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 Mexico 2002

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July 2003

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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization 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 Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website 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.

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ii Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems. An important deliverable of Task 1 is the annual International Survey Report on PV power applications. This report gives information on trends in PV power applications in the twenty member countries and is based on the information provided in the National Survey Reports produced annually by each Task 1 participant. This 2002 National Survey Report gives an overview of the key developments and achievements in the field of PV in Mexico during the year 2002.

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 Wp 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^{o}C, AM 1,5 solar spectrum – (also see 'Peak power').

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

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 Wp 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.

SENER: The Energy Secretariat of Mexico

GOM: The Government of Mexico

IIE: The Electrical Research Institute of Mexico

PEMEX: State owned Mexican oil company

1 Executive summary

- Installed PV power

The total installed power of PV systems in Mexico was 16.16 MW at the end of 2002. The installed capacity in 2002 was 1189 kW, which was 14% grater than the previous year.

The PV market was still dominated by off-grid domestic sector that occupied the 50 % of total installed power The share of off-grid domestic non-domestic sector was 50 %. Among the various off-grid non-domestic applications, telecommunication and marine offshore oil platforms accounted for 474 kW. During 2002 only one grid-connected system with capacity of 1.03 kW was installed.

- PV production

There is no cell nor module production in Mexico with locally developed technology. Sanyo Electronics announced the construction of a new 10 MW assembling facility for PV modules in the Mexican city of Tijuana for export purposes.

- Budgets for PV

The total 2002 budget for R&D remained unchanged with respect to the previous year, at around 7.6 million MXN.

- Government policy and programmes

In the National Energy Programme 2001-2006, the Federal Government has declared renewable energy of national interest. Policy actions are being instrumented to encourage private sector participation in new renewable energy projects and to expand the scope of previous programmes such as PV rural electrification

2 The implementation of PV systems

2.1 Applications for photovoltaics

A variety of PV applications, beyond those of providing rural communities with basic electricity services, is taking place in remote sites of Mexico. An overview for the most relevant ones is given in the following paragraphs.

Telecommunications

This could be the single largest application of PV systems in Mexico after electrification of rural communities. Specific projects include telephone links and microwave, VHF, telephone and TV repeating stations. The telephone company and most television networks, along with the highway patrol and the national petroleum, railroad and electric companies, have switched to PV to power their remote communications stations, replacing diesel generators and gas turbines, owing to the higher reliability and lower operational costs of the PV option. In some cases, the difficulties of bringing fuels to very remote sites have been the driving force behind the switch . Over 300 links have been powered by PV in the past 10 years, some with PV generators as large as 16 kW each and battery banks of several thousand Ah. Most installations are stand-alone PV systems, but a few have diesel-gen-sets, gas turbines, or even the electrical grid as back-up power.

Off-shore platforms

Between 1986 and 1993 the Mexican oil company PEMEX installed over 30 stand-alone PV systems and some PV-wind hybrid systems to power telecommunications, safety systems and remote control electronic units that are vital for the operation of off-shore oil wells. Photovoltaic panels range in power from 1.5 to 3.5 kW each, with battery storage capacity in the 1000-1500 Ah range. Most systems use Ni-Cd batteries, the rest being of the flooded lead-acid type.

Cathodic protection

During the past years, photovoltaics has proven its way as a reliable source of electricity for cathodic protection devices in oil and gas pipelines of PEMEX. More than 20 such systems with PV panels of several kilowatts each (the largest one being 5.5 kW) have been installed in remote sites far away from the electrical grid. It is expected that in the coming years this application will grow as the natural gas pipeline network is expanded.

Luminaires

Some ecological parks, housing developments and natural preserves, even within city limits, are being provided with light points powered by photovoltaics. Over 500 such luminaries have been installed, with PV panels of around 150 W each. Typical systems use 35-W low-pressure sodium vapour lamps, which operate from 4 to 10 h per day depending on the application. Some installations have been made in public parking areas such as shopping centers and theaters

Traffic signals

Roads and railroad track signals, as well as marine navigational aids, are being powered by PV panels in growing numbers. The Mexican Ministry for Transport and Communication (SCT) has been purchasing and installing beacons, warning signals and billboards on land and sea, now amounting to at least 1000 such devices with one or two PV panels each. Hundreds of emergency 'calls boxes' have also been installed, one every few kilometers along the main highways, to help drivers get on-road help.

Water pumps

Two-thirds of the Mexican territory is arid or semi-arid land with hardly any surfaces waters. Photovoltaic pumps are now used to water cattle and even to supply small villages with the vital liquid. Submersible PV pumps capable of pumping up 20 m^3 per day of water from depths of up to 100 m have been installed, although most installations are small , with one or two PV modules each for shallow wells.

Miscellaneous

Photovoltaics systems of 1-12 kW each have been installed for a number of applications, including power for road construction and oil exploration campgrounds, remote astronomical observatories and at least one history museum next to a pre-Columbian ceremonial site. This latter application is of relevance because there are thousands of archeological sites in Mexico that have not yet been developed and are far away from electrical grid. A new PV application was introduced the so called "*cyber-kiosk*" . The PV system provides a portion of the load for air conditioning of the kiosk retrofitted to house a number of desktop computers which provide Internet services.

2.2 Total photovoltaic power installed

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

Sub-market/ application	31 Dec. 1992 kWp	31 Dec. 1993 kWp	31 Dec. 1994 kWp	31 Dec. 1995 kWp	31 Dec. 1996 kWp	31 Dec. 1997 kWp	31 Dec. 1998 kWp	31 Dec. 1999 kWp	31 Dec. 2000 kWp	31 Dec. 2001 kWp	31 Dec. 2002 kWp
off-grid domestic	5 200	6700	7920	8270	9020	9870	10673	11228	11828	12349	1294
off-grid non-domestic	200	400	900	950	1000	1150	1347	1692	2092	2614	320
grid-connected distributed	0	0	0	0	0	1.8	1.8	1.8	8.6	8.6	9.
grid-connected centralized	0	0	0	0	0	0	0	0	0	0	
TOTAL	**5400***	**7100**	**8220**	**9220**	**10020**	**11021**	**12021**	**12021**	**13928**	**14971**	**1616**

* PV installed before 1992 accounts for 3700 kWp mainly used for rural electrification

2.3 Major projects, demonstration and field test programmes

In , 2002 the municipality of San Pedro Garza Garcia of the northern state of Nuevo Leon launched a project called The Intelligent City Project. The project includes providing internet services in public buildings called kiosks. In one of these buildings was installed a grid-connected PV system that partially supplies the electricity needs of the kiosk during the sun hours.

The system is integrated by an 1.03 kW a-Si PV array with a tilt angle of 34^{o} , facing the SSE ,and a 0.85 kW inverter. The operating voltage of the system is 120 VDC. The system cost was 10.5 MXN/Wp

This system is the first PV Grid-connected PV system installed in public buildings in Mexico and the fourth in Latin America. The municipality is planning to replicate this project in other cities

One of the goals of the project is to evaluate the PV grid connected systems and how PV can be integrated into public buildings besides showing the citizens the use of green electricity in town.

Table 2: Summary of major projects, demonstration and field test programmes

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2002/problems and lessons learned	Funding	Project management	Remarks
Cyber Kiosk 2002	*grid-connected power: 1,032 kW_p amorphous silicon PV cells area: 17.2 m^2 orientation: SSE*	*To obtain experience with grid-connected PV system in public buildings*	*The objective of providing partially the energy needs of a public building was reach*	*Municipality of San Pedro Garza Garcia*	*Private* *Tecnología Servicios y Suministros*	*Monitoring Effects of non true south facing PV modules* *Public perceptions on consuming green energy in public buildings*

2.4 Highlights of R&D

Grid-Connected PV R&D activities continued during 2002. The installed pilot systems for peak power shaving in the cities of Mexicali and Hermosillo, in northwest Mexico, have been monitored to determine system's performance since the end of 2000 and the middle of 2001 respectively. A commercial installation that provides Internet services is being monitored since mid 2002.

PV-wind hybrids research continued during 2002. Strategies for system control were tested in connection with productive activities to foster the use of this technology in rural areas.

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

Table 3 Public budgets ((in MXN millions) for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/ Field test	Market
National/federal	7.6		
State/regional		0.11	
Total	7.6	0.11	

3 Industry and growth

3.1 Production of photovoltaic cells and modules

There is no cell nor module production in Mexico with locally developed technology. One assembly plant for tandem amorphous silicon modules is producing PV modules for export purposes and another PV module manufacturing plant was announced to begin operation soon, all the production will be sent to the USA market.

3.2 Manufacturers and suppliers of other components

Mexican PV industry is mainly devoted to produce balance of system components for SHS, including batteries, lamps and charge controllers. PV modules are still being imported from

abroad as is the case of inverters for PV grid connected systems. A number of companies have been created for the commercialization of PV and renewable energy systems. Foreign companies are venturing with Mexican companies for the same purpose.

3.3 System prices

Depending on the PV system type installed, system prices ranged between 110 and 160 MXN/Wp in the case of stand-alone systems as shown in Table 6. The main PV market is still been Solar Home Systems.

Table 6: Turnkey Prices of Typical Applications

Category/Size	Typical applications and brief details	Current prices per Wp in MXN
OFF-GRID Up to 1 kWp		110-160
OFF-GRID >1 kWp		
GRID-CONNECTED Specific case	1-3 kWp roof-mounted system, if available	
GRID-CONNECTED Up to 10 kWp		
GRID-CONNECTED >10 kWp		

3.4 Labour places

There is no available information regarding this topic in Mexico

3.5 Business value

There is no available information regarding this topic in Mexico

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

There were no specific promotional initiatives on offer during 2002.

4.2 Indirect policy issues

During 2001 Federal government launched a project to provide electricity and electricity based services to indigenous communities with more than 100 inhabitants. It was stated that 25% of the allocated budget should be invested in projects using renewables. Unfortunately the project did not start, and continues in the planning stage.

4.3 Standards and codes

A set of technical specifications, design guidelines and recommended engineering practices was developed early in the process of implementing PV for rural electrification. These documents are normally used as support material in the call for bids for new projects of this type.

Technical specifications are also being developed as part of the project for on-grid distributed systems in northwest Mexico

5 Highlights and prospects

Annex A Method and accuracy of data

Information was obtained from manufacturers, government agencies and equipment suppliers. Part of the information requested for this report was not accessible, as it is normally considered confidential by the suppliers and installers