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# Business Models of Distributed Solar Photovoltaic Power of China: The Business Model Canvas Perspective

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**Abstract:** China is a world leader in the global solar photovoltaic industry, and has rapidly expanded its distributed solar photovoltaic (DSPV) power in recent years. However, China's DSPV power is still in its infancy. As such, its business model is still in the exploratory stage, and faces many developmental obstacles. This paper summarizes and analyzes the main obstacles that China's DSPV power is facing in its development, using a literature analysis methodology. Then, previous business models, such as host-owned, energy management contract (EMC), and third-party-owned (TPO), were studied using the Business Model Canvas (BMC) as an analytical tool. Moreover, the Lean Canvas (LC) method was used to further conduct a synthesis and comparative analysis with the three models, describing how and to what extent these models can overcome identified obstacles. Finally, the study highlighted the dominant position of EMC model.

**Keywords:** DSPV power; barriers; business model; business model canvas; lean canvas

## 1. Introduction

Global energy shortages and environmental pollution have continued to increase, leading to international consensus about the importance of developing renewable energy. As the economy grows, China's energy demands continue to expand, resulting in an increasingly prominent contradiction between energy supply and demand. This highlights the need to vigorously develop renewable energy in China. Strong government support, technological progress, and carbon emissions management awareness are the main drivers in the renewable energy market. This has facilitates the rapid development of China's renewable energy. According to China's Renewable Energy Development Report (2018), the installed capacity of renewable energy in China was 728.96 GW by the end of 2018, accounting for 38.4 percent of the total installed capacity of electricity. However, although renewable energy has developed rapidly, China's renewable energy market still faces a number of obstacles, including low technological R&D capacity, financing difficulties, and high costs. These obstacles restrict the scale of renewable energy and the formation of industrial competitiveness.

Today, solar energy is considered a preferred renewable energy for development and use worldwide. Solar photovoltaic (PV) power has been adopted by over 100 countries and is the third most important renewable energy source after hydropower and wind power, in terms of globally installed capacity [1]. Global solar PV power has been vigorously developed, and has experienced an annual growth rate of 40% since 2010. With rapid development in recent years, China's solar photovoltaic industry has become a strategic emerging industry with international competitive advantages. As a leader in the solar photovoltaic industry, the installed capacity of solar PV power in China reached 166.7 GW by

2018 [2]; The country has ranked first place for six years around the world. It is estimated that the installed capacity of PV power will reach 1000 GW by 2030, reflecting its significant potential [3].

The major installations of solar PV power are divided into large scale PV power and DSPV power. Compared with large scale PV power, DSPV power has positive prospects due to its unique advantages. First, DSPV power is similar in structure to nearby power generation and use, reducing or even eliminating the cost of power transmission. Second, the DSPV power system is usually installed on the roof, which requires little land. The installed capacity of DSPV power in China was about 48.52 GW by 2018, representing explosive growth (Figures 1 and 2). There are two reasons why China has chosen to develop DSPV power. First, DSPV power has significant potential to improve the ecological environment, and upgrade energy use techniques in urban and rural areas [4]. Second, China's PV industry is one of the few industries that could dominate the global market. Greatly expanding DSPV power could help support the sound development of strategic emerging industries, and could significantly cultivate and create new sources of economic growth and promote sustainable and stable economic development [4].

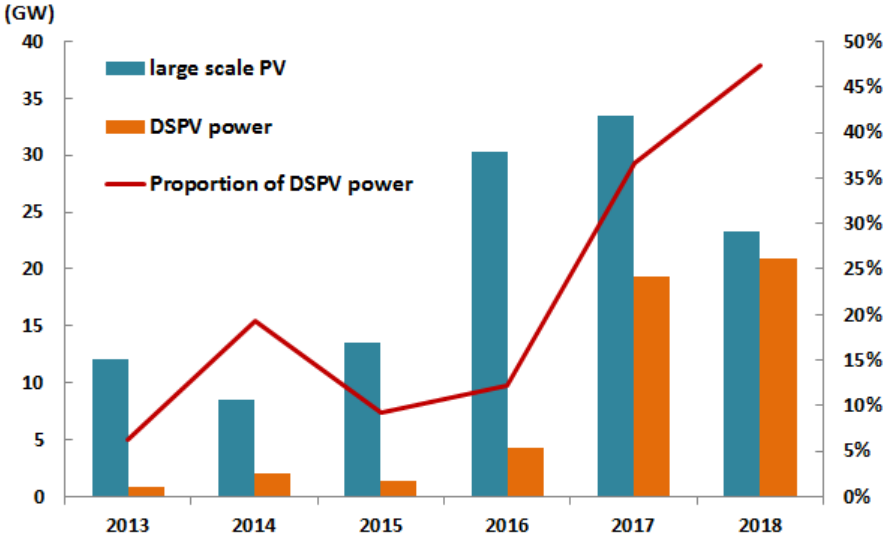



**Figure 1.** Newly installed capacity of photovoltaic (PV) in China from 2013 to 2018.

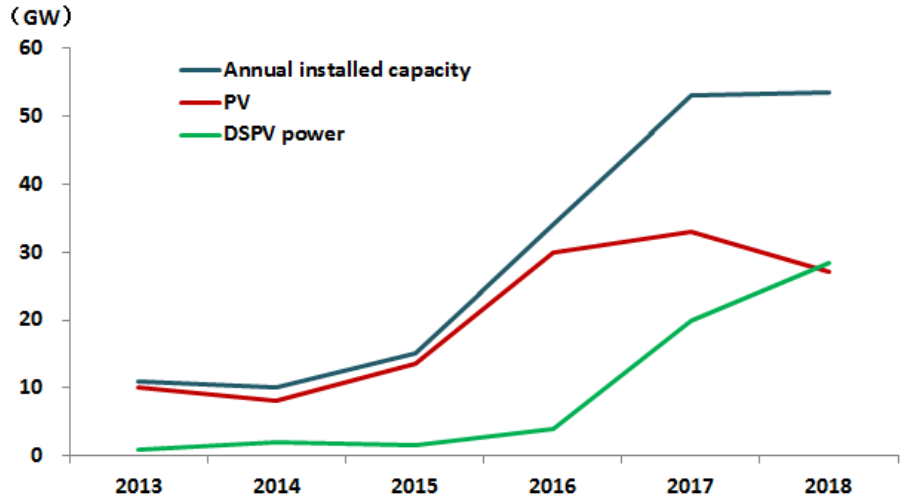



**Figure 2.** Volume changes of newly installed capacity of photovoltaic (PV) in China from 2013 to 2018.

However, DSPV power accounts for only 27.1% of the total installed capacity of solar PV generation in China [3], which is a relatively small proportion compared with major developed

countries. China's DSPV power currently faces many obstacles, including financing difficulties, technical barriers, and problems with roof resources. These barriers are the main factors that lead to its weak self-development capacity and the slow process of scale development. Therefore, identifying the barriers faced by China's DSPV power and finding effective solutions are particularly important to advance its further development.

With the booming growth of the DSPV market, the business models are also significantly changing. The United States is a leader in developing PV business models. Its unique policy support has driven an innovative business model—"third-party-owned" to emerge, and it is working [5]. The earliest business model of DSPV power in China has been host-owned, and is mainly adopted by rural and villa residents with sufficient roof space. With increasing problems, including the high upfront costs, long-term financing, and the ceaseless appearance of power sales, China can explore and learn from the third-party-owned model of the United States. However, China's DSPV power is dominated by industrial and commercial enterprises, both of whom have mainly adopt the EMC model to build DSPV power plants. The advantage of this model is that it fully uses the professional ability of PV power plant developers, reducing the transaction cost of project investment, and generating a higher income [6]. For example, the innovative mode of "government guidance, market operation, and unified management" was implemented in the Jiaxing Demonstration Zone, Zhejiang Province [7]. This mode has effectively solved common problems in the DSPV power development process and has encouraged other regions to develop DSPV power and has provided insights for them.

Chi Fujian et al. noted that establishing a business model can be a powerful tool to promote DSPV power, and posited that business model innovation is the best way to stimulate China's DSPV industry [8]. The business model of China's DSPV power is currently in the exploratory stage. A deep analysis is needed to identify a more market-oriented business model. However, there have been few studies on the business model of China's DSPV power. Chi Fujian et al. described three business models associated with small-sized DSPV power: the self-built and self-used model, the EMC model, and the co-construction model of end-users and enterprises [8]. Jiang Feng also briefly described three business models associated with China's DSPV power: EMC model, host-owned model, and leasing mode. That study emphasized the earning position of DSPV power under different operation modes [9]. Bao Yudong discussed the successful and innovative business model of Solar City in the United States, and suggested ways for China to learn from Solar City's successful business model, based on a comprehensive comparison of the similarities and differences of the distributed market between China and the United States [10]. These studies have been limited to descriptive research of the business models. Based on the concept of the platform business model, only Chen Shuyang has proposed a platform business model concept of DSPV power. That approach focused on the innovation path of the business model, working to build a business model suitable for the demands of the current Chinese market [11]. However, this innovation of a platform business model concept remains theoretical and lacks a practical basis.

There appears to be a general lack of studies that apply a systematic framework to study the business model of DSPV power in China. No studies have identified ways to overcome the developmental obstacles faced by China's DSPV power using a business model perspective. The originality of our study addresses these gaps. This paper provides three innovations. First, most existing studies have analyzed the obstacles faced by China's DSPV power in isolation and have simply summarize the obstacle factors. This study systematically summarized and analyzed the main obstacles, by adopting a literature analysis method for the first time. Second, this study is the first to use the Business Model Canvas to analyze business models of China's DSPV power. This provides an analytical framework for describing, designing, and creating those business models, and has broad applicability. Finally, based on the Lean Canvas, this study comprehensively compared the host-owned, third-party-owned, and EMC business models. Combined with the analysis of the barriers overcome by the three business models, the study concludes that the EMC business model is much more prospective.

The paper is organized as follows. Section 2 describes the theoretical background; Section 3 introduces the research methodology used in the study. The main barriers of China's DSPV power are summarized and deeply analyzed in Section 4, and the business model canvas tools are used to analyze business models in Section 5. Section 6 provides a further synthesis and comparative analysis of business models using the Lean Canvas. Section 7 describes how and to what extent these different business models can overcome identified barriers. Finally Section 8 provides the conclusions and policy implications.

## 2. Theory

### *2.1. Business Models*

Studies on business models began in the 1950s and 1960s in academic fields [12]. With the rapid development of Internet and information technology, the business environment changes with each passing day, increasing uncertainty for enterprises. Therefore, business models have become highly appreciated among entrepreneurs. However, academic attention to business models remains limited. There is currently no consensus on the definition, structure, and properties of business model in academic fields [13].

The first theoretical explanation of business models came from Joseph A. Schumpeter, who stated in 1939: "The competition between price and output is not important, what really matters is the competition from new business, new technologies, new sources of supply, and new business models [14]." Peter Drucker argued that a good business model should answer four basic questions, including "Who are the customers?", "What is valuable to them?", and "How can such kind of value be provided at an appropriate cost level?" [15]. The explanations of business models from both these scholars provides a good theoretical foundation for subsequent studies.

The term "business model" is often used interchangeably with terms like corporate strategy, operation philosophy, revenue model, business plan, and economic model. Magretta described a business model as a story of how a business works, arguing that success depends on finding a good story [16]. However, the statement made by Magretta seems too simple. Many researchers have emphasized that a business model is the logic of a business operation or profit generation. For example, Sayan Chatterjee argued that the business model represents the allocation (active systems) of enterprises (activities) and their investments (resources), based on the logic that drives the profits of the specified enterprises [13]. Teece stated that the essence of a business model is a concept, a way for enterprises to deliver value to customers and guide them to buy and then create profits. This reflects managerial assumptions about what customers need, how to meet their requirements, and how to gain profits [17]. Consistent with Osterwalder and Pigneur, "A business model describes the rationale of how an organization creates, delivers, and captures value." This final definition is in for this study, as it fits well with the business model of renewable energy [18].

Wei Luo believed that a business model consists of three parts: assumptions about the business environment, hypotheses about the business' purpose, and the key competence of a company [14]. Christensen and Johnson established four essential elements: key resources, including labor, technology, products, tools, and brands; key processes, including design, manufacturing, and research and development (R&D); the value proposition for customers, including price and payment methods; and the form of profit, including cost structure and the revenue model [19]. Osterwalder noted that the following four factors should be included in a business model. The first is "How", referring to the resources and capabilities enterprises rely on to create value. The second is "What", referring to products and services that reflect the business' value propositions. The third is "Who", referring to those end-customers provided with products and services by enterprises through marketing channels, and the reverse process to collect requirements from customers and feed the information back to the value creation department. The final factor is "How much", which includes the enterprise's

identification of cost and profit models, and ultimately the ability to obtain value from the value creation process [20].

There are six common features in successful business models. First, the business model must be consistent with firm goals [21]. Second, the core of the business model is "God's perspective," which guides the business to identify and meet customer demands, achieve customer satisfaction, constantly capture and enhance customer value, and improve the value of their partners and themselves. Third, it is crucial to preserve internal consistency, and the components of the business model must be intrinsically linked [22]. Fourth, business models must have a distinctive value orientation that is not easily replicated and surpassed by rivals in a short time [23]. Fifth, a good business model should be able to withstand the test of time, requiring its design to be forward-looking. Sixth, good business models should be succinct, simplified, and clear [24].

We have identified several triggers that lead a business to create a business model, including: (1) economic cycle pressure [25–27]; (2) customer-related issues [28,29]; (3) competitor-related issues [28,30]; (4) changes of business environment [31–34]; (5) price competition [35,36]; (6) changes of technology [37–39]; (7) changes of industrial chain [40,41] and (8) increasing digitization [42–45].

### *2.2. The Business Model Canvas*

Focusing on how organizations create, deliver, and capture value in business model design, Osterwalder and Pigneur first proposed a common language—the Business Model Canvas (BMC)—to elaborate, visualize, evaluate, and change existing business models [18]. The BMC is divided into nine parts: customer segments, value propositions, channels, customer relationship, revenue streams, key resources, key activities, key partners, and cost structure [18]. The BMC has been widely recognized by the business community and has become a globally used framework for analyzing business models. This is because it provides flexible plans, can easily meet customer demands, and has the integrity of logic, clear expression of image, and strong operability [46]. Therefore, this study adopted the BMC to study the three business models for DSPV power in China.

In the field of renewable energy, a few scholars have studied the business model of distributed energy using the BMC. Horvath and Szabo adopted the BMC as an analysis tool to analyze three different business models of global PV and demonstrated how and to what extent these business models can overcome the barriers in the process of distributed energy deployment [47], providing insights for this paper. Gabriel and Kirkwood also applied the BMC to analyze the factors that may influence renewable energy enterprises to choose a business model. They further explored regional differences and their effect on different business models to be adopted [48]. Huijben and Verbong unveiled the three business models of the Dutch PV industry using literature studies and a series of interviews, analyzing these business models with the BMC [49]. At the same time, Strupeit and Palm used the business model concept as an analytical tool to investigate how different business models can facilitate the deployment of customer-sited PV systems in Germany, Japan, and the United States [50].

### *2.3. The Lean Canvas*

The Lean Canvas (LC), first proposed by Ash Maurya in his book—Scaling Lean [51], is a method for conceptualizing and addressing firm (product) problems, completed in a particular order: customer segments, problem, unique value proposition, solution, channels, cost structure, revenue streams, key metrics, and unfair advantage [52]. The LC is a business model for hypothesis testing and validation that can be considered to be a further development of the BMC [47]. Compared with the BMC, the LC includes changes in the following four building blocks, making it easier to use and more focused.

(1) Key partners → Problem. The LC replaces key partners with the problem section. The LC's creators note that the problem is the unmet demands of targeted customers. Before selecting a business model, we need to identify what problem the business model has tackled, which is the most urgent issue to be concerned about. Most companies fail because they do not fully

understand and focus on real consumer needs and waste time and money developing the wrong products and services [47]. The section of key partners was also removed because only a few companies must build good partnerships.

(2) Key activities → Solution. Compared with key activities, once the real problems for segment customers have been discovered and a unique value proposition has been identified, enterprises can develop an effective solution that is more logic-oriented and action-oriented.

(3) Key resources → Key metrics. It is important to measure and evaluate business model performance. As a result, we need to repeatedly assess how to set a few observable and specific metrics, and not just draw them from thin air [53]. Key resources are also merged with unfair advantage, as they are considered to be similar with each other.

(4) Customer relationships → Unfair advantage. Unfair advantage, also known as a competitive advantage that cannot be easily copied or purchased by opponents, represents the obstacles that bar competitors from moving into the market [51]. Customer relationships are integrated with channels, because it is essential to establish direct personal relationships with customers and make online contacts in DSPV projects.

## 3. Methodology

This section describes the literature analysis methodology and the research steps. The literature analysis methodology is an ancient and energetic scientific research method. The method is used for the following reasons. First, China's PV industry entered the initial demonstration stage before 2007; by 2018, China's DSPV power was at the commercial application stage [54]. There have been abundant practical experience and different research reviews, making it convenient to collect the literatures. Further, the obstacles and performance of DSPV power in China can be identified using both deductive and inductive analysis. Second, this analysis method can be used not only in current research, but also in longitudinal research or a comparative study [55]. Third, compared with oral interviews or on-site investigations, the literature materials collected are often more accurate, reliable, and economical. This avoids the recording errors that may occur in other investigative approaches.

The literature analysis methodology adopted in this study followed four steps: (1) subject definition; (2) literature search; (3) literature analysis and synthesis; and (4) research agenda.

(1) Subject definition. In 2017, the global new PV installed capacity was 98.42 GW, and the total installed capacity reached 402.5 GW. China contributed 53 GW to the new installed capacity, with a grand total installed capacity of 131 GW [56,57]. As such, the new and cumulative installed capacity of China ranked first in the world at the time, making a significant contribution to the global energy transformation. However, China's existing PV industry was dominated by large-scale ground-mounted power plants, accounting for 86.36% of the total. The total amount of emerging alternatives, including building PV, the DSPV of industrial parks, and agricultural and solar hybrids, accounted for only 13.18% of China's total PV industry. Driven by "The 13th 5-Year Plan for Solar Energy Development" issued by the National Energy Administration, China has vigorously advanced the sound and fast development of DSPV power, with a large potential construction capacity [58]. There are currently no studies that have analyzed China's DSPV power by adopting the BMC. Thus, the goal of this study was to investigate the obstacles China's DSPV power faces, and to explore suitable business models that can overcome these barriers through BMC. The study also analyzed how and to what extent these business models can eliminate the identified barriers.

(2) Literature search. The databases Elsevier Science and the China National Knowledge Internet (CNKI), and the Baidu search engine, were used to search for relevant literature for this study. Of these sources, CNKI is the largest full-text digital library in the world, satisfying the document requirements of this study [59]. Relevant materials were collected in two ways. One approach was to use keyword combinations, including PV, DSPV, barriers, constraints, problems, current situation, business models, host-owned, TPO model, and EMC model. The second approach was to use citations identified from existing documents to get more information.

(3) Literature analysis and synthesis. At this stage, we synthetically analyzed the literature, excluding the irrelevant items. This left 50 valid publications. We did not limit the publication year; 48 were Chinese publications and 2 were English publications. There were 21 articles concerning barriers and 29 articles on business models (see Table 1). We further classified the papers. First, we classified relevant articles, including surveys, interviews, reports, case studies, journal articles, and master thesis. Second, we sorted barrier types, dividing them into financial and profitability barriers, institutional and policy barriers, technical barriers, awareness barriers, and roof resource barriers. We also classified the studies by business models, such as host-owned, TPO model, and EMC model. There were overlaps between these categories, as most studies covered two or three business models and barriers.

(4) Research agenda. At the final stage, the BMC was used to demonstrate the business models. A comprehensive comparative analysis was also conducted to further describe how and to what extent the three business models overcame the identified barriers by the LC. This process highlighted the benefits of the EMC model.

**Table 1.** Literature classification and the quantity.

| Classification | Detail Classification | The Number of Literature |
|---|---|---|
| Barriers | Financial and profitability barriers | 11 |
| | Institutional and policy barriers | 6 |
| | Technical barriers | 7 |
| | Awareness barriers | 2 |
| | Roof resource barriers | 4 |
| Business models | Host-owned model | 9 |
| | TPO model | 3 |
| | EMC model | 23 |

## 4. Barriers to Distributed Solar Photovoltaic (DSPV) Power of China

This study identified the main barriers facing DSPV power in China in its development process, using the literature analysis methodology. The barriers were divided into five groups (see Table 2). This section details each barrier group.

### *4.1. Financial and Profitability Barriers*

The financial and profitability barriers restricting DSPV power development are mainly illustrated through three aspects: financing difficulties; high upfront installation costs and long payback periods [60]; and revenue uncertainty.

Financing difficulties have been a consistent and crucial barrier hindering DSPV power development in China [61]. First, investors are reluctant to invest in DSPV power, due to a lack of confidence in the related policies [60]. Second, investment firms are not interested [61], because the scale of the projects is small, the dispersion is significant, the revenue from electricity fees is expected to be low, the yield rate is far lower than large-scale PV power projects, and the investment risk is high [62]. These challenges make it difficult for DSPV power projects to raise enough funds. Furthermore, DSPV power projects in China rely heavily on bank loans, while banks are only willing to invest in large-scale PV ones that can receive government subsidies and rarely invest in small and medium-sized DSPV projects [63]. In addition, banks usually offer short-term loans with high interest rates [1], whereas the payback period of DSPV projects is up to ten years [64]. This makes project funds difficult to turnover or even breaks down. Finally, the unwillingness to invest in DSPV power has made financing more difficult, because household electricity consumption is small and the domestic electricity fee is relatively inexpensive. Further, PV project installations are unstable and have low profits, repeatedly lowering the electricity price [65]. Besides, the opacity of information in the DSPV power industry has influenced decisions made by investors and financing [66].

DSPV power in China mainly targets households and small and medium-sized enterprises [11]. The bar is set high for an average family to use DSPV power, as the total construction cost is estimated to be approximately CNY 40,000 to 110,000. Further, the cost-recovery cycle of the power plant is much longer, at usually more than ten years and even as long as twenty years [65]. The initial installation cost for building medium-sized DSPV power plants generally reaches CNY 50,000 to 80,000 [60], while the payback period lasts ten years [12].

There are different and uncertain risks in DSPV power in China, resulting in unstable project returns [66]. The self-consumption proportion of electricity is not guaranteed under the mode of "self-generation, self-consumption with excess sold to the grid." This results in a decline in yields [62]. China has not yet established an effective credit system; as such, there is a risk of default, where owners may not pay their electricity bills under the EMC model. Further, no judicial means have been established to diminish this kind of risk [62]. In addition, there is also instability in rooftop ownership [1].

### *4.2. Institutional and Policy Barriers*

The Chinese government has issued a series of policies to promote the development of DSPV power in recent years; however, the policies were not well implemented. Several factors led to the insufficient policy implementation. For example, there are many barriers and blind spots in this type of enforcement system: the relationships and responsibilities between departments are not clear and their coordination is inefficient; the local government lacks enthusiasm; and it is difficult to issue local supporting documents that initiate the establishment of DSPV power [60,64,67–70]. Furthermore, supporting policies remain unsound for DSPV power. The government has provided strong policy support for subsidies and grid-integrated operation; however, the incentive support is insufficient and supporting policies on the projects remain in the exploratory stage [71]. Subsidies for DSPV power in China are mainly derived from the renewable energy development fund, however, the funding gap is expanding. This challenges the sustainability of the 20-year subsidy policy on DSPV power price. It is also uncertain how long policies encouraging the integration of the DSPV power grid with the State Grid of China and China Southern Power Grid will last [60,64]. In summary, the development of DSPV power projects is restricted by imperfect policies, insufficient implementation, and the incompatibility of local protective policies [3]. In addition, it is also constrained by the long approval process and the institutional problem that power enterprises reject grid-integration for their own interests [64,71].

### *4.3. Technical Barriers*

The development of DSPV power projects in China is a long journey and there are few independent intellectual property rights and innovation capabilities. As such, previous development has mainly relied on introducing foreign technologies and equipment. This makes the core technical foundation vulnerable, significantly restraining the sound development of PV power projects in China [71]. There are many technical shortcomings in PV power. For example, the quality of PV system itself is insufficient [7]. Further, because of the periodicity and instability of solar energy resources, and changes in day-night, weather, and season, PV power significantly fluctuates, is intermittent, and has unstable power generation performance. This results in certain negative impacts on the steady operation [67,72–74], increasing the difficulty of grid connections.

### *4.4. Awareness Barriers*

Residents in China are the mainstay of solar PV power use. Their energy-saving awareness, and their understanding of DSPV power and its prospects, can directly affect the development and use and the advancement speed of DSPV power [75]. However, due to the short development process in China and the insufficient popularization, most end-users only know something about common solar water heaters when it comes to solar photovoltaic products. They have little understanding about DSPV power products [67]. At the same time, enterprises remain unfamiliar with the concept of social

responsibility with respect to clean energy development, and few of them are willing to learn about green projects [76]. This hinders the advancement of DSPV power.

### *4.5. Roof Resource Barriers*

In China, land ownership and housing ownership are separate. As such, when there is an owner relocation or housing demolition, ownership of the rooftop is changeable and property rights are unclear [1]. It is easier to find available rooftops on detached houses or villas in rural areas [77]; however, the cost of PV equipment is high, making it necessary to think about whether farmers can afford it [78]. Most residents in urban cities live in multi-unit buildings, where rooftops are collectively owned. As such, installing a PV system on roofs requires coordination and communication with residents and property departments in residential areas. This negotiation is often difficult because it takes too much time and it is difficult for all residents to agree on installing the PV system in the roofs [1,77]. Rooftops on industrial and commercial enterprise plants are mainly used to generate DSPV power; these include color steel rooftops and concrete rooftops. The lifespan of a DSPV power system is twenty to twenty-five years, which is longer than the lifespan of color steel rooftops. This affects the profits from DSPV power [77].

**Table 2.** Overview of the main five barriers and related papers.

| Main Barriers | Related Papers | Elements, Main Factors |
| --- | --- | --- |
| Financial and profitability barriers | [1,11,60–67,71] | Difficulties in financing |
| | | High initial installation cost and long payback period of project investment |
| | | Unstable income |
| | | High costs and electricity price |
| | | Lack of attraction with respect to feed-in tariffs |
| Institutional and policy barriers | [60,64,68–71] | Poor policy development and ineffective implementation |
| | | Unsound policy measures |
| | | Policy sustainability under threat |
| | | Problems in approval process |
| | | Institutional constraints |
| | | Ambiguous responsibility and relationship among relevant departments struggling with coordination |
| | | Ineffective regulations |
| Technical barriers | [7,11,69,71–74] | Short planks of technology |
| | | Lack of independent intellectual property rights and independent innovation ability |
| | | Immature skills related to grid connections |
| | | The impacts of unstable power generation on grid connections |
| | | Insufficient network capacity in rural areas |
| Awareness barriers | [75,76] | Lack of awareness of energy conservation |
| | | Lack of knowledge about DSPV power generation |
| Roof resource barriers | [1,62,77,78] | Changeable housing ownership |
| | | Inadequate affordability and available rooftops |
| | | Short enterprise rooftop lifespans |

## 5. Analysis of Business Models

There are four types of studies about China's DSPV power business models. The first type of study considers business models from the perspective of the quantity of electricity settled. These mainly include three modes: feed-in tariffs, net metering and self-generation, and self-consumption with excess sold to the grid [8,79–81]. The second type of study includes case studies about successful business models in China, such as the model of Jiaxing in Zhejiang Province [7]. The third type of study includes empirical studies based on TPO model in the United States [5,10,63]. Another type of study explores business models from an operations perspective, including: host-owned, EMC model,

TPO model, online fund-raising, "individual rooftop leasing of PV power plant", "Internet + PV", "PV +", and other business models [82–84].

Of these types of studies, those on electricity quantity settlement are technically not a normal business model, and many of the cases are just a drop of water in the sea. Further, business models such as online fund-raising, "individual rooftop leasing of PV power plant", "Internet + PV", and "PV +" remain immature, so that they have little value for advancement. The remaining three business models—the host-owned, EMC model, and TPO model—have been in place for a long time and have a wide range of applications. As such, this study evaluated these three models using the BMC from the perspective of enterprise operations. This is designed to develop an overall picture and help understand the differences among these business models.

### *5.1. Host-Owned Business Model Canvas*

In the host-owned model, customers build their own DSPV power plants and capture the profits [9]. Several different items were analyzed from the literature, including self-generation and self-consumption [9], self-built and self-used [85], self-built and self-sale [86], and host-owned [87]. This paper applies the term "host-owned." Figure 3 shows the BMC framework for this model.

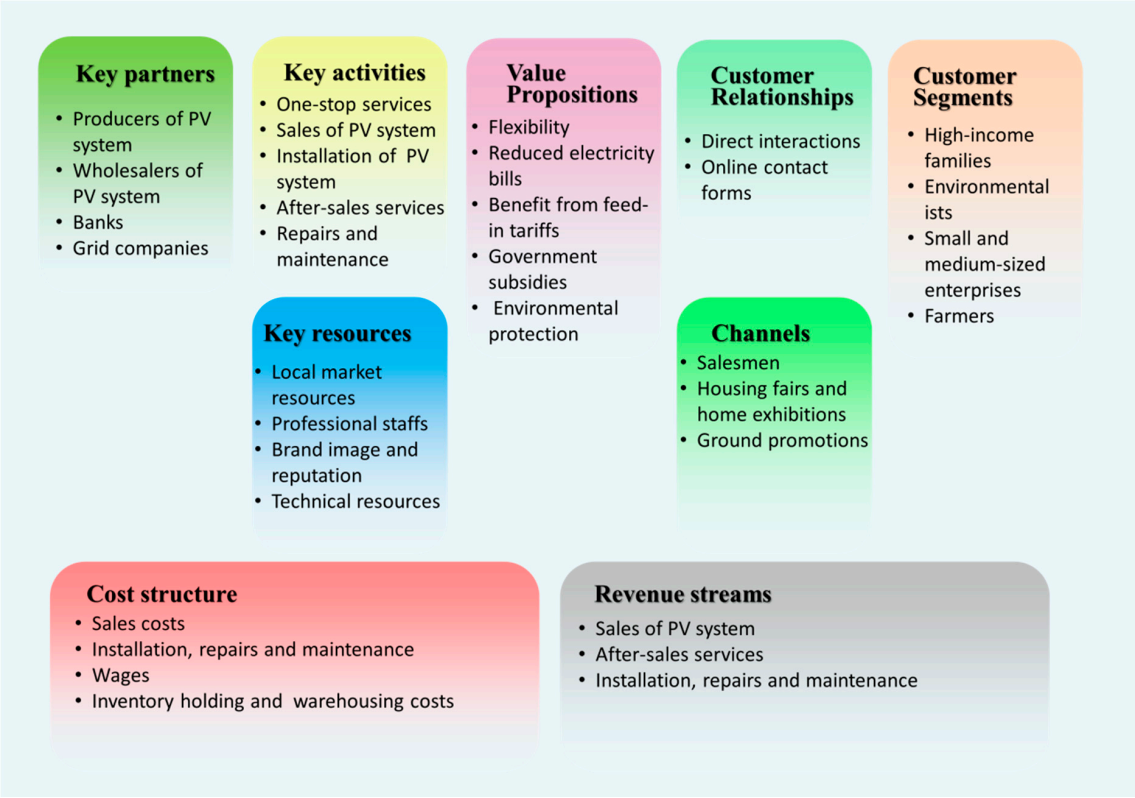



**Figure 3.** Host-owned Business Model Canvas (BMC).

#### 5.1.1. Value Propositions

Energy-saving service companies provide customers with a PV system and are responsible for installation and repairs and maintenance. Customers can also install the PV system by themselves. In this model, customers install the PV system on their rooftops and produce electricity at any time for their needs; the mode can be set as either "all sold to the grid" or "self-generation, self-consumption with excess sold to the grid". When all electricity is sold to the grid, customers can benefit from selling electricity generated to the grid company at the national unified benchmark price. When only excess is sold to the grid, customers have the priority to use electricity they generated, and the excess power

can be sold to the grid company at a price lower than the prevailing retail electricity price. Therefore, customers benefit from their own electricity savings and excess power sold to the grid company at the local desulfurization coal-fired thermal power price, and receive subsidies at CNY 0.42/kWh from the central and local government consistent with the total power generation [57]. In addition, with PV power generation, sunlight can be directly used to convert light into electrical energy, which is pollution-free and noise-free, contributing to less gas pollution and carbon emissions and ultimately protecting the environment.

#### 5.1.2. Customer Segments

The host-owned model has a high upfront cost and long payback period. Its key segment customers are those households that are enthusiastic for environmental protection and that have high payment capacity. These customers are followed by small and medium-sized enterprises [88] who have outstanding advantages in the development and operation of DSPV power and are encouraged to build their own DSPV power system financed by the authorities [89,90]. Other segment customers include farmers [47] accounting for the majority of population in China, who have sufficient and independent roof space, generally exceeding ninety square meters.

#### 5.1.3. Channels

Energy service companies offer products and services mainly through traditional channels, including salespeople, advertising, housing fairs, home exhibitions, ground promotions, and conference marketing [91]. Salespeople can directly contact customers to get insights into customer needs and deliver a better knowledge of their products and services. Regular housing fairs, home exhibitions, ground promotions, and conference marketing in communities or private stores can enhance customers' understanding of DSPV power. This can eliminate awareness barriers and stimulate the desire to purchase. In addition, these companies will also promote through network channels, such as search engines, enterprises, or specialized E-commerce websites (taopv.cn), and WeChat official accounts [92].

#### 5.1.4. Customer Relationships

A good customer relationship is significant in removing awareness barriers about renewable energy technologies under the host-owned model. Many energy service companies attach great importance to direct contact with customers through personal channels. Before purchasing, salespeople often call customers directly to gather their preferences, provide advice, help them thoroughly understand DSPV power projects, and evaluate roof resource conditions, such as rooftop available area and lighting conditions. The host-owned model often has the features of miniaturization, decentralization, and local absorption [93]. It is therefore the key to maintain customer relationships, eliminate transaction costs as much as possible, and establish a trust and long-term relationship with all customers. Energy service companies preserve and enhance their relationships with customers through after-sales service. They also establish and maintain online contact with customers like enterprise websites or other E-commerce platforms.

#### 5.1.5. Key Activities

Under the host-owned model, the most essential activity is providing one-stop services, including pre-purchase consultation, scheme design, engineering installation, support for grid connection, monitoring and maintenance, system upgrading, and other services. Companies can also sell related components of PV equipment, such as panels and inverters, and offer consulting and training services on how to operate the PV system.

#### 5.1.6. Key Partners

PV system manufacturers and wholesalers are indispensable partners for energy service companies. The grid company is another key partner, whether customers adopt the mode of "all sold to the grid" or "self-generation, self-consumption with excess sold to the grid." Both modes require a connection with the public power grid. Therefore, building a good cooperative relationship with the grid company can ensure successful grid connections. The government also grants customers subsidies for PV power generation through the grid company.

#### 5.1.7. Key Resources

The core resource for energy service companies is local market resources, including relationships with the local government, customers, communities, financial institutions, and social resources like dealers and celebrities. The local government plays an important role in DSPV power development, as they can grant high subsidies, provide technological support, and launch promotions for DSPV power. Local dealers master all sorts of channels and customer resources, including methods for approaching customers and capturing customers' potential needs, lifestyles, and personal preferences. Communities and existing customers, as well as local celebrities, can contribute to the establishment and further promotion of the enterprise's brand image. This is because these customers have high incomes, are enthusiastic for environmental protection, and have an impressive influence. At the same time, to ensure the installation quality of PV system, it is necessary to have superb technical resources and skillful human resources. It is also important for companies to establish strong brand images and reputation. This helps build walls against competitors, attract more partners, and bring successive benefits.

#### 5.1.8. Cost Structure

Because their main activity is to sell PV equipment through salespeople and other channels, energy service companies invest significantly in expanding the market to sell the equipment. These costs include promotion costs, channel costs, fees for capturing customer information, and wages for salespeople. Moreover, there are additional costs for installation, repairs, and maintenance, such as maintenance costs on components and brackets of PV system, solar inverters and grid-connection distribution boxes, as well as wages for technical staff [94]. Finally, there are likely to be stocking and warehousing costs for the components of the PV system.

#### 5.1.9. Revenue Streams

The main income for energy service companies comes from sales of PV systems. Other income comes from the installation, repairs, and maintenance of the PV system. In addition, they also deliver energy consulting and training services on how to operate PV system. This provides supplemental revenue.

### *5.2. Third-Party-Owned Business Model Canvas*

The third-party-owned business model originated in the United States [47]. Chinese scholars mainly draw on the existing experience of the United States to innovate this model with respect to business operations, financing, service, and other aspects [95]. Its greatest advantage is that customers do not need to pay high installation costs. They also do not bear the risk of PV system operation, overcoming the obstacles of financing and low profitability. In China, there are few studies on the third-party ownership model [95]. This paper consistently applies the term "third-party-owned" for the BMC analysis, as shown in Figure 4.

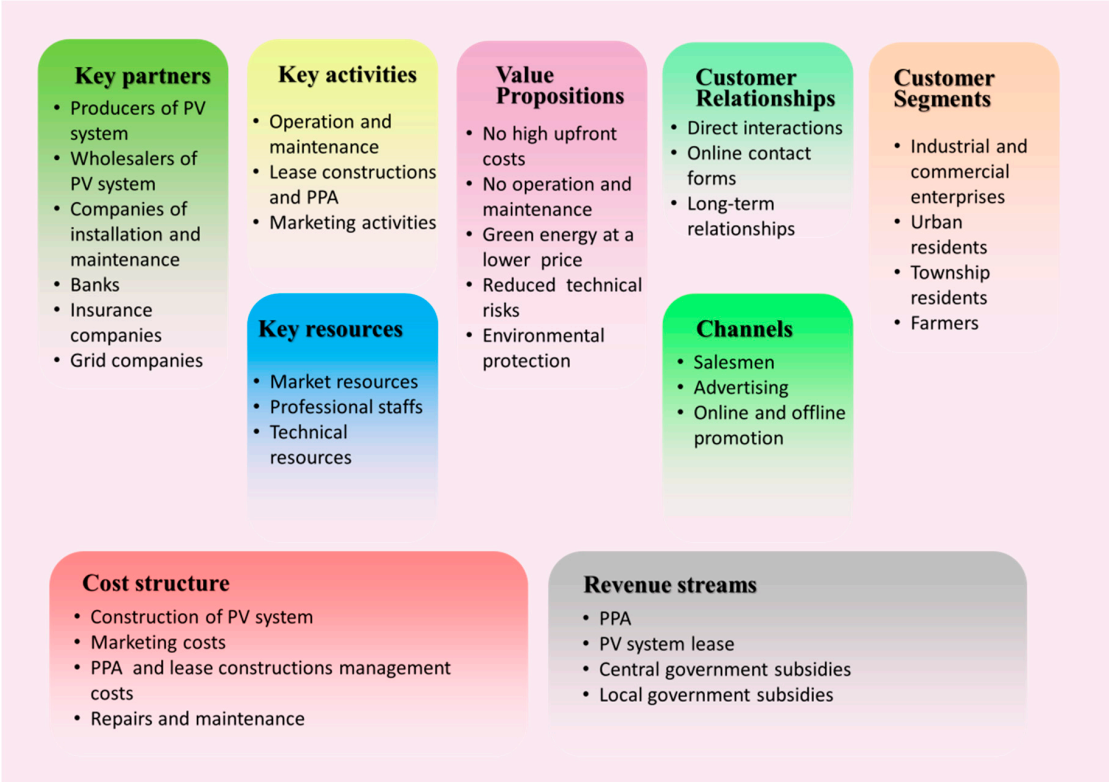



**Figure 4.** Third-party-owned Business Model Canvas (BMC).

#### 5.2.1. Value Propositions

Two of the biggest barriers in developing DSPV power are the high upfront costs and long payback period. Under the TPO model, customers can acquire clean and preferential PV power without too much input, through a power purchase agreement and lease modes. The repairs and maintenance of PV system during the use period are all completed by third-party companies. Customers do not need to invest in operation and maintenance, which makes the investment equivalent to purchasing an insurance policy. This is attractive to most customers in minimizing the holding and technological risks, as well as operation and maintenance costs [95,96]. Customers receive solar power at a price 80–90% lower than the retail price under the power purchase agreement mode [87]. While under the lease mode, customers receive clean and low-cost power generated by PV system. The subsidy income created from selling the excess power to the grid is divided into two parts, based on the proportion agreed by the third-party companies and customers [95]. In addition, with PV power generation, sunlight can be used to convert light into electrical energy, which is pollution-free and noise-free, contributing to lowered gas pollution and carbon emissions and ultimately protecting the environment.

#### 5.2.2. Customer SEGMENTS

In China, the main customer segments are underprivileged households, such as urban residents and township residents. These residents cannot afford high upfront costs, but would like to save money on electricity bills. Urban residents tend to live in multi-unit constructions or tall buildings, where the roofs are collectively owned. This makes it difficult to negotiate with residents and residential property departments on PV system installations [97,98]. In villages and towns, although families have separated roofs, they often cannot afford the high installation costs. Other segment customers are farmers, public organizations, and industrial and commercial enterprises.

#### 5.2.3. Channels

Salespeople can make direct contact with customers, through which third-party companies can further understand customer needs and completely and directly deliver value propositions to customers and convince them to purchase. Advertising, enterprise websites, or other E-commerce platforms can also help attract more potential customers. To further widen the market and strengthen ties with customers, third-party companies may also set up in-person consulting service spots in scattered markets, to help their customers learn about the power purchase agreement and lease modes and other related information.

#### 5.2.4. Customer Relationships

The third-party-owned model operates under power purchase agreement and lease modes. The power purchase agreement usually lasts ten to twenty-five years [87], and the leasing agreement is approximately fifteen to twenty-five years [95]. As such, the third-party companies need to establish long-term contact with customers. For example, third-party companies provide long-term consulting services for customers at in-person specialized consulting spots to address problems customers face, and to maintain and further enhance the relationship with them. Enterprise websites and other online contact forms are also available to capture customers, and build and maintain customer relationships.

#### 5.2.5. Key Activities

The most basic activities are to sell electricity and to lease the solar PV system; these elements are the major revenue components under the third-party model. Third-party companies should make full use of different approaches to marketing activities and to promote their services. At the same time, they should ensure the stable operation of PV system, provide sufficient and successive power, regularly conduct system repairs and maintenance for customers, and enhance the maximum possible life of the PV system.

#### 5.2.6. Key Partners

In this model, key partners are manufacturers and wholesalers; they determine whether companies can get high-quality PV equipment. Other partners include banks, grid companies, and insurance companies. The financing of China's PV power industry currently mainly depends on bank loans. As such, banks and other financial institutions are important sources of funds for third-party companies. Under power purchase agreement, they will sell the remaining electricity to the grid company after selling electricity to customers. Under the lease mode, customers will sell the excess power to the grid, so establishing a good cooperative relationship with the grid company plays an important role in grid connection. Furthermore, to lessen the risk of cooperation between third-party companies and customers, it is also necessary to cooperate with insurance companies.

#### 5.2.7. Key Resources

The key resources of this model mainly include the relationship resources established with local governments, customers, communities, and banks. Local governments can provide third-party companies with subsidies, technical support, and assistance with service promotion. It is particularly important to effectively address the relationship with the Residential Owners' Administrative Committee, which helps conduct marketing activities in residential areas. Banks and other financial institutions are important funding sources for third-party companies, so the relationship resources established with banks and other financial institutions are indispensable in this model. Under the power purchase agreement mode, third-party companies are obligated to ensure the normal operation of PV system, continuously and steadily supply power to customers, and bear the risk of system operation. Therefore, compared with the host-owned mode, it is more important for third-party companies to hold abundant technical resources and acquire more well-trained professional staff.

#### 5.2.8. Cost Structure

Third-party companies are responsible for constructing the PV system, and multiple marketing means are needed to promote the TPO model. Therefore, although construction expenses are major costs, marketing costs are also a cost component. Third-party companies must regularly repair and maintain the PV system, which generates more costs for employee wages and maintenance and material fees.

#### 5.2.9. Revenue Streams

Under the power purchase agreement, companies supply power at a price 80–90% lower than the market price, generating profits from charging customers power bills. In addition, they also benefit from selling excess electricity to the grid company at the local desulfurized thermal power price, which ranges from CNY0.25/kWh to CNY0.52/kWh. They also receive subsidies with CNY0.42/kWh from the central and local government consistent with total power generation. Under the lease mode, they lease the PV system to customers and charge rents.

### *5.3. Energy Management Contract Business Model Canvas*

The Energy Management Contract (EMC) is a new energy-saving emission reduction mechanism based on market-oriented project operation. It originated in the 1970s to the mid-term in western developed countries [99]. In June 2011, the "Golden Sun" demonstration project, adopting the EMC model, was first proposed by China's Ministry of Science and Technology, Ministry of Finance and National Energy Administration [97,100]. DSPV power projects in China mainly target large customers, such as industrial and commercial enterprises and parks, which adopt EMC model to build PV power plants. The EMC model has been increasingly adopted, and has gradually become the mainstream of DSPV power generation in China. This is due to the superior economies of scale, professional and technical advantages of energy-saving service companies in building DSPV power plants, and strong government support. This study therefore used the BMC to analyze the EMC model, unveiling the differences among the models mentioned above. Figure 5 shows the BMC analysis framework for this model.

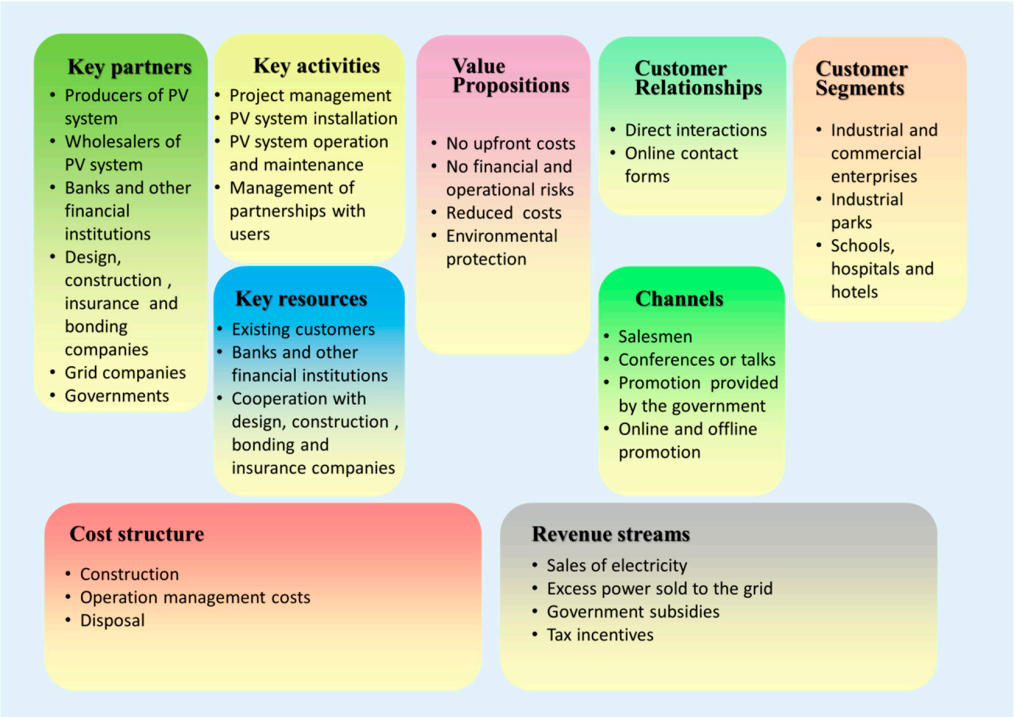



**Figure 5.** Energy management contract Business Model Canvas (BMC).

#### 5.3.1. Value Propositions

China has implemented a multistep tariff system nationwide. With high industrial electricity prices and high power consumption, industrial and commercial enterprises face significant pressure to implement energy saving and environmental protection to support national energy savings and emission reductions [101]. Enterprises have large roof space and high utilization rate. Establishing PV power plants can ease power shortages and effectively relieve power utility pressure. However, there are three major barriers facing self-built projects by industrial and commercial enterprises. First, the upfront costs are high and the initial investment is quite large. Second, the construction of PV power plants requires interaction with government departments, energy administrations, local power departments, banks, and design and constructing companies. This creates many inputs for enterprises to work through. Finally, there are no edges shown on the investment returns of power plant construction [6,101]. Therefore, it is more feasible for industrial and commercial enterprises to adopt the EMC mode.

The essence of EMC model is that customers need electricity and third parties provide effective solutions [9]. That is, customers do not need to do anything except make enough room for PV power plants that energy-saving service companies invest, build and maintain [102]. Customers do not have to pay for the high upfront costs, nor do they bear the risk of system operations. Further, they can use electricity at a price that is consistently dropping and that is lower than the market price. This greatly decreases electricity costs. Generally, PV equipment can be completely credited to customers after twenty years [103]. For industrial and commercial enterprises, the EMC model contributes to saving electricity and cutting operating costs, significantly reducing energy consumption, and promoting the use of clean energy. The goals are to achieve energy conservation and environmental protection, reduce energy consumption, and enhance the enterprise's reputation [102].

#### 5.3.2. Customer Segments

The main segment customers are industrial and commercial enterprises, which provide roofs and incur no initial installation costs. The energy-saving service companies are responsible for the investment, construction, and operation of PV power plants [102]. This model is especially favored by customers like industrial parks and economic development zones, where there is large power consumption, and the roof is centralized and connected, resulting in high utilization. Other sub-customers are schools, hospitals, and hotels [87].

#### 5.3.3. Channels

The sales team, composed of salespeople, plays an essential function in promoting this model. Energy-saving service companies often establish cooperation by hosting conferences or forums with powerful economic development zones or industrial parks [104]. The government is likely to recommend this model to public institutions and enterprises, to further spread the use of clean energy like solar power [105]. In addition, energy-saving service companies can also promote their services through enterprise websites.

#### 5.3.4. Customer Relationships

In this model, energy-saving service companies establish direct contacts with enterprises by signing contracts. Both parties agree on goals to be achieved in advance through contracts (i.e., economic contracts) on energy-saving projects [99]. As with the first two models, maintaining good customer relationships is critical to the success of the business model. The duration of energy management agreements generally lasts twenty years [100]; as such, energy-saving service companies must maintain lasting and long-term partnerships with customers through different channels, especially with parks and other large customers. For example, they may host regular talks or conferences to report on project progress and to share energy-saving benefits.

#### 5.3.5. Key Activities

The most important activities for companies is taking charge of all the management of the PV power plants, including licensing documents approved by governments at all levels for project implementation; approval documents for the environment assessment and grid connection assessment; project investment, design, and construction of PV power plants; operation, management, and maintenance of the project; and all costs produced in the process [106]. Furthermore, energy-saving service companies also need to manage contracts with every single customer.

#### 5.3.6. Key Partners

As with the first two models, manufacturers and wholesalers are also key partners for energy-saving service companies. A good cooperative relationship with the industrial park management committee and leaders of enterprises and institutions can help attract more customers. As such, they are both customers and partners. Other partners include financial institutions, such as banks, design and construction companies, insurance companies, and grid companies. Energy-saving service companies acquire financing from banks or other financial institutions to invest in the PV system construction. They must also cooperate with professional design and construction companies to install and maintain the PV system, and need to work with bonding companies and insurance agents to ensure the smooth completion of the project and minimize risks [102]. The power produced by the PV system first satisfies customer requirements; excess power is sold to the grid company. Moreover, strong support by the government facilitates the EMC model; because of this, energy-saving service companies need to keep a close and lasting partnership with them.

#### 5.3.7. Key Resources

The existing customer resources are core resources, because good relationships with the industrial park management committee and leaders of enterprises and institutions help energy-saving service companies successfully conduct business and encourage further cooperation. The EMC model tends to target big enterprises and parks, and the construction of PV power plants is so large that energy-saving service companies cannot invest in them on their own. Rather, they must get financial support from banks or other financial institutions. Therefore, the cooperative relationship with banks and other financial institutions is an indispensable resource. It is also important to cooperate with design and construction companies, bonding companies and insurance agents, as energy-saving service companies need to work with them to construct and operate PV power plants. To ensure the smooth completion and operation of PV power plants, they also need to collaborate with the insurance companies involved.

#### 5.3.8. Cost Structure

Under the EMC model, costs are mainly divided into three sections. First, the vast majority of costs are generated during the construction period. This includes the expenses of PV power plant construction, equipment purchase, installation, and other costs. Second, there are costs for operation and management, including staff wages, repairs and maintenance costs, overhaul costs, failure costs, insurance costs, financial costs, and tax costs. Finally, remaining costs include waste disposal costs and depreciation fees for PV equipment.

#### 5.3.9. Revenue Streams

The main income for energy-saving service companies is to sell electricity to industrial and commercial enterprises [103]. Other revenue streams are from excess electricity sold to the grid company at the local desulfurization coal-fired thermal power benchmark price. These companies also receive subsidies with CNY0.42/kWh from the central government, consistent with the total output of PV power plants. Local government subsidies are also a portion of their earnings. To incentivize energy-saving service companies to adopt the EMC model, authorities enforce the tax preferential

policy of "three exemptions and three reductions" for those who meet the specified conditions and conduct EMC projects in ways that support energy-saving and benefit-sharing [107]. Therefore, energy-saving service companies can also receive tax incentives.

## 6. The Lean Canvas

The benefit of the Lean Canvas framework is the ability to make synthesis comparisons of many business models. To this end, this study adopted the framework to identify the main differences between the three business models discussed above. The analysis revealed the advantages of the EMC model and the main obstacles it can overcome.

"The Lean Canvas" is a creative tool for thinking and solving enterprise (product) problems. To complete it, nine blank areas are completed on a piece of paper. These nine areas include: customer segments, problem, unique value proposition, solution, channels, revenue streams, cost structure, key metrics, and unfair advantages [52]. In this study, we used yellow for the host-owned model and green for the third-party-owned model. Performances from the EMC model are shown in orange, and blue is used to make points of commonality (see Figure 6). Here are the detailed steps:

The starting point was to identify customer segments. Business models can only improve by tapping customers more accurately and meeting the very core needs of customers at a higher level. Segment customers of the host-owned model are those families with high incomes and environmental awareness, who tend to be the first key customers in the PV market. Under the TPO model, segment customers are mainly from less-privileged households. They cannot cover high initial installation costs and need to save electricity bills. In contrast, enterprises, schools, and hospitals with independent roof resources are the segment customers of the EMC model, as are industrial parks and economic development zones. There is likely a bright future for the EMC model, because of these large customers' high willingness to conserve energy and because of their financial advantages.

Identifying problems was the second starting point. At this stage, technological risk and electric power meters are common problems faced by the three models. The high upfront cost is the main obstacle potential customers confronted by the host-owned model. The problem of TPO model is insufficient roof space. High electricity tariff at rush hours is a serious barrier for the EMC model.

Next, the unique value proposition was demonstrated. The value proposition is the clear and conspicuous statement elaborating the reasons for choosing a particular business model over the others. Compared with other business models, the EMC model appears more prominently in the value proposition area. This value comes from its flexibility and significant cost reductions, because end-users do not need to pay the high upfront cost, and the duration and variability of the contract can last for twenty years.

The fourth step was to propose specific solutions to problems experienced by the target customer group. For example, energy-saving service companies in the EMC model are responsible for investing, constructing, operating, and maintaining PV systems using an electricity metering technique and energy related contracts. This provides power to customers at a price lower than the retail electricity price. There are also benefits from electricity charges. Compared with other business models, the solution substantially reduces technical risks and barriers to financing and profitability, and therefore can also provide customers with more incentives.

The fifth step was to address the channel problem related to how products reach customers. Apart from owning channels, similar to other business models, the EMC model is more attractive to enterprises not engaged in the PV industry. This is because it can maximize the advantages of the professional abilities of PV power plant developers, effectively reduce transaction costs in project investment, and maximize the gains from PV power plant projects.

The sixth step was to identify key metrics. Operability and simplicity are quite important, particularly in the initial stage. Using less complex indicators, such as market coverage and number of consumers, is sufficient to assess fundamental PV power development.

Finally, determining unfair advantages—also known as competitive advantage—helps describe the barriers to entry for others. Unlike the other two business models, the payback period under the EMC model is usually only six to eight years. As such, it has clear advantages with respect to economies of scale [108]. Furthermore, energy-saving service companies provide services from energy diagnosis, improvements in alternative evaluations, engineering design and construction, inspection and management, funding and financial planning, operation, and maintenance. This allows for more accurate and professional energy conversations, which provides an advantage for this model [109].

The revenue streams and cost structures of the different business models are not further discussed here, as they were addressed in the sections above.

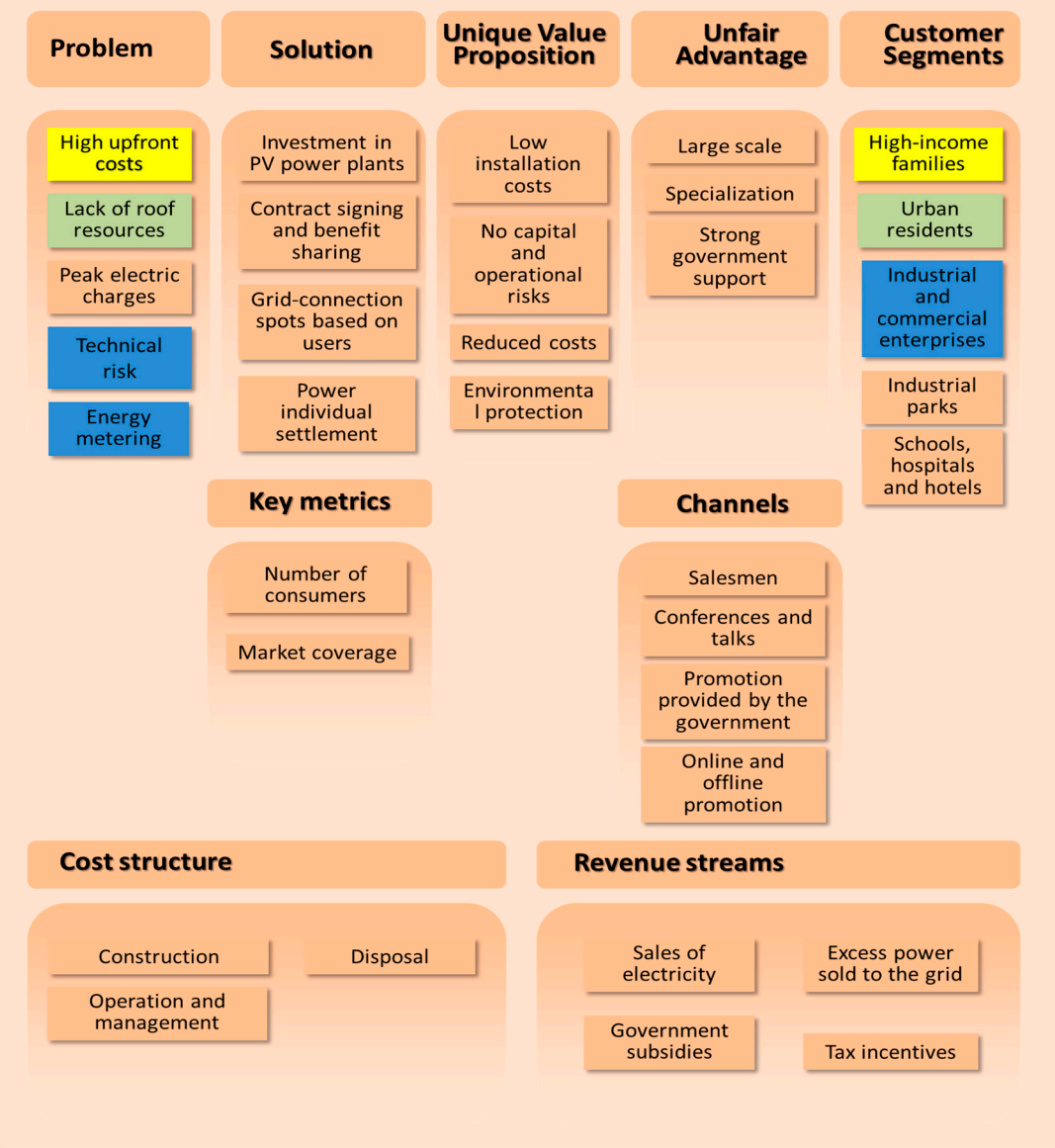



**Figure 6.** Synthesis comparative analysis of three business models (the Lean Canvas). Color legend: yellow: host-owned, green: third-party-owned, blue: host-owned and third-party-owned and energy management contract, orange: energy management contract model.

## 7. Overcoming Identified Obstacles

This section discusses how and to what extent the three business models can overcome the barriers identified in Section 4. In Table 3, one star indicates that the business model plays a part in overcoming

obstacles; two stars indicates that the model can significantly work; and no stars indicates the model is ineffective in overcoming barriers.

**Table 3.** The extent to which three business models overcome identified barriers.

| Main Barriers | Host-Owned Model | Third-Party-Owned (TPO) Model | Energy Management Canvas (EMC) Model |
|---|---|---|---|
| Financial and profitability barriers | | ★ | ★★ |
| Institutional and policy barriers | | ★ | ★★ |
| Technical barriers | | ★ | ★★ |
| Awareness barriers | ★ | ★ | ★★ |
| Roof resource barriers | ★★ | | ★★ |

Compared with the host-owned model, the TPO model can receive financing from banks and other financial institutions and can receive returns on investment by charging customers electricity or rent. This alleviates the obstacles of financing and profitability. The EMC model mainly targets large-scale customers, such as enterprises and industrial parks, with large electricity consumption. Furthermore, the economies of scale are large and the payback period lasts only six to eight years. Therefore, energy-saving service companies are more likely to get funding support from financial institutions, such as banks and other financial institutions. As a consequence, EMC model can evidently overcome barriers in financing and profitability compared with others.

A government orientation is a distinctive feature of DSPV power generation projects in China. Particularly in the early stage of market promotion, it is very important to receive supporting investments from the government. The different business models exhibit significant differences in addressing institutional and policy problems. Compared with other two models, the EMC model is likely to get universal support from the government and cooperation from power supply enterprises. This is because of its economies of scale, good relationship resources, and professional preponderance. Since the end of 2012, the local government in Jiaxing, Zhejiang Province has been an important PV industry town in China, adopting the innovative mode of "government guidance, market operation and unified management." This has effectively solved common problems in developing DSPV power and has led to some useful and meaningful "Jiaxing lessons." These lessons should be learned in each region designed to develop DSPV power [7]. China's State Grid has been seen as a monopoly supplier of power energy, facilitating its ability to integrate different resources, such as power supply companies, subordinate organizations, and scientific research institutions. The central government continuously provides policy support and incentive mechanism for China's State Grid to explore its implementation of the EMC model for DSPV power [110].

The TPO and EMC models can overcome technical barriers better than the third method. China's photovoltaic inverters have become a leading example of technology in the global market. Its energy efficiency has been continuously improved, reaching a maximum level of 99% [111]. After these inverters, the power grid-connection is also affected by the capacity and stability of power generation and other factors. Due to the large-scale PV construction and large power generation, energy-saving service companies under EMC model are more professional in the PV industry and positively invest resources to address technical difficulties, effectively putting the axe in the helve. For example, given government domination and cooperation with power supply enterprises, four key research institutes—the DSPV Grid-connection Technology Institute, PV Equipment and Intelligent Control Research Institute, and PV Energy Application Technology Academy—have been built in the Jiaxing PV High-tech Industrial Park in Zhejiang Province. Government departments, together with enterprise technicians, issue technical standards, ranging from product selection, to roof carrying capacity and construction layout, to acceptance checks, operation and maintenance. As such, many technical problems related to the PV grid-connection are being sequentially addressed [7]. In the TPO model, PV

system ownership belongs to enterprises responsible for the construction, repairs, and maintenance of PV system under relevant technical standards. This also reduces consumer technical barriers, however, the EMC model more effectively conquers such obstacles.

Segment customers of the host-owned model mainly are high-income households with environmental awareness, who can significantly influence others to better understand DSPV power. Because these customers can drive other families to install PV system, awareness barriers can be effectively overcome. As a new energy saving and emission reduction mechanism, the EMC model, together with notable energy conversation economic benefits, and the highly specialized nature of energy-saving companies in the PV industry [99], can better spread the idea of energy efficiency and draw more customers to install DSPV systems. This enrolls them in the "green army," which provides significant help in eliminating the awareness barriers. For example, the EMC model has just been applied in the "Beijing Sunshine Campus Golden Sun Project" to build DSPV power system in approximately 800 middle and primary schools and universities in Beijing. This positively cultivates young peoples' green awareness and a low-carbon lifestyle [112].

Under the host-owned model, both high-income families and farmers have sufficient and stable roofs, indicating they have few roof resource problems. Furthermore, because roof resources are more concentrated and united in industrial parks, and because economic development zones are abundant and stable, the roofing availability in most parks is more than 70% [113]. As a result, the EMC model can significantly overcome roof resource barriers.

In summary, the EMC model can partially reduce institutional and policy barriers, and significantly reduces barriers in financing and profitability, technology, grid-connection, awareness and roof resources. Therefore, the EMC model performs best among the three business models and has the greatest potential in the DSPV power market.

## 8. Summary and Conclusions

Based on the business model defined by Osterwalder and Pigneur, this section summarizes the value proposition, value creation, and delivery and capture mechanisms of each business model (see Table 4) [114]. The table shows that the common values of these models are environmental protection and cost reduction.

**Table 4.** Value proposition, value creation, delivery, and capture of PV business models.

| Value | Host-Owned | Third-Party-Owned | Energy Management Contract |
| --- | --- | --- | --- |
| Propositions | • Flexibility<br>• Reduced electricity bills<br>• Sales revenue<br>• Environmental protection | • No upfront costs<br>• Lower green energy price<br>• Decreased technical risk<br>• Environmental protection | • No upfront costs<br>• No financial and operational risks<br>• Reduced costs<br>• Environmental protection |
| Creation | • PV system purchase<br>• Repairs and maintenance<br>• Energy consulting | • Power purchase agreement<br>• Lease mode<br>• System operation and maintenance | • System investment and installation<br>• System operation and maintenance<br>• Cooperation management<br>• Project management |
| Delivery | • Salespeople<br>• Advertising<br>• Online and offline promotion<br>• After-sales service | • Salespeople<br>• Advertising<br>• Online and offline promotion | • Salespeople<br>• Conferences or talks<br>• Government-assisted promotion<br>• Online and offline promotion |
| Capture | • System sales<br>• After-sales service, repairs and maintenance service | • Electricity selling or rent charging<br>• Excess power sold to the grid<br>• Subsidies from the government | • Electricity selling<br>• Excess power sold to the grid<br>• Subsidies from the government |

In general, if there is sufficient financial support, all business models can function well in their segment markets because of the diversification of the DSPV market. However, compared with the other two models, the EMC model can achieve maximum economic benefit. Its strongest advantage is that most customers are large-scale customers from industrial parks and economic development

zones. These areas have a high demand for electricity and roof resources are centralized, united, and highly available. This helps create economies of scale. Energy-saving service companies are also more specialized in the PV industry. They offer more professional and scientific energy-saving technologies and solutions, and can achieve more investment than their rivals. This can effectively get over difficulties in grid connections, develop a series of technical standards, and adopt the latest solutions.

This study also outlined how and to what extent these business models can help overcome identified barriers. The EMC model is more effective in eliminating institutional and policy barriers in China; however, institutional and policy barriers remain the largest difficulties. Since the second half of 2012, China has shifted from large-scale solar PV to DSPV and has introduced a series of policies to advance DSPV power deployment (or development). Unfortunately, these policies have not been well implemented due to numerous restrictions on the DSPV power deployment nationwide. Therefore, it is important for policy makers to promulgate and implement more targeted policies with respect to scale control and registration management, feed-in tariffs, subsidies, financing and financial incentives, market promotion and grid-connection, measurement, and settlement. This is particularly true in China, where the DSPV power market remains in its infancy [1].

As one of the basic business models, the EMC model has greater market potential with respect to DSPV power. However, energy-saving service companies have to spend more on technology innovation and human capital to capture the sustained high ground. To receive more tax and financial incentives, companies must establish lasting and stable partnerships with grid companies, financial institutions, government departments, management organizations in the park, and PV manufacturers. This enhances their social capital. In brief, the EMC model stands out in many ways. With the intellectualization of energy technology and the rise of the sharing economy, the government should encourage enterprises and households to install DSPV systems and stimulate consumers to purchase and sell green power. In this way, EMC model may achieve further development and leap forward.

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## Abbreviations

| | |
|---|---|
| PV | photovoltaic |
| DSPV | distributed solar photovoltaic |
| EMC | energy management contract |
| TPO | third-party-owned |
| LC | lean canvas |
| LSPV | large scale photovoltaic |
| PPA | power purchase agreement |
| NEA | National Energy Administration |
| CNKI | China National Knowledge Internet |
| CNY | Chinese Yuan |

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