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Factors Affecting Photovoltaic Technology Application in Decentralized Electricity Production in Iran: A Conceptual Framework

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ABSTRACT

Using a variety of solar power plants is one of the solutions governments use to respond to energy and sustainable development needs. While Iran has a strong potential for using solar energy, the application of solar energy, especially through PV technology, has been limited due to the country's richness of fossil fuels and their low prices. Therefore, it is important to adopt effective strategies and policies to promote the development and application of this technology. The purpose of this study is to identify factors affecting the use of photovoltaic technology in Iran. To this end, 142 factors were first identified through a comprehensive review of the literature. Then, all of these factors were prioritized and categorized by "semi-structured interview" with 15 energy policy experts. The "content analysis" of the experts' opinions showed that only 59 of these factors were considered important at the sectorial level for Iran. Based on the same content analysis, a conceptual framework for the application of decentralized photovoltaic power plants in Iran was developed. The framework shows that 10 generic categories of factors should be considered by policy-makers at the solar energy sector to promote PV technology application in Iran. They include policy factors, institutional factors, finance and budgeting factors, system economy factors, macroeconomic factors, socio-cultural factors, human resource factors, factors influencing capabilities of industries, technological and related infrastructural factors, geographical, climatic and environmental factors, and foreign political factors. It is also emphasized that all these categories should be considered at three levels: industry (electricity industry) level, national level, and international level. Thus, renewable energy policy-makers in Iran should take into account all means that influence these factors in order to improve the conditions for decentralized photovoltaic technology application.

1. INTRODUCTION

"Energy" is one of the important issues in the development of countries, which has a great impact on the economy, social welfare, international relations, and the environment conservation of societies. According to the EIA[2], the required amount of energy in 2040 will increase by 56 % compared to 2010 [1]. This direction and also environmental concerns have led to the use of renewable resources in the entire world. In recent years, there has been a shift in the types of policies that are being proposed to reduce greenhouse gas (GHG) emissions. The first wave of GHG policy initiatives focused primarily on the regulation of GHG emissions in the power sector, as well as direct fuel efficiency targets in the transportation sector and appliance efficiency standards in the residential and commercial sectors. However, reducing GHG emissions by 80 % by 2050, relative to 1990 levels, consistent with the Paris Agreement, has become a stated environmental goal in many states and localities. Solar energy, as one of the most important sources of renewable energies, has the greatest potential for providing the future energy demands of the world [2]. Photovoltaic technology as the most commercialized form of solar energy is one of the solutions for governments to respond to energy demand and approach to sustainable development. The PV[3] market in 2016 for the world comprised 77.3 GW of these systems. Besides, the annual CAGR[4] for photovoltaic systems in the 2010 to 2016 period is 40 %, indicating a rapidly expanding market for this technology and industry. According to the IEA[5] and IHS[6], at the beginning of 2017, the installed capacity of photovoltaic systems in the world reached 320 gigawatts, equivalent to 1.3 % of the world's total electrical energy. This amount is 160 GW for every European countries, equivalent to 3.4 % of their electricity generation and for Germany 41 gigawatts, equivalent to 6.9 % of Germany's electricity production [3]. However, this figure for Iran at the same time was less than 100 megawatts [4]. This figure shows that PV usage in Iran is less than the world's average in the electricity basket. Meanwhile, Iran is located in high radiation of the earth, with 300 sunny days in more than two-thirds of the year and average radiation of 4.5-5.5 kWh per square meter per day, which is one of the countries with high potential in the field of solar energy [5].

This potential and the benefits of using renewable energy such as solar energy have created the upstream legal requirements for the development of renewable energy sources in Iran. At the same time, the availability of fossil

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2 U.S. Energy Information Administration

3 Photovoltaic
4 Compound Annual Growth Rate
5 International Energy Agency
6 HIS Markit

fuels in Iran is one of the main reasons for the difficulty of moving towards renewable energies. According to the EPI ranking index, which identifies the country's environmental performance index, in 2018, Iran ranks number 80 in the list of countries. It indexes countries based on the 25 indicators that cover the overall health of the environment and the ecosystem's life [6]. Further, the EAPI ranking indexes countries in terms of performance of energy systems, and according to 2017 ranking, Iran ranked 120th [7].

The development of renewable energies, especially solar energy, is mentioned in some of the upstream documents of this country. For example, general policies of the energy sector approved by the Expediency Council regarding technology and technical know-how are addressed to acquire new energies and construct power plants such as solar, wind, fuel cells, and geothermal energy. In addition, the policies communicated by the Supreme Leader for reforming consumption patterns have emphasized the importance of diversifying electricity generation methods and increasing the share of renewable and non-renewable energies.

Moreover, The Sixth Program Law of Economic, Social, and Cultural Development of the Islamic Republic of Iran has stated that “the government is obliged to increase the share of renewable and clean plants with the priority of investing the nongovernmental sector (domestic and foreign) with the maximum use of domestic potentials, and by the end implementation of the program law, this capacity should reach at least 5 % of the total electricity capacity”. With the emergence of a new legal capacity since 2014, a better relative growth has been made in utilizing this technology. By adopting and informing the 2013 Budget Law involving the subject of “Pretension 30 Rials per kilowatt of electricity consumption except rural consumers”, various related activities have been carried out in the country. Due to this law, the guaranteed electricity purchase price has been modified, and a relative progress in implementing and installing renewable energy power plants, mostly PV and wind, has been made [8]. However, this trend is not complete and should be accompanied by the completion of different chains to maximize the effectiveness of all internal capacities.

There are several obstacles for governments and policy-makers in the entire world to deal with the capacity of exploiting renewable technologies. The main issue of these obstacles is related to the competitiveness of these technologies with conventional technologies such as fossil fuel thermal power plants. excluding many benefits of clean technologies, such as CO_2 avoidance factor, has led states to take policies and interventions to determine benefits that are not economically calculated. Although these policies are somewhat similar to those of other clean alternatives, e.g., among wind, PV, and geothermal technology, there are also differences and distinctions. For example, photovoltaic systems can produce electricity on a small and domestic scales, so that they have capabilities and complexity of their own for special planning. In addition, these policies vary from one country to another, and from one region to another in a number of cases because of different requirements such as different sources, political and social conditions, alternative fuels, energy prices, and technological capabilities.

The purpose of this paper is to identify those factors that influence the development of the use of photovoltaic technology in Iran on distributed generations scale, categorization of these factors, and achievement of a conceptual framework.

2. RESEARCH METHOD

This research is qualitative and its approach is descriptive. Because of the complexity of renewable energy development, such as PV technology, the influencing factors in development of DG-based electricity generation by photovoltaic systems in Iran should be identified. This purpose can be found by some parts of literature sources:

i. General factors affecting renewable electricity development all around the world, especially in Iran;
ii. The influencing factors in development of the industry and technology of photovoltaic technology;
iii. Frameworks and models proposed or used in different countries about similar topics.

In this regard, we did literature reviews and used databases such as Scopus to identify the most influential factors in the development of renewable electricity and the development of the PV applications.

After recognizing factors, and by using patterns, models, and frameworks in the literature, the relationship between the factors was addressed and the framework was formed. Categorized factors and their sub-criteria or indicators, and the initial framework have been validated through “interviews with experts”. These interviews were formed by 15 experts in policy-making and planning for renewable energy development in Iran. The interviews were done in the form of a “semi-structured interview”.

3. INFLUENCING FACTORS IN DEVELOPMENT OF PV TECHNOLOGY USAGE IN ELECTRICITY GENERATION

A sustainable energy development program requires a multilateral intervention to develop a transparent vision of the issues and beyond committed support periods [9]. For a better classification of the factors, first, resources that are related to the development of renewable energies are considered; in addition, the resources for the development of power generation by PV technology are investigated.

3.1. Factors and elements affecting the development of renewable energy usage

L. Byrnes et al. have reviewed the barriers and challenges of renewable energy policies in Australia. They pointed out that effective policies and regulatory frameworks for encouraging the use of renewable energy are the best ways to reduce carbon emissions over the long term. Further, the lack of support for emerging technologies delays the efficient use of these technologies and the accumulation of expert human capital in the long run. Network connectivity costs, policy uncertainty, social/institutional acceptance, and the impact of networks, villages and isolated points of the network are key challenges facing renewable energy development in Australia [10]. T. Mezher et al. have pointed out that climate change and the reduction of fossil fuels are the main drivers for the recent focus on renewable resources. At the same time, the high price of renewable energy technologies is a major barrier to renewable energy utilization that makes it necessary for economic and political interventions. Sustainable policies and their amendment, government support of costly technologies that are growing, solving network connectivity problems, facilitating finances, supporting industrial production, and raising public awareness are mentioned as important experiences. The realization of the cost of generating electricity from fossil fuels together with environmental, social, and electrical costs per capita income of the country is emphasized [11].

H. M. Wee et al. evaluated the renewable energy sources in terms of the supply chain. Based on the overall value chain of the renewables, they also considered the concerns of each part in the following way [12]:

Supply	**Production**	**Distribution**	**Demand**
• Land usage • Water consumption • Intermittency • Variability • Manoeuvrability • Technology limits	• Location • Conversion efficiency • High investment • High cost • Technology limits • O&M costs • Employment	• Distribution efficiency • Storage • Employment	• Environmental impacts • Government policy • Substitution effect • Social impacts

Figure 1. Renewable Energy Considerations [12].

In an article entitled "What drives renewable energy development?", L. Alagappan et al. investigated renewable energy development in 14 markets, each with a different market structure, use of feed-in-tariff (FIT), transmission planning, and transmission interconnection cost allocated to a renewable generator. They found that market restructuring was not a primary driver of renewable energy development. The renewable generation has the highest percentage of total installed capacity in markets that use a FIT, employ anticipatory transmission planning, and have loads or end-users paying for most, if not all, of the transmission interconnection costs [13].

In Taiwan, the "Sustainable Energy Policy Principles" were unveiled in 2008, and the Taiwanese government declared that the development of renewable energy should take into account goals that pertain to energy, the environment, and the economy. In an article by Yung-Chi Shen and his colleagues, these three goals have been assessed. These criteria include the sustainability of energy prices, energy security, low energy prices, energy sustainability, carbon footprint reduction, reduction of NOx emissions and SOx, environmental sustainability, the need for smaller space, local economy development, employment growth, technology maturity, capacity and potential for commercialization, market dimensions, and the logic of investment cost [14]. The advantages and disadvantages of solar energy include the sustainability of energy prices (with price changes over time), energy security (with the reinforcement of complementary and storage systems), low energy prices (with price-cutting mechanisms), local economic development (with increasing public awareness and social participation), and the logic of the investment cost (through supportive policies) can be used as criteria used in our search.

A. Verbruggen et al. found that "technological innovation", "economy" (costs and prices), and "policies" had to be aligned and coordinated with each other to achieve full renewable energy potentials, and remove barriers impeding growth [15].

Rolf W¨ustenhagen and Emanuela Menichetti showed strategic choices for renewable energy investments derived from the best papers presented at the international conference in St. Gallen of Switzerland as a special issue. In the introduction section, they emphasized that we need private partnership and investment to meet the public policy goals of increasing the share of renewable energies and preventing dangerous climate change. They have pointed out that the role of understanding the return of risk, portfolio effects, and path dependence has been neglected in explaining energy investment decisions, and suggested that the non-heterogeneous world of investors requires a policy split [16]. In this article, the authors emphasize the linkage of policies with the amount of investment. According to what is learned from this paper, the separation of policies and tools for a variety of resources, technologies, and even the dimensions of renewable energy is required.

In a review article, G. Liu developed a general sustainability indicator for renewable energy systems. He pointed out that, despiting the positive effects of renewable energy at hand, one of their most important problems is the highly complex assessment of the stability of these systems [17]. The following figure also shows that the overlapping of criteria with each other that should be accepted.

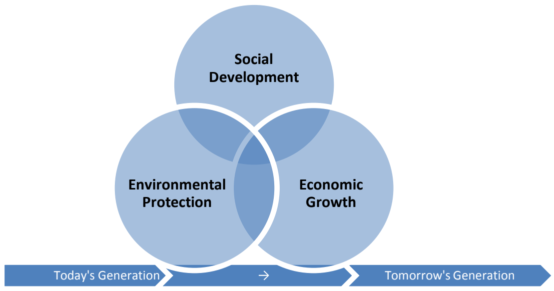

Figure 2. The dimensions and interactive process in sustainability.

A list of indicators selected for each of the criteria is as follows:

i. Environmental: CO_2, NO_X, and SO_2 emissions, energy efficiency, and renewable energy share;
ii. Economic: Costs (including capital cost, replacement cost, and operation and maintenance cost), return of investment, and payback;
iii. Social: job creation and benefited residents.

N. H. Afgan used the resource, environmental, social, and economic criteria in articles to assess energy systems with sustainability criteria [18] and [19]. At the same time, the researcher used the categorization of functional, market, environmental, and social criteria in another paper that seeks to assess the sustainability of hydrogen energy systems [20]. In another article written by the author about biomass systems, the ecosystem and the human system were given more attention [21]. The same issue of two ecosystem standards and human affairs was taken seriously in articles by Y. A. Phillis [22] and [23] as well.

In a research study conducted by V. Nikolai (2005), the quality of the resource, and economic, environmental, technological, and social issues were considered [24]. A. C. Brent (2010) investigated rural areas in Africa considering economic, institutional, context, sociological, and technological criteria [25].

W. M. Chen et al. (2010) reviewed the policies in three countries of East Asia: Japan, South Korea, and Taiwan. They examined and compared the strengths, weaknesses, opportunities, and threats (SWOT) of these countries in the framework of making progressive policies and providing technologies in terms of increasing domestic installation and exporting clean energy technologies to other countries [26]. A review of their research and set of strengths, weaknesses, threats, and opportunities led to a wealth of criteria for this study. In Japan, incentive tariffs, availability of renewable energy sources, qualified specialists, and advanced industries are considered as the strengths; dependency on nuclear power, lack of network access, and inefficient standards of renewable energies are considered to be weaknesses. General tendencies towards renewables, especially after the Fukushima incident, increased investments in the renewable sector from the business sector, local governments, and nongovernmental communities, especially in PV, wind, and the creation of multiple programs for reducing the provisions of the renewable energy sector are opportunity points. Restarting nuclear power plants through high lobbying power and, increased foreign competition are considered as threats. In South Korea, the significant potential of renewable energies, historic experience of rapid industrialization and technology acquisition, and the possession of some advanced technologies, such as IT and automation are strengths; further, the conservative goal of renewable energy deployment, low electricity prices in Korea, and ambiguity about the direct contribution of renewable energy technologies to the economy are among the weak points.

A. Darmani (2017) studied “typology” for identifying systemic drivers of renewable energies. In this study, the role of innovation in the framework of the innovative technology system (TIS) was emphasized, and the forefront motivation of renewable energy technologies was achieved [27]. He determined four categories of system structural elements and an additional group as a source of drivers in his research.

i. Incentives for actors (whether individuals or public or private organizations);
ii. Institutional or extrinsic incentives including hard institutions: policy formality, policy stability, and policy conformity; soft institutions: market norms and societal norms;
iii. Network incentives: The relationships among different firms, governments, knowledge institutions, and the third parties that have been interpreted as orchestrated are generally formed to solve a specific problem such as standardization networks, public-private partnerships, supplier partnerships, and so on;
iv. Technological incentives, as an integral part of the technology-based industry are inherent in the TIS. Technology specifications and technology infrastructure are two of the key factors behind this;
v. Regional incentives: The status of renewable resource in the region and the impacts of renewable energy extraction on the ecosystem of the region are among the main factors.

According to the results presented in the article, the role of the institutional part was found to be more affective than the others; the role of actors comes next. The role of the region, of course, was considered to be a minor role comparing other areas. The findings indicated that countries that nurture multilateral drivers enjoy a more successful development rate (i.e., Germany and Spain).

Afsharzadeh et al. (2016) discussed the importance of distributed generation renewable energy and analyzed the development conditions of rural areas in Iran. It was concluded that although renewable energy had the potentials for the development of rural areas in Iran in environmental, economic, and social terms, they faced challenges such as infrastructures, economic issues, cultural, social, and managerial concerns; therefore, an innovative and aggressive policy was required to cope with these challenges [28]. Moreover, F. Atabi (2004) determined the challenges and opportunities of sustainable development by renewable energy and found the following items [29]:

i. Lack of infrastructure, capital, and knowledge related to the capacity of renewable energy;
ii. Insufficient social and environmental policies and programs to encourage its use and application;
iii. Lack of training, repairs, and capacity to purchase technology;
iv. The practice of applying technical standards, and exerting severe restrictions on the rapid development of renewable technologies.

In a paper devoted to geothermal energy capacity in Iran, Noorollahi and Yousefi (2008) pointed out that changes in the current energy policies, incentive provisions for renewable energy, training and development of human resources, the creation of a basic flow for maintaining and promoting human resources, and planning for the technology transfer through international agreements were the main measures for the sustainable development of energy in Iran [30].

According to the “Islamic Parliament Research Centre of The Islamic Republic of Iran” (2015), the main challenges for development of renewable energy in Iran are the low cost of conventional energy compared to renewable energy, lack of national consensus among policy-makers and decision-makers on the importance of investment in renewable energy, and lack of accurate planning for renewable development (quoted from [28]). Moreover, transaction costs, uncertainties of policies, and implementation schemes increase the risk of renewable energy projects and reduce the incentives provided by the FIT in Iran. Consequently, government incentive packages cannot attract investors; hence, the gap between investor expectations and government policies appears. Other points worthy of consideration in this regard are energy storage solutions and better facilities for electricity grid connecting [28].

M. J. Bürer and R. Wüstenhagen (2009) explored the private sector's preferences for investing in clean energy. The study of the comparative benchmarking trend showed that financial policies that can affect the competitiveness of renewable resources were more promising. Therefore, the incentive tariffs and reduction of fossil fuel subsidy were more welcomed than other methods. This reveals the importance of financial and competitiveness dimensions [31].

According to the report of "RECAI" (Renewable Energy Country Attractiveness Index), published by Ernst & Young Consulting Group (2017), demand for energy (for example, in rural areas) is one of the main reasons that make investments in renewable energies attractive [32]. By this indicator, countries are categorized based on investments and opportunities for renewable energy. According to the latest analysis by this British group in 2017, China, Germany, and Britain are the most attractive countries for renewable investments. The criteria for this classification are shown in the following [33]:

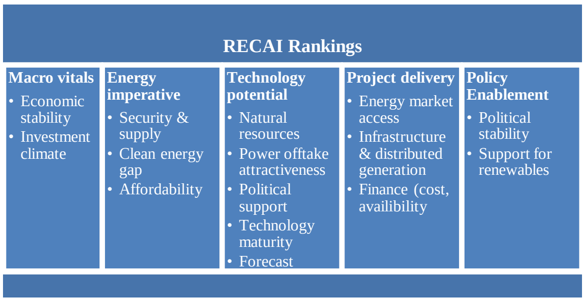

Figure 3. Criteria for the "attractiveness of countries for renewable energy".

In the second and fifth chapters of a handbook for renewable energy policymakers (2006), with regard to the failures of renewable energy development, ten key policy success factors are summarized as follows [34]:

i. Transparency;
ii. Well-defined objectives;
iii. Well-defined resources and technologies;
iv. Appropriately applied incentives;
v. Adequacy;
vi. Stability;
vii. Contextual frameworks;
viii. Energy market reform;
ix. Land use planning reform;
x. Equalizing community risk and cost-benefit distribution.

Sadirsan et al. (2014) developed biomass renewable energy models for rural electrification through the identification of factors affecting the price of incentive tariffs. Their results indicated that the key elements of the development policy model were feasible energy tariffs, appropriate human resources, and coordination between local government departments and social participation [35].

In an article titled "Market failures and barriers as a basis for clean energy policies", Brown (2001) outlined barriers and market failures as the main reasons for adopting clean energy policies. In this paper, the barriers and market failures associated with the development of clean energy are included. The following table summarizes these failures and obstacles [36]:

Table 1. Market failures and barriers inhibiting energy efficiency.

Market failures	Market barriers
Misplaced incentives Distortionary fiscal and regularity policies Unpriced benefits Insufficient and inaccurate information	Low priority of energy issues Capital market barriers Incomplete markets for energy efficiency

Aslani et al. (2012) carried out a research study to identify private sector criteria for entering into the field of renewable energy [37]. They pointed out the following factors:

i. Technical measures including engineering efficiency index based on the type of renewable resource, the annual utilization rate, and the energy potential of the region;
ii. Indicators of business and government policies including financial indicators, market share and market divisions, and coordination with the support policy of the government;
iii. Environmental indicators as EPR indicators.

In addition, in another research (2014) aimed at developing the relevant criteria in the renewable energy market, Aslani et al. used three items that should be considered for increasing the standard of living in a region and defining local policies such as (a) sustainable economic development (rising people's income, reducing dependence on energy, etc., (b) sustainable social development (unemployment reduction, Increasing the quality of jobs, etc.), and (c) focusing on sustainable environmental development (reducing emissions, maintaining non-renewable resources, etc.) [38].

Obstacles and constraints of renewable energy development from the perspective of Aslani and his associates can be removed by providing the following grounds: funds and credits, market information, demands and potentials, policy coordination, final cost, conversion efficiency, operating and maintenance costs, existence of services in rural areas, sufficient incentives (such as incentive tariffs and tax exemptions), existence of policies and programs for renewable energy development, public awareness, acquaintance with certificates and green standards, possibility of energy storage, the relation between research projects and market needs, the quality of manufacturing and utilization, skilled manpower, and convenient and accessible location.

3.2. Factors and elements affecting the development of power generation with photovoltaic technology

Although photovoltaic systems have become more competitive than before, their "diffusion" and "utilization" are still low in comparison to traditional energy sources and face numerous barriers. What are the current barriers to the diffusion of these systems? The answer to this question varies in each country and each condition, depending on issues such as the level of income, qualification of the grid, etc. (Karakaya, 2015) [39].

Karakaya and Sriwannawit (2015) did a comprehensive and systematic overview of various data sources. They reviewed 103 articles and studied 73 of them completely and finally used 33 articles to address the barriers to the development of PV technology usage. These articles are based on the experience of 28 countries from four continents. The results showed that these problems, even for low-income or high-income economies, can be categorized into four dimensions: Sociotechnical, Management, Economic, and Policy barriers. One of the important results of this article is that stakeholder participation, including local communities, companies, international organizations, financial institutions, and government, is vitally important. There is no way to overcome these barriers without proper coordination, efficient marketing, and allocation of government support [39].

In his article, Palit (2013) referred to the quality of photovoltaic systems as one of the most important factors. This is different from country to country according to the standards laid down. He pointed out in his article that Bangladesh and India had better quality standards than Sri Lanka, especially regarding batteries. The poor quality of equipment or improper use of them will create a lack of trust in the next buyers [40].

Agostino et al. (2011) and Sriwannawit (2012) pointed out in their papers that the lack of information between technology users and those who have not yet deployed the system was one of the obstacles. In the case of those who have provided the system, the lack of information leads to its inaccurate use and inability to repair and maintain the system causing the creation of an inappropriate image in both groups of users and those who have not yet used it. This issue has received great attention in rural areas; generally, the diffusion of innovation in rural areas is facing a lot of challenges [41] and [42]. Koinegg et al. in an Australian study showed that there was the lack of proper information about both the users and the suppliers. The unfamiliarity of designers and architects results from the lack of using these systems or their attempts to obtain customer satisfaction, and the perception of users, e.g., regarding the complexity of technology, is one of the important factors in the diffusion of this technology [43]. Venkatesh (2000) and Davis (1989) also pointed out in their papers that in areas where electricity consumers are able to use grid electricity, it is more difficult to overcome complexity [44] and [45]. Drury et al. (2012) and Zhai and ED (2012) showed in studies that the entry of a third-party property could reduce such risks and complexity. Briefly, the concerns of the users result from system complexity, technological maturity, system life span, efficiency, security, and system stability. In addition, there are other concerns for isolated points of the network such as power and low battery storage [46] and [47]. The demonstration of solar systems is one of the solutions for these topics and production and use of the panels should be tailored to the geography and conditions of each region [39].

Ondraczek (2013) and Agostino (2011) considered the impact of social factors on the use of photovoltaic systems. Distances between urban and rural areas, reluctance to use new technologies, improper conditions of the education system, and lack of sufficient public awareness, and recognition are such parameters [48] and [41].

In this regard, Urmee and his colleague Md (2016) addressed the social, cultural, and political dimensions of the distributed generation of renewable energy programs in the developing world. They pointed out that, according to the United Nations Sustainable Development Program, the requirements of a sustainable rural electricity supply include:

i. Technical sustainability;
ii. Economic sustainability;
iii. Institutional sustainability;
iv. Environmental sustainability;
v. Social and cultural sustainability [49].

According to their results, the relation between the "sustainability" and the "successfulness" of a renewable development program depends on a number of factors including the socio-economic and cultural context of the community, policies for renewable energy, and the reliability of renewable energy systems; three items (social, cultural, and political) have been discussed.

According to the "diffusion of innovation" theory considered in this paper, the success of the diffusion of technology in a society depends on factors such as type of technology, social acceptance, government policy, and other social and cultural factors. Moreover, the level of technology diffusion complexity between developed and developing societies is different due to differences in their perceptions about technology, socio-economic capabilities, and cultural freedoms for applying new technology. It is also noted that the long-term success of projects depends on the level of social participation, and for development projects such as rural energy programs, community participation is an active process in which stockholders benefit from the advantages of the project, and they also affect the process of implementation. Creating ownership, profits, feeling of security, and feeling of self-confidence can strengthen this partnership [49].

Architectural dimensions such as inadequate installation space (shortage of space in cities), and housing status (owner or tenant) because of the ease and amount of installation capacity in terms of ownership over the cities with many tenants are some of the other socio-technical factors [50] and [51] quoted from [39].

Karakaya and Sriwannawit (2015) noted that institutional problems were also important issues that could encourage the involvement of private sector in developing photovoltaic technology. Institutions can increase collaboration among relevant actors for further diffusion [39].

Another issue is the fitting of capacities with the financial capability of individuals to install the system and invest. For example, when high-capacity systems with a complete package are introduced in the market, those with low incomes cannot purchase these systems (Bawakyillenuo, 2012) [52].

Müggenburg et al. (2012) and Ondrczek (2013) focused on the importance of demand. They found that the diffusion would stop without demand. In many areas, the availability of affordable and economic power reduces the incentive to use photovoltaic panels [53] and [48].

Palit (2013) and Karakaya and Sriwannawit (2015) confirmed the part of the barriers known as management barriers. Inappropriate and inadequate management make a group of problems that affect the development and diffusion of photovoltaic systems in the world. The implementation of photovoltaic projects in rural and low-income areas requires special management arrangements by private companies and government institutions. Companies that offer these services should have different strategies between urban and rural areas. Appropriate financial programs, such as fee for service and micro-credits, are required for low-income markets [40] and [39].

Another problem is the lack of stakeholder engagement and their interaction in policy development, for example, the lack of participation of building specialists in connection with construction permits and so on. Creating a proper interaction between the two building and photovoltaic industries is one of the experiences that has been considered in Austria. This means that both sectors need to review each other's strategies for their proper coordination [39].

Agostino et al. (2011) also mentioned the weakness of after-sales services that have been particularly endangered in rural areas. This is related to the region's economy and the quality of photovoltaic panels [41].

Adopting appropriate strategies, such as the selection of suitable early users, will result in the success of the diffusion of photovoltaic technology [39].

The existence of relevant technical infrastructure at the national level can be effective in the diffusion of PV systems. This is more evident in developing countries. For example, in Ghana, in contrast to Kenya and Zimbabwe, where fewer photovoltaic companies, technicians, and support institutions existed, it faces more obstacles for development. In Tanzania, the lack of transport infrastructure has led to the concentration of PV installation in large urban areas (Ondraczek, 2013; Bawakyillenuo, 2012) [48] and [52].

This subject is discussed regarding the developed countries equipped with sufficient infrastructure for supporting innovations. As shown in the study about Japan and the Netherlands, Japan has a better technological innovation system to support PV industry. In addition, in the Dutch case, there is a lack of collaboration and knowledge exchange between researchers and policymakers with adopters (Vesseur et al., 2013) [58].

Sarzynsk et al. (2012) considered a large category of economic barriers. They noted that economic criteria (or barriers) are mainly related to time and place. As in the literature of innovation mentioned, the cost of innovation usually decreases over time and can vary depending on the location. At the same time, the principle of economic criteria results from the high price of PV modules. Even the diffusion of PV technology depends on the price of other energy sources in the region, because PV users must choose between PV systems and other options; in addition, if the price of other options is lower, this is a hindrance to the diffusion process [54]. Nevertheless, consumers' perceptions of prices are important too. Koinegg et al. (2013) pointed out that, for building integrated PV systems, the cost is not necessarily as high [43].

Karteris and Papadopoulos (2013) considered that the economic conditions of a particular region also had an impact on the purpose. If a country has been hit by the economic crisis, there would be unwillingness of banks to fund medium- or long-term investments, including investments for PV systems. In addition, the shrinking economy results in reducing electricity demand and reducing interest in PV systems (Karteris and Papadopoulos, 2013; Bawakyillenuo, 2012) [55] and [52].

The unstable political conditions over the years will lead to different economic growths, and consequently, an insecure economic context that reduces the willingness of investors to enter such a country or region (Bawakyillenuo, 2012) [52].

Pode (2013) pointed out that purchasing power is a factor influencing the diffusion of PV systems in rural areas, as seen in many developing countries in Asia and Africa. The author of this article considers this issue as "high total cost, high up-front price, and payment inflexibility" [56]. In a study for identifying the diffusion of PV systems in Hong Kong, it was determined that the initial cost, maintenance cost, and return of investment were the main economic factors [50]. Similar to this research, Zhang (2012) and colleagues in China stated that insufficient government subsidies and inconsistencies between consumer demand and warranty programs were important economic barriers [57].

Two other factors found by Bruderman and colleagues (2013) in a study on Austrian network connections include the required high investment and uncertainty in the financing process [58].

Vasseur et al. (2013) realized the contradictory subsidy schemes in the Netherlands that reduced the entrepreneur’s incentives in this field [59]. Jeong (2013) investigated the inadequate motivation and incentives in South Korea. Whereas there were some policies in this country, some investors were not intended to enter this area yet, because they preferred direct subsidies to low-yield loans [60].

In a paper on solar city indicator, Goodingand et al. (2013) pointed out that, in some cases like some cities in the UK, there is a lack of coordination between demand and policy measures. This situation arises from a lack of coordination between policy criteria and socioeconomic factors [51].

In their research on the policies of Japan and Germany, Huenteler et al. (2012) suggested to the Japanese that, for an efficient policy, the government should reduce the interest of industry in regulating structures. In the same vein, there are three main policy obstacles: failure to institutionalize incentive tariffs, challenges of overcoming borders of internationalism, and difficulty of implementing a coherent policy mix [61].

In Sarzynski's paper (2012), the effects of policies that have addressed cash incentives are more than those of non-cited methods [54]. In addition, the lack of appropriate subsidies and inconsistencies between customer demand and the certification program in China are as diverse experience [41].

Another interesting point about some low-income countries that target off-site applications is that some potential investors prefer to wait for network development instead of using a network-separated system. This means that the prospect of PV employers about the future is considered as an obstacle in some cases (Bawakyillenuo, 2012) [52].

In some cases, supportive policies of other energy sources (such as subsidies to fossil fuels) are an obstacle to the use of PV systems, which have been emphasized by articles such as Blum and his colleagues (2012) [62].

Rio et al. (2016) found that the overall policy assessment and the assessment of solar energy support specifically required the consideration of several factors, including evaluation criteria, market failures, policy issues for investigating these failures, prospects, goals, technologies, tools, design elements, and different levels of implementation. They emphasized long-term goals, defined goals, policies, and criteria in planning (Figure below) [63].

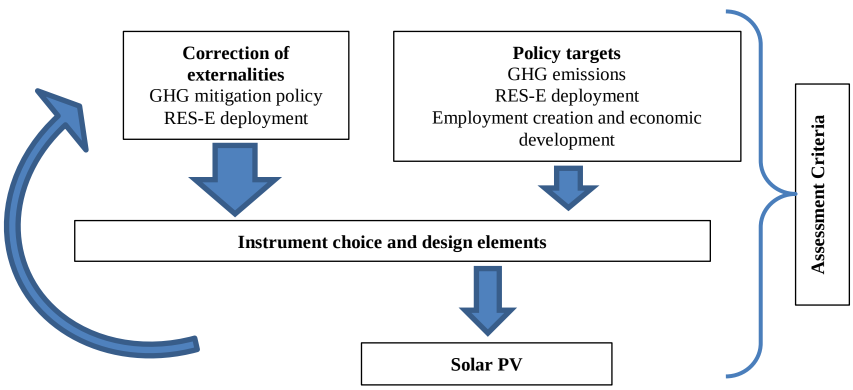

Figure 4. Relation between solar energy policy components [63].

In their article in 2017, Hafeznia and colleagues used three categories of geographic, technical, and socioeconomic indicators, because they believed that "the effectiveness of government supportive policies for the exploitation of renewable energy depends on the socioeconomic, climatic, and technical aspects" [23]. In this paper, the “socioeconomic” benchmark is defined by a combination of five indicators of social development, public security, knowledge and skills, electricity demand, and private sector partnerships. The “climate criterion” is presented with two characteristics of daily irradiance (horizontal) and air temperature. In the category of “policy”, two groups of technical topics (modules, inverters, etc.) and economics including initial costs (land, BOS, etc.), annual costs (such as repair and maintenance), financial parameters (inflation, taxes, etc.), and loans (interest rates, return periods, etc.) that are used to calculate NPV are used.

The paper by Hyun Jin Julie Yu and his colleagues (2014) explored the approaches of the three countries, Germany, China, and Japan, with the following goals: PV development, green energy growth, and development of country road maps. They considered 5 inputs including policy, research, and development supply, industrial conditions, financial resources and time considerations [64]. This paper focuses on key context factors in various environmental mechanisms and contexts, natural and human contexts, such as labour and training costs, the quality of the grid, lack of domestic electricity supply, the production capacities of fossil fuels, social perspectives on energy sources and energy price changes, as well as external factors such as energy prices and globalization. However, it has been emphasized that these factors are not well under control. One of the results of this paper is the identification of uncontrollable external factors such as globalization and their impact on supportive mechanisms. This experience has been achieved due to the great detriment of Europe, especially Germany, by lack of attention to price liberalization on the one hand and attractive incentive tariffs on the other hand that caused many controversies in the market for the production and installation of PV cells.

Hansen (2015) reviewed politics, interventions, and diffusion of photovoltaic in East Africa. He identified five key factors at the higher level of SHS emissions in Kenya compared to those in Tasmania and Uganda:

i. A growing middle-class;
ii. Geographical conditions;
iii. Local sub-component suppliers;
iv. Local champions;
v. Business culture [65].

Niknam et al. (2015) outlined the SWOT matrix for photovoltaic technology in Iran, pointing out strengths, weaknesses, opportunities, and threats. If the strengths and weaknesses are considered here as interior factors in the control, seven strengths and seven weaknesses mentioned in this matrix can be found as useful factors [66]:

i. Industrial capability (panel production and ...);
ii. Maintenance costs;
iii. Approach of decreasing costs;
iv. Academic and Research Ability;
v. Ease of use;
vi. Implementation of pilot projects;
vii. Raw material availability;
viii. Purchase price of PV electricity;
ix. Ground condition;
x. Experienced advisors and contractors;
xi. Internal test centres and standards;

Yousofi et al. (2017) investigated the local criteria for the construction of solar power plants in Iran, which is based on principles and methods for assessing ecological capability and land use planning. The results of this study showed that the most important criteria for this issue in Iran are sunshine, cloudy, dust, relative humidity, altitude, solar potential map, use and type of land cover, power lines, and access roads [67]. At the same time, it should be noted that the criteria of this article are focused on the construction of a "solar power plant" that requires its own specific attention.

In another paper, Sheikh-Hosseini et al. (2017) discussed "locally based design of a guaranteed purchasing incentive for a home-based PV system". In the presented model, an economic analysis was carried out with respect to the performance of the PV system in different regions and the guaranteed purchase rate calculated with indicators of net present value (NPV) and internal rate of return (IRR) [68].

Literature reviews and countries’ experiences are inserted in a table in the Appendix. A list of factors influencing the development of photovoltaic technology application with related categories and levels (categories and levels will be described in the fourth section) are shown in the table of the appendix.

4. OFFERING A CONCEPTUAL FRAMEWORK FOR IRAN

Given the nature of the factors, they are mainly of a qualitative nature or in such a way that there is no accurate statistical information about them. On the other hand, their impact on attracting stakeholders (investors, consumers, etc.) can be identified through surveys; therefore, the method of data collection is "qualitative." Thus, this study aims to correct or complete the development and categorization of the influencing factors of the photovoltaic application, which is the result of a comprehensive review of the literature. The following figure shows the route of the process:

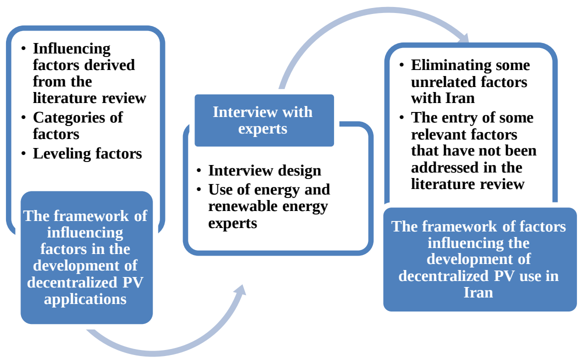

Figure 5.The process route of Interview design for research topic.

In this research, the initial research information is obtained from the literature and the interviewees are experts in the field of renewable energy. The semi-structured interview method is selected from the types of interview methods. In this method, we should ask similar questions from interviewees; however, they are free to submit their answers in any way they wish to offer and the researcher will be free to encode their responses and categorize them.

In order to use relevant and knowledgeable experts, a group of specialists and managers of the energy industry has been used with relevant backgrounds. The nature and expertise necessary to answer the questions is required as follows: familiarity with the importance and necessity of developing renewable energy, awareness of the criteria of microenterprise investors, specialization in industrial development and renewable energy development, familiarity with the world-wide methods of developing new technologies, especially renewable energy, strategic visibility, and familiarity with the methods and generalities of Iran's strategies for the development of renewable energy.

Questions have been designed in the following areas:

i. Do you recognize the proposed titles of the categories and the levels of the factors, appropriate?
ii. What is your opinion about the susceptibility of factors to renewable policy-maker? Are some of these criteria unifiable? Is there another factor left to add to the list?
iii. What is the significance and impact of each factor?

The following table presents an example of interviewees' response codification:

Table 2. Example of interviewees' response codification.

Expert code	Opinion about categories and levels	Important factors that the renewable policymaker can affect	Other factor related to the purpose of research in Iran
A	In general, the classification is complete. Of course, we can see some overlaps showed to be found in the criteria; however, maybe we should approve them. If we want to speak at the "national" level, "Institutional Factor" is also a basic class. Stimulating or exploring value aspects, such as environmental issues, is important in development of renewables.	Very important criteria: 1, 3, 4, 9, 11, 12, 13, 14, 15, 17, 19, 23, 30, 33, 35, 38, 39, 46, 47, 72, 86, 111. Vague criteria: 42, 56, 57, 67, 75, 97, 102 Repeat Criteria: 41, 45, 47, 48, 50, 52, 53, 55	-
B	Suitable	Very high-priority criteria: 2, 16, 23, 25, 29, 30, 51, 54, 58, 63, 77, 96, 101 Parametric criteria with a relatively high priority: 4, 6, 7, 9, 11, 22, 33, 34, 35, 43, 45, 47, 48, 56, 79, 81, 82, 88, 94, 98, 99, 100, 109, 116	A criterion, entitled "simplification of the use of PV systems in common areas, such as installation in residential complexes," can be added.

The first result of the literature review, especially the study of existing criteria and models, is their numerous varieties, depending on the type of study, climatic, political, social, system conditions, and so on. In the meantime, some scholars have emphasized the need for localization of policy models and frameworks; a framework or method that has been successful in a country cannot be generalized for all countries and may be incomplete and even a reason for failure for some countries. After reviewing all the criteria that can influence the development of photovoltaic technology application in Iran, 142 criteria can be measured (noted in appendix). By scrutinizing them in this research, these criteria were ranked in ten categories of the subject with the views of 15 prominent experts in Iran in the energy policy field. At the same time, according to some of the papers, the overlapping of criteria has to be accepted in relation to various categories.

i. Policy factors including governance decisions in the field of energy;
ii. Foreign political factors such as political pressure;
iii. Institutional factors related to organized establishments and foundations, especially formal organizations;
iv. Factors related to finance and budget like credits, source of budgets, and ways of preparing budget for investors;
v. Macroeconomic factors such as inflation, currency rate, and so on;
vi. System economy factors, including parameters related to photovoltaic systems such as module prices, maintenance cost, and so on;
vii. Geographical, climatic, and environmental factors such as temperature, existence of solar source, and environmental necessity;
viii. Capabilities of industries, technologies, and related infrastructure such as the possibility of network connection, loss of power in the transmission and distribution network and factors related to the capabilities of industries, technologies and related infrastructure, including the supply chain, and the production of solar panels;
ix. Human resource factors including human resources specialized in different parts of supply, production, and maintenance chain;
x. Socio-cultural factors including public awareness level and institutional acceptance.

What is known about the initial relationship between the general categories of factors is shown in the following figure.

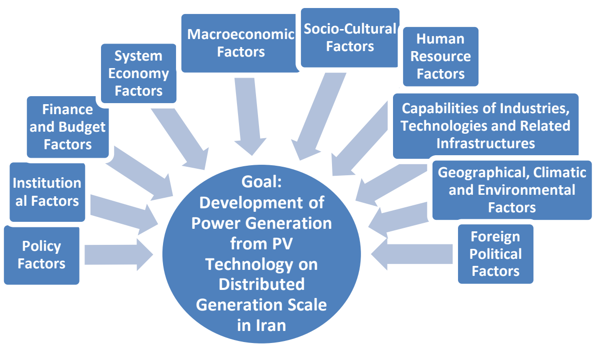

Figure 6. Factors influencing the development of power generation from photovoltaic technology in distributed generation scale.

In addition, it should be noted that the range of influence on each of these factors and their management can be different. For example, "determining the appropriate method for encouraging the use of the photovoltaic system" is within the scope of the influence of the electricity industry and its custodians; however, the "labour and employment regulations" are at a higher level of governance. Therefore, we should specify the system level for each of the criteria. It can be distinguished between different levels by defining the boundary of the system at three levels below:

i. Sector Level or Power Industry Level (including decision-makers and custodians of the industry in the private and public sectors);
ii. National Level (including matters within the boundaries of Iran and at the will of the government and the ruling and authorities of the country);
iii. International Level (including factors outside the realm of state domination such as possible political necessity and constraints arising therefrom).

The figure below shows this system.

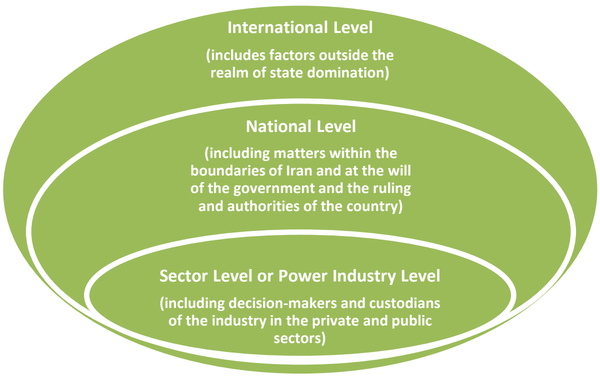

Figure 7. Environments governing the development of the application of photovoltaic technology.

Certainly, the specific conditions of Iran are taken into account in various matters.

i. Removing some of Iran's intrinsic properties that cannot be changed or improved. For example, the source of solar energy, which is a good situation for nearly the whole of Iran, is not necessarily mentioned in the final criteria list.
ii. Many of the features that are important in some developing countries for the development of decentralized PV application may not be important in Iran, such as power distribution network or pilot project implementation; Iran has passed the two recent cases.
iii. Specific conditions of Iran in terms of foreign policy and international interactions and partnerships have been observed.
iv. The levelling of the criteria in three categories, i.e., sector, national, and international, has led to the factors that are considered at the level in which policy-makers can influence them. Therefore, we selected most factors at the sector level and some factors at the national level for the final revision.
v. Considering the purpose of the problem is also important. Our goal is to develop the application of decentralized PV technology. This means that some of the criteria that are specific to power plant scale development or solely related to the development of local technology are excluded from the list.
vi. Importance and impact of the criteria from the viewpoint of experts in Iran as a research method is considered.

Eventually, out of about 140 general criteria derived from literature, about 60 criteria were selected and would be presented in the new edition of the article.

Table 3. List of factors influencing the development of photovoltaic technology application with related categories at national and sector levels, which can be influenced by energy policy-makers in Iran.

Number	Category	Factors and criteria
1	Policy	Determining goals and strategies tailored to the development of renewable energy electricity
2		Existence of effective policies for the development of renewable energy in Iran
3		Legal monitoring and evaluation of energy policies in terms of formality
4		Sustainability of the electricity industry policies (credit time)
5		Continuity of government incentives for renewable energy
6		Simplicity and transparency of regulations in the renewable energy sector
7		Coordination of policies with the demand for investment in the power industry and renewable energy
8		Interpolation of environmental objectives at different levels of policies
9		On-time correction of encouraging policies
10		Definition of incentive mechanisms
11		Separation of incentive mechanisms and tools, tailored to a variety of renewable energy sources
12		Support for industrial and indigenous production in the field of electricity generation from photovoltaic technology
13		The presence of multilateral drivers (various supporting techniques)
14	Institutional	Institutional acceptance (legitimacy) at different levels of decision-making bodies such as parliament and government
15		Institutional and structural mechanisms such as the presence of governor organization and inter-institutional coordination
16		Existence of a power sector regulator or a renewable energy regulator
17		Coordination between local government departments and local communities
18		Radical changes in energy sector policies towards integration such as power ministry and oil ministry
19	Finance & budgeting	Availability of required funds and credits
20		Reliability and sustainability of incentive tariffs budgets
21		Assisting the process of providing initial financing to investors
22		Tax exemptions for panel and solar system importers
23		Subsidies to fossil fuels (supporting other energy sources)
24	Economic	Network connectivity costs
25		Realizing the cost of generating electricity
26		Initial capital cost of the photovoltaic system on a decentralized scale
27		Investment rate of return of decentralized photovoltaic systems in Iran

28		Changes and fluctuations in the price of energy and electricity in Iran
29		The downturn in the cost of photovoltaic systems in recent years
30		Tendency of the private sector to invest in Iran
31		Stability of energy prices in Iran
32		Existence of efficiency and lifetime insurance for photovoltaic system
33	Socio-cultural	Social acceptance of electricity generation from photovoltaic technology
34		Existence of social and environmental programs to encourage the application of PV technology
35		Selecting suitable initial users for informing and promotion
36		The relationships network between different companies, governments, knowledge institutions, and third parties
37		The initial cognition of users because of system complexity, technological maturity, system life span, efficiency, security, and sustainability
38	Human recourse	Human capital in PV system design
39		Human capital in PV system maintenance of the PV system
40		Knowledge infrastructure and technology absorption capacity in Iran
41	Capabilities of industries, technologies and related infrastructures	Possibility to connect to the network and its guarantee
42		Possibility of energy saving
43		Forecasting and scheduling of power transmission
44		Creating or restructuring of energy and electricity market in Iran
45		Existence of photovoltaic systems supply chain inside the country, especially the production of panels and systems
46		Existence of relevant technical standards
47		Diversity in technology of photovoltaic systems
48		Existence of energy service companies (consultants and experienced contractors)
49		The plurality of installed systems and making their installation and repair procedures routine
50		Manufacturers' access to the electricity market
51		Existence and dissemination of relevant information such as solar radiation potential
52		Quality and life span of PV systems in the country (imported or manufactured), especially panels and inverters
53		The proper interaction between the building industry and photovoltaic industry
54		Possibility to prepare panels in accordance with the geographical conditions of each region
55		Effective marketing by manufacturers and importers of photovoltaic systems
56		Existence of testing centers inside the country
57		The provision of fundamental services and infrastructures in rural areas
58	Geographical, climatic, and environmental	Identifying each region characteristics in terms of incentives, potentials, and risks
59		Appropriate amount and design of urban spaces for project implementation

5. DISCUSSION AND CONCLUSIONS

According to the necessary requirements of addressing the issue of developing renewable energies and the provision of electricity from these sources and also, the requirements and complexities of influencing factors, such as political, economic, geographical, cultural, and individual capabilities of each country, the aim of this research is obvious. This complexity for Iran, which owns the most fossil fuel resources of the world and its specific conditions, is more clear and necessary.

This study attempted to identify, define, and categorize these criteria for Iran from a comprehensive review of literature and experience related to the development of the use of photovoltaic technology. Following the numerous references that have presented models, investigated the criteria, and depicted different views for developing this technology, 142 criteria were obtained for Iran. These criteria were completed and categorized by using 15 expert opinions in ten categories identified in this paper: policy factors, institutional factors, finance and budget factors, system economy factors, macro-economic factors, socio-cultural factors, human resource factors, capabilities of industries, technologies and related infrastructure, geographical, climatic, and environmental factors, and foreign political factors at three levels of industrial (electricity industry), national, and international environments.

From a combination of the two recent figures with the initial information of the above, the following figure can be depicted as a conceptual initial framework:

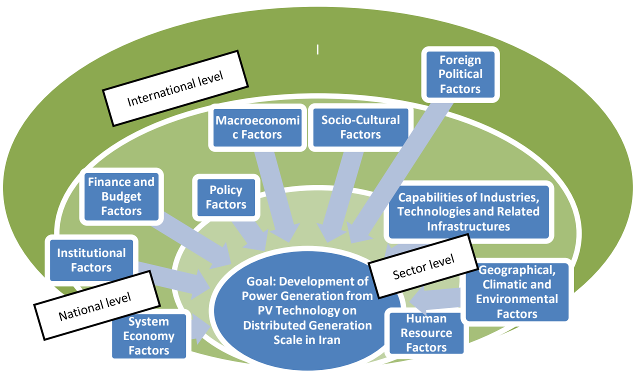

Figure 8. The primary conceptual framework of the factors influencing the development of power generation from photovoltaic technology in distributed generation.

3Most of the factors include domestic policy factors that can be considered at both sectorial and national levels. These factors include the formulation of appropriate goals and strategies for the development of renewable energies, formality, sustainability, simplicity, coordination, modification, diversity, and differentiation of policies. Institutional factors include the institutional acceptance of governance components and the deployment of necessary organizations such as the electricity regulator. These categories of factors are both at the national and national levels. Credit and budget factors also include credit allocation, resource feeds, and the provision of early credit support to investors. This category is also available at both sector and national levels. Indeed, staying at both levels means that demand, tracking, and suggestion at the sector level and the support and accountability at the national level are required.

Economic issues are classified into two parts. One of them is related to macroeconomic conditions that affect the development of PV, such as inflation, exchange rates, energy sector subsidies, investment risks; the other part is related to the economics of photovoltaic systems such as the downturn process of system components or system return rates with respect to renewable energy purchasing mechanisms.

Cultural and social factors include issues such as social acceptance of this technology, appropriate early users, and early perception of users from complexity, efficiency, security, sustainability, and system economics. Factors related to the foreign policy include the possibility of international cooperation, political sustainability, and sanctions that may be defined at the national and international boundaries. Obviously, renewable energy policymakers have the least chance of planning and influencing these factors. Human resources related to the development of the use of photovoltaic technology, mainly related to human capital in the downstream of the value chain, include system design and maintenance. It can also be applied to the national and sector levels.

The country's industry and technology infrastructure is also a very important issue that can be accessed from a variety of perspectives. The possibility of network connection, the possibility of energy storage, the planning of the country's electricity transmission, the supply chain of photovoltaic systems in the country, existence of relevant technical standards, experienced consultants and contractors, relevant information such as radiation potential, the quality of manufacturing of supplied systems in the country and their life span, especially panels and inverters, proper interaction between the two construction and photovoltaic industries, existence of testing centres in the country, and the provision of basic services and infrastructure in the rural area are among the parameters. Geographic, climatic, and environmental parameters are also at a level that can have little effect on them, e.g., the amount of sunlight. Of course, identifying and distinguishing features of each region in terms of incentives, potentials, and risks can be programmed.

In conclusion, these categories and classes (levels) have been shown in a conceptual framework. Obviously, for more precise planning, researchers need to focus on the elements of the sectorial level in the electrical industry, which are dominated by the influence of policymakers in the electricity industry. They also should consider the influential factors at the other two levels respecting their drivers and barriers to achieving the purpose.

6. ACKNOWLEDGEMENT

The authors thank experts of energy and renewable energy policy in Iran, who helped us to explore the criteria and factors affecting the photovoltaic use and to categorize them.

APPENDIX

List of factors influencing the development of photovoltaic technology application with related categories and levels.

Number	Factors and criteria	Category of factor	Level of factor
1	Existing effective policies for the development of renewable energy	P	S
2	Stability of the electricity industry policies (time of policy validity)	P	S
3	Network connectivity costs	SE	S
4	Social acceptance of electricity generation from photovoltaic technology	SC	S
5	Institutional acceptance of electricity generation from photovoltaic technology	P	S & N
6	Extent of the country and the scattering of the villages	GCE	N
7	Connectivity of the villages to the electricity grid	CI	S
8	Usual support from emerging technologies in the country	P	N
9	Human capital in PV system design	HR	S & N
10	The human capital in PV system manufacturing	HR	S
11	Human capital in PV system maintenance	HR	S
12	On-time amendment of encouraging policies	P	S
13	Connection possibility to the network and its guarantee	CI	S
14	Facilitating finance	ME	S & N
15	Support for indigenous and industrial production	P	S & N
16	Energy demand	ME	All Levels
17	Making the cost of generating electricity and water real	ME	S & N
18	Electricity tariffs relative to per capita income	ME	S & N
19	The existence of suitable land	GCE	N
20	Possibility and facilitating the allocation of land for decentralized investors	P	S & N
21	Water source availability	GCE	N
22	Initial investment level on decentralized scales	SE	S
23	The technological limitations of decentralized PV systems	CI	S
24	Maintenance costs	SE	S
25	Possibility for energy saving	CI	S
26	Environmental demand (environmental status of the country)	GCE	N & I
27	Existence of incentive mechanisms	P	S
28	Forecasting and scheduling for power transmission	CI	S
29	Creating or restructuring the energy and electricity market	CI	S
30	Stability of energy prices in the country	ME	S & N
31	Ensuring security of energy supply	CI	S
32	The need to develop a regional economy	ME & SC	N
33	Tendency of private sectors to invest	ME	S & N
34	Capital rate of return	SE	S
35	Different policies and tools for a variety of resources and technologies	P	S
36	Demand for job creation	SC	N
37	Residents' profit from side issues (except for direct investment earnings or employment)	SC	N
38	Existence of suitable solar resources	GCE	N
39	Ensuring functional conditions	CI	S
40	Institutional tools such as the presence of a trustee organization, inter-organizational coordination	IN	S & N
41	Historical experience of industrialization and technology attainment	CI	N
42	Dependence on alternative energy supply options	CI	S & N
43	Local and regional section supports	P & SC	S & N
44	Clear and transparent regulations for renewable energy	P	S
45	Lobbying power supply competitor options	P & IN	S & N
46	Existence of advanced industry development experience	CI	N
47	Owning advanced technologies such as IT and automation	CI	N
48	ordaining suitable goals and strategies for developing renewable energy	P	S & N
49	Existence of PV supply chain in the country	CI	S
50	Economic and commercial relations with	P & FP	N & I

	international partners		
51	Government support to complete the PV value chain	P	S & N
52	Existence of an electricity and renewable energy regulator	IN	S
53	Existence of relevant technical standards	CI	S
54	Labor and employment regulations in the country	P	N
55	Intellectual property regulations in the country	P	N
56	Practices and values of individuals	SC	N
57	Networking among different companies, governments, knowledge institutions, and third parties	SC	S & N
58	The formalization of energy policies	P	S & N
59	The norms and rules of the market for similar technologies	ME	N
60	Existence of technology diversity in PV technology	CI	S
61	Maturity state of photovoltaic technology	CI	S & I
62	Suitable entry times for the development of PV technology application	CI	S
63	Knowledge and learning infrastructure	HR	S & N
64	Presence of multilateral proponents (various supporting techniques)	P	S
65	Existence of energy services companies (consultants and experienced contractors)	CI	S
66	Dependence on fossil fuels in the country	CI	N
67	The status of the regular power plants and also transmission and distribution networks (efficiency, network losses, etc.)	CI	S
68	Possibility and existence of large investors in the country	ME	N
69	The plurality of system installation and making installation and repairing processes routine	CI	S
70	Technology acquisition capacity	CI & HR	S
71	Existence of social and environmental programs to encourage the use and application of PV technology	SC	S
72	Collaboration between international and local institutions	FP	I
73	Rational changes in energy policies in the direction of integrating energy decisions (fossil fuel and electricity organizations)	P & IN	S & N
74	Environmental goals at different policy levels	P	S & N
75	Creating a basic flow for human resources motivation and promotion	HR	S & N
76	Planning for technology transfer through international agreements	CI	N & I
77	Providing energy storage technology	CI	S
78	Source of incentive tariffs	ME	S & N
79	Economic stability of the country	ME & FP	N & I
80	Political stability of the country	P & FP	N & I
81	Access to the electricity market	CI	S
82	Distributed generation infrastructure	CI	S
83	Possibility to move liquidity	ME	N & I
84	Determining the regulatory dimension of related projects	CI	S
85	Identification and separation of the characteristics of each region (drivers, potentials, and risks)	GCE	S & N
86	Continued government subsidies and incentives	ME & P	S & N
87	Coordination between local government departments and local communities	P & SC	S & N
88	The existence of microfinance mechanisms	ME	N & I
89	Considering the invisible and uncertain costs and benefits	SE & FP	S
90	Presence and dissemination of relevant information such as radiation potential	CI	S
91	Engineering efficiency issues in the country	CI & HR	S & N
92	Annual utilization of current photovoltaic systems	CI	S
93	People's income	ME	N & I
94	Desire to increase the quality of jobs	SC	N
95	Budget and credits needed	ME	S & N
96	Coordination between policies and methods at different levels	P	S & N
97	The provision of basic services and infrastructure in rural areas	CI	S & N
98	Tax exemptions for panel and solar system importers	ME‹P	S & N
99	Relationship between research projects and market needs	CI & HR	S
100	Quality of construction and operation of the supplied systems in the country	CI	S
101	Proportion of capacity with applicants' financial strength	SE ME	S
102	The proper interaction between the two building and photovoltaic industries	CI	S
103	Selecting appropriate initial users	SC	S
104	Possibility to prepare a suitable panel for each geographical condition	CI	S
105	Effective marketing by manufacturers and importers of photovoltaic systems	CI & SE	S
106	The initial cognition of users, especially because of system complexity, technological maturity, system life span, efficiency, security, and sustainability	SC & HR	S & N
107	Distance between urban and rural areas	GCE	N
108	People's desire to utilize new technologies	SC	N
109	Appropriate amount and design of urban spaces for project implementation	GCE	S & N
110	Property status: owner or tenant inhabitants	-	N
111	Coordination of policies with the investment demand	P	S
112	Existence of transportation infrastructure	CI	S & N
113	Existence of systematic technology innovation in the country	HR	N
114	Expectation of users from electricity grid extension	CI & SC	S & N
115	Possibility for supporting initial funding process	P & FB	S & N
116	Supportive policy of other energy sources (such as subsidies to fossil fuels)	ME & P	S & N
117	Globalization rate		N & I
118	Research and development supply	CI & HR	S & N
119	Quality of the electricity network	CI	S
120	Capabilities of fossil fuels in electricity generation	CI	N
121	Social perspectives on types of energy sources, conservation of fossil resources, and related beliefs	SC	S & N
122	Changes and fluctuations in price of energy and electricity in the country	ME	S & N
123	Global energy price	FP	I
124	Training costs in the country	ME & HR	S & N
125	Daily radiation in the region	GCE	N
126	Air temperature in the region's climate	GCE	N
127	Lifetime of manufactured or imported photovoltaic modules	CI	S
128	Lifetime and operating conditions of the inverter	CI	S
129	Justice in socio-economic development in different regions of the country	-	N
130	Public security of the country	-	N
131	Inflation rate in the country	ME	N
132	Interest rates on loans in the country	ME	N
133	The appropriateness of supportive mechanisms with the climatic conditions of each region	GCE & P	S
134	The conditions of the growing middle class people in the country	ME & SC	N
135	Ability to produce panels and systems in the country	CI	S & N
136	Decreasing rate of PV system costs	SE	S
137	Academic and research capabilities in the country	HR	S & N
138	Pilot projects implementation in every region	CI	S
139	Accessibility y to raw materials in the country	CI	S & N
140	Existence of testing centers	CI	S
141	Dust level situations	GCE	N & I
142	Relative humidity situations	GCE	N & I
143	Presence of Atlas Solar Energy Potential	CI	S
144	Power transmission lines	CI	S

S: Sector Level; N: National Level; I: International Level; P: Policy; SE: System Economy; SC: Socio-cultural; GCE: Geographical, Climatic and Environmental; HR: Human Recourse; CI: Capabilities of Industries, Technologies and Related Infrastructures; ME: Macroeconomic; IN: Institutional; FP: Foreign Political; FB: Finance & Budgeting

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