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The economics of coal power generation in China

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ABSTRACT

The Chinese government recently released the 13th FYP (five-year plan) power development plan and proposed a capacity installation target of 1100 GW for coal power. Considering the weak demand growth of coal power since 2014, continuous decline in the annual utilisation hour and the coming market competition, such a planning target is unwelcome and could further the economic deterioration of coal power. In this paper, we employ LCOE (levelised cost of electricity) and project evaluation models to conduct a nationwide survey on the economics of coal power. The economic analysis has clearly indicated that the recent boom of coal power investment in China, which is absurd in many perspectives, is largely the aftermath of uncompleted market reform in the power sector. However, the fundamentals of electricity demand and supply are changing at a speed beyond the imagination of power generators and have foreboded a gloomy prospect for coal power. Our study shows that by 2020, with several exceptions, in most provinces the internal rate of return for coal power will drop below the social average return rate or will even be negative. In this regard, the 13th FYP capacity planning target for coal power is economically untenable and requires radical revision.

1. Introduction

With a 2.3% reduction in thermal power generation and only 0.5% growth in total electricity consumption, China's new addition of coal power capacity in 2015 is incompatibly high at 52 GW (CEC, 2016a). Regarding the operation efficiency and profitability of coal power, the paradox is self-evident. The annual utilisation hour of thermal power was only 4329 h in 2015, down by 410 h as of the 2014 level and hit the lowest record since 1969 (CEC, 2016a). But in terms of profitability, the coal power sector appeared to take advantage of the apparent imbalance between coal price and on-grid benchmarking tariff and reaped high profits, reaching a historic record since the 2000s (Polaris Power Net, 2016). In China, the government strictly regulates the on-grid tariff of coal power, although market force largely determines coal price. Though a co-movement mechanism for adjusting on-grid tariff had been formulated by the National Development and Reform Commission (NDRC) since 2004 and updated three times since, it was only loosely and arbitrarily implemented (Polaris Power Net, 2016; NDRC, 2015a).

It seems that the interest of power generation companies in investing new coal power projects is strong. A recent study by Greenpeace and CoalSwarm (2016) indicated that approximately 73–79 GW-capacity projects are currently under construction, which represents significant growth compared to new installation in the previous year. Such a discord in supply and demand is further illustrated by the project scale under the Environment Impact Assessment (EIA) approval announced by either the Ministry of Environment Protection or its provincial counterparts in 2015. The total capacity amounted to 169 GW, of which 159 GW has been granted or pre-granted by the EIA approval (Yuan et al., 2016a, 2016b, 2016c). This represents a significant increase when compared with the total EIA-approved capacity for the same period in 2014—which was 48 GW (Greenpeace, 2015).

Although thermal power has enjoyed the best economic return since the 2014 downturn of coal price, discrepancies are apparent in the sector's profitability. In 2015, the thermal power utilisation hour in Yunnan, a province well-known for its rich resources in hydropower, was only 1879 h, while the utilisation hour in Sichuan was 2682 h. In Gansu, a province rich in renewable energy resources, fewer than 3800 h of annual utilisation was recorded, while Jilin documented only 3300 h. The coal power sector fell below the break-even point rapidly in these provinces.

The industry institution, China Electricity Council (CEC), expressed its deep worry on the profitability of coal power by publishing a report

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in March 2016 (CEC, 2016b). The National Energy Administration (NEA) and NDRC (2016) subsequently issued a prewarning mechanism, which consists of an economic warning indicator, a capacity adequacy indicator and a resource constraint indicator. The first prewarning is for new projects that will be commissioned by 2019. With a traffic-light reading system, the result shows that the alert status of 28 provincial grid regions are rated as "red", and only Jiangxi, Anhui and Hainan Province are rated as "green", while Hubei Province is in the "orange" status. For capacity adequacy indicator, 24 provinces obtain "red alert", and only Jiangxi, Anhui, Hainan, Southern Hebei, Sichuan and Yunnan obtain "green" pre-warning. For the economic warning indicator, 14 provinces are given "red" alert, while the remaining 17 provinces are read as "green". Considering the overcapacity in these provinces, the economic warning results are not convincing.

In November 2016, the 13th FYP Power Planning was issued (NDRC and NEA, 2016). The 1100 GW planning target for coal power, which requires new installation of 200 GW by 2020, has aroused hot debate in industry observers. The controversies are mainly on two interrelated aspects: the rational capacity target for coal power and the economic base underlying it. For the first point, though the future role of coal in China's energy supply has been extensively discussed without dispute (see, for example, Yuan et al., 2012, 2014; Hao et al., 2015; Tang et al., 2015, 2016; Zhang et al., 2016; among others), academic inquiry on coal's role in China's power system is surprisingly rare and disputable (Na et al., 2015; Hui et al., 2016; Yuan et al., 2016a, 2016b, 2016c). For the second point, to the best of our knowledge, only a recent report by Yuan (2016) studied the economics of coal power in six typical provinces. Because economic return is central to the debate and has direct impact on the perspective of coal power in China, this issue deserves systematic study.

This study's purpose is to provide a panoramic overview on coal power's economics in China into 2020 and answer whether the 1,100 GW target proposed in the 13th FYP planning is economically feasible. The paper's structure is organized as follows: Section 2 briefly describes the methodology. Section 3 presents the results and discussions. Section 4 concludes the paper with policy implications.

2. Methodology

2.1. Economic indicators

2.1.1. LCOE

A 600 MW coal power plant is chosen as the objective because currently in China, a 600 MW ultra-supercritical (USC) unit is the mainstream of new installation. Projecting the economy of coal power first necessitates the estimate of generation cost and its dynamics. LCOE refers to the costs of electricity per kWh of power generation during the entire operation period and is a widely recognized and highly transparent calculation method for electricity costs (Branker et al., 2011). This paper will calculate the LCOE 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 of a 600 MW coal-fired plant.

2.1.2. Full investment internal rate of return (IRR) and its grading scale

Appraising the economics of new coal power involves project financial appraisal. An economic appraisal method analyses the investment, costs, revenues, taxes and profits of the engineering projects under an existing accounting system and tax regulations and price system of the state (Fu and Quan, 1996). It involves a study of the profitability, solvency and financial viability of the project after being put into operation, and judges the financial economics of the project based upon such an appraisal. In addition to specifying the value of the engineering project to the financial entity and the contribution to investors, the project financial appraisal also provides a basis for investment and financing decision making.

IRR refers to the discount rate when the total present value of fund inflow equals the total present value of fund outflow, and the NPV is equal to zero. The advantage of the IRR method is to link the project returns during its lifetime with its total investment and indicate the rate of return of the project to provide a benchmark rate of return to confirm whether the project is worthy of investment. IRR is generally recognized as a profitability indicator for project investment. In project financial appraisal, "full investment" and "proprietary funds" assessment are differentiated. Because the purpose here is the economics of the project, not the profitability of own investment, we use full investment IRR as the indicator, which is consistent with that employed by NEA and NDRC (2016).

NEA and NDRC (2016) employed a traffic-light warning system. With return rate of long-term treasury bond as the baseline, a projected IRR below it will get a "red" alert. Those between treasury bond return rate and the average IRR (8% in China) of power generation projects will get an "orange" alert. The projects with IRR higher than 8% will have a "green" reading. Actually, 8% benchmarking return requirement is for proprietary funds, and with a convention of 30% own investment ratio, the sector's benchmarking full investment IRR is 6.6% (NDRC and MOC, 2006). Accordingly, we design the grading scale system as follows (Table 1).

2.2. Data and estimate process

Many variables and parameters are involved in conducting an LCOE estimate and project financial appraisal, which may be divided into four categories: technical and economic variables, operation and maintenance costs variables, taxes and charges and financial variables (Fig. 1). Most are common parameters used in the LCOE model and financial appraisal; however, some parameters are used only in the LCOE model or financial appraisal. Table 2 reports the key common parameters for the estimate, while Table 3 reports the province-specific parameters.

Our economic analysis starts from the estimate of LCOEs of a typical 600 MW USC coal power plant installed in case provinces by the end of 2015. By comparing LCOEs with the current actual on-grid tariff levels in each province, we could assess the profitability of coal power in these provinces and term it as 2015 baseline. Then we will project the profitability situation by 2020 by considering the following factors:

1) The decrease of annual utilisation hour

   Given the irrationally high scale of coal power projects under construction and planning and the weak demand growth prospective during the 13th FYP period, a pessimistic prospective on the annual utilisation of coal power is predicted (Yuan et al., 2016a, 2016b, 2016c; Greenpeace, 2016). National average utilisation hours are predicted to drop to 3600 h by 2020 (Yuan et al., 2016a, 2016b, 2016c). We then calibrate the estimate for coal power in different provinces by considering the differences of national, regional and provincial demand growth rates, as well as the differences in new capacity under construction.
2) Higher generation cost incurred by more stringent environment regulation and the national carbon market

Table 1
the grading scale for the economics of coal power.

Reading	Grading scale	Illustration
Dark Red	IRR < 0	totally unacceptable
Red	0≤IRR < 4.2%	very serious, below social risk-free return
Orange	4.2%≤IRR < 6.6%	serious, merely above social risk-free return
Yellow	6.6%≤IRR < 8%	marginal, the sector's average return
Green	8%≤IRR < 12%	satisfactory, above the sector's average return
Deep green	IRR≥12%	more than satisfactory, super return