**Solar Energy**

**Abstract**

Solar energy is the post potential and pollution free source of renewable energy. Many technologies have been developed to capture and make efficient usage of this powerful energy resource. But still the technology is not cost effective but have wider range of applications. To compensate the costly and exhaustible non-renewable energy resources, effective usage of solar energy must be made and research need to be carried out to reduce the installation charges so that it reaches effectively to the middle class people and brings good impact on climate change.

**Introduction**

Alternative Energy is a form of energy that is not based on fossil fuels but is either renewable or sustainable without depleting a finite resource. Replenishable sources of energy are biomass (biofuel), hot springs (geothermal), sun (solar), tides (tidal), ocean thermal conversion (OTEC), wave, rivers (hydro-electric) and wind (Encarta Encyclopaedia, 2009 and Encyclopaedia Britannica, 2013). Solar and wind energy are the only sources which benefit the environment (Fitzner, 2019) and often looked uncritically by environmental proponents.

Sunlight, wind and other renewable resources are increasingly converted into useful forms of energy with ever-greater efficiency. The new technologies still provide 14 percent of the total world's energy supply, but they appear to be advancing rapidly. Many experts believe a transition toward renewable, carbon-free energy technologies would go a long way toward addressing the problems of dwindling oil reserves and the potentially ruinous environmental impacts linked to the burning of fossil fuels. Such a transition could make the 21st century the age of renewable energy (Flavin and Dunn, 2009; UNDP, 2000; Flavin and Lenssen, 1994). This study provides help to understand positive and negative environmental impacts of solar energy facilities. Fossil fuel combustion has a number of negative environmental consequences. Fossil-fuelled power plants emit air pollutants, particulate matter and toxic chemicals including fossil-fuelled vehicles emit air pollutants and particulate matter. Exposure to these pollutants can cause heart disease, asthma and other human health problems. In addition, emissions from fossil fuel combustion are responsible for acid rain, which has led to the acidification of many lakes and consequent damage to aquatic life, leaf damage in many forests, and the production of smog in or near many urban areas. The burning of fossil fuels releases carbon dioxide (CO2), one of the main greenhouse gases that cause global warming (Encyclopaedia Britannica, 2013; Whitney, 2009). Growth in wind power exceeded 30 percent and production of solar energy through photovoltaics grew at 25 to 30 percent annually and renewable energy technologies continue to expand (EWEA, 2009, Gipe, 2009; Mukund, 2006; Department of Energy, 2019).

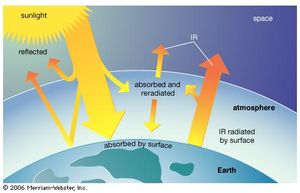
**Solar Energy**

The Sun is an extremely powerful energy source and the sunlight is by far the largest source of energy received by the Earth. “Solar energy is free, but it’s not cheap”. Solar energy refers to the energy generated from solar power, whether electrical or as heat. Solar radiation is the most important natural energy resource because it drives all environmental processes acting at the surface of the Earth.

Knowledge of the quantity and quality of solar energy available at a specific location is of prime importance for the design of any solar energy system (Anonymous, 2013; Ashok, 2013; Michael, 2012).

The relative motion of the sun with respect to the earth will allow surfaces with different orientations to intercept different amounts of solar energy. The amount and intensity of solar radiation reaching the Earth’s surface depend on the geometric relationship of the Earth with respect to the Sun. The Sun provides the Earth with an enormous amount of energy and also provides almost all the heat and light Earth receives and therefore sustains every living being as shown in figure 2. The energy stored by the oceans help maintain the temperature of the Earth at an equilibrium level that allows for stability for a broad diversity of life (Holladay, 2009). Solar energy is the radiation from the Sun capable of producing heat, causing chemical reactions, or generating electricity. The total amount of solar energy incident on Earth is vastly in excess of the world's current and anticipated energy requirements. If suitably harnessed, this highly diffused source has the potential to satisfy all future energy needs (Ashok, 2013).

Solar energy, [radiation](https://www.britannica.com/science/solar-radiation) from the [Sun](https://www.britannica.com/place/Sun) capable of producing [heat](https://www.britannica.com/science/heat), causing [chemical reactions](https://www.britannica.com/science/chemical-reaction), or generating [electricity](https://www.britannica.com/science/electricity). The total amount of solar energy incident on Earth is vastly in excess of the world’s current and anticipated energy requirements. If suitably harnessed, this highly [diffused](https://www.britannica.com/dictionary/diffused) source has the potential to satisfy all future energy needs. In the 21st century solar energy is expected to become increasingly attractive as a [renewable energy](https://www.britannica.com/science/renewable-energy) source because of its inexhaustible supply and its non-polluting character, in stark contrast to the finite [fossil fuels](https://www.britannica.com/science/fossil-fuel) [coal](https://www.britannica.com/science/coal-fossil-fuel), [petroleum](https://www.britannica.com/science/petroleum), and [natural gas](https://www.britannica.com/science/natural-gas).

[](https://cdn.britannica.com/85/73585-004-B7B8FA0D/Reflection-absorption-solar-energy-surface-atmosphere-sunlight.jpg)

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The Sun is an extremely powerful energy source, and [sunlight](https://www.britannica.com/science/sunlight-solar-radiation) is by far the largest source of energy received by [Earth](https://www.britannica.com/place/Earth), but its intensity at Earth’s surface is actually quite [low](https://www.britannica.com/science/cyclone-meteorology). This is essentially because of the enormous radial spreading of radiation from the distant Sun. A relatively minor additional loss is due to Earth’s [atmosphere](https://www.britannica.com/science/atmosphere) and [clouds](https://www.britannica.com/science/cloud-meteorology), which absorb or scatter as much as 54 percent of the incoming sunlight. The [sunlight](https://www.britannica.com/science/sunlight-solar-radiation) that reaches the ground consists of nearly 50 percent visible [light](https://www.britannica.com/science/light), 45 percent [infrared radiation](https://www.britannica.com/science/infrared-radiation), and smaller amounts of [ultraviolet](https://www.britannica.com/science/ultraviolet-radiation) and other forms of [electromagnetic radiation](https://www.britannica.com/science/electromagnetic-radiation).

[](https://cdn.britannica.com/27/198827-050-1C027B7D/Earth-power-potential.jpg)

[solar energy potential](https://cdn.britannica.com/27/198827-050-1C027B7D/Earth-power-potential.jpg)

The potential for solar energy is enormous, since about 200,000 times the world’s total daily electric-generating [capacity](https://www.britannica.com/dictionary/capacity) is received by Earth every day in the form of solar energy. Unfortunately, though solar energy itself is free, the high cost of its collection, conversion, and storage still limits its exploitation in many places. Solar radiation can be converted either into [thermal energy](https://www.britannica.com/science/thermal-energy) (heat) or into [electrical energy](https://www.britannica.com/technology/electric-power), though the former is easier to accomplish.

World's energy demand is growing fast because of population explosion and technological advance ments. It is therefore important to go for reliable, cost effective and everlasting renewable energy source for energy demand arising in future. Solar energy, among other renewable sources of energy, is a promising and freely available energy source for managing long term issues in energy crisis. Solar industry is developing steadily all over the world because of the high demand for energy while major energy source, fossil fuel, is limited and other sources are expensive. It has become a tool to develop economic status of developing countries and to sustain the lives of many underprivileged people as it is now cost effective after a long aggressive research done to expedite its development. The solar industry would definitely be a best option for future energy demand since it is superior in terms of availability, cost effectiveness, accessibility, capacity and efficiency compared to other renewable energy sources. This paper therefore discusses about the need of solar industry with its fundamental concepts, worlds energy scenario, highlights of researches done to upgrade solar industry, its potential applications and barriers for better solar industry in future in order to resolve energy crisis.

Solar energy is the radiation from the Sun capable of producing heat, causing chemical reactions, or generating electricity. The total amount of solar energy received on Earth is vastly more than the world's current and anticipated energy requirements. If suitably harnessed, solar energy has the potential to satisfy all future energy needs.

More energy from the sun falls on the earth in one hour than is used by everyone in the world in one year. A variety of technologies convert sunlight to usable energy for buildings. The most commonly used solar technologies for homes and businesses are solar photovoltaics for electricity, passive solar design for space heating and cooling, and solar water heating.

Businesses and industry use solar technologies to diversify their energy sources, improve efficiency, and save money. Energy developers and utilities use solar photovoltaic and concentrating solar power technologies to produce electricity on a massive scale to power cities and small towns.

Developing sustainable energy resources is one of the most urgent missions for human beings as increasing energy demand is in drastic conflict with limited global fossil fuels. Among the various types of sustainable energy resources, solar energy is considered to be promising due to its inexhaustible supply, universality, high capacity, and environmental friendliness. However, natural solar irradiation is decentralized, intermittent and fluctuates constantly. Therefore, effective utilization of solar energy in a clean, economic, and convenient way remains a grand challenge.

Solar energy can be utilized through photothermal, photovoltaic and photocatalytic approaches. Photoelectrochemical conversion of solar energy into chemical energy and fuels, by means of artificial photosynthesis and photocatalytic chemical synthesis, could realize the application of solar energy in a variety of fields. This themed issue on advances in solar energy conversion brings together experts in this field to describe current research and future prospects in this area. The topic of the issue focuses on, but is not limited to, the rational design, fabrication, and advanced characterization of components of photoconversion systems, materials, processes and technologies.

**Solar Photovoltaic Technology Basics**

Solar cells, also called photovoltaic cells, convert sunlight directly into electricity.

Photovoltaics (often shortened as PV) gets its name from the process of converting light (photons) to electricity (voltage), which is called the photovoltaic effect. This phenomenon was first exploited in 1954 by scientists at Bell Laboratories who created a working solar cell made from silicon that generated an electric current when exposed to sunlight. Solar cells were soon being used to power space satellites and smaller items such as calculators and watches. Today, electricity from solar cells has become cost competitive in many regions and photovoltaic systems are being deployed at large scales to help power the electric grid.

## **Silicon Solar Cells**

The vast majority of today's solar cells are [made from silicon](https://www.nrel.gov/pv/silicon-materials-devices-rd.html) and offer both reasonable prices and good efficiency (the rate at which the solar cell converts sunlight into electricity). These cells are usually assembled into larger modules that can be installed on the roofs of residential or commercial buildings or deployed on ground-mounted racks to create huge, utility-scale systems.

## **Thin-Film Solar Cells**

Another commonly used photovoltaic technology is known as [thin-film solar cells](https://www.nrel.gov/pv/polycrystalline-thin-film-photovoltaics.html) because they are made from very thin layers of semiconductor material, such as cadmium telluride or copper-+indium gallium 0  
d=--0-i10selenide. The thickness of these cell layers is only a few micrometers—that is, several millionths of a   
108eter.

Thin-film solar cells can be flexible and lightweight, making them ideal for portable applications—such as in a soldier’s backpack—or for use in other products like windows that generate electricity from the sun. Some types of thin-film solar cells also benefit from manufacturing techniques that require less energy and are easier to scale-up than the manufacturing techniques required \*98by silicon solar cells.

## **III-V Solar Cells**

A third type of photovoltaic technology is named after the elements that compose them. [III-V solar cells](https://www.nrel.gov/pv/high-efficiency-iii-v-solar-cells.html) are mainly constructed from elements in Group III—e.g., gallium and indium—and Group V—e.g., arsenic and antimony—of the periodic table. These solar cells are generally much more expensive to manufacture than other technologies. But they convert sunlight into electricity at much higher efficiencies. Because of this, these solar cells are often used on satellites, unmanned aerial vehicles, and other applications that require a high ratio of power-to-weight.

## **Next-Generation Solar Cells**

## Solar cell researchers at NREL and elsewhere are also pursuing many new photovoltaic technologies—such as solar cells made from [organic materials](https://www.nrel.gov/pv/organic-photovoltaic-solar-cells.html), [quantum dots](https://www.nrel.gov/news/press/2017/scientists-elevate-quantum-dot-solar-cell-world-record.html), and [hybrid organic-inorganic materials](https://www.nrel.gov/pv/perovskite-solar-cells.html) (also known as perovskites). These next-generation technologies may offer lower costs, greater ease of manufacture, or other benefits. Further research will see if these promises can be realized.

## **Reliability and Grid Integration Research**

## Photovoltaic research is more than just making a high-efficiency, low-cost solar cell. Homeowners and businesses must be confident that the solar panels they install will not degrade in performance and will [continue to reliably generate electricity](https://www.nrel.gov/pv/reliability-engineering.html) for many years. Utilities and government regulators want to know how to [add solar PV systems to the electric grid](https://www.nrel.gov/esif/renewable-energy-grid-integration.html) without destabilizing the careful balancing act between electricity supply and demand.

## **Passive Solar Design**

A passive solar building uses south-facing windows to collect heat from the sun and stores that heat in materials throughout the building known as thermal mass.

A successful design must include the following elements:

* **Aperture** —a large glass area through which sunlight enters the building, should face within 30 degrees of true south and should not be shaded between 9 a.m. and 3 p.m. during the heating season.
* **Thermal mass**—commonly concrete, brick, stone, and tile. These materials absorb heat from the sunlight during the heating season and also absorb heat from warm interior air during the cooling season.
* **Distribution**— a method by which solar heat is transferred from where it is collected and stored to different areas of the house by conduction, convection, and radiation.
* **Control**—devices such as roof overhangs used to shade the aperture area during summer months.

## Passive Solar Heating

## Passive solar heating systems capture sunlight within the building's materials and then release that heat during periods when the sun is absent, such as at night. South-facing glass and thermal mass to absorb, store, and distribute heat are necessary in the design.

## Passive Solar Cooling

## Passive solar cooling systems use shading, thermal mass, and natural ventilation to reduce unwanted daytime heat and store cool night air to moderate temperatures.

## Additional Resources

* [Passive Solar Home Design](https://www.energy.gov/energysaver/energy-efficient-home-design/passive-solar-home-design)
* [Sunrooms and Sunspaces](https://www.energy.gov/energysaver/sunrooms-and-sunspaces)
* [Energy Efficient Window Attachments](https://www.energy.gov/energysaver/energy-efficient-window-attachments)
* [Landscaping for Energy-Efficient Homes](https://www.energy.gov/energysaver/design/landscaping-energy-efficient-homes)

# Solar Water Heating

Solar water heating turns sunlight into a cost-effective way to generate hot water for residential buildings.

Solar water heating systems collect the thermal energy of the sun and use it to heat water in homes and businesses. The systems can be installed in any climate to reduce utility bills and are composed of three main parts: the solar collector, insulated piping, and a hot water storage tank.

Both solar water heating systems and [solar photovoltaic (PV) systems](https://www.nrel.gov/research/re-photovoltaics.html) involve collector panels, however, they are different technologies. Solar water heating systems use radiation from the sun to generate heat for water, whereas PV systems produce electricity.

Solar water heating systems can either rely on electric pumps to circulate water (active) or rely on thermodynamics (passive). Active solar water heating systems are more common in residential and commercial use. Passive solar water heating systems are typically less expensive, but they are also less efficient.

# Solar Process Heat Basics

To make them more energy efficient, commercial and industrial buildings can use solar process heat technologies for space and water heating, ventilation, and space cooling.

**Space Heating**

## Many large buildings need ventilated air to maintain indoor air quality. In cold climates, heating this air can use large amounts of energy. But a solar ventilation system can preheat the air, saving both energy and money. This type of system typically uses a transpired collector, which consists of a thin, black metal panel mounted on a south-facing wall to absorb the sun's heat. Air passes through the many small holes in the panel. A space behind the perforated wall allows the air streams from the holes to mix together. The heated air is then sucked out from the top of the space into the ventilation system.

## **Water Heating**

Solar water-heating systems are designed to provide large quantities of hot water for nonresidential buildings. A typical system includes solar collectors that work along with a pump, heat exchanger, and/or one or more large storage tanks. The two main types of solar collectors used for nonresidential buildings—an evacuated-tube collector and a linear concentrator—can operate at high temperatures with high efficiency. An evacuated-tube collector is a set of many double-walled, glass tubes and reflectors to heat the fluid inside the tubes. A vacuum between the two walls insulates the inner tube, retaining the heat. Linear concentrators use long, rectangular, curved (U-shaped) mirrors tilted to focus sunlight on tubes that run along the length of the mirrors. The concentrated sunlight heats the fluid within the tubes.

## **Space Cooling**

Space cooling can be accomplished using thermally activated cooling systems (TACS) driven by solar energy. Because of a high initial cost, TACS are not widespread. The two systems currently in operation are solar absorption systems and solar desiccant systems. Solar absorption systems use thermal energy to evaporate a refrigerant fluid to cool the air. In contrast, solar desiccant systems use thermal energy to regenerate desiccants that dry the air, thereby cooling the air. These systems also work well with evaporative coolers (also called "swamp coolers") in more humid climates.

# Concentrating Solar Power Basics

Concentrating solar power systems harness heat from sunlight to provide electricity for large power stations. Many power plants today use fossil fuels as a heat source to boil water. The steam from the boiling water spins a large turbine, which drives a generator to produce electricity. However, a new generation of power plants use concentrating solar power systems and the sun as a heat source. The three main types of concentrating solar power systems are: linear concentrator, dish/engine, and power tower systems.

## **Linear Concentrator Systems**

## Linear concentrator systems collect the sun's energy using long rectangular, curved (U-shaped) mirrors. The mirrors are tilted toward the sun, focusing sunlight on tubes (or receivers) that run the length of the mirrors. The reflected sunlight heats a fluid flowing through the tubes. The hot fluid then is used to boil water in a conventional steam-turbine generator to produce electricity.

## There are two major types of linear concentrator systems: parabolic trough systems, where receiver tubes are positioned along the focal line of each parabolic mirror; and linear Fresnel reflector systems, where one receiver tube is positioned above several mirrors to allow the mirrors greater mobility in tracking the sun.

## **Dish/Engine Systems**

A dish/engine system uses a mirrored dish similar to a very large satellite dish, although to minimize costs, the mirrored dish is usually composed of many smaller flat mirrors formed into a dish shape. The dish-shaped surface directs and concentrates sunlight onto a thermal receiver, which absorbs and collects the heat and transfers it to the engine generator.

The most common type of heat engine used today in dish/engine systems is the Stirling engine. This system uses the fluid heated by the receiver to move pistons and create mechanical power. The mechanical power is then used to run a generator or alternator to produce electricity.

## **Power Tower Systems**

## A power tower system uses a large field of flat, sun-tracking mirrors known as heliostats to focus and concentrate sunlight onto a receiver on the top of a tower. A heat-transfer fluid heated in the receiver is used to generate steam, which, in turn, is used in a conventional turbine generator to produce electricity.

## Some power towers use water/steam as the heat-transfer fluid. Other advanced designs are experimenting with molten nitrate salt because of its superior heat-transfer and energy-storage capabilities. The energy-storage capability, or thermal storage, allows the system to continue to dispatch electricity during cloudy weather or at night.

**Environmental Impact of Solar Energy**

During the operation of solar energy generation, there are no gaseous or liquid emissions and also the photovoltaic array acted as an environmental heat shield in protecting the building on which it is mounted. Solar energy affects the environment negatively that Solar panels contain toxic metals like lead, which can damage the nervous system, as well as chromium and cadmium, known carcinogens as pollutants. All three metals are known to leach out of existing e-waste dumps into drinking water supplies. The washed out of the fragments of solar panel modules over a period of several months by rainwater could pose threat to human health (Environmental Progress, 2017; Solar Energy and the Environment, 2018; Fitzner, 2019). The solar panel disposal is another problem which can cause adverse environmental effect in future. Solar panels can take up large chunks of desert previously used by a host of wildlife from pronghorns and tortoises to coyotes and rattlesnakes (Fitzner, 2019). The production of photovoltaic systems can cause very similar health and safety problems to those found in the semiconductor industry. The quantities of pollutants generated from photovoltaic production plants are relatively small.

**Conclusion**

Since the solar energy is the best renewable energy resource available, related technology gap need to be filled in by increasing the applications in real life usage. As it also helps in reducing global warming by bringing down the harmful gas emissions, solar energy need to be used as power resource in all major industries. Research on reducing the installation charges helps in wider application of the technology across the world which may result in very good impact on the climate change.

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