

Solar Thermal Energy

an Industry Report

Solar Thermal Technology on an Industrial Scale

The Sun is Our Source

Our sun produces 400,000,000,000,000,000,000,000 watts of energy every second and the belief is that it will last for another 5 billion years. The United States reached peak oil production in 1970, and there is no telling when global oil production will peak, but it is accepted that when it is gone the party is over. The sun, however, is the most reliable and abundant source of energy.

This site will keep an updated log of new improvements to solar thermal and lists of projects currently planned or under construction. Please email us your comments at:

comments@solar-thermal.com

Companies featured in this report:

eSolar

ABENGOA SOLAR

acciona
Energy

ausra

BrightSourceEnergy

SCHOTT
solar



An eSolar project in California.



Abengoa's PS10 project in Seville, Spain.



The Acciona Nevada Solar One plant.

Solar Thermal Energy

an Industry Report

Solar Thermal vs. Photovoltaic

It is important to understand that solar thermal technology is not the same as solar panel, or photovoltaic, technology. Solar thermal electric energy generation concentrates the light from the sun to create heat, and that heat is used to run a heat engine, which turns a generator to make electricity. The working fluid that is heated by the concentrated sunlight can be a liquid or a gas. Different working fluids include water, oil, salts, air, nitrogen, helium, etc. Different engine types include steam engines, gas turbines, Stirling engines, etc. All of these engines can be quite efficient, often between 30% and 40%, and are capable of producing 10's to 100's of megawatts of power.

Photovoltaic, or PV energy conversion, on the other hand, directly converts the sun's light into electricity. This means that solar panels are only effective during daylight hours because storing electricity is not a particularly efficient process. Heat storage is a far easier and efficient method, which is what makes solar thermal so attractive for large-scale energy production. Heat can be stored during the day and then converted into electricity at night. Solar thermal plants that have storage capacities can drastically improve both the economics and the dispatchability of solar electricity.



This Stirling engine is driven by a parabolic dish that collects and concentrates the sun into a heat source to run the engine and produce power.

Solar Thermal Energy

an Industry Report

Competing with Fossil Fuels

Solar thermal power currently leads the way as the most cost-effective solar technology on a large scale. It currently beats other PV systems, and it also can beat the cost of electricity from fossil fuels such as natural gas. In terms of low-cost and high negative environmental impact, nothing competes with coal.

But major solar thermal industry players such as eSolar, Brightsource, or Abengoa, have already beaten the price of photovoltaic and natural gas, and they have plans to beat the price of coal in the near future.

With an increasingly industrializing planet, the leaders in solar thermal technology have an ever-growing market. The issue is, and will always be, how to make solar thermal technology more economical. There are currently two methods for solar thermal collection. The first is line focus collection. The second is point focus collection.

Line focus is less expensive, technically less difficult, but not as efficient as point focus. The basis for this technology is a parabola-shaped mirror, which rotates on a single axis throughout the day tracking the sun. Point focus technique requires a series of mirrors surrounding a central tower, also known as a power tower. The mirrors focus the sun's rays onto a point on the tower, which then transfers the heat into more usable energy.

Point focus, though initially costlier and technically more nuanced, outshines line focus when results are concerned. The point of focus in a line focus mirror array can only reach temperatures around 250° C. That is a sufficient temperature to run a steam turbine, but when compared to the 500° C and higher temperatures that point focus can reach, the extra effort and cost is balanced out by its greater efficiency capability. High efficiency matters because it drives down both the land usage, and the effective cost per kWhr of the plant.



Although coal is currently the lowest cost power provider, it also has the most negative effect on the environment.



Point focus: *The Solar Two project in California USA uses a field of mirrors to focus solar energy onto a central boiler to produce steam and electricity. (Photo courtesy NREL)*



Line Focus: *The Ausra Line Focus demonstration in Australia.*

Solar Thermal Energy

an Industry Report

Major Solar Thermal Players

Spain and Australia are the current leading countries in solar thermal energy production. Spain already produces a large portion of their electricity through their solar thermal facilities, some built by solar thermal powerhouses such as Acciona and Abengoa – the creator of the PS10 and soon PS20. The California based solar thermal company, eSolar, and the Israeli company, Brightsource, are fast growing competitors.

Abengoa is opening the first power tower to be used for commercial energy production. eSolar is working with Southern California Edison to use solar thermal technology to generate 245 MW of power. Similarly, BrightSource has contracts with Pacific Gas and Electric Company to bring even more solar thermal generated power to California.



Europe's first commercial concentrating PS10 solar power tower is operating near the sunny southern Spanish city of Seville. The 11 megawatt solar power tower produces electricity with 624 large movable mirrors called heliostats.

eSolar
BrightSourceEnergy
ABENGOA SOLAR

eSolar, Brightsource, and Abengoa have plans to beat the price of coal generated power in the near future.

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an Industry Report

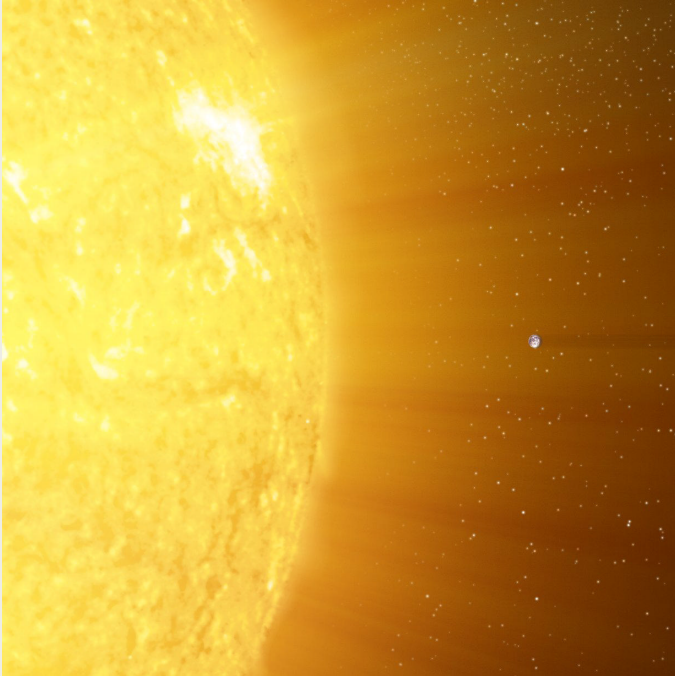
Technical Challenges

Despite the sun's enormous size, and because of its distance from the earth, it is not quite a point source. It actually occupies $1/2^\circ$ in the sky. When making a concentrator, the architecture of the system needs to take into account this subtended angle of the sun.

The maximum theoretical concentration of line focus is 212:1. Line focus solar thermal plants are reporting 80-100x concentration, with some claiming 112x – in other words, people are achieving about half of the maximum theoretical concentration. It's hard to get more than this because of errors in the parabolic shape, thermal expansion and shifting of parts over time, and optical alignment of all the moving parts. At these concentrations a steam turbine can be run at roughly 25% efficiency. Even with great technological advancements, the ceiling is set at a maximum of 212:1, so there is not much room for growth.

Point focus, however, has a much higher maximum concentration ratio at 44,000:1. Current technology is reaching 1,000x concentration. Despite being a small fraction of the maximum concentration ratio, point focus' concentration can run a steam turbine at anywhere from 35-50% efficiency. Also, with point focus concentration, there is a lot of room to further improve and run at higher temperatures, and thus even higher efficiencies.

Solar thermal technology faces some challenges. The most obvious is competition with abundant and inexpensive coal. Until more nations begin taxing carbon emissions, especially the United States and China, the cost of coal-fired plants will remain economical. Every ten days another coal power plant is built in the People's Republic.



This image from NASA shows the relative size of the earth compared to the sun.

Solar Thermal Energy

an Industry Report

Technical Challenges *(cont.)*

Obviously, such growth will have a natural cap, but currently such expansion and consumption is severely impacting global climate change. With the development and advancement of solar thermal, the rapid growth of China and other industrializing nations will hopefully be diverted away from coal. Large scale conversion to solar around the world will not occur until solar is the cheaper alternative, and industry leaders hope to reach that point within a decade.

Such technological replacements allow the exploitation of the Leapfrog Effect, which will be an important factor in global development and emergent markets in an era facing serious climate change. The Leapfrog Effect is a principle that certain technological progressions are necessary, but only once. The end result, or product, is autonomous from all the preceding stages. For example, look at the slow transition that industrialized nations are making right now from coal to alternative energies. They all needed coal technology in order to develop new, cleaner methods of energy production. Now that these new technologies are developed, however, developing nations and emerging markets need not follow the same path, but instead could just leapfrog over coal-fired to the cleaner technologies.



eSolar technicians configuring a point focus mirror array.

Solar Thermal Energy

an Industry Report

Land Requirements

Another challenge for solar thermal is the amount of space required for efficient production of energy. Not only space, but space that gets a consistent amount of direct sunlight. Solar thermal power plants typically require 1/4 to 1 square mile or more of land. One silver lining of global climate change and human impact on the land is that more and more farmland is becoming unsuitable for agricultural production. This land, presumably originally chosen for its sun exposure, begs to be used for solar thermal energy production. Utilization of desertification can prove to be a boon for solar thermal real estate procurement and growth.

With solar thermal technologies being developed and advanced by companies such as eSolar, Brightsource, Abengoa, Acciona, Ausra and Schott Solar, the world has a new alternative. The benefits of eliminating coal from our energy diet are many. By not burning fossil fuels, countries can be truly energy independent. Also, by limiting, and hopefully eliminating, carbon emissions, a nation's pollution will not be windswept into another nation's territories, further cementing the concept of independence.

Solar thermal plants are being built around the world, and many new planned plants are in the works. Solar thermal is the current solar electricity cost champion, but more improvements are needed to beat the cost of the lowest-cost fossil fuels in a legislative climate without subsidies or carbon taxes.



eSolar's unique approach to solar thermal power plants requires much less land than other companies' solutions and allows for plants to safely be located closer to populated areas.