# ISRAEL

PHOTOVOLTAIC TECHNOLOGY STATUS AND PROSPECTS: AN UPDATE
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*Fig. 1- Prototype dust-removing device Kinnor-2; one of the consequent stages of widening of the dust-free zone from the central to the peripheral region of a 400-mm wide PV panel (in the laboratory).*

## GENERAL FRAMEWORK

At present, photovoltaic activity in Israel is concentrated mainly in academic research, with limited industrial involvement. The ubiquity of the electricity grid makes most applications non-cost-effective, except in unique situations.

About 1,3 MW of peak power has been installed so far; 275 kW were installed in 2006. Nearly all the applications are off-grid remote electrification systems (remote homes, agriculture, security and alarm systems, communications and exterior lighting). Most installations were justified on an economic basis, the PV system being the most economically viable alternative (because of the project's distance from the electric grid).

Things appear to be moving as a result of intensive Government activity during the last years:

- The Ministry of National Infrastructures has recently set a target of 10 % of electricity supply from renewable energy by 2020 (today just 0,1 % of the country's electricity supply comes from all sources of renewable energy).
- The Government will publish international tenders for a number of solar power plants in the Negev desert, up to a total of 250 MW, during 2008. It is expected that at least one of the tenders will mandate use of PV technology.
- The Public Utility Authority (PUA) plans to introduce tariffs for distributed PV systems in 2008. The tariff is expected to be about 0,52 USD/kWh. The total installed power will be limited to 50 MW over a period of seven years. The tariffs will be guaranteed for 20 years, and it is expected that they will influence strongly the local PV market. In 2006, the PUA published feed-in tariffs for solar power plants, ranging between 0,23 and 0,18 USD/kWh for systems between 100 kW and 100 MW. However no solar power systems have so far taken advantage of these tariffs, chiefly because of land acquisition problems.

There is a growing interest among the general public, as well as among investors, in clean and local energy sources. In view of the worldwide increase of energy prices and with the new measures planned, an increase in PV implementation is expected.

## INDUSTRY INVOLVEMENT

A few firms are active in the PV field, and they deal mainly with system integration. Most companies are small, and are not exclusively dedicated to PV. Some of the local production of systems are exported.
Presently, there is no local production of either PV cells or inverters. The technological infrastructure required to produce all the components needed for integration in PV systems is available; however, due to economic considerations, components such as modules are imported. In spite of this, some unique Israeli PV systems have high added value related to the balance of system (in particular, control systems), and therefore they have international market potential.

## RESEARCH AND DEVELOPMENT

A relatively large number of research teams are involved in photovoltaic R&D, most of them from academe, spread over most research areas. Many of these teams cooperate with leading teams worldwide (both in academe and in industry).

*Fig. 2 - A pilot project in the city of Ariel, providing free wireless LAN (photo SolarPower).*

*Fig. 3 – 1,5 kW PV system at a large water control station (photo Interdan).*

Among the current R&D projects, a number are highly innovative and worth noting:

- DiSP Ltd. is developing a Miniature Concentrating PV (MCPV) system for distributed power applications, in cooperation with Tel Aviv University. The system is designed to provide both electricity and high-grade heat, making it a true Combined Heat and Power (CHP) system. It includes a 1 m-diameter concentrating dish and a high-efficiency CPV module. The heat can be provided at temperatures suitable for steam generation, cooling, space and water heating, and process heat.
- An innovative inverter topology developed at Ben-Gurion University of the Negev's Blaustein Institutes for Desert Research (BIDR) overcomes the main deficiencies of present day solutions: the hard switching operation and the problem of connecting a voltage source to the grid. The new approach is designed around a current source rather than a voltage source. This implies that connection of the inverter to the power line is inherently safe since the current source will automatically adjust itself to the voltage of the grid. Consequently, there is no need for extra monitoring, controlling, protecting and current shaping circuitry, improving thereby the reliability of the system. Another important feature of the invention is the soft-switched operation that is possible with the new power stage design. The soft switching operation reduces losses, enables economic utilization of the switching transistors and allows the increase of the switching frequency. Consequently, the size and weight of the inverter are reduced; the efficiency and reliability are increased while the cost is in fact reduced, due to better utilization of the components.
- Researchers from Ben-Gurion University of the Negev's Blaustein Institutes for Desert Research (BIDR) designed and participated in the development of the two generations of high-flux photovoltaic concentrating systems being produced, researched and commercialized by the SolFocus Corporation of San Jose, California. They were also co-inventors on the patents for the two concentrator generations (the first being air-filled, 31 cm in linear dimension, and the second being all-glass, 3,1 cm in linear dimension). These are currently 500-sun units (about 625X) with triple-junction ultra-efficient solar cells and completely passive cooling within miniature and ultra-miniature devices. SolFocus has recently announced the installation of the first solar array in the 3 MW Spanish CPV project.
- During 2006, Ben-Gurion University's BIDR embarked upon a 3-year project in collaboration with two German research institutes (Fraunhofer ISE and TUV), in which it will use its extreme desert conditions and unique AM 1,5 natural sky spectrum to quantify the rate of degradation of PV modules in the power rating range 150-200 $W_p$. This project is an extension of the EU 6th Framework PERFORMANCE project in which all three research institutes are also involved. In the project, module temperatures and relevant meteorological data are recorded at 5-minute intervals. In addition, I-V curves will be measured at noontime on clear days, at approximate intervals of one month throughout the 3-year test period.
- Another EU-funded project, HiConPV, in which BIDR was involved, finished at the end of 2006. Its giant solar dish PETAL achieved a world record by subjecting a 10 cm x 10 cm concentrator photovoltaic (CPV) "module" - i.e. the size of a conventional small solar cell - fabricated by partners at the Fraunhofer ISE, to a flux intensity of 1 000 X, and producing more than 1 500 W of electric power. This result helps raise the credibility of a thesis argued in the IEA Task 8 book "Energy from the Desert II - Practical Proposals for Very Large Scale Photovoltaic Systems," that CPV can provide cost-effective, country-scale solutions for electricity production throughout the Middle East and other sunrich regions.
- Cleaning of light-collecting surfaces constitutes a significant component of the O&M budget of a commercial solar power plant. The search for effective and economical cleaning methods, as an alternative to conventional washing with large amounts of de-ionized water, is an important direction in scientific program of the BIDR. The investigation into the possible application of an electric field to the surface has led to creation of a number of prototypes. Testing of one of them (Kinnor-2) in the spring of 2007, under various meteorological conditions, including severe dust storms, confirmed its high cleaning efficiency, which is typically higher than 90% (Figure 1). This research continues now in several directions; one of them started in late 2007, in collaboration with the Fraunhofer ISE.
- The Solar Energy Laboratory of the Jerusalem College of Technology (JCT), Jerusalem, is pursuing the development of Si solar cell fabrication technology based on the combination of thermal and ion implantation processes. Solar cells under

Fig. 4 - 520 W tracking system (photo SolarPower).

Fig. 5 - Home system at Drijat (photo Beit-Hazavdi).

development are thin, have improved optical properties and are suitable for use as bifacial PV converters. High conversion efficiency and decreased fabrication costs are the goals of the JCT activity. Another area of the JCT Solar Energy Laboratory activity is the development of a low cost anti-reflective (AR) glass coating for PV modules. The AR layer deposited by dip-coating provides more than 3 % relative improvement of module energy generation. The coated glass samples are undergoing special tempering treatment for improved resistance to environmental conditions. This program is progressing with an industrial partner.

## DEMONSTRATION AND APPLICATION

The higher fuel prices have caused increased installation of off-grid systems, replacing diesel generators (Figure 2). PV in water supply and irrigation control are widespread applications (Figure 3). In addition, there is growing interest in grid-connected applications, including tracking systems (Figure 4).

A large PV project, aimed at electrifying an Arab village, was started in 2005. The village of Drijat, in the Negev desert, in which about a hundred families live, is about 6 km from the nearest grid. Electricity had been supplied by old and inefficient diesel generators, which only worked a few hours a day. In the first phase of the project, stand-alone PV systems were provided to 20 homes, 6 lighting poles, a school and a mosque. The home systems (Figure 5) provide about 1 000 W of peak power each, with batteries storing 14 kWh (enough for two to three days of consumption). The total cost of the first phase was 300 000 USD.

## EDUCATIONAL ACTIVITIES

In the Nitzana village in the Negev desert, an educational project is underway, called “Science Following the Sun.” The project brings the message of solar energy, including photovoltaics, to hundreds of school children.

## GOVERNMENT ACTIONS

It is expected that the Government activity described above (solar power plant tenders and tariffs for distributed PV) will favorably influence the PV market. In addition, a number of actions are being taken to encourage the PV activity. Among them:

- Support of R&D excellence centers through selective funding of projects. The R&D expenditures in photovoltaics of the Ministry of National Infrastructures were only about 75 000 USD in 2006; however, additional funding is available in this area from other research foundations.
- Partial funding of innovative demonstration projects.