Energy Policy ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Analysis of the policy effects of downstream Feed-In Tariff on China's solar photovoltaic industry

Hongwei Wang [a,*], Shilin Zheng [a], Yanhua Zhang [b], Kai Zhang [a,c]

[a] Institute of Quantitative & Technical Economics, Chinese Academy of Social Science, Beijing 100732 PR China
[b] Global Economics Group, United States
[c] Business College, Luoyang Normal University, Luoyang 471000 PR China

HIGHLIGHTS

- The article focuses on the analysis of the effect of downstream FIT policy.
- We test how FIT policy affects overcapacity and profitability of solar PV companies.
- We find FIT policy significantly solved the overcapacity of China's solar PV industry.
- We find FIT policy improved profitability of listed solar PV companies.
- FIT policy can't be played alone and should be combined with taxation and R&D policy.

ARTICLE INFO

Article history:
Received 9 September 2015
Received in revised form
2 March 2016
Accepted 19 March 2016

JEL classification:
Q20
L50

Keywords:
Solar PV industry
Feed-In Tariff policy
Policy effect

ABSTRACT

The Chinese government initiated the Feed-In Tariff ("FIT") policy for downstream power generation in August 2013. The effectiveness of the downstream FIT policy has attracted the attention of academia and government. Using the quarterly data of listed solar PV companies between 2009 and 2015, this paper provides an empirical analysis regarding the effects of the downstream FIT policy. We find that (1) the FIT policy has significantly enhanced the inventory turnover of listed PV firms and improved their profitability; (2) the FIT policy has significant effects on the inventory turnover of midstream companies and mixed industry-chain companies mainly engaged in downstream operations; (3) FIT policy is more favorable towards increasing the inventory turnover of private enterprises. Our results indicate that the FIT policy can have substantial effects on the sustainable development of China's solar photovoltaic industry.

1. Introduction

Driven by the growth of international photovoltaic ("PV") market, owing to China's construction of large solar PV power plants and the Golden Sun demonstration projects between 2006 and 2010, China rapidly developed a relatively complete industry chain, which is dominated by crystalline cells and covering crystalline materials, components, manufacturing equipment and application systems.[1] At this stage, both ends of China's solar PV industry chain are outside of China", i.e. both the upstream silicon material manufacturing and downstream application of power generation markets are outside China.[2] China's domestic solar PV

* Corresponding author.
E-mail addresses: wanghw361@163.com (H. Wang), zhengsl@cass.org.cn (S. Zheng), vzhang@globaleconomicsgroup.com (Y. Zhang), zhangkailuck@126.com (K. Zhang).

[1] According to the classification of industrial organization, industry chain is mainly divided into upstream and downstream industries. Given the uniqueness of China's solar PV industry, i.e. both upstream silicon materials manufacturing and downstream power generation market are all outside China while China has a huge domestic manufacturing capacity of solar PV cells and components. In order to reflect the characteristic of China's solar PV industry, this paper further decomposes the upstream of PV industry chain into upstream and midstream. In other words, we have classified solar PV industry chain into three segments of upstream, midstream and downstream. Products of upstream solar PV manufacturers mainly include the extraction and manufacturing of mono-crystalline silicon, polycrystalline silicon, silicon wafers and other materials; midstream products mainly include the manufacturing of silicon wafers, cell wafers and solar PV cells and components; downstream segment refers to the installation, construction, operation and maintenance of PV systems.

[2] Current technology pathways of solar PV power generation mainly include crystalline silicon cell, Hull cell, crystalline compound cell (represented by GaAs cell), dye-sensitized solar cell, and new-type solar cell technology. Since current mainstream technology pathway remains crystalline silicon cell, this study will focus on the discussion of the industry chain of crystalline silicon.

http://dx.doi.org/10.1016/j.enpol.2016.03.026
0301-4215/

cell manufacturing, as a midstream of solar PV industry chain, experienced rapid capacity expansion. The total production in China has exceeded 50% of the world total output, ranking the first in the world for several years. China's solar PV industry boasts the largest manufacturing output and the lowest cost in the world. Also, more than 95% of its products are sold overseas. Such a business model is highly vulnerable to the risks of business operation, as it excessively relies on overseas markets. Regarding the companies in the solar PV industry, private enterprises represent the majority and the overall market is relatively more competitive.

Solar PV enterprises consider technology progress as an important means to increase their profitability, and to maintain competitiveness. They have achieved significant technology progress, and have developed technology innovation, which is highly adapted to the market. Great technology progress has been made in the manufacturing of upstream silicon materials. Chinese polycrystalline silicon manufacturers have already possessed modified Siemens Technology for producing 1000-ton polycrystalline silicon. As compared to manufacturers in Japan, the United States and Germany, Chinese manufacturers are still left behind in terms of polycrystalline silicon purification, energy efficiency and material recovery rate. They remain at the low end of technology grade. Rapid improvement has been made in the manufacturing process of midstream cells, and, in particular, the conversion efficiency has been improved significantly. The average photovoltaic conversion efficiency for domestic polycrystalline cells ranges from 17% to 17.8%. The potentials to enhance efficiency via current process improvement are very limited. Further improvement of cell efficiency will greatly depend on the creation of new cell structures as well as new processes.

Overall, there are still problems, which need to be tackled, in China's solar PV power generation in the aspects such as technical economy, solar PV grid connection, energy storage equipment manufacturing and system integration, as well as power system applicability. Regarding the market of solar PV products, the anti-dumping and countervailing policies imposed by the European Union and United States against the solar PV cells made in China have slashed China's export. Meanwhile, due to sluggish demand of domestic downstream solar PV market, serious overcapacity has occurred in the midstream industry. Market pressures of overcapacity are mainly reflected in the fierce competition of product prices. Given the homogeneous nature of product, the crowding out effect became increasingly strong. “Cost minimization” and “price reductions” inevitably became the competition strategies currently adopted by solar PV firms. In this manner, after several years of dramatic industry development, prices plummeted across various segments of the solar PV industry chain in 2011, resulting in widespread losses of manufacturers of polycrystalline raw materials, wafers, cells and components from the upstream to the downstream solar PV industry chain.

With a view to resolve the overcapacity of solar PV industry, the National Development and Reform Commission (2013) issued a new set of policies to replace the upfront subsidy with a new performance-based national Feed-In Tariff (FIT) scheme. Such a scheme provides the nationwide subsidy to all distributed-generation solar PV power plants through a subsidy level of 0.42 RMB per kWh in a notice released in August 2013, a 20% increase from the planned level of 0.35 RMB per kWh, which had been proposed in its draft version six months ago. In addition, with the enactment of the national Feed-In Tariff (FIT) scheme to solar PV power generation, many provinces and municipalities have also formulated local policies to support solar PV development on the basis of national subsidies. Hence, the question arises whether the government is able to rapidly kick start the domestic solar PV market with the subsidies for downstream solar PV power generation, and to resolve the serious overcapacity of China's solar PV industry, whether it is able to promote the healthy and sustainable development of solar PV industry. These have become important questions and common concerns of the Chinese government and scholars.

Existing literature has different conclusions over the question whether government subsidy policies play a positive role in promoting the sustainable development of solar PV industry. Some literature parts on the subject reveal that the subsidy policy plays a significant positive role reflected in tariff subsidy and relevant indirect government subsidies. Such a subsidy policy may encourage and promote the production of renewable energy, and increase their market demand (Liou, 2010; Hsu, 2012; Keyuraphan et al., 2012; Moosavian et al., 2013; Biswas et al., 2014). However, Yu et al. (2016) consider that government subsidies have provided significant incentives for the R&D investments of state owned renewable energy firms, yet may not always generate incentives for private R&D investments of renewable energy firms. Shen and Luo (2015) find that subsidy policy may demonstrate certain negative short-term effects for renewable energy of different types. Therefore, there is no simple answer regarding the effect of government subsidy policy, which needs to be adjusted according to different government objectives or development stages (Hagerman et al., 2016). Even the need may arise to coexist with other regulatory policies in order to provide the proactive role of subsidy policy (Huang et al., 2013). In addition, from an industry chain perspective, right incentive scheme should be offered for each and every participant of value chain (Srinivasan, 2009).

Solar PV energy is clean, totally natural, and has great potential as the best energy supply source in the future. However, the installation cost for a solar PV system is still high, while the benefit is lower incremental cost in comparison to alternative electricity sources (Chou et al., 2015). There have been discussion on the implementation of a Feed-In Tariff (FIT), a fixed payout per kilowatt hour (kWh) for electricity generated from PV. With a FIT, large scale solar PV plant managers could put more resources into cost reduction instead of complex and subjective negotiations for the highest price on a plant–by-plant basis (Cherni and Kentish, 2007). In addition, an adequate FIT, fixed for a longer period of time, would promote the wide spread deployment of smaller scale solar PV systems (Rigter and Vidican, 2010). Feed-In Tariffs (FITs) implemented by city councils in the USA have proven to be an effective means of stimulating installation of renewable-electricity generation capacity at local level, and is almost certain to drastically increase installed solar PV for New Zealand cities (White, et al., 2013). In less than six years, Italy has become one of the leading markets for solar PV power plants, and one of the countries in the world with the largest number of installations and installed peak power. Such a quick and large growth is due to a series of Feed-In Tariff schemes that have been uncapped until 2012 (Antonelli and Desideri, 2014).

Therefore, the FIT policy of most developed countries has played an important role in promoting the rapid development of solar PV industry. Differences in the economic and social conditions as well as differences of solar radiation and industrial policy of each country will affect the development of solar PV industry. China's government has formulated many policies supporting the development of renewable energy, especially solar PV energy. In reality, China's government not only provides subsidy on demand, but also focuses on Research and Development (R&D). Currently, many literature studies have provided detailed descriptions of the development environment and government industry incentive policies for solar PV industry, and reviewed the lessons and mistakes of China's solar PV industry policy (Dincer, 2011; Grau et al., 2012; Huo and Zhang, 2012; Zhang et al., 2014). In September 2013, the Chinese government adopted the FIT policy which, however, was less discussed in the literature of Chinese solar PV

Please cite this article as: Wang, H., et al., Analysis of the policy effects of downstream Feed-In Tariff on China’s solar photovoltaic industry. Energy Policy (2016), http://dx.doi.org/10.1016/j.enpol.2016.03.026