

Variable Generation Integration in China

A BRIEF FROM ESIG

Variable generation in China has grown rapidly in recent years, with the cumulative installed capacity reaching 359 GW at the end of 2018 and accounting for 19 percent of the national total installed capacity (figures 1 and 2). An initial focus on lowest-cost variable generation development, resulting in high increases in solar and wind generation in northern China, has given way to more attention to serving China's load centers with renewably generated electricity and to more efficiently integrating renewables into the power system overall.

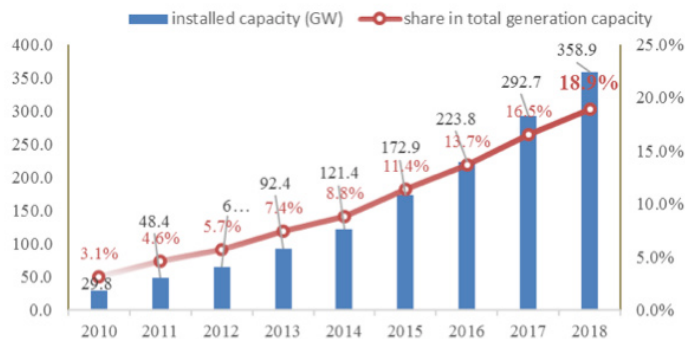


Figure 1. Installed capacity and share of variable generation in China from 2010 to 2018.

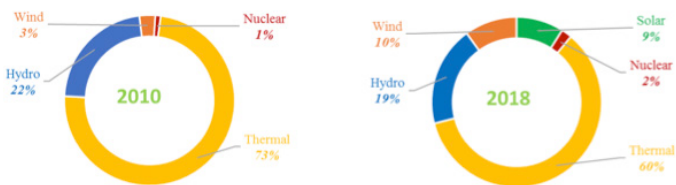


Figure 2. China's generation sources in 2010 and 2018.

A Focus on Scale and Speed

During the early stage of expansion of variable generation in China, between 2006 and 2015, national policies focused on the rapid development of these resources, employing a feed-in tariff and cost-sharing system. However, a lack of guidance around the scale and layout of variable generation led to large regional differences. Variable generation developed at a much higher rate in resource-rich northern China, including the provinces of Xinjiang, Gansu, and Inner Mongolia. This concentration of development, along with a lack of focus

on integration, resulted in significant curtailment of both wind and solar in these regions. This rapid development was accompanied by a subsidy shortfall: the subsidy fund collected from consumers via a renewable energy surcharge failed to cover the high levels of development.

Managing Scale and Layout

In 2016, in response to these problems, the National Energy Administration began to shift the focus of variable generation policies away from scale and speed, and toward quality. In 2016 and 2017, it began monitoring the development of wind and solar power projects in the provinces. In regions with an annual variable generation curtailment rate above 20 percent, no new installations of utility-scale wind or solar power are allowed (as of this writing, in 2020). In 2018, the National Energy Administration introduced a policy limiting the annual installed capacity of variable generation that requires government subsidies.

While the cumulative installed capacity of variable generation remains concentrated in northern, northwestern, and northeastern China (regions which collectively accounted for 71 percent of the national total capacity in 2018), the location of newly installed variable generation is shifting to the northeastern, eastern, and central regions of the country—China's load centers. Between 2015 and 2018, the share of newly installed wind and solar capacity in central and eastern China (much of which is distributed generation) has increased to 40 percent and 39 percent, respectively. In 2019, the National Energy Administration enacted a renewable energy quota system in which a minimum share of renewable energy is specified in the total electricity consumption of each province.

To reduce costs for variable generation development, in 2015 China launched the "Front Runner" program to encourage the manufacturing and application of technologically advanced products for solar installations. Front Runner projects were implemented by bidding with a price cap which is the local feed-in tariff of solar and wind generation determined by the government. In 2018, this competition mechanism was expanded to all annually procured central solar power stations and onshore and offshore wind power plants. To address the cumulative subsidy deficit, which by 2018 exceeded 120 billion yuan, the government has begun giving priority to the construction of wind and solar projects that do not require subsidy funding.

Facilitating Variable Generation Integration Systemwide

The national government, local governments, and power companies have implemented several technical and market-based measures to address the curtailment of variable generation occurring in northern China.

Efforts to unlock flexibility for greater variable generation integration include increasing electrification—most notably, increased use of electric vehicles and electric heating. In addition, coal-fired generators are beginning to be retrofitted for flexibility, including through reducing the minimum power generation of traditional boilers or adding electric boilers. To encourage these retrofits, market mechanisms specific to China's still-maturing electricity market were introduced in northern China in 2014 to incentivize downward regulation from coal-fired generation.

In 2015 a new round of market reforms were begun to promote the increased integration of variable generation. These include bilateral trading between variable generation enterprises and some industrial and commercial end users, transregional trading between variable generation companies from regions having surplus power generation and power grid enterprises in other regions, and trading of power generation rights between variable generation in northwestern China and conventional thermal power plants in the central and eastern regions.

Lastly, transregional transmission lines have played an important role in variable generation integration, connecting variable generation in the north with load centers in central and eastern China. In 2007, China commissioned its first ultra high voltage DC transmission line connecting a hydropower plant in the Yunnan province to the city of Shanghai. By the end of 2018, 17 ultra high voltage DC and 11 ultra high voltage AC transmission lines had been built (see figure 3).



Figure 3. The ultra high voltage transmission system in China in 2018.

Looking Ahead

In 2017, China issued the Energy Production and Consumption Revolution Strategy for 2016 through 2030, setting strategic targets for medium- and long-term energy development. According to the strategy, non-fossil energy will account for 20 percent of the total primary energy consumption by 2030. As China looks toward a future with more diverse players in the power sector and a need to integrate increasing amounts of variable generation into a reliable grid, the ongoing power sector reform includes the promotion of variable generation consumption as an important part of the market design. The country is currently working to establish a variable generation quota system, a green certificate market, carbon markets, and mechanisms for distributed generation and battery storage to participate in market trading.

Adapted from Liping Jiang, Caixia Wang, Guohui Xie, Zhu Li, Hongpeng Zhang, Zheyi Pei, Pingliang Zeng, Chongqing Kang, Ning Zhang, Qionghui Li, and Anping Hu, "Variable Generation Integration in China," IEEE Power and Energy Magazine November-December 2019. Guest editor, Charlie Smith, ESIG. DOI: 10.1109/MPE.2019.2932640.