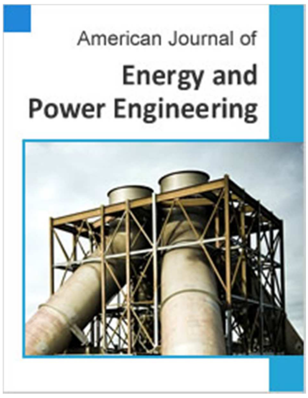
American Journal of Energy and Power Engineering
2017; 4(6): 67-70
http://www.aascit.org/journal/ajepe
ISSN: 2375-3897

American Association for Science and Technology



A Non-Subsidized Economic Model for a Business Solar Energy System

Jacob Gargir

Department of Industrial Engineering, Shenkar College, Ramat Gan, Israel

Email address
gargir.jake@gmail.com

Citation
Jacob Gargir. A Non-Subsidized Economic Model for a Business Solar Energy System. *American Journal of Energy and Power Engineering.* Vol. 4, No. 6, 2017, pp. 67-70.

Keywords
Major Factors Affecting Economic Models,
For Non-Subsidized Businesses,
Investing in Solar Energy Systems,
Research in Israel Energy Network

Received: July 15, 2017
Accepted: November 1, 2017
Published: November 16, 2017

Abstract
The article examines new developments in the Climate Conference in Paris. It also reviews changes in the institutional policies in Israel on solar energy systems. Key factors for a profitable model of a solar energy system are examined: cost of the initial investment, geographical location & sun utilization, the placement of solar system, price of electricity and the firm's cost of capital. A 50 Kwh capacity for a business solar system is examined with full details of the investment components. Calculations include: reduction of panel efficiency, inflation, cost of capital, taxes, charges, and tax savings on loan's interest. The result is a project that provide investors with a profitable 33% return on the investment, without any governmental or municipal subsidies.

1. Introduction

Approximately 10 years ago, advocates of solar energy systems had to resort to issues of global warming and greenhouse gas emissions to motivate investors. Investments were not profitable and governments had to offer subsidies and other incentives. Today solar energy systems are profitable projects and entice many investors.

For several years there has been a steady decline in the costs of panels, the efficiency of systems has increased, and these projects have become very desirable without subsidies.

This article deals with a non-subsidized project of a solar energy system for a business in Israel. It investigates the factors that affect a successful economic model.

While such projects are still required to endure much government and municipal bureaucracy, the result is gratifying. The solar energy growth trend has become irreversible and its benefits are more than just financial feasibility.

In collaboration with Nevo Potok whose Master's Degree theses the author supersized.

2. Acknowledgment of Global Warming & National Commitments

Global warming caused by Greenhouse Gas Emissions was brought to public awareness since the Climate Conference in Kyoto, Japan. In 2011, research results showed that China and the USA alone produced 44% of world emissions (28% and 16% accordingly) [1]. However, it was only in December 2015, in the Climate Conference in Paris France, that China and the USA finally acknowledged their responsibilities, and signed the agreement.

After deliberations, all 195 participants agreed that collectively the rise in temperature would be limited to 2.7 degrees Celsius until 2100. There is no specific schedule for the short run, and there are no set objectives for individual countries. [2]

3. Institutional Policies in Israel on Solar Energy Systems

In 2009, the Israeli government offered economic subsidies, issued tenders to build solar farms and invested in improving the electric grid. Investors in solar energy were promised an income of 53.15 ¢ for every kilowatt they entered into the grid for a period of 20 years. This was a generous subsidy when the costs of solar systems were still high. Since 2009 the subsidies for new investors continued to shrink as the price of solar panels was reduced.

Private producers of electricity from solar energy use the output for their own use, however any excess production that flows into the grid costs the producer 2.64 ¢ for every Kw.

In a survey of 200 municipalities, only 5% of households producing electricity from solar systems were taxed for this activity [3].

4. Key Factors for a Profitable Model of a Solar Energy System

a. Cost of the Initial Investment & Technological Developments

Research and development is taking place in several aspects of solar systems, such as: panel efficiency, electricity storage, exposure time to the sun and maintenance systems. Leading the innovations are universities and research institutions mainly in the USA, China, Germany and Israel.

Some interesting developments based on the inclusion of receptors in raw materials have been used to build structures and produce electricity. Examples can be found in the use of thin sheets covering greenhouses [4], glass sheets as the sides of office buildings and skyscrapers and solar roof tiles [5].

The inevitable conclusion from this research and development is that the future cost of solar systems is in a downward slope, which will lead to more profitability.

b. Geographical Location & Sun Utilization

The efficiency of a solar system depends on two major factors: 1. The panels' angle of exposure to the sun. 2. The geographical location of the solar system.

To improve efficiency, the solar panels' surface should be placed perpendicularly to the sun's rays for as many hours of the day as possible. Some sophisticated systems have been developed with rotating panels that follow the rays of the sun. This article is based on a fixed panel position.

The duration of sunshine hours is different for a given location on the globe. Clear skies, isolation, dry areas, and high pressure systems are major factors affecting the sunshine values. In dry areas in the subtropical latitudes between 25° to 40° north/south, the highest sunshine values exist [6] – [8].

This research is based in central Israel, 32° north, having 1,650 yearly average hours of sunshine. Many locations such as Copenhagen, London, Berlin, Paris, Rome, Moscow, Beijing, and Mumbai, have an equal or greater number of sunshine hours per year [9].

As the hours of sunshine per year increases, efficiency of the solar system improves and profitability rises.

c. Placement of Solar System: Roof-Tops versus Land

The cost of purchasing or leasing land can reduce the viability of solar system projects dramatically. Businesses that have roof-tops can use them for the placement of solar panels. This study is based on a roof-top solar system.

d. Price of Electricity

Price of electricity directly affects the business's savings from the alternative use of solar energy. Prices of electricity vary widely from country to country and in some cases from city to city. For example, in the USA the price in Louisiana is 8.37 ¢/Kwh, in New York 17.62 ¢/Kwh, and in Hawaii 37.34 ¢/Kwh. The prices of electricity are relatively high in Europe (as high as 33 ¢/Kwh in Denmark) and lower in the region of North Africa (Egypt 8.7 ¢/Kwh & Saudi Arabia 4 ¢/Kwh). In Russia, China and India prices are subsidized in specific areas of the country [10]- [12].

As the electricity rates rise, savings from solar systems are greater.

e. *Firm's Cost of Capital.*

The net future cash flow of savings on electricity is being discounted at the rate of the cost of capital. A higher cost of capital for the business shows a lower profitability for the project.

5. Specifications, Costs & Assumptions for This Business Solar System

a. Technical Specifications & Assumptions for a 50 Kwh capacity system

1. Panels' life = 24 years.
2. Converter's life = 12 years. A second converter will be purchased after year 12.
3. Solar System output = 50 Kwh.
4. The system will required 800m² of roof-top structures.
5. Location - central Israel (latitude - 32°04'51" N; longitude - 34°46'50" E).
6. Exposure to sun hours = 1,650 hours/year.
7. Reduction of Panel efficiency = 0.2%/ year.
8. Firm's Cost of Capital = 8%
9. Price per 1 Kilowatt-hour (including VAT) = 14.23 ¢/Kwh.
10. Self-Consumption = 80,000 Kwh/year.
11. Tax on income from electric output above self-consumption is 25%.
12. Tax Savings - Interest on loan is tax deductible. A 45% tax rate will result in a tax savings of 45% on the yearly sum of interest.
13. Electric Company charges for the use of its grid on excess output = 2.64 ¢/Kwh.
14. Maintenance costs include: periodic cleaning of panels, periodic check-ups on electronics & construction, monitoring mishaps.

b. Initial Investment

Table 1. *Initial Investment for a Solar System - 50 Kwh capacity.*

Item	Model	Guaranty	Cost (US $)
Solar Panels	Poly Scott Germany 245 w	25 years	39,159
2 Voltage Converters	Solar edge 5000TL	12 years	*10,338
Electric Counter			264
Storage Element	Solan Deep Cycle Battery		**2,591
Construction & Installation***			18,186
Total Initial investment			70,538

* The first converter costs $6,875. A second converter is needed at the end of the 12^{th} year.
Its price adjusted for a 2% increase due to inflation/year (to the end of the 12^{th} year), and then discounted at 8% cost of capital, is equal to a present value (PV) of $3,463. Total PV is $10,338.
** The battery was added as a storage element of electricity for emergencies. It is an essential item especially in rural areas with no connection to the electric grid. A similar calculation for the converters was done for the purchase of six batteries. The first battery cost $708. One battery is purchased every four years over the 24 year life span of the project. The price of the each of the remaining batteries is adjusted for inflation of 2%/year and the adjusted price is then discounted at 8% cost of capital. The total PV of the six batteries is equal to $2,591.
*** Installation costs include: shipping & customs duties, architectural & electric plans, installation of the electric system, construction, connecting the converters to the internet, receiving permits from the electric company and the municipality.

c. Annual Costs

There are no additional costs for producing the energy but there are costs of maintenance and insurance. Maintenance costs are $1,980/year; Insurance costs are $1,060/year. Total annual costs = $3,040/year.

6. Savings and Profitability

a. Annual Savings

Electric production per year - Given 1,650 hours/year of sun and efficiency reduction in output of 0.2%/year, the yearly production of electricity can be shown as a declining geometric series.

a. Electric production for the first year: 1,650 hours/year X 50 Kwh = 82,500 Kwh.
b. Annual Savings for the first year: F1 = 82,500 Kwh x $0.1423 cost/ Kwh = $11,740.- The Present Value (PV) of a 24 year geometric series, declining at 0.2%/year, discounted at 8% cost of capital = $121,652 (see attachment)
c. The Equivalent Yearly savings on electricity (Financial Calculator): PV = $121,652; I = 8%; N = 24; CMT PMT = $11,554 per year
d. The Equivalent Yearly electric production:

$$\frac{11{,}554\ \$/\text{year}}{0.1423\$/\text{Kwh}} = 81{,}195\ \text{Kwh/year}$$

Tax Savings –Interest on the loan (4%) is tax deductible.

a. The size of the loan is 80% of the initial investment ($70,538) and equals $56,430. The loan is for 24 years.
b. The interest is on the declining balance, so the interest declines from year to year.
c. Each yearly interest is discounted to the Present Value (PV), with the cost of capital (8%), and then summed up for 24 years.
d. The sum of the Present Values of interest is $29,995.
e. The Total Present Value of Tax Savings is equal to the sum of the PV of the interest multiplied by the tax rate (45%) = $29,995 X 0.45 = $13,498.
f. Finally the equivalent tax savings/year is: PV = $13,498; I = 8%; N = 24; CPT PMT = $1,282.

Income from excess capacity

a. The Equivalent Yearly electric production calculated is 81,195 Kwh.
b. Self-Consumption is 80,000 Kwh/year.
c. Excess yearly capacity = 81,195 - 80,000 = 1,195 Kwh/year.
d. On the excess capacity, the Electric Company charges 0.0264 $/Kwh, and on the net income there is a government tax of 25%. Therefore the after tax Income per Kwh from excess capacity is: (0.1423 $/Kwh – 0.0264 $/Kwh) x (1 - 0.25) = 0.0869 $/Kwh.
e. Total yearly after tax income from excess capacity is: 0.08.69 $/Kwh x (81,195 – 80,000) = 104 $/year

Table 2. *Summary of Annual Savings.*

Source of Savings	Amount/year US ($)
Savings on Electricity	11,554
Tax savings on interest on loan	1,282
Net income - excess capacity	104
Total Yearly Savings	12,940

b. Profitability of the above proposed solar system

a. Total Initial investment = $70,538.
b. Bank loan (80% of investment) = $56,430.
c. Yearly equivalent payment on the loan (principle + interest): PV = $56,430; I = 4%; N = 24; CMT PMT = $3,701.
d. Net cash outlay at the time of investment (investment minus loan): $70,538 - $56,430 = $14,108.
e. Net yearly cash flow Annual savings *minus* annual costs *minus* annual payment on the loan $12,940 - $3,040 - $3,701 = $6,199.
f. Internal Rate of Return (IRR) on the investment: PV = -$14,108; N = 24; PMT = $6,199; CMT I = *IRR = 33%/year*

A yearly return of 33% on the investment is a very profitable project.

7. Conclusions

It was shown that an investment in solar systems is very profitable for businesses, even without government subsidies. It is difficult to find projects where investors get a yearly return of 33% on their invested capital. In order to achieve such a viable investment several factors must be considered: a. Location and sunshine hours/year, b. Available roof-top area, c. Price of electricity, d. Cost of capital, e. Interest on loans & tax rates, and f. Cost of initial investment. Governments and municipalities will also reap benefits without having to subsidize such projects. They can save on energy costs, reduce dependency on outside energy sources, and improve the quality of life of their residents. The entire world will enjoy reduced Greenhouse gas emissions, improved health because of cleaner air and world funds can be reassigned to undeveloped countries to reduce hunger and illness.

Recommendations

A non-subsidized economic model for a business solar energy system should include the following factors' characteristics: *1. Location and sunshine hours per year* - 1,600 sunshine hours per year or more are needed. Many locations around the globe meet this requirement. South-West USA, North Africa, Southern China and many more areas having 2,700 to 3,600 sunshine hours per year will experience a dramatic rise in the profitability of their investment. *2. Roof-top area* –Where land is expensive the system will require roof-top surfaces. The following are possible business applications: a. Agricultural structures - barns, hen houses, hothouses, warehouses. b. Public structures - government offices, hospitals, schools, prisons. c. Business structures - manufacturing, office buildings, commercial centers, covered parking lots. *3. Price of electricity* - Higher price of electricity will improve profitability. It is reasonable to say that for a standard project a price of 14 ¢/Kwh or higher will contribute to a profitable project. *4. Cost of capital* – This varies from firm to firm. Discounting the savings with higher cost of capital will show lower profitability. This research used 8% which is reasonable for today's lower interest rates. 5. *Interest on loans & tax rates*. Tax savings are available in countries where interest on loans is lower than the cost of capital. The greater this difference and the greater the tax rate of the firm, the higher the profitability. *6. Cost of initial investment* – Costs of panels have been reduced considerably in the past 10 years. With present costs this project has shown very high returns on the investment. Considering the research in solar systems and its fast developments, costs are constantly being reduced leading to higher profitability in the future.

A final recommendation is for governments and municipalities to reduce the red tape on their regulations. This would reduce businessmen's apprehension and encourage the investments in solar energy systems.

Appendix

Calculating the Present Value (PV) of a declining geometric series when: Value at year 1 = F1 = \$11,740; g = 0.2% = -.002; I = 8% = 0.08; n = 24

$$PV = \frac{F_1\left[\left(\frac{1+g}{1+i}\right)^n - 1\right]}{g-i} = \frac{11{,}740\left[\left(\frac{1-0.002}{1+0.08}\right)^{24} - 1\right]}{-0.002-0.08} = \$121{,}652$$

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