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Examining the Economic Impact of Renewable Energy in Green Buildings: A Case Study of Jordan

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ABSTRACT

This paper aims at testing whether an increase in energy spending has placed a negative or positive impact on the Jordanian economy. Following the economic scale theory and the results of model simulation, we reached to a conclusion that such level of growth in public spending threatens the next generations living in Jordan, as the gap between produced energy and the total energy used. The question is how to shrink this energy gap, or even eliminate it. The paper contributes to bridging such gap by suggesting an increase in the production of domestic energy which depends on what resources Jordan has and whether these resources are renewable or fossil as well as the economic feasibility of using such resources. The influential use is related to social awareness as well as to the supports that are given by government regulations. The paper concludes that it is about time to reduce the amount of support needed by residential energy users in order to invest in other energy projects such as hydroelectric, wind, or large solar farms.

Keywords: Renewable Energy, Green Building, Energy Spending, Jordan

JEL Classifications: O13, Q43, Q48, Q51, Q56

1. INTRODUCTION

The three aspects of sustainability (environmental, social equity, and economic) have come to form the foundation of how human beings have interacted with our surroundings. The first and most obvious component of sustainability is the environmental component, which is the basis on which the other two components are built. The value of any environmental resource would depend on its existing conditions. For example, the value of a litter of potable drinking water is much higher in a water-scarce country such as Jordan, than the value of the same litter of drinking water in a water-rich country such as the Netherlands, (Ekins, 2011). Therefore, assigning a reliable value to the impact of human activities on the environment requires sufficient knowledge of the full effect of those activities. This is difficult in most cases, as the effects may not be fully realized for a long time, as in the case of nuclear accidents and disasters.

Due to the difficulty in tracking many types of energy used in today's urban environment, and the limited availability of statistical data, the analysis was confined to electrical power consumption. Considering residential power use, it was found that several factors account for the continuous increase in energy use. The economic factors that drive electrical energy demand are income and price. The income is reflected by the Gross Domestic Product of a nation where the demand is expected to increase with the growth of the economy. Heating, Ventilation, and Cooling (HVAC) is the largest user in the residential sector of energy, (Momani, 2013). To meet the increase in demand, governments and industry are always devising new, more efficient ways to produce energy. The most common method of generating electricity today is fossil fuels, in the form of natural gas, coal, and oil. The other major category of energy production is renewable energy. It is an important aspect of sustainability because reducing the amount of energy used is not enough to meet future energy demands. This is because the resources available to us today, are not likely to be

there tomorrow, thus alternative ways of producing energy must be found, (Minzhen, 2012; Sustainable Urban Energy, 2012).

The rapid growth in renewable energy has to be supported across society by all sectors, industrial, governmental, civilian masses, commercial institutions such as banks, and most importantly, research powerhouses providing innovations to fuel this growth. This support can be seen in cities and communities that are already integrating their existing resources and activities into a more efficient and economically profitable model.

2. REVIEW OF LITERATURE

The capability of a building to save energy apart from thermodynamic and heat retention qualities of materials depend on its shape, orientation, the layout of transparent envelopes, size, the facade colour, and the measures of protection from the sun, (Givoni, 1981). Parasonis et al. (2012) stated that the building shape manipulation changes its energy use-value, even though the physical characteristics of the envelopes stay unchanged. The most important benefit of green building to our environment is not only to reduce the environment negative impact using less water or energy but by generating their own energy or increasing biodiversity, (World Green Building Council, 2019). There are four economic benefits for the use of the green building, which are less energy usage, more jobs, lower operating costs, and a stronger economy, (Atalian Global Service, 2019).

Residential energy use accounts for a significant portion of total energy use, which makes it a great place to start curbing energy consumption and encouraging sustainable initiatives, (Sustainable Urban Energy, 2012). The first step to integrate energy-saving products and practices into the design is to enact and enforce legislation that will give the end-user an incentive to place sustainability as the very foundation of building design. Unfortunately, in most countries, lack of legislation and weak enforcement has led to an absence of significant progress in sustainable design, (Iwaro and Mwashia, 2010; Deringer et al., 2004). These issues are also emphasized in recent studies, (Gou et al., 2013; Jayantha and Man, 2013; Matisoff et al., 2016; Shad et al., 2017; Uğur and Leblebici, 2018). Over the last decades, the idea of Zero Energy Building (ZEB) has acquired much international awareness and it represents now the master future target for the new building design, (Ferrante, 2012).

Since Jordan is a Mediterranean country, the findings in this study relate to the issues facing the advancement of sustainable practices quite well. The recent practices in the construction of the building housing sector show finite signs of change. This is particularly true within the context of the Mediterranean climate, where mild winter and hot summer conditions, together with different social and economic factors, determine a sort of opposition to the deeper penetration of ZEB principles into building construction practices.

3. METHODOLOGY AND DATA

3.1. Methodology

The software used to run all simulation in this study is PVSYS, which is able to import metadata from several sources, as well as

from the custom data. The end-user can also purchase a support contract that allows the system to be updated with the latest atmospheric data and online customer support in case the user needs any assistance.

This power production limits equal to the amount of energy the end-user consumes. In addition, it is assumed that the system will be designed, built, and installed by a single procurement agency providing a turnkey solution. Local regulations and standards will be followed. String inverters will be used to maximize output from the modules and to mitigate the risk of any one of the modules being down for maintenance or shaded at any given time. A monitoring system will be installed to allow the residents access to the following key parameters of the system:

1. Continuously monitors the solar power system
2. Automatically reports system status via email
3. Records, stores and presents power and PV system performance data
4. Exports stored data for evaluation using standard formats
5. Performs system diagnostics and configurations locally or remotely using a computer
6. Automatically transfers data to a web portal at selectable intervals
7. Displays customized PV performance visualizations to the user
8. Collects weather data, including solar irradiation, module and ambient temperatures.

The following minimum information shall be displayed, and recorded for later retrieval by the monitoring system, which is: grid voltage, grid frequency, generated system voltage, generated system frequency, earth fault and insulation monitoring condition, inverter unit failure indication, and operational status indication. A weather station will be attached to the system to record performance relative to weather conditions; it will monitor the ambient air temperature, module temperature, and incident solar irradiation in the tilt of the array using an irradiation sensor. This is in addition to other assumptions related to the performance and system warranty, such as:

1. No near shading objects around the site
2. Energy calculation is based on Alternating Current output from the inverter
3. Annual global horizontal irradiation is assumed to be 2.088 kW-h/m². Any variation will proportionally change the system performance
4. The system is always clean with no assumed soiling losses
5. Operations and maintenance procedure is followed with no system downtime
6. No shutdown or downtime
7. Projected monthly-generated energy is calculated based on the proposed design and the weather data using PVSYS software
8. National Aeronautics and Space Administration (NASA) weather data records are used to calculate monthly-generated energy for 25 years
9. The projected generated values included in the table are for the 1st year only, and the values are expected to degrade by a percentage of 0.8% for each year.

3.2. Data

The case study conducted is for an actual residence in Amman. First, to determine what type of system and sub-components will be required, a pattern must be drawn of the annual residential energy consumption. In this case study, a system with a nominal power of 3.5kW system was chosen. Since the manufacturer provides the nominal power of each module, all that is needed would be to install enough modules in order to provide 3.5kW. The next factor will be the expected amount of power that the system will produce by giving its location on earth relative to the sun.

4. RESULTS AND DISCUSSION

At this stage, the study has obtained the irradiance and nominal system power; the next step would be to translate the amount of power produced into financial terms. This can be done by simply finding the tariff applied for a particular month, given that the tariff changes depending on the consumption bracket the end-user falls into (Table 1).

This tariff is then multiplied by the amount of energy produced. The result is a monetary value relating directly to the monthly savings.

If a PV system was not installed, the monthly bill of April only would be 105.79 JOD. This simple calculation is based on taking the month of April consumption, which is 649 kW h and multiplies it by a cost of 0.163 JOD/kW-h. However, since the PV system produced 528 kW-h in April, we multiply the production figure by the same tariff applied above in this study, which represents the minimum tariff; the result is a savings value of 86.06 JOD.

The payback period for a 3.5 kW-h system studied in this work will be approximately 9 years, as shown in Figure 1 below where the two lines representing the time value of the system and the value of the power produced intersect.

This is slightly higher than the number used by the company providing the system, because this study used a lower tariff from the weighted average of the monthly tariffs, as opposed to the most commonly used tariff, and used a time value of money approach to account for inflation at 3.5%, as shown in Table 2.

However, if a time value approach is used to account for inflation and an 8% bank loan, the project is no longer feasible, as inflation,

interest on the bank loan, and cell degradation will make it hard to pay back the initial cost of the system. This is why the two lines representing the system cost and the value of the power produced in Figure 2 do not intersect.

The theoretical case study conducted is for a residence in western Amman. First, to determine what type of system and sub-components will be required, a pattern must be drawn of the annual residential energy consumption.

However, since this is a theoretical system, there are no records to draw a pattern from, so the study assumed a constant energy use. While it is certainly unrealistic that the energy consumption would be unaffected by the seasons month after month, in this case, the goal is to simply use the high consumptions figures to showcase its effect on payback periods and use the total annual expected energy use to apply for a system installation permit from the local grid owner.

In this case, a system with a nominal power of 10 kW systems was chosen, as shown in Figure 3. Since the manufacturer provides the nominal power of each module, all that is needed would be to install enough modules to provide 10 kW. The next step after obtaining the irradiance and nominal system power is to translate the amount of power produced into financial terms. This can be done by simply finding the tariff applied for a particular month,

Figure 1: 3.5 kW-h system feasibility checks

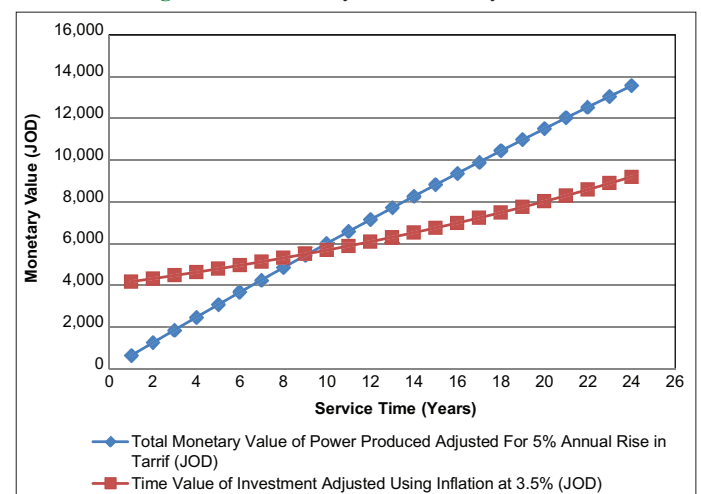


Table 2: Value of adjusted investment using 3.5% inflation

Years in service	Value of investment adjusted using inflation at 3.5% (JOD)
1	4165.875
2	4311.680
3	4462.589
4	4618.780
5	4780.437
6	4947.752
7	5120.924
8	5300.156
9	5485.661
10	5677.660
11	5876.378
12	6082.051

Table 1: Tariff in JOD paid every month of the year

Month	Tariffs paid per month (JOD)
January	0.086
February	0.114
March	0.114
April	0.163
May	0.114
June	0.114
July	0.086
August	0.086
September	0.086
October	0.086
November	0.086
December	0.086

Figure 2: 3.5 kW-h system unfeasibility

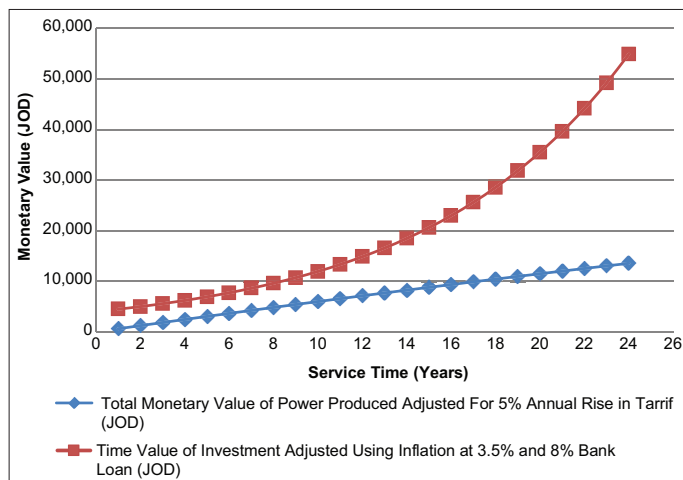
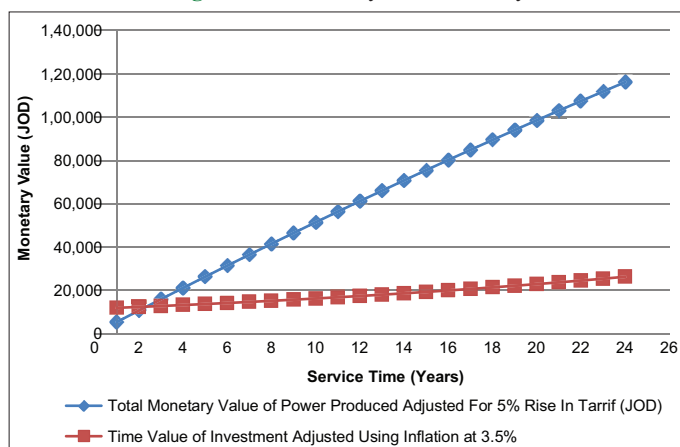


Figure 3: 10 kW-h system feasibility

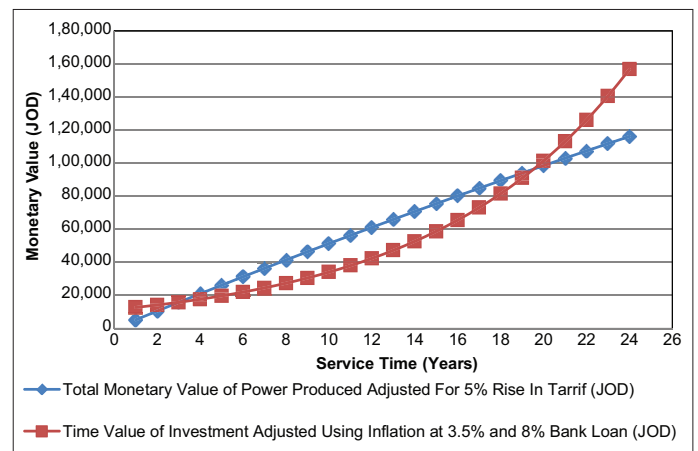


given that the tariff changes depending on the consumption bracket the end-user falls into from the billing information obtained online from the local energy provider. This tariff is then multiplied by the amount of energy produced. The result is a monetary value which relates directly to the monthly savings. For example, if we take the month of April, consumption is 1575.38 kW-h, at a cost of 0.271 JOD/kW-h. If a PV system was not installed, the monthly bill would be 426.93 JOD. However, since the PV system produced 1170 kW-h in April, we multiply the production figure by the same tariff applied above; the result is a savings value of 463.1 JOD. This is a unique situation, in that we have a positive net gain in the power produced, thus, the system produced a financial gain of 463.1 JOD less 426.93 JOD, totalling 36.17 JOD.

It should be noted that the increase in the value of tariffs will increase the value of the power produced as well, as they are proportionally linked. The payback period for a 10 kW-h system was found to be approximately 2.5 years, as shown in the Figure 3 below where the two lines representing the time value of the system and the value of the power produced intersect. This is slightly higher than the 2.3 years' figure given by the company providing the system, because this study used a time value approach to account for inflation, without requiring external financing in the form of a loan.

If the external financing through a bank loan of 8% taking into account, then the payback period will be approximately 3 years.

Figure 4: 10 kW-hour system unfeasibility



However, Figure 4 shows that there are two points of intercept between the 3-year mark and the 20-year mark. The area below the line no. 1, representing the monetary value of the power produced, marks a grace the period when the system is producing power at a rate that can cover the loan. If any circumstances prevent the loan from being paid back during this period, when the system has been in operation for more than 20 years, the exponential increase in the cost of the loan will defeat the incentive of building the system in the first place.

5. CONCLUSIONS

In the past few years' significant progress has been made in the adoption of the alternative energy system on the industrial scale. This has been supported through government subsidies, tax credits, and business incentives. The gap that exists in the support offered to high energy users or producers and the support offered to relatively low energy use residential entities has delayed the adoption of alternative energy generation. The Jordanian government already subsidizes electrical power for a large number for residential users. This is a shortsighted approach as it is not taking into account the draining effect this has on the national budget and does nothing to mitigate the eventual rise in the national energy bill as energy demand increases. An intelligent approach would be to follow in the footsteps of developed nations and start enabling partial energy independence of the most highly subsidized users by cooperating with the commercial sector.

This approach would reduce the amount of support needed by residential energy users, thus freeing up national funds to invest in other energy projects, such as wind farms, hydroelectric, and large scale solar farms. These alternative sources of renewable energy are underutilized in Jordan but could provide homegrown energy to mitigate global instability in oil and gas prices.

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