Journal of Engineering Research and Applied Science Available at www.journaleras.com Volume 12 (2), December 2023, pp 2414-2424 ISSN 2147-3471 © 2023



2,5 MW Photovoltaic Solar Power Plant Maintenance, Operation and Design: Konya/Comaklı Case

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Accepted 13 October 2023

Abstract

In this study, routine maintenance techniques such as planned and unplanned maintenance activities, regular inspections and cleanings, which are the types of maintenance activities in a photovoltaic power plant, are described. A solar power plant with a power of 2.5 MW in the Comaklı region of Konya province was designed by the PVsyst program, and a simulation report was prepared. According to the simulation report, it is seen that the highest energy production is in August, and the lowest energy production is in December. The annual energy the plant supplies to the grid is 4113.7 MWh, and the plant performance ratio is 82%. Since the energy source in photovoltaic solar energy is the sun, there is no depletion of the energy source as in fossil fuels. With the increase in the world population and its dependence on technology, energy consumption is increasing daily. People have started to consume limited resources on Earth to meet their unlimited needs and have begun to turn to renewable energy sources from fossil fuels, which are decreasing daily. Renewable energy sources help to protect the environment by reducing carbon dioxide emissions and reducing foreign dependence on energy. Our country is fortunate in terms of solar energy compared to many countries. The annual sunshine duration is 2,741 hours, and the average yearly total radiation value is calculated as 1,527.46 kWh/m².

Keywords: PVsyst, photovoltaic energy, inverter, solar cell, tilt angle, azimuth angle, Comakli

1. Introduction

1.1. Operation and Maintenance in Photovoltaic Energy Systems

Maintenance and operation in photovoltaic solar power plants is a set of works to be carried out for the plant to provide the best performance. Correct operation and timely maintenance ensure that the equipment in the plant generates the maximum amount of energy throughout its operational life, maximizing the interests of customers and investors. The performance of photovoltaic solar power plants is adversely affected by dust accumulation on the equipment, shading, improper installation, improper connection not following standards, improper cable selection, and improper cable termination. Especially in solar panels installed in dirty and dusty environments and kept outdoors 24/7, a power loss of 30 percent can be experienced. Figure 1.1. Factors affecting the performance of PV power plants.



Figure 1.1. Factors affecting the performance of PV power plants.

Pollution and dust in the panel cause hot spots in the photovoltaic cell, reducing energy production efficiency and panel lifetime. Figure 1.2. Hot spot in PV cell. The monthly production effect in a 10kWp

PV plant is 1443kWh for a clean module and 1143kWh for a dirty module. It causes 300kW energy loss per hour.

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1.2. Types of Maintenance **1.2.1. Planned maintenance**

It is also defined as preventive maintenance. It aims to reduce the probability of equipment failure. The possibility of malfunctioning is also reduced by regular maintenance work on the equipment. For newly commissioned equipment to operate efficiently during its service life without any problems, routine maintenance work must be carried out. These are the periodic activities in the maintenance control timetable specified in the user manual of the equipment. [8]

1.2.2 Unplanned Maintenance

It is called Corrective maintenance too. It is a restorative activity carried out for the commissioning of the power plant in an unplanned shutdown that occurs when it is not known when the equipment will be out of service. When the malfunction occurs,

production planning is adversely affected by this situation as it is unknown. Minimizing unplanned maintenance depends on correct and timely planned maintenance.

1.3. Maintenance and Periodic Controls of **Photovoltaic Modules**

Photovoltaic panels are generally considered to be maintenance-free. To make the panels more efficient and to prevent unplanned downtime and loss of production, maintenance, and periodic checks should be carried out. In daily visual inspections, modules are checked for cracks, rain-snow water leaks, snail marks, bird droppings, and discoloration. In periodic maintenance, physical control of the DC connectors on the modules, corrosion control between the module-profile connection, control of shading that may occur due to a tree or other object, control of whether the connection hooks between the module and the profile are properly mounted on the panel or the tightness of the connection, control of whether there is any deformation in the cables on the cable route of each panel, control of the grounding of each module, thermal controls of the modules. [8]

The detected problems should be solved in planned or corrective maintenance according to the urgency. Before starting panel cleaning, it must be checked whether there is a damaged panel. During cleaning, a crack in the panel, a broken area, or a loose connection may cause electric shocks. Panel cleaning is done with water, manually or automatically. The cloth or brush used should be soft, and the detergent should not have abrasive properties. The panels should not be stepped on during cleaning; even if there is no visible crack on the panels stepped on, it causes micro-cracks.

1.4. Periodic Controls of Inverter

The inverter must be easily accessible in case of malfunction or during maintenance. It should be checked for abnormal conditions, such as odor, heat, or sound. The cooling fan control and the filter used must be cleaned and replaced if necessary. Whether there is any alarm or warning on the inverter display to be checked. The inverter against dust and pollution to be checked. String connection connectors and earthing cables to be checked for looseness.

1.5. Periodic Controls of Distribution Panels, **Cables and Connections**

In distribution panels, earthing connection, panel cable glands, tightness control of cable terminal connections inside the panel, whether there is insulation weakness of the cables inside the panel, whether there is any sign of heating in the equipment inside the panel, control of panel fixing bolts, damage, and control of the panel cover against corrosion. In addition, the panel must be checked for tightness against rainwater. In case of heavy rain, rainwater may enter the panel. The worn, torn panel cover gasket must be replaced.

The cable installation should be checked for any insulation weakness, crack in the cable, damage, or deterioration in the cable. Rodents may cause short circuits and fire due to gnawing the cables. Distribution panels should be checked against rodent nesting.

1.6. Test Equipment and Hand Tools to Be Used **During Maintenance**

The first goal of the enterprise is to protect the safety, health, and business of the employees. To serve this purpose, the employee and the enterprise must comply with occupational health and safety rules. Since these rules are not an option but necessary, personal protective work safety equipment must be used during work and in the field. The enterprise is obliged to provide this equipment to its employees, and the employee is obliged to use them. Figure 1.3. work safety equipment and hand tools.

Occupational health equipment

- Helmet
- Safety Glasses
- Safety shoes
- Flame resistant workwear
- Firt aid kit

Test equipment and instruments

- Digital multimeter
- Thermography camera
- Angle gauge, IV Meter
- Compass
- Hand tools, (must be insulated)



Figure 1.3. Work safety equipment and hand tools.

1.7. Locking and Labelling of Equipment Used in Photovoltaic System

All equipment must be labeled (inverters, strings, arrays, modules). During the periodic maintenance check, it is necessary to check whether the equipment labels are in place, and if there is an old or difficult to read label, it should be replaced with a new one. In addition, the labels of the equipment used in the outdoor environment should be resistant to the external environment (factors such as rain and sun) that are not easily deformed.

The lock-out tag-out (LOTO) system is a fundamental occupational safety rule to prevent any person from accidentally switching off the power supply switch of the equipment being maintained or repaired and to avoid electrical accidents. Electrical panels, inverters, batteries, and equipment must be labeled, locked, and electrically isolated before maintenance. Thus, precautions are taken against electric shocks due to uncontrolled energization.

2. Design and Simulation of A 2.5 Mw Grid-Connected Photovoltaic Energy Power Plant in Konya Comakli with PVsyst Programme

2.1. Konya Comaklı Geographical Location, Plant Technical Data

The coordinates of the facility to be installed from Google Earth were found as latitude 37,7437022, longitude 32,5426689, and altitude 1.008m. The plant power will be 2.5MW DC and connected to the grid. Figure 2.1. Google Earth Konya Comakli geographical location.[1]



Figure 2.1. Google Earth Konya Comaklı geographical location.

2.2. Adding Geographical Location of Comaklı Region to PVsyst Program

The coordinates of the plant to be established in Konya Comaklı taken from Google Earth are latitude 37,7437022, longitude 32,5426689, and altitude 1.008m. In the window opened in the PVsyst program, click on "Databases," "Geographical sites," and then "New" icon. Figure 2.2. PVsyst Database, geographical locations.

📢 Welcome to PVsyst 7.2	📥 Meteo database	0		
Project design and simulation	Main meteo data:			
井 Grid-Connected	© Geographical sites	Notes about meteo	Muqla/Dirlivan Niqde/Kumluca SalihlerAfyon GES Sinop/Bostanoli	Turkey Turkey Turkey Turkey
Utilities	Display and compare meteo files:			
Databases	Meteo tables and graphs	Compare meteo data	Export	• New

Figure 2.2. PVsyst Data base, Geographical Locations

In the geographical coordinates window, enter the latitude, longitude, and altitude information of the detected region. When the "Get from coordinates"

icon in the upper right corner is clicked, the Comaklı location name is automatically added to the program. Figure 2.3. PVsyst geographical coordinates



Figure 2.3. PVsyst geographical coordinates

2.3. Retrieval of Konya Comaklı Annual Irradiance Data to the Database in PVsyst Programme

To obtain the weather data of Comaklı, the "Metronom8.0" box under the geographical coordinates heading is ticked and the "Import" icon is pclicked. Figure 2.4. PVsyst Metronome 8.0

Global horizontal irradiation, horizontal diffuse irradiation, temperature, wind speed, relative humidity and total annual solar radiation of Konya Comaklı region are calculated as 1770 KWh/m2 by the programme. The collected data is saved to the database by clicking the "OK" icon. Table 2.5. PVsyst monthly weather forecast.

Geogr	aprical Coordinates Monthly meteo Interactive Map		CHO S	paprical courses	and representation		P						
-Lo	cation	Please import the monthly meteo data (from	2	te ata source	Comakk (T	orkey)	- 300%					1	
SI	e name Genève Get from coordinates	manually)										1	
6	untry Tukey V Region Europe V				Global horizontal irrediation	Horizontal diffuse irradiation	Temperature	Wind Velocity	Linke turbidity	Relative			
			1	Jamaary	22.5	29.9	0.2	3.00	2.637	50 01.3		Required Data	
-60	ographical Coordinates	Meteonorm 8.0		March	132.9	35.4	0.8	3.80	3.440	50.0		Clobal horizontal irradiation	
	Sun paths	O NASA-SSE		April May	212.8	71.1 66.3	11,1	3.51	3.650	53.1		Extra data	
	Decimal Dec. Min. Sec.	O PIGIS TMY Version 5.2 V		xily	230.4	58.8	25.0	4.71	3.185	38.0		Wind velocity Linke turbidity	
	Landole (hs.2022 [1]0 [0 [0 (+=Nerty=South Remight.)	O NEEL / NEEDE THY O Sekest TMY	3	september September	200.9	40.0	23.4	3.60	2.968	94.1		Relative humidity	
	Althude 308 Nabous sea level	O Solar Anywhere ® TGY		November	72.8	34.0	0.0	2.70	2.777	70.4		Orradiation units O KWh/m²/day S KWh/m²/day	
	Time zone 1.0 0 Corresponding to an average difference	Import		Year 🕜	1769.5	580.0	12.3	3.6	3.135	57.9		O M3/m2/day O M3/m1/mth O Wiler	
	Legal Time - Solar Time = Oh 35m			G	obal horizontal in	rradiation year-t	o-year variability	4.4%				O Clearneas Index K3	
	Get from name												
Ш.									_				
				 Import 		Export line	🔶 Export	table		+ New Site	i Prist	X Cencel	₩∝
		1											

Figure 2.4. PVsyst Metronome 8.0

2.4. Creating a New Grid Connected Project

Since the photovoltaic solar power plant to be installed will be a grid-connected facility, "New grid connected

Table 2.5. PVsyst monthly weather forecast.

project" is selected from the "Project" menu in the PVSyst program. Figure 2.6. PVsyst new gridconnected

Preliminary design Project Settings Language License Help New grid-connected project Project design and New Damping project Condectorected Utilities Databases Tools Tools

Figure 2.6. PVsyst new grid-connected

Project	📩 Ver 🎦 Lood 💾 Sane 🛛 🛱 Project settings 🏢 Delete 💡	Qient .
Project's name	Konya Conaki 2,5 MII Fotovoltak Güneş Santral	Ömer CIKISIR

Figure 2.7. PVsyst project name

2.5. Entering Panel Tilt Angle and Azimuth Angle for Comaklı Region

Click the "Orientation" symbol in the variant section and enter the plane inclination information. Figure 2.9. PVsyst variant.

Plane inclination=Latitude angle x 0,87+3.1= $38x0,87+3.1=36^{\circ}$. [7]

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In the window that opens, "Project name" is entered (Figure 2.7. PVsyst project name) and the region previously added to the Comaklı geographic information database from the location file is called from the project list. Table 2.8. PVsyst Metronom8.0 monthly weather zone list. The "Save" icon is clicked.

🐣 Meteo File	
omakiMN80_SYN.MET	Çomaklı
comaklMN80_SYN27 ekm.MET	Çomaklı
Dakar_SYN.MET	Dakar
Dakar_Yoff_MN72_SYN.MET	Dakar/Yoff
Eski_ehir Salihler 5MW GES_MN80_SYN.MET	Eskişehir Salihler 5MW GES
Eski_ehir _jfteler Mevkii 5MW Güne_Santrali_MN80_SYN.MET	Eskişehir Çifteler Mevkii 5MW Güneş Santri
Geneva_MN80_SYN.MET	Geneva
Ghantoot_MN80_SYN.MET	Ghantoot
Hamburg_Ohe_MN80_SYN.MET	Hamburg/Ohe
K_t as S_dah_MN80_SYN.MET	Küt as Sādah
K_z_lp_nar_MN80_SYN.MET	Kızılpınar
Marseille_Marignane_MN72_SYN.MET	Marseille/Marignane
omaklMN80mod_SYN.MET	Çomaklı
omaklMN80_SYN.MET	Çomaklı

Table 2.8. PVsyst Metronom8.0 monthly weather zone list

The azimuth angle is the angle at which the panels face south and is zero degrees. The panels are mounted on a fixed inclined plane with no sun tracking system, they are motionless. Figure 2.10. PVsyst plane tilt and azimuth.[2]



Figure 2.9. PVsyst variant

2.6. Determination of the Inverter and Panel Model to be used, Determination of the Number of Panels according to the Power Plant Power

From the variant menu shown in Figure 2.9, the system connected to the grid is defined by clicking the "System" icon. Figure 2.9. PVsyst variant.

Figure 2.10. PVsyst plane tilt and azimuth

Power plant DC power is 2500kWp, PV module Vikram Solar 540Wp35VSOMERAVSMH, Inverter: Conergy270kW450-800VTL50/60Hz400VAC threephase. Figure 2.11. PVsyst variant system

		0	List of subarrays		3
Sub-array name and Orientation	Pre-sizing Help O No sizing	Enter planned power	* 🔿 🖓 v 🔺 🗊 👲		
Drient. Fixed Tilted Plane Tilt Azimuth	36° 0° ✔ Resize	or available area(modules) O 11940 m ²	Name	#Mod #Inv.	#String #MPPT
Select the PV module Available from Filter All PV modules V Waren Solar Limited S40 Wp 35V S-mono S Use optimizer Staing voltages : Winpp Var of	OMERA VSM1.72.540.05 P Since 202 (60°C) 36.2 V	Approx. needed modules 4630 22 Manufacturer C C Open	Viaram Viaram Solar Limited - SOMERA . Conergy - IPG 270C	14 8	331 1
select the inverter Available Now Output voltage 400 V Tri 50Hz Conergy 270 kW 450 - 800 V Tr. 50	0/60 Hz IPG 270C	Since 2009 ✓ C, Open			
Nb. of inverters 8 🗘 🗘 Operating voltage: Input maximum vo	450-800 V Global Inverte Itage: 1000 V	e's power 2160 kWac			
No. of inverters 8 C Operating voltage: Input maximum vo Design the array Rumber of modules and strings Mod. in series 14 C between 13 and 18	450-800 V Global Inverte tage: 1000 V Cperating conditions Wrop (60*C) 506 V Wrop (65*C) 582 V Vice (10*C) 763 V Vi	r's power 2160 KWac	Global system summary Nb. of modules 4634 Module area 11950 m ² Nb. of neverse 8		

Figure 2.11. PVsyst variant system

Inverter DC input minimum MPP voltage is 450V, and maximum MPP voltage is 800V. With 14 string modules and 331 strings, the total number of panels to be used is calculated by the program as 4634. In this case, the voltage to be produced by 14 string modules at -10oC is 763V, and the voltage to be produced at 60oC is 506V and is within the operating conditions of the inverter. (The operating condition of the inverter is between 450-800V). The nominal panel DC

power is 2502 kWp, the maximum panel power is 2757 kWDC, and the nominal AC power is 2160 kWp. [4]

2.7. Losses

Power plant losses are defined by clicking the "Detailed losses" icon from the variant menu shown in. Figure 2.12. PVsyst losses.

Thermal parameter	Ohmic Losses	Module quality - LID - Mismatch	Soiling Loss	IAM Losses	Auxiliaries	Aging	Unavailability	Spectral correction
	You can define	either the Field thermal Loss fact the program gives the e	or or the star quivalence!	ndard NOCT co	efficient:			
Field Thermal L	oss Factor			equivalent f	actor			
Thermal Loss facto Constant loss fact Wind loss factor U	or or Uc v	U = Uc + Uv * Wind vel 29.0 W/m ⁻ K 0.0 W/m ⁻ K m/s	NOCT (often sj itself. T U-value applied	Nominal Opera pecified by mar his is an altern definition whit to the operati	ting Cell tem nufacturers f ative informa ch doesn't ma ng array.	perature or the m ation to t ake sens) is odule he e when	
Default value	acc. to moun	ting	Don't i confus	use the NOCT ing when ap	l approach. plied to an	This is array !	quite	
V "Free" mount	ed modules with	air circulation						
Semi-integrat	ed with air duct	behind					_	
Integration w	ith fully insulate	d back		See t	he NOCT any	yway		

Figure 2.12. PVsyst losses

The panel using IAM (Incidence angle modifier) incidence angle losses is coated with AR (anti-reflected) anti-reflector (Figure 2.13. Panel data

sheet). The model of the reflection angle is selected as anti-reflective. Figure 2.14. PVsyst IAM losses. [6]

Mechanical Data					
Length × Width × Height 2274 × 1134 × 35mm (89.53 × 44.65 × 1.38 inches)					
Weight	28.2 Kg (62.17 lbs)				
Junction Box	IP68, Split Junction Box with individual bypass diodes				
Cable & Connectors*	200 mm (+ve terminal) and 300 mm (-ve terminal) length cables,MC4 Compatible/MC4 Connectors				
Application Class	Class A (Safety class II)				
Superstrate	3.2 mm (0.125 inches) high transmission low iron tempered glass, AR coated				
Cells	72 Mono PERC (144 half-cells) P-Type solar cells				
Back Sheet	Composite film				
Frame	Anodized aluminium frame with twin wall profile				
Mechanical Load Test	5400 Pa (Snow load), 2400 Pa (Wind load)				
Maximum Series Fuse Rating	254				



Figure 2.13. Panel data sheet

Figure 2.14. PVsyst IAM losses

2.8. Retrieval of the year-round solar horizon line of the region from the Web to the Programme Database The grid connected horizon is defined for Comaklı region by clicking the "Horizon" icon from the variant menu shown in Figure 2.15. PVsyst variant horizon.

Variant	한 <u>N</u> ew 💾	Save Import The Delete Manage
Variant n° VCO : Vary	anti	~
Main parameters Orientation System Detailed losses Self-consumption	Optional Horizon Near Shadings Module layout Energy management	Simulation Run Simulation Advanced Simul. Report

Figure 2.15. PVsyst variant horizon

In the window that appears, the PVGIS horizon is selected from the Web by clicking the Read/retrieve icon, and the year-round horizon line of the Konya Comaklı power plant region, whose geographical coordinates are automatically retrieved, is imported from the Web. Figure 2.16. PVsyst horizon line legal time.



Figure 2.16. PVsyst horizon line legal time.

2.9. Creating Close Shading 3D Scene

The grid-connected horizon is defined for Comaklı region by pclicking the "Near shadings" icon from the

Variant Menu. Figure 2.17. PVsyst variant near shadings.

Variant			t New	Eave Save	Import	Delete	🔯 Manage
Variant n°	VC0 : Varya	ant1					\sim
Main parameters Crientation System Detailed losses Self-consumption Storage		Optional Horizon Near Shadings Module layout Energy manager Economic evaluat	nent tion		Simulation Run Advance Report	Simulation ced Simul.	

Figure 2.17. PVsyst variant near shadings

In the window that appears, click on the "Construction/Perspective" icon. Then select the table

array from "Create". Figure 2.18. PVsyst near shading 3D scene.

-Near shadings 3D sce	ne			
Comment	New shading scene		File Create Select Edit View Teels Help	Scene objects Tools Reference
Connienc	Construction / Perspec	ive Import		V Some ubjects Name Operation (0) () Objects (0)
Compatibility with Active area Fields tit Fields azimuth Shading factor tab	Orientation and System parameter 20 scene Contr. (Pystem 20 scene 11556 m² 12122 m² 36.0° 36.0° 0.0° 0.0° le			
Use in simulation No Shadings Linear shadings According to moduli Detailed electrical of	e strings alculation (acc. to module layout)	Calculation mode Pract (table) O Slow (amul.) Praction for electrical effect 100.0 () % (2)		Y Grap and some
Q System overv	iew 🥅 Print	🗶 Cancel 🗸 OK		🗙 Cancel 🗸 Close scene

Figure 2.18. PVsyst near shading 3D scene

The required surface area of the power plant to be installed on the right side of the opened window is automatically calculated as 11949 m². North-South spacing is the distance between the arrays and is entered as 7m. Panels were used horizontally. Thirty arrays and 2x77 PV modules were designed for each

array length. The panels used are single crystal SOMERA VSMH.72.AAA.05 Half-Cut, and the number of transverse rectangles is 2. The total surface area was calculated as 12123 m2 with 30 arrays X 145 modules. Figure 2.19. PVsyst near shading panel array layout

Anna bar anie anie a su sera mega i bar aport	Denne per directer at an auto affest Per stort	
Description Name Distington	Sizes definition By modules (adjust sizes) O By sensitive sizes	Electrical shadings calculation Defines the partition in strings of modules. You should
Dizi alam	By modules	define rectangles representing one string of modules
Array parameters	Reference PV module	(when possible)
Nb. of sheds 30 0	SOMERA VSMH.72.540.05_P Type	Define partition
Pitch N-5 7.00 m	Module width 1.134 m	Number of rectangle-strings
	Module length 2.274 m	
Misaign [0.00] m	Orientation Landscape V	no. rectangles in neight (r)
Shed to Shed slope 0.0	Nb. of modules in length (X) 27	Nb. rectangles in width (X) 2 C
	Nb. of modules in height (Y)	String sizes
Limit Angle 14.8 *	Modules X spacing 0.02 m	Height of the sectander
GCR 32.7%	Modules Y spacing	rieght of the rectanges
Global sensitive area		Length of the rectangles 88.31
Total area 12123.06 m ²	Height 2.20 m	i.e. about 78 modules per rectangle
Required area 11949.77 m ²	Length (126.63) m	Apply the partition to:
Defined by modules	Table area 404.1 m ²	Cancel al partitions State
Number of modules 30 sheds x 154 mod. = 4620	Shed area 12123.06 m*	
Orientation	Required area 11949.77 m ^a	O The selection of tables
Shed tit 36.0 *	Frame around modules	 All tables of same size
Azimuth 0.0 *	Left/right 0.02 0.02 m	O All tables of the scene
	Top/bottom 0.02 0.02 m	
Baseline slope 0.0 C *	Outpin I away contar and	C Apply

Figure 2.19. PVsyst near shading panel array layout

After the shading 3D scene is completed, the design is right corner saved by clicking the "Close scene" icon in the lower shading 3I **3. Simulation Report of Konya Comakli Power Plant in PVsyst** Figure 2.20 and 2.21 shows simulation reports.

right corner of the window. Figure 2.18. PVsyst near shading 3D scene

							PV An	ray Characte	ristics	-		
	to ang m		Version 7.2.16	PV module				Inv	erter			
				Manufacturer		Vikran	n Solar Limited	Ma	nufacturer			Conergy
PROTOVOLTATE SOFT			100	Model	80	MERA VSMH 72	540.05 P Type	Mo	del			IPG 270C
			project	(Custom na	rameters definit	tion)	read in the		(Original PVeuel	(atabase)		- 5 6199
Ditte	at Circu	Intinu		Linit Nom Down	nameners udimi	and a	LED Win	164	Non Dower	onangogoe j	220.1	War
PVs	yst - Simu	lation i	eport	Number of Dia	not les		wher of investors		2/01	units.		
	Grid-Connect	ed Systen	n	Nominal (STC)	nooures	40	Units Line Line	Tel	al countr		2460.1	Was
				Nominal (STC)		201 Chie	Ad in cardina	105	a power		2160	NYY BC
Project: Konya	Comakli 2,5 MV	/ Fotovoltai	k Güneş Santrali	Modules		331 Strings x	14 in series	Op	erating voltage		450-800	v
	Variant: Va	aryant1		At operating c	ond. (25°C)			Pho	m ratio (DC:AC)	6	1.16	
	Sheds, sing	le array		Ртрр		25	502 KWp					
	System power:	2502 kWp	nrainat	U mpp		5	582 V					
	Çomaklı -	Turkey	LJI LJICELI	I mpp		42	199 A					
1 1 2 1 2	- General par	ameters		Total PV now	ior.			Tel	al inverter no	wor		
Grid-Connected System	Sheds, single array			Nominal (STC)		26	i02 kWp	Tet	al nower		2160	Wac
cite comected aystem	scheus, angle array			Total		40	34 modules	100	mbar of investors		2100	units
PV Field Orientation	Shada configuration		Medala used	Madale area		40	Min mit	nur Der	cover or inventoria		1 40	
Eixed plane	Nb. of sheds	30 units	Transposition Perez	woode area		119	NOV III.	Ph	an raco		1.10	
Titl/Azimuth 36 / 0 *	Single array		Diffuse Perez, Meteonorm	Cell area		110	150 mª					
	Sizes		Circumsolar separate				1.1.1					
	Sheds spacing	7.00 m	ARRAY CONTRACT AND AND A CONTRACT					uddan beer				
	Collector width	2.29 m	11				— A0	wiring loss	ies —			
	Ground Cov. Ratio (GC	R) 32.7 %		the set of the	a sur in taken	diam and at						
	Top inactive band	0.02 m	ar 27	Inv. output lin	he up to inject	tion point						
	Bottom mactive band	0.02 m	nroioot	Inverter voltage		4	100 Vac tri					
	Limit profile angle	14.8."	UTUTEGE	Loss Francisco								
				Loss Fraction 0.10 % at PNom								
Horizon	Near Shadings		User's needs	Inverter: IPG 2	70C							
Average negos 1.0	According to strings		Command road (Brid)	Wea sartion (R Inv.) Cremer 8 v 3 v 240 mm ²								
	Project su	mmary -	VI VI VVI	the second lo		ooppor o x o x a						
Committee 101	Alt when		Destanting	Average wires i	ength		12 m					
Geographical Site	Situation		Project settings									
Çomaklı	Lathude	37.74 N	Albedo 0.20									
Turkey	Longitude	32.54 °E						Array losses				
	Altitude	1011 m										
	Time zone	UTC+3		IAM loss fact	or							
Natao data				Incidence effect	(IAM): Fresnel	AR coating, n(g)	lass)=1.526, nj	AR)=1.290				
Comakt					1000		CORNER DATE	22572.0105				
Volume				02	30'	50'	60'	70*	75*	80*	85'	90*
Meteonorm 8.0 (2003-2013), Sat=% 100 - Se	ntetk					w	vv	14	10	00	w	~
				1.000	0.999	0.987	0.962	0.892	0.816	0.681	0.440	0.000
1000 N N	System su	immary -										
Grid-Connected System	Shade single array		much									
Gild-Connected system	oneus, single array		nrniert									
PV Field Orientation	Near Shadings		User's needs									
Fixed plane	According to strings		Unlimited load (grid)									
Titt/Azimuth 36 / 0 *	Electrical effect	100 %										
	These and Autom	100 10										
System information												
PV Array		Inverters										
Nb. of modules	4634 units	Nb. of units	8 units									
Pnom total	2502 kWp	Pnom total	2160 kWac									
1999 (1977) - 1977)		Pnom ratio	1.159									
			1.140									
	Denuite											
	- Results su	annary –										
Produced Energy 4114 MWh/year	Specific production	1644 kWh/kWp	olyear Perf. Ratio PR 81.99 %									

Figure 2.20. Simulation report data



Figure 2.21. Simulation report diagrams

4. Conclusion and Recommendations

Photovoltaic solar energy systems have become the most preferred renewable energy source due to low facility installation costs, increasing energy production efficiency with the advancement of technology daily, decreasing panel production costs, ease of operation, and maintenance costs.

Compliance with the planned maintenance instructions of the power plant ensures that the plant operates with a longer operating life and performance, achieving maximum energy production and maximizing the interests of customers and investors.

According to the PVSyst simulation report of the 2.5 MW photovoltaic power plant designed in the Comaklı region of Konya province, the nominal power was 2502KWp using 4634 Solar Vikram panels with 540Wp capacity. The panels used were grouped in series as 14 strings and connected in parallel

as 331 strings in each string. While the performance rate was 85% in January, it decreased to 78% in July,

and the annual performance rate was 82% on average. the According to isometric [5] shading azimuth/elevation diagram, the highest sun angle is 750 in July, and the lowest elevation angle is 250 in December. The reason why the performance ratio is lower in summer months compared to winter months is that the heat losses are higher due to the increased air temperature. In the PVSyst simulation program, the annual horizontal irradiation of the Konya Comaklı region is 1769Kwh/m2, and the total energy injected into the grid is 4113,7MWh. [3]

The PVsyst simulation program gives realistic results, and the simulation made using the program before the installation of a solar power plant provides benefits in terms of the amount of energy to be supplied to the grid, the overall performance of the plant, the losses, the selection of the right equipment and the choice of the location where the plant can benefit from the best solar radiation.

Author(s) Contributions

LU and OC did the analyses and wrote the article together. Both authors read and approved the final version of the article.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

[1]. Limem, F. (2022) Evaluation of the effectiveness of photovoltaic design/simulation software used in the solar energy sector for Kocaeli province. Master's thesis 765304

[2]. Yilmaz, M (2013). Methods of obtaining electrical energy from solar energy with solar tracking system and determination of optimum efficiency Master's thesis 341350.

[3]. Ceylan, (2017). Investigation of the accuracy of simulation results of photovoltaic programs Master's thesis 487731

[4]. Cekinir, S. (2012). Modeling and Simulation of Photovoltaic Power Systems. Master Thesis, Ege University, Institute of Science and Technology, Izmir, 301878

[5]. Turmuş, A. (2018). Planar Reflectance Assisted Planar Solar Panel Design - Electricity Generation and Efficiency Analysis. Master's Degree, 492723

[6]. Internet: EMO. Solar energy systems losses. URL-8: https://www.emo.org.tr/ekler/38f0038 bf09a40b_ek.pdf. Last Access Date: 08.10.2023

[7]. Internet: Lighting portal. Recommended solar panel tilt angle. URL-9: https://www.aydinlatma. org/81-il-icin-onerilen-gunes-paneli-egim-acisi.html. Last Access Date: 10.10.2023

[8]. Internet: Field inspection guide for photovoltaic systems. URL: http://brooksolar.com/files/PV-Field-Inspection-Guide-June-2010-F-1.pdf.html. Last Access Date: 10.10.2023