DESIGN AND MODELING A OFF-GRID PHOTOVOLTAIC SYSTEM TO MEET THE ELECTRICAL ENERGY REQUIREMENT OF A HOUSE IN GAZIANTEP REGION, PERFORMING TECHNICAL ANALYSIS AND BASIC SIMULATION

GAZİANTEP BÖLGESİNDEKİ BİR EVİN ELEKTRİK ENERJİSİ İHTİYACINI KARŞILAYACAK ŞEBEKE DIŞI FOTOVOLTAİK SİSTEM TASARIMI VE MODELLENMESİ İLE TEKNİK ANALİZ VE TEMEL SİMÜLASYON YAPILMASI

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ABSTRACT

Generating energy using by solar energy is one of the most popular alternative energy source applications. Photovoltaic battery applications that generate electricity directly from solar energy are gradually gaining momentum and standalone (Off-Grid) solar-powered electric production in Turkey is becoming increasingly common in recent years. In parallel with these developments, national Photovoltaic (PV) generation technologies are also developing rapidly and taking their place in the markets. In this study, a PV system has been designed for the Gaziantep region to meet the electrical energy needs of a five-person house, meeting the electricity consumption from solar energy with photovoltaic battery application has been examined financially and technically. Electrical project design, mathematical analysis, and feasibility have been performed for a house whose electrical energy need is provided by a PV system. PV systems have been designed to meet the electrical energy needs of a house according to the electrical energy demands. The designed microgrid is modeled and simulated on MATLAB/Simulink with a 24-hours scenario. Simulation results are presented, evaluated, and discussed in detail. Since the designed PV System is designed according to the Gaziantep region conditions, this study can be considered as a model and an example for those who want to obtain electricity from PV energy in Southeastern Anatolia as well.

Keywords: Solar, PV, Electricity, Production, Design, Gaziantep, Standalone, Energy, Simulation.

ÖZET

Güneş enerjisi kullanarak enerji üretmek, en popüler alternatif enerji kaynağı uygulamalarından biridir. Doğrudan güneş enerjisinden elektrik üreten Fotovoltaik pil uygulamaları giderek ivme kazanıyor ve Türkiye'de son yıllarda Şebekeden Uzak (bağımsız) güneş enerjili elektrik üretimi giderek yaygınlaşıyor. Buna paralel olarak ulusal Fotovoltaik (PV) üretim teknolojileri de hızla gelişiyor ve piyasalarda yerini alıyor. Bu çalışmada Gaziantep bölgesi için beş kişilik bir evin elektrik enerjisi ihtiyacının karşılanması için bir PV sistemi tasarlanmış, Fotovoltaik pil uygulaması ile güneş enerjisinden elektrik tüketiminin karşılanması mali ve teknik olarak incelenmiştir. Bir PV sistemi ile elektrik enerjisi ihtiyacı karşılanan bir evin elektrik proje tasarımı, matematiksel analizi ve fizibilitesi yapılmıştır. PV sistemleri, elektrik enerjisi taleplerine göre bir evin elektrik enerjisi ihtiyacını karşılayacak şekilde tasarlanmıştır. Tasarlanan mikro şebeke, 24 saatlik bir senaryo ile MATLAB/Simulink üzerinde modellenerek simüle edilmiştir. Simülasyon sonuçları temel olarak sunulmuş, değerlendirilmiş ve tartışılmıştır. Tasarlanan PV Sistemi Gaziantep bölge şartlarına göre tasarlandığından, bu çalışma Güneydoğu Anadolu'da PV enerjisinden elektrik elde etmek isteyenler için bir model ve örnek olarak düşünülebilir.

Anahtar Kelimeler: Güneş Enerjisi, Elektrik, Üretim, Tasarım, Simülasyon, PV.

1. INTRODUCTION

The biggest energy source in the world is the sun and solar energy is one of the cheapest and the most environmentally friendly sources, among others. Solar energy is a clean and inexhaustible source of energy and it is very suitable for local regional applications. There is no external dependence for anyone who wants to use it, and no complicated technology is required. Therefore, in recent years, studies and applications on solar (PV) systems, where electrical energy is obtained from solar energy have become widespread. The most important reasons for the PV systems are to meet the investment costs in a short period of time, to convert the solar energy directly into electrical energy, not to pollute the environment, to be simple in their structure, and easy to apply. In the design of PV systems, modeling of the system, keeping it stable at a constant voltage to obtain maximum power from solar cells, the optimum solar panel angle is vital for energy production efficiency. Besides, periodic maintenance of the equipment used in solar systems is essential to extend the life of the system and maximize production.

In Turkey, one of the regions where the solar energy capacity is highest in Southeast Anatolia. Gaziantep has the highest solar energy capacity region after Sanliurfa in Southeastern Anatolia. This region is above the average of Turkey in terms of the annual duration of sunshine and solar radiation potential. For these reasons, in recent years, it has become an important goal to increase the solar energy production capacity in the Gaziantep region and to contribute to the economy of the region by increasing its industrial and residential use.

In this study, electrical project design, mathematical analysis, and feasibility have been introduced for a house fed with PV energy for the Gaziantep region. A standalone PV system with the power to meet the electrical energy needs of a house has been realized. Power analyzes in the installation of systems with 2.5kW, the number of PV elements needed in the installation, and cost calculations have been made. To analyze, model, and design the PV system, a solar cell model has been created in MATLAB/Simulink environment, Current-Voltage and Power-Voltage curves have been obtained for the modeled solar cell depending on different temperature values. Mathematical models of designed PV system components (Battery, Inverter, PV, Load) have been created in the MATLAB environment and basic simulations have been performed.

The organization of the paper is as follows; defining the goals and scope, basic knowledge about the chosen renewable energy source are presented in this section. Section 2 presents a literature review and related works on this field. Section 3 presents the background of the Off-Grid (Standalone) PV system. In section 4, the technical features of the region to be installed PV system such as radiation values, sunshine duration, optimum tilt angles are presented. The next section 5 contains the numerical modeling and design process of the standalone PV system. Section 6 presents some simulations carried out for the designed PV system. In section 7, results and discussions are presented and evaluated. Finally, sections 8 and 9 consist of conclusions and future works.

2. LITERATURE REVIEW AND RELATED WORKS

Several studies on the modeling of standalone solar systems are available in the literature. The angle of incidence of solar rays, the location of the PV panels with the angle of inclination, and the time the PV system is exposed to the sun, are essential parameters that directly affect the production of electrical energy [1-3]. A mathematical model based on these parameters was created to examine the effect of radiation and temperature on solar cells, and this model was tested for different types of solar cells and the results were compared with the catalog information of solar cells [4]. The efficiency and performance evaluations of the PV system designed in the simulation environment were made [5].

The inverter's PWM switching signal, direct current transducer, active power, and reactive power responses and response times of the system were examined in the computer environment [6]. Methods such as the geographic factor method, turbidity index method, and declaration angle method have been used to find the most suitable inclination angle of the PV panel [7]. Solar photovoltaic system design for residential hall in the Bute region was completed [8] and analysis of remote PV-diesel based hybrid mini-grid for different load conditions was completed [9].

In addition, analysis of solar radiation data in different regions of Turkey, such as azimuth angle, Optimization of tilt angle, photovoltaic parameters, solar energy potential, methods of use, and degree of studies was conducted [10-14]. Also, determination of tilt angles of solar panels for Gaziantep region was performed [15], determination of the optimum tilt angle of solar collectors for building applications was studied [16], correlations optimum tilt angles of solar collectors for Erzurum region was conducted [17] and designing solar panels systems was studied in [18]. These studies show that working in support of the practical application of PV energy production for a residential environment in Turkey is not yet adequate.

3. FUNDAMENTALS AND BACKGROUND

Standalone systems are used especially in areas that are far from residential areas, without electricity grids, when it is difficult and expensive to transport fuel to the generator. However, solar cells can be used in any application where electrical energy is required to provide the energy needs of systems such as military purposes, telecommunications, and traffic signaling systems. Besides, the rise in electricity prices in recent years has shifted residential consumers to cost-free and alternative electricity production.

In the simplest terms, solar panels are required to produce energy at the desired capacity, batteries are needed to store its energy, and a solar inverter is needed to convert the energy produced as DC to AC and send it to load. These are essential mandatory types of equipment. Besides, additional equipment can be integrated into the solar system to increase efficiency and support stability and to monitor the system such as charge controller, converter, software, etc. Figure 1 shows the standalone PV diagram and the types of equipment used in the system. Generally, it consists of a solar panel, charge controller, battery bank, and inverter.

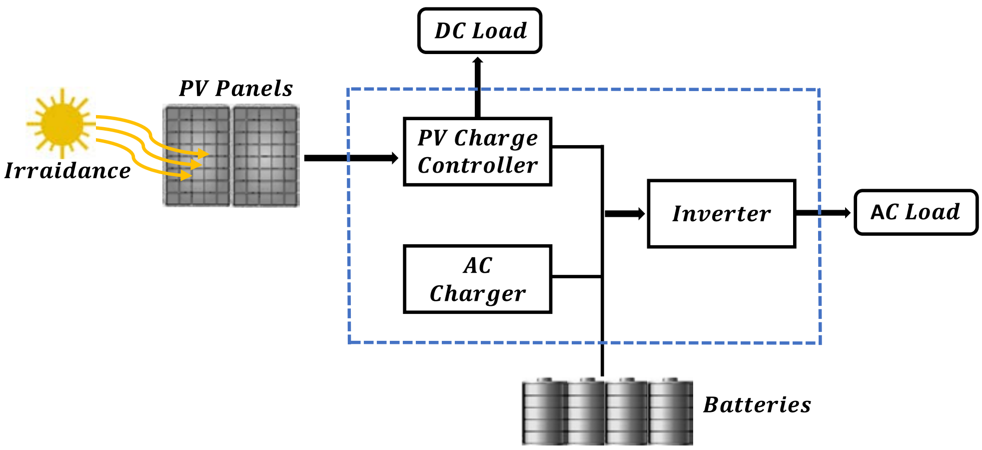

Figure 1. The standalone PV system diagram

4. ANALYSIS OF THE LOCATION AND CONSIDERATIONS

In the design of renewable energy technologies, climatic conditions are very important. PV systems cannot give good results where sunlight is inadequate. Therefore, all technical and climatic characteristics of the region to be installed PV system should be examined in advances such as radiation values, sunshine duration, optimum tilt angles, equipment, and capacity should be determined according to the existing conditions. Also, it is necessary to know the slope and direction in determining the potential of the panels as mentioned in the research in section 2.

These parameters of course very essential to provide better power-producing and to help the fill-up battery very good. It can be changed according to locations. Because of the climatic and technical conditions, the designed microgrid is primarily intended to be used in the Gaziantep region in Turkey. Figure 2 shows the annual average sunshine duration (hours) of the installation site. An important point that should be also considered in the design of standalone PV systems is that the annual average sunshine duration should not be used for the installation site. Since the system is off-grid and the only energy source is PV energy, the energy production plan should be made according to the worst-case scenario at the location to be installed. The worst-case scenario plan is achieved by identifying the month with the least sunshine duration and calculating the daily Peak-Sun Hour (PSH) values in that month. This is very essential in terms of energy efficiency and production continuity. In the literature studies to our knowledge, this important strategic knowledge has not been taken into consideration. Also, Table 1 shows the optimum tilt angles and average monthly radiation values of the Gaziantep region where the PV system will be installed. These parameters of the region should also be considered during design for maximum efficiency.

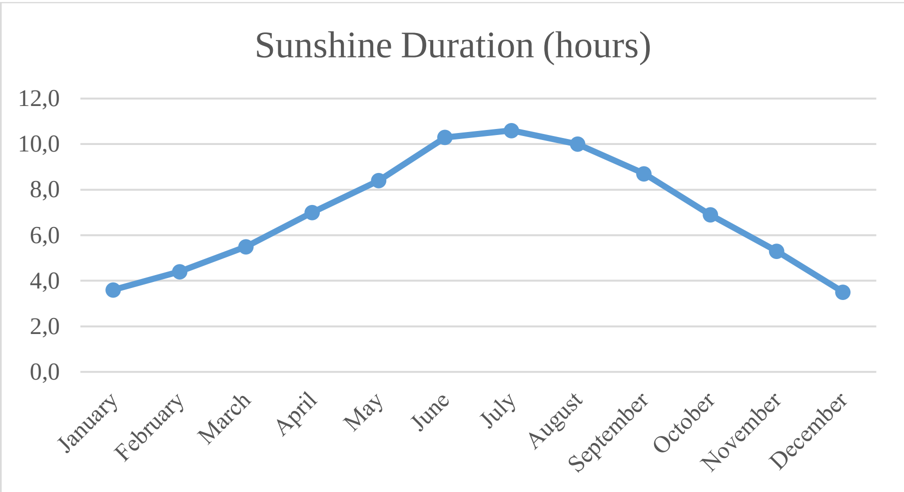

Figure 2. Annual sunshine duration (hours) of the Gaziantep region

Table 1. Optimal tilt angels and average radiation for the installation site

Months	**Fixed-Optimal Tilt Angle [°]**	**Average Radiation** $[kWh/m^2day]$
January	56	2.883
February	50	4.388
March	39	6.004
April	20	6.217
May	5	6.61
June	0	7.573
July	0	7.582
August	14	6.589
September	32	6.014
October	47	4.986
November	58	4.223
December	59	2.038

Source: https://www.mgm.gov.tr/, MGM, (2021).

The angle of tilt to be found in Table 1 refers to the angle between the PV panel and the ground. In other words, 0° PV panel tilt means full horizontal and 90° PV panel incline means full vertical positioning. Tilt Angle for the Gaziantep region can be 36° South for summer, and 36°+ 15° South for winter. But if it is preferred not to adjust the tilt during the year then the tilt at 36° South can be fixed for the whole year. In every city of Turkey, the solar panel should face towards the south.

5. NUMERICAL MODELING AND DESIGN PROCESS

In this section, the equipment required for the design of the PV system is investigated and calculations are made afterward. The mathematical steps of the designed PV system are listed below.

Calculation of the Energy Consumption (Daily, weekly),

Calculations: Peak Continuous Power, Essential Power, Surge Power (Startup Power),

Efficiency Calculation for the designed PV system,

Calculation of the Energy to be Produced,

Number of panels to be used of the designed PV system,

Calculation of the Battery Capacity,

Calculation of the Inverter Capacity,

Preparation of the Cost Table.

The daily energy needs of a house can be changed day to day. Therefore, one-day average energy consumption can be calculated by finding the total weekly energy consumption. The weekly energy need values of a house are presented in Table 2.

Table 2: Weekly Energy Need for a House

Appliance	Essential	Running Wattage (W)	AVG Daily Usage (hours)	Unit	Total Energy Watt-hours (Wh)	Working Days	Weekly Energy Consumption (Wh)
Refrigerator	N	44	24	1	1056	7	7392
49" LED TV	Y	98	4	1	392	7	2744
Laptop PC	Y	90	3	2	720	7	3780
Iron	N	2400	1.3	1	3120	1	3120
Oven	N	1900	1.5	1	2850	1	2850
Washer	N	303	3	1	909	3	2727
Dishwasher	N	510	2.2	1	1122	2	2244
Hoover	N	750	0.8	1	600	1	600
LEDs	Y	12	5	6	360	7	2420
Cell Charging	Y	5	1	4	20	7	140
Kettle	N	2100	0.2	1	420	7	2940
Microwave	N	800	0.1	1	80	4	320
Blow Dryer	N	2200	0.2	1	440	3	1320
FAN	N	250	1	1	500	2	1000
Toaster	N	1900	0.25	1	380	2	760
TOTAL WEEKLY ENERGY CONSUMPTION	**34357kWh**						

Source: This study and https://www.ckbogazici.com.tr/tr/tuketim-hesaplama, (2021).

Considering the values taken from Table 2, the daily average energy consumption is calculated as $34357/7 \cong 4908Wh$. It is essential in terms of efficiency that the design of the system is carried out after obtaining information such as daily energy requirement, autonomous duration, operating voltage, and daily load profile. Moreover, Essential Power (EP) is calculated as $1590W$ from table 2. The above load calculation table is used to add up the running wattage of all the essentials equipment that could run at the same time.

The most power we may need at any given time is called the Peak Continuous Power (PCP) of the PV system. So, the PCP is the calculated same as EP. These parameters should be considered in the design part of the system. Motorized equipment used in homes may include washing machines, dishwashers, and vacuum cleaners, etc. When they are operated for the first time, they can use an instant-start power up to 10 times the power they use than normal energy consumptions. It is known as Surge Power. For this reason, surge power calculations of these motorized electrical devices should be made and taken into consideration as well.

It is not possible to transfer all of the power generated in solar systems to the load. Energy losses can occur, depending on the quality of the equipment used in the network. Thus, the energy loss must be considered in the measurement of the energy to be produced. Advances in the technologies of solar power generation equipment in recent years have reduced these losses to a minimum. The efficiency rates of all equipment in the system are different. The efficiency of the solar panel is 85%, the efficiency of the battery is 80% and the efficiency of the inverter is around 95%. Considering all these rates of the equipment, efficiency for the PV system has been calculated by using equation (1).

$$\eta_{eff} = \eta_{pv} * \eta_{batt} * \eta_{inv} \tag{1}$$

where,

η_{eff} is the efficiency of the PV system,

η_{pv} is the efficiency of the PV panel,

$* \eta_{batt}$ is the efficiency of the battery,

η_{inv} is the efficiency of the solar inverter.

System efficiency is determined as 0.65 when calculations are made.

η_{eff} = *(0.85)(0.80)(0.95) = 0.65*

Equation (2) is used to calculate the power of the load.

$$E_{load} = E_{prd} * \eta_{eff} \tag{2}$$

where,

E_{load} is the energy need of the load,

E_{prd} is the energy need to be produced,

η_{eff} is the efficiency of the system.

Accordingly, the energy to be produced has been calculated as $7550Wh$ to meet $4908Wh$ load energy.

$4908Wh = E_{Prd} * (0.65),\ E_{Prd} = 7550Wh$

The number of panels is determined according to daily energy needs and sunshine time. Equation (3) is used to determine the number of panels.

$$PV_N = \frac{E_{daily}}{PV_P * T_{sunshine}} \tag{3}$$

where,

PV_N is the number of PV panels to be used in the designed system,

E_{daily} is the daily energy need,

PV_P is the power of the PV panel,

$T_{sunshine}$ is the duration of sunshine.

In this calculation, the daily energy is expected to be equal to the energy that must be produced. In the case of using $200W$ PV panels, the number of PVs is determined as 10 according to equation 3.

$$PV_N = \frac{7550Wh}{200W * (4_{hours})} = 9{,}43$$

Figure 3 shows that the PV sizing and connection of the PV modules for $24V$ output with $10PVs$. While the number of modules was found, calculations were calculated as $200W$ per PV module. However, the cost of $200W$ to $250W$ PV modules is almost the same. Since it will not be a financial burden, it is quite logical to increase the number of modules from $2kW$ to $2.5kW$ by using $250W$ PV modules instead of $200W$ PV modules. It can be a good choice considering the daily fluctuations in solar radiation and the performance losses in PV panels over time due to overheating. Keeping the PV module capacity slightly more than needed is a common application in practice.

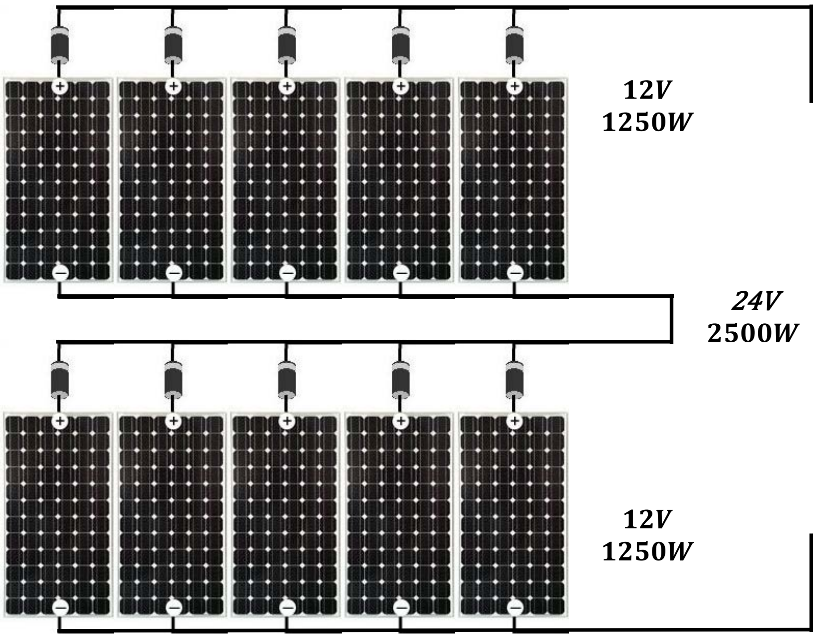

Figure 3. PV sizing and connection of the modules for 24V output with 10 PVs

Since the energy requirement will be supplied from the batteries when the energy is not produced, it is calculated by considering the capacity to be stored as much as the number of days off when determining the battery capacity.

$$C_{batt} = \frac{E_{daily}}{DoD} * D_{off} \quad (4)$$

where,

C_{batt} is the battery capacity,

E_{daily} is the daily energy need,

DoD is the dept of discharge,

D_{off} is the number of days off.

Considering the $7550Wh$ daily energy requirement, 0.75 dept of discharge, and 1.5 closed days, the battery capacity has been calculated as $15100Wh$ according to equation 4.

$$C_{batt} = \frac{7550Wh}{0.75} * 1.5 = 15100Wh$$

The number of batteries is determined by the battery capacity and the ampere-hour (Ah) value, which indicates how much current the battery can produce for how many hours. If two $12V$ batteries are connected in series, the system voltage will be $24V$. $200Ah$ batteries are used to obtain $15100Wh$ energy, 2 parallel arms are needed where 2 batteries are connected in series. In this case, 4 batteries in total, each $200Ah$ are needed. Such a system can store $200x24x4 = 19200Wh$ energy. When price research is done for the battery in the markets, it is seen that using 4 unit $200Ah$ batteries is more advantageous than using 8 unit $100Ah$ batteries, this reduces cost and saves installation space. Figure 4 shows that the battery sizing and connection of the batteries for $24V$output with 4 batteries.

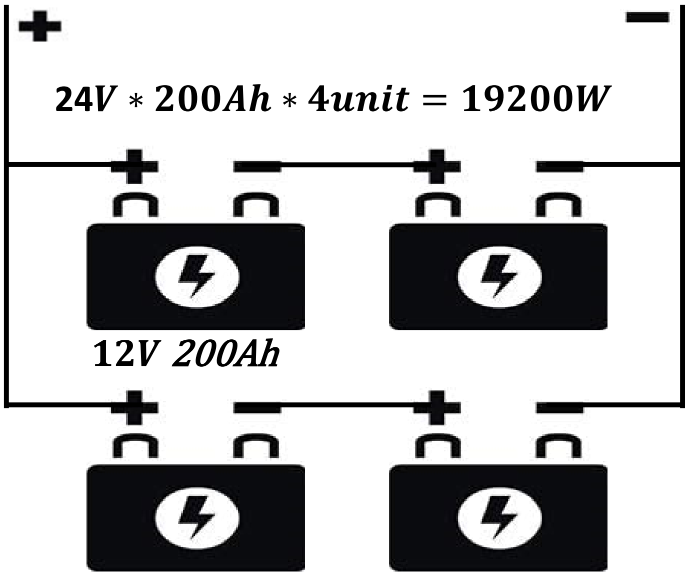

Figure 4. Battery sizing and connection of the batteries for 24V output with 4 batteries

The inverter used to convert the direct current value produced in PV panels to the alternating current value to be used in the house should be able to handle the maximum power that the load can draw. For a home, this is based on the total load captured while devices such as refrigerators, computers, ironing lights, and televisions are operating at the same time. Considering Table 2, the inverter with a value of $3kW$ should be preferred as a result of;

$$200Wh * 4 + 250Wh + 1600Wh + 25\,Wh * 6 = 2700W$$

Besides, an inverter with a capacity to meet the startup-surge power demands of motorized electrical devices must be used in the design.

Table 3. 2.5kW Solar system Cost Table

Equipment	**Unit Cost ($)**	**Each**	**Total Cost ($)**
Solar Panel 250W	175	10	1,750
Solar Gel Battery 225 Ah 12V	350	4	1,400
MPPT Charge Controller 12-24V	130	3	390
Solar Inverter 3750VA 3kW 12-24V	300	1	300
Solar Cable 200 Meter	200	1	200
Connector	40	4	160
Triangular Foot	50	6	300
Solar Panels Tracking System 2.5kW-5kW (optional)	2700	1	2,700
Total Cost of the Solar System (USD)			**7,200**

Source: This study, (2021).

As a result of all calculations presented above, the energy needs are determined. The equipment to be used in the designed solar system is determined according to the energy needs. The cost table has been prepared accordingly. Table 3 shows that the 2.5kW Solar system cost Table.

6. SIMULATIONS CARRIED OUT FOR THE DESIGNED PV SYSTEM

In this section of this study, the simulation results of the designed microgrid are presented basically. The microgrid is modeled and simulations are executed on MATLAB/Simulink. The parameters of the simulated model are defined in Table 4 and Table 5. Also, the basic overview of the Simulation Model of the standalone microgrid is shown in Figure 5, As seen in Figure 5, a $1.2kW$ small diesel engine module is used to microgrid to initiate power if it is needed and to use it as backup power. A $2.5kW$ PV module is used to produce solar energy, and one $1.92kWh$ energy storage module is integrated into a microgrid to store energy in the batteries and to support the load. The size of the microgrid supports $4.95kWh$ energy in a 24-hours scenario (daily). I should also mention that there is no generator in the main design and calculations. Generators are generally used in standalone systems and so the generator is added to the simulation as an option.

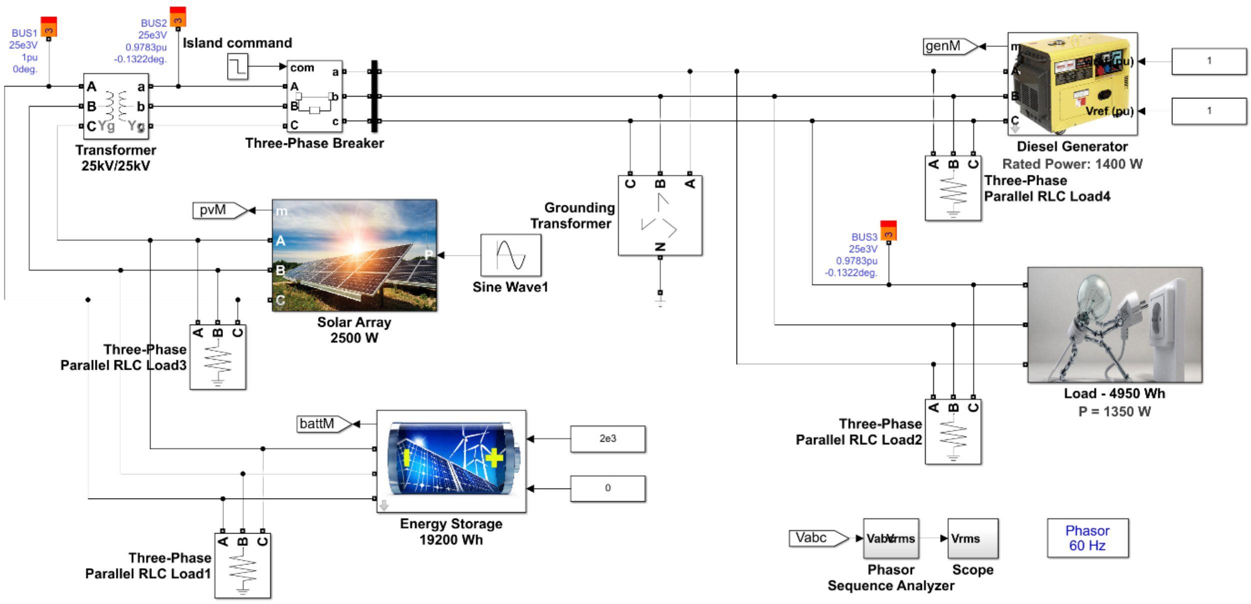

Figure 5. Overview of the designed microgrid model in the MATLAB/Simulink

Table 4. Simulink Parameters of Solar Inverter, Energy Storage, and Generator

Solar Inverter	
Nominal L-L voltage and frequency [Vn(Vrms) fn(Hz)]:	[Vn Fn]
Active and reactive power at initial voltage [Po(W) Qo(var)]	[-250000 -3.38813e-13]
Initial positive-sequence voltage Vo [Mag(pu) Phase (deg.)]	[0.999844 -0.0038635]
External control of PQ	Yes
Filtering time constant (s):	1.00E-02
Energy Storage	
Nominal L-L Voltage [Vrms]	1000
Nominal Frequency [Hz]	60
Rated Power [kW]	2

Rated Capacity [kWh]	10
Overall System Efficiency [%]	96
Upper/Lower Charge Limits [%]	[90 10]
SOC to Recharge [%]	11
Recharge Rate [% of Rated Power]	50
Enable auto-recharge	Yes
Initial State-of-Charge [0-100%]	85
Initial Active/Reactive Cmds	[5e3 0]
Diesel Generator	
Generator Rated Power [W]	1400
Rated Voltage [V]	1000
Rated Frequency [Hz]	60
Load Flow Type	PQ
Initial Power, [P0 Q0] [pu]	[0.05 0]

Source: MATLAB/Simulink, (2021).

Table 5. Simulink Parameters of Breaker, Grounding Transformer, Load, and Solar Array

Three-phase breaker	
Initial status	closed
Switching times (s)	/60 50/60
Breaker resistance Ron (Ohm)	1.00E-02
Snubber resistance Rs (Ohm)	1000
Snubber capacitance Cs (F)	inf
Grounding Transformer	
Nominal power and frequency [Pn(VA) fn(Hz)]	[100e6 60]
Nominal voltage Vn Ph-Ph(Vrms)	2.50E+04
Zero-sequence resistance and reactance [Ro(pu) Xo(pu)]	[0.025 0.75]
Magnetization branch [Rm(pu) Xm(pu)]	[500 500]
Load	
Configuration	Y (grounded)
Nominal phase-to-phase voltage Vn (Vrms)	1000
Nominal frequency fn (Hz):	60
Active powers [Pa Pb Pc] (W):	[10e3 9e3 11e3]
Inductive reactive powers [QLa QLb QLc] (positive var)	[100 90 110]
Capacitive reactive powers [QCa QCb QCc] (negative var)	[100 90 110]
Load flow	constant Z
Solar Array	
Nominal L-L Voltage [Vrms]	1000
Nominal Frequency [Hz]	60
Initial Power [W]	2500

Source: MATLAB/Simulink, (2021).

7. RESULTS AND DISCUSSIONS

In this section, the designed solar system is evaluated, and the simulation results are discussed briefly. The microgrid Vrms voltage and the battery SOC as a percentage results are presented in Figures 6 (a) and 6 (b), respectively. Active power on the load, battery power, and PV power are shown in

Figures 7 (a), 7 (b), and 7 (c) as kW. Also, the microgrid voltage is shown in Figure 7 (d), respectively.

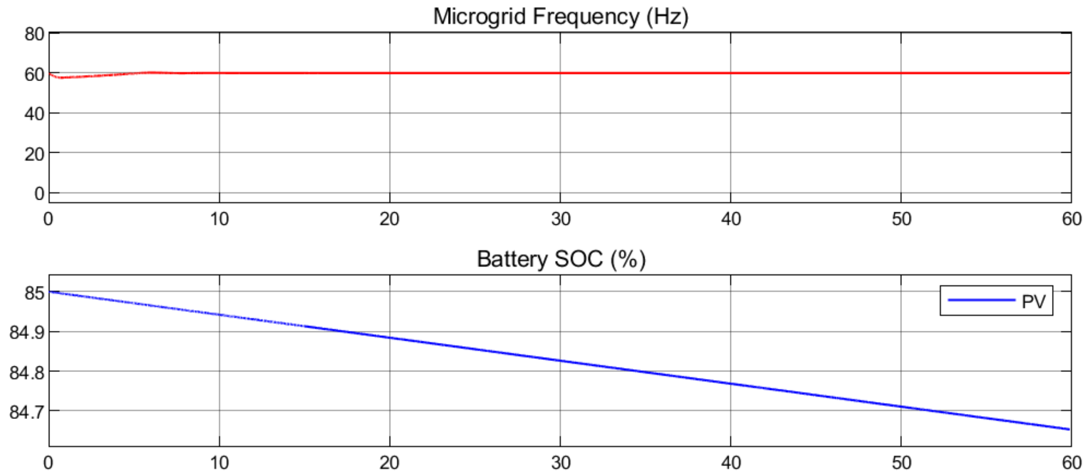

Figure 6. Results of the frequency and battery SOC, (a) Microgrid frequency, (b) Battery SOC.

As a criterion, the energy consumption amounts of a family with 5 persons in a house are taken into consideration to determine production capacity accordingly. In the theoretical calculations, it has been found that a $2.5kW$ solar panel module and a battery module that can store approximately $2kW$ energy are sufficient to meet 5kWh daily energy demand. In simulation studies conducted in accordance with these criteria, the results support the accuracy of the calculations and that the designed system can operate under 24 hours scenario without any problems.

The simulation graphics show that the PV power is around $2.5kW$, and the stored energy is almost $2kW$. It seems adequate and stable power and energy sources in terms of providing the current and voltage to the designed microgrid. It is seen that there is enough available energy to store it in the batteries and the energy from the PV panels is stable and efficient.

The microgrid frequency is 60Hz as desired. It is important to obtain a $60Hz$ frequency in a 24-hours scenario for a standalone system. Accurate SOC estimation is also important to manage the battery, SOC helps to improve the system performance and increase the lifespan of the batteries. The battery SOC is measured at 85% level which is a highly acceptable value.

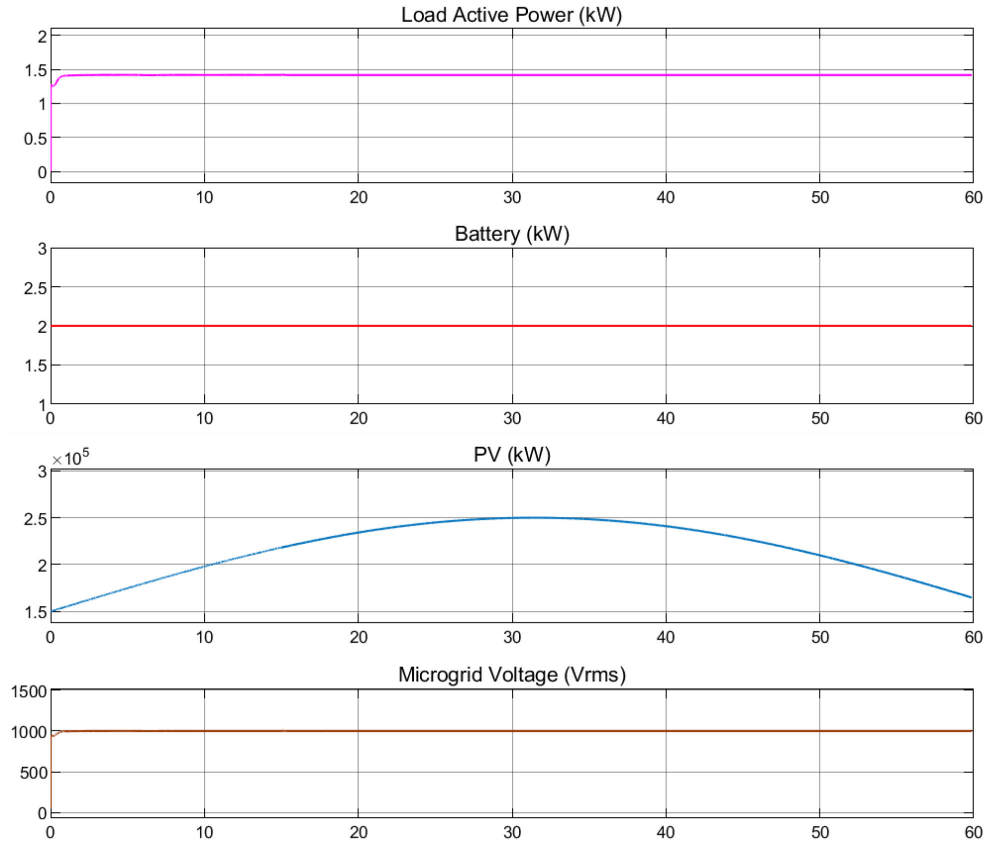

Figure 7. Measurements of the active power, battery, PV, and microgrid voltage

(a) Active power on load, (b) Energy storage capacity, (C) PV power capacity, (d) Microgrid voltage.

8. NATIONAL AND REGIONAL CONTRIBUTIONS

When the subject at the macro level is considered, it can be said that thanks to its geopolitical position, in Turkey, specifically the Southeast Anatolia region falling amount of radiation is much higher than the European countries. For example, Turkey has the opportunity to benefit from 60% more solar radiation than Germany. However, the solar energy produced in Turkey is highly below the expected level [19]. Germany's solar energy production is become the primary energy supply by 23%, while the production is just 7% in Turkey [20-21]. In the Southeastern Anatolia region, Gaziantep is receiving the most radiation after Sanliurfa. Increasing the solar production capacity of Gaziantep is not only contributes to the economy of the region and the country, but also the people of the region living at home. Using the methodology and numerical calculations described in this study, it is quite possible to produce solar energy at home with appropriate domestic production equipment.

9. CONCLUSIONS

In this study, a standalone microgrid is based on solar energy is designed in off-grid mode with suppling full day time load demand. With this study, the electrical design of a house fed with renewable energy was made for the $2.5kW$ solar system. The solar energy unit is integrated to produce electricity. In order to provide energy flow regularly and to make a stable energy balance, the battery bank is integrated into the designed microgrid. The size of the battery has been reduced as much as possible with optimum specifications. Cost calculation is carried out by revealing mathematical analysis and feasibility studies. Besides, the theoretical data, technical data, and simulation are also included. The tests conducted in the simulation environment show that the solar system is capable of providing energy to the load efficiently and stable. It is found that possible to establish an efficient solar system in the Gaziantep region by following the identified steps in this study.

10. FUTURE WORKS

A solar system can be installed at the specified location with the capacity and criteria indicated in this study. Cost analysis can be compared with the actual installation cost. After the solar system is installed, the actual data can be compared with the simulation data and the results can be evaluated more precisely.

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