THE CURRENT STATE OF THE PV MARKET, THE IMPACT OF THE PV FEED-IN TARIFF ON THE ELECTRICITY PRICES IN GREECE

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ABSTRACT: An overview of the status of the developing PV market in Greece will be presented, in terms of applications to the Regulatory Energy Authority (RAE) and PV systems installed and connected to the grid. As the penetration of PV systems in the Greek electricity market is going to increase to over 800 MWp by the year 2015 the feed-in tariff contribution collected from the electricity consumers will allegedly increase substantially. An attempt is made for reasonable assumptions according to the international experience and along the lines of the national reports and binding targets of RES introduction in the following years in Greece. The real value of the PV electricity produced is assessed and the cost–benefit balance is calculated for the large introduction of PV systems until 2020. The economic impact on the average Hellenic household depends on the Feed-in tariff, the cost of electricity production in the country and the PV system cost evolution. The special RES charge is calculated and conclusions will be drawn. Keywords: PV Market, Funding and Incentives, Economic Analysis

1 INTRODUCTION

A new Hellenic Law 3468/2006 for the promotion of RES electricity production was passed in June 2006. The law foresees a Photovoltaic program for the introduction of PV systems in Greece that will be ending on the 31.12.2020 for a total installed capacity of at least 640 MWp in the interconnected electrical system and at least 200 MWp in the autonomous island systems. The PV electricity produced will be sold to the electric system operator between 40,282 and 50.282 € cent/kWh (2007 prices) depending on the size and the location of the PV system. Such a support scheme is attractive for the introduction of larger PV systems by companies.

Table I: The number and total power capacity of the applications submitted for the interconnected system.

PV system power category	No Applications	Applications in MWp	Planned to be licensed until 2010MWp
>20KWp and ≤ 150KWp	**6,647**	**714.646**	**159.490**
>150KWp and <2MWp	**1,004**	**1,217.039**	**147.980**
≥ 2MWp	**296**	**1,824.900**	**147.480**
TOTAL	**7,947**	**3,756.585**	**504.950**

The support measures are not as appealing to private persons, as the private PV system owner is considered an auto-producer able to sell up to 20% of the annually produced electric energy. For private PV system owners there is a tax rebate of up to 700 Euro. On the other hand, the option fro private persons to establish a business to sell electricity for small PV systems, <10kWp, is not profitable. In Table 1, the number and the total equivalent power of applications submitted to he Regulatory Energy Authority (RAE, www.rae.gr) as of April 2008 are summarised, when the application procedure was postponed by RAE, for all PV power system categories above 20 kWp, due to the large number of applications. The planned power shown in the third column is according the announcement of RAE for the distribution of PV capacity in the different PV system categories.

A study on the penetration level of PV and small wind generators based capacity on non-interconnected islands has been completed and the results were announced by RAE. The penetration level from PV on each island is a function of the conventional generation installed capacity, the annual load profile and the prediction of the demand in the coming years. Particularly for PV, the results indicated that in Crete, the cap is 52.50MWp while for the remaining island regions in the north and the south Aegean Sea, the overall capacity was determined at 46.76MWp. Thus the total PV potential for non-interconnected islands was calculated to be 99.26MWp.

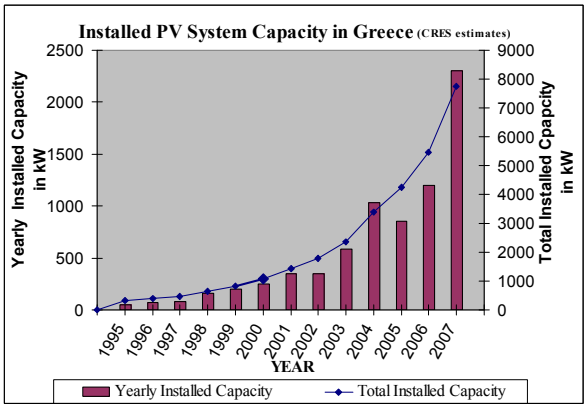

Figure 1: Yearly installed and total PV capacity in Greece according to CRES's estimates.

Additionally, the maximum allowed capacity per project is 150kWp. RAE announced in the summer of 2007 a call for application submissions for PV systems, in the non-interconnected islands that was closed in September 2007. In the following months a new call for applications will follow from RAE for the interconnected islands, such as the Ionian islands and Evia.

The annual installed capacity of Photovoltaic systems in Greece before the new law, excluding demonstration programs and research projects, did not exceed 200 to 300 kWp. Figure 1, presents the installed capacity of PV systems in Greece until 2007 according to the estimates of CRES. Last year the installed PV system capacity was raised by 2.3 MWp, half of it coming from grid-connected PV systems due to the law 3468/2006. This year (2008), we expect an additional installed and connected capacity anywhere between 5 to 10 MWp, mostly in grid-connected PV systems. Our estimates for the year 2009 are running between 20 and 80 MWp.

2 THE COST-BENEFIT RELATION

In the recent months, there is a public debate going on regarding the viability of the Hellenic PV system support program (Law 3468/2006). It is claimed that with the introduction of PV systems to the grid the Feed-in Tariff (FiT) will increase significantly as well as the electricity cost per household in Greece. As it is known the extra funds needed to pay for the electricity production from renewables (RES) and specifically for PV, are collected from all the electricity consumers according to their consumption through the "special RES charge". At this time, with about 900 MW of RES (mainly wind parks) connected to the Hellenic system the charge for the consumers is 0.30 €/MWh. This charge may be adjusted to account for the different mix of renewables. For the time being, the cost for electricity production from PV is more expensive. But this is exactly the reason that PV are supported, in order to increase the PV capacity and thus PV system production and this in turn will reduce the PV system cost and the Photovoltaic kWh produced.

It is very important in the following months to clarify that the electricity sale contract will be valid for at least 20 years in order for the investors to have a clear picture for their investment. It is noted that currently the PV system projects may also apply for a capital support (up to 40%) through the Investment law of the Ministry of Economics. After the initial introduction of the PV program (up until 2010), it is suggested, for the new PV installations, to formulate a new support scheme based only of Feed-in Tariff and make it attractive also for private persons and building PV installations. The Feed-in Tariff will be adjusted on a yearly basis according to the international PV system price reduction and the maturity of the Hellenic PV market. Below the results of a study conducted for the years 2007 to 2020, are presented taking into account the national goal set by the proposed EU directive {COM(2008) 30 final} on promoting renewable energy, to help achieve the greenhouse gas emissions targets. The hypotheses of the study are presented in figures 2 to 4. In Figure 2, the estimated yearly and cumulative introduction profiles of PV systems are presented. The RES charge per kWh consumed for the average Hellenic households is calculated for the introduction of 2400 MWp of PV systems and 6000 MW of wind parks by the year 2020.

For the study, it was accepted that the Feed-in Tariff will be increased, as it was already done by RAE in 2007, at 0.7% per year until the year 2020. From the year 2010 and on, the FiT will be decreased by 5% per year because of the PV market maturity. The average annual electricity production from PV systems in Greece is taken at 1300 kWh/kWp. The average PV system cost at 2007 is taken 6000 €/kWp and it is decreased to 2250 €/kWp in 2020. The annual consumption of electric energy in Greece is taken 64 TWh, for the starting year (2007) and is increased at +3% per year. The production of photovoltaic electricity has a number of advantages that should be evaluated and be included for the assessment of the cost-benefit estimation. The average annual high System Marginal Price (SMP) is taken as the cost of electricity generation that is replaced by PV. This is due to the fact that PV systems inject electricity at medium and high value periods of the day. The current average high SMP is around 90 €/MWh. In the calculations, the SMP is increased 5% annually. The "external" cost of electricity production was calculated during the European program ExternE (2001) to be 30-80 €/MWh [1] for the Hellenic electricity production mix. For this study the benefit from the "external" cost from the PV production is taken 80 €/MWh constant for the all time period. One of the supplementary benefits of PV system installations is the reduction of losses in transmission and distribution, as well as the shift of the investments of infrastructure reinforcement and upgrade, as the distributed PV systems contribute in the reduction of the electricity traffic in the electric system. A study in California (in 2005) indicated that the added value of photovoltaic systems due to the reduction of losses and the postponement of conventional investments amounts to about 60-170 €/MWh [2]. A study completed by RAE in Greece concluded that only for the new additional power generation equipment, the cost amounted to 37-75 €/MWh. It was recently announced by the President of the Hellenic Transmission System Operator (DESMIE) [3] that in order that consumers be served without the danger of black-out during the highest demand hours (the number of the highest demand hours are estimated to be about 40 annually), new infrastructure is required in order to support the Transmission and Distribution grids (in terms of new lines and cables, transformers, compensation capacitors and in provisions of protection, telemetry and tele-control, etc.). The cost for the upgrade amounts to 1.062 €/MWh for the high demand period. For this study the avoidance cost of additional infrastructure is taken 80 €/MWh, constant for the period 2007-2020. According to the Public Power Corporation (PPC) [4] the cost of transport and distribution of electric energy in Greece in the Low Voltage grid, which is avoided by distributed PV systems, is evaluated at 26 €/MWh. Since January 1, 2005, the European Commission has put in effect the EU Emissions Trading Scheme for CO2. The current prices in the European market for the medium-term price is around 20 to 25 €/tn of CO2. According to the "Guide for Energy Investments of The Ministry of Development, July 2005, in page 75, a forecast is presented, where the average emissions of CO2 of the Hellenic electricity production mix in 2015, will be 0.85 kg/kWh, which is translated to 17 €/MWh, taken constant over the whole duration of the study. The uncertainty of the cost of purchase of rights of CO2 is so large that there no point to make an effort for a better approximation. In the beginning of 2008, Deutsche bank increased the forecast for the price of one ton of CO2 to 40 €/tn, from 35 €, which is well above the current price of roughly 25 €. For 2020, it is estimated that the price of one ton of CO2 will exceed 67 €/tn. For the needs of the study the cost of purchase of CO2 rights is increased progressively between 2007 and 2020, from 20 to 70 €/tn CO2 (or 60

€/MWh).

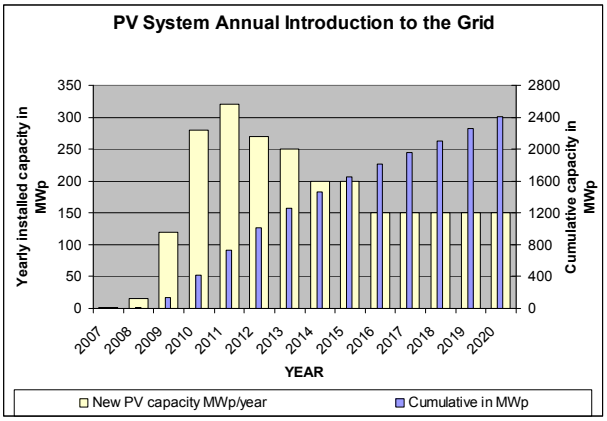

Figure 2: Yearly installed and cumulative PV capacity in Greece for the study scenario.

Finally, the net cost of production of PV electricity for the society is calculated on an annual basis, in the following way. From the Feed-in Tariff the following values are subtracted: the average annual high System Marginal Price (SMP), the "external" cost (EC), the additional infrastructure avoidance cost (IFC), the cost of transport and distribution of electricity (TDC) and the income that results from the sale of CO2 rights (CRC). In the figures 3 and 4, presented below, the variation of all parameters, are indicated on a yearly basis. One additional important parameter is the yearly introduction capacity of the PV systems in the electric network (Figure 2).

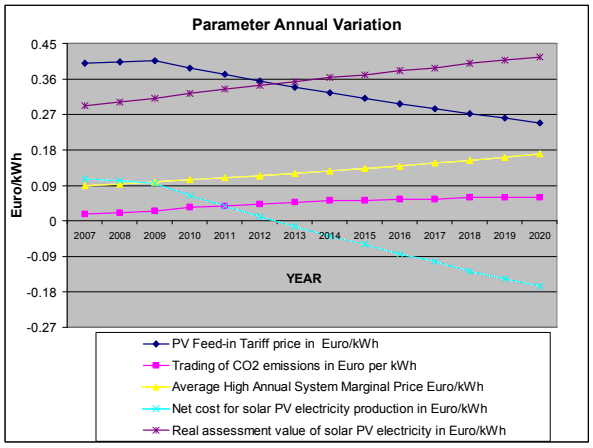

Figure 3: Study parameters variation on an annual basis.

The real value of the PV electricity produced is assessed and the cost–benefit balance is calculated for the large introduction of PV systems in Greece. The sum of the annual average high SMP, EC, IFC, TDC and CRC, give the real value of the PV electricity produced (Figure 3).
As it appears in figure 4, the net cost of solar PV electricity becomes negative from year 2013 and on and therefore a net benefit for the society exists, without even taking into account the new employment created in the workplace by the introduction of the PV technology. The new employment that will be created up to 2020, according to the scenario of introduction of PV systems (Figure 2) and the coefficient of additional employment that has been evaluated (50 Man-years/MWp) in the studies [5,6], are of the order of 10.000 new jobs.

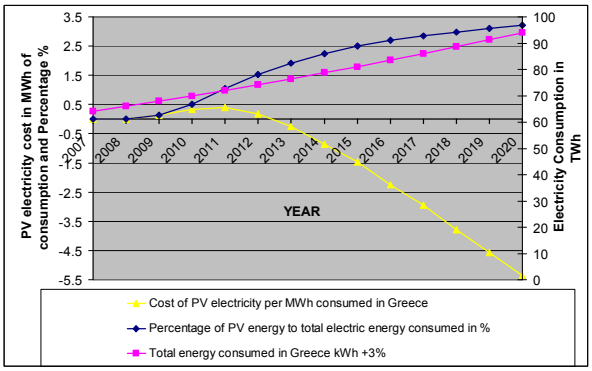

Figure 4: Variation of the consumed electricity in Greece, % of production from PV and Net cost of solar PV electricity production per MWh of consumption.

3 THE "SPECIAL RES CHARGE" IMPACT ON THE AVERAGE HELLENIC HOUSEHOLD

In order to approach the annual economic impact on the average Hellenic household by the "Special RES Charge" due to high penetration of RES, an estimate for the electricity production from the all renewable energy technologies should be made. For the next 15 years, the wind energy will produce most of the power capacity in Greece.

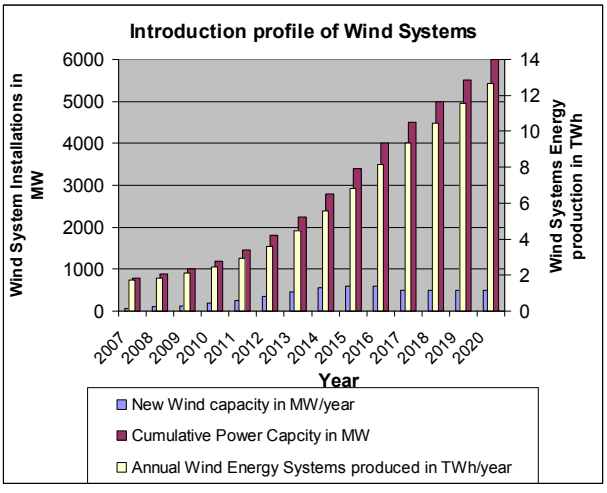

Figure 5: Introduction profile of Wind systems

To a first approximation, in the calculation of the special RES charge only wind and photovoltaic systems are considered. The participation of the other RES technologies is considered limited as it also evidenced from the study of "Long-term Energy Planning 2008-2020" [7]. In figure 5, the estimated introduction profile per year of the Wind parks is presented.
At the recent meeting of the Hellenic Wind Energy Association (February 2008), the President of RAE, Mr M. Karamanis, announced for the first time, that the realization (which means after the planned investments in infrastructure are put in place) of the approved Transmission System Development Study ensures the unhindered introduction of 5.500 MW of wind parks in the interconnected system without economic or other consequences for them. If the wind parks in the

autonomous island systems are included [8], this capacity may be increased to 6.000-6.200 MW. For the needs of this study, the globally installed power of wind parks in Greece is assumed to reach 6000 MWp in 2020. This capacity will be able to produce roughly 13.5% of the electric consumption at that time. The specific average annual energy produced by the wind systems is taken to be 2200 kWh/kW. As for the PV systems, the assumed introduction of 2400 MWp by the year 2020 will represent about 3.2% (Figure 4) of the national electricity consumption. Even at these high relative introductions of PV and wind systems the share to the total RES electricity consumption will be roughly 16.7% at the year 2020, when the proposed RES Directive is setting a binding target for Greece with a renewable share in the final energy demand of 18% by 2020. This means a production of RES electric energy equal roughly to a share of 35% of the domestic national consumption of electricity. Thus today, the objective of 29%, legislated officially with the Law 3468/2006, is insufficient. This means that the remaining RES electricity of 12.3% or 18.3% depending on the target, of either 29 or 35% respectively, should be covered from large hydroelectric (LH) plants. But according to the "Long-term Energy Planning 2008-2020", LH are accounted only for 6-7% [7] in 2020, from 14% contribution in 2006. The other RES technologies such as: small hydroelectric, biomass, geothermal and wave energy are not expected to become important before 2020 [7]. Consequently, the following possibilities are on hand in order to achieve the 2020 objective, either to reduce further the energy consumption, and/or to support an even larger penetration of PV and wind systems to the electric grid.

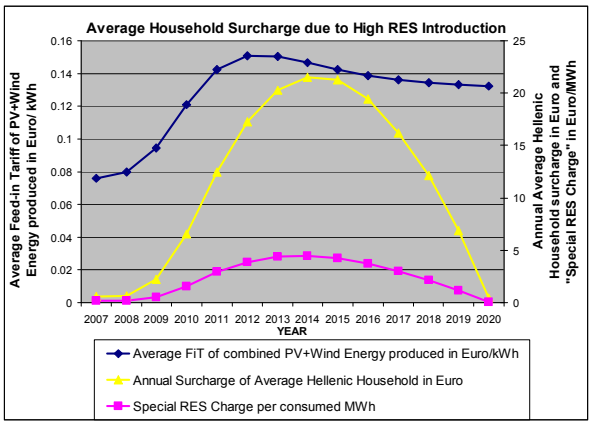

Figure 6: Average household surcharge due to high RES introduction.

The economic elements that are presented in this study show that, provided that the required capital for the initial investment exists, then the balance of cost-benefit will be positive for the society as evidenced in Figure 4.
For the calculation of the annual economic impact on the average Hellenic household, the average annual consumption is taken 3700 kWh at the starting year 2007. The average household consumption is then increased at 4% per year. The "special RES charge" is calculated as follows: from the combined average Feed-in Tariff of PV systems and Wind systems the annual average System Marginal Price is subtracted. The result is then multiplied by the total annual energy produced by PV and Wind systems and the last result is divided by the total annual electric consumption in Greece. Note that in Figure 6, the peak of the annual Hellenic household RES charge contribution occurs around 2014-2015 and it never exceeds 22 € per year or 4.5 €/MWh. This is a small price to pay for the abatement of climatic changes, the diversification of our energy supplies and the development of a new trade in Greece. The peak amount of 22 € is less than 5% of the annual electricity bill of the average household in the worst case.

4 CONCLUSION

With regards to the introduction of Photovoltaic systems, the large penetration is projected and hoped to come in the building sector that constitutes the "natural environment" for photovoltaic systems. The photovoltaic technology is suitable for building integration, thus constituting the main component for a decentralised RES energy production model. In countries with developed photovoltaic market, such as Germany, the small PV systems in buildings (<10 kWp) constitute 40% of the market, while globally the building sector has a share of the order of 90%. A potential Photovoltaic program for buildings will have to take into consideration economic, technical and environmental parameters of our times. The PV program should be suitable for private individuals, that is to say simplified, but also appropriate for companies. As the international experience has shown, it is important to have continuity to the PV market, without stop and go situations. This will bring also benefits in the employment and the economy of the country. Furthermore, the building integrated PV systems will contribute in the achievement of the 2020 objectives with regard to the generation of electricity from RES, while exploiting the advantages of distributed generation.

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