Economic evaluation on the use of polycrystalline PV installations in Cyprus

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Abstract

The objective of this work is to evaluate the Current and the New Subsidisation schemes which are applied in Cyprus by simulating a series of different scenarios for grid-connected polycrystalline PV system applications in both seaside and inland locations. This is done in order to have a more realistic and specific view on which option gives the most economically profitable benefits for each case. More specifically, the locations considered are that of the cities of Pafos, Larnaca and Nicosia and the examined installations' power are 5, 20 and 150 kW. The simulation procedure was carried out using PVSyst® which is a well known design software for PV systems. The results of the simulation procedure show some very useful conclusions concerning the option which is more profitable and economically viable. Finally, the results can be easily used for the preliminary evaluation of PV system investments by taking into consideration the current price of the PV system.

1. Introduction

Cyprus lies in the outskirts of the sunny belt in south eastern Mediterranean Sea with an average annual solar potential on a flat horizontal surface of around 1790 kWh/m^2. Thus, the solar energy potential is rather high which implies that its utilization is promising. One way solar energy can be harnessed successfully is by using photovoltaic (PV) panels. For this purpose and in order to promote the creation of PV installations with a power between 21-150 kW the Ministry of Commerce, Industry and Tourism of the Republic of Cyprus developed a New Subsidisation scheme which is in effect from July 2009. This Subsidisation scheme mainly concerns the creation of PV parks with a generating capacity between 21-150 kW only for individuals and organisations who exercise economic activity in contrast to the Current Subsidisation scheme, which concerns PV systems with a maximum generating capacity up to 20 kW. Also, the number of PV parks to be built under this scheme until 2015 is limited to 2 MW per year.

Photovoltaic (PV) panels are solid-state devices that convert sunlight, the most abundant energy source on the planet, directly into electricity without intervening heat engine or rotating equipment. PV equipment has no moving parts and as a result requires minimal maintenance and has a long life. It generates electricity without producing emissions of greenhouse or any other gases and its operation is virtually silent. Photovoltaic systems can be built in virtually any size, which range from milliwatt to megawatt and the systems are modular, i.e., more panels can be easily added to increase output. Photovoltaic systems are highly reliable and require little maintenance.

In the early days of photovoltaics, about 50 years ago, the energy required to produce a PV panel was more than the energy the panel could produce during its lifetime. During the last decade however, due to improvements in the efficiency of the panels and manufacturing methods, the pay-back times were reduced to 3-5 years depending on the sunshine available at the installation site. Today the cost of photovoltaics is around 2.5 US$ per watt peak and the target is to reduce it in the order of 1 US$/watt peak by 2020.

The PV panel is the principle building block of a PV system and any number of panels can be connected together to give the desired electrical output. This modular structure is a considerable advantage of the PV system, where further panels can be added to an existing system as required. Photovoltaic (PV) devices, or cells, are used to convert solar radiation directly into electricity. Photovoltaic (PV) cells are made of various semiconductors, which are materials that are only moderately good conductors of electricity. The materials most commonly used are silicon (Si) and compounds of cadmium sulphide (CdS), cuprous sulphide (Cu2S), and gallium arsenide (GaAs). These cells are packed into modules which produce a specific voltage and current when illuminated. A comprehensive review of cell and module technologies is given by Kazmerski [1]. PV modules can be connected in series or in parallel to produce larger voltages or currents. PV systems rely on sunlight, have no moving parts, are modular to match power requirements on any scale, are reliable and have a long life. Photovoltaic systems can be used independently or in conjunction with other electrical power sources.

Applications powered by PV systems include communications (both on earth and in space), remote power, remote monitoring, lighting, water pumping and battery charging. The global installed capacity of photovoltaics at the end of 2002 was near 2 GWp [2].

Basically there are two types of systems; stand-alone and grid connected. Stand-alone PV systems are used in areas that are not easily accessible or have no access to mains electricity. A stand-alone system is independent of the electricity grid, with the energy produced normally being stored in batteries. A typical stand-alone system would consist of a PV module or modules, batteries and charge controller. An inverter may also be included in the system to convert the direct current (dc) generated by the PV modules to the alternating current form (ac) required by normal appliances.

Nowadays it is usual practice to connect PV systems to the local electricity network. This is called a grid connected system and means that during the day, the electricity generated by the PV system can either be used immediately (which is normal for systems installed in offices, other commercial buildings and industrial applications), or can be sold to an electricity supply company (which is more common for domestic systems where the occupier may be out during the day). In the evening, when the solar system is unable to provide the electricity required, power can be bought back from the network. In effect, the grid is acting as an energy storage system, which means that the PV system does not need to include battery storage, and this creates savings in initial expenditure and maintenance requirements.

Despite their high cost, photovoltaic systems are cost-effective in many areas which are remote from utility grids, especially where the supply of power from conventional sources is impractical or costly. For grid-connected distributed systems, the actual value of photovoltaic electricity can be high because this electricity is produced during periods of peak demand, thereby reducing the need for costly extra conventional capacity to cover the peak demand. Additionally, PV electricity is close to the sites where it is consumed, thereby reducing transmission and distribution losses thus increasing system reliability.

The objective of this paper is to evaluate the Current and the New subsidisation schemes of Cyprus for grid-connected PV systems of different capacities, using polycrystalline PVs, and investigate the most economically profitable option for three possible locations both seaside and inland.

2. Current and New Subsidisation Scheme

The Current subsidisation scheme for grid-connected applications in Cyprus, which is in effect since February 2008, concerns PV systems with a maximum generating capacity of 20kW, has a duration of 15 years and is divided into two categories depending whether or not the applicant exercises economic activity. In the first category, one can choose from two options, either to:

- Apply for a subsidisation grand of 55% of the total initial investment (not exceeding a maximum amount of €65,000) and supply the produced energy to the grid at a price of 0.225 €/kWh for 15 years, or
- Apply for a subsidisation grand of 0% and supply the produced energy to the grid for purchasing at a price of 0.383 €/kWh for 15 years.

In this category the percentage subsidisation covers 55% or 0% of the actual cost of the installation before VAT is added on the total price plus the 15% VAT.

In the second category, there is only one option which is to apply for a subsidisation grand of 40% of the total initial investment (not exceeding a maximum amount of €48,000) and supply the produced energy to the grid at a price of 0.205 €/kWh for 15 years. In this category the percentage subsidisation covers 40% of the actual installation cost before VAT is added on the total price. The 15% VAT is returned to the individual or the organisation.

There is also a New Subsidization scheme that was approved by the EU in July 2009. This scheme works supplementarily to the Current one while having several important differences, and applies only to individuals and organisations who exercise economic activity. The differences are:

- It has a duration of 20 years instead of 15,
- It gives a new option, for ≤20kW installations, to individuals or organisations who exercise economic activity to apply for a subsidisation grand of 0% and supply the produced energy to the grid for purchasing at a price of 0.36 €/kWh and
- Finally, it gives the option to build larger PV systems with a generating capacity between 21-150 kW where the subsidisation is 0% and the produced energy is supplied to the grid for a price of 0.34 €/kWh.

Table 1. Current and New Subsidisation Scheme

Current Subsidisation Scheme					
Subsidisation Schemes	Maximum PV power [kW]	Subsidy [%]	Maximum Subsidy [€]	Price of energy [€/kWh]	Duration [years]
1st Scheme	20	55	65,000	0.225	15
	20	0	-	0.383	15
2nd Scheme	20	40	48,000	0.205	15
New Subsidisation Scheme					
-	20	40	48,000	0.205	20
	20	0	-	0.36	20
	21-150	0	-	0.34	20

3. Input data and assumptions

Both the Current and New subsidization schemes, are evaluated for three different generating capacities for application in the cities of Pafos and Larnaca, which represent typical seaside climatological conditions and Nicosia which represents typical inland climatological conditions. The power generating capacities that are examined are those of 5, 20 and 150 kW. Additionally, it should be stated that during the simulation process the invested money are considered to be fully given by the investor and there is no loan taken. The type of PVs used during the simulation process is polycrystalline photovoltaic panels manufactured by Photowatt® with the following main characteristics maximum power P_{max}= 175 ± 5 W, open circuit voltage V_{oc}= 43.4 V and short circuit current I_{sc}= 5.3 A

4. Simulation procedure

The software used for the simulation procedure and analysis is PVSyst® V4.33 which is a widely known design tool for photovoltaic system applications. PVSyst® is a PC software package used for the simulation, data analysis and design of complete PV systems. It is suitable for grid-connected, stand-alone and DC-grid (public transport) systems, and offers an extensive meteorological and PV-components database.

The PVSyst® meteorological database (monthly values) is based on the METEONORM. Also, the software gives the opportunity to easily import meteorological data from multiple popular sources (NASA, WRDC, PVGIS, RetScreen, Helioclim).

Simulations are performed using hourly meteorological data files. In the absence of measured values, PVSyst® generates synthetic hourly data based on monthly values of irradiation and temperature, using well-established models which reproduce realistic distributions.

5. Results and discussion

After the completion of the simulation process the results were recorded for both Current and New subsidization schemes. These results include the payback period in years, which is calculated using the simple payback period method, and the money income per year which represents the financial income because of the use of the system per year).

As it can be seen in Fig. 1 the city with the highest total energy produced per year, according to PVSyst®, is that of Larnaca with Pafos coming second and Nicosia last. The decreasing trend observed in this figure is due to the annual reduction on the performance of the PVs which is 2.5% for the first year and 0.45% on a per year basis.

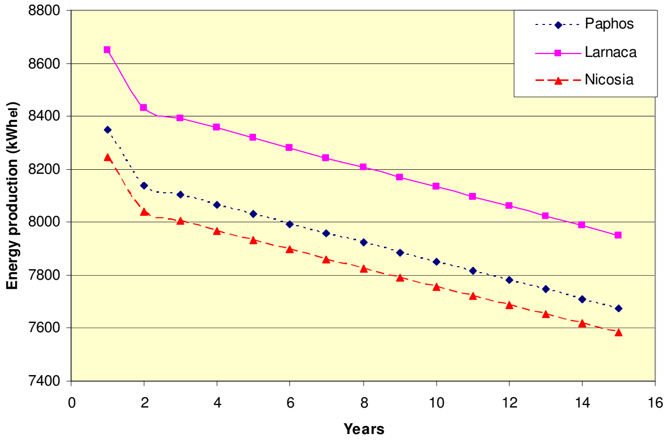

Fig. 1. Energy production per year of a 5 kWp system for a period of 15 years for all three locations examined

By using the data of the simulation process two graphical presentations were plotted for all three locations examined and for all possible subsidisation options for a 5 kW system. More specifically, these graphical representations concern the total money income per year and the simple pay back period. Due to the fact that the trend observed in these figures is also followed in the case of the 20 kW system it is decided not to present the figures for this system to conserve space.

In Fig. 2 we can observe that the options without any initial subsidisation grant benefit, for both applicants that exercise and do not exercise economic activity, have much higher income per year (41%) than those using the initial subsidisation grant benefit. Also, another important observation is that the options for applicants that do not exercise economic activity have higher monetary income per year (6%) than those who do, due to the higher tariff paid for the produced electricity.

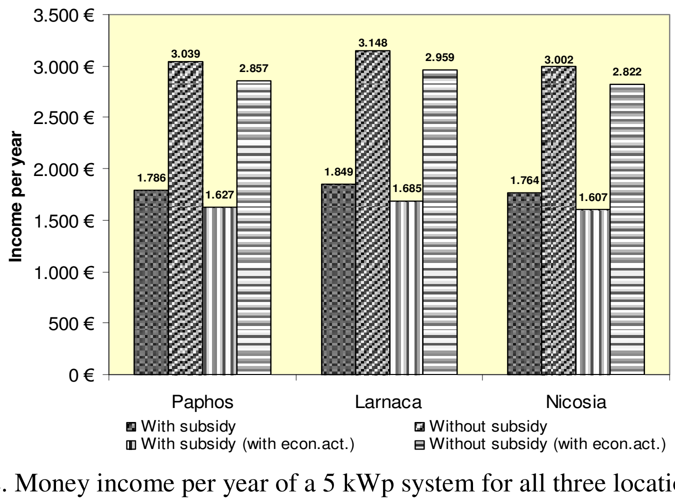

Fig. 2. Money income per year of a 5 kWp system for all three locations examined

In Fig. 3 the pay back period is graphically presented. It can be observed that for the cases of applicants that do not exercise economic activity the option without initial subsidization grant benefit as it is obvious it has higher pay back period (12%) due to the higher initial investment. As for the cases of applicants who exercise economic activity the results are rather contradictory with. More specifically, the pay back period for the option with initial subsidization grant benefit is lower than the one without initial subsidization grant benefit. This happens due to the fact that the price of the produced electricity is lower than the one given to applicants that do not exercise economic activity (0.36 € instead of 0.383 €) and also due to the exclusion of the taxes (~3000 €) for the applicants that exercise economic activity.

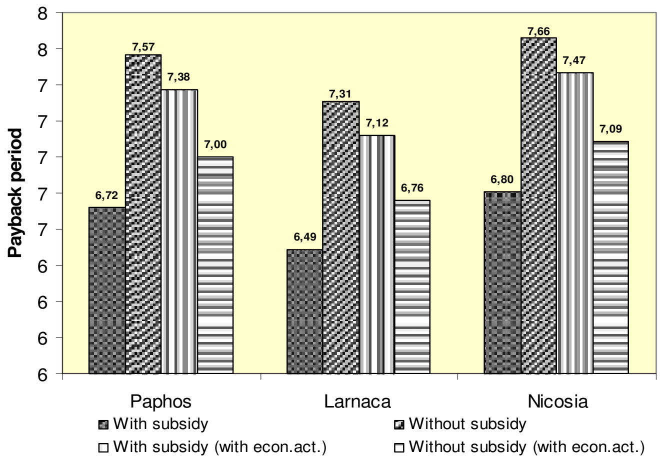

Fig. 3. Pay back period of a 5 kWp system for all three locations examined

Concerning the New subsidization scheme as aforementioned the main differences with the Current one is that it has a duration of 20 years instead of 15 and the fact that it gives another option to individuals or organisations who exercise economic activity to apply for an initial subsidisation grant of 0% and supply the produced energy to the grid for purchasing at the rate of 0.36 €/kWh and finally it gives the option to build up PV systems with a generating capacity between 21-150 kW, apply for an initial subsidisation grant of 0% and supply the produced energy to the grid for purchasing at the rate of 0.34 €/kWh.

It is proved above that the option of not benefiting from the initial subsidisation grant and sell the produced electricity at a higher price is more profitable. This trend which is followed for the case of the 5 kW system is representative for all the other systems of different capacities. It is worth noticing that the same option which is also given in the New Subsidisation scheme for PV systems up to 20 kW concerning individuals who exercise economic activity, is much more profitable.

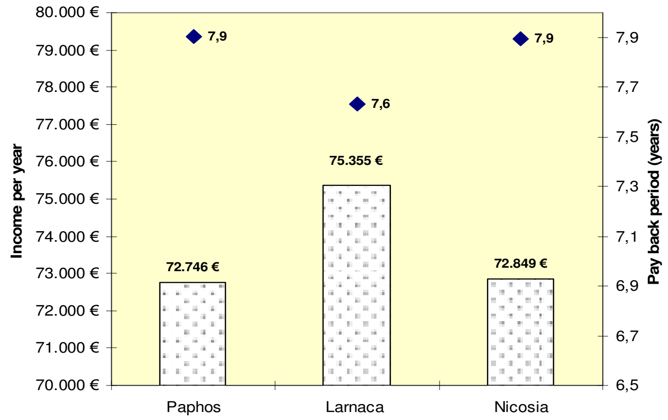

Fig. 4. Money income per year and pay back period of a 150 kWp system for all three locations examined

Finally, in Fig. 4 the single option for a 150 kW PV system is illustrated in terms of both total money income per year and pay back period for all three locations examined. As it can be observed the range of the monetary income per year for all locations is between 72-76.000 € while the pay back period is between 7.6-7.9 years. It is worth noticing that the cost of such a system in Cyprus is roughly around 575.000 € while it depends on a number of different parameters such as the current price of the systems components and the site specific modifications required and characteristics.

6. Conclusions

The simulation results indicate that the energy production by using PV system is slightly higher on seaside locations like the cities of Larnaca and Pafos than in inland locations like the city of Nicosia. As for the current subsidisation scheme, concerning private households and other non-profit organisations that do not exercise economic activity, it occurs that the best option is the one without a subsidisation grant taken and to supply the produced energy to the grid for purchasing at a price of 0.383 €/kWh for 15 years.

Additionally, concerning the New Subsidisation scheme the option offered for generating capacities of up to 20 kW is much more profitable than the one offered by the Current one. The option of building up PV systems of 21-150 kW generating capacities is rather promising and it is believed that the results of this action would be very beneficial for the energy mixture of Cyprus.

References

[1] Kazmerski L. 1997. Photovoltaics: a review of cells and module technologies, Renewable and Sustainable Energy Reviews. Vol. 1, No. 1-2, pp. 71-170.

[2] Lysen E., 2003. Photovoltaics: an outlook for the 21st century, Renewable Energy World, Vol. 6, No. 1, pp. 43-53.