# CHINA COAL CONSUMPTION CAP PLAN AND RESEARCH REPORT:

## *Recommendations for the 13th Five-Year Plan*

## EXECUTIVE SUMMARY

## 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, accounting for nearly half of the world's total annual coal consumption. 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 response to climate change and air pollution, the China Coal 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 Action Plan") and the ***Energy Development Strategy Action Plan (2014-2020)*** ("Strategy Action Plan"). The "Air 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." Close to 21 provinces and autonomous regions and more than 30 cities have set different targets for coal consumption reduction. With this foundation, China must design and implement coal consumption caps at the national and local levels, as well as in coal-intensive sectors.

The China Coal Cap Project ("China Coal Consumption Cap Plan and Policy Research Project") has conducted research on environmental and red line restrictions, analyzed and researched 13$^{th}$ Five Year coal cap targets, and assisted in transitioning the energy sector in order to provide policy-makers with advice and suggestions for a 13$^{th}$ Five Year coal cap plan.

# 1 THE GOAL OF 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 nitric oxide, 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 haze 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 620,000 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. The death rate per one million tons of mined coal is relatively high, and lung disease from coal dust accounts for over 50% of all professional illness.

As estimated by the 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 was 303 RMB per ton in 2012, while the loss and damage from $CO_2$ emissions from coal were estimated at 160 yuan/ton, for a total cost of 463 RMB/ton. In 2012, total coal production and consumption reached 3.51 and 4.12 billion tons respectively, with total external costs up to 1.8688 trillion yuan, making up 3.7% of GDP that year (see Appendix 1). Controlling coal consumption can promote the sustainable development of the coal industry, with green, safe, and efficient coal production capacity reaching 74% of total coal output. Increasing the scientific production capacity of the coal industry can substantially reduce environmental damage, mining deaths, and threats to workers' health.

The goal of the coal consumption cap plan is to adhere to red-line restrictions 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 clean up of coal utilization, adopt both market mechanisms and government policies to achieve coal consumption cap targets during the 13th Five-Year Plan period, and place priority on adopting a plan that incorporates coordinated management and control in an effort to achieve multiple targets connected to environmental protection, safeguarding the public's health, conserving energy and resources, and controlling the temperature rise from climate change. Through the coal cap, the chare of coal in energy consumption will decrease from the current 66% to below 58% by 2020, protecting the environment and conserving resouces efficiently and at low cost.

# 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 face 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 concept for governing and administrating China, put emphasis on human-oriented practices, and advance the "four comprehensives" strategy. The 13th Five-Year Plan period will focus on the central tasks of "building a well-off society in an holistic manner." The economic development of China has entered a "new normal," providing a valuable strategic opportunity for comprehensive reform 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 a low-carbon, green, and circular economy as an important goal in the ongoing push to modernize, significantly decrease the environmental footprint of China's energy use, make a series of top-level designs and overall 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, environment-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 safe, green, efficient, and low-carbon development. It is a critical measure for resource conservation efforts, and other development goals, from transitioning the economic structure to 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 discharge 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 SETTING THE 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 purpose of the coal consumption cap.

## 3.1 ECOLOGICAL RED-LINE RESTRICTION PRINCIPLE

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 efforts made to improve it. 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 on the national, regional, provincial (city, autonomous regions) and municipality level must meet the restrictive conditions at different levels. These restrictive conditions not only different trends in their timing, but also display different characteristics 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 red-line standards in the areas where the enterprises are located. Under the restriction of various ecological red lines, the most powerful restriction is the bottom line for setting the target, i.e., applying the most restrictive limitation to determine policy.

## 3.2 INTEGRATION OF THE COAL CAP MODELS

The scheme for setting coal consumption cap targets adopts the top-down macro-economic model, the bottom-up regional differentiation model, and the sectoral analysis model. After adjusting and integrating the models multiple times, a scenario analysis with several unique advantages was developed. This analysis was effective under a range of restrictive red-line conditions and solved the previous problem of meeting multiple red-line restrictions using a conventional scenario analysis model. This new solution is the integrated model, shown graphically in Figure 1.

Figure I: Methodology for Setting Coal Cap Targets


# 4 ANALYSIS OF 2020 COAL DEMAND

In order to clearly illustrate the situation for coal demand in 2020, the Coal Cap Project analyzed 2015-2050 energy and coal demand. Table 2 shows coal demand for the reference, energy-saving, and 2°C scenarios. In the energy-saving and 2°C scenarios, coal peaks in 2014 at 2.812 billion tons of standard coal and consequently begins to decrease. The coal cap scenario follows the energy-saving scenario line up to 2030 and is able to satisfy each ecological red line restriction. After 2030, as a result of climate change's strict 2°C ceiling for temperature rise, the coal cap adopts stricter restrictions, decreasing to met the 2°C scenario line. The space for coal demand becomes more compressed, reaching a level of 2-3 tons of per capita $CO_2$ emissions by 2050.

For the coal demand analysis, determining the 2020 environmental, ecological, and resource-driven red line restrictions is the first priority (see Table 1).

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

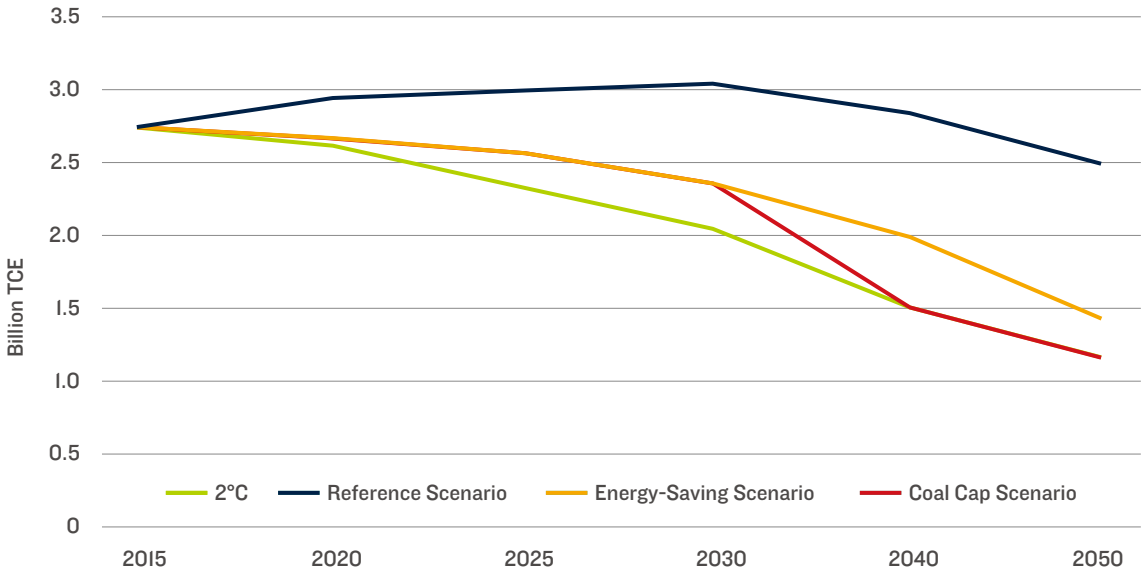



Table I: Environmental, Ecological, and Resource-driven Red Line Restrictions for Coal Demand

| | Environmental Restrictions | Restriction on Coal Demand |
|---|---|---|
| $CO_2$ emissions | With reference to a high carbon intensity pathway:<br>Decrease carbon emission intensity by 48%-50% by 2020<br>Peak carbon emissions before 2025 | 4 billion tons or less in 2020<br>3.6 billion tons or less in 2025 |
| Air Quality | Average $PM_{2.5}$ emissions should be around 45 μg/$m^3$ by 2020 and 35 μg/$m^3$ by 2025 | 3.9 billion tons or less in 2020<br>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 pollution was about 700,000 people.<br><br>By 2020, this number should be reduced significantly | Coal and air quality restrictions<br><br>Under the coal cap scenario, permature deaths will fall to 590,000 |

Based on the progress of efforts in emission reduction, the trends in coal demand, and 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 $\mu g/m^3$, and the number of level two blue sky days more than 85%. 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 $\mu g/m^3$. According to the restriction 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 relatively severe. In 2020, water use from coal mining and consumption should be limited to no more than 74.7 billion cubic meters, which means that coal consumption cannot exceed 3.8 billion tons. In 2030, quotas for water consumption will have become even stricter, a result of the need to closely maintain a balance with existing water resources.

China's economic and energy development situation in 2020 is shown in Appendix 2. The coal cap macroeconomic model parameters are as follows: a GDP growth rate of 7%, urbanization level of 61%, and population of 1.36 billion. In the GDP, tertiary and secondary industry accounts for 54% and 39% of the economy, respectively. In stimulating GDP growth, the consumption rate is 56.9%, the investment rate is 42.1%, and the export rate is 22.6% (net export 1%). Energy-intensive industries account for 31.6% of the economy, and the growth rate of energy demand is between 2 and 2.5%. In this scenario, natural gas and renewable energy grow rapidly, oil rises slowly, and coal consumption is in a period of gradual decline.

By 2020, the coal consumption scenario analysis shows that the coal cap targets in 2020 will be 2.72 billion tons of standard coal (3.8 billion tons of coal), meeting the carbon emissions restriction from climate change (4 billion ton of coal), air quality restriction of approximately 45$\mu g/m^3$ (3.9 billion tons of coal), water resource restriction (3.8 billion tons of coal) and land restriction (no coal exploitation and utilization in prohibited areas). The baseline, energy-saving, and 2°C scenarios are shown in Table 2.

In the coal cap (energy saving) scenario, the consumption of coal, oil, natural gas and non-fossil energy in 2020 will account for 57.3%, 17.4%, 10.1% and 15.2% of total energy consumption respectively. Compared with the reference scenario, the proportion of coal and natural gas change greatly: coal consumption will reduce by 300 million tons of standard coal, and natural gas consumption will reduce by 79 million tons of standard coal. The energy structure of the coal cap scenario will tend to be more low carbon, and $CO_2$ emissions will reach 9.6 billion tons. If the $CO_2$ emissions caused by coal is restricted to 7.5 billion tons in 2020, then it will be possible for energy intensity and carbon intensity to drop by more than 18% and 20% based on 2015 levels. Compared to the 2°C scenario, the coal cap scenario has coal demand that is 50 million tons of standard coal higher. However, a coal cap can push carbon emissions to peak a few years before 2025. As climate restrictions become stricter, the coal cap scenario follows the the 2°C scenario after 2030.

The bottom-up regional coal consumption scenario analysis meets various environmental and water resource red-line restrictions in different regions, considers the technological progress and cost of coal consumption and emission reduction of various pollutants, and sets coal cap targets for various regions. This model has solved the

problem of regional differentiation and provided a foundation for investment, decision-making, and the development of a carbon and emissions trading market.

In the coal scenario analysis by sector, the coal consumption in steel, cement and other energy-intensive industries will reach their peak in 2015-2016. The manufacturing industry in China will still keep production capacity at a certain scale. Coal consumption in the building and electricity sectors will peak by 2020, with the installed capacity of coal power peaking at 970 GW. Future coal demand in the coal chemical industry future has a uncertainty.

Based on this analysis, the coal cap plan during the 13th Five Year Plan will use an 18% energy intensity reduction target and a 20% carbon intensity reduction target. During the 13th Five Year Plan, China will establish a national carbon trading market, with an absolute $CO_2$ emissions cap allocated to provinces and sectors. Coal is the largest contributor to $CO_2$ emissions, and the six 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 sector. China's energy and carbon saving targest have already been implemented for many years, accumulating plentiful experience. During the 13th Five Year Plan period, energy savings should reach 700 million tons standard coal, reducing $CO_2$ emissions by 1.8 billion tons.

Table 2: Coal Demand Scenario Analysis in 2020

| Scenario | Reference | Coal Cap (Energy-Saving) | 2°C Scenario |
|---|---|---|---|
| Coal (billion tons standard coal) | 3.02 | 2.72 | 2.68 |
| Oil (billion tons standard coal) | 0.88 | 0.825 | 0.81 |
| Natural gas (billion tons standard coal) | 0.34 | 0.479 | 0.54 |
| Non-fossil (billion tons standard coal) | 0.71 | 0.72 | 0.78 |
| Total energies (billion tons standard coal) | 5.01 | 4.74 | 4.81 |
| $CO_2$ emission (billion tons) | 10.32 | 9.52 | 9.4 |
| GDP (trillion, 2010 RMB) | 84 | 84 | 84 |
| Energy consumption of unit GDP (ton standard coal/10,000 RMB) | 0.60 | 0.573 | .553 |
| Reduction of energy consumption (%) | 16.9 | 21.3 | 19.9 |
| Proportion of coal (%) | 63 | 57.4 | 55.7 |
| Proportion of non-fossil fuel energy (%) | 14.2 | 15.2 | 16.1 |

# 5 NATIONAL COAL CAP, TASKS AND IMPLEMENTATION PATHWAY

The national coal cap target is established according to environmental, ecological, and resource-driven red-line restrictions, as well as analysis of coal demand. A coal cap is a mandatory target that corresponds to ecological red lines and targets for energy intensity, carbon intensity, and renewable energy. This analysis clarifies the coal cap's key tasks and implementation pathways. China can achieve the national coal cap target through reduction, clean utilization and replacement of coal, and use of coal consumption and production dual controls.

## 5.1 TARGETS

| | |
|---|---|
| National cap target: | 2.72 billion tons of standard coal (3.8 billion tons of physical quantity) |
| Total energy consumption: | 4.74 billion tons of standard coal |
| Coal's share of primary energy consumption: | 57.4% |
| Natural gas share: | 10% |
| Non-fossil energy share: | 15.2% |
| Oil share: | 17.4% |
| Coal reduction target: | 300 million tons of standard coal (420 million tons of coal) |
| Coal production cap target: | 3.7 billion tons |

## 5.2 MAIN TASKS

(1) Strive to make adjustments to the economy, industry and products. Adjust the policies governing exports of energy-intensive industries, and resolve overcapacity issues.

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

(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 sectoral coal cap plan. The manufacturing industry

includes iron and steel, cement, building materials, the chemical industry, and the coal chemical industry.

(4) Implement a 3.7 billion tons of standard coal production cap.

(5) Based on the 12th Five Year Plan, strengthen and promote the establishment of an ecological civilization. Establish co-control, co-management and coordinated plans to achieve those caps. A comparison of the key energy and environmental targets in the 12th and 13th Five Year Plans is shows in Appendix 3.

(6) Propose a safeguard plan for the coal cap that includes reforms in the energy system, technology, supply, and demand. Outline market mechanisms and measures, and establish an low-carbon international energy regulatory agency appropropriate for a coal cap.

## 5.3 IMPLEMENTATION PATHWAY

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 pathway for coal reduction has three components: reducing coal use, coal utilization of coal, and replacing coal in the energy mix. A coal production cap can also help a coal cap achieve its desired outcome.

### 5.3.1 COAL REDUCTION AND EFFICIENT UTILIZATION

**Coal reduction target: 218.25 million tons of standard coal, 72.9% of total coal reductions**

**Coordinated targets:**

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

Carbon intensity (carbon intensity per unit of GDP) is reduced by 20% over 2015 levels

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

Total $CO_2$ emissions from coal consumption: 7.5 billion tons

**Other resource indexes:**

Total national water resources: 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%

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

Forest coverage rate: 24%

Forest coverage area increases by 40 million hectares over 2005

Forest stock increases by 3 billion cubic meters over 2005

Remediance of coal mining-related subsidence: 85%

There are two primary aspects of coal reduction. One is high-efficiency use and raising the utilization rate of existing equipment. A second aspect is indirect energy savings, such as those achieved through a more effective arrangement of industry and the economy, shutting down outdated production capacity, solving overcapacity issues, concentrating manufacturing enterprises, greening manufacturing, etc. Our analysis indicates that a more efficient use of coal can reduce coal consumption by 102 million tons of standard coal, 39.3% of potential coal reductions. Indirect energy savings can reduce consumption by 108.4 million tons of standard coal, 60.7% of potential energy savings. Contributions from indirect coal reduction are about 20% higher than those from more efficient use of coal. Reducing coal use 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 tons of coal equivalent, 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 SO2 over 2015 levels: | 17% |
| Decrease of NOx over 2015 levels: | 21% |
| Decrease of particulate matter over 2015 levels: | 25% |
| Decrease of volatile organic compound (VOC) over 2015 levels: | 18% |
| Decrease of ammonia nitrogen over 2015 levels: | 16% |

Clean coal technology targets:

| | |
|---|---|
| Raw coal washing and selection rate: | 80% |
| Establish a regional coal blending center | |
| Rate of coal mine gas collection: | 65% |
| Rate of coal mine gas utilization: | 60% |
| Fly ash utilization rate: | 75% |
| Substantially increase the re-filling rate for coal gangue | |

The total emission reduction system is an important means to promote the improvement of environmental quality. The various emission reduction indices of the 13th Five-Year Plan period will double those of the 12th Five-Year Plan period. The starting point for total emission

reductions targets for newly-added particulate matter, volatile organic compounds (VOC) and ammonia nitrogen is high, set at 25%, 18% and 16%, respectively. The emission reduction potential of five different air pollutants in the 13th Five Year Plan are shown in Table 3. On January 1, 2015, the most rigorous environmental protection law in China's history came into force. The Air Pollution Action Plan has been implemented very quickly. The Law on Prevention of Air Pollution was amended and will be implemented on January 1, 2016. The supporting policies and measures are focused, and the public is active about participating in prevention and control of atmospheric pollution. These factors push forward the clean utilization of coal.

Table 3: Reduction targets and emission reduction potential 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 | 24 | 16 | 18 |
| 2020 Reduction Amount (thousand tons) (based on 2015 levels) | 3,280 | 4,230 | 2,560 | 1,450 | 3,940 |

Efforts will be made to strengthen coordination in controlling multiple pollutants and to promote the application of clean coal technology. The raw coal washing rate will reach 70% in 2017 and 80% in 2020. Coal quality processing should be expanded. 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 would 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. These measures can increases coal's overall utilization rate by 5%. With coal production at 3.7 billion tons in 2020, the above clean coal technologies will reduce coal consumption by 29.6 million tons of standard coal, 9.9% of potential coal reductions. This will also decrease $SO_2$ emissions by 3.8 million tons.

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 limits for 25 key sectors, formulated according to the requirements of the Air Pollution Action Plan, has been finished. The emission standards for air pollutants have also been basically completed. Efforts shall be made to improve the environmental regulatory system, establish an environmental protection management system for all pollutants, establish and improve an emissions permit system, and ban emissions without a permit and excessive emissions in excess of total emission control limits.

## 5.3.3 COAL REPLACEMENT

**Coal reduction target: 51.85 million tons of standard coal, representing 17.3% of potential reductions**

**Replacement targets:**

Consumption of natural gas: 468 million tons of standard coal (360 billion cubic meters)

Including coal mine gas extraction rate of 65%

Coal mine gas utilization rate of 60%

Consumption of renewable energy: 720 million tons of standard coal

Electricity used in place of coal: 80 TWh/year

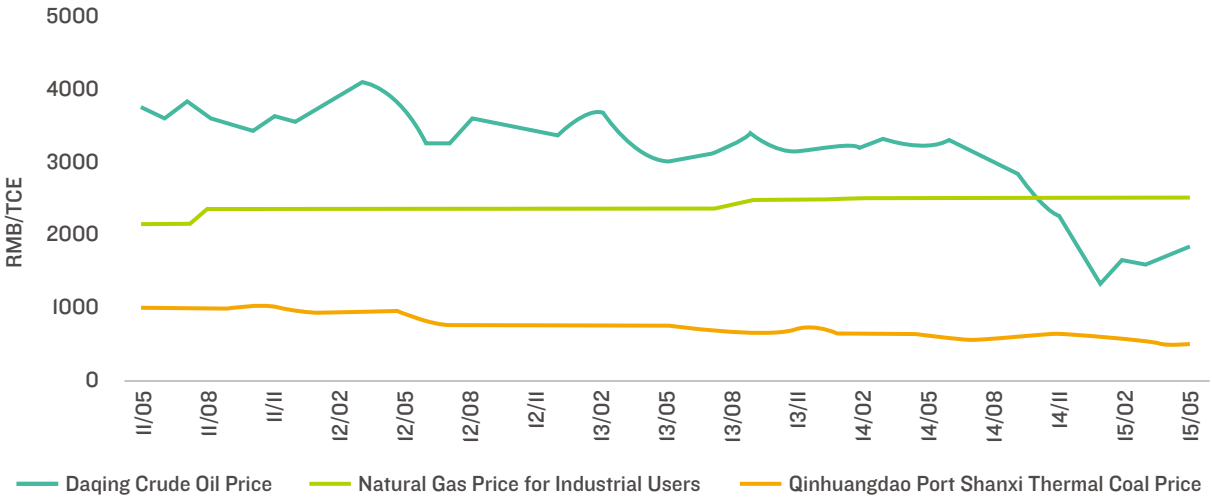
In terms of alternative energy, the goal of producing 15% of primary energy from non-fossil fuel sources is a set target that must be accomplished. During the 13th Five-Year Plan period, renewable energy should account for 37.5% of total installed capacity and account for 26.9% of total power generation. 15% of all building heating should be accomplished through renewable energy. The government should establish a renewable energy generation quota for each province, and building renewable energy heating should be set according to each local area.

Replacing coal with electricity will become more widespread. In large cities and megacities, due to air quality requirements, only electricity or natural gas can be used in central areas or in areas where coal is banned. During the 13th Five-Year Plan period, the State Grid Corporation's investment in alternative energy will reach 65 billion yuan in an effort to achieve 75 TWh of alternative electricity. Besides the State Grid Corporation, other programs replacing coal with electricity will total 10-15 TWh. The total installed capacity of alternative energy to replace coal-fired power is about 6.7 GW; utilization hours for alternative energy sources can also be increased.

At this time, natural gas is the most realistic choice to replace coal. If other conditions remain unchanged, by adopting the world's average energy consumption structure, China's energy system efficiency in 2020 would reach 38.5%, an increase of 2.4 percentage points over the 36.1% energy system efficiency in 2012. 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 will reach 360 billion cubic meters, making up 10% of total energy consumption, an increase of 4.3 percentage points. From the perspective of gas supply, the supply of the 360 billion cubic meters of natural gas resources is assured.

The key obstacle to natural gas replacing coal is price. As shown in Figure 3, the price of oil with the same thermal value drops more rapidly than that of coal, but 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 natural gas demand market is not improved, 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 coal substitute.

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




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 tons of standard coal; 2) Other sectors will use natural gas to replace 15.65 million tons of standard coal

## 5.4 IMPLEMENTING SCIENTIFIC COAL PRODUCTION CAPACITY AND A COAL PRODUCTION CAP

Coal production cap target: 3.7 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, including 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 total of 3.387 billion tons (Table 5).

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 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 |

**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:

*Increase the concentration of 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 3 billion tons of coal per year, 70% of total production. Small-scale coal mines with less than 300,000 production capacity should have a collective production capacity of 300 million tons per year, 7% of national production capacity.. Through mergers and 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:* The rate of raw coal selection should be over 80%, with coal selection mandatory. Scientific production capacity at coal mines should have a raw coal selection rate 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 occupational death rate in coal mining (deaths per 1 million tons mined) to 0.15%. Scientific production capacity would further decrease the death rate to 0.1%, as well as reducing the death rate from occupational pneumoconiosis to 0.2%.

*Increase the comprehensive utilization rate of coal and decrease environmental and ecological damage:* The utilization rate of coal gangue should be more than 75%; the rate of remediation for land subsidence from coal mines should reach higher than 80%. Coal gangue and open-pit mining refuse discharge fields remediation rates should reach 90% or more. 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 is used) and 20 billion cubic meters of gas collected from underground mines (which should have a utilization rate of 60% or more). Scientific production capacity can increase the utilization rate of coal waste to 80% or higher, the utilization rate of coalbed methane (coal mine gas) to 65% or more, the rate of remediated land subsidence areas to 85% or more, and the rates for coal gangue and open-pit discharge fields remediation to 95% or more.

## 5.5 CO-BENEFITS OF THE 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, air pollution reduction at the source, 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 (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, 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.

The coal cap will create around 1.86 million new positions in the energy saving and green power sector. The coal mining industry, due 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 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 the downward trend in job creation will reverse itself. Overall, the coal cap will have no 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 water flooding (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 | | Source Reduction | End-of-pipe reduction | |
| | $SO_2$ emission reductions (million tons) | 5.59 | 3.28 | 8.87 |
| | NOx emission reductions (million tons) | 1.92 | 4.23 | 6.15 |
| | Particulate emission reductions (million tons) | 0.9 | 2.56 | 3.46 |
| Public Health | Reduction in premature deaths (1000 persons) | | | 71 |
| | Reduction in mining deaths (persons) | | | 32 |
| | Reduction in occupational pneumoconiosis (cases) | | | 844 |
| Energy System Transition | Increase in investment (billion yuan) | | | -1.55 |
| | Reduction in system costs (billion yuan) | | | 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 | GHG reductions (million tons) | | | 980 |

# 6 LOCAL COAL CAPS

With the province as the key player, China should establish local coal caps based on environmental, ecological, and resource-driven at three levels: regional, provincial, and city level. At the regional level, environmental, ecological, and resource-driven red-line restrictions establish a better production arrangement – particularly for electricity generators, steel factories, cement factories, and highly polluting industries – that will come from coal-saving and emission reduction regulations. 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 20 provinces and 30 cities have established local coal cap plans based on the Air Pollution Action Plan (see Appendix 4). A 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 Province, City, and Autonomous Prefecture

| 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. The 429.8 million tons saved based on local statistics and the 420 million tons (300 million tons standard coal) saved based on national statistics are basically the same.

## 6.2 MAIN TASKS

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

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

(3) Allocate the national energy intensity and carbon intensity targets to the provincial level. Establish provincial-level renewable energy quotas and renewable energy heating 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 characteristics of the three red lines (environmental, ecological, and resource-driven). Establish effective regional, provincial, and city-level coal cap measures.

(6) For coal caps at the regional, provincial and municipal levels, establish a three-level joint prevention and control mechanism, which will emphasize key points, implementation, and practical result.

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

## 6.3 IMPLEMENTATION PATHWAY

### 6.3.1 FOCUS ON A COAL CAP PLAN THAT TAKES INTO ACCOUNT ENVIRONMENTAL, ECOLOGICAL, AND RESOURCE-DRIVEN RED LINE RESTRICTIONS IN KEY REGIONS

#### (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 regional joint prevention and control of air quality. According to the national $PM_{2.5}$ annual average concentration target goal (45μg/$m^3$ 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, water resource and coal cap targets

| Region | Air quality targets (μg/m$^3$) | | Total water consumption red line (billion cubic meters) | Coal cap (million tons) |
|---|---|---|---|---|
| | 2013 | 2020 | 2020 | 2020 |
| Beijing, Tianjin, Hebei | 106 | 50 (-55%) | 30.6 | 290.9 |
| Shanxi, Henan, Shandong, Hubei, Anhui | 86 | 47 (-45%) | 128.8 | 1,348.3 |
| Yangtze River Delta | 67 | 40 (-40%) | 89.8 | 435.7 |
| Sichuan, Chongqing, Guizhou | 67 | 43 (-36%) | 55.3 | 372.1 |
| Pearl River Delta | 47 | 35 (-26%) | 45.6 | 178.8 |
| National | 73 | 45 (-38%) | 670.0 | 4,648.5 |

In 2020, the total for provincial coal caps targets will be 4.65 billion tons of coal, corresponding to a national target of 3.8 billion tons.[1] The coal cap target in the Beijing, Tianjin and Hebei region in 2020 will be a reduction of over 130 million tons over 2012 and that in the Yangtze River Delta will be a reduction of over 39 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 be worsened, other regions will make greater efforts in 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 attention, especially the shortage of water in Beijing, Tianjin, Hebei, Shanxi, Shandong, Henan, Shanghai, and Jiangsu. Industries must determine their production based on water resource availability, and the municipalities and the agricultural sector should pay special attention to water use efficiency.

By 2020, Henan and Shanxi province around Jing-Jin-Ji will add new coal-fired power capacity of 19.34 GW, with total installed coal-fired power generating units in the region capped at 298 GW. The newly added coal-fired power generating units in Anhui and Zhejiang around the Yangtze River Delta will reach 28.71 GW with installed 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 will reach 26.28 GW, with the main additions in Guizhou and Hubei; here installed coal-fired power generating units will be capped at 128 GW. The newly added coal-fired power generating units in the Pearl River Delta and surrounding regions will reach 1 GW. No new coal-fired power plants will be built in the Pearl River Delta, with installed coal-fired power generating units capped at 60 GW.

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 provnicial coal consumption data in national statistical yearbooks is taken as the basis to reach the combined local coal cap target of 4.65 billion tons of coal by 2020, equivalent to a national coal cap target of 3.8 billion tons.

The existing production capacity of crude steel in the Jing-Jin-Ji region is around 370 million tons. Hebei Province has targeted a reduction of 60 million tons. The Yangtze River Delta will relocate part of its production capacity and manufacturers to the southern coastal area. Before 2020, Sichuan and Guizhou are expected to launch some new iron and steel projects, but they will eliminate out-dated production capacity in advance. In 2020, the cement clinker output in the Jing-Jin-Ji region is expected to reach 65 million tons, keeping output in 2014 relatively stable.

A three-level joint prevention mechanism needs to be established, encompassing the regional, provincial and municipality levels and emphasizing key points, implementation, and practical results. In respect to air pollution and water pollution caps, joint prevention and control across different regions is a sound measure and 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 way to achieve the most cost-effective results. In the last few years, both central and local governments have made great efforts in air pollution control in the "three regions" (Jing-Jin-Ji, the Yangtze River Delta, and the Pearl River Delta) and achieved some 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 setting up a coordinating office to coordinate the air pollution prevention and control of this large area.

The coal consumption for winter heating in the north is obviously 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 heating, and adopt gas-fired and electric boilers for heat and hot water supply. For those areas in which centralized heating cannot be achieved, low-cost alternatives can be chosen. The cities in which conditions permit can 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 10% and sulfur content higher than 1% in cities; 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 utilization of various alternative energies such as distributed solar energy and methane, 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 cities in this region is serious, and water resources are an important ecological red-line restriction for its development.

The development of the coal industry in the northwestern region is being accelerated. This new expansion has reached 650 million tons/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 has exceeded 60% 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 exceeded the red line restriction for 2015. In the Xinjiang base, there is a certain margin between total water use for coal consumption and the red-line restriction, but a serious water shortage in the coal base still exists. The size of 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 that will be advanced in the future. Quite a few coal chemical industry projects feature large coal consumption, more 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 forecast to grow by 68% by 2020 over 2012 levels.

Table 10 shows the restrictions and coal cap targets for water resource conservation and air quality in the northwestern region. The water consumption red line in 2020 is much lower than water resources in 2012. By 2020, the air quality in the region should also be better than the national level in 2012. Coal consumption is subject to serious restrictions by water resource. The 2020 coal cap target is 1.066 billion tons, a reduction of 22% over the original coal demand.

Table 10: Water use redline, air quality targets and and coal cap targets in the northwestern region in 2020

| Province/Municipality | Water use red line (billion cubic meters) | Water use red line (billion cubic meters) | Coal Cap (million tons) |
|---|---|---|---|
| Coal Cap (million tons) | 21.2 | 38 | 399.4 |
| Shaanxi | 11.3 | 47 | 200 |
| Gansu | 11.4 | 38 | 95.2 |
| Qinghai | 3.8 | 40 | 31.8 |
| Ningxia | 7.3 | 38 | 110.8 |
| Xinjiang | 51.6 | 38 | 229 |
| Total | 106.6 | Average 40 | 1,066.2 |

### 6.3.2 PROVINCIAL-LEVEL COAL CAPS BASED ON ECOLOGICAL PROTECTION

China should establish provincial-level coal cap plans in 30 provinces. The governments of provinces, municipalities and autonomous regions should formulate integrated provincial-level coal control planning considering regional differences. The coal caps at sub-national levels shall meet local resource, environment, and ecological red line constraints, and governments should formulate provincial-level targets for coal reduction, clean use and fuel switching.

#### (1) Establish provincial resource, environment, and ecological red line constraints

Provincial, municipal and autonomous region governments should map out ecological function areas, economy and urban development plans in strict accordance with the region's key functions and land planning requirements. The Coal Cap Project has established $PM_{2.5}$ control targets for 30 provinces, municipalities and autonomous regions across the country (see Appendix 5), based on the existing provincial $PM_{2.5}$ emission concentration, the nation's and major areas' $PM_{2.5}$ emission targets, as well as the coal control targets for 2020. Among these targets, the $PM_{2.5}$ concentration in Beijing, Tianjin, Hebei and surrounding Shandong, Henan, and Shanxi provinces needs to have the biggest reduction by 2020. That of the Yangtze River Delta, Sichuan, Chongqing, Guizhou and the three northeastern provinces needs 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.

Issued by the State Council, the Measures on Assessment for Implementing the Most Rigorous Water Resource Management System set out the total water consumption control red line limits for all provinces in 2020 and 2030 (see Appendix 5). The limits for cities have also been gradually released. Under the coal cap scenario, CO2 emissions from coal consumption will reach 7.5 billion tons by 2020. The carbon emissions from coal are also allocated to the provinces (see Appendix 5), so as to limit the increase in coal consumption.

#### (2) Provincial-level coal cap targets

Following the State Council's Air Pollution Action Plan, over 20 provinces, cities or autonomous regions have set coal cap targets, coal consumption limits or $PM_{2.5}$ concentration goals. With set limits on air quality targets and coal-related carbon emissions, and using environmental cost-benefits analysis, the Coal Cap Project has set the 2020 coal cap targets for all 30 provinces (see Figure 4). Compared with 2012 coal consumption levels, Beijing, Tianjin, Hebei, Liaoning, Jiangsu, Shanghai and Shandong should see clear reductions; Heilongjiang, Guangdong and Chongqing should be limited to current levels; and six northwestern provinces – Xinjiang, Ningxia, Qinghai, Gansu, Shaanxi and Inner Mongolia – will experience the most growth.

#### (3) Provincial targets for energy intensity and carbon intensity

To allocate the 18% energy intensity target to 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 low energy intensity targets as it did in the 12$^{th}$ Five Year Plan period, the targets will likely be ineffective and easily achieved. Hence we divide the provinces into six categories and design varied targets (see Appendix 6). As meeting its target for the 12$^{th}$ Five Year Plan has proven to be difficult, the western Xinjiang autonomous region's energy intensity reduction target is set at a mere 5%, with annual reduction rate at 1%.

To allocate the 20% carbon intensity reduction targets into provinces, similar categorization is used (see Appendix 6). The sum of provincial energy and carbon intensity targets will be slightly higher than the national targets. China has announced plans to establish a national cap and trade market in 2017. China shouldto learn from the lessons in the European carbon market, i.e., low carbon reduction targets will lead to carbon market failure.

### (4) Provincial air pollution emission reduction targets

At the end of the 13th Five Year Plan period, city average $PM_{2.5}$ concentration nationwide 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 nitric nitrogen and VOCs have less relevance with coal, the five gaseous pollutants contribute significantly to secondary $PM_{2.5}$.

### (5) Coal replacement based on local conditions

See Table 11 for our recommended renewable energy targets (installation and generation) in the 13th Five Year Plan. The share of renewable energy generated electricity can best reflect the level of energy structure optimization. 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 bidding, grid connection, to quota system – to encourage renewable energy development. Grid connection has spurred the development of renewables in China. The new challenges currently are to develop distributed renewables and reduce cost. And the renewable energy quota system which has long been discussed should be a good solution for developing high penetration renewable energy and reducing subsidy. 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 all provinces. 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.

Figure 4. Provincial Coal Cap Targets under Resource, Environmental, and Ecological Redlines

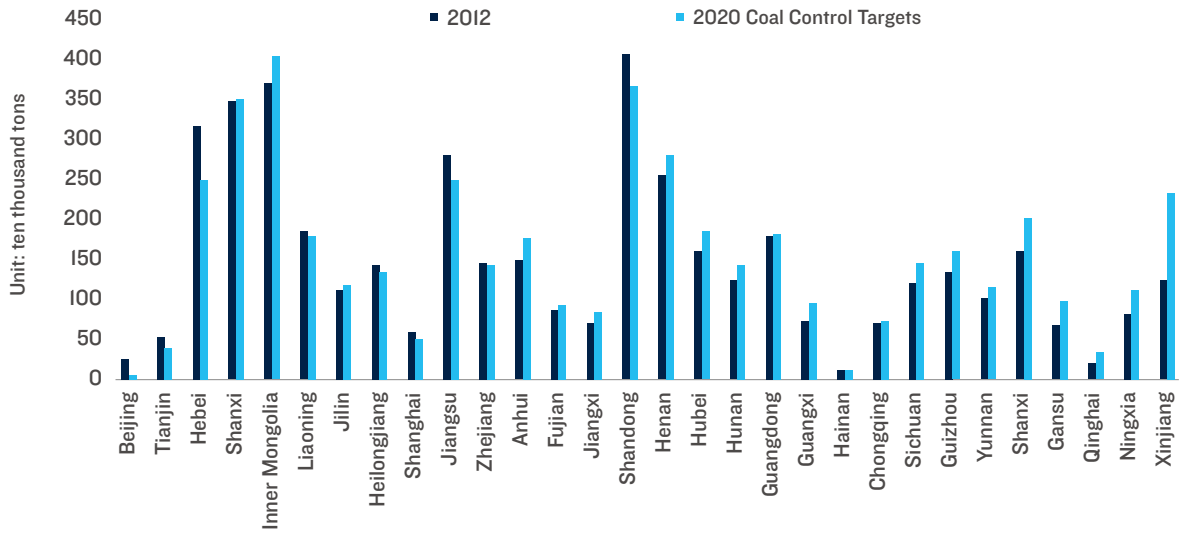


Table 11: 13th Five Year Plan renewable energy installation and generation targets

| | 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 | 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 the northern severe cold regions, winter heating uses a large amount of energy. Using geothermal energy, underground water, solar energy and heat pumps can provide clean heating for winter. Besides power generation, renewable energy can also 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. Targets for renewable energy heating for the Yangtze River Delta hot summer/cold winter region and souther hot summer/warm winter regions; see Appendix 6.

In super-large and large cities, efforts will be made to achieve no coal consumption in urban core areas, replace coal-fired boilers with ones based on gas or electricity, convert coal-fired heating boilers larger than 20 steam tons in size to boilers based on clean energy, popularize the application of gas-fired boilers and heat storage electric boilers. The coal consumption in various for-profit service sectors will be transformed into electricity, natural gas and other clean energies so as to increase the proportion of purchased power, enhance the cooperation and development of external power sources and establish stable bases of external electricity sources.

### 6.3.3 CITY COAL CAP PLANNING BASED ON A HUMAN-CENTERED APPROACH AND REDLINES

Cities are the key to implementing the coal control planning on such three levels as regions, provinces and municipalities. There are 74 key cities, 293 prefecture-level cities and 361 county-level cities across the country. Along with the rapid urbanization in China, the urban population in 2020 will make up 61% of the total population and the size of cities will be further expanded.

### (1) Establish and allocate city-level resource environmental ecology red lines

The Ministry of Water Resources has allocated the red lines of national total water consumption to prefecture-level cites. In accordance with the allocation method of air quality $PM_{2.5}$ concentration and carbon emission restrictions from the national to the provincial level, the coal cap project has allocated the city-level air quality and carbon emissions targets.

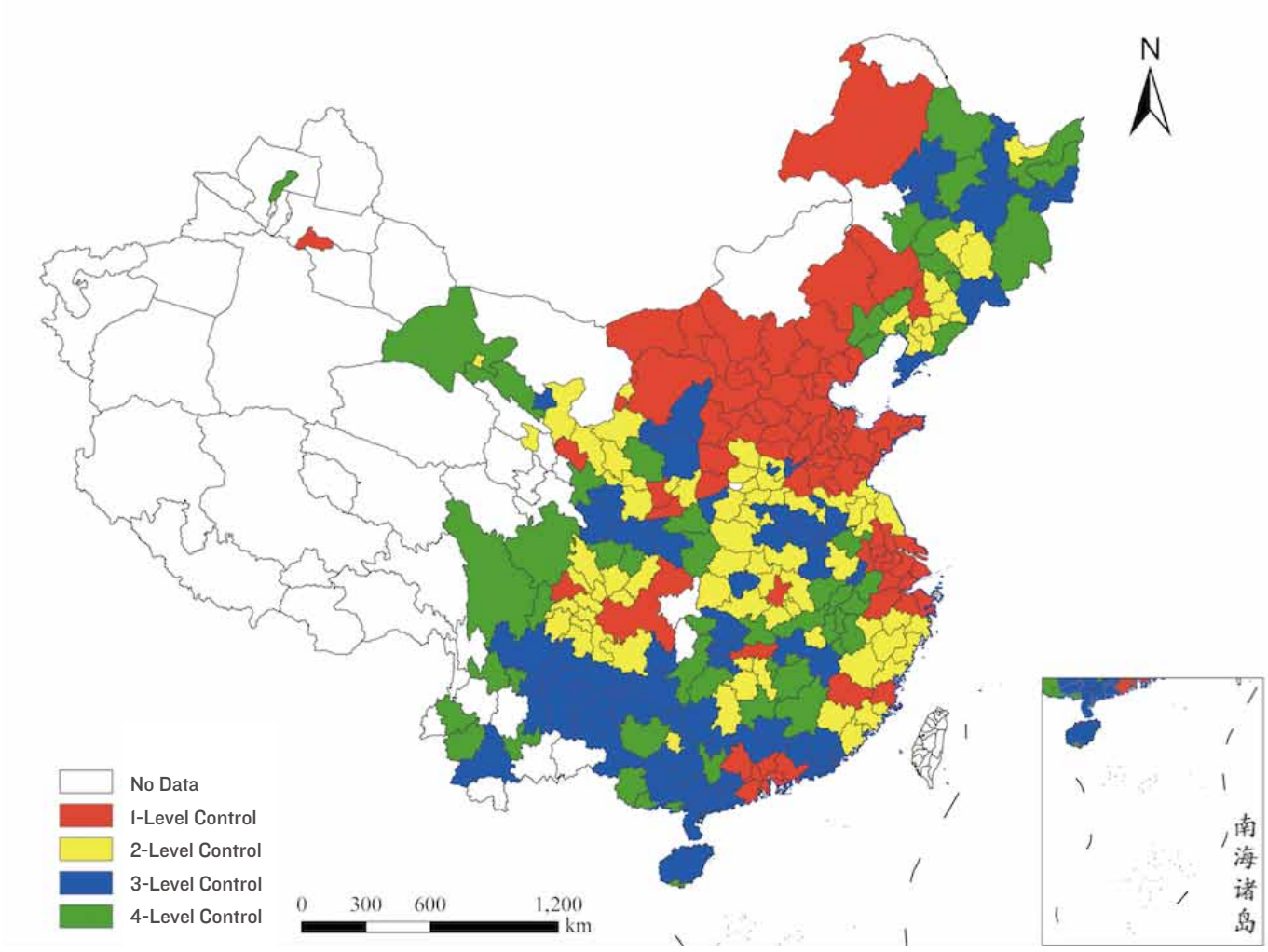
### (2) The classification of city coal caps and allocation of total coal cap targets

Based on the classification of city size and coal consumption intensity, the coal cap project has divided the 293 prefecture-level cities into thirteen categories, with the classification result as shown in Appendix 8. By combining the air quality status and coal consumption intensity of various cities in China, air pollution restrictions in the 293 cities are also divided into four levels. Among the 83 cities of Class I restriction, in addition to the 47 key control cities clearly specified in national atmospheric pollution prevention and control scheme covered, an additional 36 cities around the Jing-Jin-Ji region and surrounding areas with the most severe atmospheric pollution have also been added. Most cities which have high development level and poor air quality have been given Class I and Class II restrictions. For these cities, their current stage of economic development means they are capable of stronger air pollution restrictions, and it is essential to strictly control their coal consumption and improve their air pollution.

Under the coal control scenario, the total coal consumption peak in the 13 categories of cities by 2020 will be around 3.2 billion tce (4.48 billion ton raw coal)[2], with the peak period in various kinds of cities as shown in Appendix 8. City classification is an innovative total coal consumption management mechanism. While choosing total coal consumption cap policies and measures of different kinds for cities, it is necessary to follow the principle of taking effective measures according to local conditions, giving full consideration to economic development stage, resource endowment and comparative advantages, making use of combined policies and measures, and employing emission reduction measures with minimum marginal cost. Based on city classification, the provincial coal control caps can be allocated to city-level coal cap targets.

2.There are 334 prefecture-level regions in China, including 293 prefecture-level cities. The 4.48 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: Categories of City Air Pollution Control



From 2010-30, the coal consumption of the 13 categories of cities continues to grow. Under the reference scenario, the increase during the first ten years is fast, with the latter 10 years slowing down, and 2020 coa consumption reaching 4.19 billion tons of standard coal. Coal consumption will peak in 2030 at 4.28 bilion tons of standard coal. Afterwards, coal consumption will gradually decrease at a stable rate. Under the coal cap scenario, the peak coal consumption of the 13 categories of cities will be brought forward from the reference scenario's 2030 to 2020, with a peak of 3.23 billion tons of standard coal, a reduction of about 24.5%. The coal cap scenario's 2020 coal consumption will be 960 million tons of standard coal less than the reference scenario, showing the clear effect of the coal cap policy. After 2020, the coal cap scenario's coal consumption will gradually reduce.

The more coal-intensive cities are focused in Shanxi, Shaanxi, Henan, Hebei, Ningxia, Inner Mongolia and Guizhou provinces, with eastern coal cities less than central-western cities. Urumqi, Taiyuan and Taiyuan are the most coal-intensive cities in among the super-large cities. Of the large cities, there are 11 coal-intensive cities including 11 cities including Pingding, Laiwu, Baotou, Datong, Handan, Yinchuan; of the medium-size cities, there are 32 coal-intensive including Wuhai, Linfen, Shizuishan, Yuncheng, and Liupanshui; and of the small cities, there are 16 coal-intensive cities including Wuzhong, Zhongwei, Jiaguguan, and Lvliang.

### (3) Giving top priority to air pollution control of key cities and main city groups.

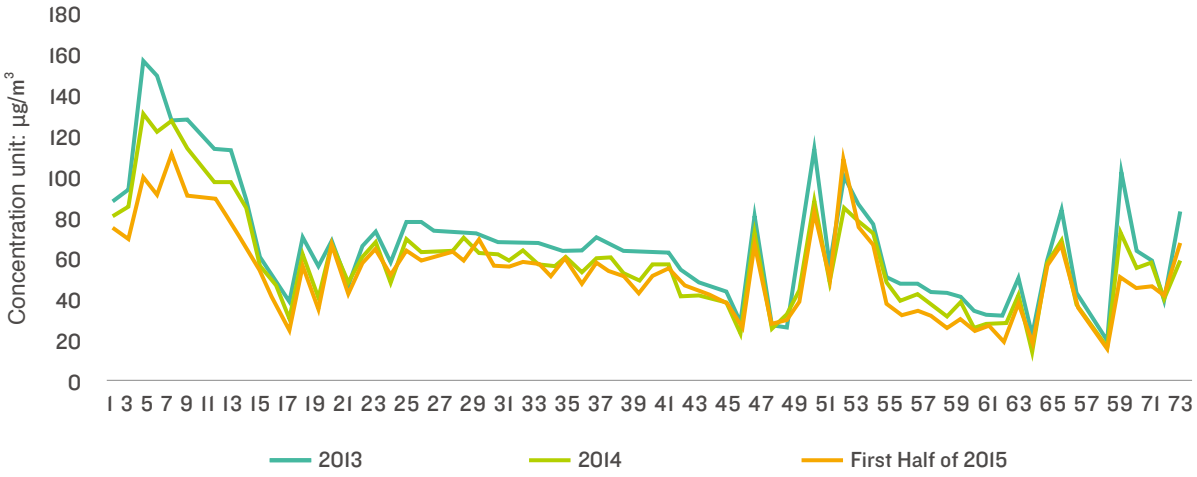
The state's 74 key air pollution cities are characterized by heavy population, high density, strong economic scale, severe air pollution and great impact upon the public's physical health, so top priority should be given to air pollution control of these cities. In 2013, among the 74 key cities across the country, the annual average rate of $PM_{2.5}$ concentration was 70.2 μg/$m^3$, and only 3 cities reached the national standard. In 2014, the average rate $PM_{2.5}$ concentration of the 74 key cities was 62.4μg/$m^3$. In the first half of 2015, the average $PM_{2.5}$ concentration of the 74 key cities was 57.6μg/$m^3$, down by 7.8% and 18% over 2014 and 2013. Among them, 11 cities have reached the standard. The air quality in most of the cities has been greatly improved, as shown in Figure 6.

Among the ranking of $PM_{2.5}$ concentration in the first half of 2015, the top 10 polluted cities among the 74 key cities are Baoding, Zhengzhou, Xingtai, Handan, Shijiazhuang, Hengshui, Tangshan, Jinan, Langfang and Wuhan. To give priority to the top 10 cities with the most serious air pollution, we should first reduce their coal consumption, change the urban energy structure and change the status of serious air pollution within a short time.

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 value in 2013, except for the western costal cities where average $PM_{2.5}$ concentration value is equal to and less than 35μg /$m^3$, the $PM_{2.5}$ concentration of other city groups is very high or relatively high.

Looking nationally, 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 Henan Central Plains city cluster also jumped to second place nationally, behind the city clusters of Beijing, Tianjin and Hebei. Targeted to such a change, the national control scope of city groups should be adjusted to some extent. The city clusters on the western coastal area and the Pearl River Delta region should have "graduated". The air pollution of the Henan Central Plains city cluster and the whole province should be placed under key supervision. The central part of Liaoning, Urumqi

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




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 of key city clusters and adjustment should be made every two years by relying on local governments. The central government should provide differentiated policy and financial support to support urgent needs. Table 12 has listed the annual average target value of $PM_{2.5}$ concentration in 2020 and 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 will be 45.2μg/$m^3$. Along with the good air quality in numerous medium and small cities, the target annual average value of $PM_{2.5}$ concentration of 45μg/$m^3$ by 2020 should be able to be realized.

Joint management and control of air pollution by cities should be able to more effectively address the air pollution among cities, especially with super-large cities as the focus. In terms of responsibilities and coordination, the central government should support cross-provincial city clusters, the provinces should support city clusters within the province, and large cities should support surrounding small cities.

Table 12: Statistics of $PM_{2.5}$ concentration ($\mu g/m^3$) in key cities of the country between 2013 and the first half of 2015

| | $PM_{2.5}$ average value in city groups | | | | | 2015 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|
| City groups | 2013 full year | 2014 first half | 2014 full year | 2015 first half | # of cities | Max. value | Min. value | Target value |
| Henan Central Plains city groups | 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 ECOLOGICAL RED LINES, ACT TOGETHER AT ALL THREE LEVELS 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 shall set up coordination and management groups for strengthening the communication and coordination among various departments and various levels of government, as the current regional government management and supervision system is weak. Management of coal involves energy, land, water conservation, environmental protection and other departments, which need to be better coordinated. We should establish an air pollution control and water resource protection discussion and coordination mechanism across departments, regions and river basins, to give play to the role of regional water resource protection agencies and air pollution control regional supervision and inspection agencies. We should also establish prevention and control linkage and coordination mechanisms to carry out regular consultation, joint monitoring, joint enforcement, joint emergency response, and information sharing with a clear division of power and responsibility. Finally, we should establish a performance assessment and accountability system for ministries and regional offices based on the national industrial layout.

Mechanisms for regional air pollution joint prevention and control are much talked about but there is often little action. Other than the Beijing-Tianjin-Hebei and Yantze River Delta region which have joint committee meetings, other regions have difficulty coming together. Even more importantly, without the active assistance of neighboring provinces, the Beijing-Tianjin-Hebei and Yantgze River regions will also have difficulty to accomplish their goals. Therefore, a key question is how to establish an agency within the national governance system that has suitable responsibilities, 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 ecological red lines as guidance and restrictions into a provincial-level integrated regulation, work out an overall plan of ecological civilization construction in all the provinces, and include adherence to eco-environmental red line bottom lines in the entire process of plan formulation. The provincial governments shall be responsible for establishing coal control plans and relevant ecological red lines. The provincial-level governments' regulatory agencies shall mobilize the resources in the provinces and carry out coordination and mutual assistance with agencies at all levels inside and outside the province. The provincial governments shall formulate assessment methods and standards, carry out the construction of the environmental and ecological monitoring network, and ensure the accuracy, seriousness and authoritativeness of data collection. Coal cap planning shall take environmental and ecological protection as the top priority and promote the coordinated development of the society and economy.

The municipal governments shall stand at the front line of work, production and economic development. In the earlier stage of rapid economic development, local governments at all levels went all out for economic development

and competitiveness, and achieved outstanding economic development. However, this development model is unsustainable and will reach natural limits. As the saying goes, "Blue water and skies are the real source of wealth." Governments at all levels should strictly adhere to resource environment ecological red lines, and develop their economies and deepen promotion and construction of low-carbon ecologically smart cities, to attain the objective of building a well-off society in an all-round way.

### 6.4.2 USE MARKET MECHANISMS TO DEEPEN THE RESULTS OF LOCAL COAL CAP IMPLEMENTATION

Use of market mechanisms and economic measures are indispensable measures for addressing increasing resource and environmental challenges. China should establish quota and trading systems for energy use, water use, emissions discharge and carbon emissions. The market mechanisms and administrative management measures should be complementary, to more effectively implement coal cap plans and achieve coal cap targets.

The design of a coal consumption cap mechanism provides a foundation and opportunity for a coal quota trading system. The coal cap project has designed a city coal consumption quota trading system. China should establish a city coal consumption cap and quota trading system, which should be connected with current efforts to establish carbon trading, emissions trading and water use rights trading markets. Saving coal should be connected with saving water, reducing emissions and reducing carbon as co-benefits. China will establish a national carbon cap and trade program by 2017, with national coverage and rules. Given that coal is the main source of carbon emissions, reducing coal use will be key to reducing carbon.

China's emissions trading pilots have already expanded from provincial to national in scope, with the aim of promoting the construction and improvement of a national system that requires compensation for use of environmental resources, guides industrial structure adjustment, achieves targets for total emissions control of key pollutants, promotes effective environmental regulation and enforcement, and improves environmental quality. At present, the pollutants subject to mandatory total emissions control at the national level include $SO_2$, NOx, COD and ammonia nitrogen, but local governments can choose to include other pollutants which have particularly harmful effects on their local environment. Coal is a key contributor to $SO_2$ and NOx.

The establishment and implementation of a water rights trading market can help achieve the optimal allocation of water resources. Under the framework of the overall local water resource plan, the local government and the water agency should actively guide water rights trading and water market construction, to promote the coordinated sustainable development of the economy and protection of water resources. The construction of a water rights trading market can change the current situation under which water's resource value is undervalued. Coal mining and use uses substantial water resources, so reducing coal use can clearly save water.

Better coal data will also provide an important foundation for carbon, emissions and water rights trading. City coal consumption quota trading can have multiple benefits. As carbon, emissions and water trading markets mature, coal consumption allocation trading can connect with these markets to provide support and multiple forms of market participation, to provide an economic impetus for saving coal and deepen coal controls. The other three types of trading are comparatively independent and closed, with no mutual trading between them; coal consumption quota trading is unique in its ability to bridge these markets, so we should develop city level coal consumption quota trading pilots as soon as possible.

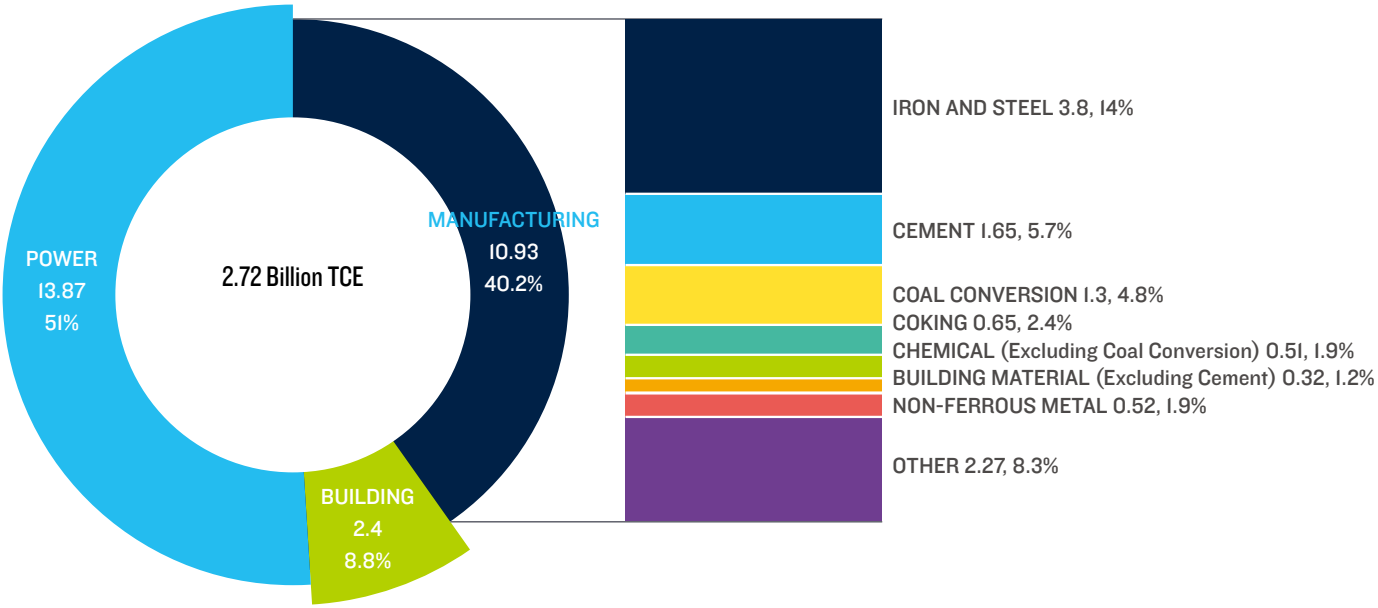
# 7 SECTORAL COAL CAPS

During the 13th Five-Year Plan period, Chinese industry will enter a new stage. The production output of many energy-intensive industries will reach their peak during the 13th Five-Year Plan 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. Urbanization will also add to industrialization. The continued increase in urbanization will contribute to the continued production of steel, cement and other energy-intensive products. By 2020, the installed capacity for the Chinese power industry is expected to reach 1,920 GW and power generation is expected to reach 7,470 TWh; industrial output will hit 780 million tons of crude steel, 2.6 billion tons of cement and 81 million boxes of glass. Building floor area will reach 70 billion square meters. 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 Annex 2 for the prediction of Chinese economic and industrial development during the 13th Five-Year Plan period.

## 7.1 TARGETS

Coal control targets for various sectors for 2020 have been established, with specific targets as follows: coal consumption in the power sector is 1.387 billion tons of standard coal equivalent, accounting for 51% of total coal consumption; coal consumption in the manufacturing sector is 1.173 billion tons of standard coal equivalent, accounting for 42% of total coal consumption; and coal consumption in the building sector is 240 million tons of standard coal equivalent, accounting for 8.8% of total coal consumption. In the manufacturing sector, the coal consumption in steel, cement, coal chemical industry, coke, the chemical industry (excluding the coal chemical industry), building material (excluding cement), non-ferrous metal and other industries is 380 million, 165 million, 130 million, 65 million, 51 million, 32 million, 52 million and 227 million tons of standard coal equivalent, respectively. The coal control objectives of various sectors by 2020 are as shown in Figure 7.

Figure 7: Coal cap targets of various sectors for 2020




## 7.2 KEY TASKS

(1) Set resource environment ecology red lines for each sector, including restrictions on water consumption and carbon emissions

(2) Each sector's coal and electricity saving potential

(3) Set water consumption, coal consumption, and power consumption standards for unit product and unit output value, and set energy consumption per unit industrial added value for each sector in 2020

(4) Investment for sectoral coal cap coal/electricity saving and environmental protection

(5) Major policies and measures for sectoral coal caps

## 7.3 IMPLEMENTATION PATHWAYS

### 7.3.1 SETTING OF RESOURCE, ENVIRONMENT AND ECOLOGICAL RED LINES

The coal cap project has set totala water consumption control red line index for each coal consuming sector and allocated 7.5 billion tons of carbon emissions to coal-related sectors, as shown in Table 13. The allocation of the 7.5 billion tons of coal-related carbon serves as a carbon restriction for each of the sectors.

In 2020, if no coal control and water saving measures are adopted, the total water consumption in coal-related industry will be close to 100 billion cubic meters, 25.3 billion cubic meters over the water consumption red line. Under the double measures of coal control and water saving, total water consumption will decrease by a big margin, and can basically meet the requirements of the water resource red line index. Many people have paid close attention to the water resource and water pollution treatment challenges from coal mining, coal power and coal chemicals development In the water-scarce northwest region.

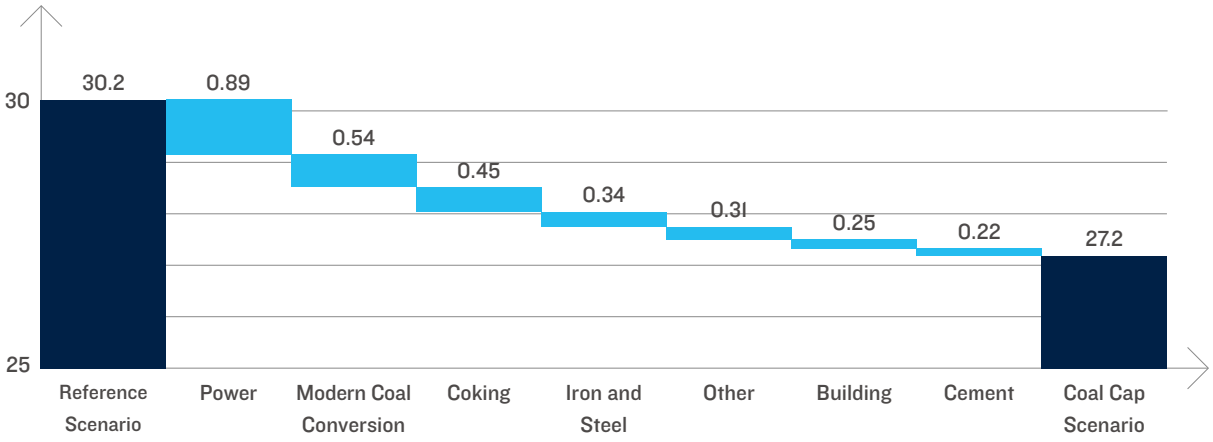
Table 13: Total water consumption and carbon emissions restriction red lines for coal mining and consuming sectors in 2020

| | Water control red line in 2020 (billion cubic meters) | Carbon emission restriction in 2020 (billion cubic meters) |
|---|---|---|
| National total | 670 | 95 |
| 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 | 3.42 |
| Coke | 1.088 | .2 |
| Modern coal chemical industry | .491 | .32 |
| Other industries (paper-making and textiles, etc.) | 7.564 | 1.00 |

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

2020 unit industrial added value (for minimum-scale enterprises) energy consumption should be about 23% lower than 2015 levels. Under the coal cap scenario, coal-consuming sectors should save 300 million tons of standard coal equilvalent during the 13$^{th}$ Five Year Plan period, and total electricity saved should reach 581 TwH. The coal savings for each sector are found in Figure 8 and Table 14.

Figure 8: Coal Savings in Various Sectors




Within industry, coal reduction, high-efficiency utilization and replacement each save 132.74 million, 115.61 and 51.65 million tons of coal equivalent, respectively.

The increase in coal consumption in the coal chemicals, power, buildings and other sectors is effectively controlled, while existing coal consumption in the steel, cement, building materials and other manufacturing sectors is reduced.

The proportion of major products which reach the advanced energy saving standards will increase greatly, with most industries and large and medium enterprises energy-saving performance reaching the world's advanced levels. The efficiency index of fans, water pumps, air compressors, transformers and other newly-added energy-consuming equipment will reach or approach internationally advanced levels. The efficiency index of home electric appliances and some types of electric motors will reach internationally advanced levels. The total pollutant emissions in each coal-consuming sector will be significantly reduced.

In order to research and quantify industrial sector energy savings, we should establish energy saving targets, evaluate work progress and completion, regularly measure major products unit energy consumption and enterprises' unit output value energy consumption, and learn and push on the enterprises' improvement in energy consumption. Table 14 has listed the double energy-saving objectives of the sector. The energy-saving conditions of the sectors and enterprises in the 13th Five-Year Plan period should be assessed one by one.

Table 14: Joint standard for energy consumption per unit industrial added value and per unit product, and energy and electricity savings in coal-intensive sectors

| Sector | Energy consumption per unit industrial added value in 2020 (tons standard coal/10,000 RMB) | Total energy consumption per unit product | | | Coal savings (10,000 tons standard coal) | Annual electricity savings (TWh) |
|---|---|---|---|---|---|---|
| Power | —— | 285 g/kWh | | | 0.89 | 75 |
| Steel | >8 | <560 kg standard coal/ton steel | | | 0.34 | -18.7 |
| Cement | 5.71 | 104.6 kg standard coal/ton clinker | | | 0.22 | 94.73 |
| Buildings | —— | Newly built residential buildings | Coal control | Heating energy consumption limit 45 kWh/$m^2$ per annum | 0.25 | 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 | —— | Coal to gas, 230,000 tons standard coal/100 million cubic meters | | | 0.54 | —— |
| | | Coal to oil, 3.6 tons standard coal/ton oil | | | | |
| | | Coal to olefins, 3.5 tons standard coal/ton olefin | | | | |
| | | Glycol, 2.9 tons standard coal/ton glycol | | | | |
| Coke | | | | | 0.45 | |
| Chemical industry (excluding coal chemical industry) | | | | | 0.0435 | |
| Building material (excluding cement) | 2.99 | | | | 0.0279 | |
| Non-ferrous metals | 1.87 | | | | 0.0442 | |
| Other sectors | 0.61 | | | | 0.1945 | |
| Total | | | | | 3 | 581.03 |

### 7.3.3 ESTABLISHING WATER SAVING, EMISSION REDUCTION AND CARBON REDUCTION INDICES

In 2020, the water consumption per 10,000 RMB GDP and per 10,000 RMB industrial added value should decrease by more than 35% and 30% compared to 2013 levels, respectively. The leakage rate of public water supply pipelines across the country should be controlled within 12% by 2017 and within 10% by 2020. Buildings can reduce network losses, saving 420 million tons of water per year. We shall push forward the development of water recycling and re-use, and strengthen the recycling and re-use of industrial water. By 2020, we should seek 100% comprehensive utilization of mine water and coal washing wastewater. We should further tighten the water consumption restrictions for coal-intensive sectors in 2020, as shown in Table 15. Compared with advanced water consumption quota management, water saving efficiency still needs to be further improved.

Table 15: Water consumption restrictions for coal-intensive sectors

| | | Unit product water consumption in 2020 |
|---|---|---|
| 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 $m^3$/heavy box |
| Residential ceramics production | | < 0.18 $m^3$/ton |
| Aluminum refining (oxidized aluminum) | | < 4$m^3$/ton |
| Aluminum refining (electrolytic aluminum) | | <3.6$m^3$/ton |
| Synthetic ammonia | | <22$m^3$/ton |
| Leakage rate of national water supply pipe network | | 2017<12%, 2020<10% |
| Recycling and re-use of coal mine water | | 100% utilization |
| Recycling and re-use of coal washing wastewater | | 100% |

The prediction of carbon dioxide emissions for major coal-consuming sectors is shown in Table 16. The predicted carbon dioxide emissions for major coal-consuming sectors are higher than the $CO_2$ emissions restriction allocations for key national sectors found in table 10; in particular, the $CO_2$ emissions from the power sector are 970 million tons higher than the recommended limit. Therefore, the power sector needs to quickly reduce its coal-fired power generation and increase generation from natural gas, renewables and nuclear, or it may hinder the achievement of China's goal to peak its $CO_2$ emissions by 2030. The $CO_2$ emissions in the steel sector will also exceed the set limit by 300 million tons and the cement sector's $CO_2$ emissions will be close to the limit.

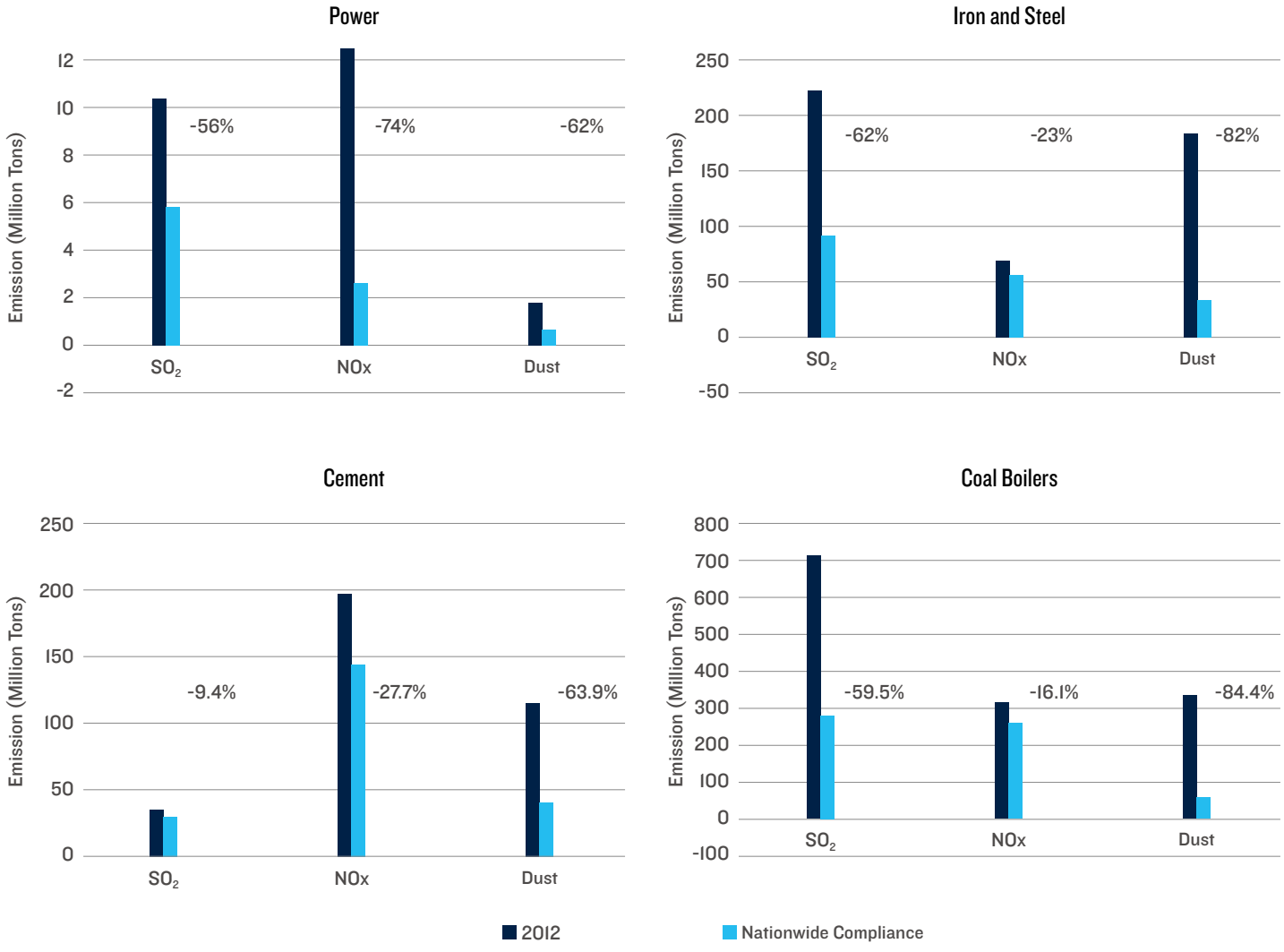
Enterprises shall strictly observe the emission limits and standards for major air pollutants in their region. Table 16 shows the predicted air pollutant emissions of various sectors. In general, different regions shall establish total emissions control targets for air pollutants, including $SO_2$, NOx and particulate matter, and the addition of atmospheric ammonia nitrogen and volatile organic compounds (VOC) in the 13th Five-Year Plan, and allocate the targets 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 standard 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 (1000 tons)

| Sector | Total emission of major pollutants | | | Carbon emission |
|---|---|---|---|---|
| | $SO_2$ | NOx | Particulate Matter | $CO_2$ |
| Power | 3,563 | 4,947 | 831 | 439 |
| Steel | 624 | 1,092 | 546 | 132.6 |
| Cement | 1,197 | 1,109 | 489 | 124.1 |
| Building | —— | —— | —— | 64 |
| Modern coal chemical industry | 3,751 | 3,657 | 1,097 | 15.2 |
| Coke | -- | -- | -- | 17.3 |
| Chemical industry (excluding coal chemical industry) | 952 | 780 | 375.6 | 1.2 |
| Building material (excluding cement) | 425.7 | 864.9 | 113.0 | 0.7 |
| Non-ferrous metals | 879.2 | 1,773.9 | 239.1 | 1.2 |
| Other industries | 2,186.6 | 2,696.3 | 1,5268 | 5.1 |
| Total | 13,578.5 | 16,920.1 | 5,217.5 | 800.4 |

If enterprises all strictly observed the various pollutant emission standards for equipment and industrial enterprises issued by the Ministry of Environmental Protection, and the provisions of the Air Pollution Action Plan, national $PM_{2.5}$ pollution concentration levels would be reduced by more than 50%. Even implementing only the three pollution standards for boilers, cement, and brick and tile, requiring a total investment of 429.5-515.5 billion yuan, with annual operating expenses of more than 53.5 billion yuan, would bring about an obvious improvement in air quality. Figure 9 shows the reduction in $SO_2$, NOx and particulate matter that would result from implementing the pollution standard for power plants, iron and steel, cement and boilers. If each enterprise in the country earnestly implemented existing emission standards, air quality across the country would be greatly improved. By 2017, coal blending center regions should produce 50% specialized clean coal for industrial boilers and residential use, increasing to over 90% by 2020.

Figure 9: Emission reductions from implementing emission standards for power plants, boilers, iron and steel and cement (fugitive emissions not included)



### 7.3.4 SECTORAL COAL AND ELECTRICITY SAVING INVESTMENT

China energy-intensive industry is at a key turning point, with economic growth slowing, while at the same there is a great need for investment in energy efficiency, reducing coal consumption, development of alternative energy and other environmental protection. Based on estimates, the energy saving and renewable energy investment needs are about 2.98 trillion RMB, and environmental protection needs are about 780 billion RMB, as shown in Table 17. These are all huge green investment areas that can promote energy saving, environmental protection, clean energy development and economic growth. As a result, the national coal cap plan will reduce coal sector investment, but it will also provide a new, even larger sector for investment.

Table 17: 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 | | 135 | | 10.2 |
| Chemical industry (excluding coal chemical industry) | | 218 | | 52.2 |
| Building material (excluding cement) | | 70 | | 16.7 |
| Non-ferrous metals | | 177 | | 22.1 |
| Other industries | | 778 | | 155.6 |
| Total | | 29808 | | 777.48 |

## 7.4 SECTORAL COAL CAPS POLICIES AND MEASURES

China has made considerable progress in end-use energy efficiency. Many high-end technologies are among the most efficient in the world. However, compared with internationally advanced levels, China still has the potential for huge progress in efficiency technology. China still has room to upgrade its economy, industries, products, energy structure and technical efficiency, and there exist huge opportunities for investment, development and innovation. It can take advantage of its late-mover advantage in the energy sector. The gap between China and the international advanced levels in 2014 is shown in Annex 9.

### (1) Resolving overcapacity in Chinese industry by sector

***Chinese industry faces serious overcapacity.*** Some local governments will continue to blindly pursue rapid economic growth, intervene and hinder market competition by administrative means, and support the expansion and redundant construction of local enterprises. It is better to cut short such ill-planned activity rather than prolong the suffering. Serious illness needs a potent drug. Significant measures will be adopted to solve industrial overcapacity. The status of overcapacity in energy-intensive sectors is shown in Table 18.

Table 18: 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 case) | 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.*** Through reorganization of enterprises, China should achieve sharing of information on resources, markets and prices, optimize the industrial structure and sharpen the competitveness of industry, while at the same time avoiding market monopolies (i.e., a single enterprise group controlling a 20% market share). The relevant government department should improve the guidelines, finance, taxation, auditing, and property rights policies related to merger and reorganization, and encourage enterprises to implement merger and reorganization. Mergers and reorganization should not be used to keep running backward enterprises which should be eliminated. Restructuring should be driven by enterprises.

***Strengthen national laws and regulations, environmental protection standards and energy consumption standards to eliminate backward enterprises.*** The government should carry out inspections in accordance with relevant laws on environmental protection, work safety and resource conservation, and shut down backward enterprises which do not conform to requirements. Governments at all levels should reduce unfair support and subsidies for local enterprises and improve the role of market competition in eliminating backward enterprises; they should also make use of economic measures such as land, taxation, finance, differential power prices etc. in to favor competitive enterprises and force 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 should be punished with daily penalties, and public interest lawsuits should be used to enforce standards. Environmental standards and total emissions 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, development concepts and development models, and make enterprises the key market players in solving overcapacity. First, deepen enterprises reform, especially through developing diversified ownership and standard corporate governance structures. Second, establish a development strategy based on comparative advantage, endeavor to improve technological innovation capacity, and achieve green development and overall performance of enterprises' social responsibilitie. Third, enhance and accelerate the establishment of an industry self-discipline mechanism. Enterprises should be able to arrange their production and operation activities reasonably in accordance with the laws of the market and national policy and achieve the industry's reasonable and effective self-discipline.

### (2) Control industry's existing and future coal consumption

First, attention should be paid to industries with the potential to increase coal consumption in the future, such as the modern coal chemical industry, power sector and buildings; next, industries which will greatly reduce their existing coal consumption, such as iron and steel, cement and building materials. See table 19 for the main coal cap policy recommendations for each sector.

Table 19: 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, | Keep at pilot stage, allow some coal to olefins/ethylene projects, much debate on coal to gas/oil projects. End project approvals. |
| Power | Economics of coal power plants are worsening, increasing risk of stranded assets | Coal to power should move from a leading role to a supporting role, with new approvals for coal power plants to end by 2017, greatly expand clean electricity sources, power sector cannot consume any more coal. Coal and coal power co-operation should be limited. End approvals for coal gangue and low-heat value coal power plants. |
| Buildings | Buildings sector to continue to increase, energy saving potential is large | Establish building energy use caps, increase energy efficiency levels. Increase proportion of green buildings, with renewables reaching 15% of heating needs. |
| Iron and Steel | 2014 should be the peak/plateau period | Scrap iron should be comprehensively re-used, reduce iron and steel exports |
| Cement | 2016 should be the peak/plateau period | Cement kilns should replace coal with household waste, sludge and industrial waste |
| General Technology | Eight large general-use energy saving projects | Increase energy saving, resource conservation and emission reduction at both source and end-use |

***Modern coal chemical industry:*** Modern coal chemical industry is a new powerful growth area for coal consumption. According to available statistics, presently there are 26 coal-to-oil projects, 58 coal (methanol) to olefin projects and 67 coal-to-gas projects in China which are currently in operation, under commissioning, construction or at the preparatory stage. If all of the projects are put into operation, China is expected to attain production capacity of 40 million tons/year coal-to-oil, 41 million tons/year olefins, and 280 billion $m^3$/year coal-to- gas by 2020. Coal consumption would increase from 128 million tons of standard coal to 477 million tons of standard coal, an increase of 273%. The coal chemical industry urgent needs to strengthen planning and guidance to limit over capacity.

The modern coal chemical industry is a sector with high energy consumption, high pollution, high water consumption and high carbon emission. The determining factors for development of the coal chemical industry are its economics, competitiveness, social and environmental externalities and climate change risk. Among modern coal chemical industry products, coal-to-oil and coal-to-gas projects transforming coal to other forms of fossil fuels are the most controversial ones. From the view point of practical experience, coal-to-oil projects in South Africa and and the United States' Great Plains coal-to-gas project in the 1980s indicate that these projects could not compete with commercially developed oil and gas on the international energy market.

Domestically, the increase in water price, collection of environmental tax, and the future levy of a carbon tax will further weaken the competitiveness of coal chemical industry projects based on energy transformation. If the social and

environmental external costs of coal and energy transformation are considered, the coal-to-oil and gas projects will be unable to pass muster. Coal chemical industry projects are mostly located in the central and western regions with scarce or extremely scarce water resources and a vulnerable eco-environment. The modern coal chemical industry is based on different qualities of coal which affects the production process, immature production processes, instability, poor water quality and high water consumption. Accidental discharges occur from time to time. The level of management for projects is highly variable, with low recycling rates for reclaimed water and large evaporation ponds. Even after treating the high oil, high COD and highly organic toxic phenol ammonia created, it is difficult to attain the water quality of direct biochemical treatment. Inspections have shown the wastewater contains over 140 pollutants, with more than 30 cancer-causing organic compounds that are difficult to break down. And just where to discharge the pollution is another difficult question. To attain suitable levels of environmental protection, the costs for air pollutant emission reduction and wastewater treatment will be doubled. 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 13$^{th}$ Five-Year Plan period, coal-based olefin and ethylene development will be decelerated and projects approvals will be delayed. Modern coal chemical industry should at most develop demonstration pilot projects. We should base future development decisions based on goals of clean energy, high efficiency, environmental protection and low carbon, and consider the tremendous changes in supply and demand in the international oil and gas market. Except as a strategic technical reserve, the commercial outlook for coal energy transformation projects is not bright.

***Power industry:*** As the Chinese economy enters a new normal of slower growth, annual electricity demand growth is expected to be around 4% during the 13th Five-Year Plan period. By 2020, the installed capacity of coal power plants will reach the peak of 970 GW, with coal power making up 51% of total coal consumption, which will provide a rare opportunity for a greener and low-carbon power sector.

If the planning for power development during the 13th Five-Year Plan period continues the development path of the past 10 years, the following risks may likely occur from major planning mistakes: 1) power sector planning which is not corresponding to the new normal of economic growth will result in overcapacity of coal-based power; 2) the healthy development of renewable energy will be restricted; 3) the continuing high growth of coal power capacity will further worsen the economics of coal-based power; 4) reducing the share of coal-based power after 2020 will become more difficult and the costs of for low-carbon transformation for the power sector will be more expensive.

During the 13th Five-Year Plan period, the power sector should plan for coal-power plants to shift from the role of a major generation source in newly installed capacity to supplementary generation source. We will restrict the increase of coal-based power effectively through the restrictions of air quality red lines, water resource red lines in the western region, and a national greenhouse gas emissions cap. Under the coal control scenario, by 2020, the installed power capacity will reach 1,920 GW, with non-fossil energy-based installed capacity increasing to 44.2% and coal-fired power capacity reducing to around 51% of the total. In view of the long period of power engineering projects, except for individual coal power projects subject to approval of relevant ministries of the central government, no new coal power projects should be approved after 2017.

During the 13th Five-Year Plan period, energy efficiency improvements are an important strategy for coal control in the power sector. We shall attain the goal that the annual efficiency target should account for 0.6%—1% of total electricity consumption. During the 13th Five-Year Plan period, coal power capacity will be basically saturated and enough to meet China's demand for economic development in the future. During this period, blindly pursuing an increase in the proportion of coal-based power as a share of total coal consumption, or relieving the difficulties of the coal industry through joint management of coal mines and power plants, or encouraging more power generation through loose coal will increase the risk enterprises face in stranded assets. Moreover, approvals for coal gangue and low-heating value coal power generation projects should end. Before 2020, we will 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 standard coal/kWh in 2014 to 300 grams by 2020.

***Building industry:*** In 2012, the per-capita energy consumption for civil buildings was only 0.5 tons standard coal/m2, which is lower than the world average level of 0.6 ton standard coal/m2. In the future, building energy consumption will increase from about 22% of total energy consumption currently to 35%. By 2030, around 3.6 trillion yuan needs to be invested in the building sector to tap the huge energy-saving potential, by implementing various energy-saving projects for reducing emissions. So far, however, such investment is lacking.

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

(1) Propose building area caps for different periods based on urbanization level and new rural construction levels. By 2020, the building area cap should be set at 70 billion square meters or below. The excess over the building cap should be obtained by reducing existing building stock that is old, dangerous or dilapidated and replacing with new buildings.

(2) By 2020, the energy-saving design standard of new buildings in China shall be equivalent to 85% of the world advanced level, and 50% of new construction should be green buildings.

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

***Iron & steel industry:*** 2014 should be the peak/plateau period for iron and steel production. The industry should establish and improve policies on 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 the incompleteness of scrap exclamation policy and limited scrap steel resource, steel plants are not very enthusiastic about using scrap steel. The amount of accumulated scrap has been increasing year by year, but the scrap utilization rate has been on the decline for consecutive years. The major reason for continuous reductions in scrap consumption is that enterprises have paid more for using scrap than using iron ore, as iron ore prices have fallen. In 2014, iron and steel exports were around 100 million tons. In the long run, continuing such high exports is not conducive to dissolving overcapacity and may lead to international trade disputes.

Thus, exports of high-energy consumping iron and steel should be reduced in the future.

***Cement industry:*** 2016 should be the peak/plateau period for cement production, at 1.5 billion tons of clinker and 156 million tons of standard coal. In China, two-thirds of cities are surrounded by household waste, with a total quantity of waste up to 7 billion tons and land coverage of 750,000 mu (50,000 hecatres). In addition, it is still increasing at the rate of 9% per annum. The quantity of sludge generated from sewage plants has reached 6.5 million tons/year. Because cement kilns are able to use domestic garbage and sludge as a heat source and the the technical characteristics of calcining, cement kilns have inherent advantage in disposing of various wastes, reducing pollution and protecting the environment. Cement kiln co-disposal technology is recommended as a key measure for energy saving and emissions reductions in the cement sector. We should encourage and spread the use of cement kiln co-disposal technology in cement plants to around 600 large and medium-sized cities across the country in which conditions are favorable for undertaking such waste disposal and popularize it 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, to pursue world advanced levels for green, energy efficiency and environmental protection in the manufacturing sector by 2025. China can do so through eight energy efficiency projects, promoting four new source efficiency projects and implementing four existing end-use efficiency projects:

- Information communication technology: Application field includes intelligent power grid, intelligent building, intelligent logistics, fuel-efficient vehicles, industrial energy conservation, intelligent motor, alternative transportation and virtual service (communication, e-commerce, telecommuting, teleconferencing etc.).
- Internet-plus: Information exchange, big data computing and application can push forward the design, quality control and management of the manufacturing industry tremendously, reform the manufacturing process, inventory logistics procedures and user service, etc.
- Quality control technology: Chinese manufacturing industry features low and unstable quality. We should improve the product quality of the manufacturing industry, strive for low cost and high quality to be competitive in domestic and foreign markets.
- Green manufacturing based on design: Design products and equipment from the beginning with the goals of energy-saving, material-saving, reuse and recycling in mind.
- High-efficiency low-emission coal-fired industrial boilers: The thermal efficiency should reach 87%-90%, which can replace several hundred thousand low-efficiency boilers, with significant energy savings and emission reductions.
- High-efficiency electric motor: Based on reasonable economics and feasible technology, the average operating efficiency of China's motor systems can be increased by 15-20%, greatly reducing the gap with developed countries, with power-saving potential of 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 market entrance standards for efficient Chinese end-use energy-consumption products and energy-intensive industries.

# 8 PROMOTING ENERGY SYSTEM AND TECHNOLOGY REVOLUTION TO ACHIEVE THE COAL CAP

China's new wave of complete and deepened reform will push the country to develop its economy, environment, and society better and more sustainably. In terms of progress and effect, the reform in the energy sector lags behind that of other economic domains. China's most efficient energy technologies are at international medium-high level. Coal control – at the core of China's energy transition – needs to find opportunities and breakthroughs in China's energy revolution.

## 8.1 ENERGY SYSTEM REVOLUTION

Energy transition and coal control call for reform. Energy system revolution aims to improve and form an effective public governance structure. During the 13th Five Year Plan period, a government that produces will be transformed into one that produces and serves, fostering economic development and helping the country leap over the "middle income trap" in an effort to realize the goal of building a well-off society in an all-around way.

Table 20 lists the timetable for energy-related departments' reform in laws, institutions, and planning. The focus of overall reform includes establishing guiding principles, updating the governance system, introducing market mechanisms and rebuilding the regulatory system.

Reform of China's coal industry should aim at coal production control, marketization, and environmentally friendly and low carbon development. Producers and users who fail to meet environmental protection, ecology or safety standards should be forced to exit the market. Reform should also remove local pricing monopolies and any other protectionist actions, enabling market competition.

Since its promulgation in 1996, the Coal Law has been subject to a number of minor revisions without significant effect or complete implementation, and is unable to meet the current development situation. Under the backdrop of energy transition and coal control, the coal industry faces tremendous challenges; its development direction and path need a fundamental shift. Closely related to the coal cap, the Coal Law needs to be revised and adopted soon in order to support coal cap planning.

Agency reform: The energy regulating agency should observe the separation of administration and supervision. China is the world's largest energy producer and consumer, and also the biggest carbon emitter. China's energy system reform will have a big impact on its future energy development and even international energy markets. China should establish an Energy Ministry to serve as the key energy regulatory agency. The ministry should establish policy and

planning for energy supply, energy saving, and climate change under the authorization of the State Council. The National Energy Committee is the strategic policymaking body, while the Ministry of Energy would be its implementing agency. China should re-organize its agencies and establish an independent, authoritative, preofessional and effective energy regulatory agency, to manage electricity, natural gas networks and transportation, carbon markets and other related areas.

Establish a coal cap coordination mechanism. The creation of a coal cap coordination mechanism can guide the implementation of coal consumption control. Such a team can be led by the National Development and Reform Committee, and joined by 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.

Table 20: Timetable for revolution progress of energy system

| | 2015-2017 | 2017-2020 | 2020-2030 |
|---|---|---|---|
| Department laws | Revise coal law<br>Revise of power law<br>Draft climate change law<br>Draft natural gas law<br>Draft nuclear safety law<br>Draft energy law | Enact climate change law<br>Enact natural gas law<br>Enact law on nuclear safety<br>Enact energy law<br>Draft petroleum law | Improve energy law system and implementation mechanisms<br>Strictly manage and reform energy departments according to law<br>Enact petroleum law |
| Department reform | Further streamline administration and delegating power<br>Conduct power sector reform<br>Establish Ministry of Energy<br>Establish Energy Regulatory Committee<br>Initiate national carbon market<br>Initiate emission trading market | Reform energy pricing system<br>Reform energy market<br>Establish national carbon market<br>Consult and prepare to set up Asia energy security cooperation agency | Improve domestic energy market and supervisory system<br>Link domestic carbon market with international carbon markets<br>Effectively respond to energy security risks and develop international energy markets |
| Planning | Energy and coal consumption cap<br>Energy development strategic action plan<br>National climate change program<br>Energy-saving planning and targets<br>Total $CO_2$ emission and carbon intensity targets | "One Belt and One Road" infrastructure planning<br>Interim evaluation of 13th Five Year Plan energy targets<br>Assess coal consumption control targets | Achieve an early carbon emissions peak by 2025<br>Cap coal consumption at 3.6 billion tons in 2025 and 3.4 billion tons in 2030<br>Set national air quality $PM_{2.5}$ concentration target at around 35μg/$m^3$ in 2025 and 30 μg/$m^3$ in 2030 |

## 8.2 TECHNOLOGY REVOLUTION

Advance energy science and technology revolution. The government should strengthen the research around major scientific and technological issues; advance key technologies on energy conservation, resource recycling, new energy exploitation, pollution control, ecological restoration and beyond; and strive for breakthrough in basic research and cutting-edge technology research and development. Enterprises should be at the central position of technological innovation. The government should allow the market to choose and allocate resources for the green industry development paths and technology pathways.

Strengthen the enterprises' position of technological innovation as key players, and give full play to the market's decisive role in choosing the development direction of green industry and technology pathways. The current strategy of encouraging business start-ups and innovation is a good way to boost science and technology innovation.

Increase enterprise' international competitiveness through technical innovation. The coal cap will drive capital investment. Recent years have seen a significant increase in labor cost; China's cheap labor force and "demographic bonus" are disappearing. The government needs to encourage technological advancement, improve the quality of the labor force (7.27 million Chinese students graduated in 2014), strengthen labor force skills training to meet the needs of economic development, provide appropriate rank and wage for high-level technical personnel, advance technological innovation, invest in research and development, and foster and shape competitive advantages in all factors of the green economy. Technical innovation will be the main driver for achieving "Made in China 2025." Chinese manufacturing industry, in general, enjoys late-mover advantage in green technology and huge potential. It should keep learning, digest and innovate.

In 2014, China invested 2.5% of its GDP on research and development, while the share for the United States and other developed industrial nations was mostly over 2.5%. In Finland and Sweden, the share is as high as 3%-3.5%. The private sector has paid inadequate attention to R&D. As a result, the investment of Chinese manufacturing industry on R&D in 2012 accounted for only 1.6% in sales; 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 world-leading successes in industrial technology, but weak innovative capacity still makes China mostly rely on foreign import for core technologies. Though the Ministry of Finance does not prefer to have a fixed proportion of public expenditure to support a given plan or special 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 finance and taxation policies to incentivize private investment in R&D. For example, enterprises R&D investments' income tax deduction should be increased.

Research, development, and apply key coal control technologies. There are four main categories of key 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 coal to raw material (non-energy) utilization technology. To control

coal consumption, promote environmental governance and low-carbon development, China needs to widely adopt coal reduction technology and further develop coal replacement technology. Since coal will still maintain an important position in China's energy fix in the foreseeable future, the government should accelerate the development of clean coal technology and achieve clean and efficient use of coal. The development of energy conversion technologies (coal-to-liquids, coal-to-gas) should be extremely limited. For coal to raw material (non-energy) utilization technology, the government should only allow demonstration projects and small-scale promotion at this moment.

# 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 purposefully design applicable, effective and accountable safeguard measures.

## 9.1 FORMULATING AND IMPLEMENTING CO-CONTROL AND PLANNING

Coal control can be implemented in a coordinated way to yield significant co-benefits. The government should plan in a coordinated way the coal control effort at the national, sectoral, and sub-national levels. At the central level, the multi-stakeholder coal cap coordination team should make coordinated control planning, and focus on implementation.

Vertically, regions, provinces, and cities also need to form coal control coordination groups, in order to strengthen coordination. Relevant central government agencies and local agencies can work together and in coordination, increasing 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.

The total monetary value of the coal cap (including greenhouse gas emissions reductions) can reach 334.36 billion yuan in 2020 (see Table 21). Coal cap measures will create 1.3 million green jobs in energy-saving, environmental protection, clean energy and other fields, outnumbering the 350,000

jobs lost in coal mining, washing and coal-fired power generation under a coal cap. Indirect green jobs created by the coal control will also add up to several million jobs.

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, and Sichuan, Chongqing, Guizhou, Shanxi, Henan, Shandong, Anhui, Hubei, and Hunan provinces where air quality is the main constraint of coal consumption, the Ministry of Environmental Protection should lead the coordinated regional effort to curb coal consumption. In the northwestern provinces where water resource is the main constraint, the Ministry of Water Resources should take the lead. In the many industries in the manufacturing sector, industry associations should play an active role in the making of coal cap plans for coal-intensive industries.

When planning in coordination, 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 conditions, to support and ensure the effective implementation of coal control targets. We should emphasize practical results.

Table 21: Monetary Value of Coal Control Co-Benefits, 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 | Technological improvements | -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 REGULATIONS AS WELL AS 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 regulatory system with forceful enforcement and supervision elements. 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 have kept growing. Protecting the environment is a primary goal for coal control. Coal consumption and utilization are closely related to our air, water and land pollution, and coal control is a key measure for addressing the source of environmental pollution. Therefore, coal control 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 Intended Nationally Determined Contribution (INDC) submitted to the UNFCCC's 21st Conference of the Parties, the Chinese government made a commitment to peak its carbon emissions by 2030. Such a peak target requires coal control. More specifically, it asks the country to curb coal consumption at 3.8 billion tons by 2020, and 3.4 billion tons by 2030. To control global warming below 2C, China's 2050 per capita $CO_2$ emissions need to stay at around 2-3 tons, and coal consumption by then should be lowered to below 1.6 billion tons.

During the 13th Five Year Plan period, total carbon emission and carbon intensity should be controlled at the same time. Meanwhile, provinces and cities should also set their own carbon emission, carbon intensity and peaking targets. These objectives, together with air quality, water resource and pollutant emissions caps, can forcibly restrict coal consumption in regions, provinces and municipalities. With the dual engine of environmental protection and climate change, coal control can be beneficial to both endeavors.

## 9.3 FOSTERING A NATURAL GAS MARKET TO REPLACE COAL USE

In our proposed coal cap scheme, China's natural gas consumption will reach 360 billion cubic meters in 2020. China has guaranteed sources of natural gas supply, the volume of which is likely to grow. On the consumption end, however, growth has been slow, and 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 strictly control pollutant emissions. (3) Foster a natural gas consumption market through complete residential gas tier-pricing reform by 2017 and make natural gas more affordable. (4) Increase natural gas-fired power generation capacity to 100 GW by 2020,

and use it primarily for load following with an appropriate pricing mechanism. (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 the grid connection for combined natural gas heat and power. (8) Ban bulk coal burning for city center commercial and service industries, 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.

In addition to central government natural gas pricing policy, provinces should put natural gas market expansion on their agenda. Table 22 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 in total, China's 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 and compensate each other. The government must set favorable peak load natural gas prices to enable such development. Moreover, the government should encourage industries that are suitable to use natural gas and increase product quality – such as glass and enamel – to use natural gas instead of coal or gas converted from coal.

Table 22: Timetable for residential natural gas tier-pricing reform

| Time | Province, municipality and autonomous region |
|---|---|
| January-June 2016.1 | 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 the inter-provincial pipeline network, and the provincial governments should design policies to attract diversified investment to pipelines within their jurisdiction. In areas with serious air pollution, natural gas 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 coal-fired boilers with gas-fired boilers in cities.

Continue implementing effective policies on import VAT rebate for natural gas and resolve the current natural gas price inversion. China should gradually cancel current fiscal and taxation benefits for natural gas. However, given the domestic energy structure and the need to replace coal with natural gas, and without 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) with higher than domestic prices should enjoy VAT tax rebate in an amount that correlates to the

inversion between import and domestic prices. When natural gas prices are fully determined by the market, tax rebate policy should automatically become invalid.

Strengthen the financial and taxation 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 greatly promoted the exploitation and utilization of unconventional oil and gas resources. We should also increase financial support for investment in the 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 October 2015, the average coal price for 5500 kcal thermal coal in the Bohai rim was around 380 yuan/ton currently, and coal prices are still declining. The low coal price makes coal more competitive. Fossil fuel subsidies in China mainly consist of two parts: the first is that the government intervenes in the market and provides a subsidy to energy enterprises directly; the second is that the social externalities of fossil fuels are not internalized. The coal price is determined by competitive markets, but coal's social and environmental external cost is huge. Analysis by the China Coal Cap Project found that in 2012, the external cost of coal was 463 RMB/ton, while the current environmental tax on coal is only 40-50 RMB/ton and focuses mainly on its production. The fee paid for pollutant discharge 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.

China needs to further improve coal's pricing mechanism, especially by increasing the environmental tax level on coal consumption. China's residential power tier-pricing levels should be adjusted to reflect the true cost of coal. The government can also implement peak-valley power pricing in due time. For natural gas prices, the government should further develop policies for residential tier-pricing policy, while considering non-residential seasonal pricing and interruptible gas pricing. Comparing various power sources' Levelied Cost of Electricity[3] in 2014 (Table 23), coal's generation price was the lowest, yet its gap with clean power has quickly narrowed. If coal's external cost is accounted for in a higher environmental tax, and with the expanding capacity and technical development of clean energy, clean power will become very competitive.

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.

Table 23: 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<br>0.44 (External Cost) |

Note: 2020 coal price calculated by an annual 1% increase from 2015, and the corresponding external cost of coal is 50 RMB/ton.

## 9.4.2 RESOURCE PRICING

Resources are valuable, with their specific value is related to their involvement in social and economic activities. The Chinese government's current advocacy on "Blue water and skies are the real source of wealth" is a great reflection of the true value of ecosystem services. Air and water are essential components of social and economic production and have their values. The appreciation of these values should change with their contribution to society and economy over time as well as citizens' willingness to pay.

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%, and that in areas with adequate water areas 1%.

Currently, 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 stand 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 price 16%, all very low levels.

Before the end of 2016, the urban sewage disposal fee should be raised to, in principle, no less than 0.95 RMB/ton for residents and no less than 1.4 RMB/ton for non-residents. For the counties and key towns with 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 not reached 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 has not reflected the actual value of resources. It ignores the long-term effect of resource and environmental damage, encourages the damage and excessive consumption of the environment and resources, and is a root cause of current environmental woes, especially with regard to air quality, which is not listed in the government's resource catalogue. If we can set ascending prices on key resources, including the air, enterprises will reduce their harm to the resource and environment as soon as possible in order to prevent larger costs in the future. We recommend the government establish higher prices resources in the 13th Five-Year Plan for coal control, using resource pricing to achieve coal control and realize sustainable development.

### 9.4.3 FINANCIAL AND TAXATION POLICIES

***Reform taxes and fees on coal resources.*** On December 1, 2014, China's central government reformed the coal resource tax to be determined by coal prices rather than quantity. The range of the coal tax rate is 2%-10%, determined by provincial governments. In general, this reform of the coal resource tax has not achieved the hoped for results on coal control. Resource taxes should aim at incentivizing resource recovery rate and promoting green mining. The current tax regimes have failed to achieve such purposes. The government should further strengthen and improve the key function of the resource tax, to promote sustainable production and incentivize high quality clean coal supply.

***Improve the design of and levy 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 for air pollutants, and 1.4 RMB/unit of pollutant for water pollutants to 2.4 RMB/unit and 2.8 RMB/unit, respectively. We also recommend a moderate increase in the environmental tax levels on powdered coal ash, coal gangue and other solid waste. During the 13th Five Year Plan period, if the Ministry of Environmental Protection set total emissions control reduction targets for particles, VOCs and ammonia nitrogen, these pollutants should also be taxed. Appropriate pollution standards and discharge allowances should be studied and determined so the tax burden for polluters will in fact increase. Past low level taxes have allowed enterprises to enjoy de facto tax benefits when only achieving half of the pollution standards.

***Levy a carbon tax.*** The government should include the carbon tax in the environmental tax law, so it does not need to undergo a separate and difficult legislative process. Legislative resources are limited, yet our time for curbing carbon pollution is now. If incorporated into the environmental tax, the carbon tax has a chance to be adopted soon. 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 cannot replace each other, but can complement each other. The Carbon tax can be a supplementary means when the carbon pricing mechanism is ineffective, i.e., by setting the lowest price for carbon. The carbon tax and carbon trading are not mutually exclusive and have co-existed and been effective in foreign carbon policies. Enterprises participating in carbon trading should not be subject to carbon tax; while those that are not trading should be taxed. The government can conduct carbon tax pilots in existing carbon trading pilot provinces or conduct these separately. Pilot projects will harvest valuable experience and lessons, and settle the issues between the two policies.

China's carbon tax should start at a low rate, and increase progressively. The China Coal Cap Project recommends that the carbon tax can start at the range of 20-30 RMB/ton carbon dioxide. Its impact will vary in different industries, ranging from a higher level of impact to a lower level; the coal chemical industry, coal mining and washing, power industry, natural gas mining, non-ferrous metals, iron and steel, building material, paper-making, petrochemical industry will be affected. For bulk coal users (such as boilers and kilns) that are great in number and wide in range, the carbon tax will promote their active reduction in coal and emission. Coal to oil, coal to gas and other key coal-intensive energy conversion industries should bear a high carbon tax. Compared with the environmental tax, the carbon tax does not require expensive measurement equipment or transaction cost, and the administrative cost is very low.

***Cancel coal import tariff.*** In the long run, the coal import tariff hinders the competition and linkage between domestic and international coal markets. We recommend canceling the coal

import tariff, while putting forward compulsory quality requirements for imported coal. The purpose of free trade agreements lies in promoting economy integrity, eliminating trade barriers and allowing free flow of products and services among countries. The government should connect China with Asian and global energy markets to increase our product competitiveness, rather than set obstacles to hinder the integrated Asian energy market.

***Formulating financial and taxation policies to promote clean coal utilization technology adoption.*** The key clean coal technologies that should receive incentives for their development and deployment are: ultra-super-critical power generation technology, large circulating fluidized bed, integrated gasification combined cycle technology, flue gas desulfurization technology, carbon capture, utilization and storage (CCUS), etc. The government should include clean coal technology into the country's key technological advancement projects, and allow it to enjoy special loans for energy saving and loans enabling enterprises' 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 as well as financial support should be given to key imported technologies, equipment technologies, and demonstration projects. Enterprises purchasing clean coal generation and other production facilities should enjoy corporate income tax credit; and those importing such facilities should receive tariff exemptions. Commercialized clean coal projects should be included as environmental protection projects under the corporate income tax category, and enjoy income tax exemption for three years and half exemption for another three years.

### 9.4.4 INVESTMENT AND FINANCIAL INSTRUMENTS

Investment is an important condition to achieve the coal cap. It is estimated that during the 13th Five Year Plan period, energy saving, coal clean utilization and alternative energy targets will require around 3.758 trillion RMB of investment, 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 yet another 2-3 trillion RMB. The massive capital needs for coal control can drive economic growth. Implementing coal control requires diversified investment, and open investment policies for nuclear power, grid, and oil and gas resources.

Based on the financing needs for coal reduction, cleaning and substitution, the China Coal Cap Project puts forward a coal control financial support framework and green credit scheme, to reduce industrial excess capacity and lower the capital risk for the financial sector. We also propose suggestions on financial opportunities and risk aversion arising from national strategic objectives in emission reduction and coal control. We will formulate an investment risk assessment mechanism and highlight risky coal industries and enterprises. Our analysis shows that if the coal industry's credit is significantly reduced to 16 billion RMB annually, China's coal production will consequently drop to 3.7 billion tons, which will – from the supply side – indirectly contribute to the coal consumption cap of 3.8 billion tons.

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

Accelerate the development of and improve China's green bond market system. 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 and improve a green insurance market, build an environmental pollution risk management database and improve the environmental capital cost of coal-related industries. Listed companies must disclose information on environmental and carbon emission. When the time is ripe, financial authorities should require mandatory insurance for potential polluters.

The government should establish a policy-based green financial institution and strengthen green finance intermediary agencies. Learning from international experience, special policy-based green financial institutions such as a "green bank" or "ecological bank" 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 distributed PV utilization. Internet financial service can help suppliers reduce intermediate trading links, reduce the financing costs of end users, accelerate the integration of the industrial chain and promote the rapid development of the PV industry.

## 9.5 COAL ENTERPRISE EXIT MECHANISM AND INDUSTRY TRANSITION

Improve the ecological protection compensation mechanism. With the current financial and taxation reform, the government should improve the transfer payment system and increase the ecological transfer protection fund used for ecological restoration in old coal bases, to repay the "ecological debt" these bases owe from past decades. The government should encourage local industry upgrade, capacity transfer, new industry development, and the training of laid-off workers. It also needs to establish independent and just environmental damage assessment and restoration evaluation systems so that ecological restoration is done right. China should adhere to the "who develops, protects; who damages, remedies; who benefits, compensages; who pollutes, pays," principles, in order to remedy the long-term environmental deficit 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 the 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 a smaller production capacity by 2020, the share of scientific capacity – determined by safety, environmental sustainability, efficiency, and other seven indexes – can reach 74%; and that share will continue to rise to 100% by 2030.

The central government's taxation and financial support can help establish mechanisms to aid coal mining enterprises' smooth exit, 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 coal cap policies. The government should also strive to break local protectionism and market monopoly, and introduce marketization to coal companies. Industrial policies should push for small coal companies' merge and acquisition, 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 coal storage so as to minimize 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.

The central government should strengthen coal workers' re-employment policies. A coal production cap will directly impact coal mining and washing industries, resulting in reduced and eliminated job opportunities. By 2020, the job losses mmay reach 671,000 and 191,000, respectively.[4] During the 13th Five Year Plan period, based on State Council jobs and enterprise policies, fiscal and taxation policies should be strengthened and implemented to to help coal workers that have lost their jobs to be re-employed.

## 9.6 EVALUATION INDEX AND PERFORMANCE ASSESSMENT

Coal control'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 statistical system and institution on climate change preliminarily established a national, sub-national, and sectoral three-level emission accounting system for greenhouse gases; its coal-related content should be reported separately.

Based on the requirement for ecological civilization construction, the government should establish a sound official performance assessment system with specific coal control objectives, assessment measures, and a reward and punishment mechanism. Such an evaluation system should also incorporate and increase the weight placed resource consumption, environmental damage, and ecological benefit, making them hard targets for government officials. The central government should also improve performance assessment method and design differentiated evaluations for officials in different ministries and locations. Regions, units, and individuals with outstanding achievements should be rewarded. Based on the calculations from the true cost of coal, coal resource balance sheet and social loss sheet can aid the evaluation on coal control targets. Please see Attachment 10 for a proposed coal cap performance evaluation index.

Government leaders and Party members are the key for implementing environmental protection. Following the limit of resource consumption, the bottom line of environmental quality, and the redline for environmental protection, the government should specify cadres' responsibilities during the decision-making, implementation and supervision of coal control, and 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. In places with serious environmental deterioration, relevant departments' officials and staff should be hold accountable.

4.These job loss estimates include those from increased labor productivity and coal mining closures and mergers. See the report on the "Analysis of the Coal Consumption Cap on the Coal Industry," Coal Research Institute, June 10, 2015. The direct job losses from a coal cap would be 310,000 persons, see Table 7.

# 10 PUBLIC PARTICIPATION

The Chinese government has established a series of resource, environmental and ecological laws and regulations. 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 these laws.

Enterprises are the main actor for environmental protection. The government should support and acknowledge low-carbon alliances, energy-saving pioneers and other self-organized social groups. Chinese companies need to increase social responsibility awareness and practice, 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 initiating new laws and policies and their implementation. The energy sector witnesses a significant amount of undemocratic procedures, lack of transparency, and unpublicized mandate during 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 hearing views from a wide audience, and resolve concerned, contested, and challenging issues through discussion, negotiation, and research. Furthermore, public interest litigation should be a key piece in environmental protection, 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. China's current pace of consumption would require double the resource endowment of what it possesses, and such a pace has seen no sign of decrease. Government policies and expenditure should support "setting 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 NGO initiatives focusing on environmental protection and public participation. The government should also support "C+ climate citizens beyond action," an initiative by some 30 domestic and international NGOs to encourage citizens of different walks of life to take actions addressing climate change.

The media should discover and acknowledge grassroots individual campaigns on climate action. China's current development and energy structure transitions coincide with high environmental pollution. Sensitive media's in-depth report can help coal control implementation, and gather more effective solutions for the government, enterprises, social organizations as well as 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 transition. In international energy cooperation, China needs to advocate for a new perspective on energy security that is inclusive, transparent, cooperative, and win-win. It will allow China to 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 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 producing, consuming, and transiting countries. 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 the new trend. The International Energy Agency, established under OECD, has no other developing country other than Turkey as formal members, and hence cannot represent the current global energy governance structure. With the 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 successful experience from existing energy governance systems, and strengthen the exchange of energy technology and information among member countries. When market needs arise, it should enable negotiations to maintain energy market stability. It should also play an active role in China's "One Belt and One Road" energy infrastructure initiative. The agency needs to cooperate with the existing energy governance structure, safeguarding energy supply and preventing price manipulation.

China should take the lead in the advance discussion and preparation of the 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 developed into maturity, 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 |
| Chinese Academy for Environmental Planning |
| 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: Research Steering Committee Members

| | |
|---|---|
| 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<br>HU Zhaoguang, Vice President, State Grid Energy Research Institute |
| 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: International Partners

| | |
|---|---|
| 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, Public Health and Social Cost of Coal Production, Transport 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 Economic and Energy Sector 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 | 7.0 |
| GDP (in trillions of yuan) | 1.8774 | 9.9776 | 1.85895 | 4.08913 | 5.88018 | 6.36462 | 9.55157 |
| 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 | 39 |
| Tertiary Industry | 32.4 | 39.8 | 41.4 | 44.2 | 46.9 | 48.2 | 54 |
| Per capita GDP (in U.S. dollars) | 344 | 949 | 1805 | 4433 | 6807 | 7575 | 10773 |
| Primary Energy Consumption (Mtce) | 987 | 1469.4 | 2613.7 | 3606.5 | 4169.1 | 4260 | 4744 |
| Per Capita Energy Consumption(Kgce) | 864 | 1148 | 1805 | 2426 | 2756 | 3114 | 3451 |
| Coal Consumption (Mtce) | 752 | 1006.5 | 1892.3 | 2536.2 | 2810 | 2811.6 | 2720 |
| Percentage of Coal Accounting for China's Energy Needs | 76.2 | 68.5 | 72.4 | 69.2 | 67.4 | 66 | 57.3 |
| Amount of Coal Produced (Mt) | 771.1 | 1010.2 | 1772.7 | 2378.3 | 2705.2 | 2635.2 | 3700 |
| 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 | 1920 |
| Generating Capacity (TWh) | 621.2 | 1355.6 | 2500.3 | 4207.1 | 5431.6 | 5649.6 | 7470 |
| Steel Production (Mt) | 51.21 | 131.46 | 377.71 | 802.77 | 1082.01 | 1125.57 | 741.0 |
| Crude Steel Output (Mt) | 66.35 | 128.50 | 353.24 | 637.23 | 813.14 | 822.7 | 780.0 |
| Pig Iron Production (Mt) | 62.38 | 131.02 | 343.75. | 597.33 | 711.5 | 711.6 | 688.0 |
| Cement Production (Mt) | 209.7 | 579 | 1068.9 | 1881.9 | 2416.12 | 2476.1 | 2500 |
| Plate Glass (Millions of boxes produced) | 8067 | 18352.2 | 40210.2 | 66330.8 | 79285.8 | 79261.7 | 8100 |
| 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 | 6.45 |

Sources: "2015 China Statistical Yearbook Summary," China Statistics Press, June 2015; "2015 Energy Data," edited by Wang Qing, August 2015; "China Total Coal Consumption Control Report," January 2015.

## Appendix 3: Key Comparisons between the Energy and Environmental Goals of the"12th Five Year Plan" and the "13th Five Year Plan"

| Goal | 12th Five Year Plan's Target (%) | 13th Five Year Plan Target (%) | 13th Five Year Plan Annual Reduction(%) |
|---|---|---|---|
| Energy | | | |
| Reduce Energy Intensity (%) | 16.0 | 18 | 3.9 |
| Reduce Carbon Intensity (%) | 17.0 | 20 | 4.4 |
| Proportion of Non-Fossil Fuel Energy Sources (%) | 11.4 | 15 | 5.6 |
| Total Coal Production Cap (billion tons) | - | 37 | |
| Pollution | | | |
| Reduce CO2 (%) | 8.0 | 17 | 3.7 |
| Reduce Chemical Oxygen Demand (COD) (%) | 8.0 | 14 | 3 |
| Reduce Ammonia (in water) (%) | 10.0 | 15 | 3.2 |
| Reduce Nitrogen Oxides (%) | 10.0 | 16 | 4.6 |
| Reduce Atmospheric Particulate Matter (%) | - | 24 | 5.6 |
| Reduce Volatile Organic Compounds (VOCs) (%) | - | 18 | 3.9 |
| Reduce Ammonia (in the air) (%) | - | 21 | 5 |
| Water | | | |
| Water Consumption per Unit Industrial Added Value (tons of water per 10,000 RMB) | 30.0 | 30 (Based on 2013 levels) | 5.0 |
| Water Consumption Per Unit Gross Domestic Product (GDP) (tons of water per 10,000 RMB) | - | 35 (Based on 2013 levels) | 6.0 |
| Forests (Increase) | | | |
| Forest Coverage Rate (%) | 21.7 | 24 | |
| Forest Cover | | Increase of 40 million hectares (based on 2005 levels) | |
| Forest Volume | | Increase of 3 billion square meters (based on 2005 levels) | |

## Appendix 4: China's Provinces' and Cities' Total Coal Consumption Cap Plans

| Province (or City) | Coal Cap Goal | Province (or City) | Coal Cap Goal |
|---|---|---|---|
| Beijing | Reduce coal consumption by 13 million tons starting from 2012 to 2017; establish a coal consumption cap 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 | By 2017, establish a total coal consumption cap for the entire province at 300.93 million tons. Compared with the total coal consumption amount in 2012 (tons), this represents a decrease in coal consumption. By 2017, the coal should account for 65% or less of total energy needs. |
| Shanxi Province | By 2017, establish a total coal consumption cap for the entire province at, or below, 138 million tons. Compared to 2014, the cities from this province 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% of energy needs. | Liaoning Province | By 2017, establish a total coal consumption cap at, or below, 201 million tons; increase the use of natural gas to 10 billion cubic meters, which will account for 6% of the province's energy needs. |
| Zhejiang Province | Establish a total coal consumption cap at, or below, 144 million tons. Compared with the total amount of coal consumption in 2012, this represents a decrease in coal consumption. In the future, coal should account for 44.1% or less of total energy needs. | Tianjin | Compared with coal consumption in 2012, in 2017, the city will reduce total coal consumption by 10 million tons, which means coal will account for 65% or less of total energy needs. |
| 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 essentially be powered by natural gas. | Shandong Province | By 2017 total coal consumption will decrease by 20 million tons (compared to 2012 consumption values). Coal will account for 60% or less of total energy needs. |
| Chongqing Province | The province's total coal consumption cap for 2017 is set at 53 million tons of standard coal. 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 | By 2015 the total coal consumption cap will be at 210 million tons of standard coal. | Xinjiang Province | By 2017, Urumqi's city cluster will achieve zero-growth in total coal consumption |
| Henan Province | Compared with 2012 total coal consumption levels, by 2017 the province will reduce total coal consumption by 20 million tons. 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 | Compared with 2012 total coal consumption levels, by 2017 the province will reduce total coal consumption by 40 million tons. | 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 | Establish a total coal consumption cap for the entire city at, or below, 29.14 million tons. In 2015, have a total coal consumption cap for the entire city at, or below, 32.11 million tons. In 2016, have a total coal consumption cap at 30.89 million tons.<br>In 2015, the total GDP per energy consumption fell to 0.5 tons of standard coal. By 2017, 6% of the city's energy needs will be met by new energy and renewable energy resources. | Ningbo | Establish a total coal consumption cap at 10.4985 million tons. By 2017, reach a goal of 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) | Establish a total coal consumption cap at 19.31 million tons. In 2015, the total coal consumption cap is 18.67 million tons; in 2016 the coal cap will be at 18.98 million tons.<br>The average annual growth rate of natural gas consumption will remain at 15%. | Qingdao | Compared to 2016, in 2017 the city will reduce its coal consumption by 1.51 million tons.<br>(The projected coal consumption in 2016 will be 3 million tons less than the coal consumption value in 2012.) By 2016, 10% of the city's energy needs will be met by clean energy resources. |
| Nantong | Establish a total coal consumption cap 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.<br>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.<br>Reduce the city's reliance on coal by 21%. |
| Cangzhou | Compared with 2012 coal consumption values, by 2017 there will be a 2 million ton increase in coal consumption (this increase is largely due to the relocation of a steel factory) to the city.<br>By 2015, achieve a net reduction of 300,000 tons of coal consumed. | Shenyang | Coal consumption reduces each year, with the increase in new coal consumption less than the reduction of existing coal consumption.<br>Each year, the scale of the city's clean energy and renewable energy sector has increased by 3%. |

| | | | |
|---|---|---|---|
| Ningxia | By the end of 2017, the proportion of energy needs met by coal will be on the decline. By 2020, new energy will account for 15% of the region's energy needs. | Yinchuan | By 2017, the proportion of coal consumption will be on the decrease. 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 | Compared to 2012 coal consumption values, in 2017 there will be zero-growth in coal consumption. 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. | Jiangxi Province | By 2017, coal consumption will be on the decline in Nanchang and Jiujiang. 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 | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 25.60 million tons. | Langfang | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 4.5 million tons. |
| Shijiazhuang | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 15 million tons. | Hengshui | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 1 million tons. |
| Qinhuangdao | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 6 million tons. | Jinan | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 1.3 million tons. |
| Handan | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 16.70 million tons. | Zhuzhou | By 2017, 65% or less of the city's energy needs will come from coal. |
| Baoding | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 2.5 million tons. | Hefei | The city will take progressive steps to reduce coal consumption. |
| Xingtai | Compared to the coal consumption amount in 2012, by 2017 coal consumption will be reduced by 2.5 million tons. | Suzhou | Compared to 2013 values, the city will reduce its coal consumption amount by 2 million tons. |
| Taiyuan | 45% or less of the city's energy needs will be met by coal. | Xi'an | By 2016, 95% of the city's energy needs will be met by gas. |

## Appendix 5: China's Provinces, Cities, and Autonomous Regions Natural Resources and Ecological "Red Line" Constraints under the 13th Fifth Year Plan

| Area | $PM_{2.5}$ Concentration Target ($\mu g/m^3$) | Total Water Use (100 million $m^3$) | Total Coal 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: China's Provinces, Cities, and Autonomous Regions Energy Intensity Targets, Carbon Intensity Targets, Renewable Energy Quotas, and Renewable Energy Heating Supply Targets in the 13th Fifth Year Plan

| Area | Energy Intensity (%) | Carbon Intensity (%) | Renewable Energy Quota (%) | Renewable Heating (in 10,000 tons standard coal) |
|---|---|---|---|---|
| Beijing | 19 | 22 | 15.8 | 198.54 |
| Tianjin | 20 | 22 | 15.8 | 133.2 |
| Hebei | 20 | 22 | 13.6 | 640.19 |
| Shanxi | 15 | 18.5 | 13.6 | 357.98 |
| Inner Mongolia | 18 | 19.5 | 14.6 | 311.58 |
| Liaoning | 19 | 22 | 14.6 | 484.25 |
| Jilin | 18 | 20 | 12.6 | 272.85 |
| Heilongjiang | 18 | 19.5 | 12.6 | 439.02 |
| Shanghai | 20 | 22 | 15.8 | *38.58 |
| Jiangsu | 20 | 22 | 15.8 | *111.98 |
| Zhejiang | 19 | 22 | 15.8 | *82.55 |
| Anhui | 17 | 19 | 13.6 | *59.96 |
| Fujian | 18 | 20 | 15.8 | *35.71 |
| Jiangxi | 18 | 19 | 13.6 | *57.35 |
| Shandong | 19 | 22 | 15.8 | 1077.08 |
| Henan | 18 | 19 | 13.6 | 1043.78 |
| Hubei | 18 | 20 | 14.6 | *67.16 |
| Hunan | 18 | 19 | 14.6 | *89.14 |
| Guangdong | 20 | 22 | 15.8 | *101.05 |
| Guangxi | 17 | 18.5 | 13.6 | *34.4 |
| Hainan | 15 | 18.5 | 14.6 | *5.74 |
| Chongqing | 19 | 20 | 15.8 | *35.04 |
| Sichuan | 18 | 19.5 | 15.8 | *79.96 |
| Guizhou | 17 | 18.5 | 13.6 | *28.54 |
| Yunnan | 16 | 18.5 | 12.6 | *28.21 |
| Tibet | 5 | 6 | 11.4 | - |
| Shaanxi | 18 | 20 | - | 378.45 |
| Ganxu | 16 | 18.5 | 11.4 | 283.23 |
| Qinghai | 10 | 12 | 11.4 | 58.05 |
| Ningxia | 10 | 12 | 11.4 | 60.3 |
| Xinjiang | 5 | 6 | 14.6 | 245.82 |

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

## Appendix 7: China's Provinces, Cities, and Autonomous Regions Air Pollution Emissions Reduction Goals

| Area | Sulfur Dioxid | Nitrogen Oxides | Particulate Matter ($PM_{2.5}$) | Ammonia | 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 | Municipalities | Low | 4 | 2017 | Chongqing, Tianjin, Shanghai, Beijing |
| 2 | A-I | Megacities | Low | 20 | 2017 | Nanjing, Jinan, Xi'an, Changchun, Huai'an, Qingyuan, Wuhan, Dalian, Shenyang, Suzhou, Hangzhou, Chengdu, Xiamen, Hefei, Nanning, Dongguan, Foshan, Guangzhou, Shantou, Shenzhen |
| 3 | A-2 | Megacities | Medium | 7 | 2020 | Urumqi, Zibo, Anshan, Harbin, Kunming, Xuzhou, Zhengzhou |
| 4 | A-3 | Megacities | High | 2 | 2020 | Taiyuan, Tangshan |
| 5 | B-I | Large cities | Low | 59 | 2017 | Xiangyang, Guigang, Yiyang, 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 |
| 6 | B-2 | Large cities | Medium | 32 | 2020 | Pingdingshan, Jining, Wuwei, Rizhao, Qiqihar, Xinxiang, Shijiazhuang, Guang'an, Linyi, Xining, Liaocheng, Fushun, Baoji, Jinzhou, Leshan, Jilin, Daqing, Nanyang, Ezhou, Yichang, Tai'an, Heze, Weifang, Neijiang, Shangqiu, Yonzhou, Zhuzhou, Xinyang, Luohe, Hengyang, Kaifeng |
| 7 | B-3 | Large cities | High | II | 2020 | Laiwu, Baotou, Datong, Handan, Yinchuan, Hohhot, Anyang, Chifeng, Lanzhou, Guiyang, Zaozhuang |
| 8 | C-I | Medium-sized cities | Low | 38 | 2020 | 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 |
| 9 | C-2 | Medium-sized cities | Medium | 43 | 2020 | 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, Puyang, Hebi, Shaoyang, Yueyang, Zhumadian, Zhoukou |
| I0 | C-3 | Medium-sized cities | High | 3I | 2020 | 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 |
| II | D-I | Small cities | Low | I8 | 2025 | 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 |
| I2 | D-2 | Small cities | Medium | I4 | 2025 | Liaoyuan, Jinchang, Huludao, Lijiang, Karamay, Dazhou, Pu'er, Sanming, Chongzuo, Lincang, Heihe, Xuchang, Huaihua, Sanmenxia |
| I3 | D-3 | Small cities | High | I4 | 2025 | Wuzhong, Zhongwei, Tongren, Jiayuguan, Luliang, Loudi, Wulanchabu, Jincheng, Miao and Dong Autonomous Prefecture, Tonghua, Hulunbeier, Baise, Qiannan Buyi and Miao Autonomous Prefecture, Sanmenxia |

## Appendix 9: A Comparison of Energy Intensive 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. The overall energy use for the production of Chinese and foreign products is calculated assuming electricity is generated by standard coal-fired plants.

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 from 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's standard.

7. Calculations for total energy used in cement production are based on cement clinker production and total electricity used in cement production, assuming electricity from coal-fired power plants. The international advanced level energy use standard is based on Japan's standard. 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 standard.

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's standards. The primary raw material used in ethylene production is ethane (C2H6).

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 to power large, medium, and small-sized enterprises. In 2012, 76% of all synthetic ammonia was produced from coal-generated power, while 22% of synthetic ammonia was produced from natural gas. The international advanced level energy use standard is based on the United States standard, 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 System Table

| 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 SO2 Emissions | |
| | | | Reduction in Total NOX 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 | |

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|---|---|---|---|---|
| | 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 |