



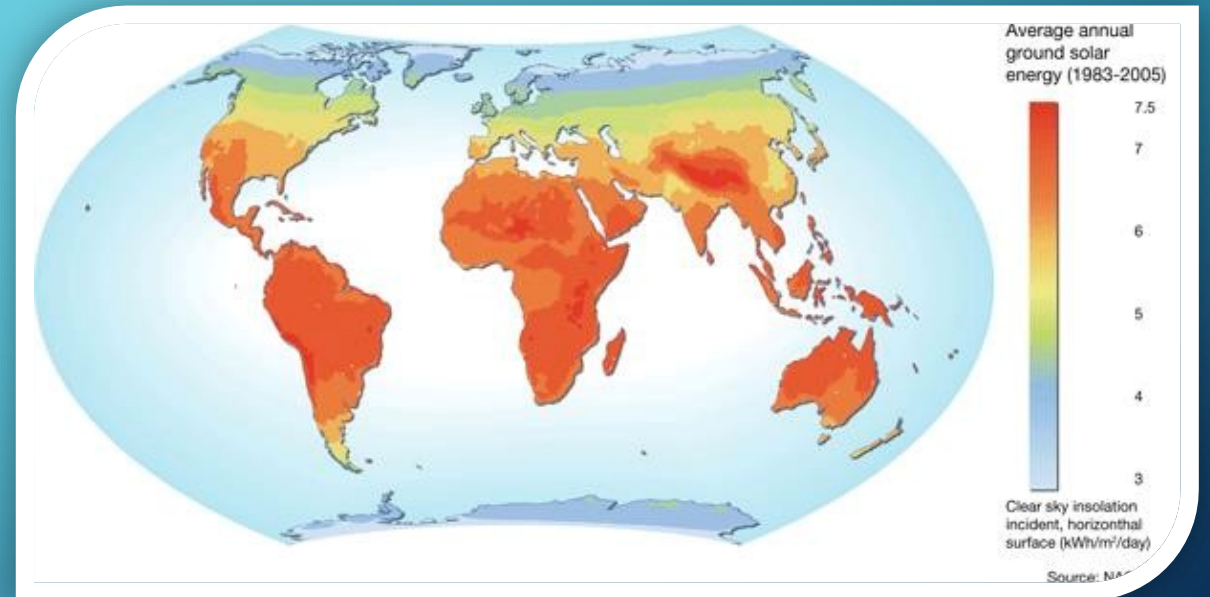
SOLAR POWER 101:



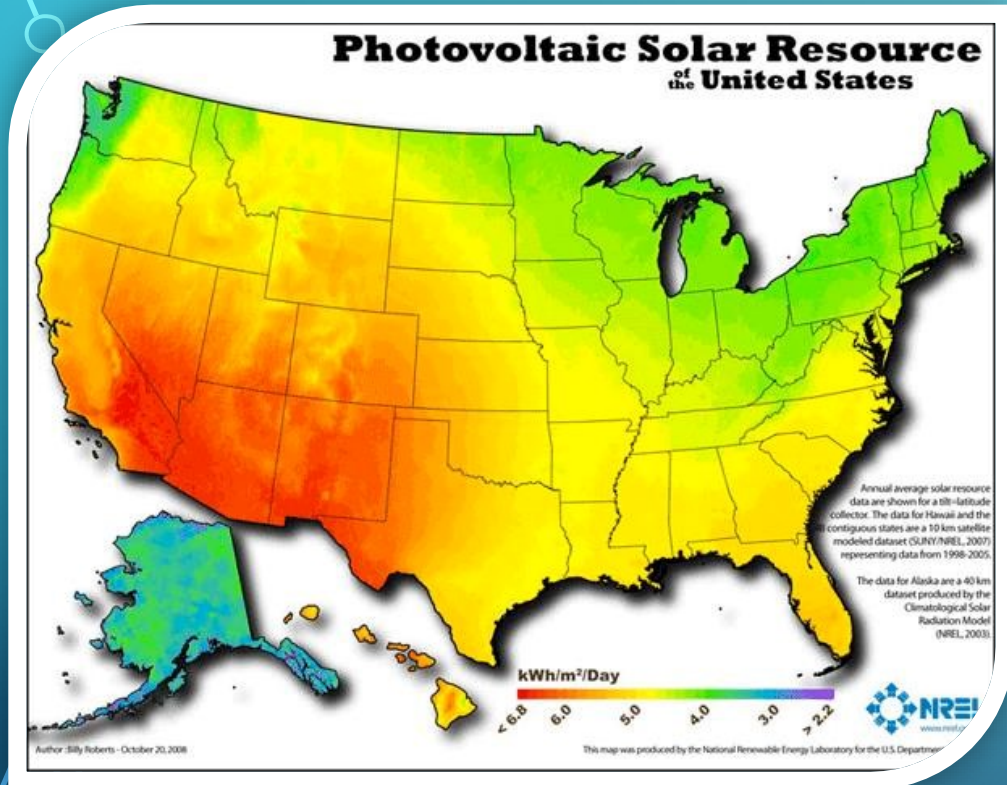


SOLAR POWER TECHNOLOGY

- Solar energy is primarily collected in one of two ways: photovoltaic solar cells and solar thermal. A photovoltaic cell is basically a semi-conductor connected to two electrical contacts. Photons from the sun are absorbed into the semi-conductor (usually a silicon alloy) and knock loose a few electrons. The electrons then travel through the semi-conductor creating an electrical current. Solar thermal is a system of giant mirrors that reflect and concentrate the sun's rays to heat a fluid, which produces steam to power a turbine that creates electricity.
- Both methods require a large amount of sunlight. Under optimal conditions, this solar radiation, or insolation, directly strikes a solar panel without any interference. In practice, the amount of solar radiation varies depending on the latitude, time of day and season (which affect the angle of the sun); and atmospheric conditions like clouds, water vapor, and pollution (which scatter the light). This is why dry areas in the mid latitudes of the globe tend to have the greatest solar potential, as seen below.



SOLAR POWER PROS & CONS.



- Solar power is a renewable source of energy that can be gathered practically anywhere in the world. Solar power plants don't produce any air, water, or noise pollution and doesn't emit any greenhouse gases. Large-scale power plants can disturb local plant and wildlife due to their size, but compared to fossil fuels, still have a lower environmental footprint. Solar power plants also have less safety risks than fossil fuel plants. Once built, solar power plants have extremely low operating costs, since their major input, sunlight, is free.
- There are, however, several major disadvantages that historically have kept solar power from becoming a major supplier of energy. Solar panels can't collect solar energy at night and the amount they collect during the day varies based on the season and time of day. Solar panels aren't very good at converting sunlight to electricity - most solar panels have at best a 20% efficiency rate. And their costs are high. For a homeowner wishing to install solar panels on their house in the U.S, the average cost for a typical system is around \$20,000. For power plants, solar photovoltaic costs 11 cents per kilowatt hour. Compare this to a conventional coal plant (9 cents per kilowatt hour) and natural gas (6 cents per kilowatt hour).
- Costs, though, are plummeting. In 2010, the cost was 21 cents per kilowatt hour, nearly double what it is today. In countries such as Germany, Italy, and Spain, the cost of solar power has reached grid parity, having fallen to the same price as purchasing it from the electrical grid.



HOW DOES A SOLAR POWER PLANT WORK?

- Solar PV power plants work in the same manner as small domestic-scale PV panels or the tiny one on your calculator but on steroids.
- Most solar PV panels are made from semiconductor materials, usually some form of silicon. When photons from sunlight hit the semiconductor material free electrons are generated which can then flow through the material to produce a direct electrical current.
- This is known as the photo-effect in physics. The DC current then needs to be converted to alternating current (AC) using an inverter before it can be directly used or fed into the electrical grid.
- PV panels are distinct from other solar power plants as they use the photo-effect directly without the need for other processes or devices. For example, no liquid heat-carrying agent, like water, is needed as in solar thermal plants.
- PV panels do not concentrate energy they simply convert photons into electricity that is then transmitted somewhere else.

Linear, Parabolic Trough Solar Thermal and Solar Dish Power plants.

This is the most common form of a solar power plant that is characterized by their use of fields of either linear U-Shaped, parabolic trough collectors or solar dishes. These types of facility tend to consist of a large 'field' of parallel rows of solar collectors.

They tend to consist of three discrete types of system:

Parabolic trough systems.

Parabolic troughs use parabola-shaped reflectors that are able to focus between **30 and 100 times** normal sunlight levels on to the collector. The method is used to heat a special type of fluid, which is then collected at a central location to generate high-pressure, superheated steam.

These systems tilt to keep track of the sun throughout the day. Because of their parabolic shape, these kinds of reflectors are able to focus between **30 and 100 times** the normal sunlight intensity on the collector.

The longest operating solar thermal plant in the world, the Solar Energy Generating Systems (SEGS) in the Mojave Desert, California, is one of these types of power plants. The first plant, SEGS 1, was built in 1984 and operated to 2015 with the second, SEG 2, operating between 1984 and 2015. The last plant built, SEGS IX, with an electricity generation capacity of **92 megawatts (MW)**, began operation in 1990. Today there are currently seven operating SEGS plants with a combined capacity of **357 MW** - this makes it one of the largest solar energy thermal electric power plants in the world.



How does Parabolic Trough system work?

- These kinds of solar thermal power plant work by focusing sunlight from long parabolic mirrors onto receiver tubes that run the length of the mirror at their focal point. This concentrated solar energy heats up a fluid that continuously flows through the tubes.
- This heated fluid is then sent to a heat exchanger to boil water in a conventional steam-turbine generator to generate electricity.



SOLAR POWER TOWERS.



Solar power towers are an interesting method in which hundreds to thousands of flat sun-tracking mirrors (heliostats) reflect and concentrate solar energy onto a central tower. This method is able to concentrate sunlight as much as **1,500 times** than would normally be possible from direct sunlight alone.

One interesting example of this kind of power plant can be found in Jülich, North-Rhine Westphalia, Germany. The facility is spread over an area of **18,000 km squared** that houses more than **2,000 heliostats** that focus sunlight onto a central **60-meter** high tower.

The U.S. Department of Energy and other electric utility companies built and operated the first demonstration solar power tower near Barstow, California, during the 1980s and 1990s.

Some are currently in development in Chile too.

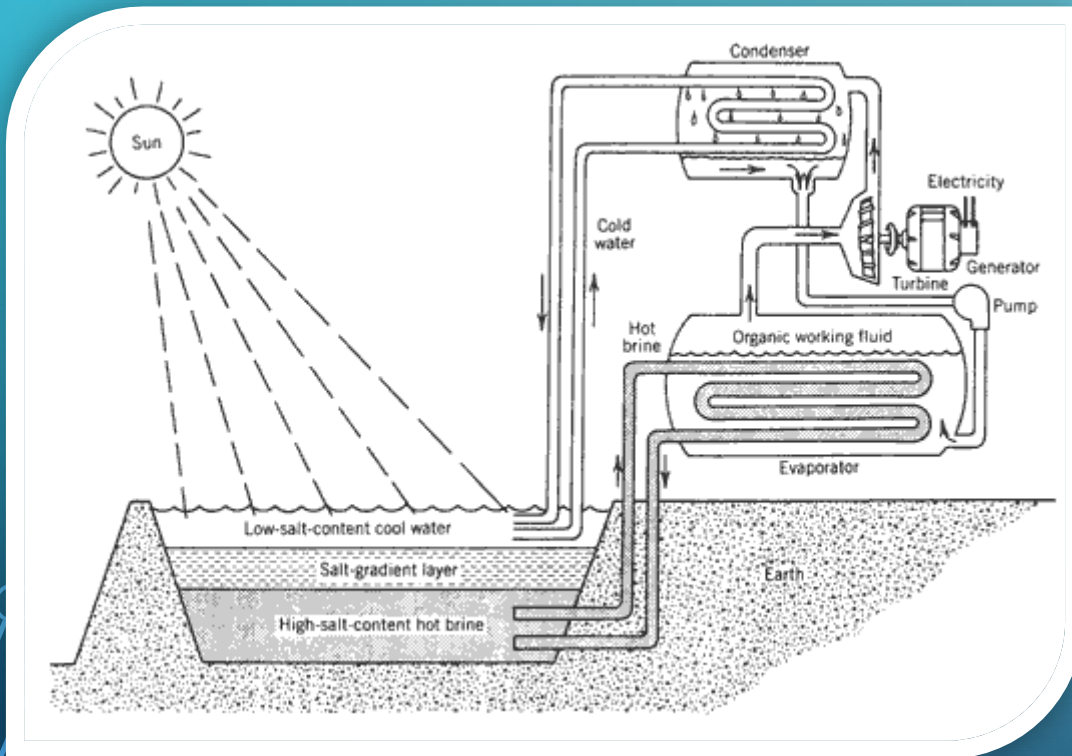


How does the Solar Tower work?

- The concentrated solar energy is used to heat the air in the tower to up to **700 degrees Celsius**. The heat is captured in a boiler and is used to produce electricity with the help of a steam turbine.
- Some towers also make use of water as the heat-transfer fluid. More advanced systems are currently being researched and tested that will use nitrate salts because of their higher heat transfer and storage properties compared to water and air.
- The thermal energy-storage capability allows the system to produce electricity during cloudy weather or at night.
- These kinds of solar power plants are ideally suited for operations in areas with adverse weather conditions. They're used in the Mojave Desert in California and have withstood hailstorms and sandstorms.

SOLAR POND.

- Solar pond solar power plants make use of a pool of saltwater that collects and stores solar thermal energy. It uses a technique called salinity-gradient technology.
- This technique acts as a thermal trap within the pond that can either be used directly or stored for later use. This kind of power plant has been in use in Israel at the Beit HaArava Power Plant since 1984.
- There are also other examples at the Bhuj in India and was completed in 1993.





How does the Solar Pond work?

- Solar Ponds use a large body of saltwater to collect and store solar thermal energy. Saltwater naturally forms a vertical salinity gradient, known as a halocline, with low-salinity water on the top and high-salinity water at the bottom.
- Salt concentrations levels increase with depth and, therefore, density also increases from the surface to bottom of the lake until the solution becomes uniform at a given depth.
- The principle is fairly simple. Solar rays penetrate the pond and eventually reach the bottom of the pool.
- In a normal pond or body of water, water at the bottom of the pond is heated, becomes less dense and rises setting up a convection current. Solar ponds are designed to impede this process by adding salt to the water until the lower levels become completely saturated.
- As the high-salinity water doesn't mix easily with low-salinity water above it, convection currents are contained within each discrete layer and minimal mixing between them occurs.
- This process concentrates thermal energy and reduces heat loss from the body of water. On average the high-salinity water can reach **90 degrees Celsius** with low-salinity layers maintaining around **30 degrees Celsius**.
- This hot, salty water can then be pumped away for use in electricity generation, through a turbine or as a source of thermal energy.



Photovoltaics.

Photovoltaic power plants use large areas of photovoltaic cells, known as PV or solar cells, to directly convert sunlight into usable electricity. These cells are usually made from silicon alloys and are the technology most people have become familiar with - chances are you may have one on your roof.

The panels themselves come in various forms:

- Crystalline solar panels - As the name suggests these types of panels are made from crystalline silicon. They can be either monocrystalline or poly- or multi-crystalline. As a rule of thumb monocrystalline versions are more efficient (**about 15-20%**) but more expensive than their alternatives (tend to be **13-16% efficient**) but advancements are closing the gap between them over time.

- Thin-film solar panels - These types of panels consist of a series of films that absorb light in different parts of the EM spectrum. They tend to be made from amorphous silicon (aSi), cadmium telluride (CdTe), cadmium sulfide (CdS), and copper indium (gallium) diselenide. This type of panel is ideal for applications as flexible films over existing surfaces or for integration within building materials like roofing tiles.



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