ENERGY FROM THE SUN

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ABSTRACT

This paper deals with the useful of energy from the sun. This paper described produce of electrical energy with parabolic trough collectors and dish/engine systems and power towers and last chapter is conclusion.

1. INTRODUCTION

We have always used the energy of the sun as far back as humans have existed on this planet. As far back as 5,000 years ago, people "worshipped" the sun. Ra, the sun-god, who was considered the first king of Egypt. We know today, that the sun is simply our nearest star. Without it, life would not exist on our planet. We use the sun's energy every day in many different ways. Plants use the sun's light to make food. Animals eat plants for food. And decaying plants hundreds of millions of years ago produced the coal, oil and natural gas that we use today. So, fossil fuels is actually sunlight stored millions and millions of years ago. Indirectly, the sun or other stars are responsible for ALL our energy. Even nuclear energy comes from a star because the uranium atoms used in nuclear energy were created in the fury of a nova - a star exploding.

2. SOLAR THERMAL ELECTRIC GENERATION

The intense energy of the sun has long been used to heat liquids. The sun's heat can be used in two ways with homes and businesses. The sun is used to heat water for domestic hot water systems, or the sun's light can be concentrated and water temperatures increased to make steam and electricity. [1]

This thermal energy from the sun can also generate electricity. While solar photovoltaics (PV) are better known, the largest central solar power stations in the world are the 360 MW from the solar thermal power plants located in California’s Mojave Desert. These solar thermal power plants rely upon curved mirrored troughs that concentrate sunlight. The sun heats a liquid that creates steam to turn a traditional turbine. [1]

There are four main types of solar thermal electric systems [1]:

Parabolic Trough Collectors	These collectors combine a curved mirror, shaped like a parabola to maximize the amount of sunlight collected, with an absorber tube embedded along the center of the mirror. The absorber tube is filled with oil or another fluid that can easily be heated. When sunlight hits these collectors, the mirrors focus it on the tube, heating the fluid inside. This hot fluid is then used to boil water and produce steam in a connected device and the steam is transferred to a generator that can produce electricity. A large array of connected parabolic trough collectors is needed to provide enough power for a generator.
Dish/Engine Systems	These systems use an array of mirrors, arranged in the shape of a dish, to concentrate sunlight onto a receiver placed at the focal point of the dish. The heat produced by these systems is transferred to a heat engine which converts the heat into mechanical energy. This energy then drives a generator to produce electricity.
Power Towers	Power tower systems use a circular array of mirrors that track the sunlight and concentrate it on a receiver, placed at the top of a central tower at the focal point of the array. In much the same way as parabolic trough collectors, heat produced by the receiver is used to create steam which then powers a generator.
Hybrid Systems	Hybrid systems combine power towers with natural gas generators, creating a system that can continuously generate electricity, even when the sun isn't shining. This technology is still in development and experimental systems have been connected to several utilities in the Southwest.

3. PARABOLIC TROUGH COLLECTORS

Solar Hot Water Systems

The intense energy of the sun has long been used to heat liquids. Among the first mechanical uses of the sun was a 20-square-meter, parabolic concentrating reflector that boiled water and produced steam. This steam was used in a steam-driven printing press at the 1878 World's Fair in Paris. [2]

In the late 1800s, relying upon the sun to heat water was common practice in the southwestern United States. Photos can be found showing pioneer families proudly showing off new homes equipped with solar water heaters. At one point, almost a quarter of the residents of Los Angeles relied upon the sun to heat their water with rooftop solar thermal systems. [2]

The sun's heat can be used in two ways with homes and businesses. The sun is used to heat water for domestic hot water systems, or the sun's light can be concentrated and water temperatures increased to make steam and electricity.

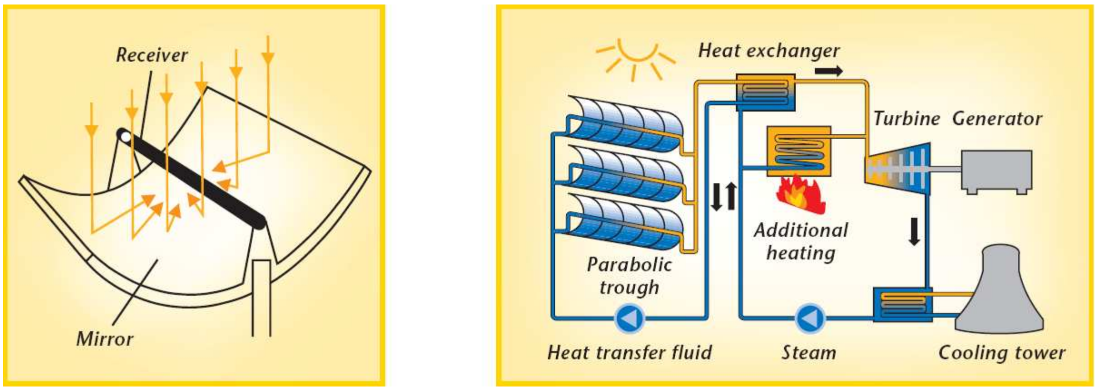
Solar energy can also generate electricity. Over the past 20 years, solar electricity generation technologies have grown by leaps and bounds, registering annual growth rates between 25 and 41 percent. Costs have also fallen by 80 percent. Global solar electric generation technologies contribute roughly 2,000 MW of electricity today. That figure is less than a tenth of the world's global electricity supply. [2]

While solar photovoltaics (PV) are better known, California actually gets far more of its electricity from a solar thermal power plant. Nine distinct solar thermal power plants located in the Mojave Desert (Shown in picture above) total 360 megawatts, by far the largest central solar power station in the world. (That's enough electricity to power about 360,000 homes.) [2]

These solar thermal power plants rely upon curved mirrored troughs that concentrate sunlight. The sun heats a liquid that creates steam to turn a traditional turbine. A more efficient technology is called the "stirling dish" which is powered by an entirely new kind of engine. Instead of the internal combustion engine, which relies upon an explosion inside the engine walls to turn pistons, the dish stirling engine relies upon the sun to heat tubes filled with hydrogen that turn the crankshaft. [2]

How a parabolic Trough Power Plant Works

Hundreds of trough-shaped parabolic mirrors, which are continuously adjusted to face the sun, serve as collectors. They concentrate the sun's rays on receivers located along the focal line.
A SCHOTT receiver consists of a specially coated absorber tube embedded in an evacuated glass envelope. The absorbed solar radiation warms up the heat transfer fluid flowing through the absorber tube to almost 400 C (752 F). This is conducted along a heat exchanger in which steam is produced, which then generates power in the turbines. The output of the power plant is between 25 and 200 MW of electricity at its peak. And thanks to storage systems, plant operation can be maintained at a constant load. With the highest degree of performance and the lowest electricity production costs of all the different types of solar power plants, the Outlook for parabolic trough power plants is excellent. [3]



a) b)

Fig.1. a) parabolic mirrors focus the sun's rays onto the receivers
b) Diagram of the parabolic trough power plant [3]

4. DISH/ENGINE SYSTEMS

System description

Dish/engine systems convert the thermal energy in solar radiation to mechanical energy and then to electrical energy in much the same way that conventional power plants convert thermal energy from combustion of a fossil fuel to electricity. As indicated in Figure 2, dish/engine systems use a mirror array to reflect and concentrate incoming direct normal insolation to a receiver, in order to achieve the temperatures required to efficiently convert heat to work. This requires that the dish track the sun in two axes. The concentrated solar radiation is absorbed by the receiver and transferred to an engine. [4]

Dish/engine systems are characterized by high efficiency, modularity, autonomous operation, and an inherent hybrid capability (the ability to operate on either solar energy or a fossil fuel, or both). Of all solar technologies, dish/engine systems have demonstrated the highest solar-to-electric conversion efficiency (29.4%) [6], and therefore have the potential to become one of the least expensive sources of renewable energy. The modularity of dish/engine systems allows them to be deployed individually for remote applications, or grouped together for small-grid (village power) or end-of-line utility applications. Dish/engine systems can also be hybridized with a fossil fuel to provide dispatchable power. This technology is in the engineering development stage and technical challenges remain concerning the solar components and the commercial availability of a solarizable engine. The following describes the components of dish/engine systems, history, and current activities. [4]

Concentrator

Dish/engine systems utilize concentrating solar collectors that track the sun in two axes. A reflective surface, metalized glass or plastic, reflects incident solar radiation to a small region called the focus. The size of the solar concentrator for dish/engine systems is determined by the engine. At a nominal maximum direct normal solar insolation of 1000 W/m2, a 25-kW dish/Stirling system's concentrator has a diameter of approximately 10 meters. [4]

Concentrators use a reflective surface of aluminum or silver, deposited on glass or plastic. The most durable reflective surfaces have been silver/glass mirrors, similar to decorative mirrors used in the home. Attempts to develop low-cost reflective polymer films have had limited success. Because dish concentrators have short focal lengths, relatively thinglass mirrors (thickness of approximately 1 mm) are required to accommodate the required curvatures. In addition, glass with low-iron content is desirable to improve reflectance. Depending on the thickness and iron content, silvered solar mirrors have solar reflectance values in the range of 90 to 94%. [4]

The ideal concentrator shape is a paraboloid of revolution. Some solar concentrators approximate this shape with multiple, spherically-shaped mirrors supported with a truss structure. An innovation in solar concentrator design is the use of stretched-membranes in which a thin reflective membrane is stretched across a rim or hoop. A second membrane is used to close off the space behind. A partial vacuum is drawn in this space, bringing the reflective membrane into an approximately spherical shape. Figure 2 is a schematic of a dish/Stirling system that utilizes this concept. The concentrator's optical design and accuracy determine the concentration ratio. Concentration ratio, defined as the average solar flux through the receiver aperture divided by the ambient direct normal solar insolation, is typically over 2000. Intercept fractions, defined as the fraction of the reflected solar flux that passes through the receiver aperture, are usually over 95%. [4]

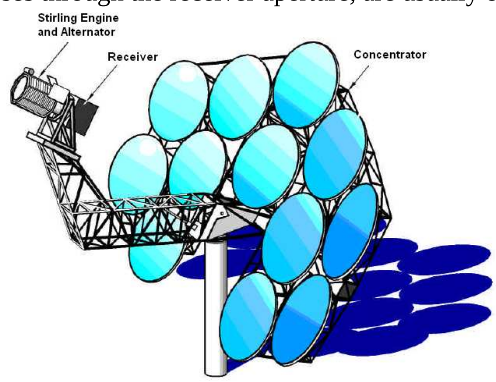


Fig. 2. Schematics of a dish/engine system with stretches/membrane mirrors. [4]

Tracking in two axes is accomplished in one of two ways, (1) azimuth-elevation tracking and (2) polar tracking. In azimuth-elevation tracking, the dish rotates in a plane parallel to the earth (azimuth) and in another plane perpendicular to it (elevation). This gives the collector left/right and up/down rotations. Rotational rates vary throughout the day but can be easily calculated. Most of the larger dish/engine systems use this method of tracking. In the polar tracking method, the collector rotates about an axis parallel to the earth's axis of rotation. The collector rotates at a constant rate of 15º/hr to match the rotational speed of the earth. The other axis of rotation, the declination axis, is perpendicular to the polar axis. Movement about this axis occurs slowly and varies by +/- 23½º over a year. Most of the smaller dish/engine systems have used this method of tracking. [4]

Receivers

The receiver absorbs energy reflected by the concentrator and transfers it to the engine's working fluid. The absorbing surface is usually placed behind the focus of the concentrator to reduce the flux intensity incident on it. An aperture is placed at the focus to reduce radiation and convection heat losses. Each engine has its own interface issues. Stirling engine receivers must efficiently transfer concentrated solar energy to a high-pressure oscillating gas, usually helium or hydrogen. In Brayton receivers the flow is steady, but at relatively low pressures. There are two general types of Stirling receivers, direct-illumination receivers (DIR) and indirect receivers which use an intermediate heat-transfer fluid. Directly-illuminated Stirling receivers adapt the heater tubes of the Stirling engine to absorb the concentrated solar flux. Because of the high heat transfer capability of high-velocity, high-pressure helium or hydrogen, direct-illumination receivers are capable of absorbing high levels of solar flux (approximately 75 W/cm2). However, balancing the temperatures and heat addition between the cylinders of a multiple cylinder Stirling engine is an integration issue. [4]

Liquid-metal, heat-pipe solar receivers help solve this issue. In a heat-pipe receiver, liquid sodium metal is vaporized on the absorber surface of the receiver and condensed on the Stirling engine's heater tubes. This results in a uniform temperature on the heater tubes, thereby enabling a higher engine working temperature for a given material, and therefore higher engine efficiency. Longer-life receivers and engine heater heads are also theoretically possible by the use of a heat-pipe. The heat-pipe receiver isothermally transfers heat by evaporation of sodium on the receiver/absorber and condensing it on the heater tubes of the engine. The sodium is passively returned to the absorber by gravity and distributed over the absorber by capillary forces in a wick. Receiver technology for Stirling engines is discussed in Diver et al. [4]. Heat-pipe receiver technology has demonstrated significant performance enhancements to an already efficient dish/Stirling power conversion module [3]. Stirling receivers are typically about 90% efficient in transferring energy delivered by the concentrator to the engine. Solar receivers for dish/Brayton systems are less developed. In addition, the heat transfer coefficients of relatively lowpressure air along with the need to minimize pressure drops in the receiver make receiver design a challenge. The most successful Brayton receivers have used "volumetric absorption" in which the concentrated solar radiation passes through a fused silica "quartz" window and is absorbed by a porous matrix. This approach provides significantly greater heat transfer area than conventional heat exchangers that utilize conduction through a wall. Volumetric Brayton receivers using honeycombs and reticulated open-cell ceramic foam structures that have been successfully demonstrated, but for only short term operation (tens of hours). Test time has been limited by the availability of a Brayton engine. Other designs involving conduction through a wall and the use of fins have also been considered. Brayton receiver efficiency is typically over 80%. [4]

Engines

The engine in a dish/engine system converts heat to mechanical power in a manner similar to conventional engines, that is by compressing a working fluid when it is cold, heating the compressed working fluid, and then expanding it through a turbine or with a piston to produce work. The mechanical power is converted to electrical power by an electric generator or alternator. A number of thermodynamic cycles and working fluids have been considered for dish/engine systems. These include Rankine cycles, using water or an organic working fluid; Brayton, both open and closed cycles; and Stirling cycles. Other, more exotic thermodynamic cycles and variations on the above cycles have also been considered. The heat engines that are generally favored use the Stirling and open Brayton (gas turbine) cycles. The use of conventional automotive Otto and Diesel engine cycles is not feasible because of the difficulties in integrating them with concentrated solar energy. Heat can also be supplied by a supplemental gas burner to allow operation during cloudy weather and at night. Electrical output in the current dish/engine prototypes is about 25 kW_e for dish/Stirling systems and about 30 kW for the Brayton systems under consideration. Smaller 5 to 10 kW_e dish/Stirling systems have also been demonstrated. [4]

5. Solar Power Towers

Solar power towers consist of a large field of sun-tracking mirrors, called heliostats, which focus solar energy on a receiver atop a centrally located tower. The enormous amount of energy, coming out of the sun rays, concentrated at one point (the tower in the middle), produces temperatures of approx. 550°C to 1500°C. The gained thermal energy can be used for heating water or molten salt, which saves the energy for later use. Heatened water gets to steam, which is used to move the turbine-generator. This way thermal energy is converted into electricity. [5]

Heat storage and transfer

As already mentioned there are two main fluids which are used for the heat transfer, water and molten salt. Water for example is the oldest and simplest way for heat transfer. But the difference is that the method in which molten salt is used, allows to store the heat for the terms when the sun is behind clouds or even at night. Molten salt-better: the heat of it - can be used until the next dawn when the sun will be back to heat the cooled down salt again.

The molten salt consists of 60% sodium nitrate an 40% potassium nitrate. The salt melts at about 700°C and is liquid at approx. 1000°C, it will be kept in an insulated storage tank until the time, when it will be needed for heating up the water in the steam generator. This way of energy storage has an efficiency of approx. 99%, i.e. due to the imperfect insulation 1% of the stored energy gets lost. [5]

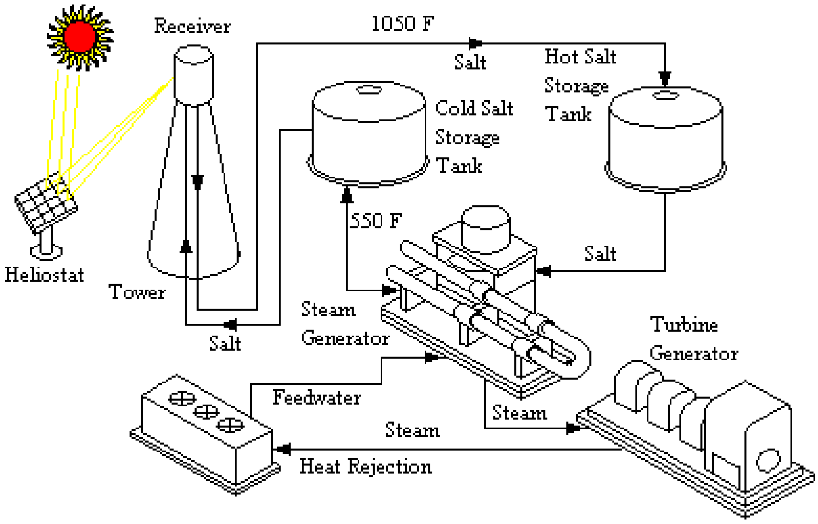


Fig.3. Schema of Solar Power Towers [5]

Technical, Facts and Tests

E.g.: The Power Tower Project „Solar II“ (California) [5]:

- 1,926 sun-tracking heliostats (mirrors)
- Molten salt thermal storage system
- Tower (300 ft) with central receiver
- Conventional steam driven turbine and generator
- Produces about 10 MW_e, enough power to serve 10 000 homes with electricity
- Costs about 40 million US $
- Will be used in an experiment until 1998

4. Conclusions

The regions around the Earth’s sunbelt are ideal for profitably running solar thermal power plants. There are currently three 50-megawatt power plants in the planning stage in the United States and Spain. Solar energy has the highest technologically exploitable potential of all types of regenerative energy. As supplies of fossil fuels are running out, it is obvious that other sources of energy must be developed. These new energy sources not only need to meet current and future demands, but must be environmentally safe as well. A solution to this problem could be solved with the development of more renewable energy sources, such as solar, wind, and geothermal energy. Geothermal energy has been shown to work, not only in the United States, but all over the world as well, including thousands of years ago. In order to develop this energy source, there must be a concentrated effort in the government, private enterprise and especially individuals to steer clear of fossil fuels.

5. REFERENCES

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