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Analysis of distributed-generation photovoltaic deployment, installation time and cost, market barriers, and policies in China

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HIGHLIGHTS

- We review China's distributed PV market development and policy changes since 2013.
- We present cost and time requirements for installing distributed PV in China.
- We conduct IRR analysis of distributed PV under different policy frameworks.
- We identify barriers to China's distributed PV, especially feed-in tariff barriers.

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ABSTRACT

Beginning in 2013, China's photovoltaic (PV) market-development strategy witnessed a series of policy changes aimed at making distributed-generation PV (DG PV) development an equal priority with large-scale PV development. This article reviews the DG PV policy changes since 2013 and examines their effect on China's domestic DG PV market. Based on a 2014 survey of DG PV market and policy participants, we present cost and time breakdowns for installing DG PV projects in China, and we identify the main barriers to DG PV installation. We also use a cash flow model to determine the relative economic attractiveness of DG PV in several eastern provinces in China. The main factors constraining DG PV deployment in China include financial barriers resulting from the structure of the self-consumption feed-in tariff (FIT), ambivalence about DG PV within grid companies, complicated ownership structures for buildings/rooftops/businesses, and the inherent time lag in policy implementation from the central government to provincial and local governments. We conclude with policy implications and suggestions in the context of DG PV policy changes the Chinese government implemented in September 2014.

1. Introduction

China has abundant solar energy resources (Liu et al., 2010; Zhang et al., 2009; Li et al., 2007). The estimated technical potential for installing photovoltaics (PV) in China is up to 2070 GW or 1.7 times the country's cumulative electricity capacity in 2013 (see Table A1 in Appendix A). Beginning in 2009, the Chinese government formulated a series of policies and regulations to encourage domestic PV deployment. The government primarily encouraged the adoption of large-scale PV (LS PV) first, via upfront subsidies of up to 50–70% under the Golden Sun Demonstration Program and PV Rooftop Subsidy Program (Grau et al., 2012; Sun et al., 2014; Zhang et al., 2012; Zhang and He, 2013). Several disadvantages of providing an upfront subsidy to LS PV, however, became apparent. First, an upfront subsidy provides an incentive

Abbreviations: BNEF,, Bloomberg New Energy Finance; DG PV,, distributed-generation photovoltaics; FIT,, feed-in tariff; IRR,, internal rate of return; LS PV,, large-scale photovoltaics; MHURD,, Ministry of Housing and Urban–Rural Development; MOF,, Ministry of Finance; MOST,, Ministry of Science and Technology; NDRC,, National Development Reform Commission; NEA,, National Energy Agency; NREL,, National Renewable Energy Laboratory; O&M,, operations and maintenance; PV,, photovoltaics; RMB,, renminbi; SAT,, State Administration of Taxation; SERC,, State Electricity Regulatory Commission; SOE,, state-owned enterprise; VAT,, value-added tax

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Table 1
PV projects installed, under construction, or permitted in China through June 24, 2014.
Source: BNEF Project Database (https://www.bnef.com/core/data-explorer, subscription required to access), accessed June 24, 2014.

	≤ 6 MW	6 MW < X ≤ 20 MW	20 MW < X ≤ 100 MW	X > 100 MW	Total
Commissioned/partially commissioned PV projects					
Number of projects	425	558	219	5	1207
Average capacity (MW)	2.4	14.6	42.0	244	16.2
Capacity (GW)	1	8.2	9.2	1.2	19.6
Percentage of total capacity (%)	5	42	47	6	100
Financing-secured/under-construction PV projects					
Number of projects	54	136	108	7	305
Average capacity (MW)	3.5	14.9	48.8	176.5	28.6
Capacity (GW)	0.2	2.0	5.3	1.2	8.7
Percentage of total capacity (%)	2	23	60	14	100
Permitted PV projects					
Number of projects	63	89	54	3	209
Average capacity (MW)	2.7	14.6	44.3	293.3	22.7
Capacity (GW)	0.2	1.3	2.4	0.9	4.7
Percentage of total capacity (%)	4	27	50	19	100

to install PV but does not provide a strong incentive for the systems to produce electricity, which resulted in concerns about the installation of low-quality PV projects and cheating the subsidy programs (Zhou, 2012). Second, the central government found the subsidies increasingly difficult to afford. Third, the policy focused on subsidizing LS PV systems, which resulted in installed systems —many in northwest China – being remote from demand centers, creating challenges to the transmission system and the ability to use the generated power. In addition, there is increasing concern about the water required for PV panel cleaning, especially in the dry and sandy northwest area of China (Xie, 2014).

Distributed-generation PV (DG PV) has several advantages over remote LS PV: (1) typically installed on rooftops, it requires little land, which is at a premium in China; (2) it requires no additional transmission lines, which can reduce installation cost and time; and (3) by being situated close to demand centers, it produces power where needed and thus has reduced electricity losses during transmission (Rigter and Vidican, 2010). Thus the Chinese government has increasingly focused on developing the country's DG PV market since 2013. DG PV projects are defined as "projects with generation on or close to the user site, instantaneously consumed by end users themselves, i.e., self-consumed, and for which redundant power can be grid-connected and the system can be balanced in the grid" (NDRC, 2013), with project sizes smaller than 6 MW (National Grid Company, 2012); the size criterion was expanded to include systems up to 20 MW in 2014 (NEA 2014a).[1] In August 2013, the National Development Reform Commission (NDRC) issued a new set of policies to replace the upfront subsidy with a new performance-based national feed-in tariff (FIT) scheme providing 0.42 RMB/kWh to all generation from DG PV systems for 20 years (Zhang and He, 2013; Sun et al., 2014; Zhang et al., 2014). The new FIT policy for DG PV also distinguishes between self-consumed and excess generated electricity. Self-consumed generation (generation used on site at the time of generation) will be reimbursed at the local retail rate of electricity (in addition to the 0.42 RMB/kWh). Excess generation fed into the grid at the time of generation will be purchased by the local grid enterprises at the local wholesale benchmark price for non-sulfur coal-fired generation (around 0.35–0.45 RMB/kWh) (NDRC, 2013).

The DG PV market, however, has not responded rapidly to this new performance-based policy framework. In August 2013, the NDRC and the National Energy Agency (NEA) announced the approval of 1823 MW of DG PV demonstration projects, of which 793 MW were scheduled for completion by December 31, 2013. All these DG PV projects were funded by the Golden Sun Program rather than the new policy scheme (AECEA, 2014). In 2014, China's government set a target of adding 8 GW of DG PV and 6 GW of LS PV. According to Bloomberg New Energy Finance (BNEF, 2014), about 3.3 GW of PV were connected to the grid in China during the first half of 2014, including roughly 1 GW of DG PV. Many of the DG PV projects installed through the first half of 2014 were approved under the Golden Sun Program, with only a few DG PV projects installed under the new FIT structure.

We obtained detailed information from BNEF's database of 1207 commissioned or partially commissioned PV projects (19.6 GW) as well as another 305 financing-secured/under-construction PV projects (8.7 GW) and 209 permitted PV projects (4.7 GW) in China. The project information was downloaded from BNEF's database on June 24, 2014. The data, as shown in Table 1 (cumulative installations) and Fig. 1 (annual installations), provide detailed information on the status of PV projects in China, including the average size of projects as well as information about projects in the pipeline. The average size of PV projects installed in China is 16.2 MW. The 6–20 MW and 20–100 MW categories account for the majority of systems installed in China to date: 42%

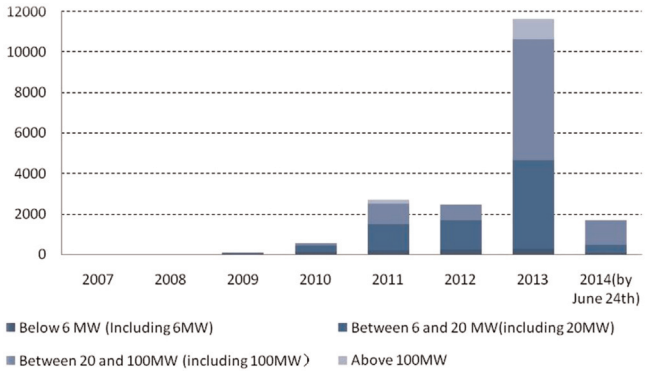

Fig. 1. PV projects installed in China through June 24, 2014 (Source: BNEF Project Database).

[1] In September 2014, NDRC expanded the definition of DG PV to include all systems connected to the distribution network up to 20 MW in size, regardless of whether the energy is self-consumed or the system is on a building or ground mounted. When comparing estimates across studies, it is important to note that different studies may use different definitions. For example, other studies have defined DG PV in China to include all rural electrification, communications, and industrial applications and all PV on buildings (IEA-PVPS, 2014).