Evolution of Solar Photovoltaic Policies and Industry in China

Yueqi Zhang¹,²*, Pengcheng Xie¹, Ying Huang¹, Cuiping Liao¹, and Daiqing Zhao¹

¹Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, Guangzhou, China.
²University of Chinese Academy of Sciences, Beijing, China

*Corresponding author: zhangyq1@ms.geic.ac.cn

Abstract. China has experienced a rapid growth of both SPV manufacturing capacity and installed capacity in the last twenty-five years. However, this growth has followed a very erratic path. This study identifies policies issued through this period for a closer look on the impact of these policies to the solar photovoltaic (SPV) industry development in China. This paper examines five stages in China’s SPV policy from mid-1990s to 2019. Each stage has implemented different combinations of policy program. These changes in government policy and the effects to the SPV sector are attributed to three main sets of variables. First and foremost, the events that influence the policy and strategy priorities of Chinese government. Secondary factors include the government’s poor management of the policy impacts to the SPV manufacturing industry and the domestic SPV market at early days, as well as policymaking and problems coping within government. The subsidy, FIT policies and other programs had stimulated the deployment of SPV in a large scale but brings several problems such as subsidy reliance. The fundamental measure to improve SPV development into a grid parity era is the technological advancement of photovoltaic in efficiency and manufacturing.

Keywords: Solar energy, Photovoltaic, Policy, Subsidy, SPV industry, Installed capacity.

1. Introduction

The Chinese 13th Five-Year plan of Solar Energy has made a specific goal for the development of solar energy: achieve 105 GW total installed capacity by 2020(NDRC, 2016). After 2015, the development of SPV projects in China has experienced a fast expansion. The total installed capacity is 130GW in 2017, which has surpassed the 2020 target set by the planning [39]. Such rapid increase of SPV in China due to the stimulation from the SPV subsidy policies as well as the massive cost reduction on SPV module [39]. Several problems had revealed during the rapid development of SPV project in China. For example, the reliance of subsidy in many SPV projects, the high non-technical cost during the development of the project such as land rent and local taxation policy, the huge and growing subsidy gap brings difficulty for subsidy application. In order to solve these problems and encourage a better and high-quality development of SPV in China, the government had announced
several policies in the recent years. These policies have promoted the expansion of SPV applications and achieved market adjustment to a more advanced and high-efficiency SPV technology application.

At the early days of 2000s, the status of China’s SPV industry was considered underdeveloped. By the end of 1994, in the 5 MW of China’s PV module manufacturing capacity, only about 3 MW of them were in use, of which about one third was in distributed domestic systems [41]. By 2018, the total SPV module manufacturing capacity and output in China had reached 85.7 GW and 43 GW, accounting for 71% and 52% of the world respectively [40]. China’s SPV production has experienced an exponential growth in the last 2 decades. Since 2007, China has become the world’s largest producer of SPV with a share of over 68% of global production (Fig.1). Moreover, the total installed capacity of SPV in China reached 173 GW in 2018, more than 24 times greater than the installed capacity in 2012[45].

![Figure 1. Annual solar photovoltaics production by country, 2001–2018.](image)

Source: Authors’ compilation data from National Renewable Energy Laboratory (2001-2019).

The outstanding achievements in terms of PV manufacturing and the development in PV power installation since 2009 were come from a series of policy programs. Since the mid-1990s, the Chinese government had implemented a number of different SPV policies, from industry development to subsidies and feed-in tariff. Despite these policy changes, the overall growth of China’s SPV industry has been a great support to the low-carbon and energy system transition within China. This study identifies the policies which have influenced the SPV’s industry development and technological application in China from mid-1990s to the present day. The main goal of this paper is to demonstrate the influences and interactions between SPV policies and the SPV deployment and provide recommendations on the policymaking for a better and effective SPV development.

Most of the published studies about China’s SPV policy only provide a description perspective or focus on a certain period in the 25 years SPV development in China [13, 15-20, 45-48]. Several incentive policies had announced after 2012 which brings many changes in the SPV sector. Different from previous papers, this paper makes a contribution to the literature on China’s SPV sector from four aspects. First, it overviews the evolution of China’s SPV policies and the development of the SPV industry in order to demonstrate and explain the unstable path of implementation of this technology. Second, it makes a comprehensive study into the period from 1990s to the present day to provide a throughout and sequential aspect on the policy effects to the solar energy development. Third, it shows the significant impact of the related policies put in place in 2018 on the SPV sector which started the
subsidy reduction process for sustained and high-quality development of SPV to support the grid parity realization of solar power as well as the country’s green energy transition. Fourth, it summarizes the experience of the solar energy policy making during these 25 years.

This paper identifies five stages of SPV policy in China from mid-1990s to mid-2019: namely from mid-1990s to 2003, from 2004 to 2008, from 2009 to 2011, from 2012 to June 2018, and June 2018 onwards. Sections 2–6 overview the China’s SPV policy at each period in order to identify the overall policies for the sector and the impacts of the policy tools deployed, and to illustrate their effects on the PV manufacturing industry and on the implementation of SPV. The last Section 7 provides conclusions.

2. The first stage (mid-1990s–2003): rural electrification with renewable energy

In this section, we provide accounts for China's SPV power policy during the mid-1990s and 2003. The key government lead programs which represent the milestone of SPV development at this stage is the Brightness Program (1996), The Township Electrification Program (2002) and International cooperation projects. Since 1950, the Chinese government had considered the rural electrification to be a long-term development priority. However, at the end of 1996, over 70 million people in rural areas had still no electricity [45]. Although there are several measures existed for rural electrification, such as grid extension, implementing micro-grids system, or installing isolated off-grid power generation systems [11], the majority of the rural electrification programs in China were fossil fuel-based grid extension programs until mid-1990s [29]. But the problem was that the economy development status and the geographical distribution of settlements in northern and western provinces makes most people lived in there were unable to access any electricity grids. The extension of existing grids brought many technical difficulties and had poor financial performance. However, these areas had abundant wind and solar energy resources. As a result, developing solar energy had become the main option for the government to provide electricity in those areas. There were two programs launched to achieve rural electrification during this period: The Brightness Program in 1996 and the Township Electrification Program in 2002.

2.1. The Brightness Program

The Brightness Program was the first national policy formulated by the Chinese government to bring electricity to remote areas of western China through renewable energy. The 1996 World Solar Peak Conference in Zimbabwe proposed an international effort designed to bring electricity to rural areas. This program was thus a response to such efforts [27]. The Chinese program was formulated by the State Development Planning Commission (SDPC), and its overall target was to help 23 million people in remote areas gain access to electricity using renewable energies like wind or solar by 2010 [2]. Since the mid-1990s, the Brightness Program has also constituted part of the government’s national development plan to develop renewable energy. Since 1997, they had help 8 million people gain access to electricity in 5 years. By the end of 1999, there were more than 7 million houses and 20 thousand villages in remote areas without electricity. Additional SPV approaches needed to further extend the grid to remote areas.

2.2. Township Electrification Program

The ‘Western Development Strategy’, a comprehensive development strategy, was announced by Chinese government in 2000 for the purpose of supporting the development of western China. This strategy was mainly focused on improving electricity access in remote rural areas. This was the reason that rural electrification was made part of the government 10th Five-year plan ranging from 2001 to 2005 [29]. Then a significant development was done by the Chinese government as they financed a project of worth 2.6 billion RMB. The State Council authorized this project in 2002 named as Township Electrification Program. It was made part of the Brightness program so that to improve the SPV development [32]. There were many grid stations constructed under this program that has the unique feature of being stand-alone, off-grid with the microgrid systems. This program resulted in a
massive success as the beneficiaries were 2 million population of the area received electricity [33]. The high electrification rate in China showed that the effectiveness of the power production and distribution through centralized public sector energy initiatives [45].

2.3. International cooperation projects
Chinese government opted many other ways to improve access to electricity in rural areas. The foreign corporation was taken onboard in the various projects so that to try different other means of electricity generation such as renewable energy. Foreign Countries and organizations involved into this cooperation are Japan, Germany, Netherlands, Canada and the World Bank. The total investment of these projects was about $800 million RMB [45].

2.4. Discussion
China’s SPV market initial development is attributed to the various programs that were started in the mid-1990s. China’s national programs played a positive role in the growth of the SPV industry. Due to these programs, the PV cells installed capacity was improved significantly from 6.63 MWp in 1995 to 45 MWp in 2003 [14], and domestic demand for PV systems grown rapidly in the late 1990s [13]. A number of foreign solar cell companies (BP, Shell, Siemens Solar, Sharp, Sayo and SEC) arrived having high expectation on the sales in China. Trina solar and Yingli, representing the new generation of Chinese PV firms, were established and grown up [3]. Nevertheless, the quality of Chinese SPV products such as mono-crystalline solar cell and solar modules were still below the level in developed countries [8].

A convergence of trends in the late 1990s brought support to the SPV development in China and across the world. Other features of the world witness the cost reduction of SPV technology that has played an important role in the SPV industry growth. It was the dire priority of the world to make sure access to electricity in the poor areas of the world; that’s why it was included in the Millennium Development Goals.

The international players very much influenced China’s focus on the renewable energy sector. The international organization such as the World Bank influenced the plans and policies along with the other countries such as Japan, Canada, and Germany were looking forward to promoting their developed technologies. The Western Development Strategy has greatly enhanced the scale of support given to SPV development in China. It was aimed to reduce the economic imbalance between the provinces situated in the inland and coastal areas.

The state was seen as playing a central role in the governance of the energy sector, which is consistent with the energy policies to promote SPV development [1]. Consequently, the implementation of the programs to support SPV installations was promoted through the direct provision of government funds. However, this approach failed to provide incentives for the maintenance of the equipment after the construction. These SPV systems’ lifetime had seriously reduce which leads to a poor financial as well as power production performance. This stage of SPV development in China is funds and programs-oriented therefore lack of sustainability.

3. The second stage (2004–2008): export-oriented growth
China has shifted its SPV policy to the export-oriented side during the timeframe of 2004 to 2008. It was due to the massive demand generated at the global front in 2004 and the domestic policies of the country. Chinese government supported the development of green technologies that was generous support to the SPV manufacturing industry. The demand in the domestic SPV market provided insufficient incentives for the development of SPV.

3.1. Explosive global PV demand
It was the Kyoto Protocol in 1997 that made the countries all over the world to increase the renewable energy generation due to incentive policies provided. Germany was leading in this regard that has introduced the feed-in tariff policy that was about giving guarantee to the PV electricity fixed price for
a longer period [9]. This has resulted in increasing demand for PV systems in the country. Germany and Spain became the global leaders in the PV demand [13]. A massive annual growth rate of 294% was observed of PV demand in Germany that has resulted in doubling the global demand in 2004. Spain witnessed a vast increase as well in the install capacity of 461% in 2007 and 348% in 2008 due to the FIT policy [13].

3.2. Strong support for SPV industry

China’s central and local government provided vital support to the SPV manufacturing industry in the wave of fast-growing global PV demand. It was due to the stance of the Chinese government to seize the opportunity at the global scale to become the technological and economic leader by looking into low carbon energy production. China has resulted in investing heavily in the green industries and technologies so that to be the significant player in the SPV industry at the global scale [44].

Local governments also seized the opportunity due to the Central government support to the clean energy and facilitated the growth of local PV industries. Some of the local policies were directly aligned with the Central government policy. But some of the provinces take extraordinary measures so that to turn their provinces in the clean energy hub such as Jiangsu Province that has developed solar development policies in a more constructive manner.

It was the positive market indicators and Chinese government support that has shifted the focus of many other Chinese companies as well to invest in the SPV industry. Funds were acquired quickly by focusing on the economy of scale. China local and central government facilitated the process by introducing policies that helped these companies to set up joint ventures. A significant step in this regard was updated the Chinese High Technology Products Catalog in 2006 in which the PV industry was as one of the critical sectors. This was a big step because it enables the private sector to obtain more financial resources for the R&D. Import-Export Bank of China provided the credit at low rates along with the insurance through the China Export and Credit Insurance Corporation. Chinese companies were able to raise funds through IPOs from overseas markets as well due to these preferential policies. Suntech was the very first company in this regard that raised funds from NYSC in 2005 [34]. Other major companies such as Tina Solar and Yingli also followed the footsteps of Suntech and got listed in the NYSE. China Sunergy and JA solar entered into the National Association of Securities Dealers Automated Quotations (Nasdaq) in the next 2 years. When the abundant capital was poured from the foreign capital markets into the Chinas local PV industry, it resulted in increasing the production capacity to the new levels. This triggered the growth of the PV industry in China, and it became the leader of PV manufacturing in 2008 [13].

3.3. Low demand in domestic market

There was a lack of incentive policies which slowed the growth of the domestic PV market even though PV production was increasing rapidly in 2004. Since the China’s Renewable Energy Law was passed in 2005, the development of SPV in China is slow because of the relatively high cost of solar energy. Economically viability is a significant characteristic in renewable energy development as well as a basic principle set by the Law. China’s annual increased install capacity of SPV was 40MW in 2004 and increased to 300 MW in 2008 that was marginal, and its share in the world SPV capacity was 1.31% [13, 45]. It means that most of China’s PV production were for exportation. It was the year 2006 when the export-oriented strategy and increased local demand stimulated the growth in the SPV industry.

Around 80% of PV n China was exported to the European market at this time [6]. Such characteristic of SPV development was described as “two head at the outside” in China. This saying means that the technology of SPV production came from abroad and their SPV products market is also aboard.
3.4. Discussion
During the period 2004–2008, although the external trends and Chinese government’s prioritized policy for domestic solar industry supported the low-carbon transition by enhancing the deployment of SPV in many countries around the world, except China itself. The FIT policies were implemented in the developed countries outside China which had caused SPV capacity increase in an unprecedented rate. The Asian Financial Crisis caused four years of relatively slow growth of Chinese economy. Therefore, boosting the economy is the priority of the government’s SPV industry development. At the same time, the authority had considered that China’s long-term economic future depended on developing high technology and high value-added industries. The West’s growing demand for SPV panels for coping with climate change provided the country with an opportunity to combine manufacturing advantages (low capital and labor costs, skillful workers) to build an industry, which dominated the global market.

The government provided the SPV industry with direct support as in the previous phase. China’s accession in 2001 to the World Trade Organization assisted the implementation of the export-oriented strategy for the SPV industry and in other sectors [6]. This strategy causes a massive increase in production capacity of SPV products in China, as well as quality improvement, and a rapid decline of module prices. This promoted the implementation of SPV around the world in turn.

Despite the passing of the Renewable Energy Law in 2005, the deployment of SPV within China itself was slow. The domestic SPV projects only had financial incentives policy 3 years later than that of wind energy in 2006. The main reason is the cost of PV system, which was seen as too high in financial support.

The development trends in the SPV development in China at this stage showed the massive proportion of Chinese SPV panels that deployed around the world but limited installed capacity within China.

4. The third stage (2009–2011): industry and market support
Global financial crisis dented almost every sector all over the world, and the PV industry was no different in this regard that damaged the growth in China as well. The exports of the country saw a significant decline in the following year of this crisis. In response to this, the Chinese government announced mix industrial and economic policy to manage the effects of this financial crisis. Chinese policymakers were in favor of this stance that domestic growth should be stimulated so that to offset the economic damage done by the global financial crisis. This has resulted in supporting the SPV industry at every government level, and new policies were implemented so that demand for SPV can be increased in the country.

4.1. Industry support policies
It was the package of 4 trillion RMB that was announced by the Chinese government in November 2004 to deal with the effects of the financial crisis. This macro economy policy was aimed to focus on the public infrastructure and transport sector to stimulate domestic demand. There was an announcement made regarding the 7 emerging industries in the country. These industries include new energy, biotechnology, energy saving and environmental protection [36]. These renewable energy related industries played an important role in the industry development because rapid urbanization and industrialization has polluted the environment back in the country very much. Making these renewable energy related industries a top priority is the necessary means to improve this situation.

The China Development Bank implemented a guide in 2009 for the developing of SPV industry. It was also included in the policymaking for the National Strategic Emerging Industries. A substantial financial sum was poured into the SPV product manufacturing sector in China of worth 250 billion RMB in the shape of extensions credits. At the same time, $30 billion from the CDB line of credit was also received [9]. In 2009, with the support of sufficient tax revenues, Chinese local government introduced the refund policies so that investment in the PV manufacturing plant can be increased. Jiangsu province included the corporate income tax, electricity tariffs, land transfer fee and VAT
Payments in the refund policies in Huai’an City. It has promoted the massive investment into the SPV industry.

The tremendous growth was observed in the production of different SPV products. PV cells had 8.3 times increased in production, 10 times for wafer and 18 times for polysilicon from period ranging from 2009 to 2011[20]. China’s share in global PV increased from 32% to 60% over the same period [20]. This situation resulted in overcapacity into China’s manufacturing industry of SPV. The situation got into more alarming trouble when EU and USA entered into legal matters through countervailing and anti-dumping cases against the solar panel producer of the country.

4.2. Market support
The economic recession following the 2008 financial crisis caused a decline in demand for SPV cells in international market, which in turn adversely affected China’s heavily export-oriented SPV industry. Recognizing the importance of addressing the mismatch between China’s SPV product capacity and its domestic deployment, in early 2009 the government started to implement policies to shift its SPV policy toward the domestic market. The weak external market led to the changes of SPV manufacturing industry as well as its export-led economic model toward expanding on domestic demand.

4.2.1. Solar Power Rooftop Subsidy Program. Solar Power Subsidy Program was the joint effort of the Ministry of Housing and Finance along with the Urban-Rural development of China in 2009. It was the very first program of its nature with the subsidy rate of 15 RMB/W for rooftop related SPV projects while 20 RMB/W for the tasks associated with the building-integrated PV projects. There was also a subsidy of a massive 50% regarding the supply of critical components. The scale of the project needed to be no less than 50 kW to be included in this program.

4.2.2. Golden Sun Demonstration Program. Golden Sun Demonstration Program was launched in July 2009 with the mutual collaboration of the Ministry of Finance, the Ministry of Science and Technology (MOST) and National Energy Administration (NEA) of the National Development and Reform Commission (NRDC). This Program was also based on massive subsidies such as 70% for the off-grid PV system while 50% for the investment cost for grid-connected systems. This program was launched during 2009 to 2011. Target capacity was set at 20 MW for each province. This program gained the mix results and installed capacity approved was about 5930 MWp, of which 3044 MWp was constructed. Other than the power generated from SPV system for own-use, the rest electricity could be sold to the power grid at the local benchmark coal-fired grid price. These demonstration projects in the programs have experimental and experience gathering meanings for the formulation and preparation of nationwide SPV policies in the future.

There were many flaws in this program due to which it was criticized by the stakeholders involved in the PV industry. The major drawback that was highlighted regarding the lack of criterion of project approval. the lack of incentives for the companies to build high-performance systems because of its one-time payment of the subsidies, the lack of supervision of project implementation brings severe fraud and abuse of subsidy funds, and subsidies payment delays [43]. A report was released in this regard by China’s National Audit Office in 2013 which shows that amount of 207 million RMB was deceived by 7 different SPV projects that demonstrate the lack of accountability and a massive waste of financial resource through unfair means [43]. Companies in this regard exaggerated their plans on generation capacity as compared to the actual outputs. Fake documents were prepared by them to gained more subsidy from the government. That was the reason that the government has changed its approach form the capacity-based subsidies to the generation-based subsidies so that transparency and fair usage of financial resources can be ensured.
4.2.3. **Two rounds of concession program.** Government has also sorted out policies for the large-scale PV (LSPV) in two rounds of SPV concession programs. The concession program would set a solar power selling price through bidding and provide a large amount of market demand in China. The LSPV has great potential in the high solar resource’s endowment such as the northwest provinces of China with the local annual insolation duration is over 1500 h [16]. The first program was started in the Dunhuang City of Gansu Province with a capacity of 10 MW LSPV station.

The winning bid for the project was 1.0928 RMB/kWh. In June 2010, 280 MW LSPV station was launched as the second round of the concession program began. The winning bids were between 0.7288–0.9791 RMB/kWh [12], leading to a ‘less than 1 RMB’ era for solar power price. The companies who win the bid were required to complete project construction in 2 years and the system operation duration has to be 25 years.

These concession programs were significantly advanced China’s SPV domestic industry development because it helped them to further reduce the on-grid price of SPV power. Tariffs bids were set very low as compare to market structure that’s why these programs resulted into on-grid price reduction from 4 RMB/kWh to 1 RMB/kWh or less from 2008 to 2010. These efforts also helped the NDRC to determine the FIT based on the previously applied programs.

4.2.4. **Nationwide FIT policy.** In July 2011, the NDRC announced its first nationwide FIT policy for SPV power [21]. According to the Notice on Perfection of Policy Regarding Feed-in Tariff for SPV Generation that define the FIT policy, SPV projects which will achieve commercial operation by the end of 2011 would have a tariff of 1.15 RMB/kWh for solar power. For those who will not completed before the end of 2011 would have a tariff of 1 RMB/kWh (NDRC, 2011). The introduction of this policy was warmly praised by the Chinese SPV companies and lending institutes.

A significant flaw in this FIT policy was regarding the solar resource distribution in the different parts of the country. Solar energy distribution was uneven in the country because the West part of the country is having more radiation as compared to the East. According to a research, 17 eastern provinces’ average yearly radiation was only 4836.23 MJ/m2 while merely 9 Western provinces were having the numbers of 5519.46 MJ/m2 [10]. It shows the significant difference in the two parts of the country but the policy was not taken it into the account. As a result, the disparity of SPV projects’ profitability is still exist between these two regions after the FIT policy implemented.

These government-led incentives prices still managed to increase the installation of SPV in the country as an offsetting the negative effects of the financial crisis despite the flaws. Despite these disadvantages, these government-led policies created a sharp increase in the SPV installation in China and have helped China’s PV manufacturing companies offsetting the negative effects of the financial crisis. Total installed PV capacity of the country had an increase from 300 MW to 33000 MW from 2009 to 2011 [31]. But experts believe that China’s PV market is more in experimental stage due to the project’s basis only for the demonstration.

4.3. **Discussion**

The financial crisis of 2008 jolted the economies of the world. It also changed the dynamics of economic development in China as it triggered the government’s determination to change its SPV policy. The country was forced to come up with innovative plans to offset the negative effects of the financial crisis. Their policy regarding SPV sector was also changed accordingly. The overall demand of the SPV products in the world was reduced sharply that has threatened not only sustainable growth of the SPV market in China, but the government developments strategies regarding the industry. This was the reason a huge 4 trillion RMB package was released into the economy by focusing on the emerging sector in which SPV was also included.

Recovering the Chinese PV industry was successfully achieved through a combination of policies in industry and energy sectors in a short-term period. It has further enhanced the production capacity and accelerated the implementation of SPV in China, but it had many side effects. Massive overcapacity and high levels of debt was occurred in the manufacturing industry, despite growing
installation within China. Meanwhile, the Golden Sun Program caused serious problems in the solar energy market for its deficiencies. Furthermore, the FIT policy is not considerate enough in China’s solar resource distribution. This set of problems would be addressed in the next stage.

5. The fourth stage (2012 to June 2018): rapid development of SPV in China

This heavy investment led to massive production of the solar panel by 2012 that result in overcapacity. China’s annual production share at the global scale reached 64% with the capacity of 22.5 GW [28]. Some of the companies in the EU and USA go bankrupt due to the declining PV products prices. These efforts were taken as threatening measures by the US and EU which triggered the investigation in terms of “ antidumping” and “anti-subsidiary” that has impacted significantly on China’s SPV industry. It is under this circumstance that, from September 2012 to May 2018, the Chinese government issued a series of policies and programs to provide stronger support for distributed SPV (DSPV) projects and high-efficiency PV products, introduced the generation-based subsidies and a resource-based FIT policy with a gradual adjustment on tariff through these years.

5.1. Supportive policies for Distributed SPV power

China’s trade disputes with the US and later, the EU heavily damaged the profitability for the SPV industry that already faced low-profit margins due to overcapacity. SPV sector exports to both regions had a drop of 35% in 2012 and struggling signs were recorded in early 2013 as well. The most significant market player, Suntech Power announced the loss for the consecutive four quarters in the financial year 2012 along with massive debt default of $541 million bonds in 2013 [7].

In order to mitigate the adverse impact on SPV industry, the Chinese government increased the support to reshape the overcapacity sector by increasing domestic market demands that have great potential at the end. The government came up with two innovative plans as first was regarding the promotion of DSPV technology. At the same time, the second was the categorization of FIT by aligning it with regional solar resources.

The market stimulation work over the past few years indicated that the centerpiece of China’s solar energy development should be LSPV power plants in remote area. Northwest China is labelled as the best place for construction due to the richest region form a solar energy perspective. These power stations became the dominant role of PV application in the country until the country announced the 12th five-year plan for Renewable Energy Development. This plan adopted a more balanced approach by focusing on both LSPV as well as DSPV. NEA released the 12th five-year plan for Solar Energy Development in July 2012 and target of solar installed was set of 21 GW by 2015 [23]. This was divided into LSPV, DSPV and concentrated solar power by 10 GW, 10 GW and 1 GW respectively.

New policies to promote DSPV and a resource-based FIT was released to support the realization of this Plan.

This new strategy was aimed to solve the mismatch problem between the solar energy supply and demand experiences of solar energy. China’s resources of solar energy are mostly located in the North and West Region, but power demands come mainly from the coastal provinces in the Eastern side. LSPV installations in Northern China have been the center of solar power development due to their resource advantages. However, grid connectivity, insufficient local power consumption and limited power transport capability have posed the biggest challenges to the development of the large-scale solar power since 2009. There is an indicator called “Solar Abandon Rate”, which is commonly used in China to describe the level of solar power wasted in local area. The solar abandon rate is 14% nationwide with certain provinces, Gansu province for example, up to 40% from July 2014 to May 2015 [4]. For DSPV, its direct connection to the local grid can assure that its solar power can be completely consumed in local region. Its relatively small scale brings flexibility of the install location from residence or factory rooftop in urban area to single house in rural area. The application of DSPV will not only mitigate the mismatch problem but also significantly decrease the solar abandon rate, which is an important indicator of the healthy development of solar power in the government perspective.
In December, 2016, the DSPV development was also being highlighted in the China’s 13th Five-Year Plan for Renewable Energy Development and the Solar Power Development. The plan had announced the massive deployment of DSPV on rooftop for industrial and commercial buildings as well as demonstration program of “1kw” DSPV for every resident. The planning also suggested new applications of DSPV called “PV+”, which combined DSPV system with agriculture and forestry utilization. These moves stimulated the diversified development of SPV technologies and applications in China.

Table 1. Favorable policies for DSPV issued during January 2012 and March 2018.

| Issuing time   | Issuing agency | Document title                                                                 |
|---------------|----------------|--------------------------------------------------------------------------------|
| January 2012  | State Council  | 12th Five Year Plan for Renewable Energy Development                           |
| July 2012     | NEA            | 12th Five Year Plan for Solar Energy Development                              |
| September 2012| NEA            | Notice on Application for Scaling Up Demonstration Zones for Distributed Solar Power |
| November 2012 | State Grid     | Opinions on Providing Good Services to the Grid Connection of Distributed PV Power Generation (Provisional) |
| July 2013     | State Council  | Opinions on Promoting the Healthy Development of Photovoltaic Industry          |
| August 2013   | NDRC           | Notice on Promoting the Healthy Development of SPV Industry through Price Leverage |
| August 2013   | NEA            | Notice on the Construction of Scaling Up Demonstration Zones for Distributed Solar Power |
| August 2013   | NDRC           | Provisional Management Measures for Distributed Power                          |
| February 2014 | NEA            | Notice to allocate new construction scale of SPV projects in 2014               |
| November 2014 | NEA            | Notice to add new construction scale of SPV projects to Xinjiang Autonomous Region in 2014 |
| March 2015    | NEA            | Notice to announce the construction implementation planning of SPV projects in 2015 |
| September 2015| NEA            | Notice to increase the construction scale of SPV projects in some regions in 2015 |
| June 2016     | NEA            | Notice to announce the construction implementation planning of SPV projects in 2016 |
| December 2016 | NEA, NDRC      | The 13th five-year plan for Renewable Energy Development                         |
| December 2016 | NEA, NDRC      | The 13th five-year plan of Solar Power Development                              |
| March 2018    | NEA, SCOPAD    | Regulation of SPV Poverty Alleviation Projects Management                       |

5.2. Incentive Policies for DSPV power
State Council, NEA, NDRC and State Grid collaborated on the DSPV development, and a series of preferential policies were put in place between January 2012 to March 2018. In September 2012, a notice was released by the NEA regarding the scaling up of demonstration zones for DSPV power [25]. The NEA set a limit of 3 demonstration zones and maximum install capacity of 500 MW through this notification along with mentioning the priority zones of Eastern and Central Regions due to their high electricity demand.
The overelaborated grid connection procedures have long been the obstacle of the massive expansion for SPV power in China. It is largely a result of the State Grid’s unwillingness to simplify the process and assume its responsibility in facilitating solar power development. But the NEA’s directives have required the State Grid to announce plans such as allowing small-scale DSPV generators with less than 6 MW capacity to connect to its power lines and providing technical assistance and remit fees in grid connection [38]. NDRC also played a positive role and helped the companies in shortening the timeframe for getting the approval regarding setting up DSPV power projects regardless of their size. Stakeholders having an interest in the development of such projects only have to inform the local Development and Reform Bureau that has resulted in reducing the paperwork and resources. This was the reason that installed capacity of DSPV also witnessed a massive increase from 608.5MW to 3375 MW in 2012, of which 2372.49 MW were from the Golden Sun Program in 2012. In the same time, installed capacity of LSPV program remained at 2000 MW [16].

The trade disputes between China and the EU started in June 2013 when the EU came up with anti-dumping tariffs on the solar panel imports coming from China. This has forced the Chinese government to announce a series of policies in response to this severe situation. On 14th June 2013, China’s State Council came up with the plan with six measures to the solar industry. These measures included establishing the feed-in tariffs on based on nationwide resources level, expansion of DSPV and Renewable Energy Development Fund and purchasing all PV generated electricity in full price at the national scale [42].

The State Council issued issued the Opinions on Encouraging the Healthy Development of the Solar Photovoltaic Industry on July 24, 2013. It also set up the development goal for the SPV industry [37]. NEA also announced to set up 18 SPV distributed power generated demonstration zones in the country on August 20, 2013. It was decided that the total installed capacity of these demonstration zones will be 1.823 GW by the end of 2015 while the completion of 749 MW will be done in 2013 [26].

The NDRC also announced new Subsidiary policies on August 30, 2013, with the sole aim of facilitating the SPV industry. A subsidy of 0.42 RMB/kWh was announced for all the DSPV projects by NDRC. China’s Renewable Energy Development Fund will be the source of this subsidy. The DSPV power purchase mechanism is the same as in the Golden Sun Demonstration project. Still, the only exception was made in terms of system reserve charges, electricity charges, and grid station services charges [22].

After the subsidy mechanism was all established for the SPV industry, the NEA set the development goal for the SPV projects from 2014 to 2016(NEA,2014; NEA,2015; NEA,2016). These planning install target for the SPV had ensured the steady and high increase of DSPV in China.

5.3. Resources-based categorized FIT scheme
In addition to drawing-up policies favoring DSPV, the government has also adjusted the FIT policy to support large scale PV power stations(ground-based). On 30th August 2013, the NDRC’s announced that this kind of PV power stations will receive a FIT of 0.9 RMB/kWh for Zone I, 0.95 RMB/kWh for Zone II, and 1 RMB/kWh for Zone III. Provinces in each zone was categorized by their solar resources. All PV power stations registered after 1st September 2013 and those projects that start operation after 1st January 2014 are under this standard for 20 years. Distributed PV projects that directly receive an investment grants from the government budget are excluded from these subsidies (NDRC, 2013).

5.4. Top runner Bases Programs
The “Top Runners Bases Program” is a special program for SPV support that the NEA plans to start in 2015 and then implements every year. The technologies and components used in the “Top Runner” programs are the leading technologies and products of the SPV industry. The implementation method of these programs is to build PV power generation demonstration bases with advanced technology and
new technology application demonstration project. According to the “Energy Efficiency Top Runner System Implementation Plan” issued by NDRC on January 8, 2015, the so-called “energy efficiency top runner” refers to the PV products, enterprises or units with the highest energy efficiency in the same comparable range. The NDRC will work with relevant departments to formulate incentive policies to encourage PV technology research and development and promote energy-efficient “top runners” products. The "PV top runner" is a special program to promote the application and industrial upgrading of advanced SPV technology products and strengthen the quality management of photovoltaic products and engineering. Its major goal is to reduce the cost of PV, improve the industry and technological development and finally achieve grid parity.

The NEA proposes the main technical progress indicators and other requirements of the program. Then through the competitive comparison and selection mechanism, the eligible PV developers will be selected. The first top runner base program was approved in June, 2015 in Shanxi province of with total capacity of 1GW. Its major technical standard is:

1. The PV conversion efficiencies of the polycrystalline silicon component and the monocrystalline silicon component are 16.5% and 17% respectively;
2. The PV conversion efficiency of high-concentration photovoltaic modules reaches more than 30%;
3. The PV conversion efficiencies of silicon-based, CIGS, cadmium telluride and other thin film modules are 12%, 13%, 13% and 12%, respectively.

In May 2016, the NDRC and the NEA’s Guiding Opinions on Improving the Scale Management of Photovoltaic Power Generation and Implementing Competitive Mode Allocation Projects [24] pointed out that the state will arrange special construction scales to organize SPV top runner technical base construction every year to guide the advancement of photovoltaic technology and the decline in cost and SPV electricity prices. The northern and western provincial governments combined ecological management of coal mining subsidence area, facility agriculture, fish farming, industrial wasteland, abandoned oil fields and other comprehensive utilization projects with the top runner bases construction. The planned capacity of each base is not less than 500MW. Thus, most of the of top runner bases are in the coal mining subsidence areas situated in the northern and western provinces of China, with a total installed capacity of 5.5GW. The technical requirements of these second group programs are the same as the first program in 2015.

Different from before, the 2017 SPV top runners’ bases are divided into two categories: 10 application top runner bases and 3 technology top runner bases with total capacity of 6.5GW. The technical requirements of polycrystalline silicon and monocrystalline silicon modules efficiency in application top runner bases had increased to 17% and 17.8% respectively. For the technology top runner bases, the requirement is 18% and 18.9% respectively. In order to encourage higher efficiency SPV modules’ application, the competitive preference standard for the companies to win the top runner bases bidding had stipulated that if the efficiency is up to 17.9% and 18.7% for poly-module and mono-module, the company will get a full mark on technical score in bidding. For the technology top runner bases, the full mark standard is 19.4% and 20.4% respectively.

5.5. SPV Poverty Alleviation Projects
According to the statistics, 2016 China’s rural population in poverty is over 43 million people. The Chinese government had announced a goal to achieve Comprehensive poverty alleviation by 2020. Thus, The State Council Poverty Alleviation Office (PAO) decided to implement the “Ten Precision Poverty Alleviation Project” in 2015, one of which is SPV poverty alleviation project. The purpose of SPV poverty alleviation is new energy utilization, energy conservation and emission reduction. Those advantages as well as the full support from the central and local governments make SPV Poverty alleviation projects had become a new growing point of the industry. Many SPV enterprises have also generated great incentive for SPV poverty alleviation projects.

From 2015 to 2018, the PAO had announced the SPV poverty alleviation projects scale target each year with larger scale and higher number of families in poverty that will be affected. In 2018, the
Guide Opinion on the energy work in 2018 (NEA, 2018) had proposed the SPV poverty alleviation projects with 15GW of total capacity, helping 2 million families achieve poverty alleviation.

5.6. Discussion
This phase of the evolution of the SPV industry in China reflects a combination of major events and policy learning and adjustment within the government. The main external events were the US and EU’s trade disputes in 2012. After 2013, structural reform of the economy and expand the domestic demand are the priority agenda of the government. But the massively debt and overcapacity in solar industry is not consistent with the national strategy. The trade disputes simply emphasized the urgency to significantly restructure the industry to a cheaper and more efficient PV era.

The policies and mechanism that supporting SPV implementation have been reflected a policy learning from the problems occurred in the previous stage. The content of the policies is detailed and comprehensive as far as possible, which brings effective incentives to the major SPV systems. The SPV top runner base program and SPV poverty alleviation projects had expanded the application of SPV in China to benefit more people. In the meantime, new SPV technologies have started to put into business application faster than before, brings cost reduction and income benefits for SPV projects. As a result, China had become the largest SPV installed country in the world after 2015. Nevertheless, problems had surfaced during this rapid developing phase. For example, the compatibility between SPV power and the grid is hard to achieve in many regions because of the lack of smart grid control and micro-grid management. This phenomenon causes the generated solar power unable to provide to the grid. Meanwhile, the universality of the subsidy reliance in the SPV industry had brought heavy burden on the subsidy funds and causing insufficient funding problem intensified.

6. The fifth stage (June 2018 onward): SPV in “after subsidy” time
When the total installed capacity of SPV surpass the 2020 SPV national goal three years ahead the schedule, Chinese government has considered that the SPV industry is ready to evolve to the next level: achieving grid parity. In 2018, many industry stakeholders and experts had predicted a subsidy reduction in the next year because the module price will decline to the level where the LCOE of solar power is the same or lower than that of conventional coal-fired power. However, on May 31th 2018, the “Notice to the relative matters of the SPV project in 2018” issued by NEA brought solar power price and subsidy reduction as well as limited newly installed DSPV scale. This policy had a great impact to the Chinese SPV industry and lead the solar power into a grid parity time. From June 2018 to the first half year of 2019, a series of policies had released to provide support and guidance for SPV development, adjusted the capacity-based subsidies on different type of SPV projects and programs, and expanded the application of bidding mode to all SPV projects.

6.1. Expanding Gap in Subsidy Funds
Additional income for renewable energy is an important financing source for renewable energy project subsidies. On February 28, 2005, the National People’s Congress deliberated and adopted the Renewable Energy Law of the People’s Republic of China. The law stipulates that renewable energy tariffs are levied from the electricity sale price as the China Renewable Energy Development Fund. The additional income is levied since June 30, 2006 with a levy standard of 0.002RMB/kwh. However, the fast development of renewable energy in China make the subsidy required increase dramatically in the next decade. In order to catch up the amount of subsidy needed; the levy standard was augmented gradually from 0.002 RMB/kwh to 0.019 RMB/kwh in 2016 [30]. Nevertheless, the China Renewable Energy Development Fund is still far behind the subsidy required. In 2018, China's renewable energy subsidy gap had exceeded 140 billion RMB, of which the SPV subsidy gap is over 60 billion yuan and it is still increasing with the development of SPV as well as other renewables projects. Some enterprises with large scale capacity projects have arrears of up to several billion RMB subsidies.
This phenomenon has made more and more SPV projects difficult to apply national subsidy. Even they have successfully proposed the application of the subsidy, they would probably face subsidy default problem. This problem has occurred in several provinces which has last 18 months.

According to the China Electricity Council, By the end of June 2018, the total installed capacity of photovoltaic power plants in China is 156 million kW, while the first to seven batches of photovoltaic power plants entering the renewable energy subsidy catalogue is about 50 GW in total, accounting for only 32% of the SPV total installed capacity in China. In addition, by the end of June 2018, 196 million kW of wind power had been connected to the grid, 140 million kW had entered the catalogue. Thus, about 28% of wind power projects had not entered the subsidy catalogue. Figure 2 is the subsidy gap growing situation from 2015 to 2018 by assuming all renewables projects have entered the subsidy catalogue and the subsidy they should have. It shows that the subsidy gap is more than 208 billion RMB by the end of 2018.

![Figure 2. The Renewables Subsidy Gap Growing Situation in China.](image)

Source: Authors’ compilation data from NDRC.

6.2. “531” New Policy
Under such circumstances, despite the SPV plants have developed rapidly, the purpose of the so-called “531” policy is not only to mitigate the supply-demand mismatch problem of solar power, but also to leave room for development of advanced technology and high-quality SPV generation projects. In addition, in the past two years, DSPV in some regions have emerged problems such as rapid development and inconsistency with the power grid. The major content of the policy is summarized as followed:

1. There is no construction scale target of SPV stations in 2018. Only the target of DSPV projects construction of about 10GW is set in this policy.

2. From the date of the publication of the policy, the on-grid tariff of the newly built SPV station will be reduced by 0.05 RMB/kWh. So that the on-grid tariffs of the I, II and III resource zones will be adjusted to 0.5 RMB, 0.6 RMB and 0.7 RMB per kWh respectively (including tax).

3. The subsidy for any DSPV project that its generated power is for owner’s self-use and sell the rest to the grid will reduce 0.05 RMB to 0.32 RMB/kwh.

Table 2 shows the FIT of the SPV projects from 2015 to June 2018 and the average solar power generation cost in China. Each Class resource zone is determined based on the average solar irradiation intensity of the region. Generally speaking, class I and II resource zones include the
western and northern part of China, class III resource zone is the rest regions. The on-grid tariff of the SPV projects has reduce 0.3-0.4 RMB/kwh in 3 years. And the on-grid tariff in Class I resource zone is lower than the average power generation cost.

Table 2. Comparison of average solar COE and FIT from 2015 to today.

| Unit: ¥/kwh | Before 2015 | 2016 | 2017 | 2018 | After June 2018 |
|-------------|-------------|------|------|------|-----------------|
| Zone I      | 0.90        | 0.80 | 0.65 | 0.55 | 0.50            |
| Zone II     | 0.95        | 0.88 | 0.75 | 0.65 | 0.60            |
| Zone III    | 1.00        | 0.98 | 0.85 | 0.75 | 0.70            |
| Average solar COE | 0.68 | 0.65 | 0.60 | 0.57 | 0.53            |

The PV industry has certain expectations for subsidies reduction policy, but it came earlier than expected, and the reduction amount is more than expected. Few of them had expected to limit the construction scale of the SPV projects. After the sudden announce of the policy, many analysts have made conclusions that the China's SPV development will usher in an inflection point to the end of rapid growth era. Moreover, the SPV market will face an industry “reshuffle” [35]. Thus, the government react quickly to this situation. The National DRC, Ministry of Finance and the National Energy Administration published a notification of the policy shortly after June 2018. The notification has specific details of the policy implementation. For the SPV projects, if they can up and run before June 30th 2018, they will have on-grid tariff of 2017. Otherwise, their on-grid tariff will reduce 0.15 RMB/kwh. For the DSPV projects, if the project has begun the construction before May 31th 2018 and will be up and run before June 30th 2018, its on-grid tariff and subsidies will not change.

6.3. After Math of Subsidy Reduction

The scale control of the DSPV in the “531” policy is 10GW in 2018. However, the newly installed capacity of DSPV from January to April is already 8.75GW. Because of the date mentioned in the notification of the policy, many SPV projects had tried to up and run before the end of June 2018 to gain more subsidies and higher on-grid tariff. Therefore, before the release of the “531” policy, 13.6GW of SPV projects were up and run and 30.5GW of SPV projects had been installed afterwards. The total newly installed capacity in 2018 is 44.1GW, 18% less than that in 2017, which is the record high-capacity increase so far. Figure 3 shows the newly installed capacity of SPV projects from 2014 to 2019. The actual installed capacity had been twice as much as the government’s planning scale since 2015. According to the report from CPIA, the additional SPV installed capacity in the first half of 2019 is only 11GW, declined 45% year-on-year. The number for the whole year is 30.1 GW. As a result, the growth rate of the SPV deployment will be 17.3%, an unprecedented low in 2019 (Fig. 4). The “531” policy had significantly altered the trend since 2018, making a distinct decrease of the newly installed capacity in that year compared to that in 2017.
Figure 3. SPV Newly Installed Capacity in China from 2014 to 2019.

Source: Authors’ compilation data from NDRC and NEA.
Note: there is no scale planning in 2019.

Figure 4. SPV Newly Installed Capacity in China from 2008 to 2019.

Source: Authors’ compilation data from CPIA and NEA.
Note: the 2019 installed capacity is estimated number from CPIA.
The DSPV newly installed capacity is 20GW, only increase 5% compared to that in 2017. For the centralized SPV projects, its newly installed capacity is 31% less than that in 2017. The decline in newly installed capacity also led to a slower-than-expected growth in production capacity at all stages of the manufacturing end. Although the production capacity of polysilicon, silicon wafers, battery
chips, and modules has continued to grow, the “531” policy has significantly dragged down the growth rate. In 2018, the polysilicon production had exceeded 250,000 tons, an increase of only 3.3% compared to 2017, of which polysilicon production in the first half of the year was 143,000 tons, an increase of about 24%. The silicon wafers production has increased 39% at the first half of 2018, but the increase rate of the whole year is only 19.1%.

However, the SPV market is far from saturated. The SPV components and cells production growth rate had recovered in 2019. The production of polysilicon, silicon wafers, battery chips, and modules had a double digit’s growth in 2019 [5]. The production capacity expansion in major SPV manufacturers is continued. Meanwhile, the solar energy potential in China is still abundant when the total SPV installed capacity had surpassed 200GW in 2019. A GIS-based (geographic information system) study on the land use of Guangdong Province to identify area suitable for SPV deployment had conducted (Fig. 5). The result shows that the SPV capacity potential of the whole province is 2572 GW. The potential is only for one province in South China which belongs to Zone III in FIT policy, a relatively minor solar energy resource region.

Figure 5. Guangdong Province Land Cover and Area Suitable for Solar PV Installation (GIS-Based).

Source: Authors’ compilation data from GADM database, ESA, Global Solar Atlas and United States Geological Survey.

Multiple factors could cause the decline of SPV installation. But the manufacture industry had shown rapid recovering growth while the newly installed capacity keeps on declining. And the SPV potential is far from fully utilized. As a result, the “531” policy has caused an apparent decrease on the growth rate of the PV components production.

6.4. Achieving Grid Parity
On January 19th 2019, the NEA issued a notification on improving the grid parity of SPV power. It had set up regulations and bidding mechanism for the SPV grid parity projects that must have fix electricity selling price equals to local coal-fired power price. On May 28th 2019, NEA issued regulations that the construction of SPV power generation project will adopt a new approach to subsidize the rated installed capacity and change the situation that the Ministry of Finance, the ND RC and the NEA “respectively” caused the total subsidy and installed capacity to be out of line. SPV projects will be divided into two categories: those requiring state subsidy and those without state subsidy. For SPV projects requiring subsidy will be divided into five categories: SPV poverty alleviation projects (power price will be 0.65/0.75/0.85 RMB/kwh for class I, II and III areas respectively), household projects (750 million RMB subsidies with 0.18 RMB/kwh), LSPV power
plants, industrial and commercial DSPV projects, government-specific projects or demonstration projects (Top Runner Base). LSPV power plants, industrial and commercial buildings DSPV projects have 2.25 billion RMB subsidies and must go through bidding process to obtain subsidy. On the other hand, SPV project development was divided into two major management modes according to the state subsidy demand. The locals will organize SPV projects that do not require state subsidies, under the premise of meeting the management requirements such as planning and market environment monitoring and evaluation, and implementing network access and other conditions, the construction.

According to the resource zone where the project is located, the quotation of the on-grid electricity price is compared with the lower limit of the price of the bidding for each resource zone, and the projects with lower on-grid electricity price will be before the line to determine the projects that will be included in the subsidy, until the total amount of subsidies for the projects reaches the current total increased number of subsidies set by the government.

The project bid is calculated based on the quarter of project production, that is, when it has grid connection. If it is not completed for various reasons, it can be postponed for two quarters, and the electricity price will be reduced according to relevant regulations; if it has not been completed after two quarters, the subsidy will be cancelled.

From NEA’s statistic, the newly installed capacity of SPV in China in the first half of 2019 is 11.4GW including 4.85 GW of DSPV projects. The China Photovoltaic Industry Association (CPIA) reports that there will be 5.5 GW of SPV projects finished in 2019 with average subsidy of 0.065 RMB/kwh through FIT bidding process. The bidding mechanism and subsidy amount control in these projects had made a huge reduction (5 times less than before) on subsidy level. Moreover, there will be 5 GW of SPV projects with grid parity in 2019 most of which are situated in the northern and western part of China. CPIA also predicts that the total newly capacity in 2019 will be less than 40GW, but next year it will return to the same increase amount of 2018. The “531” policy had caused temporary “turmoil” in the Chinese SPV market. Nevertheless, the policies afterward have provided guidance to the industry and developers to develop projects with apparently low subsidy or even grid parity. These projects will be expected to account for 25% of the newly installed capacity in 2019.

6.5. Discussion
The solar industry in this stage suffered serious policy impacts from the subsidy reduction. The FIT scheme had created a reliance of the subsidy for the project developers, particularly in the southern and eastern regions of China. The financial performance of these projects will be significantly damaged if they can’t receive the FIT from the grid. Moreover, the growing subsidy gap from the Renewable Energy Development Fund had made a longer delay for the subsidy allocation as well as more projects waiting in line for subsidy application, after getting great results from the Top Runner Bases programs, which led to a further decrease on the PV cost, the government believed that the financial and technological conditions for solar power grid parity is mature. However, the timing of the “531” policy and the reduction level are still a surprise to the SPV industry.

The reaction from the practitioners and experts towards the “531” policy is pessimistic. The expected depression on SPV development is temporary on account of the rapid introduction of policy support from the government. These collaborative policies had not only turned the trend of SPV development to a lesser FIT needed even grid parity nature, but also promoted the high-power and high-efficiency products in the PV market. The SPV policy din China, after more than 20 years of evolution, has become more sophisticated and effective for the healthy development of SPV industry.

7. Conclusions
The paper reviews the SPV policies of China from mid-1990s to current stage with the analysis of some complications and imprecision of the state solar policies. The study put forward policies and their impact on the SPV development in China as well as major problems emerged during this period. The application of renewable energy technology forms an important element of national strategies for the green energy structure transition in China. This paper has shown that the development path of
China’s SPV sector over the last two decades reflects outstanding advances but has been deeply affected by the government’s policies.

Through the analytical study and timeline sorting, this study has identified every key phase in the development of the SPV in China. First is the start-up phase, SPV technology application in China was started since the mid-1990s by forces of national and international level. National level efforts were implemented by the government along with local administration to facilities the overall process of companies to set up their plants accordingly. Some of the broad events that have also affected the SPV industry includes the accession of WTO, financial crisis of 2008, trade dispute with the US and EU. The international organizations, national agencies of western countries, private and public sector was fully involved in the development of the SPV sector more constructively. This was the reason that China has become the leader in the PV products with the maximum share.

Second phase is the sharp growth of China’s PV manufacturing industry.. The explosive demand of PV products in foreign market had stimulated the manufacture capability in China. However, the development of China’s SPV had experienced significant impact due to the poor management of policy interactions between renewable energy sector and industry sector [45]. The massive overcapacity in the SPV industry and neglecting domestic demand is an apparently common phenomenon in other manufacturing industry because of the overly pursuit of industrial growth. This phenomenon existed not only in the export-oriented growth stage but also in the earlier stage of supporting industry development and the domestic PV market. The subsidy was based mainly on investment criterion rather than power generation that led to deceptive measures as well by different companies and projects. These policy approaches and outcomes show the nature of long-standing subsidy deception problems for industrial and energy development.

The third key phase is the FIT subsidy era for the SPV industry. The policy learning and adjustment from the government has been evidenced reflected in the evolution of China’s SPV sector at this phase. The adjustment from capacity-based subsidies to generation-based subsidy as well as the modifications in FIT policies had effectively promote the domestic PV market into the biggest one in the world. The shift of SPV policy to boost DSPV power in this stage demonstrates that the government has learned lessons from the defects in their previous policies and from the experience of other countries.

The fourth phase is the ongoing grid parity promotion. In order to make grid parity of SPV feasible, the government has initiated several programs and projects to promote advanced and high-efficiency SPV modules. Coupling with the growth of industry, the administration has reduced the resource-based categorized FIT gradually each year in a steady pace. Instead of a sweeping approach on cancelling the SPV subsidies throughout the entire industry, the state policies develop specific and detailed subsidy regulations and plans on different types of SPV projects to guide the SPV industry into the grid parity level.

One of the major problems in SPV development is the growing subsidy gap. Reducing and further cancelling the SPV subsidy to achieve solar power grid parity is a necessary and important measure on narrowing the gap and relieve the financial burden.

Government should keep on expanding other specific plans to strengthen the advanced production capacity such as “Top Runner Bases”. The application of these plans has accelerated the elimination of backward production capacity and achieved industry upgrade, which represent a new trend of solar industry in China. Due to the implementation of these bases, the module cost has continuously decreased and the efficiency of the solar panel has gradually increased in the recent years. Nowadays the new SPV projects in the northern and western China had achieved grid parity using these modules. Hence the “Top Runner Bases” program has expected effects that the government wanted on the SPV industry development. Through the application of these new SPV technologies from the Bases, the levelized cost of the PV power can be low enough compare to the local benchmark coal-fired power in the rest of the country.
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