Solar Energy

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: ***Solar Energy: 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: ***Solar Energy: Uses***

- 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: ***Solar Water Heating: Direct vs. Indirect***

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 cost 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 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 CO_2 per year.
   - If solar energy were to be used instead, households would not only save money, but also electricity, which would in turn benefit the environment in which we live.

Slide 6*: Solar Water Heating: 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 be used.
- It can be used for anything from heating domestic hot water and living spaces, to heating swimming pools.
- Sometimes the panels are used for solar-assisted cooling, industrial processes and the desalination of drinking water.

Slide 7: ***Solar Water Heating: Evacuated Tube System***

- Consists of multiple evacuated glass tubes with solar absorbers that collect the heat energy from the sun.
- The vacuum between the inner and outer tubes serves as a form of insulation to minimise heat loss.
- The absorber inside the vacuum tube absorbs the radiation from the sun and heats up the fluid inside the copper pipe.
- 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.

Slide 8: ***Concentrated Solar Thermal Power Plants (CSP): Concentrated Solar Energy***

- Concentrated Solar Thermal Power Plants make use of concentrated solar energy.
- Solar energy can be concentrated onto a central receiver with the following technologies:
    a. Parabolic Trough
    b. Fresnel
    c. Parabolic Dish
    d. Central Receiver

Slide 9: ***Concentrated Solar Thermal Power Plants (CSP): Converting Solar Energy (Heat) into Electricity***

- A concentrated solar thermal power plant converts solar energy into electricity.
- The temperature in a concentrated solar thermal 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 energy are used to produce the heat.

Slide 10: ***Concentrated Solar Thermal Power Plants (CSP): Examples***

- Fresnel
- Parabolic dish
- Central receiver
- Parabolic trough

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, thus limiting harmful emissions.
- 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.
- Thermal storage (heat) makes it possible for solar thermal power stations to generate electricity at night.

Problems:

- You cannot use the sun’s energy at night and there is less of it on cloudy days.
- In spite of the fact that sunlight is free of charge, solar power plants are still more expensive to build than conventional coal power plants.

Slide 11: ***Photovoltaic Panels: Photovoltaic Effect***

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

Slide 12: ***Photovoltaic Panels: Converting Solar Energy (Light) into Electricity***

- PV panels consist 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 an electric current 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 13: ***Photovoltaic Power Plants***

At a photovoltaic power plant solar energy (light) is converted into electricity.

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.

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 to photovoltaic panels).
- Large-scale plants are expensive to build.
- Solar cells are also expensive and often only have a 15% efficiency.