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Original Research Article

Installation of solar power plant in Adıyaman region and analysis of solar energy potential

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ABSTRACT

Energy is one of the most necessary and fundamental needs for human beings to continue their lives. Solar energy, which is one of the most important renewable energy sources, has great energy potential in our country with its long radiation duration and radiation amount.

The primary thing to do in solar power plant (SPP) installation is to analyze the climatic characteristics of the region. Therefore, having and analyzing the meteorological data of the region has important advantages for the solar power plant to be established. The importance of solar radiation data in the installation of a solar power plant in a region is directly proportional to the payback period of the plant under normal conditions. In this study, a 1 MW SPP feasibility study was conducted in Besni district of Adıyaman province. Depending on the energy potential of the regions, it is calculated that the payback period is between 2-5.7 years for Adıyaman province. Considering the state's electricity pricing, it is seen that the payback period in the industry is about 2 years, while it has a period of 5.7 years for house installation.

SPP is analyzed in the light of solar radiation data in the Adıyaman region which will be a pioneer for future studies thanks to the depreciation period as well as analyses performed. In addition to these, the parameters to be considered during the SPP installation stages will be specified in detail.

Keywords: Green Energy; Renewable Energy; Solar energy; Solar Power Plant

1. Introduction

Energy is the work capacity required for the use of machines and tools we use in every aspect of our daily life and it is an essential need for people to continue this lifestyle. Energy is also the backbone of the industrialization of the world and the growth of the economies of the countries [1-3].

On our planet, where the amount of energy used is increasing, many problems such as environmental problems, greenhouse gases and climate change have been encountered as a result of the use of fossil fuels. The disadvantages of fossil fuels such as being unsustainable and limited may cause difficulties in providing energy supply in the future, and at the same time, greenhouse gases such as carbon dioxide, methane and nitrous oxide may cause serious effect on the earth. For similar reasons, mankind is turned to more alternative energy sources [4-6].

Renewable energy sources, which are considered to be the most reliable and sustainable energy sources, are increasing day by day with the developing technology and it is predicted that they will meet approximately 50 % of the total global energy production by 2050 [7]. It is very important to analyze the regional potentials of all renewable energy sources, especially solar energy, and to increase their efficiency. In literature, some studies considered this notion and some of them are given here briefly.

Şevik and Aktaş (2022) examined the performance effects of panel cleaning, rainwater collection system, thermal

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monitoring and snow effects for a 600 kW solar PV plant. They determined that pollution causes a power loss of approximately 5.56 % in PV modules and the dust removal effect of rain can be up to 0.94 % [8].

Bansal et al. (2021) made techno-economic and performance analysis for a 5 MW solar PV with the data between 2013 and 2019 in Gujarat, India which is considered to have a hot and dry climate. In addition, data such as monthly average performance data, final efficiency, the working capacity ratio was calculated with the help of recorded energy production and environmental data, and they underlined the payback period, electricity production cost and CO_2 gas reduction amount [9].

Ömeroğlu (2018) mentioned that solar energy is not only important for humanity, but also a trigger of other renewable energy sources. At the same time, he mentioned that studies continue to further improve the efficiency of photovoltaic systems [10].

Çağlar (2018) conducted research on the efficiency of collectors, which is one of the methods of utilizing solar energy. Besides, the solar radiations in the determined regions were analyzed for different angles. As a result, the optimum inclination angles of solar radiation for both collectors and photovoltaic systems from four cities with different degree-day regions were determined and compared separately by applying theoretical calculations as well as Hottel & Woertz methods [11].

Alcan et al. (2018) mentioned the need for energy resources of humanity and stated the importance of solar energy in terms of renewable energy resources. In addition, he emphasized in his study the solar potential of our country by comparing the Sinop region with the data obtained from the country Germany [12].

Kırcıoğlu et al. (2018) mentioned the importance of photovoltaic systems in terms of renewable energy sources and stated that these systems vary according to atmospheric conditions. They also emphasized that photovoltaic systems should not be connected directly to a load or battery, otherwise the efficiency of photovoltaic systems will decrease considerably. They determined the most used converter types and evaluated their performance in photovoltaic systems experimentally [13].

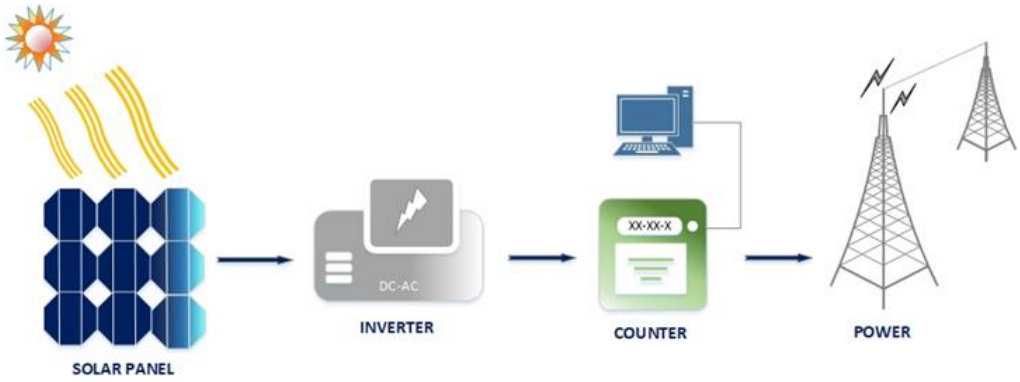

Fig. 1. Solar power plant working diagram

The working principle of photovoltaic systems is shown in Figure 1. and the main parts of the system are solar panel, inverter, counter and distribution to the grid. In this study, the process of obtaining the necessary official permits and the steps to be followed for the 1 MW SPP, the appropriate land selection, the necessary government incentives and grants, the optimum system selection for the region and the depreciation period are determined. By referring to the solar energy potential of Adıyaman, the feasibility and cost of the 1 MW SPP in Besni was analyzed. While geography, climate and agricultural abilities of the region where the solar power plant to be established are considered, the annual solar potential of the city is also provided in this study, which is not commonly found in the literature.

Evaluation of Adıyaman Besni Solar Power Plant in terms of investment applicability

Adıyaman Besni is located at latitude 37.66 N and longitude 37.86 E. The average altitude of Adıyaman Besni is 752 meters. Whereas its climate is warm and hot in the summer, it is rainy during winter. Annual average temperature is 17.4 °C between 1963-2021 [14].

Fig. 2. Solar energy potential of Adıyaman province [16]

When the annual average solar radiation and sunshine duration for Adıyaman Besni are examined, high values such as 4371.66 W/m^2 and 8.11 hours could be reached, respectively. These data show that the solar energy potential of the province is above the Türkiye average. Therefore,

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investments to be made in solar energy in the province will be efficient [15]. The solar energy potential of Adıyaman province is shown in Figure 2.

2. Material and Methods

After the determination of the land where the SPP will be established, the necessary legal permits must be obtained. The legal permit process takes approximately 4-6 months. The first step is to apply to TEDAS and receive the call letter. In the second stage, TEDAS approves the project and the connection agreement is made. In the last stage, the provisional acceptance is made and the system usage agreement is made. In order to establish an SPP, non-agricultural land use permission letter, environmental impact assessment exemption letter, electricity connection preliminary opinion, TEDAS project approval and facility acceptance to TEDAS are required.

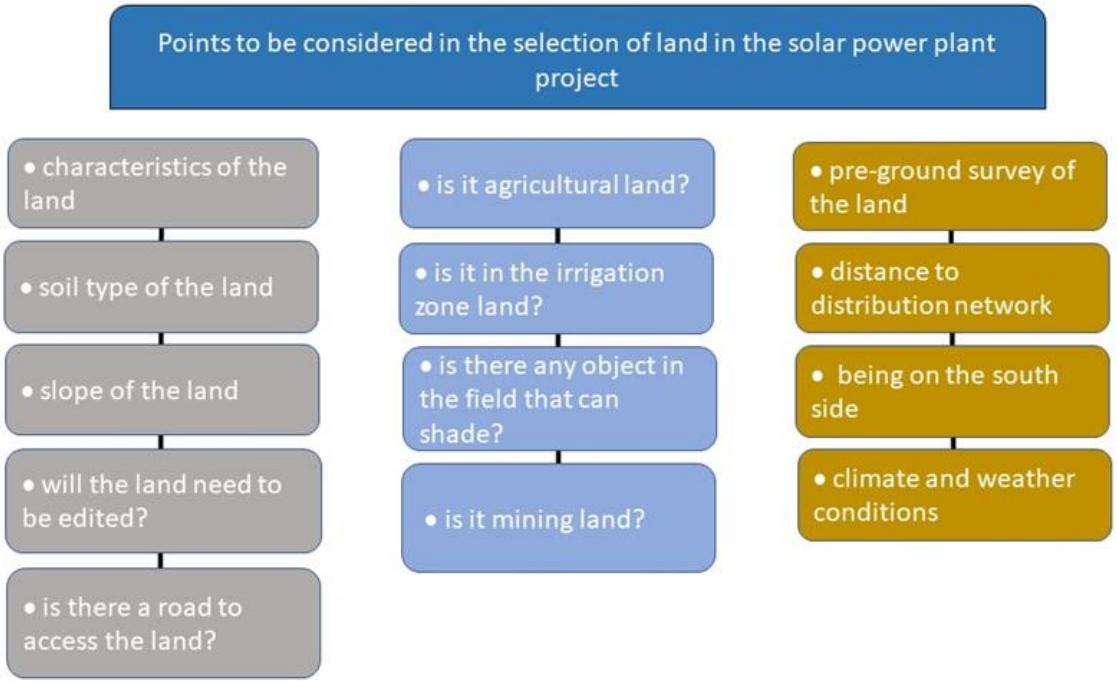

Fig. 3. Points to consider in solar power plant project

After approving the project, by signing a connection agreement with TEDAS, the on-site installation phase for the SPP can be started. The points to be considered in the selection of land in the SPP project are given in Figure 3 [17]. In this study, the necessary cost analysis for 1 MW SPP is made. For the installation of the SPP, the necessary permits must be obtained and a land of 20000 m^2 is required. SPP AC power is 1000 kW and DC power is expected to increase by 35% and it is planned to be completed at 1350 kW.

1. Solar panels (Photovoltaic); 2500 units of 540W 0.59cent/$ per W Total:1350000*0.59cent/$*18.5₺ =14735000 ₺
2. Inverter: 10 of the 100 kW inverters ($ 4500) will be used. Total: 10*4500 $*18.5 ₺= 832500 ₺
3. The cost of construction; Galvanized steel constructions with a lifespan of 25 years and at least 3-4 mm will be selected for use. Total steel construction cost: 80000 $*18.5 ₺= 1480000 ₺
4. The cost of counter; One unidirectional and one bidirectional counter will be used. In total: 4500 ₺
5. The cost of the cable duct for panels: For 1 MW SPP, approximately 3500 meters of galvanized cable duct is required. The unit meter price is 100 ₺. Total cable duct cost is 3500*100 =350000 ₺
6. The cost of the cable; The cable required for 1 MW SPP should be 6 mm in diameter and 15000 meters long. Cable cost 15000 m*1.3$*18.5 ₺= 360750 ₺
7. The cost of the lightning protection; 3 lightning rods of 10m are sufficient. Total: 3*7500 ₺=22500 ₺
8. Energy Transmission line and transformer central; average for 1MW SPP (varies according to main transformer distance) is around 882635 ₺.
9. The cost of wire fences: 1500 meters of wire is needed in an area of 20000 square meters. The unit meter price is 35 ₺. In total 1500*35 ₺ = 52500 ₺
10. The cost of control building and security camera systems; 10000$*18.5 ₺ = 185000 ₺
11. Cost for site construction works; 180000 ₺ for 20 acres of land
12. Tax and other costs for 1 MW SPP; Total 400000 ₺
13. Project and land cost; We need 20000 m^2 of the land, Total 20000*50=1000000 ₺

Grand Total Cost for 1 MW SPP 20485385 ₺

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3. Results and Discussion

The annual potential calculated for Adıyaman is approximately 1595 kWh/m^2-year [19].

$$Payback\ Period = \frac{Total\ cost}{Annual\ Earnings}\ [20] \quad (1)$$

In the Adıyaman Besni region, 1595 kWh/year electricity is produced annually from the SPP with an installed capacity of 1 kW. The electrical energy produced annually in the 1350 kW solar power plant can be calculated as;

$1\ {}^{kW}/_{year} = 1595\ {}^{kWh}/_{year} \Rightarrow$

$1350 \times 1595 = 2153250 kWh$ is obtained.

1. $2153250\ {}^{kWh}/_{year} \times 5.1364\ {}^{₺}/_{kWh} = 11059953₺$ (Industry)
2. $2153250\ {}^{kWh}/_{year} \times 3.3387\ {}^{₺}/_{kWh} = 7189055₺$ (Busines)
3. $2153250\ {}^{kWh}/_{year} \times 1.7345\ {}^{₺}/_{kWh} = 3734812₺$ (Residence)

$$Payback\ Period_{Industry} = \frac{20485385₺}{11059953\ {}^{₺}/_{year}} = 1.85\ year$$

Considering the cleaning and power plant maintenance costs of our panels, SPP will be able to pay for itself in an average of 2 years

$$Payback\ Period_{Business} = \frac{20485385₺}{7189055\ {}^{₺}/_{year}} = 2.85\ year$$

Considering the cleaning and power plant maintenance costs of our panels, SPP will be able to pay for itself in an average of 3 years.

$$Payback\ Period_{Residence} = \frac{20485385₺}{3734812\ {}^{₺}/_{year}} = 5.48\ year$$

Considering the cleaning and power plant maintenance costs of our panels, SPP will be able to pay for itself in an average of 5.7 years.

4. Conclusion

The application stages for the public institutions required for the AC power 1 MW SPP project to be established in Adıyaman Besni are given. Afterwards, the materials at the optimum level to be used are selected and the properties of the required land are determined. In addition, the depreciation period for a 1 MW SPP is calculated and its annual return is indicated. According to the results, it is a project that can be established in the industrial area with a minimum payback period around 2 years. This depreciation period is very advantageous thus the installations of solar power plants as well as determinations of the potential locations are very important. The use and promotion of these resources instead of fossil fuels not only increases sustainability in energy, but also reduces the damage to the environment.

Authorship contribution statement for Contributor Roles Taxonomy

Veysel Turan: Investigation, writing – review. **Cuma Karakuş:** Writing - review & editing, Supervision, Conceptualization. **İsmail Üstün:** Investigation, writing – review.

Conflict of interest

The author(s) declares that he has no conflict of interest.

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