Journal of
Renewable Energy Research and Applications (RERA)

Vol. 3, No. 1, 2022, 71-78 *DOI: 10.22044/rera.2021.11011.1066*

Analysis of a Proper Strategy for Solar Energy Deployment in Iran using SWOT Matrix

Z. Molamohamadi[1*] and M. Talaei[2]

1. Department of Industrial Engineering, Kharazmi University, Tehran, Iran.
2. Iranian Solar Energy Scientific Society.

Receive Date 21 July 2021; Revised 02 August 2021; Accepted Date 27 August 2021
**Corresponding author: zmmohamadi@gmail.com (Z. Molamohamadi)*

Abstract
In this work, we aim to analyze and identify the most appropriate strategies in order to deploy solar energy in Iran. For this purpose, in a comprehensive framework of strategy development, the internal and external factors of a general and specific environment are determined. Then four different strategies including the aggressive (strong expansion and development), conservative (maintaining, internal protection), competitive (maintaining, external protection), and defensive strategies (withdrawal, reduction of costs, ceasing on investment, joining another corporation) are considered using the internal-external and SWOT (strengths, weaknesses, opportunities, and threats) matrices. According to the numerical results of the internal and external factor evaluations, which are 2.74 and 3.06, respectively, the aggressive strategies would be acceptable for Iran. However, since the location of these values in the internal-external matrix is close to the conservative cell, the effective strategy for the present condition of this country is a combination of the aggressive and conservative strategies.

Keywords: *Solar energy; sustainability; SWOT analysis; PESTEL analysis; renewable energy. policies.*

1. Introduction

The environmental deterioration, natural resource scarcity, global warming, air pollution, and other similar threats have obliged many countries to reduce the consumption of fossil fuels and substitute them for clean energy sources. Additionally, the imposed international law to control fuel consumption and reduce harmful emissions declares the necessity of a universal movement toward sustainable consumption and replacement of non-renewable fuels. Another critical reason for transition to renewable energy is its accessibility to almost all countries of the world that can assist in avoiding the economic and military struggles for preferential access to the traditional energy supplies.

Therefore, the renewable energy systems are being used worldwide in both the industrial and domestic sectors in order to meet the growing population demand and meet the global restrictions in the green gas emissions reduction [1]. Moreover, the climate change has accelerated the transition to use renewable energies [2].

Solar energy is one of the best renewable energy resources in generating electricity [3]. It often consists of small manufacturing units accessible to customers. This, in turn, increases the energy security and reduces the local power transmission losses. Another advantage of this energy is the zero or minimal toxic emissions positively, affecting the environment and contributing to pollution prevention. Solar energy deployment can also provide more employment opportunities and develop productive capacities in less-developed countries. For Iran, as a rich country in natural resources, economic dependency on crude oil and gas is another key factor for the necessity of transition to renewable energies since this has caused the country's underdevelopment and has reduced its economic growth during the past years.

Since solar energy is an accessible renewable energy in Iran (according to Figure 1), the purpose of this paper is to review the positive and negative features of this resource, and study the internal and external circumstances according to the comprehensive framework of strategy for transition to sustainable energy resources. In order to analyze and evaluate the characteristics of solar energy as a new economic opportunity, the SWOT analysis is used here in order to formulate the

appropriate strategies through investigating both the internal and external environments.

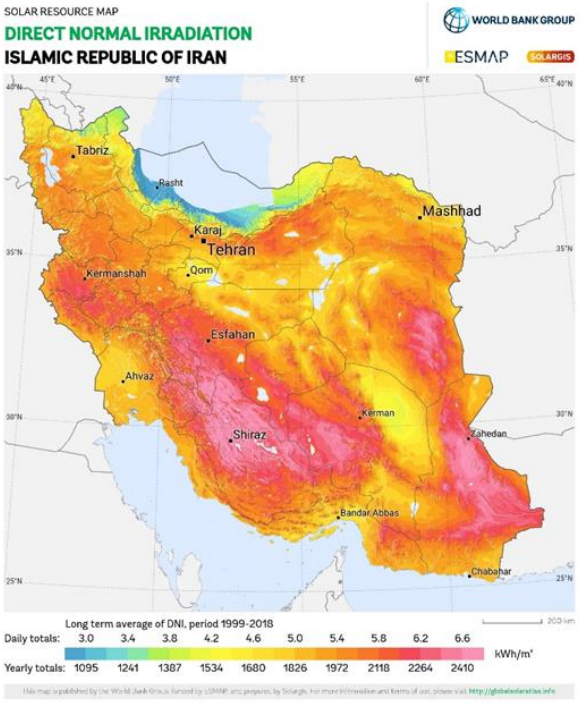

Figure 1. Solar map potential of Iran.

The SWOT analysis is a structured planning method used in order to evaluate the strengths, weaknesses, opportunities, and threats of a project or economic activity, and assesses the degree of compliance among domestic environment and external environment [4]. The strengths represent accessible resources that can improve the performance of a project or activity, and benefit it. The weaknesses are the defects reducing competitive advantages and efficiency or decreasing financial resources. The opportunities are considered the exterior changes assisting in further improvements, and the threats are the external factors creating problems and increasing the risks of business projects [5]. The SWOT structure is illustrated in Figure 2. As it is shown, PEST (political, economic, socio-cultural, and technological) analysis is a technique for recognizing the external factors.

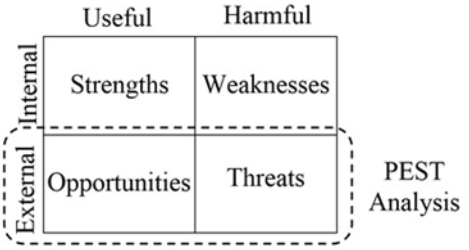

Figure 2. SWOT general framework.

SWOT is used in the literature of renewable energies in order to define the positive and negative factors of a system or country but they have rarely concentrated on the PEST/PESTEL (political, economic, socio-cultural, and technological factors) analysis and internal-external factors evaluation, and neglected finding the appropriate strategies for the system. [6] have assessed the uncertainties of the green gas implementation by a series of SWOT analyses, and have concluded that green gas could be implemented in the long term. [7] have conducted a SWOT analysis in order to depict the current status of Romania's renewable solar energy sector and have concluded that being a viable competitor in the global market requires knowledge, new solar technology development, and securing financial support. [8] have investigated the conditions of India for using solar energy, and have discussed its strengths, weaknesses, opportunities, and threats. They stated that large corporations would be more beneficial than small entrepreneurs, and stated that gradual rising in the people awareness would increase the demand in the near future. In their viewpoint, besides focusing on the solar panels' cost reduction, the government must consider skilled people and innovations on solar technology in order to maintain solar panels and arrays. [9] have studied the current status as well as the future requirements of photovoltaic technology in India, while concentrating on SWOT. They have concluded that for utilizing solar energy, which helps conserving the environment, it is necessary to track the identified threats appropriately. In order to determine the market's potential and demand of Indonesia's renewable energy, and verify its current marketing strategy, [10] have applied the internal and external factor evaluation analysis as well as SWOT matrix. They stated that Indonesia had a very great potential for renewable energy in the world, and a strong desire of both government and private investors was required to make energy transition happen. [11] has focused on the SWOT analysis in order to highlight the internal and external factors for economic growth and the use of floating solar technology. [12] have applied SWOT analysis in order to determine the key factors of the Bangladesh renewable energy sector, and have explored the foreign direct investment (FDI) determinants. They concluded that attracting new foreign investments required strengthening regulations, controlling corruption, and protecting intellectual property rights as well as improving the coordination between the ministries. [13] have investigated the motivators

and hindrances of developing renewable resources in some countries including India, Sweden, Iceland, US, and China. They determined the strengths, weaknesses, opportunities, and threats of renewable energies through the SWOT analysis, and assessed each country's potential for generating green energies. [14] have applied the SWOT analysis in order to highlight the Romania's status of solar energy, recommending the key measures for its solar systems growth. They mentioned the knowledge and financial security as the significant factors for Romania in sustaining on the global market. [15] have examined various renewable resources and their potentials in South Africa through the SWOT analysis. This research work revealed that the policy-makers should develop programs in order to transit to renewable energy resources.

2. Technical and Theoretical Framework

The strategic management is the art and science of taking, implementing, and evaluating decisions for multiple tasks enabling the organizations to reach their goal. It involves three major stages as the strategy formulation, implementation, and evaluation. In the first stage, which is the focus of this paper, the organization's mission, and internal and external factors will be reviewed in order to identify the opportunities, threats, strengths, and weaknesses. Moreover, the organization's strategies will then be set accordingly. In the implementation phase, the defined strategy should be implemented. For this purpose, the resources would be allocated after recognizing the targets and policies related to the organization's missions. Finally, the formulation and implementation phases are reviewed in order to explore the possible deviations and make efforts for resolving them [16].

For the strategy formulation, a comprehensive framework, which is represented in Figure 3, is used in this research work in order to make reasonable offers and assist the strategists in identifying, evaluating, and selecting the best possible strategies for various organizations. This framework consists of four different phases: start phase, input phase, adaptation phase, and decision-making phase. In the start phase, the mission is determined, and its statement will be prepared. The input phase includes the internal and external factors evaluation matrices. In the adaptation stage, the main external factors and internal factors will be analyzed through the SWOT matrix in order to identify the strategies compatible with the organization's missions. The last stage of this framework, which is beyond the scope of this paper, is the assessment of the selected strategies using the quantitative strategic planning matrix (QSPM) and objective evaluation of various options identified in the previous stage [16].

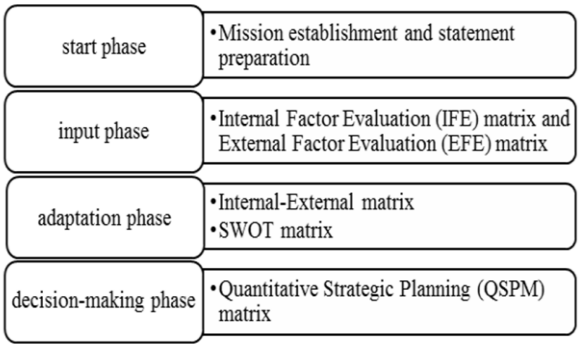

Figure 3. Comprehensive framework of strategy formulation.

In the mission statement (start phase), the time and place are not certain, and the mission differs based on the size, content, shape, and other details of the organizations. Depending on the operators as well as the internal and external factors, the mission may change within a few days or remain unchanged for a long time [16]. The following sections discuss the input and adaptation phases in detail regarding the solar energy development.

2.1. Internal Factor Evaluation

The internal factor evaluation identifies and prioritizes the interior factors of an organization for a further review. The strategic internal factors will be ranked by the IFE matrix (Internal Factor Evaluation Matrix) in order to delineate the overall status of the organization. Afterward, the major strengths and weaknesses must be listed and set in a column of the matrix to specify whether the strengths overweigh the weaknesses using special rates. The following structure is used in this paper to form the IFE matrix:

As it is demonstrated in Table 1, the internal factors with higher priorities are set in the first column of the matrix as the strengths and weaknesses. The type of each factor is then specified in the second column. In the third column, a weight is assigned to each factor according to its importance in comparison to the others [17]. In this paper, the Likert scale (1 to 5 where 1 indicates very low importance and 5 means very high importance) is used first in order to determine the relative importance of the factors. They are then normalized by dividing each value by the summation of all scales, as demonstrated in the fourth column.

Table 1: IFE matrix*.

Internal factors	Type	Weight	Normalized weight	Rating	Weighted Score
Strengths					
Solar energy resources are accessible and local (decentralized production)	Eco	5	0.086	4	0.344
Despite fossil fuels, which take a very long time to be replaced, solar energy is refreshed on a daily basis	Pol- Soc	5	0.086	3	0.258
Solar energy is a stable resource without price fluctuations	Eco- Soc	5	0.086	4	0.344
A proper transportation system can reduce the cost	Eco	3	0.052	3	0.156
Solar power maintenance cost and depreciation is considerably low	Eco	5	0.086	4	0.344
Solar energy can reduce dependence on a single resource (energy mix optimization/energy diversification)	Pol- Soc	5	0.086	3	0.258
Despite the high initial setup cost, increasing the production volume will be more economical and competitive in long time (economies of scale).	Eco	4	0.069	3	0.207
Security of investment in solar power for its supply reliability as well as supporting fossil fuels	Pol- Eco	4	0.069	3	0.207
It is easy to recycle solar energy	Env	5	0.086	3	0.258
Weaknesses					
There is a low share of renewable energy in the global energy market	Pol	4	0.069	1	0.069
If the Government does not devote considerable attention to solar energy, its importance will continue to remain after fossil fuel	Pol- Leg	4	0.069	1	0.069
The setup cost for solar power is relatively high, and requires a storage system	Eco	5	0.086	1	0.086
Solar resources require technology development since old technologies increase the costs	Eco- Tec	4	0.069	2	0.138
Total			**1.00**		**2.74**

* Pol, Eco, Soc, Tec, Env, and Leg refer to political, economic, socio-cultural, technical, environmental, and legal factors, respectively.

A 1 to 4 rating is then allocated to the fifth column of the table to represent whether the factor is a major weakness (rating = 1), a minor weakness (rating = 2), a minor strength (rating = 3) or a major strength (rating = 4) [17].
The weight of each factor is then multiplied by its rating in order to obtain a weighted score, which is finally summed to provide the total weighted score for the internal factors. The total weighted score of the internal factors acquired in this work (2.74) is greater than 2.5, which means that the strengths of the solar energy outweigh its weaknesses.

2.2. External Factor Evaluation

The external factor evaluation checks, assesses, and publishes the data obtained for the organization and its key personnel. Here, the opportunities and threats with which the country will be confronted are recognized by the PEST analysis in order to help the managers to adopt the effective strategies to exploit opportunities and reduce or avoid the effects of the threatening factors. The PEST analysis is a simple and effective tool to determine the key external drivers or forces (macro-level environment) that may affect an organization. These forces can create the opportunities or threats for the organization [18].
The PEST analysis aims to a) find the existing external factors influencing the organization, b) determine the external factors subject to change in the future, and c) utilize the opportunities or defend against the threats. The PEST outcome is an overall understanding of what surrounds the company or business. It can also be used to assess the new markets' potential [18]. The PESTEL analysis is a generalized type of PEST that the authors believe can cover all the macro-environmental factors of solar energy.
Generally, the environment can be divided into two parts: the general environment including the economic, technological, socio-cultural, political, legal, and global trends that indirectly affect all organizations and the specific environment that is unique to the organization's industry, and directly affects the way it conducts its business. After determining all the external factors by considering the PESTEL analysis into account, the EFE (External Factor Evaluation) matrix evaluates any of the general and specific strategic factors in order to examine whether the opportunities overcome the threats. According to the same structure of the IFE matrix, explained in the

previous section, the priority factors are then set in a column of the matrix, and will be scored by particular coefficients and ratings in order to determine whether the organization encounters more opportunities or threats in its future. The result of the EFE matrix is represented in Table 2. The total weighted score obtained for the external factors (3.06) in this table shows that the opportunities of solar energy outweigh its threats.

Table 2: EFE matrix*.

External factors	Type	Weight	Normalized weight	Rating	Weighted score
Opportunities					
Sun is a massive free energy resource	Eco-Env	5	0.035	4	0.14
Instability of fossil energy prices can be a motivation for sustainable movement toward renewable energy, especially for a country with oil-based economy, such as Iran	Pol-Eco	4	0.028	3	0.084
Rials instead of foreign currency can be gained from power generation that prevents inflation	Pol-Eco-Soc	5	0.035	4	0.14
Industry and new technologies can be developed	Eco-Soc-Tec	5	0.035	4	0.14
Using solar energy can ensure the country's energy security (energy diplomacy)	Pol	5	0.035	4	0.14
Unlike most fossil energy sources and nuclear power plants located in the southern region of the country, the solar energy resource is not focused in one area (passive defense)	Pol-Eco	5	0.035	4	0.14
The international contracts oblige countries to reduce greenhouse gases	Pol-Env	5	0.035	4	0.14
Solar energy can insure energy exchange and free power market	Pol	5	0.035	3	0.105
Subsidies are planned to support a transition from fossil fuels to renewable energy (targeted subsidies)	Pol	4	0.028	4	0.112
Enforcing huge consumers to have power plant	Pol-Leg	5	0.035	3	0.105
Higher speed in using solar energy due to fast start-up of solar power plants compared to fossil power plants.	Eco-Tec	5	0.035	3	0.105
Capacity factor in almost all regions of Iran, there is a possibility to produce far more electricity than the European countries.	Eco-Tec	4	0.028	3	0.084
Iran contains a high potential of radiation severity based on its geographic location	Pol-Eco	5	0.035	4	0.14
Upward trend of investment in renewable industry in the world	Pol-Eco	5	0.035	3	0.105
Reducing greenhouse gas emissions (solar energy is green and ecological)	Soc-Env	5	0.035	3	0.105
Less water consumption in energy production from solar energy (in fossil power plant systems, water is used as a coolant)	Soc-Env	5	0.035	3	0.105
Solar energy can create new job opportunities	Pol-Eco-Soc	4	0.028	4	0.112
Possibility of providing off-grid power for rural and remote areas	Pol-Soc	5	0.035	4	0.14
The need to implement Article 139 of the Fifth Development law to increase the country's wind and solar power plants	Pol-Leg	4	0.028	3	0.084
90% dependency of the country to gas in electricity production (more than 50% dependency to a source is not reasonable)	Eco	3	0.02	3	0.06
International sanctions reduce the country’s accessibility to technology and capacity in the oil and gas sector	Pol-Tec	5	0.035	4	0.14
Fossil fuels have passed their life cycle’s maturity stage, and their competitiveness is decreased.	Eco	4	0.028	4	0.112
Sensitivity toward environmental pollution under the Kyoto Protocol, the strict requirements of environmental institutions, and efforts to curb the use of fossil fuels that lead to increased cost of finished products	Pol-Eco-Soc-Env-Leg	5	0.035	4	0.14
Threats					

Lack of cooperation between the political authorities and businesses slows down the process of moving toward solar energy technology	Pol	5	0.035	1	0.035
Solar energy should be supported by the Government. Lack of government funding disables renewable energy in competing with fossil fuels	Pol-Eco	5	0.035	1	0.035
Possibility of reducing fossil fuel prices due to the global movement toward renewable energy	Eco-Pol	4	0.028	1	0.028
Self-sufficiency in power generation that eliminates the need for power plants and changes the business model	Soc-Tec	5	0.035	1	0.035
If the government does not reduce tax, the price of solar energy will be higher than the fossil fuels	Eco	4	0.028	2	0.056
Solar energy initial start-up cost has a negative effect on its arrival in the market	Eco	4	0.028	2	0.056
With the development of technology in digging techniques, new sources of shale gas can be detected, which may jeopardize the future of solar and renewable energy	Tec-Env	4	0.028	2	0.056
No public acceptance of renewable energy is a serious obstacle in the way of solar energy development	Soc	4	0.028	2	0.056
Total			**1.00**		**3.06**

* Pol, Eco, Soc, Tec, Env, and Leg refer to political, economic, socio-cultural, technical, environmental, and legal factors, respectively.

2.3. Internal-External Matrix

The internal-external matrix, which is a suggestive combination model of the internal and external factor evaluation, is used here in order to determine the most appropriate types of strategies to follow. Figure 4 shows the internal-external matrix of solar energy deployment according to the values obtained from the IFE and EFE matrices for the internal and external factors (2.74 and 3.06).

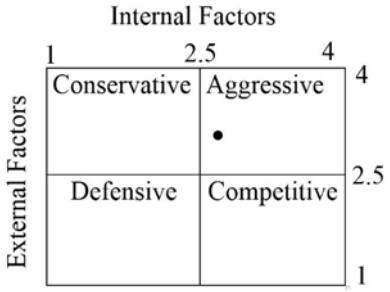

Figure 4. Internal-external matrix.

This matrix shows that regarding the strengths, weaknesses, opportunities, and threats of solar energy development, aggressive strategies must be applied in the country. Since its location in the aggressive cell is weak and its position is close to the conservative cell, following conservative strategies is also suggested.

2.4 SWOT Matrix

Similar to the internal-external matrix, the SWOT matrix contains four different strategies, as:

1) SO strategies that apply the strengths to exploit the opportunities (aggressive),

2) ST strategies that use the strengths to avoid the threats (competitive),

3) WO strategies that take advantage of opportunities in order to eliminate the weaknesses (conservative),

4) WT strategies that try to overcome the weaknesses and reduce the threats (defensive).

This is depicted in Figure 5.

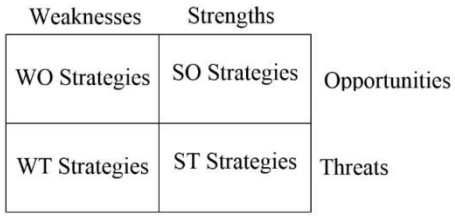

Figure 5. SWOT matrix.

Since the strengths and opportunities of the solar energy defined in the evaluation of the internal and external factors outweigh its weaknesses and threats, the SO strategies are the most suitable ones for implantation. Moreover, regarding several opportunities of the solar energy, mentioned in the EFE matrix, and considering the internal-external matrix, the opportunities can be used to reduce the effects of some weaknesses.

3. Further Discussions

The outcomes of the internal-external and SWOT matrices indicate that the most appropriate strategies for the solar energy development are aggressive strategies to take advantage of the strengths to use the opportunities (SO strategies). Furthermore, it is suggested to apply the WO (conservative) strategies in order to compensate for the weak position of the solar energy development in the aggressive cell of the internal-external matrix. This includes the strategies benefitting from the opportunities to overcome the

weaknesses. Some of the strategies that can be considered are recommended here:
1) Iran has a considerable potential for using the solar energy and advancing energy efficiency; therefore, the country's dependency on oil must be reduced (aggressive).
2) In order to benefit from the solar energy in each one of the regions, a powerful strategic planning based on regional potential is essential (aggressive).
3) Foreign financial support can be a good source to supply the initial capital required to construct the solar power plants (conservative).
4) Despite the high cost of developing the required technology to exploit solar energy, this technology, which is a factor to develop the country in the long term, must be deployed (conservative).

4. Conclusions

Relying on oil revenues over the last decades has hindered the progress of the country as well as its economic growth and development. In addition, the necessity to consider the requirements of the international obligations to reduce air pollution requires transition from fossil fuels to clean and sustainable energies. Thus in this article, we analyzed the strengths, weaknesses, opportunities, and threats of the solar energy to pave the way for future plans of using the solar energy resources in Iran.
In this research work, we analyzed the solar energy development in Iran through a comprehensive framework using the internal-external and SWOT matrices. The numerical results, obtained from internal and external factors evaluation (2.74 and 3.06) points to the aggressive strategy as the best solution for Iran solar energy.
However, since it is not far from the conservative cell, this strategy is also recommended.
Regarding the equivalent cells in the SWOT matrix, Iran must take advantage of the solar energy strengths to use the opportunities (aggressive strategies), and also benefit from the opportunities to overcome the weaknesses (conservative strategies). As a result, Iran is required to reduce its dependency on fossil fuels according to a strategic planning. For this purpose, deploying solar energy in potential areas by using foreign financial support would be of great importance.
This paper focused mainly on reviewing and analysing the internal and external environments of the solar energy development as well as determining the suitable strategies among the aggressive, defensive, conservative, and competitive ones. Future research works may focus on developing mathematical models, defining more strategies, and conducting further analyses by the QSPM matrix to prioritize the strategies.

5. References

[1] A. Ahmadi et al., "Recent residential applications of low-temperature solar collector," J. Clean. Prod., vol. 279, 2021.

[2] A. Khosravi, S. Syri, X. Zhao, and M. E. H. Assad, "An artificial intelligence approach for thermodynamic modeling of geothermal based-organic Rankine cycle equipped with solar system," Geothermics, vol. 80, no. November 2018, pp. 138–154, 2019.

[3] M. H. Ahmadi et al., "Solar power technology for electricity generation: A critical review," Energy Sci. Eng., vol. 6, no. 5, pp. 340–361, 2018.

[4] B. Igliński, R. Buczkowski, A. Iglińska, M. Cichosz, and M. Plaskacz-Dziuba, "SWOT analysis of the renewable energy sector in Poland. Case study of Wielkopolskie region," J. Power Technol., vol. 95, no. 2, pp. 143–157, 2015.

[5] R. Paliwal, "EIA practice in India and its evaluation using SWOT analysis," Environ. Impact Assess. Rev., vol. 26, no. 5, pp. 492–510, 2006.

[6] H. Geerlings, P. Van Hemert, V. Marchau, P. Nijkamp, and C. Withagen, "The potential of green gas in the Dutch transport sector," Int. J. Glob. Energy Issues, vol. 37, no. 5/6, pp. 236–252, 2014.

[7] A. G. Lupu, A. Dumencu, M. V Atanasiu, C. E. Panaite, G. Dumitraşcu, and A. Popescu, "SWOT analysis of the renewable energy sources in Romania - case study : solar energy SWOT analysis of the renewable energy sources in Romania – case study : solar energy," IOP Conf. Ser. Mater. Sci. Eng., pp. 1–10, 2016.

[8] A. Khader J and M. Idris P, "SWOT Analysis of Solar Energy In India," Int. J. Commer. Bus. Manag., vol. 5, no. 2, pp. 323–326, 2016.

[9] C. Sharma and A. Jain, "SWOT Analysis for Solar PV-Technology," AKGEC Int. J. Technol., vol. 8, no. 2, pp. 42–45, 2017.

[10] W. Arafah, L. Nugroho, R. Takaya, and S. Soekapdjo, "Marketing Strategy for Renewable Energy development In Indonesia Context Today," Int. J. Energy Econ. Policy, vol. 8, no. 5, pp. 181–186, 2018.

[11] K. Sudhakar, "SWOT analysis of floating solar plants," MOJ Sol. Photoenergy Syst. Rev., vol. 3, no. 1, pp. 20–22, 2019.

[12] R. Karim et al., "Paving towards strategic investment decision: A swot analysis of renewable energy in Bangladesh," Sustain., vol. 12, no. 24, pp. 1–30, 2020.

[13] R. Madurai Elavarasan, S. Afridhis, R. R. Vijayaraghavan, U. Subramaniam, and M. Nurunnabi, "SWOT analysis: A framework for comprehensive evaluation of drivers and barriers for renewable energy development in significant countries," Energy Reports, vol. 6, pp. 1838–1864, 2020.

[14] M. S. Raboaca, A. M. Nasture, and A. Corbu, "SWOT of renewable energy sources in Romania," in Proceedings of the 12th International Conference on Electronics, Computers and Artificial Intelligence, ECAI 2020, 2020.

[15] S. E. Uhunamure and K. Shale, "A SWOT Analysis Approach for a Sustainable Transition to Renewable Energy in South Africa," Sustainability, vol. 13, no. 7, p. 3933, 2021.

[16] S. M. Erabi, Strategic Planning Handbook. 2013.

[17] A. R. Ommani, "Strengths, weaknesses, opportunities and threats (SWOT) analysis for farming system businesses management: Case of wheat farmers of Shadervan District, Shoushtar Township, Iran," African J. Bus. Manag., vol. 5, no. 22, pp. 9448–9454, 2010.

[18] O. Jurevicius, "PEST & PESTEL Analysis," Strateg. Manag. Insight, pp. 1–8, 2013.