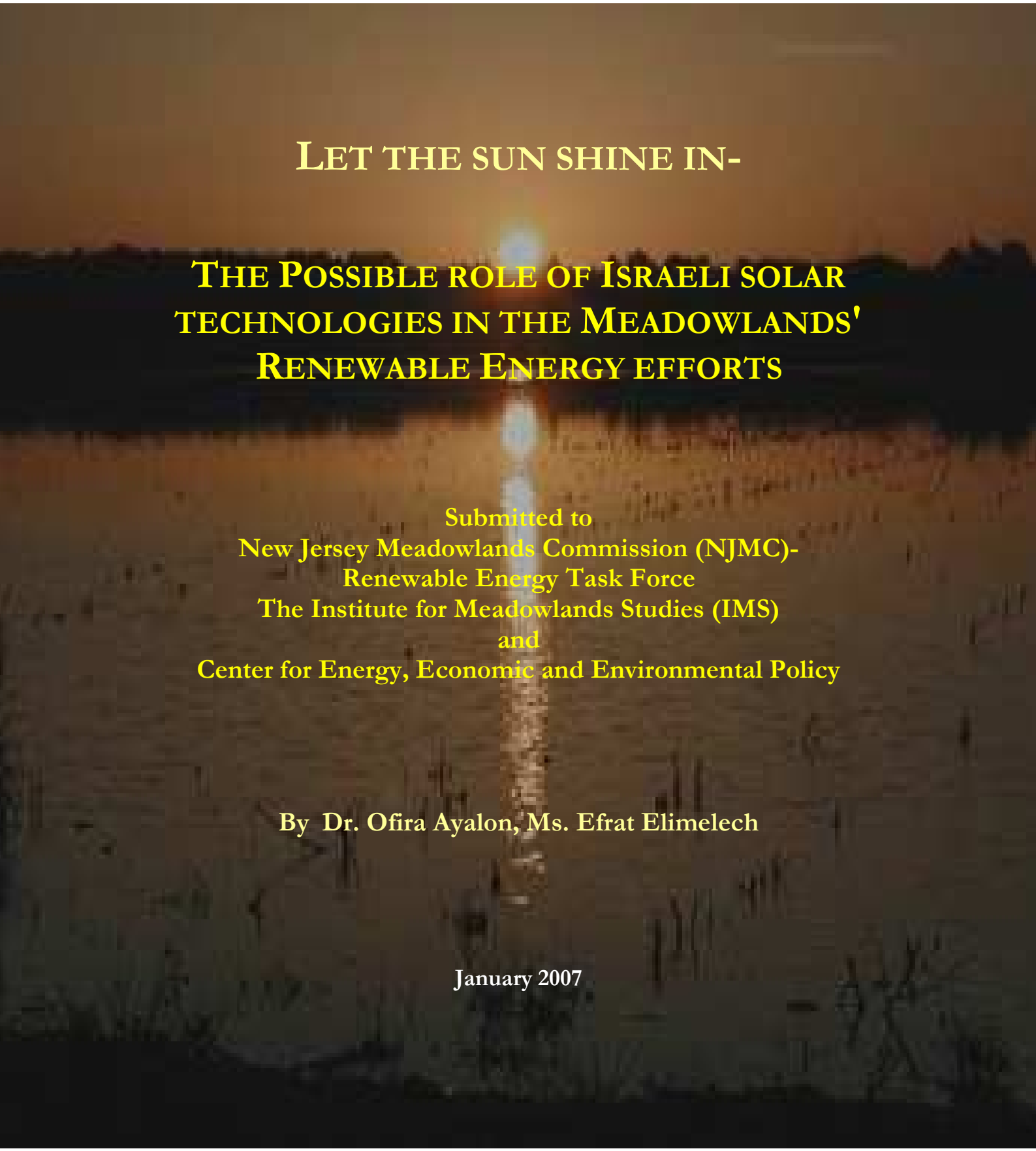

Samuel Neaman Institute
FOR ADVANCED STUDIES IN SCIENCE AND TECHNOLOGY

LET THE SUN SHINE IN-

THE POSSIBLE ROLE OF ISRAELI SOLAR TECHNOLOGIES IN THE MEADOWLANDS' RENEWABLE ENERGY EFFORTS

Submitted to
New Jersey Meadowlands Commission (NJMC)-
Renewable Energy Task Force
The Institute for Meadowlands Studies (IMS)
and
Center for Energy, Economic and Environmental Policy

By Dr. Ofira Ayalon, Ms. Efrat Elimelech

January 2007

Preface

The Samuel Neaman Institute (SNI) for Advanced Studies in Science and Technology in Haifa, Israel, is an independent, interdisciplinary public-policy research institute located at the Technion – The Israel Institute of Technology. SNI established the Israel Energy Forum to serve as a hub for knowledge exchange among experts and to undertake projects to demonstrate the feasibility of promoting energy efficiency, energy conservation and the accelerated introduction of renewable energy and alternative energy technologies into the Israeli economy. The Forum aims to provide options and recommendations in support of the implementation of the Israeli government's energy policy decisions and the search for economically viable means of reducing greenhouse gas emissions and local air pollution while increasing the diversity of energy sources.

The Samuel Neaman Institute became the Israeli affiliate of Global Energy Network (GEN- an international affiliation of organizations collaborating to develop and disseminate resources for energy and resource-smart community development and management) in 2005 when a Memorandum of Agreement between the two parties was signed. Further information can be found in Appendix 1 and in our website www.neaman.org.il

The SNI was asked by the NJ Meadowlands Commission (NJMC)- renewable energy task force, the Institute for Meadowlands Studies (IMS) and the Center for Energy, Economic and Environmental Policy to pinpoint Israeli companies, which are capable of participating in solar energy tenders at NJ, Meadowlands.

The current report examines Israeli companies in the field of solar energy, among them companies that specialize in: photovoltaics (PV) for electricity, concentrating solar power, solar heating and solar lighting.

The report introduces companies' profiles, including: products, sample projects, main market activities, and relative advantage. In some cases it also provides financial data.

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Introduction

Environmental technologies can contribute to economic growth as well as improve environmental quality and protection of resources. The annual world market for clean technologies ("cleantech"), valued at more than $200B, is one of the fastest growing markets in the world. At the same time access to vital energy supplies is critical to the smooth function of homes, businesses and the whole economy. Solar energy provides reliable access to energy where it is used and it can supplement energy needs in blackouts and disaster recovery as well as lessen dependence on imported resources.

There is a wide spectrum of solar energy technologies that are being used worldwide, including: Photovoltaics (PV) for power generation, concentrating solar power at the utility scale and for distributed generation, solar heating and solar lighting.

Photovoltaic systems

Photovoltaic systems are becoming increasingly important amongst renewable energy sources used to generate electricity, and their utilization growth rate exceeds that of other sources despite their comparatively high cost. Worldwide installed capacity of electricity generated by photovoltaic systems currently exceeds 2GW with a growth rate of 30% per annum, valued at $7B. The photovoltaic cells technology, which used to be very expensive, has developed very quickly and the global price has decreased to $5,000-6,000 per kilowatt-peak (in megawatts sized systems) – this amounts to about half of what it used to be five to ten years ago. Today, one of the obstacles preventing rapid growth of this industry is the worldwide shortage of crystalline silicon (which can be produced from abundantly available, cheap material). Yet, with the growing efforts and with increased investments it can be expected that this problem will be overcome and the price will continue to decline. Several countries, predominantly China and Japan, have set targets for themselves of building, at huge investments, PV cells production capacity that could supply the whole world.

Background Information

- PV panels use a semiconductor material to absorb photons of solar energy and generate a current, an inverter is used to convert the DC current that is generated to AC that can be used in buildings[1]
- A PV system can be stand-alone or connected in parallel with the utility power grid
- Excess generated electricity can be exported into the grid due to New Jersey's net metering laws[2]

Advantages

- Commercially available from a variety of suppliers and installers
- No fuel costs, as well as low operating and maintenance costs
- Economic incentives in the form of rebates, federal tax incentives, net metering, and the sale of Renewable Energy Certificates (RECs)
- Reduces Peak Demand because production will be highest during summer days

Disadvantages

- High capital cost ($3,000 - $10,000 per kW)[3]
- Power generation might be limited by weather and location constraints

The efficiency of existing silicon panels reaches about 17%. Concurrent to these panels another technology has been developed, utilizing Multi-Junction type solar cells coupled with radiation concentration (CPV) that has been utilized in the space industry. These systems would be able to obtain enhanced efficiency (currently reaching approximately 35%). The price of these cells is quite high but their integration within an optical concentrator unit enables the reduction of the system's cost yet allows for several different possibilities of utilization of the residual heat – that same solar energy residue that impinges on the solar cell that is not converted into electricity.

[1] US Department of Energy. http://www1.eere.energy.gov/solar/pv_basics.html
[2] New Jersey Board of Public Utilities. Renewable Portfolio Standards Rules Adoption. N.J.A.C. 14:8-2. April 13, 2006.
[3] US Department of Energy. http://www1.eere.energy.gov/solar/pv_quick_facts.html

Several developed countries provide generous subsidies for photovoltaic electricity generation within the framework of an overall program that encourages increased utilization of solar energy. During a discussion at the Israel Energy Forum information was presented on the prices paid for PV generated electricity in several European countries. These include, for example, Germany – 0.45-0.60 Euros/kWhr; France 0.087-0.153 Euros/kWhr; andAustria 0.036 – 0.073 Euros/kWhr. In Korea, the government support reaches up to 0.57 Euros/kWhr.

Such a commitment from the authorities provides the leverage for entrepreneurs seeking financial support for photovoltaic projects in these countries. In the USA and Japan there are subsidy programs that apply both to the capital investments and to the price of electricity sold to the grid.

In Israel today the market is small and insignificant. There are neither incentives nor programs that enable inclusion of PV systems in the grid. Under conditions like these even Israeli companies are forced to move the majority of their operations out of the country. The cost of a system in Israel today is about $10/Wp for small systems and up to $7-9/Wp for Megawatt-sized systems.

Concentrating solar power[4]

Concentrating solar power (CSP) plants produce electric power by converting the sun's energy into high-temperature heat using various mirror configurations. The heat is then channeled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, and the other that converts heat energy into electricity.

Concentrating solar power systems can be sized for village power (10 kilowatts) or grid-connected applications (up to 100 megawatts).

[4] U.S Department of Energy- Energy Efficiency and Renewable Energy: http://www1.eere.energy.gov/solar/solar_lighting.html

[5]Concentrating solar systems make use of direct normal insulation (DNI), that part of the radiationcoming directly from the sun. Insolation is typically rated as a power density in units of kW/m^2, $Btu/h\text{-}ft^2$, or $MJ/h\text{-}m^2$.

The daily amount of DNI is seasonal, with greatest DNI on days close to the summer solstice, and least DNI on days near the winter solstice. Annual electrical energy production from CSP plants is roughly proportional to the annual average DNI level.

The amount of power generated by a concentrating solar power plant depends on the amount of direct sunlight it collects. Therefore it is most important to conduct a comprehensive study that will determine the exact amount of the DNI at the Meadowlands NJ.

It is strongly recommended to perform a full review of the solar resource of the area with an analysis of siting opportunities for concentrating solar power plants. A sample work is shown in the Appendix 2.

[5] Energy, and Environmental Benefits of Concentrating Solar Power in California, April 2006, National Renewable Energy Laboratory Economic

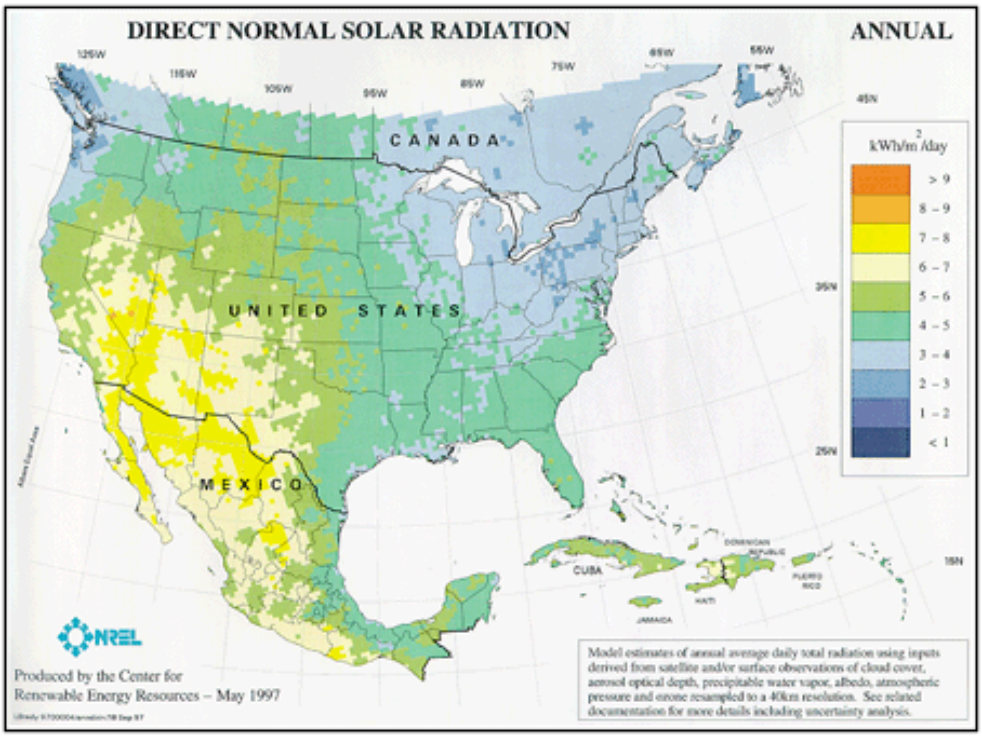

Figure A: Direct normal solar radiation at the U.S

[6]Solar heating

Solar heating harnesses the power of the sun to provide solar thermal energy for solar hot water, solar space heating, and solar pool heaters. A solar heating system saves energy, reduces utility costs, and produces clean energy. Solar water heaters and solar space heaters are constructed of solar collectors, and all systems have some kind of storage, except solar pool heaters and some industrial systems that use energy "immediately." The systems collect the sun's energy to heat air or a fluid. The air or fluid then transfers solar heat directly to a building, water, or pool.

[7] Solar lighting

The most recent technology, Hybrid solar lighting, collects sunlight and routs it through optical fibers into buildings where it is combined with electric light in "hybrid" light fixtures. Sensors keep the room at a steady lighting level by adjusting the electric lights

[6] U.S Department of Energy- Energy Efficiency and Renewable Energy: http://www1.eere.energy.gov/solar/solar_lighting.html

[7] U.S Department of Energy- Energy Efficiency and Renewable Energy: http://www1.eere.energy.gov/solar/solar_lighting.html

based on the sunlight available. This new generation of solar lighting combines both electric and solar power. Hybrid solar lighting pipes sunlight directly to the light fixture and no energy conversions are necessary, therefore the process is much more efficient.

Israeli Cleantech

According to the Israel Export and International Cooperation Institute there are currently 500 companies in the cleantech field in Israel. Furthermore, Israel has a well-established technological knowledge base and a reputation for innovation, especially in the fields of drip-irrigation, desalination and renewable energy. Despite this potential, the Israeli cleantech industry accounts for only $200-300M - less than 0.5% of total world production.

Advantages of the Israeli Cleantech Industry

Israel has a well-established technological knowledge base in environmental protection. It has particularly strong expertise in utilization and management of water resources, including reclamation of marginal water and wastewater.

Israel also has the technical know-how, experienced researchers, and practical infrastructure for the development and application of technologies in the areas of desertification (including desalination and advanced irrigation systems), solar technologies and geothermal energy. Moreover, it has the capacity to respond to the needs of the global environmental market through innovation, creativity, and the ability to adapt unique solutions to local problems.

Israel's advantages relative to other countries derive from two major factors. First, it is an industrial country with an arid climate, with vast experience in developing systems for water, agriculture, sewage treatment (recycling), solar energy, and land resource management for the domestic market. Second, in the wake of the waves of immigration of the early 1990s, Israel gained scientists with expertise in two major fields:
(a) Materials (e.g., metallurgy, a field most prominent in Germany and Russia), and

(b) Processing (development of separation processes and assembly of fabrication and production).

The combination of materials and processing expertise has led to development in fields such as water; waste recycling; air and alternative energy sources. Furthermore, Israel's defence industry has generated technologies and knowledge base that can be adapted for environmental applications based on separation and assembly of materials.

The recent report of the New Energy Finance (NEF) shows that Israel has already generated a large number of the world's leading clean energy companies, such as: the publicly traded Ormat Technologies (market cap $1.35 Billion), which specializes in geothermal power, and Medis Technologies (market cap $711B.), a specialist in direct liquid fuel cell technology.

The British report, 'And on the Eighth Day', reviews all sectors of renewable energy, biofuels, and low carbon technology. The report indicates that Israeli clean tech companies are particularly strong in the areas of solar energy (photovoltaic and thermal), power storage, grid intelligence, hydrogen and fuel cells. Nevertheless, Israeli clean tech companies are active across the whole renewable energy spectrum.

Compared to other countries, Israel spends more on R&D per unit of GDP and has more engineers per capita. It has a good track record in technology investments. Shortage in natural resources has forced Israel to develop renewable energy sources, in order to reduce its dependence on fossil fuels.

Companies Profiles

1. Millennium Electric Ltd.

Background

Millennium Electric is an Israeli based company with vast experience in the solar energy industry. The company has representatives in the U.S.A., South America, Australia, Africa and Europe.

Millennium Electric develops, produces and sells solar electricity from Photovoltaic (PV) panels, applications, and the Multi Solar System.

Millennium Electric has designed and installed many international projects in over 40 countries around the world. In addition, the company owns many international patents, all related to the PV Solar Industry, and ranging from simple consumer products, to very high tech systems.

Financials

Millennium is funded by private investors. The company plans to raise money in the stock exchange in order to expand activities around the world.

Millennium focuses on the countries that subsidize alternative energy sources such as solar energy, such as Germany, Spain, Italy, Greece, South Korea and the USA.

Millennium's turnover forecast for the year of 2007 is around $34M USD, $76M USD for the year of 2008 and $88M USD for the year of 2009 (around $200M USD turnover for the next 3 years).

Company Products and Services

1. **Production and sale of Solar Photovoltaic (PV) Panels (under the Millennium brand name), from 10 watts and up to 300 watts**

Millennium produces photovoltaic cells- Mono and Polycrystalline ("solar PV cells"), which directly converts sunlight to electricity. The average efficiency of Millennium Panels approaches **15%**. Millennium sells its solar PV panels in the major markets today: Germany, Spain, Italy, Greece, U.K, South Korea and the USA. The company plans to expand its PV panel production capacity up to 56MW by year-end 2008.

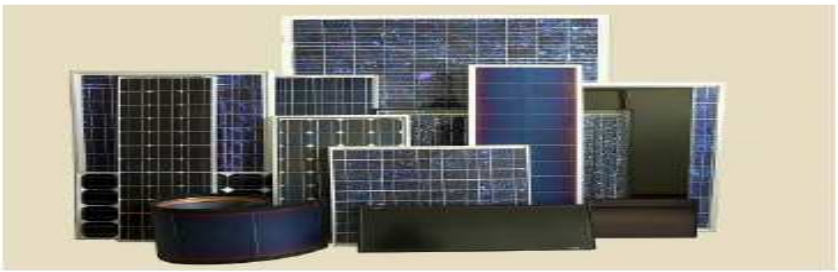

Figure no.1: Millennium's PV panels (Mono & Polycrystalline)

2. **Production and sale of Multi Solar Systems and Collectors PVT (MSS collectors) -Millennium's Unique Technology-**

The **Multi Solar PV/T technology** is an innovative, patented (PATENT NO 5522944) Solar PV/Thermal System that makes it possible to convert solar energy into thermal energy and electric energy at the same time using a single integrated system.

The Multi Solar System (MSS) collects the visible and infrared side of the spectrum, cools the PV cells, which generate electricity, and makes the heat available for thermal control of the building.

The MSS behaves like a "living" skin surrounding the building, allowing the flow of water/air, capturing heat and storing it in an insulated tank, thus making it available for the heat control of the living environment while the PV cells that are cooled by water flow in pipes and air, generates 30% higher PV efficiency for production of electricity and 70% additional thermal energy for the same price.

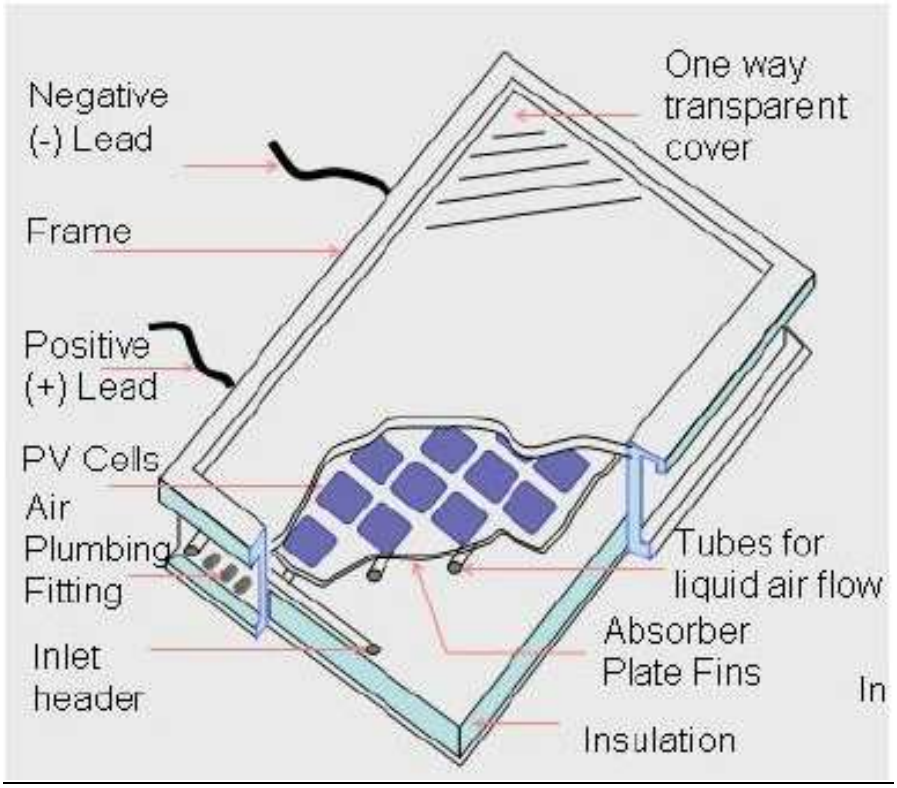

Figure no.2: The combined PV/T collector concept

System advantages

- **Integral cooling system:** Enables 30%, PV annual efficiency enhancement
- **High electricity production:** Utilizes a "sun trap" by using low iron double glazing polarized one-way mirror glass on the PVT collector
- **Better use of the Light Spectrum**: Using IR wavelength for thermal energy and the Visible Light wavelength for electricity
- **Savings in framing costs, hard glass lamination costs, construction costs and rooftop area costs**.

Figure no.3: The Multi Solar collector (MSS)

MSS is a built-in Multi Solar System with the **highest utilization that exists today**: 85% (15% electricity, 35% hot water, 35% hot air). The thermal energy can be converted into electrical energy by the use of Thermal turbo generator and gain additional 15% of electrical energy.

The Multi Solar System has been developed with a very innovative and unique feature. Beyond flat plate hot water panels, special double glass PV panels have been developed; the air/water fluid flows within the two-water/air pipe channels, capturing the infrared

radiation, but allowing the visible spectrum to flow through, lighting the interior environment. In this way, the same window can become an active element capable of providing electricity beyond lighting and heat control.

The Multi Solar System works with circulating air, and it is fitted with automatic valves for interior ventilation with filtered and humidified air using small fans. It is integrated in the outer shell of the building and produces zero oxide or dust emission.

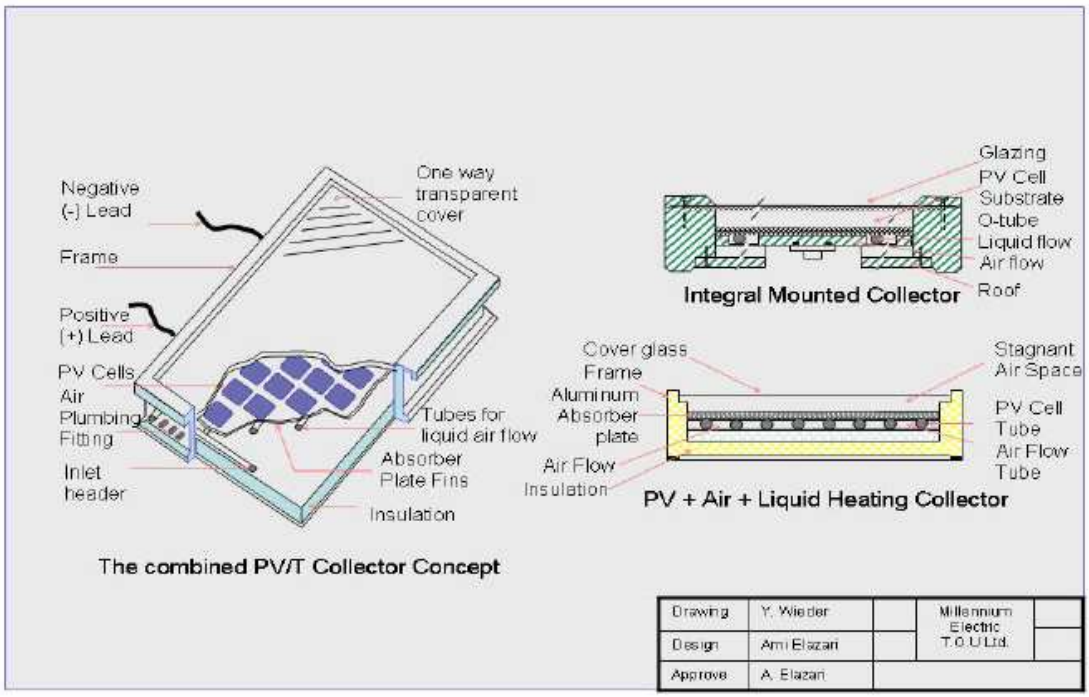

Figure no.4: The combined PV/T collector concept

3. Planning, construction and maintenance of Solar PV Power stations (turn key projects) for supplying electricity using solar energy

Central Solar Power Stations applications use solar energy in the same configuration that a utility would utilize a major power station.

Feed-in-tariff programs (selling electricity to grid-connected systems) are the engines of the PV industry. Such programs that exist today in Germany, Spain, Italy, USA (mainly

California and NJ), South Korea and other countries, promote mass construction of Solar Power stations.

Millennium plans the construction of Solar Power Stations in the range of 40MWp (€200M Euro) during the years of 2007 – 2009:

- 1MWp Solar PV power station in Southern Italy
- Many PV stations of 50kWp each around Italy
- 20MWp MSS (using our unique solar technology) power station in South Korea
- 10MWp (minimum) solar PV power station in the Canary Islands, Spain (totaling 65MWp)
- 5MWp solar PV power stations in Greece
- 10MWp solar power stations in the USA

Figure no.5: 7MWp Solar Power station in Germany

4. Planning, production and sale of various solar PV applications for lighting, infrastructures, etc.

Industrial Applications

Solar energy has been the power supply of choice for industrial applications, where power is required at remote locations. These solar powered applications are economical, even without subsidies. Most systems for individual uses require a few kilowatts of power. Examples are powering repeater stations for microwave, TV and radio, telemetry and radio telephones.

Solar Home Systems (SHS) in the Developing World

Apart from off-grid homes, other remote buildings such as schools, community halls, and clinics can all benefit from electrification with solar energy. This can power TV, video, telephony and a range of refrigeration equipment, which is available to meet World Health Organization standards for vaccine refrigeration, for instance.

Building Integrated PV (BIPV)

A BIPV system operates as a multi-functional building construction material. It generates energy as well as serves as part of the building envelope. On an office building, atria can be covered with glass/glass PV modules, which can be semi-transparent to provide shaded light. On a factory, large roof areas have been the best location for solar modules. If they are flat, then arrays can be mounted using techniques that do not breach the weatherproof roof membrane.

Figure no.6: Building Integrated (BIPV) in the Netherlands

Solar Powered Military Devices Design Services

Solar Powered Military Devices have several advantages: Power independent, maintenance free, robust, user friendly, easy operation. Photovoltaic powered military systems: transmission, signaling and control devices**.**

Solar Lighting

Light Emitted Diodes (LED) based light system represents a new step forward for solar lighting. The LED system used never needs replacement resulting in the most reliable solar light system on the market and results in the lowest maintenance cost of any solar light system. By using long life LED technology (expected life 100,000 hrs or over 25 years of normal use), the Light fitting will last the life of the system and you will never be a need to change a bulb.

5. R&D for the future solar technologies

Millennium is taking part in the field of R&D as a part of the 7th framework program of the European Commission as well other European and American research Funds.

	Project	Budget	Description
1.	**SOLARDIST**	413,344 Euro	Development of a Solar Distillation Wastewater Treatment Plant for Olive Oil Mills
2.	**HELSOLAR**	989,171 Euro	High Efficiency Low Cost Solar Cells
3.	**SOLARPOWER**	359,900 Euro	Development of Innovated Quality Assurance Measures to Improve the Efficiency of Solar Panel Production
4.	**MORES**	518,374 Euro	Remote Monitoring for Renewable Energy Systems
5.	**MULTISOLAR**	599,000 Euro	Development of Integrated Solar System for Buildings
6.	**REFLECTS**	908,493 Euro	Novel Bifacial Single Substrate Solar Cell Utilizing Reflected Solar Radiation
Total Existing Budget:			**3,788,282 Euro**

2. Di.S.P.

Background

Di.S.P. – Distributed Solar Power Ltd., is a development stage company, using superior technology, licensed from Tel Aviv University.

Di.S.P. operates within the Yozmot HaEmek Technological Incubator, sponsored by the Government of Israel. It is supported by a strategic investor – a European energy company that assists in product definition and first installations.

Status

Di.S.P. has installed an operational proof of concept demonstration unit. It currently seeks additional funding to complete the design and installation of a commercial prototype.

Company Products and Services

Di.S.P. primary markets are public, business, commercial, industrial and residential customers who require clean, renewable electricity and high-grade heat. These include hospitals, shopping malls, business centers, schools, industry, public buildings, residences, and more.

1. **Developing a novel miniature solar energy system for generation of electricity and heat (CHP – Combined Heat and Power)**

Di.S.P. is developing a miniature solar energy system which is a distributed generation power system located at the customer's site. The base unit is the Miniature Concentrating Photovoltaic (*MCPV*) unit – a sun tracking apparatus that concentrates sunlight. Its products are:

- Electric power – by means of advanced PV cells designed for concentrated sunlight (CPV – Concentrated PV).
- Heat at elevated temperatures – by capturing the sun's thermal energy.

Concentrated PV (CPV) is a technology in which sunlight from a large area is concentrated onto a small number of specially designed, high efficiency, solar cells.

In sunny locations, a CPV system can generate 30-40% more electricity than flat panel systems.

System description

The system is composed of four main components or subsystems (Figure no.7)

- A sun tracking mechanism and support structure that follows the motion of the sun. The tracker includes two motors and transmissions for two axes tracking.
- A glass reflector that is mounted on the tracker and concentrates the sunlight onto a small area located near its focal point. The diameter of the reflector is approximately 1.1 meter.
- A module composed of an array of CPV cells and a heat absorbing plate. The module is located at the focal point of the reflector. It captures the concentrated sunlight and converts it to electricity and heat.
- A control sub-system (not shown).

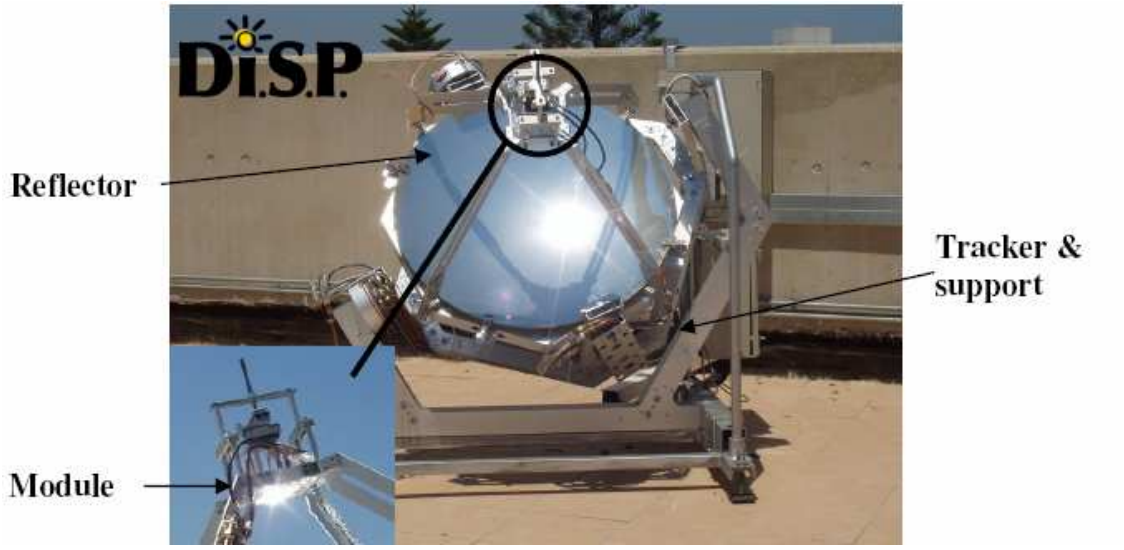

Figure no.7: The MCPV unit

System advantages

- The overall CHP **efficiency is up to 75%** thanks to generation of both thermal and electric power
- Utilizing concentrated sunlight it is possible to achieve:

- High electrical conversion efficiency – The CPV cells operate at a proven 35% efficiency enabling total system **solar-to-electric conversion efficiency of 28%.** Higher efficiency PV cells (45%) are under development and should become available in 2007.
- **Heat at high temperatures** (>100÷C). Heat at such temperatures is more valuable than conventional solar heat (typically at approximately 60÷C) as it can be utilized in high-value processes such as air conditioning, steam generation, and process heat.

▪ By tracking the sun it is possible to capture the maximum amount of sunlight throughout the day (unlike stationary systems whose output varies with the sun's angle in the sky).

System performance

Each *MCPV* unit is designed to generate 200 Watts of DC power and 480 Watts of thermal power under direct insolation of 900 Watts per square meter. The units will be installed in clusters at the customers' sites. A typical installation will be 20 kW electric (kW_e) and will also generate 48 kW of thermal power. The typical installation will consist of 100 units and require approximately 350 square meters of roof space.

An illustration of a 40 kW_e (two typical systems together) is shown in Figure no.8.

Figure no.8: Di.S.P.'s CHP system illustrated

System pricing

A detailed analysis of large scale manufacturing costs of the *MCPV* unit shows that the normalized cost for electricity alone is in the range of $1.5-1.75 per Watt. When factoring the value of the thermal energy, the cost is reduced to approximately **$0.9 per Watt**.

For comparison, the current FOB price of standard flat panel PV (FPPV) systems is around $2.4 per Watt peak. Thus **the manufacturing cost of Di.S.P. systems is much lower**. In addition, thanks to sun-tracking, higher conversion efficiency, and combined heat and power energy production, the Di.S.P. collectors can generate much more energy than similar flat panel PV systems. Consequently, in areas with good solar conditions (e.g., southwest USA, Spain, Italy, China, Australia) the cost of energy from the Di.S.P. system can be as much as 79% lower than utility energy prices, while with FPPV systems the savings will be only 5%.

3. Chromagen

Background

Chromagen is a worldwide leader in the field of thermal solar energy (DHW- Domestic Hot Water) systems and one of the three largest collector's manufacturer worldwide. Chromagen's products are sold in more than 35 countries.
The company dominates the Israeli's market by holding approx 40% of it.

Chromagen's major markets are: Spain, Australia, Germany, Greece, Italy, France and the USA.

Chromagen Spain

Chromagen Spain is one of Chromagen's holdings. The company has a market share of more than 30%. It holds three regional distribution centers and more than 300 independent authorized dealers. Chromagen has launched a unique Termosiphon system recently, due to the new building law in Spain, which requires using Solar systems by law.

USA

Chromagen's highest performing, most cost effective systems, are distributed in the US by Heliocol. The federal tax reduction and the state's rebate contributed to the awakening of the US market. Our Solar dealers' partners are located nationwide - in the sun-belt and in Northern countries.

Company Products and Services

1. Solar collectors

Chromagen's collectors are assembled using quality materials and advanced techniques, which result in highly efficient, durable products.

The products are environmentally friendly, remarkably versatile and offer high performance even in extreme environments.

The wide range of solar collectors enables Chromagen to provide cost-effective solutions, which comply with a variety of international standards, and fulfill different requirements.

2. Forced Circulation Installations

Chromagen has developed a range of models and configurations to answer a variety of conditions, enabling the installation of environmentally friendly, custom-tailored systems for all climates.

In forced circulation systems, a pump is utilized to ensure correct water circulation.

This allows the collectors to be at a great distance from the tank. For example, the tank can be situated in a basement. In addition it allows a series of collectors to supply heated water to several large tanks, as is suitable for hotels, swimming pools and other commercial applications.

Individual Home Installation

- Open-loop System for Warm Climates

  Mains water flows to the tank and then is pumped to the lower part of the collector where it is heated. It then ascends the collector and flows on to the storage tank, and from there to the user. The open-loop system is recommended for those climates where there is no risk of freezing.

- Close-loop System for Cooler Climates

  The closed-loop system uses Chromagen's wide surface heat exchanger, allowing anti-freeze to be added and avoiding the buildup of scale in the collector. Heated water from the collector is pumped into the external heat exchanger that encompasses the tank, and then returns to the collector. This warms up the water flowing into the tank from the mains, which can then be used.

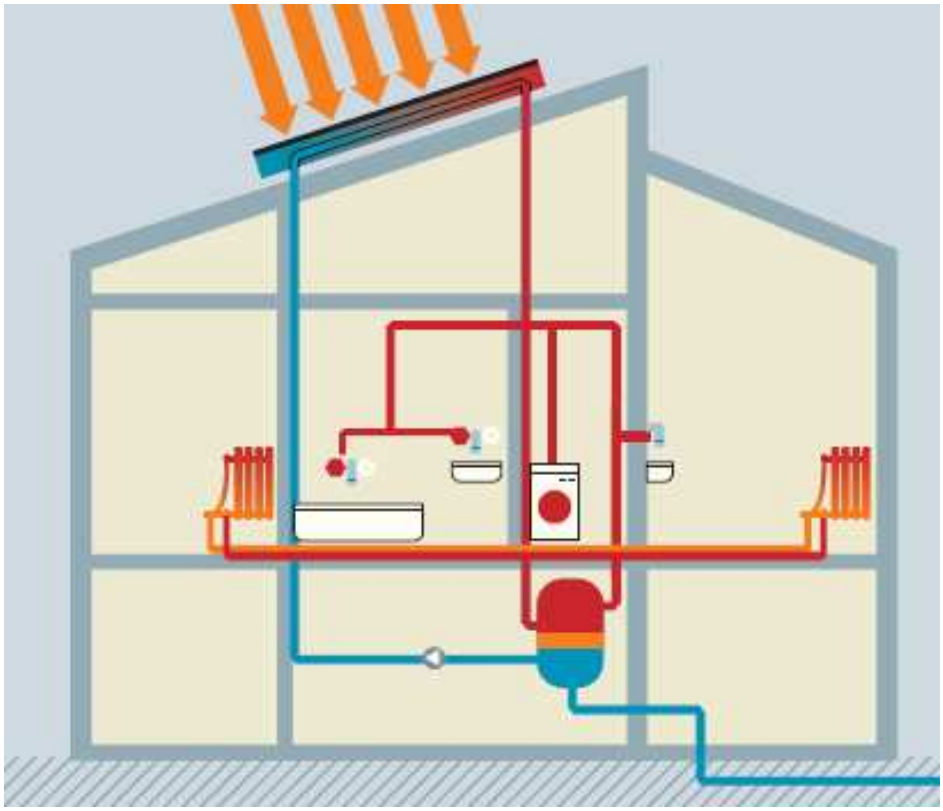

Figure no.9: Individual Home Installation

Central installations

Chromagen's central installations can provide heated water in significantly large quantities, serving domestic and institutional consumption.

Central installations use an array of collectors. The number and size vary according to the water heating requirements. A handful can service apartment blocks or small hotels, where as hundreds working together can answer the needs of large hotels, hospitals and industrial plants. Such a configuration can be backed up by conventional energy sources such as electricity, gas and oil, and is supported by sophisticated control systems.

- Central Solar Installation with Individual Tanks

  Individual storage tanks for each unit of consumption, generally installed in apartment buildings and backed up with electricity.

- Central Solar Installation with One or More Central Storage Tanks

  One or more large storage tanks, generally for use in institutions or industrial plants, with conventional energy backup and control system.

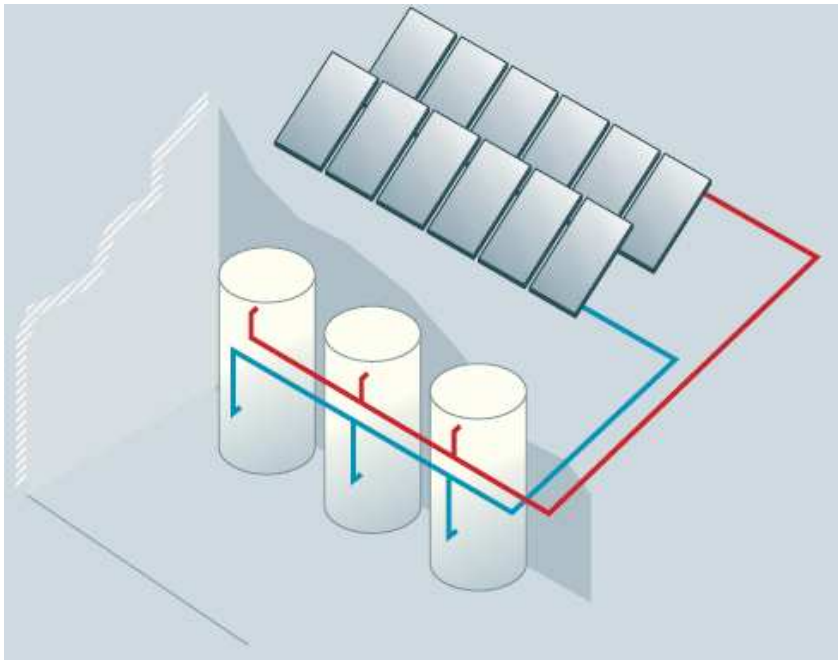

Figure no.10: Central Solar Installation with One or More Central Storage Tanks

Sample project

Maris hotels- Candia Maris Hotel- Greece

Project's budget: 1.600.000 €

The project is located at Ammoudara of Heraklion, 3 km west from the International Airport of Heraklion – Crete.

The project's energy needs (estimates- based on historic data)

- Thermal energy 2.166 MWh
- 3 machinery rooms
- 6 boilers
- 47.630 lt oil
- 449.651 lt gas (LPG)
- Water supply to 3 tanks (500 m3) from city line, drills and brought by trucks.

General description

- Central solar field for hot water production.
- Withdrawal of the thermal energy of the chillers at sea with partial recovery of the thermal energy.
- New Machine rooms
- Desalination unit (R/O)
- Building Management System (MMS) and best control strategy

The Solar system

- 4 solar fields
- 900 high performance collectors (2.520 m2)
- 12 new storage tanks (60 m2)
- New Machinery rooms
- 3 flat plate heat exchangers
- 3 uses: hot water (central Engine room), seawater heating, and heating of swimming pools.

Figure no.11

Figure no.12

Thalassotherapy center (SPA)

- 10 m3 tanks of seawater to be stored at 40-45oC
- Boilers (back up)
- Reconstruction of hydraulic installations

Partial recovery of thermal energy and rejection of the rest to the sea (chiller)

- Replacement of the cooling towers with 4 flat plate heat exchangers (titanium), which are to be chilled by seawater.
- Flow of the water to be controlled for heat.
- Heat recovery (water preheat for desalination)
- Higher COP
- Higher cooling possibility

Desalination unit

- Reverse osmosis plant (3rd generation)
- Capacity: 120-m3 daily
- Pressure exchanger
- Supply with pre heated water for better efficiency

Central control

- Central Control System (BMS)
- Control of whole system of heat production and of saving energy
- Supervision of the complete system by monitors
- Graphical display
- All measurement data (thermidometers, temperatures, hot water supply, operation time & solar energy consumption).

Results

The exact measurement of the accurate saving is basic requirement for the further penetration of the solar technology in the market.

Binding for guaranteed performance the plant started operating step by step as from the 1st of August 2002. From 1st August 2002 to the 1st August 2003: **1.350 MWh** actual energy saving (equal to 210.762 lt oil) although during the said period sunshine at Heraklion was less that the average of last 10 years.

The water production out of the desalination system reached the 36.500 m3 and an additional 25% saving of electric energy from air-conditioning units.

Further technical details are presented in Appendix 3.

4. SolarPower Ltd.

Background

SolarPower Ltd. is focused on providing renewable energy solutions for a variety of customers. The company provides solar energy systems for telecommunication applications, rural electrification, security applications and irrigation.
SolarPower is a major source for renewable energy components and products, integrated energy systems, consultancy and projects design.

SolarPower systems manufactured under high quality standards. The company's quality management system is ISO 9001:2000 certified.

Company products and services

The company is active in several fields:

- Solar power for telecommunications systems
- Grid connected PV systems
- Solar outdoors lighting
- Portable solar powered systems
- Projects managements
- Solar chargers
- Solar stand-alone systems for rural electrification
- Solar modules from all types and sizes
- DC-AC inverters for stand-alone and grid-connected systems

1. Solar Panels

SolarPower provides all types of solar panels for a variety of applications. The company works with the world's leading brands, among others Kyocera, and provides the highest quality panels. SolarPower also provide tailored made panels for special applications such as uncommon voltage and power.

2. Inverters

An inverter is a device that changes a low DC voltage into usable 230V AC voltage. It is one of the solar energy system's main elements, as the solar panels generate DC voltage. Inverters are differ by the output wave format, output power and installation type. The company carries a wide range of inverters, from 120 Watts to 5000 Watts.

There are two types of output wave format:

Modified sine-wave inverters (MSW)- can operate most of the appliances and applications. These inverters are the economic solution for low power applications, where an accurate waveform is not critical.

Pure sine-wave inverters- produce a perfect waveform, which is similar to "normal electricity". All the appliances and application will operate smoothly with these inverters.

There are two types of installation:

- Stand-alone inverters - installed where there is a battery bank
- Grid-Connected inverters - no need for batteries, the sophisticated inverter delivers the power directly from the solar panels into the grid

3. SolarPower Systems for Telecommunication and Security Applications

Telecommunications and security applications are typically located far from the reach of the electrical grid. In other cases, the costs of infrastructure and other power alternatives are too high. SolarPower solar Energy systems were developed to provide a reliable cost-effective source of energy for telecom and security systems for these remote locations.

System description

The systems are designed to provide either DC or AC voltages (DC systems will be normally 12/24/48VDC). The systems will provide sufficient energy for the specific application and will store the energy in maintenance-free batteries. It will provide energy even on rainy days, depending on the specifications - up to 7 days without sun. The systems installation is simple with virtually no maintenance.

System components

- Photovoltaic Panels
- Charge Controller
- Deep Cycle Maintenances free Batteries
- Outdoors mounting structure and closet

System options

- Temperature compensated battery charging
- Data logging /Remote monitoring

4. Solar trackers

Tracking greatly improves the performance of PV system. Trackers let the PV panels follow the course of the sun, so that the panel surface is always in an optimum angle to the sunrays. This guarantees highest efficiency. Single-axis solar tracking increases the energy return of solar modules, dependent on location, by 25% up to 40% per year in average, respectively up to 55% during the summer months.

Typical applications

- Remote houses
- Rural electrification
- Grid connected systems
- Water pumping
- Plantation irrigation
- Telecom systems

System advantages

- 1-axis, active solar tracker
- Total module surface max. 15 m2, approx. 2.4 kWp
- Maintenance-free
- High reliability and life expectancy
- Low power consumption

- Designed to withstand wind speeds up to 150 km/h
- 2 years manufacturer's warranty against defects in material and workmanship
- Manufactured by: Lorentz, Germany

5. Aviation Solar Obstruction Lights

The SPL-810L is a stand-alone solar-operated FAA L-810 style obstruction light, designed to mark tall structures that present hazards to air navigation. This light, when installed in accordance with FAA AC 70/7460-1, warns pilots flying at night about structural obstructions.

Figure no.13: The SPL-810L

System applications

- Antennas
- High Voltage Electricity Poles
- Water Towers
- Cellular Towers
- Smokestacks
- Skyscrapers
- Airport Perimeter Fencing
- Marine applications

System advantages

- Solar based system- No need for power
- sourceLED based lights last up to 5 time more than an incandescent bulb
- Consumes 90% less power than an incandescent bulb
- Easy installation
- Maintenance free

Main features

- Independency of up to 12 days - due to the battery reservoir
- Available in both single and dual light
- Optional auto operation (dusk to dawn) by photocell or light controller
- In a dual system, optional transfer relay that powers the standby light if main light fails
- Outdoors enclosure that houses the batteries and the electrical components
- Solar panel size is defined according to the geographical location
- Expected battery life - 5 years

6. Stand-Alone Solar Lighting Systems

System overview

SolarPower's Area Lighting systems (SPAL) are designed to provide continuous and reliable source of light, where there is no grid electricity available, or where infrastructure works are complicated or expensive. The SPAL system is equipped with provides long-term reliable maintenance free operation. The SPAL produces its own clean energy from the solar (photovoltaic) module. In order to achieve full performance the system needs 4 Hours of direct sunlight. Even during rainy days, the SPAL will normally operate up to 3 concessive dark days.

System description

The system designed to be installed on standard pole. The Solar panel tilt can be adjusted and have 360-degree rotational ability to suit any geographical location. The battery and system controller are housed in a ventilated weatherproof housing. The programmable controller is set to the required lighting program.

System applications

- Parks lighting
- Parking lots
- Pedestrian walks
- Cross roads
- Bus stations
- Historical sites
- Tourism and recreation (beach, nature resorts)
- Green building projects

System advantages

- No need for excavations
- No need of cabling
- Reduces the effect on other infrastructure (sewage, water)
- Smoot installation - no road blocking
- Reduces the project duration and costs - fast and simple installation
- Green energy
- No electricity bill anymore
- In many cases, the SPAL returns the investment on the day of the installation!

System components

- Solar Panels (Photovoltaic)
- Solar light controller
- Heavy Duty, maintenance free deep cycle Battery.
- Weatherproof electronics enclosure
- Mounting structure
- Light fixture

Technical specifications

Lighting duration: customer selectable 4/6/8/12 hours

Lighting bulb: Compact Fluorescent (CFL) or Low Pressure Sodium

Lighting Power: from 26 Watts to 72 Watts

Autonomy duration: 3 days sunless

Battery type: deep discharge, sealed, maintenance free

Programming options:

- Dusk to dawn
- Dusk to pre-set time
- From pre-set time to dawn

Battery location: Top or Bottom of the pole

7. SolarPower AC stand-alone systems

SolarPower's solar systems use solar power as the main source, and can be attached to other power sources, such as wind turbine or diesel generator. The systems are designed for use in rural locations, for telecommunications and other stand-alone applications.

System description

SolarPower's systems produce an output voltage of AC 230V that can run all types of applications. The systems will operate independently - without sun or wind - up to 2 days, due to the included battery bank.

System components

- Solar Panels (Photovoltaic)
- Wind turbines (when applicable)
- DC-AC inverter and charger
- Battery bank
- Mounting structure

Sample project

1. Solar parking lot in Karmiel

SolarPower installed solar outdoors lighting for a supermarket parking lot in Karmiel, north of Israel. Installation included 3 double-headed and two single-headed poles. The lighting system is automatically switches on at sun-set, and turns off at mid-night

2. Solar system for ecological farms

At Modiin city, SolarPower installed a hybrid system of 800-Watts photovoltaic and 400-watts wind turbines. The systems covers the farm's power needs.

3. Solar systems for cellular repeater

SolarPower provided a solar powered system that powers a cellular repeater of one of the cellular providers in Israel. It saves expensive infrastructure at rural locations, where cellular signals should be amplified.

4. Rural electrification

For remote population, the solar power could be the best choice. No need of diesel generators, which required daily care and high diesel expanses. By installing a solar system, one can have reliable 24 hours a day energy supply.

5. Contribution for the community

A human rights organization donated money for a medical clinic in the Israeli desert SolarPower was responsible for the solar system planning and installation.

Figure no.14: Grid-Connected systems

5. E.D.I.G

Background

E.D.I.G is a privately owned company, which is active in a wide range of electro-mechanical projects. The company performs mechanical works, diesel-generator installation and maintenance, piping systems, electrical projects, control systems and development projects.

The company is certified by the Standards Institution of Israel for compliance with ISO 9001:2000 quality management standard. The company is a listed supplier for the Israel ministry of Defense and other Government Ministries.

Company products and services

1. Development of Solar Power Plant

E.D.I.G has developed a solar hybrid power plant, capable of operating using solar radiation, fuel or combination of both.

A complete solar-hybrid power generation demonstration unit has been constructed in Nanjing, China, in cooperation with Chunhui Science and Technology Co.
It includes a Power Conversion Unit (comprising a solarized gas turbine and a solar receiver for heating the working air using solar radiation) installed on a tower and a field of heliostats (sun-tracking mirrors). The unit is fully operational and has supplied power to the local electric grid.

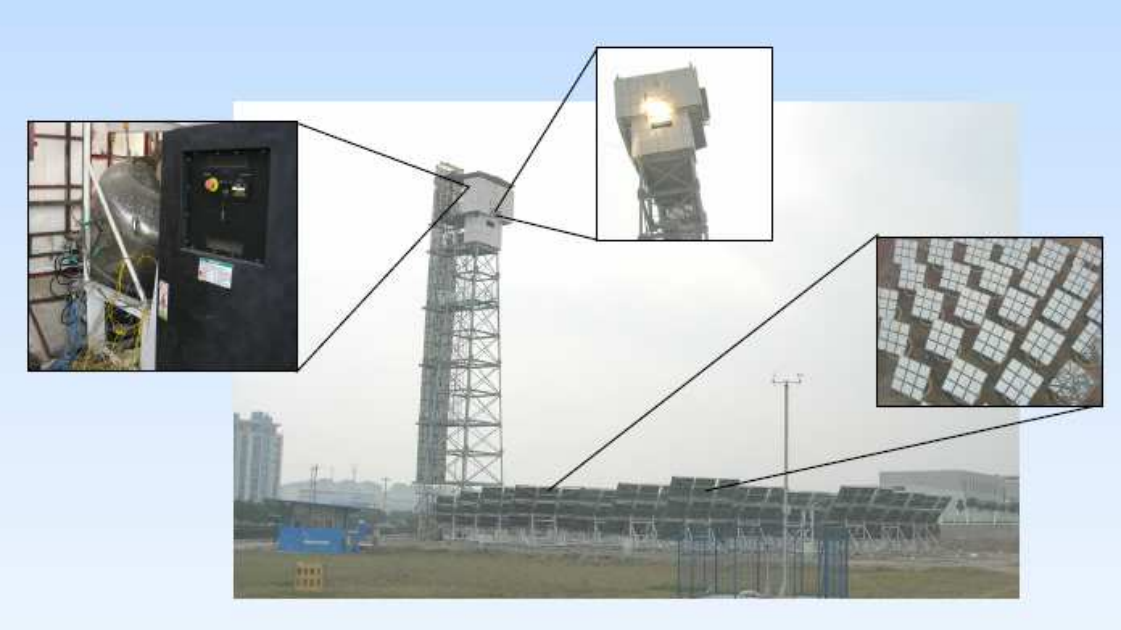

Figure no.15: Full system operational demonstration unit installed in China

System description

The system uses a gas turbine (Brayton thermodynamic cycle) to generate electricity using either concentrated solar radiation or fuel or combination of both.

Radiation is concentrated by reflecting light from an array of sun-tracking mirrors (heliostats) unto a unique, advanced solar receiver (1), where it heats compressed air that drives the turbine (2). Fuel combustion (3) is used only when solar input is insufficient or at periods with no sun. Operation at high temperature and a recuperated (4) scheme enable high conversion efficiency.

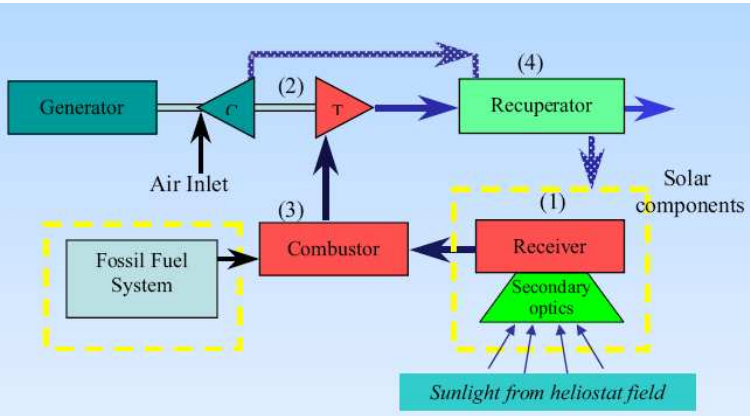

Figure no.16: Hybrid Power Conversion Unit Schematic

Hybrid solar-fuel system design enables supply of power per demand, provides operation flexibility, improves system efficiency, and ensures reliability of power delivery.

System features

- High temperature (~1000÷C) operation to provide superior performance and efficiency
- Incorporates break-through technology initiated at the world renowned Solar Research Center of the Weizmann Institute of Science (Rehovot, Israel)
- Tested, innovative, IP protected components
- Dispatchability, supplies power per demand, and reliability
- Modularity: Allows sizing to customer's needs and expansion as demand increases
- Needs area of less than 40x50m per 100kW base unit, and not limited to flat terrain
- Favorable financial indicators
- Large market potential
- Highly qualified and experienced team
- Cash flow: Units can generate revenues before entire plant is completed
- Optional CHP (Combined-Heat-and-Power) configuration

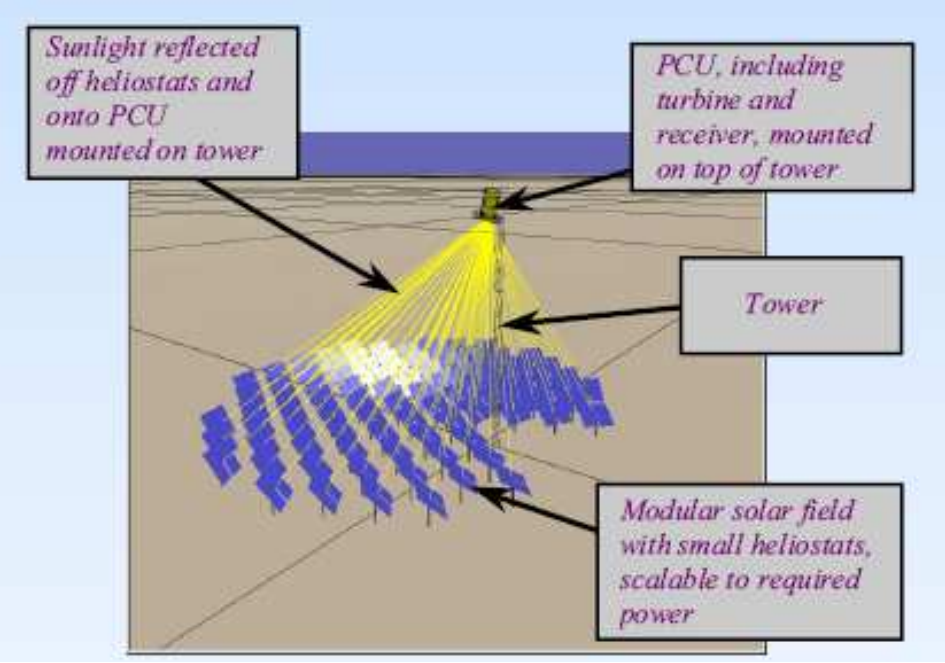

Figure no.17: 100 kW base unit

Present status

- System development has been completed
- Operational full system demonstration in China
- System is being improved based on the demo performance
- E.D.I.G continues to develop the next generation solar power plant technology, in collaboration with the Weizmann Institute of Science and other leading institutions

Appendix 1

THE SAMUEL NEAMAN INSTITUTE

The S. Neaman Institute for Advanced Studies in Science and Technology is an independent, interdisciplinary public-policy research institute, established in 1978 and located at Technion-Israel Institute of Technology. The mission of the Institute is to research, identify and evaluate solutions for national problems in the areas of science and technology, education, economics, industry, and social development. Through its sponsored research, workshops and publications, the Institute serves as a bridge between academia and decision makers in government, public institutions and industry.

The scope of professional activity at the S. Neaman Institute is the interface between science, technology, economy and society. In Israel, as in many parts of the world, science and technology are major driving forces behind economic growth and prosperity, and are making a profound impact on almost all areas of society. As such, the Institute's multi-disciplinary research activity is more important than ever before.

To achieve its mission, the Institute undertakes **sponsored research, organizes workshops and implements continuing education activities on topics of significance for the development of the State of Israel**. It also maintains a publications program for the dissemination of research and workshop findings. Specific topics for research may be initiated by the Institute, researchers, government agencies, foundations, industry or other concerned institutions. As an independent not-for-profit research organization, the Institute does not advocate any specific policy or embrace any particular social philosophy. Each research program undertaken by the Institute is designed to be a significant scholarly study worthy of publication and public attention.

With its academic and national agenda, the Institute is ideally situated at Technion, Israel's leading scientific-technological university. The Institute draws on Technion faculty and staff, as well as scientists from other institutions in Israel, and specialists from abroad.

As befits a democratic society, choosing among policy alternatives is the prerogative and responsibility of the elected representatives of the citizenry. The Samuel Neaman Institute endeavors to empower the process of informed choice with the authority of academic research.

Origins

The initiative for establishing the Institute in Israel was undertaken by Mr. Samuel Neaman, who resolutely brought the idea to fruition with an agreement signed in 1975 between himself, the **American Society for Technion and Technion. It was ratified in 1978 by the Technion Senate. Mr. Neaman, a prominent U.S. businessman noted for his insightful managerial concepts and innovative thinking**, as well as for his success in bringing struggling enterprises to positions of fiscal and marketing strength, devoted his time to the activities of the Institute until he passed away in 2002.

Organization

The Director of the Samuel Neaman Institute, appointed jointly by the President of Technion and the Chairman of the Institute Board, is responsible for formulating and coordinating policies, recommending projects and appointing staff. The Director is Professor Nadav Liron. The Institute Board of Directors is chaired by Professor Zehev Tadmor. The Board is responsible for general supervision of the Institute, including overall policy, approval of research programs and overseeing financial affairs. An Advisory Council, made up of members of Technion's Senate and distinguished public representatives, consults on program development.

NATIONAL POLICY IN THE FIELD OF ENERGY

Project Leader: Prof. Gershon Grossman; **Project Coordinator:** Dr. Ofira Ayalon

During 2005, energy issues topped public agendas in countries around the world. Driven by geo-political conflicts between the Western and Arab worlds, and the accelerated growth in the East (China and India), the demand for, and price of, oil has steadily risen, in Israel as in the rest of the world. In light of the short and long-term implications of this situation, and the S. Neaman Institute's central role in addressing national issues related to science and technology, we are now leading several initiatives in the field of energy.

In 2005, the S. Neaman Institute signed a cooperation agreement with the United States Department of Energy to jointly promote technologies that produce clean energy, and conserve energy sources. In this agreement, which was signed by the Director of the Institute, Prof. Nadav Liron and Global Energy Network, Executive Director, Mr. Doug Newman, the Neaman Institute is recognized by the U.S. Department of Energy as one of 10 Centers of Excellence in the world which are involved in applied research in the field of energy. This recognition renders projects that are carried out at the S. Neaman Institute eligible to receive special funding from the U.S. Government.

In addition, the S. Neaman Institute has taken the leading role in an Energy Forum, led by Prof. Gershon Grossman and coordinated by Dr. Ofira Ayalon, with the aim of creating a professional platform for discussions related to the field of energy in Israel. The forum is broad in its scope and provides a meeting place for sharing ideas and promoting projects in the fields of alternative energy and energy conservation. Through the activities of the forum, ideas are developed and professional policy determined by relevant entities in the field and by decision makers from the various governmental agencies.

Appendix 2

An Analysis of Siting Opportunities for Concentrating Solar Power Plants in the Southwestern United States

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Abstract

In 2002, Congress asked the U.S. Department of Energy to "develop and scope out an initiative to fulfill the goal of having 1000 megawatts (MW) of new parabolic trough, power tower, and dish engine solar capacity supplying the southwestern United States [1]." The major purpose of a large solar installation initiative would be to accelerate the transition of concentrating solar power (CSP) generation technologies to a point where they could establish sustainable markets. A recommendation was made at the North American Energy Summit in April 2004 that the Western Governors' Association (WGA) form a task force to coordinate the development of 1000 MW of new CSP capacity. A formal declaration of the WGA-led effort was presented and accepted at the WGA annual meeting held in Santa Fe, New Mexico, in June 2004.

In this paper, we present a review of the solar resource for Arizona, California, Nevada, and New Mexico. These four states have the greatest number of "premium" solar sites in the country and each has a renewable portfolio standard (RPS), or in Arizona's case an environmental portfolio standard. In addition, we present information on the generation potential of the solar resources in these states, and present regions within each state that may be ideally suited for developing large-scale CSP plants because of their proximity to load and access to unconstrained transmission.

Southwest Overview

Southwest Solar Resource

The direct-normal solar energy resources in the southwestern United States, shown in Figure 1, are among the best in the world. Unlike other solar technologies based on flat surface collectors, such as conventional photovoltaic systems and solar water heaters, CSP requires direct-normal solar radiation. The direct-normal component of sunlight emanates directly from the solar disk and does not include diffuse or "blue-sky" radiation.

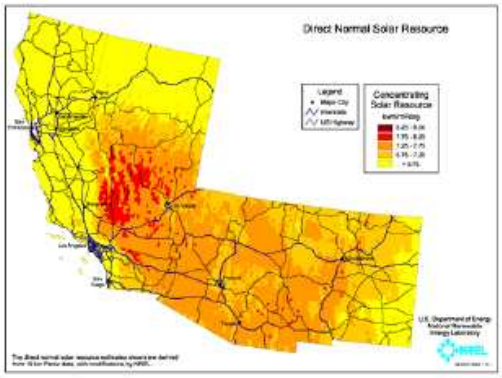


Figure 1. Direct normal solar radiation in the southwestern United States.

The direct-normal resource shown in Figure 1 was derived from a new, high-resolution solar resource data set that was developed with satellite data and correlated to good ground station data. Annual solar direct normal incident (DNI) estimates are provided on a grid of 0.1 degree in both latitude and longitude (nominally, 10 km). These estimates were created with the Perez irradiance model [2].

Concentrating Solar Power Generation Potential

Not all the land area shown in Figure 1 is suitable for large-scale CSP plants because such plants require relatively large tracks of nearly level open land with economically attractive solar resources. Geographical information system data were applied on land type (urban, agriculture, etc.); ownership (private, state, federal); and topography. The terrain available for CSP development was conservatively estimated with a progression of filters as follows:

- Lands with less than 6.75 kWh/m^2/day of average annual direct-normal resource were eliminated to identify only those areas with the highest economic potential.
- Lands with land types and ownership that were incompatible with commercial development were eliminated. These included national parks, national preserves, wilderness areas, wildlife refuges, water, and urban areas.
- Lands with slope greater than 3% and, alternately with 1%, and with contiguous areas smaller than 10 km^2 were eliminated to identify lands with the greatest potential for low-cost development.

Figures 2 through 5 show the progression of applying these filtering criteria.

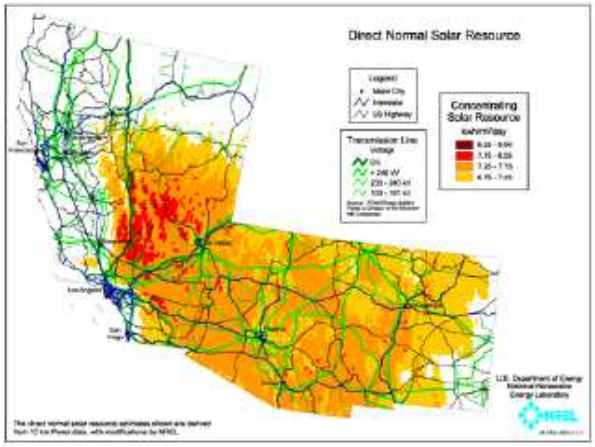


Figure 2. Annual average direct-normal solar resource > 6.75 kWh/m^2/day

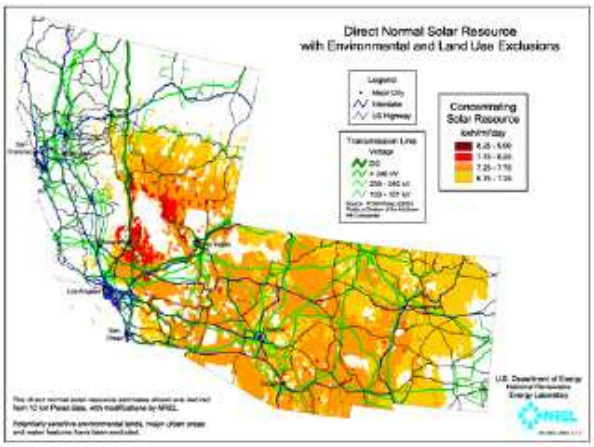


Figure 3. Additional filter for land use exclusions.

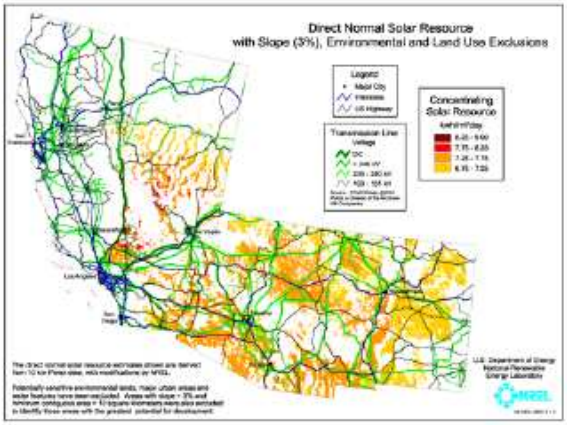


Figure 4. Additional filter for slope > 3% and minimum contiguous land area < 10

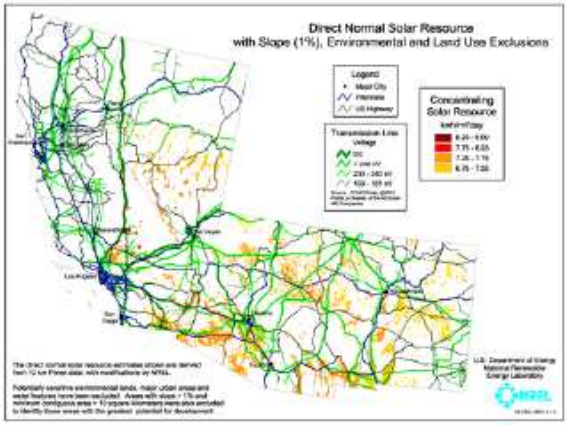


Figure 5. Additional filter for slope > 1% and minimum contiguous land area < 10

The resulting land area and associated CSP generation capacity when all filters were applied are given in Table 1.

Table 1. Suitable Land for CSP Plants and the Associated Generation Potential.

	Available Area (mi^2)	Capacity (MW)*
Arizona	25,527	3,267,456
California	6,421	821,888
Nevada	5,807	743,296
New Mexico	23,640	3,025,920
Total	**61,395**	**7,858,560**

* CSP power plants require approximately five acres of land area per megawatt of installed capacity

The data in Table 1 show that, even if we consider only the high-value resources, there are more than 7 million MW of solar generation capacity in the Southwest. Currently, there are about 100,000 MW of generation capacity in these four states. Each state has enough land illuminated by only the highest solar radiation levels, such that only a small segment would be enough to generate its current electricity needs.

Transmission Constraints for the Four-State Region

The United States is divided into a number of transmission control regions. The largest is the WECC, which covers the western third of the United States. The electric grid in the WECC is essentially isolated from the rest of the grid in the United States. The four states in this assessment are all part of the larger WECC control system and have high-voltage transmission lines that interconnect the states to move power from regions with coal and hydroelectric resources to population centers. Siting of a new solar power plant would need to consider how it fits into the transmission system.

California Transmission

The transmission infrastructure in California includes two high-voltage, direct-current lines: one connects Los Angeles to hydroelectric generation in northern Oregon; the other connects Los Angeles to coal generation in central Utah. However, the bulk of California's infrastructure is operated at 500-kV and 230-kV. In general, during peak summer conditions, power flows into California from Arizona and Nevada, but during the winter the flows typically shift from California to the Pacific Northwest. Path 15, a transmission path in central California, is the most binding constraint in the south to north transmission. Power flows from the Four Corners region through Arizona, and power delivered from the Palo Verde nuclear power plant and other gas-fired generations in Arizona, create a significant bottleneck along the California-Arizona border. Power that flows through Las Vegas en route to southern California, and power that flows between northern Nevada and northern California, have resulted in a bi-direction east to west transmission bottleneck along the California-Nevada border.

Arizona, New Mexico, and Nevada Transmission

The Arizona, New Mexico, and Nevada transmission grid consists of 500-kV, 345-kV, 230-kV, and lower voltage transmission infrastructure. Almost the entire 500-kV transmission infrastructure is in Arizona. Load centers are in central and southern Arizona, southern Nevada, and central New Mexico. These correspond to the metropolitan areas of Phoenix and Tucson in Arizona; Las Vegas, Nevada; and Albuquerque, Santa Fe, and Las Cruces in New Mexico. Historically the highest generating resource centers have been located at Palo Verde, Arizona, northern Arizona, and the Four Corners areas. These result in predominant power flows from northeast to southwest in Arizona and from northwest to southeast in New Mexico during peak periods. The general direction of these flows is not likely to change in the foreseeable future. The region has substantial interconnections with California, one 230-kV connection with Utah, and connections with Colorado.

Potential Development Locations in the Four-State Region

The resource and land exclusions shown in Figure 5, together with the regional transmission constraints and proximity to urban load centers described earlier, led to the following preliminary recommendation of regional development centers for large-scale CSP installations. These recommendations are described graphically in Figures 6-9.

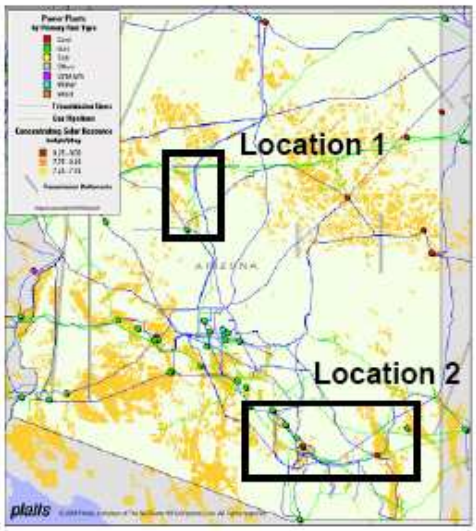


Figure 6. Arizona Siting Analysis

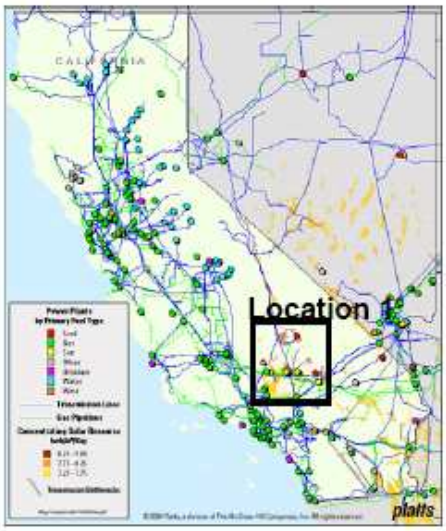


Figure 7. California Siting Analysis

Arizona

Potential Development Location 1

There may be potential to site a new plant north of Phoenix, perhaps in the Prescott Valley region, which lies inside the Path 54 bottleneck created by power flows from the Four Corners region to Phoenix and southern California. A plant sited in this location may be able to serve demand in Phoenix without facing any transmission bottlenecks. In addition, the northern branch of the El Paso natural gas pipeline could offer an opportunity for solar plant hybridization.

Potential Development Location 2

The southeastern corner of Arizona may offer the same opportunities. A plant placed in a high-quality solar resource location east of Tucson may be able to serve that population center's load without facing any bottlenecks. Exports into New Mexico, however, would likely be off limits because of the Path 47 bottlenecks and limited transmission capacity between southern Arizona and New Mexico.

California

Potential Development Location 1

As a result of the large number of constraints both within California, and leading into and out of the state, the most suitable location for a new solar plant is in southern California in the vicinity of the solar electric generating system plants. This area contains extremely good solar resources, and some lines may have enough transmission capacity to move power from the plant to the large load

centers in southern California. Further, the Pacific Gas & Electric natural gas pipeline system and the Kern River Expansion pipeline run through this region.

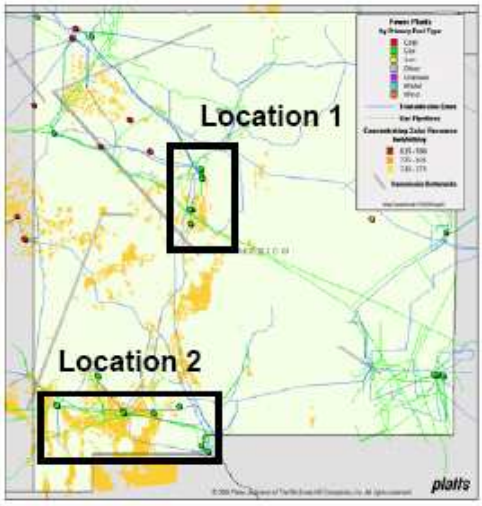


Figure 8. New Mexico Siting Analysis

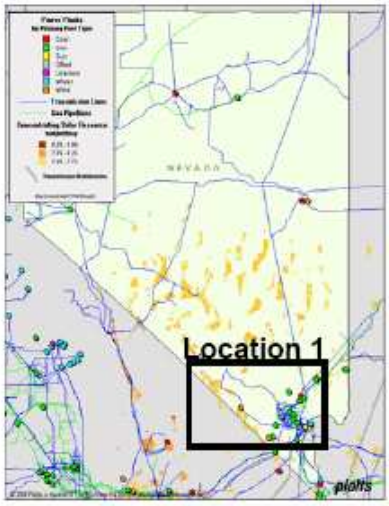


Figure 9. Nevada Siting Analysis

New Mexico

Potential Development Location 1

A new plant designed to serve Albuquerque would have to be built within the Path 48 constraint. Los Lunas and the surrounding region south of Albuquerque may be one candidate location. These areas possess high-quality solar resources and the transmission capacity to move power to Albuquerque. Also, the northern El Paso natural gas pipeline moves through this area. A plant located in this area may be able to serve local demand despite the near-term surplus of power.

Potential Development Location 2

The southwestern corner of the state contains an abundance of coal-fired generation, natural gas pipeline infrastructure, and transmission capacity. These factors, combined with the Las Cruces and El Paso population centers, may make this area a candidate for a new solar plant.

Nevada

Potential Development Location 1

Unfavorable solar resources, limited transmission infrastructure, and bi-directionally constrained power flows between northern Nevada and northern California, make northern Nevada a less desirable location for a new solar power plant. However, in southern Nevada the most favorable development scenario may

involve the construction of an in-state solar resource to serve native load close to the Las Vegas population center. This would avoid aggravating transmission bottlenecks into and out of the state. Favorable solar resources west of Las Vegas, along with limited transmission infrastructure (a 138-kV line), might be suitable for upgrade to support a new solar facility.

Summary and Next Steps

The solar energy resource in the southwestern United States is enormous and largely untapped. As demonstrated in Table 1, there is no shortage of economically suitable land. At its June 2004 meeting, the Western Governors Association recognized the 1000 MW CSP Initiative as one of its projects and formed a regional task force to coordinate the efforts of the interested states, which include New Mexico, Nevada, California, Arizona, Colorado, and Utah. Nevada has already contracted 50 MW of trough power that is likely to become part of the initiative. New Mexico has formed a solar power task force to develop a plan for deploying CSP power. Under the leadership of the WGA, other states are expected to start to explore ways in which they too can support the deployment of large-scale CSP power projects.

To fully identify favorable solar power plant siting opportunities, additional factors such as land ownership, road access, and local transmission infrastructure capabilities and loadings must be examined in greater detail. This will involve discussion with local experts and utility specialists, and may include visits to prospective locations. In addition, the impact of solar resources on the transmission system must be fully analyzed by constructing security-constrained load flow model scenarios. Finally, state-level policies and regulatory frameworks must be assessed to determine the favorability of renewable resource development in a particular state. The availability and relative cost of other renewable power technologies must be considered in this context.

References

[1] DOE Fiscal Year 2002 Energy and Water Development Appropriation.

[2] Perez, R.; Ineichen, R.; Moore, K.; Kmiecik, M.; Chain, C.; George, R.; Voignola, F. (2002): "A New Operational Satellite-to-Irradiance Model," *Solar Energy* 73, 5 pp. 307-317.

[3] Energy Information Agency (EIA) Existing Electric Generating Units in the United States by State, Company and Plant, 2003 (Preliminary Data), data downloaded from www.eia.doe.gov/cneaf/electricity/page/capacity/capacity.html.

Appendix 3

chromagen

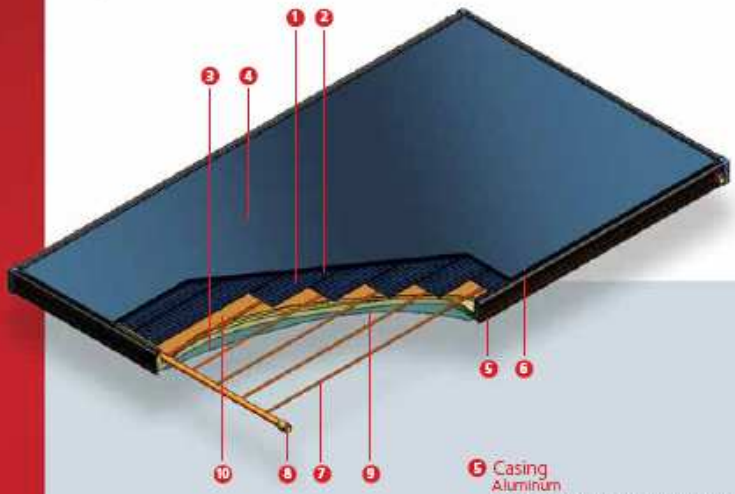
SOLAR COLLECTORS

Solar Collectors

Chromagen has fine-tuned the design and manufacture of solar collectors to an art. Collectors are assembled using quality materials and advanced techniques, which result in highly efficient, durable products you can depend on for years to come.

The products are environmentally friendly, remarkably versatile and offer high performance even in extreme environments.

The wide range of solar collectors enables Chromagen to provide cost-effective solutions which comply with a variety of international standards, and fulfill different requirements.



1 Absorber Plate
The Absorber Plate consists of copper fins ultrasonically welded to copper risers, which provide excellent heat transfer between the fins and risers, ensuring high efficiency. Superlative selectivity offers a high absorption rate of 0.95 with extremely low emissivity.

2 Absorber Plate Coating
The absorber plate is coated either with a sputtering coating or with black chrome on nickel, or with a special selective solar paint. All provide a superior surface, highly efficient in solar energy applications. This also allows for excellent energy absorption even in cooler climates.

3 Insulation
The absorber plate is encased in 30mm rigid polyurethane foam that meets US and European standards. A 20mm layer of mineral wool protects the polyurethane while providing additional insulation to retain the heat in the collector.

4 Solar Glass Glazing
The single pane 3.2 mm solar glass is patterned to reduce reflection and tempered to maximize strength and durability. The low iron oxide content of 0.03% enables a high solar transmittance of 91%.

5 Casing
Aluminum
All the aluminum extrusion casing is fitted with integral slots for easy rooftop attachment with solid construction available in black or red. Its unique design bolts on and anchors to the roof (shingled, tiles, tar) or collector stand.

Stainless Steel
Stainless steel casing provides maximum protection against corrosion, particularly important for costal locations with a high salt content.

Galvanized Steel
Inexpensive yet durable, galvanized steel casings are available in black or white polyester finishes.

6 Gasket
The all-around EPDM gasket is highly resistant to temperature variations and UV radiation. Absorbing the differential expansion of frames and glazing.

7 Tubing Grid
5/8" or 8 mm copper risers brazed to 1 1/8" or 7/8" copper manifolds with optimal flow distribution.

8 Piping Connection
Four BSP female brass connections.

9 Back Plate
Made of Black Polypropylene sheet.

10 Aluminum Foil
Attached to the insulation. The aluminum foil acts as a barrier against out-gassing.

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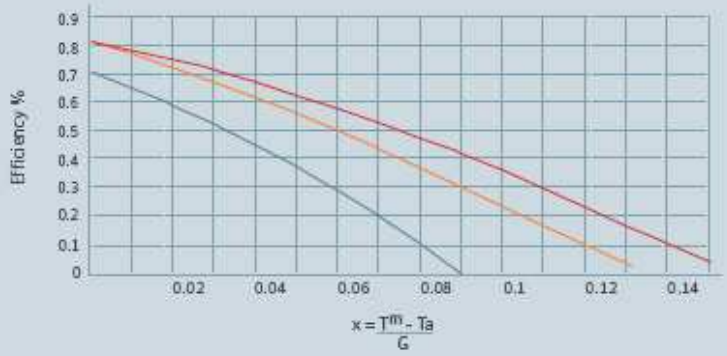
Specifications

Model	CR-90	CR-100	CR-110	CR-120
Gross area (m^2)	1.70	2.10	2.40	2.80
Net aperture area (m^2)	1.50	1.90	2.20	2.60
Ratio net/gross area	0.88	0.90	0.91	0.92
Length (cm)	182	190	219	219
Width (cm)	93	109	109	129
Thickness (cm)	9	9	9	9
Weight (kg)	32	39	44	51
Fluid capacity (liter)	2.70	3.20	3.50	4.10
Test pressure (bar)	14	14	14	14
Operating pressure (bar)	10	10	10	10
Thermal efficiency (x = 0.050) (%)	61	62	62	63
Heat output				
Summer (850 W/m2) (kW)	0.92	1.2	1.3	1.6
Winter (450 W/m2) (kW)	0.43	0.52	0.57	0.71

Due to on-going development specifications are subject to change, without notice

Efficiency Curve



T^m = Water temp; $\frac{T\,out + T\,in}{2}$

T^a = Ambient temp

G = instantaneous solar radiation

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