International Energy Agency

Co-operative Programme on Photovoltaic Power Systems

Task 1

Exchange and dissemination of
information on PV power systems

National Survey Report of PV Power Applications in Portugal

2003

Alberto Tavares
ADENE - Portuguese Agency for Energy
Estrada de Alfragide, Praceta Nº 1, Nº 47
2720-537 Amadora

on behalf of
Directorate General for Geology and Energy (DGGE)

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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Co-operation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Nine tasks have been established, and currently six are active. Information about these tasks can be found on the public website www.iea-pvps.org. The new task concerning urban-scale deployment of PV systems is now underway.

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

ii Introduction

This report gives information about the most important achievements in the PV power field in Portugal during 2003.

It is only a summary of the most important developments and applications of photovoltaic power systems and does not pretend to be complete in any way.

iii Definitions, symbols and abbreviations

For the purposes of the National Survey Reports, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25^oC, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: System installed in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

Off-grid non-domestic PV power system: System used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers. etc. These may be used for support of the utility distribution grid.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication systems in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, utilities etc.

NC: National Currency

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

1 Executive summary

There´s a new trend for photovoltaics in Portugal based in national investment subsidies and a legal framework for feed-in tariffs for the production of electricity from PV systems.

However, there´s still a few critical barriers that must be surpassed for the widespread of PV in the built environment, namely public unawareness, heavy licensing requirements and procedures and lack of specific regulation for photovoltaics.

A total of 401 kW of PV power has been installed until the end of 2003. Nearly all the photovoltaic applications done in Portugal were stand-alone (251 kW), followed by off-grid non domestic (145 kW), and grid connected installations (5 kW). The rate of growth of the total installed capacity between 2002 and 2003 was 25 %.

System prices for on-grid turnkey applications costs maintains steadily at approximately 7 € per each W installed.

2 The implementation of PV systems

2.1 Applications for photovoltaics

Stand-alone PV systems constitute by far the largest proportion of applications for photovoltaics in Portugal, mainly to provide electricity to dwellings, telecommunications and water pumping systems.

The installed grid-connected PV power went down drastically as the BP´s Harmony Programme came to an end towards the end of 2002. This programme consisted in the integration of PV modules on BP filling stations canopies. As a result of this programme, BP Solar was responsible for most of the grid-connected PV systems installed in Portugal. The harmony programme is also the only reference as integrated PV systems are concerned, being the remaining systems mostly roof-mounted or ground mounted.

In spite of the favourable legal and incentive framework in the grid connected domain, there´s no visible effect on the deployment of such systems. In 2003 only a few number of installation have been realised. However, a large number of requests have been presented to the Directorate General for Geology and Energy (DGGE), for the connection of PV systems to the public grid, with a special emphasis to large centralised PV plants.

2.2 Total photovoltaic power installed

The total cumulative PV power for each sub-market on the 31 December of each year from 1992 onwards is listed in Table 1. These figures are based in surveys carried out by DGGE (Directorate General for Geology and Energy), EDP (electrical utility), ADENE (Agency for Energy) on a yearly basis, and rely on the data provided by PV system installers and the main institutions/organisations/companies which promote PV in Portugal.

Table 1 The cumulative installed PV power in 4 sub-markets.

Sub-market/application	31 Dec. 1992	31 Dec. 1993	31 Dec. 1994	31 Dec. 1995	31 Dec. 1996	31 Dec. 1997	31 Dec. 1998	31 Dec. 1999	31 Dec. 2000	31 Dec. 2001	31 Dec. 2002	31 Dec. 2003
Off- grid domestic	138	171	202	255	321	384	434	484	639	718	901	1152
Off-grid non-domestic	31	38	46	69	91	126	176	226	237	273	375	520
Grid-connected distributed	-	10	10	12	12	17	38	184	268	319	392	397
Grid-connected centralised	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	169	219	258	336	424	527	648	894	1144	1310	1668	2069

2.3 Major projects, demonstration and field test programmes

The most significant project realised during the year of 2003 was the first grid-connected PV system licensed under the Independent Power Producers law, delivering all the generated power to the grid at a tariff of about 0,5 €/kWh (up to date the generated electricity were supplied freely to the grid). This installation was licensed in November 2003, and consists of a 4,96 kWp PV system installed in S. Brás, in the municipality of Barcelos, northern Portugal, designed by SunTechnics/COEPTUM Engenharia.

System Description:

Modules: Conergy C160P, 160Wp (+/-3%), multi-crystaline,
Inversor: Fronius IG20 + Fronius IG30
Energy meter: Actaris

Most of the problems encountered were mainly related with heavy administrative requirements and procedures. It took at least one year for the project to be licensed.

2.4 Highlights of R&D

PV research activities mainly address amorphous and thin film silicon technologies and are carried out by public bodies, namely:

- CENIMAT: Department of Materials Science, Faculty of Sciences and Technology (New University of Lisbon).
- LAFS: Laboratory of Photovoltaic Applications and Semiconductors (University of Lisbon)
- Department of Ceramics and Glass Engineering/UIMC (University of Aveiro).

Applied R&D and demonstration is carried out by Universities and Public Research Laboratories (INETI – National Institute for Engineering and Industry Technology), as well as Energy Agencies (ADENE and regional agencies), utilities and private research institutions (INESC Porto - Institute for Systems and Computers Engineering).

Associations such as SPES (National Solar Energy Society) and APISOLAR (manufacturer and installer association) are mostly involved in dissemination activities.

Demonstration systems concern mainly remote electrification and professional system applications (TV and telephone repeaters, parking meters, water pumping).

The largest Portuguese electrical utility (EDP) participated in a number of PV projects, as part of R&D activities on New Energy Technologies. The company Labelec (EDP Group) recently designed a small hybrid PV (3,2 kWp)-wind (0,9 kW) grid-connected system, to be installed early 2004 at its premises (campus of Sacavém), aimed mainly at demonstration and grid interconnection impact assessment.

2.5 Public budgets for market stimulation, demonstration / field test programmes and R&D

There´s no specific programme in Portugal aiming the support of projects in the photovoltaic domain. The available funding programmes are mostly generics covering several economic sectors and scientific domains.

Demonstration initiatives may apply to the measure MAPE of the POE/PRIME Programme (Operational Programme for Economic Activities) which support projects in the energy sector, aiming energy diversification, improved energy efficiency and increased use of renewable energy.

Research and Development initiatives may be funded by the Portuguese Foundation for Science and Technology under the Programme POCTI - Operational Programme for Science, Technology and Innovation.

3 Industry and growth

3.1 Production of photovoltaic cells and modules

Shell Solar signed an agreement with A. J. Lobo to expand the solar module yearly production of the sole photovoltaic factory located in Portugal (Évora), from the current 10 MW to 17 MW per year.

In addition to assembling solar mono crystalline cells, imported from Shell´s factory in Amarillo (United States), into solar modules, the plant will now also assemble multi crystalline cells imported from Gelsenkirchen (Germany). Shell Solar announced that this production facility will become Shell Solar's sole PV module assembly plant in Europe.

Most of the past solar modules production were mostly meant for export, this trend may change in future as a result of the expected boost of the Portuguese market demand.

Table 4a: Typical module prices (€/W)*

Year	2001	2002	2003
Modules price (s) *	4	3,5	3,5

* the price varies widely upon the size of the order

3.2 Manufacturers and suppliers of other components

AUTOSIL is the sole Portuguese stationary battery manufacturer, since SPAT – Portuguese Society of Tudor Accumulator, S.A., no longer produce stationary lead-acid batteries in Portugal.

A dozen companies are supplying and installing PV modules and BOS components imported
from the EU, USA and Japan. A few of theses companies produce power electronics for stand-alone PV applications (small charge regulators, ballasts, etc...).

3.3 System prices

Table 5: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Current prices per W in €
Off-grid up to 1 kW	Telecommunications, water pumping	Typically 12
Off-grid > 1 kW	Domestic	Typically 10
Grid connected Specific case	1-5 kW mounted system	Typically 6,5
Grid connected Up to 10 kW	Filling stations integrated system	-
Grid connected > 10 kW	Filling stations integrated system	-

Table 5a.: National trends in system prices for off-grid applications

Year	1998	1999	2000	2001	2002	2003
Price €/W	From 11 to 13,5	From 10 to 12,5	From 9 to 11	From 9 to 11	From 9 to 11	From 9 to 11

3.4 Labour places

About five new companies have initiated their activities in the Portuguese PV market during 2003, stimulated by the new government favourable framework for photovoltaics. They are however mostly small companies that provide support services with two employees mainly involved in PV issues.

Apart from these new actors, there´s been no significant changes in labour places since 2002. Shell Solar is still up to date absorbing most of the labour force involved in the PV market.

R&D remains an important source of jobs accounting with 17 % of direct labour places. CINEMAT is taking the lead with a permanent senior staff composed with 14 full professors, researchers and post-graduates in engineering.

The following table shows the actual labour places within the PV energy sector:

Research and development : *(universities and private-public research institutions)*	29
Manufacturing of PV modules:	90
All other: *(electricity companies, installation companies, consulting companies specialised in PV, local & regional authorities)*	50
Total labour places:	**169**

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

The new Council of Ministers Resolution on Energy Policy (Cabinet Resolution No. 63/2003), reinforced the Portuguese Government commitment for the achievement of an ecologically sustainable society, given continuity to the previous energy policies established under the framework of the E4 Programme (Endogenous Energy and Energy Efficiency), promoting renewable electricity.

The differentiated regulated tariff rates (as a function of the technology and operation conditions), for the purchase of electricity produced from specified energy sources were established under decree-law Nº 339-C/2001, 29 December. The current buy-back rates for PV grid-connected systems are ~0,30 €/kWh (systems over 5 kWp) and 0,51 €/kWh (systems under 5 kW) guaranteed for the lifetime of the plant, with automatic adjustments based on the inflation rate. This legislation is aimed exclusively at Independent Power Producers (IPP), which must deliver all the generated power to the grid, the utility being obligated to buy the whole power.

In alternative, the “producer-consumer” law, mainly aimed at the residential and small industry sectors, allows the interconnection of micro-generators to the low voltage public grid. Under this legislation any individual or company may apply, provided at least 50% of the generated energy is self-consumed. Therefore, the utility is only obligated to buy half the

generated power at a feed-in tariff depending on the technology. For PV, the buy-back rate is about 0,25 €/kWh, which, for small systems up to 5 kWp, is considerably lower than the IPP tariff, making this scheme considerably less attractive.

Public grants for RES and energy efficiency applications are available under the Measure MAPE, integrated in the framework of the PRIME Programme (former POE Programme). Grants are provided up to 50 % of the total eligible costs, with a maximum of 1 500 k€ per application (maximum eligible limit: 3 000 €/kW). The non-reimbursable part accounts for 50 % of the total subsidy (it may reach 100 % for stand-alone systems, when the promoter is a public entity), up to a limit of 300 k€.

Under the ministerial resolution n.o 63/2003, the Government decided to settle a new target for photovoltaics, lifting up the previous 50 MW photovoltaic power generation goal to 150 MW, to be installed until 2010. Although under negotiation, the planned world largest centralised PV power plant (64 MWp) in the municipality of Moura, southern Portugal, have certainly influenced this decision. As proposed to the government's Directorate General for Geology and Energy by the promoter Amper Central Solar, S.A., BP Solar is expected to provide an turkey installation service, building a module factory nearby Moura.

Most of the interconnection points with the national electricity grid are saturated due to the large number of requests for wind farms interconnection points. As a result DGGE published a dispatch in April 2003, limiting the power of generators connected to the grid. As regards PV systems interconnection requests, an allowable power range from 100 kW to 300 kW was settled. At this date this limitation is settle at 100 kW.

Despite the favourable feed-in tariffs for grid-connected PV systems created in December 2001, photovoltaic grid-connected applications are still in the beginnings. This situation may be justified by the unawareness of the public about the current incentives and the long periods of time required for the evaluation of the processes, which have reached in some cases about 8 months. The fact that under the actual legislation small PV grid-connected systems with less than 100 kW are evaluated in the same manner as large wind farms are seen by the majority of the promoters as the main reason for this last constraint.

4.2 Indirect policy issues

A new concern about environmental issues have brought forth among the industry sector, being more receptive to the potential application of sustainable technologies in order to be ISO 14000 certified. The adoption of solar technologies is now seen as a way to contribute to environment protection by reducing energy consumption and hence reducing greenhouse gas emissions.

Under the "Solar Hot Water for Portugal" (AQSpP) initiative a set of integrated activities was created that includes the increase of the public awareness of solar water systems through advertising campaigns. These campaign have promoted the social-economical-environmental benefits of solar energy, thus helping to emphasis the value of other solar technologies as photovoltaics.

An environmental fiscal reform has just begun to progress in Portugal under the scope of the National Plan for Climate Change (PNAC) working version. The new taxation scheme will be designed on the basis of an ecological criteria, consisting in an environmental related tax applied accordingly with the carbon content or environmental impact of energy products (in Euro/g of CO2). The tax revenues are to be reverted to an environmental fund aimed to support, among others, energy efficiency and air pollution control investments.

4.3 Standards and codes

There´s no specific national PV standards applied for PV in Portugal as European or IEEE standards are applied in general. There´s also a lack of building codes for PV integration.

For the interconnection of power generation systems to the public grid, only generic guidelines are provided by DGGE, under the Independent Power Producer Law.

DGGE also issued guidelines which establishes the procedures and requirements for the licensing of micro-generators installations connected to the low voltage public grid, under the "producer-consumer" law. Once again these are generic rules for grid interconnection of micro-generators that can also be applied to PV systems.

These lack of specific regulation for PV systems are a serious drawback to built confidence in the effectiveness of photovoltaics as the utility feels that PV systems randomly connected to the grid will adversely affect the grid stability and reliability.

5 Highlights and prospects

As expected there´s a growing interest from promoters for photovoltaic grid connected applications , which is better expressed by the large number of requests for interconnection points received by the government's Directorate General for Geology and Energy, (600 request for systems from 5 kW up to 100 kW). DGGE is working with the utility to simplify the licensing process for PV installations, which is currently too complicated and time-consuming.

From these, 2 projects deserve a special emphasis:

- The first integrated PV facade (12 kW), has been designed by INETI and will be installed and demonstrated at the campus of INETI.

- The world largest PV power plant project (64 MW). A new facility is foreseen for the manufacture of the modules in the South of Portugal. This new plant will boost the total production capacity of PV modules in Portugal which is actually 15 MW.

The creation of a regulation to advance the energy and environmental performance of buildings may in time play an important role for the spreading of solar technologies in the building sector. The revision of the building regulation will imposes conditions in order to improve the building design and the adoption of EE measures.