Study of the Utilization of PV Technology in Mosques in Jordan: Case study

Nidal M. Hussein
Department of Civil Engineering, Isra University
Amman – Jordan
n.hussein@iu.edu.jo

ABSTRACT

The rising cost of importing energy in Jordan has forced the government to reconsider its energy consumption policies and address the issue of reliance on international energy markets for direct imports. Solar energy in particular carries a very good potential to give an alternative that can help in solving the energy problem in Jordan. In this paper, the economic feasibility of solar projects for civil buildings in Jordan is analyzed. Abu Darweesh mosque's 10KWp solar system is considered and investigated in this study. The analysis shows that for such a project the payback period is less than three years with an annual rate of return of more than 39%.

KEY WORDS: Pv, Solar Energy, Jordan, Feasibility.

1. INTRODUCTION

Jordan faces a serious and complicated challenge in meeting its growing energy demand at a rate of more than 5% annually. Jordan currently imports about 96 per cent of its energy needs costing annually about 20 per cent of the gross domestic product, will not only be able to fulfill its energy needs but will also be capable of exporting energy when a series of energy projects in different areas go operational in 2018. Those projects, among others, include the development of a nuclear power plant and utilizing its good raw Uranium reserve, oil production from its shale oil reserve.

Renewable energy, particularly wind and solar energy, in Jordan offers strong potential for securing a good porting of the country's energy needs. Jordan's recently released energy strategy aim to increase the renewable energy share in the energy mix to 10% by the year 2020 [1]. Solar energy has been used in Jordan to heat water in Jordanian homes and businesses and for off-grid water pumping and as a power sources in communications equipment in remote areas of the country.

Previous experience indicates that in order to make renewable energy program successful, the right policy must be adopted nationally with the right incentives [2][3]. By November 2012, the government of Jordan completed the legal framework to encourage electricity user to use solar energy by installing Photo Voltaic (PV) solar system and connect it to the national grid. Electricity exchange with the grid is regulated by the net metering system. The government aims to make solar energy an important contributor to the country overall energy needs.

Under net energy metering, the customer's electric meter keeps track of how much energy is consumed by the user and how much excess energy is generated by the PV system and sent back into the electric utility grid. Therefore, the customer has to pay only for the net amount of electricity used from the utility over and above the amount of electricity generated by their solar system. Furthermore, the net meter accurately captures energy generated and consumed providing customers with annual performance data.

The site selected for this study is Abu Darweesh mosque one of the most famous and old mosques on top of Jabal Ashfiyyah in the city of Amman, Jordan's capital. It is the first mosque that has installed a PV system to generate electricity that partially covers the mosques electricity needs.

Figure 2: Abu Darweesh mosque.

2. PV SYSTEM AND ITS COMPONENT

PV systems are considered nowadays by many experts as the best technology for generating renewable energy. They utilize sun light for producing electricity using photo-voltaic cells packaged and electrically connected as solar panel (module) which are the basic element of a PV system. They convert solar energy into direct-current (DC) electricity. This technology has proven to be the simplest and most reliable option of electricity generation. The system contains some other main elements such as the PV modules, inventers, AC and DC

cables and a net meter. The electricity produced will be fed into the internal grid in synchronization with the conventional electricity so that the power consumption is complemented by the national grid.

The PV inverter converts the variable direct current (DC) output of the solar panels into a utility frequency alternating current (AC) for grid integration and use with most electrical appliances.

The net meter is a device provided by the electric utility to measure imported and exported power. This special billing arrangement allows customers to credit their accounts at full retail value of the electricity their system generates

Table 1. The PV system components.

	Item	Quantity
1	PV module (250 W)	42
2	Inverter (rated power output 10 KW)	1 set
3	Mounting system	For the whole system
4	Cables & Wires	For the whole system
5	Earthing Protection	For the whole system

Cabling in the yard is carried out as per IE Rules. All other cabling above ground should be suitably mounted on cable trays with proper covers. Only copper wires of appropriate size and of reputed-make have to be used. Cables Ends: All connections are to be made through suitable cable/lug/terminal; crimped properly and with use of Cable glands. Each structure of the PV system is grounded properly.

Solar photovoltaic systems have many advantages that include the following:

- Reducing your electricity bill significantly.
- Paying back your investment in a short period reaching up to less than 3 years depending in your electricity tariff.
- Almost zero cost to maintain and operate your PV system and it has long life extends over 25 year and it is highly reliable.
- Can be used as a shadowing structure.

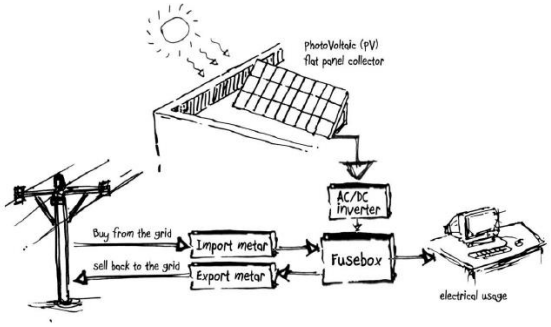

Figure 1: On-grid PV system components.

3. ELECTRICITY CONSUMPTION AND PV SYSTEM SIZE OPTIONS

According to the instruction issued by the Electricity Regulatory Commission, the electricity customer can install a PV system that could cover all its average monthly power consumption over a year. Therefore and in order to decide on the possible and best PV system size, the historical monthly power consumption data is needed.

The Jordan Electric Power Company (JEPCO) and Electricity Regulatory Commission (ERC) set couple of constraints on the possible size of the PV system that can be installed as following:

- The maximum PV system sizes installed in one transformer zone should not exceed 15% of its total power capacity.
- The maximum PV system that can be installed for a 3-phase customer is 11 KWP, unless a technical study is carried out to assess the ability of the grid and transformers to take larger power output from the PV system. The technical study should be conducted by a third party and its cost depends on the initial investigation of the grid and transformer supplying the customer that is carried out by JEPCO. The technical study and application process takes more than 3 months to complete.

Yet in addition to the above constraints, the optimal system size financially and technically will depend on future power needs, the available area to install the PV system, the future electricity tariff and the available finance.

4. POWER YIELD AND MONTHLY SAVINGS

The power output for the selected system is presented and summarized in the table and chart below.

The power output varies from one month to another depending on the values of solar irradiance, hours of sunshine, and climatic conditions including and more importantly temperature.

Table 2. Monthly Power Output and Savings of Abu Darweesh PV System.

Month	Monthly power generated	Monthly
Feb,	1123	292
Mar,	1515	394
Apr,	1851	481
May,	1827	475
Jun,	1796	467
Jul,	1829	475
Aug,	1636	425
Sep,	1363	354
Oct,	1452	378
Nov,	1036	269
Dec,	933	243
Jan,	909	248
Year	1439	375
Total	17269	4502

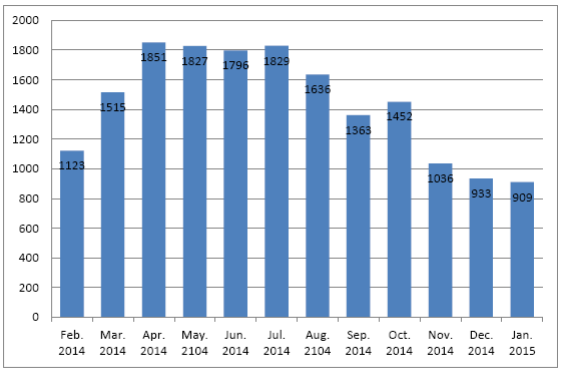

Figure 2: Monthly Power Output Variation of Abu Darweesh PV System in Kw-h

5. FINANCIAL FEASIBILITY

The total cost of PV system under investigation is Jordanian Dinar (JD) 11,500 (1USD=0.7085 JD). This cost covers the cost of the complete PV system components and the installation cost.

The current value of the average monthly power generated during the investigated period based on the current electricity tariff for mosques is 0.273 JD/kw-h (increased from 0.260 JD/kw-h in 2014) is JD 4,502 annually. Therefore, the simple payback period is calculated at 2.6 years. However, the tariff will increase by 33% during the coming two years, which will reduce the payback period to less than 2 years.

6. CONCLUSIONS

The electricity output of Abu Darweesh mosque's 10KWp solar system was investigated as well as the monthly savings of such projects in Jordan. Solar system can annually generate electricity that has a monetary value of about 39.1% of the capital investment needed for such projects in Jordan. It is expected that with the proposed governmental plan of electricity tariff increase that solar systems will become more attractive to consumers in Jordan.

7. REFERENCES

[1] Ministry of energy and mineral recourses of Jordan, (2007), "Updated Master Strategy of Energy Sector in Jordan for the period (2007-2020).

[2] L. Mundaca and J. Luth Richter (2015), "Assessing 'green energy economy' stimulus packages: Evidence from the U.S. programs targeting renewable energy", Renewable and Sustainable Energy Reviews, 42, 1174–1186.

[3] E.R. Frederiks et al. (2015), "Household energy use: Applying behavioural economics to understand consumer decision-making and behavior", Renewable and Sustainable Energy Reviews, 41, 1385–1394.