Research Article

Analysis of A Photovoltaic System Planned to be Installed Under Diyarbakir Conditions Using Pvsyst and Pvsol Software

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ABSTRACT

In this study, in case of a grid-connected photovoltaic system to be installed in Diyarbakır conditions, the plant to be installed was simulated using the trial versions of PVsyst and PVSOL programs. For the study, the roof of Technical High School in Diyarbakır province was selected as a sample study area. As a result of the simulations, the performance and economic analysis of the system were performed together. As a result of the analyses, it was observed that the data of both programs were close to each other. The performance data of the system was analyzed, the approximate cost was calculated and the time for the system to cover its own cost was calculated approximately. Thus, these programs made significant contributions to us both in terms of predicting the performance of our system and the payback period of the system. The novelty of this study lies in conducting a comparative performance and economic assessment of PVsyst and PVSOL simulation tools under the climatic conditions of Diyarbakır, which is one of the regions with the highest solar energy potential in Turkey but has been rarely investigated in the literature. Unlike previous works that mainly focus on general PV performance, this study evaluates the consistency and differences between two widely used simulation programs. The comparative analysis provides additional insights into the accuracy and reliability of software-based predictions, which can support more informed PV project planning and investment decisions in southeastern Turkey.

1. INTRODUCTION

Energy is widely used in the sectors of agriculture, transportation, and housing. However, the increasing consumption of fossil fuels in energy production leads to a rise in greenhouse gas emissions, which in turn intensifies the greenhouse effect and contributes to global warming. Therefore, the need to replace fossil fuels with clean energy sources such as solar, wind, and biomass is becoming increasingly important. These naturally self-renewing sources are referred to as "renewable energy."Among the most promising solutions to the global energy crisis, solar energy stands out as a reliable method of electricity generation through photovoltaic (PV) systems, particularly in rural and hard-to-reach areas where expanding the electricity grid is not economically feasible [1].

The radiant energy produced by the fusion process (conversion of hydrogen into helium) in the core of the Sun is referred to as solar energy. The intensity of solar energy outside the Earth's atmosphere averages around 1370 W/m²; however, due to the atmosphere, the amount that reaches the Earth's surface varies between 0 and 1100 W/m². Even a small fraction of this energy that reaches the Earth exceeds the total energy consumption of humanity. Especially after the 1970s, studies on the utilization of solar energy gained momentum. With technological advancements, solar energy systems have made significant progress, while their costs have decreased. Considering environmental factors, solar energy is recognized as a clean energy source [2].

The Earth is approximately 150 million kilometers away from the Sun. The energy that reaches the Earth from the Sun in one year is nearly 20,000 times greater than the total energy consumed on Earth annually. Not all of the solar radiation reaches the Earth's surface; about 30% of it is reflected back by the atmosphere. Approximately 20% of the sunlight is absorbed by clouds and the atmosphere. The transmission path of solar radiation from the Sun to the Earth is illustrated in Figure 1.1. Approximately 50% of the solar radiation passes through the atmosphere and reaches the Earth's surface. The energy that reaches the surface increases the Earth's temperature, making life on Earth possible. The warming of the Earth's surface also causes wind movements and ocean wave formations [3].

Although numerous studies have analyzed PV system performance using either PVsyst or PVSOL in different regions, a comparative assessment of these two programs specifically for Diyarbakır has not been reported in the literature. Therefore, the main objective of this study is not only to simulate a grid-connected PV system but also to identify the similarities and differences in the results provided by PVsyst and PVSOL, thereby filling an existing research gap and offering a methodological contribution for future PV projects in Turkey.
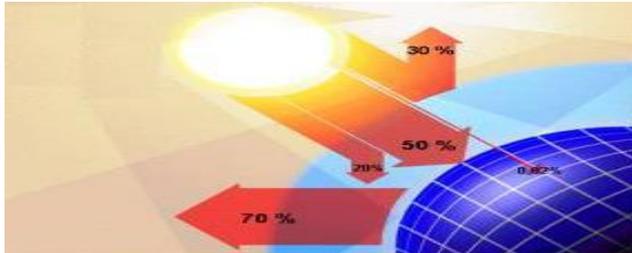

Figure 1.1 Transmission of Sunlight from the Sun to the Earth

1.1 Photovoltaic Systems And Their Characteristics

In this section, the characteristics of PV systems, which are the main focus of this study, will be addressed. PV systems will be briefly defined, and the components of PV systems along with their descriptions and features will be discussed. The term "PV" is derived from the words "photo" (light) and "voltaic" (producing voltage/electricity). The photovoltaic (PV) effect refers to the direct conversion of sunlight into electrical energy using semiconductor materials, such as PV cells. PV systems are designed in various configurations depending on their intended use, and are formed by assembling different components according to specific design criteria. The main components of these systems typically include batteries, PV panels, charge controllers, inverters, and the loads (consumers) that use the generated energy. The system diagram of energy production using PV systems is shown in Figure 1.3 [4].

Figure 1.2 System diagram of the energy generated using PV systems

1.1.1.   PV Panels, Battery, and Inverter

PV panels are structures that capture sunlight through multiple PV cells and convert it into direct current (DC) electricity. A single PV cell cannot generate a sufficient amount of energy on its own; therefore, cells are connected in series or parallel to form panels. These panels, when grouped together, constitute PV panel arrays. The structure of cells, panels, and arrays is illustrated in Figure 1.3.Depending on the type of PV cell used, the efficiency and cost of the panel may vary. In laboratory conditions, PV panels developed with the highest efficiency have achieved a conversion efficiency of up to 43.5% [5]. Based on the type of PV cell used in their

construction, PV panels are categorized into types such as monocrystalline PV panels, polycrystalline PV panels, etc. Structures that enable the conversion of electrical energy into chemical energy for storage, and then convert the stored chemical energy back into electrical energy when needed, are called batteries (or accumulators). In PV systems, battery banks are required in standalone (off-grid) systems. The energy generated during periods of solar irradiation is stored in batteries for use during times when solar irradiation is not available [7].
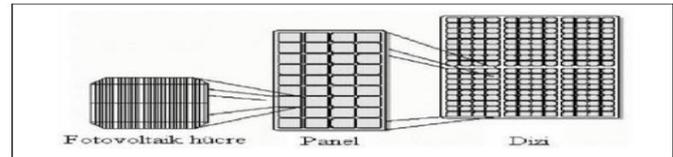

Figure 1.3 PV cell, panel, and arrays [6]

The devices that convert the direct current (DC) produced at the output of solar panels into alternating current (AC) are called inverters. Inverters are among the most important components that complement solar power plants. With the embedded software they contain, maximum power point tracking (MPPT) can be performed. In addition, inverters can store production data and enable remote monitoring when necessary. They provide high current and voltage protection on both the AC and DC sides and also offer protection against potential issues that may arise in PV arrays [8].

1.1.2.   Charge Controller

The main function of charge controllers is to regulate the DC power generated by PV panels and provide a stable DC electrical energy output for proper battery charging. For batteries to be charged from DC sources, it is essential that the charging current and voltage are regulated and kept stable. Since the voltage and current output from PV panels are not constant, charge controllers are used to ensure appropriate charging of the batteries. Additionally, these controllers prevent reverse current discharge from the batteries back to the panels. When the battery is fully charged, the charge controller disconnects the electrical flow from the PV panels to prevent overcharging. There are two main types of charge controllers: MPPT (Maximum Power Point Tracking) and PWM (Pulse Width Modulation) [9].

1.2 Solar Energy Potential of Turkey

Geographically located between 36°–42° north latitudes and 26°–45° east longitudes, Turkey lies within the solar belt and thus possesses a high solar energy potential. According to GEPA (Solar Energy Potential Atlas), the country's annual total sunshine duration is approximately 2,740 hours, which corresponds to a daily average of about 7.5 hours. The total annual incoming solar energy is estimated at an average of 1,527 kWh/m².year, with a daily average of 4.18 kWh/m².day. Based on these figures, Turkey is considered a country rich in solar energy potential. According to Figure 1.4 – Turkey Solar Energy Potential Map (GEPA), which shows the annual total solar radiation across the country, the solar energy potential is particularly high in the southeastern and southern provinces. On the map, color tones closer to red indicate high radiation values ranging from 1,800 to 2,000 kWh/m² per year, while in the northern regions, these values decrease to around 1,400–1,500 kWh/m² per year [10,11].

When Figure 1.5 – Turkey's Global Radiation Value, Sunshine Duration, and Energy Production by PV Type (GEPA) is examined, it is observed that the daily average radiation values peak at around 6.5–7 kWh/m² during June and July, while the sunshine duration approaches 10 hours.
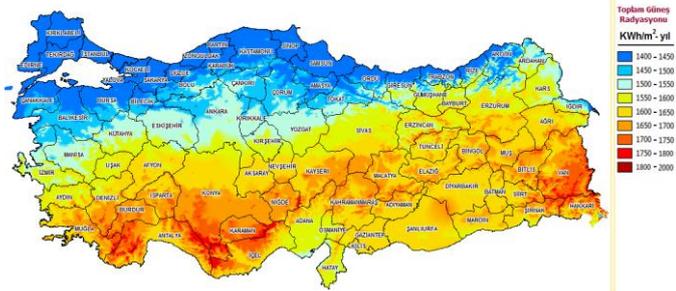

Figure 1.4 Turkey Solar Energy Potential Map (GEPA) [12].

Additionally, the graph showing the relationship between PV type and panel area in terms of energy production clearly indicates that PV panels with monocrystalline silicon provide the highest electricity generation per unit area.
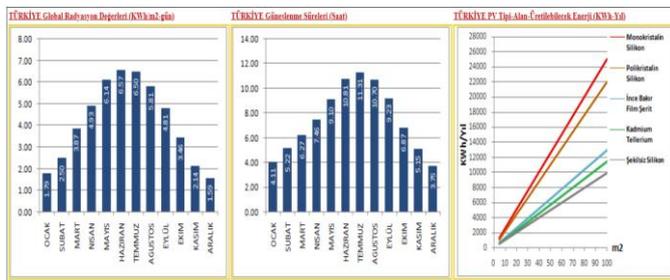

Figure 1.5 Turkey's Global Radiation Value, Sunshine Duration, and PV Type (GEPA) [12]

Diyarbakır province, with its climatic and geographical advantages, is one of the most favorable regions in Turkey in terms of solar energy potential. When Figure 1.6 – Solar Energy Potential Atlas of Diyarbakır Province (GEPA) is examined, it is observed that the annual solar radiation values across the province range between 1,700 and 1,850 kWh/m².year, with even higher values recorded particularly in the southern parts of the province.

Figure 1 6 Solar Energy Potential Atlas of Diyarbakır Province (GEPA) [13].
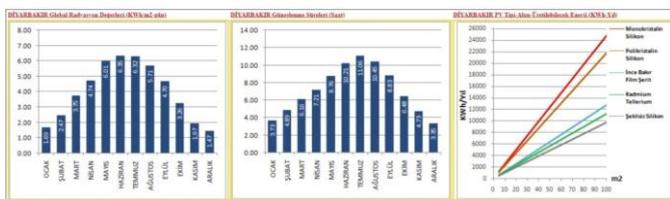

Figure 1. 7 Global Radiation Value, Sunshine Duration, and PV Type for Diyarbakır Province (GEPA) [13].

Figure 1.7 – Global Radiation Value, Sunshine Duration, and Energy Production by PV Type for Diyarbakır Province (GEPA) provides detailed information on the monthly average radiation and sunshine duration for Diyarbakır.

In particular, during June and July, the daily radiation values reach levels of 7.5–7.8 kWh/m², indicating that maximum efficiency can be achieved from PV systems during these months [10].

2. MATERIALS AND METHODS

2.1. System Simulation Using PVsyst Software

In this study, the design of a Solar Power System (PV system) planned to be installed on the rooftop of a Technical High School in Diyarbakır was carried out using the PVsyst 7.2 software. During the simulation process, various parameters related to the school's physical and locational characteristics were entered into the program, and the results were evaluated accordingly. As the first step, the type of system was determined after launching the program. Since a grid-connected system was designed in this study, the "Grid-Connected" option was selected, as shown in figure 2.1 – Project Type Selection Screen.
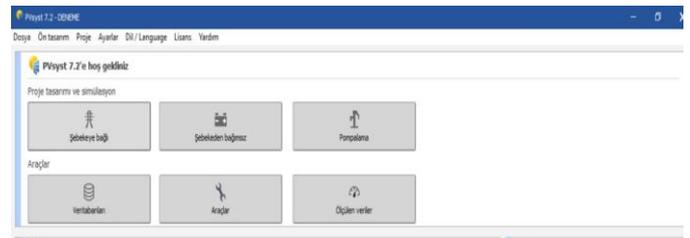

Figure 2.1 Project Type Selection Screen

Then, the "New Location" tab was used to determine the installation site. In the window that opened, the desired installation location was selected using the "Interactive Map" feature, as shown in Figure 2.2 – Desired Project Location. Similarly, the Google Earth view of the building where the project is to be implemented is presented in Figure 2.3. The rooftop areas were measured using this image and taken as a reference for the panel layout.
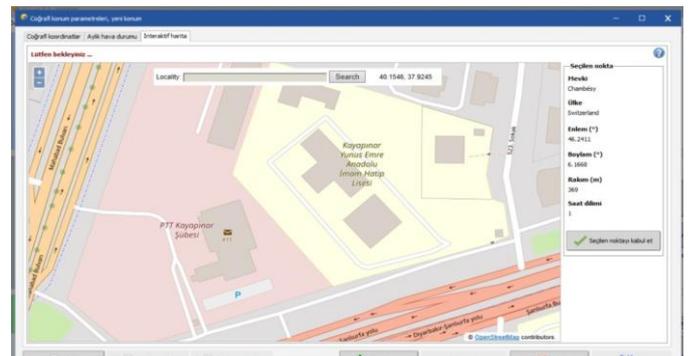

Figure 2.2 Project Location for Implementation

In the next step, the "Orientation" tab was used to define the orientation of the PV panels. Since the roof has four different directions, individual azimuth and tilt angles were entered for each direction. The interface where these values were entered is shown in Figure 2.4 – Input Screen for Panel Tilt and Azimuth Angles for PV Panels. The azimuth values were determined with reference to the south, while the tilt

angles were obtained by physically accessing the rooftop and taking measurements using various mobile applications.

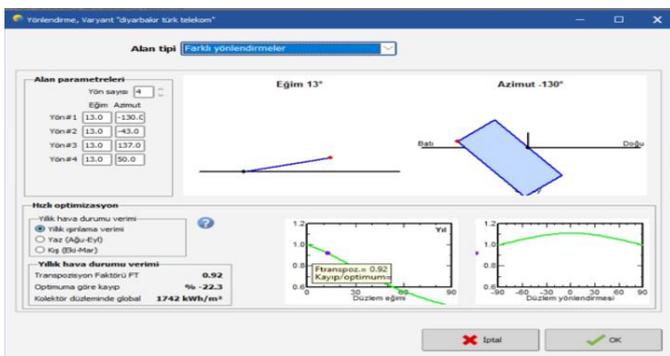**Figure 2.3** Project Location for Implementation (Google Earth View)

Figure 2.4 Input Screen for Panel Tilt and Azimuth Angles for PV Panels

Next, the "System" tab was accessed to select the panels and inverters. In this step, considering the available area, the program calculated and suggested the appropriate number of panels and the required inverter power. As shown in Figure 2.5 – PV Panel and Inverter Selection Screen, a total of 126 panels were selected based on the four different roof surfaces, and compatibility with inverters was ensured for each. The specifications of the inverters and modules were entered in accordance with the actual operating conditions of the system.
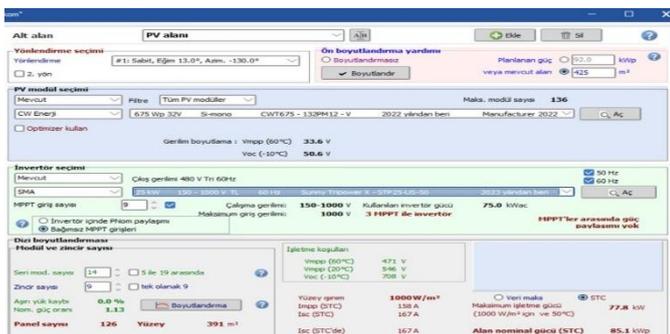

Figure 2.5 PV Panel and Inverter Selection Screen

To increase the accuracy of the simulation, in the next step, the "Horizon" data was entered from the "Optional" section. These data include information such as the sun's position and altitude angle throughout the day, and are illustrated in Figure 2.6 – Horizon Data Entry Selection Tab. The required azimuth and altitude values were obtained from the suncalc.org website using Figure 2.7 – Location Selection Screen and Figure 2.8 – Azimuth and Solar Altitude Values Table for the Selected

Location. These values were manually entered into the program and visualized through the graph shown in Figure 2.9 – Horizon Data Entry Screen and Generated Horizon Line Diagram.
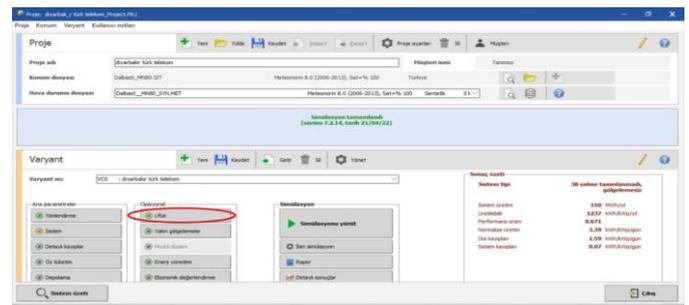
Figure 2.6 Horizon Data Entry Selection Tab
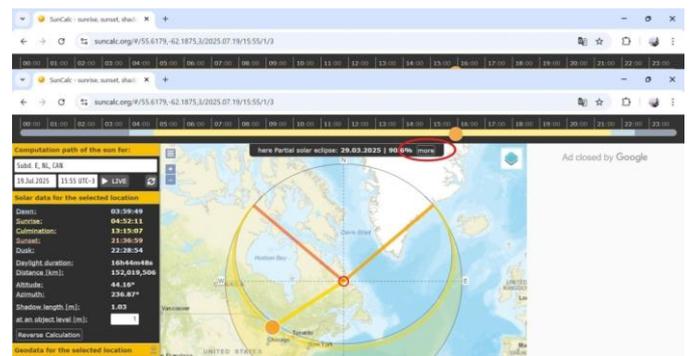
Figure 2.7 Location Selection Screen
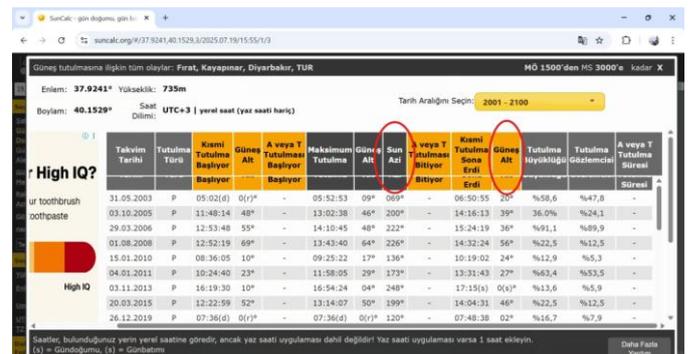
Figure 2.8 Azimuth and Solar Altitude Values Table for the Selected Location

Figure 2.9 Horizon Data Entry Screen and Generated Horizon Line Diagram

After all data entries were completed, the system was ready for simulation. Once all sections in the program were marked in green, the simulation was initiated as shown in Figure 2.10 – Simulation Execution Screen. The 3D panel layout and shading analysis of the study were obtained using Figure 2.11

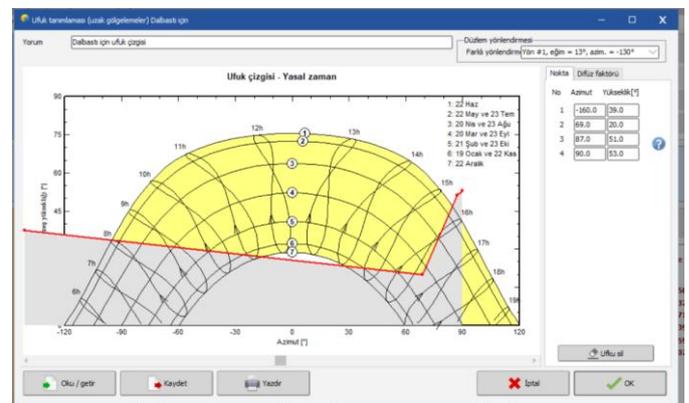– Simulation Execution Screen (3D Visualization). In this view, the positions of the panels on the rooftops were visually verified, and the system design was finalized.
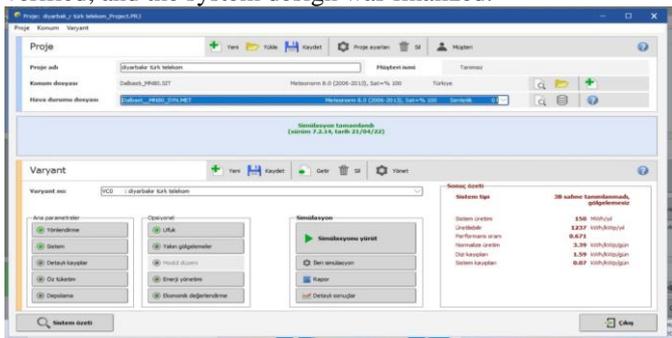

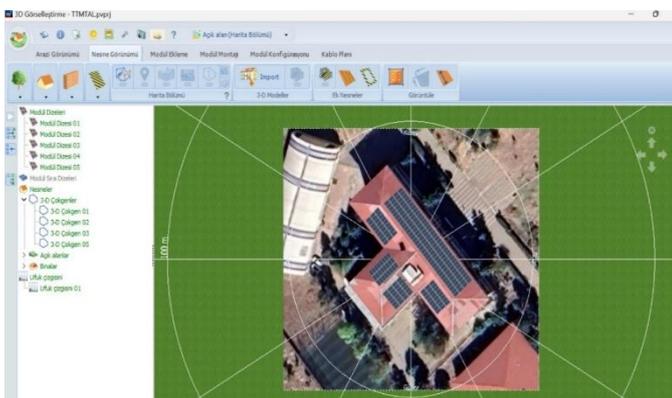
Figure 2.10 Simulation Execution Screen

Figure 2.11 Simulation Execution Screen

The same system parameters were also entered into the PVSOL simulation software to support the analysis process. The key information and design specifications of the system are summarized below:

The system is designed as a grid-connected solar power plant to be installed on the rooftop of Diyarbakır Technical High School. The total installed capacity of the system is 156 kWp. The selected panel model is CW ENERJİ CWT675-132PM 12-V, and the inverter model used is SMA Sunny Tripower X 25 kW. The mounting type has been chosen as fixed, with all panels installed at a tilt angle of 13°.Since the rooftop structure consists of four surfaces facing different directions, the panel layout has been planned according to these varying orientations. The rooftop area allocated for each direction and the corresponding azimuth angles are provided in Table I. These values were determined to ensure that the PV system operates with maximum efficiency based on the duration of sunlight and the angle of solar radiation.

TABLE I
PANEL AREA AND PLACEMENT INFORMATION

Direction	Area	Azimuth
Northeast	425 m²	-130°
Southwest	165 m²	50°
Northwest	75 m²	137°
Southeast	75 m²	-43°

3.   RESULTS

In this section, the results of the simulations conducted for the PV system design are presented in detail. Since the PVsyst and PVSOL software used in the analysis process operate based on different algorithms and simulation parameters, the results obtained from each program were evaluated independently. This approach allowed for a comprehensive analysis of the system's performance and enabled a comparative assessment of the accuracy and consistency of the simulation data.

3.1. PVsyst Simulation Results

The results obtained from the simulation conducted using the PVsyst software are presented below. Figure 3.1 illustrates the annual path of the sun (in terms of elevation and azimuth angles) for four different orientation options, along with the corresponding solar irradiation potential incident on the plane. In each diagram, the times and positions at which the sun is visible throughout the year have been analyzed based on the tilt and azimuth angles of the surface placed on a fixed plane.
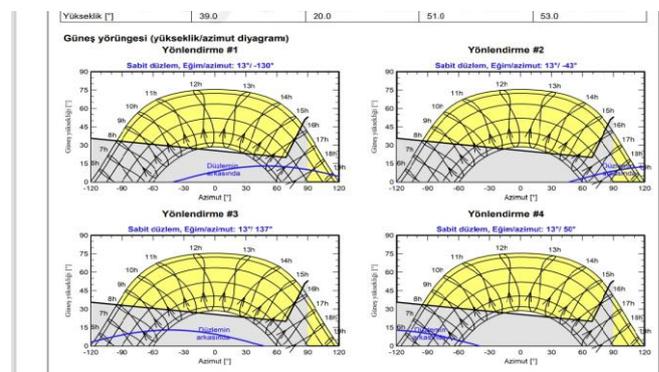

Figure 3.1 Horizon Line Diagram

For Orientation #1 (Tilt: 13°, Azimuth: -130°), the sun's path remains behind the surface during early morning and late afternoon hours. As a result, solar rays cannot reach the surface at certain times. This is clearly shown in the "Behind the Plane" area, indicated by the blue curve on the diagram.

For Orientation #2 (Tilt: 13°, Azimuth: -43°), it is observed that the surface is oriented closer to the south. In this case, a larger portion of the sun's trajectory becomes accessible to the surface, thereby reducing the "Behind the Plane" area. This orientation captures more sunlight in the morning hours but performs slightly lower in the afternoon.

Orientation #3 (Tilt: 13°, Azimuth: 137°) presents a west-facing configuration, where a significant portion of the morning sunlight remains behind the surface. However, solar irradiance increases in the afternoon, which may offer advantages for post-noon energy production, though energy loss may occur during morning hours.

Orientation #4 (Tilt: 13°, Azimuth: 50°) represents an eastward orientation. In this configuration, solar irradiance is more intense during the morning, as the sun's path intersects the surface more extensively. Therefore, energy production can be higher in the early hours, while a decline may occur in the afternoon.

Overall, these diagrams allow for a comparative analysis of how different orientation options affect solar energy collection efficiency throughout the year. The gray areas labeled "Behind the Plane" indicate time intervals during which the system cannot benefit from solar irradiance due to its tilt and azimuth configuration, providing valuable insights for optimizing panel placement.

The graph in Figure 3.2 clearly illustrates that the production capacity of the solar energy system fluctuates throughout the year due to seasonal variations. The highest production levels are reached during the summer months (especially June–July–August), while the lowest levels occur in the winter months (December–January–February). This information is highly critical for system design and energy demand planning. For instance, to meet energy needs during the winter months, the use of storage systems or support from the power grid may need to be considered.

The graph in Figure 3.3 illustrates the monthly Performance Ratio (PR) of a solar energy system. PR is defined as the ratio of a PV system's actual energy output to its theoretical potential and is one of the most important indicators used to evaluate the system's efficiency. The PR value accounts for system losses (such as temperature effects, inverter inefficiency, cable losses, shading, etc.) and reflects the actual performance. The value ranges between 0 and 1; the closer it is to 1, the more efficiently the system is operating.

This graph clearly demonstrates the seasonal variation in the PV system's efficiency. The spring months (particularly April) represent the periods when the system operates at peak efficiency. In the summer, efficiency slightly decreases due to high temperatures, while in the winter months, the performance ratio drops significantly due to reduced solar irradiance and shorter daylight hours. This analysis provides valuable insights into when maintenance, cleaning, and system optimization efforts should be prioritized.
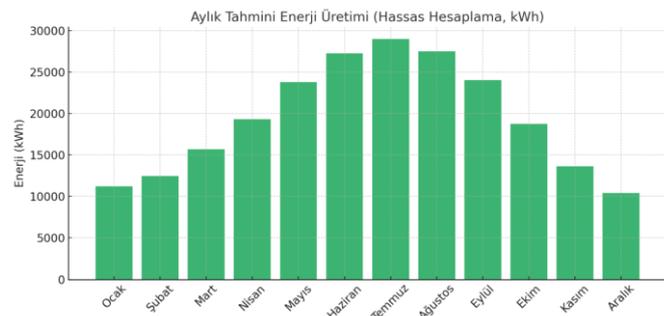

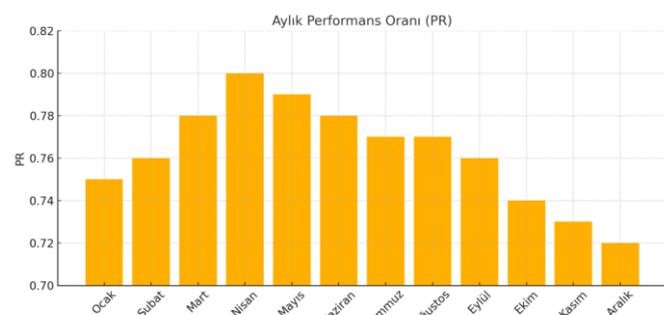*Figure 3.2* Estimated Annual Normal Production

Figure 3.3 Monthly Performance Ratio Variation Chart

The graph in Figure 3.4 shows the daily input/output diagram of a solar energy system. The horizontal axis represents the energy received from the sun (input), while the vertical axis represents the energy delivered to the grid by the system (output). All data covers a one-year period from January 1 to December 31.

X-Axis (Horizontal): Represents the global solar energy reflected onto the collector (kWh/m²/day), indicating the amount of solar irradiance received on the system surface on a daily basis.

Y-Axis (Vertical): Represents the daily amount of energy injected into the grid (kWh/day), which is the net electrical energy delivered by the system.

This graph clearly demonstrates that the PV system responds strongly, consistently, and efficiently to solar irradiance. There is a positive, nearly linear relationship between the solar irradiance received by the collector and the energy supplied to the grid. No significant deviations or efficiency losses due to seasonal or environmental factors are observed in the system, indicating that it is a well-designed and well-operated solar energy system. The graph also confirms that the system provides reliable data in terms of performance modeling and energy forecasting.
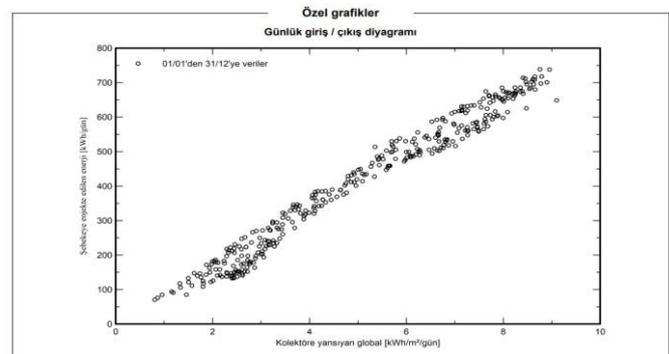

Figure 3.4 Daily Average Irradiance Reflected onto the Collector

The graph in Figure 3.5 displays the distribution of output power injected into the grid by a solar energy system throughout a one-year period. This histogram, titled "System Output Power Distribution," includes data from January 1 to December 31.

- X-Axis (Horizontal): Represents the instantaneous power values injected into the grid, measured in kilowatts (kW). This axis indicates the power ranges within which the system operates.

- Y-Axis (Vertical): Represents the total amount of energy (in kWh) produced at each corresponding power level. For example, it shows how many kilowatt-hours of energy the system generated over the year while operating at 75 kW.

This histogram clearly reveals the performance characteristics of the solar energy system. It shows that the system frequently operated at near-maximum capacity under high irradiance conditions, producing energy efficiently over extended periods. Furthermore, since a significant portion of the system's operation occurred within the 40–85 kW power range, it can be concluded that the site receives sufficient sunlight and that the inverter and other system components have been appropriately sized.The graph provides valuable insights into the system's load profile and energy production distribution, highlighting the effectiveness and suitability of the overall system design.

In addition to the technical data obtained from the simulations, the economic analysis results clearly demonstrate how efficient the system is in terms of investment. Table II – Investment Cost

Breakdown details all the cost components related to the system installation. The total investment cost, excluding VAT, was calculated as 2,168,512 TL. The largest expense item is the 231 units of 675 W PV panels, followed by 6 SMA 25 kW inverters. Other components such as the mounting structure, cabling, labor, and engineering services also contribute significantly to the total investment cost.
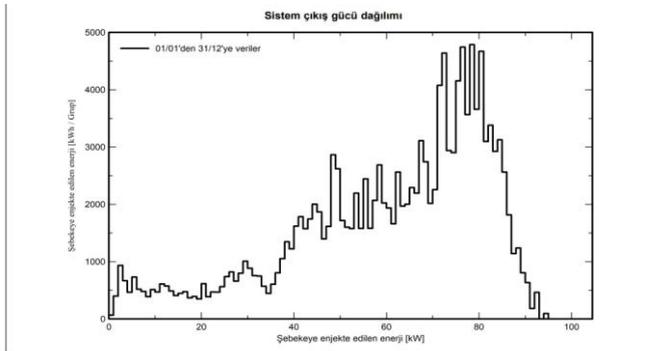

Figure 3.5 System Output Power Distribution Chart

When examining Table III – Annual Income Analysis, it is seen that the system produces approximately 233,064 kWh of electricity per year. Based on the current electricity sales price of 4.46 TL/kWh, the annual gross income reaches 1,039,465 TL. The annual operation and maintenance (O&M) cost is calculated as 1.5% of the investment, amounting to 32,528 TL. After deducting this expense, the net annual income is calculated to be 1,006,938 TL.

Table IV – Economic Analysis Summary provides highly valuable insights regarding the investment payback period, showing that the system pays for itself in approximately 5 years. This analysis highlights the system's high efficiency, the use of high-quality components (such as SMA inverters and high-wattage panels), optimal orientation, and low maintenance costs as key contributing factors. The balance between the generated energy and financial returns makes the investment economically attractive.

In conclusion, the system demonstrates reliable performance from a technical perspective and has the capacity to repay itself within a short period economically. These analyses clearly indicate that the system design is well-conceived and that the investment decision is technically and financially sound.

TABLE II
INVESTMENT COST BREAKDOWN [14]

Item	Cost (TL)
PV Panels (675W, 231 units)	3,777,774
İnverter (SMA 25kW x 6 units)	850.000
Mounting Structure and Mechanical Materials	150.000
DC/AC Cabling and Installation	85.000
Labor and Installation	100.000
Project, Permits, and Engineering	70.000
Total (Excl. VAT)	5.032,774

TABLE III
ANNUAL INCOME ANALYSIS

Item	Value
Annual production	233.064 kWh
Electricity Sale Price	4.46 TL/kWh
Annual Gross Income	1.039,465
Annual operation/maintenance cost(1.5%)	32.528 TL
Net annual income	1.006,938

TABLE IV
ECONOMIC ANALYSIS SUMMARY [15]

Item	Value	Description
Annual production	233.064kWh	Precise production calculation
Electricity Sale Price	4,46 TL/kWh	Fixed unit price set by EPDK
Annual Gross Income	1,039,465 TL	Total production × unit price
Annual O&M cost	32.528 TL	1.5% of investment cost
Net Annual Profit	1,006,938 TL	Income – Expenses
Total Investment	5.032,774 TL	Cost excluding VAT
Payback Period	5 yıl	Investment return period

3.2. PVSOL Simulation Results

In this section, the results obtained using the PVSOL simulation software for the designed photovoltaic system are presented in detail.

The graph provided in Figure 3.6 illustrates the monthly energy production (in kWh) of a solar energy system. The visual clearly shows the variation in the amount of electricity generated by the system throughout the year, depending on solar irradiance. The graph demonstrates that solar energy production is highly dependent on seasonal cycles. Production reaches its highest levels particularly in late spring and early summer, while it drops to a minimum during the winter months.

These findings highlight the importance of considering energy storage or grid-supported systems in the planning of solar power plant investments. Moreover, understanding this production profile is crucial for annual energy yield estimations and economic feasibility studies.

Figure 3.6 System Output Power Distribution Chart

The graph presented in Figure 3.7 clearly reveals that temperature and orientation/tilt issues are among the primary factors affecting the performance of the solar energy system. To reduce such losses, careful attention must be given during the engineering design phase to thermal management, geographic optimization, and panel placement planning. Additionally, operational factors such as inverter efficiency, cable quality, and cleanliness also significantly impact the overall system efficiency.

This analysis is particularly valuable for identifying the key areas that should be prioritized in system optimization. Figure 3.7 displays the percentage losses of all components that reduce the system's performance ratio. The system experiences various losses due to temperature, orientation, cabling, and

inverter inefficiencies. As a result of the calculations, the total Performance Ratio (PR) of this system is given as 83.8%.

The technical and economic data obtained from the PVSOL simulation program demonstrate that the system is not only efficient in terms of energy production but also a financially viable investment. When Table 3.4 – Monthly-Based Total Annual Production Table is examined, it is observed that the system generates a total of 254,976 kWh of electricity annually.
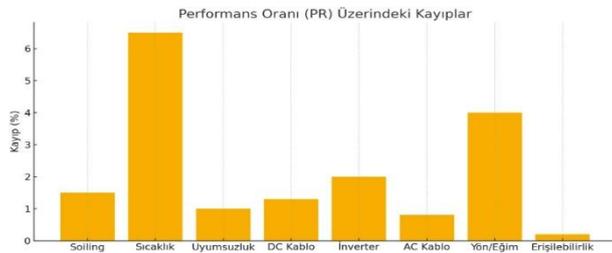

Figure 3.7 Losses Affecting Performance Ratio (PR)

Production peaks particularly in April, May, and June, while a noticeable decline is seen during the winter months (December, January, February). This variation is due to seasonal changes in sunshine duration and solar irradiance intensity, making it highly valuable for understanding the system's annual production curve.

From an economic perspective, Table V – Technical and Economic Analysis clearly reveals the system's payback period and annual income potential. The total system cost was calculated as 5,631,600 TL, and the system's annual gross income reached 1,137,193 TL. After deducting maintenance expenses calculated at 1.5%, the net annual income is 1,052,719 TL. According to these figures, the system's payback period is approximately 5.3 years. These results prove that the system is a sustainable and attractive investment not only due to its environmental benefits but also thanks to its strong financial return. Tables V and VI clearly demonstrate that both technical performance and economic feasibility have been successfully achieved.

TABLE V
MONTHLY-BASED TOTAL ANNUAL PRODUCTION TABLE

Month	Production (kWh)
January	13.393
February	16.483
March	23.180
April	29.618
May	31.679
June	30.391
July	29.361
August	27.043
September	20.089
October	14.423
November	10.817
December	8.499
Total	254.976

TABLE VI
TECHNICAL AND ECONOMIC ANALYSIS

Item	Value(TL)
Total System Cost	5.631.600 TL
Annual Energy Production	254.976 kWh
Electricity Sale Price (TL/kWh)	4.46 TL
Annual Gross Income	1.137.193 TL
Annual Maintenance Cost (1.5%)	84.474 TL
Annual Net Profit	1.052.719 TL
Payback Period	5,3 yıl

4. CONCLUSION AND EVALUATION

In this study, the technical and economic performance of a grid-connected PV system planned to be installed on the roof of Diyarbakır Türk Telekom Vocational and Technical Anatolian High School was evaluated using PVsyst and PVSOL simulation programs. The findings obtained from the simulations provide significant insights in terms of both energy production potential and investment payback period.

According to the analysis conducted with the PVsyst program, the system is estimated to generate an average of 233,064 kWh of electricity annually. The PVSOL software, on the other hand, predicts a slightly higher value, indicating a production potential of 254,976 kWh per year. The data obtained from both simulations clearly demonstrate the impact of seasonal variations on energy production. While solar irradiance reaches its peak during the summer months, performance ratios (PR) tend to be lower compared to the spring months due to the decrease in PV panel efficiency caused by high temperatures. This highlights the significant effect of temperature on PV system performance and indicates that it is an important parameter to consider during the system design phase.

The economic analysis results also show similar trends for both programs. According to the PVsyst simulation, the total investment cost excluding VAT is approximately 2,168,512 TL, with an estimated annual net income of 1,006,938 TL and a payback period of about 5 years. Based on the PVSOL analysis, the investment cost is calculated as 5,631,600 TL, the annual net income as 1,052,719 TL, and the payback period as 5.3 years. These calculations are based on an exchange rate of 38 TL/USD (as of the current rate) and an electricity unit sales price of 4.46 TL/kWh, as determined by the Energy Market Regulatory Authority (EPDK).

The consistency of the results from both programs is a strong indication of the reliability of the modeling and forecasting processes. Furthermore, such simulation tools enable not only technical feasibility assessments but also economic return analyses of solar power plants before

installation, allowing for more accurate and data-driven investment decisions.

In conclusion, PV system investments in regions with high solar potential such as Diyarbakır are found to be highly favorable in both technical and economic terms. This study serves as a valuable reference for similar-scale applications and provides a foundation for future design and optimization efforts aimed at enhancing system performance.

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