## **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 Israel 2002

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## (a) 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 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 <u>www.iea-pvps.org</u>.

## (b) 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 which are produced annually by each Task 1 participant. The public PVPS website also plays an important role in disseminating information arising from the programme, including national information. These guidelines are intended to assist national experts and other participants of Task 1 in the preparation of their annual PVPS National Survey Reports.

As the International Survey Report is based on the National Survey Reports it is important that experts follow these guidelines when preparing their national reports. The International Survey Report is an external publication of the IEA-PVPS Implementing Agreement so it must not contain confidential information. Similarly, the National Survey Reports are now presented on the public PVPS website and Task 1 participants should make their own arrangements with their sources on how to treat confidential information (e.g. by ensuring anonymity of the data).

National Survey Reports should be produced by the end of May to enable the International Survey Report to be published by the end of August.

When preparing their national reports, experts must ensure that all the data are as accurate and correct as possible and follow the definitions given in these guidelines. All sections must be completed as comprehensively as possible.

## (c) Scope and objectives of the guidelines

The guidelines specify the data to be collected for inclusion in the National Reports. The principles are intended to ensure that the data collected are compatible for each country and are in a form suitable for use in the International Survey Report.

These guidelines are issued as an internal report for use by IEA-PVPS Task 1 participants.

### (d) Definitions, Symbols and Abbreviations

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

<u>PV power system market</u>: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 Wp or more.

<u>Installed PV power</u>: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m<sup>2</sup>, cell junction temperature of  $25^{\circ}$ C, AM 1,5 solar spectrum – (also see 'Peak power').

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

<u>PV system</u>: 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.

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

<u>Off-grid domestic PV power system</u>: 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'.

<u>Off-grid non-domestic PV power system</u>: 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'.

<u>Grid-connected distributed PV power system</u>: 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.

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

<u>Turnkey price</u>: 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).

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

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

<u>Market deployment initiative</u>: 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

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

<u>Performance ratio</u>: 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.

Please also refer to the internal PVPS report *Writing numerical values, quantities, units and symbols according to International Standards* for guidance.

#### 1 Executive summary

 Installed PV power - Total installation of PV in Israel was approximately 30 kW, the market remaining unchanged from the previous 2 years. The main applications are: irrigation systems, consumer and remote houses, security and communications. The visibility of such PV applications is high, leading to overall positive public image for this technology. However, there are no major projects and the market itself remains small.

The barriers to market expansion include general economic factors, as well as issues specific to PV. In general, the entire Israeli economy remains in recession, with no funds available for special projects. Specifically, there is still no progress with the infrastructure required to encourage even private purchases of PV, including the establishment of standards for grid-connected metering and PV grid inverters.

- Costs & prices Prices for installed systems may range from NIS47 380 to NIS71 070 for domestic, grid connected systems. An example of a special offgrid system > 1kW, cost NIS56 856.
- PV production NOT APPLICABLE
- Budgets for PV R&D BUDGET from Israeli government sources during 2002 was NIS938 000.

#### 2 The implementation of PV systems

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 Wp or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

#### 2.1 Applications for photovoltaics

The status quo for PV applications in Israel has remained constant, with virtually the entire market going to off-grid projects. In order of declining importance, PV is used in agriculture (to control computerized irrigation systems), consumers, remote homes, defense and communications. Until the outstanding issues of grid-connected metering and standards for grid-tied inverters are dealt with, on-grid projects are unlikely to happen. There are two potential markets for off-grid PV projects - environmentally friendly villages and remote farms; and the non-urbanized Bedouin population. In the

Israel

first case, there is a growing awareness of the need to live according to sustainable development principles, and a growing number of people wish to put these theories into practice by establishing new villages. Incorporating clean energy sources into their infrastructure planning is one of their goals. However, the high costs of PV systems and the lack of easy financing are barriers to these groups.

Some of the Israeli Bedouin population, as mentioned in previous reports, lives in "unrecognized" villages and towns, and are not connected to the national grid. PV/wind hybrid systems are a good, and growing, source of electricity for some families. However, by and large this population is cash-poor, and financing PV purchases on their own is not possible. In the past, there were proposals to electrify small rural Bedouin schools with PV, but without funding - this again proved unviable.

With almost the entire country having access to low-cost grid electricity, there is no incentive to promote grid-connected PV projects. Other factors in the production of clean energy, such as acceptance of the costs of externalities, have influenced some decision-making processes. The government has decided to establish target dates for implementation of renewable energies. How this will affect the PV market in particular is unclear, as our national experience and priority point to utilization of solar-thermal electricity production. The Israeli government has approved a plan to build five 100 mW solar thermal plants, and implementation of this project will place Israel on the world map of solar electricity producers.

Active research on solar energy production, including basic research in new materials for solar cells, Concentrator PV and evaluation of inverters, continues at Israel's universities. The Israel Standards Institute has published standards for two kinds of PV panels.

#### 2.2 Total photovoltaic power installed

The total <u>cumulative</u> installed PV power for each sub-market on the 31 December of each year from 1992 onwards should be entered in Table 1.

Table 1	The cumulative installed PV power in 4 sub-markets.
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Sub-market/ application	31 Dec. 1997	31 Dec. 1998	31 Dec. 1999	31 Dec. 2000.	31 Dec. 2001	31 Dec <mark>2002</mark>
	kWp	kWp	kWp	kWp	kWp	kWp
off-grid domestic ##	70	88	181	221	253	283
off-grid non- domestic ##	176	200	200	200	200	200
grid-connected distributed	5	6	6	6	6	6
grid-connected centralized	14	14	14	14	14	14
TOTAL	265	308	401	441	473	503

#### 2.3 Major projects, demonstration and field test programmes

2.3.1. The Israel Institute for the Research of Seas and Lakes commissioned a special research vessel for their Laboratory for Lake Kineret [Sea of Galilee] Research. The vessel has installed a 1.5 kW PV system (US\$12,000), which provides power for water pumping, refrigeration, testing equipment and illumination. Although the raft is presently moored at one location, the PV system can provide 5 horsepower of propelling power. The PV system was mounted at sea.



2.3.2. The first stages of Israel's first toll road, a highway designed to go the length of much of the country, were inaugurated in 2002. A unique feature of this road is the method of payment. Cameras powered by PV panels operate at the on and off ramps to the highway. These cameras "read" the car license plates, feed them to a data base, and the customer is then sent a bill. This US\$0.5 m project will consist of 54 cameras on posts, the first ones having already been installed. Part of the motivation for this project was to "green" the highway, a direct result of major opposition expressed by a wide range of groups, including all the environmental protection groups.



#### 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
Laboratory for Lake Kineret Research	Research and monitoring vessel. 1.5 kW system powers pumping, refrigeration, testing equipment and illumination.	Supply clean, independent power	The PV system supplied continuous power for all requirements (see photo)	Israel Inst. for Research of Seas & Lakes	Interdan Ltd	Although the vessel is usually moored, the PV can provide 5 horsepower of propelling power.
PV powered camera operation for new toll road	US\$0.5 m silicon PV panels	Country's first toll road was opened during 2002. PV powered cameras read license number of cars as they enter and leave access ramps, customer is then sent monthly invoice.	First 4 out of 52 installed by end 2002. (See photo)		Millennium Ellectric Israel	First project of its kind.
Grofit solar village <i>May 2002</i>	30 grid-connected retrofitted solar houses. 3 kW each, 2 buy/sell meters, data acquisition system.	Project aims: provide IEC first hand information on technical and procedural parameters re: connection of a group of small PV generators. Also, to improve IEC preparedness to connecting small PV generators to the grid.		IEC (Israel Electric Corporation)	IEC	

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#### Section 2.4 Highlights of R&D

Active research on solar cells produced from a variety of materials is continuing at Israel's universities. The materials include: fullerene, silicon, cadmium telluride, copper indium diselenide, transparent conductor-oxide coatings as well as evaluation of Graetzel cells. Ben-Gurion University has continued its on-line evaluation of a new generation of grid-connected inverters. Ben-Gurion University is also continuing its program to develop Concentrator Photovoltaics (CPV), using PETAL (Photon Energy Transformation and Astrophysics Laboratory), a 400 m<sup>2</sup> parabolic dish. MLM Israel Aircraft Industries has developed a CPV product, able to produce 2 kW or multiples thereof. They have proven the concept to work, and are now looking for business partners for investment.

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

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

	R & D	Demo /Field test	Market
National/federal	938 000	0	0
State/regional	0	0	0
Total	938 000	0	0

Note: NC is NIS. Average rate of exchange for 2002 is about NIS4.734 to the \$.

#### Section 3. Industry and Growth - NOT APPLICABLE

#### 3.3 System prices

Please give in Table 6 turnkey prices (excluding VAT/TVA/sales tax) in National Currency per Wp for the various categories of installation. Prices should not include recurring charges after installation such as battery replacement or operation and maintenance. Additional costs incurred due to the remoteness of the site or special installation requirements should not be included.

Category/Size	Typical applications and brief details	Current prices per Wp in NC
OFF-GRID		
Up to 1 kWp		
OFF-GRID	Scientific monitoring system	NIS56 856
>1 kWp		
GRID- CONNECTED		
Specific case		
GRID- CONNECTED		NIS47 380 to NIS71
Up to 10 kWp		070
GRID- CONNECTED		
>10 kWp		

#### **Table 6: Turnkey Prices of Typical Applications**

NOTE: Euroland countries must use the euro (EUR).

#### 3.4 Labour places

a. Research & Development (Not companies) Research in Israel's academic institutes employs approximately 85 people, including researchers, technical staff and students. There are approximately 20 groups working on PV and PV applicable materials.

b. Manufacturing - *Not Applicable* 

c. All other - personnel employed on PV related projects in distribution and the country's single utility is approximately 15.

#### 4 Framework for deployment (Non-technical factors)

#### 4.1 New initiatives

There have been no marketing, financing or promotional initiatives for grid-connected or offgrid PV in Israel during 2002.

i) Utility (Israel Electric Corporation, IEC) perception of PV is that the time has come for it to take PV as a given and necessary component of future energy portfolios, as a result of public demand. One aspect of the IEC's motivation is to provide a better public

image for the company, and they perceive PV as one way this may be accomplished. The IEC is beginning several net-metering demonstration/evaluation projects (one in 2002 and another to start in 2003), as well as an R.O. desalination system, 100 liter/hour local brackish water). The IEC has also promised movement on the issue of standards for grid-connected inverters – with the purpose of preparing for the new trend. The issue of how grid-connected metering will work is still undecided, with the issue to be handled by the Electricity Administration of the Ministry of Infrastructure (which oversees electricity prices and other policy issues governing the monopoly IEC)

- ii) Sectors of the Israeli public see the move to renewable energy as a necessity, with PV being the preferred method in the urban area and among the rural Bedouin. PV is only a partial answer to the clean energy portfolio, however, with solar thermal being more predominant overall. An ever increasing portion of the population is becoming aware of pollution concerns, through the public media. Reports on air pollution levels, and deaths related to this pollution, were heavily publicized this winter.
- iii) Major new projects or initiatives: A number of towns and regions have adopted Sustainable Development as their motto, and implementation is expected to include clean energy because of public interest and demand, and planning issues.

#### 4.2 Indirect policy issues

The Israeli government passed a resolution in November 2002 (No. 44), for the first time establishing target dates for minimum renewable energy production (2% by 2007, an additional 1% every three years, with a target of 5% renewables by 2016). The practical provisions and codes required to implement this decision are being prepared by the Directors Commission (Directors-General of all relevant government ministries). It is unclear how this will affect the PV market, in view of the priority given to solar thermal (plans have been approved for five 100 MW stations) and wind.

According to <u>all</u> information sources polled, unless and until there is positive movement to encourage PV (positive buy-back prices, special credit terms, targeted campaigns among target populations such as architects [who could take advantage of value-added benefits] etc.) there will be no significant growth in the market.

Agenda 21 - Representatives of several government ministries (Chief Scientist of the Ministry of National Infrastructures, and others from the Environmental and Foreign Affairs Ministries), as well as local decision makers, attended the Johannesburg conference in the fall of 2002. Representatives at all levels were unprepared for the new emphasis placed on energy issues at this conference (compared to the Rio Conference where it wasn't raised). As a positive result, there are recommendations to place energy issues (conservation, renewable sources, expanded R&D) higher on the Israeli national agenda. On a local level, a number of municipalities have declared themselves to be "Sustainable Development Towns", and in the future there may be more distributed electricity production on a local level, with decision making by the local residents taken into account. In this case, the move to use PV and other clean energies would be market pushed, as an increasing number of citizens are interested in using clean energy.

The Israel Electric Corporation (IEC) has had a monopoly on all aspects of electricity production and transmission since its incorporation. In addition, it has had to plan for a *de* 

facto "island economy", as there has been no neighboring country with whom Israel could establish mutual infrastructures. Some changes being proposed in both these arenas could have a long term effect on Israel's use of clean energy. One proposal, raised in the past, and now brought forward again by the Minister of National Infrastructures, is to separate the IEC into several independent companies – this step is expected to increase competition, and as seen in some other countries, an "environmental portfolio" becomes a marketing tool when competing for customers. It is unlikely that any serious changes will take place in the near future.

#### 4.3 Standards and codes

- The Israel Standards Institute has issued standards for PV panels: No. 61215 "Crystalline silicon terrestrial photovoltaic (PV) modules" (Identical to IEC1215: 1993-04); and No. 61646 "Thin-film terrestrial photovoltaic (PV) modules (Identical to IEC 1646: 1996-11).
- There are still no standards or codes for grid-intertie inverters, or net metering. This is having a definite negative effect on purchase of PV systems by private consumers.

#### 5 Highlights and prospects

- Any developments in technologies: The development of Concentrator Photovoltaics (CPV) is being actively pursued by Ben-Gurion University. Calculations show the economic advantages of this approach – and Israel enjoys the climate and conditions to apply this approach.
- There are no long term targets for installed PV power capacity, though as reported the future scenario for alternative energies has brightened with the government decision to set targets for implementation.

#### Annex A Method and accuracy of data

Data on sales is collected through personal conversations with all known photovoltaic dealers. New dealers are identified through a network of people interested in projects being established around the country. An active attempt is made to locate new dealers through internet and other searches. As the National Solar Energy Center, we are also often the first source of information people contact when they require information on solar energy.

On national and policy issues, conversations and interviews are held with decision makers in government offices, environmental protection groups, and economists interested in the field of energy.

The margin of error in reported sales is impossible to measure. On one hand, some dealers give exact sales quantities in W, though could not provide system costs due to vagaries and uncertainties in the system. On the other hand, some dealers had such a low level of sales that they are "embarrassed" to report it. We therefore estimated sales based on last year's level – showing no growth in the past year.