**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 2004*

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## 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 ***Trends in photovoltaic applications*** report. This report gives information on trends in PV power applications in the PVPS member and other countries and is largely 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 ***Trends in photovoltaic applications*** report is based on the National Survey Reports it is important that experts follow these guidelines when preparing their national reports. The **Trends** 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).

## 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$^o$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 to provide power mainly to a household or village not connected to the (main) utility grid(s). Often a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'. Can also provide power to domestic and community users (plus some other applications) via a 'mini-grid', often as a hybrid with another source of power.

Off-grid non-domestic PV power system: System used for a variety of industrial and agricultural 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 to provide power to a grid-connected customer or directly to the electricity grid (specifically where that part of the electricity grid is configured to supply power to a number of customers rather than to provide a bulk transport function). Such systems may be on or integrated into the customer's premises often on the demand side of the electricity meter, on public and commercial buildings, or simply in the built environment on motorway sound barriers etc. They may be specifically designed for support of the utility distribution grid. Size is not a determining feature – while a 1 MW PV system on a rooftop may be large by PV standards, this is not the case for other forms of distributed generation.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station. The power supplied by such a system is not associated with a particular electricity customer, and the system is not located to specifically perform functions on the electricity grid other than the supply of bulk power. Typically ground mounted and functioning independently of any nearby development.

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.

## *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 nineteen participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), 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 five are active. Information about these tasks can be found on the public website www.iea-pvps.org. A new task concerning PV hybrid systems is now being developed.

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.

# 1 Executive summary

- Installed PV power in Israel: Installations of approximately 353 kW during 2004 (nearly double previous years). Total installation of PV in Israel has shown a remarkable jump in reported installations for 2004, compared to low steady rates in the past few years. Some of this increase is due to greater public awareness finally leading to actual purchases, including several privately-funded, public grid-connected PV projects. Some of this increase is due, however, to increased depth of reporting. With the legalization of grid-connected private power production imminent, it was deemed important to attempt to obtain as accurate a picture as possible of the pre-legalization market.
- Costs & prices: Typical module prices range from NIS19.8-NIS27.28 /W, depending on the size of the order. There was a minor reduction in prices compared to 2003.
- PV production – reported manufacture of multi-solar modules in Israel [defined as location of cell encapsulation]. Multi-solar combines PV and thermal collection plates. No numbers (quantities/market value) were made available.
- The Israel Ministry of National Infrastructures spent NIS 688,000 for PV-related R&D, with an additional NIS 200,000 from non-governmental public funding.

## 2.1 Applications for photovoltaics

The major application of photovoltaics in Israel continues to be for off-grid projects. Israel is a small, densely populated country, with a thoroughly developed infrastructure. Access to grid-electricity is almost universal, dependable and relatively inexpensive. There is no financial justification for installing photovoltaic systems in the urban environment (and therefore no public programs or incentives), and BIPV is practically non-existent. Typical uses include (in order of volume use):

- Remote homes;
- Agriculture (computerized irrigation systems in a water-poor country);
- Security and alarm systems;
- Communications
- Exterior lighting.

During 2004, the various government authorities and Israel Electric Corporation (IEC) introduced, and during 2005 are still in the process of implementing, a series of laws and regulations which will permit private clean energy producers to connect to the grid. One factor will be the offer of premium payments to renewable energy producers. This may have a significant affect on the future of PV installations, for the first time permitting legal access to grid connections. We may expect an increase in future installations as the environmentally-aware population begins to initiate their own purchases.
Israel's primary emphasis on solar energy electricity production remains solar-thermal plants. The Israeli government has issued a *Call for Information*, the final stage before issuing a public tender for the building of a 500 MW solar electricity plant.

## 2.2 Total photovoltaic power installed

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

| Sub-market/ application | 31 Dec. 1998 kW | 31 Dec. 1999 kW | 31 Dec. 2000 kW | 31 Dec. 2001 kW | 31 Dec. 2002 kW | 31 Dec 2003 kW | 31 Dec 2004 kW |
|---|---|---|---|---|---|---|---|
| off-grid domestic ## | 88 | 181 | 221 | 253 | 283 | 313 | 653 |
| off-grid non-domestic | 200 | 200 | 200 | 200 | 200 | 200 | 210 |
| grid-connected distributed^ | 6 | 6 | 6 | 6 | 6 | 6 | 9 |
| grid-connected centralized | 14 | 14 | 14 | 14 | 14 | 14 | 14 |
| TOTAL | 308 | 401 | 441 | 473 | 503 | 533 | 886 |

## **Most reports of actual installations gave undifferentiated numbers, therefore this category contains some non-domestic and some grid-connected distributed installations.**

**^Most grid-connected domestic numbers are not publicly admitted, as there was still no legal way to connect such systems to the grid.**

## 2.3 Major projects, demonstration and field test programmes

Two privately-financed grid-connected PV school projects were installed in 2004 – with the twin purposes of providing an educational tool and contributing to environmental protection.

2.3.1 **Lakia Science School** – 1,000 W grid-connected system. The system, installed on the school's roof, feeds electricity straight into the electric board, resulting in financial savings for the school. The project's display shows current and daily electricity output, and allows data downloading and analysis, as well as contribution to environmental quality.

Photos provided by: Interdan Ltd., Haifa, Israel (2004)

2.3.2 **Shittim School**, Arava, Israel – 960 W grid-connected system. The system includes 12 x 80 W panels (Kyocera), a 1100 W inverter, meteorological station and on-line live reports on current output, viewable via public internet access. The project was initiated and funded by the Arava R&D Center and Arava Regional Council who decided to start a green energy project, and offered the school to be part of the study. System efficiency is ~92%, operating costs are zero. One problem encountered is lowered efficiency since the system is not facing due south, and necessarily had to line up with existing building orientation. This is an accepted feature of this project whose primary purpose is educational. Lessons learned: having an on-line monitoring system is a great tool for post installation phase, as no on-site visits are required.

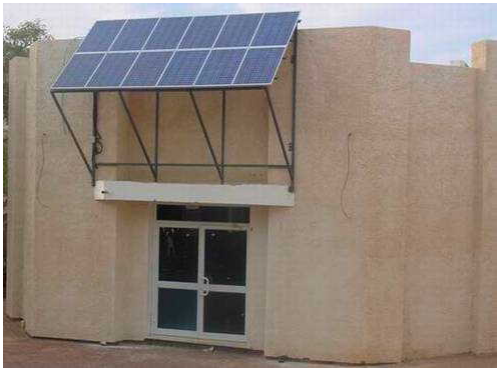

Photo provided by Solarpower Ltd., Israel (2004)

2.3.3 Solar lighting for mosque and residents of East Jerusalem. Two street lights (400 W) installed during 2004, out of a total order of 120.

(Photos, right: Millenium Electric, Israel)

2.3.4 Heraklion, Greece - Solar Powered Water Distillation System (EU sponsored development project). The 4800 W system can distill up to 10,000 liter/day of any waste/sea water. At Heraklion, the system distills olive oil mill wastewater. The Project was valued in the range of Euro 413,000, and includes several European partners along with the Israeli partner.

(Photos: Millenium Electric, Israel)

2.3.4 HIGH WAY 6 TOLL ROAD – UPDATE. Previously (NSR 2002) we reported on the installation of PV panels to operate cameras (Traffic Probe Readers – TPR's) used to "read" the license plate number of vehicles entering and exiting the country's first toll road. Following a one winter with a particularly heavier than usual cloud cover, which resulted in a few days when the batteries could not be adequately recharged, the highway operating commissioned an evaluation of the system. The conclusions of this report were that "the solar power system for the TPR's substantially exceeds design specifications and continues to demonstrate excellent reliability." The system has also experienced downtime due to theft of some panels, but the policy has become to quickly replace stolen panels. **This is a**

**change in local approach to such issues**: in the past, such thefts were used to ostensibly "demonstrate" that PV systems are unreliable, and were allowed to go out of use – limiting further growth of PV into other sectors. This psychological change in the public image of PV installations, as a standard part of basic infrastructures rather than as some impermanent whim, could also help increase the installations for public and private applications.

## 2.4 Highlights of R&D

All of Israel's universities and some high-tech start ups continue research on various PV-related projects. Basic research includes:

- Materials studies, including fullerene, silicon, cadmium telluride, copper indium-di-selenide;
- Cell studies: Dye sensitized solar cells, design synthesis, characterization and application of a full solar cell;
- Modelling of solar devices and systems;
- Energy conversion and storage devices; and the fabrication technology of Si solar cells (single and multi-crystal, and bifacial).
- Concentrator Photovoltaics (CPV). Teams at Ben-Gurion University, Tel Aviv University and local industry are investigating various technologies for CPV. BGU is working on several aspects of Concentrator Photovoltaics (CPV):
    a. Large Dish dense-array systems and
    b. small-dish individual cell systems.

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

Public funding for R&D in PV and PV-related projects was NIS 888,000 [NIS680,000 by the government, another NIS200,000 from semi-public funds]. Direct investment in PV R&D by the government declined from last year by USD 90,000.

**Table 2 Public budgets (in National Currency) for R&D, demonstration/field test programmes and market incentives.**

| | R & D | Demo/Field test | Market |
|---|---|---|---|
| National/federal | NIS888,000 | -- | -- |
| State/regional | | | |
| Total | NIS 888,000 | | |

## 3 Industry and growth

**Table 4a: Typical module prices (NC) for a number of years**

| Year | 1992 | 1993 | 2003 | 2004 |
|---|---|---|---|---|
| Module price(s):<br><br>Typical Range | | | 22.5-28.35 NIS/W | 19.8 - 27.28 NIS/W |
| Best price - range | | | | 13-22 NIS/W |

### 3.3 Manufacturers and suppliers of other components

PV production [new in this year's report] –manufacture of multi-solar modules in Israel [defined as location of cell encapsulation]. Multi-solar combines PV and thermal collection plates. No numbers (quantities/market value) were made available.

### 3.4 System prices

**Additional information** – In Israel, all PV sales continue to be via the services of several distributors, including DIY sales. There are no PV system kits marketed through retail outlets).

**Table 5: Turnkey Prices of Typical Applications**

| Category/Size | Typical applications in your country and brief details | Current prices per W in NC (to one decimal point) |
|---|---|---|
| OFF-GRID<br>Up to 1 kW | | 39.6 NIS/W |
| OFF-GRID<br>>1 kW | | 30.8-39.6 NIS/W |
| GRID-CONNECTED<br>Specific case | Two schools, 1KW – 2 different installing companies. | Unavailable! |
| GRID-CONNECTED<br>Up to 10 kW | | |
| GRID-CONNECTED<br>>10 kW | | |

## 3.5 Labour places

Provide an estimate of labour places in the following (where these are mainly involved with PV):

a) Research and development (not including companies); **Academic = 70**
b) Manufacturing* of products throughout the PV value chain from feedstock to systems, including company R&D; **200**
c) All other, including within electricity companies, installation companies* etc. **25**

*Source of this information: Companies self-reporting.

## 3.6 Business value

***Insufficient information***

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

## 4.1 New initiatives

The Israel Ministry of National Infrastructures has published for public evaluation a new **Energy Master Plan** designed to coordinate the direction our planning authorities should be taking over the next 20 years. One of the basic recommendations is the "Promotion of Renewable Energies, including investments in further R&D for advanced solar energy technologies". The Master Plan promotes active and extensive action in this area, covering both the implementation of centralized solar power plants (i.e. the planned 500 MW solar thermal plant), as well as **encouraging PV in the private, commercial and industrial sectors. A specific advantage of PV as specifically mentioned is the ability to utilize building roof tops and walls, thereby saving scarce open areas. The report specifically stages that it is still not possible to evaluate the potential application of this technology for Israel.** The report does make a positive comparison with Israel's successful use of solar hot water heating (following legislation, 80% of Israel's households use it, thereby saving some 4% of energy imports, the largest such factor in the world), suggesting PV could be introduced in the same way.

This Master Plan indicates directions planning should take, with no legal standing nor specific recommendations for programs, subsidies or investments. We therefore concur that it still not possible to evaluate potential future market size.

The Israeli government has proceeded with implementation of its decision of November 2002 to increase the production of clean energy, though these did not affect the 2004 market. It is too early to predict how the new regulations will affect the market during 2005 and further.

As previously reported, the primary vehicle for implementing this policy is approval of a 500 MW solar-thermal power plant. This large project, utilizing Israeli technology, has continued to progress through the approval process. Land allocation was approved in 2004**. In January 2005, the Israel Ministry of National Infrastructures issued an international "Call for Information", inviting offers for building a station of this size. This is the mandatory legal step required before issuing a Public Tender.**

The Israeli government and the Israel Electric Corporation (IEC, Israel's monopoly power company) issued a number of complementary draft provisions in the spring of 2004, which could have significant impact on the clean energy market in general, and PV in particular. They are:

### 4.1.1. Ministry of National Infrastructures: Revision of Electricity Regulations

The Minister of National Infrastructures issued a draft of the "Revision of Electricity Regulations (Transactions with Licensee of Supplier of Essential Service) -2004". The stated purposes of the new policy are: a) Enlarge Israel's electricity production capacity and

provide sufficient reserves[1], through encouraging private producers, including special financing opportunities; b) create conditions for fair competition and encourage private producers to sell directly to their consumers/customers; c) **encourage the production of electricity by efficient technologies or those with high environmental value.** Though not dedicated solely to renewable energies, the law does specifically mention them, through encouraging private electricity producers to enter the market. The significance of this new legislation lies in the fact that the IEC will no longer have a monopoly over production of electricity - and which methods to encourage - though it will continue to be the sole deliverer.

**Of particular interest to the PV market are: a) the encouragement of commercial size renewable energy production; and b) the recognition and permission to link households, via a net-metering scheme.**

### 4.1.2. Public Utility Authority Electricity - Renewable Energy Premiums

The Public Utility Authority - Electricity (PUA) has issued Guidelines and Regulations providing premium payments to private electricity producers, using renewable technologies. These "Environmental Premiums" will be restricted to specific renewable sources of energy, where the primary source of energy is renewable. Although premium payments will be available to both large and small (residential) power producers, the current regulations apply solely to the non-residential power producers. Regulations applying to residential users will be available at a future date, when a number of other factors are considered, such as balancing the ease of using a net-metering system vs. higher premiums for even the small producers.

Hybrid-systems may also qualify for such premiums, e.g. PV and wind.

Payment of the premiums will be based on calculations of the displaced pollution by type and quantity. Establishment of the premium is only the first step in the process of "environmental quality tariff". Further steps are expected to include: a) Net Metering for household producers, expected to be primarily PV; b) Decentralization of renewable power production capacity, with tariff's which will reflect the location of stations, and their contribution to savings in electricity conduction and distribution; c) Definition of mechanisms for trading in pollutants.

***Update as of May 2005: Following up on the process of receiving feedback of its draft Premium Payments Proposal from the public, the PUA will be holding public meetings prior to finalizing the details of this new law. It is expected that some time during the summer of 2005, the final details will be passed.***

### *4.1.3. Israel Electric Corporation - Procedures for connecting Private Solar Electricity Producers to the Grid*

The draft procedures define the technical, operational, commercial and legal conditions for connecting "solar homes" in synchronization with low-tension grids of the IEC. Their definition of a "solar home" is an "installation including photovoltaic panels, inverter and other electrical apparatus". The procedure suggests applying existing Israeli laws

[1] Note: Israel is an "island" in terms of electricity production, and must supply all its own needs.

concerning the supply of electricity, the European standard for electricity quality EN-50160 from 1999. The standards for specific PV equipment will be those already published and recommended by: ASTM PV, IEEE PV, IEC, UL, and the NEC.

The IEC is recommending Net Metering for the small household produer, with the applicable tariff to be chosen by the home producer, either standard household tariff or voluntary adoption of time-of-use readings. Their draft contract includes a ceiling for monthly W fed into the grid and once-a-year "zeroing" of the balance of payments.

***Update as of May 2005: The IEC has still not issued a final standard contract for grid-connected projects. To date, there has been one formal application to the IEC for a grid-connected public project (Science school), which took 8 months to obtain approval. Application to the IEC for grid-connection is made by the PV supplier to the IEC regional office.***

4.a Utility perception of PV

The Israeli utility IEC has not, in recent years, implemented PV as a legitimate source of electricity, for inclusion in its portfolio, due to its high cost. However, according to the new regulations mentioned above, the IEC will be required to connect any approved private electricity producer, even PV.

4.b Public perceptions of PV - the environmentally aware public has always viewed PV positively, and personal purchases were usually limited because of the inability to connect to the grid. Once all regulations are formalized, and the private market will be allowed for the first time to connect home-PV systems to the grid, it will be interesting to see how many people will actually do so.

There are no marketing, financing or promotional initiatives for grid-connected or off-grid PV (or any other alternative electricity production), for the same basic reasons as in the past:

- there are no local PV producers, and therefore no public support of local industry;
- until now there has been no legal possibility to develop grid-connected projects, of the kind usually associated with large scale implementation.

## 4.2 Indirect policy issues

NA

## 4.3 Standards and codes

The standards for photovoltaic panels to be applied by the IEC are the standards for specific PV equipment are already published and recommended by: ASTM PV, IEEE PV, IEC, UL, and the NEC. The Israel Standards Institute (ISI) adopted module standards as Israel's.

Standards for grid-connected transformers – with emphasis on transformers with cut-out ability: in the first stage, the IEC will accept those standards already accepted in Europe. Israeli standards will soon be established.

## *5 Highlights and prospects*

Our Trends report focuses on the issues already discussed above, specifically:

1) permission to connect private energy producers to the grid;

2) Construction of the 500 MW Solar Thermal Plant;

3) Adoption and implementation of the Energy Master Plan.

## *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 still had such a low level of sales that they are “embarrassed” to report it, or are concerned with the possibility that confidential business information would somehow be revealed.

***Annex B Country information (May 2005)***

This information is simply to give the reader some background about the national environment in which PV is being deployed. It is not guaranteed to be 100 % accurate nor intended for analysis, and the reader should do their own research if they require more detailed data.

**1)** retail electricity prices (NC) –

**General: standard fee of NIS 67.87/month + 0.571 /kWh**

**Household: standard fee of NIS 17.74/month + 0.5104/kWh**

2) typical household electricity consumption (kWh) : **500 kWh/month**

3) typical metering arrangements and tariff structures for electricity customers (for example, interval metering? time-of-use tariff?):

- :Private consumer: **standard tariff** throughout the day and the year. Last year, IEC announced that Time-of-Use Tariff would be applicable also to the small consumer
- Time-of-Use: primarily industry.

4) typical household income (NC):

**5)** typical mortgage interest rate: **4.5%**

**6)** voltage (household, typical electricity distribution network): **220**

7) electricity industry structure and ownership

- vertically **integrated monopoly**
- **state owned**;
- electricity industry regulator: **State of Israel, Public Utilities Authority Electricity**

8) price of diesel fuel (NC): **NIS 3.85-5.2** (open to internal competition)

**9)** typical values of kWh / kW for PV systems in parts of your country. In the Negev (southern part of the country) **1kWp PV would give ~1750 kWh/year***

**Sources: Israel Central Bureau of Statistics, and Israel Electric Corporation,**

- **Source: Prof. David Faiman, Ben-Gurion University of the Negev, Ben-Gurion National Solar Energy Center**