Advanced Engineering Days

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Application and cost analysis of different roof types of photovoltaic energy generation systems integrated to buildings for Mardin Province

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Cite this study: Cakmak, F., Aydogmus, Z. & Tur, M. R. (2022). Application and cost analysis of different roof types of photovoltaic energy generation systems integrated to buildings for Mardin Province. 2nd Advanced Engineering Days, 19-22

Keywords
Photovoltaic panel
BGS
GGD
inverter
Battery

Abstract

In recent years, the use of renewable energy sources such as solar and wind has increased in order to reduce the dependence on fossil fuels. Southeastern Anatolia region is the richest region of our country in terms of sunshine duration. The province of Mardin is one of Turkey's priority regions that receive a high amount of sun. In this study, it is aimed to provide electrical energy from the sun by placing roof type solar panels on the terrace floor of Şatana Mansion, which serves as a Social Facility and Application Hotel affiliated to Mardin Artuklu University.

Introduction

Today, it is seen that energy production and consumption increase in parallel with the development of technology. Since fossil energy resources are limited and will run out after a certain time, people have directed them to different renewable energy sources. The most important features of renewable energy sources are; They reduce carbon dioxide emissions, help protect the environment, contribute to the reduction of foreign dependency in energy, increase employment, and receive widespread and strong support from the public [1]. Among the renewable energy sources, the most striking one is photovoltaic systems, which provide electricity generation by using unlimited solar energy [2]. The reasons for this are noiseless, clean, low maintenance costs, modular structure and not harming the nature. PV systems, whether directly connected to the grid or independent from the grid, are systems that should be used with maximum efficiency when their costs are considered [3].

Photovoltaic Systems (PV)

In terms of connection, PV systems can be applied in three different ways as grid-connected (non-storage) (on-grid), off-grid (with storage) and hybrid (grid-connected and storage) systems. The solar panel can be positioned as fixed or can be designed as mobile systems. Studies in the field of PV systems can be listed under sub-headings such as modeling and design of the system, keeping the maximum power from solar cells constant at the voltage, optimum solar panel angle, controlling the devices used in PV systems [4,5].

Hybrid systems (grid connected and storage)

These photovoltaic systems are primarily established to provide their own energy needs. However, on the days when there is no sun (cloudy days), the energy stored in the batteries is used, and on the days when the sun is too long, it gives the excess energy to the grid. With smart grids, these photovoltaic systems will enable to make the electricity generation and distribution structure decentralized.

Material and Metod

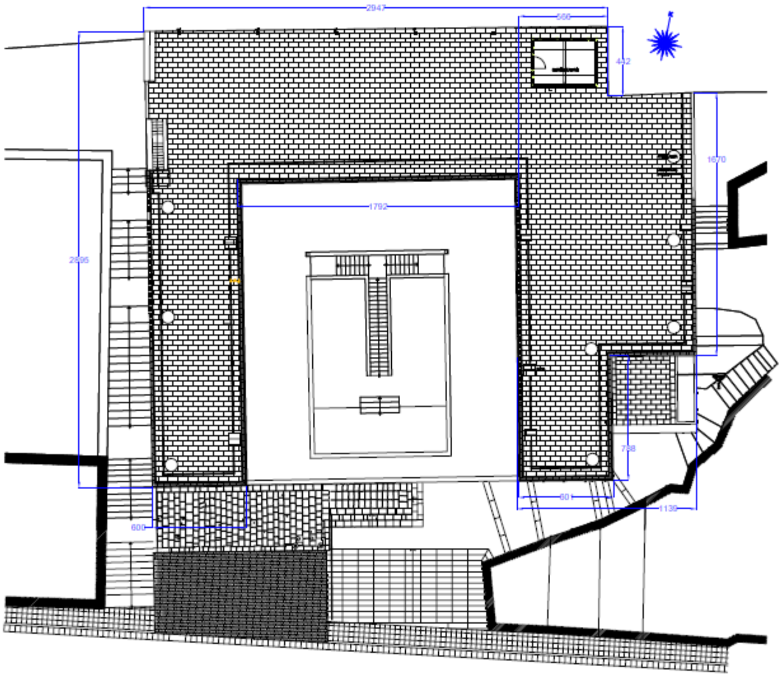

Figure 1. Terrace floor plan with scale

Mardin houses are generally built with their fronts facing south. When we look at the direction figure on the upper right in the same figure 1, the application hotel faces south. In this case, it faces the appropriate direction for the PV system to be applied to the building. Here; The application will be made by placing the solar panels on a flat roof (in the form of a terrace roof).

Photovoltaic systems are mostly applied on vacant land, building facades and roofs. Here, an example of a different roof application (on a flat roof) with an installed capacity of approximately 66.6 KW in order to place roof type solar panels on the terrace floor of Şatana Mansion, which serves as a Social Facility and Application Hotel affiliated to Mardin Artuklu University, is discussed. Photovoltaic systems installed in buildings are normally calculated over the installed power. In this study, it is aimed to place the maximum panel by calculating the total area of the existing terrace floor. The total usable area of the terrace floor is 671 m^2. The panel to be used here is SHARP brand with a capacity of 330 Watts and has a polycrystalline cell structure.

According to the monthly radiation and sunshine duration values obtained from meteorology for Mardin province, the average radiation value for Mardin is 4,635 kWh/m^2. The daily sunshine value is 7.6483 hours [6]. Considering these values, Mardin has very good values in terms of solar energy.

Used SHARP 330WP/POLY:NDAF330C panel features[7]:
Number of cells: 72
Yield: 17%
Open circuit voltage (VAD): 45.9 V
MPP voltage(VMPP):39.1 V
Short circuit current(IKD):3.91 A
MPP current(IMPP):8.45 A
Weight: 22.5 kg
Dimensions: 1960*992*40mm

- The area covered by a panel is =1.96*0.992=1.95 m^2.
- Number of panels to be placed on the terrace floor = 237 panels will be used.
- Number of modules to be connected in series (ns)= Inverter DC max trip voltage / Panel open circuit voltage
- ns= 1000 / 45.96 = Panels less than 21.75 modules will be connected in series. For this, 20 panels will be connected in series.
- Number of modules to be connected in parallel (np)= 237/ 20=11.85 approximately 12 branches (array)
- Max DC input voltage for inverter= VMPP * ns =39.11*20=782.2 Volts
- But the inverter to be used mpp DC input voltage value 400≤ VMPP≤800 V will use 782 V here.
- Power produced by a PV module arm(array) = VMPP * IMPP =782*8.45=6608 W

- Total generated power =6608*12= 79296 W= 79,296 KW
- If it is calculated that there will be a total power loss of 30% in the panels;
- Total power produced in PV Panels =79,296 -(79,296 *0.3) =55.5 KW power will be produced.
- 1.2 times the power produced is taken for the inverter to be used [8].
- 55.5 * 1.2 = 66.6 KW approximately 75 KW inverter will be used.

3 ABB inverters TRIO-20.0/27.6 TL-OUTD branded inverters will be used. The purpose of using 3 instead of a single inverter here is not to affect the whole system due to errors that may occur in a string. Max. Our PV system continues to work efficiently.

- Energy produced (consumed / produced) for 1 hour during the day = 55.5 kWh (power produced by the panels)
- Battery losses: 20% Efficiency: 80% Discharge depth: 50%
- The number of cloudy days (BGS) = 1 for Mardin province. Battery voltage will be 48 Volts. Because the battery charger will be designed at 480 volts and 100 amps.
- The daily sunshine value (GGD) is 7.6483 hours.
- Battery capacity = [Daily produced energy* BGS*GGD] / [Battery efficiency*Discharge depth*Battery voltage]
- Battery capacity =[55.5*1*7.65]/[0.80*0.50*48]= 88453.125 AH
- The battery to be used is 12 Volt 100 AH Deppower brand dry type battery

Number of batteries =88453 /100 = 884,53 approximately 885 batteries will be used. A battery charger will also be used for every four batteries. In other words, by connecting each 40 batteries in series, 480 V DC voltage will be obtained. There will be 885/40=22,125=22 parallel arms in total. Weight due to the panels on the terrace floor = 237*22.5kg = 5332.5 kg. (Steel construction is not included in this weight.) Battery group and inverters will be mounted next to the main distribution panel (energy room). It will not be a burden on the building and it will be easier to reach in a possible situation. In the calculations, an additional load of 5.5 tons was added to the dead load of the building of the panels. In Figure 2, the building area is used at the optimum level.

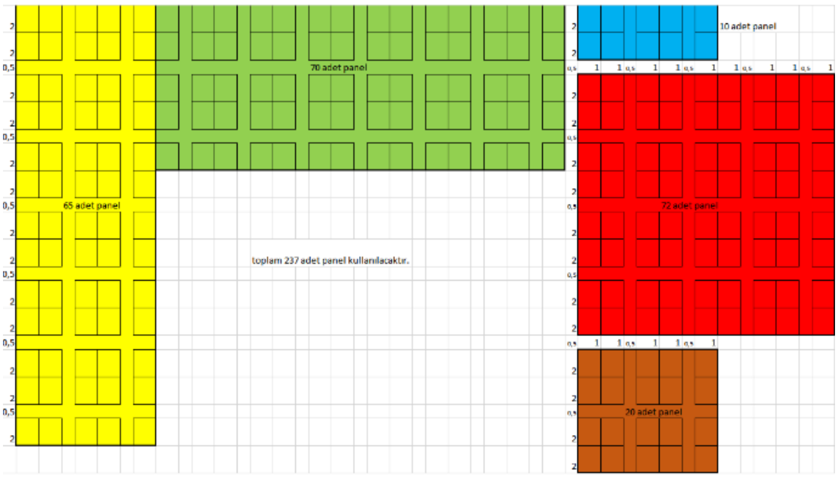

Figure 2. Panel layout with scale

Conclusion

In the study, the establishment costs of solar energy, which is suitable for the geological and geographical features of Mardin among renewable energy sources, were investigated. Solar energy systems have proven to have very high initial investment costs. It is inevitable that these costs will be lower if the main components of photovoltaic systems, such as panels and inverters, are domestically produced. Considering the average of the last six months' summer period consumption values of the Şatana applied hotel, which is affiliated with Mardin Artuklu University, it is seen that the system pays for itself in 11 years thanks to the photovoltaic system to be installed. If a solar energy system is installed in our region, where the consumption is higher in the summer months, it will further shorten the depreciation period by selling the excess energy that it both pays for itself and does not use in a very short time. Considering the costs of investments and environmental effects in solar energy systems, it will be possible to say that they are systems that produce sustainable, clean, cheap and reliable electricity.

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