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The Importance of Fixed and Variable Angle in Solar Power Plants Analysis

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Abstract: The need for energy is increasing by the day. Renewable energy sources already have a significant place in electricity production both around the world and also in Turkey and the share of solar energy going higher within the renewable energy sources. Solar energy is extremely easy to use, it is preferable too because it is environmentally friendly-clean energy. Solar energy plant is the energy source of the future, because the production costs of solar plants are lower than other energy sources and the economic difficulties are overcome. To get optimal production, the solar energy plant must make maximum use of the sun. In the designed system, solar panels are provided with both fixed and seasonal variations. The first variations of solar panel systems is are placed at constant 25° angle and the position angle of second variation is shifted from 10° to 30°in summer and winter accordingly. In this study, the performance of 1148 kWp PV plants which is established in Altınekin district of Konya and planned to be connected to the grid was evaluated by PVSYST analysis program. Power generation of the two different systems, specific data and performance value are calculated. Result of the study shows that the seasonal system produced 32.2 MWh more per year than the fixed system. Global irradiation in the seasonal system is 26.4 kWh/m², and the specific yield is concluded to be more than 28 kWh / kWc / year.

Keywords: *Fixed system, Solar power plant, Solar energy, Variable angle system.*

1. Introduction

With the development of science and technology in the world and in Turkey, energy needs are increasing day by day. In order to meet the requirements of the country, the importance of alternative sources in energy production has emerged. The share of solar energy in electricity generation, which has a very important place among renewable energy sources, is increasing and the studies in this area are becoming increasingly important. Turkey trying to become one of the leading countries using solar energy in the world and aware of its solar energy production potential for very long time is trying to make the optimal use of this resource in today. Especially in recent years, Turkey has been making big investments in solar energy systems sector and many studies are being carried out on behalf the sector actors. According to European and other world states, our country's solar energy potential and annual sunny day time lengths are quite high. Solar energy is preferred because it is extremely easy to use and environmentally friendly clean energy.

The growth in energy demand in the world is caused by the depletion of fossil fuel reserves. 40 years of the world's oil reserves, the reserves of natural gas 67 years and coal reserves are predicted to be exhausted after 227 years. These figures after that renewable energy sources would be much more important, and shows a sharp increase in investment in this area.

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One of the reasons of global warming is due to the increase in carbon dioxide (CO_2) and greenhouse gases in the atmosphere which are result of using fossil fuels for electrical energy. Due to energy crises and global warming, interest in renewable energy sources is growing against fossil fuel based production. Among these sources, the sun has become the center of attention because it is a clean and never-ending source of Energy [1].

Turkey's increasing population, industrialization and economic growth as a result of the energy needs are increasing day by day. Our country cannot provide enough energy in terms of the need to increase the dependence on foreign fossil fuels. Especially in the range of 43 to 50 percent of the increase in the share of natural gas power generation it is indicative of the last decade highly dependent on natural gas. In this context, it is utilized from various sources to meet its energy needs.

Electricity production in Turkey is carried out from different sources these resources are composed of hydroelectric dams and rivers, thermal power plants using natural gas and coal, wind turbines, geothermal power stations as shown in Fig. 1 [1].

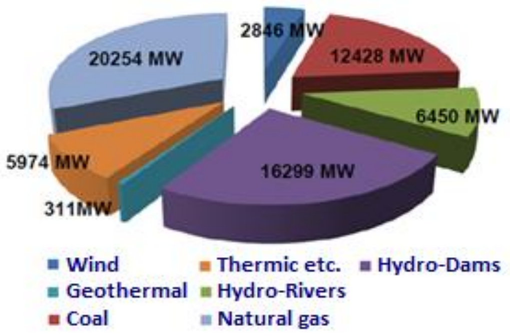

Fig. 1. Distribution of installed power of Turkey's electric power

Turkey's annual rate of electricity consumption has increased by an average of 5.4 percent in the last 15 years. At the end of 2016, Turkey’s electricity production was 273,387 GWh, 184,889 GWh of which from thermal power plants, 67,268 GWh of which from hydroelectric power plants and 21,230 GWh of which from other renewable energy sources [2].

Turkey has largely renewable energy resources in terms of location. Especially solar energy has come to the fore in terms of its renewability, cleanliness, and ease of use. According to Turkey's solar energy potential Atlas (GEPA), the total annual sunny time is 2.741 hours (daily average 7.5 hours), while the total annual incoming solar energy is 1.527 kWh/m2*year (daily average 4.18 kWh/m2*day) [3]. Turkey has a solar energy potential as high as 110 days, so that if necessary investments are made, it can produce 1100 kWh of solar energy per unit square meter per day. Southeast Anatolia is the region with the highest amount of solar energy in our country, followed by the Mediterranean region and the Eastern Anatolia region [1].

In their work, Kandasamyet al. (2013) assessed the performance of the grid-connected solar system using the PVsyst analysis program. They calculated the performance ratio of 1 MW solar system in southern Tamil Nadu, India. [4].

Subhadeep Bhattacharjee and colleagues (2013) evaluated the performance of a 60 kWp PV power plant in their study. They examined various parameters for the performance estimation of 60 kWp PV power plants installed in India. They investigated various losses in the PV system, performance index, solar fraction, etc. They stated that 74.336kWh of energy per year could be obtained by the PVsyst program [5].

Saueret al. (2015) in their study, they stated that the correct choice should be made according to the radiation and module temperature, which affect the performance of the solar panel. They provide suitable temperature conditions for the solar panel. They increase the strength of the panel PVsyst simulation program. They noted that the program should be used for energy yield prediction PVsyst [6].

Clifford Hansen (2015) they found that there are other methods for estimating parameters for single diode models, especially for PVsyst ™ 6. PVsyst ™ version 6 has the ability to predict model parameters for uploaded data. They identified errors using specific prediction tools. They stated that they had developed an alternative method to overcome these deficiencies. It was determined that using a three-step procedure you should determine all the parameters for PVsyst ™ version 6. I-V curves of the temperature or radiation, which should be stable as measuring [7].

Karkiet al. (2012) in their study, they noted that the performance of photovoltaic cells, have indicated that due to its geographical location and the technology applied to use the existing energy. They noted that Nepal lies along the 300 North parallel of the northern latitude and that although it receives an average of 300 days of sunlight per year, total electrical energy from different sources cannot meet the energy demanded. In the study, they analyzed network-connected systems in Kathmandu and Berlin using the PVsyst program. They analyzed the total amount of electrical energy generated by the grid connected panels and the different losses generated in the systems and graphically showed the results [8].

Haydaroglu (2016) a solar power plant has also been established within the Faculty of engineering of Dicle University. They stated that the use of simulation programs is important in the design and analysis of photovoltaic solar power plants. In this study, the simulation of 250 kWp solar power plant established by Dicle University was carried out with PVsyst program. Its performance was analyzed in accordance with the performance criteria specified in IEC 61724 standard. One year production values of the plant were compared with the simulation results. From the analysis of the results, the Reference Yield, string yield and final yield were found to have reached their greatest value in August. This is due to the fact that the largest radiation occurs in August. The lowest performance rate was determined to occur in August. Although the highest radiation value is in August, the lowest performance rate occurs in the same month due to the decrease in panel efficiency due to temperature. According to the simulation results, the plant is projected to produce an average of 380.6 MWh of energy per year [9].

Axaopouloset al. (2014)’ stated that there were demands on software programs used by investors for planning and performance forecasting of solar energy systems. In the programs of Polysun , TRNSYS, Archelios, PVSyst, PV*SOL and PVgis, they analyzed the electrical energy data generated by the 19.8 kWp system connected to the grid. They compared using actual climate data over the same calendar year. As a result, they stated that the analysis programs gave approximate results in estimating the radiation coming into the modules, but still significantly underestimated the electrical energy generated by the system setup [10].

André Mermoud (2012) conducted the analysis of the mutual shading effect on PV power plants in the PVsyst program. They have optimized the radiation in the Seville region. He has done a deep analysis of the main parameters involved in optimization, in particular the comparison of plane slope and shading boundary angle. Over the course of a year he observed that different components (beam, propagation, albedo, and incompatibility electrical effects) were dominated by shading effects and widespread and albedo losses. Electrical effects are also important with a single string in the width of the lines. In row edits, he confirmed that the entire array is affected by this shadow when the subtypes of a string are shadowed. The analysis is based on their annual simulations [11].

Mermoud and Lejeune (2010) it is intended to analyze the results of the "standard" single diode model from long-term detailed measurements of PV modules. They proposes some changes specifically to improve amorphous, micro-crystalline, and CdTe modules. They stated that an antilogarithm behavior of the shunt resistance parameter for any module should be considered. They determined that there must be recombination loss and spectral correction to improve modeling of amorphous Technology Modules. These analyses were performed in PVsyst software [12].

Ahsan at all. (2016) examined a 1kW PV system in small homes in India. The performance of the system and the cost analysis for the designed system were evaluated using PVsyst software. PVsystem produces 3101.2 kWh/year solar power. However, only 2933.4 kWh/year solar energy is given to the user. Unused 167.8 kWh of energy can be caused by a fully battery-filled or low energy demand during production. Comparing the energy generated by PV to the energy provided and needed by the user was also calculated by PVsyst [13].

To get the most out of solar energy, you need to direct solar panels in the direction of the sun. However, there are some variables in finding the optimal direction. This study is designed to help achieve the best efficiency of solar energy. Solar panels in the northern hemisphere should always appear in the true southern direction or in the southern hemisphere in the true north direction. Installing your solar panels on a fixed slope is the easiest method. However, since the sun is higher in summer and lower in winter, it helps to get more energy all year round by adjusting the slope of the panels according to the season. In the study, we assume that either the panel is fixed or has a seasonally adjustable slope. The system designed either solar panel to be in a constant 25 degrees or to change their angles seasonally having summer to winter angles of 10-30 degrees. In the study, the efficiency of the fixed-angle or different-angle system was evaluated by the PVsyst program.

2. MATERIALS METHOD

2.1. Field

The planned solar power plant in the province of Konya, Altınekin district is located Oguzeli. It is located at 996 m altitude at coordinates 38.305597, 33.171152. The total field area is 20,000m² [30].

Based on data from the Solar Energy Potential Atlas (GEPA), it is understood that the insolation time is 8 hours per day on the basis of the insolation times in Konya province mentioned in Figure 2.

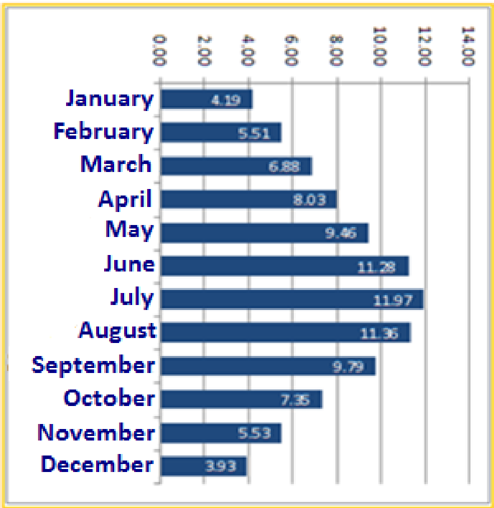

Fig. 2. Insolation time in Konya province hour

Insolation time and the amount of radiation per panel lead to an increase in electricity production from the sun. Therefore, the position of solar panels against the sun is important. If the panel surfaces are positioned facing south, the power obtained from solar radiation is maximum.

Two different types of panel angles have been determined for the planned solar power plant. As can be seen in Figure 3 and 4 in the fixed system, the panels placed on the fixed two metal columns to receive sun rays from a 25 degree angle throughout the year.

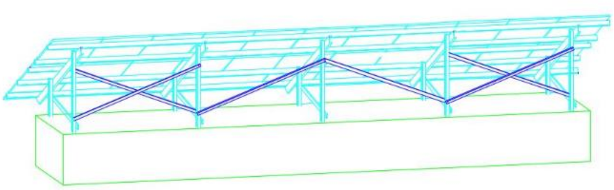

Fig. 3. Fixed 25 Degree Table Structure

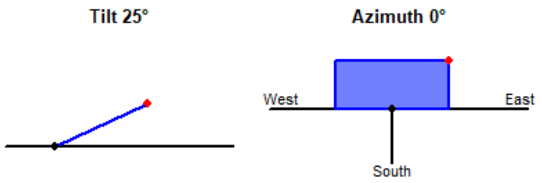

Fig. 4. The panels overlook the south and are 25 °

As seen in figure 5 and 6 variable angle system, panels placed on adjustable columns to receive sun rays throughout the year at a 10 degree angle in summer and 30 degree angle in winter. Summer winter angles are changed manually in April and September.

Fig. 5. 10-30 Degree Variable Table Structure

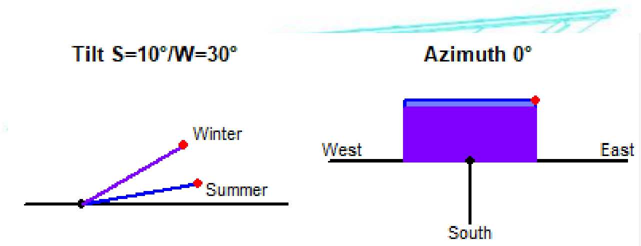

Fig. 6. Panels overlook south and 10 °for summer, 30 ° for winter

Solar tracking systems are used to increase solar radiation from solar panels [14]. It is stated that the power obtained from a 2-axis solar tracking system at the Mugla University Campus is 30.79% higher than the fixed-slope system [15]. The adjustable 10- and 30-degree table structure is based on a kind of manual solar monitoring system.

2.2. Materials

The planned solar plant consists of 330 Wp polycrystalline 3480 pieces of solar panels and 16 pieces of 60kWa string inverter. The panels are the PS 330P-24/T model of Smart Solar. Panels 330 Wp (Pmpp), Maximum power voltage Umpp [V] = 38.53V, Maximum power current Impp [A] = 8.57V, open circuit voltage Uoc [v] = 17.01V, short-circuit current Isc [A] = 9.15A.The panels provide 17.01% efficiency with a 12-year product 25-year performance guarantee. The inverter used is a series of 60kW rated DC power produced by Huawei and runs in the 200 to 1000Vdc (400V rated) MPPT input voltage range. The nominal power output of the facility is 1148.4kWp. Panel and inverter forces are selected the same for both projects in the system that is constant at 25 degrees and can adjust 10-30 degrees. In a field area of 20,000 m², 3480 panels are made in a total of 20 series 174 strings. 1 string was created with 3 rows and 20 column panels for each table. Panel foot distances are important in terms of the lack of interlocking shading of the panels (Fig 7) panel foot distances are calculated with the formula 1 shown below.

$$A=\left[\frac{\sin\alpha}{\tan\beta}+\cos\alpha\right].L \tag{1}$$

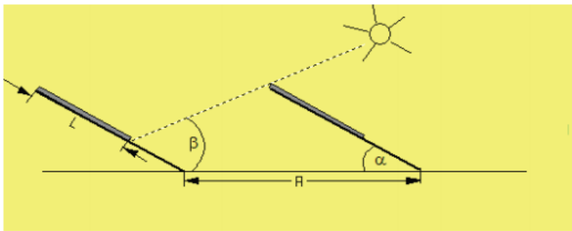

Fig. 7. The distance that should be left Between Panels

Panel foot distances are 6 meters as shown in Figure 8 for solar power plants. In this way, the shading effect of the panels on each other was eliminated.

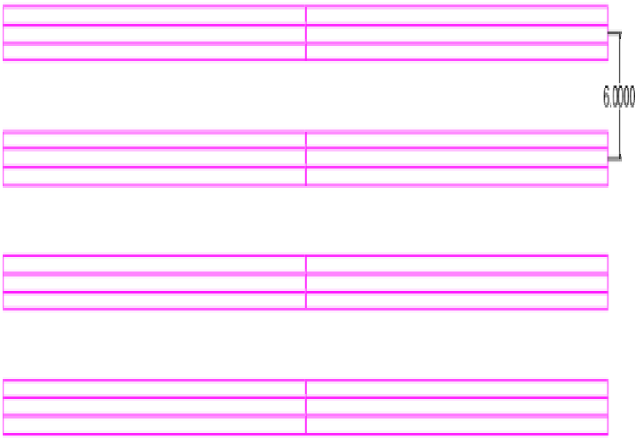

Fig. 8. Panel Layout

2.3. Capacity Factor (CF)

Capacity is the maximum generating capacity of a power plant and is usually measured in kW, MW or GW. [26, 28]. The capacity factor (CF) indicates the efficiency of any pitch. The nominal power of the plant is the ratio of the energy produced in a period (usually one year) between its annual powers to the annual PV panel potential energy. The capacity factor of PV santrals is calculated from PV array DC output values or inverter AC ' value [16]. CF formula 2 is also indicated.

$$CF=\frac{\text{Real Power generated}}{365 \text{ x } 24 \text{ x Nominal Power}} x100\% \quad (2)$$

2.4. Performance Ratio (PR)

Performance ratio (PR) helps to compare the energy produced by solar power plants installed in different regions. PR is available among the IEC 61724 standard criteria. According to this ratio, PR is the ratio of the energy produced by the system to the reference energy entering the system [17].

$$PR = \frac{Y_F}{Y_R} \quad (3)$$

Y_F (system efficiency factor) specified in equation (3) is the ratio of the energy given to the system (AC power) to the installed power:

$$Y_F = \frac{E_{Use,PV}}{P_0} \quad (4)$$

The Y_R (Reference Yield) specified in equation (3) defines the sources, location and direction of solar radiation. The ratio of total solar radiation (Ht) to reference radiation G (1kW/m2) is: (3) [9, 27].

$$Y_R = \frac{H_t\,(kWh/m^2)}{G(kW/m^2)} \quad (5)$$

PR, optical losses (shading, IAM, contamination), array losses (PV conversion, aging, module quality, mismatch, wiring, etc.) and includes system losses (network-connected inverter efficiency or storage / battery / unused) [18].

String efficiency: (Y_A) String efficiency is the ratio of energy (DC) generated in panel strings in the system to installing power in a certain period (day/month/year) in case the plant operates at nominal power. [14].

$$Y_A = \frac{E_a}{P_0} \quad (6)$$

String loss (Lc): is found by the difference between Reference Yield (Y_R) and string yield (Y_A). (7)

$$L_C = Y_R - Y_A \quad (7)$$

System loss (Ls): found by the difference between string yield (Y_A) and system yield (Y_F). (Equation 8)

$$L_S = Y_A - Y_F \quad (8)$$

Specific Yield (SY): Specific efficiency normalizes the energy produced according to system size. The formula is calculated according to (equation 9).

$$SY = \frac{AC_{energy\ output}\,(kWh)}{Nameplate\ or\ DC\ rated\ power\ on\ PV\ module\ (kWp)} \quad (9)$$

2.5. PVSYST

PVsyst software is accepted worldwide as a standard for PV system design and simulation. It developed by Michel Andre Mermoud and Michel Villoz. They are designed to use this software by architects, engineers, researchers and students.

PVsyst is a software that allow the user to use the full-featured operation and analysis of a PV project. PVsyst combines simulation of the PV system with the evaluation of pre-feasibility, sizing and financial analysis, regardless of whether it is a network-connected, independent, pumping system or dc grid system [19].

The shading status of the plant can be analyzed by PVsyst by 3D modeling method. Panel shadows can be displayed depending on the sunrise and sunset. Thanks to the many inverter and panels in the program interface, the desired central structure is defined and analyzed.

The annual radiation values of the planned solar power plant are calculated automatically by entering coordinates in the European Union Photovoltaic Geographic Information Systems Database (PVGIS) online computing environment. The European Union Photovoltaic Geographic Information Systems Database (PVGIS) includes the European and African countries with a global radiation map prepared by the Joint Research Centre (EC JRC) within the European Union (EU). PVSYST applies the Perez model to predict radiation occurring on an oblique plane. As a result of these calculations, monthly radiation values are assigned to the PVsyst program.

2.6. Parameters Used in PVSYST

The information for the 330 Wp panels used for the power plant is indicated in Table 1. The panels are positioned so that 20 modules are 174 strings.

Table 1. Panel Details

Panel Parameters	Values	Unit
Voc (k) Temperature Coefficient	-0,33	%/°C
Vmpp(k) Temperature Coefficient	-0,33	%/°C
Standard Test Temperature (Ts)	25	°C
Nominal Voltage (Vmpp)	38,53	Volt
The Open-Circuit Voltage (Voc)	46,74	Volt
Nominal Current (Impp)	8,57	Amper
Short Circuit Current (Isc)	9,15	Amper

The inverter properties used are as indicated in Table 2. The Huawei brand Sun 2000 60Ktl model is selected in 16 units and has AC power of 62. It is set as kWac. In this way, a total power of 1000kWac has been reached.

Table 2. Inverter Information

Inverter Information	Values
Maximum Input Voltage	1100 Volt
Maximum MPPT Voltage	1000 Volt
Minimum MPPT voltage	200 Volt
Maximum MPPT Input Current	22 A
MPPT Number	6 Pcs
Max AC Power	66,000 W
Rated AC Power	60,000 W

The annual radiation values of the planned solar power plant are calculated automatically by entering coordinates in the online calculation environment of the European Union photovoltaic Geographic Information Systems database (PVGIS). The European Union photovoltaic Geographic Information Systems database (PVGIS) covers European and African countries in a global radiation map prepared by the Joint Research Centre (EC JRC) within the European Union (EU) [18]. PVSYST applies the Perez model to predict the radiation occurring in an oblique plane. As a result of these calculations, monthly radiation values are assigned to PVsyst program. In Figure 8 the radiation values and Figure 9 the annual temperature are indicated.

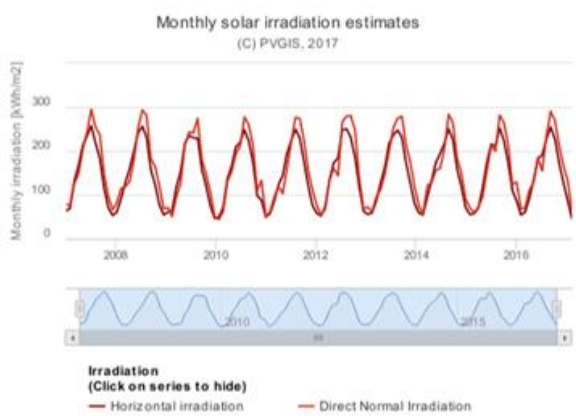

Fig. 9. Monthly Radiation Values

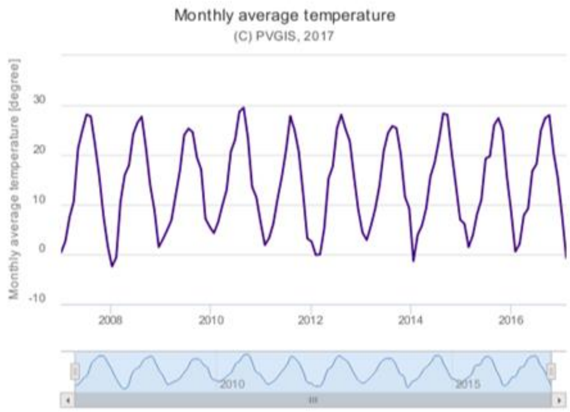

Fig. 10. Monthly Temperature Values

a- Mismatch Losses

Each solar panel is composed of a series of connected cells. To reach this voltage level of the panel, many cells must be connected in series, and in this connection, manufacturing tolerance, differences and incompatibilities radiation may occur due to different current values of the cells [14]. In the Kaushika study, the panel mentions losses that range from 2% to 12% as their lifespan progresses. Given this situation, if panel companies combine cells with the same voltage value in the same panels, mismatch loss is 1% for the planned site.

b- Soling Losses

Dirt accumulation and its effect on system performance is an uncertainty that depends on the environment of the system, rain conditions. In moderate rainy climates (such as the middle of Europe) and residential areas, it is generally low, negligible (less than 1%). In rural environments with agricultural activity, pollination is a significant loss during some seasonal activities. The accumulation of powders and the growth of algae and lichens along the framework of the modules creates partial shadows on the lower cells and tends to hold more dust. Moreover, these impurities are not eliminated by rainfall [18]. Therefore, the loss of pollination in the areas to be established is approximately 2%.

c- Transformer and Cable Losses

Transformer loss and wiring loss are selected as %1 in the system to be installed.

3. ANALYSIS AND EXPERIMENTAL FINDINGS

3.1. Fixed System Analysis

Three main parameters were evaluated from the main simulation results. The first parameter is the total amount of energy generated in 1967 MWh / year, which is expressed as the energy generated annually from the 1148 kWp Si-poly photovoltaic system. The second parameter is the specific production per installed kWp on an annual basis and 1713 kWh/kWp/year. The third parameter is the average annual performance rate (PR) 85.33%.

Table 3. Balance and Main Results

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	65.3	23.60	-0.57	98.9	92.4	105.2	102.6	0.904
February	84.8	35.34	0.77	115.3	107.6	123.3	120.5	0.910
March	134.5	55.27	6.74	163.0	152.3	169.6	165.9	0.887
April	161.4	67.77	11.03	173.6	161.4	176.6	172.9	0.867
May	206.2	71.45	16.13	205.3	191.4	203.1	198.8	0.843
June	223.2	65.81	20.94	215.0	200.8	209.1	204.7	0.829
July	235.2	61.10	24.78	229.8	215.4	220.0	215.4	0.816
August	214.2	57.24	24.53	227.0	213.0	218.1	213.5	0.819
September	171.6	43.86	18.93	202.3	190.4	198.7	194.4	0.837
October	119.8	38.87	13.67	158.6	149.0	160.7	157.2	0.863
November	79.7	27.69	6.48	121.2	112.9	125.4	122.6	0.881
December	61.5	24.68	1.25	97.3	89.6	100.9	98.5	0.881
Year	1757.6	572.68	12.13	2007.3	1876.1	2010.7	1967.0	0.853

The balances and main results are shown in Table 3 include variables such as global radiation in the horizontal plane, ambient average temperature and global radiation in the collector plane without the optical plane, effective global radiation taking into account pollution losses and shading losses. The calculated values of each variable specified in the results and the main results were obtained in monthly and annual values. The annual values of the variables are possible as the average of the sum for temperature, yield and radiation and energy [23].

The annual spherical radiation in the horizontal plane for the workplace is 1757.6 kWh / m². Effective spherical radiation after global event energy and optical losses on a yearly basis in the adder is 2007.3 kWh / m² and 1876.1 kWh /m². This impressive radiation, the yearly DC energy generated from the PV array and the yearly AC energy injected into the grid are 2010.7 MWh and 1967 MWh, respectively. The energy transferred to the network will not be the same as the energy generated by the PV system [23].

Some cable losses occur during energy conversion [24]. The 1148 kWp Si-Poly photovoltaic plant, designed, annually transmitted 1967 MWh of energy into the grid.

The PV plant produced and injected 215.4 MWh more energy into the grid in July. The lowest amount of AC energy transmitted into the grid is 98.5 MWh in December. AC Energy transferred to the network is given in Table 3.

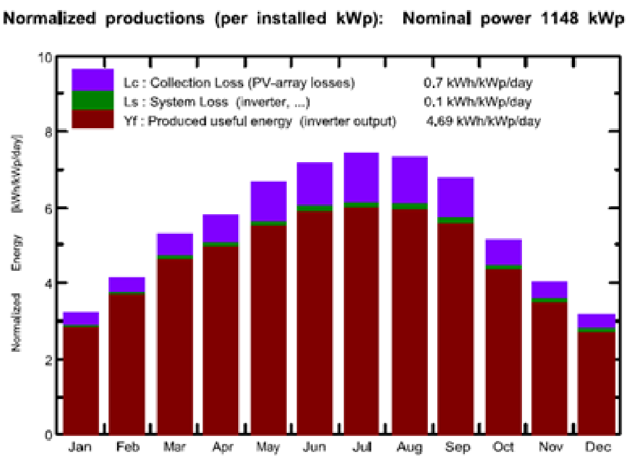

Fig. 10. Normalized Productions

Collection losses, system losses and useful power generation per installed kWp / day are as shown in figure 10 in the simulation study. That losses and installed kWp/day-to-day utility energy production are defined by IEC norms [20] and are standardized variables to evaluate PV system performance [23].

Lc are collection losses or PV array capture losses, i.e. 0.7 kWh / kWp / day. Ls is the system loss and is 0.1 kWh / kWp / day. Yf, the useful energy produced is 4.69 kWh / kWp / day.

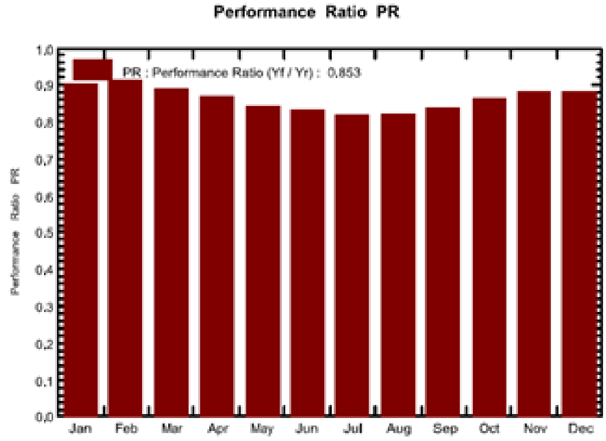

Fig. 11. Performance Ratio (%)

The performance rate (PR) for the simulated 1148 kWp Si-poly photovoltaic system is 85.3% with an average annual PR value. There are slight differences in PR on a monthly basis, given in Figure 11.

Various losses to be expected while installing PV plant were obtained as a system loss diagram as a result of analysis. Loss factors are considered module quality, contamination, wiring mismatch losses, inverter efficiency, transformer, system availability and network availability [21, 22]. The system loss diagram is seen in figure 12. It represents various losses in the system. The spherical teleportation in the horizontal plane is 1758 kWh / m². However, the effective radiation on the collector is 1876 kWh / m². This causes energy loss, i.e. 0.14% depending on the level of teleportation. When this effective radiation falls on the surface of a photovoltaic module or array, electricity or electrical energy is generated. After PV conversion, the nominal energy under standard test conditions (STC) is 2156 MWh [29].

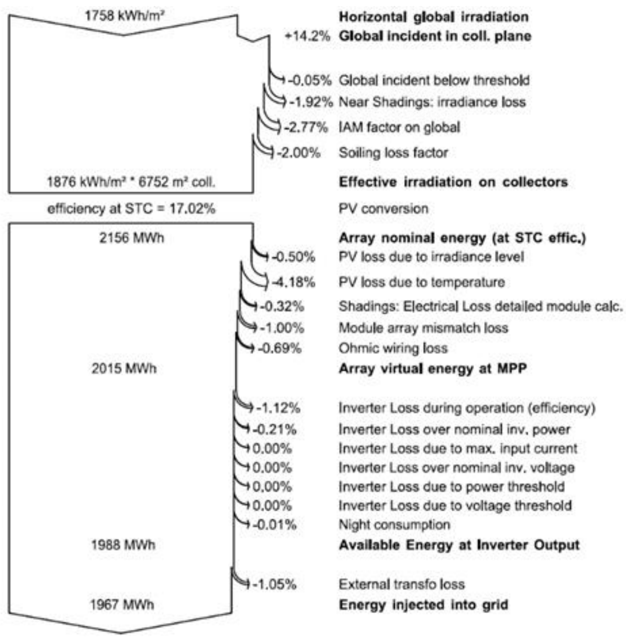

Fig. 12. System Loss Diagram-1

The yield of the PV array in the STC is 17.02%. The yearly series virtual energy at MPP is 2015 MWh. Various losses at this stage are 4.18% owing to temperature, 1.0% due to module array mismatch, and 0.69% due to Ohmic losses. The energy available at the inverter output facility on an annual basis is 1988.3 MWh and is injected into the same network. Two losses were possible here, one being the loss of the inverter during the operation of the inverter i.e. 1.12% and the value of the inverter is nominal inv. power is 0.21%. Transformer loss is 1.05%.

3.2. Variable System Analysis

The main simulation results were evaluated three main parameters for the system of 10 and 30 degrees. The first parameter is the total amount of energy generated in 1999 MWh/ year, which is expressed as the energy generated annually from the 1148 kWp Si-poly photovoltaic system. The second parameter is the specific production per installed kWp on an yearly basis and 1741 kWh/kWp/year. The third parameter is the average yearly performance rate (PR) 85.6%.

Table 4. Balance and Main Result

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	65.3	23.60	-0.57	103.9	96.3	107.8	105.1	0.881
February	84.8	35.34	0.77	119.4	110.8	126.2	123.4	0.900
March	134.5	55.27	6.74	165.8	154.0	171.0	167.3	0.879
April	161.4	67.77	11.03	169.3	159.7	175.6	172.0	0.885
May	206.2	71.45	16.13	209.6	198.4	211.0	206.6	0.858
June	223.2	65.81	20.94	223.7	212.2	220.9	216.2	0.842
July	235.2	61.10	24.78	237.2	225.1	230.0	225.2	0.827
August	214.2	57.24	24.53	223.5	212.3	218.2	213.6	0.832
September	171.6	43.86	18.93	187.5	177.5	187.5	183.5	0.852
October	119.8	38.87	13.67	163.5	153.0	164.5	160.9	0.857
November	79.7	27.69	6.48	127.4	117.8	128.9	126.0	0.861
December	61.5	24.68	1.25	102.8	93.3	101.8	99.3	0.841
Year	1757.6	572.68	12.13	2033.7	1910.4	2043.4	1999.2	0.856

The balances and main results are shown in Table 4 are 1757.6 kWh / m² of annual spherical radiation in the horizontal plane for the workplace. Effective spherical radiation after global event energy and optical losses on a yearly basis in the collector without optical corrections is 2033.7 kWh / m² and 1910.4 kWh/m². With this effective radiation, the annual DC energy generated from the PV array and the annual AC energy injected into the grid are 2043.4 MWh and 1999.2 MWh, respectively.
The 1148 kWp Si-Poly photovoltaic plant, designed, annually injects 1999.2 MWh of energy into the grid. The PV plant will generate and inject more energy into the grid, 225.2 MWh, in July. The lowest amount of AC energy transmitted to the grid is 99.3 MWh in December.

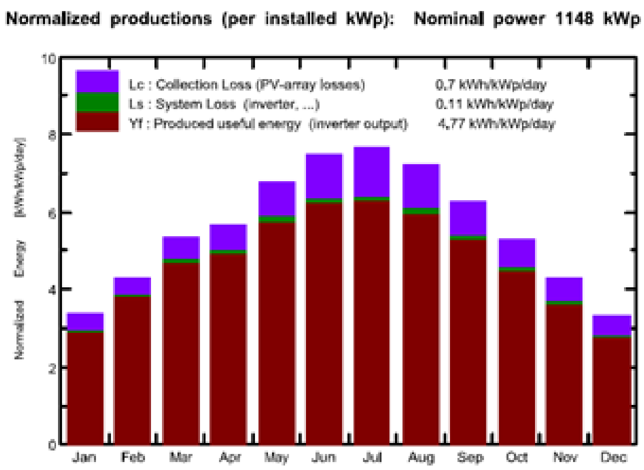

Fig. 13. Normalized Productions

Normalized products are as shown in figure 13 in the simulation study. Lc are Collection losses or PV array capture losses, Lc, collection losses or PV array capture losses, 0.7 kWh/kWp/day. Ls is a system loss and 0.11 kWh/kWp/day. Yf, the useful energy produced is 4.77 kWh/kWp/day.

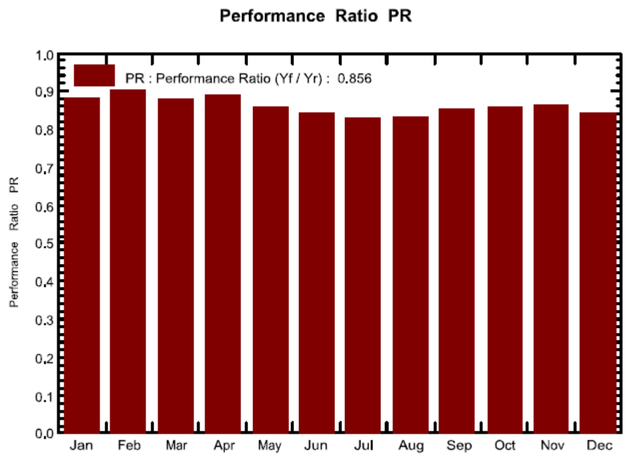

Fig. 14. Performance Ratio (%)

The performance rate (PR) for the simulated 1148 kWp Si-poly photovoltaic system is 85.6% with an average annual PR value. There are slight differences in PR on a monthly basis and these are given in Figure 14.

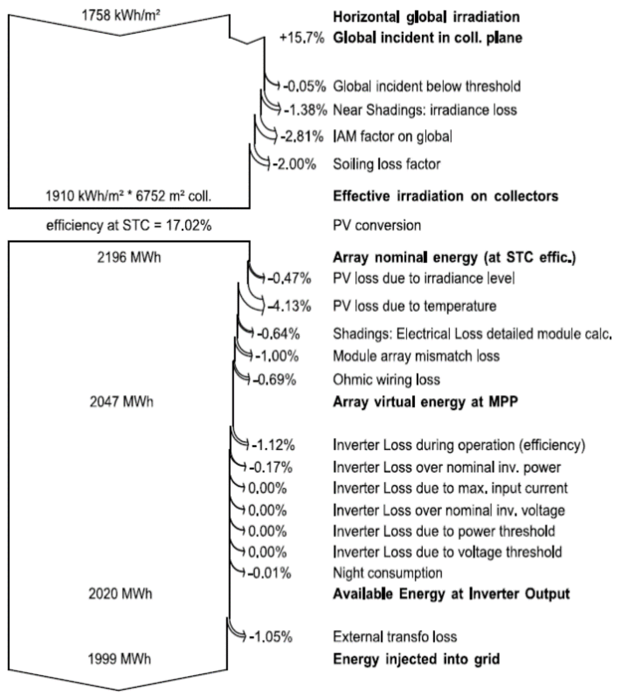

Fig. 15. System Loss Diagram-2

The diagram representing the various losses in the system is given in figure 15. The spherical teleportation in the horizontal plane is 1758 kWh / m2. However, the effective radiation on the collector is 1910 kWh / m2. This causes energy loss, i.e. 0.15% depending on the level of teleportation. PV conversion, the nominal energy under standard test conditions (STC) is 2196 MWh [29]. The yield of the PV array in the STC is 17.02%. The yearly array virtual energy in MPP is 2047 MWh. various losses are 4.13% due to temperature, 1.0% due to module array mismatch, and 0.69% due to ohmic losses. The current energy on a yearly basis at the inverter output capability is 2020 MWh and is injected into the like grid. Two losses were possible here; one being the loss of the inverter during the operation of the inverter i.e. 1.12% and the value of the inverter is nominal inv. power is 0.17%. Transformer loss is 1.05% [23].

4. CONCLUSION

This study provides evaluation of seasonal manual tracker system performance of 1148 kWp PV power plant connected to the planned network in Altinekin district of Konya province, which can be adjusted to fixed 25 streams and can be changed as summer and winter angle 10-30. Energy production, specific efficiency and performance ratio (PR) values of two different systems were analyzed. The measured data from the installed system was compared in Table 5. It was determined that the seasonal system produced more than 32.2 MWh per year. Global teleportation is 26.4 kWh per m² in seasonal system; the specific yield is more than 28 kWh/kWc/year.

Table 5. Units for Comparison of Main Results

Parameters	Fixed (25 Degree)	Seasonal (10-30 Degree)
Global Horizontal Irradiation (kWh/m²)	1.757,6	1.757,6
Ambient Temperature (°C)	12,13	12,13
Global incident Irradiation (kWh/m²)	2.007,3	2.033,7
Effective Global, corr for IAM and shadings (kWh/m²)	1.876,1	1.910,4
Energy at the output of the array (MWh)	2.010,7	2.043,4
Energy injected into grid (MWh)	1.967	1.999,2
Specific energy yield (kWh/kWc/year)	1.713	1.741
Performance ratio (%)	0,853	0,856

Through PVSYST, we conducted a comparative study between the two configurations. The two simulations were conducted under the same conditions and for the same geographic region. The tables show the energy generated by both systems, as well as the losses. The seasonal system is more advantageous in production than the fixed system [25].

Today, the importance of power plants installed with solar monitoring system is increasing. In our subsequent studies, solar tracking systems will be examined.

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