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A review of photovoltaic poverty alleviation projects in China: Current status, challenge and policy recommendations

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ABSTRACT

Photovoltaic Poverty Alleviation (PVPA) projects, which utilize the subsidies and income from PV power to alleviate poverty in rural areas, are part of a comprehensive energy policy innovation in China. It is expected that the projects will deploy at least 10 GW PV and benefit more than two million poor households in total by 2020. To achieve this goal, specific supporting policies and novel business models are necessary. In the present paper, the current status and existing supporting policies are introduced to give an overview of PVPA projects. Then representative business models in PV projects are summarized and compared to provide a reference for PVPA projects. Obstacles, such as subsidy delays, insufficient infrastructure, low quality of PV equipment, and inflexible profit allocation mechanism may reduce the revenue from PV operation and increase the costs of PV deployment. Therefore, this paper also proposes corresponding recommendations for policy makers considering the existing challenges.

1. Introduction

With imbalanced economic development among different regions, China's impoverished population reached 55.75 million in 2015. In order to enhance the annual income of impoverished people to over 3000 RMB per capita, the specific poverty alleviation fund provided by the central government in 2016 was raised to 67 billion RMB [1]. Helping the rural poor population is defined as the most arduous task as well as a symbolic sign of building a more prosperous society. Starting from 2013, China has created profiles for 89 million people in poverty, and sent over 130,000 working groups to impoverished villages. The 18th National Congress of the Communist Party of China (CPC) proposed a goal of lifting 100% of the impoverished population out of poverty by 2020 [2].

In order to achieve this target, the Chinese government changed its approach from blanket and all-inclusive policies to more specific policies. As the main project in targeted poverty alleviation, photovoltaic poverty alleviation (PVPA) has attracted increasing attention from the public and government. Off-grid photovoltaic systems are proposed to solve energy poverty problem and promote rural electrification in some African countries, like Niger [3], Mali [4] etc., with the funds from World Bank. Inspired by the global experiences, Chinese government applied it to cope with the economic poverty and improve the unbalanced energy mix over the country. The pilot projects of PVPA were implemented in some poverty-stricken regions in 2016. These were aimed to encourage impoverished people to use their own assets and labor to lift themselves out of poverty. Under this policy, if a registered impoverished citizen has land or a roofed house and there are more than 1100 h of sunshine in a year, then he/she can benefit from this policy and get a 3000 W or 5000 W photovoltaic (PV) system built on the land or roof [2], and the PV system would be connected to the power grid. From the specific subsidy and income from selling PV power, the poverty problem may be reduced and the development of PV will be boosted at the same time.

Starting in 2014, PVPA is a relatively new concept in China. However, some scholars have already started studying on the combination of renewable energy promotion and poverty alleviation from different perspectives, both in China and abroad [5–7]. Ürge-Vorsatz and Tirado [5] explored the synergy effect between greenhouse gas (GHG) emission mitigation and poverty alleviation. The results indicate that policy integration in these two areas would lead to better use of financial resources as well as lower costs, which explains the intrinsic merit of PVPA. However, two major barriers in implementing the integrated policy for renewable energy and poverty alleviation were also highlighted: financing difficulties [7] and technological complexity [6].

To improve social welfare and promote fairness in income

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allocation, poverty alleviation is a common topic for both policy makers and scholars. Financing tools, such as microloans, microcredits, and village banking, are often used to eradicate poverty [8–11]. There are also many non-governmental organizations (NGOs) devoted to poverty alleviation [12]. Chandra et al. [13] concluded that the lack of energy-finance options and finance management skills for poor people calls for energy-microfinance intervention. On broader related issues, Eijk and Kumar [7] proposed bio-rights as an innovative financing mechanism for reconciling poverty alleviation and environmental conservation.

Apart from increasing the income for impoverished people, PVPA projects also offer benefits in other ways. As an efficient approach to promoting PV, it can improve the energy mix and mitigate air pollution problems by deploying more PV panels [14]. EPIA (European Photovoltaic Industry Association) and Greenpeace [15] proved that PV can contribute to energy security in all countries without producing any harmful emissions in the operational phase. Moreover, PVPA projects would also contribute to absorbing the surplus manufacturing capacity of PV panels. The Chinese PV industry has been largely export oriented [16], and intensive support policies like feed-in-tariffs (FiT),[1] pilot projects, subsidies and concessional bidding mechanisms have been proposed to expand the domestic PV market [17]. Therefore, the development of solar energy is supported by local governments, large energy utilities, and manufacturing corporations [18]. Combining with the manufacturing and policy advantages, PVPA is expected to deploy at least 10 GW capacity and benefit more than two million poor households by 2020 [19], which can largely mitigate the oversupply issue in the PV panel industry.

With the aforementioned merits, PVPA has developed over the initial three years to 2017. A sketch of the development process for PVPA projects in China is introduced in Section 2 and the current challenges for PVPA are summarized in Section 3. Finally, corresponding policy recommendations are proposed in Section 4 followed by the conclusions in Section 5.

2. Development process of PVPA

2.1. Current status

2.1.1. PVPA current progress and future plan

As shown in Fig. 1, China has abundant solar resources. The annual solar insolation in each province exceeds 1100 kWh/m^2. The right axis shows the number of poor villages in the 12th five-year plan.[2] Except for some southwestern areas, provinces with large poor populations tend to have higher solar energy endowments. The concordance between the distribution of solar endowment and poor villages provides physical feasibility and benefit for PVPA projects.

Based on the aforementioned physical feasibility, in 2014, the National Energy Administration (NEA) and Poverty Alleviation Office of China under the State Council first proposed PVPA projects and the corresponding working program [21]. After investigating and gathering the poverty information and solar endowment, the pilot projects of PVPA were launched with a total scale of PV systems of 5.16 GW, including 2.98 GW of ground-mounted centralized systems. The distribution of the pilot projects is shown in Fig. 2, including 14 provinces and 0.556 million poor households. The PV installation in pilot projects was basically determined according to the policy of developing PVPA trials in areas with high solar insolation as a priority [22], such as Shandong, Hebei, Anhui, and Jiangxi. Accordingly, Shandong province obtained the largest percentage of PV installed capacity in pilot projects. Meanwhile, the supporting policies of the local governments were also crucial. For example, Hebei province set a power generation subsidy of 0.2RMB/kWh for PVPA projects; Shanxi province provided a PV installation subsidy of 0.1 million RMB per 20 kW [23,24]. Some western provinces, like Qinghai and Ningxia, were excluded from the pilot projects due to high solar curtailment ratio.

2.1.2. PVPA financing models

In the same year (2014), National Development and Reform Commission (NDRC) and National Energy Administration (NEA) published the 13th energy five-year plan. In this document, distributed rooftop PV systems were given great emphasis. The total target for installation of PV systems is 110 GW by 2020, and more than half of the installation is expected to be in the form of distributed systems [25]. We therefore believe distributed PV systems with subsidy support are the most likely to grow quickly and significantly.

To expand the financing source for PVPA projects, Public-Private Partnership (PPP) models have played an important role. As shown in Fig. 3, the PPP model can be applied to both centralized PV stations or distributed PV system, with government and private companies involved. Centralized PV stations are usually built on uncultivated land where the rent is low. After paying the operation and maintenance cost, capital cost and land rent, the local government will distribute the revenue to poor households. Since the village collective owns and operates the PV stations, once a poor household significantly improves his economic viability, the revenue from the centralized PV station will be transferred to other poor people. In contrast, distributed PV systems are usually built on a poor household's rooftop or in their yard, which provides more flexibility in sites selection. However, poor household own the PV systems on his rooftop. Even when he significantly and stably improves his economic viability, the PV system is difficult to be transferred. Apart from the government subsidy, the funds for the distributed PV system come from socially inspired financial investments. Besides, in most cases, poor households have to apply for loans to cover the financing gap for equipment and installation costs, which is unaffordable for them. On the other hand, donations cannot stimulate the enthusiasm of investors to participate in the projects. Novel business models need to be introduced to attract socially inspired financial capital.

From the perspective of poor households, how would they benefit from PVPA projects? Based on the relevant costs in Table 1, a lifetime assessment of PVPA cash flow was conducted. Assuming a household provided 20 m^2 rooftop to build a distributed PV system in 2016, the initial investment would be about 27,000 RMB. Combined, the central and local government would cover around 19,500 RMB on average, and three ways were proposed to meet the financing gap: obtaining social donations, applying for a 15-year loan or applying for a 5-year loan with equal payments. The loan interest rates were 5.5% and 4.9% respectively. The project would be put into operation in 2017, with a lifetime of 25 years. After 25 years, the installation capacity is anticipated to decline by 20%. All the electricity generated will be sold to the power grid at the FiT level set by the government. There are three categories of PV power generation areas according to the different level of annual generation hours [26]. PVPA projects have been launched in areas with more than 1400 generation hours. Therefore, only the first level and the second level of PV power generation will be involved in PVPA projects. Accordingly, the FiT is set according to the different levels of solar resource, at 0.80 RMB/kWh and 0.88 RMB/kWh in level 1 and level 2 areas respectively [27]. The cost for maintenance, overhaul, malfunction, and waste treatment are taken into consideration with a percentage of the initial investment as per Gerilemanda [28] and distributed equally across each year of the lifetime of the project. What's more, the incremental tax is paid at a 50% discount [29]. After paying the costs and tax, the remaining revenue from selling electricity will be returned to poor households.

[1] FiT means the subsidies for electricity price for renewable power generation. It was first introduced for Germany in 2000, for Canada in 2006, and for Australia in 2008 etc. In August 2011, a national solar tariff was issued in China.

[2] The Chinese government makes a systemic plan every five year for the future key work in economic development, social management, environmental protection, and technological progress etc. In 2011, the Chinese government drew up the 12th Five-Year Plan.