REVIEW ON THE DEVELOPMENT OF PHOTOVOLTAIC ACTIVITIES IN GREECE

C Protogeropoulos[1] and J Chadjivassiliadis[2]

[1]CRES – Centre for Renewable Energy Sources
Department of Photovoltaic Systems
19th km Marathonos Av., 190 09 Pikermi, Athens, Greece
Tel.: +30 21 06603370, FAX: +30 21 06603318, eMail: cprotog@cres.gr

[2]Consultant Engineer
6, Korinthou Str., 166 74 Glyfada, Athens, Greece
Tel.: +30 21 08949075, FAX: +30 21 09680366, eMail: chadjiva@attglobal.net

ABSTRACT: The paper gives a thorough review of the past and recent activities in the field of photovoltaics in Greece. Reference is given to all affiliated governmental bodies, the interactive mechanisms, the main RTD organisations and the industry involved in the development of solar business in the country. Policy planning and some actions taking into consideration the local situation in harmonisation with the policy of EU member states are also discussed. Potential areas for PV applications are highlighted and recommendations for the development of system's technology and market are made. A National Programme must be initiated by the government to encourage PV applications on the islands and to create a favourable framework for small grid-connected roof-top PV systems, covering the household sector in the country.
Keywords: R&D and Demonstration Programmes – 1; PV Market – 2; PV Industry Development – 3

1 INTRODUCTION

Solar radiation in Greece is very favourable for use to cover locally energy demands. The sunshine duration in the south part of the country is about 3,000h per year and the average annual global solar radiation is around 1,700kWh/m^2 on the horizontal surface, see Fig. 1. A good example of solar energy exploitation is the extended applications of solar water heaters in the country, which was initiated in the '70s.

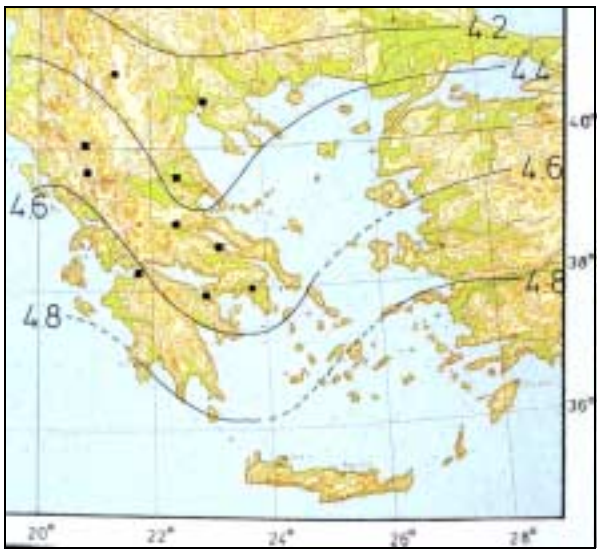

Fig. 1: Solar map of Greece on the horizontal, daily iso-irradiance values in [kWh/m^2]

The electrification in the country has been very well developed by the Public Power Corporation (PPC) and today more than 99.9% of the inhabitants have access to electricity grid. The primary energy sources for power generation is lignite of low calorific value, hydro, oil and natural gas, while for the islands only oil is used. The potential of renewable energy sources is very attractive for power generation.

2 OVERVIEW OF PV ACTIVITIES IN GREECE

2.1 PV Applications in Greece

In Greece, activities on PV applications started in 1980 by PPC within the EC RTD projects for the electrification of island communities and remote areas. Two pilot plants were developed and installed, one in Agia Roumeli (Crete) of 50kWp was commissioned in 1982 and the other on the island of Kythnos of 100kWp commissioned in 1983.

The system in Kythnos is a hybrid PV/wind plant with advanced power control and sufficient storage. The operational experience of the hybrid system in Kythnos shows that this topology can provide a viable solution for the islands.

In the following years, three demonstration projects were developed in small islands to provide electrification, namely, Antikythira (27.6kWp, 1987), Gavdos (20.8kWp, 1987) and Arki (27.5kWp, 1988). Another 60 small systems of total power 61.6kWp were installed in a number of small islands.

Aims of this relatively early development of PV plants by PPC were mainly R&D and demonstration to gain experience on the operation of solar power supply systems for the electrification of remote areas using local energy resources. These applications had a strong social content and assisted in the development of the local communities in terms of tourism business and local economy.

Important PV applications have been developed for sea navigation and for telecommunication systems. Approximately 900 lighthouses in the Aegean and Ionian Sea are powered by photovoltaics (about 70kWp in total), as the most cost-efficient and reliable solution. Additionally, a grid-connected PV plant of 60kWp was installed on the island of Sifnos and was coupled on the diesel power system of PPC. A total of 52kWp PV grid-connected systems have been installed at the premises of CRES, mainly for R&D and demonstration purposes. Important PV applications have been developed also in Mount Athos for electrification of the Monasteries in a successful harmonisation with the natural beauty.

Some large PV plants have been developed within National Programmes, such as the Operational Energy Programme (OEP, 1997–2000) and the Operational Programme for Competitiveness (OPC, 2001–to date) and the Development Law. These programmes provided subsidies in the range 40% to 55% of the investment budget depending on the system size and the location of the application.

Very poor results were experienced from a programme for large PV plants in Crete where a subsidy of 70% was provided to the investors. In this case, the main barrier for success was reported to be the bureaucratic procedures to grant a licence for an installation. Applications of budget above 44k€ per project are supported from the National programmes, basically excluding PV applications in the household sector.

As of the end of 2003, the overall PV installed capacity in Greece is estimated around 2.2MWp. The annual evolution of the PV installations in Greece from 1995 to 2003 is shown in Fig. 2 below.

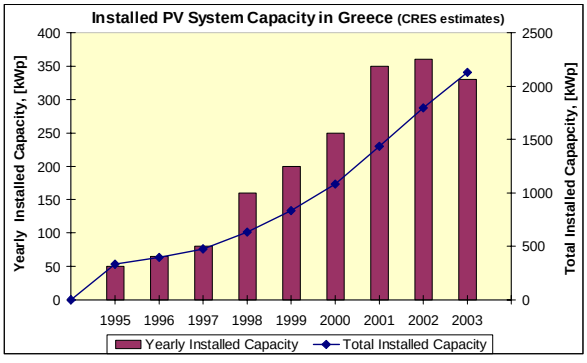

Fig. 2: Annual growth of PV applications in Greece 1995–2003

In 2002, total PV energy production was estimated 2.3GWh, while in 2003, approximately 1.5GWh were fed into the grid. As is seen in Fig. 3, about half of the PV systems in Greece are grid-connected (mainland and island grids).

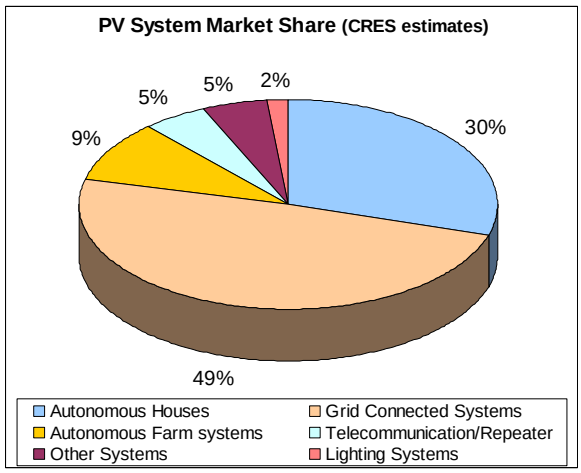

Fig. 3: PV market share in Greece

The turnover from PV activities in 2003 was ~3.0M€ with a capacity workforce of 60–70 persons. The year 2003 National subsidy in the PV sector for R&D and applications was in the order 2.2M€ and 2.0M€ respectively.

Although the potential for PV applications in the country is good and the high level technical background on PV technology due to early development of applications as well as the unexceptionable public acceptance, the development of the PV market and the applications are not satisfactory and still in an embryonic phase.

2.2 RTD and Industrial Activities in the PV Sector

An indicative list of research centres and universities that are involved in PV related R&D activities, is as follows:

- CRES – National Centre, R&D on the system level, power electronics, battery storage, hybrid systems etc.
- AUTh – power quality issues, thin-films and coatings, materials characterisation and metrology
- University of Patras – development on a-Si, power electronics, combined PV/solar thermal systems, etc.
- NTUA – power quality issues, design of μgrids, thin-film technologies with emphasis on chalcopyrites
- Agricultural University of Athens – PV system technology, battery storage
- Democretos Institute – dye-sensitised materials and cell development
- ITE Patras – polymer based cells

Industrial activities on PV system technology and components are being developed by a number of SMEs as follows:

- Heliodomi SA – manufacturing of a-Si modules (5MWp annual capacity, commissioning expected end of 2004)
- Energy Solutions SA – manufacturing of mono-crystalline modules (factory to be erected in Bulgaria by a large Greek industrial group, commissioning expected in 2005)
- ELPRA SA – power electronics, manufacturing of grid-connected DC/AC inverters

- RESPECT Ltd – power electronics, development and manufacturing of stand-alone inverters and charge controllers
- ERGON Ltd – manufacturing of lead-acid solar batteries
- Sunlight SA – manufacturing of batteries and development of PV systems applications
- Symmetron Ltd – measuring devices and data acquisition systems dedicated to RES applications

The Hellenic Association of Photovoltaic Companies is a lobbying institution for the promotion of PV applications in Greece.

2.3 Legislation and Governmental Institutions

The main law for RES 2244/94 provides access to the grid for individual producers and power supply at fixed feed-in tariffs for the islands and for the mainland system. This law is uniform for all renewable sources. The establishment of the Regulatory Authority for Energy (RAE) and the legislation for the deregulation of the electricity market, such as Law 3175/2003, affect the development of RES. The Development Law provides incentives for RES applications.

The weak aspects of the existing legal framework in the development of PV applications are the bureaucratic procedures that result in significant delays to obtain the necessary licences and permits for the installation of a PV system, the lack of the appropriate rules for grid connection and the low feed-in tariff of about 8€c on the islands and 7€c in the mainland.

The main governmental institutions related with licensing and financial support for the development of PV applications are:

- Ministry of Development – regulations for the construction/installation licences and National programmes for subsidies in the energy sector
- Ministry for Development/General Secretariat for Research and Technology – National research programmes and financial support
- RAE – energy production licence for PV systems above 20kWp, in collaboration with the Ministry of Development
- Ministry of Environment – main involvement in the licence for an installation and development of codes for BIPV
- PPC – access and connection to the grid. A DNO has not yet been established in the system.
- Local Prefectures – construction/installation licence

3 POTENTIAL AREAS FOR PV APPLICATIONS AND PERSPECTIVES

Presently, the target audience in the PV sector is limited to small stand-alone and specific applications and the framework does not encourage grid-connected applications. Obstacles for sufficient development of PV applications in Greece include technical, economical and institutional barriers. Clear policy for photovoltaics and supporting measures to remove the barriers are necessary.

The electricity system in the country consists of the interconnected system in the mainland with large fossil fuel and hydro plants and the autonomous power systems on the islands based on oil plants. Usually, peak demand occurs in the summer season due to air conditioning units and the tourism, especially in the islands, with very low annual load factor. Solar radiation seems to be a high value local energy resource as peaking of the irradiance in summer periods almost coincides with demand in tourist resorts as reported by [1], see Fig. 4 (data refer to year 2000 and the solar radiation profile is for the island of Rhodes).

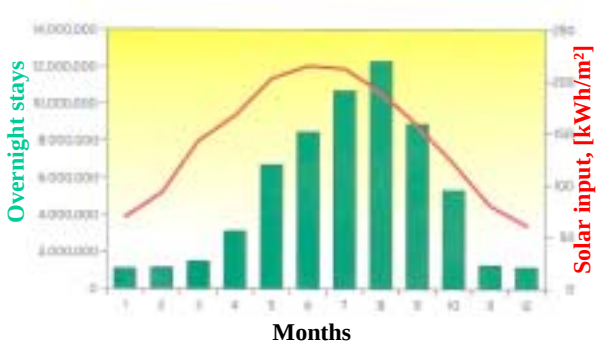

Fig. 4: Correlation of monthly tourism volume in Greece with solar input

The power generation cost in the islands is too high and in medium and small islands it is a multiple of the generation cost in the mainland, [2]. On the other hand, a unified tariff policy for all consumers is applied in the country and the extra cost of the energy production in the islands is included in this tariff. In addition, the externalities mainly due to environmental impacts and the power quality of the weak systems have not been considered into the energy economic calculations.

Under these circumstances, solar PV is very attractive for the island power generation systems from both technical and economical aspects and thus, islands represent a potential area for PV applications. However, it should be pointed out that the islands, due to their small annual power capacity, are excluded from the rules of the new electricity market and competition. In addition, due to the lack of transparency on the actual local power generation cost and of the appropriate framework, the penetration of PVs into the island systems has not been yet effective.

The development of photovoltaic applications on the islands should be combined with solar water heaters to cover the demand of domestic hot water. In general, new concepts for exploitation of solar energy on the islands to meet the local demands in a sustainable and economic way should be initiated. Moreover, future demands for water desalination to solve the water shortage on the islands could be contributed by solar PV and wind, leading to an efficient load management tool in the system.

Public awareness on solar energy in Greece is positive, mainly due to the success of solar thermal applications. This positive experience could be repeated and a rapid solar market development through a PV-roof Programme

is effective. A special programme for the islands is of high priority and another programme for the mainland, for widespread applications in the country is today necessary. Such favourable market conditions and an appropriate framework environment would be the driving force for the PV industry, which is already developing in Greece. Finally, specific research actions are needed for the integration of solar PV and solar thermal systems to local environments and design considerations, standardisation issues and components should be developed.

4 RECOMMENDATIONS FOR ACTIONS AND POLICY PLANNING

PV technology is compatible to the Distributed Generation concept, in line with a new development of the energy production / transmission / distribution chain by major utilities in Europe towards sustainable electricity systems. Stand-alone PV applications and PV/hybrid systems are ideal for local power generation and supply. Transparency of power generation on the islands and actions to introduce new concepts for the integration of PV systems and wind plants into the island's systems should be achieved. PPC, which is responsible for the power generation and distribution on islands, should reconsider its policy in regions where local generation by conventional means is costly.

The National Policy in solar energy must be expressed via the elaboration and development of a National Programme for Photovoltaic applications in Greece with high priority to PV integration to the island's systems. It is essential that this activity is encouraged and supported by the government. The Programme would establish a framework and a feed-in tariff policy, well adapted to the certain conditions in the country. Simplification of the procedures for installation licence and connection to the grid should be achieved to save time and cost. Small size grid-connected PV applications for the domestic sector should be developed in the mainland within a PV-roof National Programme. The establishment of the Distribution Network Operator (a DNO has not been yet established in Greece), provided by the directive for the deregulation of the electricity market, will facilitate the access to the grid and integration of the PV systems.

The market development will create further industrial development and competitiveness in the PV sector and will increase the economic activities of SMEs.

5 CONCLUSIONS

In concluding, there are good prospects for the development of the PV market in Greece. The valuable background in PV development for more than two decades and the positive public awareness for solar energy, as well as the conditions in Greece favour the development of PV technology and applications. A PV National Programme must be elaborated by the government to support this action. Experience gained from early innovative applications shows that electricity production from PVs is cost effective on the islands. Large-scale PV applications will cover the energy demands in a sustainable and cost-efficient way and will contribute to the development of ecological tourism.

In addition, a considerable added value to affiliated economical activities, creation of SMEs, industrial development and regional development by PV development is expected.

6 REFERENCES

[1] Winfried Hoffmann, "*Towards an Effective European Industrial Policy for Photovoltaics*", 20th EPIA Annual General Meeting, Athens, May 2004

[2] Public Power Corporation, "*Programme of Autonomous Power Plants 2001*"