THE RISE AND CHALLENGES FOR CHINA'S PV DEPLOYMENT REGULATION

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Abstract

Designated as one of the seven "strategic emerging industries" in China's 12th Five-Year-Plan (2011-2015), the solar photovoltaic (PV) industry has become the main focus of China's renewable energy policies to combat climate change. A recent drastic regulation change has seen that the government's focus on PV deployment methods was shifted from centralized large-scale PV generation (LSPV) to distributed PV generation (DPV). This research compares the different regulation tools used by the Chinese government in relation to the deployment of LSPV and DPV projects and assesses their respective development challenges as well as regulatory impacts.

I. INTRODUCTION

Designated as one of the seven "strategic emerging industries" in China's 12th Five-Year-Plan (2011-2015), the solar photovoltaic (hereinafter referred to as "PV**"**) industry has become the main focus of China's renewable energy policies to combat climate change. The Chinese PV deployment market consists of two main types of application: (1) centralized large-scale PV generation (hereinafter referred to as "LSPV"), and (2) distributed PV generation (hereinafter referred to as "DPV"). As defined by China's National Energy Administration (hereinafter referred to as "NEA"), distributed generation is small-scale generation mainly for self-consumption, located near or at the point where the power is used (i.e. the opposite of centralized power generation). China's biggest grid company, the State Grid has further defined on-grid DPV generation as PV electric generation that feeds into local distribution network that is less than 10KV, with an installation capacity less than 6MW.

While LSPV projects are usually connected to high-voltage *transmission* grid, on-grid DPV projects are connected to low/medium-voltage *distribution* grid. Typical examples of on-grid DPV projects are building-attached PV (hereinafter referred to as "BAPV") projects such as rooftop installation, and building-integrated PV (hereinafter referred to as "BIPV") projects such as installation as a part of building facades.

Although solar is only a small fraction of the renewable energy sector in China, scholarship on Chinese PV industry is abundant.

Nevertheless, the vast majority of literature reviews the *lex superior* of policies and administrative measures taken by Chinese authorities.[1] For example, a succinct summary of China's governmental interventions in the PV industry is provided by Zhao et al. (2011),[2] who classified the intervention methods into legislation, policies, financial incentives, and/or taxation. Other scholars such as Sun et al. (2014)[3] and Liu & Shiroyama (2013) rightly commented that China's PV policies focused mainly on the supply side while ignoring the importance of the consumer demands. Although Liu & Shiroyama (2013)[4] have summarized the PV industry regulations with respect to three areas: (1) rural electrification; (2) large-scale PV generation; and (3) small-scale distributed PV generation, few scholars studied in details the industry chain and focused on the regulations and policies on the downstream PV deployment sector. This research therefore intends to fill the void by comparing the different policy tools used by the Chinese government in relation to the deployment of LSPV and DPV projects and assessing their respective regulation impacts as well as their development challenges.

The observations generated from this research will not only identify the evolution and milestones of China's PV deployment market, but also help to predict future industry trends and potentially lay the groundwork for further regulation studies of the PV industry in China. In addition, this research might shed light on other questions such as whether the maturity of the PV industry reflects broader energy regulation trends in China; or whether the

[1] For example, see Huo Molin & Zhang Danwei, Lessons From Photovoltaic Policies In China for Future Development, 51 ENERGY POLICY 38, 38-45 (2012); Wang Qiang, Effective Policies for Renewable Energy – the Example of China's Wind Power – Lessons for China's Photovoltaic Power, 14 RENEWABLE & SUSTAINABLE ENERGY REVIEWS 702, 702-712 (2010); Zhang Sufang & He Yongxiu, Analysis on the Development and Policy of Solar PV Power in China, 21 RENEWABLE & SUSTAINABLE ENERGY REVIEWS 393, 393-401 (2013); Zhao Ruirui et al., Present Status And Prospects of Photovoltaic Market in China, 39 ENERGY POLICY 2204, 2204-07 (2011).

[2] Zhao Zhenyu, Zhang Shuangying & Zuo Jian, A Critical Analysis of the Photovoltaic Power Industry in China – From Diamond Model to Gear Model, 15 RENEWABLE & SUSTAINABLE ENERGY REVIEWS 4963, 4963-71 (2011).

[3] Sun Honghang et al., China's Solar Photovoltaic Industry Development: The Status Quo, Problems and Approaches, 118 APPLIED ENERGY 221, 221-30 (2014).

[4] Liu Dawei & Hideaki Shiroyama, Development of Photovoltaic Power Generation in China: A Transition Perspective, 25 RENEWABLE & SUSTAINABLE ENERGY REVIEWS 782, 782-92 (2013).

development of PV regulation is representative for other energy sectors.

This research lies within the field of "law and policies" and "law and industry development". Due to its strategic position, the energy industry is heavily regulated and governed by various government policies and administrative orders. Laws and policies are hence so often intertwined in this industry that it is difficult to define one without reference to the other. Moreover, given the tradition of policy overriding legislation on energy regulation in China, law has played a relatively limited role in the country's energy sector. The Renewable Energy Law enacted in 2006 and amended in 2009 so far is the only national legislation governing the solar PV industry. China continues to face challenges in improving its existing solar industry legal framework.[5]

The rest of the paper is organized as follows: Part II provides a general PV regulation background; Part III elaborates on the rise and challenges for LSPV projects; Part IV lays out the existing DPV laws and policies together with the main challenges for developing DPV projects; Part V provides some regulation suggestions and concludes with a table comparing the key features of LSPV and DPV deployment laws and policies.

II. CHINA'S PV INDUSTRY REGULATION

A. Legal Framework

The Chinese government's legal toolbox for regulating the PV industry is the Renewable Energy Law (hereinafter referred to as "REL") (enacted in 2006, amended in 2009) which provides an overarching legal framework under which PV regulations and policies are established. Conceived to boost the PV deployment market, the law consists of five core management mechanisms: (1) mandatory renewable energy target; (2) guaranteed grid access; (3)

[5] Qiu Xin & Li Honglin, *Energy Regulation and Legislation in China*, 42 ENVTL. L. REP. 10678, 10678-93 (2012); Joel B. Eisen, *China's Renewable Energy Law: A Platform For Green Leadership?*, 35(1) WM. & MARY ENVTL. L. & POL'Y REV. 1-52 (2010).

categorized and fixed electricity on-grid price; (4) cost allocation; and (5) the special renewable energy development funds.[6]

To implement the REL 2006, the National Development and Reform Commission (hereinafter referred to as "NDRC") promulgated the "*Medium and Long Term Renewable Energy Development Plan*" in 2007 and set explicit quantifiable goals for renewable energy development, including the first ever focus on solar energy. Various administrative orders issued by the NDRC such as the "*Trial Management Measures for Renewable Power Pricing and Cost sharing*" in 2006 and the "*Trial Management Measures for Allocation of Renewable Energy Tariff Surplus Revenue*" in 2007 implemented the cost sharing and fund allocation scheme (hereinafter referred to as "the Scheme") set out under the REL 2006: (1) a fixed solar power grid price is guaranteed by the government in the form of production cost plus a reasonable profit; (2) the amount beyond the regular coal-fired on-grid price will be compensated by the "renewable energy surcharges" levied on all end users of electricity based on their consumption; and (3) the collection and allocation of "renewable energy surcharges" will be coordinated between provinces via an interprovincial equalization program.

As much as this legal framework sent out a clear signal that the development and utilization of renewable energy was a priority for energy development, the REL 2006's impact on the PV market was limited. Renewable energy project developers during this period of time preferred to invest in wind projects rather than solar PV projects as solar projects were less cost-competitive. To illustrate, in 2009, the on-grid cost for solar PV power was about RMB￥1.5/kWh, compared to RMB￥0.56/kWh of wind power, RMB￥0.35/kWh of

[6] The mandatory renewable energy target provision specifies the government's total development targets in a certain time period, which sends the market a clear signal and promotes the exploration and utilization of renewable energies. The guaranteed grid access provision requires all power grid enterprises to buy up all the renewable energy available to them. The categorized electricity pricing allows different types of renewable energy to set up its own prices based on its average social costs. The cost allocation requires each region to allocate the extra cost of generating renewable energy in a fair manner, so that the energy producers do not have to absorb the whole additional costs. The special funds are set up to address the problem of the additional costs of renewable energy production, and they provide subsidies and other forms of financial support to some renewable energy projects whose costs cannot be fully allocated to all market players.

coal-fired power and RMB￥0.265/kWh of hydropower,[7] which obviously deterred the development of the solar PV power market in China.

The law was also criticized for its vagueness in formulation, ambiguous definition of rights and obligations, uncertainties relating to compliance, and inherent conflicts among the principles. Nevertheless, the relevance of the REL did not hinge on the few regulatory details it included, but rather on the signal it sent out to different stakeholders of the Chinese government's commitment to pursuing renewable-related goals.

Moreover, although the guaranteed grid access and full purchase of renewable power was well set out in the REL 2006, the implementation of these policy provisions was not effective due to the grid companies' unwillingness to purchase expensive and unstable solar PV power. To resolve this problem, the central government made two amendments to the REL 2006 in 2009 in order to strengthen the effectiveness of some measures, namely, mandatory connection and purchase requirement.

First, the REL 2006 was amended to balance the responsibilities between power generators and grid companies. The original REL 2006 simply required grid companies to unconditionally buy up all renewable power available for purchase. The REL 2009 has now limited the grid companies' responsibility of purchasing renewable power only from those renewable power generators which had met certain technical requirements for connection. By including technical standards for connection, generators and grid companies are now mutually responsible for ensuring grid stability.

Second, the 2009 amendments incorporated a renewable energy quota system. The NDRC together with the NEA and the Ministry of Finance (hereinafter referred to as "MOF") has determined and imposed on the grid companies a required ratio of renewable energy power to the total power purchased, to ensure at least a certain amount of solar PV power would be purchased and consumed. This ratio would be reviewed periodically according to the national

[7] Zhao Zhenyu et al., A Critical Analysis of the Photovoltaic Power Industry in China – From Diamond Model to Gear Model, 15 RENEWABLE & SUSTAINABLE ENERGY REVIEWS 4963, 4963-71 (2011).

medium and long-term plans. The grid companies are also required to dispatch the renewable energy power with priority.

The preference of wind projects over solar PV projects by energy project developers due to the higher costs solar projects incurred was also considered in the 2009 amendments. Built on the Scheme set out in the REL 2006, the REL 2009 amendments further boosted the total Renewable Energy Development Fund (hereinafter referred to as "the Fund") and directed more financial support to the PV power generation. The Fund now includes both (a) the special renewable energy development funds specified under the REL 2006 which was funded through the central government's budget allocations; and (b) the renewable energy surcharges collected from all electricity end users.[8] In 2012, only about 2 billion RMB was used to facilitate the development of solar energy, comparing with the 25 billion RMB used for wind energy in the same year. After 2013, the newly-increased 22 billion RMB provided more funding for solar power development. The resulting increase in profitability of developing PV projects led to large deployment volume between 2009-2011. Amendments to REL 2006 have well demonstrated the Chinese government's policy-learning and policy-experimenting process.

B. Regulation Policies

Intensive series of PV regulation policies have been rolled out by the Chinese government since 2004, but they were mainly industry policies focusing on the development of the PV manufacturing sector (i.e. as shown in Figure 1 below, the upstream and midstream sectors). PV market policies to encourage PV deployment (downstream sector) have not been issued until 2009. In 2008, the global financial crisis caused shrinkage of the international PV market. With 90-95% of Chinese manufacturers' production made for exportation, the Chinese government recognized the urgent need to reduce dependency on overseas markets and started to stimulate its

[8] The surcharge from the user-side electricity was priced at ￥0.002/kWh for the industrial/commercial customers in July 2008. It was increased first to ￥0.004/kWh for the industrial/commercial customers in November 2009, then to ￥0.008/kWh in December 2011 for both the industrial/commercial and the residential customers, and finally to ￥0.015/kWh for all customers in August 2013. This means that the Fund has been increased from 28 billion RMB in 2012 to 50 billion RMB after 2013.

own domestic PV market. Regulation focus has been shifted from upstream and midstream to the downstream.

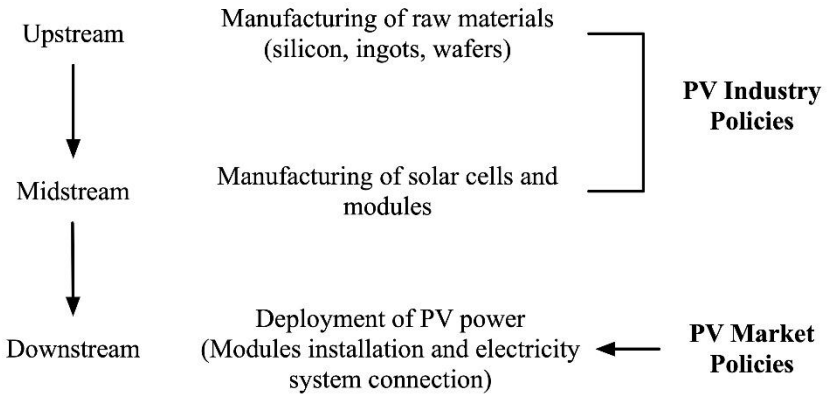


Figure 1 Solar PV Industry Chain

The State Council issued "*Several Opinions on Promoting the Healthy Development of the Photovoltaic Industry*"[9] in 2013, further clarifying the policy framework of PV power generation from the aspects of price, subsidy, tax and grid connection, etc. Similarly, local governments have successively formulated policies and measures to support the application of PV power generation.

In addition, China's Five-Year Plans (hereinafter referred to as "FYP") also proposed periodic PV development goals in line with the REL. The "*13th Five-Year Plan for Energy Development*" issued by the NEA in December 2016 specified that by the end of 2020, the cumulative installed capacity should reach 110GW, comprising 45GW of LSPV, 60GW of DPV and 5GW of concentrated solar power.[10]

C. Regulation Changes

China's PV regulation development has gone through four stages:

[9] Guanyu Cujin Guangfu Chanye Jiankang Fazhan de Ruogan Yijian (关于促进光伏产业健康发展的若干意见) [Several Opinions on Promoting the Healthy Development of the Photovoltaic Industry], (promulgated by the St. Council, Jul. 4, 2013) (Chinalawinfo).

[10] Guanyu Yinfa Nengyuan Fazhan "Shisanwu" Guihua de Tongzhi (关于印发能源发展"十三五"规划的通知) [China's 13th Five Year Plan for Energy Development] (promulgated by the Nat'l Dev. and Reform Comm'n and the Nat'l Energy Admin., Dec.26, 2016) (Chinalawinfo).

2004 – 2008: Industry policies focusing on the PV manufacturing sector[11]

2009 – 2011: Market policies focusing on the deployment of LSPV projects

From 2012 onwards: Market policies to align the development of LSPV with DPV.

From 2016 onwards: Market policies focusing on the deployment of DPV projects.[12]

2004-2008 was the "golden era" for Chinese PV manufacturers. The Kyoto Protocol signed in 1997 triggered the global demand for PV installation to double in 2003 and 2004 in response to the climate change challenge. Profitable PV subsidy schemes introduced by Germany and Spain in 2004 opened up an international PV market for Chinese PV manufacturers. Domestically, the new 2003 government of Hu & Wen wanted to boost the economy after four years of relatively low growth following the Asian Financial Crisis. The explosive demand for Chinese PV exports was seen as a great opportunity to achieve the leadership's economic goals and hence received strong support from the central government.

In 2008, the global financial crisis led to the shrinkage of the international PV market and Chinese PV exports dropped sharply in early 2009. As it is the government's long-term belief that China's political stability is highly dependent on continued economic growth, the leadership was aggressive in stimulating domestic demand as a means to offset the effect of the financial crisis. Therefore, between 2009-2011, the central government was gradually changing its PV development model from export-led growth towards a greater reliance on domestic demand (i.e. a move from midstream to downstream). In contrast to previous policies which mainly had

[11] Module production was 27GW by first half of 2016, 19.6GW by first half of 2015, an increase of 37.9%. *See "6·30" Qiangzhuang Chao Hou Guangfu Qiye Zhongbao Liangyan, Xiaban Nian Jiang Tiqian Rudong?* ("6 • 30抢装潮"后光伏企业中报亮眼 下半年将提前入冬?) [*Interim Statements of PV Corporations Gave Outstanding Performances After the "6 30 Installation Upsurge", Will the Second Half Year Be An Early Winter?*] 21ST CENTURY BUSINESS HERALD (Aug. 26, 2016), http://business.sohu.com/20160826/n466059127.shtml.

[12] Nengyuanju Fabu <Nengyuan Fazhan "Shisanwu" Guihua> Deng (能源局发布《能源发展"十三五"规划》等) [National Energy Administration to Release the 13th Five Year Plan for Energy Development], GOV.CN (Jan.5, 2017), http://www.gov.cn/xinwen/2017-01/05/content_5156795.htm#1.

encouraged PV manufacturing sector, new policies released mainly targeted at promoting the downstream PV market.

In addition, there has been a shift in the government's focus on PV deployment methods. Most of the PV deployment projects encouraged between 2009 and 2012 were LSPV installations located in western China regions due to its economies of scale. However, more than 70% of the energy demand is concentrated in the Eastern and central parts of China which are about 1,000-3,000 kilometers away from the generation sources. Grid constraint for electricity transmission has become the major bottleneck for LSPV development. As a result, since 2012, the Chinese government has shifted the solar power development strategy to "align the development of LSPV with DPV". This has indicated that the government is to place equal emphasis on LSPV and DPV and it would no longer encourage the development of centralized LSPV projects which requires long-distance electricity transmission.

The importance of DPV generation is further stepped up in the latest 13th FYP for Solar Energy Development (2016-2020). The development direction of PV power generation is clearly manifested in the plan to strengthen DPV projects and to facilitate DPV technological progress, especially actively promoting rooftop DPV projects in cities with good industrial and commercial foundations. LSPV power stations in western regions, on the other hand, are strictly planned with condition of avoiding the problem of PV power curtailment.

III. THE RISE AND CHALLENGES FOR LSPV REGULATION

Prior to 2012, the Chinese government's perception had been that centralized LSPV projects in western China should be the centerpiece of China's PV power generation industry as these projects could maximize electricity production from eligible systems and significantly bring down the generation costs by exploiting economies of scale. Energy project developers also preferred LSPV projects as they could avoid significant transaction costs from easier permitting processes by building one large-scale solar farm in underdeveloped rural areas as opposed to numerous small DPV projects in urban cities.

In China, project developers for LSPV projects are mainly state-owned enterprises (hereinafter referred to as "SOEs").[13] China's electricity industry was restructured in 2002 by breaking up the vertically-integrated State Power Corporation into two grid companies,[14] and five big generation companies.[15] All five generation companies have been involved with the development of LSPV projects, among which the China Power Investment Corporation holds the largest market share.[16]

The main LSPV deployment regulations include:

Two rounds of public tendering for utility-scale centralized LSPV projects in western China; and

A PV Feed-in Tariff (hereinafter referred to as "FiT")[17] scheme for all other LSPV projects.

These PV market policies were aimed at the "*Medium and Long Term Renewable Energy Development Plan*" announced by the NDRC in 2007, China's major macroeconomic planning agency, which targeted the non-fossil fuel energy to be 15% of China's total energy supply by 2020 and 20% by 2030. PV power generation was designated by the central government to play an important role in achieving this target. In other words, the heavy involvement of SOEs in LSPV projects was strategic and was under clear direction from the top leadership to balance China's energy mix.

A. Two rounds of public tendering

The rise of LSPV projects started from two rounds of government-initiated public tendering for utility-scale LSPV projects

[13] See Dianzhan Kaifa Yinglai Touzi Liangji Fenbushi Zhuangji Zhanbi Da (电站开发迎来投资良机 分布式装机占比大) [Good Investment Opportunity for Power Station Development, Distributed PV Installation Takes a Large Portion], FINANCE.CHINA.COM (Sep 14, 2013), http://finance.china.com.cn/roll/20130914/1813765.shtml. See also, Chinese Renewable Energy Industries Association (CREIA), Annual Review and Outlook for China Solar PV Industry 2013, p.50 (June 2013) (in Chinese, on file with author).

[14] State Grid Corporation and China Southern Power Grid, the two national grid companies are the only buyers of electricity from the generation companies and the only sellers of electricity to the consumers.

[15] The five companies are: Huadian Corporation, Guodian Corporation, Huaneng Group, Datang Corporation and China Power Investment Corporation.

[16] *Supra* note 1, China Power Investment Corporation owns cumulative installation capacity of 573MW at the end of 2012.

[17] FiT means the price that the grid company pays to the PV power producer for the amount of PV electricity feeds into the public grids.

located in the Northwestern China. In 2009, the NEA organized the first public bidding for the 10MW project in Dunhuang city, Gansu Province, and approved a FiT at RMB￥1.09/kWh. In June 2010, the NEA announced an invitation to the second round of tenders for 280MW of LSPV projects.[18] Project developers were selected according to their bid prices and technical solutions. The NEA required the successful bidder to complete the construction in 24 months and gave the company the exclusive right to operate the plant for 25 years with a fixed FiT. In October 2010, the FiTs of these second round bidding projects were announced by the NEA. The highest one was ￥0.9907/kWh for the 20 MW project in Hetian, Xinjiang Province, while the lowest one was ￥0.7288/kWh for the 30 MW project in Gonghe, Qinghai Province. The China Power Investment Corporation won seven utility-scale PV projects with the lowest bid prices.

However, such strong government support for LSPV projects no longer exists. According to the latest instrument "*Notice on Matters Related to PV Power Generation in 2018*" (hereinafter referred to as "May 2018 Notice") issued by NDRC, MOF and NEA on 31 May 2018,[19] the construction plan for LSPV power stations is stalled for 2018. FiTs for LSPV generation have been lowered every year since 2013. The May 2018 Notice also requires that from 31 May 2018 onwards, the feed-in price of all newly installed LSPV power stations shall be determined through competitive bidding. The price determined through bidding shall not be higher than the national FiTs.[20] The government's direction is clear that the focus has been shifted to development of DPV projects and unless the problem of PV generation curtailment is solved, new LSPV power stations are not encouraged.

[18] 60 MW in Inner Mongolia, 60 MW in Xinjiang, 60 MW in Gansu, 50 MW in Qinghai, 30 MW in Ningxia and 20 MW in Shanxi.

[19] Guanyu 2018 Nian Guangfu Fadian Youguan Shixiang de Tongzhi (关于2018年光伏发电有关事项的通知) [Notice on Matters Related to PV Power Generation in 2018] (promulgated by the Nat'l Development and Reform Comm'n, the Ministry of Finance and the Nat'l Energy Admin., May 31, 2018) (Chinalawinfo).

[20] *Supra* note 19.

B. National PV Feed-in-Tariffs

Nevertheless, the above two rounds of concession bidding provided the central government with valuable experience in setting an appropriate national FiT for PV power generation. The NDRC pricing department was in the process of formulating a national FiT scheme in 2010. As it was difficult to identify the FiT on the actual generation costs, public bidding was then used as a market-based measure to identify and arrive at a suitable national FiT. Experience gained from the tendering helped NDRC to determine that the PV power generation price was in the "less than RMB￥1/kMh" region and contributed to its decision on the 2011 national FiT. The NDRC issued a notice in August 2011 and set a national unified tariff of RMB￥1/kWh (USD$0.16/kWh) for feeding the PV electricity onto the public grid.[21] For projects awarded under the two rounds of public tendering, the bid tariffs would continue to apply but should not be higher than the FiTs.

Such nationwide uniform tariff however failed to consider the uneven distribution of solar resources in China, with western China having more hours of sunshine than eastern China. As a result, the 2011 national FiT led to a severe divergence of profitability between the western and the eastern regions in developing PV projects. The neglect was later corrected by the Chinese government. The single uniform FiT was modified in August 2013. The nationwide power generation was then divided into three levels of resource areas based on the solar resource endowment, with each level implementing a different FiT.

Moreover, in order to monitor and encourage technological cost reduction, NDRC reviews and decreases national FiTs every year. Different from other years in which FiTs were only adjusted once, FiT levels were lowered twice in 2018, showing the determination of the government to push the PV industry to achieve grid parity on the generation side. Please refer to Table 1 below for the year-on-year

[21] Specifically, RMB￥1.15/kWh (USD$0.18/kWh) was the FiT for solar PV projects that had been completed and put into operation prior to 31 December 2011. For projects completed and put into operation after that day, the FiT was RMB￥1/kWh (USD$0.16/kWh). An exception was for projects in Tibet which would still employ the former FiT of ￥1.15/kWh.

comparison and currently effective resource-based categorized FiT scheme for LSPV generation.

Table 1 National generation-based subsidies for PV systems since August 2013

Solar Resource Area	**LSPV (in 2014) (RMB ￥/kWh)**	**LSPV (in 2016) (RMB ￥/kWh)**	**LSPV (in 2017) (RMB ￥/kWh)**	**LSPV (Before 31 May 2018) (RMB ￥/kWh)**	**LSPV (After 31 May 2018) (RMB ￥/kWh)**	**DPV (RMB￥/kWh)**	
	Feed-in Tariffs	Feed-in Tariffs	Feed-in Tariffs	Feed-in Tariffs	Feed-in Tariffs	Self-consumption	Surplus electricity fed back to the grid (the amount end-users received from the grid company)
I – Best Resources (e.g. Ningxia, Western Qinghai, Inner Mongolia, etc.)	0.90	0.80	0.65	0.55	0.5	Retail electricity price (the amount end-users saved from paying the grid company) + 0.32 (subsidy from government)	Local tariff of desulfurized coal generation (grid company pays to the end-users) + 0.32 (subsidy from government)
II – Medium Resources (e.g. Beijing, Tianjin, Sichuan, etc.)	0.95	0.88	0.75	0.65	0.6		
III – Lowest Resources (Others)	1.00	0.98	0.85	0.75	0.7		

C. Regulation effect of LSPV deployment

1. Total Installation Targets

Industry reports have shown that the regulation impact of the LSPV deployment laws and policies is positive and effective. Public bidding forced manufacturers and investors to survive on lower profit margins, which resulted in lower average PV generation costs. For example, in 2008, when public bidding method was not used, the FiT of two utility-scale LSPV projects was set at RMB￥4/kWh, much higher than an average bid tariffs in 2010, which was less than RMB￥1/kWh. In addition, from 2010, public bidding was used to

select suppliers of PV modules, inverters and batteries to avoid unqualified products. It therefore has encouraged PV project developers to coordinate their innovation and cost reduction activities with equipment suppliers.

The FiT scheme has also helped to achieve China's PV installation targets. The total annual new installation of PV in 2017 reached 52.83 GW, with an increase of 68% over the previous year.[22] By the end of December 2017, the cumulative PV installation in China was 130.25 GW,[23] more than twice of the total amount of solar power in operation in the U.S.,[24] and well exceeds the target of 105 GW as set out in the 13th FYP. Among the total installation of 130.25 GW, more than 77% was centralized LSPV projects.[25] Following the current trend, it is expected that the cumulative PV installation in China will reach 250 GW by the end of 2020.

2. Business Model and Legal Contractual Arrangement

LSPV projects operate under the "feed in all generation" business model. It means all PV electricity generated will be fed into high voltage transmission grid (more than 110kV). As shown in Figure 2 below, there will be two separate meters measuring the total amount of consumption and the total amount of generation respectively. The grid company pays the generation company the FiT rate for

[22] *2017 Woguo Xinzeng Guangfu Zhuangjiliang Huoyu 50GW* (2017我国新增光伏装机量或逾50GW 分布式光伏接近20GW) [New PV Installation May Exceed 50GW in 2017, with Nearly 20GW Being Distributed PV], NATIONAL BUSINESS DAILY.COM (Jan.17, 2018), http://www.nbd.com.cn/articles/2018-01-16/1183865.html. The cumulative PV installation in China at the end of 2016 was 77.42GW. *See 2016 Bingwang Guangfu Fadian Zengzhang 81.6% Leiji Zhuangji 77.42GW* (2016并网光伏发电增长81.6% 累计装机77.42GW) [*81.6% Increase For On-grid PV Power in 2016, with Cumulative PV Installation of 77.42GW*], SOHU.COM (Jan 17, 2017), http://www.sohu.com/a/124503112_131990. According to data from the European Photovoltaic Industry Association (EPIA), the cumulative PV installation in China was 300MW at the end of 2009, 800MW at the end of 2010 and 3,300MW at the end of 2011. *See* EPIA, *Global Market Outlook for Photovoltaics 2013-2017* (May 2013), https://resources.solarbusinesshub.com/solar-industry-reports/item/global-market-outlook-for-photovoltaics-2013-2017.

[23] *2017 Nian Xinzeng Guangfu Zhuangji 52.83gw Leiji Bingwang 130.23GW* (2017年新增光伏装机52.83GW 累计并网130.25GW) [*New PV Installations Reached 52.83GW in 2017, Raising the Cumulative PV Installations to 130.25GW*], SOLARBE.COM (Jan. 23, 2018), https://news.solarbe.com/201801/23/123640.html.

[24] The U.S. installed 2.3 gigawatts (GW) of solar PV capacity in Q2 2018 to reach 58.3 gigawatts (GW) of total installed capacity. *See U.S. Solar Market Insight*, SOLAR ENERGY INDUSTRIES ASS'N (Sep. 13, 2018), https://www.seia.org/us-solar-market-insight.

[25] LSPV100.59GW, DPV29.66GW by December 2017. *See 2017 Nian Zhongguo Guangfu Zhuangji Shuju Jianxi* (2017年中国光伏装机数据简析) [*Analysis of 2017 China PV Installation Data*], YIQI GUANGFU (Feb. 8, 2018), http://guangfu.bjx.com.cn/news/20180208/879829.shtml.

generation,[26] and the generation company pays the grid company the retail electricity price for its own power consumption.

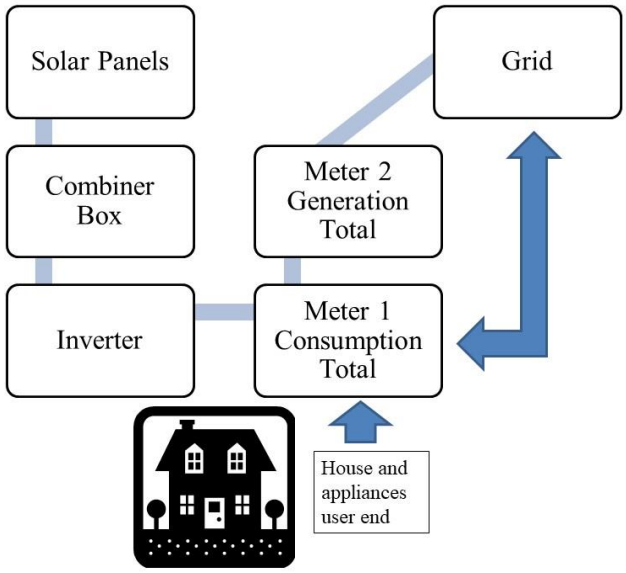


Figure 2 LSPV Business Model-feed in all generation

LSPV business model possesses several advantages compared with that of DPV projects. *First*, the contractual relationship between grid companies and generation companies is governed by standard Power Purchase Agreements (hereinafter referred to as "PPA"). The NEA has provided a standard PPA template online as guidance for all parties.[27] Contract prices are set by the government. As it is direct government guidance, most of the PPAs would not deviate too much from it (or there is not much room for contract negotiation to start with). *Second*, from the banks' perspective, they are more willing to lend loans to LSPV projects as this arrangement strictly

[26] Note that the grid company only pays the local tariff of Benchmark Desulfurized Coal-fired Power (BDCP). The price difference between FiT and BDCP price will be subsidized by the government from Renewable Energy Development Fund. The generation company nevertheless receives the total FiT amount from the grid company.

[27] Guangfu Dianzhan Gouxiao Hetong Shifan Wenben (光伏电站购售电合同示范文本) [Power Purchase Agreement Template] (promulgated by the Nat'l Energy Admin., (July 10, 2014), http://zfxxgk.nea.gov.cn/auto92/201407/P020140717523341942475.doc.

under government guidance is simple and clear. Banks are experienced with PPA contractual arrangements, and moreover, as LSPV project developers are SOEs, they could always ask for parent company guarantees to further lower lending risks. *Third,* with banks' support, it is convenient and transparent for project developers to calculate profit margins and make future investment plans. As will be elaborated below, the above present a drastic contrast against the financing difficulties of DPV projects. *Lastly*, as there is no "off-set" arrangement as that of the case of DPV projects, the government's GDP figure looks more favorable. The grid company's revenue calculation will not be affected as it still receives income from the generation companies' own consumption. The government's tax revenue would also be boosted from the two-way transactions (both generation company's income from FiT and grid companies' income).

D. Challenges for developing LSPV projects

To be sure, there are many positive benefits for development of LSPVs. However, long-distance transmission from generation sources to end-users is a *must* due to the mismatch between the geographic distribution of solar resources and the power consumption. Reliability concerns and grid constraint problems are the major obstacles threatening continued growth of centralized LSPV projects.[28]

In general, the transmission grid system in China suffers from three main problems. *First*, most transmission lines in operation in China today still use outdated technology which wastes power and is prone to blackouts and shortages. *Second*, certain parts of the transmission system lack adequate capacity to handle sufficient amount of electricity during peak demand time. Grid managers have to therefore intentionally curtail electricity deliveries from PV generation sources, which makes generation wasteful and expensive. *Third*, many places in western China where there is abundant solar

[28] *See Jiedu Guowang Xinzheng: Xibu Daxing Dimian Jizhongshi Guangfu Dianzhan Keyi Xiuyi*（解读国网新政:西部大型地面集中式光伏电站可以休矣）[*National Grid New Policy Direction: the Centralized Large-scale PV Power Station in Western China Can be Stopped*], GUANGFU BJX (Oct.30, 2012), http://guangfu.bjx.com.cn/news/20121030/397929.shtml.

resource lack either transmission lines or adequate transmission capacity.

Moreover, expansion and upgrading of existing transmission lines is often difficult due to institutional and political barriers. For example, decisions to turn on, turn up, turn down or turn off power generators on the grid (collectively referred to as "dispatch") are fragmented by regions, provinces and localities. Dispatch is fairly rigid due to a set of bilateral contracts between provinces stipulating how much electricity can be transmitted across boundaries. Creating an interconnected high-voltage grid network across several provinces could improve the ability to flexibly smooth out generation, load over a large number of units, and ultimately facilitate the development of LSPV generation. However, this plan advanced forward by the State Grid was blocked by the top leadership. Interconnected power network has the potential risk of triggering large-scale electrical blackouts. The national government was concerned with social instability and political upheaval arising from large-scale power blackouts. Political considerations often play a central role in the top leadership's energy decisions.

Consequently, these transmission and reliability constraints significantly affect the revenues of LSPV project developers from electricity sale as intermittent PV power is more likely to receive transmission curtailment orders than firm power from coal-fired power plants. In addition, LSPV installations in desert areas (most of China's western regions is desert or close to being so) are subject to severe performance degradation due to climatic conditions. Analysis of PV power plants performance in the Phoenix, Arizona area carried out by the Arizona State University and TÜV Rheinland has shown that up to 2.5% annual performance degradation appears on power plants in desert after ten years' operation. This above-average performance degradation further causes investment uncertainties for LSPV projects as most of the investment plans were calculated based on a 25-year lifespan.

IV. THE RISE AND CHALLENGES FOR DPV REGULATION

As a result, integrating distributed PV generation into the existing power system would offer several advantages over the current development trajectory of only building LSPV power plants located far away from consumption end. A balanced system combining DPV

with LSPV generation would reduce transmission congestion and improve the overall reliability of the electricity supply system, and without increasing dependence on fossil fuels for backup power. For existing LSPV investors, additional investments in DPV projects could also help diversify investment risks. As each DPV project involves less upfront capital input and the investors can have multiple projects underway, they face much less investment risks if one or two DPV projects fail. Another plus point is that there will be no fuel costs to run once DPV facilities are built. Given the low risks and small capital inputs, most of the DPV project developers in China are upstream or midstream PV manufacturers who have expanded their business into downstream deployment market. They save significant costs by using their own PV panels. According to targets set by the 13th FYP, by 2020, additional installation for ground LSPV projects is 37GW and for DPV projects is 63GW. There will be massive growing space for DPV projects.[29]

A. Solar Roofs Program and Golden Sun Program

China has started initiating DPV projects alongside LSPV projects since 2009. Two capital subsidy programs: the Solar Roofs Program and the Golden Sun Program have supported both the DPV projects and the LSPV projects. A comparison of the two programs is provided in Table 2 below.

Table 2 Comparison between the two deployment programs

	Solar Roof Program	Golden Sun Program
Supported application type	On-grid BIPV and BAPV projects	-on-grid BIPV or BAPV projects -off-grid systems in remote rural areas -on-grid LSPV (supported in Phase I but no longer support LSPV since Sep 2010)

[29] *Zhongguo Guangfu Qiye Dongjin Fenfushi Guangfu Fadian Qianjing Bei Kanhao* (中国光伏企业东进，分布式光伏发电被看好) [*Chinese PV Company Moving to the East, Distributed PV Are Promising*], ECONOMIC INFORMATION DAILY (Sept. 12, 2016), http://auto.chinanews.com/cj/2016/09-12/8001060.shtml.

Minimum Installation Capacity	More than 50KW	More than 300KW
Subsidy standard	Max RMB￥13/Wp for BAPV rooftop systems Max RMB￥17/Wp for BIPV systems	50% of total cost for on-grid systems 70% of total cost for off-grid systems

The Solar Roofs Program was announced by the MOF and the Ministry of Housing Urban Rural Development in March 2009. It subsidized capital investments in on-grid BIPV and BAPV projects with funds from the Renewable Energy Development Fund.[30] The first phase started in March 2009 and included 111 projects with a total capacity of 91 MW. The BIPV projects at phase 1 received subsidies of a maximum of RMB￥20/Wp and the BAPV projects (rooftop systems) received a maximum of RMB￥15/Wp. The second phase started in April 2010 and included about 99 projects with 90.2MW in total capacity. Subsidies at phase 2 were adjusted to RMB￥17/Wp for BIPV projects and RMB￥13/Wp for BAPV projects respectively.

The Golden Sun Program was initiated by the MOF, the Ministry of Science and Technology (MOST) and the NEA in July 2009. Over the period of 2009-2011, the program provided a 50% upfront subsidy on the investment cost for on-grid systems and a 70% upfront subsidy for off-grid PV systems. An investor could be subsidized by either the Solar Roofs Program or the Golden Sun Program, but not both. Each Chinese province was also capped at a total installation of 20MW under both programs. The owner of the PV system could replace electricity consumption from the grid with his own PV generation, or sell it to the grid companies at the local tariff of desulfurized coal generation.

What makes the Golden Sun Program particularly attractive is that unlike the LSPV FiT in 2011 (mentioned above in relation to LSPV projects), which paid RMB 1/kWh (US$0.16/kWh) at

[30] The Renewable Energy Development Fund is established under the Renewable Energy Law (2009 Amendment) and includes both (a) the central government's budget allocation; and (b) the renewable energy surcharges collected from all electricity end users. The surcharge is ￥0.015/kWh from all electricity customers since August 2013.

generation, PV developers under the Golden Sun Program could pocket the upfront capital subsidies before any power was dispatched to the grid. And with module prices falling precipitously in 2012, the profit return on such projects was safe in the double-digit range. By November 2009, 294 projects of 642 MW were approved, including 290 MW on-grid BIPV or BAPV projects on commercial buildings, and 306MW centralized utility-scale LSPV projects. With this success, by the end of 2012, the total installed capacity approved under the Golden Sun Program was increased to 5.93GW.

However, these two programs were heavily criticized by industry stakeholders. Main deficiencies included: 1) these one-off upfront subsidies failed to provide incentives for investors to build long-term high-performance systems; 2) simply focusing on promoting installed capacity rather than the generation efficiency resulted in many projects that were built but never connected for generation; 3) lack of oversight of the project implementation process caused severe corruption, fraud and backdoor dealing behaviors. Finally, in June 2013, the MOF wound up the Golden Sun Program after a four-year run since 2009. A new era of DPV deployment scheme that is based on real power production and replaces one-time capacity-based subsidies with generation-based subsidies has set to take place.

On the other hand, these two programs have clearly exemplified the "learning by doing" "policy experiment and diffusion" regulation making process in China. The Chinese government normally initiates a pilot project on a smaller scale. Once the pilot project is proved to be successful, the experience and practices will then be diffused on a larger scale. The Golden Sun and the Solar Roofs programs were both initiated in small-scale first to serve the demonstration purpose before scaling up to implement key PV technologies. This demonstrated that regulation implementation in China is often carried in phases.

B. Latest DPV Regulations

Several important administrative orders promoting DPV generation were issued by the government in 2017 and 2018. On 31 October 2017, the NDRC and the NEA jointly issued the "*Notice on Carrying out the Pilot Market Transaction of Distributed Power Generation*" which allowed distributed generation project units and nearby users within the distribution network to conduct power

transactions directly, and grid enterprises would facilitate the sale and purchase of electricity and only charge network fees. If the pilot scheme is successful, it could reduce the dependence of the DPV projects on the rooftop enterprises, and would further stimulate the development of the distributed power station.

In May 2018, The NEA proposed in the "*DPV Power Generation Project Management Measures (draft)*" (hereinafter referred to as "the Draft**"**) that DPV power generation projects will no longer be included in the national PV generation scale management. It is left to the provincial (regional and municipal) energy authorities to work out the regional DPV project planning and annual construction plan together with relevant departments of development and reform, land, environmental protection, planning and price, and power grid enterprises, and to make rolling revision in a timely manner according to the actual development. This measure would significantly cut the time and red tape for households and small businesses invested in DPV projects.

Moreover, to solve the problem of payment arrears of DPV subsidies and to promote the healthy development of the industry, the Draft proposes that power grid enterprises shall be responsible for settling electricity charges and transferring the state subsidy funds to the project units (including individuals) in full amount on a monthly basis. Once a DPV project is connected to the grid, the power grid enterprise shall submit the application for subsidies to the MOF, NDRC and NEA on behalf of the project unit. Power grid enterprises should give priority to the budget and plan for the use of subsidy funds, so as to ensure national subsidies could be transferred and paid in full in a timely manner.

However, as shown in the table below, the national subsidies for DPV projects are also reduced every year to encourage cost reduction and achieve grid parity. The May 2018 Notice indicated that only 10GW DPV projects installed before 31 May 2018 would receive national subsidies while the rest of DPV projects will only receive local government support.

Table 3 National Government Generation-based Subsidies for DPV Projects

2017 (RMB ¥ /kWh)	Jan – May 2018 (RMB ¥ /kWh)	Jun – Dec 2018 (RMB ¥ /kWh)

0.42	0.37	0.32

C. Regulation effect of DPV deployment

1. Total Installation Targets

The 13th FYP (2016-2020) for energy development proposes to achieve 60GW of cumulative DPV installation by 2020. In 2016, only 4.24GW of new DPV installation was added, bringing total to 10.32GW. By the end of 2017, a total of 29.66GW of DPV has been installed.[31] 19.66GW was added in 2017, which is not only 4.7 times that of 2016 new installment, 14 times that of 2015, 9.5 times that of 2014 and 24.3 times that of 2013, but also far more than the accumulated installed capacity at the end of 2016 (10.32GW). Spurred by the government subsidies, 2017 is coined as the first year of China's DPV development.

In addition, with the rise of DPV deployment, the trend of China's PV power installation has begun to shift from the former northwest region to the central and eastern region.[32] In 2017, new PV installment in eastern China was 14.67GW, up 1.7 times year-on-year, accounting for 27.7% of the total new installment. New installations in central China were 10.64GW, up 70% year-on-year, accounting for 20% of the total. One the other hand, new installment in the northwestern region was 62.2MW, down 36% year-on-year.

2. DPV Business Model

According to the Draft, a small DPV facility that does not exceed 6MW can choose between two modes: all self-use or surplus on-grid (on-grid generation should be less than 50% of the total generation). Household use DPV projects, which does not exceed 50KW, can choose from three modes: full generation on-grid, surplus on-grid or all self-use. DPV power stations with a total installed capacity of more than 6MW but no more than 20MW should adopt all self-use operation mode.

Nevertheless, DPV projects encouraged under the deployment regulations mostly operate under the "direct consumption, feed in

[31] *Supra* note 25.
[32] *Id*.

surplus" business model.[33] As shown in Figure 3 below, compared to LSPV business model, DPV business model has one additional meter installed to measure the surplus generation fed into the public grid. This model encourages most of the PV generation to be self-consumed so that less electricity will need to be bought from the grid company. Consumers will benefit from saving electricity costs. However, the unified DPV subsidy for all end-users suggests that the installation would be more attractive to non-residential users (e.g. industrial users), who are paying higher retail power tariffs. Besides, the government receives less tax due to reduced amount of electricity sales transactions. Revenues of the grid company will also be affected as less electricity is sold to end-users. Grid companies are therefore not motivated to connect DPV projects, and large influx of surplus generation may also affect the grid security and stability.

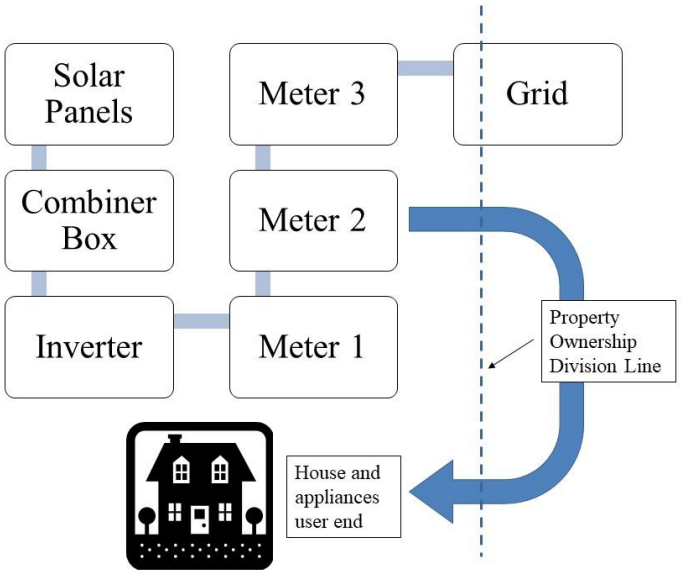


Figure 3 DPV Business Model - direct consumption, feed in surplus generation

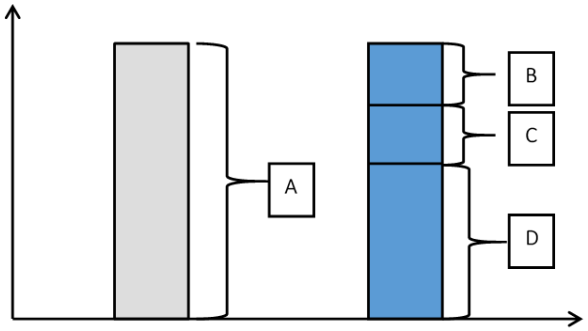
[33] *Shendu Jiexi: Weihe Zanting Fenbushi Guangfu Quane Shangwang Butie* (深度解析：为何暂停分布式光伏全额上网补贴？) [Analysis: Why Subsidies Stopped for Distributed PV Projects Operating Under the "Full Generation On-grid" Mode?], NEWENERGY.IN-EN.COM (Oct. 08, 2015), http://newenergy.in-en.com/html/newenergy-2248075.shtml.

Meter 1: Measuring the total amount of PV generation
Meter 2: Measuring surplus generation feed into the grid, part of the generation is used directly by user end
Meter 3: Measuring the amount getting from the grid

3. DPV Legal Contractual Arrangement

For most of the DPV projects under the Golden Sun Program, project developers own the PV systems and install them on consumer's rooftop.[34] The contractual relationship between the project developer and the electricity consumer is governed by a "Contract of Price Difference". To explain the concept, as shown in Figure 4 below, "A" represents the total amount of electricity costs *before* the installation of a DPV project. "D" represents the total amount of electricity costs paid to the grid company *after* the DPV installation. Consequently, "B"+"C" represents the contractual value of the "Contract of Price Difference" and is the total amount that the consumer saves from electricity costs by self-generation and self-consumption. This amount will then be shared between the project developer and the consumer by stipulating the respective percentage of B and C in the contract. In other words, in exchange for PV power generation, the consumer pays project developer "B" amount and pays less of "C" amount to the gird company compared with previous electricity costs. In some contracts, consumers can own the PV system after certain number of years.

[34] *Fenbushi Guangfu de Shangye Moshi Ruhe Xuanze*? (分布式光伏的商业模式如何选择?) [*How to Choose Business Model for Distributed Generation?*], ESCN.COM (Dec. 4, 2013), http://www.escn.com.cn/news/show-90443.html.



A – The total amount of electricity costs paid to the grid company before DPV installation
B – The amount consumers paid to DPV project developers
C – The amount consumers saved from previous electricity costs
D – The total amount of electricity costs paid to the grid company after the DPV

Figure 4 Contractual Arrangement for DPV projects – Contract of Price Difference[35]

However, the implementation of this "Contract of Price Difference" was problematic under the Golden Sun Program. First, it is difficult to ascertain "A" and "D" as the amount of "A" and "D" varies under several circumstances (e.g., if the industrial consumer changes its production level and uses less electricity, "A" will have to be recalculated). It then makes it complex for the project developer to calculate its profit margins due to unforeseeable events. In addition, this Contract of Difference is difficult to pass down to another consumer if the previous consumer moves out of the building.

D. Challenges for developing DPV projects

Given the business model and unclear profit from the contractual arrangement, the main problem for Chinese DPV project developers is the inability to obtain financing. DPV projects are capital-intensive and usually require 80% of financial support for their initial investment. Without enough financial supports, it is difficult for a DPV project to start constructing. However, most Chinese banks are holding a wait-and-see attitude toward DPV projects because of the following risks:

[35] *Id.*

(1) Uncertainty on end-users' total amount of consumption (e.g., how much amount is really used for direct consumption and how much amount is fed into the public grid? It is also difficult for project developers to demonstrate stable profit margins to banks);

(2) Uncertainty on the end-users' sustainable consumption level given it takes at least 9-11 years to recoup the capital investment (e.g., what happens if the consumer is moved away, insolvent, or changes its production level?); and

(3) Uncertainty on the property rights of the rooftop (e.g., what happens if not the consumer but the property management company owns the rooftop? how to set out the property rights in the contract?) as well as the ownership rights of the PV system (e.g., what happens if the building will be admonished within the 25-year lifespan of the PV system?).

In other words, while the banks are experienced with LSPV PPA arrangements, they are generally not familiar with the legal risks involved for "Contracts of Price Difference." Small and privately-owned DPV project developers are also unable to obtain third-party guarantees from insurance companies to satisfy banks' requirements.

Besides, the closed Golden Sun Program exacerbates the situation. On the one hand, the Golden Sun Program has occupied lots of ideal rooftops for DPV projects; on the other hand, this demonstration program was stopped because of scandals and related criticism. The initial aim of the program was to subsidize PV manufacturers and encourage them to build DPV projects by using their own panels. However, many companies were subsidized while built nothing or did not connect the projects to the grid. This failure made Chinese banks hesitant and cautious when dealing with DPV financing. Rooftop owners are also sometimes reluctant to install DPV systems on their houses due to concerns over rooftop safety and water leaking problems from poorly installed DPV projects.

In order to solve the problems mentioned above, and to achieve China's DPV installation goals, innovative DPV business model and contractual arrangements need to be devised and learnt from other countries. For example, China can learn from U.S. experience such as financial leasing arrangements and Solar City business model. Local governments should facilitate DPV installation by unifying the rooftop ownership and collectively represent electricity consumers within a specific region so that the project developers do not have to

negotiate contracts with each individual consumer. Industry standards and quality certification regarding DPV projects need to be established to boost banks' confidence in investing in DPV projects. Insurance companies could potentially be involved more to provide various guarantees to assist project developers getting funding. There also have been talks in the central government to establish a special fund to promote DPV installation. This fund, if established, will consist of a central fund in Beijing and some local funds. Local funds will become bridges between regional and central governments, managing equities and subsidies.

Table 4 Comparison of LSPV and DPV regulation in China

	LSPV Projects	DPV Projects
Project Developers	Mainly State-owned companies (e.g. the five national generation companies)	Mainly private companies (e.g. PV panel makers who expand into downstream deployment market)
Regulation Impact on Development Status	Positive, effective Installation targets achieved	Not so effective, slow development Installation targets did not achieve
Supporting Laws and policies	-Two rounds of public tendering -National Feed-in Tariff scheme -Amended Renewable Energy Law 2009	-Solar Roofs and Golden Sun programs -DPV feed-in subsidy of RMB 0.32/kWh + additional provincial/local subsidies -18 demonstration projects covering 7 provinces and 5 cities in Aug 2013 -Free connection services from the State Grid from 1 November 2013 -Waive of approval from the NDRC regardless of DPV size -Pilot Market Transaction for DPV power generation *-DPV Power Generation Project Management Measures (draft)*
Business Model	Feed in all generation, Separation of generation and consumption	Can choose from three different modes Mostly direct consumption, Feed in surplus generation

Contractual Arrangement	PPA + Feed-in Tariffs	Contract of Price Difference
Funding	Easy to get loans from banks -Projects guaranteed by SOE parent companies -Supported by government -Simple business model and contractual arrangements, -Less risks for the lender, as banks are experienced with PPA financing	Difficult to get loans from banks -High capital costs, low profits -Small private companies, no insurance companies to provide third-party guarantees for the loans -Unclear profits and legal risks from Contracts of Difference as banks are not familiar with this type of contractual arrangement
Siting resources	Adequate, Western China desert area Easy permitting process	Limited suitable rooftop resources in Eastern China urban areas: -Not all rooftop has the quality to support heavy panels and suitable for DPV projects -Good rooftop resources have already been taken by the Solar Roof and Golden Sun programs
Major Bottleneck for further development	Grid constraints for transmission system	Profitable Business Model Contract Model Funding

V. CONCLUSION

DPV generation has the potential to radically alter and improve the current Chinese electricity system. Local DPV generation could add resilience to the power system, increase its efficiency, lower overall electricity costs, and reduce environmental impact of coal-fired power. DPV generation could also promote a broader transition to renewable energy use by providing backup power for large, remote LSPV generation and reducing transmission congestion. Although there are many obstacles to develop DPV in China, shifting

from centralized generation to distributed generation is inevitably the future trend.

China has rich solar PV energy resources and is aggressively promoting PV energy to cut carbon emissions while strengthening its energy security. Its PV industry experiences, therefore, are of great reference value for the rest of the world. Close examination of China's PV deployment regulations may reveal not only the direct impact of the government policies on the PV market but also signal policy and market trends that may help other countries better understand and anticipate shifts in China's PV regulation. Such analysis may also provide experience for countries beginning to develop or scale up their own solar PV market.

This research has:

- presented an overview of all the deployment laws and policies for LSPV and DPV projects in China;
- compared the different regulation tools used and their regulation impact on China's PV market (please refer to Table 4 above);
- assessed the challenges and opportunities for future LSPV and DPV development; and
- evaluated the development of China's clean energy regulation tools to combat climate change.

Therefore, this research represents a first step for future more in-depth study on China's energy laws and policies.