Solar Energy: The Future Renewable Resource

Solar Energy Basics

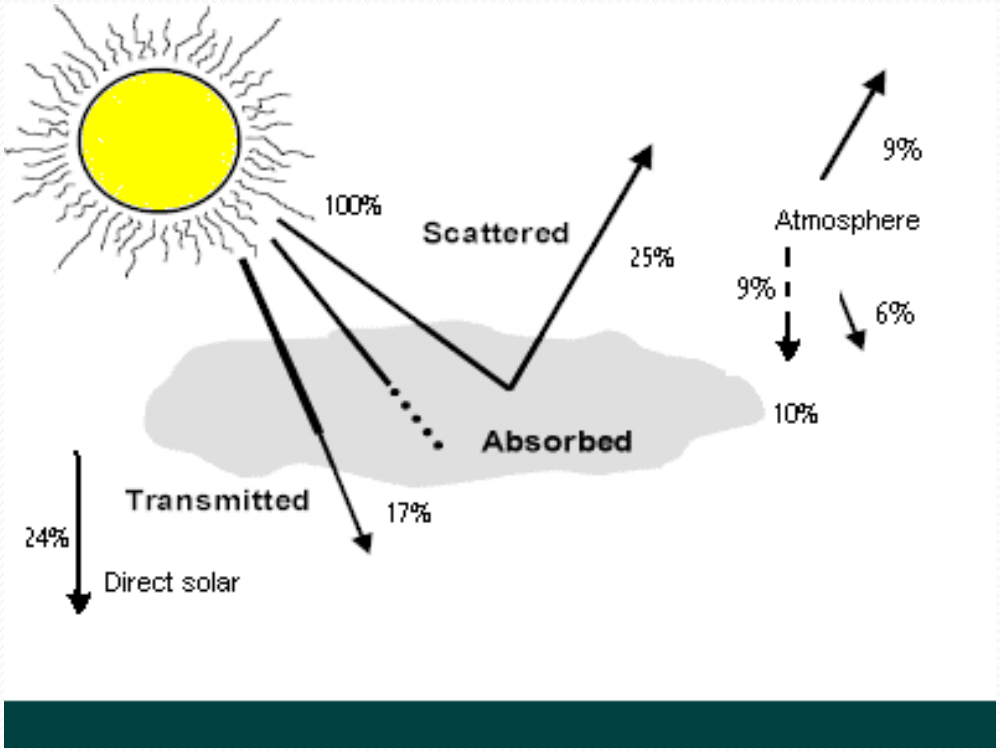
- *Solar energy is intense radiation energy produced by thermonuclear reaction in the sun – It takes approximately eight minutes for a "packet" of light to reach earth's surface*
- *This energy can be captured and converted into two major useful forms: Heat and Electricity*
- *The amount of energy captured depends on geographical location and amount of "radiation source" available*
- *The amount of energy is greatest in afternoon compared to morning and evening times*
- *No survival is possible without some sun light for all living organisms – reasons also why the water is transparent for helping aquatic animals*

Advantages and Disadvantages

- ***Advantages***
  - *All chemical and radioactive polluting by-products of the thermonuclear reactions remain behind on the sun, while only pure radiant energy reaches the Earth.*
  - *Energy reaching the earth is incredible. By one calculation, 30 days of sunshine striking the Earth have the energy equivalent of the total of all the planet's fossil fuels, both used and unused!*
  - *The heat energy produced by sun, if ever captured completely, can satisfy entire mankind's energy requirement for hundreds of years*
- ***Disadvantages***
  - *Sun does not shine consistently throughout the season and varies across geographical locations – Also the 23 ½ degree tilt of earth axis ensures non-uniform distribution of solar energy*
  - *Solar energy is a diffuse type of heat source. To harness, it must be concentrated into an amount and form that we can use such as heat and electricity. The diffusion occurs due to various environmental factors like clouds, moisture, dust, pollutant and altitude of the location*
  - *The intensity of solar radiation after diffusion can vary from 10% to 100%*
- *Methods of concentration –*

  1) Collection 2) Conversion 3) Storage

How much solar energy?



On a typical dry day, the surface receives about 47% of the total solar energy that reaches the Earth which is usable

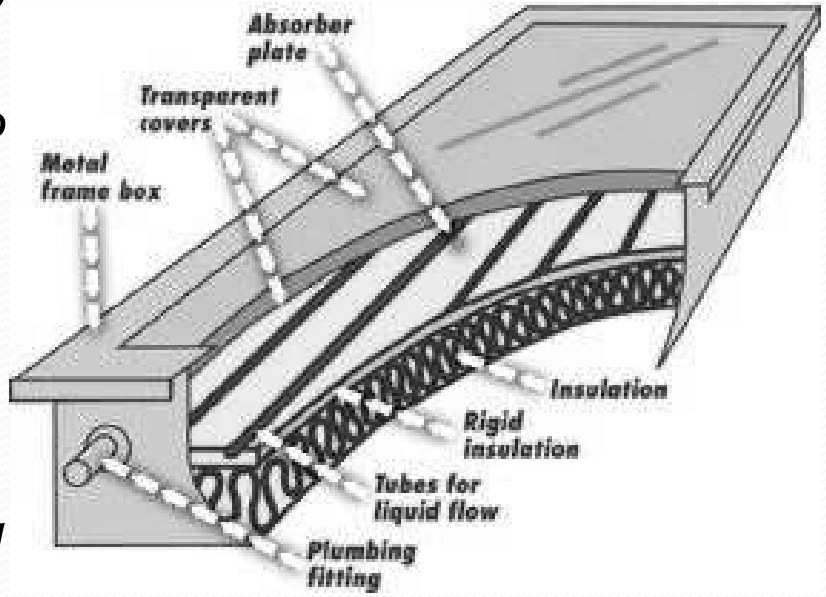
Units of Solar Energy

- *Photo-Voltaic (PV) cells are used for generating electricity from solar radiation – It is often represented using kilowatt-hour per square meter (KWh/m²) or Watt per square meter(W/m²) – The energy collected by photo voltaic is generally in DC mode. Using an INVERTER, it is converted to AC mode for domestic applications. A single PV module can generate between 10 to 300 watts.*

- *Solar energy used for water and space heating application is generally represented in British thermal units per square feet (BTU/ft²) – Based on type of collector used, the quantity of water (or space) to be heated varies – As a thumb rule 20 square feet (2 square meters) of solar panel is necessary for heating around 50 to 60 US gallons (190 to 230 liters) of water. For every additional family member, add 8 to 10 square feet (0.73 to 1 square meter) of solar panel. The tank size should be accordingly increased – For every square feet of panel area, consider 1.5 gallons (5.7 liters) to 2 gallons (7.7 liters)*

Solar Energy for heating Water

- *Two methods of heating water: Passive (no moving parts) and Active (utilizing pumps).*
- *In both, a flat-plate collector is used to absorb the sun energy to heat the water.*
- *The water circulates throughout the closed system due to convection currents.*
- *Insulated tanks can be used for storing hot water throughout the day*



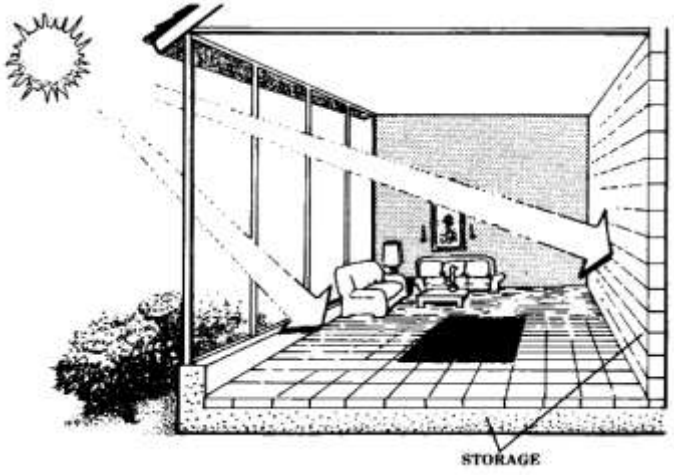
Heating Water—Last Thoughts

- *Efficiency of solar heating system is always less than 100% because:*
  - *Percentage of heat transmitted depends on angle of incidence*
  - *Number of glass sheets (single glass sheet transmits 90-95%), and*
  - *Composition of the glass*
- *Solar water heating saves approximately 1000 megawatts of energy annually equivalent to eliminating the emissions from two medium sized coal burning power plants*
- *By using solar water heating over gas water heater, more than 30% energy conservation can be achieved*
- *Although the initial installation is a complex process, the heating system saves "conventional energy" in long run*

Heating Living Spaces

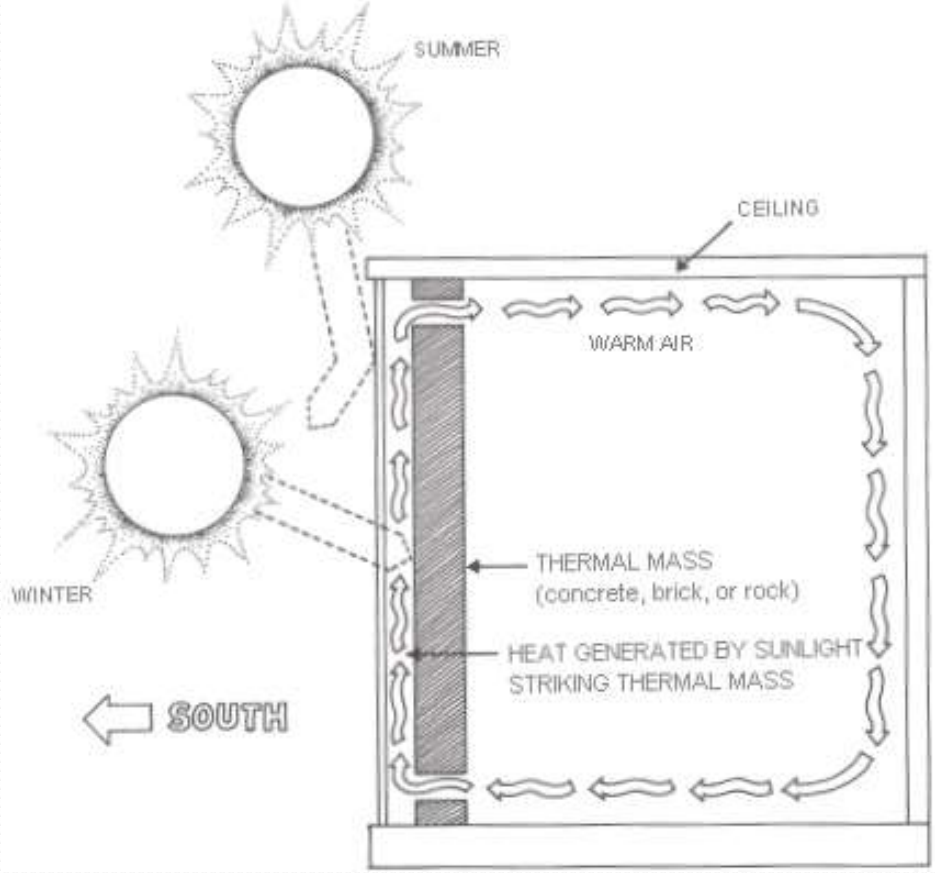
- *Best design of a building is for it to act as a solar collector and storage unit. This is achieved through three elements: insulation, collection, and storage*
- *Efficient heating starts with proper insulation on external walls, roof, and the floors. The doors, windows, and vents must be designed to minimize heat loss*
- *Collection: south-facing windows and appropriate landscaping*
- *Storage: Thermal mass – amount of heat holding capacity*
  - *Water= 62 BTU per cubic foot per degree F*
  - *Iron=54, Wood (oak) =29, Brick=25, concrete=22 and loose stone=20*

Heating the living spaces



Passive Solar

Passively heated home



Trombe Wall

Heating Living Spaces

- *A passively heated home uses about 60-75% of the solar energy that hits its walls and windows*
- *In almost any climate, a well-designed passive solar home can reduce energy bills by more than 50% , but with an added construction cost of only 5-10% initially*
- *About 25% of energy is used for water and space heating*
- *With minimum maintenance, the solar heating systems can last longer – almost close to 25 years !*

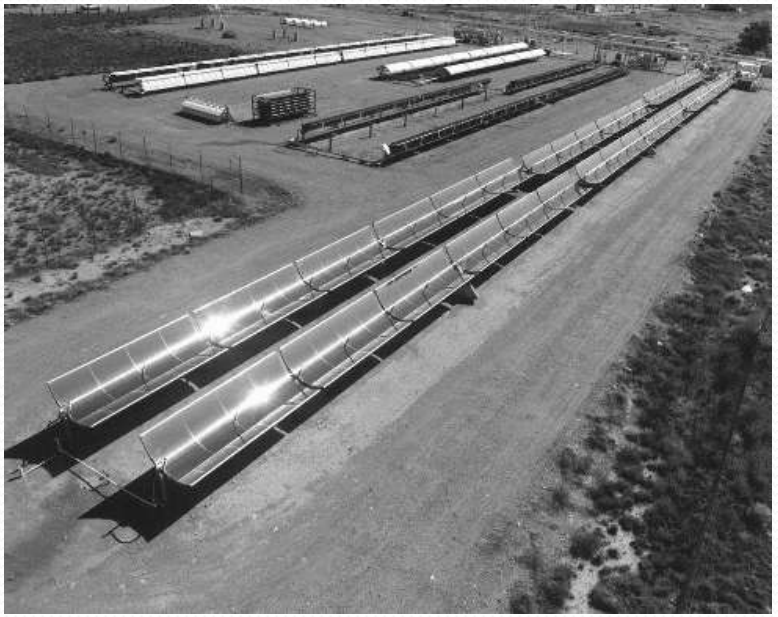
Solar-Thermal Electricity: Power Towers

- *General idea is to collect the light from many reflectors spread over a large area at one central point to achieve high temperature.*
  - *Example is the 10-MW solar power plant in Barstow, California having 1900 heliostats, each measuring 400 square feet with a 295 feet central tower*
- *An energy storage system allows it to generate 7 MW of electric power*
- *Capital cost is greater than coal fired power plant, despite the no cost for fuel, ash disposal, and stack emissions*
- *Capital costs are expected to decline as more and more power towers are built with greater technological advances*
- *One way to reduce cost is to use the waste steam from the turbine for space heating or other industrial processes.*

Power Towers

Power tower in Barstow, California.

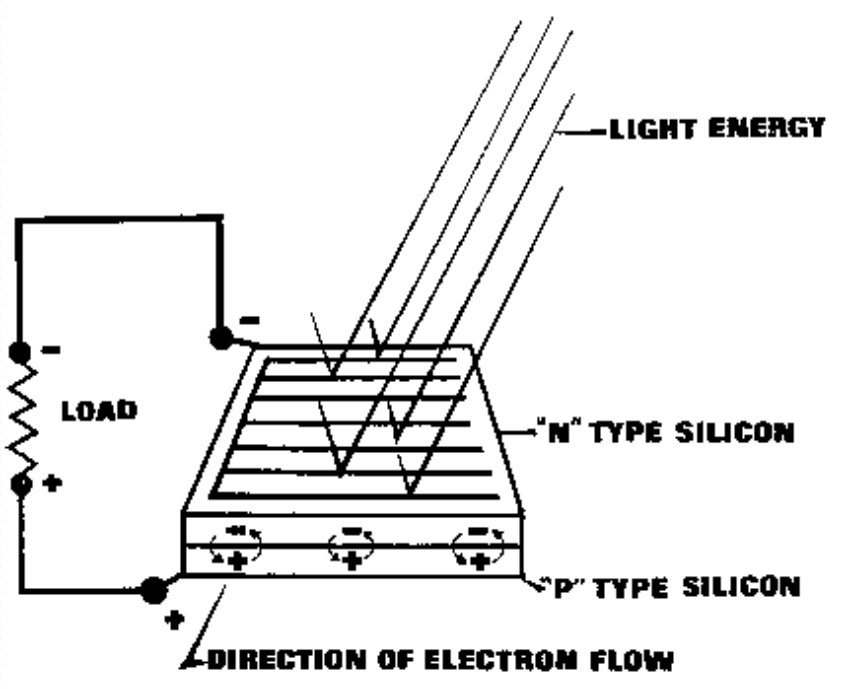
Parabolic Dishes and Troughs



- *Assembly of collectors*

- *Because they work best under direct sunlight, parabolic dishes and troughs must be steered throughout the day in the direction of the sun.*

Direct Conversion into Electricity



- *Photovoltaic cells are capable of directly converting sunlight into electricity.*
- *A simple wafer of silicon with wires attached to the layers. Current is produced based on types of silicon (n- and p-types) used for the layers. Each cell=0.5 volts.*
- *Battery needed as storage – Higher the power, higher will be the battery capacity*
- *No moving parts means they do o no wear out. But because they are exposed to the weather, their lifespan is about 20 years.*

Efficiency and Disadvantages

- *Efficiency is far lass than the 77% of solar spectrum with usable wavelengths.*
- *Efficiency drops as temperature increases (from 24% at 0°C to 14% at 100°C.)*
- *With proper designing, the electricity generated from solar energy can light up entire house*
- *The solar energy is noise free, pollution free, and maintenance free*
- *Does not reflect the true costs of burning coal and its emissions to the nonpolluting method of the latter.*
- *Underlying problem is weighing efficiency against cost.*
- *Crystalline silicon-more efficient but expensive to manufacture*
- *Amorphous silicon- Half as efficient but expensive to produce*
- *The cost of power generation will be three to four times conventional method with present day technologies*
- *At present, solar heating system components are expensive*

Final Thought

- *Argument that sun provides power only during the day is countered by the fact that 70% of energy demand is during daytime hours. At night, traditional methods can be used to generate the electricity*
- *Goal is to decrease dependence on fossil fuels*
- *Currently, 75% of electrical power is generated by coal-burning and nuclear power plants*
- *Solar energy reduces the effects of acid rain, carbon dioxide, and other impacts of burning coal and counters risks associated with nuclear energy*
- *Pollution free, indefinitely sustainable*
- *The primary source – SUNLIGHT – is available, free, throughout life!*

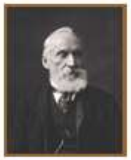
°K - Degree Kelvin

The KELVIN indicates very low or extremely high temperatures. The absolute zero temperature which can be achieved by any object is equal to 273.15 degree Kelvin or 273.15°K. Kelvin is one of the seven SI (International Systems) fundamental units. For conversion between degree Celsius, degree Fahrenheit and degree Kelvin, use the following simple formula:

Degree Celsius °C = (°K - 273.15) or °K = 273.15 + °C
Degree Fahrenheit °F = °K x 9/5 - 459.67 or °K = (459.67 + °F) x 5/9

Temperature at the core - almost geometrical center - of the sun is equal to 15,000,000°C or 27,000,000°F or 15,000,273.15°K and surface temperature is almost 6000°C or 10832°F or 6274°K. The energy from surface of Sun is what reaches Earth that we all can potentially use for heating and generating electricity.

Lord Kelvin - Inventor of Thermometric Scale,



Lord Kelvin, originally known as William Thomson 1st Baron Kelvin, is one of the most admired scientists of the 19th century. His inventions not only revolutionized the thermodynamic field, but also contributed immensely to electrical engineering, electronic engineering and refrigeration. He was the first to prove that any object cannot reach below certain value called ABSOLUTE ZERO which was measured at 273.16°K. Four Thermal sensing (4-wire sensing) is widely used in designing of Strain Gauges and Resistance Thermometers. Although forgotten, SIPHON RECORDER was one of his not very successful inventions which indirectly has influenced designing of modern inkjet printers. Lord Kelvin also improvised and popularized the modern thermometers.

The End, only for now….