

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

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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 2004.

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/m², cell junction temperature of 25°C, 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

As expected from the revised feed-in legislation, there was a noticeable growth of interest regarding grid connected applications, which was made clear by the large number of requests for interconnection points received by the government's Directorate General for Geology and Energy. The overall power requested in 2004 totalled 5,28 MWp, for a total number of 471 PV systems, most of them (453) for 5 kWp systems able to benefit from the highest value of the feed-in tariff. However, most of these requests are yet to have a reply and the market hasn't actually deployed. If all these systems are realised in 2005/2006, they will more than double the total current installed capacity and cause a complete change in the share of on-grid applications when compared to off-grid applications, which still dominate the PV market. A total of around 574 kW of PV power has been installed in 2004, which means a 40% increase from the previous year. Nearly all the photovoltaic applications done in Portugal were stand-alone (505 kW), followed by off-grid non domestic (49 kW), and grid connected installations (20 kW).

Within the grid connected systems, two different concepts emerged as particularly relevant in 2004: one is the centralised PV power plants, with 25 projects scaled around 100 kWp and the other is the distributed generation with a few hundred small PV systems (5 kWp or less) supplying the grid in the radius of a one or two municipalities. Although no such projects have been implemented in 2004, these form the base of the power requested to DGGE by project promoters this year and if all these systems are realised in 2005/2006, they will more than double the total current installed capacity and cause a complete change in the share of grid-connected applications when compared to off-grid applications, which still dominate the PV market.

System and component's prices have had no significant changes from previous years and a relatively wide range of costs is still noticed. R&D activities focused on aspects like the nanocrystalline silicon flexible materials and building integrated systems have also been subject to particular interest.

In 2004, the limit to investment grant has been increased from 3000 to 3500 EUR/kW within the MAPE/PRIME Programme. Labour places in the PV business remained more or less similar (175) to previous years. Although strongly claimed by the installation companies, no specific technical and administrative regulations have yet been issued for PV systems, to simplify and speed up planning procedures.

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. However, in 2004 an unprecedented interest in grid connected systems was made evident by the large number of requests for preliminary information on grid connection submitted to DGGE (Directorate-General for Geology and Energy) by project promoters. These were not only for large centralised PV power installations but also (mainly) for small distributed PV generation plants. But since there was no reply to this requests during 2004, only a few plants were actually built, thus not changing significantly the existing scenario regarding the applications for photovoltaics.

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. Until 2001, these figures have been prepared by DGGE (Directorate General for Geology and Energy). From 2002 onward, the yearly installed capacity has assessed by ADENE (Agency for Energy) based on answers to a questionnaire submitted to the main PV installer companies working in the Portuguese market.

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

Sub-market/appli cation	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	31 Dec. 2004
Off-grid domestic	138	171	202	255	321	384	434	484	639	718	901	1152	1657
Off-grid non-domestic	31	38	46	69	91	126	176	226	237	273	375	520	569
Grid-connected distributed	-	10	10	12	12	17	38	184	268	319	392	397	417
Grid-connected centralised	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	169	219	258	336	424	527	648	894	1144	1310	1668	2069	2643

2.3 Major projects, demonstration and field test programmes

Despite the fact that there are not yet specific programmes or strategies defined for the development of PV in the country, a few projects and initiatives can be pointed out as relevant to illustrate the development of the PV market in 2004:

- The “Solar Energy in Schools” project in the municipality of Moura (Alentejo, south of Portugal), which started with the implementation of grid-connected PV systems in three schools, with installed power of 15, 25 and 35 kWp, respectively. This project was a front end for the integrated Moura project described more ahead.
- The Renewable Energy Demonstration Platform, installed near Lisbon (Sacavém) at Labelec premises, comprises three different grid-connected PV systems: a 1,4 kWp two-axis tracking system, a 1,4 kW fixed system and a hybrid PV (0,5 kWp) / Wind (0,9 kWp) system. Labelec is a laboratory and R&D services company within the EDP Group, the largest Portuguese electricity utility. The demonstration platform was installed by the company F.F. Sistemas de Energias Alternativas Portugal, Lda and started operation on March 2004.
- The PV plant of Barcelinhos is an independent 4,8 kWp system connected to the low voltage grid and is made of 30 multi-crystalline modules of 160 Wp each and a DC/AC inverter. The plant is owned by a private investor and it was installed by COEPTUM Lda. Licensing of the plant took more than one year, mostly due to heavy administrative requirements and the lack of experience of the grid utility in dealing with this type of small scale projects.
- A 3,78 kWp off-grid hybrid system was installed in the Sarnadas farm, owned by a private investor near Portalegre. The system comprises twenty four 85 Wp PV modules, divided in three individual 8 modules arrays installed on single axis tracking systems, eighteen 55 Wp PV modules on a fixed structure and a 750 W Aircraft wind generator. Main BOS components are a 4000W, single phase, 24V inverter and twelve 900 Ah batteries. Installed by AeroSolar Lda, it cost about 25.000 EUR and started operation in July 2004.

There has been no significant developments concerning the announced world largest centralised PV power plant (64 kWp) to be built at the municipality of Moura, in Alentejo. The complex negotiation process between the major stakeholders and the authorities is still underway. This involves the promoter (Amper Central Solar, S.A.), the Moura municipality, BP Solar (which will do the turnkey installation and will build a module assembly factory in the region), the financial institutions (which will provide the capital required on a project finance basis) and the Directorate General for Geology and Energy (discussion about the grid connection and the feed-in tariff).

2.4 Highlights of R&D

PV research activities mainly address amorphous and thin film silicon technologies. In 2004, nanocrystalline silicon flexible materials and the growth of silicon crystal materials have been the subject of particular interest. The main entities carrying out research activities in PV are:

- CENIMAT: Department of Materials Science, Faculty of Sciences and Technology (New University of Lisbon)
- LAFS: Laboratory of Photovoltaic Applications and Semiconductors (University of Lisbon)
- IN+: Center for Innovation, Technology and Policy Research (Instituto Superior Técnico, in Lisbon)
- UIMC/Ceramic Materials Research Unit (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 Regional Energy Agencies), utilities and private research institutions (INESC Porto - Institute for Systems and Computers Engineering).

Besides RD&D, some of these entities also carry out other activities related to photovoltaics like the participation international co-operation projects, information and promotion actions, organisation of specialised events and hosting of Master and PhD students.

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

In 2004, building integrated systems and small scale distributed generation have been subject to particular interest in what regards grid-connected PV applications.

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

Similarly to previous years, no specific programmes or funds were made available for activities on PV. The available funding programmes are mostly generics covering several economic sectors and scientific domains. Therefore, most of the R&D was made on a limited project basis, largely supported by funds from the European FP6, the National Foundation for Science and Technology and from the State's Budget. Estimates are that less than 0,9 EUR were spend in 2004 by the main R&D entities referred before on R&D and other activities related to PV.

The existing programmes for market stimulation and support to RD&D are not specific to PV but usually cover other technologies in renewables or in other areas. Some options are the MAPE of the PRIME Programme (2000-2006) which support projects in the energy sector, aiming energy diversification, improved energy efficiency and increased use of renewable energy and the Programme POCTI - Operational Programme for Science, Technology and Innovation (2000-2006), which support research and development initiatives and is funded by the Portuguese Foundation for Science and Technology (FCT)

3 Industry and growth

3.1 Production of feedstocks and wafers

There is no industrial production of feedstocks and wafers taking place in Portugal yet.

3.2 Production of photovoltaic cells and modules

Lobo Solar, located in Evora, is a Shell Solar module assembly plant with a total capacity of 17 MWp per annum. The factory, which employs about 90 people, manufactures both mono and multi-crystalline modules. Most of the past solar modules production was meant for export, a trend that may change in future as a result of the expected boost of the Portuguese market demand.

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

Year	2001	2002	2003	2004
Modules price (s) *	4	3,5	3,5	3,5 - 4

* the price varies widely upon the size of the order

3.3 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 these companies produce power electronics for stand-alone PV applications (small charge regulators, ballasts, etc...).

3.4 System prices

Table 5: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Current prices per W in EUR
Off-grid up to 1 kW	Telecommunications, water pumping	From 7 to 15
Off-grid > 1 kW	Domestic	From 7 to 11
Grid connected Specific case	5 kW mounted system	6
Grid connected Up to 10 kW	Decentralised production	From 6 to 8,5
Grid connected > 10 kW	Decentralised production	From 5 to 6,2

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

Year	1999	2000	2001	2002	2003	2004
Price EUR/W	From 10 to 12,5	From 9 to 11	From 9 to 11	From 9 to 11	From 9 to 11	From 7 to 11

3.5 Labour places

There has been a growing interest from non-specialised companies in the PV market, offering services and product in addition to their usual activities. But apart from these new actors, there has been no significant changes in actual dedicated labour places since 2003. Shell Solar is still up to date absorbing most of the labour force involved in the PV market.

According to information gathered through enquiries to the main universities and private or public research institutions working on PV, about 30 people dedicate most of their reasearch time to activities in this area. The Shell Solar manufacturing plant in Évora absorbs most of the labour force in the PV market, with nearly 90 people employed. By questioning most of installation companies working in the market, a total of, at least, 15 dedicated labour places can be reported. Accounting with the remaining installation companies and all other entities participating in the market, and additional figure of, at least, 40 labour place may well be considered, totalling about 175 jobs.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

Following the increase in the indicative target for PV power by 2010 from 50 to 150 MW established by the Cabinet Resolution No. 63/2003, also the limit set for the feed-in tariff (it was applicable only to the first 50 MW installed) in the Decree-Law n° 339-C/2001 was increased accordingly. In 2004, all projects installed up to an accumulated power of 150 MW could benefit from buy-back rates for PV grid-connected systems that are ~0,30 EUR/kWh (systems over 5 kWp) and 0,51 EUR/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 obliged to buy the whole power.

Having this framework, clearly the main point of interest during 2004 were grid-connected PV systems. There was a huge amount of requests for preliminary information regarding grid connection (the first stage of the licensing process in order to get the full installation permit) submitted to the Directorate General for Geology and Energy (DGGE), the government agency in charge of this process. The overall power requested in 2004 totalled 5,28 MWp, for a total number of 471 PV systems, most of them (453) for 5 kWp systems able to benefit from the highest value of the feed-in tariff.

Within the grid connected systems, two different concepts emerged as particularly relevant in 2004: one is the centralised PV power plants, with 25 projects scaled around 100 kWp submitted to DGGE and the other is the distributed generation with a few hundred small PV systems (5 kWp or less) supplying the grid in the radius of a one or two municipalities.

Despite this awesome increase in requests for grid-connection, the actual deployment of this market didn't took place, as the reply to the grid connection requests was yet to happen by the end of 2004. If all these systems are realised in 2005/2006, they will more than double the total current installed capacity and cause a complete change in the share of on-grid applications when compared to off-grid applications, which still dominate the PV market.

Public grants for RES and energy efficiency applications continued to be 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 kEUR per application. In 2004, the maximum eligible limit was increased from 3 000 to 3 500 EUR/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 kEUR.

4.2 Indirect policy issues

In 2004, the Cabinet Resolution n° 119/2004 introduced a number of additional measures under the National Programme for Climate Changes (PNAC), including strengthening the role of renewables in accordance with the energy policy update in 2003. Solar PV, together with the other renewables can have an estimated additional benefit of further 0,92 to 0,32 Mt

CO₂ eq towards the total CO₂ reduction needed by 2010. The PNAC can act as an additional argument for the global framework in support of renewables in the country but still need to be put to practice in some areas, including PV.

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 since 1994, under the Independent Power Producer Law.

In 2002, 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. Solar PV companies, in particular, claim for technical regulations and specific administrative procedure to be put in place for safer and faster processes of connecting small PV plants to the utility grid. The main PV project and installation companies state this has been the main barrier for the deployment of the market.

5 *Highlights and prospects*

As expected from the revised feed-in legislation, there was a noticeable growth of interest regarding grid connected applications, which was made clear by the large number of requests for interconnection points received by the government's Directorate General for Geology and Energy. Accounting for all requests submitted in the last few years nearly 130 MW of power capacity have been requested by the end of 2004. However, most of these requests are yet to have a reply and the market has not yet actually deployed. That is expected to happen shortly and will cause a complete shift in the predominant type of PV systems, from off-grid stand alone to grid-connected plants for both large scale centralised and small scale decentralised generation.