On Grid Pv System Simulation Analysis On Terrace Of Faculty Building

Urim BUZRA
Department of Engineering Physics
Polytechnic Univeristy of Tirana, Faculty of Engineering Mathematics &Engineering Physics
Tirana, Albania u.buzra@fimif.edu.al

Matilda Tola
Department of Finance
University of Tirana, Faculty of Economy
Tirana, Albania

***Abstract*—In this study PVsyst serves as a tool to simulate a grid tied PV system on terrace of our faculty building. The objective of this study is to evaluate the potential and economic viability of installing a PV system on the terrace of the Faculty of Mathematical Engineering and Physical Engineering, FME&EP, Tirana, connected to the electrical network. The terrace of the FIM & IF building has an area of about 288 m^2, and offers a good opportunity to install a PV system as it creates little or no shading, a very important element in the design of solar systems. The electricity consumed by the facility under study for 2019 is 66.8 MWh / year. The energy generated by the PV system would partially meet the energy needs of the facility and partially connected to the electricity grid at a certain price set by the Energy Regulatory Authority (ERE).**

Keywords—PVsyst software, Shading, Economic evaluation, Economic Viability.

I. Introduction

The way electricity is generated from PV systems installed on the terraces of buildings is gaining more and more interest. Based on the law on renewable energy in Albania, every consumer can turn into a producer of electricity through the installation of PV systems. Installing these systems by integrating them into the building increases the energy performance of the building by trying to approach the "zero energy building". PV systems connected to the electricity grid have many advantages, both in reducing the complexity of the system and in terms of costs. Another advantage of the PV system connected to the electricity grid is the fact that they use two-way meters, which measure the energy consumed by the facility equipment as well as the energy injected into the grid, significantly reducing the energy bills purchased from the grid. In grid tied PV system roofs are the most important part of the building because it is the place where the panels installed. The panels on a flat roof should be placed in such a way that, together, they will produce as much as energy. Care must be taken in selecting the optimal tilt angle of the solar panels, as well as in the distance between them, in order to minimize the mutual shading between the solar modules. The purpose of this study is to evaluate the economic feasibility of using solar PV systems at the terrace of the FEM&EP faculty as an attempt to establish the use of solar energy. The results of the analysis are prepared to become an essential guide for the utilization of PV systems in building construction in the future. [1, 2, 3]

II. Materials and Methods

PVsyst is used as simulation software to design and simulate the PV system. The main design parameters such as panel orientation, near and far shading effects are evaluated. System-related data such as module type are selected from the database that the software has integrated. The climatic data used are satellite data for a period of 20 years. Economic and financial data are obtained from several companies that offer this service in Albania.

The PV project is simulated for Tirana city (41.32^{o}N and 19.80^{o}E), in the terrace building of the Faculty of Mathematical Engineering and Physical Engineering, FME&PE. The PV (photovoltaic) system is simulated on the terrace of FME&PE which is positioned in the northern part of the building of faculty. The project is on grid type or connected to the electrical grid, which means that the energy produced by the system will go in part to meet the electricity needs of the facility and is partly injected to the grid. For this reason, the energy consumption data of the building for the years 2017-2019 have been obtained.

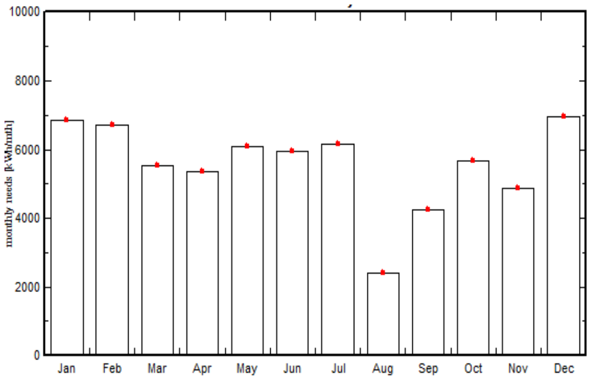

Figure 1.*Monthly profile of electricity consumption of building*

The power capacity of simulated PV system will be determined by the (i) energy consumption of the building and the (ii) surface area of the terrace of building.

Fig.1 Show the Monthly profile electricity consumption of the building.

PVsyst is a simulation tool which facilitates the options for designing a PV system. It is used in all configurations of PV systems (stand alone, Grid tied, pumping and DC Load. PVsyst allow user to estimate the simulation results in order to identify the best technical and economical solution. PVsyst also provide a database for meteorological parameters for particular sites and components management.

The tool requires some data to be fulfill that is mandatory as primary data, as well as some optional data, before being executed for simulation.

Mandatory parameters require by the software are:

- orientation data (tilt angle of solar panels)
- system data (selecting the PV module, the Inverter etc)
- self consumption (energy consumption of the facility)

Optional data the tools required is:

- Horizon (objects that are located sufficiently far away from PV system)
- Near shading (construction of the near shadings)
- Module layout
- Economic evaluation

III. Results and discussion

In this study, the design of the rooftop grid-tied PV power system with the capacity of 36.9 kWp in FEM&EP building was simulated by using specialized software PVSYST.

The PV array characteristics of the simulation system are shown in table 3.1.

Table 3.1 PV array characteristics

Number of PV modules	In series 30 module	In parallel 41 stings
Total number of PV modules	*1230*	*Unit nom power 30 Wp*
Array global power	*36.9 kWp*	*36.0 kWp (50 °C)*
Array operating characteristics (50 °C)	*U mpp 475 V*	*I mpp 67 A*
Total area	*288 m^2*	*Cell area 177 m^2*

The total area of the building terrace is 288 m^2. The installation of PV panels should be done in such a way as to optimize the surface area of the building, as well as to optimize the tilt angle of PV panels to produce maximum power.

In PVsyst the losses, yield factor, performance ratio are determined as below:

Array Yield (Ya) in [kWh/kWp day]:

$$Y_a = \frac{E_a}{P_o} \quad (1)$$

Where Ea is output array yield [kWh] and P_o is is power of solar array [kWp].

Reference system Yield (Yr) in [kWh/m^2 day]

$$Y_r = \frac{H_t}{G_o} \quad (2)$$

H_t is the total horizontal irradiance on array [kWh/m^2] and G_o is the global irradiance at standard condition (STC) (W/m^2).

System Yield (Yf) in [kWh/kWp day]:

$$Y_f = \frac{E_{AC,out}}{P_{max,STC}} \quad (3)$$

$E_{AC,out}$ is the amount of electrical energy generated by the solar power plant; P_{max}, STC is the total installed power of solar arrays at standard test condition (STC).

Performance Ratio (PR):

$$PR = \frac{Y_f}{Y_r} = \frac{E_{AC,out}\ G_o}{P_{max,STC}\ H_t} \quad (4)$$

PR- is the global system efficiency with respect to the nominal installed power and the incident energy. It indicates the overall effect of losses on the overall performance of the PV system, and includes effects of PV array temperature, incomplete utilization of irradiation, system component limited efficiencies, and failures.

Collection Loss (Lc):

$$L_c = Y_r - Y_a \quad (5)$$

where, L_c (Collection Loss) is the array losses, including thermal, wiring, module quality, mismatch and IAM losses, shading, dirt, MPP, regulation losses, as well as all other inefficiencies; Y_r is Reference system Yield; Y_a is Array Yield.

System Loss (Ls):

$$L_s = Y_a - Y_f \quad (6)$$

where, L_s (System Loss) is inverter loss in grid-tied solar power system; Y_a is Array Yield; Y_f is System Yield. [4] [5, 6]

Table 3.2 PV array loss factors

Thermal loss factor	**U_c (const) 20.0 W/m^{2}K; U_v (wind) 0.0 W/m^{2}K**
Wiring Ohmic Loss	***1.5 % at STC***
Module Quality Loss	***-0.8 %***
Module Mismatch loses	***2 % at MPP***
String Mismatch loss	***0.1 %***

Table 3.2 represents the PV array los factors of simulated system.

There are several factors that affect the performance ratio, these factors are:

Environmental factors such as:

- Temperature of PV modules
- Intensity of solar radiation
- Parameters that affect shading
- Impurities in PV modules
- Other factors
- Analysis period
- Losses in the conductor
- Yield of PV modules and inverter

Based on the PVsyst simulation, the system performance ratio is about 85% as shown in Figure 4. Figure 4 shows that the performance ratio has higher values in the winter months period compared to the summer months period.

Figure 3 shows the normalized production of the PV system, which is the total energy produced by the system, and the energy fractions lost by the inverter and PV array losses.

Fig.2 Shows the schematic view of the facility and the PV system.

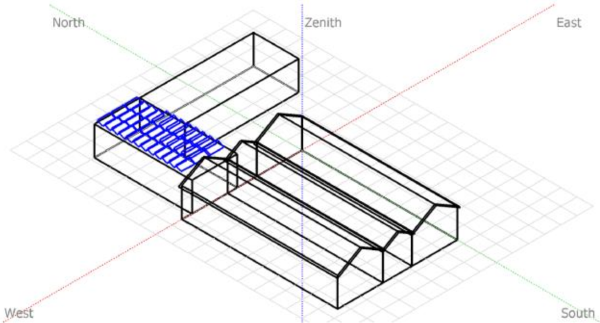

Figure 2. *Schematic view of the facility and the PV system*

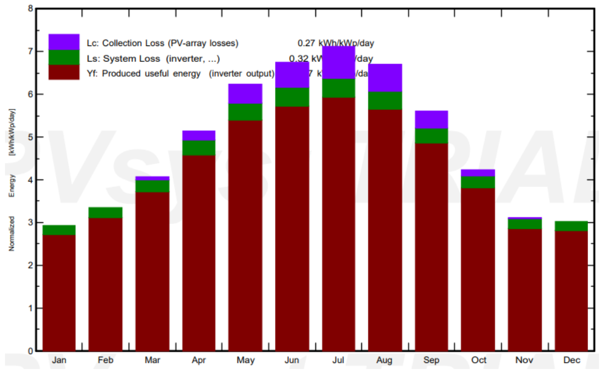

Figure 3. *Normalized productions*

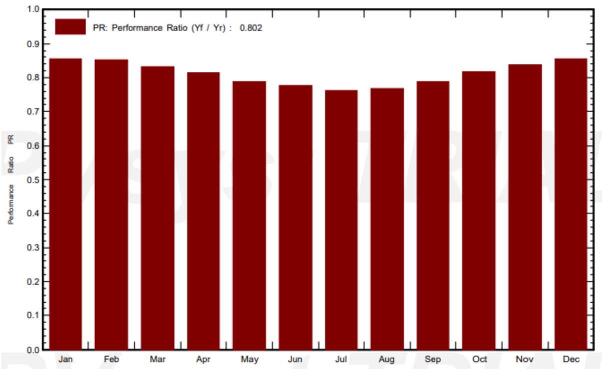

Figure 4. *Performance ratio*

IV. Conclusions

The Main objective of this study was to assess the potential and economic viability of installing a PV system on the terrace of the Faculty of Mathematical Engineering and Physical Engineering, FIM & IF, Tirana, connected to the electrical network. The terrace of the FIM & IF building has an area of about 380 m2, and offers a good opportunity to install a PV system as it creates little or no shading, a very important element in the design of solar systems. The electricity consumed by the facility under study for 2019 is 66.8 MWh / year.

The implementation of a PV system would partially meet the energy needs of the facility and would be partially connected to the electricity grid at a certain price set by the Energy Regulatory Authority (ERE).

The simulation shows that the energy produced by the PV system is 46.63 MWh about 70 % of the energy required by the facility. From this value of energy generated by PV system 46.63 MWh about 21.34 MWh is consumed by the facility, and 23.29 MWh is injected to the grid, and approximately 45.42 is imported from the central grid to the facility.

The simple payback period of the project is 5.83 years

References

[1] Elieser Tarigan, Djuwari, Fitri Dwi Kartikasari, " Techno-Economic Simulation of a Grid Connected PV system Design as Specifically Applied to Residentia in Surabaya, Indonesia, Energy Procedia , 2015, pp. 90-99.

[2] Pankaj Kalita, Samar Das, Dudul Das, Pallab Borgohain, Anupam Dewan and Rabindra Kangsha banik, " Feasibility study of installation of MW level grid connected solar photovoltaic power plant for northeaster region of India, Indian Accademy of Sciences , 2019.

[3] B. Kailash Krishna Prasad, K. Prahlada Reddy, K.rajesh, P. Viswanath Reddy, "Desing and Simulation Analysis of 12.4 kWp grid connected Photovoltaic systems by using PVSysy software" International Journal of recent Technology and Engineering, Vol. 8, no. Issue-5, January 2020, pp. 2859-2864.

[4] Vu Minh Phap, Nguyen Thuy Nga, "Feasibility Study Of Rooftop Photovoltaic Power System For A Research Institute Towards Green Building In Vietnam," EAI Endorsed Transactions on Energy Web, Janary 2020.

[5] André Gomes Barros, Denise Cristina de Oliveira Nascimento, Cristiane de Jesus Aguiar, "Economic Feasibility Study of Photovoltaic Panels Installation by PVsyst 6.73 Simulator," International Journal of Advanced Engineering Research and Science (IJAERS), vol. 5, no. 9, pp. 154-162, 2018.

[6] H Umar, M Amudy and T A Rizal, "Feasibility study of installation photovoltaic system at a university in Indonesia: A case study," in IOP Publishing, Orlando, 2019.