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The prospective of coal power in China: Will it reach a plateau in the coming decade?

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HIGHLIGHTS

- Conduct electricity demand scenario analysis for China during 2015–2030.
- Outline China's power generation planning roadmaps for 2020 and 2030.
- Analyze coal power prospective in China under "new economic normal".
- Coal power is expected to reach its peak at around 970 GW by 2020 in China.

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ABSTRACT

Coal power holds the king position in China's generation mix and has resulted in ever-increasing ecological and environmental issues; hence, the development of the electric power sector is confronted with a series of new challenges. China has recently adopted a new economic principle of the "new economic normal," which has a large effect on the projection electricity demand and power generation planning through 2020. This paper measures electricity demand based upon China's social and economic structure. The 2020 roadmap presents China's developing targets for allocating energy resources to meet new demands, and the 2030 roadmap is compiled based upon an ambitious expansion of clean energy sources. Results show that electricity demand is expected to reach 7500 TWh in 2020 and 9730 TWh in 2030. Coal power is expected to reach its peak in 2020 at around 970 GW, and will then enter a plateau, even with a pathway of active electricity substitution in place.

1. Introduction

China's social and economic development has experienced tremendous growth, despite an inadequate electric power supply (Yuan, Xu, and Hu, 2012); however, the new century has witnessed an impressive growth of the electric power industry. New records on annual capacity installation have been constantly set and renewed. According to the China Electricity Council (CEC) (2015a), China's per capita generation capacity achieved 1 kW in early 2015, which equals the global average.

China's political leaders are dedicated to pursuing the "new economic normal" development principle, which led to a structural change in China's electricity consumption in 2014 (CEC, 2015b). The term "new economic normal" was proposed in 2014 by the standing committee of China, which is also the principle of China's economic development in responding to the 7.4% GDP growth rate in the third quarter of 2014. The concentration of China's new economic normal is on restructuring the economic structure, instead of simply focusing on the total quantity of economic size. Under the "new economic normal", the projected electricity demand will be greatly affected. Thus, it is critical to re-evaluate the future clean energy roadmaps of China's low-carbon economy. With decentralization of project approval rights from the central government to province governments, however, an upsurge in approving and building new coal power plants occurred in 2015 (Shearer et al., 2016). After a delay, the central government released three policy documents in a rush to curb the irrational growth of coal power (NEA, 2016a, 2016b, 2016c). A feasible power sector plan with specific consideration on coal power, therefore, has important policy implications for China.

China's electric power industry contributes to more than 23% of particle material (PM), 45% of SO_2, 64% NO_x, and 44% of CO_2 emissions (Yuan et al., 2015), which has become a great threat to

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public health (Pan et al., 2012; Deutsche Bank, 2013). Since 2013, controlling unchecked primary energy consumption (coal in particular) has become the major task of China's energy and environment policy at the national level. Meanwhile, a Sino-U.S. Climate Change Communiqué was declared in 2014, in which the Chinese government announced its determination to cap CO_2 emissions by 2030 (State Council of China, 2013a; Xinhuanet, 2014). A new sustainable pathway would be explored in the electric power industry for air quality improvement and for achieving the peak of greenhouse gas (GHG) emissions.

According to the operation rule of China's administrative system, 2016 is the critical year between the 12th Five-year-plan (FYP) (2011–2015) and the 13th FYP (2016–2020). It is essential to project scientific demand before enacting a feasible power-planning roadmap. Comprehensive and detailed electricity demand projections are studied by international institutions (e.g., Zhou et al., (2013)). On the other hand, the approaches employed by domestic authoritative institutions tend to be oversimplified. In a recent article, a senior field expert criticized this kind of oversimplified approach (Zhu, 2015). The complication is that human beings are unable to make precise predictions about future social and technological systems, let alone their underlying uncertainties. Prediction models that are too complex are apt to fall into trouble due to misspecifications of numerous detailed parameters. Because of data availability, a balance must be established when using an analytical model to project electricity demand. A number of studies explored China's electricity demand scenario (Zhou, et al., 2011; Hu et al., 2013). Most were conducted before 2014 and could not capture the new status of China's economic roadmap. In 2015 three influential publications were published on this topic. The first study, a CEC (2015b) report, presented a comprehensive analysis on the power sector in 2014, and concluded that by 2020 total electricity consumption would reach 7700 TWh and per capita electricity consumption would reach 5570 KWh. Although the methodology is not specified, an assumption of the GDP electricity consumption elastic coefficient, based upon historical trend, is essential to its conclusion. The second study elaborated on the assumptions for GDP electricity consumption elastic coefficient based upon an international comparison study. It concluded that total electricity consumption would reach 7600–8000 TWh by 2020 (Wang and Wu, 2015). The consensus of these two studies was that coal power capacity is expected to be over 1100 GW by 2020 and 1350 GW by 2030. The third report by China Coal Cap Group (2015a) concentrated on China's electricity demand and power generation planning up to 2050, and focuses less on the near future.

The GDP electricity consumption elastic coefficient could have different features depending on social and economic stages; thus, employing an elastic coefficient for electricity demand prediction is not recommended. It could also be misleading to use international comparisons for estimating elastic coefficients based upon urbanization or per capita GDP. According to Wang and Wu (2015), a newly industrialized economy will simply follow the path of early industrialized economies, largely neglecting the fact that per capita electricity consumption in developed economies doesn't converge and vast national condition differences exist.

The Kaya identity evaluates the impact of population, income, per capita energy consumption, and primary energy emission factors on CO_2 emissions (Kaya and Yokobori, 1997). Yuan et al. (2014b) constructed a modified analytical framework based on the Kaya identity which models the impact of several additional policy variables, including industrial energy efficiency, the urbanization process, and income distribution. This framework could capture the critical variables for projecting electricity demand. There are a number of publications about power generation planning in China (Hu et al., 2010; Yuan et al., 2014c; Zheng et al., 2014), but all these studies focused on novel planning models, instead of a detailed exploration on planning for capacity under a rigorous social and economic scenario.

The first objective of this paper is to project the electricity demand under China's new economic normal through constructing different scenarios. The second objective is to explore the development of coal power through reviewing China's current clean energy development targets for 2020, and extending to 2030 under the guiding principle of sustainable and low carbon development. The study presented in this paper adds new policy perspectives to China's national energy policy and sheds insights on low carbon development. The structure of the paper is organized as follows: Section 2 briefly describes the methodology. Section 3 presents the assumptions and results of different electricity demand scenarios. Section 4 outlines China's 2030 power generation plan, with a special concentration on coal power. Section 5 concludes the paper with policy implications.

2. Methodology

2.1. Electricity demand scenario model

Following the analytic framework proposed by Yuan et al. (2014b), we employed a scenario model adapted from the Kaya identity to project China's future electricity demand (Eqs. (1)–(4)). In the model, total electricity consumption (E) is separated into two factors: production use (E_P) and household use (E_R). The production factor could be expressed as the sum of products of output shares (primary, secondary, and tertiary, S_i, $i=1–3$) and the corresponding electricity intensities (I_i). The residential consumption could be distinguished by two variables: rural and urban consumption (E_{RR} and E_{UR}). Hence, the process of urbanization (R_U) in China and its impact on electricity consumption were represented in the model. Household electricity consumption is subject to the status of disposable income (I_U for rural net per capita income and I_R for urban disposable per capita income). In China, because income growth has been slower than the GDP growth, the government has committed to improve income distribution and reduce the urban-rural income gap. To model the impact of income distribution policy on energy consumption, intermediate variables (I_U and I_R) between per capita GDP and per capita electricity consumption were used in the model. As a result, the electricity demand model was designed to be simple and intuitive; on the other hand, this model captured the impact of critical policy drivers such as economic policy (GDP growth rate and output structure), social policy (population growth and urbanization policy, POP stands for total population), energy conservation policy (industrial electricity intensity), and income distribution policy (per capita disposable income).

$$EI_{GDP} = \frac{E}{GDP} = \frac{E_P + E_R}{GDP} \tag{1}$$

$$\frac{E_P}{GDP} = \frac{E_{PP} + E_{PS} + E_{PT}}{GDP} = \sum_{i=1-3} (S_i \cdot I_i) \tag{2}$$

$$E_R = E_{UR} + E_{RR} = \frac{e_U}{I_U} \times \frac{I_U}{gdp} \times R_U \times POP + \frac{e_R}{I_R} \times \frac{I_R}{gdp} \times (1 - R_U) \times POP \tag{3}$$

$$EI = GDP^{*}EI_{GDP} \tag{4}$$