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RESEARCH

Quarter MW solar power plant installation on the roofs of the higher institute of sciences and technology in Alasaba

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In recent years, public organizations have actively participated in the installation of solar power plants (SPPs) in Libya, in addition to the private sector. In the study, SPP installation on the roofs of five institute buildings within the Higher Institute of Sciences and Technology was planned, and PVsyst software was used for simulation. The findings show that SPP provides about 35.17% of the Institute's electrical energy needs after installation, with a return on investment of about 4.65 years. As a result, after the amortization period has passed, this system will still be usable within the panels' warranty duration.

Keywords: PVsyst software, solar power plant, simulation, investment, warranty duration

Introduction

Libya is situated in an area with high levels of solar radiation and extended daily sunshine hours. As a result, solar energy can be regarded as the most important renewable energy source (1). The photovoltaic conversion technique should be employed extensively to generate electricity using this enormous energy. Unless alternate forms of energy are employed to save energy supplies, studies predict that Libya's demand for power is rising swiftly and may exceed 115 gigawatts by 2020. This will result in a high demand for fossil fuels (2).

Libya was the first country to employ solar power in the 1970s.. Its special applications include the rural electrification, water pumping, communication repeaters, and cathodic protection for oil pipelines in remote and arid regions. Historically, photovoltaic conversion was the main use of solar energy, whereas solar thermal applications were utilized to heat water (3).

This study plays out the installation of SPP atop the Higher Institute of Sciences and Technology (HIST) in Alasaba City. In this instance, SPP is low voltage connected to the grid and directly connected to the distribution boards of the buildings. The simulation program Pvsyst 6.41 was used in this experiment (4, 5).

Location details and meteorological data for the proposed location

The location's coordinates can be used in PVsyst as the input for the solar resource. Data pertaining to meteorological data can be accessed from the NASA website based on location coordinates.

The site was chosen at Alasaba City's HIST, which is located at 32.065° N and 12.90° E. A landlocked province in northern central Libya, Alasaba City, is around 100 kilometers south of Tripoli, see **Figure 1** (1, Administration;

FIGURE 1 | PV system location.

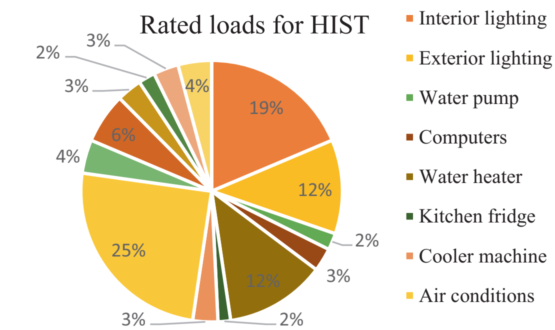

FIGURE 2 | Load estimation for Higher Institute of Sciences and Technology (HIST).

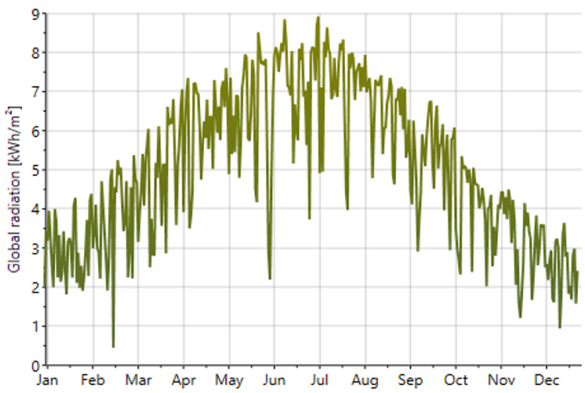

FIGURE 3 | Annual average solar radiation in HIST.

2, Theater; 3, The Library; 4, halls and laboratories; 5, scientific departments).

Figure 2 presents the appliances and loads for HIST (Administration, Theater, library, halls and laboratories, and scientific departments).

Libya has a significant capacity for producing solar energy. For instance, Alasaba, a city in Libya, experiences 3750 h of non-stop sunshine annually and receives an average daily solar radiation of 7.7 kWh/m^2 (**Figure 3**). The finest systems for usage in rural Libya are photovoltaic (PV) systems since they offer comfort and economy (6).

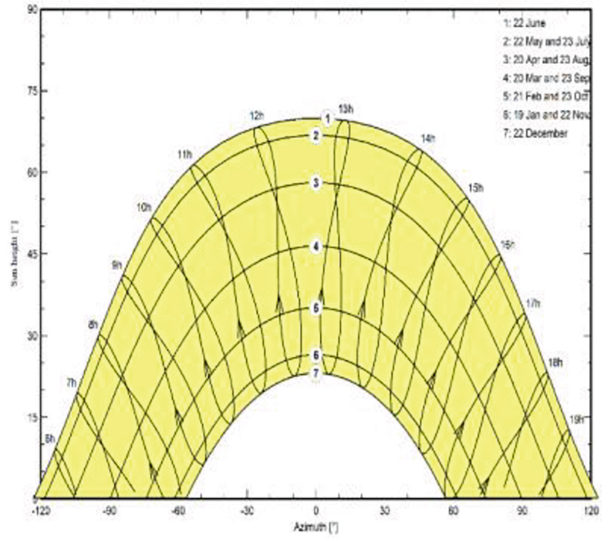

FIGURE 4 | Solar paths for HIST.

Figure 4 represents the sun paths for the testing institute, and 0°C azimuth angle is the South (7).

According to the institute, **Table 1** displays the AC power of the roof-mounted solar panels. The combined installed power of the inverters is AC power.

Materials and methods

Utilized software

There are many modeling tools for PVs around the world. For preinvestment forecasting, these systems are often preferred in academia and business. The most well-known and commonly used simulation tools are PV-SOL (8, 9), PV Syst (10), HOMER Pro (11), and SAM (1).

Our study used PVSYST Expert to simulate on-campus YPPs. In PVsyst, design features like 3D building design, placement of objects that can create shadows, and tilting of panels in the right direction and at the right angle provide great user convenience. The METEONORM software exports meteorological data to the PVsyst software, including solar radiation and air temperature. If economic parameters like the guaranteed tariff, interest, cost of power in kWh, and investment costs are started, PVsyst can also do economic calculations (12, 13).

Design specifications

Technology is constantly evolving, and this has led to differences in solar panels available on the market. The 440W polycrystalline PV panel was chosen because the delivery time was the shortest in our project, and the most widely used panel in the market is the 440 W panel. Panels subject

TABLE 1 | AC powers according to the institute.

Loads for HIST	AC installed power (kWe)
Administration	101.6
Theater	110
Scientific departments	92.6
Halls and laboratories	95.6
The library	99.8
Total	500

TABLE 2 | Energy from unit power and total energy produced in accordance with the instructions.

Directions	Unit power produced energy (kWh/kWp)	Energy generated in total complying with directions (kWh)
South 29° inclined	1298	528015.5
North	1274	226950.3
East	484	17698
West	266	20216
		792879.83

TABLE 3 | Energy produced, percentage, according to the institute.

Loads for HIST	Energy produced yearly (kWh)	(kWh/kWp) energy produced from unit power
Administration	205082	656.45
Theater	172465.8	640
Scientific departments	78268	672.83
Halls and laboratories	186148	563.145
The library	37665.7	691.7

to the same shading are integrated in the same order to reduce the shading effect. For this reason, four inverters with a capacity of 60 kW were selected. These inverters have 8 MPPT inputs.

Design based on software

With the aid of the PVsyst software version 6.49, a 0.25 MW solar power plant may be designed and its output estimated. Data from preliminary and postevaluation tests for commercially viable power generation are both possible.

Entering the requirements of a given design enables the evaluation of the overall system performance and efficiency of each system inside the plant. We design the system in accordance with the component specifications listed above.

Results

The outcomes are assessed both technically and economically in this part. Both the quantity of energy generated and economic factors like return on investment are impacted by the system's architecture. With a higher angle, unit kW power can produce more energy, but to do so, slanted equipment must be positioned underneath the panels. Utilizing this equipment raises the cost of the investment. High-slope patterns also result in the shade. For roof constructions, designs with fewer panels are taken into consideration to reduce shadowing. Less electricity is generated as a result of these designs. Due to this, even though the yields were a little low, we chose the design with higher energy and cheaper expenses.

Technical evaluation

The energy produced overall (kWh) and the energy produced per unit of electricity (kWh/kWp) are shown in Table 2. According to the instructions, calculations were done using panels placed in the faculties. The slope of the faculties' roofs, which is typically 8 degrees, is taken into account while computing. PV panels with a southerly 29° tilt have the maximum efficiency measured in terms of the energy produced from unit power. When the overall amount of energy is taken into account, the south-facing panels produce the most energy (528015.5 kWh).

Due to the different numbers of panels installed in each of the institute's buildings, the annual energy production varies. Additionally, because each faculty has a different number of panels installed in accordance with the regulations, each unit of power produces a different amount of energy. The most effective area is the library's PV panels on the top, while the least efficient areas are the halls and laboratories, which are 29 degrees to the south and west (see Table 3).

TABLE 4 | Period of amortization.

Price (Ld)	kWh power charge (Ld)	Production each year (kWh)	Revenue per year (Ld)	Period of amortization (year)
2127939.46	0.031	792879.83	24579.27	4.65

TABLE 5 | Annual institute consumption and the production-to-consumption ratio.

Consumption annually for the institute (MWh)	Yearly production (kWh)	Production-to-consumption ratio
1.25	792879.83	35.17%

Economic evaluation

Table 4 shows the amortization period for the system. The annual production amount is based on simulation results, and the power (kWh) fee in the table reflects per-unit cost of the institute's electricity use. The institution will therefore save 24579.27 Libyan Dinar (Ld) year if the energy distribution of the company's kWh balance is negative overall. In contrast, if the system costs 2127939.46 Ld, the amortization period is 4.65 years.

Table 5 displays the institute's yearly electricity usage, the 0.25 MW system's annual production, and the relationship between the two. This means that SPP accounts for 35.17% of the institute's 1.3 MWh consumption.

Conclusion

The Pvsyst V6.10 modeling software is used to design a grid-connected PV system for the HIST load in Alasaba. Using this simulation software and the 0.25 MW PV energy yield analysis with an annual average horizontal global irradiation of 2556 kWh/m^2, solar power generation was carried out for geographic position HIST, which is situated at a latitude of 32.065^o N and a longitude of 12.9^o E.

Inverters with more MPPT should be utilized since roof installations typically have a significant number of panels arranged at various angles and facing various directions. Therefore, efficiency is increased if the PV panel–MPPT connection is established in accordance with the angles and orientations. The annual increase in the electricity purchase charge provides a positive return on investment for power plants that are set up to net off the electricity produced instead of sell it. According to our research, after installation, SPP provides about 35.17% of the university's electrical energy needs, with a return on investment of about 4.65 years.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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