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Installation and Techno Economic Analysis of 12.5kW Solar Photovoltaic Project

Onuoha Christopher C., Mohammad Alshoubaki

ABSTRACT-This project presents the installation and techno-economic analysis of a 12.5kW solar photovoltaic project. The design involves evaluation of the entire building total electricity demand/consumption and as well obtaining the required solar radiation this information was used to analyse the various component of the photovoltaic system, On the other hand several calculations were recorded to determine an approximate number of solar panels, inverters that comprise of the solar section of the photovoltaic system. Also, the simple payback period (SPP) and net present value (NPV) were calculated and used to assess the viability of this project. (SPP) simple payback period is 3.8 years, the (NPV) net present value calculated as 8414 JD and the SIR savings-investment ratio was calculated as 1.96. When 1W (PV) equals 2080Wh/year where the total consumption of the building is 25500kWh. Therefore 12.26kW of energy was needed to cover 25500kWh of electricity consumption. Thus, this project is seen to be more economical, environmentally friendly, conducive, and viable considering the abundance of sun radiation and cost effectiveness.

Keywords: Jordan, NPV, Photovoltaic, sun radiation, SPP, SIR.

1 Introduction

The sun's radiation is directly converted to electricity using solar cells. Semiconductor materials alike to those in manufacturing computer chips are used in the production of solar cells. This material absorbed the radiation from sunlight; the solar energy hits electrons loose from their atoms thus, allowing the free flow of electrons through the material to generate electricity. Converting light (photons) to electricity (voltage) is called the photovoltaic effect. Photovoltaic (PV) is, therefore, the area of technology and research related to the application of solar cells that convert sunlight directly into electricity. [1]

In Jordan, the solar energy potential is vast as it lies within the solar belt of the world with average solar radiation fluctuating between 5 and 7 kWh/m2, this means that the potential is not less than 1000 GWh per year because other forms of renewable solar energy are still unexploited in Jordan. Decentralized photovoltaic units in rural and far-off villages are currently used for lighting, water pumping and other social services (1000KW of peak capacity). In addition, about 15% of all households are built with solar water heating systems. [2]

Jordan has major plans for raising the use of solar energy. The Government is hoping to build the first Concentrated Solar Power (CSP) demonstration project in the short to medium term and is considering Aqaba and the south-eastern region for this purpose. It also plans to be a solar desalination.

According to the national strategy, the planned installed capacity will reach 300 megawatts - 600 megawatts (CSP, PV, and hybrid power plants) by 2020. [3]

The main objectives of this project are:

- Provide sustainable power supply to this house.
- Provide clean energy with zero emission recording to environmental analysis.
- Provide quicker energy with quick payback period.
- Provide the total energy required for this residential flat.

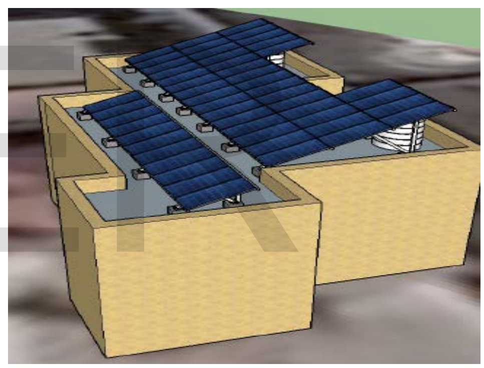

Fig. 1. Solar PV panels installed on building

2 System Description

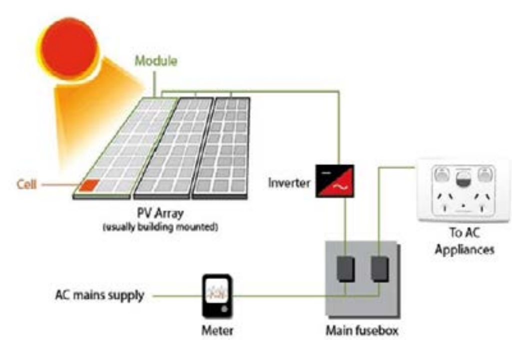

Fig. 2. PV System

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Most modules produce DC electricity, a car battery also provides DC power. When connected to the electrical grid in the city this electricity is converted to AC power supply by the inverter so that it can be used in the inverter so that it can be used in your home or business. AC electricity is the energy required by most electrical devices.

Batteries can be included in network-connected systems to provide backup power, but are mostly used in off-grid systems. Batteries are nice to have, but they add cost to a system and they may require maintenance. In systems connected to the network, there are available inverters that have the power to save standby power but only provide energy when the sun is shining.

Solar PV systems produce the most energy on sunny, summer days where there is little cloud cover and the sun is high in the sky. The largest production occurs when the sun is perpendicular to the surface of the units. This point in time will depend on the angle that the modules were installed at, often the angle of the roof, and the time of day and the time of year.

3 Methodology

The methodology used for this study is designing and appropriate calculations. The site radiation rate, the total number of panels needed, type of inverter required to power the needed panels in other to obtain the calculated energy was considered and calculated for. Load analysis for the residential building was calculated as 25500kWh/year and the result was used in determining the system capacity (12.5kW) for the residential building.

3.1 Load Analysis

TABLE 1
Assumed Appliance Specification and Calculated Power Consumption

APPLIANCE TYPE	NUMBER OF Appliances	OPERATION TYPE(HOURS)	POWER (Wh)
Air conditioner	2X1000W	8	16,000
Water heater	1X1300W	2	2,600
Water pump	1X200W	2	400
Steam Iron	1X1000W	1	1000
Oven or Microwave	1X600	1	600
Washing Machine	1X500	1	500
Light Bulb	22X25W	8	4,400
Total consumption of appliances			25,500

3.2 System Selection

Various systems and materials were used in the design of this project. As seen in Table 4. Aluminum stands were used especially because of its properties, aluminum is a lighter material and there are not prone to corrosion they have long life span. Table 3. Shows the type of inverter used and its specifications, the efficiency of this inverter is 97.7% and have a power rating of 15kW which is enough to power 39 panels as required for this project [4], it is cost effective and thus economical and durable for this project

TABLE 2
Specifications of Jinko PV Panels used for this Project

Jinko brand solar panel	
Power	320Wp Polycrystalline
Country of Origin	China
Dimensions	1956*992*40
Manufactories Warranty	10 years
Production Warranty	25 years
Price	137JD

Fig. 3 Solar Panel

TABLE 3
Specifications of Kostal brand inverter used for this project [5]

Kostal brand Inverter	
Power	15 kW
Country of Origin	Germany
Efficiency	97.7%
Manufacturing Warranty	5 years
Price	2085 JD


Fig. 4 Inverter

TABLE 4

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Fig. 5 Solar panels stands

TABLE 5
OTHER NECESSARY EQUIPMENT USED FOR THE PURPOSE OF THIS PROJECT

Cables Type	AC, DC
Circuit breakers:	Schneider
GS Cable Tray, PVC	
Reinforced concrete	
Materials Transportation	
Component's Installation	

TABLE 6
REQUIRED PARAMETERS FOR THE EXECUTION OF THE PROJECT

Capacity	12.5	kW
Azimuth Angle	28	Degree
Tilt Angle	20	Degree
Performance ratio	81.4%	Percent
Expected monthly generation	26 389	kWh

TABLE 7
YEARLY GLOBAL RADIATION (KWH/M^2) OF VARIOUS COUNTRIES AROUND THE WORLD [4]

City	Yearly global radiation (kWh/m^2)
Amman, Jordan	2080
Berlin, Germany	1000
Paris, France	1038
London, UK	944
Cairo, Egypt	2074
Dubai, UAE	1929
NY, USA	1427
Hong Kong	1371

3.3 Calculation (Mathematical Modelling)

Panel Generation factor (PGF) indicates the maximum watt peak needed to meet the requirement of electricity from solar panels. PGF varies from location and climate, meaning different

The locations may be having different PFG depending on the quality of the solar insolation and the falling radiation on that place. In this case, the PGF of Jordan was measured between the hours of 8 am to 5 pm and compared to other countries as shown in Table…. as thus;

PGF = (solar irradiance(w/m)x sunshine hours)/
(Standard test condition Irradiance)

PGF = (2080 kWhyear)/(1000 W/m^2)
= 2080kWh/kW

1 Watt photovoltaic produce 2080wh/ year, so 25,500 kWh/year want 12.26 kW.

- Total consumption of electricity per day:

(25500kWh/year)/(12 months * 30 days) = 70 833Wh/day

- Number of panel needs for project:

12.26kW/(320 W) = 39 panels

- Required inverter needed for the implementation of this project:

SPP = (Total cost)/(Annual saving) 15kW/320W = 47 panels

As shown in Table 3. 15kW inverter was enough to cover for 39 panels as needed for this project, thus enabling for more economic savings.

$$System\ Capacity = 39\ panels\ x\ 320W = 12.5kW$$

- Total cost of all panels:
  As calculated in Table 2, the cost for each panel is 137JD, for this project, 39 panels were needed.

$$137\ JD \times 39\ panels = 5343\ JD$$

- Total cost of all inverter: only one 15kW inverter was used after proper economic evaluation.

$$2085\ JD \times 1\ inverter = 2085\ JD$$

- Total cost of project: the summation of all required equipment was calculated to show the total cost for this project.

$$Total\ cost = Price\ of\ (Inverters + Panels + Stands + Cable\ and\ Equipment)\ in\ JD$$

$$(5343 + 2085 + 800 + 500) = 8728\ JD$$

4 Economic Analysis

Total electricity generated after the completion of this project was 25500kWh and the total consumption of electricity by the building was 70.833kWh/day.

4.1 Evaluation of Electricity Savings Before and After PV Installation

Note: Electricity tariff is equal 0.09JD per 1kWh.

- Price of bill before project:
  $70.833kWh \times 30\ days \times 0.09 = 191.25\ JD/month$

- Price of bill after project:
  $70.833kWh \times 30\ day \times 0\ JD = 0\ JD/month$

- Benefit of the project
  $191.25\,JD - 0\,JD = 191.25\,JD\,/\,month$

- Annual savings
  $191.25\ JD \times 12 = 2295JD/year$

- Simple payback period (SPP)

$$SPP = (Total\ cost)/(\ Annual\ saving)$$

$$= (8728\ JD\ )/(2295\ JD/year\ ) = 3.8\ years$$

- Net present value (assume: I=12%, N=20)

NPV = Annual value (P/ A * I *N) – present value

$$NPV\ = 2295\ JD\,(7.4694) - 8728\ JD = 8414\ JD$$

- Savings/Investment Ratio (SIR):
  $SIR = (Life\ time\ saving\ )/(\ Cost\ value\ )$
  $SIR = (\ (2295\ JD)(7.4694))/(8728\ JD) = 1.96$

SIR is greater than 1 so the project is cost-effective

5 Environmental Analysis

Every energy generation and transmission method affects the environment. As it is clear conventional generating selections can harm air, climate, water, land and wildlife, landscape, as well as rise the levels of harmful radiation. Renewable Energy are greatly safer offering a solution to many environmental and social problems associated with fossil and nuclear fuels. This residential solar power building makes an environmental difference that level of offset emission.

6 Conclusion

The use of PV for generation of electricity in residential building was accounted for in this project. After proper designing and evaluation, calculations were made using the figures of specified materials to get the SPP simple payback period which is 3.8 years, the NPV net present value *as calculated was* 8414 *JD* and the SIR savings investment ratio was calculated as 1.96. 1 W (PV) → 2080 Wh/year where X → 25500 kWh/year therefore 12.26kW of energy was needed to cover 25500kWh of electricity consumption.
From the calculated result gotten from this project, the following conclusion was reached; this project is effective because the SPP is less than five years, the NPV of this project was greater than zero and the SIR was greater the one which shows that the project was cost effective.

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