peaked during the 12th FYP period or will peak in the early stages of the 13th FYP period. In general, the industrial sector is in the late stage of industrialization. After reaching peak production, heavy industry and the chemical industry will have a relatively long period to plateau and decline. The long plateau is partly supported by China's continued urban development, which will contribute to the demand for steel, cement, and other energy-intensive industrial products, keeping demand for these products at a relatively high level. By 2020, the installed capacity for the Chinese power industry is projected to reach 1,910 GW and power generation is expected to reach 7,320 TWh; 700 million tons of crude steel, 2.1 billion tons of cement, and 68 million weight cases of glass are expected to be produced. The total floor area of all buildings is projected to reach 70 billion square meters. Production in the modern coal-to-chemicals industry will reach 16 billion cubic meters of coal-to-natural gas, 10.45 million tons of oil, 960,000 tons of olefins and 3.78 million tons of ethylene. See Appendix 2 for the full prediction of Chinese economic and industrial development during the 13th FYP period.

7.1 TARGETS

The sector-specific coal cap targets for 2020 are as follows: coal consumption in the power sector should be capped at 1.33 billion tce, which will account for 53% of total coal consumption in 2020 under the cap; coal consumption in the manufacturing sector should be capped at 950 million tce, which will account for 37.8% of total coal consumption in 2020; and coal consumption in the building sector should be capped at 230 million tce, which will account for 9.2% of total coal consumption in 2020. In the manufacturing sector, the coal consumption in the steel, cement, coal chemical, coke, chemical (excluding the coal chemical industry), building material (excluding cement), non-ferrous metal industry and other industries should be capped at 340 million, 140 million, 120 million, 46 million, 48 million, 30 million, 50 million and 176 million tons tce respectively. The 2020 coal control targets of various sectors are shown in Figure 7.

Figure 7: 2020 Coal cap targets for various sectors



7.2 KEY TASKS

(1) Set environmental, ecological, and resource-driven red-line restrictions for each sector, including restrictions on water consumption and carbon emission quotas.

(2) Evaluate each sector's coal and electricity saving potential.

(3) Set 2020 standards for unit product and unit output value, as well as energy consumption per unit industrial added value for water consumption, coal consumption, and power consumption.

(4) Invest in sectoral coal cap/electricity savings and environmental protection efforts.

(5) Design major policies and measures for sectoral coal caps.

7.3 IMPLEMENTATION

7.3.1 SETTING RED LINES

The China Coal Cap Project has set a total water consumption red line target and allocated 7.5 billion tons of total carbon emissions among coal-related sectors as their allowable water use and carbon emission limits, as shown in Table 13.

If no coal control and water saving measures are

adopted, then by 2020, total water consumption in coal-related industries is projected to reach approxiamately 100 billion cubic meters; 25.3 billion cubic meters over the water consumption red–line restriction. If both coal control and water saving policies are adopted, the total water consumption will decrease to the point where it can meet the requirements of the water red line . Policy observers have been closely following the water resource and water pollution treatment challenges resulting from coal mining, coal power, and coal chemical development activities in China's water-scarce northwestern region.

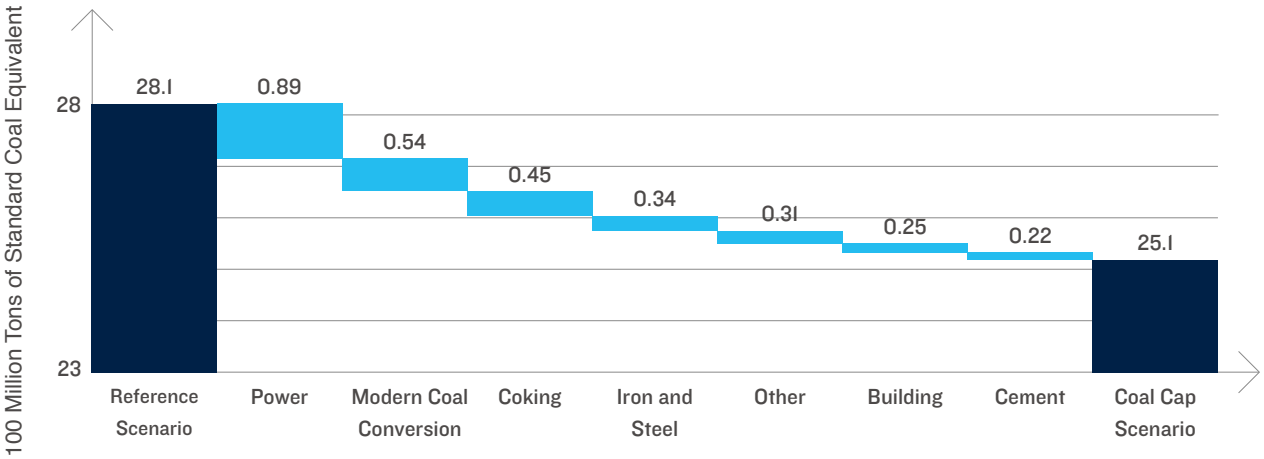
Table 13: Total water consumption and carbon emission red lines for coal mining and consuming sectors in 2020

	Water consumption red line in 2020 (billion cubic meters)	Carbon emission restriction in 2020 (billion cubic meters)
National total	670	9.09
Coal-related industries	74.698	7.5
On which:		
Coal mining and washing	3.271	.53
Steel	3.031	1.00
Cement	1.155	.41
Building	2.277	.63
Power	55.822	3.6
Coke	1.088	.15
Modern coal chemical industry	.491	.33
Other industries (paper-making and textiles, etc.)	7.564	.85

7.3.2 PRODUCTION AND INDUSTRIAL ADDED VALUE ENERGY CONSUMPTION STANDARDS AND COAL/ELECTRICITY POTENTIAL

By 2020 the energy consumption per unit of industrial value added (for enterprises above a designated size) should be about 23% lower than 2015 levels. Under the coal cap scenario, coal-consuming sectors should save 300 million tce equilvalent during the 13th Five Year Plan period, resulting in 581 TwH of electricity savings during this period. The coal savings for each sector can be found in Figure 8 and Table 14.14.

Figure 8: Coal Savings in Coal-intensive Sectors



Coal reduction, high efficiency utilization, and replacement within industry is projected to save 132.74 million, 115.61 million, and and 51.65 million tce respectively. The increase in coal consumption in the coal chemical, power, and building sectors should be effectively controlled, and existing coal consumption in the steel, cement, building materials, and other manufacturing sectors should be reduced.

A greater number of China's major products will reach advanced energy efficiency standards, and the majority of industries, as well as large and medium-sized enterprises, will also reach advanced international levels of energy efficiency. The efficiency index for fans, water pumps, air compressors, transformers and other newly-added energy-consuming equipment will reach or approach international levels of energy efficiency. The efficiency index of home electric appliances and some types of electric motors will also reach international levels. Each coal-consuming sector's total pollutant emissions will be significantly reduced.

In order to research and quantify energy savings for the industrial sector, China should establish energy saving targets, evaluate progress and completion of coal control efforts, regularly measure the energy consumption for producing major products and the energy intensity of enterprises, and continue to learn from and encourage enterprise improvements in energy consumption. Table 14 has listed the double energy-saving objectives (in coal savings and annual electricity savings) of coal-intensive industries, which should be used to evaluate energy-saving achievements of the industrial sector and enterprises in the 13th Five-Year Plan period.

Table 14: Joint Standard for Energy Consumption Per Unit of Industrial Added Value and Per Unit of Product, as well as Energy and Electricity Savings in Coal-intensive Sectors

Sector	Energy consumption per unit industrial added value in 2020 (tce/10,000 RMB)	Total energy consumption per unit product			Coal savings (million tce)	Annual electricity savings (TWh)
Power	——	285 g/kWh			89	75
Steel	<8	<560 kg standard coal/ton steel			34	-18.7
Cement	5.71	104.6 kg standard coal/ton clinker			22	94.73
Buildings	——	Newly built residential buildings	Coal control	Heating energy consumption limit 45 kWh/m^2 per annum	25	430.0
			Coal control	Heating and air-conditioning energy consumption limit 55 kWh/m^2 per annum		
			Coal control	Heating and air-conditioning energy consumption limit 15 kWh/m^2 per annum		
		Newly built public buildings	Coal control	Overall energy limited to 90 kWh/m^2 per annum		
Modern coal chemical industry [8]	——	Coal to gas, 230,000 tce/100 million cubic meters			54	——
		Coal to oil, 3.6 tce/ton oil				
		Coal to olefins, 4.4 tce/ton olefin				
		Glycol, 2.9 tce/ton glycol				
Coke					45	
Chemical industry (excluding coal chemical industry)					4.35	
Building material (excluding cement)	2.99				2.79	
Non-ferrous metals	1.87				4.42	
Other sectors	0.61				19.45	
Total					300	581.03

7.3.3 ESTABLISHING TARGETS FOR WATER SAVINGS, EMISSIONS REDUCTION, AND CARBON REDUCTION

Under the coal cap, the water consumption per 10,000 RMB GDP and per 10,000 RMB industrial added value is set to decrease by more than 35% and 30% from 2013 levels by 2020. By 2017, the leakage rate of national public water supply pipelines should be kept under 12%; by 2020, it should be kept under 10%. If the building sector can reduce cumulative water leakage in heating systems, water savings are projected to reach 420 million tons of water per year. China should encourage the development of water recycling and re-use, as well as the strengthening of water re-use and recycling within the industrial sector. By 2020, China should seek to utilize 95% of mine water and coal washing wastewater. The water consumption restrictions for 2020 should be further tightened for coal-intensive sectors, as shown in Table 15. Compared with the advanced water efficiency levels in other countries, China's water efficiency still needs to be improved.

Table 15: Water Consumption Restrictions for Coal-intensive Sectors

	Water consumption intensity in 2020 (tons/unit of product)	
Power	7.66 tons/10,000 kWh	
Steel	< 3.8 tons/ton steel for the entire sector	
	< 3.1 tons/ton steel for key enterprises	
Cement	0.25 tons/ton cement	
Building sector reduction of pipeline loss and system water additions	Save 430 million tons of water	
Modern coal chemical industry	Coal-based natural gas	5.5 tons/1,000 cubic meters
	Coal-based oil	7.5 tons/ton oil direct liquefaction
		7 tons/ton oil indirect liquefaction
	Coal-based olefin	16 tons/ton olefin
	Coal-based glycol	14 tons/ton glycol
Flat glass production	< 0.24 tons/heavy box	
Residential ceramics production	< 0.18 m^3/ton	
Aluminum refining (oxidized aluminum)	< 4m^3/ton	
Aluminum refining (electrolytic aluminum)	<3.6m^3/ton	
Synthetic ammonia	<22 tons	
Percent Leakage of national water supply pipe network	2017<12%, 2020<10%	
Recycling and re-use of coal mine water	95%	
Recycling and re-use of coal washing wastewater	100%	

The bottom-up prediction for carbon dioxide emissions from major coal-consuming sectors is shown in Table 16. These are higher than the allocations for CO_2 emissions from coal for key sectors found in Table 13; in particular, the CO_2 emissions from the power sector are 970 million tons higher than our recommended limit. Thus the power sector should quickly reduce its coal-fired electricity generation and start increasing the proportion of natural gas, renewable, and nuclear power sources. The CO_2 emissions in the steel sector are also forecasted to exceed the set limit by more than 300 million tons. Coal-intensive industries should use CO_2 emissions limits as a restrictive condition for their coal consumption.

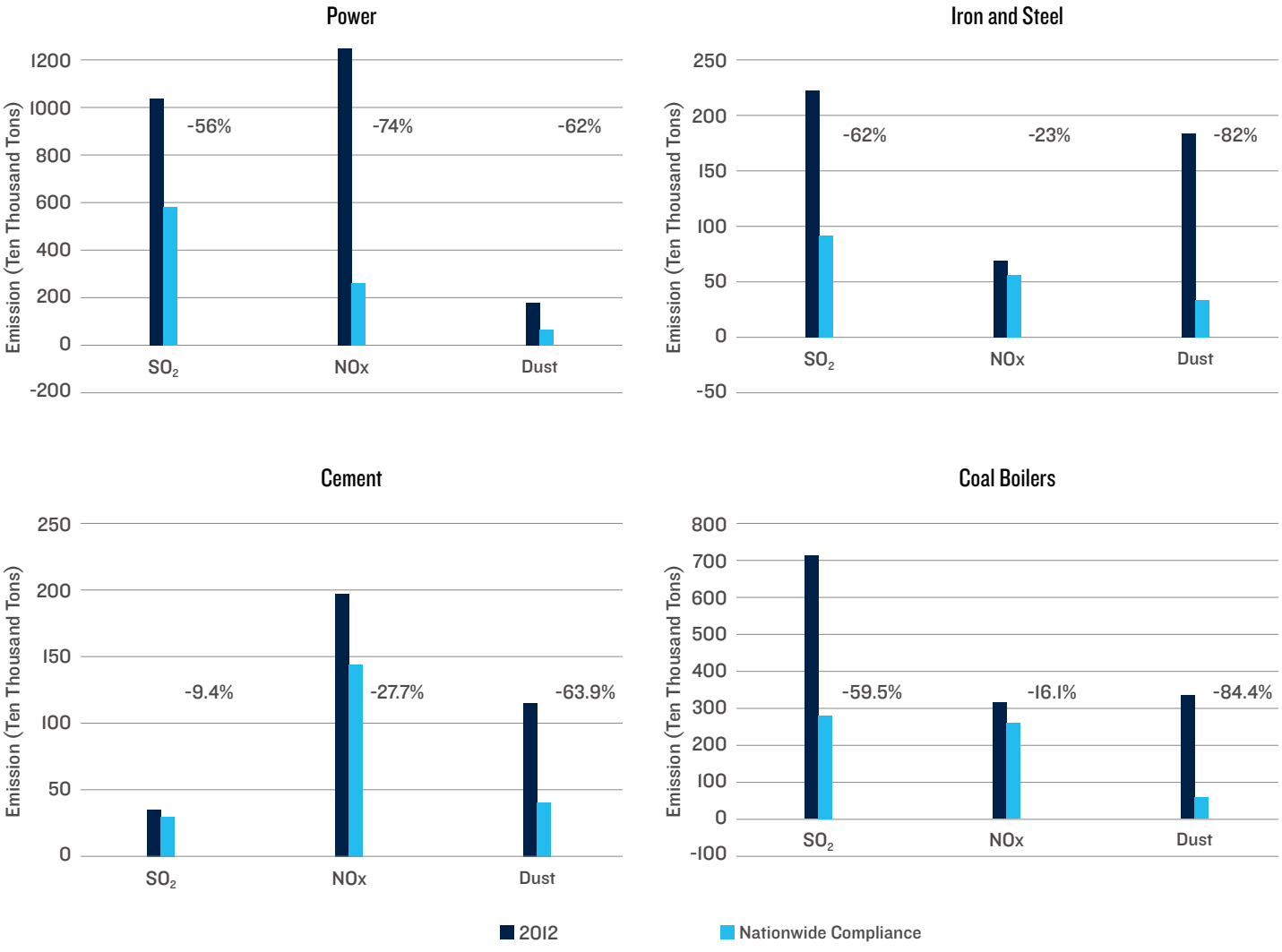
Enterprises should strictly observe the emission limits and standards for major air pollutants in their region. Table 16 shows the predicted air pollutant emissions of various sectors. In general, different regions should establish targets for total emissions control of air pollutants, including SO_2, NOx and particulate matter, and the addition of atmospheric ammonia nitrogen and volatile organic compounds (VOCs) during the 13th Five-Year Plan. These targets should be allocated to local areas and enterprises. So far, the Ministry of Environmental Protection has already issued 59 national standards for atmospheric air pollutant emissions, including the emission standards for thermal power plants (GB 13223-2011), boilers (GB 13271-2014), the cement industry (GB 4915-2013), the brick and tile industry (GB 29620-2013), the iron and steel industry (GB 28662-2012) and the coking industry (GB 16171-2012).

Table 16: Emissions of Major Air Pollutants and CO_2 for Coal-intensive Industrial Sectors in 2020

Sector	Total emission of major pollutants (thousand tons)			Carbon emission (million tons)
	SO_2	NOx	Particulate Matter	CO_2
Power	3,563	4,947	831	4,390
Steel	624	1,092	546	1,326
Cement	1,197	1,109	489	1,241
Building	--	--	--	640
Modern coal chemical industry	3,751	3,657	1,097	152
Coke	--	--	--	173
Chemical industry (excluding coal chemical industry)	952	780	375.6	12
Building material (excluding cement)	425.7	864.9	113.0	7
Non-ferrous metals	879.2	1,773.9	239.1	12
Other industries	2,186.6	2,696.3	1,526.8	51
Total	13,578.5	16,920.1	5,217.5	8,004

If enterprises all strictly observed the pollutant emission standards for industrial enterprises and equipment issued by the Ministry of Environmental Protection (MEP), as well as the new provisions of the Air Pollution Action Plan and the recently implemented Air Pollution Law, national $PM_{2.5}$ pollution concentration levels would be reduced by more than 50% compared to 2012 levels. Indeed, implementing three pollution standards for boilers, cement, and brick and tile alone would significantly improve air quality. This would require 429.5 to 515.5 billion RMB of investment, plus annual operating expenses of 53.5 billion RMB, and would have clear emissions reductions and economic benefits. Figure 9 shows the reduction in SO_2, NOx and particulate matter that would result from implementing the pollution standards for power plants, iron and steel, cement, and boilers. If each enterprise in the country fully implemented existing emission standards, air quality across the country would be greatly improved. By 2017, coal blending center regions should produce and distribute 50% or more of the specialized clean coal for industrial boilers and residential use, and 90% or above by 2020.

Figure 9: Emission Reductions from Implementing Emission Standards for Power Plants, Boilers, Iron and Steel, and Cement (fugitive emissions not included)



At the end of 2015, the Chinese government instituted the "Ultra-low Emission Standards for Coal Power Plants" (Table 17). The government required that coal power plants, especially those in areas with severe air pollution, quickly implement ultra-low emission standards. At the end of 2015, the national installed capacity for coal-fired power was 880 GW, including 520 GW which are suitable for upgrading to ultra-low emission coal power plants. The ultra-low emission standards are stricter than the Chinese coal power plant standard implemented in 2011 as well as current foreign emissions standards, and their standards for SO_2, NO_x, and soot are not much different than those for natural gas-fired plants. It is clear that if China fully completes its ultra-low emission standard conversions in 2020, pollutant emissions from the power sector would markedly decrease. At the same time, it is worth noting that ultra-low emission power plants consume more energy, which will increase their operating costs. Mercury emissions will also still exist, and CO_2 emissions will actually increase. In addition, during the actual operation of the coal power plants, pollutant emissions will be much greater than the ultra-low emission standard.

Table 17: Comparison of Ultra-low Pollutant Emission Standards and Other Standards for Coal-Fired Power Plants

Units: $\mu g/m^3$

Pollution / Standards	Dust	SO_2	NO_x	Hg
China's 2004 Standards	50	400	450	-
GBI3223-20II	30	200(old standard) 100(new standard)	100	0.03
Ultra-low Emission Standards	5	35	50	-
Natural Gas-Fired Power Plant Standards	5	35	50-100	None
Europe's 2001 Standards	20	184	135	-
United States' 2005 Standards	30	200	200	-

7.3.4 SECTORAL COAL AND ELECTRICITY SAVING INVESTMENT

As economic growth slows in China's 13th FYP period, China's energy-intensive industry is at a key turning point. Economic growth is slowing, and the need for investment in energy efficiency, coal consumption reduction, and the development of alternative energy and other measures for environmental protection are being given greater attention. Based on estimates, energy efficiency requires an investment of about 2.98 trillion RMB, and environmental protection requires an investment of about 780 billion RMB, as shown in Table 18. These sizeable areas for green investment can promote energy saving, environmental protection, clean energy development, and economic growth. As a result, the coal cap will reduce investment in the coal sector and at the same time encourage investment in the more promising green sector.

Table 18: Coal-intensive Sector Investment in Energy Saving, Renewable Energy and Emissions Reduction During the 13th Five Year Plan Period

Sector	Energy saving and renewable energy investment (billion RMB)		Environmental protection investment (billion RMB)
Power	29		188.5
Iron and Steel	70		100
Cement	142		192
Buildings	Building energy efficiency	Renewable energy	14
	1,686	916	
Modern Coal Chemicals	Coal-to-gas		6.8
	Coal-to-oil		7.84
	Coal-to-olefins		9.65
	Coal-to-glycol		1.89
Coke	13.5		10.2
Chemical industry (excluding coal chemical industry)	21.8		52.2
Building material (excluding cement)	7		16.7
Non-ferrous metals	17.7		22.1
Other industries	77.8		155.6
Total	2,980.8		777.48

7.4 POLICIES AND IMPLEMENTATION PLANS FOR SECTORAL COAL CAPS

China has made considerable progress in end-use energy efficiency. Many of its high-end technologies are among the most efficient in the world. However, room for improvement within Chinese efficiency technology is especially apparent when compared to internationally advanced efficiency levels. As China continues to improve its economic standing, industries, product quality, energy structure and technical efficiency, huge opportunities will open up for investment, development, and innovation. In this way, China can still enjoy the advantage of being a late developer in the energy sector. The gap between Chinese efficiency levels and international advanced efficiency levels for primary industries and products in 2014 is shown in Appendix 9.

(1) Resolving Overcapacity in Chinese Industry by Sector

Chinese industry faces serious overcapacity. Some local governments still continue to blindly pursue rapid economic growth by continuing to intervene in and hinder market competition by administrative means, and support the expansion and construction of local enterprises even when market demand is lacking. It is better to cut short such ill-planned activity rather than prolong the suffering. Serious illness requires an equally potent dose of medicine. Significant measures will be adopted to solve industrial overcapacity. The status of overcapacity in energy-intensive sectors in 2013 is shown in Table 19. China's overcapacity issues have continued to worsen since then.

Table 19: Rate of Utilization of Production Capacity for Energy-intensive Sectors in China (2013)

	Output	Production capacity	Production capacity utilization rate %
Coal (Mt)	3680	4630	79.5
Coke (Mt)	479.3	626.6	76.5
Steel (Mt)	779.0	1070.0	72.8
Electrolytic aluminum (Mt)	22.06	32.0	68.9
Cement (Mt)	2416	3220	75.0
Plate glass (hundred million weight boxes)	7.8	12.6	62.0
Oil refinding (Mt)	478.0	611.0	78.2
Ethylene (Mt)	16.23	21.9	74.1
Synthetic ammonia (Mt)	57.45	74.1	77.5
Caustic soda (Mt)	28.59	39.1	73.1
Sodium carbonate (Mt)	24.35	31.0	78.5
Alcohol (Mt)	28.79	56.5	51.0
Calcium carbide (Mt)	22.34	33.0	67.7

Break down administrative barriers, use mergers and restructuring to increase industry concentration. China should share information on resources, markets and prices, optimize the industrial structure, and encourage industry competition while also avoiding market monopolies (defined as a single enterprise group controlling a 20% market share). Relevant government departments should establish and improve guidelines for mergers and acquisitions, finance, taxation, auditing, and property rights policies related to mergers and reorganization, and encourage enterprises to implement such mergers. Mergers and reorganization should not be used to keep backwards enterprises running; these should ultimately be eliminated. Restructuring should be driven by enterprises; enterprise profits should be the standard for evaluating efforts to concentrate industry.

Strengthen national laws and regulations, environmental protection standards, and energy consumption standards to eliminate backward enterprises. The government should carry out compliance inspections in accordance to relevant laws on environmental protection, work safety, and resource conservation, and shut down backward enterprises which do not conform to these requirements. Governments at all levels should reduce unfair support and subsidies for local enterprises and improve the role of market competition in eliminating backwards enterprises. They should also make use of economic measures such as land, taxation, finance, and differential power pricesto encourage enterprises to compete, thus forcing less competitive enterprises out of the market. The government should also make use of the public as a watchdog and increase enterprise information transparency. Violators of environmental regulations should be punished with daily penalties, and public interest lawsuits should be used to enforce standards. Environmental standards and total emission control targets should be strictly enforced.

Deepen enterprise reform. Efforts should be made to solve the problems leading to industrial overcapacity, namely outdated enterprise systems and development concepts and models. Through these efforts, enterprises should be the key market players in solving overcapacity. The first step is to deepen enterprise reform through developing diversified company ownership and standard corporate governance structures. The next step is to establish a development strategy based on comparative advantage, work to improve technological innovation capacity, and ultimately achieve green development and improve the overall level of enterprise social responsibility. The third step is to enhance and accelerate the establishment of an industry self-regulation mechanism. Enterprises should be able to arrange their production and operation activities in accordance with the laws of the market and national policy, thus achieving a level of industry self-regulation that is effective and reasonable.

(2) Control existing and future industrial coal consumption

Coal control should prioritize industries that will potentially increase their consumption of coal in the future, such as the modern coal chemical industry, power sector, and buildings. Industries with large existing coal consumption, such as iron and steel, cement, and building materials, will be a secondary but still important priority. See Table 20 for the main coal cap policy recommendations for each sector.

Table 20: Coal Cap Policy Recommendations by Sector

Sector	Characteristics	Main Recommendations
Modern Coal Chemicals	High energy and water consumption; high pollution and emissions; high risk, high investment risk; high cost to treat pollution; challenging to develop environmentally; poor market competitiveness for coal-to-oil and coal-to-gas	Strictly control the construction of coal chemical projects. Keep coal-to-gas production at 16 billion cubic meters, coal-to-oil projects at 10.45 million tons. Allow some coal to olefins/ethylene projects while keeping them at the pilot stage and continuing to debate coal to gas/oil projects. Coal-to-gas and coal-to-oil projects are very controversial. Halt project approvals and construction of projects that haven't begun construction yet.
Power	The economic situation of coal power plants is getting worse; increasing risk of stranded assets; greater challenges from climate change	Peak coal-fired power capacity at 960 GW. Coal-fired power should move from a leading role to a supporting role, with new approvals for coal power plant projects ending in the 13th FYP period. Coal and coal power co-operation should be limited. End approvals for coal gangue and low-heat value coal power plants. Implement green dispatch. For projects that have already been approved, a portion should be delayed, another portion halted, and another portion canceled.
Buildings	The buildings sector will continue to grow; energy saving potential is large; urban energy supplies should be clean, efficient, and low-carbon	Cap nationwide building floor area at 70 billion square meters or less and increase energy efficiency levels. Increase proportion of green buildings, with renewables providing 15% of heating and air conditioning needs.
Iron and Steel	2014 should be the peak/plateau period; overcapacity issues are severe; concentration in the industry is low; pollution is high	Scrap iron should be re-used and iron and steel exports should be reduced.
Cement	2014 should be the peak/plateau period; non-competitive companies should be allowed to go under	Cement production should be 2.3 billion tons. Cement kilns should be encouraged to use more household waste, sludge, and industrial waste as fuel.
General Technology	Eight large general-use energy saving projects.	Increase energy saving, resource conservation and emission reduction at both the source and end-use stages.

The modern coal chemical industry: The modern coal chemical industry is a new and powerful sector where coal consumption is projected to grow. According to available statistics, there are currently 26 coal-to-oil projects, 58 coal (methanol)-to-olefin projects, and 67 coal-to-gas projects, which are currently operating, under commission, construction, or at the preparatory stage in China. If all of these projects were to be put into operation, China would attain production capacity of 40 million tons/year for coal-to-oil, 41 million tons/year for olefins, and 280 billion m^3/year for coal-to-gas by 2020. Coal consumption would increase from 128 million tce to 477 million tce, an increase of 273%. The coal chemical industry urgently needs to strengthen planning

and guidance in order to limit overcapacity.

The modern coal chemical industry is a sector with high energy consumption, high pollution, high water consumption, and high carbon emissions. The determining factors for the development of the coal chemical industry are its economics, competitiveness, social and environmental externalities, and climate change risk. Coal-to-oil and coal-to-gas projects are among the most controversial within the modern coal chemical industry. Examples of coal-to-oil projects in South Africa, and the United States' Great Plains coal-to-gas project in the 1980s, indicate that these projects are unable to compete with commercially developed oil and gas on the international energy market.

The domestic increase in water prices, collection of environmental taxes, and the future levy of a carbon tax will further weaken the competitiveness of coal-to-energy projects. If the social and environmental externalities are imposed, the coal-to-oil and coal-to-gas projects would not be profitable. Coal chemical industry projects are mostly located in the central and western regions of China, which are characterized by scarce or extremely scarce water resources, as well as environmental fragility.

The modern coal chemical industry also faces the several other challenges, including inconsistent coal quality (whichaffect the production process), immature production processes, instability, poor water quality, and high water consumption. Accidental discharges of wastewater occur from time to time, and developers' capaibility to safely manage waste vary significantly. Even after recycling with high oil, high COD, and high organic toxic phenol ammonia content in the wastewater, it is to toxic to be treated through direct biochemical treatment. Inspections have shown that the wastewater from coal-to-energy projects contains over 140 pollutants, with more than 30 cancer-causing organic compounds that are difficult to break down.

Deciding on the location of pollution discharge presents another problem. The costs for air pollutant emission reduction and wastewater treatment would have to be doubled in order to comply with existing standards for environmental protection. According to one estimate, the wastewater treatment cost alone will reduce a project's economic rate of return by 1-2 percentage points. The high carbon emissions of coal-to-oil and -gas projects will make it difficuilt for China to reach its goals in addressing climate change.

During the 13th Five-Year Plan period, coal-based olefin and ethylene development should be decelerated, and project approvals should be delayed. The modern coal chemical industry should only develop pilot projects, without moving into further stages of development. We should base future development decisions on the attainment of goals for clean-energy, high efficiency, environmental protection, and low carbon development, while considering the tremendous changes for both supply and demand in the international oil and gas market. Except as a strategic technical reserve, the commercial outlook for coal-to-energy energy projects is not bright. With the exceptions of projects that have already started production, no new projects should be approved, and projects that haven't begun production yet should be halted. New coal chemical projects promoted by local governments should be prohibited.

Power industry: As the Chinese economy enters a 'new normal' of slower growth, the growth of annual electricity demand is expected to be around 4% during the 13th Five Year Plan period. The installed capacity of coal power plants will reach the coal cap limit peak of 960 GW by 2017, with coal power making up 53% of total coal consumption in 2020. This is an extremely crucial point for the transition to a green, low-carbon power sector.

If the planning of power development during the 13th Five-Year Plan period continues the development path of the past 10 years, the

following consequences are likely to occur as the result of major planning mistakes: 1) power sector planning will fail to respond to the 'new normal' of economic growth, and will cause overcapacity in coal-fired power, resulting in power production overcapacity and difficulties in reducing capacity; 2) the healthy development of renewable energy will be restricted; 3) the continuing rapid growth of coal power capacity will further worsen the economics of coal-based power, large levels of investment will be stranded, and risk from debt will rise; 4) reducing the share of coal-based power after 2020 will become more difficult, CO_2 emissions will icrease, and the costs of low-carbon transformation in the power sector will become more expensive.

During the 13th Five Year Plan period, the power sector should plan for coal power plants to shift from their current role as a major generation source to one that is more supplementary. We will restrict the increase of coal-based power through air quality red line restrictions, water resource red line restrictions in the western region, and a national greenhouse gas emissions cap. Under the coal control scenario, the installed power capacity will reach 1,920 GW by 2020, with the installed capacity of non-fossil fuel energy increasing to 44.2% and coal-fired power capacity decreasing to around 51% of the total. Looking at the long term, no new coal power projects should be approved after 2017, except for individual coal power projects subject to approval by relevant central government ministries. Local governments should strictly control the approval of new coal-fired power plant projects in the 13th Five Year Plan period. Those who approve the projects should be held responsible and accountable when environmental violations occur.

In 2015, the installed capacity of coal-fired power was about 830 GW. The capacity of new coal power plants that were approved and began construction during the 12th FYP period and that are set to enter the market after 2015 is between 110 GW and 170 GW, and if planned projects are included, then total coal power capacity will exceed 1200 GW. This will far exceed the 960 GW cap on coal-fired power. Operating hours for thermal power plants were 5,021 in 2013, and in 2015 they had decreased to 4,329. Some of these new projects should be delayed, some halted, and some canceled. Coal-fired power plants about to enter the market should be used to replace backwards and small-scale units (200 MW or less). Some 300 MW units can be stopped and held in reserve in order to control total coal power installed capacity to 960 GW.

During the 13th FYP period, improvements in energy efficiency will be an important strategy for coal control in the power sector. China should aim for an annual efficiency target of 0.6%-1% of total electricity consumption during this period. During the 13th Five-Year Plan period, coal power capacity will reach a level that is sufficient to meet China's demands for future economic development. During this period, blindly increasing the share of coal-fired power in total coal consumption, relieving the difficulties of the coal industry through joint operation of coal mines and power plants, or encouraging more power generation through loose coal will increase the risk of stranded assets for enterprises. Moreover, approvals for coal gangue and low-heating value coal power generation projects should be halted. Before 2020, enterprises should carry out comprehensive and systematic retrofits of existing coal-fired power generating units. Coal consumption for power generation is expected to reduce from 318 grams of standard coal/kWh in 2014 to 300 grams by 2020. Green dispatch, when implemented, will further reduce coal power's economic competitiveness.

Building sector: In 2012, the per-capita energy consumption for civil buildings was only 0.5 tce/m^2, which is lower than the world average level of 0.6 tce/m^2. In the future, energy consumption of buildings will increase from about 22% of total energy consumption to 35%. By 2030, around 3.6 trillion RMB needs to be invested in the building sector in order to tap this huge potential for energy savings through the implementation of various energy-saving projects for reducing

emissions. However, this type of investment has so far been lacking.

Unlike the previous three plans for building energy savings and efficiency improvements, the major targets of the fourth round of building energy-saving policy should include:

(1) The proposal of building area caps for different periods based on urbanization level and levels of new construction in rural areas. By 2020, the building area cap should be set at 70 billion square meters or lower. For any construction that occurs over this building cap limit, steps should be taken to reduce existing building stock that is old, dangerous, or dilapidated.

(2) By 2020, the energy-saving design standards of new buildings in China should be equivalent to 85% of international standards, and 50% of all new construction projects should be green buildings.

(3) By 2020, the proportion of renewable energy in building heating should reach 15%. The proportion of renewable energy use for buildings should be allocated to the building sectors of each province. The underground infrastructure in Chinese cities is fairly weak, so attention should be paid to grid construction for heat, water, power, and gas. City governments should improve the efficiency of the heating grid and water pipelines, advocate for the use of water-saving equipment in public and residential buildings, and set annual targets. We should develop low-carbon ecological cities adapted to local conditions that are flexible and dynamic, making them able to respond to climate change.

Iron & steel industry: In 2020, steel production should be controlled to 700 million tons or less. The iron and steel sector already entered the peaking period in 2014. The industry should establish and improve policies on the comprehensive utilization of scrap steel resources. The comprehensive utilization of scrap steel resources is one of the most effective coal-saving approaches in the iron and steel industry. However, due to limited scrap steel resources and insufficient policies to incentivize scrap re-use, steel plants have been reluctant to use scrap steel. The amount of accumulated scrap has been increasing each year, but the scrap utilization rate has been declining. The major reason for continuous reductions in scrap consumption is that, as iron ore prices have fallen, enterprises have paid more for using scrap than iron ore. In 2015, iron and steel exports were over 100 million tons. In the long run, continuing such high levels of exports is not conducive to solving the problem of overcapacity and may lead to international trade disputes. Thus, exports of high energy-consuming iron and steel should be reduced in the future.

Cement industry: In 2020, cement production should be contained at 2.1 billion tons or less. 2014 should be the peak/plateau period for cement production, at 2.49 billion tons. In China, two-thirds of cities are surrounded by waste, with the total quantity of waste totaling 7 billion tons and covering an area of 750,000 mu (50,000 hectares). In addition, household waste is still increasing at the rate of 9% per year. The quantity of sludge generated from sewage plants has reached 6.5 million tons per year. Because the special characteristics of cement kilns allow them to use domestic garbage and sludge as a heat source, cement kilns are a potential solution for disposing of various wastes, thus reducing pollution and protecting the environment. Cement kiln co-disposal technology is recommended as a key measure for energy saving and emissions reductions within the cement sector. There are approximately 600 large and medium-sized cities across the country in which conditions are favorable for undertaking such waste disposal; China should encourage and increase the use of cement kiln co-disposal technology in cement plants in these cities as a top-priority solution.

(3) Popularize and promote eight general-use energy efficiency and environmental protection projects

China should strengthen and upgrade energy saving and emissions reductions standards every three years, with the goal of achieving advanced international levels for energy efficiency and environmental protection in the manufacturing sector by 2025. China can do so through eight energy efficiency projects, promoting four new types of efficiency projects and implementing four existing end-use efficiency projects:

• Information communication technology: This field includes an intelligent power grid, intelligent buildings, intelligent logistics, new energy and fuel-efficient vehicles, industrial energy conservation, intelligent motors, alternative transportation, and virtual services (communication, e-commerce, telecommuting, teleconferencing, etc.).

• Internet-plus: Information exchange and big data computing and application can improve the design, quality control, and management of the manufacturing industry tremendously, reforming the manufacturing process, inventory logistics procedures, and user service.

• Quality control technology: The Chinese manufacturing industry features low and unstable quality. We should improve the product quality of the manufacturing industry, striving for low cost and high quality products in order to be competitive in domestic and foreign markets.

• Green manufacturing based on design: Design products and equipment from the beginning stages with the goals of energy saving, material saving, reuse, and recycling in mind.

• High-efficiency, low-emission, coal-fired industrial boilers: The thermal efficiency of coal-fired boilers should reach 87-90%. This would allow for the replacement of several hundred thousand low-efficiency boilers, creating significant energy savings and emission reductions.

• High-efficiency electric motors: Based on reasonable economic assumptions and feasible technology, the average operating efficiency of China's motor systems can be increased by 15-20%, significantly reducing the gap with developed countries and potentially saving around 400 TWh/year.

• Metal recycling: The share of metal recycled will increase year on year. Compared with raw metal, the use of recycled metal can save more than 65 TWh/year.

• Industrial and building end-use energy efficiency products: Increase the standards that enterprises need to meet to enter the market for end-use energy-consuming products and energy-intensive industries.

8 USING REFORMS IN CHINA'S ENERGY SYSTEM AND TECHNOLOGY TO PROMOTE A COAL CAP

China has recently embarked on a new wave of reform aimed at making its economic, environmental, and social development more sustainable. Reforms in the energy sector specificially have long lagged behind reforms in other sectors of China's economy. Currently, most of China's energy efficiency technologies are not up to the same standard as what is available internationally, a fact that will need to change if China is to fully transition its economy to a more environmentally sustainable model. Coal control will be at the core of China's energy transition, and a coal cap will need to take advantage of opportunities and breakthroughs in China's energy revolution.

8.1 ENERGY SYSTEM REVOLUTION

An energy transition and coal cap both call for reform, and a revolution in China's energy system is one of the key components of this reform. This "revolution" will not just be technical, but will also work to improve the governing structure China uses to oversee its energy system. During the 13th Five Year Plan period, China's government will need to transform from one that simply produces to one that both produces and serves, a transition that should help bolster the country's economic development and help it avoid the "middle income trap." The ultimate goal of this revolution is to develop a holistic society that not only has a strong economy, but also a healthy environment and robust society.

Table 21 gives the timetable for reforms in the laws, institutions, and planning processes for energy-related government departments. Reforms will focus on a number of key issues, including establishing guiding principles, updating the governance system, introducing market mechanisms, and rebuilding the regulatory system.

Table 21: Timetable for China's Energy System and Policymaking Reform

	2016-2017	2017-2020	2020-2030
Department laws	Revise coal law Revise of power law Draft climate change promotion law Draft energy law Enact nuclear safety and atomic energy law Draft natural gas law Enact environmental tax law	Enact climate change promotion law Enact natural gas law Enact energy law Draft petroleum law Pass environmental tax and carbon tax	Establish a comprehensive energy legal system and implementation mechanisms Manage and reform energy departments according to the new law Enact petroleum law
Department reform	Further streamline administration and delegating power Conduct power sector reform Reform energy pricing system Reform energy market Initiate national carbon market Initiate coal use trading market	Establish Ministry of Energy and Climate Change Establish Energy Regulatory Committee Establish national carbon market Consult and prepare to set up Asia energy security cooperation agency	Improve domestic energy market and supervisory system Link domestic carbon market with international carbon markets Effectively respond to energy security risks and develop international energy markets Develop global leadership in addressing climate change
Planning	Energy and coal consumption cap Energy development strategic action plan National climate change program Energy-saving planning and targets Total CO_2 emission and carbon intensity targets	Domestic and "One Belt and One Road" infrastructure plan Interim evaluation of 13th Five YearPlan energy targets Assess coal consumption control targets	Strengthen 2020 and 2030 nationally determined contribution mitigation targets Cap coal consumption at 3.5 billion tons in 2025 and 2.8 billion tons in 2030 Set national air quality $PM_{2.5}$ concentration target at around 35μg/m^3 in 2025 and 30 μg/m^3 or less in 2030

Reform in China's coal industry should focus on controlling coal production, increasing marketization, and advancing environmentally friendly and low carbon development. Producers and users of coal who fail to meet standards for environmental protection, ecological health, or safety should be forced to leave the market. Reform should also remove local pricing monopolies and other protectionist institutions in order to enable market competition.

Unfortunately, China's current Coal Law is inadequate for addressing these changes. The Coal Law has seen some minor revisions since it was published in 1996, but none of them were ever fully implemented, and thus its impact has been negligible. China's ongoing energy transition and

efforts to cap coal are challenging the coal industry in ways that will require it to fundamentally shift the direction of its development. The Coal Law will need to be revised and adopted quickly in order to support this shift and bolster the country's efforts to cap its coal consumption.

In terms of reforming the agencies for managing China's energy system, it is important that the principle of separating administrative and supervisory responsibilities be respected. China is the largest energy producing and consuming country and largest carbon emitter. China's energy system reform will have a significant impact on its future energy development, climate change mitigation, and even international energy and carbon markets. China should establish a Ministry of Energy and Climate Change to serve as the key regulatory agency for its energy sector. This ministry should be authorized by the State Council and be tasked with establishing policy and developing plans for supplying energy, saving energy, and mitigating climate change. China's National Energy Committee and National Climate Change Committee should be the strategic policymaking body, while the Ministry of Energy would be the implementing agency. China should re-organize its agencies and establish an independent, authoritative, professional and effective energy regulatory agency to manage electricity, natural gas pipelines and transportation, carbon markets, and other related areas.

Finally, China should establish a mechanism to coordinate different coal cap policies. Such a coordination mechanism could guide the implementation of coal consumption control measures and for now could be led by the National Development and Reform Committee in collaboration with the National Energy Administration, Ministry of Environmental Protection, Ministry of Industry and Information Technology, Ministry of Finance, Ministry of Housing and Urban-Rural Development, and other relevant agencies.

8.2 TECHNOLOGY REVOLUTION

China's "energy technology revolution" will require continuing advancements in R&D and upgrades to the technology used in the energy sector. The government should strengthen research into major scientific and technological issues and advance key technologies for energy conservation, resource recycling, exploitation of new energy sources, pollution control, and ecological restoration. It should strive for breakthroughs in basic research and conduct R&D for cutting-edge technology.

However, although government support is important, the market should ultimately decide where resources will be allocated and in which directions green industry will develop. Innovation and entrepreneurship from the public should be encouraged.

As such, enterprises should play a central role in the development of technological innovation. In order to do this, China should strengthen its enterprises'

position as the key players in technological innovation, a move that will allow the market to guide the green industry's development. China's current strategy of encouraging innovative business start-ups is a good example of this, allowing the country to boost scientific and technological innovation in many sectors of the economy.

Technological innovation will also increase the international competitiveness of Chinese enterprises. Labor costs in China have increased significantly in recent years, meaning that China's cheap labor force and "demographic bonus" are disappearing. To address this, the government will need to improve the quality of the labor force by strengthening the skills training to meet economic development needs and by providing appropriate wages and professional standing to high-level technical personel. The green industry is a promising sector for China to develop its international competitiveness. In order to do this, it will need to encourage technological advancement and innovation, and invest in R&D in order to foster and shape its competitive advantages in the sector. China's manufacturing industry, in general, enjoys late-mover advantage in green technology and has huge potential. Continuing technical innovation will be the main driver for achieving "Made in China 2025," and a coal cap will help in driving capital investment in the appropriate technology.

In 2014, China invested 2.09% of its GDP on R&D, while the share for the United States and other developed industrial nations was mostly over 2.5%. In Finland and Sweden, the share was as high as 3-3.5%. The private sector has paid inadequate attention to R&D. As a result, R&D investment in China's manufacturing industry in 2012 accounted for only 1.6% in sales revenue. In comparison, the share in the U.S., Japan and Korea was 2.85%, 3.48% and 3.45%, respectively.

China has achieved a series of exemplary successes in industrial technology, but weak innovative capacity still makes China mostly rely on foreign imports for core technologies. Though the Ministry of Finance dislikes having a fixed proportion of public expenditure to support a given plan or project, the China Coal Cap Project still believes that R&D should account for more than 2.5% of central and local public finance. The government should strengthen intellectual property rights protection and adopt a series of financial and tax policies to incentivize private investment in R&D. For example, the tax deductions that enterprises receive for R&D investments should be increased.

An important component will be the research, development, and application of key coal control technologies. There are four main categories of coal control technology. The first is coal reduction technology, i.e. efficiency and consumption reduction technologies; the second is coal replacement technology; the third is clean coal technology and energy transfer technology; the fourth is technology for converting coal to raw, non-energy materials. To control coal consumption and promote environmental governance and low-carbon development, China needs to adopt a wide set of coal reduction technologies and further develop technologies for the replacement of coal. Since coal will still maintain an important position in China's energy mix in the foreseeable future, the government should promote and accelerate the development of clean coal technology in order to make coal use cleaner and more efficient. The development of coal-to-energy technologies (i.e. coal-to-oil, coal-to-gas) should be extremely limited. At the moment, the government should only allow demonstration projects and small-scale promotion for technology used to convert coal to raw, non-energy materials.

9 COAL CAP SAFEGUARD MEASURES

Effective safeguard measures need to be implemented to ensure coal control targets are successfully achieved. The government can identify key difficulties, challenges, and weaknesses during implementation and design applicable, effective and accountable insurance measures to address these.

9.1 FORMULATING AND IMPLEMENTING COORDINATED PLANNING AND CONTROL MEASURES

When coordinated, the implementation of coal control measures can yield significant co-benefits. The government should take this coordination into account when planning efforts to cap coal at the national, sectoral, and sub-national levels. At the central government level, a multi-stakeholder coal cap coordination team should make sure that this coordination occurs in the planning process , with a focus on implementation.

Regions, provinces, and cities should also form coal cap coordination groups in order to strengthen coordination. Relevant central government agencies and local agencies can work together to improve coordination, increase the effectiveness of coal control, and ensure on-the-ground implementation. The central government should dedicate special funds for regional joint prevention and control, key provinces, key departments, and key projects.

Benefits from the coal cap will be economic as well as environmental. Financial benefits from the coal cap (including greenhouse gas emission reductions) are significant, potentially reaching 334.36 billion RMB in 2020 (see Table 22). Coal cap measures will create 1.86 million green jobs in energy-saving, environmental protection, and clean energy, outnumbering the 350,000 jobs lost in coal mining, washing, and coal-fired power generation through a coal cap. Indirect green jobs created by the coal control will also add up to several million new employment opportunities.

At the regional and sectoral levels, the coal cap should strengthen weak areas and implement an accountability system. In the Jing-Jin-Ji and Yangtze River Delta regions, as well as in Sichuan, Chongqing, Guizhou, Shanxi, Henan, Shandong, Anhui, Hubei, and Hunan provinces where air

quality is the main constraint on coal consumption, the Ministry of Environmental Protection should lead a coordinated regional effort to curb coal consumption. In the northwestern provinces where water resources are the main constraint, the Ministry of Water Resources should take the lead. In the manufacturing sector, industry associations should play an active role in designing coal cap plans for coal-intensive industries.

When coordinating, each sector needs to specify the distribution of labor, timeline, and implementation measures. Each industry and region should plan investment, technology, management, market, and administrative management measures according to its own situation in order to support and ensure the effective implementation of coal control targets. Above all, policymakers and enterprises should emphasize practical results.

Table 22: Monetary Value of Coal Cap Co-Benefits in 2020

	Co-Benefits	Value (billion RMB)
Water Resources	Reducing water resource consumption	12.379
	Preventing ground water resources loss	13.754
	Preventing erosion and damage to the water ecological environment	15.283
	Reducing water pollution	16.981
Public Health	Reductions in premature deaths	97.63
Energy Transition	System cost reductions	85.88
Greenhouse gas emissions	Societal cost reductions	88.9
Coal Industry	Social cost from decrease in jobs	-22.667
	Mining fatality reductions	0.556
	Occupational disease incident reductions	7.111
	Environmental improvements	18.556
Total		334.363

9.2 ADVANCING COAL CONTROL USING ENVIRONMENTAL LAWS AND STANDARDS AND CLIMATE CHANGE REQUIREMENTS

Without a revised Coal Law, the energy policy apparatus does not have compulsory energy laws and regulations to support it. The environmental protection apparatus, however, has established a complete set of laws, policies, standards, and a regulatory system with elements ofenforcement and supervision. China's Supreme Court has established a special court for environmental and resource protection cases. Public participation in environmental protection is on the rise, and environmental social organizations are growing in size and scope. This is an important development because protecting the environment is a primary goal for capping coal. Coal consumption and utilization are closely related to our air, water and land pollution, and a coal cap is a key measure for addressing the source of environmental pollution. Therefore, a coal cap can rely on the authority endowed by the Environmental Protection Law and Atmospheric Pollution Prevention and Control Law to push forward coal cap measures and implementation.

In its Nationally Determined Contribution (NDC) submitted to the UNFCCC's 21st Conference of the Parties, the Chinese government made a commitment to peak its carbon emissions by 2030. This target will require a coal cap. Specifically, in order to meet this target, China will need to curb coal consumption at 3.5 billion tons by 2020, and 2.8 billion tons by 2030. To control global warming below 2°C, China's 2050 per capita CO_2 emissions need to stay at around 2-3 tons; coal consumption by then should be under 1.3 billion tons.

During the 13th Five Year Plan period, total carbon emissions and carbon intensity should both be controlled. Meanwhile, provinces and cities should also set their own carbon emissions, carbon intensity, and peaking targets. These objectives, together with air quality, water resources, and pollutant emission caps, can forcibly restrict coal consumption in regions, provinces and municipalities. The need to control coal use is driven by both environmental protection and climate change concerns, and a coal cap can be beneficial to both goals.

9.3 FOSTERING A NATURAL GAS MARKET TO REPLACE COAL USE

In our proposed coal cap plan, China's natural gas consumption will reach 360 billion cubic meters in 2020. China has secured sources of natural gas supply, the volume of which is likely to grow. However, growth in consumption has been slow, which will affect how much natural gas can replace coal. The following measures will help expand the natural gas market:

1.Levy an environmental tax on coal and raise coal prices.

2.Implement more rigorous environmental standards and controls for pollutant emissions.

3.Foster natural gas consumption by completing residential gas tier-pricing reform by 2017 in order to make natural gas more affordable.

4.Increase natural gas-fired power generation capacity to 100 GW by 2020, and use natural gas fired power primarily for peaking, with pricing that reflects its use for peaking.

5.Encourage natural gas use in vehicles.

6.Encourage certain manufacturing industries to use natural gas and increase product quality by providing discounted gas prices.

7.Prioritize grid connection for combined natural gas heat and power.

8.Ban bulk coal burning for commercial and service industries in the city center, and replace it with natural gas, electricity, or other clean energy.

9.Raise the proportion of natural gas-based heating and centralized heating. Accelerate household gas switching in cities and towns. By 2020, residential gas penetration should reach 70%.

10.Delay the cancellation of natural gas subsidies until gas markets mature.

11.Accelerate the construction of natural gas infrastructure.

12.When the time is appropriate, relax control of natural gas prices and encourage development of conventional and unconventional natural gas.

In 2015, 134.6 billion cubic meters of natural gas were consumed, an increase of 3.4% from 2014. After 2015, the government will reduce the price of natural gas by 0.7 yuan per cubic meter, which will encourage consumption of natural gas to rise. In the first two months of 2016, natural gas consumption increased by 15% or more. In addition to the central government's natural gas pricing policy, provinces should put natural gas market expansion on their agenda. Table 23 proposes the timetable for residential gas tier-pricing reform in different provinces. Coastal and pollution-plagued city clusters should construct gas-fired power plants so that China's total gas generation capacity can reach 100 GW, with annual power production approaching 300 TWh. The gas-fired generation fleet will work with renewable energy generation so that each industry complements the other. In order to enable this development, the government must set favorable peak load natural gas prices. Moreover, the government should encourage suitable industries – such as glass and enamel – to increase product quality and use natural gas instead of coal or gas converted from coal.

Table 23: Timetable for Residential Natural Gas Tier-pricing Reform

Time	Province, municipality and autonomous region
January-June 2016	Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Liaoning, Sichuan, Chongqing, Hainan, Jilin
July-December 2016	Shanxi, Anhui, Shandong, Henan, Hubei, Hunan, Jiangxi, Guizhou, Heilongjiang, Guangxi, Yunnan, Guizhou
2017	Xinjiang, Gansu, Ningxia, Qinghai, Tibet, Inner Mongolia

The central government should be responsible for the construction of an inter-provincial pipeline network, and the provincial governments should design policies to attract investment to pipelines within their jurisdiction. In areas with serious air pollution, natural gas pipelines should be connected to medium-level cities. During the 13th Five Year Plan period, local governments should adopt various policies and measures to reduce natural gas prices for large consumers and encourage the replacement of urban coal-fired boilers with gas-fired boilers.

The central government should continue the current policy of providing value-added tax (VAT) rebates for imported natural gas to address the issue faced by retailers who must purchase natural gas at high prices and sell at low prices. China should gradually cancel current fiscal and tax benefits for natural gas. However, given the pressing need to replace coal with natural gas, and lacking an enabling pricing structure, policy support for natural gas is and will still be necessary in the short- to medium-term. Before 2020, government-approved natural gas import projects (including liquefied natural gas) whose prices are higher than domestic prices should be provided with a VAT rebate in an amount that correlates to the difference between import and domestic prices. When natural gas prices are fully market-determined, this tax rebate policy should be anulled automatically.

One final step is to strengthen the financial and taxa policy support for coal bed methane (CBM), shale gas, and other unconventional oil and gas resources. The current domestic CBM and shale gas subsidies have already helped promote the exploitation and utilization of unconventional oil and gas resources and should be bolstered in the future. China should also increase financial support for investment in its gas pipeline network, heat supply pipeline network, and other infrastructure. The government needs to adjust natural gas prices and push for an overall decline in price levels, and apply residential gas prices to gas-based central heating facilities.

9.4 MARKET MECHANISM AND MEASURES

9.4.1 PRICE LEVERAGE

In December 2015, the average coal price for 5500 kcal of thermal coal in the Bohai rim was around 383 RMB/ton, and coal prices are still declining. The low coal price makes coal more competitive, as do subsidies that the Chinese government provides to coal. Fossil fuel subsidies in China mainly consist of two parts: the first is government intervention in the market and the provision of direct subsidies to energy enterprises; the second is the social externalities of fossil fuel consumption that are not internalized. The coal price is determined by competitive markets, but local government officials often erect market barriers and obstacles for the market to function properly.

Coal's social and environmental cost is substantial. Analysis by the China Coal Cap Project found that in 2012, the external cost of coal was 463 RMB/ton. However, the current environmental fee on coal is only 40-50 RMB/ton and focuses mainly on its production, while the fee paid for pollutant emissions on the consumption end is only about 5 RMB/ton of coal. Furthermore, much of the other resources damaged during coal exploration and utilization are unaccounted for.

China needs to further improve coal's pricing mechanism, especially by increasing the environmental tax on coal consumption. The Chinese government has implemented residential power tier-pricing levels, in which electricity prices are adjusted based on the time and situation. The government can also gradually implement peak-valley power pricing and reduce overlapping subsidies for electricity consumption.

For natural gas prices, the government should further develop policies for residential tier-pricing policy and examine the potential of non-residential seasonal pricing and interruptible gas pricing. Coal's Levelized Cost of Electricity [3] (LCOE) was the lowest of any energy source in 2014 (Table 23), but its price gap with clean power has narrowed quickly. Taking into account the growing generation and technological development of clean energy, if coal's external cost is accounted for in a higher environmental tax, clean power will become very competitive

Table 24: LCOE of Various Power Sources, RMB/kWh

Power Sources	2014	2020
Hydro	0.35	0.35
Pumped Hydro Storage	0.58	0.58
Natural Gas	0.76	0.60
Nuclear	0.37	0.37
Wind	0.64	0.51
Solar PV	0.935	0.62
Concentrated Solar Power	1.60	1.22
Biomass	0.8	0.75
Coal	0.39 (2015)	0.41 0.44 (External Cost)

9.4.2 RESOURCE PRICING

The value of environmental resources is related to their involvement in social and economic activities, but they are currently undervalued in most sectors of the economy. The saying that "Blue water and skies are the real source of wealth" is a great reflection of the true value of ecosystem services. Air, water, soil, and mineral resources are essential components of social and economic production and have corresponding value to society. The appreciation of their value should change with their contribution to society and economy over time, as should citizens' willingness to pay for them.

According to the standard released by the International Water Association and the World Bank, the share of water cost in per-capita disposable income should reflect the country's water shortage. In the countries and regions where water shortage is severe, water's share in per-capita disposable income can reach 3-5%, as opposed to 1% in areas with adequate water areas. C urrently, China's water price only makes up 0.6%-0.7% of public disposable income. In drier areas, water price is contradictorily even lower. The low water cost has led to massive waste and incentivized water-intensive coal-based power plants and coal chemical plants. Globally, China's water prices are low when compared both with other countries and against per capita disposable income. China's water supply is priced at only 17% of the global average, with sewage treatment priced at 14% and overall water priced at 16%, all very low levels.

3.The Levelized Cost of Electricity takes the cost of a power plant's generation divided by the overall generation, to express the levelized cost of electricity per unit of generation. Under a system of government approved power pricing, it is a basic foundation for setting electricity prices. Within a power market, it is an important measure for evaluating each generation source's market competitiveness.

Before the end of 2016, the urban sewage disposal fee should be raised to, in principle, no less than 0.95 RMB/ton for residential users and no less than 1.4 RMB/ton for non-residents. For counties and key towns that have administrative status, the fee should be no less than 0.85 RMB/ton and 1.2 RMB/ton. The central government planned to raise the average surface water price in Beijing and Tianjin to 1.6 RMB/cubic meter by the end of the Twelfth Five Year Plan, and that for ground water to 4 RMB/cubic meter. The current prices in Beijing, however, have yet to reach these levels. By 2020, the government should roll out a pricing mechanism to increase the cost of water when non-residential users consume more than their allowance, so as to widen the water cost gap between water-intensive industries and others.

The current policy system does not reflecte the actual value of resources, or their value-added. It ignores the long-term effect of resource and environmental damage; in fact, it encourages environmental damage and the excessive consumption resources. This is one of the root causes of China's current rapid resource depletion and environmental woes, especially with regard to air quality, which is not listed in the government's resource catalogue. If we can set prices on key resources, including the air, then enterprises will reduce their consumption of resources and harm to the environment as soon as possible in order to prevent larger costs in the future. We recommend the government establish higher resource prices for coal control in the 13th Five-Year Plan, using resource pricing to achieve coal cap targets and realize sustainable development.

9.4.3 FINANCIAL AND TAX POLICIES

Reform taxes and fees on coal resources. On December 1, 2014, China's central government reformed the coal resource tax so that it is determined as a percentage of coal prices rather than per ton of coal. The range of the coal tax rate is 2-10%, depending on the province. In general, the reform of the coal resource tax has not achieved the results it hoped to achieve for coal control. Resource taxes should aim to increase resource recovery rates and promote green mining, but the current tax regimes have failed to achieve these goals. The government should further strengthen and improve the positioning and function of the resource tax in order to establish scientific production of coal, alleviate production overcapacity, and incentivize the development of a clean, high-quality coal supply.

Improve the design and application of an environmental tax. On June 11, 2015, the Legislative Affairs Office of the State Council released the Law of the People's Republic of China on Environmental Protection (draft for comment) co-signed by the Ministry of Finance, State Administration of Taxation, and Ministry of Environmental Protection. We recommend raising the rates of the new environmental tax from 1.2 RMB/unit of pollution to 2.4 RMB/unit of pollution for air pollutants, and from 1.4 RMB/unit of pollutaion to 2.8 RMB/unit of pollution for water pollutants. We also recommend a moderate increase in the environmental tax on powdered coal ash, coal gangue, and other solid waste. During the 13th Five Year Plan period, if the Ministry of Environmental Protection puts particulate matter, VOCs, and ammonia nitrogen on the list of taxed air pollutants, these pollutants should also be subject to an environmental protection tax. Appropriate pollution emission standards and total emissions targets should be set. If pollution standards are set too low, most enterprises (over 50%) will be able to meet them and will thus enjoy tax benefits. The enterprise's total pollutant emissions limit should also be set appropriately, so that implementation of the limit will increase enterprises' environmental tax burden.

Levy a carbon tax as soon as possible. The government should include the carbon tax in the environmental tax law so it does not need to be classified as a new tax and undergo a separate and arduous legislative process. Despite limited legislative resources, now is the ideal time for curbing carbon pollution. If incorporated into the environmental tax, a carbon tax has a chance to be adopted in the near future. The carbon tax and carbon trading are both important economic policies to reduce carbon dioxide emissions. Both have advantages as well as disadvantages, so they should be use to complement each other rather than replace each other. The carbon tax can be a supplementary policy for when the carbon pricing mechanism is ineffective, i.e. by setting the lowest possible price for carbon. The carbon tax and carbon trading are not mutually exclusive and have co-existed effectively in other countries' carbon policies. Enterprises participating in carbon trading should not be subject to a carbon tax, while those that are not participating in trading should be taxed. One should not be limited only to one or the other instrument. The government can conduct carbon tax pilots in existing carbon trading pilot provinces, or conduct them separately. Pilot projects will gather valuable experience and lessons and settle the issues between the two policies.

China's carbon tax should start at a low rate and increase gradually. The China Coal Cap Project recommends that the carbon tax start in the range of 20-30 RMB/ton of carbon dioxide. Its impact will vary by industry, impacting some industries to a greater degree than others. The coal chemical industry, coal mining and washing, power industry, natural gas mining, non-ferrous metals, iron and steel, building material, paper-making, and petrochemical industry will all be affected. For bulk coal users like boilers and kilns, the carbon tax will promote an active reduction in coal use and emissions. Coal to oil, coal to gas, and other key coal-intensive energy conversion industries should bear a higher carbon tax. Compared with the environmental tax and carbon market, a carbon tax does not require expensive measurement measures or transaction costs, and the administrative cost is very low.

Cancel the coal import tariff. In the long run, the coal import tariff hinders competition and obstructs the linkage between domestic and international coal markets. We recommend canceling the coal import tariff while simultaneously putting in place compulsory quality requirements for imported coal. The purpose of free trade agreements lies in promoting economic integrity, eliminating trade barriers, and allowing the free flow of products and services between countries. The government should connect China with the Asian and global energy markets to increase Chinese products' competitiveness, rather than set obstacles to hinder the integration of the Asian energy market.

Formulating financial and tax policies to promote the adoption of clean coal utilization technology. The key clean coal technologies that should receive incentives for their development and deployment are: ultra-super-critical power generation technology, large circulating fluidized beds, integrated gasification combined cycle (IGCC) technology, flue gas desulfurization and denitrification technology, and carbon capture, utilization, and storage (CCUS). The government should include clean coal technology in the list of key technological projects that the country is trying to advance, and allow it to enjoy special loans for energy saving and technological innovation.

The government should also actively guide market forces to invest in clean coal technology and incentivize enterprises to understand and promote such technology. Tax benefits and financial support should be given to key imported technologies, equipment technologies, and demonstration projects. Enterprises purchasing clean coal energy generation plants and similar production facilities should enjoy corporate income tax credits, and those importing energy from such facilities should receive tariff

exemptions. Commercialized clean coal projects should be included as environmental protection projects under the corporate income tax category so they can enjoy income tax exemption for three years and half exemption for another three years.

9.4.4 INVESTMENT AND FINANCIAL INSTRUMENTS

Adequate investment is an important condition for achieving the coal cap. Forecasts estimate that during the 13th Five Year Plan period, investment in energy saving, coal clean utilization, and alternative energy targets will require around 3.758 trillion RMB, including 2.98 trillion RMB on energy saving and alternative energy and another 777 billion RMB on environmental protection and low-carbon projects. Energy infrastructure improvement will need another 2-3 trillion RMB. These massive capital needs for capping coal can drive economic growth. Implementing coal control requires investment from a number of different sources, as well as open investment policies for nuclear power, the electricity grid, and oil and gas resources.

Based on the financing needs for coal reduction, cleaning, and substitution, the government should propose a coal cap financial support framework and green credit scheme. The goal of these two proposals is to reduce industrial excess capacity and lower the capital risk for the financial sector. It should also provide recommendations on financial opportunities and risk avoidance strategies arising from national emission reduction and coal control strategic goals. The government should formulate an investment risk assessment mechanism and highlight risky coal industries and enterprises. Our analysis shows that if the coal industry's credit is reduced to 15 billion RMB annually, China's coal production will consequently drop to 3.4 billion tons, which will – from the supply side – indirectly contribute to the coal consumption cap of 3.7 billion tons.

The government should establish a robust green credit, bond, securities, and insurance policy system in order to inhibit the development of overcapacity in industries like coal, steel, and cement, as well as to encourage high-efficiency energy production and efficiency-improving and energy-saving technologies. It will also help establish a green finance system and guide capital and financial derivative markets to support natural gas, solar energy, wind energy, and other renewable energy industries.

In order to cap coal, the development and improvement of China's green bond market system should be accelerated. Green bonds are an important financial instrument to support the energy transition. Their long terms and low cost can provide long-term financial support to clean energy, environmental protection, energy saving, and other industries. China should establish a green insurance market, build an environmental pollution risk management database, and increase the environmental compliance cost of coal-related industries. Listed companies must disclose information on environmental and carbon emission. When the time is ready, financial authorities should require mandatory insurance for potential polluters.

The government should establish a policy-based green financial institution and strengthen the development of intermediary agencies for green finance. Learning from international experience, special policy-based green financial institutions such as a "green banks" or "ecological banks" can be established in the long run, so as to provide policy-based finance for green development and sustainable development projects. The government should support internet finance for distributed energy and introduce financial and insurance institutions through an internet e-commerce model to reduce the financial risks of using distributed solar energy. Internet financial service can help suppliers reduce transaction costs, reduce the financing costs for end users, accelerate the integration of the industrial chain, and promote the rapid development of the solar energy industry.

9.5 COAL ENTERPRISE EXIT MECHANISM AND INDUSTRY TRANSITION

According to regulatory documents from the State Council, 500 million tons of capacity should be reduced and another 500 million tons restructured within 3-5 years from 2016. Approvals of new coal mining projects should be halted within 3 years. Based on the Coal Cap Project's recommended targets for the 13th Five Year Plan, overcapacity in these sectors is even more severe than in the reference scenario, meaning that targets for reducing excess capacity must be higher.

The compensation mechanism for ecological protection should be improved. As a part of China's ongoing financial and tax reform, the government should improve the system for payment transfers and increase the ecological transfer protection fund used for the ecological restoration of old coal bases in order to repay the "ecological debt" these bases owe from past decades. The government should encourage local industry upgrades, capacity transfer, development of new industries, and re-training for workers who have been laid off. It also needs to establish independent and just environmental damage assessment and restoration evaluation systems so that ecological restoration is carried out correctly. China should adhere to a principle of "whoever develops, protects; whoever damages, remedies; whoever benefits, compensates; whoever pollutes, pays," in order to remedy the long-term environmental damage of coal production bases and remediate the environment more effectively.

A coal production cap paves the way for the coal industry to innovate itself out of a depression. It will ease unhealthy competition between companies, reduce excess capacity, stabilize coal prices, and aid the country's industrial upgrade. The foundation of a coal production cap is a safe, efficient, green, and scientific production strategy. With production capacity in 2020 expected to be smaller than it is now, the share of scientific capacity – determined by safety, environmental sustainability, efficiency, and seven other indexes – should be able to reach 74%. That share will continue to rise to 100% by 2030.

The central government's tax and financial support can help establish mechanisms to aid coal mining enterprises' smooth exit from the industry, ensure laid-off workers' re-employment, implement ecological compensation in coal bases, and transition resource-exhausted cities away from old development models. These mechanisms need to be in place to safeguard coal cap policies; otherwise coal enterprises will fight against these policies. The government should also strive to break local protectionism and market monopolies and introduce marketization to the coal industry. Industrial policies should push for mergers and acquisitions of small coal companies and close small coal mines with outdated production. The government should establish mechanisms to oversee companies' entrance and exit from the coal market, while diversifying its coal storage strategy so as to minimize the impact of market volatility. In the next five years, coal mining and washing enterprises should reduce their numbers from 6,390 in 2015 to 3,000 or less in 2020.

The central government should strengthen policies assisting coal workers' re-employment. A coal production cap will directly impact the coal mining and washing industries, resulting job opportunities being reduced and, in some cases, eliminated. By 2020, job losses in the coal mining and washing industries may reach 671,000 and 191,000, respectively. With the addition of other factors, approximately 1.3 million coal mining jobs will be lost. During the 13th Five Year Plan period,

fiscal and tax policies should be strengthened and implemented to to help coal workers that have lost their jobs be re-employed in accordance with State Council jobs creation policies. The coal mining industry needs to wake up and recognize that, in the wake of the coal industry's growing productivity and China's decreasing demand for coal, the current measures to address layoffs – such as transfer of positions within an enterprise – cannot cope with the long-term challenges that the coal industry is facing. The coal industry must truly "thin down" and continue to do so as long as these external conditions exist, in order to meet the clear long-term trend of decreasing future coal consumption.

9.6 EVALUATION INDEX AND PERFORMANCE ASSESSMENT

The coal cap's evaluation system needs to be executable, measurable, reportable, and verifiable. At the end of each year, relevant government departments or third parties entrusted by the government need to report on the coal control progress made by major coal-consuming sectors, regions, provinces, and municipalities. The existing government climate change statistics system preliminarily established a three-level emission accounting system for greenhouse gases that looks at the national, sub-national, and sectoral levels. The coal-related data from this this system should be reported separately.

In order to achieve China's goal of constructing an ecological civilization, the government should establish an effective performance assessment system with specific coal cap objectives, assessment measures, and a mechanism to reward compliers and punish non-compliers. Such an evaluation system should also incorporate and increase the weight placed on resource consumption, environmental damage, and ecological benefits, making them hard targets for government officials. The central government should also improve performance assessment methodology and design differentiated evaluations for officials in different ministries and locations. Regions, enterprises, and individuals with outstanding achievements should be rewarded. By factoring in calculations of the true cost of coal, balance sheets and social loss sheets for coal resources can aid the evaluation of coal cap targets. Please see Attachment 10 for a proposed coal cap performance evaluation index.

Government leaders and Party members are the key to implementing environmental protection. The government should specify cadres' responsibilities during the decision-making, implementation, and supervision processes for the coal cap, making sure that they uphold limitations on resource consumption, a bottom line for environmental quality, and red lines for environmental protection. When cadres fail to do this, the government should hold them accountable. Meanwhile, Party members should lead the work on environmental protection. The Party and the government share the same responsibility for environmental protection, so in places with serious environmental deterioration, relevant departments' officials and staff should be held accountable.

10 PUBLIC PARTICIPATION

The Chinese government has established a series of resource, environmental and ecological laws and regulations. These laws have long been overlooked, however, and Many citizens, however, have long overlooked and refused to obey them. The government needs to educate and encourage citizens to obey these laws and empower the judicial system to implement them effectively.

Enterprises are the actors that are most responsible for upholding environmental protection efforts. The government should support and acknowledge low-carbon alliances, energy-saving pioneers, and other self-organized social groups. Chinese companies need to increase their awareness and practice of social responsibility, implement energy saving and environmental protection, and fulfill their responsibility in low-carbon development. Companies should obey environmental laws, regulations, standards, and policies; manage, constrain, and supervise themselves; and connect corporate earnings with social responsibility.

Public participation in environmental protection includes not only supervising and reporting polluters' actions and officials' misconduct, but also participating in the formulation and implementation of policies, laws, and regulations, as well as in the initiation of new laws and policies and their implementation. The energy sector witnesses a significant amount of undemocratic procedures, lack of transparency, and unpublicized mandates during its decision-making processes. The government has the responsibility to establish comprehensive platforms for public participation and information sharing. For example, the power sector should establish a platform that allows it to hear views from a wider audience. Concerns and challenging issues should be resolved through discussion, negotiation, and research. Furthermore, public interest litigation should be a key piece of environmental protection efforts, complementing government implementation of environmental laws and regulations. Social organizations should file public interest lawsuits on pollution episodes that significantly threaten public health.

The government should advocate and cultivate a green lifestyle and encourage frugality in consumption. If China's current pace of consumption continues, it would require double the resource endowment of what it possesses. Yet at the moment, there's no signs showing that this pace of consumption is decreasing. Government policies and expenditures should support NGO intiatives like "setting the A/C at 26°C," "car-free day," "one kWh of electricity and one drop of water," "blue sky," "a cup of clean water" and other initiatives focused on environmental protection and public participation. The government should also support "C+ climate citizens beyond action," an initiative by around 30 domestic and international NGOs to encourage citizens of different walks of life to take actions addressing climate change.

The media should uncover and acknowledge individual grassroots campaigns on climate action. China's current development and energy structure transitions have coincided with high environmental pollution. In-depth reporting by the meida can help with the implementation of a coal cap, gathering more effective solutions for the government, enterprises, social organizations, and the public.

11 BUILDING AN ASIAN ENERGY SECURITY COOPERATION AGENCY

China should use domestic and international resources and markets to reduce its coal consumption. Many developed countries have taken advantages of international energy markets to import oil and natural gas resources to replace domestic coal consumption during economic transitions. Internationally, China should advocate for a new perspective on energy security that is inclusive, transparent, cooperative, and mutually beneficial. This will allow China to support further exchange and cooperation with other nations, introduce advanced equipment and management experience, promote global energy security, develop the international energy market, and reduce domestic coal consumption.

The center of the global economy and worldwide energy consumption is shifting to Asia. This new trend calls for an open and transparent platform based on equality and mutual benefit to allow cooperation and dialogue between all stakeholders in the market, and to align the interest of countries involved in the production, consumption, or transportation of energy. This new trend requires more developing countries to cooperate and maintain a stable, peaceful, effective, and sustainable global energy market. Only when Asia's energy security is guaranteed can global energy security be achieved.

The existing international energy governance structure can no longer adapt to this new trend. The International Energy Agency, established under OECD, has no Asian developing nations other than Turkey and South Korea as formal member countries, and hence cannot represent the current global energy governance structure. With so many significant changes in the global energy market, it is high time to establish a new Asian energy government institution to ensure Asian and global energy security.

The new Asian energy security agency should, on the basis of mutual benefit and stability, strengthen cooperation and establish a collective security system. It needs to draw experience from existing energy governance systems and strengthen the exchange of energy technology and information among member countries. When problems arise, it should facilitate negotiations to maintain energy market stability. It should also play an active role in China's "One Belt, One Road" energy infrastructure initiative. The agency needs to cooperate with the existing energy governance and institutional structure, safeguarding energy supply and preventing price manipulation.

China should take the lead in the discussions and preparations for an Asian energy agency, actively promoting the establishment of a new energy order in Asia. Through bilateral and multilateral cooperation, China and other Asian countries can improve their energy governance capacity. Importantly, the establishment of an Asian energy agency is not an attempt to create a whole new structure on its own. Rather, it is an open, equal, and transparent platform for cooperation and mutual benefit. When it's fully developed, it should work with other international organizations to establish a global energy governance structure and promote the sustainable development of global energy.

POST SCRIPT: ABOUT THE CHINA COAL CAP PROJECT

The China Coal Consumption Cap Plan and Policy Research Project is composed of the organizations below, in Table 1.

Table I: Project Member Organizations

Energy System Analysis Research Center, Energy Research Institute, NDRC
Beijing Energy Efficiency Center, Energy Research Institute, NDRC
Energy Economy and Development Strategy Research Center, Energy Research Institute, NDRC
National Center for Climate Change Strategy and International Cooperation
Development Research Center of the State Council
Research Institute for Fiscal Science, Ministry of Finance
School of Environmental Engineering, Tsinghua University
Institute of Energy, Environment and Economy, Tsinghua University
Institute of Industrial Economics, Chinese Academy of Social Sciences
Institute for Urban and Environmental Studies, Chinese Academy of Social Sciences
People's Bank of China, Greenovation Hub
North China Electric Power University
China Iron and Steel Industry Association
China Cement Association
China Coal Processing and Utilization Association
Center of Science and Technology of Construction, Ministry of Housing and Urban-Rural Development; Beijing Jiaotong University
China Coal Research Institute
School of the Environment, Renmin University
School of Public Health, Peking University
China Institute of Water Resources and Hydropower Research

Eighteen experts in relevant fields constitute the Project's Research Steering Committee. They provide guidance to the Project's research. These experts are in Table 2:

Table 2:

DU Xiangwan	Chairman, National Climate Change Expert Group
HAN Wenke	Director-General, Energy Research Institute, National Development and Reform Commission
HE Jiankun	Deputy Director, National Climate Change Expert Group
LI Junfeng	Director, National Centre for Climate Change Strategy and International Cooperation
PAN Jiahua	Director, Institute of Urban and Environmental Studies, Chinese Academy of Social Sciences
ZHOU Dadi	Former Director, Energy Research Institute, National Development and Reform Commission
WANG Jinnan	Vice President, Chinese Academy of Environmental Planning, Ministry of Environmental Protection
ZHAO Changwen	Director-General, Research Department of Industrial Economy, Development Research Centre of the State Council
JIA Kang	Former Director, Research Institute for Fiscal Science, Ministry of Finance
SHI Dinghuan	State Council Councilor
WU Yin	Former Deputy Director, National Energy Administration, National Development and Reform Commission
BAI Rongchun	Former Director-General, National Energy Administration, National Development and Reform Commission
DAI Yande	Deputy Director, Energy Research Institute, National Development and Reform Commission
Yang Fuqiang	Senior Advisor on Energy, Environment and Climate Change, NRDC
HU Zhaoguang	Vice President, State Grid Energy Research Institute
WANG Yi	Deputy Director-General, Institute of Policy and Management, Chinese Academy of Sciences
ZHOU Fengqi	Former Director, Energy Research Institute, National Development and Reform Commission
QIAN Jingjing	China Program Director, Natural Resource Defense Council

The project cooperates with international partners as provided in Table 3:

Table 3:

Lawrence Berkeley National Laboratory	Institute for Industry Productivity
International Energy Agency	Health Effects Institute
World Bank Group, Asian Development Bank	World Resources Institute
Regulatory Assistance Project	International Labour Organization

The China Coal Cap Project thanks the UK Children's Investment Fund Foundation for its funding support, and the Natural Resources Defense Council and the World Wide Fund for Nature for their coordination.

APPENDICES

Appendix I: Environmental, Health and Social Costs of Coal Production and Consumption (2012)

Process	Category	Items	Cost (RMB/ton)
Coal Production	Coal Resources	Resource Waste	11.00
	Water Resources	Water Depletion	27.65
		Water Pollution	5.81
	Ecosystems	Agro-Ecosystems	2.00
		Soil Erosion and Ecological Degradation	19.30
	Human Health	Miners' Deaths	0.23
		Direct Loss from Occupational Disease	0.14
		Indirect Loss from Occupational Incapacity	0.21
	Sub-Total		66.34
Coal Transport	Road Transport	Accidents, Noise, Environmental impact, etc.	23.6
	Rail Transport	Accidents, Noise, Environmental impact, etc.	2.75
	Water Transport	Accidents, Noise, Environmental impact, etc.	1.48
	Sub-Total		27.8
Coal Consumption	Human Health	Deaths from coronary artery disease, stroke, chronic obstructive pulmonary disease (COPD), lung cancer, etc.	166.2
	Acid Rain	Damage to agriculture, forests, and other ecosystems.	30.32
	Solid Waste	Affects soil quality, biodiversity, and groundwater	4.40
	Wastewater Discharge	Biodiversity, contamination of water resources	7.56
	Sub-Total		208.48
Total			302.62
	Climate Change	Society, environmental damage and biodiversity loss, economic costs	160.8
Grand Total			463.42

Appendix 2: China's Economic and Energy Development (1990-2020)

	1990	2000	2005	2010	2013	2014	2020
Population Size (in billions)	1.14333	1.26743	1.30756	1.34091	1.36072	1.36782	1.37466
Urbanization Rate (in %)	26.4	36.2	43	49.95	53.7	54.8	61
GDP Growth Rate (in %)	3.8	8.4	11.3	10.4	7.7	7.4	6.7
GDP (in trillions of yuan)	1.8774	9.9776	1.85895	4.08913	5.88018	6.36462	9.36291
Structure of the Economy (in %)							
Primary Industry	26.7	14.7	11.7	9.6	9.4	9.2	7
Secondary Industry	40.9	45.4	46.9	46.2	43.7	42.6	36
Tertiary Industry	32.4	39.8	41.4	44.2	46.9	48.2	57
Per capita GDP (in U.S. dollars)	344	949	1805	4433	6807	7575	10642
Primary Energy Consumption (Mtce)	987	1469.4	2613.7	3606.5	4169.1	4260	4580
Per Capita Energy Consumption(Kgce)	864	1148	1805	2426	2756	3114	3332
Coal Consumption (Mtce)	752	1006.5	1892.3	2536.2	2810	2811.6	2510
Percentage of Coal Accounting for China's Energy Needs	76.2	68.5	72.4	69.2	67.4	66	54.8
Coal Produced (Mtce)	771.1	1010.2	1772.7	2378.3	2705.2	2635.2	2428.6
Average per Capita Household Electricity Consumption (kWh)	42	132	217	380	499	507	680
Installed Capacity (GW)	137.89	319.32	517.18	966.41	1257.68	1360.19	1910
Generating Capacity (TWh)	621.2	1355.6	2500.3	4207.1	5431.6	5649.6	7320
Steel Production (Mt)	51.21	131.46	377.71	802.77	1082.01	1125.57	1015.5
Crude Steel Output (Mt)	66.35	128.50	353.24	637.23	813.14	822.7	700.0
Pig Iron Production (Mt)	62.38	131.02	343.75.	597.33	711.5	711.6	588.0
Cement Production (Mt)	209.7	579	1068.9	1881.9	2416.1	2492.1	2100
Plate Glass (Millions of boxes produced)	80.67	183.522	402.102	663.308	792.858	792.617	680
Ethylene (Mt)	157.2	470	755.5	1421.3	1599.3	1696.7	1812
Fertilizer (Mt)	1879.7	3186	5177.9	6337.9	7026.2	6887.2	6900
Urban per Capita Residential Construction Area (m^2)	13.7	20.3	27.8	31.6	33.5	34.4	38
Rural per Capita Residential Construction Area (m^2)	17.8	24.8	29.7	34.1	39.2	40.7	40
Total Construction Area (in billion m^2)	20.5	32.2	42.4	51.2	58.5	60.7	70.0
Total Area of Urban Central/District Heating (in billion m^2)	.21	1.11	2.52	4.36	5.72	5.91	7.5
Total Value of Commodity Exports (in billions of U.S. dollars)	62.09	249.2	761.95	1577.75	2209.37	2342.75	3140.0
Total Value of Commodity Imports (in billions of U.S. dollars)	53.35	225.09	659.95	1396.24	1950.32	1960.29	2340.0
Renminbi (RMB) vs. U.S. Dollar Exchange Rate	4.7832	8.2785	8.1943	6.7695	6.1932	6.1428	6.4

Sources: "2015 China Energy Statistical Yearbook," China Statistics Press, December 2015; "2015 Energy Data," edited by Wang Qing, August 2016; "China Coal Consumption Cap Report," China Coal Cap Project, January 2016.

Appendix 3: Comparison of the Energy and Environmental Goals of the 12th Five Year Plan and the Coal Cap Project's Recommendations for the 13th Five Year Plan

Goal	12th Five Year Plan's Target (%)	13th Five Year Plan Target (%)	13th Five Year Plan Annual Rate of Decrease (%) [Cumulative]
Energy			
Energy Intensity Reductio(%)	16.0	18 (15)	3.9
Carbon Intensity Reductio(%)	17.0	21 (18)	4.6
Proportion of Non-Fossil Fuel Energy Sources (%)	12.0	15.7 (15)	[3.7]
Total Coal Production Cap (billion tons)	-	3.4	
Pollution			
CO_2 Reduction (%)	8.0	17 (15)	3.7
Chemical Oxygen Demand (COD) Reduction (%)	8.0	14 (10)	3
Ammonia (in water) Reduction (%)	10.0	15 (10)	3.2
Nitrogen Oxides Reduction (%)	10.0	21 (15)	4.6
Atmospheric Particulate Matter Reduction (%)	-	25 (18)	5.6
Volatile Organic Compounds (VOCs) Reduction (%)	-	18	3.9
Ammonia (in the air) Reduction (%)	-	16	3.4
Water			
Water Intensity Reduction (tons of water per 10,000 RMB industrial added value) (% decrease)	30.0	30 (Based on 2013 levels)	5.0
Water Intensity Reduction (tons of water per 10,000 RMB GDP) (% decrease)	-	35 (Based on 2013 levels) (23, based on 2015 levels)	6.0
Forests (Increase)			
Forest Coverage Rate (%)	21.7	24 (23.04)	[2.3]
Forest Cover	-	Increase of 40 million hectares (based on 2005 levels)	-
Forest Volume (bcm)	15.1	16.5 (16.5)	[14]

Note: Numbers within parentheses ( ) are the government's official targets in the "13th Five Year Plan"

Appendix 4: Coal Consumption Cap Plans and Carbon Emissions Plans of Chinese Provinces and Cities

Province/City	Coal Cap Goal	Province/City	Coal Cap Goal
Beijing	Reduce coal consumption by 13 million tons by 2017 (based on 2012 levels); cap consumption at 10 million tons with total coal consumption accounting for 10% of energy needs. By 2020, have total coal consumption be at or below 9 million tons.	Jiangsu Province	Cap provincial coal consumption cap at 300.93 million tons in 2017. This represents a decrease in coal consumption compared to 2012 levels. By 2017, coal should account for 65% or less of total energy needs.
Shanxi Province	Cap coal consumption at or below 138 million tons in 2017. Compared to 2014, the cities from this province that were examined by our study will reduce their coal consumption by 8 million tons, with Xi'an reducing its coal consumption by 1.4 million tons. By 2017, coal should account for 67% or less of total energy needs, while renewable energy will account for 10% of energy needs and natural gas will account for another 10%.	Liaoning Province	Cap coal consumption at or below 201 million tons in 2017. Increase the use of natural gas to 10 billion cubic meters, which will account for 6% of the province's energy needs.
Zhejiang Province	Cap coal consumption cap at or below 144 million tons. This represents a decrease in coal consumption compared to 2012 levels. In the future, coal should account for 44.1% or less of total energy needs.	Tianjin	Reduce total coal consumption by 10 million tons by 2017 (compared to 2012 levels), which means coal will account for 65% or less of total energy needs.
Ningxia Province	By the end of 2017, the proportion of energy needs met by coal will be declining. By 2020, new energy will account for 15% of the region's energy needs.	Shandong Province	Decrease total coal consumption by 20 million tons by 2017 (compared to 2012 levels). Coal will account for 60% or less of total energy needs.
Chongqing Province	Cap coal consumption at 53 million tce in 2017. Coal will account for 65% or less of total energy needs.	Guangdong Province	By 2017, the Pearl River Delta will reduce its coal consumption, with coal accounting for 36% or less of total energy needs.
Shanxi Province	Cap coal consumption cap at 210 million tce .	Xinjiang Province	By 2017, Urumqi's city cluster will achieve zero-growth in total coal consumption.
Henan Province	Reduce total coal consumption by 20 million tons by 2017 (compared to 2012 levels). At this time, coal will account for 70% or less of the province's energy needs.	Inner Mongolia Province	By 2015, 85% or more of the cities in Inner Mongolia will be powered by gas.
Hebei Province	Reduce total coal consumption by 40 million tons by 2017 (compared to 2012 levels).	Hunan Province	By 2017, coal will account for 65% or less of the province's energy needs.
Hubei Province	By 2017, coal will account for 60% or less of the province's energy needs.	Fujian Province	By 2015, coal will account for 52.2% or less of the province's energy needs.

Shanghai	By 2017, coal consumption will decrease below the city's 2012 coal consumption amount.	Heilongjiang	By 2015, coal will account for 52.2% or less of the province's energy needs.
City	Coal Cap Goal	City	Coal Cap Goal
Nanjing	Cap coal consumption for the entire city at, or below, 29.14 million tons. Cap coal consumption cap for the entire city at or below 32.11 million tons in 2015. cap coal consumption cap at 30.89 million tons in 2016. In 2015, energy intensity to decrease to 0.5 tce/10,000 RMB. By 2017, 6% of the city's energy needs will be met by new energy and renewable energy resources.	Ningbo	Cap coal consumption at 10.4985 million tons. By 2017, reducing oil consumption below approximately 4.2 million tons, and have 6.3% of the city's energy needs met by natural gas and renewable energy by 2017.
Benxi (Coal Cap Case Study City)	Cap coal consumption at 19.31 million tons. In 2015, cap coal consumption at 18.67 million tons; in 2016, cap coal consumption at 18.98 million tons. The average annual growth rate of natural gas consumption will remain at 15%.	Qingdao	Reduce coal consumption by 1.51 million tons by 2017 (compared to 2016 levels, which is projected to be 3 million tons less than the level of coal consumption in 2012.) By 2016, 10% of the city's energy needs will be met by clean energy resources.
Nantong	Cap coal consumption for the entire city at 21.32 million tons. Power generation from renewable energy sources is expected to exceed 2 million kilowatts.	Chengdu	By 2017, less than 19% of the city's energy needs will be met by coal. In 2015, have 46% of the city's energy needs met by electricity and 16% of the city's energy needs met by natural gas. Reduce the city's reliance on coal by 21%.
Cangzhou	Compared with coal consumption in 2012, there will be a 2 million ton increase in coal consumption by 2017 (this increase is largely due to the relocation of a steel factory to the city). By 2015, achieve a net reduction of 300,000 tons of coal consumed.	Shenyang	Coal consumption will decline; the increase in coal will be less than the reduction of the city's existing coal reserves. Each year, the scale of the city's clean energy and renewable energy sector will increase by 3%.
Changsha	By 2017, coal should account for 30% or less of the city's total energy needs. By 2017, the city of Changsha and its surrounding suburbs will mainly powered by natural gas.	Yinchuan	By 2017, the proportion of coal consumption will be declining. In 2015, the city's clean energy utilization rate will be at or above 70%.

Zhengzhou	By 2020, 60% or less of the city's energy needs will be met by coal. Clean energy and renewable energy resources will meet 20% of the city's energy needs.	Wuhai	By 2017, 85% or more of the city will be powered by gas; electricity produced by biogas will provide 30,000 kilowatts of energy.
Lanzhou	In 2015, the urban center (excluding suburbs) will reduce its household coal consumption by 1.5 million tons. Each year, the city will reduce its industrial coal use by 1 million tons.	Wuhan	In 2017, coal consumption will be at the same level as in 2012. Coal consumption will account for 50% or less of the city's energy needs.
Shenzhen	By 2020, coal consumption is expected to remain at around 5.107 million tons.	Nanchang, Jiujiang	By 2017, coal consumption will be on the decline. 65% or less of the province's energy needs will be met by coal.
Dongguan	By 2015, total coal consumption will be capped at 10% or less.	Xiangtan	By 2017, 65% or less of total energy needs will be met by coal.
Tangshan	Reduce coal consumption by 25.60 million tons by 2017 (compared to 2012 levels).	Langfang	Reduce coal consumption by 4.5 million tons by 2017 (compared to 2012 levels).
Shijiazhuang	Reduce coal consumption by 15 million tons by 2017 (compared to 2012 levels).	Hengshui	Reduce coal consumption by 1 million tons by 2017(compared to 2012 levels).
Qinhuangdao	Reduce coal consumption by 6 million tons by 2017 (compared to 2012 levels).	Jinan	Reduce coal consumption by 1.3 million tons by 2017 (compared to 2012 levels).
Handan	Reduce coal consumption by 16.70 million tons by 2017 (compared to 2012 levels).	Zhuzhou	By 2017, 65% or less of the city's energy needs will come from coal.
Baoding	Reduce coal consumption by 2.5 million tons by 2017 (compared to 2012 levels).	Hefei	The city will take progressive steps to reduce end-use coal consumption.
Xingtai	Reduce coal consumption by 2.5 million tons by 2017 (compared to 2012 levels).	Suzhou	Reduce coal consumption by 2 million tons by 2017 (compared to 2013 levels).
Taiyuan	45% or less of the city's energy needs will be met by coal.		

City	Year of Carbon Emissions Peak	City	Year of Carbon Emissions Peak
Hangzhou	2017	Jingdezhen	2023
Ningbo	2017	Daxing'anling	2024
Wenzhou	2017	Hulunbuir	2025
Zhenjiang	2020	Huan'an	2025
Beijing	2020	Jinchang	2025
Guangzhou	2020	Qinghuangdao	2025
Jiyuan	2020	Shijiazhuang	2025
Nanping	2020	Guiyang	2025
Qingdao	2020	Jilin	2025
Shanghai	2020	Kunming	2027
Suzhou	2020	Chizhou	2028
Wuhan	2022	Yan'an	2029
Shenzhen	2022	ürümqi	2030
Ganzhou	2023	Zunyi	2030
Jincheng	2023	Guangyuan	2030
Guilin	2030		

Appendix 5: The Resource and Environmental Red Line Constraints for Provinces, Cities, and Autonomous Regions in the 13th Fifth Year Plan

Area	$PM_{2.5}$ Concentration Target ($\mu g/m^3$)	Total Water Use (100 million m^3)	Total Coal-Related CO_2 Emissions (100 million tons)
Beijing	49	46.58	0.0728
Tianjin	50	38.00	0.5980
Hebei	53	221.00	3.7941
Shanxi	44	93.00	5.6425
Inner Mongolia	35	211.57	6.5599
Liaoning	45	160.60	2.7582
Jilin	43	165.49	1.8780
Heilongjiang	35	353.34	2.1375
Shanghai	39	129.35	0.7547
Jiangsu	47	524.15	3.8731
Zhejiang	37	244.40	2.3273
Anhui	48	270.84	2.8448
Fujian	30	223.00	1.4476
Jiangxi	38	260.00	1.3084
Shandong	51	276.59	5.5119
Henan	58	282.15	4.4791
Hebei	55	365.91	2.7810
Hunan	51	359.75	2.2403
Guangdong	31	456.04	2.8288
Guangxi	40	309.00	1.4619
Hainan	20	50.30	0.1456
Chongqing	43	97.13	1.1296
Sichuan	42	321.64	2.2973
Guizhou	33	134.39	2.6342
Yunnan	29	214.63	1.7783
Tibet	15	36.89	-
Shaanxi	43	112.92	3.3141
Gansu	42	114.15	1.7989
Qinghai	42	37.95	0.5680
Ningxia	42	73.27	1.9824
Xinjiang	50	515.97	4.0518

Appendix 6: Coal Cap Targets, Energy Intensity Targets, Carbon Intensity Targets, Renewable Energy Quotas, and Renewable Heating Targets for Provinces, Cities and Autonomous Regions in the 13th Fifth Year Plan

Area	Total Coal Consumption Cap Target (million tons of physical coal)	Energy Intensity (%)	Carbon Intensity (%)	Renewable Energy Quota (%)	Renewable Heating (10,000 tce)
Beijing	4.3	19	22	15.8	198.54
Tianjin	32.5	20	22	15.8	133.2
Hebei	221	20	22	13.6	640.19
Shanxi	309.5	15	18.5	13.6	357.98
Inner Mongolia	353.5	18	19.5	14.6	311.58
Liaoning	157.5	19	22	14.6	484.25
Jilin	102	18	20	12.6	272.85
Heilongjiang	115.5	18	19.5	12.6	439.02
Shanghai	42	20	22	15.8	*38.58
Jiangsu	219	20	22	15.8	*111.98
Zhejiang	125.5	19	22	15.8	*82.55
Anhui	155	17	19	13.6	*59.96
Fujian	81.5	18	20	15.8	*35.71
Jiangxi	72.5	18	19	13.6	*57.35
Shandong	322.5	19	22	15.8	1077.08
Henan	246	18	19	13.6	1043.78
Hubei	163.5	18	20	14.6	*67.16
Hunan	127	18	19	14.6	*89.14
Guangdong	160	20	22	15.8	*101.05
Guangxi	81.9	17	18.5	13.6	*34.4
Hainan	7.8	15	18.5	14.6	*5.74
Chongqing	62	19	20	15.8	*35.04
Sichuan	126	18	19.5	15.8	*79.96
Guizhou	140	17	18.5	13.6	*28.54
Yunnan	99	16	18.5	12.6	*28.21
Tibet	176	5	6	11.4	-
Shaanxi	176	18	20	-	378.45
Ganxu	84	16	18.5	11.4	283.23
Qinghai	26	10	12	11.4	58.05
Ningxia	97	10	12	11.4	60.3
Xinjiang	204	5	6	14.6	245.82

Note: Regions with data marked with a "*" have a unit of "one hundred million kwh."

Appendix 7: Air Pollution Emissions Reduction Targets for Provinces, Cities and Autonomous Regions in the 13th Fifth Year Plan

Area	Sulfur Dioxid	Nitrogen Oxides	Particulate Matter ($PM_{2.5}$)	Ammonia Nitrogen	Volatile Organic Compounds (VOC)
Beijing	0.241	0.221	0.271	0.210	.220
Tianjin	0.169	0.274	0.305	0.190	.210
Hebei	0.267	0.292	0.254	0.200	.200
Shanxi	0.237	0.292	0.237	0.150	.190
Inner Mongolia	0.065	0.099	0.237	0.140	.170
Liaoning	0.2087	0.267	0.237	0.180	.180
Jilin	0.046	0.117	0.237	0.190	.190
Heilongjiang	0.036	0.056	0.224	0.170	.175
Shanghai	0.247	0.315	0.271	0.210	.215
Jiangsu	0.311	0.368	0.254	0.200	.185
Zhejiang	0.259	0.351	0.254	0.190	.170
Anhui	0.119	0.191	0.254	0.180	.165
Fujian	0.119	0.146	0.237	0.160	.170
Jiangxi	0.135	0.124	0.203	0.170	.160
Shandong	0.3123	0.338	0.254	0.195	.205
Henan	0.250	0.309	0.258	0.185	.195
Hubei	0.162	0.14	0.237	0.175	.180
Hunan	0.162	0.176	0.237	0.180	.175
Guangdong	0.289	0.330	0.305	0.195	.215
Guangxi	0.134	0.15	0.203	0.160	.170
Hainan	-0.175	-0.112	0.254	0.205	.160
Chongqing	0.1385	0.135	0.271	0.205	.190
Sichuan	0.189	0.145	0.237	0.190	.180
Guizhou	0.181	0.206	0.254	0.160	.175
Yunnan	0.068	0.099	0.203	0.155	.180
Tibet	0	0	0.136	0.100	-
Shaanxi	0.155	0.193	0.237	0.165	.195
Gansu	-0.02	0.031	0.203	0.140	.160
Qinghai	-0.098	-0.077	0.169	0.135	.150
Ningxia	0.061	0.083	0.237	0.145	.175
Xinjiang	0	0	0.224	0.130	.160

Appendix 8: 293 Cities Classified According to Population Size and Coal Intensity

Number	Category Code	Type of City	Coal Intensity Ranking	Number of Cities	Year When Peak Coal Will Be Reached	List of City Names
I	S	Provincial-Level Municipalities	Low	4	2013-2015	Chongqing, Tianjin, Shanghai, Beijing
2	A-I	Megacities	Low	2I	2013-2015	Nanjing, Jinan, Xi'an, Changchun, Huai'an, Qingyuan, Wuhan, Dalian, Shenyang, Suzhou, Hangzhou, Chengdu, Xiamen, Hefei, Nanning, Dongguan, Foshan, Guangzhou, Shantou, Shenzhen, Zhengzhou
3	A-2	Megacities	Medium	5	2014-2016	Zibo, Anshan, Harbin, Kunming, Xuzhou,
4	A-3	Megacities	High	3	2014-2016	Taiyuan, Tangshan, Urumqi
5	B-I	Large cities	Low	64	2013-2015	Xiangyang, Guigang, Mianyang, Hezhou, Laibin, Liuzhou, Luzhou, Changde, Yichun, Zhenjiang, Zigong, Suining, Huaibei, Huzhou, Baoding, Jingzhou, Fuyang, Yulin, Nanchong, Huainan, Maoming, Bazhong Nanchang, Liangshan Yi Autonomous Prefecture, Jiaxing, Changsha Suizhou, Suzhou, Jinhua, Ningbo, Qingdao, Ziyang, Nantong, Quanzhou, Tianshui, Wuxi, Lu'an, Yantai, Huizhou, Fuzhou, Qinzhou, Wenzhou, Bengbu, Wuhu, Fuzhou, Putian, Bozhou, Changzhou, Jiangmen, Taizhou, Haikou, Lianyungang, Zhongshan, Suqian, Yangzhou, Yancheng, Zhanjiang, Zhuhai, Luohe, Zhuzhou, Yongzhou, Xinyang, Nanyang, Kaifeng
6	B-2	Large cities	Medium	27	2013-2015	Jining, Wuwei, Rizhao, Qiqihar, Shijiazhuang, Guang'an, Linyi, Xining, Liaocheng, Fushun, Baoji, Jinzhou, Leshan, Jilin, Daqing, Ezhou, Yichang, Tai'an, Heze, Weifang, Neijiang, Yiyang, Luoyang, Guiyang, Hengyang, Xinxiang, Zaozhuang
7	B-3	Large cities	High	II	2014-2016	Laiwu, Baotou, Datong, Handan, Yinchuan, Hohhot, Anyang, Chifeng, Lanzhou, , Pingdingshan, Shangqiu
8	C-I	Medium-sized cities	Low	43	2013-2015	Shangluo, Xianning, Hengshui, Yan'an, Songyuan, Nanping, Yibin, Deyang, Chizhou, Dongying, Weihai, Cangzhou, Longnan, Guangyuan, Taizhou, Ji'an, Jiujiang, Shaoxing, Beihai, Fangchenggang, Zhoushan, Yicheng, Guilin, Ganzhou Langfang, Anqing, Lishui, Jieyang, Chuzhou, Zhaoqing, Zhangzhou, Baicheng, Ningde, Yangjiang, Shanwei, Sanya, Zhoukou, Yuxi, Zhangjiajie, Yueyang, Shaoyang, Zhumadian, Puyang, Zhoukou

9	C-2	Medium-sized cities	Medium	37	2014-2015	Pingxiang, Zhangye, Yulin, Qujing, Chenzhou, Hanzhong, Panzhihua, Shuangyashan, Yingkou, Chengde, Siping, Baoshan, Huangshi, Liaoyang, Zhaotong, Xinyu, Binzhou, Jiamusi, Xiangtan, Ankang, Quzhou, Fuxin, Qinhuangdao, Panjin, Dandong, Ma'anshan, Chaoyang, Xianyang, Mudanjiang, Xiaogan, Meishan, Texas, Jiuquan, Shiyan, Jingmen, Suihua, Shaoguan,
10	C-3	Medium-sized cities	High	32	2015-2016	Wuhai, Linfen, Shizuishan, Yuncheng, Liupanshui, Changzhi, Jinzhong, Bayannur, Anshun, Xinzhou, Yangquan, Weinan, Qitaihe, Zunyi, Guyuan, Buyi and Miao Autonomous Prefecture in southwest Guizhou, Zhangjiakou, Yichun, Jiaozuo, Benxi, Pingliang, Baiyin, Shuozhou, Tieling, Hegang, Jixi, Xingtai, Hakusan, Tongliao, Ordos, Tongchuan, Hebi
11	D-1	Small cities	Low	20	2015-2016	Hechi, Dingxi, Huanggang, Chaozhou, Yunfu, Tongling, Longyan, Yingtan, Shangrao, Ya'an, Jingdezhen, Meizhou, Aba Tibetan and Qiang Autonomous Prefecture, Qingyang, Ganzi Tibetan Autonomous Prefecture, Wuzhou, Heyuan, Huangshan, Xuchang, Huaihua
12	D-2	Small cities	Medium	11	2016-2017	Liaoyuan, Jinchang, Huludao, Lijiang, Karamay, Dazhou, Pu'er, Sanming, Chongzuo, Lincang, Heihe,
13	D-3	Small cities	High	16	2016-2017	Wuzhong, Zhongwei, Tongren, Jiayuguan, Luliang, Loudi, Wulanchabu, Jincheng, Miao and Dong Autonomous Prefecture, Tonghua, Hulunbeier, Baise, Qiannan Buyi and Miao Autonomous Prefecture, Sanmenxia, Jiyuan

Note: This report used the coal consumption data from each province's energy balance table in the energy statistical yearbook. This was then multiplied by a coefficient to get a standardized coal consumption share for each province.

Appendix 9: A Comparison of Energy Consumption in Key Sectors and Products in China and Internationally

	China							International Advanced Level
	2000	2005	2010	2011	2012	2013	2014	
Coal Mining, Washing and Selection Total Energy Use kgce/t								
Total Energy Use kgce/t	38.2	32	32.7	32.5	31.8	30.2		
Electricity Use kWh/t	29	25.1	24.0	24.0	23.4	25.8		17.0
Oil and Gas Extraction								
Total Energy Use/kgce/t	208	163	141	132	126	121	125	105
Electricity Use/kWh/t	172	171	121	127	121	103		90
Coal Consumption for Thermal Power Generation /gce/kWh	363	343	312	308	305	302	300	291.5
Coal Consumption for Thermal Power Provision/gce/kWh	392	370	333	329	325	321	318	302.4
Total Energy Use in Iron and Steel Production/kgce/t								
Industry Tota	1475	1020	950	942	940	923	913	
Medium and Large Enterprises	906	760	702	695	694	682	674	
Iron and Steel Comparative Energy Use/kgce/t	784	732	681	675	674	662	654	610
Electrolytic Aluminum Electricity Use/kWh/t	15418	14575	13979	13913	13844	13740	13596	12900
Total energy use in copper smelting/kgce/t	1227	780	500	497	451	436	365	360
Total energy use in cement production/kgce/t	172	149	134	129	127	125	123.6	118
Total energy use in building wall material production Kgce per ten thousand standard bricks	763	478	468	454	449	449		300
Total energy use in building ceramic production /kgce/m^2	8.6	8.0	7.7	7.4	7.3	7.1	7.0	3.4
Total energy use in plate glass production Kgce per case (by box)	25.0	22.7	16.9	16.5	16.0	15.0	7.1	13.0
Total energy use in crude oil refining kgce/t	118	114	100	97	93	94	97	73
Total energy use in ethylene production kgce/t	1125	1073	950	895	893	879	860	629
Total energy use in synthetic ammonia production kgce/t	1699	1700	1587	1568	1552	1532	1540	990
Total energy use in caustic soda production/kgce/t	1439	1297	1006	1060	986	972	949	910
Total energy use in soda ash production/kgce/t	406	396	385	384	376	337	336	310
Energy use in calcium carbide production/kWh/t	3475	3450	3340	3450	3360	3423	3272	3000
Total energy use in paper and cardboard production/kgce/t								
All Industries	912	528	390	380	364	362		
Self-pulping Enterprises	1540	1380	1200	1170	1120	1114		580
Total electricity use in synthetic fiber production/kWh/t	2276	1396	967	951	878	849		800

Note:

1. The energy use of the international advanced level is based on the average energy use of the leading countries of the world.
2. To calculate the energy consumption for the production of Chinese and foreign products, electricity consumption is converted to tons of coal equivalent using a coal power generation conversion factor.
3. The international advanced level energy use value for coal mining and washing is based on the United States. In 2013, 66% of mines in the United States were open-pit mines; in China, 12% of mines were open-pit mines. Open-pit mines use about 1/5 of the electricity consumed in underground coal mines.
4. The international advanced level energy use value for oil and gas exploration comes from estimated energy use values for Royal Dutch Shell and British Petroleum.
5. In China, coal consumption for electricity generation and provision is based on power plants of at least 6 MW in size. The international advanced level energy use standard for electricity generated and provided by thermal coal power plants comes from the average energy use values of Japan's nine largest power companies. In 2010, China's thermal power structure was 94.3% coal, 0.5% was oil, and 2.3% gas. Japan's thermal power structure was 38.0% coal, 14.0% oil, and 43.4% gas.
6. In China, the comparison values for energy use in steel production are based on medium and large enterprises, which represented 80.5% of the country's steel production in 2014. The international advanced level energy use standard is based on Japan.
7. Calculations for total energy used in cement production are based on cement clinker production heat consumption and the total electricity used in cement production, with the electricity converted to tons of standard coal equivalent using a coal power generation conversion factor. The international advanced level energy use standard is based on Japan. In 2010, the energy used for cement clinker production was 115 kgce/t in China, compared to 96 kgce/t in Japan. The total electricity use for cement clinker production was 89 kWh/t in China, and 78 kWh/t in Japan.
8. The international advanced level energy use standard for total energy used in building wall material production is based on the United States.
9. In China, the primary raw material used in ethylene production is naptha. The international advanced level energy use standard is based on the Middle East region. The primary raw material used in ethylene production is ethane.
10. The total energy used in caustic soda production is the weighted average of the energy used in the diaphragm and membrane production methods.
11. The total energy used in synthetic ammonia production in China is based on the average amount of coal, petroleum, and natural gas used as a raw material in large, medium, and small-sized enterprises. In 2012, 76% of all synthetic ammonia was produced from coal in China, while 22% of synthetic ammonia was produced from natural gas. The international advanced level energy use standard is based on the United States, where 98% of synthetic ammonia is produced from natural-gas generated power.
12. The total energy use for building ceramic, caustic soda, paper and cardboard production in 2013 are based on estimated values.

Sources:National Bureau of Statistics; Ministry of Industry and Information Technology; China Coal Industry Association; China Electricity Council; China Iron and Steel Association; China Non-Ferrous Metals Industry Association; China Building Materials Industry Association; China Building Ceramic Industry Association; China Chemical Energy Conservation Technology Association; China Petroleum Planning & Engineering Institute; China Technical Association of Paper Industry; China Chemical Fiber Association; the Institute of Energy Economics, Japan - IEEJ, Handbook of Energy & Economic Statistics in Japan (2014 Edition); the Iron and Steel Institute of Japan; Korea Iron & Steel Association; Japan Cement Association; Japan Society of Energy and Resources; IEA, Energy Statistics of OECD Countries.

Appendix IO: Total Coal Consumption Cap Performance Evaluation Index

Segment (Points Allocated)	Category Number (Points Allocated)	Individual Category Name	Sub-category Name	Points
Coal Utilization (62)	I (8)	Adjustments to and Optimization of the Coal Industry	Resolution of Coal Industry Production Overcapacity and Level of Industry Concentration	
			Phase-Out Outdated Coal Production Capacity and Relocation of Heavy Polluting Enterprises for Environmental Protection Reasons	
			Share of Tertiary Industry	
			Growth of New Industries	
	2 (7)	Eco-Production and Clean Production	Product Quality Improvement	
			Ratio of Production Methods Adhering to Eco-Production Standards	
			Steel, Cement, Ceramic, Glass, Tiles and Bricks	
			Clean Production Rating	
	3 (I5)	Completion of Mandatory Indicators	Coal Cap Target	
			Development and Implementation of Coal Cap Plan	
			Energy Intensity Reduction Target	
			Coal Reduction Target	
			Electricity Use Reduction Target	
			Water Use Reduction Target	
			Total Carbon Emissions and Carbon Intensity	
	4 (8)	Addressing Small Coal-Fired Boilers and Bulk Coal Utilization	Phase-Out of Small Coal-Fired Boilers	
			Introduction of New High-Efficiency Coal-Fired Boilers	
			Combined Heat and Power in Industrial Parks	
	5 (3)	Alternative Energy	Natural Gas Utilization Growth Rate	
			Substitution of Electricity for Coal	
	6 (I5)	Air Pollution Control	Reduction in Total Particulate Matter Emissions	
			Reduction in Total SO_2 Emissions	
			Reduction in Total NO_x Emissions	
			Reduction in Total NH Emissions	
			Reduction of Industrial Volatile Organic Compounds	
			Reduction of Ammonia (in fertilizer)	
			COD (Chemical Oxygen Demand) Compliance Rate	
			Real-Time $PM_{2.5}$ Measurements	

	7(3)	Buildings	Total Building Area Control	
			Percentage Share of Combined Heat and Power and District Heating Area	
			Self-Heating Area	
			Proportion of Renewable Energy Utilization	
	8 (3)	Power	Coal Storage Area Environmental Management and Coal Ash Treatment	
			Reduction in Coal Consumed Per Unit Electricity	
			Fly Ash and Wastewater Treatment	
Transport and Storage (3)	1 (1)	Transport	Coal Dust Management	
	2 (2)	Coal Storage Sites	Coal Storage Site Environmental and Dust Management	
Mining and Development (35)	1(5)	Eco-Mining	Coal Recovery Rate	
			Coal Gangue Backfilling	
	2 (10)	Ecological and Environmental Protection	Coal Gangue Pile Treatment and Comprehensive Utilization	
			Coal Mining and Washing Wastewater Treatment Rate	
			Mining Well Water Utilization Rate	
			Area of Soil Erosion	
			Land Subsidence Remediation (Land Collapse)	
			Ecological Restoration	
	3 (10)	Occupational Safety	Mine Gas Collection and Utilization Rate	
			Mine Safety Equipment and Accident Prevention Level	
			Purchase of Miners' Safety Insurance	
			Decrease in Rate of Miners' Deaths	
			Reduction in Coal Worker's Pneumoconiosis (Black Lung Disease)	
	4 (10)	Coal Management	Total Coal Production Cap Target	
			Increase in Labor Productivity	
			Coal Processing Labor Rate	
			Amount of Coal Blending	
			Implementation and Inspection of Coal Mining Rules and Regulations	
			Relationship with the Local Community	
Total 100	(100)	Each Individual Category Evaluation Score	Each sub-category's completeness evaluation and areas for improvement	Evaluation