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A Business Model for Developing Distributed Photovoltaic Systems in Iran

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Abstract: The necessity of increasing the utilization of renewable energies and lowering the dependence on fossil energies for power generation has been increasingly regarded worldwide. Thanks to its desirable solar radiation potential, Iran can lower its level of dependence on fossil fuels for power generation significantly by developing distributed solar photovoltaic (DSPV) systems. The present research began with identifying, through a literature review, relevant business models in terms of ownership and control and the barriers encountered by the PV industry. Continuing with the research, semi-structured interviews were performed with elites in the power industry to explore different barriers hindering the development of DSPV in Iran and weigh them appropriately. Next, according to the elites' opinions, three business models differing in ownership and control were compared and scored in terms of their ability to address the identified barriers. According to the results, the business model with customer/third party ownership and utility control was identified as the most appropriate business model in Iran. As a final discussion, the business canvas and the roles and associations of all players of this industry in relation to the development of DSPV in Iran were explained.

Keywords: distributed solar photovoltaic; renewable energy policies; barriers; business model; energy strategy; PV markets

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1. Introduction

The ever-increasing consumption of energy coupled with the reduction in the supplies of fossil fuels has led different countries toward using renewable resources for sustainable power generation [1,2]. Listed among the top 30 consumers of electricity globally, Iran is currently generating 94% and less than 6% of its electricity from fossil fuels and hydropower plants, respectively, leaving the share of wind and solar energies down to below 1% [3]. The application of photovoltaic (PV) systems has been recommended to reduce the dependence on fossil fuels. Enjoying some 2900 h of sunlight per year (which is even higher, e.g., 3200 h, in particular places across the country), and receiving a yearly average of 1800–2200 kWh of solar energy per square meter (above the world's average), Iran has great potentials for adopting PV systems for the sake of electricity generation [4]. Conventional PV-based solar power systems have been classified under two broad categories: centralized large-scale PV systems and distributed solar PV (DSPV) systems. In DSPV systems, in contrast to large-scale PV systems, power is generated right where it is supposed to be consumed, cutting the cost of power transmission. In many cases, a DSPV system is simply installed on a rooftop, indicating its small space requirements. These advantages make DSPV systems desirable choices for attracting electricity customers toward participation and investment to achieve grid independence [5].

Nevertheless, energy development and service companies have encountered numerous challenges, including reduced market demand and increased investment risk and cost [6,7]. In order to address these challenges, it is necessary to develop a unique business model that can extract economic value out of the capacities of the DSPV as an industry. A business model is a description of the way a business can be managed. In order to retain competitive advantage and success in the long run, organizations must be able to take the most out of their capabilities and advantages while formulating new innovations. In this respect, a business model is shaped on the basis of achieving new opportunities and/or tackling the barriers encountered by the industry [8,9].

The United States has long been a pioneer in developing business models for the PV industry [10,11]. As of writing this article, the market of DSPV industries in the US is led by innovative business models owned by third parties [12]. Initial DSPV business models in China were owned by electricity customers, mainly including villagers and residents of villas with adequate rooftop space. However, as the demand for such systems increased, the Chinese business atmosphere turned to third party-owned models, very much like the US [12].

Considering the lack of an appropriate approach and the use of DSPV systems in Iran, despite the high potential of solar capacity, due to the existence of obstacles in this industry and the lack of appropriate incentive and support policies from the government, there is a need to investigate and identify the obstacles of this industry in Iran to form the suitable business model of DSPV. Despite numerous studies on the potentials of PV systems in Iran, systematic studies on special business models for DSPV systems are yet to be conducted in the country. Accordingly, the main objective of the present article is to formulate a unique business model for DSPV systems in Iran in an attempt to address the pitfalls in this industry. In this work, an analysis of the literature and interviews with industrial elites were devised to identify, for the first time, the barriers encountered in this industry and classify them to build a business canvas for DSPV systems in Iran based on the industrial elites' opinions. This article further explains the roles and associations of various players in the industry to develop DSPV systems.

The rest of this article is organized as follows. Section 2 presents a review of existing business models and their design, followed by appropriate business models for DSPV systems. In Section 3, the research methodology is described, where literature review and content analysis are used to identify barriers to the development of the DSPV industry, and a business model is developed based on semi-structured interviews with industrial elites. Section 4 investigates the barriers to the development of DSPV systems in Iran, as extracted from the literature review and the interviews, and analyzes the developed business model. Finally, the structure of associations and roles of different business players and their impacts on the developed business model is explained.

2. Theoretical Background

2.1. Business Models

The rapid development of technologies is profoundly affecting the commerce and business environment daily. According to business researchers, a company/system/organization cannot achieve a competitive advantage unless it builds on the appropriate business model. A successful business model represents a better way than other alternatives, offering greater values to a particular group of customers and realizing more benefits. Despite the crucial importance of business models for the commerce-related players, only limited systematic research has been performed on this subject, with no comprehensive definition for the business environment in the academic literature [13].

The first theoretical definition of the business model was proposed by Shumpter et al. [14]. They appreciated the importance of the business environment and commerce in terms of competition on not only the price of the end product but also the novel commercial environment, implementation of new technologies, utilization of new supplies, and, in general, the development of new businesses. Later on, Druker [15] referred to a successful and efficient business model as one that properly acknowledges customers and product value to the customer and can, at the same time, handle product procurement at affordable prices. Many researchers have referred to the business model as the logic behind a business or the key to income generation. For example, Chatterjee [13] introduced the business model as the flow of the company with its capitals and assets towards generating profit. In another piece of work, Teece [16] referred to the business model as the conceptual method of providing customers with value and guidance to attain a profit. Johnson [17] defined the business model as the logic behind generating, presenting and realizing values by an organization. Among other definitions proposed for a business model, this latter definition better suits renewable energy-related businesses. Accordingly, the present article takes this concept as a basis for building a business model.

Innovation in business modeling enables companies to strengthen their value propositions, build on their uniqueness, and explore new long-lasting markets and customers. Bashir and Verma [18] introduced business models as a sustainable advantage because the emulation of a brand-new business system is much more difficult than that of a product or service. Aspara et al. [19] referred to innovation in business modeling as initiatives for creating new values or challenging particular existing business models, roles, and associations in the market. Amit and Zoot [20] declared that innovation in business modeling is simply introducing new activities to business operations, innovative linking of activities, or making changes to the individuals who actually carry out the activities. Other factors of innovation in business models include (1) economic pressure [20–22], (2) product development-related issues [22], (3) price competition [22–25], (4) customer-oriented issues [22], (5) strategic conditions [26], (6) background conditions [27], (7) positional factors [28–30], and (8) increased level of digitization [21,31,32], among others [33–35].

A business canvas presents an attractive domain for demonstrating new or existing business models. Given that a business model describes the logic behind creating, presenting, and attaining value, the following nine components are the main constituents of the design of a business model: customer segment, value propositions, channels, customer relations, revenue streams, key resources, key activities, key participations, and cost structure (Table 1).

2.2. A Review of Business Models for DSPV Systems

The downstream structure of the PV technology, which refers to the application development of the technology, is known as PV business models and has been extensively studied so far [24,25,27,28,36]. These studies have mainly investigated the role and performance of the government in promoting business models for PV development. Horváth et al. [37] used the concept of business canvas to analyze business models for PV systems and reported the positive influence of the business models for identifying and tackling the barriers to the development of the application of PV systems. Gabriel et al. [38] checked for regional changes and their impact on the choice of business model using the business canvas. In another work, Huijben et al. [31] conducted a literature review and interviews with experts to introduce a business model for the PV industry in the Netherlands, with the model further analyzed using its business canvas.

According to the results of these studies, the government may contribute to the PV system supply chain at four levels, namely at local government, state and federal government, regulator, and utility levels.

In the meantime, ownership of a PV system may take either of three forms:

System user

Here, the PV system is owned by the landlord or the owner of the residential or commercial building on top of which the PV panels are installed, or by the end-user of the power generated by the PV system

Third-party

Here, the PV system is owned by external individuals or institutes beyond the utility system, who usually install such systems to sell the generated electricity to the owner or user of the underlying building.

Table 1. Business canvas.

Customer segment	Different groups of individuals or organizations to whom the system tries to gain access or provide a service comprise the core of any business model.
Value propositions	Value propositions refer to a bundle of products and services that can create value for a particular customer segment. Indeed, these comprise why a company/system is preferred over other companies by the customers. In reality, a set of value propositions takes the form of a pack of selected products and services that are designed to meet the needs of a particular segment of customers.
Channels	Channels represent how the system reaches and communicates with the target customer segments to present the value propositions. Distribution and sales channels serve as an intermediate between the company/system and the customers. Different classification schemes have been proposed for channels, including direct and indirect channels or dedicated or shared channels. Different channel phases include awareness, assessment, purchase, delivery, and after-sale services.
Customer relation	Customer relations describe different paths through which the company/system communicates with particular customer segments. The company/system shall clarify its relationships to different segments of customers. The extent of such relationships can span from in-person contacts to fully autonomous support services.
Revenue streams	Revenue streams reflect the revenue that the company/system is making out of each customer segment. A business model may accommodate two different types of revenue streams: (1) interaction revenues, which are generated as a customer pays for a one-time purchase, and (2) Repeatable revenues, which are results of frequent payments by customers for receiving the value proposition or after-sale services.
Key resources	Key resources are crucial assets that are required for the proper operation of a business model. With the help of these resources, the company/system can create and present its value propositions, reach markets, preserve its relationship with different customer segments, and generate profit. A key resource can be physical, fiscal, spiritual, or humankind. It may be owned or rented by the main company/system or rather procured by key partners.
Key activities	Key activities are the most significant activities that are required before a business model can operate adequately. These are the most important measures that a company/system shall take to achieve successful performance.
Key participations	Key participations represent a network of suppliers and partners by which the business model can operate properly. There are four different types of participation in a business model, including (1) strategic alliances between companies that are no longer rivals to one another, (2) partnership with rivals, (3) joint investments for establishing new businesses, and (4) buyer-supplier relationships for ensuring the realization of requirements.
Cost structure	Cost structure describes all costs incurred by the implementation of a business model. It is trivial that cost minimization is an objective in every business model. In this respect, one may distinguish between two groups of business models, namely cost-driven business models, focusing on cost minimization, and value-driven business models. The value creation represents the core focus, and the cost is of relatively lower priority. Offering premium values and high-level dedicated services are characteristics of a value-driven business model.

Utility

Although the utility-owned PV systems possess the smallest market share of DSPV systems, their contribution to market control is dominant because of their reliability.

Investigating the current state of the PV systems market in Iran in the framework of ownership and application, the dominant ownership model in the country is the end-user ownership, and both residential and commercial applications are relatively dominant [29]. Presently, third-party ownership is rapidly becoming the dominant ownership model for commercial applications, not to mention its suitability for grid applications as well.

The ownership character is the main factor defining the future business models. The answer to who controls a PV system will be a determinant factor to future business models. Therefore, the business models introduced in this report are characterized by their "ownership" and "control" characters. Accordingly, it is herein assumed that the PV supply chain is complete in terms of application (e.g., the place where the system is installed), and, hence, its application is generally less important than who and how is the controlling manner of the system [30].

Considering the business models introduced in the literature, one can classify them by complexity and time to implement, as demonstrated in Figure 1. These three models are the main business models for DSPV systems, which have been implemented in not only the United States, as the premier in the industry, but also in other countries such as Germany [32], China [12], and the Netherlands [28] (Figure 1). According to the mentioned cases and the use of these three business models for both developing and developed countries in the DSPV industry in the world, these three models were used as the basis for interviewing experts to determine the DSPV business model in Iran.

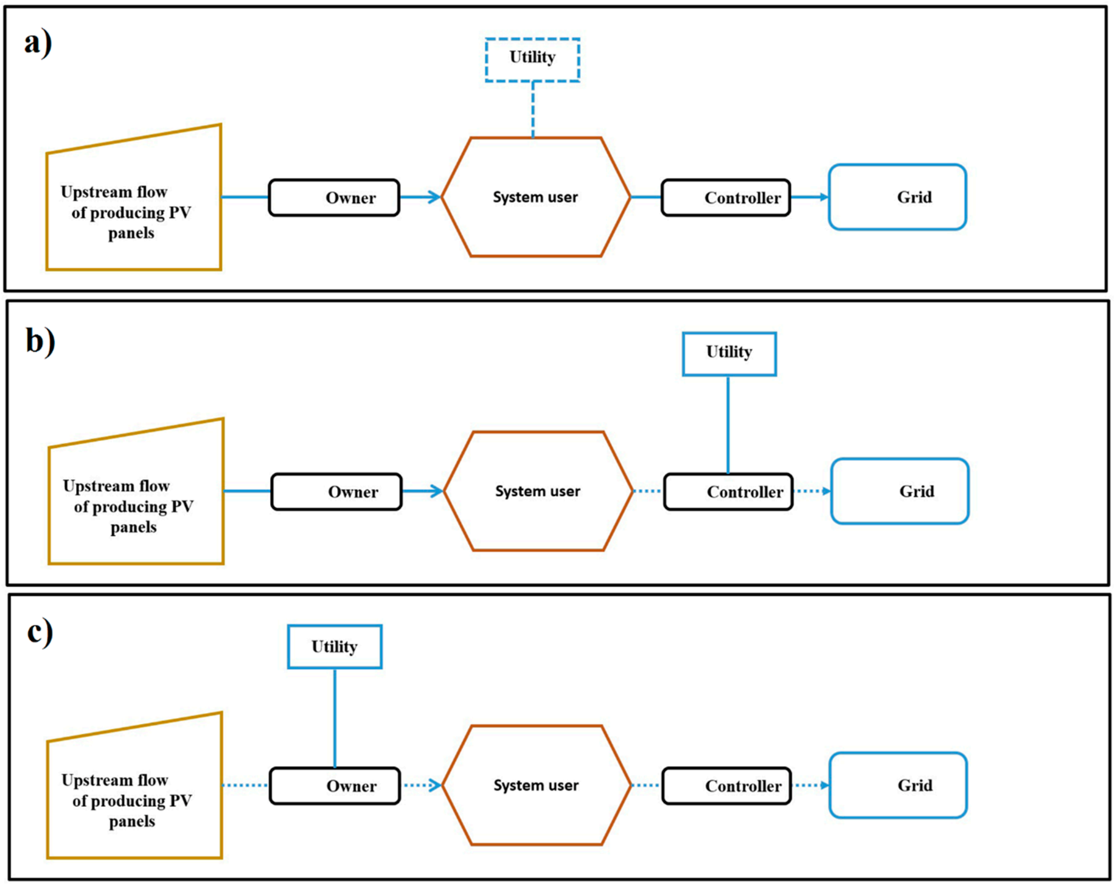

Figure 1. Schematic of different business model for DSPV systems: (**a**) third-party/customer-owned and controlled business model, (**b**) utility-controlled third-party/customer-owned business model, and (**c**) utility-controlled and owned business model.

Model 1: Third-party/customer-owned and controlled business model

The essential characteristic of this model is that excessive sources of revenue are harvested by owners based on variations in regulation and policy-setting systems and the use of intelligent network and energy storage technologies combined with the PV system. In this model, the utility is generally seen as a facility mainly generated upon changes in regulation or policies. The utility deals with the value-added products and services associated with the PV system and then can receive and compensate the interest rate through traditional methods [21].

Suppose the customer/third party ownership and control business model is developed. In that case, the distribution network must be redesigned to be able to respond to abrupt changes in power consumption during different hours of a day, or the changes resulting from sunlight availability or the owner's decision because utilities do not control PV systems. A challenge in this business model is that owners have complete liberty in managing their systems. Therefore, the development of this business model tends to raise problems for utility in the long run, and the revision of promotional regulations would become necessary.

Model 2: Utility-controlled third-party/customer-owned business model

The characteristic distinction of this model compared to Model 1 is the more significant contribution of the utility to the operation and control of systems, and this defines an approach to increasing the value of assets. Like the customer-controlled business model, one needs to modify regulatory regimes and policies before the utility can be attached to the PV system. In this case, the customer exhibits no price signal since the utility controls the PV system, at least partly.

This business model fits cases where a response to aggressive demands or similar programs are followed, or wherever the incorporation of PV systems may lead to serious grid control and operational problems. A DSPV system shall be of an adequately large scale before the utility can recognize some value in controlling it. For example, the installation of a DSPV system builds value into a utility, in proportion to its capacity, for replacing the required investment for power generation, transmission, and distribution.

Model 3: Utility-controlled and owned business model

This business model represents the dominant target model today because the utility has clear controls over its assets while offering a wide spectrum of services to the customers. This model attempts to directly use the utility in the arenas of asset ownership and control to increase revenue generation out of the asset values and flourish the value of DSPV systems. This arrangement is well consistent with the core competencies of asset ownership and operation. Knowing that PV is a capital-driven asset, the value of utility-owned assets is reflected in the interest rate.

Allowing utility to play a dominant role in location control and proceeding asset-related operations, this business model must produce the largest overall quantities for the utilities. In addition, this model can simply include in the initial cost of services the grid interests and sales of value-added services to the end-user. Among the three types of business models presented in this work, this model is the simplest variant for utility to consider participation in the installation and start-up of PV systems when undertaking capital planning. They have control over the final decision on the installation. Nevertheless, the competition represents a pitfall to this model because utility can lead to unfair results in offering customer-oriented (rather than grid-oriented) value-added services.

In his paper, where he investigated the role and influence of utility in the development of PV systems in Germany, Richter [22] concluded that the main responsibility of utility is to change attitudes toward DSPV systems. Indeed, utility must not see such systems simply as alternative power generation systems that are there to compete with traditional electricity generation supplies, but rather must perceive them as a strategic gate toward an emerging market of electricity generation and distribution, and, hence, support them by legislating proper regulations and tariffs.

Many researchers have regarded the development of DSPV systems by presenting novel business models for addressing the high capital cost of such systems [23,26,33]. Huijben et al. [35] presented a business model for suppressing subsidies while expanding PV systems in the Netherlands. According to their results, the high cost of PV modules and thr lack of required financial support from the government and local organizations represent the main barriers to the development and acceptance of these systems. Acknowledging this finding, they recommended tax reliefs on PV contracts and net-metering mechanisms for promoting this business among small customers. In another work, Li et al. [39] evaluated the development and use of PV systems in greenhouse spaces to reduce the cost of such systems. This study showed that upgrading a greenhouse from a production base to a commercial foundation plays a significant role in evolving the business model for operating greenhouse PV systems. This was conducted through innovation in the business model and required regulations and policies to sustain such systems in China. Zhang [40] reviewed the business models and fiscal mechanisms adopted for DSPV systems in the United States, as the premier in the field, and presented the most appropriate fiscal system and business model for China considering the new financial regulations and policies set in the country. Table 2 presents a summary of the papers reporting on the analysis of business models.

Table 2. A review of the literature on the analysis of business models.

	Business Models	Case Study	Research Methodology	Achievements	Reference
1	host-owned, energy management contract, and third party-owned	China	literature review	Formation of business canvas and lean canvas, comparison of overcoming obstacles, and EMC model was recognized as the best model	[12]
2	Discounted cash flow	China	Costs and investment	Feasibility study of using PV system for water pumping	[41]
3	host-owned, third party-owned, and community shared	-	literature review	Formation of business canvas and lean canvas, comparison of overcoming obstacles, and community shared model was recognized as the best model	[37]
4	community energy model	England	literature review	Investigating the evolution of energy supply business models in the UK and examining the role of industry actors in these models	[42]
5	community energy model	Swiss	literature review	Identify the target community of the business model of using solar panels in the building	[43]
6	integrating investment and consulting services model	China	Simulation	Improve energy consumption Increase the security of the electricity network Investor benefits Reduce users' electricity costs Reduce government subsidies	[44]
7	third-party ownership, cross-selling, and host owned	Japan, Germany, and the USA	literature review	Examine the business models canvas to support and deploy DSPV systems	[45]
8	host-owned, third party-owned, and community shared	China and USA	literature review and Interviews with industry experts	Provide an approach and insight for renewable energy policymakers in China as well as other countries	[25]
9	Ownerships of PV system models	Germany	literature review and Interviews with industry experts	Investigate the threats and opportunities of PV power generation for different climatic zones	[4]

Currently active business models in PV systems try to achieve lower-cost financing, improved productivity of the supply chain, and a reduced level of complexity, especially for customer-related problems. Due to the limited number of PV systems installed across the distribution grid, there has been little interest in paying any significant attention to the control and accumulation of PV as a political subject that is worth regarding. In the future, a large number of DSPV systems could lead to either material and operational concern or the opportunity for water and power utilities. At that time, political and regulatory considerations will become particularly important. Accordingly, at the beginning of the development path of such industries, the utility's role is primarily in the form of promotional plans and policies. In Iran, such promotional policies have been limited to two main programs: (1) guaranteed purchase of the generated electricity by domestic renewable systems at a higher rate (the per-kWh rate for the PV-generated electricity is currently 10,400 Iranian Rial (IRR) and 9100 IRR for systems with output powers of up to 20 kW and 20–100 kW, respectively, compared to the relatively low rate of electricity (~1000 IRR per kWh) in Iran) and (2) requiring all governmental electricity consumers to obtain at least 20% of their power requirements from renewable resources. Oppositely, remarkable fluctuations in the foreign exchange rate and the very low rate applied on electricity bills for end-users are the main barriers to accepting the use of PV systems. Therefore, one must take into account all factors affecting the development and implementation of business models for DSPV systems.

3. Research Methodology

Despite the numerous studies performed on the potential and use of PV systems in Iran, a consistent business model for such systems is yet to be presented. The main objective of this article is to introduce a particular business model for the development of DSPV systems in Iran (Figure 2). Before such a model can be designed and built, one must identify barriers to the industry. As explained previously, ownership and control are the main characteristics of business models for DSPV systems in Iran. Accordingly, these two criteria were used to find an appropriate business model for the business canvas of Iran.

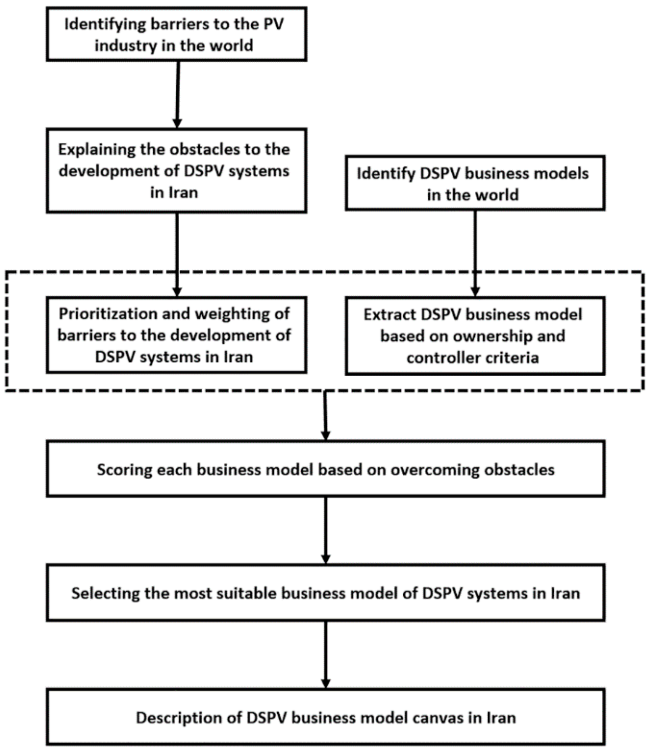

Figure 2. Schematics of the research methodology.

Barriers to the PV industry and common types of business models for DSPV systems in the world were extracted from the literature review and content analysis. In order to perform a systematic review of the literature, the techniques presented in the works of Sovacool et al. [46] and Efron and Ravid [47] were used. We checked different types of literature, namely articles, book chapters, conference papers, and a selection of reports prepared by government agencies or organizations. This was carried out by searching for some keywords (solar energy, business model, DSPV, development of solar industry, PV, barriers, effective factors, challenges, and benefits) in well-known science databases, including ScienceDirect, Web of Science, Scopus, and Google Scholar. The reviewed pieces of literature were all originally written in English, with no limitation applied to the time or place of publication. Performing content analysis on a total of 42 relevant pieces of work on barriers to the PV industry, the barriers were identified and categorized in three levels. At Level 1, the barriers were sub-grouped into three classes, namely global, national, and industrial-wide barriers. At Level 2, a total of 11 sub-groups of barriers were distinguished, with all of the identified barriers (142 barriers) being present at Level 3. Moreover, from 37 relevant documents, we further extracted three business models differing the ownership and control.

Continuing with the analysis, semi-structured interviews were used to characterize the barriers to the PV industry in Iran. The studied society of this research includes academic professors in the field of renewable energy and environment and the activists of the photovoltaic and renewable energy industry. In fact, the sampling method is non-probability targeted (judgmental) sampling. The reason for using purposeful non-random sampling in this research is that selected people are in the best position to provide the required information [48]. Experts have the advantage of a much stronger understanding of situations and more experience and knowledge about causal relationships than novices. Therefore, in general, they provide more insightful opinions, and their opinions are deeper and more acceptable. The interviewees were 15 individuals, including experts at the Iranian power industry, academics, and energy policy setters (a list of whom is provided in Appendix A). The interviewees were asked to identify or, if needed, complete the barriers to the PV industry in Iran considering such barriers in the world. Next, the experts were kindly requested to rank the barriers to the PV industry in Iran by assigning a significance score to each of the 11 barriers at Level 2. Finally, the significance of each barrier was evaluated, a weight that was calculated by taking average value over scores assigned to that barrier by all interviewees and multiplying the result by the weighting factor of that barrier in relation to the entire pool of barriers.

Once ranking and weighting all barriers to the PV industry was complete, the experts were asked to select a business canvas for DSPV systems in Iran, considering ownership and control as the main selection criteria. With reference to a lean canvas, the interviewees were asked to score, using a 1–10 scale, three business models for DSPV systems in terms of their ability to address the identified barriers. Finally, the success of each business model was evaluated by summing up the products of the score of the model for tackling each barrier by the final weight of that barrier, as follows:

$$\text{Model Score} = \sum_{n=1}^{11}\left(\text{n}^{\text{th}}\text{ barrier weight } \times \text{model score for tackling n}^{\text{th}}\text{ barrier}\right) \quad (1)$$

Ultimately, the model attaining the highest score was selected as the business model for developing DSPV systems in Iran. Due to the lack of a clear policy for PV systems in Iran and the disparity of the measures taken to develop this industry, we used the panel of experts (Delphi technique) to complete the business canvas. In this study, a two-stage modified Delphi process was used to complete the business canvas [49]. As a well-known research methodology, the Delphi technique has been widely used in future studies. Using this system, relying on the expertise of the participants, one can predict the future and evaluate and explore the probability of occurrence and desirability of such predictions. The traditional Delphi technique was based on questionnaire completion, while a one in-person interview with each expert at least to achieve deeper inferences [50] was performed in this study. In the first-stage interviews, the experts were asked to complete the business canvas of the DSPV industry in Iran based on their own opinions. Once the first-stage data were collected, in the second stage, the experts were kindly requested to give their opinions on the developed canvas and provide corrections, if necessary. Finally, the developed business canvas was modified and completed by applying the experts' opinions.

4. Results and Discussion

4.1. Barriers to Developing DSPV in Iran

Performing content analysis on the relevant literature and semi-structured interviews, barriers to developing DSPV systems in Iran were identified at three levels. According to the experts, the identified barriers were ranked and weighted as depicted in Table 3.

Table 3. Barriers to developing DSPV in Iran.

	1st Level	2st Level	The Weighting Factor	3st Level (Major Barriers)	References
The identified barriers	International level	Global economy	0.10	Reducing oil prices	[51–53]
		Foreign policy	0.11	Sanctions, Political conflicts	[54–56], Interview
		International laws	0.06	Ignorance of international environmental laws	[57]
	National level	National policy	0.14	Electricity subsidy, Lack of support for clean energy production	[35,58–61]
		Macroeconomic	0.10	Inflation, Currency instability, High bank interest rates	[35,45,55,62]
		Sociocultural	0.03	Lack of awareness and sensitivity of society to renewable energies	[63–65]
		Geographical, environmental, and climatic	0.05	Lack of sufficient solar potential in some areas, Lack of enough space for PV panels	[66–68]
	Industrial level	System economics	0.14	Low electricity prices, Low down guarantee to buy electricity from the manufacturer, High cost of PV power generation, High cost of PV equipment supply	[35,45,61]
		PV supply chain technological capability	0.13	Lack of complete formation of PV production chain in Iran, The need to import equipment and accessories for PV systems, Iran's dependence on the production of advanced materials for PV panels	[56,63,69–72], Interview
		The capability of the electrical industry and technology	0.06	The low capability of the country's electricity network to connect PV power to the network, Power outage in the transmission network, Distribution and power grid problems	[71,73]
		Experts	0.06	Lack of specialized and trained technicians	[63], Interview

Barriers at the international level

International barriers include all political or policy-related factors beyond the Iranian territories that impose direct or indirect impacts on the development of PV systems. In the framework of the global economy, the most significant barrier is the oil prices. A reduction in oil prices favors the use of fossil fuels rather than renewables for generating electricity. This is especially the case in Iran with its huge oil reserves, where renewable resources, rather than fossil energies, are economically not efficient. Acting to reverse this flow, international climatic agreements such as Kyoto Protocol and Accord de Paris have failed to promote governmental approaches to the generation of clean energy. When it comes to Iran, however, the most important barriers hindering the development of DSPV systems include the burdens resulting from international sanctions and political disputes; these have interrupted the inflow of the required technology and equipment into the country and have kept international financing and foreign investment out of reach of the Iranian DSPV industry.

Barriers at the national level

A major domestic barrier is a national policy regarding energy, given the crucial significance of the orientation of government and legislator for the growth and development of renewable energies in any country. High levels of subsidies allocated to electricity, which has led to wide gaps between the power generation costs and the corresponding sell rates, and inadequate legislation in supporting clean energy are the most important barriers against developing DSPV industry in Iran. Promotional policies in Iran have been limited to two main programs: (1) guaranteed purchase of the generated electricity by domestic renewable systems at a higher rate (the per-kWh rate for the PV-generated electricity is currently 10,400 IRR and 9100 IRR for systems with output powers of up to 20 kW and 20–100 kW, respectively, compared to the relatively low rate of electricity (~ 1000 IRR per kWh) in Iran)) and (2) requiring all governmental electricity consumers to obtain at least 20% of their power requirements from renewable resources.

Add to this the special economic conditions under which the country is operating. Without any doubt, a country suffering from serious problems in its macroeconomy, including high inflation rates, highly unstable currency, and high interest rates, cannot gain adequate support from domestic investors for developing such DSPV systems.

Alongside the political and economic barriers, there are geographic, climatic, and environmental barriers that tend to affect the development of DSPV systems in Iran. Lack of adequate space for implementing PV systems, variations in solar radiation potential over different geographical locations, and operating conditions, in terms of humidity and temperature, for these systems are examples of non-political non-economic barriers affecting the development of DSPV systems.

Public awareness and trust in clean energy systems can accelerate the development of DSPV systems in a country. When public awareness about the necessity of transition from energy fossils toward clean energies is established, people and non-governmental organizations (NGOs) tend to see such a transition as a concern. In Iran, the lack of such awareness and insensitivity of a society toward clean energy has acted as a big social barrier to the development of such systems.

Barriers at the industrial level

The power industry- and technology-related barriers include grid connection problems, power outage on transmission and distribution grids, and the development of smart grids. Add to this the lack of technological capabilities for establishing a complete domestic supply chain for PV systems, including the production and procurement of solar panels, which has led to a dependence on the imports of the required products and peripherals. PV-related economic parameters, including high prices of PV modules and their high maintenance costs, coupled with low electricity costs and the inadequacy of the guarantees furnished to ensure that once generated, the electricity will be admitted by the grid (due to inadequate revenues for the utility companies as a result of low electricity sell rates) are also major barriers against developing DSPV systems in Iran. Last but not least, deficiencies in the required human resources in terms of expertise and skills at different segments of the supply chain and maintenance sector were found to represent another factor affecting the development of PV systems.

4.2. Business Model for DSPV in Iran

Considering the business models introduced in the literature review, three business models were focused, differing in ownership and control, for managing the canvas of DSPV in Iran:

Model 1: Third-party/customer-owned and controlled business model
Model 2: Utility-controlled third-party/customer-owned business model
Model 3: Utility-controlled and owned business model

Analyzing the collected data and experts' opinions, the ability of different business models to cope with the identified barriers to the PV industry in Iran was evaluated (Table 4). Once the three models were scored by the experts in terms of their ability to address different barriers, we came up with a final score for each model. According to all experts, Model 1 was identified as the best business model for developing DSPV systems in Iran.

Table 4. Capability scores of various business models differing in ownership and control for tackling the barriers to the development of DSPV in Iran.

	1st Level	2st Level	The Weighting Factor	Model Score		
				Model 1	Model 2	Model 3
The identified barriers	International level	Global economy	0.10	6	6	3
		Foreign policy	0.11	4	4	6
		International laws	0.06	0	0	0
	National level	National policy	0.14	4	2	1
		Macroeconomic	0.10	1	1	3
		Sociocultural	0.03	8	6	1
		Geographical, environmental, and climatic	0.05	7	7	2
	Industrial level	System economics	0.14	4	3	1
		PV supply chain technological capability	0.13	5	5	2
		Capability of electrical industry and technology	0.06	3	3	4
		Experts	0.06	8	8	8
The final score of the model				4.16	3.68	2.65

In the third-party/customer-owned and controlled business model, a customer/third party initiates purchasing and installing PV panels and then sells the entire or part of the generated power to the grid. The choice of time when such a sale to the grid takes place is entirely controlled by the customer/third party. Following the research, the business canvas of the Model 1 (Table 5) was completed using the Delphi technique on the basis of the experts' opinions. Due to the lack of a clear roadway for the development and DSPV systems in Iran, the experts' opinions were categorized under two broad classes, namely, the activities performed so far and those anticipated for developing DSPV systems in Iran. Since DSPV systems are yet to be declared an independent business in Iran, DSPV-related activities performed so far have been barely sporadic. Accordingly, based on the experts' opinions, the performed activities of the business Model 1 in the relevant canvas were marked by asterisks (*).

Table 5. Third-party/customer-owned and controlled business canvas for developing DSPV systems in Iran.

<table>
<tr><th>Customers</th><th>Customer Relationship</th><th>Value Proposition</th><th>Core Activities</th><th>Key Partners</th></tr>
<tr><td rowspan="3">-Mass customers: all Iranian citizens, as they all practically enjoy environmental benefits of this technology and can potentially generate and sell electricity.
-Diverse customers: investors and operators of power from non-distributed PV systems (most of whom step in the market for generating some revenue, although some of them invest in this industry for the sake of environmental concerns or achieving stable power supplies)
-Niche markets: these include public authorities that seek to generate some revenue. Examples include Imam Khomeini Relief Foundation and Organization of Owghaf and Charity Affairs.</td><td>-Agreement between SATBA* () and electricity distribution company
-Contract between electricity distribution company and investor customer through different channels, including relevant website, etc.
-Corresponding contracts between different segments of the supply chain</td><td rowspan="3">-Generation of clean and eco-friendly electricity
-Guaranteed purchase of electricity at promotive rates (ensuring sustainable income from sales of renewable power to the electricity grid for customers)
-Insensitivity to possible fluctuations or power outages across the nation-wide grid, especially for key customers
-Installation and maintenance services for PV system</td><td>-Budget allocation and expenditure
-Concluding contract between SATBA and electricity distribution company
-Concluding contract between electricity distribution company and customer
-Transporting PV systems to the site of work
-Sale and maintenance of the systems
-Transacting funds in relation to the generated power</td><td rowspan="3">-Electricity distribution companies
-Ministry of Energy
-SATBA
-Suppliers of required equipment
-Maintenance companies and experts
-Banks and financial supporters of customers</td></tr>
<tr><td>Distribution channel</td><td>Main resources</td></tr>
<tr><td>-Electricity-bill exchange channel
-Transportation and distribution of system components
-Counter distribution
-Sellers
-Equipment stores</td><td>-Government-backed budgets for purchasing electricity from power generator customers
-Human resources, including experts at installation, start-up, and maintenance of PV systems
-non-tangential resources, including environmental requirements caused by domestic or foreign forces</td></tr>
<tr><td colspan="2">Revenue streams</td><td colspan="3">Cost structure</td></tr>
<tr><td colspan="2">Although the system is not currently aimed at revenue generation, different parties are involved in monetary transactions.
Indeed, the primary gain of the system is latent and includes environmental benefits for social health upon widespread development of this system, preservation of fossil energy, creation of value-added in relevant sectors, etc.</td><td colspan="3">Costs incurred for implementing the business model, including current costs, cost of equipment procurement for customers, and electricity purchase cost</td></tr>
</table>

* SATBA: Renewable Energy and Energy Efficiency Organization of Iran.

Value proposition

Service companies are responsible for the installation and maintenance of PV systems, and the owners can carry out the installation and start-up of the system by themselves to establish a revenue stream within the system. Under this business model, the owner installs the system on the rooftop or other suitable spaces to generate electricity; the generated electricity is then either consumed itself or sold out to the grid. This keeps the owner well protected against possible fluctuations, presenting a great benefit for sensitive consumers such as hospitals and medical centers. According to a resolution by the Ministry of Energy (Ref. No. 100/20/15224/1400 dated May 2021), the Iranian government guarantees the purchase of electricity from power plants operating at maximum output powers below 10 MW (the per-kWh rate for the PV-generated electricity is currently 10,400 IRR and 9100 IRR for systems with output powers of up to 20 kW and 20–100 kW, respectively, compared to the relatively low rate of electricity (~1000 IRR per kWh) in Iran). Given this, customers can generate some revenue by selling the entire deal or part of the generated power to the grid. Seen as a value, this revenue encourages the customers, investment companies, and niche markets toward stepping into the business. Furthermore, the use of renewable energy itself is a core value of this business.

Customer segments

All Iranian citizens are customers of a DSPV system as they all practically enjoy the environmental benefits of this technology and can potentially generate and sell electricity. Investors and operators of power generation systems from non-distributed PV technology can step into the market and invest in generating revenue, although some of them do the same for the sake of environmental concerns and/or their need for a sustainable power supply. Niche markets are public authorities that seek to generate some revenue. Examples include Imam Khomeini Relief Foundation and the Organization of Owghaf and Charity Affairs.

Distribution channels

The main distribution channel for PV equipment is made up of energy service companies that merchandise PV equipment and the required after-sale services by means of their websites or environmental advertisements. Moreover, upon the installation of net-metering counters by the Tavanir Organization, an exchange channel is developed for the electricity as a product, and a monetary exchange channel must be further established for exchanging bills and money between customers and Tavanir Organization.

Customer relationship

Establishing effective and supportive relationships with customers builds on trust in renewable energies. Accordingly, informing about the agreement between SATBA and the electricity distribution company for guaranteed purchase of the generated electricity, concluding a contract between the electricity distribution company and the investor customer through various marketing channels such as direct sale via service provider companies or relevant websites, and signing corresponding contracts between different sectors of the supply chain for procuring and supporting PV systems contribute to the mentioned objective.

Key activities

In the proposed model, the key activities for attracting customers and building on trust include signing agreements and contracts or supporting them via after-sale services by means of customer relationships. Budget allocation, signing an agreement between SATBA and electricity distribution companies, concluding contracts between electricity distribution companies and customers, transporting the systems to the site of installation, maintaining the systems, and surveilling the power generation and exchange of its price is among the key activities in this model.

Key partners

Ministry of Energy, electricity distribution companies, Iran's power generation, distribution, and transmission holding company (Tavanir), and customers (owner of DSPV systems or end-users of electricity) are the key partners in the proposed system. As key partners, STABA, the government, the parliament, other relevant authorities, banks, and other financial supporters support and encourage the customers toward adopting this system. Added to the list of key partners are the suppliers of the equipment and service companies supporting PV systems.

Key resources

In this model, key resources include three groups of resources, namely, credit resources, human resources, and spiritual resources. The government shall furnish the required financial credit for purchasing the generated electricity from customers in virtue of subsidies, taxes, and penalties. Human resources refer to expert human resources in installation, start-up, and maintenance of PV systems. Spiritual resources are indeed environmental requirements for generating energy from renewable energies in virtue of domestic laws (issued by the Environmental Protection Agency) as well as international treaties (e.g., Kyoto Protocol and Accord de Paris).

Cost structure

The core activity of the model is to develop the system among customers via existing channels. Accordingly, the costs of implementing this business model include equipment procurement cost, current cost, and support service cost, forming the cost structure for the customers. At the end of the spectrum, the cost of purchasing the generated electricity by the Ministry of Energy tends to complete this cost structure and establishes a flow of funds within the system.

Revenue streams

Although the system is not currently aimed at revenue generation, different parties are involved in latent revenue streams related to the trading of PV systems and generated electricity. Indeed, the primary gain of the system in Iran includes environmental benefits for social health upon the widespread development of this system, preservation of fossil energy, creation of value-added in relevant sectors, etc.

Finally, the participants stipulated that despite the tendency of the Ministry of Energy and SATBA toward purchasing as much electricity as possible from renewable resources, the high levels of subsidies allocated to electricity in Iran have led to numerous problems for providing the required funds for paying the electricity-purchase contracts prices. In this respect, the experts referred to low-interest loans funded by banks, tax reliefs, and special supportive laws for renewable electricity (e.g., requiring all government-administered users of electricity to supply a minimum of 20% of their consumption from renewable resources) as possible solutions to this problem, increasing the motivation of the electricity customers and third parties toward investing in this industry. Accordingly, before a proper environment is prepared for carrying out business in this industry and tackling the identified barriers, one must define clear roles for different components of the business canvas and clarify the way such components interact within the system. Therefore, considering the roles of different players in this business canvas and the downstream flow of adopting the PV industry and tackling the barriers, the experts' opinions were devised to complete the model (Figure 3).

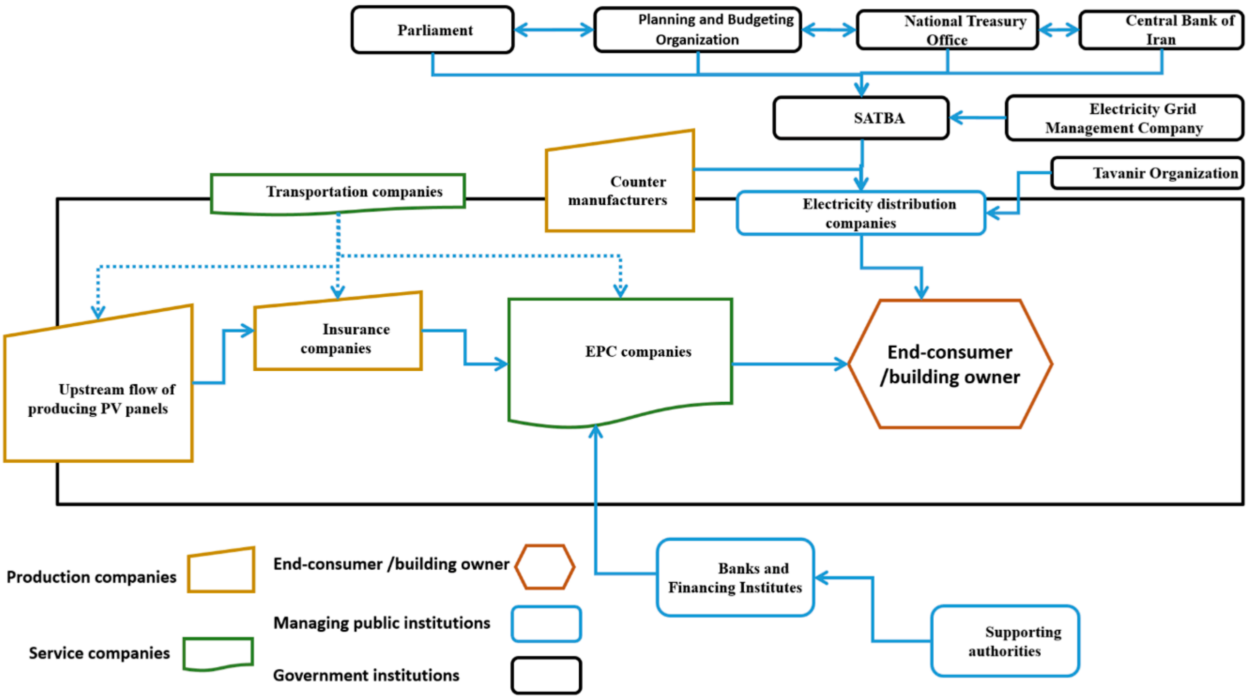

Figure 3. The business model of developing DSPV systems in Iran: from the supply chain to end consumer/building owner.

The components shown in Figure 3 play the following roles:

Central Bank of Iran: Determining the exchange rate and adjusting the trend of inflation rate.

Planning and Budgeting Organization: Preparing budget plans for the country and allocating the required funds for developing renewable energies.

National Treasury Office: Operating under the administration of Financial Surveillance and Treasury Deputy to the Ministry of Economic Affairs and Finance, this office is responsible for allocating funds monthly.

Electricity Grid Management Company: Exchanging the price of generated electricity across the grid over the electricity market.

Tavanir Organization: Determining technical requirements of connection to the grid and coordinating electricity distribution companies for working with SATBA as the upstream authority to the electricity distribution companies.

SATBA: Signing agreements with electricity distribution companies for promoting them toward interacting with customers and paying the price of generated electricity while receiving some operation fee.

Electricity distribution companies: Signing contracts with interested customers, surveilling good performance of the contract, reading production quantities on a monthly basis and paying the price, and preparing a list of recommended contractors for the customers or third parties.

The upstream flow of producing PV panels: Manufacturing solar cells or modules from poly (silicon) to ingot and then wafer. These components can be either domestic or foreign-sourced; as of present, the panels and inverter are usually foreign-sourced, with the other components made domestically.

Engineering, Procurement and Construction (EPC) firms: These are contractors and suppliers of equipment, engineering, and power plant construction. They are responsible for procuring equipment (supplying the modules, system, and peripherals) from domestic or foreign sources and providing engineering design and power plant construction services (design and assemblage of domestic power generation systems followed by their maintenance).

Insurance companies: These companies must guarantee the quality of equipment. Currently, however, there is no insurance company that can actually guarantee the efficiency of the system as a whole and its components, with the offered insurance coverages being limited to civil liability insurance.

Transportation companies: Facilitating the process of transporting and distributing the required equipment items over different parts of the supply chain.

Counter manufacturers: Procuring smart two-way counters.

Banks and Financing Institutes: Financing third-party intermediating companies, supporting agents, and/or customers and receiving monthly reimbursements.

Third-party or suppliers: Financing the customers and performing administrative and executive tasks including the design, construction, and fee-based maintenance; examples are energy services companies. A minimal number of such companies have been established in Iran, with them being yet to take any effective action in practice.

Supporting authorities: These are supposed to finance customers and assist them in doing administrative and executive steps for free (supportive). An example of such authorities is the Imam Khomeini Relief Foundation, which is supposed to finalize general contracts with suppliers or design and engineering companies and specific contracts with customers.

Once finished with declaring the proposed roles for different players of the industry and the introduced business model, the success of the model in tackling the identified barriers was evaluated, as listed in Table 2. The effective contribution of banks in terms of furnishing loans and facilities alongside supportive investments by supporting authorities and non-profit organizations tend to partly alleviate the negative impacts of fluctuations in the exchange rate and domestic economic problems. Given that the customer/third party is the investor in this business model, the required geographical location and climatic conditions are fully under control as the investor is free to select the best place for the power plant. Customer relationship channels can be established via physical and online advertisement to enhance social awareness and promote the culture of adopting clean energies. The Planning and Budgeting Organization and National Treasury Office reflect the political contribution of the government to the industry by allocating the required funds, albeit one must consider the necessity of legislation by the parliament toward promoting such systems in the future. In order to provide consistent services and support, EPC companies are responsible for training expert human resources. In the meantime, the lack of upstream processes for domestic manufacturing of PV panels in Iran tends to limit the provision of human resources, industrial capabilities, and related technologies and infrastructures. The production of smart counters and incorporation of DSPV systems into the grid reflects the capability of the power industry in adopting DSPV systems.

5. Conclusions

Thanks to great solar radiation potentials, Iran is highly suitable for developing PV systems. Given the absence of any appreciable research on the development of DSPV systems in Iran, a business model was developed for this industry, and the extent to which it can tackle the barriers to the development of this industry was further investigated. First, based on a literature review, the barriers to the PV industry were identified at three levels, followed by formulating three business models differing in ownership and control. Next, the barriers were weighted, and the models were completed based on semi-structured interviews with experts in the PV industry in Iran. The experts' opinions were then utilized to score the success of the business models for developing DSPV in Iran in overcoming the identified barriers. Analyzing the results of interviews and calculating final scores for different models, the customer/third party-owned and controlled model was found to be the best business model for developing DSPV systems in Iran, as per the experts' opinions. It is worth mentioning that energy prices in Iran and the decreasing trend of oil prices in the world (from 97.98 USD/STB in 2013 down to 39.68 USD/STB) have interrupted positive revenue streams that were otherwise anticipated for DSPV systems, leaving the spiritual and environmental aspects of the industry as the only concerns that are being focused on at the moment. Moreover, the current laws and policies codified by SATBA are inadequate to guarantee the purchase of electricity at a rate that is about ten times higher than the sell rate to customers, with the required financing for purchasing PV modules still being the main barrier to enter the industry. This barrier can be tackled by increased participation of financing institutes for providing the required funds for importing the needed equipment and furnishing low-interest loans to interested customers. This can be facilitated by legislating promotional laws to encourage such customers. Finally, the roles of and relationships between different players of this business model were explained thoroughly.

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Appendix A

-Semi-structured interview

Considering the applications of different types of interviews and the interviewees (experts in renewable energies), semi-structured interviews were used in this work. Accordingly, all participants were asked similar questions in relation to the development of DSPV systems in Iran, although they had the liberty of presenting their answers in any manner they found appropriate, with the researchers coding and classifying the answers afterward.

In order to take advantage of relevant experts, a group of experts and managers in the renewable energies industry were selected. A brief summary of the participants is given in the following. Since two primary questions were asked from the experts at this stage, the following qualifications were necessary for the participants:

Experts' qualifications in relation to the criteria and their classification: The experts must be well familiar with requirements of developing renewable energies, the criteria considered by micro investors, industrial development and its relation to the development of renewable energies, world-class conventional methods of new technology development, especially renewable energies, managerial and strategic perspectives, strategic methods and atmosphere of Iran in relation to the development of renewable energies.

Experts' qualifications in relation to the current business model of using PV technology: In addition to the qualifications mentioned earlier, the experts must be well informed about the current method adopted by the government (i.e., Ministry of Energy) for supporting renewable energies as well as supply and value chains of the PV technology. He/she must be relatively familiar with specific budgeting solutions and relevant regulations in Iran.

On this basis, the individuals listed in Table A1 were selected, with their relevance and expertise categorized, as per the two sets of qualifications indicated above, under three classes of excellent (***), fair (**), and moderate (*).

Table A1. List of the experts selected for semi-structured interviews in this work.

Number	Post	Relation to the Criteria	Relation to the Current Business Model
1	Former Technical Deputy of the Renewable Energy Organization of Iran	***	**
2	Former Planning and Development Deputy of the Renewable Energy Organization of Iran	***	***
3	Regularity office Manager of the Renewable Energy Organization of Iran	**	***
4	Renewable energy development expert	**	***
5	Advisor of the Renewable Energy Organization of Iran	*	***
6	Former deputy Energy Technologies Development Headquarter	**	**
7	Deputy Minister of Energy Affairs of Center for Progress and Development of Iran	***	*
8	Deputy Minister of Non-Governmental Development of the Renewable Energy Organization of Iran	***	***
9	Former manager of the Licensing Office of the Renewable Energy Organization of Iran	*	***
10	A faculty member of Malek Ashtar University of Technology	**	**
11	The former head of the Presidential Center for Technology Cooperation and Innovation and President of the Renewable Energy Association	***	*
12	Member of the Board of the Renewable Energy Association	***	**
13	Technical and Executive Vice President of Renewable Energy and Electricity Efficiency Organization (SATBA)	**	***
14	Master of Regulation of Renewable Energy and Electricity Efficiency Organization (SATBA)	***	***
15	Director of the Clean Technologies Department of the Presidential Center for Transformation and Progress	**	**

*, **, ***: Good, Very Good, Excellent.

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