Study on Economics of Coal-fired Power Generation Projects in China

By Coal Power Economics Study Group of North China Electric Power University

Report Briefing

After analyzing the thermal-power (coal-power) related phenomenon and data of the power sector in 2015, the mismatching of use and resources remains complex. With a 2.3% annual drop in thermal power generation and only 0.5% growth in total electricity consumption, the addition of installed capacity of coal-fired plants is incompatible with demand at 52,000 megawatts (MW) capacity. This has been shown by independent analyses from both Greenpeace and the CoalSwarm Project, indicating that there is approximately 73-79 GW capacity currently under construction, which collectively represents significant growth compared to increases recorded in the previous year. Such discord in supply and demand is further illustrated by the total installed capacity of coal-fired plant projects under the Environment Impact Assessment (EIA) approval announced by either Ministry of Environment Protection or its provincial counterparts in 2015. The total capacity announced amounts to 169GW, of which 159GW has been granted or pre-granted the EIA approval. This represents a significant increase when compared with the total EIA-approved installed capacity for the same period in the preceding year—which was 48GW. Additionally, the annual thermal power utilization hours are only 4,329 hours, which is down 410 hours year-on-year, and the lowest since 1969. With these weak demands, over-capacity, and declining operational efficiency, the thermal power sector—especially the coal power sector—appears to take advantage of this apparent imbalance between the coal price and tariff to continue to reap high profits. In March of 2016, the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) jointly issued a critical document to urge all local governments and enterprises to slow the pace in coal-fired power construction in order to cope with the increasingly severe situation of over-capacity and to alleviate the operational risks in the energy industry created as a result. However, despite these efforts, severe coal power over-capacity has continued to occur mainly due to two reasons. On one hand, since January 2014 to March 2015, the approval authorization of all projects for regular coal-fired power generation plants were delegated to provincial institutions from the NEA, the NDRC and the Ministry of Environmental Protection (MEP) respectively. On the other hand, guaranteed investment return fueled by the obvious economic advantages of coal power, the current low coal price and the high on-grid tariff has facilitated the growth of the addition of installed capacity of coal power well in excess of actual needs.

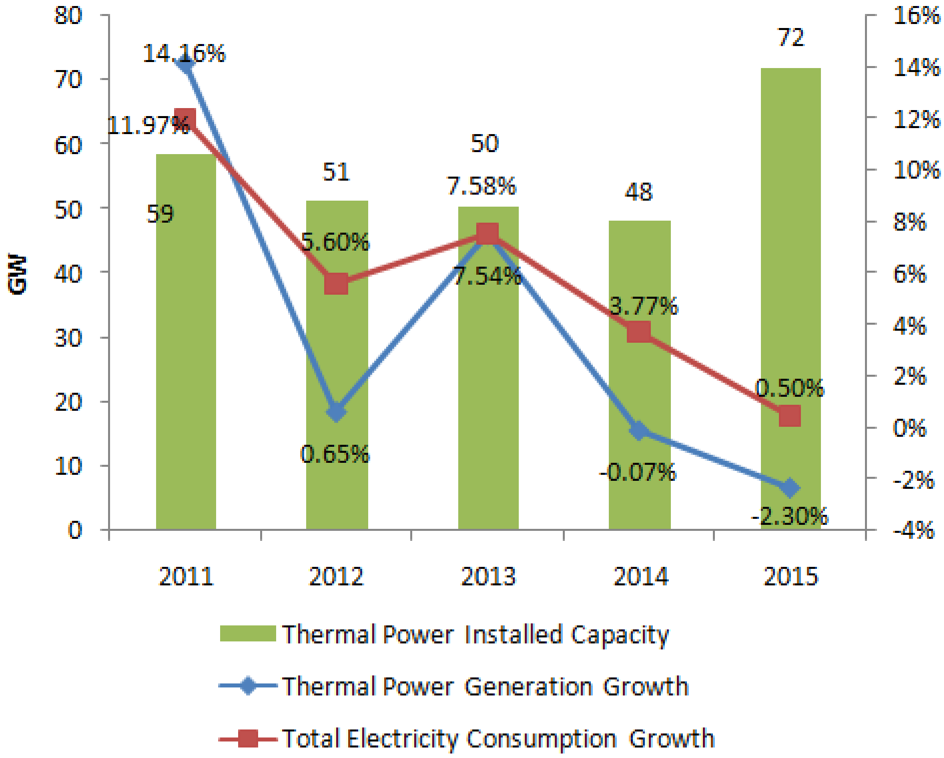

Figure 1: Addition of Thermal Power Installed Capacity, Power Generation Capacity Growth and Total Electricity Consumption Growth during the "12th Five-year-plan (FYP)" Period

However, despite the current state of the energy sector, the performance and profitability of the thermal power sector is not necessarily "good for every enterprise", and discrepancies are apparent between provinces. In 2015, the thermal power utilization hours of Yunnan, a province well-known for its rich resources in hydro power, were recorded at only 1,879 hours, while hours in Sichuan measured 2,682. Additionally, in Gansu, a province rich in resources of new energy, less than 3,800 hours are in record, while Jilin documented only 3,300 hours. In these provinces, the coal power sector fell below the break-even point more rapidly than in other areas. This Report mainly assesses the economics of the coal-fired power generation projects in six provinces, namely Shanxi, Inner Mongolia, Xinjiang, Hebei, Jiangsu and Guangdong. Selection of these particular provinces is based on the abundance of coal power or status as the load centers, with large portions of the coal-fired generation projects under construction or newly approved, and with thermal power utilization hours in 2015 at or even higher than the national average level. These provinces also represent those with relatively good economies in coal-fired power generation projects in China at present.

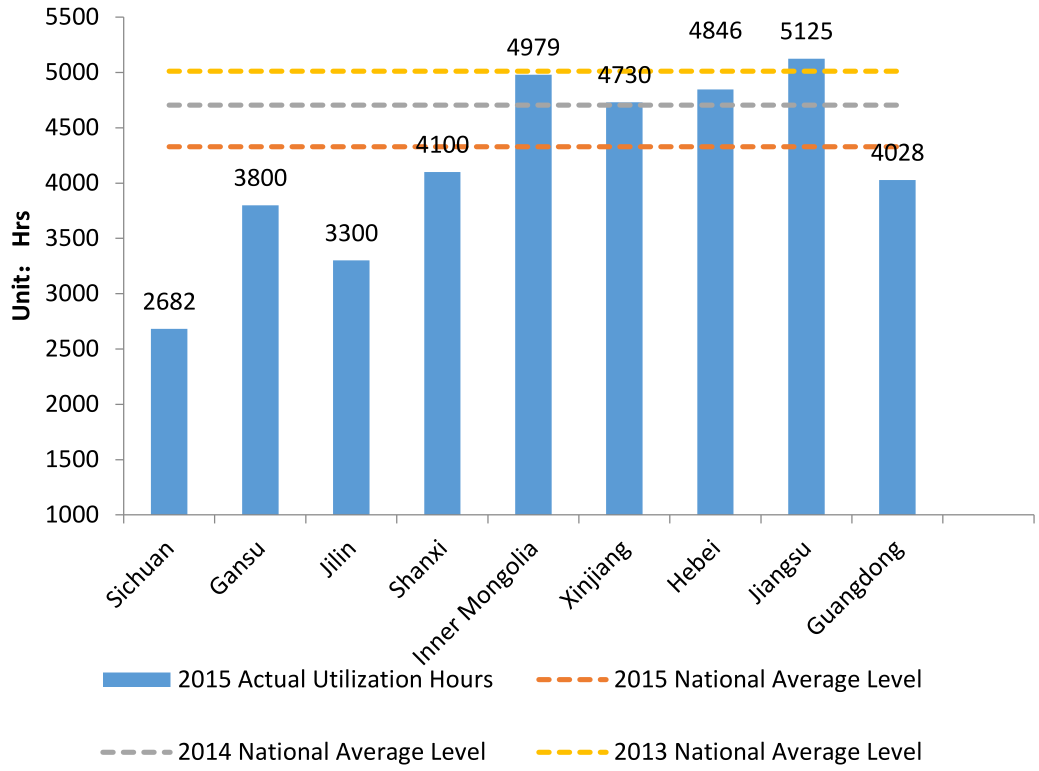

Figure 2: Comparison Diagram between the Current Status of Thermal Power Utilization Hours of Typical Provinces and the National Average Level

Comparing with the actual benchmark on-grid tariff in 2015, in a scenario where the utilization hours of coal-fired power generation projects in these six provinces continues to decrease, the benchmark tariff will remain higher than the levelized cost of electricity (LCOE), and seems to have relatively good profitability. As to the actual coal power profitability trend, one question remains: Is it still possible to recoup investments if we continue to expand the construction of coal power? This Report seeks to analyze and discuss issues regarding this problem. Specifically, this report is aimed at providing systematic, detailed, technical and economic evaluations to governing authorities and the power industry in support for policy formulation and investment decision-making.

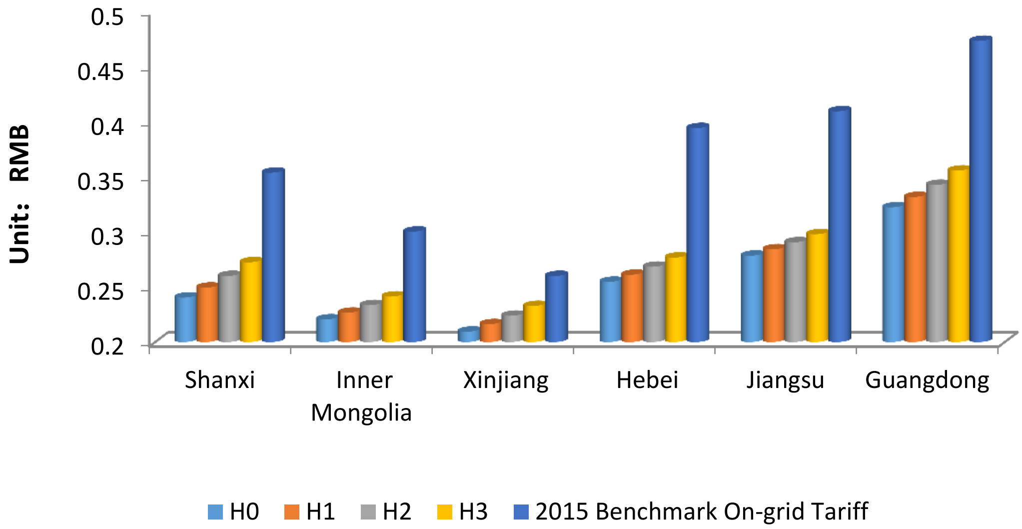

Figure 3: Changing trend of LCOE in the Scenario of Continuous Falling of Utilization Hours in Six Typical Provinces

Note: H0: LCOE under Actual Utilization Hours in 2015; H1: LCOE if the Utilization Hours Reduce 300 hours; H2: LCOE if the Utilization Hours Reduce 600 hours; H3: LCOE if the Utilization Hours Reduce 900 hours

This report adopts the LCOE model and the financial appraisal methods for engineering projects. The report surveys the economics of the 600 MW newly-built pure condensing coal-fired power units in different provinces and under multiple scenarios. Furthermore, this report attempts to explain the micro-economic explanations behind the disparate and perplexing data. This report adopts the step-up accumulation methodology against the expected change in the external environment for coal power development to construct scenarios and anticipate the sequence and order of events based on the probability and timing for the realization of each scenario. In doing so, this report first takes into consideration the national on-grid tariff adjustment plan and the retrofitting requirements for the ultra-low emission of coal-fired plants that are currently in place. The report further seeks to include the carbon trading market expected to launch in 2017 as well as continued electricity marketization reform and the possibility of the rebound of coal price. Thus, this report focuses on providing a systematic outlook over the economic benefits of coal power generation companies under the predictable change in the external development environment during the “13th FYP” period (i.e., such as the electricity market competition and the continuous deterioration of the units utilization rate).

The findings of this report are as follows:

(1) The continuous falling coal prices have lowered the power generation costs of the coal power companies across all provinces. There has been insufficient adjustment to the benchmark on-grid tariff, enabling coal power generation companies to obtain unprecedented excess profits.

Comparing the current benchmark on-grid tariff and LCOE of all provinces, excess profits per kWh of typical provinces (except for RMB0.02-0.03 in Inner Mongolia and Xinjiang) are within RMB0.05-0.08. Such excess profits have caused acceleration in the investment interest of coal power generation companies and caused local government to over-rely on coal power under the economic downturn pressure. This, in turn, boosts the contrarian investment in coal power generation companies. This report show that, in the context of the sharp fall of demands and the low-carbon transformation and upgrading, such conflict is the main economic reason for the "unabated interest" of coal power investors.

(2) However, this profitability is not sustainable in the long-term. If the power generation enterprises make decisions regarding capacity expansion based on short-term profitability, they will be exposed to the long-term risks of incurring losses and failure to recoup their investment in the future. During the 13th FYP period, the external environment for coal power development could change greatly, and the economics of coal power generation companies will be heavily affected.

Facing more stringent policy and environment restraint, increasing carbon emission pressure and intensifying price competition under electricity marketization, except for Hebei and Jiangsu, the coal-fired power generation projects in the remaining typical provinces cannot reach benchmark rates of return. They are, therefore, unable to recoup their investment during their life time. Additionally, if we further consider the change of two sensitivity factors, namely the unit utilization rate and the degree of reduction in tariff for direct power purchase, the coal-fired power generation projects in all selected typical provinces will be unable to recoup their investment during their life time and their investment prospect is bleak. The chart below shows the change of full investment IRR in the coal-fired power generation projects in each typical province from Scenario 1 to Scenario 4-Assumption 1 (please see the specific definition in the body of the report).

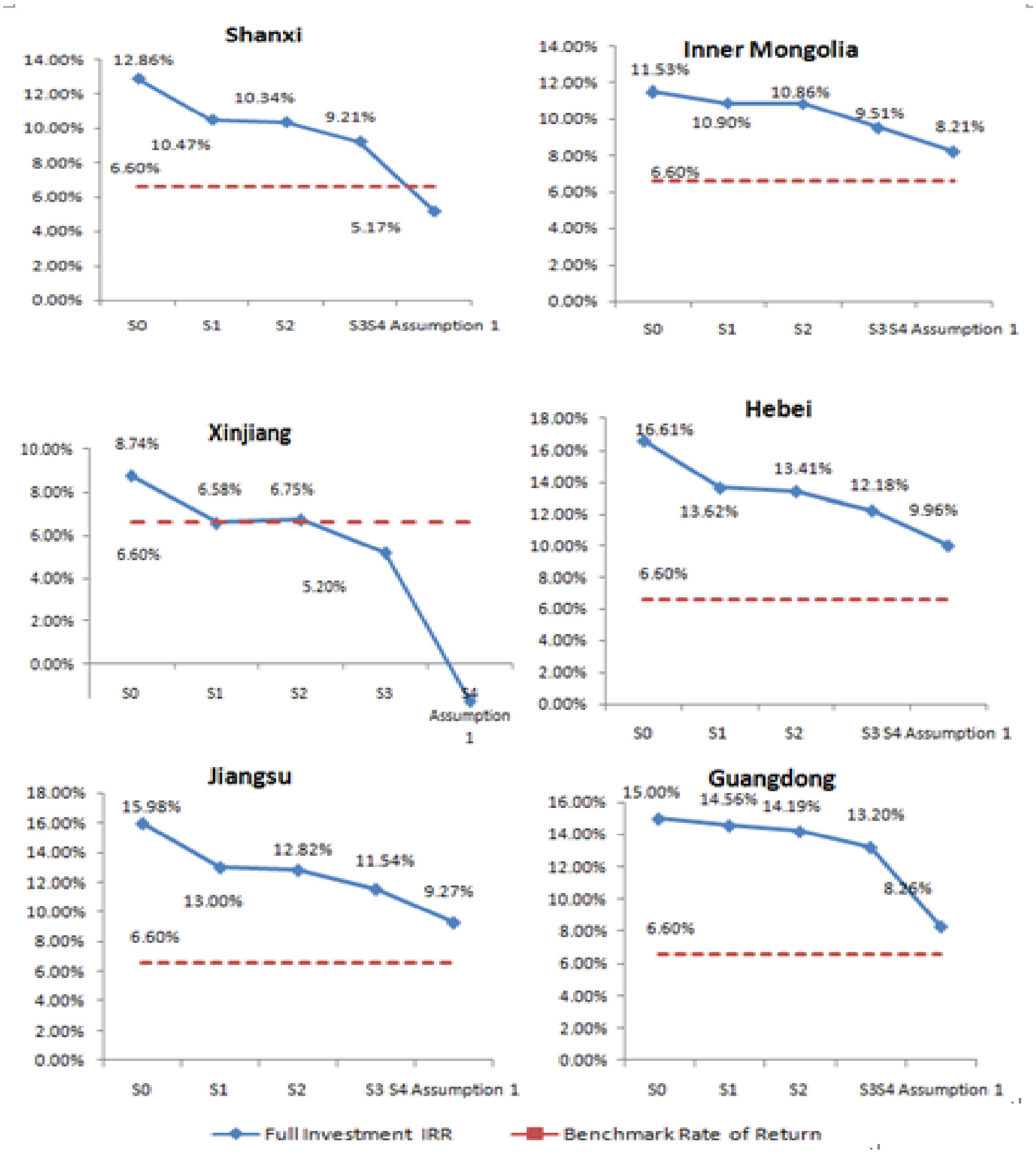

Figure 4: Change in Full Investment IRR of Typical Provinces under Progressive Scenarios

Results from the scenario analysis in this report show that merely the new tariff adjustment plan issued by the NDRC at the end of 2015 will have a significant effect on the coal-fired power generation projects in Xinjiang, making them unable to recoup the full investment. Furthermore, in areas with additional environmental constraints, carbon costs internalization and the deepening electricity marketization, the expected internal rate of return of coal-fired power generation projects in Shanxi will fall well below the benchmark value of the industry. Areas such as Hebei, Jiangsu, Inner Mongolia and Guangdong, however, have profit forecasts expected to remain above the benchmark rate of return of the industry. After taking into consideration of the falling trend of the thermal power units utilization hours of all provincial and regional grids in China since 2014, as well as the national coal power capacity during the “13th FYP” period, this report seeks to set forth a sensitivity interval for the expected reduction of coal power utilization hours. Additionally, pursuant to the falling trend of direct power purchase transaction in typical provinces in last two years, this report also conservatively sets forth a sensitivity interval for tariff reduction ranging from RMB0.01 to RMB0.03. However, despite this more optimistic outlook for these areas, either the annual utilization hours dropping 100 hours (compared to 2015) or the tariff for direct power purchase being cut by RMB0.01, would results in the coal power projects in Guangdong not being able to recoup their investments. And, again, either the annual utilization hours dropping 500 hours or the tariff for direct power purchase being cut by RMB0.02, would likewise lead to the coal power projects in Inner Mongolia being unable to recoup their investments. Thus, under the combined effect of utilization hours and deduction degree of tariff for direct power purchase, the coal-fired power generation projects in the power consumption provinces with best economies (i.e. Jiangsu and Hebei) will deteriorate disastrously, and the internal rate of return on proprietary funds will be even lower than the long-term lending rate (6%) of the bank, which contributes to the miserable investment prospect (see Figure 5).

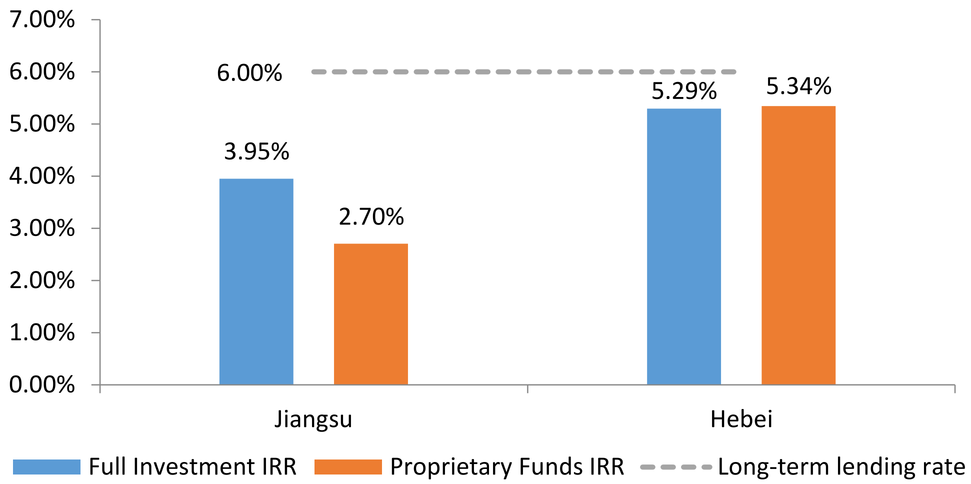

Figure 5: Expected Internal Rate of Return of Typical Provinces under the Combined Effect of Utilization Hours and Deduction Degree of Tariff for Direct Power Purchase

It is forecasted by the China Electricity Council (CEC) that the total electricity consumption in 2016 is expected to have 1%-2% annual growth, and the addition of coal power installed capacity will reach at least 50GW, which, together with the market reduction by renewable energy, contributes to the continuous fall of coal power utilization hours (somewhere between 300 and 400 hours). If the mismatch between electricity demand growth and addition of coal power installed capacity persists in 2017, the unit utilization rate will continue to further deteriorate. Therefore, the scenario prospect analysis in this report selects 2020 as the time point, however, if the electricity demand growth continues to be at low level (i.e., less than 2% annually) and the scale of units newly commissioned remains at high level (e.g., the annual addition of coal-fired power units approaching 50GW), the losses of the whole coal power sector may be realized early in 2017.

The policy suggestions are as follows:

(1) It is fundamental to formulate a strategic power development plan adapted to the new

economic normal. The current year is the first year of the “13th FYP” and also the year when the “13th FYP” Energy Development Plan and Power Plan will be implemented. Relevant national authorities are advised to study and issue power development plans adapted to the new economic normal as soon as possible. Such plans should provide for low-carbon power transformation, arrange sufficient lead time for completion of 20% non-fossil energy targets by 2030, set up the coal-fired power development targets in strict compliance with the principle of prioritizing clean renewable energy, demand side energy, and rein the irrational growth of investment in coal-fired power generation projects. In provinces with obvious power redundancy, key areas for air pollution control and regions with red-alert of water resources, no arrangement of new coal-fired power generation projects should be approved. With this plan, it is imperative to include strengthening and reform in the examination and approval systems, with the provincial planning under national planning guidance and project approving under planning guidance, respectively. Under such guidance, project approval principles should be emphasized and reinforced and the evaluation and accountability system upon project decision-making should also be improved.

(2) Of top priority is the suppression of irrational investment by coal power generation enterprises and the reasonable regulation and control of the coal power capacity scale. Pursuant to the capacity currently under construction and demand growth trend, the administrating department is urged to upgrade and execute the urgent order that “places a hard brake on” expansion of coal-fired power: 1) to improve the dynamic coal-fired units planning and construction risk alerting mechanism, and, in terms of risk alerting on sufficiency of coal power installed capacity, to give comprehensive consideration of the existing power sources, capacity under construction and transferred power sources and fully tap the demand side potential and scientifically evaluate coal power over-capacity in all provinces and areas. Orange alert should be given to provinces and areas with coal-fired power capacity under construction that can satisfy the electricity demand in the next three years. And red alert should be given to provinces and areas with capacity under construction that can satisfy the electricity demand in the coming five years. The resources constraint indicator system should be elaborated to take full consideration of the risk alerting binding effect of water resource constraint over coal power projects. The economic indicators for coal power construction should be improved to fully consider the influence on the economics of coal power caused by such factors as reduction of utilization hours, decrease of benchmark tariff, market-oriented competition and internalization of carbon costs and pollutant emission reduction costs. 2) To adopt the method of “cancelling a batch of projects, deferring the construction of a batch of projects, stop giving approvals” to carry out specific regulation and control of the coal-fired power generation projects. All coal-fired power generation projects failing the approval conditions should be cancelled. The construction of all coal-fired power generation projects in provinces with orange alert before 2018 should be deferred, and all approved but unconstructed projects (except for civil thermal power) should be cancelled. In provinces with red alert, the construction of all coal-fired power generation projects before 2020 should be deferred, and all approved but unconstructed projects (except for civil thermal power) should be cancelled. Besides the approval for all additional coal-fired power generation projects should be suspended during the 13th FYP period, and the power supply capacity in regions without sufficient resources should be guaranteed by strengthening the trans-provincial or trans-regional allocation of resources, which could also mediate the wide range of coal power overcapacity to some extent.

(3) Adherence to marketization is a fundamental resolution. The electricity marketization

should be steadily promoted on the principles of “implementation of government pricing and relaxing control on market access at the power generation side and the power sales side”, and the prices at the grid side and the retail side should be orderly relaxed if the power transmission and distribution tariff reform is thoroughly implemented, so as to have the valid price signal to play a fundamental role in guiding power generation investment. Only marketization may break the stubborn expectation of power generation enterprises on the utilization hours and on-grid tariff, so as to gradually establish a truly market-oriented power generation investment mechanism. It is advised that no annual power generation plan for any coal-fired power generation project that is newly commissioned in 2015 and thereafter will be approved, and all such projects should directly participate in the electricity market, and that the marketization construction should be steadily promoted in accordance with the established timetable for relaxing control on power generation and consumption plan. Besides, in the marketization process, the government should pay more attention to the adjustment of its own role, and should gradually rectify the negative externality of coal-fired power generation by means of construction of a national carbon market, increase of pollution fee (or tax) standards and other measures to provide a fairer market environment for the development of renewable energy.

1. Foreword

With the advent of the new economic normal, the electricity consumption growth of China has made an abrupt shift from high rate to a moderate or low rate. Despite the ultra-low growth of total electricity consumption (0.5%) in 2015 will not last long, it is expected that the electricity consumption growth at moderate or low rate during the "13th FYP" period will become the new normal[1]. Meanwhile, the annual utilization hours of coal-fired power have hit the bottom one after another since 2014, and the addition of coal-fired power capacity remains at high levels. The report "*Coal Power Overcapacity and the Investment Bubble in China*"[2] collaborated published by North China Electric Power University and Greenpeace East Asia in November, 2015 has issued an alert on overcapacity of coal power during the 13th FYP period, and this report will provide an in-depth analysis of the economic driven factor behind the contrarian growth of coal power investment and the economic consequence of coal power sectors due to the unabated and irrational investment.

This report selects the 600 MW coal-fired units as the representative units in six typical power input/output provinces with high coal power investment (i.e. Shanxi, Inner Mongolia, Xinjiang, Hebei, Jiangsu and Guangdong) for analysis, and adopts the LCOE model[3] and financial appraisal methods for engineering projects[4] to study the major technical and economic assessment indicators of a representative new-built plant, including profits, internal rate of return and investment payback period, etc. This report mainly analyzes: (1) the profitability expectation of the new-built coal-fired power plants under the 2015 coal price and coal-fired unit utilization rate level,; and (2) under the macro environment of deepening electricity marketization reform, deteriorating unit utilization rate, more stringent environment constraint, and larger carbon emission reduction pressure—specifically how will the economics of coal power change during the "13th Five-Year-Plan" period.

2. External Environment for Coal Power Development

Coal power is the mainstream power source in China and has the largest installed capacity and electricity contribution in all types of power sources. Pursuant to the data of China Electricity Council (CEC)[5], power development in China has experienced three different stages, namely the domination period of coal power in the early years after the founding of PR China, the coal power-led and hydro power-supplemented development period from 1970 to 2000, and the diversified power sources development period after 2006. After 2006, the share of coal power in total power capacity is expected to drop annually. Nevertheless, because China was still in the state of regional short supply of power until 2012 and due to its resource endowment (i.e. abundance in coal resources), the annual average growth of coal power capacity from 2007 to 2011 still reached as high as 8.4%[5].

With the advent of the new economic normal in 2014, the electricity demand of China fell sharply, and the coal power utilization hours in many regions (for example, the large electricity consumption province Guangdong and the large coal production province Shanxi) produced multiple new low records. However, despite these statistics, the addition of coal power capacity remained at high levels and the coal power capacity in 2014 increased 35.55 GW, maintaining a growth rate of 5.0%[6]. CEC forecasts in the *Status and Outlook of China's Power Sector* that the national addition of coal power installed capacity in 2015 is approximately 38 GW[6]. However, despite the decrease of thermal power generation capacity and only a 0.5% total electricity consumption growth, the annual addition of coal power installed capacity still reached 52 GW[1]—representing far more than what was forecasted. This indicates a distinct contrarian rise in coal power investment trends. Moreover, it has been shown by the statistics of both Greenpeace and the CoalSwarm Project[7], that there is approximately 73 - 79 GW installed capacity currently under construction, which constitutes a significant increase when compared to the previous years, and the total installed capacity of coal-fired plant projects under the EIA approval announced by either Ministry of Environment Protection or its provincial counterparts in 2015 amounts to 169 GW, of which, coal power projects with 159 GW have been granted or pre-granted the EIA approval, while the total EIA approved installed capacity of coal-fired plant projects for the same period in 2014 was 48 GW. Therefore, it is evident that the commissioned coal power capacity will exceed 50 GW per year for the consecutive three years from 2015 to 2017.

Because investment in coal power projects can greatly enhance economic growth, local governments remain interested in providing support to the coal power development despite the discouraging trends in the unit utilization rate. However, it is the economic benefits in market economy that should determine the construction of new coal power projects. Hence, besides the bottomed-out coal price and the electricity market competition, all that remains is to determine what other challenges may be faced by the coal power development environment during the 13th FYP period? This report suggests they mainly include:

2.1 Demand Growth Slowdown and Sharp Fall in Unit Utilization Rate

With the initiation of new economic normal in 2014, the electricity consumption growth of China has begun the shift from high rate to the moderate or low rates of consumption. The electricity consumption growth at moderate or low rate will continue during the 13th FYP period, and this will cause continued stark decreases in the coal power unit utilization rate. Nationally, the annual average thermal power utilization hours during the 12th FYP period[1] fell 18.46%[1,5,8,9], with an average annual drop of 4.97%. For the same period, the coal power utilization hours were about 100 higher than thermal power utilization hours, without significant discrepancy, and their change in trend is nearly identical. The regional thermal power utilization situation is consistent with the national trend, and, except for the slight rise in 2013, all remaining years show an annual decreasing trend. As to the typical provinces, in 2014, the thermal power utilization hours in Jiangsu, Xinjiang, Hebei and Inner Mongolia remain higher than 5,000 hours[10]. However, in 2015, except for the 5,125 hours of Jiangsu, the thermal power utilization hours in Xinjiang, Hebei and Inner Mongolia have respectively dropped to 4,730, 4,846 and 4,979 hours. And thermal power utilization hours of the large electricity consumption province Guangdong and the large coal production province Shanxi have even fallen to 4,028 hours and 4,100 hours[11]. Notably, the provinces selected by this report as typical

[1]The statistics data of this Report is collected from plants above designated size.

provinces have relatively high coal power capacity under construction, and are either abundant in coal power resources or are considered power load centers. Additionally, the unit utilization status of these provinces is close to or above national average level. Other than these selected typical provinces, the thermal power utilization hours data of several provinces is more disappointing: the large hydro power provinces Yunan and Sichuan have only 1,879 and 2,682 thermal power utilization hours respectively in 2015; provinces with relatively good development in wind power such as Gansu have less than 3,800 thermal power utilization hours, and Jilin reached only 3,300 hours. Such provinces as these have all fallen below the break-even point.

The *Coal Power Overcapacity and the Investment Bubble in China*[2] further forecasts the changes in trend of coal power utilization hours in 2020 in accordance with the demand forecast and units capacity under construction during the 13th FYP period. Where the addition of coal power capacity is strictly regulated and controlled to be matched with the demand growth, the coal power utilization hours in 2020 could maintain at approximately 4,800 hours. If the existing proposed new coal-fired power generation projects are all completed and commissioned before 2020, the coal power capacity will reach 1,150 GW and the utilization hours will further decrease to 3,791 hours, leading to a serious overall overcapacity across China. In the six typical provinces analyzed in this report, Shanxi has the most severe situation and its utilization hours are expected fall to 3,472 hours, while Xinjiang is expected to barely maintain the operation level of 3,600 hours. Of mention, the above analysis is provided on basis of the 4.2% average annual electricity consumption growth during the 13th FYP period, and, judging from the current situation, the electricity consumption growth during the 13th FYP period will likely struggle to achieve this level. Thus, even though the number of actual units went into operation is less than the forecast, considering the growth of the coal power installed capacity as high as 6.2%[1,5] and 0.5%[1] total electricity consumption growth in 2015, this trend will continue in 2016, and the coal power units utilization hours may be lower than the above analysis. We can infer and expect through extrapolation that the national average coal power utilization hours in 2020 may be only 3,498 hours. And, in the short-term, the 2016 national coal power utilization hours could fall below 4,000 hours.

2.2 More Stringent Environment Constraint and Larger Carbon Emission Pressure

As the air pollution in most areas of China continues to exacerbate, unprecedented attention will likely be paid to air pollution prevention and control and energy saving and emission reductions. In terms of emissions of pollutants, pursuant to the target put forward in the *Working Plan for Overall Implementation of Ultra-low Emission and Energy Saving Retrofitting of Coal-fired Plants* jointly promulgated by the NDRC, the MEP and the NEA, which is that the eastern, central and western regions need to respectively and principally complete ultra-low emission retrofitting of coal-fired units before 2017, 2018 and 2020 respectively[12], coal-fired plants will face larger pressure in investment of pollutant control devices and the charging standards of emission charge, even accounting for any subsidies that may be available to the plants upon implementation of the ultra-low emission retrofitting.

In June, 2015, China submitted the *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions* to the United Nations. This plan accepts that the emission of greenhouse gas will likely reach its peak in 2030 and China will make efforts to reach such peak as soon as possible. 13th FYP is the crucial stage for the implementation of China's greenhouse gas policies, and in 2017, China will launch a national carbon emission trading system. It will then be inevitable that the rigidity of carbon price will increase the coal power costs. In such a lack-of-demand and over-supply market environment, power generation enterprises will and must internally bear carbon costs of considerable percentage.

2.3 Low-carbon Energy Transformation and Diminished Coal Electricity Market

After 2013, it becomes the central theme of China's energy policies to control the total primary energy consumption, to inhibit the excessive growth of coal consumption and accelerate the development of non-fossil energy. The *National Plan on Climate Change (2014-2020)* published in September, 2014 specifies that the percentage of non-fossil energy in primary energy consumption should be 15% by 2020. The *Enhanced Actions on Climate Change: China's Intended Nationally Determined Contributions* submitted by China in June, 2015 even proposes the target of 20% non-fossil energy by 2030. For the power sector, it is imperative to optimize the energy structure. On one hand, the clean and efficient utilization of coal should be strengthened so as to control the total coal consumption by the power sector; on the other hand, the development of clean energy should be accelerated, especially the wind power and the solar power. The established clean renewable energy development targets of China include: (1) the grid-connected wind power capacity reaches 200 GW by 2020; (2) the wind power feed-in tariff is roughly equivalent to the coal power on-grid tariff; (3) the PV capacity reaches approx. 100 GW by 2020; and (4) the PV power generation price should be roughly equivalent to the grid sale price[13]. China is currently formulating the 13th FYP energy development plan, and it is likely that the development targets of renewable energy will be set higher. Recently, the NEA sought opinions for the *Development Plan for Renewable Energy for the 13th Five-Year Plan Period (Draft for Comments)* and proposed to increase renewable energy capacity investment during the 13th FYP period. According to NEA's proposal, by the end of 2020, the solar power will reach 160 GW (PV 150 GW) and the wind power will reach 250 GW[14]. Thus it can be seen that the market space of coal power will be further restricted under the energy transformation targets of acceleration of innovation on energy technologies and construction of clean, low-carbon, safe and efficient modern energy system.

2.4 Electricity Marketization and Intensifying Price Competition

In March, 2015, the issuance of the *Several Opinions on Further Deepening Electric Power System Reform* ("No.9 Document" for electric power system reform) kicked off the new round of deepening the electric power system reform. The No.9 Document sets forth the recent key tasks for electric power system reform, including “the realization of the market-oriented power generation and retail price by steps (except for public welfare undertakings), the on-grid tariff of the power generation enterprises participating in electricity market transactions shall be independently determined by the power generation enterprise and the user or power retail entity by means of negotiation or market auction”, “guiding the market entities to carry out multi-party direct transaction” and “encouraging the establishment of long-term stable transaction mechanism and construction of the long-term stable bilateral market mode reflecting the will of market entities”. The steady implementation of the No.9 Document means the market-oriented purchase and sale of electricity will be promoted at a faster pace, and under the oversupply status of the electricity market, this means the on-grid tariff of the coal power enterprises in the environment of large electric power overcapacity is expected to fall sharply.

The direct purchase of power has made obvious progress in practice since 2014, and the scope of implementation and transaction scale has been largely expanded compared to ten years ago. In 2014, except for Beijing, Shanghai, Tianjin, Chongqing, Hebei, Qinghai, Tibet and Hainan, the remaining 23 provinces and autonomous regions have carried out the reform of direct power purchase for large consumers. In 2014, transaction power consumption of direct power purchase for large consumers reached 154,000 GW, accounting for approximately 3% of the total electricity consumption [15]; in 2015, the direct power purchase accounted for 5.4% of the total electricity consumption [16,17], and it is forecasted by this report that, in 2016, this percentage will reach 10% of the total electricity consumption.

In practice, the main influence of direct power purchase for large consumers on coal power enterprises is to transfer profits to power users collectively on the basis of the benchmark tariff. Local governments take advantage of power generation distribution rights to cut part of the original planned power to serve as transaction power consumption for direct power purchase for large consumers in order to facilitate the competition among coal power enterprises and to reduce the tariff. It is reported that there are 355 enterprises participating in pilot projects for direct power purchase in Zhejiang Province in 2015, and the annual transaction power consumption reaches 14,800 GW, reducing RMB0.0385 transaction tariff on an average basis.[18] On May 22-25, 2015, Shanxi Province organized a third batch of direct transaction of power in the year, and the completed transaction power consumption between 17 power users and 29 power generation enterprises reached 2,139 GW, with an average transaction tariff of RMB0.2832/kWh, RMB0.07/kWh lower than the benchmark on-grid tariff (i.e. RMB0.3538/kWh) on average.[19] Pursuant to the tariff adjustment plan approved by the State Council in December, 2015, the coal-fired power on-grid tariff will be reduced approximately RMB0.03/kWh nationally and on an average basis from January 1, 2016. However, the mainstream views of sector all believe that the decrease of transaction tariff caused by the competition tendency of price is likely larger than "RMB0.03". [20]

The *Opinions for Impementation of Promoting the Electricity Market Construction* promulgated in November, 2015 as a supporting document to the No.9 Document points out the necessity to "orderly relax the power consumption plan and competitive tariff". The *Several Opinions of the Central Committee of the Communist Party of China and the State Council on Promoting Price Mechanism Reform* also specifies the overall requirements for "basically relaxing the control on price in the competition field and segment by 2017". The recent *Letter of the Comprehensive Department of National Energy Administration on Seeking Opinions for the Circular on Carrying out Effective Work Relating to Electricity Market Construction (Draft for Comments)* also puts forward that: (1) the control on power generation and consumption plan as well as the explicit timetable should be gradually relaxed through expanding the size of direct transaction power consumption and its established timetable: efforts should be made to enhance the percentage of direct transaction power consumption to reach 30% of the local industry power consumption in 2016, and the control on industry power consumption should be relaxed to 100% in 2018; and (2) an electricity market pilot program including middle- and long-term transaction and spot transaction should be formulated and improved. In combination with the steady promotion of direct power purchase work in the recent two years, this report assumes the electricity marketization will be realized by the end of the 13th FYP period. Essentially, 80%-90% power consumption of the coal power enterprises in the late 13th FYP period will be completed through market transaction, and the electricity market characterized as co-existing of middle- and long-term transaction and spot transaction and with complete types of transaction and functions will be established steadily. Referring to international experience, in circumstances that supply and demand is balanced or supply exceeds demand, the spot transaction price will form on the basis of short-term marginal costs. This will produce larger downward pressure for the middle- and long-term contractual transaction price and the economic benefits of coal power enterprises.

3. Study Methodology

3.1 Levelized Costs of Electricity (LCOE) Model and Financial Appraisal Methods for Engineering Projects

3.1.1 LCOE Model

LCOE refers to the costs of electricity per kWh of the power generation project during the construction and operation period and is a widely recognized and highly-transparent calculation method for costs of electricity. This report will use the LCOE model to calculate the LCOE (costs per kWh) by calculating the percentage between the present value of total costs and expenses from initial construction to operation and the economic time value of the energy output during the life time of the 600 MW coal-fired plant project, and its derivation process is as follows:

The value of each known future period (F) is lower than the value of current period (P), and the discount rate (r) shall be used to measure this difference, i.e.:

$$P = F(1+r)^{-n}$$

And NPV is the set of present value of different periods, which usually refers to all periods of a project during its life time. The definition of LCOE comes from the identical equation (revenues' NPV equals to costs' NPV), that is:

$$\sum_{n=0}^{N} \frac{\mathrm{Re}venues_n}{(1+r)^n} = \sum_{n=0}^{N} \frac{Cost_n}{(1+r)^n}$$

$$NPV = \sum_{n=0}^{N} PV = 0$$

$$\sum_{n=0}^{N} \frac{(LCOE_n) \times (E_n)}{(1+r)^n} = \sum_{n=0}^{N} \frac{Cost_n}{(1+r)^n}$$

$$LCOE = (\sum_{n=0}^{N} \frac{Cost_n}{(1+r)^n}) / (\sum_{n=0}^{N} \frac{E_n}{(1+r)^n})$$

Based on the above formula, the complete calculation method of LCOE can be inferred as follows:

$$LCOE = \left(\sum_{n=1}^{N} \frac{(CAPEX_n + OPEX_n + TAX_n)}{(1+r)^n} \right) \Big/ \left(\sum_{n=1}^{N} \frac{(C \times H \times (1-o_u))_n}{(1+r)^n} \right)$$

$CAPEX_n$ _____ annual value of the costs of initial investment, including proprietary funds, loan and depreciation;

$OPEX_n$ ____annual value of operation and maintenance costs, including fuel, operation and maintenance costs, insurance premium, and labor costs, etc.;

TAX_n ____ annual payable taxes of the plant, including VAT, income tax, education surcharge, urban maintenance and construction tax and land use tax, etc.;

C ___installed capacity, H ___ annual utilization hours, O_u ____auxiliary power consumption rate, N __ operation years of the plant, r __ discount rate.

3.1.2 Financial Appraisal Methods for Engineering Projects

The financial appraisal of engineering projects is an important constituent of the engineering economic analysis. It is an economic appraisal method that appraises and analyzes the investment, costs, revenues, taxes and profits of the engineering projects under the current accounting system, tax regulations and market price system of the State. It involves a study of the profitability, solvency and financial viability of the project after being put into operation from the perspective of the project, and assesses and makes judgment upon the financial economics of the project based upon such appraisal, analysis and study. In addition to specifying the value of the engineering project to the financial entity and the contribution to investors, the financial appraisal of engineering project also provides a basis for investment and financing decision-making. The composition of funding sources, the method of repayment of lending capital and other factors will affect the cash flow, which, in return, affects the economic effects of the enterprise. Thus, when making the project financial analysis, it is important to study the economic effects in two distinct steps. First, eliminate the influence of financial conditions and all funds are treated as proprietary funds. This analysis is called “full investment” financial effects assessment. Second, analyze the results of the influence of all factors including financial conditions. This analysis is called the “proprietary funds” financial effects assessment. “Full investment” assessment examines the economic effects of the project within the scope of enterprise, and the “proprietary funds” assessment focuses on the profitability of the enterprise’s investment to reflect the benefits of the enterprise.

This report mainly utilizes three financial appraisal indicators to assess the economics of the coal power projects, namely, internal rate of return (IRR), static payback period (SPP) and dynamic payback period (DPP), and the calculation basis of these financial indicators is the Cash Flow Statement (for full investment and proprietary funds). Therefore, this report takes the cash flow statement as the starting point to prepare relevant financial statements, including the Income Statement, the Liquidity Fund Estimate Statement and the Statement of Sales Tax and Surcharge, and calculates the liquidity fund borrowing interest based on the short-term borrowing rate, and then carries out financial analysis based on the cash flow statement (e.g. Figure 3-1).

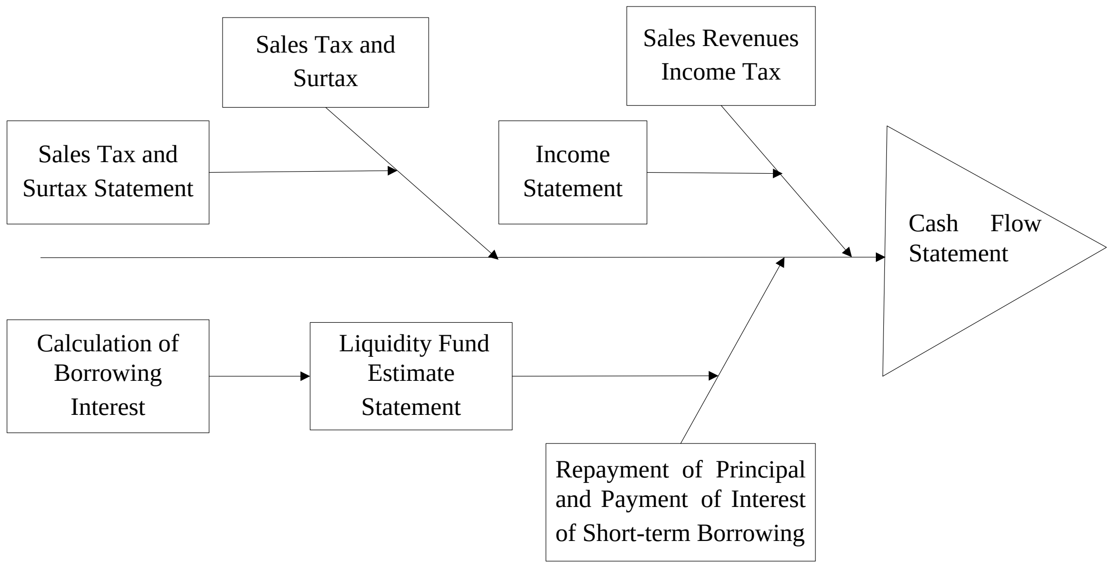

Figure 3-1: Thoughts on Preparation of Financial Appraisal Statements

3.2 Model Variables and Parameters

There are many variables and parameters in the LCOE model and project financial appraisal, which may be divided into four categories by type, namely: technical and economic variables, operation and maintenance costs variables, main taxes and charges and financial variables, and specifically as follows:

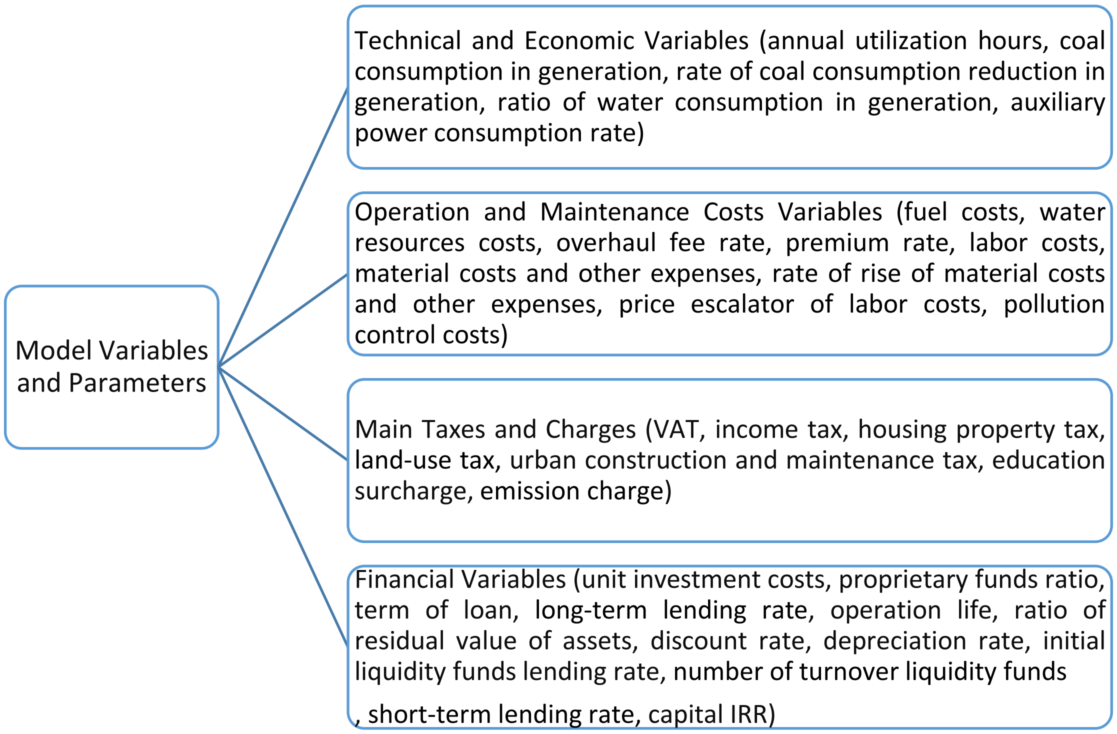

Figure 3-2: Model Variables and Parameters

In these parameters, most of them are common parameters used in the LCOE model and the financial appraisal; however, there are some parameters that will only be used in the calculation of LCOE model or the financial appraisal, and they are distinguished as follows:

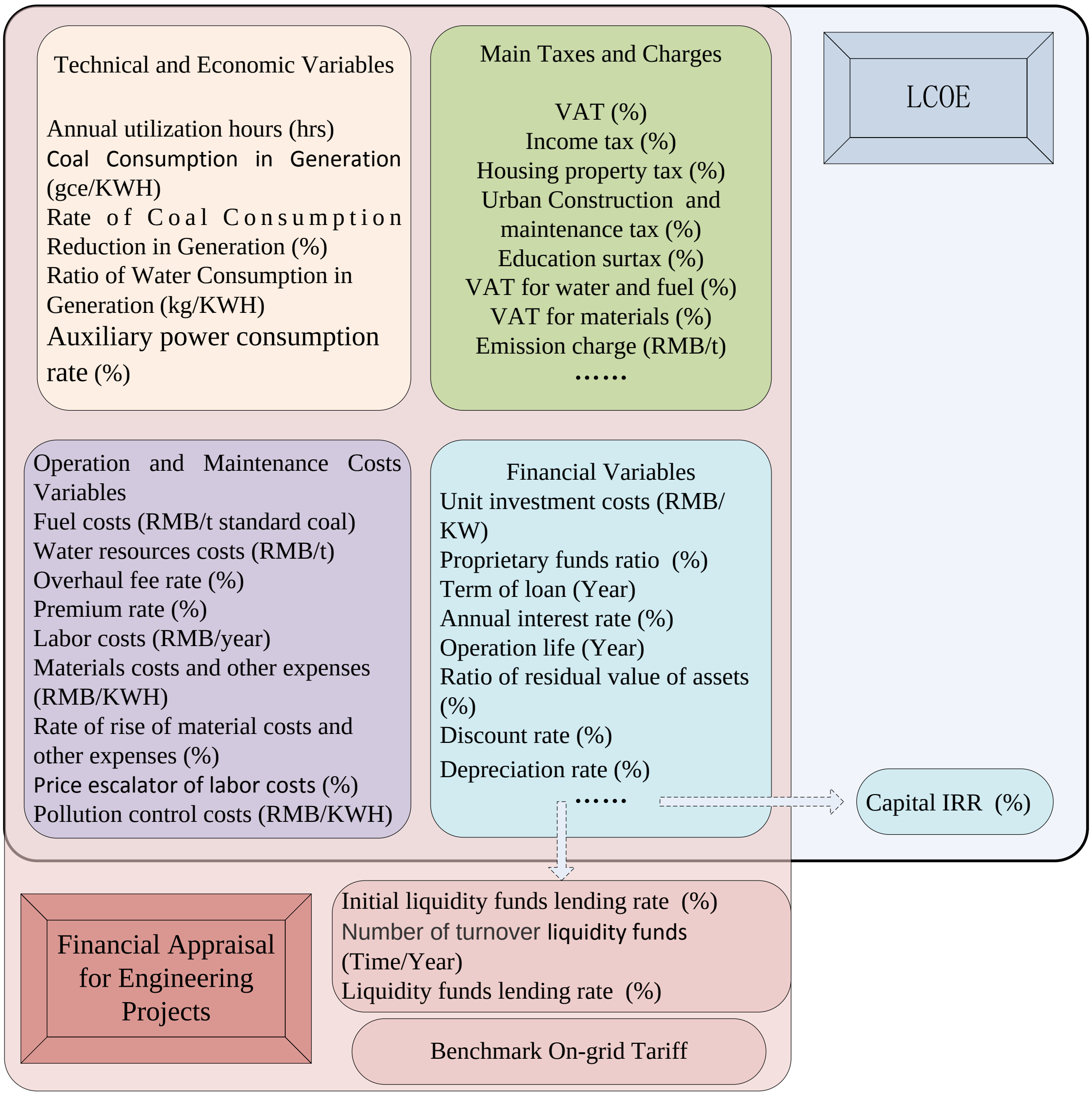

Figure 3-3 Common Parameters of the Model

3.3 Key Technical and Economic Indicators

In all technical and economic indicators, IRR and payback period are the most convincing and instructive indicators for the appraisal of the economics during the life time of a coal-fired plant. Hence, this report provides analysis on basis of the full investment scenario and the equity capital scenario, and uses such two indicators as the key technical and economic indicators to appraise the economics of the 600 MW coal-fired power plants.

a. Internal Rate of Return (IRR)

Internal Rate of Return (IRR) refers to the discount rate when the total present value of fund inflow equals to the total present value of fund outflow, and the NPV is equal to zero. The advantage of IRR method is to link the project returns during its life time with its total investment, and indicate the rate of return of the project, so as to compare the same with the benchmark rate of return on investment of the sector to confirm whether the project is worthy of construction. IRR is generally recognized as the profitability indicator for project investment and reflects the utilization efficiency of investment.

b. Payback Period

Payback period refers to the years required for repaying the original investment by the net proceeds obtained from the project, from the date of investment and construction of the project. Payback period is divided into static payback period (SPP) and dynamic payback period (DPP). SPP refers to the time required for paying back its full investment from the net proceeds of the project without considering the time value of funds. DPP refers to the payback period inferred from converting the net cash flow of each year of the invested project into present value on basis of the benchmark rate of return.

4. Analysis of Economics of Current Coal Power

4.1 Setting of Key Parameters

There are many factors that can affect the economic benefits of a coal-fired power plant. Aside from coal price, unit utilization hours and other key factors, water price, charging rate of emission charge, direct power purchase percentage and other parameters can also have certain influence. This report selects the 600 MW coal-fired units in six typical power input/output provinces (Shanxi, Inner Mongolia, Xinjiang, Hebei, Jiangsu and Guangdong) as hypothetical units for the basis of this analysis. Coal price will be based on the China's Coal-fired Power Generation Price Index established and published by the Price Monitoring Center of the NDRC, Qinhuangdao Coal Trading Market and other institutions in November, 2015(and the representative specification goods should be the 5,000kcal/kg steam coal). In terms of utilization hours, based on those in the study and other representative units, the estimate is made on basis of the average coal power utilization hours of each province. Other parameters (including the parameters to be used by the LCOE model and the financial appraisal of engineering project) are set in accordance with the specific circumstances and industrial data of each typical province. Specifically as follows:

Table 4-1: Set Values of Common Parameters of Typical Provinces

Common Parameters	**Set Value**	**Common**	**Set Value**

		Parameters	
Unit Investment Costs (RMB/kW)	3590	VAT(%)	17
Proprietary Funds Ratio (%)	30	Income Tax (%)	25
Term of Loan (Year)	15	Housing Property Tax (%)	1.2
Annual Interest Rate (%)	6	Urban Maintenance and Construction Tax (%)	5
Operation Life (Year)	30	Education Surcharge (%)	0.5
Ratio of Residual Value of Asset (%)	5	VAT for Water and Fuel (%)	13
Discount Rate (%)	8	VAT for Materials(%)	17
Depreciation Rate (%)	5	Overhaul Fee Rate (%)	2
Capital IRR (%)	8	Premium Rate (%)	0.25
Coal Consumption in Generation (g standard coal/kWh)	286	Labor Cost (RMB/Year)	80000
Rate of Coal Consumption Reduction in Generation (%)	0.10	Materials Costs and Other Expenses (RMB/kWh)	0.02
Emission Charge (RMB/Ton)	1260	Rate of Rise of Materials Costs and Other Expenses (%)	2
Ratio of Water Consumption in Generation (kg/kWh)	1.6	Rate of Rise of Employees' Salary	6
Auxiliary Power Consumption Rate (%)	5	Pollution Control Costs (RMB/kWh)	0.006

Particular Parameters	**Shanxi**	**Inner Mongolia**	**Xinjiang**	**Hebei**	**Jiangsu**	**Guangdong**
Fuel Costs (RMB/t)	210	193	168	285	362	405
Water Resources Costs (RMB/t)	2.738	6.9	3.64	3.95	3.0	3.46
Utilization Hours (Hours)	4212	5115	4859	4978	5265	4138
Direct Power Purchase	8.4	25	5	3	2	6

Percentage in 2015 (%)[2]						
Benchmark On-grid Tariff in 2015 (RMB/kWh)	0.35	0.30	0.26	0.39	0.41	0.47

Note: part of the data above is set with reference to the References of [39] –[53].

4.2 LCOE and Actual On-grid Tariff of the Representative Units in All Provinces

Using the LCOE model, we are able to calculate the LCOE of the coal power of each typical province, and, by comparing LCOE with the current actual on-grid tariff of each province, we are able to assess the current status of coal power profitability of such provinces.

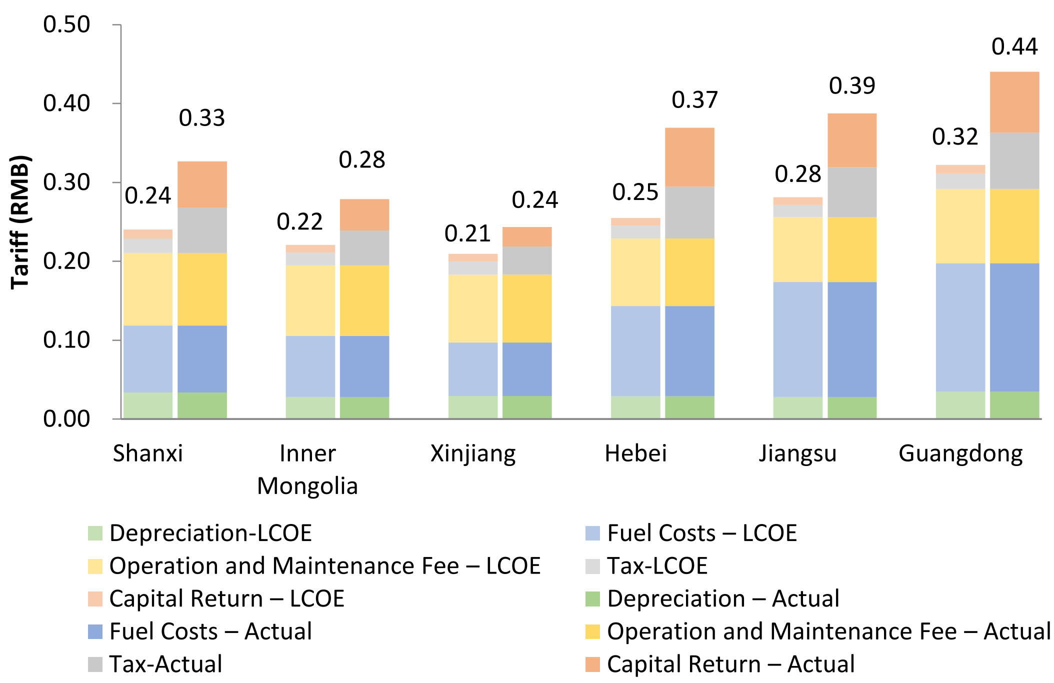

Figure 4-1: Constituent Comparison of LCOE and Actual On-grid Tariff of Each Typical Province

Note: this report adopts the assumption of overnight investment costs, without considering the construction period of the project (i.e. completed overnight) and the financial costs during the construction period; the on-grid tariff indicated in the Figure has taken into account the factors of direct power purchase and auxiliary power.

It is not difficult to recognize that the current actual on-grid tariff of coal power

[2] As Hebei has not yet launched the direct power purchase policies for the time being, this Report assumes such percentage to be 3%.

in all provinces is higher than the LCOE. In terms of tariff constituent, the depreciation, fuel costs and operation and maintenance fee[3] are identical; however, in reality, the coal power projects in all provinces have excess profits under the on-grid tariff, and the tax contribution is in excess as well. The excess profits per kWh of coal power projects in Shanxi, Hebei, Jiangsu and Guangdong Provinces all exceed RMB0.05. Considering the annual power generation capacity of a 600MW coal-fired power plant, the economic benefits brought by such excess profits are considerable. *Figure 4-2* shows the estimates of the annual average profits and payable taxes [4]of a 600 MW coal-fired power plant during its life time in each selected typical province under the current on-grid tariff, and we are able to infer from the large numbers that coal power enterprises have huge profit margins and the local tax contribution is also one of the important economic driven factor behind the contrarian and irrational coal power investment.

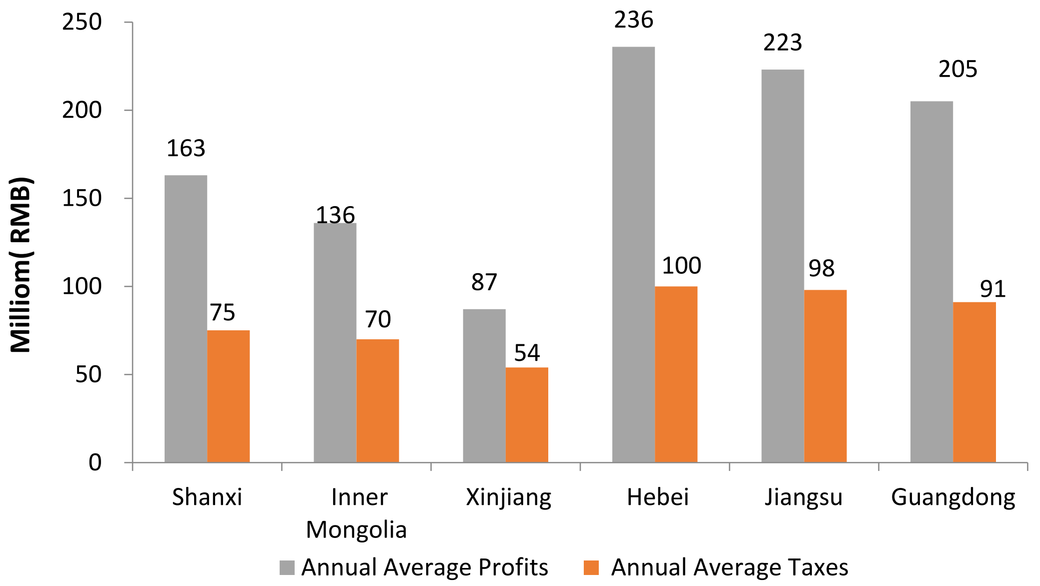

Figure 4-2: Estimates of Current Annual Average Profits and Taxes of A 600MW Coal-fired Power Plant in Each Typical Province

4.3 Technical and Economic Appraisal of Current Coal Power Projects

The current cash flow statements for full investment and equity capital of the 600MW coal-fired units were prepared in accordance with the financial appraisal method of the engineering projects. The key economic and technical indicators (i.e.

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[3]Operation and maintenance fee refers to all other fees after deducting the depreciation and fuel costs.
[4]When calculating the VAT, this Report does not take into account the deduction for equipment fee import tax.

project payback period[5] and IRR) of coal power projects under the current basic scenario (i.e. prior to the average reduction of RMB0.03 of the benchmark tariff of national coal-fired plants in 2016) of each typical province can be calculated through the cash flow statement, as shown below.

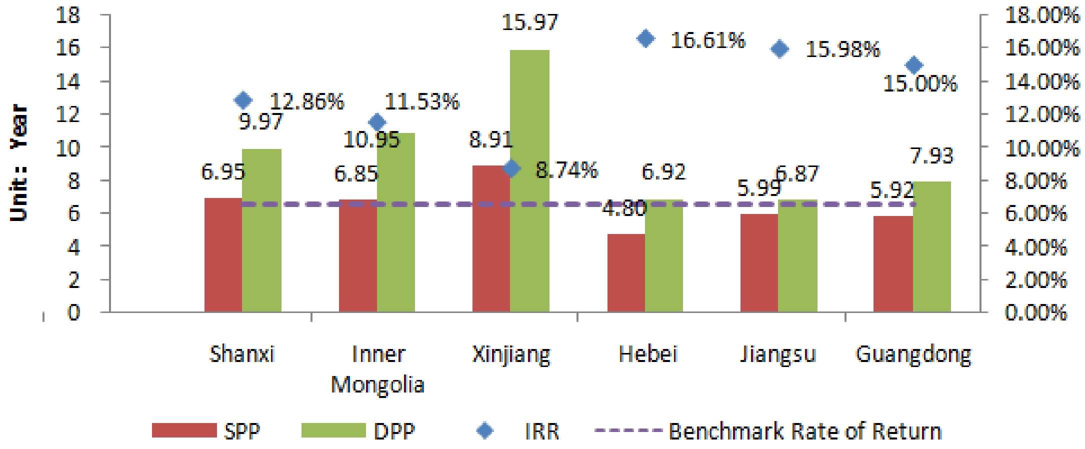

Figure 4-3: Full Investment IRR and Payback Period of Coal-fired Power Generation Projects under Current Conditions (Basic Scenario S0)

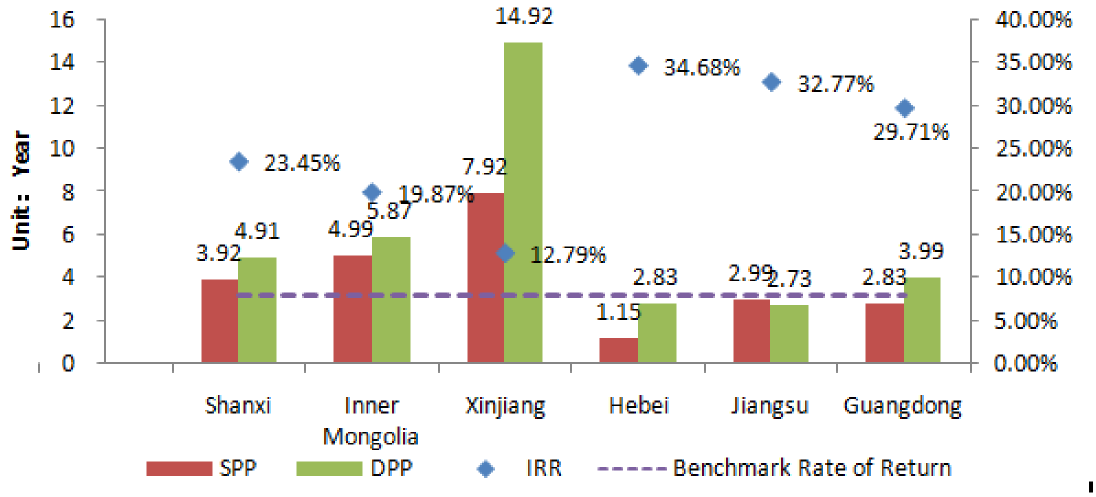

Figure 4-4: Proprietary Funds IRR and Payback Period of Coal-fired Power Generation Projects under Current Conditions (Basic Scenario S0)

Pursuant to the method for determination of the practices and discount rate of the energy sector, the full investment IRR of a 600MW coal-fired power plant is set to 6.6% and the proprietary funds IRR is set to 8%[21], i.e. the benchmark rate of return of the sector. This analysis shows that the rate of return of the coal power project of each

[5]In this Report, the starting point of the calculation of the payback period shall be the time when the project is completed and commissioned, i.e. without considering the project construction period.

typical province is far higher than the benchmark level of the power sector. Especially for Hebei, Jiangsu and Guangdong, the full investment IRR exceeds 15% and the equity capital IRR close to or exceeds 30%, and the coal power enterprises can even recoup equity capital in less than three years for specific projects while went into operation. This high IRR and this short payback period likely reveal the economic driven factor for the unabated interest in coal power investment in the environment of weak demand and low-carbon transformation.

5. Economics Analysis and Prospects of Coal Power Projects during 13th FYP Period

5.1 Forecast and Fluctuation of Key Parameters

As the electricity market competition and unit utilization rate continue to deteriorate during the 13th FYP period, the external environment for coal power development faces many challenging changes. Under this forecast, change to the economics of coal power is inevitable.

This report comprehensively takes account of the influence of the change in each key parameter of the on-grid tariff, and carries out several scenario analyses from coal price, utilization hours, pollution control costs, national carbon market operation, marketization process and policy factors. This report also adopts the step-up accumulation methodology to conduct scenario design and sets up the sequence and order based on the probability and timeline for the realization of each scenario. In doing so, this report first takes into consideration the nation-wide coal-fired power generation on-grid tariff adjustment plan and subsequently the retrofitting requirements for the ultra-low emission of coal-fired plants that are in place, and then the carbon trading market to be launched in 2017, the deepening of the electricity marketization reform and the possibility of the rebound of coal price.

5.2 Economics Analysis Results

A. Scenario Design and Analysis

Scenario S1: The National Development and Reform Commission issued the new tariff adjustment plan at the end of 2015, and from January 1, 2016, the national coal-fired power on-grid tariff shall be reduced approximately RMB0.03 per kWh on average[22]. Pursuant to the specific on-grid tariff reduction range of each province, this report has analyzed the IRR and payback period of the investment in a 600MW coal power project under this scenario in each sellected typical province, and the results are shown in the table below:

Table 5-1: IRR and Payback Period of Full Investment under Scenario S1

	IRR	SPP (Year)	DPP (Year)
Shanxi	10.47%	7.92	12.98
Inner Mongolia	10.54%	7.93	12.99
Xinjiang	6.58%	10.93	Non-recoverable
Hebei	13.62%	5.82	8.94
Jiangsu	13.00%	6.97	9.99
Guangdong	13.26%	6.98	8.91

Table 5-2: IRR and Payback Period of Proprietary Funds under Scenario S1

	IRR	SPP (Year)	DPP (Year)
Shanxi	17.01%	5.99	7.92
Inner Mongolia	17.26%	4.78	7.95
Xinjiang	7.99%	14.68	Non-recoverable
Hebei	25.73%	2.58	3.77
Jiangsu	24.02%	3.95	4.95
Guangdong	24.65%	3.99	4.98

From the above analysis, it can be concluded that, when each province implements the tariff reduction policy, the benefits of the coal-fired power plants will all be influenced to some extent. From the perspective of full investment, Hebei and Jiangsu could suffer the largest fall in IRR, down 3%, and their SPP extends for 1 year while the DPP extends for 2-3 years. But Xinjiang Autonomous Region has the worst situation—its full investment IRR could drop below the benchmark rate of return of the sector, making it difficult to recoup its investment during the project dynamic life time (30 years). As for other typical provinces, if Shanxi Province and Guangdong Province reduce RMB0.08 in their on-grid tariff, while Inner Mongolia RMB0.04, Jiangsu Province RMB0.1 and Hebei RMB0.11, all such provinces will undergo what is now happening to Xinjiang. From the perspective of proprietary funds, the influence on Inner Mongolia is relatively small, while the IRR of other provinces may fall 5-9% and the payback period may be correspondingly extended. Again, the IRR of Xinjiang could be lower than the benchmark value of the sector.

Scenario S2: On basis of Scenario S1, considering the more stringent environment procedures, in order to realize the ultra-low emission target, the coal-fired plants would further increase their investment in pollutant control devices.

We assume that, in order to reach the ultra-low emission standards, a current 600 MW coal-fired plant needs to increase RMB40 million investment in denitration equipment and RMB70 million investment in desulphurization equipment so that the corresponding desulphurization efficiency and denitration efficiency will respectively rise from 80% to 95% and 90%, and the coal consumption in generation will eventually increase 2 kg standard coal/MWh due to the rise of auxiliary power consumption rate resulting from the use of emission control devices, and the emission charge of the power plants will subsequently fall as a result. In order to thoroughly implement the requirements on "promoting the ultra-low emission retrofitting of coal-fired plants" in the 2015 *Report on the Work of the Government*, the coal-fired power plants that carry out ultra-low emission would enjoy a plus of RMB0.005/kWh(tax-inclusive) to its on-grid tariff for central purchase. Under this Scenario, the technical and economic analysis of a 600MW coal-fired power plant is as shown in the table below:

Table 5-3: IRR and Payback Period of Full Investment under Scenario S2

	IRR	SPP (Year)	DPP (Year)
Shanxi	10.34%	7.90	12.97
Inner Mongolia	10.51%	7.92	12.99
Xinjiang	6.75%	10.94	29.00
Hebei	13.41%	6.99	8.92
Jiangsu	12.82%	6.95	9.97
Guangdong	12.95%	6.96	9.98

Table 5-4: IRR and Payback Period of Proprietary Funds under Scenario S2

	IRR	SPP (Year)	DPP (Year)
Shanxi	16.62%	5.95	8.98
Inner Mongolia	17.14%	4.76	7.93
Xinjiang	8.32%	14.76	28.00
Hebei	25.06%	2.52	3.73
Jiangsu	23.43%	3.92	4.91
Guangdong	23.71%	3.93	4.92

We see from this analysis that, despite the enhanced environment restrictions, due to the government's implementation of the tariff subsidy policy for ultra-low emission, the extra investment of a coal-fired plant in pollutant control may be recovered by means of tariff and its benefits are therefore not subject to obvious damage. Yet, if the subsidy is cancelled, the full investment IRR of each province will fall approximately 0.5%, and the equity capital IRR will fall approx. 1%.However, it should be noted that under more stringent environment restraint in the near future, a coal-fired plant's investment in pollutant control will gradually change into "obligation", the subsidy it can obtain from the government will decrease, and the emission charge standards will be inclined to largely rise as the environment restrictions become stronger. Thus, the economic benefits of the coal-fired power plant may be negatively affected.

Scenario S3: Considering the reduction in on-grid tariff and ultra-low emissions, carbon price becomes another influence factor that should be considered. In 2017, China's carbon trading market will fully launch, and the internalized CO_2 emissions costs will become an important constituent of the daily costs of a coal-fired power plant. Scenario 3 is based on Scenario 2 taking into account the influence of carbon costs on the benefits of coal-fired power plants. In this report, the carbon price is set to be RMB30/t[23], and 70% of the carbon price will be socialized (i.e. passed onto the users), and the plants need to responsible for the remaining 30%. The analysis shows that the equity capital IRR of a new-built 600MW coal-fired power plant during its life time will further fall approximately 2-4%, and the DPP will be correspondingly extended, of which, coal power projects in Xinjiang will not be able to recoup their investment during their life time, while coal power projects in Inner Mongolia will take another 6 years to recoup their investment, and the DPP of coal power projects in other provinces will be correspondingly extended 1-4 years.

Table 5-5: Full Investment IRR and Payback Period under Scenario S3

	IRR	SPP (Year)	DPP (Year)
Shanxi	9.21%	8.94	14.97
Inner Mongolia	9.15%	8.94	14.97
Xinjiang	5.20%	12.97	Non-recoverable
Hebei	12.18%	6.90	11.00
Jiangsu	11.54%	6.84	10.95
Guangdong	11.93%	6.87	10.98

Table 5-6: Equity Capital IRR and Payback Period under Scenario S3

	IRR	SPP (Year)	DPP (Year)
Shanxi	13.85%	6.87	12.97
Inner Mongolia	13.75%	6.87	14.00
Xinjiang	5.16%	17.92	Non-recoverable
Hebei	21.62%	3.79	5.99
Jiangsu	19.92%	4.98	5.88
Guangdong	20.88%	3.73	5.94

If the carbon price is introduced and only 70% can be socialized, the IRR of coal-fired power plants will significantly decrease, and the payback period may be substantially extended. In fact, the carbon price of RMB30/t is relatively low. As the carbon market price gradually comes close to the marginal social costs and the socialized shifting coefficient decrease, the carbon costs may become one of the primary costs of the coal power enterprises. Below is the LCOE of all selected typical provinces under Scenario 3. It is apparent from this analysis that, except for Xinjiang, the coal power benchmark on-grid tariff of the remaining typical provinces is still obviously higher than their LCOE, but the excess profits decrease slightly.

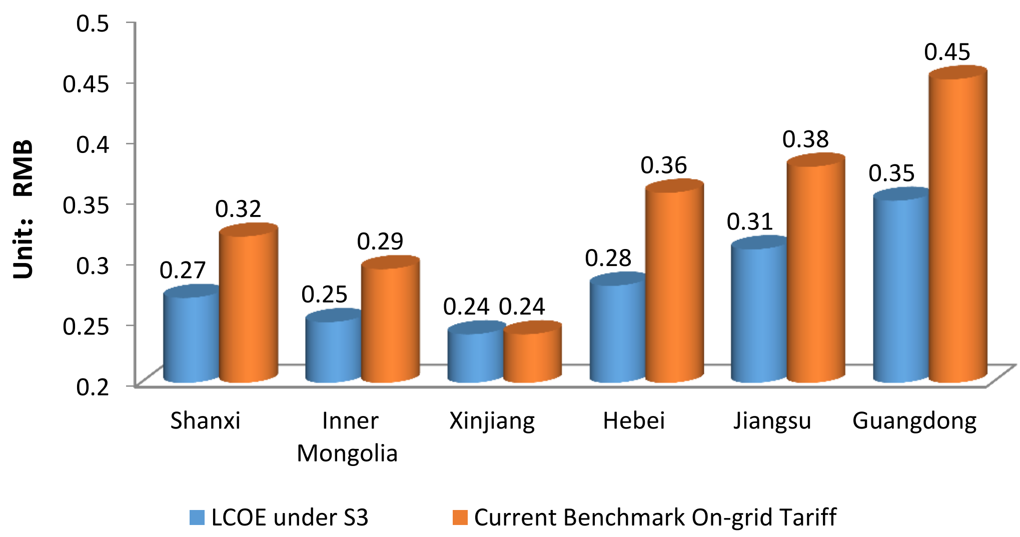

Figure 5-1: Comparison between LCOE and Current On-grid Tariff of Typical Provinces under Scenario 3

Scenario S4: As the electricity marketization deepens, the commodity nature of electricity will be restored. As the electricity market gradually forms, direct transaction will be the major from in the future, and the spot market will gradually be established. Taking Shanxi, the comprehensive pilot province for electricity system reform, for example, pursuant to the approved *Comprehensive Pilot Project Scheme for Electricity System Reform of Shanxi Province*, the direct transaction volume of electricity in Shanxi Province will reach 30% of the total electricity consumption in Shanxi Province by 2017, and for another three years or longer period, the electricity market system will be fully established to form the market-oriented pricing mechanism for electricity[24]. Scenario 4 is based on Scenario 3 after further consideration of the influence of electricity marketization on the economics of coal power, and provides for two possible hypothetical sub-scenarios.

Assumption 1: By 2020, the direct transaction between power generation enterprises and the users becomes the major electricity transaction method, and a small part of the planned electricity quantity will be maintained for the public welfare power generation plan. Assuming that the contractual electricity purchase percentage rises to 80% and then settles in accordance with the tariff for direct power purchase of each province in 2015, the planned electricity quantity percentage reduces to 20%, and the local benchmark on-grid tariff will still be carried out. The IRR and payback period of the new-built coal-fired power plants of each province under this assumption is shown in the table below:

Table 5-7: Full Investment IRR and Payback Period under Assumption 1 of Scenario S4

	IRR	SPP (Year)	DPP (Year)
Shanxi	5.17%	12.97	Non-recoverable
Inner Mongolia	7.83%	9.94	18.98
Xinjiang	<0	—	—
Hebei	9.96%	7.87	13.99
Jiangsu	9.27%	8.96	14.98
Guangdong	6.76%	10.95	29.00

Table 5-8: Proprietary Funds IRR and Payback Period under Assumption 1 of Scenario S4

	IRR	SPP (Year)	DPP (Year)
Shanxi	5.10%	17.90	Non-recoverable
Inner Mongolia	10.70%	10.98	17.96
Xinjiang	<0	—	—
Hebei	15.78%	5.89	9.99
Jiangsu	14.13%	6.92	11.96

Guangdong	8.36%	14.82	26.99

Analysis reveals that, when the contractual electricity quantity rises to 80%, the coal power rate of return of Xinjiang may become negative, and the full investment IRR and the equity capital IRR of coal power projects in Shanxi Province could fall below the benchmark rate of return for the sector. In terms of full investment of other provinces, Guangdong may have the largest fall, down about 5%, and the DPP may extend for 18 years. In terms of equity capital, coal power projects in Hebei, Jiangsu and Guangdong could greatly suffer. The IRR in Hebei and Jiangsu may decrease about 6% while Guangdong's IRR is projected to fall approximately 13%, and the DPP of these three provinces have correspondingly extended about 4, 6 and 21 years, respectively. It can be seen that, though the coal power projects in these provinces are able to recoup their investment during their life time, the fall in rate of return could be substantial and the uncertainty in economics can impose a huge impact. Considering the further decrease of tariff for direct power purchase and the benchmark tariff, then, aside from Hebei and Jiangsu, the benchmark revenues of projects in the other remaining typical provinces will be unable to recover.

Assumption 2: by 2020, the electricity marketization process will have completed, and the market share will consist of 90% middle- and long-term markets and 10% spot market. In middle- and long-term market, the transaction price is determined by the power generation party and the power consumption party upon negotiation. Under conditions that supply and demand are balanced or supply exceeds demand in the spot market, the power generation enterprises will quote on basis of marginal costs (i.e. fuel price), and the final marginal price will be largely determined by the marginal inefficient units, and assume the marginal units are 300MW coal-fired power units. Under this Assumption, the coal power projects of all typical provinces will be unable to recoup their investment during their life time and both their full investment IRR and equity capital IRR will be lower than the benchmark rate of return for the sector.

B. Sensitivity Analysis

The scenario analysis reveals that, as the constraint conditions enhance, the rate of return for coal power enterprises of all provinces will likely gradually reduce and the payback period will gradually extend. Under the conditions of Assumption 1 of Scenario 4, the coal power projects in Shanxi and Xinjiang have already been unable to recoup their investment during their life time, and the economics of projects of other provinces could also seriously deteriorate. In fact, the settings before Scenario 4 of this report are based on facts or analysis made under almost determined scenarios, without considering influences or changes in utilization hours or other key factors. Therefore, this report further provides sensitivity analysis of the coal power projects in Inner Mongolia, Hebei, Jiangsu and Guangdong, which can still recoup their investment under Assumption 1 of S4.

a. Sensitivity Analysis of Utilization Hours

Unit utilization hours is one of the most important factors that affect the return of coal power enterprises. This report's forecast on coal power utilization hours in the four typical provinces, namely Hebei, Inner Mongolia, Jiangsu and Guangdong, has mainly referred to the coal-fired unit utilization level of the regional grid to which each province belongs. It is shown by the thermal power utilization hours data of all provinces in China from 2012 to 2015 that[10,11,25], the utilization hours of Hebei and Inner Mongolia are slightly higher than the average level of the Northern China Grid. Given that the high-consumption sectors play an important part in the electricity consumption structure of Hebei and Inner Mongolia, and the high-consumption sectors in China are facing a series of challenge including de-capacity in the coming five years, this report also assumes that the utilization hours of these two provinces will be lower than the average level of the Northern China Grid. The thermal power utilization hours of Jiangsu and Guangdong are slightly higher than the average level of the regional grid to which each of them belongs, and this report assumes this situation will continue in the future. Pursuant to the estimates of this analysis it is assumed that, in 2020, the coal power utilization hours of Hebei Province are 4,100 hours, while Inner Mongolia 4,000 hours, Jiangsu Province approximately 4,200 hours and Guangdong at around3,500 hours. We determined the sensitivity interval for change in hours and calculate the forecasted coal power IRR under different rates of decrease, based on the forecast on the utilization hours of each province in 2020. Given that the actual situation of each province is different, Inner Mongolia and Jiangsu Province are respectively set to decrease 300 hours, 500 hours and 1,000 hours, while Hebei Province and Guangdong Province are respectively set to decrease 100 hours, 300 hours and 800 hours, specifically as follows:

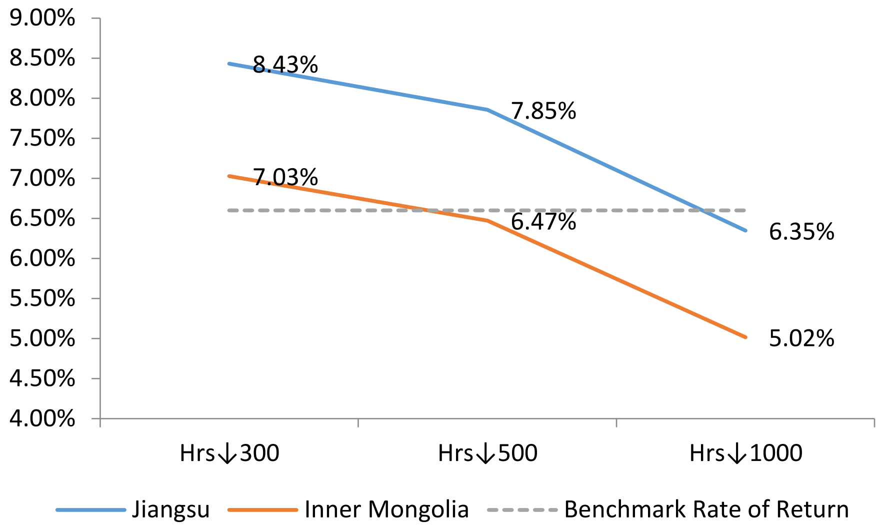

Figure 5-2: Full Investment IRR of Jiangsu and Inner Mongolia under Change of Utilization Hours

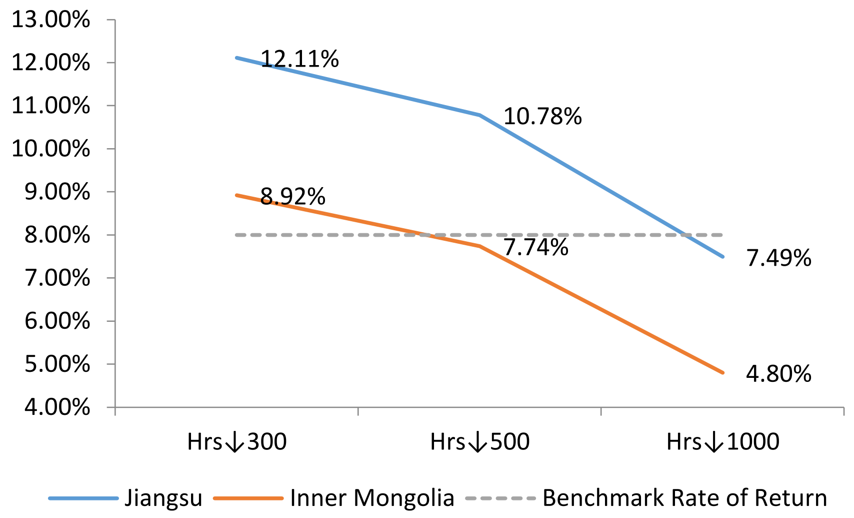

Figure 5-3: Equity Capital IRR of Jiangsu and Inner Mongolia under Change of Utilization Hours

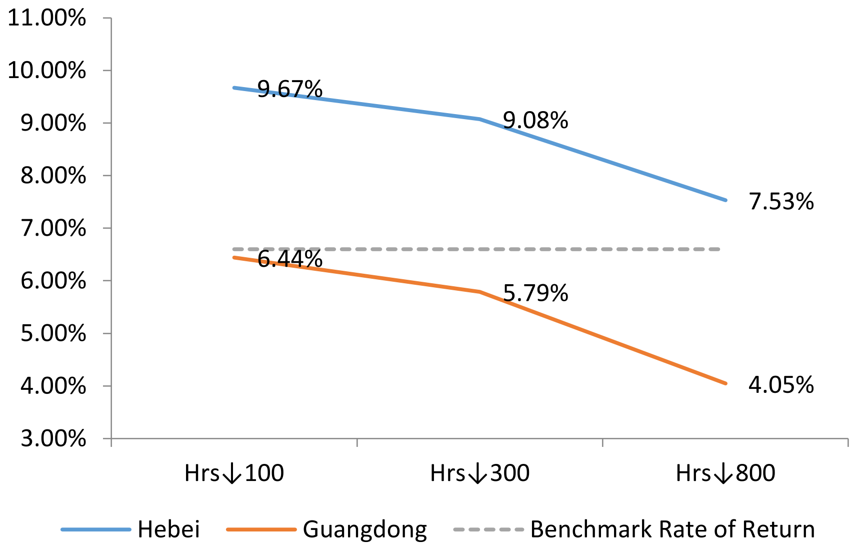

Figure 5-4: Full Investment IRR of Hebei and Guangdong under Change of Utilization Hours

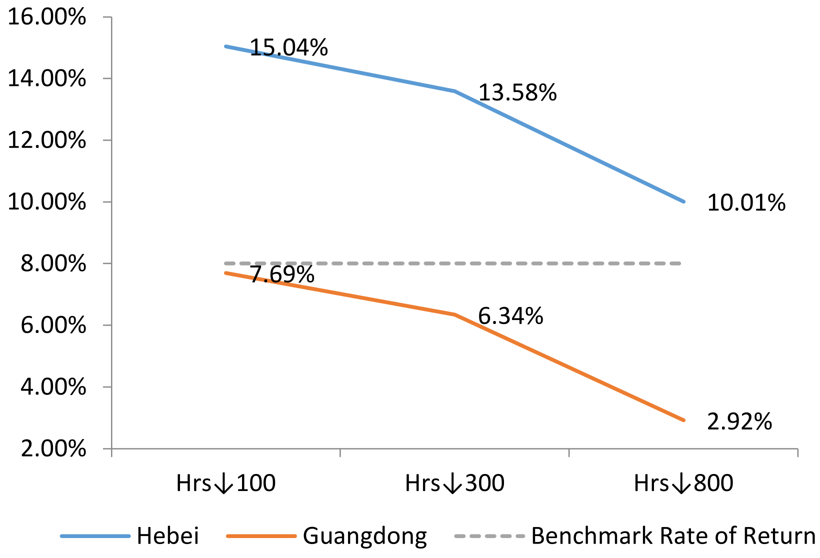

Figure 5-5: Equity Capital IRR of Hebei and Guangdong under Change of Utilization Hours

From the above Figures, when the magnitude of utilization hours decline successively increases, the full investment IRR and the equity capital IRR of the 600MW coal power projects of each province successively decrease. Inner Mongolia and Jiangsu will still be able to recoup their investment if the utilization hours are decreased by 300 hours; however, when it comes to 500 hours, both the full investment IRR and equity capital IRR of the coal power projects in Inner Mongolia will both fall below the benchmark rate of return of the sector, and when it comes to 1,000 hours, the same will occur to Jiangsu Province. When the utilization hours are decreased merely by 100 hours, the coal power projects in Guangdong Province cannot recoup their investment during the project life time, and in all typical provinces, only the coal power projects in Hebei Province will have fair economics (4,100 annual utilization hours) to ensure recouping their investment.

b. Coal Price Sensitivity Analysis

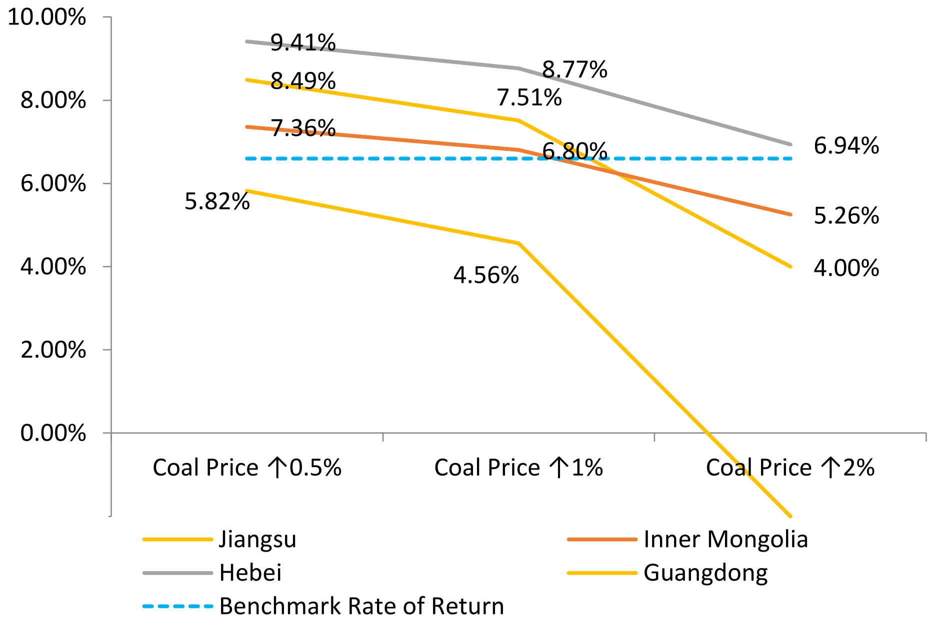

Figure 5-6: Full Investment IRR under Change in Coal Price

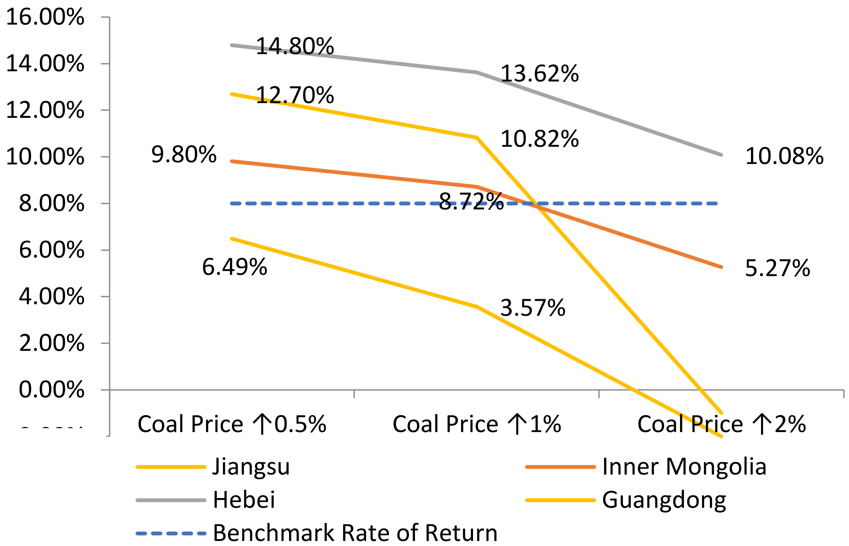

Figure 5-7: Equity Capital IRR under Change in Coal Price

Coal price is a very crucial sensitive factor for the return of a coal-fired power plant, and the current extremely-low coal price in China is one of the important reasons for the great economic benefits of coal-fired power plants. However, the downward trend of coal price has continued for many years, and the coal price could rebound by 2020. This analysis assumes three scenarios under which the coal price is set to go up 0.5%, 1% and 2% annually. It should be noted that this report assumes: either (1) the coal and electricity linkage mechanism is still valid, but the coal price rise does not trigger the linkage mechanism[6]; or (2) the coal and electricity linkage mechanism steps down from the stage with the marketization, thus the tariff will be mainly determined by the demand and supply of electricity, and, despite the rise of coal price due to the imbalanced supply and demand, the power generation enterprises need to absorb the pressure of coal rise themselves. From the above Figure, when the coal price goes up 0.5%, the coal power projects in Guangdong Province cannot recoup their full investment and proprietary funds investment, while the coal power projects in other provinces can maintain their economics. However, when the coal price goes up 2%, except for Hebei in which coal power projects can barely maintain economics, the full investment IRR and equity capital IRR of the coal power projects in Jiangsu, Inner Mongolia and Guangdong will all fall below the benchmark rate of return of the sector, and cannot recoup their investment during the life time of the projects.

c. Sensitivity Analysis of Tariff for Direct Power Purchase

With the formation of the electricity market, the tariff for direct power purchase will continue to decrease. This report presents three scenarios for further decreases of RMB0.01, RMB0.02 and RMB0.03 in the tariff for direct power purchase by 2020 on basis of that of 2015. When the tariff for direct power purchase decreases RMB0.01, the full investment IRR and equity capital IRR of the coal power projects in Guangdong Province will fall below the benchmark rate of return of the sector. When the tariff for direct power purchase falls by RMB0.02, the same will occur to Inner Mongolia and they cannot recoup the investment during their life time. Similarly, when the tariff for direct power purchase falls by RMB0.03, only the coal power projects in Jiangsu Province and Hebei Province will be able to recoup their investment during their life time. Based on the market situation in the last two years, the tariff for direct power purchase in 2020 is expected to have an average fall of over

[6]Pursuant to the circular of the National Development and Reform Commission on matters concerning the improvement of coal and electricity price linkage mechanism, the setting of the rise of coal price in this Report will not trigger the coal and electricity linkage mechanism, that is the power generation enterprises will digest the costs resulting from the rise of coal price internally. The specific provision is that "When the fluctuation of the thermal coal price is less than RMB30/t (inclusive) during the cycle and comparing with the benchmark coal price, the change in costs shall be digested by the power generation enterprises themselves, without initiating the linkage mechanism."

RMB0.03 (i.e. same decrease as the benchmark tariff). Challenges regarding how to recoup their investment will be faced by all power generation enterprises at that time.

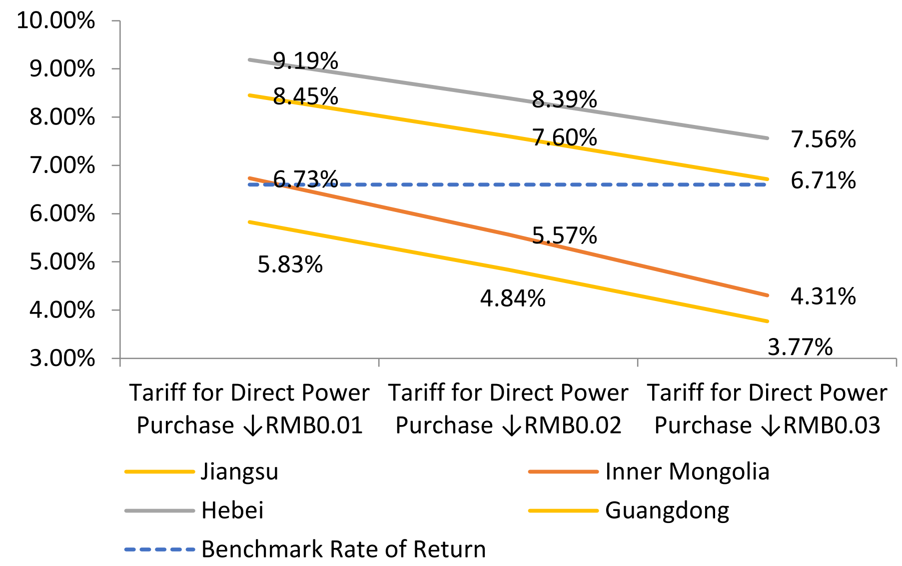

Figure 5-8: Full Investment IRR under Change in Tariff for Direct Power Purchase

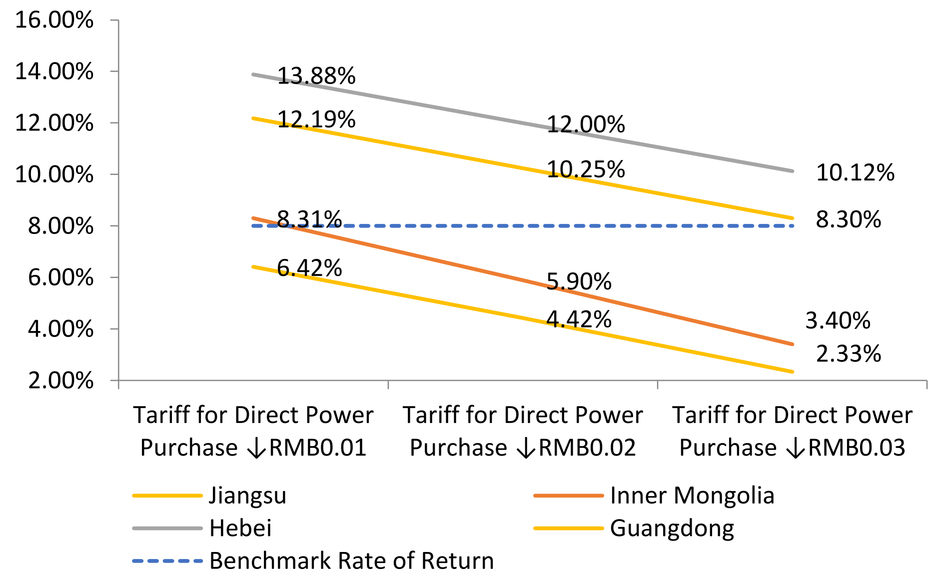

Figure 5-9: Equity Capital IRR under Change in Tariff for Direct Power Purchase

d. Sensitivity Analysis of Emission Charge

It is an inevitable trend to improve the emission charge (tax) rate standards for all provinces in the future. On this sensitivity factor, this report assumes the emission standards in 2020 for SO_2 and NO_X to be respectively enhanced to RMB2,000/t, RMB6,000/t[7] (between the emission charge standards of Shanghai in 2015 and that in 2017) [26]and RMB10,000/t (equivalent to the current standards of Beijing)[27].We can see from the Figure below that, as the emission charge standards increase, the IRR of coal power projects of all provinces successively decreases. Specifically, when the emission charge rises from RMB2,000/t to RMB10,000/t, the full investment IRR in all provinces decreases about 0.6%, and the equity capital IRR even drops more than 1%.Especially for Guangdong Province, when the emission charge is raised to RMB6,000/t, the full investment IRR and equity capital IRR will both fall below the benchmark rate of return of the sector. Certainly, it would be unpractical for the emission charge collection standards of all provinces to be enhanced to the local standards of Beijing; however, the rise of emission charge is inevitable. Hence, the increasingly stringent environment requirements in the future will undoubtedly become a big challenge to the economics of the coal-fired power plants.

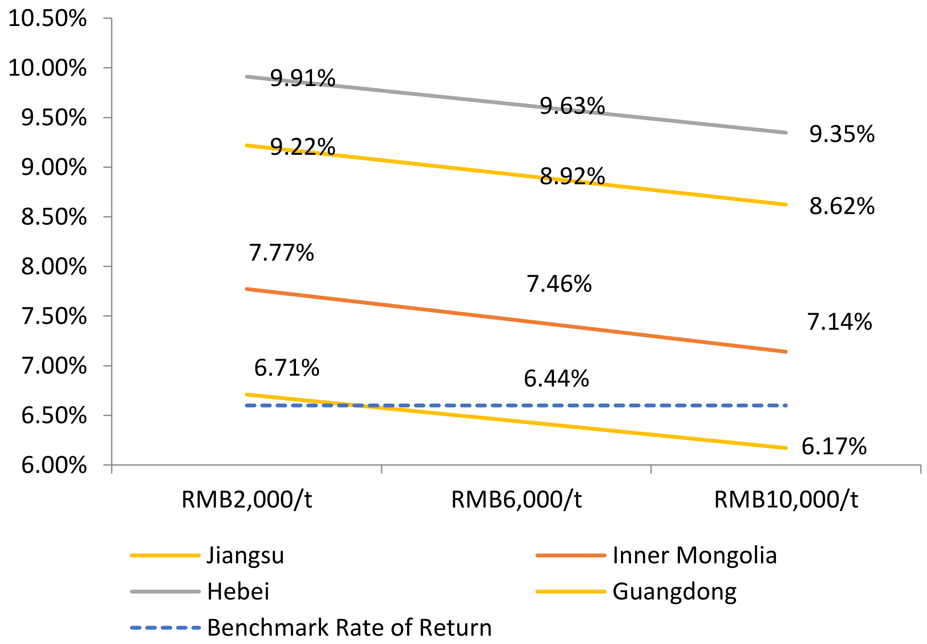

Figure 5-10: Full Investment IRR under Change in Emission Charge

[7]The emission charge standards for SO_2 and NO_X of Shanghai are RMB4,000/t in 2015, and will respectively be RMB7,000/t and RMB8,000/t in 2017, and this Report sets the emission charge for these two pollutants to be somewhere between the emission charges standards in 2015 and that in 2017, and takes the value of RMB6,000/t.

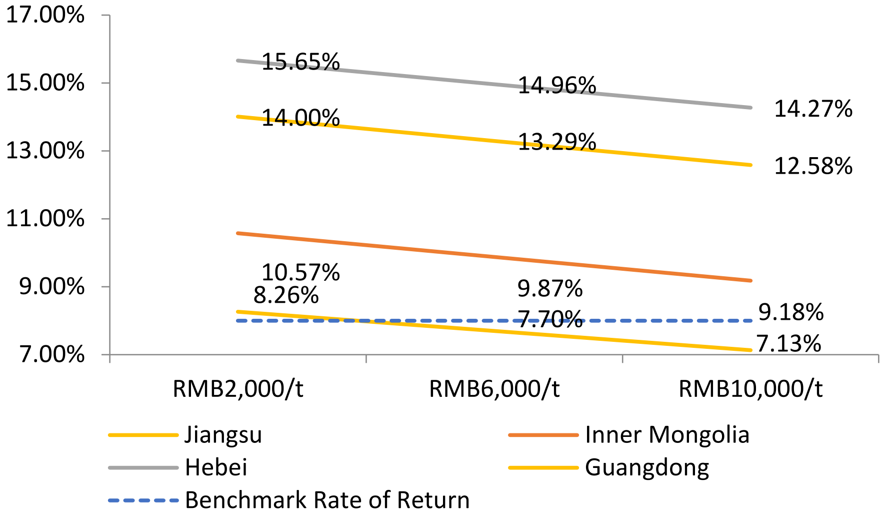

Figure 5-11: Equity Capital IRR under Change in Emission Charge

e. Sensitivity Analysis of Unit Investment Costs of Coal-fired Power Plants

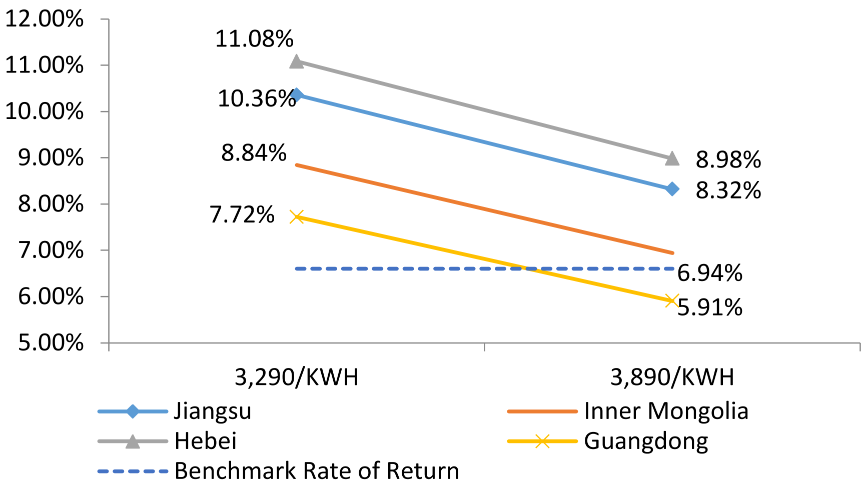

Figure 5-12: Full Investment IRR under Change in Unit Investment Costs

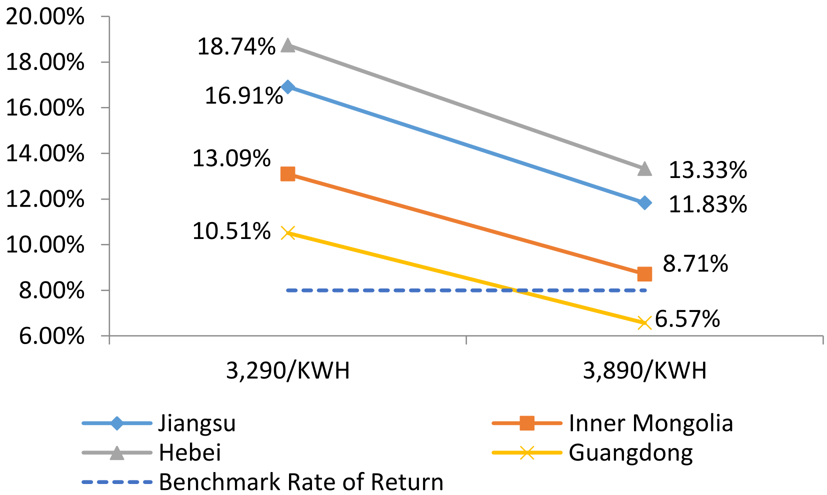

Figure 5-13: Equity Capital IRR under Change in Unit Investment Costs

Unit investment cost is also a sensitive factor that will affect the economic benefits of coal power enterprises. Since environmental retrofitting of all units will be completed after 2018, the State will possibly then terminate the environmental tariff policy, and the remaining retrofitting costs will be borne by the power generation enterprises independently. We, therefore, included a sensitivity analysis interval of ± RMB300 on the basis of the parameter of RMB3,590/kW unit investment costs to calculate the investment IRR of coal power projects in all provinces. The sensitivity analysis shows that, if the unit investment costs of the plants went up due to the rise in environmental protection costs and other compliance costs, the profitability of the plants will be further diminished. From the above Figure, we see that, if the unit investment cost rises to RMB3,890, the full investment IRR of all provinces will decrease about 2%, and the equity capital IRR will decrease around 4-5%. It is worthy to note that the full investment IRR and equity capital IRR of the coal power projects in Guangdong Province will both fall below the benchmark rate of return for the sector.

f. Comprehensive Sensitivity Analysis

In all sensitivity factors, in 2020, it is very probably that the utilization hours will fall sharply and the tariff for direct power purchase will further decrease, and this report considers the largest change in the setting of these two sensitivity factors, to carry out comprehensive sensitivity analysis against Jiangsu Province and Hebei Province, the top two provinces with best economics in coal power projects in the above analysis. The results are as follows:

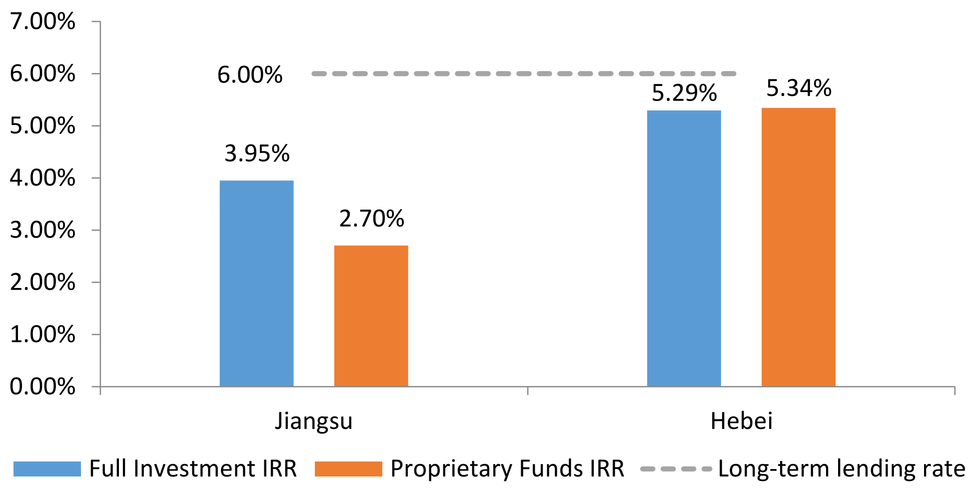

Figure 5-14: IRR under Comprehensive Sensitivity Analysis

We could see that, under the comprehensive influence of utilization hours and tariff for direct power purchase, the economics of the coal power projects in these two typical provinces deteriorate severely, and the full investment IRR and equity capital IRR fall down the benchmark rate of return of the sector, or even both below the bank's long-term lending rate of 6%. That is to say, after considering the decrease in utilization hours and tariff for direct power purchase, even in Hebei and Jiangsu which have the best profitability in 2015, coal power projects will have no market prospects during the 13th FYP period.

6. Discussion on Policy Prospects of Coal Power Development

6.1 Economic Interpretation of the Contrarian Coal Power Investment

The *2016 National Power Supply and Demand Situation Analysis and Forecast Report* published by the CEC points out that the major power enterprises complete power source investment in China totaled RMB409.1 billion in 2015, up 11.0% year-on-year. The national net addition of generation capacity reached 140 GW, creating the historically highest record of annual went-into operation capacity. The annual net addition of thermal power reached 72.02 GW (of which, coal power reached 51.86 GW), the largest annual went-into operation capacity since 2009, and national full-aperture thermal power capacity at the end of year reached 990 GW (of which, coal power contributed 880 GW, accounting for 89.3% of the thermal power), up 7.8% from previous years [1].

Meanwhile, the downward trend of the coal economy has been continuing for over three years. Since 2015, the steam coal price has dropped over 30% and the current coal price has fallen back to the level that existed at the end of 2004. In the context of sufficient electricity supply, continuous negative growth of thermal power generation capacity and continuous falling of unit utilization hours, there are still huge amount of thermal power projects that have been approved and have completed investment. The sharp fall of coal price has led to the decrease of the thermal power generation costs, making the investment interest in thermal power projects surge.

Figure 6-1: History of Thermal Coal Price and Tariff Adjustment Situation [28]

In the rapid economic growth from 2006 to 2008, the conflict between coal and electricity became prominent, and from 2008 to 2012, the coal price remained at a historical high. The State had increased the on-grid tariff and sales tariff several times and coal enterprises took advantage of this situation. After 2012, the coal price kept falling, and the government gradually decreases the sales tariff and on-grid tariff; however, the amount of adjustment was insufficient to match the falling the coal price, which gave more benefit to power generation enterprises[28].

As the electricity supply capacity is sufficient, the thermal (coal) power generation capacity continues its negative growth and the unit utilization hours fall sharply on a year-on-year basis. Meanwhile, many newly approved local thermal (coal) power projects and the coal power investment increase despite the slow growth in electricity demand. Pursuant to the analysis of this report, it is not difficult to decipher that the main drivers of this phenomena is likely the insufficient adjustment to the benchmark tariff for coal power and the lagging adjustment period make the investment in coal power projects still profitable. Meanwhile, the analysis also indicates that the profitability of coal power projects will soon be reversed after 2016.

6.2 Negative Influence of Unabated Interest in Coal Power Investment

6.2.1 Economic Influence on China’s Energy Transformation

The energy sector standing as a pillar industry plays an important role in national economic development. Electricity as the principal part of the energy system is also the hub of the energy sector or even other sectors. China is shifting from the coal-based, coal-intensive and heavy-polluting energy consumption model to a direction of cleaner, sustainable energy by the reducing and replacing of coal power. The unabated interest in coal power investment will not contribute assistance to the transfer of China's energy to renewable energy, but instead, it will likely continue to waste a large quantity of funds in a doomed sector. China's Intended Nationally Determined Contributions also specifies its own action targets by 2030: CO_2 emission will reach peak at or about 2030 and China will make efforts to reach such peak as soon as possible, and the non-fossil energy will account for approximately 20% of the total primary energy consumption. Overinvestment in coal power is obviously contrary to the realization of such targets.

6.2.2 Economic Influence on Power Generation Enterprises

The imbalance highlighted by this report between the "market-oriented coal" and the "planned electricity" has caused conflict between coal and electricity which has been difficult to mitigate for many years. Under this struggle between coal and electricity, it will never be too discreet to make investment in coal power. In the first three quarters of 2015, the total operating profits in thermal power sector reach RMB170.9 billion, up 12% year-on-year, and the profits per kWh is RMB0.054, up RMB0.005 year-on-year, and the gross margin is 24.3%, up 2.4% compare to the previous year[29]. As the coal price on the market continues to fall, power enterprises will continue to obtain relatively high profits therefrom in the short term. The analysis in this report has clearly showed that, in the long term especially in the wake with the launch of a series of national power reform policies—if power enterprises continue to construct new coal-fired power plants, they will face losses of economic benefits and non-recoverable investment. This short-sighted investment activity of power enterprises is in direct opposition to the objective of the planned reform of state-owned enterprises.

6.2.3 Influence on Ecological Environment

The 14 hundred-million-tonne large-scale coal bases and 9 ten-million-kW large-scale coal power bases as deeply concerned in *Thirsty Coal (A Research on Coal-power Base Development and Water Resources)* are mostly scattered in the ecologically fragile western regions (e.g. Huaidong and Ningdong)[30].The collapse caused by the coal base in Huainan, Anhui and the large-scale collapse of the grassland caused by the open pit of the Mengdong coal base in "Suspended Village" of Shanxi coal mining area should cause serious reflection. Building up coal-fired power generation projects (which are high in water-consumption) in such areas where water resources are scarce will only intensify the regional water resource crisis. The excessive investment in coal-fired power plant may also serve to increase the greenhouse gas emission pressure.

6.3 Evolution of Coal Power Regulation Policies

6.3.1 Evolvement of Coal Power Regulation Policies in 2015

With the gradual delegation of the coal power project approval powers since 2014, the scale of coal-fired power generation projects newly approved in 2015 reached an "unprecedented" level, and in the 2nd half of 2015, a large-scale debate on the coal power overcapacity and investment bubble widespread over the country. Increasingly stringent coal power regulation policies issued by competent authorities will need to carry stronger administrative efficacy and efforts in policy execution:

1) The *Circular on Carrying out Effective Work on Planned Construction After the Delegation of the Power for Approval of Power Projects*[31] issued by NDRC and the NEA in October 10, 2015 has specified "to establish and build up a new management mechanism for the planned construction of power projects integrating and coordinated by 'planning, policy, rule and regulation', and to ensure 'the simultaneous delegation of powers and responsibilities and the simultaneous reinforcement of regulation and supervision' after the delegation of approval power." This is the first official reply from the governing authority after local governments approved coal power projects "on a large scale" upon the delegation of project approval power.

2) On the 2016 National Energy Conference convened on December 29, 2015, the NEA specifies "to orderly develop coal power and effectively control the scale of coal power capacity"[32]. Literally speaking, at that time, the governing authority had not taken stand on whether there is coal power overcapacity issue.

3) On February 18, 2016, on the meeting of the Leading Group for Comprehensively Deepening Reform of National Energy Administration, Nur Bekri, Director of the NEA put forward "to mitigate the coal power overcapacity". For regions with power redundancy, based on the actual situation, a batch of projects failing approval conditions were to be cancelled, and the approval for a batch of coal power projects were to be deferred, and the construction of a batch of approved projects were to be postponed[33]. In the *Guiding Opinions on Energy-related Work in*

2016 published on March 22, the policy keynote is “to control the scale of coal power capacity” [34].

4) On March 17, 2016, the media reported that the NDRC and the NEA jointly issued an extremely urgent document, the *Circular on Promoting the Orderly Development of Coal Power in China* (which has not been officially published on the website of the governing authority so far), which officially specifies “to establish risk alert mechanism”, “strictly control the scale of aggregate coal power capacity” and “orderly push the coal power construction” and take other coal power regulation measures [35].

5) On April 12, 2016, the media reported that “the coal power planned construction risk alert mechanism rushes out”, and disclosed the 2019 Coal Power Planning and Construction Risk Alert Information [36].

6.3.2 Coal Power Planning and Construction Risk Alerting Mechanism and its Brief Assessment

It is reported by the Energy Observer[36] that, the coal power planning and construction risk pre-warning mechanism indicator system is composed of three components: coal power construction economics pre-warning indicators, coal power installed capacity sufficiency pre-warning indicators and resource constraint indicators (which shall be respectively rated in green, orange and red).

The coal power construction economics pre-warning indicator is based on the return on investment (“ROI”) of the newly commissioned coal power projects in all provinces (autonomous regions and municipalities directly under central government) after three years. If the ROI is (i) lower than the middle- and long-term treasury bond rate, it will be a red pre-warning; (ii) between the current middle- and long-term treasury bond rate and the general project rate of return (usually 8% for power projects), it will be an orange pre-warning; and (iii) higher than general project rate of return, it will be at green level.

The coal power installed capacity sufficiency pre-warning indicator is the rate of reserve capacity of power system of all provinces (autonomous regions and municipalities directly under central government) after three years: red pre-warning means obvious redundancy in installed capacity and excessive rate of reserve capacity of power system; orange pre-warning means relative sufficiency in coal power installed capacity and relatively high rate of reserve capacity of power system; and green means the basic balance in or gap between power supply and demand, and the appropriate or slightly low rate of reserve capacity of power system.

The resources constraint indicator is based on the air pollutant emissions, water resources quantity, total coal consumption and other related resources situation of all provinces (autonomous regions and municipalities directly under central government), and is divided into the red level and green level. The red level refers to severe air pollution, shortage in water resources quantity, urgent need in controlling the total coal consumption or that coal power planned construction subject to any other resources constraint, and the rest situation shall be green level.

Based on the pre-warning indicator system above, the NEA will publish the coal power planned construction risk pre-warning indicators by province in January of each year. The final risk pre-warning rating will be determined according to the highest rated level in the three indicators, and the top-down alert degree shall be red, orange and green. Based on the alert rated, a red alert result indicates power redundancy or any new-built coal power project not permitted by the policy: local governments in regions with red alert shall defer the approval of coal power projects and enterprises in such region shall make prudent decision on the commencement of the project. The orange alert indicates relative sufficiency in power, and suggests local governments and enterprises to make prudent decision on coal power projects. And the green result indicates normal, and local governments and enterprises may reasonably push forward the planned construction of coal power projects based on the electricity demand.

The first pre-warning year initially published is 2019. The result shows that the alert status of 28 provincial grid regions are the rated as “red”, and only Jiangxi Province, Anhui Province and Hainan Province are rated as “green”, with Hubei Province in the “orange” status.

The coal power installed capacity sufficiency is the most stringent indicator, showing red alert for 24 regions. Except for Jiangxi Province, Anhui Province and Hainan Province, only Southern Hebei, Sichuan Province and Yunnan Province obtain “green” pre-warning, that is, only the coal-fired power generation units in 6 provincial grid regions maintain a reasonable utilization rate.

In terms of coal power construction economics indicator, 14 regions are given red alert in total, and the remaining 17 regions are green. As to the resources constraint indicator, there is relatively strong regional tendency. The 5 big provincial grid regions in Beijing-Tianjin-Hebei Region and Shandong are all given red alert. Shanghai, Jiangsu Province and Zhejiang Province in the Yangtze River Delta Economic Zone are all given red alert. And Guangdong Province, located in the Pearl River Delta Economic Zone, is also given red alert.

The study group responsible for this report agrees that the governing authority has established a competent coal power planning and construction risk alerting mechanism in such a short time and has fully revealed the surge in coal power investment and the robust rise in the contrarian growth of newly approved projects. Additionally, the determination of the governing authority has shown great initiative to inhibit the coal power overcapacity and the policy space for further regulation. However, combining with the quantitative economic analysis results presented by this report, this alerting mechanism can still be improved from the following aspects:

First, the time window alerting based on the three-year prospects period certainly matches with the construction period of coal power projects; however, in order to match with the energy power planning, the coal power installed capacity sufficiency indicator should also include the five-year prospects period alert.

Second, it is important that the resources constraint indicator needs to consider the air pollutant emission, water resources quantity, total coal consumption and other related resources situation of all provinces (autonomous regions and municipalities directly under central government) in its policy framework. However, judging from the actual alert information, the red alert regions concentrate in regions with heavy pollution in air quality, and the water resource constraint indicator has not been really internalized. Despite the huge water resources pressure in coal base provinces such as Inner Mongolia, Shanxi, Xinjiang, Shaanxi and Ningxia, the resources constraint indicator in these provinces is still at green level.

Third, judging from coal power economics alert indicator, the alert results in 17 provincial and regions including Inner Mongolia, Xinjiang, Zhejiang, Guangdong and Hebei are still at green level. That is, the rate of return of the newly-built coal power projects in these provinces and regions in 2019 will remain above the normal rate of return of projects. The systematic and detailed economics prospect results presented in this report show that, influenced by the decrease in benchmark on-grid tariff and further decrease in utilization hours, the economics alert result of the coal power projects in Xinjiang, Inner Mongolia and Guangdong has reached red, and the coal power projects in Hebei has also reached the orange alert level under the joint efforts of different factors.

7. Study Conclusion

7.1 Study Findings

This report first provides a brief analysis of the current situation of economics of the coal power projects in selected typical provinces and carries out a systematic study over the economic benefits prospect of the coal power enterprises under predicted changes to the external development environment such as electricity market competition and continuous deterioration of unit utilization rate during 13^{th} FYP period. The findings are as follows:

(1) The continuous falling coal prices have lowered the power generation costs of the coal power companies across all provinces. There has been insufficient adjustment to the benchmark on-grid tariff, enabling coal power generation companies to obtain unprecedented excess profits. Comparing the current actual benchmark on-grid tariff and LCOE of all provinces, the excess profits per kWh of typical provinces (except for RMB0.02-0.03 in Inner Mongolia and Xinjiang) are within RMB0.05-0.08. Such excess profits have caused acceleration in the investment interest of coal power generation companies and caused local governments to over-rely on coal power projects under the economic downturn pressure. This, in turn, boosts the contrarian investment by the coal power generation companies. This report suggests that, in the context of the sharp fall of demands and the low-carbon transformation and upgrading, such conflict is the main economic reason for the "unabated interest" of coal power investors.

(2) During the "13^{th} FYP" period, the external environment for coal power development could change greatly, and the economics of coal power generation companies will be heavily affected. Facing more stringent policy and environment restraints, increasing carbon emission pressure and intensifying price competition under electricity marketization, except for Hebei and Jiangsu, the coal-fired power generation projects in the remaining typical provinces cannot reach benchmark rates of return. They are, therefore, unable to recoup investments during their life time. Additionally, if we further consider the change of two sensitive factors, namely the unit utilization rate and the degree of reduction of tariff for direct power purchase, the coal-fired power generation projects in all selected typical provinces will be unable to recoup investments during their life time and their investment prospect is very bleak.

7.2 Policy Suggestions

It is fundamental to formulate a strategic power development plan adapted to the new economic normal. The current year of 2016 is the first year of the "13th FYP" and also the year when the "13th FYP" Energy Plan and Power Plan will be implemented. Relevant national authorities are advised to study and issue power development plans adapted to the new economic normal as soon as possible. Such plans should provide for low-carbon power transformation, arrange sufficient lead time for completion of 20% non-fossil energy targets by 2030, set up the coal-fired power development targets in strict compliance with the principle of prioritizing clean renewable energy, demand side energy, and rein the irrational growth of investment in coal-fired power generation projects should be approved. In provinces with obvious power redundancy, key areas for air pollution control and regions with red-alert of water resources, no arrangement of new coal-fired power generation projects should be approved. In preparation for further deepening reform in examination and approval systems, the provincial planning under national planning guidance and the planning guidance projects approval principles should be reinforced, and the evaluation and accountability system for project decision-making should be improved.

Of utmost priority is the termination of irrational investment by coal power generation enterprises and the reasonable regulation and control of the coal power capacity. Pursuant to the capacity currently under construction and demand growth trend, the governing authority is advised to implement measures that place "a hard brake on" coal-fired power by: 1) to improve the dynamic coal-fired units planning and construction risk alerting mechanism, and, in terms of risk alerting on sufficiency of coal power installed capacity, to give comprehensive consideration of the existing power sources, capacity under construction and transferred power sources and fully tap the demand side potential and scientifically evaluate coal power over-capacity in all provinces and areas. Orange alert should be given to provinces and areas with coal-fired power capacity under construction that can satisfy the electricity demand in the next three years. And red pre-warning should be given to provinces and areas with capacity under construction that can satisfy the electricity demand in the coming five years. The resources constraint indicator system should be elaborated to take full consideration of the pre-warning binding effect of water resource constraint over coal power projects. The economic indicators for coal power construction should be improved to fully consider the influence on the economics of coal power caused by such factors as reduction of utilization hours, decrease of benchmark tariff, market-oriented competition and internalization of carbon costs and pollutant emission reduction costs. 2) To adopt the method of "cancelling a batch of projects, deferring the construction of a batch of projects, freezing approvals" to carry out specific regulation and control of the coal-fired power generation projects. All coal-fired power generation projects failing the approval conditions should be cancelled. The construction of all coal-fired power generation projects in provinces with orange alert before 2018 should be deferred, and all approved but unconstructed projects (except for civil thermal power) should be cancelled. In provinces with red pre-warning, the construction of all coal-fired power generation projects before 2020 should be deferred, and all approved but unconstructed projects (except for civil thermal power) should be cancelled. Besides the approval for all additional coal-fired power generation projects should be frozen during the 13th FYP period, and the power supply capacity in regions without sufficient resources should be guaranteed by strengthening the trans-provincial or trans-regional allocation of resources, which could also mediate the wide range of coal power overcapacity to some extent[37].

Adherence to marketization is a fundamental resolution. The electricity marketization should be steadily promoted on the principles of "implementation of government pricing and relaxing control on market access at the power generation side and the power sales side", and the prices at the grid side and the retail side should be orderly relaxed if the power transmission and distribution tariff reform is thoroughly implemented, so as to have the valid price signal to play a fundamental role in guiding power generation investment. Only marketization may break the stubborn expectation of power generation enterprises on the utilization hours and on-grid tariff, so as to gradually establish a truly market-oriented power generation investment mechanism. It is advised that no annual power generation plan for any coal-fired power generation project that is newly commissioned in 2015 and thereafter will be approved, and all such projects should directly participate in the electricity market, and that the marketization construction should be steadily promoted in accordance with the established timetable for relaxing control on power generation and consumption plan. Besides, in the marketization process, the government should pay more attention to the adjustment of its own role, and should gradually rectify the negative externality of coal-fired power generation by means of construction of a national carbon market, increase of pollution fee (or tax) standards and other measures to provide a fairer market environment for the development of renewable energy[38].

By the said measures, "a hard brake is placed" to effectively control the trend of irrational overinvestment in coal power so as to maintain the coal power utilization hours at around 4,000 hours by 2020 and avoid any long-term loss for the whole sector.

8. Appendices

Appendix 1: Description and Reference for Parameters Setting

Parameters	Basis and Description
Unit Investment Costs	China Electricity Council, Power Development Report of 2015: Unit Costs Analysis for 600MW Coal-fired Plant in 2014
Initial Value of Annual Utilization Hours	National Energy Administration: Statistics of Average Utilization Hours of Power Generation Units of Plants of 6MW or More in China in 2014
Financial Parameters (proprietary funds ratio, loan term, return on proprietary funds during depreciation life, annual interest rate, etc.)	Proprietary fund ratio and return on proprietary funds ratio shall be obtained pursuant to the industry practices, and the term loan (15 years) shall be shorter than the depreciation life (20 years), and the annual interest rate (lending rate) shall be obtained through the comprehensive estimate of long-term lending rate of different periods.
Rate of coal consumption reduction in generation	National Energy Administration: Action Plan for Energy Saving, Emission Reduction, Upgrading and Retrofitting of Coal-fired Power Plants (2014-2020)
Auxiliary power consumption rate	The auxiliary power consumption rate of power plants relates to such factors as type of coal fired power plants, mechanization and automation degree, type of fuel and steam parameters of the plants. This Report selects pure condensing generation units, and the auxiliary power consumption rate of condensing plants is 5%-8%, and this Report selects the data of 5%.
Water consumption in generation	China Electricity Council: Energy Efficiency Benchmarking Data of Thermal Power Generation Units of 600 MW in China in 2014
Sulfur content of coal, SO2 emission factor of coal, CO2 emission factor of coal and NOx emission factor of coal	Based on the generation and emission coefficient of industrial pollutants, Sulfur content of coal: in China, coal with sulfur content of less than 1% is called low sulfur coal, therefore we set the sulfur content of coal as 1% in this Report.
VAT, enterprise income tax, urban maintenance and construction tax, education surcharges, house property tax, fuel input tax, materials input tax, water input tax and land use tax	Based on the tax laws and relevant regulations promulgated by the State
Rate of overhaul charge, insurance premium, materials costs and other expenses, etc.	Set up in accordance with the management quota of the power generation enterprise (e.g. *Standards for Limit of Material Costs and Costs of Overhaul of China Huadian Corporation*)
Employee salary and	Research data of typical enterprises and national labor allocation

insurance benefits surcharges	policies
Emission charge	Emission charge rate policies of relevant provinces as reported on the websites of http://huanbao.bjx.com.cn, http://www.gmw.cn, and http://www.sina.com.cn, RMB1.2/pollution equivalent (conversion rate: RMB1.26/kg =RMB1,260/ton)
Fuel costs	Price Monitoring Center of the National Development and Reform Commission: China's Coal-fired Power Generation Price Index in November
Direct power purchase percentage	Reporting on Polaris Power Website (http://huanbao.bjx.com.cn): A Decade of Direct Power Purchase
Fee for industrial water	Water fee inquiry website of each province

Appendix 2: Description of Items of Cash Flow Statement of Full Investment

Serial No.	Item	Figure Selection Instructions
1	Cash Inflow	1.1+1.2+1.3
1.1	Product Sales (Operating) Income	From “Income Statement”
1.2	Recovery of Residual Value of Fixed Assets	Calculated on basis of total investment and residual rate
1.3	Recovery of Working Capital	From “Liquidity Fund Estimate Statement”
2	Cash Outflow	2.1+2.2+2.3+……+2.7
2.1	Fixed Assets Investment	From the total investment and desulfurization and denitration investment in the LCOE model
2.2	Liquid Assets Investment	From “Liquidity Fund Estimate Statement”
2.3	Operating Costs	From the fixed costs and variable costs in LCOE model
2.4	Emission charge	Calculated from the emission load and emission price
2.5	Carbon Emission	Calculated on basis of the carbon market assumptions
2.6	Sales Tax and Surcharges	From the “Statement of Sales Tax and Surcharge”
2.7	Income Tax	From “Income Statement”
3	After-tax Net Cash Flow (1-2)	1-2
4	After-tax Cumulative Net Cash Flow	After-tax net cash flow of this year + after-tax cumulative net cash flow of last year

Appendix 3: Description of Items of Cash Flow Statement of Proprietary Fund

Serial No.	Item	Figure Selection Instructions
1	Cash Inflow	1.1+1.2+1.3
1.1	Product Sales (Operating) Income	From “Income Statement”
1.2	Recovery of Residual Value of Fixed Assets	Calculated on basis of total investment and residual rate
1.3	Recovery of Working Capital	From “Liquidity Fund Estimate Statement”
2	Cash Outflow	2.1+2.2+2.3+……+2.7+2.8
2.1	Proprietary Fund Input	From the data in the LCOE model
2.2	Repayment of Principal of Long-term Loan + Payment of Loan Interest	From the data in the LCOE model
2.3	Repayment of Principal and Payment of Interest of Working Capital Borrowing	From “Liquidity Fund Estimate Statement” and short-term lending interest
2.4	Operating Costs	From the fixed costs and variable costs in LCOE model
2.5	Emission charge	Calculated from the emission load and emission price
2.6	Carbon Price	Calculated on basis of the carbon market assumptions
2.7	Sales Tax and Surcharges	From the “Statement of Sales Tax and Surcharge”
2.8	Income Tax	From “Income Statement”
3	After-tax Net Cash Flow	1-2
4	After-tax Cumulative Net Cash Flow	After-tax net cash flow of this year + after-tax cumulative net cash flow of last year

Note: Calculate the internal rate of return, static payback period and dynamic payback period respectively on basis of the “after-tax cumulative net cash flow” in the Cash Flow Statement of Full Investment and the Cash Flow Statement of Proprietary Fund.

Glossary

Pure Condensing Generation Units	Pure condensing generation units refer to the power generation units without supplying heat, where the exhausts from the last stage of steam turbines all enter into the condenser for condensing.
Levelised Costs of Electricity (LCOE)	The power generation costs per kWh during the construction and operation period of a power generation project, which is used to measure the ratio between the discounted value of the total costs and expenses of the power generation project from initial construction to operation and the economic time value of the power output during its life cycle, i.e. the levelised discounted costs of the project, which may be used for calculation of the tariff during the operation period. The principle of calculating LCOE is to measure and calculate tariff on basis of comprehensive consideration of all annual costs and change in demands for loan repayment during the economic life cycle of a power project, by calculating the annual cash flow of the power project, and on the condition that the net cash flow in each year within the economic life cycle can satisfy the financial IRR calculated per the registered capital of the project.
Benchmark On-grid Tariff	Refers to the tariff policy which the State carries out uniform pricing for newly-built power generation projects in accordance with the regional or provincial average costs and on basis of the tariff for operation period, for the purpose of pushing forward the market-oriented reform of tariff. China for the first time published the uniform on-grid tariff level for coal-fired units across China in 2004, and adjusts the same in subsequent years based on the change in coal-fired generation costs of power generation enterprises.
Stable Expectation	Under the institutional framework of "power generation for the government by the enterprises and power project shutdown for enterprises by the government", the annual power generation plan of thermal power is determined by the economic operation department of local government, and its on-grid tariff shall be specified in the benchmark on-grid tariff policy issued by the National Development and Reform Commission. In the context of the steady growth in electricity demand, this has formed stable expectation on the power consumption and tariff for power generation enterprises.
Excess Profits	LCOE costs may be broken down into depreciation, fuel costs, operation and maintenance costs, taxes and benchmark return on proprietary funds. And benchmark return on proprietary funds refers to the corresponding part of the tariff when the financial IRR of the project (which is set to be 8% by this Report according to the power industry practices) is satisfied. The actual benchmark on-grid tariff may be broken down in the same way, and if the actual benchmark on-grid tariff is higher than the LCOE, and on the condition that they

		have the same depreciation, fuel costs and operation and maintenance costs, then after deducting the paid taxes of larger amount, the corresponding profits part will exceed the requirement for benchmark return. For the convenience of discussion, it is called "excess profits" in this Report.
Assumption of Overnight Investment Costs		It is an internationally-accepted practice for calculation of LCOE without taking account of the project construction period (i.e. completed overnight) and the financial costs during the construction period, so as to simplify the assessment process.
Net Present Value (NPV)		NPV refers to the difference between the present value of the cash inflows forecasted to be earned by the project and the cash expenditure for implementation of such project. Projects with positive NPV may create values for shareholders and projects with negative NPV will damage the shareholders' value.
Internal Rate of Return (IRR)		Internal Rate of Return (IRR) refers to the discount rate when the total present value of fund inflow equals to the total present value of fund outflow, and the NPV is equal to zero. Generally, when IRR is higher than the benchmark rate of return, this project will be feasible.
Benchmark Rate of Return		The full investment IRR is set to be 6.6% and the proprietary funds IRR is set to be 8% according to the industry practices in the energy sector, which is the benchmark yield level of the industry.
Payback Period	Static	Static Payback Period (SPP) refers to the time required for paying back its full investment from the net proceeds of the project without considering the time value of funds.
	Dynamic	Dynamic Payback Period (DPP) refers to the payback period inferred from converting the net cash flow of each year of the invested project into present value on basis of the benchmark rate of return.
Proprietary Funds		Proprietary funds refer to the funds that are often held by an enterprise at its disposal and use for production and operation activities without any repayment obligation, as opposed to borrowed funds.
Full Investment Assumption		Refers to that, when determining the cash flow of a project, only the movement situation of full investment will be considered, without clear distinction of the forms of cash flow, such as proprietary funds and borrowed funds.
Negative Externality		Externality refers to the situation when the actions and decisions of an economic entity do harm or good to a person or a group of persons. Economic externality means the non-market-based influence of the economic activities of an economic entity (including manufacturer or individual) on others and society; that is the costs and consequences of the economic activities carried out by a social member (including organization and individual) are not completed borne by such member. Negative externality refers to that despite the economic activities of any individual entity or person have

	jeopardized the interests of others or society, such entity or person is not liable for the costs thereof.
(Carbon) Marginal Social Costs	Any additional unit of carbon emission will increase the monetary costs of the negative externality damages caused to the whole society. By carbon trading, the price mechanism should be able to discover efficient emission reduction costs, that is, according to the bottom-up emission reduction costs, the costs corresponding to an additional unit emission reduction may be founded on the emission reduction costs curve.
Socialized Pass-on Coefficient	Carbon costs have two concepts: producer responsibility and consumer responsibility. Carbon market trading is designed on basis of the principle of producer responsibility; however, producers will ultimately pass on all or part of the carbon costs to end consumers. The part passed on to consumers is defined in this Report as the socialized pass-on coefficient.
Spot Market	Spot market collectively refers to trading activities carried out through the trading platform on a centralized basis from the day immediately before the real-time operation of the system to the real-time operation. Spot market includes the day-ahead market, intraday market and real time market.
Marginal Units and Marginal Price	On spot market, the short-term marginal costs of different power generation units (mainly the fuel costs) are ranked bottom-up, and when the electricity demand for any given period is satisfied, the last units in the supply side shall be the marginal units, and the short-term marginal costs of such units shall be the marginal price for such period.
Mid- and Long-term (Contract) Market	Mid- and long-term market will mainly adopt bilateral negotiation as the way to carry out electric energy transaction. This includes the direct power transaction (i.e. the “direct power purchase” as stated in the Report), trans-provincial and trans-regional power transaction and other market-oriented transactions, transactions based on priority power generation contracts and electric energy transfer transaction carried out on basis of the contracts above, etc.
Ultra-low Emission of Coal-fired Plants	The major air pollutants emission standards of coal-fired units should achieve the emission standards for natural gas-fired units by applying multi-pollutants high-efficiency coordinated control technologies.
National Carbon Market	Pursuant to the *NDRC Climate [2016] No.57 Circular*, China will launch the national carbon emission trading in 2017 to carry out the carbon emission trading system. The first stage will cover petrochemical, chemical, construction materials, steel, non-ferrous metal, paper making, electricity, aviation and other key emission industries. According to the work progress requirements, the National Development and Reform Commission will launch and

	implement the allocation scheme of the allowances in the national carbon emission trading system in 2016.In 2017, when the national carbon market operates, enterprises with an annual aggregate comprehensive energy consumption reaching 10,000 tons of standard coal in the covered industries will at their discretion choose emission reduction or purchase (or sale) of allowances on basis of the actual production emission, allocation of carbon emission allowances and marginal emission reduction costs, which will therefore form a national uniformed carbon trading price to build the market-oriented systems for emission reduction of greenhouse gases.

9. Parameters and References

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