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DECISION SUPPORT MECHANISMON CHOICE OF PV PANELS

Lutfu Sagbansua[1,1] and Figen Balo[2]
[1,2]Department of Industrial Engineering, Firat University, 23279 Elazığ, Turkey
[2]E-mail: figenbalo@gmail.com (*Corresponding Author*)

Abstract: In this paper, the choice of the most proper PV panel is obtained by a decision support mechanism. The analytic hierarchy process (AHP) methodology is performed as decision support mechanism. Because this methodology is simple to understand, implement and compute. It is one of the most widespread multi-criteria decision making methodology. AHP has been generally performed to conclude energy decisions in regard to the requirements and the preferences of the experts.
Keywords: AHP, Renewable energy, decision support mechanism, Photovoltaic panel, Solar.

1. Introduction

Over the last decades, the need for electricity has raised quickly in the world. For electricity generation, one of the most common renewable energy sources used is solar energy. Researchers have concentrated on renewable energy sources and the choice of proper devices related to these sources. The most important decision in the PV system planned is the most proper PV panel choice due to the high price of these PV panels. In literature, Zeyuan compared different kinds of solar cell and analyzed with TOPSIS [1]. Amin et al. developed area study of different PV panels on their performance [2]. Naghiu et al. analyzed the choice of the optimum solution concerning the concentration ratio of the solar panels with Electre-Boldur Method [3]. A hybrid multi-criteria analysis based on the fuzzy Promethee, fuzzy ANP, and fuzzy Dematel, used to select the best alternative among the photovoltaic panel, gas engine, gas turbine, fuel cell, and diesel engine by Khorasaninejad et al. [4]. By Chen and Yang, the Topsis and AHP for multi-criterion decision making method are utilized to research firm-level data, obtained from the photovoltaic equipment companies in the Crystalline Silicon photovoltaic panel sector [5]. In the Mediterranean region, Stamatakis et al. analyzed with multi-criteria decision making method of solar panels affixed on characteristic south-covering shading devices of buildings [6].

In this study, a decision support mechanism is performed in choice of PV panels. The problem is solved by AHP. For this purpose, five diverse criteria (customer, mechanical, financial, environmental, and electrical) are used and four diverse PV panel brands are evaluated.

Multi-Criteria Decision Making in Photovoltaic Panels Selection

The reason for using an AHP-based decision analysis approach in this study is that it allows decision makers to analyze complex decision-making problems using a systematic approach that breaks down the main problem into simpler and affordable sub-problems. In an AHP hierarchy for choosing a solar panel, the goal would be to choose the best panel. This study aims to contribute to the existing literature significantly by helping decision makers in selecting the best solar panel based on various groups of criteria. Electrical, mechanical, financial, environmental, and customer related factors are the five main criteria that are often used in evaluation of various investment projects for making a decision. These criteria can be subdivided into several sub-criteria. In this study, the electrical criterion is subdivided into 15 sub-criteria. Mechanical group includes material, color and weight attributes. The cost criterion is subdivided into variable cost, total investment cost and state support. The environmental criterion involves area requirement and material manufacturing effect. Finally, the customer satisfaction is measured using customer service, availability of spare parts, and reliability. Four alternative solar panels are compared using AHP technique. The hierarchy tree for the selection of the best solar panel is constructed as shown in the Fig. 1.While measurements for some criteria are readily available, some others like customer satisfaction can only be estimated with respect to other variables. As it is the case in all multi-criteria decision making methods, the relative weights of such criteria need to be determined. In AHP, this is accomplished by pairwise comparison of the elements, starting with the main criteria. Below are the resulting priorities of electrical, mechanical, financial, environmental, and customer related factors.

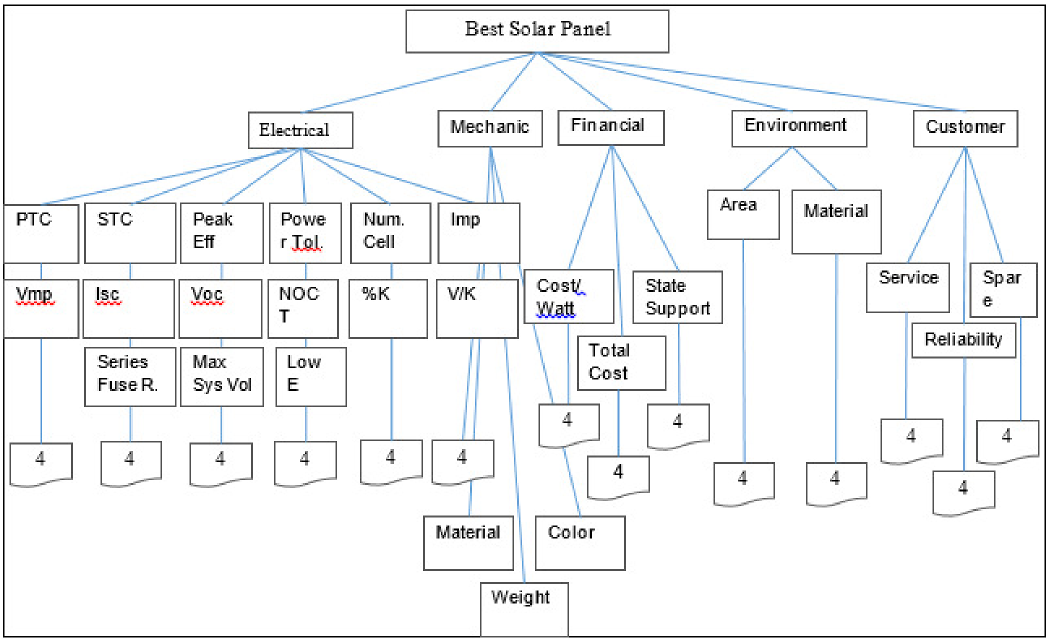

Fig. 1. The hierarchy tree for the selection of the best solar panel.

Table 1 shows main criteria priorities. In the next step, the groups of sub-criteria under each main criterion need to be compared two by two. In the electrical subgroup, each pair of sub-criteria is compared regarding their importance with respect to the electrical criterion. Below are the resulting weights for these criteria.

Table 1. Main Criteria priorities

Electrical	Mechanic	Financial	Customer	Environment
51%	24%	14%	9%	5%

These are the resulting weights for the criteria based on pairwise comparisons. At this point, the comparison for electrical criterion has been made, and the AHP method has derived the local priorities for this group. These priorities reflect on how much a sub-criterion contributes to the priority of its parent, thus we need to calculate the global priority of each sub-criterion. That will show us the priority of each sub-criterion with respect to the overall goal. The global priorities throughout the hierarchy should add up to one. The global priorities of each electrical sub-criterion are calculated by multiplying their local priorities by the priority of electrical criterion. Table 2 displays these values of electrical priorities.

Table 2. Electrical Priorities

%	**PTC**	**STC**	**PE**	**PT**	**NC**	**Imp**	**Vmp**	**Isc**	**Voc**	**NOCT**	**%K**	**V/K**	**SFR**	**MSV**	**LED**
Electrical Local	0,282	0,168	0,106	0,058	0,097	0,019	0,019	0,019	0,019	0,027	0,034	0,019	0,079	0,019	0,034

Electrical Global	0,142	0,085	0,054	0,029	0,049	0,01	0,01	0,01	0,01	0,014	0,017	0,01	0,04	0,01	0,017

Table 3. Mechanical, Financial, Environmental and Customer Priorities

Mechanic			**Financial**			**Environmental**			**Customer**		
Category	**Local**	**Global**	**Category**	**Local**	**Global**	**Category**	**Local**	**Global**	**Category**	**Local**	**Global**
Material	0,69	0,16	Cost/ Watt	0,56	0,08	Area Use	25,00 %	0,019	Service	0,34	0,02
Color	0,19	0,04	Cost	0,32	0,04	Mat.Man	75,00 %	0,057	Spare	0,08	0,00
Weight	0,13	0,03	Support	0,12	0,02				Reliability	0,58	0,03

In the financial subgroup, there are three sub-criteria; namely, cost per watt, total cost of investment and state support available. These elements are compared as to how important they are with respect to the financial criterion. These are the resulting weights based on the pairwise comparisons. Environmental factors considered are the area required to install the panels and environmental effects of the material manufacturing process. Comparison of these elements with respect to the environmental considerations leads to the resulting weights.

Finally, there are three sub-criteria in the customer satisfaction subgroup. These elements are compared as to how they add value towards the customer satisfaction. In order to measure the customer satisfaction towards the solar panels, three sub-criteria are defined: customer service, spare parts available, and the reliability of the company. Service is evaluated to be positively related to the number of branches available for each company. Spare parts are measured by the inventory levels of the companies while the reliability is measured by their market shares and sales. The companies are ranked from 1 to 4 to be able to generate a medium of comparison. The resulting weights of Mechanical, Financial, Environmental and Customer Priorities based on pairwise comparisons display in Table 3.

Pairwise Comparison of the Alternatives with Respect to the Criteria

After determining the priorities of each criterion with respect to the overall goal of selecting the best solar panel and priorities of sub-criteria with respect to their associated main criteria, the panel alternatives need to be compared two by two with respect to each sub-criterion. The properties of the selected panels are presented in the Table 1.

The next step in applying the AHP technique is pairwise comparisons of the panel alternatives with respect to each sub-criterion. Remainder of this section presents the priorities obtained under each subcategory using this technique.

Rating Priorities

These are the resulting weights for the criteria based on pairwise comparisons. Table 4 shows rating priorities of electrical characteristics. Priorities of mechanical, financial, environment, and customer characteristics are displayed in Table 5.

Table 4. The rating priorities of electrical characteristics.

	PTC	**STC**	**PE**	**PT**	**NC**	**Imp**	**Vmp**	**Isc**	**Voc**	**NOCT**	**%K**	**V/K**	**SFR**	**MSV**	**LED**	Total
T1	0,1105	0,0097	0,0082	0,0033	0,0077	0,0008	0,0422	0,0023	0,0422	0,0142	0,0116	0,0422	0,0020	0,0422	0,0232	0,3623
T2	0,0114	0,1187	0,0837	0,0138	0,0429	0,0093	0,0047	0,0255	0,0047	0,0142	0,0376	0,0047	0,0181	0,0047	0,0104	0,4042
T3	0,0122	0,0525	0,0375	0,0358	0,0761	0,0052	0,0047	0,0142	0,0047	0,0255	0,0035	0,0047	0,0181	0,0047	0,0204	0,3195
T4	0,0686	0,0219	0,0734	0,0033	0,0761	0,0052	0,0047	0,0142	0,0047	0,0023	0,0035	0,0047	0,0181	0,0047	0,0023	0,3076

Table 5. Mechanical, Financial, Environmental and Customer Priorities

Weight	Material	Color	Total	Support	Cost/Watt	Cost	Total	Area	Mat.	Total	Service	Spare	Reliab	Total	**Grand Total**
0,0095	0,0047	0,0200	0,0342	0,0114	0,0032	0,0042	0,0189	0,0021	0,0247	0,0268	0,0058	0,0006	0,0027	0,0092	**0,4514**
0,1016	0,0125	0,0200	0,1341	0,1469	0,0330	0,0180	0,1980	0,0037	0,0076	0,0113	0,0099	0,0044	0,0116	0,0259	**0,7736**
0,0891	0,0125	0,0200	0,1216	0,0434	0,0290	0,0072	0,0795	0,0021	0,0076	0,0097	0,0058	0,0016	0,0326	0,0399	**0,5702**
0,0398	0,0503	0,0200	0,1100	0,0383	0,0148	0,0505	0,1036	0,0003	0,0019	0,0023	0,0099	0,0004	0,0046	0,0149	**0,5383**

Conclusions

This paper is based on schema from investigations in the photovoltaic technology, existing literature, and expert opinions from photovoltaic industry, photovoltaic manufactures, and solar

Within the context of this study, electrical category is evaluated to be the most important criterion, followed by mechanical one. Under the electrical category, PTC power rating is the most important sub-criterion according to the experts, followed by the STC power per unit of area. This means that the PTC power rating is the most important factor in selecting solar panels. Under the mechanic characteristics, material type is the highest concern. Material manufacturing process has the biggest priority among the environmental criteria. Under the customer satisfaction category, reliability is the criterion with the highest priority.

Based on the calculations, the relative priorities corresponding to the attractiveness of each solar panel about all factors of electrical, mechanical, financial, environmental and customer

satisfaction are presented. The figure indicates that P2 is the panel that contributes most to the overall goal in terms of electrical properties with a global priority of 0,4042.
Table also presents the global mechanic priorities of the panels and according to the results, P1 is the panel that contributes the most to the overall goal of selecting the best solar panel.
The table indicates that P2 has the highest global priority in terms of financial considerations. Environmental priorities listed in the table shows that P1 is the leading panel towards the overall goal from the environmental perspective. The columns presenting the customer service related priorities indicate that P3 is the alternative with highest score in terms of customer satisfaction and contributes the most towards the overall goal.
In overall, adding the global priorities in all categories, the obtained results indicate that the model P2 is the alternative that contributes the most to the goal of choosing the best solar panel that satisfies all the criteria selected. Although the results may be case specific, AHP model proposed can be applied and tailored to other cases in diverse countries or sites as a reference when choosing the most efficient solar panels.

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