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# Overall review of peak shaving for coal-fired power units in China

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ABSTRACT

With the development of new-power generation sources, the difference between maximum and minimum power requirements from a power grid is growing. However, the peaking power installed capacity, such as pumped-hydro energy storage and gas-fired power, is too small to meet the peaking regulation requirements. Chinese coal-based energy resources structure determines coal-fired power plants to be the main source of power. This means that coal-fired power units will need to undertake more peak shaving tasks for a long period of time. In this paper, we provide an overall review of China's coal-fired power units' peak regulation with a detailed presentation of the installed capacity, peak shaving operation modes and support policies. High energy-consumption problems, environmental pollutants and safety barriers when coal-fired power units run in low-load operation are noted from the power generation perspective. Some policy recommendations are given to solve the peak shaving problem to some extent and to ensure the sustainable development of the power energy system.



**Contents**



## 1. Introduction

In recent years, with the rapid development of the economy, the demand for electricity in China has been soaring. However, Chinese economy has been in the“new normal” since 2013, the total electricity consumption increment has dropped, which means that power facilities will stay in low-load operation for hours in the future. Additionally, renewable energy sources, particularly wind and solar, increase their share of the nation's generating capacity, while those of coal and oil decline. Unfortunately, renewable energy outputs are random, unstable and hard to predict, which makes peak shaving difficult. The peak shaving problem has become a big barrier to the development of new energy sources in China.

Currently, the proportion of peaking power capacity in China is too small to meet the soaring peak shaving requirements. Several

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studies on peak regulation mainly focused on the new energy construction, for example, developing pumped-hydro energy storage stations, gas-fired power stations and energy storage [1–5], or optimization models and methods for peak shaving on the power grid side [6–8]. However, the development of renewable energy peaking power has been restricted because the majority of energy resources are coal in China. In recent years, the existing coal-fired units are capable of supplying 50% peak regulation load factor with the development of manufacturing and thermal control automatic levelling. Thus, it is necessary to make coal-fired power units responsible for the majority of the peak shaving. Nonetheless, this presents conflicting issues. On the one hand, large-capacity and high-parameter coal-fired power units should replace small ones to reduce energy consumption; on the other hand, coal-fired power units that stay in low-load hours for the sake of peak shaving have a low efficiency, are not environment friendly and are a safety risk. This leads to a dilemma for coal-fired power units. However, little attention has been paid to systematic studies of the power peak shaving situation of traditional energy sources or future strategies to relieve their peak shaving pressure. In this paper, the history, status quo, barriers and trends of peak shaving for coal-fired power units are systematically analyzed from the generation side based on the power supply and demand situation in China. Additionally, powerful policy recommendations are proposed.

This paper is structured as follows: Section 2 briefly discusses the peak shaving demand of coal-fired power units based on the energy resources status quo and peak shaving operation modes of coal-fired units. Section 3 introduces existing problems, barriers and trends of peak shaving for coal-fired power units. Support policies of coal-fired power units for peak shaving in China are introduced in Section 4. Several powerful policies and suggestions according to the results are proposed in Section 5. Finally, some conclusions are given in Section 6.

## 2. Peak shaving demand and operation modes analysis for coal-fired power units

### 2.1. Demand analysis

The Chinese economy has been in the “new normal” for the last few years. The total electricity consumption in 2014 was 5.5233 trillion kW h in China, a 3.8% increase from 2013, which dropped sharply compared with 7.5% increase in 2013, according to the data in “national electric power industry statistics” issued by the National Energy Administration in China [9]. It was also found that there were 4268 utilization hours in 2014, 235 h less than the previous year. This means that the electricity production capacity has a serious surplus, as shown in the “China electric power industry running situation analysis” released by China Electricity Council [10].

Additionally, under the influences of energy saving and emission reduction goals, energy source adjustments and the development of clean energy resources have accelerated as part of the “12th Five-Year Plan”, which requires the power industry to develop wind power, photovoltaic generation and other renewable energy resource preferentially [11]. Recently, wind power, solar power and other renewable sources have developed rapidly due to the support and development policies regarding clean energy. According to the statistics from the China Electricity Council, at the end of 2014, the installation of wind power and solar power is 95.81 million kilowatts and 19.88 million kilowatts, respectively [9]. Since 2009, the installed capacity of wind and solar has grown prodigiously (Fig. 1). However, renewable power inherently has intermittent, peak anti-regulation and other characteristics [12] that put the peak regulation pressure on the power system in China.

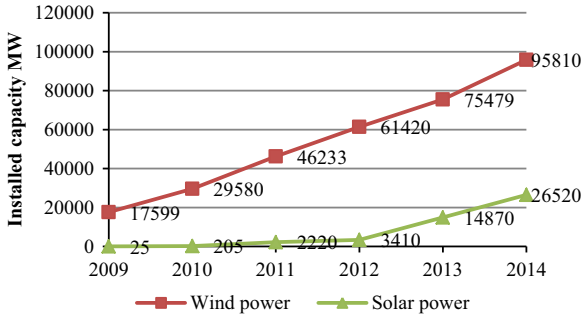


**Fig. 1.** Wind power and solar power installation (MW) in China (2009–2014). (Source: National Energy Administration).

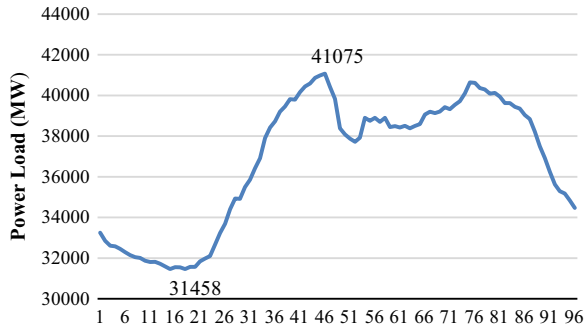


**Fig. 2.** Typical daily load curve with 96 points of the Jing-Jin-Tang power grid.

Meanwhile, the electricity consumption of tertiary-industries, municipalities and residences increases every year, which makes the peak-valley difference of the grid larger. A typical daily load curve of Beijing–Tianjin–Tangshan region power grid is shown in Fig. 2; peak-valley difference in this area has reached 30.6%. Therefore, one of the most urgent problems facing power grids is the need for the peak shaving.

There are several types of peaking power plants in every power grid, such as hydropower, pumped storage and gas-fired generation. However, the structure of the power supply in China is irrational and primarily depends on thermal power units [3].

Hydropower is one of the most effective peaking power sources. The amount of installed hydropower has increased rapidly in recent years due to the construction and expansion of hydro-electric stations. However, it should be noted that the installed capacity is not same as actual generation. Hydro-electric generation is limited by the environment, immigration and seasons. Therefore, hydropower generation is only a small percentage of the total national electricity generation capacity [9], and cannot meet the peak shaving requirements.

Pumped-hydro energy storage stations that serve the functions of peak regulation, frequency modulation, and black start emergency standbys are the well-known ideal peaking power sources [13]. However, due to the resource distribution and geographical conditions, pumped-hydro stations only accounted for 1.73% of the installed capacity in China by the end of 2013, which was not enough to balance the power demand and supply [14].

Gas-fired power stations are another perfect peaking power, with higher thermal efficiency and lower pollutions than coal-fired power plants [15]. Unfortunately, the proven natural gas reserves are too small to support the large demand in China. Additionally, the production cost of a gas-fired unit is much higher than a comparable coal-fired unit. For example, the energy cost of Yuyao gas-fired power station in Zhejiang province and Beijing thermal power station is 0.731 yuan per kW h and 0.65 yuan per