100% RENEWABLES
FACTSHEET SERIES

100% RENEWABLES CITIES & REGIONS ROADMAP

ICLEI Local Governments for Sustainability

SOLAR ENERGY

WHAT IS SOLAR ENERGY?

Solar energy is one of the cleanest and most abundant proven sources of renewable energy.[1] The enormous energy from the sun, in the form of sunlight, results from the process of nuclear fusion which occurs inside of the center of the sun.[2]

A SUNNY FACT

To get a sense of the incredible intensity of the sun's energy, consider that that every 50 minutes the sun provides enough energy to meet the needs of annual energy consumption worldwide.[3]

Solar energy is mainly classified into two types - **electrical and thermal solar energy**.

1 SOLAR ELECTRICAL ENERGY

This technology converts sunlight directly into electricity using photovoltaic cells that are assembled into panels and installed on various types of surfaces. It can be grid-connected and/or off-grid.

OFF-GRID PHOTOVOLTAIC (PV) TECHNOLOGY / STAND-ALONE SYSTEM

Stand-alone PV systems are designed to operate independently of the power grid. It is possible to run standalone solar PV systems with or without batteries. Solar water pumping and solar home systems are some examples of this type of solar energy.

ON-GRID PV TECHNOLOGIES

Generally large solar PV plants are grid connected, built on the ground, mounted on building rooftops or floating on large bodies of water.

- **Solar PV rooftop installations:** A solar PV unit installed on the roof or built into a building's facade that converts solar energy into electricity. This can be used to fulfill the building's own demands for energy consumption and can also be fed back into the electrical grid in certain cases.

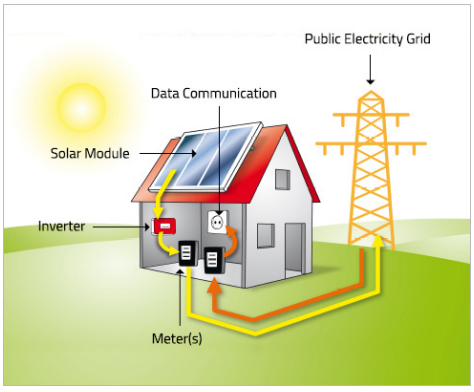


Figure 1: Grid connected solar PV system (https://www.ema.gov.sg/Solar_Photovoltaic_Systems.aspx) (2019, Government of Singapore)

- **Large solar PV power plant or solar farm:** Solar farms usually consist of solar panels installed on the ground throughout a large area. These supply electricity to the electric grid in most situations and are part of the energy mix of the utility.[4]

Figure 2: large PV power plant (Source: pixabay)

KEY FACTS

482.83 MW

Total solar installed capacity in 2018

Solar energy is now **one of the cheapest and most abundant energy sources** in the world. In December 2016, the cost of building and installing new solar electricity generation dropped to USD 1.65 per watt, giving shoulder to shoulder competition to wind (USD 1.66 per watt) and its nonconventional fuel competitors.

$ 1.65 per Watt

Numerous manufacturers **offer a cost-efficient solar panel with more than 20 percent efficiency.** Efficiency levels of solar panels have been increasing as rapidly as solar costs are decreasing.

Solar technology systems are shareable. Community solar power farms can provide electricity for hundreds of people, reducing the initial investment required by individual homeowners.[9]

Solar energy can reach new heights. In addition to powering homes, businesses, roads, trains and cars, it can also power airplanes. Swiss pilot Bertrand Piccard **flew a solar-operated airplane without any backup power source** in 2015.[10,11]

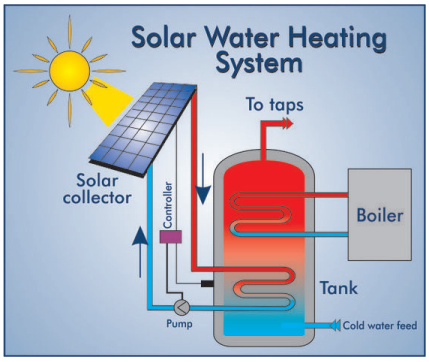
2 SOLAR THERMAL ENERGY

Solar thermal energy converts the absorbed heat from the sun into a usable form of energy. The heat absorbed is used for various applications directly or transformed into **electricity**.

SOLAR WATER HEATING

Solar water heaters, also known as solar domestic hot water systems, can be a cost-effective way to generate hot water for your home. Solar water heating systems capture and use the sun's thermal energy to heat water. They consist of three main parts: a solar collector, isolated piping and a tank for hot water storage. Figure 3 shows the operation of a solar water heating system. It can be classified as active or passive.[5]

Figure 3: Typical solar water heating system (https://www.pinterest.co.uk/pin/468233692477777051/)



- **Passive solar water heating system:** The solar system is said to be passive if the heat is stored and used without excessive mechanical pumping.
- **Active solar water heating system:** The solar system is said to be active if the solar energy is collected in a liquid, normally water or air, which is then transferred for use by pumps or fans.

SOLAR PROCESS HEAT

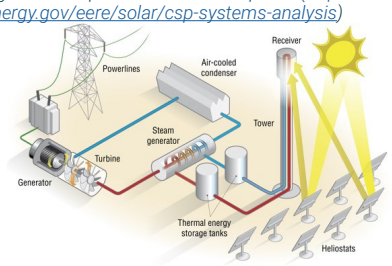
Solar process heat technology can be used for space and water heating, ventilation, and space cooling to make commercial and industrial buildings more energy efficient. It can be further classified as space heating and cooling.[6]

- **Space heating:** Generally, this type of system uses a transpired collector, consisting of a thin, black metal panel installed on a south-facing wall to absorb the heat of the sun. Eventually, heated air is then sucked into the ventilation system from the top of the room.
- **Space cooling:** Solar absorption systems and solar desiccant systems are the two technologies currently in operation to provide space cooling.

CONCENTRATED SOLAR POWER (CSP)

CSP technologies concentrate solar heat on mirrors and achieve a large temperature range to heat a gas, solid or liquid which can then be used for electricity generation. The three main categories of CSP technologies are linear Fresnel concentrations, parabolic trough, and power tower systems.[7]

Figure 4: A power tower CSP plant (https://www.energy.gov/eere/solar/csp-systems-analysis)



SUN & SUSTAINABILITY

The United Nations defines sustainability as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs.*" Solar energy satisfies this widely accepted definition of sustainability because the **sun's energy can be used forever without lessening its future availability**.[12]

However, some of the materials required in the manufacturing process of solar panels are not sustainable and they are difficult to recycle. **We are currently depending on continuous fast paced research and development to achieve more sustainable manufacturing processes for solar energy**.

Programs such as rural electrification have played a vital role in social and economic growth in developing countries. **Photovoltaic technologies are environmentally friendly without creating air or noise pollution in use.** Solar plants have a lifespan of about 20 years or more, making them a reliable energy investment.

3 PASSIVE SOLAR TECHNOLOGY

A passive solar building uses windows facing the sun to absorb heat and store it in materials to heat up inside the buildings. It can be further classified as:[8]

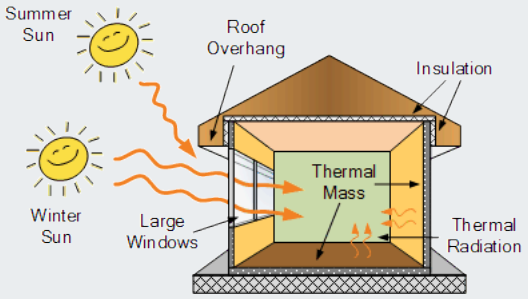


Figure 5: Passive solar technology (https://solyntaenergy.com/2018/01/27/how-effective-passive-solar-design-is-in-generating-energy/)

- **Passive solar heating:** Passive solar heating buildings are designed in such a way that it has glass facing the sun, and thermal mass that absorb energy within the materials of the building and then releases the heat during hours, such as at night, when the sun is absent.
- **Passive solar cooling:** Shading, thermal mass and natural ventilation are used by passive solar cooling systems to reduce unnecessary daytime heat and keep the room at a comfortable temperature.

REFERENCES

1. "Solar Energy Basics, NREL", Nrel.gov. Available at: https://www.nrel.gov/research/re-solar.html

2. J. Hanania, K. Stenhouse and J. Donev, "Nuclear fusion in the Sun - Energy Education", Energyeducation.ca, 2015. Available at: https://energyeducation.ca/encyclopedia/Nuclear_fusion_in_the_Sun

3. "The Two Types of Solar Energy.", Planète Énergies, 2014. Available at: https://www.planete-energies.com/en/medias/close/two-types-solar-energy

4. "What is a solar farm and how are they different than rooftop solar systems?" Solar Power World, 2019. Available at: https://www.solarpowerworldonline.com/2019/05/what-is-a-solar-farm/

5. "Solar Water Heaters", Energy.gov. Available at: https://www.energy.gov/energysaver/water-heating/solar-water-heaters

6. "Solar Process Heat Basics, NREL", Nrel.gov. Available at: https://www.nrel.gov/research/re-solar-process.html

7. "Concentrating Solar Power Basics, NREL", Nrel.gov. Available at: https://www.nrel.gov/research/re-csp.html

8. "Passive Solar Technology Basics, NREL", Nrel.gov. Available at: https://www.nrel.gov/research/re-passive-solar.html

9. "Solar", Irena.org, 2019. Available at: https://www.irena.org/solar

10. J. O'Donnel, "7 Facts About Solar Energy: What You Need To know About This Renewable Energy", Conservation Institute, 2018. Available at: https://www.conservationinstitute.org/facts-about-solar-energy/

11. "Solar Impulse - Around the world to promote clean technologies", Solar Impulse. Available at: https://aroundtheworld.solarimpulse.com/our-story

12. "Sustainability | Academic Impact", Academicimpact.un.org. Available at: https://academicimpact.un.org/content/sustainability

Author
Mohamedarif Patel - ICLEI World Secretariat

Collaborator
Rohit Sen - ICLEI World Secretariat
Laura Noriega - ICLEI World Secretariat

Design
Olga Tokareva - ICLEI World Secretariat

Supported by:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag