International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 205-211, May-2024

https://doi.org/10.47001/IRJIET/2024.805030

A Professional Design Approach and Investigation of an On-Grid Solar Structure Using PVSyst Software in North Al-Sharqiyah Region, Oman

Ms. Santoshi Kanagala

Department of Engineering and Technology, University of Technology and Applied Sciences – Ibra, Oman
E-mail: Kanagala.Santhoshi@utas.edu.om

Abstract **- Oman is actively reducing its dependence on non-renewable energy sources as the rest of the world transitions towards renewable energy. Oman's renewable energy sector has great promise, particularly in solar power, with several large-scale solar PV projects underway. Rooftop solar is the optimal method for Oman to attain its goals and address its current energy crisis. In this study, a solar PV grid-connected energy generation system was built and simulated using the PVSyst software. The solar photovoltaic system's technical, financial, and annual performance is also shown. The technical analysis evaluates the system's ability to perform, its effectiveness, and the anticipated amount of energy it will generate. The economic analysis encompasses the initial capital outlay, ongoing expenses, and the time required to recoup the investment. The proposed solar photovoltaic (PV) plant model produces a total power output of 4.41 kilowatts peak (KWp) in the Ibra area in the North Al-Sharqiyah region of Oman. This generated power contributes to decreased electricity expenses for both residential and business use. Furthermore, renewable solar energy is a form of environmentally friendly and sustainable energy, as it releases small amounts of carbon dioxide into the atmosphere. This proposed concept aims to promote the expansion of rooftop systems in Oman.**

Keywords: Solar PV Plant, PVSyst Software, Meteo data, Grid Linked PV, Sun Path, Array Cost Plan, Routine Ratio, Regularized Manufacture.

I. INTRODUCTION

The major challenge is meeting the increasing load demand, which is increasing daily. The growing demand also increases the pressure on the electrical infrastructure [1]. Because of population growth and rising electricity consumption, conventional energy sources like fuel, oil, and gas are running out in nature, leaving behind hazardous gases that contribute to global warming. So, we must switch to renewable energy, which is abundant and infinite in solar, wind, rain, tide, hydro, and geothermal.

Utilising non-conventional energy sources allows for clean energy production and maintains a clean environment. Over the world, solar energy is becoming a more and more familiar alternative energy source. Oman, a nation renowned for its copious amounts of sunshine, has recently been investigating the possibility of solar energy as a viable and economical way to satisfy its expanding energy requirements. This proposed paper will provide an overview of solar photovoltaic cells, solar module types, and measurement tools. This research relies heavily on PVSyst, a popular piece of solar industry software for planning and modeling photovoltaic (PV) installations. The main focus of this project is to use PVSYST software for the The study focuses on the design and analysis of solar photovoltaic (PV) rooftop systems, including both separate and on-network configurations. By running the project through its paces in PVsyst, we can find the optimal dimensions, on-grid solar PV system settings, and power output.

The project includes a preliminary cost analysis of the solar PV plant's upkeep and operation. Shades, mismatches, internal networks, and temperature-related losses are all factors in determining the performance ratio.

The simulation results for a 4.41KWp ground-mounted solar PV plant show that the system produces 8.344KWh annually and has a performance ratio of 81.15%.The plant's energy output is enough to power a home, and any extra or unused energy is fed into the utility grid through net metering.

1.1 System Design and Objectives

A variety of PV system options must be considered in order to create a system that meets user needs.

By providing the technical specifications for residential use, we may do a performance study utilising the Meteo data available for the site location of the solar PV plant. This analysis takes into account yearly generation, sun irradiation, and performance ratio.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 205-211, May-2024

https://doi.org/10.47001/IRJIET/2024.805030

Building a photovoltaic system on top of preexisting rooftops: a feasibility study.

Managing restrictions and limitations during the design and simulation of different PV systems.

When making decisions, it's important to think about how feasible the PV systems are from a financial perspective.

II. PROPOSED SYSTEM

The proposed system for grid grid-connected block diagram is shown in Figure 1. The total quantity of energy produced by the system will be used to meet the electric demand of the house load and the excess energy will be fed back to the grid, as shown in Fig 1.

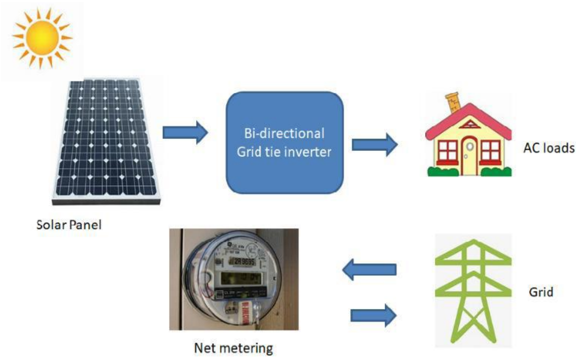

Figure 1: Grid-connected Solar PV system

The PV module produces energy that is sent to the inverter, which converts the direct current (DC) voltage to alternating current (AC) voltage and supplies it to meet the household's power needs. Surplus power produced is sold to the power grid through the utilization of an electric meter/net metering system.

Components required

Solar photovoltaic modules, a grid-tied inverter, a battery, net metering, the utility grid, and associated loads are the primary components that are required for the design of a rooftop standalone photovoltaic system by the utility.

Figure 2: Solar PV modules placed on the roof mounting structure

As the part of a PV scheme that is linked to the grid that turns energy from the sun into electricity, the solar photovoltaic system is the most important part. Many photovoltaic panels are linked together to make a solar array. This increases the amount of power that can be made. It is important to get accurate readings of the PV array so that it can meet the load all year long. The 315 Wp Generic mono-crystalline 96-cell module was chosen because it fits the needs of this project. In Table 1, you can see the details of the suggested module. At a certain set angle, the panel must be placed so that it receives as much solar radiation as possible. The most solar energy will hit the panel if it is mounted so that it faces south. Therefore, to get the most sunlight, the panel should be set up at an angle that is equal to or greater than the height of the spot. The panel has been tilted 24 degrees so that it can work with this job. Table 1 shows the specifications for photovoltaic panels.

Table 1: PV element description

Specification	Parameters
Element designation	Generic, Mono 315 Wp 96 cells
Skill used	Mono-crystalline
Valued control	400Wp
Short circuit current	6.14A
Open circuit voltage	64.60V
Extreme voltage	54.7V

The inverter is also a critical section of a grid-connected PV system. This component changes the DC power from the PV element into an AC power source. The inverter specifications must match the PV specifications for the system to function effectively. The inverter, commonly used for research, has an MPPT innovation incorporated, improving the system's efficiency. A 4.2 KW ac Generic inverter was chosen for this project. The inverter's specifications are listed in Table 2.

Table 2: Specification of the inverter

Input side (DC PV field)	Parameters	Output side (AC grid)	Parameters
Model	Generic, 4.2KWac inverter	Monophased	50/60 Hz
Minimum MPP voltage	120V	Grid voltage	230V
Maximum MPP voltage	550V	Nominal AC power	4.2KW
Absolute max. PV voltage	600V	Maximum efficiency	97.90%

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 205-211, May-2024

https://doi.org/10.47001/IRJIET/2024.805030

III. METHODOLOGY

One must have PVsyst software in order to operate a PV system. This software was developed by Swiss scientist Andre Mermaid and electrical engineer Michel V. When it comes to developing PV technology, PVSyst is a program that may help users carefully test various configurations, analyze the results, and find the best practicable solutions. There are four main elements of PVSyst: preliminary design, project design, database, and equipment. Regarding PV system design and simulation software, it's practically a standard issue. With an unlimited license costing around $950 and a 30-day demo mode available, the most current version of this software is V7.4.6.

To analyze, size, and interpret data from complete PV systems, one can use PVSyst, a piece of software. Standard solar power equipment, grid-connected, freestanding, pumping, and DC-grid photovoltaic (PV) systems are all compatible. It also offers a comprehensive database of PV system components and weather data. Executing the simulation requires several inputs, such as plane orientation, system components, PV array (series and number of PV modules in series), inverter model, battery pack, etc. It is possible to get monthly, daily, or hourly results after integrating many simulation variables.

Every time you run a simulation, you can print off a report that includes all the parameters you used and the first results. This program can also do a full cost-benefit analysis taking into account investment conditions, absolute component pricing, and any extra fees [4]. The various steps required to build and model a PV system are shown in Figure 3 of PVSyst.

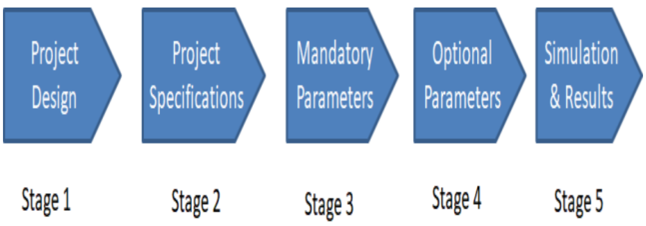

Figure 3: Methodology to design the project

3.1 Software imitation steps of Grid connected system

This program is designed with the needs of researchers, engineers, and architects in mind. The training of teachers and other school staff also benefits from this. As seen in Figure 4, the PVSYST tool is used for evaluation on the project design of a grid-connected, standalone pumping and DC grid.

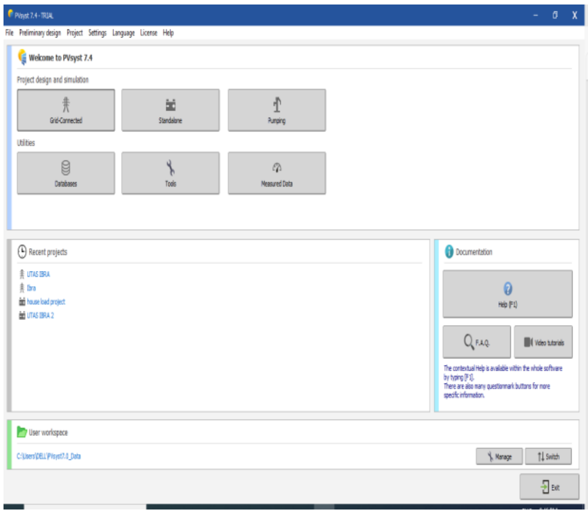

Figure 4: Evaluation mode (PVSYST V7.4.6)

Table 3: Shows the Project geographical location data where the solar plant needs to be installed

Sl.no	Characteristics	Details
1.	Solar PV system account	4.41 KWp solar PV power plant
2.	Location	Ibra, North Asharqiya, Oman
3.	Coordinates	22.6906 degreesNorth, 58.5334degrees East
4.	Altitude	442M above sea level
5.	Radiation on the tilted plane (KWh/m^2/day)	6.1%
6.	Site nature	RCC roof

As shown in Figure 5, we need to enter the site's details where the solar power plant needs to be installed. Location details include the latitude, longitude, altitude, and time zone of the particular place.

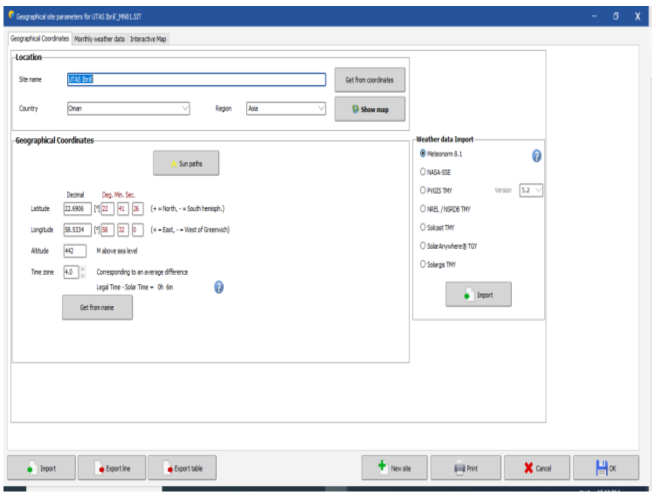

Figure 5: Meteo details of the location

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 205-211, May-2024

https://doi.org/10.47001/IRJIET/2024.805030

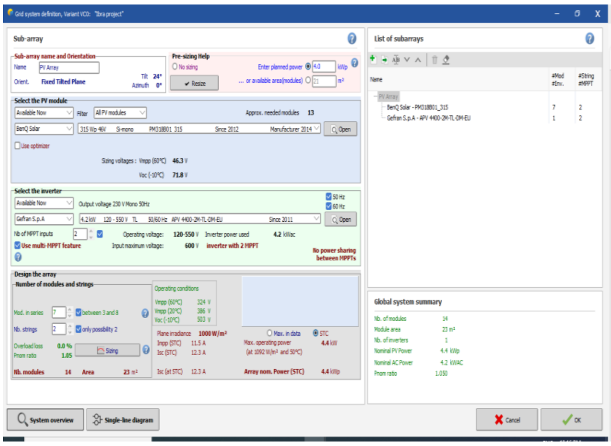

Figure 6: PV Module and Inverter Selection

The above Fig 6 gives the PV module and inverter specification for modelling the grid-connected system. The PV module selected is 315Wp, 46V with array voltage 66.4V, array current 70.5A, and Array power (STC) generated is 4.41Kwp.The number of modules required as per calculation is 14.The array voltage sizing is shown in Figure 7.

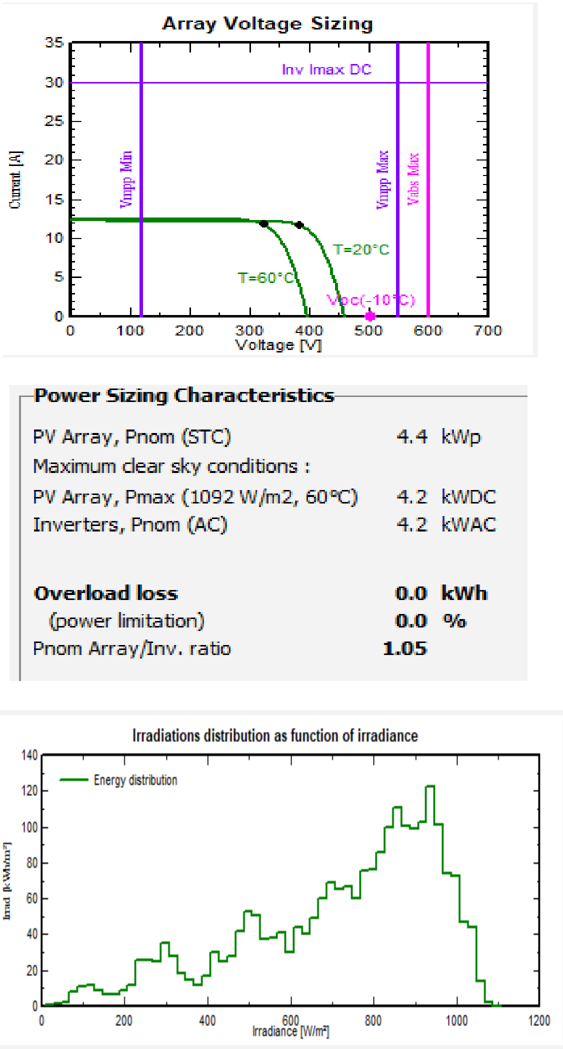

Figure 7: Sizing of the PV Module

3.2 Sun track of the position

Figure 8 shows the sun's path at the location.

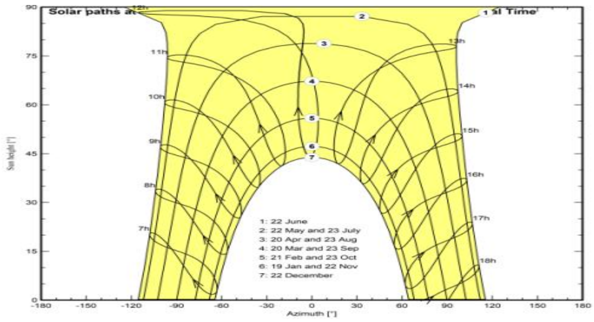

Figure 8: Shows the sun's path at the location

IV. RESULTS AND DISCUSSIONS

An architecture of a grid-connected solar photovoltaic (PV) system is modeled and analyzed in this work using the PVSyst program. The simulation was run several times, and after that calibration was carried out. The portion devoted to the results analysis examined the data obtained from this process. The results [7] include an array power distribution plot, a daily energy output plot including incident variations, a representation of losses diagram, a horizon line drawing plot of the chosen location, a performance ratio data plot, a daily energy output plot including incident variations, and normalized productions that include loss changes.

Table 4: The main result of system production of Grid Connected system

Main results Main simulation results in System production :
System Production = 8344KWh/year Specific production = 1892KWh/year Normalised Production=5.18 KWh/KWp/day Performance ratio = 0.811 System losses= 0.12 KWh/KWp/day Array losses=1.08 KWh/KWp/day

4.1 Stabilities and Key Outcomes

Figure 9 shows the balance and main results.

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	PR ratio
January	142.2	37.4	17.85	189.8	185.8	725.1	708.8	0.847
February	152.6	42.3	19.82	187.8	184.2	707.0	691.1	0.834
March	184.6	63.3	24.14	203.8	199.4	750.8	733.7	0.816
April	204.4	74.7	28.56	205.2	200.3	741.1	724.4	0.801
May	216.4	90.7	33.93	201.8	196.2	713.7	697.6	0.784
June	206.3	99.8	33.51	187.5	182.3	667.3	651.8	0.788
July	195.5	104.0	32.28	180.9	176.0	650.7	635.6	0.797
August	187.8	101.9	30.45	182.9	178.5	663.9	648.9	0.804
September	181.4	72.9	28.79	192.1	187.7	695.2	679.5	0.802
October	178.6	49.6	27.51	211.2	207.3	765.1	747.5	0.802
November	153.5	29.9	22.84	202.8	198.7	752.6	735.7	0.823
December	135.5	35.7	19.48	185.8	181.7	705.5	689.9	0.842
Year	2138.8	802.3	26.63	2331.7	2278.2	8538.0	8344.4	0.811

Figure 9: Balance and main results

ISSN (online): 2581-3048
Volume 8, Issue 5, pp 205-211, May-2024
https://doi.org/10.47001/IRJIET/2024.805030

Figure 9 illustrates the balances and crucial outcomes, encompassing variables such as global irradiance on the horizontal plane, ambient average temperature, global incidence in the collector plane, and effective global irradiance after soiling and shading losses. In addition to these elements, the direct current (DC) energy produced by the mono-crystalline solar array, the energy that is fed into the power grid after taking into account losses from the photovoltaic array, electrical components, and system efficiency, were also simulated. Every variable indicated in the specifications was simulated, and the significant findings were obtained on a monthly and yearly basis. Yearly values of the variables can be calculated as the average temperature, efficiency, and summation of irradiance and energy. The annual amount of sunlight received on the horizontal plane at the research location is 2139 kilowatt-hours per square meter. The amount of sunlight that reaches the collector plane is 2331.2 kilowatt-hours per square meter, and after taking into account optical losses, the effective amount of sunlight is 2278.2 kilowatt-hours per square meter. The PV array generates an annual DC energy output of 8.538 MWh, while the annual AC energy injected into the grid is 8.344 MWh. These values are based on a practical worldwide irradiation value of 7.

4.2 Normalized Productions

Figure 10 illustrates the standardized production of the photovoltaic power plant. The tool calculates the losses in PV array collecting, system losses, and the notable output of the inverter. The data shows the monthly energy amount produced and the corresponding losses per kilowatt-hour. The IEC regulations define standardized products and factors for assessing the performance of PV systems [8].

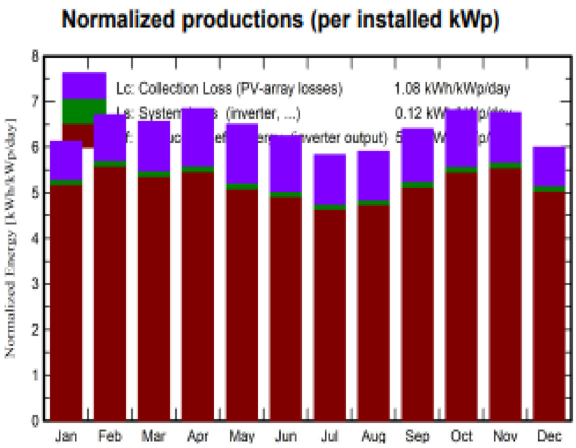

Figure 10: Normalized productions

4.3 Array loss plan

The acquisition of the array loss diagram is facilitated through simulated studies, which aid in the analysis of various types of losses that may arise during the installation of photovoltaic (PV) plants or the consideration of relevant limits. Figure 7 depicts the array loss diagram, which showcases the diverse losses present within the system.

The global irradiance, as measured on the horizontal plane, is 2138 kWh/Sq. m. The collector exhibits an effective irradiance of 2331.7 kWh/per square meter. Based on the analysis conducted, it has been ascertained that the irradiance level is accountable for a reduction in energy by 0.46%. Electricity generation takes place when a photovoltaic module or array is exposed to a simulated effective irradiance that is directed towards its surface. Under standard testing conditions (STC), the array's nominal energy after photovoltaic (PV) conversion is measured to be 10 megawatt-hours (MWh).

According to the statistics, the photovoltaic (PV) array at STC exhibits an efficiency of 19.35%. The annual production of megawatt-hours (MWh) generated by the virtual energy array of the MPP amounts to 8.5. There are several distinct factors that contribute to the losses experienced during this particular stage. In terms of the overall losses, temperature losses contribute to 9.67%, light-induced degradation contributes to 2%, module array mismatch contributes to 2%, and Ohmic writing losses contribute to 1.5% of the total losses. The inverter output plant generates an annual energy output of 8.33 megawatt hours (MWh), which is subsequently distributed to the grid. In this scenario, the two primary losses observed were a loss of 1.80% during the operation of the inverter and a loss of 0% over the nominal output of the inverter. The diagram depicting the array loss is illustrated in Figure 11.

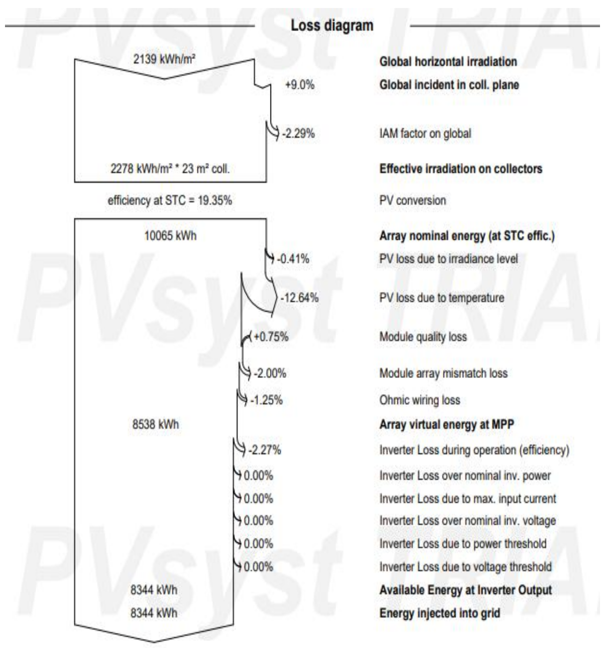

Figure 11: Array loss diagram

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 8, Issue 5, pp 205-211, May-2024

https://doi.org/10.47001/IRJIET/2024.805030

4.4 Performance Ratio

The performance ratio is a metric used to evaluate the quality of a photovoltaic (PV) plant. It elucidates the connection between the PV facility's theoretical and actual energy outputs. The PR represents the residual energy remaining after accounting for all energy use and losses. The Performance ratio typically averages approximately 81.15% due to inevitable operational losses. The performance ratio (PR) of the PV plant for the simulated 4.41KWp mono-crystalline solar system is 81.15%. This result represents the average PR over a year, as depicted in Figure 12. The PR value exhibits minor monthly fluctuations, as shown in Figure 12 [8].

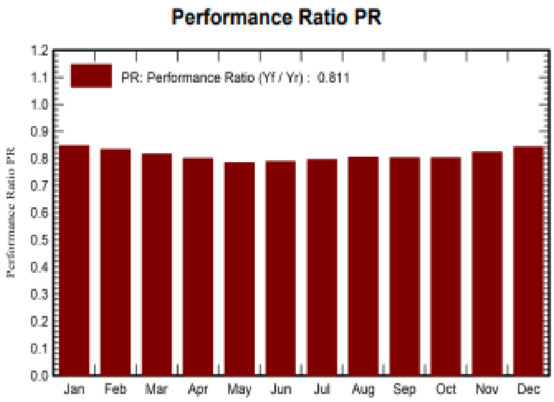

Figure 12: Performance ratio

4.5 CO_2 Emission Balance

The following Figure 13 shows the simulated values of CO_2 Emission Balance.

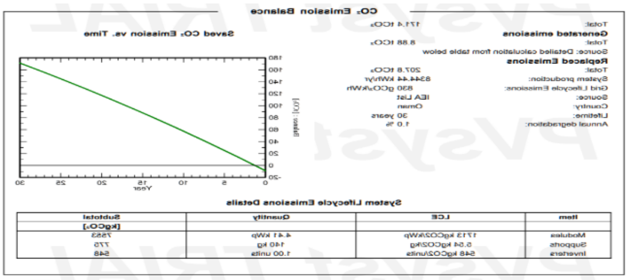

Figure 13: CO_2 Emission Balance

V. CONCLUSION

The study focuses on the design and performance analysis of a solar PV rooftop system with an installed capacity of 4.41KWp. The system is grid-connected and located in Ibra, North Alsharqiya region, Oman. The latitude and longitude of the location are 22.6906 degrees North and 58.5334 degrees East, respectively. The study aims to analyze the home load consumption and meet the energy needs by utilizing solar PV modules, an inverter, and excess energy generated by feeding it back to the utility grid through net metering. The analysis is conducted using the PVSYST software. The performance study is conducted using the PVSYST program. The software provides a global solar radiation yield of 2138.8 kWh/m^2 and calculates an excess energy generation of 8344.4 kWh/year, which may be fed into the utility grid. The inverter efficiency is 97.9%, and the DC-to-AC size ratio is 1.02. The performance ratio is determined to be 81.1%.

VI. FURTHER WORK

Additional details on the electrical arrangement, possible mechanical burdens, installation framework, protective sizing, disconnection switches, and metering are required. It may also be necessary to examine the type of soil contamination. In addition, the current market provides a wide range of module and inverter technology choices. Alternative systems can be evaluated and compared to assess their efficiency and cost. Collecting and comparing cost data from several PV system manufacturers can aid in minimising uncertainty in the economic assessment.

REFERENCES

[1] Jake Lomansoc, Ricard Jun Roloma, Kim Seer Paller, “Design and Simulation of 100 kWp Solar Photovoltaic (PV) Grid Connected Power Plant Using PVsyst”, 26 February 2019.

[2] Ashok Aryal ,Nawraj Bhattarai, “Modeling and Simulation of 115.2 kWp Grid-Connected Solar PV System using PVsyst”, Kathford Journal of Engineering and Management, Volume 1, Issue 1, Nov. 2018.

[3] Rekhashree1, Dr. J.S Rajashekar2, Dr. H.Naganagouda, “Study on Design and Performance Analysis of Solar PV Rooftop Standalone and On Grid System Using PVsyst” IRJET Volume: 05 Issue: 07 , July 2018.

[4] Siddhant Changkakati, Abhishek Kumar Sahu, Riyan Syed, Shubham Kumar and guided by J P Kesari, “Performance Evaluation of GridConnected Solar Photovoltaic Plant using PVsyst Software”, ISSN: 2278-0181 Vol. 9 Issue 10, October-2020.

[5] Nallapaneni Manoj Kumar, M. Rohit Kumar, P. Ruth Rejoice and Mobi Mathew, “Performance analysis of 100KWp grid connected Sipoly photovoltaic system using PVsyst simulation tool”, 4 March 2017.

[6] B. Kailash Krishna Prasad, K. Prahlada Reddy, K. Rajesh, P. Viswanath Reddy, “Design and Simulation Analysis of 12.4 kWp Grid Connected Photovoltaic system by using PVSYST Software”, ISSN: 2277-3878, Volume-8 Issue-5, January 2020.

ISSN (online): 2581-3048
Volume 8, Issue 5, pp 205-211, May-2024
https://doi.org/10.47001/IRJIET/2024.805030

[7] Ahmed Alnoosani, Mowffaq Oreijah, Mohammed Alhazmi, Yousef Samkari, Hosam Faqeha, “Design of 100MW Solar PV on-Grid Connected Power Plant Using (PVsyst) in Umm Al-Qura University”, 2018.
[8] Akram Abdulameer & Abbood Al-Khazzar, “A Theoretical Detailed Analysis for a Proposed 5kW PV Grid-Connected System Installed in Iraq Using PVsyst Tool”, Independent researcher, 25 May 2018.
[9] Rachit Srivastava and Vinod Kumar Giri, “Design of Grid Connected PV System Using Pvsyst”, 2017.
[10] H. Yamashita K.Tamahashi M. Michihira A. Tsuyoshi K. Amako and M. Park "A novel simulation technique of the PV generation system using real weather conditions" in 2002 Proc. Power Conversion Conf. Vol.2 pp. 839 -844, April 2002.
[11] Vasanthkumar, Dr. S. Kumarappa, and Dr. H. Naganagouda Design and Development of 5MW Solar PV Grid Connected Power Plant Using PVSYS, IRJET, volume: 13, Issue: 08, Aug – 2017.
[12] H.Mithavachan, Anandhi Gokhale and J.Srinivasan, Dz performance assessment of ͵MW scale grid connected solar plant at kolar, Karnataka. dz August.
[13] M.V. Santhi Lakshmi, DR. CH. Sai Babu Design of off-grid homes with renewable energy sources dz, IET, SEISCON, December 2012.
[14] Moslem Uddin, Mohd Fakhizan Romlie, Mohd Faris Abdullah Feasibility study of grid connected solar home system: the perspective of Malaysiadz Department of Electrical and Electronic Engineering Universiti Teknologi PETRONAS 32610, Seri Iskandar, Tronoh, Perak, Malaysia.
[15] Dr. H. Naganagouda,Solar power hand book, Director, National training centre for solar technology at Karnataka power corporation (KPCL), Bangalore. Publication book 2014.

Citation of this Article:

Ms. Santoshi Kanagala, “A Professional Design Approach and Investigation of an On-Grid Solar Structure Using PVSyst Software in North Al-Sharqiyah Region, Oman”, Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 8, Issue 5, pp 205-211, May 2024. Article DOI https://doi.org/10.47001/IRJIET/2024.805030

****