Concentrated Solar Power Plant Feasibility Study

by AHMOSE, Incorporated

AHMOSE, Incorporated
Carl R. Amos, CEO
8710 W. Hillsborough Ave #413
Tampa, FL 33615
301-455-8329 Cell 773-346-4877 Fax
ahmose_inc@yahoo.com

Table of Contents

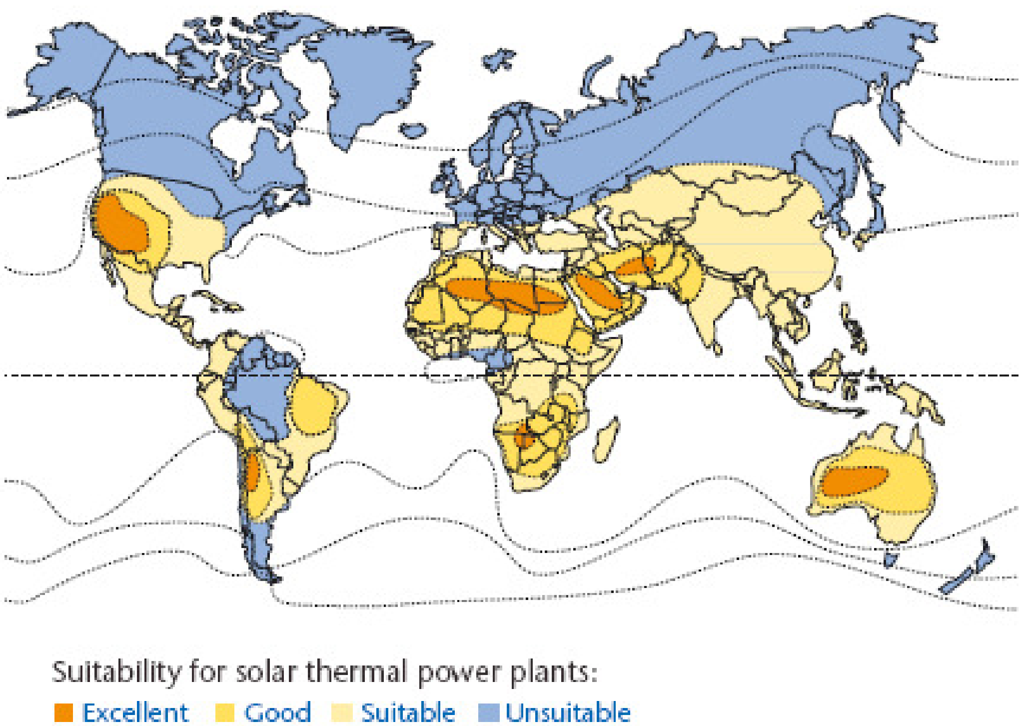
Introduction

In February 2008, the Supreme Council of Energy of Egypt, headed by the Prime Minister, approved an ambitious plan to satisfy 20% of the generated electricity by renewable energies by 2020. AHMOSE, Inc. (AHMOSE) seeks to support the realization of this strategy, under the new electricity act that encourages renewable energy utilization and private sector involvement and is looking to Egypt to host a new regional center of excellence for renewable energy.

AHMOSE, a US corporation, is looking to implement solar thermal energy generation using our proprietary technology to produce an electricity output in megawatts and higher. Upon completion the Ahmose Solar Thermal Energy Power Plant (Ahmose STEPP) would be generating electricity on a commercial scale together with implementation of related energy conservation measures.

This feasibility study aims to review the range of renewable energy technologies available for use in Egypt and will show the Ahmose STEPP as the most suitable option based on the practicality, cost, and demonstrable value. The proposed Ahmose STEPP project is extremely feasible and beneficial to the ecology, and as a renewable energy (RE) technology, it can provide large amounts of clean plentiful energy, competitive with other RE technologies.

For the US and South America and surrounding regions, the current energy demand is growing at an astounding 10-12% a year. Using the vast amounts of available solar energy, in the desert regions can range from 5-7 kW/m2 in the northern areas to as high as 32kW/m2 in southern desert areas, makes practical sense in this age of peak oil and global warming. This also would eliminate the carbon footprint that more conventional electric production methods create. This energy via high voltage DC transmission and molten salt heat storage, proven technology, provide continuous, reliable bulk electricity competitive with existing coal, oil, and gas fired nonrenewable power plants.



Looking Forward: Time is running out

The next few years will be the decisive window of opportunity for conversion of energy systems. According to the International Energy Agency, by 2030 the investment needed for the electricity business worldwide will be 7.5 trillion euro. In Germany alone, half the current power plant capacity will be off grid by that time.

Planning and constructing a power plant takes up to ten years. With a predicted operating time of about 50 years, we are now deciding the energy structure through 2060. Foreseeable shortages and today's already unreliable and distinctly expensive fossil resources are forcing a diversification of energy sources. The limit of CO2 emissions in our atmosphere has already been exceeded.

Solutions can no longer be put on the 'back burner': we must not engage in a one-sided pursuit for technologies that may not be ready for market for decades. We must take advantage of renewable energy resources that are available and affordable today.

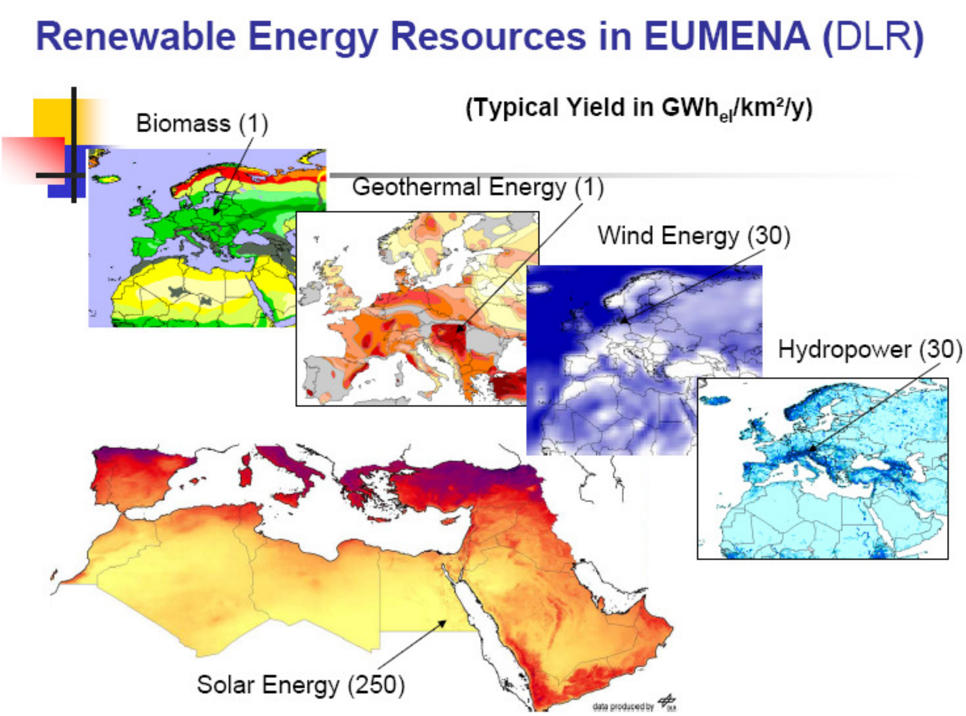
The establishment of powerful, international energy transmission structures and a really workable domestic energy market are more urgent than ever. Protection of the climate is not just a necessity, but also a future market, which the Western Hemisphere must exploit through specific, coordinated strategies.

The advantage of solar thermal power plants is that they are ready for the market and suitable for large-scale use at up to 250 MW of electricity (MWel). They can replace conventional power plants operated in the medium load range - and without any qualitative changes in the grid structure.

The turnaround in energy can be initiated today. Parabolic trough power plants are based on a proven technology and can be "delivered". They are among the lowest-cost renewable energies and in the midterm will stand up to a profitability comparison with medium-load fossil fuel systems.

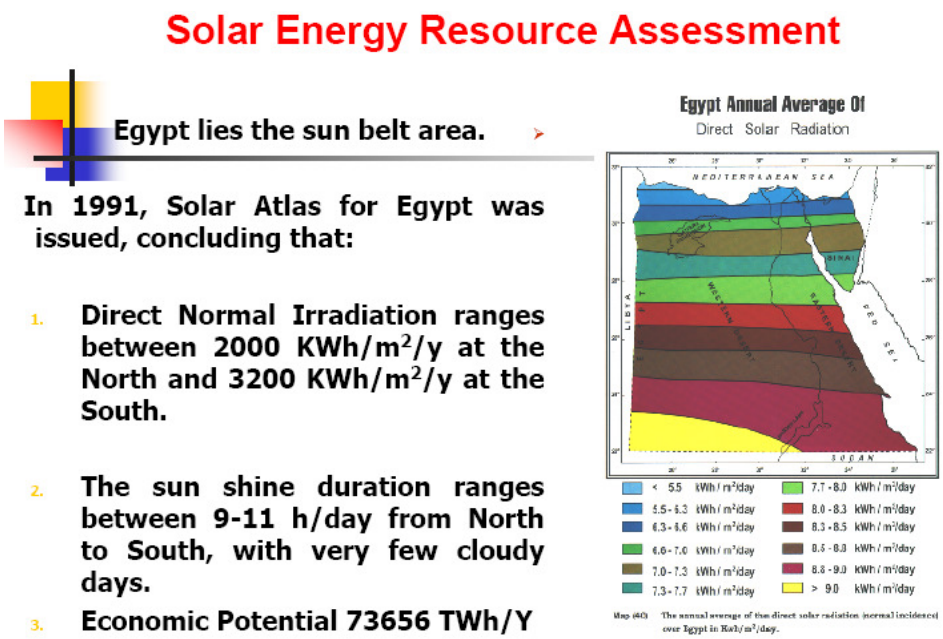
With their high efficiency and the lowest power production costs of all solar technologies, the technologically mature parabolic trough power plants in particular have outstanding prospects for the future. The technology is market-ready; it now needs the support of policy makers and the confidence of potential investors.

Concentrated Solar Power Applications



A solar thermal power plant in principle works no differently than a conventional steam power plant. However, there is one important difference. No harm is done to the environment by burning coal, oil, natural gas or by splitting uranium to produce steam. It is produced solely by the energy that comes from the sun. Solar thermal power plants use the energy from the sun to generate heat, which is converted into electricity via turbines.

Whereas photovoltaic is the right technology for decentralized utilization of solar energy, the strength of solar thermal power plant technology (CSP) is centralized energy generation. The uninhabited deserts of North Africa alone could generate many times the European power requirements. This makes concentrating solar power technology a significant technological option for a sustained energy mix in the future. It will also contribute directly to the CO_2 reduction strategy of the European Union. According to a Greenpeace study, the use of CSP can prevent 154 million tons of CO_2 emissions worldwide by 2020.



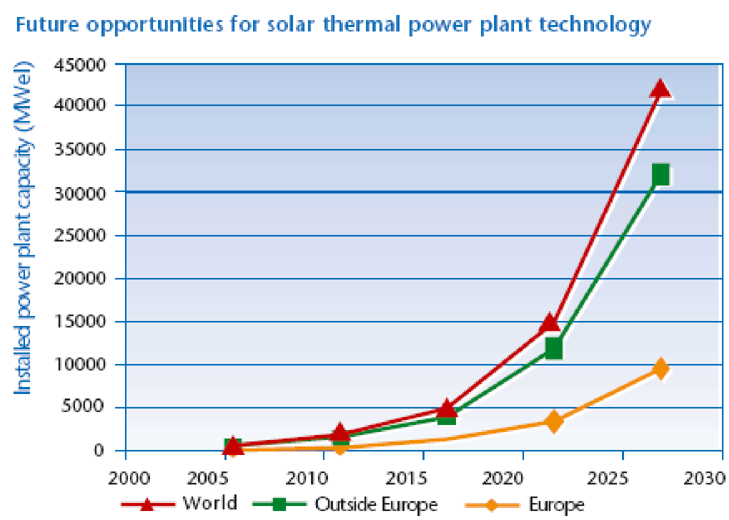
Solar thermal power plant technology is particularly efficient at high solar irradiation. Therefore it offers very good options not only for the member states of the EU, but also in many economically disadvantaged regions in the Earth's Sunbelt.

Of the various solar thermal power plant technologies, only parabolic trough technology has yet achieved market maturity. Therefore, the statement on solar thermal power plant technology in this study is based on this technology. They have been reinforced through operational practice.

In the solar field of a parabolic trough power plant, parabolic mirrors placed in long rows concentrate solar irradiation 80 times upon an absorber tube, in which a heat transfer fluid is heated. In the central generation unit, a heat exchanger produces steam to power the turbines.

Research is currently under way on the following other solar thermal power plant technologies:

- **Solar towers** consist of a central receiver tower, which is surrounded by a mirror field that concentrates the irradiation on the tip of the tower. In the receiver a heat transfer medium is used to transfer the energy to a heat exchanger in order to produce steam.
- In **Fresnel technology**, horizontal flat mirror facets track the sun. Here, too, the energy is transferred to a heat exchanger using a heat transfer medium.
- With the **Dish-Stirling** system, parabolic dishes capture the solar radiation and transfer it to Stirling motors.
- With the **solar chimney**, the sun heats air beneath gigantic, greenhouse-like glass roofs. The air then rises in a tower and drives the turbines.



The scenario of the German Aerospace Center (DLR) for expansion in the world

In contrast to these technologies, parabolic trough technology is completely ready for use. It is mature and, compared to the other forms of solar thermal power plant technologies, has a head start in development of at least twenty years.

The operating costs have dropped from originally 8 cent/KWh to just over 3 cent/KWh. Experience provided the basis for development of a new generation of parabolic trough components with substantially improved performance. Due to the inexhaustible energy potential of the sun, technical performance, and environmental friendliness, solar thermal power plant technology is in a position to make an essential contribution to future power supply.

Advantages of Solar Thermal Power Plant Technology

Parabolic trough power plants are suitable for large-scale use in the range of 10 to 250 MWel electrical output. The modular character of the solar field makes it possible to start at any power level. Currently the optimal size is 150 - 250 MWel. Parabolic trough power plants can replace conventional thermal power plants - and without any qualitative changes in the grid structure.

Due to the option of thermal storage, the turbines of solar thermal power plants can also produce power in low-radiation periods and at night. Solar thermal power plants can deliver power reliably, on a planned schedule, and in a way that keeps the grids stable.

Depending on local irradiation, parabolic trough power plants can now produce cost-effective solar power at prices between 10 and 20 cent/KWh. The high costs of the investment phase are balanced by low operating costs of currently only 3 cent/KWh. By 2015 the power production costs will be comparable to those of medium-load power plants using fossil fuels.

The use of solar energy means reliable planning. The independence of the operating costs from fluctuating fuel prices and unlimited availability permit reliable calculation throughout the entire investment period.

Particularly in the Sunbelt when most power is needed for cooling, solar thermal power plant technology is most effective. These power peaks are already covered competitively today by the nine solar thermal power plants in California.

High-voltage DC transmission lines, which are currently state-of-the-art, can conduct the power over long distances - for example from the southern US and Mexico to the north US and Canada. The costs are around 2 cent/KWh.

Parabolic trough power plants are a proven technology. In the US, the power plants of the first generation are running reliably with a total capacity of 354 MWel. With nearly 12 terawatt hours of solar power produced at a value of 1.6 billion dollars, parabolic trough technology has demonstrated its potential impressively. In nearly 20 years of operation, no disadvantageous effects on the social or the fragile natural environment have become known.

Solar thermal power plants use low-cost, recyclable materials that are available worldwide: steel, glass, and concrete. Local companies handle a great share of the construction work. The modular structure of the solar field facilitates entry into mass production with substantial potential for increased efficiency.

Solar thermal power plants have a very good ecological balance. The energy payback time of five months is low - even in comparison to other regenerative energies. Parabolic trough technology has the lowest material requirements of all solar thermal power plant technologies.

The land use of solar thermal power plants is substantially lower than for biomass, wind energy, or water power - not to mention dams in mountains. In addition, since they are erected only in the dry zones of the Earth, there is hardly any competition for land utilization. Solar thermal power plants can be used in the Earth's Sunbelt between 35° northern and southern latitude.

Parabolic trough power plants are ideally suited for "Joint Implementation" (JI) and "Clean Development Mechanism" (CDM) projects under the Kyoto Agreement. Industrial and developing countries can work together on parabolic trough power plant projects to make power generation decisively more environmentally friendly and thus protect our planet's climate.

The waste heat of solar thermal power plants can be used for sea water desalination as well as for electricity generation. Particularly countries in North Africa and the Middle East, which are outstanding locations for solar thermal power plant technology, could improve their water supply by this means.

Reliability

The Carter administration, which, due to the oil crises of the 1970's, was open to the topic of sustainability and renewable energies, supported the construction of parabolic trough power plants in the USA. They were built between 1984 and 1991 in California's Mojave Desert - 160 kilometers from Los Angeles – with a total output of 354 MWel. The power plants constructed till that time are still running reliably: nine solar fields with 2.5 million square meters of concentrating reflector surface have fed more than 12 billion kilowatt hours into the California grid, earning nearly 1.6 billion US dollars.

The positive construction and operating experience in California is the basis for current project planning in Southern Europe and in the developing countries of the Earth's Sunbelt. The performance of the power plant components has proven to be very reliable. The technical availability of the solar fields has always been over 98 percent.

This experience leads to the conclusion that the lifetime of the parabolic trough field will far exceed the planned technical life cycle of 25 years. The positive development of the privately operated California power plants shows that, for locations with suitable conditions, operation can be economical without extensive public subsidies. The prospects are improved further, when the operating costs after the end of debt service drop to only 3 cent/KWh.

The nine power plants built in California

SEGS I	14 MWel	since 1984
SEGS II	30 MWel	since 1985
SEGS III	30 MWel	since 1986
SEGS IV	30 MWel	since 1986
SEGS V	30 MWel	since 1987
SEGS VI	30 MWel	since 1988
SEGS VII	30 MWel	since 1988
SEGS VIII	80 MWel	since 1989
SEGS IX	80 MWel	since 1990
Total output		354 MWel

(SEGS: solar energy generating system)

Power Generation: When the sun doesn't shine

To generate electricity "around the clock", two methods have been developed, each of which has been technologically proven.

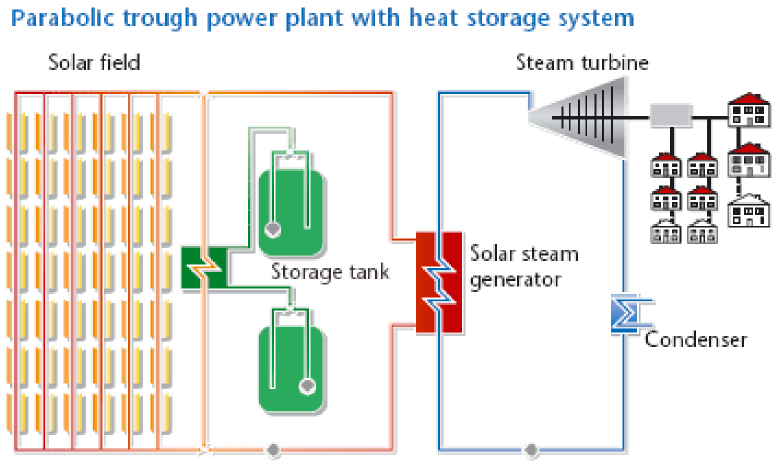
- **Hybridization:** the total compatibility of solar thermal power plant technology with steam generation from fossil fuels makes it possible to combine solar and fossil components in any ratio in a hybrid power plant. In the first-generation California power plants, the fossil component is used primarily to cover occasional cloudy and stormy phases. It is limited to 25 percent of annual power generation and provides great security for breaks in radiation. Combination with modern gas and steam ISCCS power plants (integrated solar combined-cycle system) makes it possible to produce electricity very cost-effectively; however, the solar function is limited to 15 percent.
- **Heat storage systems** also make solar power available in unfavorable weather and at night: the millions of liters of heat transfer fluid already represent a considerable storage capacity, which can cover short cloudy phases. Storage on the basis of molten salt makes it possible to produce electricity around the clock. Molten salt storage technology is proven and is rated as reliable by carriers.

The Spanish national carrier has given this kind of power plant system the same reliability status as power plants using fossils. In Spain's AndaSol power plant, a mixture of 25,000 tons of sodium and potassium nitrate is heated to 384 degrees Celsius. Fully loaded, this suffices for power plant operation for well over 6 hours.

Diagram of a solar thermal power plant with heat storage system:

In the solar field, transfer fluid is heated, and then flows to a heat exchanger. There steam is produced, which powers the turbines. If needed, a heat storage tank can be added to the cycle.

(Source: Solar Millennium AG)



A Sustainable Technology

The solar irradiation on the Earth is about 10,000 times world energy demand.

According to a study by Greenpeace, the use of CSP can prevent the emission of 154 million tons of CO2 by 2020. Just one 50 MWel parabolic trough power plant can cut annual heavy oil consumption by 30 million liters and thus eliminate 90,000 tons of CO2 emissions.

The energy balance is outstanding: the payback period for the energy expended in production of the components is 5 months. The materials used (concrete, steel, glass) can be recycled. The specific land use is quite low at 2 hectares per MWel. The property needed has a very low value. There are no social or ecological problems associated with its use. There are no hidden social costs in the form of environmental pollution, additional social services, or other resulting economic effects. Solar thermal power plants use construction materials that are available and affordable worldwide. For the most part they can be constructed and operated by local labor.

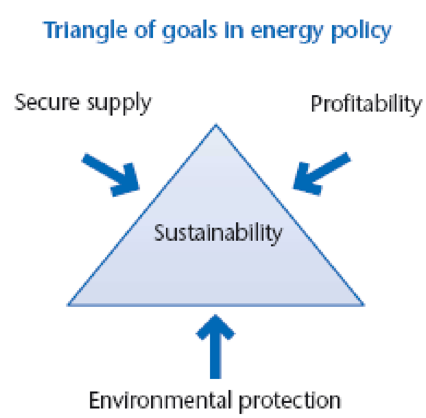
The German Advisory Council on Global Change (WBGU), which advises the German federal government, projects that world energy consumption, will triple by the year 2050. “In the long term the rising demand for primary energy can be covered only through decisive use of solar energy”, writes the WBGU in its report “World in Transition - Towards Sustainable Energy Systems”.

Energy Amortization Time

The energy amortization time describes the time the system needs to recover the energy used for production, operation, and waste removal. Power plants based on exhaustible fuels never amortize the energy expended, because they always need more fuel than the energy they produce.

- Wind power 4 to 7 months
- Hydro power 9 to 13 months
- CSP in Morocco 5 months
- Polycrystalline silicon (Central Europe) 3 to 5 years
- Gas power plant never
- Coal power plant never
- Nuclear power plant never

(Source: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)



Access to the Grid

Very large solar resources are today unutilized in the Mediterranean area and in North Africa. To exploit these energy sources for Egypt, unimpeded grid connection must be guaranteed by the potential transfer countries

(Spain, France, Italy, and Greece). The grid access fees must not be substantially higher than the technology-based costs of around 2 cent/KWh.

The EU must prevent carriers with large numbers of fossil and nuclear power plants from impeding or even preventing power transmission across national borders. Egypt can achieve a turnaround in the energy sector only if the EU ensures free access on the entire continent.

To develop a future energy partnership of the EU with the entire Mediterranean area to the benefit of all, the planning and construction of powerful high-voltage DC transmission lines should begin. Large networks like the "Euro-Mediterranean Power Pool" as well as the already operational high-voltage DC line between Spain and Morocco could be used until that time.

The directive 2001/77/EG for promotion of power generation from renewable energy sources in the interior electricity market should also be used to promote cross-border trading in renewable energies. The call for unimpeded trading in the interior electricity market also entails the corresponding expansion of the grid. The guideline even calls for priority grid access for renewable energies. Since solar thermal power plants produce electricity based on a principle very similar to that of conventional fossil fuel power plants, their integration in existing grids requires no additional restructuring or grid stabilization measures. Thus, even on the grid level, solar thermal power plant technology facilitates a smooth transition to the age of renewable energies.

Operational Profitably

Power production costs (levelized energy cost = LEC) for the currently operating Californian power plants, depending on their location, are 10-15 cent/KWh; for the planned Spanish, purely solar AndaSol parabolic trough power plants - solar power plants with molten salt storage systems and 20 percent less irradiation - they are correspondingly higher. Experts agree that these costs can be reduced to 6 cent/KWh in the next 15 years if capacity is expanded to 5000 MWel. Thus they will become competitive with medium load conventional power plants.

The cost structure of electricity produced by solar thermal power plant technology is marked by high costs for initial investment. Over the entire life cycle that means: 80 percent of the costs are expenditures for construction and the associated debt service; only 20 percent are operational costs. This is why the confidence of financial institutions in the new technology is of such great importance. Only when they make funds available without high risk surcharges a solar thermal power plant technology project can be financed and in the future become competitive with fossil fuel medium load power plants.

Once the plant has been paid for after 25 or 30 years, only operating costs remain, which are currently about 3 cent/KWh. The electricity will then be cheaper than any competition, comparable to that today from hydro power plants that have long since been written off. The Californian power plant operators will have reached this point by 2018.

Even in the current market launch phase, the energy feed-in tariff for the power grid is far below that required for photovoltaics, and can provide an adequate impulse for constructing large scale power plants. Thus the Spanish decision to set the sale of energy to the grid for solar thermal power plants at 18 cent plus market price per kilowatt hour is an adequate market launch incentive. At that rate, solar thermal power plants can be operated profitably at good sites in the southern part of the Iberian Peninsula.

This incentive is limited to a capacity of max. 50 MWel per power plant. In the view of the International Energy Agency and the World Bank, solar thermal power plant technology is the most economical way to generate electricity from solar energy. The International Energy Agency (IEA) in Paris foresees a potential cost reduction to less than 6 cent/KWh by 2020. The U.S. Department of Energy (DOE) developed a plan for solar thermal power generation back in 1996, which envisions an installed capacity of 20,000 MWel by 2020 with electricity costs of less than 6 cent/KWh. On the basis of economies of scale and the learning curve, the World

Bank also expects that electricity production costs for solar thermal power plants will drop to less than 6 cent/KWh by the year 2020.

Potential Weaknesses

Commercially available solar thermal power plants have to overcome:

- **Mirror elements:** suppression of existing residual waviness of the mirror surface through improved forming processes.
- **Receiver:** greater active length through optimized design of the receiver, distinctly improved optical key values for selective absorber tube coating, abrasion-resistant anti-reflective coating, if needed greater absorber diameter to capture lost radiation.
- **Break rate of the receiver:** the simultaneous distinct drop in the break rate from currently 4 percent to less than 1 percent through a new kind of glass-metal seal has a favorable effect on current operations (greater availability of the solar field) and on future operating costs (lower spare part demand).
- **Higher working temperature:** an increase in working temperature to over 400 °C is associated with more effective utilization of the heat. Currently the limiting factor is the thermal stability of the heat transfer fluid. Alternatives (direct steam generation, molten salt as heat transfer medium) are being worked on.
- **Progress in operation and maintenance:** constant improvements in control and monitoring technology and increased power plant size will cut operating and maintenance costs even further. This process will be flanked by the long-lasting new parabolic trough elements (torsion-resistant trough, break-resistant receiver, abrasion-resistant anti-reflective coating).
- **Power plant size:** the transition to power plants with the optimal size of 150 - 250 MWel will result in a number of specific advantages:
  - Higher efficiency of the power plant block,
  - Reduction in specific project development effort,
  - Reduction of operating and logistical costs.
- **Mass production:** the increase in annually installed power plant capacity means entry into a period of distinctly more cost-efficient mass production of components. Engineering costs will also be lowered through standardization.
- **Location:** in principle, locations in North Africa have about 20-30 percent better irradiation than those in Southern Europe. In addition construction costs can be cut through the use of local companies to construct the solar field, which makes up about 50 percent of the added value.
- **Legal and tax conditions:** if there are no limitations on power plant size and if a tax framework attuned to solar thermal power plant technology is created, further significant cost benefits can be achieved.

Memorandum on Solar Thermal Power Plant Technology, Mainz 2005

Improvements on the Technology

This is where the Ahmose STEPP project improves on previous solar thermal power plants and CSP systems in two ways.

1. The Ahmose STEPP using proprietary technology increases the electric production by at least 20-30 percent without increasing initial investment.
2. The Ahmose STEPP requires less land to produce the same amount of electricity as other types of solar plants thus either allowing for a larger power plant or reclamation of the land for other uses.

SWOT Analysis

AHMOSE sees the strengths and weaknesses of power generation, namely SWOT:

- Strengths:
  - AHMOSE has procured licenses to proprietary technology.
    The proprietary technology is covered by international patents PCT WO 91/ 02992, US 5,369,511, *Methods of and Apparatus for the Manipulation of Electromagnetic Phenomenon* and PCT WIPO US/2007/079259, *Advanced Methods of and Apparatus for the Manipulation of Electromagnetic Phenomenon E3*. In addition, architectural copyrights VAu 526-764 and VAu 318-745 are a part of the Ahmose, Inc. intellectual property rights.
  - Government Backing:
    - The Ministry of Energy and NREA is poised to give Ahmose, Inc. permission to utilize the Kuraymatt region as an appropriate site for the project and AHMOSE believes that this would be feasible considering its optimal facilities, including available electrical power for operation of equipment and lighting.
    - An important framework for international efforts to expand solar thermal power generation is the global market initiative for solar thermal power plants known as the Global Market Initiative for Concentrating Solar Power (GMI). At the world climate summit in Johannesburg in September 2002, this initiative was recognized by UNEP (United Nations Environment Programs) as an official public-private partnership program. The goal of the GMI is to create suitable conditions for worldwide implementation of solar thermal power plants by pooling the efforts of governments and financial institutions as well as those of science and business.
      The elimination of existing obstacles on electricity markets in the appropriate countries in the Earth's Sunbelt is part of the initiative, as is the provision of financial resources for implementation of concrete projects. The goal is to have about 5,000 MWel of installed solar thermal power plant output by the year 2015.
    - At the "renewables 2004" conference in Bonn, the governments of the host country Germany as well as Algeria, Egypt, Morocco, Jordan, Italy, and Spain all signed bilateral agreements to promote solar thermal power plant technology. The Global Environmental Facility of the UN (GEF) and the German KfW-Group are participating in the initiative. Of all the projects, a planned power plant project in Morocco has progressed furthest. The corresponding call for bids is expected. The GEF is also supporting projects in Egypt, India, and Mexico.
    - In 1997, the member states of the Kyoto Agreement obligated themselves to reduce CO_2 emissions. Each industrial country was assigned a country specific obligation to limit or reduce emissions. The EU agreed to a reduction goal of 8 percent, which in turn was divided among the individual member states. As part of the implementation of the Kyoto Protocol, emission trading began within the European Union on 1 January 2005. Each affected plant was first given an emission certificate and concrete reduction goals. Unneeded certificates can be traded. Whoever does not reach the reduction goal must purchase additional certificates on the market. Emission trading is also possible between countries.
      International solar thermal power plant technology projects can also profit from the Kyoto Agreement: in connection with "Joint Implementation" (JI) (among industrialized countries) CO_2 certificates can be transferred to the Investor country. In the "Clean Development Mechanism" (CDM), projects are carried out between an industrialized country and a developing country. Goal: to develop the affected states economically and simultaneously to reduce environmental pollution.
  - Cost Advantage:
    - It costs no more than the average CSP or other solar plants to operate the Ahmose STEPP.
    - The long term cost to operate the Ahmose STEPP is minimal.
  - High Grade Production:

- The sheer geometry of the STEPP allows for robust energy collection at low sun angles, namely early morning, sunrise and late evening, sunset and throughout the day.
- The STEPP is both passive and stationary and does not use, nor does it require Heliostats.
- Efficiencies are approximately equal to Output/Input, or you-get-out/what-you-put-in, what you paid for, and the values are typically less than 100%.

- Weaknesses:
  - AHMOSE has no brand recognition as of yet.
  - The Ahmose STEPP has the same high initial investment costs of other solar thermal plants.

- Opportunities
  - AHMOSE sees unfulfilled global need for clean, reliable robust power generation.
  - Newer technologies are just around the corner.
  - Governmental incentives and initiatives should give solar power the edge it needs.
  - Environmentally friendly, less land and no CO_2 footprint.

- Threats
  - The emergence of substitute technologies.
  - Resistance of existing power producers to transmission of generated power on international grids.

Ahmose Solar Thermal Energy Power Plant (STEPP) Array

The desert regions of the Mojave and Central America are favorable geographical latitudes; an area 1m^2 receives at least 1970- 2600 kWh/m^2/year. The amount is approximately 2400 kWh/m^2/year

This high intensity may work out to between 5-7kWh/m^2 per day (dividing by 365). This amount of free solar radiation is a blessing! A simple 1kW/m^2 of solar radiation each hour on a bright sunny day in other nations is considered to be extraordinary. Given the length of intense usable sunlight (9-13 hours) it is the purpose and goal of this effort to capture and convert as much as possible solar energy into a useable form and by means of well established, tried and tested methods, AHMOSE efforts will be to respect what is considered workable and practical.

Ahmose STEPP technology involves using arrays of flat and curved mirrors parabolic, spherical, and cylindrical lenses to redirect intense sunlight onto a receiving means or concentrating collector for high temperature steam generation with direct input to electric turbine, or redirecting this intense concentrated solar energy to a Solar Thermal Furnace. Considering the latter, the efficiencies of such heat engines vary and some can exceed 30% or more. The limiting factors are basically the 1st Law of Thermodynamics and the theoretically unattainable efficiency limit of a Carnot Engine/Cycle.

Since, there will be losses in any system, the objective is to minimize these losses and improve the efficiency of every component. For example, a mirror’s efficiency can be improved upon. A simple highly polished nearly flat first surface mirror with a slight or small radius of curvature can be very useful as well as having negligible cost.

The Ahmose STEPP can employ the much heralded flat mirror technology, such as the Linear Fresnel flat mirrors but is not limited to this technology. Even these flat mirrors as further developed by the Fraunhoffer Institute in Germany and others actively involved in this field are now successfully using well established technology updated with a newer Fresnel pattern and smaller radius of curvature.

However, for simplicity sakes, the following calculations are supportive of this approach. In addition storage of energy during nighttime or cloudy days can employ a variety of old and newer energy storage technologies. Also newer approaches include direct steam generation by elimination of heat exchanger absorber and merely directly generate steam by having the mirror in close proximity to water filled pipes (with secondary lens) to heat fluid to near 450 Celsius. This high temperature is necessary given that this super heated steam does work in a heat exchange process or Carnot Cycle.

The nth Law of Thermal efficiency is nth = you-get-out-what-you-put-in and generally the higher the temperature the better the efficiency. The 1st Law of Thermodynamics states that you cannot get out more than you put in, and $0 \leq nth \leq 1$ Thermal Eff = $W_{out}/Q_{in.}$

The Carnot Theorem or formula is $nth \leq 1\text{-}T_c/T_h$ wherein T_h is the high input energy in our case, 450 Celsius and T_c is the ambient (exhaust) heat of the environment. Again the higher temperature produced by the proposed system produces higher efficiency and more available usable energy. Stirling engines can be used to augment the system and is commonly used now in many solar applications. Additional technologies involving different thermal fluids/oils are available. For storage a practical approach is to use molten sodium in the form of a salt (preferably the Thermocline system i.e., a single storage tank) for night time backup. Alternately other approaches such as hydrogen cracking and electrolysis have been considered as practical approaches for reliable Solar Energy storage.

The energy provided via redirection of sunlight directly onto water filled steel absorber pipes (for high temperature steam pressure) or redirection onto a large solar tower type thermal furnace both in near proximity to the Ahmose STEPP will be substantial..

The Potential Power Production

Consider for a single Linear Flat Fresnel Mirror $1m^2$ assuming a conservative constant of $1kW/m^2$,

$E = 1kWh/m^2$ for 1 hour duration.

This is the available energy from 1 mirror unit:

Energy = PxT or more generally E = Power x Area x time.

For the desert regions with available 9-11 hours per day of intense solar radiation for $1m^2$ an average 10 hours gives over an average day:

$E= 1kW/m^2 \text{ x } 1m^2 \text{ x } 10 \text{ hr} =10kWH.$

Expanding these known values, consider a cascade linear arrangement or series of 100 units of adjacent $1m^2$ Linear Fresnel Mirror panels each uniformly receiving $1kW/m^2$ and energy being:

(E = P x A x T) Area = Length x width = 100m x 1m = $100m^2$

Hence for 1 hour this simple array will furnish:

$E = 1kW/m^2 \text{ x } 100m^2 \text{ x } 1hr = 100kW$ for each hour.

For a 10 hour day, we have

$E = 1kW/m^2 \text{ x } 100\ m^2 \text{ x10 hrs} =1{,}000kWh$ or 1 Megawatt in a 10 hour day.

However, considering the effective 5 -7 kW/ m^2 solar intensity, we can conservatively see intense solar radiation on average of $6kW/m^2$. Therefore,

$E = 6kWh/m^2 \text{ x } 100m^2 \text{ x } 10h = 6000kW$ hrs or approximately 6MW per day

available to be directed at a steel water filled absorber pipes or redirected concentrated and focused for input to a Solar Thermal Furnace.

Considering the efficiency of the latter is typically 30%we have (0.3) x 6000kW = 1800kWh per day, this is close to 2MWh/day. We know 1 acre = 0.4 hectares, 1acre =$100m^2$ and 1 hectare =10,000 m^2. AHMOSE has requested a minimum of 100 acres to 200 acres of flat desert land. However, 1 acre is the same area needed for

100 units of our series arrangement of Linear Fresnel Mirrors. Therefore, a minimum of 10 to 100 acres of land is sufficient space for the Ahmose STEPP Array.

As mentioned the apparatus can handle low sun angle at both early morning and late evening. In addition the technology has low shadow effects and essentially can pack an extremely high density of flat mirrors by considering Fourier Series concepts (piecewise continuous on an interval with at least one minimum and one maximum uniformly convergent). The Ahmose Technology relies heavily upon these well known established principles AHMOSE will work with corporations in the industry regarding safety issues and construction for the Ahmose STEPP Array. The Ahmose STEPP Array scalability allows by a factor of 5 or 10 an increase in output, this is attainable in the first STEPP Array. Maximum output can reach or exceed 10 to 20 MW daily. In addition given its unique geometry a further increase is attainable, which in principle can reach 40 to 80 MW and higher.

In consideration of the proprietary nature of Ahmose STEPP Array technology, AHMOSE will attempt to provide clarity and employ basic clear and concise calculations that should prove helpful in the understanding of this proprietary technology. The following are several basic calculations for the Ahmose STEPP Array that may be of assistance.

A.

The expected energy output for the Ahmose STEPP Array is as follows,

$$E = \text{Power} \times \text{Area} \times \text{Time}. \quad E = P \times A \times T.$$

Considering one section of the STEPP Array in the previous calculations, we arrived at approximately 6MW hrs. At a typical 30% efficiency conversion we previously reached 1.8MW or approximately 2MW available in a normal 10hr day of continuous sunshine.

Considering an entire face or one side of the STEPP Array, we have essentially a trapezoid, the area of a trapezoid is given by the formula

$$area = a\left(\frac{b1+b2}{2}\right)$$

where
b1, b2 are the lengths of the two bases
a is the altitude of the trapezoid

If one considers the base to be 100m long and the truncated top to be 80 meters, choosing an altitude of 100m, we have:

$$A = 100\text{m} \times \tfrac{1}{2}\,(100\text{m} + 80\text{m}) = 9{,}000\text{m}^2.$$

Therefore, the expected energy available for directing onto a heat absorbing/collecting surface input to a solar heat engine situated in Kuraymatt for a typical 10 hour day is:

$$E = 6\ \text{kW/m}^2 \times 9000\text{m}^2 \times 10\text{HRS} = 540{,}000\ \text{kW HRS}, \quad \text{or}$$

540MW HRS of energy available per day.

Furthermore, with accepted efficiencies of 30% of most heat engine systems, we may reach a conservative:

$$.30 \times 540{,}000\ \text{kW HRS} = 162{,}000\ \text{kW HRS}, \quad \text{or} \quad 162\text{MW HRS}.$$

B.

Choosing a more conservative, lower efficiency of conversion of 10%, we have:

$$.10 \times 162\text{MW HRS} = 16.2\text{MW HRS}.$$

These figures are still too high and probably not acceptable. Therefore, let us choose a STEPP Array unit of a smaller size.

For $A_{rea} = a \times ½(b_1 + b_2)$, let $b_1 = 50$ m, $b_2 = 25$m, and $a = 30$m:

Hence, $A_{rea} = 30\text{m} \times ½(50\text{m} + 25\text{m}) = 1125\text{m}^2$.

Therefore, $E = 6\text{kw/m}^2 \times (1{,}125\text{m}^2) \times 10\text{HRS} = 67{,}500$ kW HRS = 67.5MW HRS in a 10 hour day.

At the typical 30% efficiency, we have:

.30 × 67.5MW HRS =20.250 MW, available in a 10 hr day.

C.

At a lower efficiency of heat conversion of 10%, or less than photovoltaic PV systems 15% to 25%), we have:

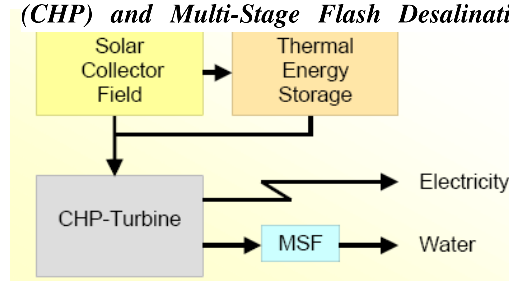
.10 × 67.5MW HRS =6.75MW, available in a typical 10 hour day.

Obviously efficient collection of solar radiation with Linear Fresnel Mirrors and similar mirror technology employing the Ahmose STEPP Array should prove beneficial. However, all of this collected energy from the mirrors can be further focused or concentrated to effectively heat oil and or boil water to produce super heated steam at 450C. The accepted methods and technology for this is well known and currently have become common practice. The Ahmose STEPP Array can employ any combination of lenses and mirrors to accomplish this goal.

Conclusion

- Centralized power generation in systems up to 250 MWel
- No qualitative change in the grid structure
- Reliable, plannable, stable grids
- Can be combined with fossil fuel heating
- In the mid-term competitive with medium-load fossil fuel plants
- Independent of fuel prices, low operating costs
- Already competitive for peak loads
- High-voltage DC transmission permits cost-effective conduction of electricity over long distances
- Proven technology
- Great proportion of added value is local
- Good ecological balance
- Lower land use than other renewable energies
- Kyoto projects for environmental protection
- CPV may be integrated into the STEPP array.
- Sea water desalination as added benefit
  Solar Power and Desalination Plants (SP&D) combine commercially proven technologies to initiate a completely new era of clean electricity and water supply. The heart of the plant is a steam turbine powered by concentrating solar thermal collectors as in the Californian SEGS. A combined heat and power system (CHP) reuses the waste heat of the turbine for thermal seawater desalination, e.g. by the well known multi-stage flash (MSF) or multi-effect-desalination (MED) technology.
  A Solar Power and Desalination Plant with 250 MWe capacity operating e.g. 5000 full load hours will deliver approximately 1000 million kWh of electricity at 5 US-cents/kWhel plus 40 million cubic meters of

Sketch of a Solar Power and Desalination Plant with Combined Heat and Power System (CHP) and Multi-Stage Flash Desalination



freshwater at 1.5 US$/m³ per year (interest rate 10 %/year, economic lifetime 25 years, investment 3500 US$/kWel). Such plants would start today with a 40 % solar share and reach 100 % solar share in about 10 years, making use of solar thermal storage technology. An equivalent base load plant with e.g. 8000 operating hours per year would deliver approximately 1.5 billion kWh/year of electricity at 3.5 US-cents/kWhel and 60 million m³/year of freshwater at 1 US$/m³, respectively. The present layout of such a base load plant would have 25 %, a future layout in about 10 years 60 % solar share or more.

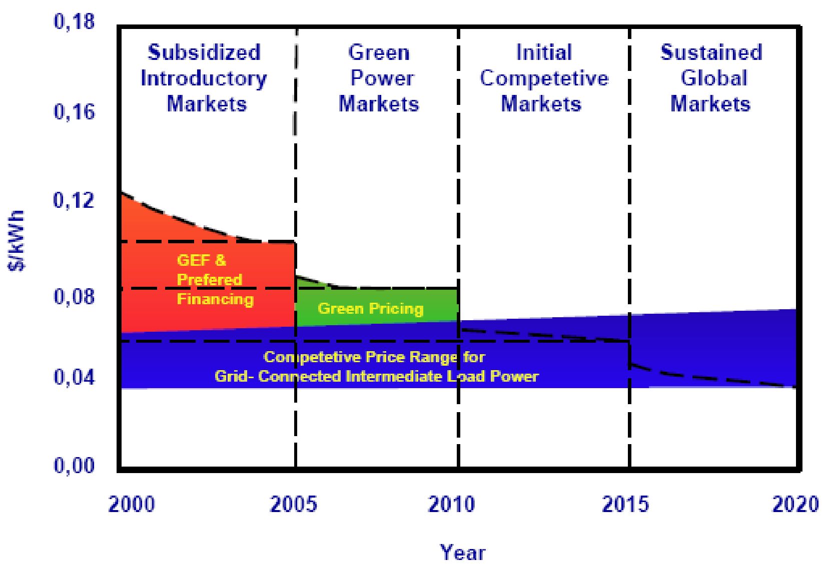
- Hydrogen Generation Value Added
  Hydrogen generation with high-pressure electrolysis will cost additionally about 2 to 5 cents/kWhH2 and transportation below 1 cent/kWh depending on the number of full load hours [4,5]. Using these assumptions the total costs of hydrogen in Middle-Europe will reach about 7 cents/kWhH2 for solar and fossil hybrid co-generation and up to 16 cents/kWhH2 for solar only power generation.

Potentials for Solar Thermal Power Plants: Hydrogen production

Resource assessment for solar power has recently become very easy, in fact much easier than for fossil or nuclear fuels: the solar radiation intensity on the ground can be measured by remote sensing technologies using weather satellites and orbiting satellites around the world. With very high spatial (up to 1 km) and temporal (up to 1h) resolution and accuracy, those technologies provide a reliable data base for the engineering and economic assessment of solar power projects, considerably lowering costs and risks in comparison to other energy prospecting activities.

Perspectives: For future cost reductions and hydrogen utilizations

In the above mentioned cost estimations decreasing electricity generation costs are assumed due to an increasing number of installed solar thermal power capacity. Prices in the range of 5 to 8 cents/kWh of generated electricity can be expected in the medium term for solar only operated thermal power plants



Market introduction of solar thermal power technologies with initial subsidies and green power tariffs (SunLAB, USA)

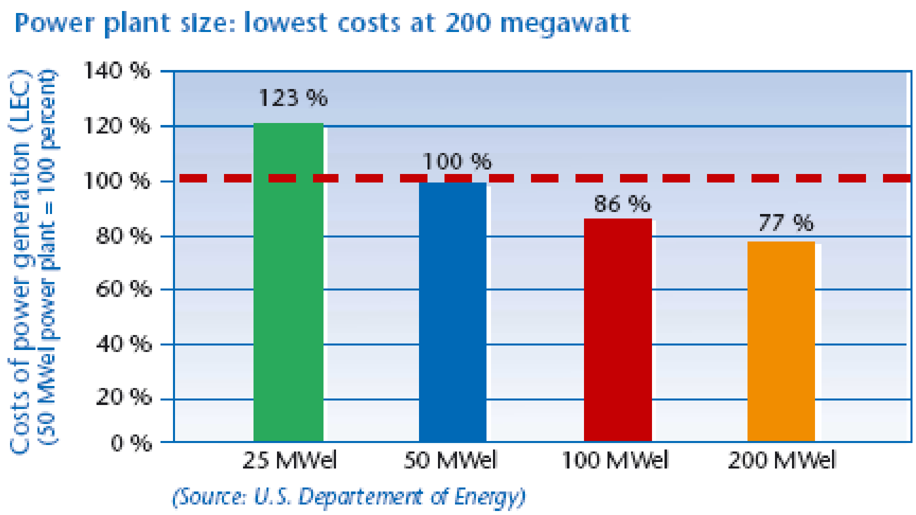
With electricity transportation costs below 2 cents/kWhel using high-voltage DC transmission solar generated electricity from solar thermal power plants in Northern Africa may be available for 5 to 9 cents/kWhel in Europe. In other words, direct electricity generation and transportation will be less expensive than hydrogen production, transportation and regeneration to electricity. However, hydrogen produced with electricity from solar thermal plants will be one major option for clean fuel alternatives and electricity supply when storage possibilities are needed. Together they are key technologies for a sustainable energy industry with a main focus on climate protection.

HYPOTHESIS IV Symposium, Stralsund, Germany, 9-14 September 2001, pp. 198-202

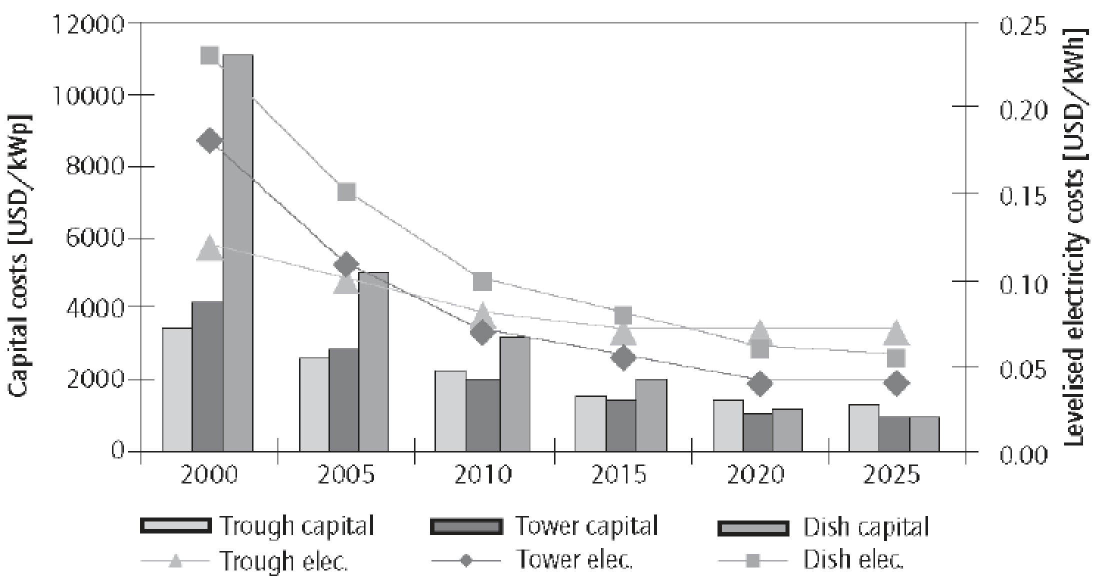
Projections

Solid financing through long-term power purchasing guarantees: the financing of the high initial investments represents the greatest obstacle for the construction of new solar thermal power plants. To overcome this

hurdle, CSP needs long-term power purchasing guarantees. The regulations in Spain regarding the premium for solar power supplied to the grid are a step in the right direction.



Forecast CSP Investment and Electricity Cost



Investment Learning Curve for Different Renewable Energy Technologies (RETs)

Technology Summary Cost (kW/$)	2006	2010	2015	2020	2022
Wind Technology (WT)	1400	1200	1100	1000	900
CSP Technology	4500	4200	4000	3800	3200
Hydropower (HYP)	950	850	800	750	750
PV	6000	5500	5000	4300	4000

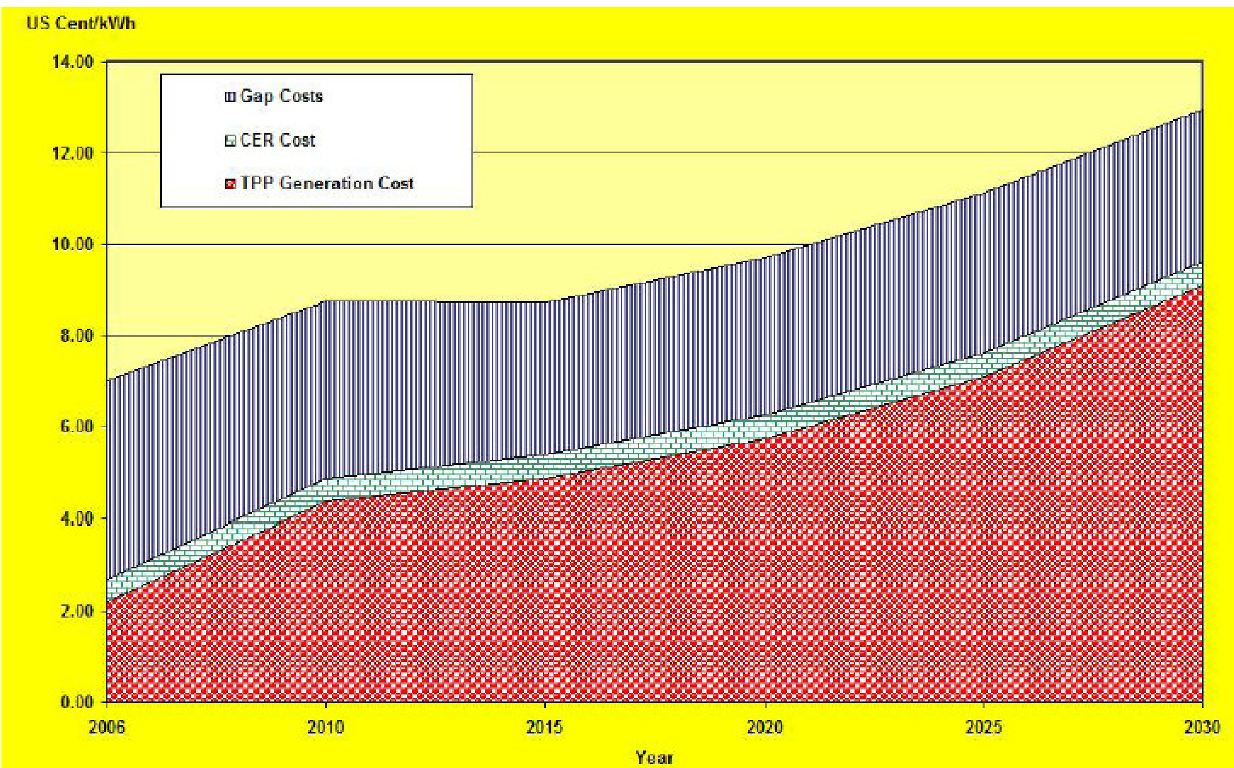
Costs and Characteristics of RETs (Source: IEA)

Technology (for Power Generation)	Typical Energy Costs Cents/kWh
Large hydro	3-4
Small hydro	4-7
On-Shore Wind	4-6
Off- shore Wind	6-10
Biomass Power	5-12
Geothermal Power	4-7
Solar PV	20-40
Solar Thermal (CSP)	12-18

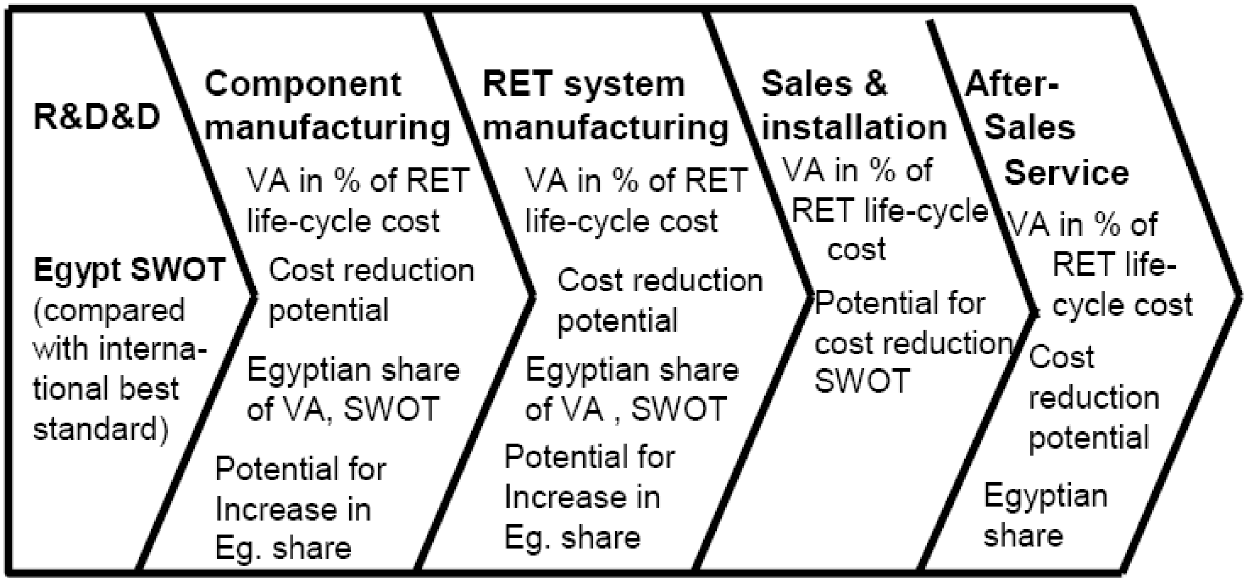
Projected Gap in Fuel Prices – Reverence Case USD/Million BTUs

Fuel	Year					
	2006	2010	2015	2020	2025	2030
NG - Egypt	1.28	2.88	2.91	3.12	3.57	4.30
NG - World	6.06	7.19	6.60	6.93	7.47	7.98
NG - Gap	4.78	4.31	3.69	3.81	3.90	3.68
HFO - Egypt	2.13	2.98	3.01	3.22	3.69	4.44
HFO - World	3.25	3.37	3.45	3.56	3.62	3.90
HFO - Gap	1.12	0.39	0.44	0.34	(0.07)	(0.54)
LFO - Egypt	3.56	5.17	5.23	5.60	6.41	7.72
LFO - World	13.20	13.69	14.01	14.46	14.70	15.84
LFO - Gap	9.64	8.51	8.78	8.85	8.29	8.12

Projected Power Generation Costs and Loss in Revenues from CER and Gap Costs



Value Chain Analysis



Potential of Egyptian Industry for RE Local Manufacturing

A. Local Manufacturing

B. Research and Development Needed

C. Technology Transfer / Joint Ventures / Import

Concentrated Solar Power

a) Parabolic Trough

Component	A	B	C
Reflector material and glass		X	X
Vacuum and absorber tube		X	X
Rotary Joints		X	X
Step Motor	X	X	
Steel structure	X		
Sun tracking system		X	X
Control system		X	X
Piping	X	X	
Auxiliaries	X	X	
Trough cleaning system		X	X
Operation and maintenance	X	X	

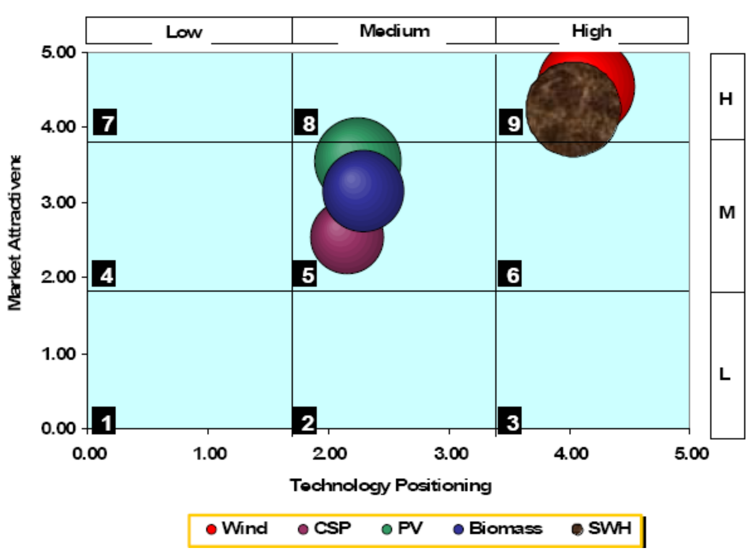
b) Fresnel Collector (flat mirror)

Component	A	B	C
Flat mirrors and surface quality	X	X	
Step Motor	X	X	
Steel structure	X		
Sun tracking system		X	X
Control system		X	X
Piping	X	X	
Auxiliaries	X	X	
Cleaning system	X	X	
Operation and maintenance	X	X	

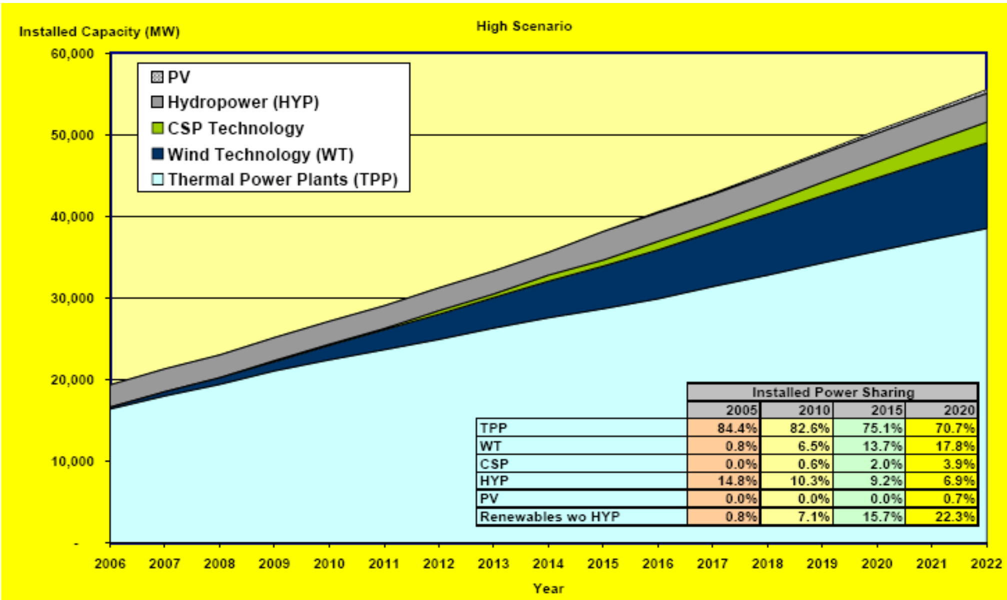
Positioning of RETs (factors effecting positioning)

a) Average annual growth rate
b) Value Added (VA) for industry
c) Competition strength
d) Technology requirements
e) Technology perspective future
f) Technology maturity
g) Environmental impact
h) Technology provisions
i) Implementation satisfaction

Positioning of RETs in Egypt

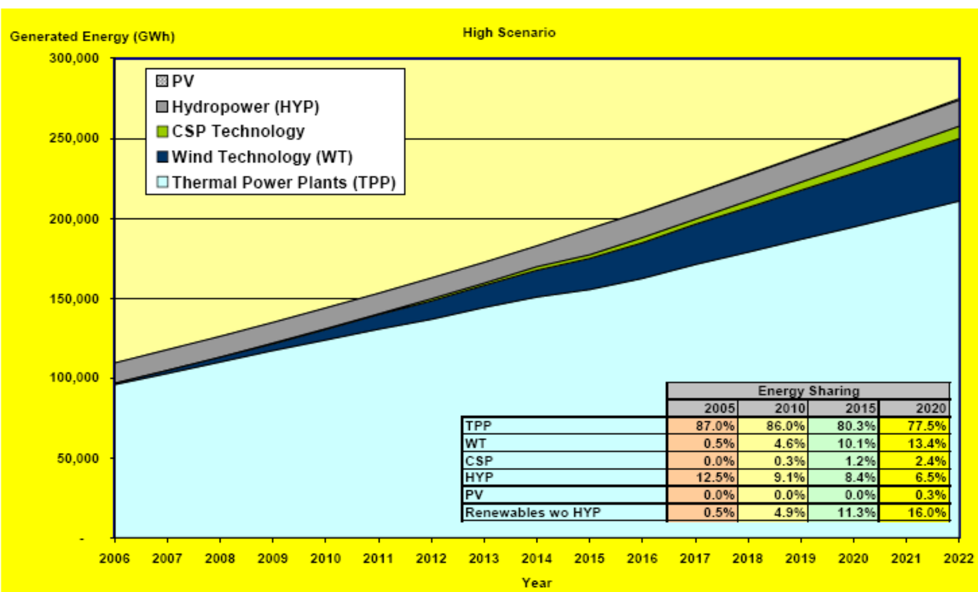


Power Generation Needs, and Recommended Energy Technologies – High Scenario



	2005	2010	2015	2020
TPP	84.4%	82.6%	75.1%	70.7%
WT	0.8%	6.5%	13.7%	17.8%
CSP	0.0%	0.6%	2.0%	3.9%
HYP	14.8%	10.3%	9.2%	6.9%
PV	0.0%	0.0%	0.0%	0.7%
Renewables wo HYP	0.8%	7.1%	15.7%	22.3%

Energy Generation Needs, and Recommended Energy Technologies – High Scenario



	2005	2010	2015	2020
TPP	87.0%	86.0%	80.3%	77.5%
WT	0.5%	4.6%	10.1%	13.4%
CSP	0.0%	0.3%	1.2%	2.4%
HYP	12.5%	9.1%	8.4%	6.5%
PV	0.0%	0.0%	0.0%	0.3%
Renewables wo HYP	0.5%	4.9%	11.3%	16.0%

There is a need to hit a development strategy for CSP to proactively achieve the 22% RE target, a proactive approach to adopt. AHMOSE recommends at least installing 2550 MW of CSP.

Local Manufacturing Investment, R&D, and Market Volume for CSP Technology (millions USD)

Scenario	CSP	2006-2010	2011-2015	2016-2022	Total
High	Market Volume	636	2,419	6,611	9665.625
	Share of Local Manufacturing	50%	60%	70%	
	Investment in Manufacturing Processes	212	762	2,343	3,316
	R&D Investment	7	27	82	116
Medium	Market Volume	636	1,209	4,324	6,169
	Share of Local Manufacturing	50%	60%	70%	
	Investment in Manufacturing Processes	212	275	1,755	2,242
	R&D Investment	7	10	61	78
Low	Market Volume	636	-	2,314	2,949
	Share of Local Manufacturing	50%	60%	70%	
	Investment in Manufacturing Processes	212	-	875	1,086
	R&D Investment	7	-	31	38

Projected Additional Revenues Due to RETs Implementation in Power Generation – High Scenario (millions USD)

Year		2006-2010	2011-2015	2016-2022
CER Costs	WT	60	290	902
	CSP	4	33	155
	HYP	5	20	105
	PV	-	-	19
	Total	69	344	1,180
	Annual Average			**94**
Gap Costs	WT	581	2,461	7,164
	CSP	38	283	1,231
	HYP	48	170	835
	PV	-	-	148
	Total	667	2,914	9,378
	Annual Average			**762**

Financials

Financial Instruments

- Soft Loans
- Commercial Loans
- Revenue Bonds
- Ownership Certificate
- Developing RE Projects as CDM-Projects
- RE Fund

Financial Assumptions

- Loan Interest Rate — up to 14%
- Coast of Capital — 7%
- Loan Repayment Period — 10-15 years
- Escalation Rate, Manpower and Spare Parts — 7%
- Technology Average Lifetime — 25-40 years

Projected Energy Generated Costs based on Soft Loan Alternative (US$/kWh)

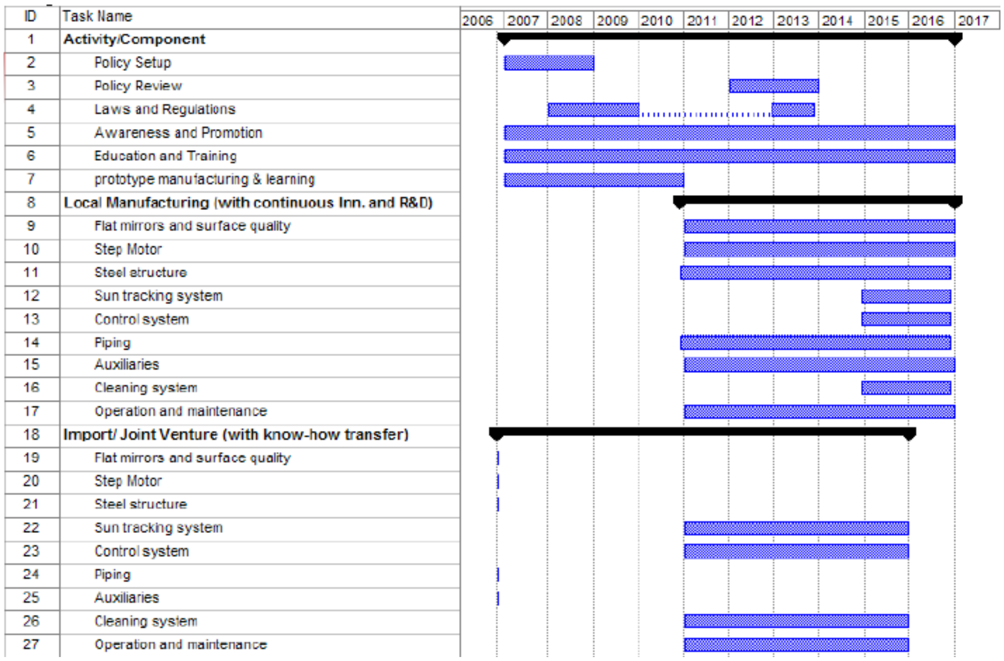
Loan Scenario					
	Debt	50.00%	Equity	50.00%	
	2006	2010	2015	2020	2022
WT	0.0405	0.0348	0.0319	0.0284	0.0256
CSP	0.1610	0.1562	0.1492	0.1403	0.1207
PV	0.2757	0.2529	0.2299	0.1949	0.1813
Hydro	0.0245	0.0220	0.0207	0.0189	0.0189

Projected Energy Generated Costs based on Grant Alternative (US$/kWh)

Grant Scenario					
	Grant	35.00%	Equity	65.00%	
	2006	2010	2015	2020	2022
WT	0.0310	0.0266	0.0244	0.0216	0.0195
CSP	0.1236	0.1213	0.1160	0.1087	0.0942
PV	0.2060	0.1889	0.1717	0.1449	0.1348
Hydro	0.0193	0.0173	0.0163	0.0148	0.0148

Action Plan for CSP Parabolic Troughs

Action Plan for Fresnel Collector (flat mirrors)



Renewable Energy Fund

- This fund can cover the gap between RE feed in tariff and the average prices of generated electricity by thermal power plants.
- The RE fund could finance R&D for RETs' systems and their components design for local manufacturing activities.
- Cost saving resulting from electricity generation by hydropower plans as compared to thermal power plants, could also finance the deficit for feed in tariff and R&D for RETs if any.

Decree by the Supreme Council of Energy (10/04/2007)

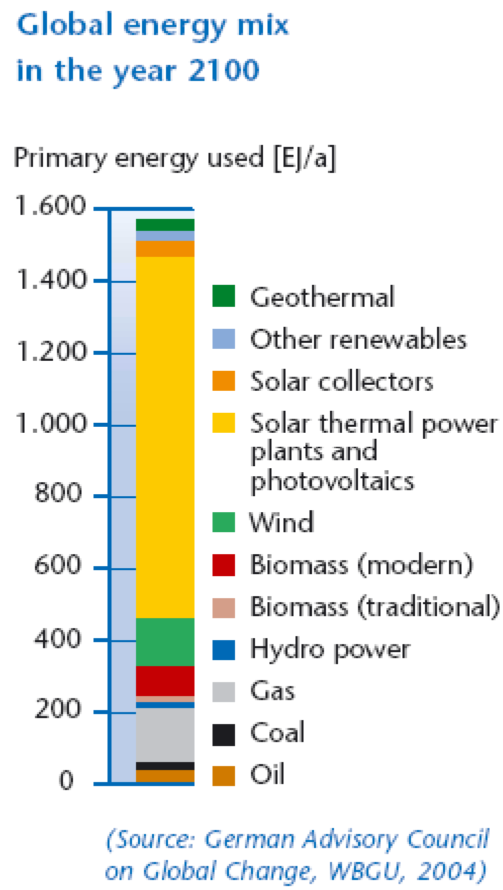
- Strategy to reach 20% of generation capacity from renewable energy by 2020.
- The strategy includes a plan for local manufacturing, legislations to encourage investments in RE, plan for tendering and electricity market liberation.

Solar Thermal Power Plants and Desalination Symposium – Cairo University, November 11, 2007, *Potential for Local Manufacturing of Solar Thermal Systems in Egypt*, Prof. Adel Khalil, Vice Dean for Graduate Studies and Research, Faculty of Engineering

Long-term prospects

According to a report published by Greenpeace and the "European Solar Thermal Power Industry Association" (ESTIA) in 2003, the solar thermal power plant industry could become a new dynamic growth sector with a market volume of 7.6 billion euro by 2020. The study "Solar Thermal Power 2020" demonstrates how solar thermal power plants in the sunny areas of the world could develop into an important energy source within fewer than two decades, which would then supply over 100 million people with clean electricity. The study calculates that solar thermal power plant technology could supply an output of 21,000 MWel by the year 2020; by 2040 as much as 630,000 MWel - that would be more than five percent of global power consumption, even if it were to increase 2.5 times by then. According to the study, solar thermal power plants could save the atmosphere about 154 million tons of carbon dioxide by the year 2020.

The global market launch initiative for solar thermal power plants (Global Market Initiative for Concentrating Solar Power, GMI) expects an expansion of worldwide installed output of solar thermal power plants to 5000 MWel by the year 2015; then further growth of about 20-25 percent per year. This includes a continuous expansion of hybrid solar thermal steam power plants with at least 75 percent solar fraction with successive expansion of thermal storage capacity and operating time from initially 2000 full load hours per year to 6500 hours per year in the year 2025. At 136 TWh/a, annual power generation from solar thermal power plants will reach an order of market share of about 1 percent of worldwide power generation in the year 2025.



The International Energy Agency (IEA) in Paris foresees a total potential of 20 - 40,000 MWel by the year 2020 at costs of less than 6 US cent/KWh. Back in 1996, the U.S. Department of Energy (DOE) developed a plan for solar thermal generation of electricity, which envisions an installed capacity of 20,000 MWel by 2020 at power production costs of under 6 US cent/KWh. The World Bank also expects that the power production costs of solar thermal power plants will drop to under 6 US cent/KWh by the year 2020 due to economies of scale and learning curves.

Acronyms

Here are common acronyms used in this document.

VA	Value Added
SWOT	Strength, Weakness, Opportunity, and Threat analysis
HYP	Hydro Power
CSP	Concentrated Solar Power
CPV	Concentrated Photovoltaic
WT	Wind Technology
PV	Photovoltaic technologies
MW	mega Watt
el	electric/electricity
MWel	mega Watt(s) of electricity
KWh	kilo Watt hour
Whel	Watt hour of electricity
Hr/hrs	hour(s)
RE/RET	renewable energy [technology]
IEA	International Energy Agency