Solar Thermal Technology

TECHNOLOGY OVERVIEW

Description

Solar Thermal Technology has been technically proven to be economically competitive as a valid, albeit overlooked renewable technology. In a Solar Thermal system, mirrors or lenses focus sunlight onto a receiver where a working fluid absorbs the solar energy as heat. The system then converts the heat to electricity via steam turbines, or supplies process heat. No pollutants are emitted in the production of electricity. In contrast, Photovoltaics (PV) convert the sun's light (photons) directly into electricity (electrons). Heat is not part of the process.

There are two kinds of solar thermal systems: central receiver systems and distributed receiver systems. A central receiver system uses a field of heliostats (two-axis tracking mirrors) to focus the sun's radiant energy onto a single receiver mounted on a tower. A distributed receiver system uses one of two optical arrangements – parabolic dishes or troughs, to focus sunlight onto either a point or line receiver. Both systems rely on mirror arrays that require expanses of desert. As a rule of thumb, one square kilometer of land can generate as much as 100 to 2500 gigawatt hours (GWh) per year[ii] using solar thermal technology. This is enough for 50,000 to 1,250,000 households. Optimal plant siting is critical to achieving highest yields.

These systems that uniquely concentrate the sun by use of mirrors to convert the sun's energy to electricity are known as Concentrating Solar Power (CSP). They enable the sun's heat to be used to produce electricity instead of heat derived from fossil or nuclear fuels. In addition, central receiver derived process heat is one of the few theoretical ways to cost effectively produce hydrogen, a confirmed next generation transportation fuel. The advantages?: the primary fuel is free, non-depletable, and without Greenhouse Gases (GHG). The disadvantages?: none, unless you are a neo-luddite.[ii]

History & State-of-the-Art

By virtue of the Carter Administration's DoE Solar Thermal Technology program, both central and distributed receiver systems have been successfully prototyped in this country. Solar (Central Receiver) Tower prototypes 'Solar I (1982)' and 'Solar II (1996)' have proven themselves suitable cost competitive energy alternatives for electric utilities and for industries requiring a clean process heat source. An energy storage sub-component and heat transfer system enables the Solar Tower plant to produce electricity for feeds into the grid after sundown, *the key advantage of central receiver tower designs yet to be exploited.*

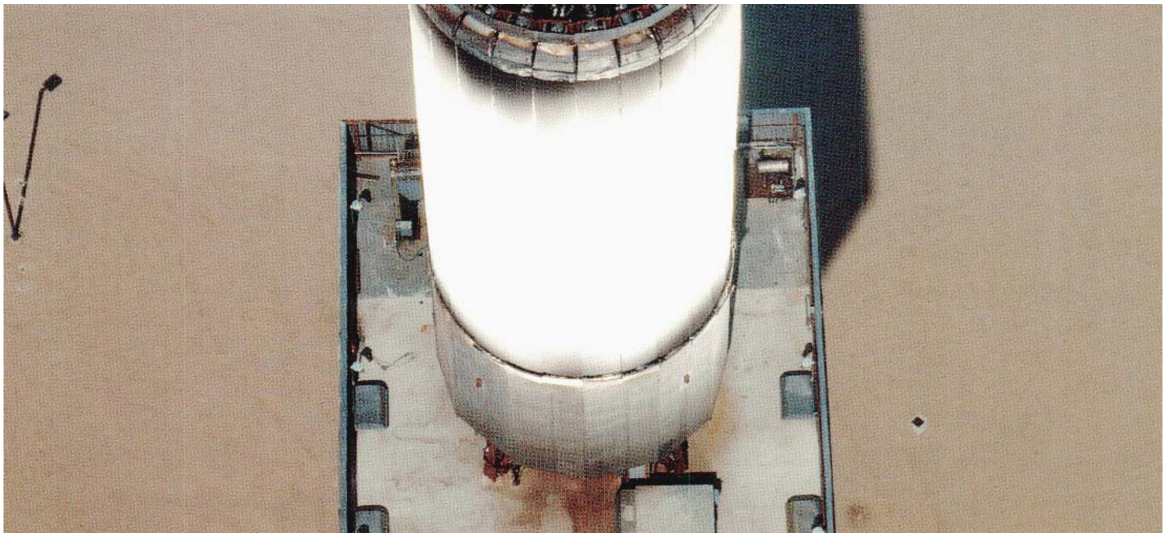
Solar energy technologies alone bear the constraint of daylight hours as their power generation window. The Solar II prototyping exercise was designed to overcome this burden, and hence free up Solar Thermal technologies to compete with all other modes of power generation. The Solar II $10MW_e$ technology demonstrator still stands, albeit mothballed, in the U.S. Mojave Desert. This upgraded design that is coupled to molten salt storage warrants scaling given the empirical system has been proven sound. A successful commercialization is waiting to happen as a result of

---

[i] 2500 GWh/yr is ~ 2.5M bbls.

[ii] The term Luddite is a powerful symbol of opposition to automation and new technology ever since the 18th c. invention of the power loom and other textile automation machines that destroyed the livelihoods of the cottage industry of English weavers who had passed down stable family businesses for hundred of years. Economic power passed from the weaving families to the owners of the machines.

unprecedented market forces coupled with a displacement business model that draws on further R&D work at DoE. Oddly enough, a Solar Tower redesign can also leverage thirty years of operational and engineering design knowledge of liquid sodium heat transfer that is now standard practice in the nuclear industry.



There is no commercialization as yet of the 1996 Solar II central receiver system design despite a 2002 Congressional order for DoE to "develop and scope out an initiative to fulfill the goal of having 1000MW of new parabolic trough, power tower, and dish engine solar capacity supplying the southwestern United States." Recently commissioned distributed parabolic trough plants in Nevada have set this goal in motion and distributed solar dish arrays are under contract to be built.

The Competition, Advantages & Disadvantages

Private industry has invested in the two variations of distributed receiver systems: dish and trough. Distributed trough systems are more rudimentary and least efficient, but they have been commercialized since the early 1980s and are very economical. Solar Towers have better long-term prospects for higher conversion efficiencies. They are the only form of solar power that has successfully been prototyped to produce electricity during times of low solar activity or during night.

Stirling Energy Systems (SES) of Arizona bases their business model on a DoE Stirling Engine Dish prototype never before commercialized. SES has plans to deploy entire field arrays of parabolic dish mirrors that focus heat directly to each dish's point receiver, a Stirling Engine. SES has contracts

Photo Credits: Page 1: A reflection of Solar II's receiver tower in one of its 2000 heliostats (Sandia National Labs). Page 2: (Top) Solar II's receiver component when it is technically operational at 'white hot' (Sandia National Labs). (Bottom Left) A Stirling dish engine as point receiver of a parabolic mirror (Stirling Engine Systems). (Bottom Ctr) The Solar Electric Generating System (SEGS) distributed array of 400,000 trough mirrors occupying 1000 acres in The Mojave (Sandia National Labs). (Bottom Right) A trough mirror with line receiver (Sandia National Labs). Page 3: Solar II at sunset (Sandia National Labs).

in place with San Diego Gas & Electric (SDG&E) to provide between 300MW to 900MW of solar power by 2010; the contract will be commissioned as the world's largest CSP plant at three square miles hosting 12,000 Stirling solar dishes in the Imperial Valley of Southern California. Their work is prescient and commendable and is a recommendation as to the timeliness and scalability of CSP technologies. The SES approach does not include a storage system thereby limiting outputs solely to peak power markets. Daily operational downtime of capital cost equipment can be as much as 66%.

Solel Solar Systems, Ltd. is an Israeli firm with an acquired U.S. subsidiary that has operated the Solar Electric Generating System (SEGS) in the California Mojave Desert since 1984. It is currently the largest commercial solar power plant (350MW) in the world. It occupies 1000 acres with 400,000 half spherically shaped trough mirrors. Solel is the world's leading and only provider of proven cost effective parabolic trough solar thermal technology. Their most recent venture is now underway in Spain (where the Renewable Portfolio Standard (RPS) is 30%) as a 150MW plant with an estimated plant cost of $890M. Solel was the supplier to the recently commissioned Nevada Solar One, the 3rd largest solar thermal trough plant, now supplying 64MW of peak power capacity.

Conclusion & Recommendations

When scaled and upgraded with state-of-the-art subcomponent materials, technologies, and vision, Solar Central Receiver Tower technology is a relatively unremarkable, thus veiled '3rd Generation' Oil & Gas Exploration & Production (E&P) technology. State-of-the-art components, fully assimilated, enable a breakthrough 'Solar Reserve™ & Hydrogen Refinery'™, heralding the next generation vertically integrated energy company.

Based on taxpayer funded lessons learned, Solar II should first be leveraged to realize a commercially viable Solar Tower engineering prototype re-engineered as a 100MW module. Engineering fees excluded, capital costs of $100M to build 100MW is less or comparable to costs currently being allowed the nuclear industry at ~$1400/kWhr to build[iii] 1400MW plants by virtue of subsidized engineering fees up to 50% plant costs. With a global entrepreneurial marketing plan, this new Solar Tower, to be branded 'SOLAR MATRIX™ Power', can begin to quietly displace[iv] fossil fuel usages in the power generation, industrial and even transportation sectors – the three most polluting. By virtue of the economies of scale enabled by a proprietary modular design and energy storage component, it will compete head to head with nuclear, while creating enviable emissions trading opportunities. One time engineering costs can serve up gigawatts (GWs) of deployed capacity. Its electricity output for the deregulated wholesale power generation market is likely to be in highest demand, and at higher than market (subsidized) prices (10¢/kWhr vs 4¢ to 6¢/kWhr) given pending legislation to mandate utilities to carry as much as 15% to 20% of renewable generated electricity in their power generation portfolios. Solar Tower generated *stored energy* can be potentially marketed to forward looking Oil & Gas E&P Companies willing to spend percentages of their cumulative $235B/year E&P budget on a systems technology tweaked to deliver an equivalent but new form of energy reserve – a bookable Solar Reserve™, and this alongside production outputs such as cheap hydrogen and carbon credits. ☐

[iii] A Solar Tower plant can be built in 2 years whereas a nuclear plant takes 4 to 5 years. There is no waste permitting involved.

[iv] Figures 1 & 2 (top left & bottom) below are from a study commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. EU-MENA = Europe, Middle East, and North Africa. An extensive plan exists (top right) among a consortium of private-public EU stakeholders to generate electricity and process heat via CSP technology in North Africa to supply an EU-MENA Grid at 5 – 7 EuroCent/kWh. The process heat is to be used for desalination of water to

be transported alongside the transmission of electricity to the EU. Note their projections of how CSP Plants (the large orange triangle in Figure 2) should begin to increase dramatically as the power generation method of choice over fossil fuel. Their study concludes, "Renewable energies are the least cost option for energy and water security in EU-MENA."

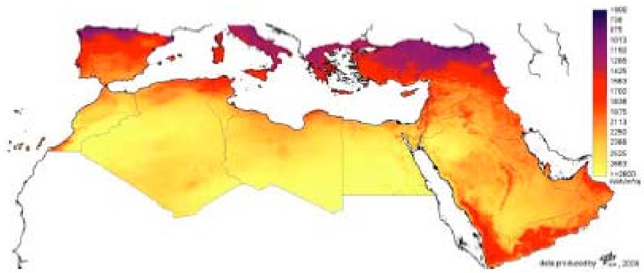
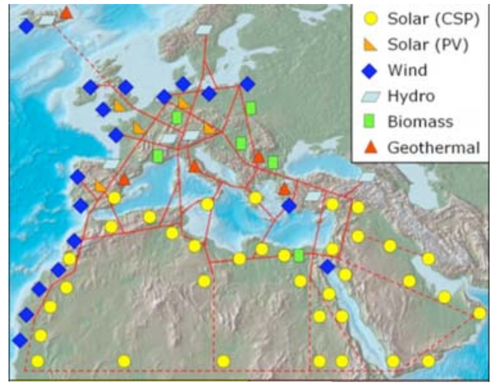


Figure 1: Annual Direct Solar Irradiance in the southern EU-MENA Region. The energy received by each square meter of land equals 1 – 2 barrels of oil per year.



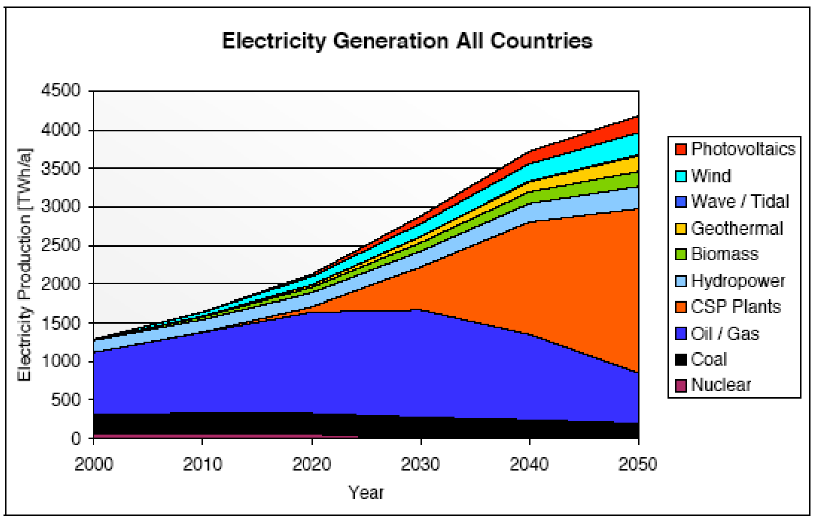


Figure 2: Annual electricity demand and generation within the countries analysed in the MED-CSP scenario

CHEBEL

GlobalSOLAR

U-LINC ENERGY + SOLAR UTILITY

UNIVERSAL **DESIGN**SCIENCE *ENGINEERING*, GlobalSOLAR, & U-LINC ENERGY + SOLAR UTILITY are trademarks and wholly owned subsidiaries of CHEBEL, Inc.

Information: (505) 312-7797, cmt@udescie.com