

Solar Energy

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Slide 2: *Solar Energy: The Sun*

- The sun is a star.
- The source of energy in the sun is at its core.
- This energy is released into space primarily as electromagnetic radiation.
- We experience this radiation in the form of heat and light.
- Life exists on the planet because of its distance from the sun, resulting in acceptable average temperatures and the greenhouse effect.
- Earth also has an atmosphere, which protects the surface from harmful rays from the sun.

Slide 3: *The Sun - How powerful is it?*

- Every hour, enough sunlight energy reaches the earth to meet the world's energy demand for a whole year.
- Even though only a percentage of that potential is accessible, this is still enough to provide just under six times more power than the world currently requires.
- Remember, this energy is distributed over the complete spherical surface of the earth!
- It is mainly a question of how to convert and concentrate solar energy as efficiently, sustainable and cost effectively as possible to electricity and hot water.
- South Africa has the perfect climate for solar energy, one of the best in the world.
- We have an average of more than 2 500 hours of sunshine every year.

Slide 4: *Uses for Solar Energy*

- Solar energy can be used for heating of water.
- Concentrated solar thermal energy can be used to generate electricity, or process heat.
- Solar energy can also be used for generating electricity through the use of photovoltaic panels.

Slide 5: *Concentrated Solar Energy*

- Concentrated solar thermal power plants.
- Solar energy can be concentrated on to a central receiver with the following technologies:
 - a. Parabolic Trough
 - b. Fresnel
 - c. Parabolic Dish
 - d. Central Receiver

Slide 6: *Solar Thermal Power Plants*

- Pictured here are thermal power plants.
- A solar thermal power plant converts solar energy into electricity.
- The temperature in a concentrated solar power station is high enough to produce steam.
- The steam is fed into a turbine which generates electricity.
- Similar systems are used in coal and nuclear power stations, where coal and nuclear are used to produce the heat.
- Thermal storage makes it possible for solar thermal power stations to generate electricity at night.

Benefits:

- Using solar energy from the sun does not cause pollution.
- Solar energy is a renewable resource, so it will never run out.
- Fossil fuels are conserved.
- The energy of the sun is free and it can be used whenever the sun is shining, from your back garden right up into space.
- Solar thermal power stations can use thermal storage.

Problems:

- You cannot use the sun's energy at night and there is less of it on cloudy days.
- Large scale plants are still very expensive to build.

Slide 7: *Photovoltaic Effect*

- Converting solar energy into electrical energy by means of solar cells is known as the photovoltaic effect
- A solar panel is a group of solar cells, which convert solar energy into electricity.
- Solar cells are predominantly made from silicon, the same type of material used to make computer chips.
- When these materials absorb solar energy, it causes tiny electrically charged particles called electrons to move through them.

Slide 8: *Photovoltaic Panels*

- PV panels consists of semiconductors.
- Each cell consists of two types of semiconductor layers, one positive and one negative.
- When light shines on the semiconductor, the electric field across the junction between these two layers causes electricity to flow.
- The p-type tends to get rid of the electrons.
- The n-type tries to collect them.

- Light gives the energy for electrons to move between the two layers, and this flow generates electricity.
- The greater the intensity of light, the greater the flow of electricity.

Slide 9: Photovoltaic Power Plants

- Pictured here are photovoltaic power plants.

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Problems:

- You cannot use the sun's energy at night and there is less of it on cloudy days.
- Expensive batteries are needed to store electricity generated during the day so it can be released at night – and batteries are a huge environmental problem! (Only applicable on PV)
- Large scale plants are expensive to build.
- Solar cells are also expensive and often only have a 15 % efficiency

Slide 10: Solar Water Heating

There are two main ways of heating water in a solar water heater:

1. Indirect system:

Indirect system uses a heat transfer fluid (typically ethylene glycol) to move the heat from the solar collector to the tank.

Indirect systems are freeze resistant, but have a higher capital compared to direct systems.

2. Direct solar systems:

Direct solar systems heat the water that is consumed or stored in the water heater.

Direct systems should be limited to warm climates or those areas that experience only a couple of freezing days per year as the water freezing in the pipes can damage the system.

The water in a direct system can be circulated in one of two of ways:

2.1 Active system:

If a solar water heating system has a circulation pump to transfer heat from the collector to the solar storage tank, it is an active system.

2.2 Passive system:

If the system has no pump or control system to transfer the heat to the storage tank, it is a passive system.

- There are **two types** of solar collectors:
 - Flat Panel
 - Evacuated Tube System
- Electrical water heating accounts for a large portion of the energy use in the average South African household.
- Comes mainly from electricity, derived from fossil fuels.
- Releases four and a half tons of CO₂/year.

- If solar energy were to be used instead, households would see a significant financial saving as well as electricity, which would in turn benefit the environment in which we live.

Slide 11: *Solar Flat Panel*

- A solar flat panel collector is a box with a glass cover.
- Inside is a series of copper tubes with copper fins attached.
- The entire structure is coated in a black substance designed to capture the sun's rays, this is called selective surface. Black paint can also be used.
- These rays heat up the water which circulates from the collector to an insulated tank ready to use.
- It can be used for anything from heating domestic hot water and space heating, to heating swimming pools.
- Sometimes the panels are used for solar-assisted cooling, industrial processes and the desalination of drinking water.

Slide 12: *Evacuated Tube System*

- The absorber inside the vacuum tube absorbs the radiation from the sun and heats up the fluid inside.
- Additional radiation is picked up from the reflector behind the tubes.
- Whatever the angle of the sun, the round shape of the vacuum tube allows it to reach the absorber.
- Even on a cloudy day, when the light is coming from many angles at once, the vacuum tube collector can still be effective.