FINANCIAL ANALYSIS OF GRID CONNECTED PHOTOVOLTAIC SYSTEMS IN GREECE, TOWARDS A NATIONAL PV ROOF PROGRAMME

S. Tselepis
Centre for Renewable Energy Sources,
19th km. Marathonos Ave., GR-190 09, Pikermi, Greece,
Tel. +301 6039 900, Fax +301 6039 905
E-mail: stselep@cres.gr

ABSTRACT: This paper presents the financial analysis and the estimated costs and benefits for the introduction of grid connected photovoltaic systems in Greece in the residential sector. Suggestions are proposed for a support framework for more effective introduction of grid connected PV systems in Greece and possibly to lay the foundation for the required assistance for a suitable national PV roof programme.

A typical demand profile for residential users in Greece, derived by measuring a number of households through the course of a SAVE project, is used in order to assess the benefits for the users of a PV system given the current support scheme.
Keywords: Grid-Connected - 1: Economic Analysis - 2: Funding and Incentives - 3

1. INTRODUCTION

The financial analysis and the estimated costs and benefits for the introduction of grid connected photovoltaic systems in Greece in the residential sector are discussed and presented. Suggestions are proposed for a support framework for more effective introduction of grid connected PV systems in Greece and possibly to lay the foundation for the required assistance for a suitable national PV roof programme.

At present, the only available incentive offered to individuals, to install photovoltaic systems, permits the deduction of 75% of the purchase and installation cost of RES systems from the taxpayer's annual taxable income. This measure is important only when the individual is taxed in the higher tax brackets of 30 to 42.5%. For those tax brackets, there is a PV system cost reduction of 22 to 31.88%, respectively. Although this measure is welcome, it does not provide a fair incentive as it is dependent on the taxable income bracket and therefore the compensation is not significant enough for lower and middle-income taxpayers in Greece. In any case, the associated PV system cost reduction with respect to equivalent programmes that promote RE System introduction is generally considered low and certainly does not make the investment into a PV system viable.

By introducing economic, technical and meteorological parameters to the developed spreadsheet, useful financial information is provided for the evaluation of an investment, such as the annual time-series of savings and payments (cash-flow) by the PV system user, the pay back time, the internal rate of return etc.

Successful national PV support programmes from other European countries were used as a guideline to propose a viable PV support scheme in Greece. The PV support scheme has to provide a framework that returns within a reasonable period of time the private investment cost plus a premium. As the lifetime of PV systems is over 20 years, the net present value of the investment has to be positive before a 20-year period.

GRID CONNECTION ISSUES

Until recently, the framework for RES electricity production in Greece was regulated by Law 2244/94 and the associated presidential decree [1]. In December 1999, a new law 2773/99 was introduced in Greece in order to setup and regulate the appropriate authorities, with respect to the liberalisation of the electricity market and changed in part the previous law. Since February 19, 2001, the Greek government has opened the competition for the first 28% of the electricity market. There is also pressure from the E.C. to move faster into a fully liberalised electricity market for all resources.

TABLE I: Payback tariffs for grid-connected PV systems.

			APs Energy ayback tari per kWh, in Drachma (in Euro)	**IPs** Energy ayback tari per kWh, in Drachma (in Euro)
utonomou sland Grid	Energy (all Voltages)		19,85 (0,05826)	25,52 (0,07491)
Main land system	Low Voltag 220/38(	nerg	19,85 (0,05826)	---
	Med. Voltage	nerg	20,65 (0,06059)	16,06 (0,04712)
		Cap-acity	---	530 X 0.5
	High Voltage	eak zone	10,49 (0,03077)	20,65 (0,06059)
		Med zone	7,27 (0,02132)	20,65 (0,06059)
		Low zone	5,39 (0,01582)	20,65 (0,06059)
		Capa-city (peak zone)	---	530 X 0.5

A 30% opening of the electricity market means an annual market of approximately 1 billion Euro, with this year's electricity consumption. The eligible customers for this market portion are those that consume annually more than 100GWh.

Regarding the status of RES, since 1994 it is permitted in Greece to produce RES electricity and selling it to the grid. The auto-producers (AP) of electricity from RES, as it is the case of individuals with rooftop PV systems, are not required to obtain a license either for installation or operation or electricity production, if the RES electricity generating system has a capacity up to 20kWp. The latter is also true for the independent producers (IP) with installed power under 20

kWp. During the connection with the public electricity grid, the installation is checked according to guidelines of PPC for grid connection of Autoproducers (those who generate electricity to cover for their own consumption and sell only their surplus energy, if any). The guideline documents are concerned with the measurement of power and safety measures (phase asymmetry issues, operation limits of voltage and frequency).
The electricity payback tariffs in Table I, are valid since July 1st 2001 for the grid-connected RES systems in the low voltage.
For the time being, the surplus energy of small grid connected systems (under 20 kWp) is always absorbed by the grid, as there is not yet any provision by the regulatory authority to control their injection to the grid.

EUROPEAN SUBSIDY PROGRAMME EXPERIENCE

Germany was the first European nation to implement a successful PV roof top subsidy programme, starting with the 1000 PV roof and moving on to the 100.000 PV roof programme. These programmes have made Germany a leader in Europe in terms of installed PV power as well as helped the PV system industry in the country. The German programme has succeeded because it made the investment in a PV system economically feasible and viable over a period shorter than the system's lifetime.
The support from the German PV roof programme has two objectives: first, to create a favourable environment for the initial cash flow requirements by providing an attractive loan and secondly to subsidise the electricity produced by the PV system, forcing the owner to care for it in the long run. The German support model was proved over 10 years to be effective in supporting the dissemination of PV systems and other RES technologies. Other efforts made form other countries without a framework to subsidise the electricity injected into the grid have failed to stimulate the market. In the last years, a few European countries have applied variations of the German approach with good results. In all cases, it is important to make sure that the investment is viable over a reasonable time with respect to the lifetime of the PV system.
The support rate for the initial investment cost and the buyback tariffs may be changed to account for local meteorological and other different system conditions.

ECONOMIC ANALYSIS

The PV support scheme has to provide a framework that returns, within a reasonable period of time the private investment with an added premium. As the lifetime of PV systems is over 20 years, the net present value of the investment has to be positive before a 20-year period.
For a private investor (the auto-producer), the cost-effectiveness of a PV system depends on the annual avoidance cost of electricity, the credit from the electricity sold to the public grid, the initial investment cost and its financing, and finally the cost of operation and maintenance.
Various economic indices can be used to valorise an investment in a RES system. The methods usually used for the economic analysis and evaluation of an energy system are:
- **The life cycle costs method (LCC)**. The sum of all the costs and benefits of the system over its lifetime. The rate used for the cost of money is the de-inflated one (interest rate minus the inflation rate taken as a constant value).
- **Net Present Value (NPV) method**. The net present value of an investment based on a discount rate and a series of future payments (negative values) and income (positive values). When the NPV becomes positive for a certain interest rate, within the lifetime of the system, then the investment is considered viable.
- **Internal Rate of return (IRR) method**. The rate of return of a series of cash flows. Within each cash flow the profits and benefits were accounted. The decision rule for this method is to accept such an investment, if the IRR exceeds the required rate of return.
- **Discounted Payback period (DPB) method**. The time it takes for the total costs minus the monetary benefits to be paid for the system and the funds that could be acquired from investment of such an amount.

The life cycle costing method is the most complete analysis and it is explicit in the flow of payments, presenting the burden that the private investors are facing. Each analysis method makes its own statement to a potential investor.

Assumptions underlying the investment evaluation:
The evaluation period of the system is considered for 25 years starting in 2001.
1. Electricity prices and thus payback tariff are increased by 2% every year.
2. The interest rate for personal saving accounts is to assumed to be 4%.
3. The discount interest rate is taken as the savings account rate minus the inflation rate.
4. The cost of the PV system installed, is taken to 2.800.000 Dra/kWp including 18% VAT (8217.17 Euro/kWp).
5. Maintenance and incidental operating costs are taken as 0.1% of the system cost, without counting the subsidy, every year.
6. The AC electric energy produced annually is taken to be 1485 kWh/kWp.

The model developed can be parameterised for: the interest rate, discount rate, electricity produced per year, percentage of the produced electricity fed into the grid, using a loan for part of the investment, the subsidy rate and the rate of electricity buyback tariff.

In the economic analysis the following cases (scenarios) are compared:

1. the current electricity buyback policy and support frame for private investors (taxable income reduction – income dependent).
2. initial investment subsidy of 50% and existing electricity buyback policy.
3. initial investment subsidy of 70% and existing electricity buyback policy.
4. initial investment subsidy of 50% and 85 Dra/kWh for each kWh injected into the grid.

In figures 1 to 4, the ecomonic analysis with 3 different methods is presented.

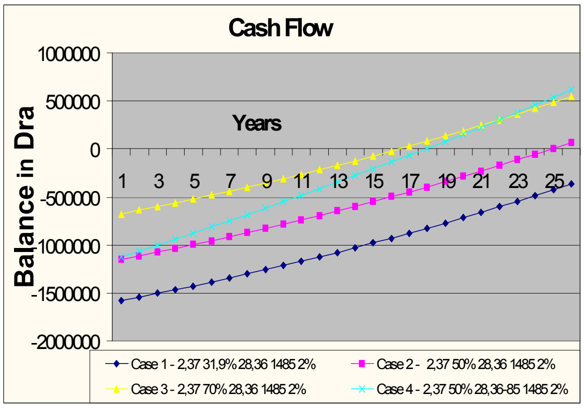

Figure 1: The cash flow versus the PV system lifetime.

The investor starts with a large negative flow, which is the initial system cost minus the subsidy, if there is one, and gradually, depending on the case, the balance becomes positive.

The frame inside figures 1 to 4 present for each of the 4 cases (scenarios) the following:

- the initial investment (here in million Dra per kWp),
- the subsidy rate,
- the electricity tariff,
- the AC electricity in kWh, produced annually per kWp and
- the discount rate.

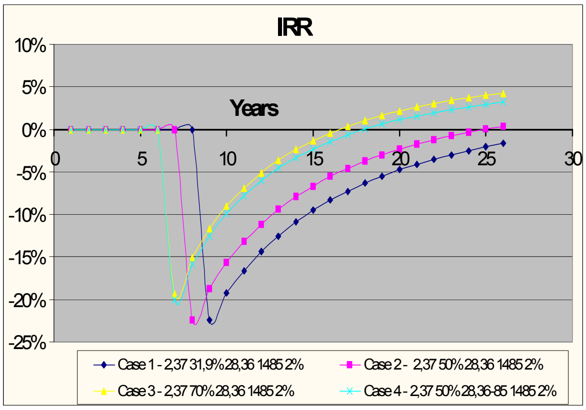

Figure 2: The Internal Rate of Return versus the PV system lifetime.

It is obvious that cases number 1 and 2 are not viable as investment as the IRR never becomes positive during the lifetime of the PV system, which may be taken to be about 25 years. Case #1 is the present situation and it represents the worse possible scenario.

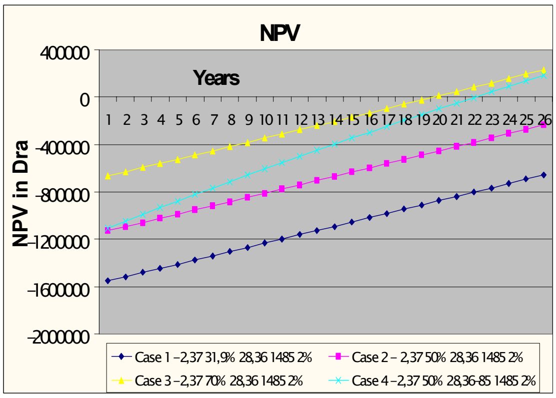

Figure 3: The Net Present value versus the PV system lifetime. Even for case #4, which by all economic analysis methods is the most profitable, it takes almost 16 years before the balance becomes positive for the investor.

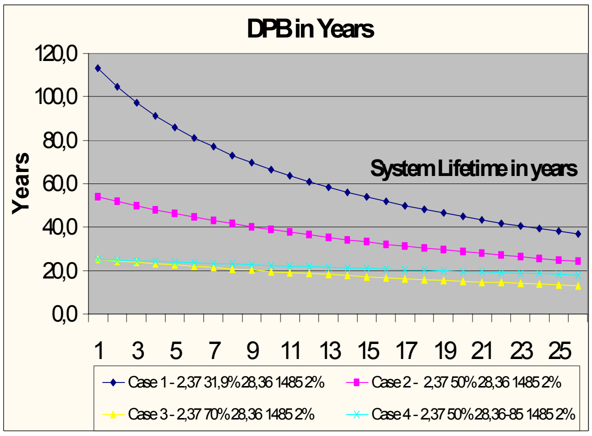

Figure 4: The Discounted Pay Back period versus the PV system lifetime.

In all of the above cases, the electricity produced is assumed to be consumed in the house, except for case 4, where 30% of the produced electricity is injected into the grid with the buyback price of 85 Dra/kWh (0,2494 Euro/kWh). Therefore, for cases 1 to 3, the local electricity consumption represents the best scenario, which may be the real situation (see figure 5).

In any case, it is important to keep the system running in good order because the investment performance depends on the production of electricity.

MAXIMUM BENEFITS FOR THE USER

A typical demand profile for residential users in Greece was derived by measuring a number of households through the course of a SAVE project (Short title: EURECO, Title: Energy Savings by using efficient end user appliances in the residential sector, XVII/4.1031/2/98-267 [1998]). These profiles are used in order to assess the benefits for the users of a PV system given the current and future support scheme in Greece with the intention to suggest a more effective one. In figure 5, two extreme profiles, the average daily consumption of 10 households and the daily average output of a 1 kWp PV system are presented.

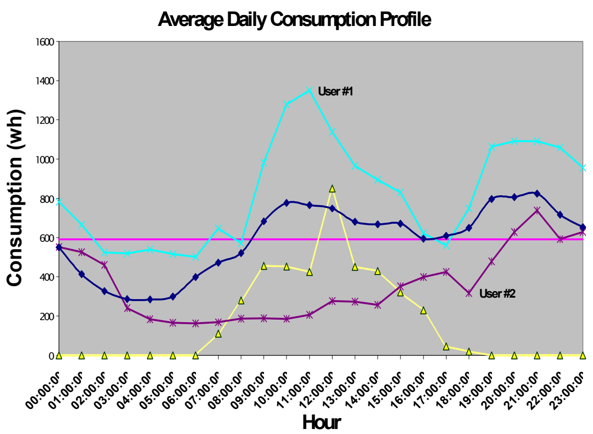

Figure 5: An average daily consumption profile of selected households in Athens.

It was found that the average consumption per resident per hour was 0,15 kWh (varying between 0,075 and 0,3 kWh per hour). By comparing the the electricity produced by a 1 kWp PV system to the presented consumption profiles, we arrive at the following observations: user #1 (see figure 5) is consuming locally all the electricity produced by a PV system, saving a corresponding amount. User #2 is consuming about 56% of the electricity locally, and is injecting 44% to the grid. These very different consumption profiles create a dramatically different situation regarding the cost effectiveness of the PV system in relation to a potential support framework.

Therefore it is concluded, that the economic viability of a PV system depends on its size and also on the consumption profile of the user. In many cases, a smaller PV system is more affordable and economically viable for a user.

CONCLUSIONS

The economic analysis provided for the viability of grid connected PV systems, examines the existing support framework in Greece. By simulating other possibilities of support measures, it gives a measure of the viability of the support actions and the related effect on viability for the user. The developed analysis can also provide an estimate of the cost for a National programme by summing up the contribution of the state for the support measures.

Finally, the user consumption profile is also important in determining the size and the maximum benefit for the investor and user.

REFERENCES

[1] S. Tselepis, "PV support and promotion mechanisms in Greece", Proceedings of 2nd World PV Conference in Vienna, Austria, July 1998, p.3352-3355.