REVIEW OF ACTIVITIES RELATED TO RESEARCH, DEVELOPMENT AND APPLICATIONS OF PHOTOVOLTAICS TECHNOLOGY IN GREECE.

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ABSTRACT: Greece combines a number of conditions that make it an excellent location for the exploitation of PV technology.
A review of the nation-wide PV applications is made. So far, a total of almost 1400kW$_p$ of PV systems have been installed in Greece and numerous installations are under construction or have been proposed. The potential is by far greater and so are the expected benefits for the environment. The impact on the economy and employment opportunities are also discussed.
The activities of the Greek industry in PV system component development and the involvement of research centres and universities provide the infrastructure for a booming market. Predictions for future market development in Greece are made. The interest of investors for PV module and solar cell manufacturing units shows the potential of the industry and new prospects are created for accelerated development.
The national policies for the promotion of PV technology and the incentives provided by the government to all interested parties and especially the private sector are discussed. Suggestions for further motivation are made. The prospects created by the recent deregulation of energy production and distribution in Greece are presented.
Keywords: Greece – 1: PV Market – 2: Financing – 3

1. INTRODUCTION

The climate in the Mediterranean countries favours the exploitation of renewable energy sources and particularly photovoltaics. Especially in Greece, a number of conditions are combined that make it an excellent location for the utilisation of PV technology: The abundant solar energy throughout most of the year, the large number of remote locations that are not connected to the mainland grid, environmentally sensitive areas where conventional energy production is prohibitive, the coincidence of high energy demand with periods of strong insolation (mainly due to cooling requirements) and the atmospheric pollution in some cities, make the use of PV technology advantageous as well as essential.

Photovoltaics are an excellent alternative solution, both for stand-alone applications, where no other energy source is readily available and grid-connected systems, where additional energy can be drawn from the grid or excess production can be sold to it.

Currently, the cost of photovoltaic systems does not allow a wide market expansion without a well-developed financing programme. Only in some cases of remote electrification the use of photovoltaic technology is considered an economically viable solution. In Greece in particular, subsidies and financing schemes are very weak to support the PV market and in most cases the payback time is a few decades, keeping the interest of energy investors at a low level. However, there is a strong interest from the public and a number of installations has already been realised, where the alternative conventional solutions are not as attractive and convenient although, in most cases, less expensive.

2. PV INDUSTRY IN GREECE

The limited market for PVs in Greece is partly due to the lack of existence of a PV industry. The only industrial activities related to PV systems at the moment in Greece are the production of power electronic components by SME's and a small battery industry. The battery industry consists of small units producing 12V batteries for automotive applications, one production facility for various battery types including PV applications and an assembly facility of so-called "solar" batteries dedicated for PV applications.

However, in June 2001 a Greek construction company founded a subsidiary company, which intends to produce amorphous silicon modules in the near future. The new company is a joint venture with a well-known US PV manufacturer, which participates with 20% in the investment capital. An application has also been submitted to the Greek Government for the financial support of the project by 40% through the Development Law. The production facility has just started being built and the buildings are supposed to be completed in September 2002. A year later the manufacturing equipment will be installed and ready for production. The planned annual production will be initially 5MW$_p$. The production volume will exceed the present Greek market requirements by far, which at the moment are not more than 500kW$_p$/year and therefore most of the production will be exported to developing countries and the Balkan region. A significant proportion will also be absorbed in the US market through the US partner and another 400kW$_p$ of the first production batch will be integrated into the production facility building. The new company will also have an R&D department for the development of new products and technologies. The targeted market section will be building integrated photovoltaics as well as consumer products with lower power requirements. In its final form, the company is expected to employ 160 people.

Another Greek company, currently active in designing and installing PV systems in Greece, is also negotiating the creation of a joint venture with a US crystalline silicon solar cell and module manufacturer, which will result in a solar module production line in northern Greece. The targeted markets will be Morocco, Tunis and Turkey.

The existence of such production facilities in Greece will promote PV technology on their own but they will also give a strong incentive to the Greek Government to create a national Programme that will support them. This could be done by a financing scheme or subsidies that will attract the interest of investors by making photovoltaics a viable investment with short payback times.

3. STATUTORY FRAMEWORK - FINANCING

Currently in Greece there is no long-standing legislation for a national financing scheme that supports investments for photovoltaic systems. The only exception is law 2364/95, which deducts 75% of the investment capital from the taxable income of the investor. This law holds for all investments related to renewable energy sources (the most common in Greece being residential solar thermal systems) and it refers to equipment and installation costs.

In 1985, law 1559/85, dealt for the first time with exceptions to the exclusive right of the Public Power Corporation (PPC) to generate electricity. Local Government authorities and individuals were allowed to produce energy with any means (renewable or conventional) and sell it to the PPC without a pre-determined kWh price. This law did not succeed in attracting the interest of investors and it was succeeded by law 2244/94.

Law 2244/94 made it possible for self-producers and independent producers to generate electricity by the exploitation of renewable energy sources as well as natural gas. Marketing issues and licenses for the establishment of power plants were finally regulated. The PPC is bound to buy the electricity generated by other producers with a fixed tariff, up to 90% of the selling price.

The Development Law (2601/26/98) provides incentives, 40-55% financing, for investments related to rational use of energy, energy saving and renewable sources of energy in the industry.

Finally, law 2773/99 established the deregulation of the electricity market in Greece according to the directive 96/92 of the European Union. This law also launched the Regulatory Authority for Energy (RAE).

In this statutory framework photovoltaics can be used by individuals or organisations for the generation of electricity, both for self-consumption as well as distribution. However, there is no strong incentive that would make such an investment profitable in less than a few decades. Periodic announcements of national programmes boost the PV market in Greece but they are not sufficient to sustain a constant market development over a longer time period. Such programmes are the so-called Operational Programme for Energy (1994-1999), which provided 40-55% co-funding for PV installations and in December 1999 a special announcement provided 70% co-funding for PV installations only on the island of Crete. This was enough to double the installations made in the year 2000 compared to the previous year. In the period 2001-2006, more calls for proposals are expected, providing 50% co-funding like the one, which ended on the 15th of October 2001, in the framework of the Operational Programme of Competitiveness. So far, these calls concern only legal entities and therefore the penetration in the household sector is negligible. Moreover, the minimum budget set for co-funding (~44000€) is prohibitive for most private investors, who are interested in small systems.

Nevertheless, these programmes may provide satisfactory motivation to some investors, particularly for stand-alone applications at remote locations. However, a scheme similar to the one that is now active in Germany, Spain, Italy and other European countries, i.e. the incentive of a high, fixed kWh price for electricity produced by photovoltaics over a long period of time, is the only way to initiate a large number of investments for grid connected systems. The PV market will expand rapidly when individual households will start installing systems by integrating them into the built environment. This will not only be beneficial to the PV market, as prices will drop due to mass production, but also for the whole electricity distribution system. PVs are ideal for peak shaving as their peak production coincides with maximum demand periods, especially during the summer, when a lot of energy is required for cooling systems. In this way, large investments for upgrading central power stations can be saved, the full capacity of which would only be used a few hours per year.

4. EXISTING INSTALLATIONS

Although the cost of PV technology is high and the incentives are weak, there are a significant number of applications that has been realised in Greece. The total installed power in Greece at the moment approaches 1400kW$_p$, which is about 1/1000 of the total installed power all over the world. The 70% co-funding that was provided for the island of Crete in December 1999, more than doubled the annually installed power for the year 2000, see fig. 1. Many of the projects proposed during that call are still under development and when completed the total installed power is expected to increase even further.

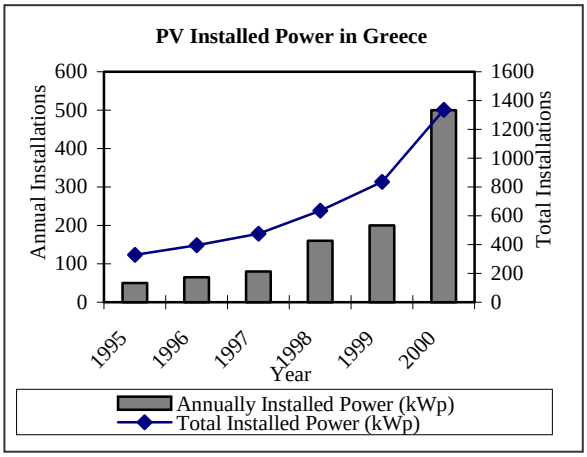

Figure 1: Annual PV installations and total installed power in Greece.

The most successful application in Greece however, is the electrification of a large number of navigational aids in the Aegean and Ionian Seas, fig. 2. More than 900 lighthouses, buoys and other navigational aids are powered by small, stand-alone PV systems, with a total installed power which approaches 100kW$_p$ [1], solving the problem of refuelling conventional acetylene lamps. The only requirement henceforth is the replacement of the batteries,

every 4 years, to ensure proper operation of such a critical application.

Other significant installations have been made on islands, that are not connected to the mainland grid and until recently, they were powered by diesel generators. For example, the islands of Kithnos, Sifnos, Gavdos, Arki and Kato Koufonisia have central PV power plants or smaller decentralised systems that cover the power requirements of small local communities, fig. 3.

The telecommunications sector has also benefited from PV technology. Repeaters and transmitters for radio, television, cellular phones and other telecom applications that are usually installed at remote, inaccessible locations are powered by stand alone PV systems of the order of a few kW_p. An example of a stand-alone telecommunication system is shown in fig. 4.

Figure 2: Stand-alone PV powered navigational aid.

Figure 3: Central PV plant on the island of Sifnos, $60kW_p$ installed power (THERMIE SE/0135/96 HE-I-D).

Recently, more grid-connected systems are being installed, although the legislation is not favourable compared to other European countries, fig. 4. However, after the 1999 call for proposals in Crete, more than $400kW_p$ of photovoltaics were installed, most of them connected to the grid. Two systems are central, grid connected power plants, with just over $330kW_p$ installed power and the rest are smaller, decentralised systems, mostly installed in the tourist sector.

Figure 4: PV powered telecommunication antenna.

Figure 5: $5kW_p$ grid-connected system, integrated into a parking shed.

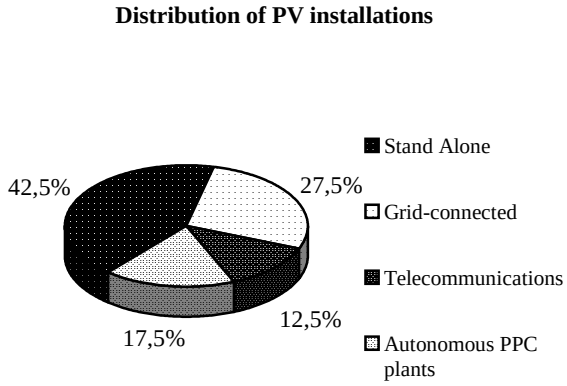

Figure 6: Distribution of installed power in Greece over different types of applications. (Source: [2]).

The PV systems that have been installed in Greece cover different types of applications and needs for electrification. A significant number of more installations is still under construction or has been proposed and is due to be completed in the near future. The distribution of the installed power over the different categories of applications is shown in fig. 6.

5. POTENTIAL

Clearly, most applications (42.5%) concern electrification of remote locations that are not connected to the mainland grid. In fact, telecommunication applications and autonomous PPC plants are also stand alone systems and only 27.5% of the installed power in Greece relates to grid connected systems. This reflects the situation in Greece, where there is a large number of remote small communities and other applications, which are not connected to the mainland grid and rely on local energy production.

However, the grid is put under a lot of strain, especially during the summer, with the increasing number of air conditioning units that being installed and used, particularly in urban areas. Therefore, as mentioned earlier, grid connected systems are very important in supporting the operation of the grid. If one considers that electricity supply interruptions in Greece, lasting up to 5 hours, occur approximately 5 times per year, and most of them are due to grid overloading during peak demand, clearly a serious problem can be overcome using PV technology. The installation of a large number of small, grid connected systems can produce sufficient electricity, in a decentralised manner, to support the grid in order to meet high peak demand without further investments for upgrading conventional power stations.

The way to accomplish this in the built environment is by integrating photovoltaic systems into buildings. Already, a number of Greek companies that are active in the construction of aluminium systems and components for building facades are adapting their profiles to incorporate photovoltaic modules. Building integration not only provides the necessary surface area for photovoltaic modules but it also replaces expensive construction materials in an aesthetically appealing manner, reducing the overall cost of the installation. At the same time, energy is produced where it is needed, avoiding losses due to energy transfer and if there is excess production, it can be sold to the grid.

6. CONCLUSIONS

The technology to convert renewable energy sources efficiently and cover the worldwide energy demand in an environmentally friendly manner exists. Solutions for the electrification of remote locations are provided, in an environmentally friendly manner, and peak demand is covered effectively in areas with weak local grids.

Clearly, Greece has great potential and need, both for grid connected and stand alone systems. A PV industry could thrive, both by covering the national market requirements, as well as by exporting, mainly to developing countries. The activity that has started in investing for the production of PV modules is a clear indication of the growing prospects and possibilities. Existing industry could benefit by undertaking the development of systems for building integration and the battery and electronic components manufacturers could expand their businesses. What is currently missing is a long-standing financing scheme that would boost the PV market and make it economically viable even for investors from the private sector. Such a programme would introduce photovoltaics in the household sector, through building integration, following the successful example of many other European countries. Building integration of PV systems is the most attractive solution for densely populated areas where no additional land is available for PV installations.

On the other hand, the deregulation of the energy production and distribution in Greece provides the framework for larger scale production and installations. The financial support of the emerging PV market and industry in Greece is paramount at this early stage for its future development.

7. REFERENCES

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