Status Report on Solar Trough Power Plants

- Experience, prospects and recommendations to overcome market barriers of parabolic trough collector power plant technology -

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The commercialization of solar thermal electric technology took a major step forward in the mid-1980's and early 1990's with the development of the SEGS plants in California by Luz International Ltd. Consisting of parabolic trough technology integrated with steam Rankine cycles, these facilities total 354 MW of installed capacity and have 72 plant-years of operation to date. Together they have provided a wealth of operating experience and instilled confidence in a wide spectrum of observers on the viability of solar thermal technology as a future power source. From this base a number of feasibility studies and development programs have been launched to develop new projects and further advance the technology. To date, however, no new facilities have been implemented despite these efforts and the encouragement of institutional and governmental sponsors.

Two important goals of this document are to explore the status of solar thermal power plant development and to provide some insight into actual and perceived barriers delaying the commercial advancement of this technology. As background, the technology is described starting with a brief overview of solar technologies, and the potential market for solar thermal plants is postulated. Integral with market considerations are an understanding of world energy and electricity growth projections, and the associated impact on the environment and global warming through emissions, both of which are treated. Technology costs, economics and financing of commercial-scale plants are discussed and recent feasibility studies and results are presented. Finally, policy recommendations and financing scenarios are postulated which could ease the path for further commercialization and accelerate future implementation.

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3.4 Other, Non-concentrating Solar Thermal Electric Technologies

Trough, tower and dish systems utilize the sun's heat by <u>concentrating</u> the radiation, and therefore they can only use the parallel rays (DNR) that come directly from the sun, unmarred by clouds, dirt or mist. Other solar thermal electric systems, namely include solar ponds and solar chimneys, are able to utilize global radiation, comprising both the direct and diffuse parts of sunlight.

3.4.1 Solar Ponds

In a solar pond, salt is used to create a dense brine on the bottom of a shallow body of water, while fresh water is supplied at the surface. As the sun's rays penetrate the top layer, they are absorbed in the lower layers, heating the brine at the pond bottom. As the hot brine is denser than the less salty water above, it cannot rise and heat losses to the atmosphere are inhibited. It is this temperature gradient between the deep hot layer and the upper cooler layers which allow power to be produced. The heat can be extracted by passing the brine through a heat exchanger to warm the working fluid of a heat engine, with the cooler water from the top of the pond used for the cycle's condensing water, as shown schematically in Figure 3-8. Its advantages are its simple design and inherent storage capability. On the other hand, solar ponds have a very low solar-to-electric efficiency, limited siting possibilities, high water and salt requirements and large land area needs. Test units of 5 MW_e have achieved 0.9% solar-to-electric net annual efficiency.

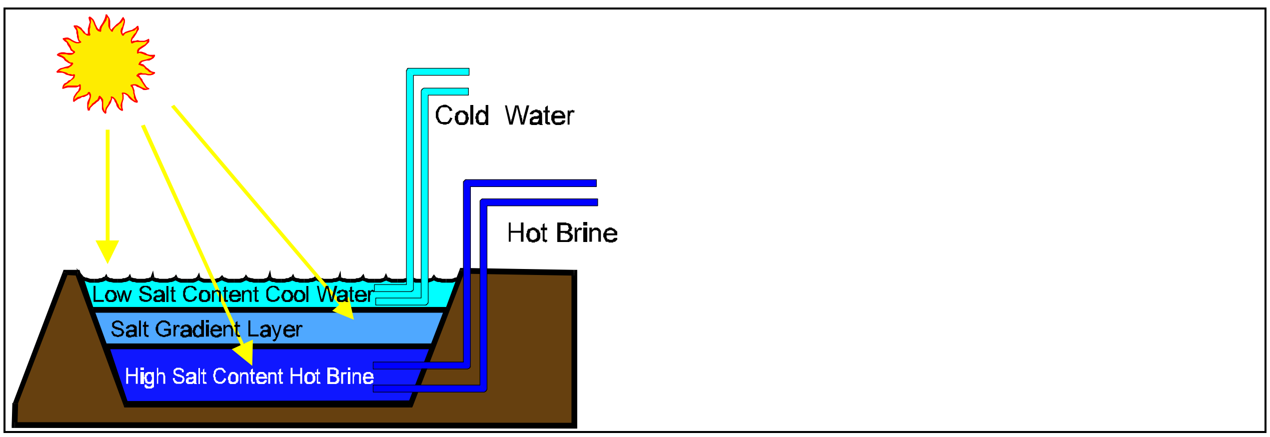

Figure 3-8 Solar Pond Principle

3.4.2 Solar Chimney

The solar chimney consists of a large area of above-ground translucent panes, a vertical pipe, the chimney, and a wind turbine. The non-concentrated solar radiation heats up the air underneath the panes, which becomes less dense, providing the driving force for the air to move upward through the chimney. The energy is extracted from the air stream through a wind turbine located at the neck of the vertical pipe, (see Figure 3-9). Test units of 50 kW_e have been built with a solar-to-electric net annual efficiency of 0.05%.

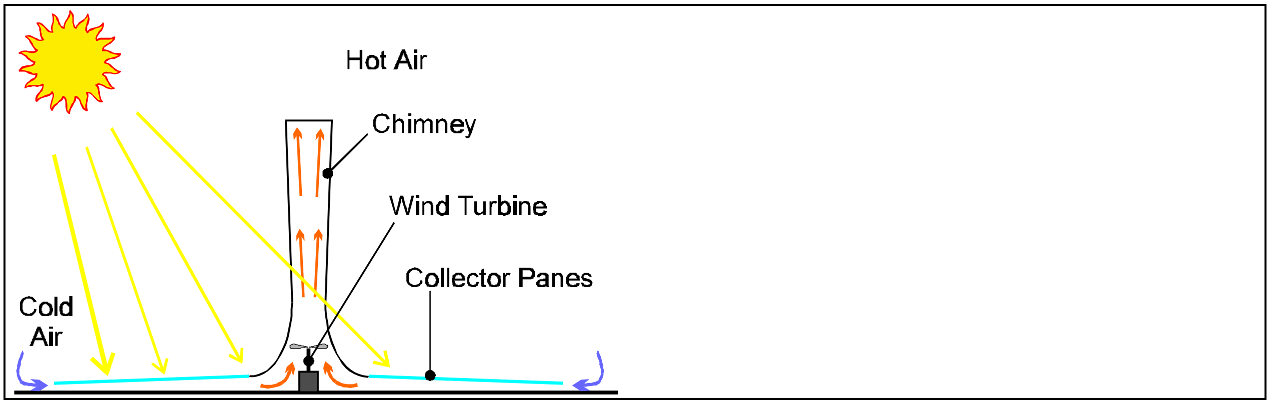

Figure 3-9 Solar Chimney Principle

The low efficiencies of these non-concentrating systems are somewhat balanced by the rather low investment cost per m² of aperture.

3.5 Photovoltaics

Photovoltaic (PV) devices, commonly called “solar cells”, convert sunlight directly into electricity using a method that differs fundamentally from the heat engines used in the solar thermal modes of electricity generation. The principle exploits the photovoltaic effect whereby photons (light), striking a specially designed solar cell, force the movement of electrons. The intermediate step of transforming radiation into heat is omitted. PV-systems are becoming widespread in low-power applications as diverse as pocket calculators, remote communication and lighting systems, and architectural facades in buildings. Utility-scale plants are also possible and proposed projects for such systems are becoming more prevalent. Due to the high cell cost PV systems thus far have tended to be limited to applications in the range from milliwatts to kilowatts; but in certain remote applications PV with battery storage is an economically viable power source. Figure 3-10 shows a grid connected PV application for households.

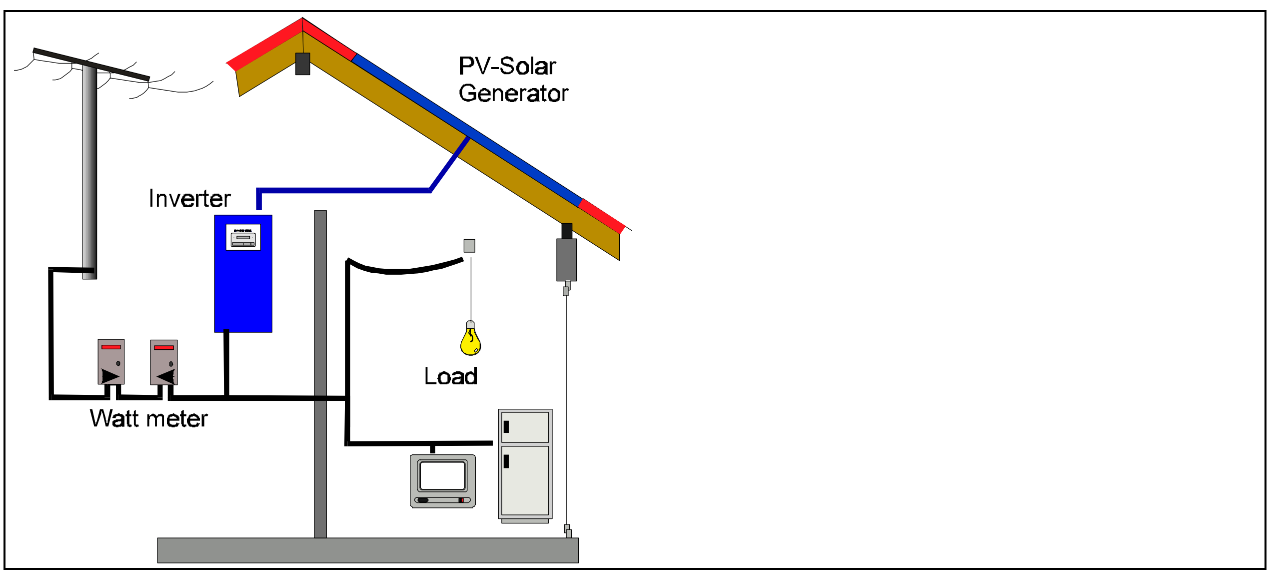

Figure 3-10 Grid Connected PV-generator for a Household