



Identification and Prioritization of Factors Affecting the Marketing of Solar Energy Production Equipment Based on a Combined Approach of Content Analysis and Fuzzy Delphi

Mohammad Hossein. Rezvanian¹, Farideh. Haghshenaskashani^{2*}, Mehdi. Karimizand²

¹ PhD student, Department of Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran

² Assistant Professor, Department of Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran

* Corresponding author email address: fahaghshenaskashani_93@yahoo.com

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ABSTRACT

Objective: The aim of this research is to identify and prioritize the factors affecting the marketing of solar energy production equipment based on a combined approach of content analysis and fuzzy Delphi.

Methodology: In this study, the purposive snowball sampling method was used to gather opinions from 15 experts and professors from the Iranian Renewable Energy Association, the Renewable Energy and Energy Efficiency Organization of Iran, and the Solar Energy Committee of the Vice Presidency for Science and Technology. The data analysis process was conducted in two stages: identifying the influencing factors through interview tools and content analysis, and screening and prioritizing these factors using questionnaire tools and the fuzzy Delphi method.

Findings: The results of the study indicated that government policies hold the highest priority among the factors affecting the marketing of solar energy production equipment.

Conclusion: Following this, the factors in order of priority are brand/product awareness, distrust in solar technology and equipment, the local lifestyle of each region, remarketing, creating added or unique value for the product, market research, defining and identifying the audience and target market, aiding in sales growth, climate change and the necessity of environmental preservation, optimizing marketing through social media, business survival in a competitive market, creativity in marketing, utilization of digital capabilities, cost reduction, improving customer experience and creating a memorable product image, building trust through social proof, the general public's benefit from the social and environmental advantages of marketing solar equipment, and the need for a communication channel to inform customers.

Keywords: marketing, solar equipment, solar energy

1 Introduction

Today, the importance of using renewable energy sources for electricity production has gained attention worldwide for various reasons. Particularly in the case of solar technologies, the sun, as a natural source, is abundant and ubiquitous during the day. Additionally, utilizing such resources helps reduce dependence on traditional fossil fuel sources that are extracted from the earth and lead to carbon dioxide emissions. This, in turn, limits the negative impact on the environment (Ibrahim et al., 2021). Therefore, given the advantages of using solar energy, the installed capacity of solar power generation systems worldwide reached 700 gigawatts by 2020. In contrast, the total solar energy produced in Iran by 2021 was 455.5 megawatts, which constitutes a small portion of the electricity generated in Iran. For solar energy to have a significant share in energy production and ultimately contribute to a green economy and the reduction of greenhouse gases, the use of solar technology must expand. However, expanding the use of solar power generation systems is not an easy task. The reality is that to deploy and utilize more solar technologies, most power companies need to overcome major market growth barriers, including marketing (Crago, 2021).

Marketing is defined as the process of planning and executing the development, pricing, promotion, and distribution of ideas, goods, and services to create exchanges that satisfy individual and organizational objectives (Ringold & Weitz, 2007). Effective marketing guides how, when, and where product information is presented to consumers, with the ultimate goal of persuading consumers to purchase a particular brand or product (Vinerean, 2017). In this context, a large body of previous literature has analyzed how to motivate consumers to use renewable energy. Moreover, related factors and barriers to investment in power generation systems from renewable sources have been examined (Alipour et al., 2020; Karakaya & Sriwannawit, 2015). However, few existing studies have directly addressed the commercialization of solar energy. Although these studies describe various types of marketing, they include very little marketing information specific to this domain. The analyzed methods in these studies are mainly focused on communication programs, such as website strategies, stakeholder relations, and educational events (Kratschmann & Dütschke, 2021; Stauch, 2021), or advertising in specific applications of solar technology, such as solar panels and solar cells (Salgado-Conrado & Lopez-Montelongo, 2019; Wirtz & Janssen, 2010). Nevertheless,

marketing in a broader sense should play a significant role in overcoming existing barriers and expanding the market for solar power generation systems, which has largely been neglected in domestic research. For this definition of marketing to succeed, the factors affecting the marketing of solar energy production equipment must first be identified. Therefore, it is necessary to understand: a) the current consumer perception of the product and what needs to be overcome to improve that perception, b) which price/value equation will be most appealing, c) how consumers come to trust reliable sources of product information, and d) where this key information should be presented in the form of advertisements and so on to align with consumer goals. When all these elements are successfully integrated through a scientific process, marketing connects with the consumer and creates a desire for the product, leading to sales. Additionally, with growth, improvement, and the provision of new platforms in this industrial field, a deep research gap is observed in our country concerning the marketing of solar energy production equipment, which the researcher seeks to identify and prioritize in this study. In other words, the researcher aims to address the gaps in this field, both in foreign and domestic research.

In the following, the theoretical foundations and the research background will be referenced. Then, the research method, including the type of research, population, and method of selecting participants, will be explained, and finally, after presenting the research findings, the discussion and conclusion of the research will be provided.

2 Methods and Materials

The research method in this study is applied based on the objective and mixed based on the data collection method. The research process includes two main qualitative and quantitative parts. The research population in both qualitative and quantitative sections, due to being expert-oriented, includes industry experts (Iranian Renewable Energy Association, Renewable Energy and Energy Efficiency Organization of Iran (SATBA), Solar Energy Committee of the Vice Presidency for Science and Technology) and university professors knowledgeable in the field of solar marketing. The sample size determination method in the interview stage is based on snowball sampling until saturation, and the logic of data sufficiency collected is considered as the criterion for complete data. Therefore, in-depth interviews were conducted with 15 experts in this field, reaching saturation by the thirteenth interview, and for

greater confidence and validation of findings, interviews were also conducted with the fourteenth and fifteenth experts.

Moreover, to test the validity and reliability of the standardized tools used in this study, the interview questions were tested in several stages with the help of research method professors, thus resolving any ambiguities in the questions. The data collected from the interviews were then analyzed using a content analysis approach through two stages of initial and secondary coding. This way, phrases and concepts were extracted from the interviews, and after grouping concepts and finding signs and similarities, uncommon concepts were removed, and finally, the factors affecting the marketing of solar energy products were identified. To examine the validity of the collected data, the interview sentences were reviewed with the help of subject matter experts to identify and remove irrelevant concepts. The quantitative section also includes members of the statistical population, such as university professors and knowledgeable experts in solar marketing. During this period, experts in all these fields were surveyed through a research questionnaire, leading to more accurate and comprehensive results. The face validity of the questionnaire was examined through content validity, and multiple experts' opinions and necessary corrections were made. To calculate the reliability of the questionnaire, Cronbach's alpha method was used, and the Cronbach's alpha coefficient was obtained using SPSS25 software at 0.81 percent, which is within the acceptable range (above 0.70). In the next step, to collect data for prioritizing the effective marketing topics of solar energy production equipment identified in the qualitative stage and selecting from the research population, starting from the questions and for analyzing the collected data, the fuzzy Delphi method was used. For this purpose, a preliminary questionnaire was prepared, and after reviewing the initial questions with the help of professors and experts, the final version was prepared, and expert researchers were asked to express their opinions on the identified topics. Below is a step-by-step explanation of one of the most popular techniques presented in fuzzy Delphi. Indeed, all steps of the fuzzy Delphi method used are exactly like the traditional Delphi method, with the only difference being in the data analysis section. The following explains the data analysis steps of the questionnaire in the fuzzy Delphi method:

Step 1) Collecting experts' opinions: In this stage, like the traditional Delphi method, experts' opinions are collected. In

this method, linguistic variables are used to design the questionnaire and collect experts' opinions.

Step 2) Calculating fuzzy values for each question: This stage involves collecting experts' opinions and calculating fuzzy values (indices) for each question based on the collected data.

To calculate the fuzzy value for each question, proceed as follows:

$$L_j = \text{Min}(x_{ij}) \quad i = 1.2. \dots n \quad j = 1.2. \dots m$$

$$M_j = \left(\prod_{i=1}^{n.m} x_{ij} \right)^{\frac{1}{n}} \quad i = 1.2. \dots n \quad j = 1.2. \dots m$$

$$U_j = \text{Max}(x_{ij}) \quad i = 1.2. \dots n \quad j = 1.2. \dots m$$

After calculating the fuzzy value of each query, to be able to judge each question, we must first defuzzify the obtained fuzzy values for each question before comparing and evaluating them. Several methods and relationships were given to defuzzify the fuzzy values of each query. Two examples are given below:

$$S_j = \frac{L_j + 2 \times M_j + U_j}{4}$$

After calculating the fuzzy (defuzzified) value of each question (index), their importance must be evaluated. There is no specific rule for evaluating the importance of each question. However, it is common to use a threshold value (rrr) to evaluate the importance of each question. Therefore, based on the threshold value, two conditions are created:

If $S_j \geq r$, it means that the question (index) j is of high importance.

If $S_j < r$, it means that the question (index) j is of low importance. Due to the low importance of these questions, they can be removed.

Step 5) Calculating weight and rank: To calculate the weight of each question, first, the sum of defuzzified values for all questions is obtained. Then, in the next step, the defuzzified value of each question is divided by the obtained sum to get the weight of each question or index. The total weight of all questions should also be equal to one.

3 Findings and Results

As mentioned in the methodology section, after a comprehensive review of theoretical and empirical foundations, in-depth interviews and content analysis were employed for coding and then identifying the factors affecting the marketing of solar energy production

equipment in the qualitative section of the research. Accordingly, after conducting the interviews, coding was performed at two levels: initial and secondary coding. During the familiarization stage with the data, 70 speech instances identified from the interview transcripts were categorized into 19 initial categories. Below is an excerpt from an interview with one of the respondents to illustrate the coding process:

Interviewee 3: "...Interest in renewable energy is increasing, which is good news for anyone in the solar solutions business. This technology is better than ever, and environmental awareness is at its peak, creating a flawless trend of increasing demand year by year. Many solar energy providers have stepped in to capture their share of the market. Since the solar industry is receiving a positive response from people, establishing a successful and sustainable solar business is a primary concern for solar business owners. Business owners must enhance their marketing to experience steady growth. In this regard, social media is a good platform for improving your marketing strategies. Internet users rely on social media to discover new products and services, besides entertainment and new

trends. Therefore, your social media profile should be set up to leverage the traffic and opportunities available there. Hence, you should find key insights about your target audience. Social media platforms have invested heavily in analytical tools to discover the demographics of your target audience. You can use the analysis of gender, location, and interests of your audience to create more optimized and targeted content to meet their needs. For instance, if you find that most of your audience is educated and holds key positions in the corporate sector, listing and optimizing your business on LinkedIn can be a great success. Include videos in your strategy. Additionally, a social media post with a video is shared several times more than plain images and texts. Therefore, videos should be used as part of your marketing strategy to showcase solar products, equipment usage tutorials, or other branding initiatives to improve customer engagement..."

Next, secondary coding and allocation of categories into secondary groupings were conducted. [Table 1](#) below shows the identified factors affecting the marketing of solar energy production equipment in the form of secondary categories along with their associated primary codes.

Table 1

Final Results from Initial and Secondary Coding

Secondary Coding (Dimensions)	Initial Coding (Elements)
Causal Conditions	Climate change and the need for environmental preservation Cost reduction Contributing to sales growth Need for a communication channel to inform customers
Contextual Factors	Market research Use of digital capabilities Creativity in marketing
Intervening Conditions	Distrust in solar technology and equipment Local lifestyle of each region Government policies
Strategies and Approaches	Defining and identifying the audience and target market Creating added or unique value for the product Optimizing marketing through social media Remarketing
Outcomes and Consequences	Improving customer experience and creating a memorable image Business survival in a competitive market Building trust through social proof Increasing brand/product awareness Public benefits from social and environmental marketing of solar equipment

Subsequently, to validate the interview results and prioritize the factors affecting the marketing of solar energy production equipment, a questionnaire and the fuzzy Delphi method were used. An initial questionnaire was designed and revised based on the opinions of professors and experts,

then finalized. Experts were asked to express their views on the identified indicators from the interviews and suggest any additional potential factors. The collected questionnaires, totaling 15, were aggregated, and the defuzzified value of

each strategy was calculated. Table 2 shows the aggregation of expert opinions for the Delphi questionnaire.

Table 2

Aggregation of Expert Opinions for Delphi Questionnaire (Importance Level)

No.	Category	Element	Very Low	Low	Relatively Low	Medium	Relatively High	High	Very High	Total
1	Causal Conditions	Climate change and the need for environmental preservation						2	4	9
2		Cost reduction					4	3	8	15
3		Contributing to sales growth					2	3	10	15
4		Need for a communication channel to inform customers				1	2	3	9	15
5	Contextual Factors	Market research					2	1	12	15
6		Use of digital capabilities					2	9	4	15
7		Creativity in marketing					2	8	5	15
8	Intervening Conditions	Distrust in solar technology and equipment				1		14		15
9		Local lifestyle of each region				1	1	13		15
10		Government policies						2	13	15
11	Strategies and Approaches	Defining and identifying the audience and target market				1	5	9		15
12		Creating added or unique value for the product				1	4	10		15
13		Optimizing marketing through social media				2	6	7		15
14		Remarketing				1	1	13		15
15	Outcomes and Consequences	Improving customer experience and creating a memorable image				1		1	13	15
16		Business survival in a competitive market				3	4	8		15
17		Building trust through social proof				1		5	9	15
18		Increasing brand/product awareness					6	9		15
19		Public benefits from social and environmental marketing of solar equipment				1	1	5	8	15

The results of the fuzzy Delphi calculations are presented in Table 3. As shown, the defuzzified value of all research questions (elements) is greater than the threshold value (0.7), indicating that all factors were confirmed by the experts, and no new variables were suggested. Therefore, the Delphi process was stopped, and the validity of the model elements was confirmed. Government policies were given the highest priority among the factors affecting the marketing of solar energy production equipment, followed by increasing brand/product awareness, distrust in solar technology and equipment, local lifestyle of each region, remarketing, creating added or unique value for the product, market

research, defining and identifying the audience and target market, contributing to sales growth, climate change and the need for environmental preservation, optimizing marketing through social media, business survival in a competitive market, creativity in marketing, use of digital capabilities, cost reduction, improving customer experience and creating a memorable image of the product, building trust through social proof, public benefits from social and environmental marketing of solar equipment, and the need for a communication channel to inform customers, which were ranked from second to nineteenth, respectively.

Table 3*Results of Fuzzy Delphi Questionnaire Analysis*

No.	Dimensions	Research Questions (Elements)	L	M	U	Defuzzified	Result	Weight	Priority	
1	Causal Conditions	Climate change and the need for environmental preservation	0.5	0.927	1	0.839	Approved	0.0528	10	
2		Cost reduction	0.5	0.890	1	0.820	Approved	0.0516	15	
3		Contributing to sales growth	0.5	0.934	1	0.842	Approved	0.0530	9	
4	Contextual Factors	Need for a communication channel to inform customers	0.3	0.892	1	0.771	Approved	0.0485	19	
5		Market research	0.5	0.947	1	0.848	Approved	0.0534	7	
6		Use of digital capabilities	0.5	0.895	1	0.823	Approved	0.0518	14	
7		Creativity in marketing	0.5	0.901	1	0.826	Approved	0.0520	13	
8		Intervening Conditions	Distrust in solar technology and equipment	0.5	0.977	1	0.863	Approved	0.0543	3
9			Local lifestyle of each region	0.5	0.970	1	0.860	Approved	0.0541	4
10	Strategies and Approaches	Government policies	0.7	0.986	1	0.918	Approved	0.0578	1	
11		Defining and identifying the audience and target market	0.5	0.943	1	0.846	Approved	0.0533	8	
12		Creating added or unique value for the product	0.5	0.949	1	0.850	Approved	0.0535	6	
13		Optimizing marketing through social media	0.5	0.914	1	0.832	Approved	0.0524	11	
14		Remarketing	0.5	0.970	1	0.860	Approved	0.0541	4	
15		Outcomes and Consequences	Improving customer experience and creating a memorable image	0.3	0.948	1	0.799	Approved	0.0503	16
16			Business survival in a competitive market	0.5	0.905	1	0.828	Approved	0.0521	12
17	Building trust through social proof		0.3	0.922	1	0.786	Approved	0.0495	17	
18	Public benefits from social and environmental marketing of solar equipment	Increasing brand/product awareness	0.7	0.959	1	0.904	Approved	0.0569	2	
19		Public benefits from social and environmental marketing of solar equipment	0.3	0.900	1	0.775	Approved	0.0490	18	

4 Discussion and Conclusion

The present study was conducted to identify the factors affecting the marketing of solar energy production equipment. Furthermore, this study examined the priority of these factors. Accordingly, using content analysis and the analysis of conducted interviews, 70 items were identified as initial concepts from the interview transcripts, which were categorized into 19 initial codes and five secondary codes. Ultimately, using the fuzzy Delphi method, the strategies were screened and prioritized.

A review of internal and external research indicates that no study specifically identifies and prioritizes the factors affecting the marketing of solar energy production equipment. However, the present study aligns with research on topics such as prior solar marketing conducted (Adabi Mamaqani et al., 2020; Ambepitiya, 2018; Luckett & Needham, 2021; Pourdarbani, 2020), which were thoroughly reviewed in the literature section.

Based on the results of the study, the theory of marketing solar energy production equipment can be explained as follows: Considering the necessity to address climate change and environmental preservation, cost reduction, sales growth assistance, and the need for a communication channel to

inform customers as a set of causes and conditions that influence the central concept of workplace curriculum with a foresight approach in Iran's higher education system; if contextual conditions such as market research, utilization of digital capabilities, and creativity in marketing are met on one hand, alongside addressing distrust in solar technology and equipment, improving the local lifestyle in each region, and government policies in this field on the other hand; the marketing strategies for advanced solar energy production equipment will be realized. These strategies include defining and identifying the audience and target market, creating added or unique value for the product, optimizing marketing through social media, and remarketing. The consequences of these strategies will be improved customer experience and creating a memorable product image, business survival in a competitive market, building trust through social proof, increasing brand/product awareness, and public benefits from the social and environmental marketing of solar equipment.

Therefore, based on the results, the present study can be utilized to prepare the best organizational conditions in the field of marketing solar energy production equipment by gradually implementing and allocating the process to downstream executive organizations or upstream decision-

makers. It is recommended that by establishing suitable infrastructure by government and private centers, necessary training should be provided in this field to prepare the required groundwork for understanding various aspects of marketing solar energy production equipment and implementing strategies within the identified research frameworks.

Authors' Contributions

All authors have contributed significantly to the research process and the development of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were observed.

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