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China's solar photovoltaic policy: An analysis based on policy instruments

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HIGHLIGHTS

- We examine the evolution of China's PV policies by using policy instruments analysis.
- China focused on supply-side policies before 2004 and then turned to demand-side policies.
- We mapped the milestones of China's PV policies with the international market share.
- The policy practices in other countries highly influenced the changes of China's PV policy.
- The rationale for China's PV policy is still government management-oriented rather than industry efficiency-oriented.

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ABSTRACT

In the last decade, China's photovoltaic (PV) industry has developed rapidly, with the joint promotion of the world market and domestic policies, and China has now become the largest PV manufacturer in the world. Meanwhile, the international market has responded to China's rapid development, in light of the Chinese government's industrial policies, and "anti-dumping and anti-bribery investigation", focusing on China's solar industry policies, has been proposed. This paper examines the development history of China's PV industry policy system from the perspective of industrial policies and compares China with United States, Germany and Japan from the perspective of both the supply and demand-side policies. The study finds that, unlike the international practice, which attaches importance to subsidies for the market demand-side, China's policies focus on government regulation, concentrating mainly on the product popularization and application stages, with insufficient investment in research and development in the early stage. On the other hand, however, China's PV policies are gradually changing from production supply prioritization to demand-side policy domination. This paper suggests that, while simultaneously increasing investment in research and development, China's PV policies should continue to reinforce the market demand-side policies and gradually exit the production supply-side policies.

1. Introduction

Since entering the 21st century, the global photovoltaic (PV) power generation capacity has increased rapidly. Capacity additions grew from 7.2 gigawatts (GW) installed in 2009 to 16.6 GW in 2010. In 2011, the total PV installed capacity in the world increased to 68GW, and exceeded 100 GW in 2012 [1,2]. China's domestic market started to increase obviously under the promotion of China's PV power generation demonstration projects, in 2009 although this lagged behind the international phase, as shown in Table 1.1.

In contrast to the installation market, China's manufacturing industry performs miracles. Since 2004, the growth rate of China's solar cell production exceeded 100% in five consecutive years. In 2007, China's production of PV cell modules ranked first in the world [4]. In 2009, it accounted for more than 50% of global total production [5]. In 2010, four of the world's largest five PV manufacturers were Chinese enterprises: Suntech, JA Solar, Yingli Green Energy and Trina Solar, with shares of 6.6%, 6.1%, 4.7% and 4.7% of global cell production respectively [6].

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Table 1.1
Production and accumulative installed capacity of solar cell modules in China 2003–2012 (MW). *Source*: Li et al. [3].

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Module production (MW)	10.3	60	200	400	1088	2600	4011	10,800	19,800	21,000
Accumulative installed capacity (MW)	40	50	65	70	100	140	300	820	3520	8020

Since July 2011, the global PV market has shrunk, following the European debt crisis, and many solar enterprises, such as Solyndra LLC, Spectra Watt and Evergreen Solar, went into liquidation in succession. In their bankruptcy declarations, these three enterprises attributed their collapse to the declining global market and excessively fierce competition, especially from their Chinese counterparts. Therefore, the US and the European Union launched an "anti-dumping and anti-bribery investigation" in China, focusing on its PV manufacturing industry policies. However, based on the limited studies on China's solar PV policies, the literature only lists China's existing PV solar policies [7,8], which cannot explain the dynamic trajectory of Chinese solar policy and its relation to the development of the industry. Thus, it is hard to understand the logic of China's policy and this may generate bias in China's industry development. Meanwhile, the current studies fail to place China's PV solar policy in the international scene, and so there is a lack of comparative policy studies between China and other countries.

To fill this gap, this paper aims to analyze the development history of China's PV industry policies and compare China with United States, Germany and Japan from the perspective of the supply-side and demand-side policy instruments. We try to find the logic underlying China's PV policy change, recognize the differences between China and other countries, and identify future trends. In the second section, we will introduce the relevant literature and the research method of this paper; in the third section, we will systematically review the evolution of China's PV industry policy system; in the fourth section, we will compare China with three other countries: United States, Germany and Japan; finally, we draw a conclusion based on our discussion.

2. Literature review and methodology

2.1. Literature review

Policy instruments are recognized as the methods used by governments to achieve a desired effect. It is a particular type of institution, a technical device with the generic purpose of carrying a concrete concept of the politics/society relationship, sustained by a concept of regulation [9]. The international discussions of the policy instruments of solar energy application can be divided into two groups: the demand-pull policies and the technology-push policies.

2.1.1. The demand-side policy instruments

The demand-side policy practices related to solar energy in different countries cover a very rich range of policy instruments, including feed-in-tariffs, subsidies, net metering, green tags, renewable energy portfolios, financial support, public investment, tax credits, government mandates and regulatory provision [10,11]. The main goal of these policy instruments is to foster the solar energy use market. The feed-in-tariff is a widely-adopted policy instrument that has been adopted in more than 75 jurisdictions around the world, including Algeria, Australia, Canada, China, the Czech Republic, France, Germany, Greece, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, the Netherlands, South Africa, Spain, Switzerland, Thailand, Uganda, the Ukraine, the United Kingdom, the United States, and Puerto Rico [12]. Feed-in-tariffs provide long-term financial stability for investors, referring to the regulatory minimum guaranteed price per kWh that an electricity utility has to pay to a private independent producer of renewable power that is fed into the grid [13]. Although these tariffs differ across different countries and regions based on their type and the size of the technology, they have been recognized as one of the most beneficial ways to accelerate the application of solar PV on the demand-side [14–16], especially when the government has good control over the cost management, fine tuning adjustments, and central-local government coordination [17]. Subsidies are another widely adopted policy tool for promoting solar energy use. The demand-side subsidies include direct and indirect subsidies for the installation of solar energy hardware, such as investment grants, capacity payments, output- or production-based payments, and soft loans [10,14,18]. Green tags and net metering are two trading-based policy instruments that use the energy market to promote the application of solar energy. Green tags, also known as Solar Renewable Energy Credits, are a trading mechanism that has been adopted by nine EU countries, whereby the property rights to the environmental benefits from generating electric energy from renewable energy sources can be sold and traded and their owners can legally demonstrate that they have purchased renewable energy [18]. Net-metering is the system whereby households and commercial establishments are allowed to sell the excess electricity that they generate from their solar systems to the grid [10]. It allows customers to offset their electricity consumption with small-scale solar power over an entire billing period using the power at a different time than it is produced, without considering when it is consumed or generated, and storing it in the utility's grid [18]. A comparison of the feed-in-tariff, green tag and net-metering policies implemented in EU countries shows that the implementation methods and processes influence the economic efficiency of these policies. The renewable energy portfolio is another trading regime which sets standards whereby utilities with no or low renewable electricity content in their overall supply portfolio buy from those with high renewable electricity content. This policy has been adopted by more than 14 countries, including the United States, where 31 out of the 50 states have introduced it. Together with the feed-in-tariff, the renewable energy portfolio is the most important policy for promoting the diffusion of solar PV [16,19,20]. Financial support is used by governments often in the form of low-interest loans. It can combine the efforts of consumers to facilitate solar application. It has been considered a good way for states to pursue sustainable PV adoption targets [21].

2.1.2. The supply-side policy instruments

Compared with the demand-pull policies, the technology-push side policies are less diversified. They have received little attention in the literature [22]. The 'push' policies support the creation of businesses in the solar supply chain, especially manufacturers. They take the form of research development and demonstration grants, low-cost loans for manufacturing, tax concessions, and subsidized support infrastructure. A broadly-used policy tool is technology R&D initiatives related to solar technology research. An empirical study of India recognized how R&D initiatives and the related semiconductor technology supports the incubation