

# Curtailement of renewable energy in Northwest China and market-based solutions



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## ABSTRACT

In 2016, solar and wind energy production were greatly curtailed in China, especially in its northwestern region. This paper identifies administrative factors and market barriers as the main causes of renewable curtailment. In 2017, the Northwest Power Grid (NWPG) successfully implemented a variety of approaches to reduce wind and solar curtailment. In this paper, we analyze the change in power generation, expansion of renewable energy delivery, and electricity-replacement projects across provinces that occurred in 2017. While acknowledging the practical results of the NWPG's efforts, we identify challenges that the northwest still faces in integrating renewable energy. We argue that trans-regional administrative barriers are preventing the effective utilization of renewable energy nationwide. To address those barriers, we explore market-based mechanisms for promoting the integration of large-scale renewable energy. In addition to long-term contracts for renewable energy across provinces, both spot-market and the ancillary service market would facilitate the uptake of renewable energy. In addition, price signals should be used to guide peak shaving. Market mechanisms will be insightful to dissolve barriers and enhance utilization of renewable energy throughout the country.

## 1. Introduction

Renewable energy is an emerging driver of sustainable economic growth. It is widely accepted in China that promoting and expanding the use of renewable energy will provide an alternative to the long-standing overreliance on fossil fuels and its associated high carbon emissions.

During the past decade, China has made remarkable progress in developing renewable energy resources, becoming the world's leading investor in installed renewable capacity. Government incentives have produced a surge in the generation capacity of installed wind and solar photovoltaic (PV) power (see Fig. 1). Since 2000, hydro, wind, and PV power capacities have increased by 9.8%, 48.5%, and 67% per year, respectively (National Energy Administration (NEA), 2017a). By the end of 2017, the total non-hydro renewable energy capacity in China reached 309 GW: 164 from wind power, 130 from solar PV power, and 15 GW from other sources. During 2017, installed wind capacity increased by 15.03 GW, and solar PV capacity increased by 53.06 GW in China, ranked first in the world in newly installed renewable energy capacity (NEA, 2018a, b).

Although the installation of renewable energy sources is mushrooming in China in response to support from the government and investors, the utilization of renewable energy is limited because wind and solar supplies have been curtailed significantly. In 2016, the curtailment of wind and solar PV energy reached 57.3 TWh: 49.7 TWh of wind energy (representing 20.6% of total wind power generation) was abandoned, an increase of 5.2% from the previous year; and 7.6 TWh of solar PV energy (representing 11.5% of total solar PV power generation) was abandoned, an increase of 4.3% from the previous year (NEA, 2017b).

The ineffective utilization of renewable power is most remarkable in the northwest region of China, which has the highest installed capacity of renewable energy in China but low local demand. Specifically, 90% of the total wind curtailment and 99% of the total solar PV curtailment on the China State Grid occurred in this area.

The situation improved in 2017, however, when the total renewable curtailment in China effectively dropped. Table 1 shows the reduction in the curtailment of renewable generation through a “double rise and double down” in both quantity and percentage. Compared to 2016, the amount of wind and solar PV energy abandoned was reduced

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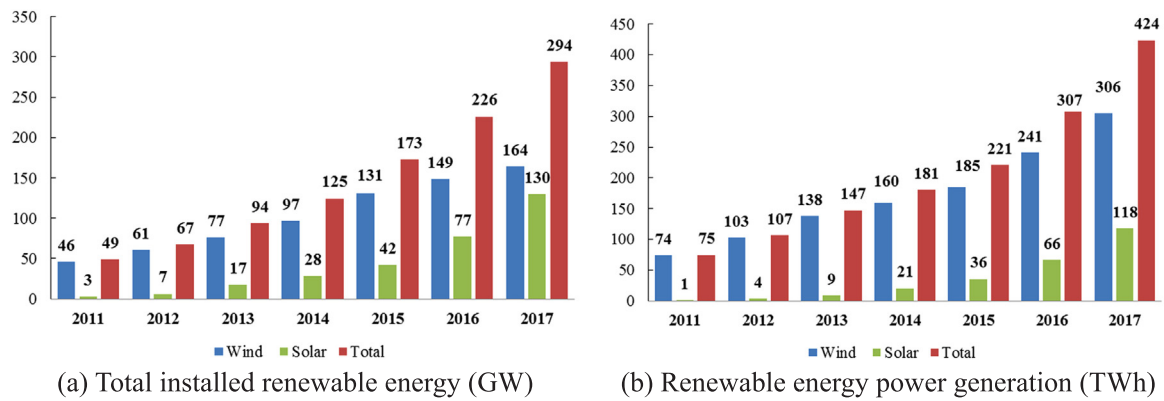


Fig. 1. Renewable energy (wind and solar) power installation and generation in China from 2011 to 2016 (data obtained from NEA).

Table 1

Renewable Energy Curtailment in China, 2016 and 2017. (Source: NEA, 2018b. NEA Press Conference on 2017 Energy-related Reports, January 2018; NEA, 2017b. 2016 Wind Power Integration Report, January 2017; GIHPD, 2017. 2016 Report on China Renewable Energy Development, October 2017)

Year	New installed capacity (GW)		Total renewable energy generation (TWh)		Curtailment (TWh)	
	Wind	Solar PV	Wind	Solar PV	Wind	Solar PV
2016	19.30	34.54	241.0	66.20	49.70	7.60
2017	15.03	53.06	305.7	118.2	41.90	7.30

dramatically—by 7.8 TWh and 0.3 TWh respectively, while the percentage curtailed fell by 6.9% and 5.3%, respectively. Compared to 2016, wind generation increased by 26.8% in 2017, while solar PV generation increased significantly (by 78.6%) (NEA, 2017b, 2018b; General Institute of Hydropower Planning and Design (GIHPD), 2017).

It is worth noting that the Northwest Power Grid (NWPG) authority contributed greatly to lowering curtailment. In Gansu Province in the northwestern region, the curtailment of wind power declined by more than 10%. Two other provinces (Ningxia and Xinjiang) in the northwestern region are among the top five provinces nationwide that lowered their percentages of curtailment by more than 5% (NEA, 2018c). Those reductions were achieved largely through the efforts of the NWPG, which worked throughout the year to enhance the integration of renewable energy and expand renewable energy utilization across provinces. It is helpful to study the practical measures that the NWPG adopted to better understand the curtailment situation, which would guide future market-oriented policies to break through administrative barriers across China.

A review of current literature reveals a number of studies on the obstacles to the integration of renewable energy in China, which can be categorized as geographical, technical, economic, and managerial (Long et al., 2017; Kardoni et al., 2014; Safarzynska et al., 2017; Ge et al., 2017; Schermeyer et al., 2018; Wakiyama and Kuriyama 2018). Zhang et al. (2014) and Zhao et al. (2013) discussed the unimplemented policies that would encourage deployment of renewable energy, addressing administrative barriers that constrain the integration of renewable energy. Lin et al. (2018a) studied the potential of regional market in reducing water curtailment and emissions in the south of China. Yang et al. (2010) and Zhao et al. (2012) identified a few policy measures for promoting wind or solar energy. However, few researchers have examined effective practices initiated by regional authorities to promote the integration of renewable energy supplies throughout China.

In this paper, we use the NWPG as a case study because of its initial success in promoting large-scale utilization of renewable energy in 2017. Although the NWPG in western China boasts greater renewable

power capacity and generation than other parts of the country, it faces the most significant curtailment problem. In the following sections we discuss the challenges the NWPG faces and how its energy policies can effectively increase trans-provincial access to renewable power from the NWPG region.

The aims of this study are threefold: (1) to identify the key factors in increasing curtailment; (2) to analyze impacts of incentive measures on renewable energy integration in the NWPG; and (3) based on the initial measures the NWPG has implemented, to recommend market-based mechanisms to improve trans-regional renewable energy integration and coordinate the development of renewable energy and traditional fossil energy capacities at a national level. The renewable portfolio standard and green certification are considered as additional areas for reforming energy policies in today's China.

The remaining of the paper is organized as follows: Section 2 reviews the challenges that the NWPG faces; Section 3 explains practical factors that increase curtailment of renewable energy; Section 4 highlights the impacts of measures and policies the NWPG instituted in 2017; Section 5 describes the design of market-oriented mechanisms for increasing the utilization of renewable energy across regions; Section 6 presents conclusions and discusses policy implications.

## 2. Curtailment of renewable energy use in Northwest China

Although it boasts the majority of China's installed renewable capacity, the northwestern region dominates the national curtailment of renewable energy because of its low local demand. The five provinces of Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang have abundant wind and solar resources. The NWPG, which oversees energy production in those provinces, has been under pressure to stop the large-scale curtailment of renewable consumption in an area that should boast a strong renewable energy industry.

The NWPG faced the most serious challenge to renewable energy utilization in 2016. Table 2 describes the integration of wind and solar PV in the five northwestern provinces (NEA, 2017b, c; Soloarzoom, 2018). Although wind capacity increased to 43.29 GW, accounting for 19.6% of the total installed capacity of the State Grid in the northwestern region, wind generation was 52.46 TWh, accounting for only 8.4% of the total. The curtailment of wind power occurs primarily in Gansu, Xinjiang, and Ningxia provinces, which accounted for 43.11%, 38.37%, and 13.05%, respectively, of the region's wind generation.

The total installed capacity of solar PV in the NWPG in 2016 amounted to 27.37 GW, accounting for 13.8% of the total solar power produced in the State Grid, whereas the total PV generation in the NWPG was 25.72 TWh, accounting for 4.57% of the total generation. Xinjiang and Gansu provinces curtailed the most solar energy in the northwest: 32.23% and 30.45%, respectively, of their total solar energy generation (see Fig. 2).

In Xinjiang and Gansu provinces, the total amount of curtailed wind

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