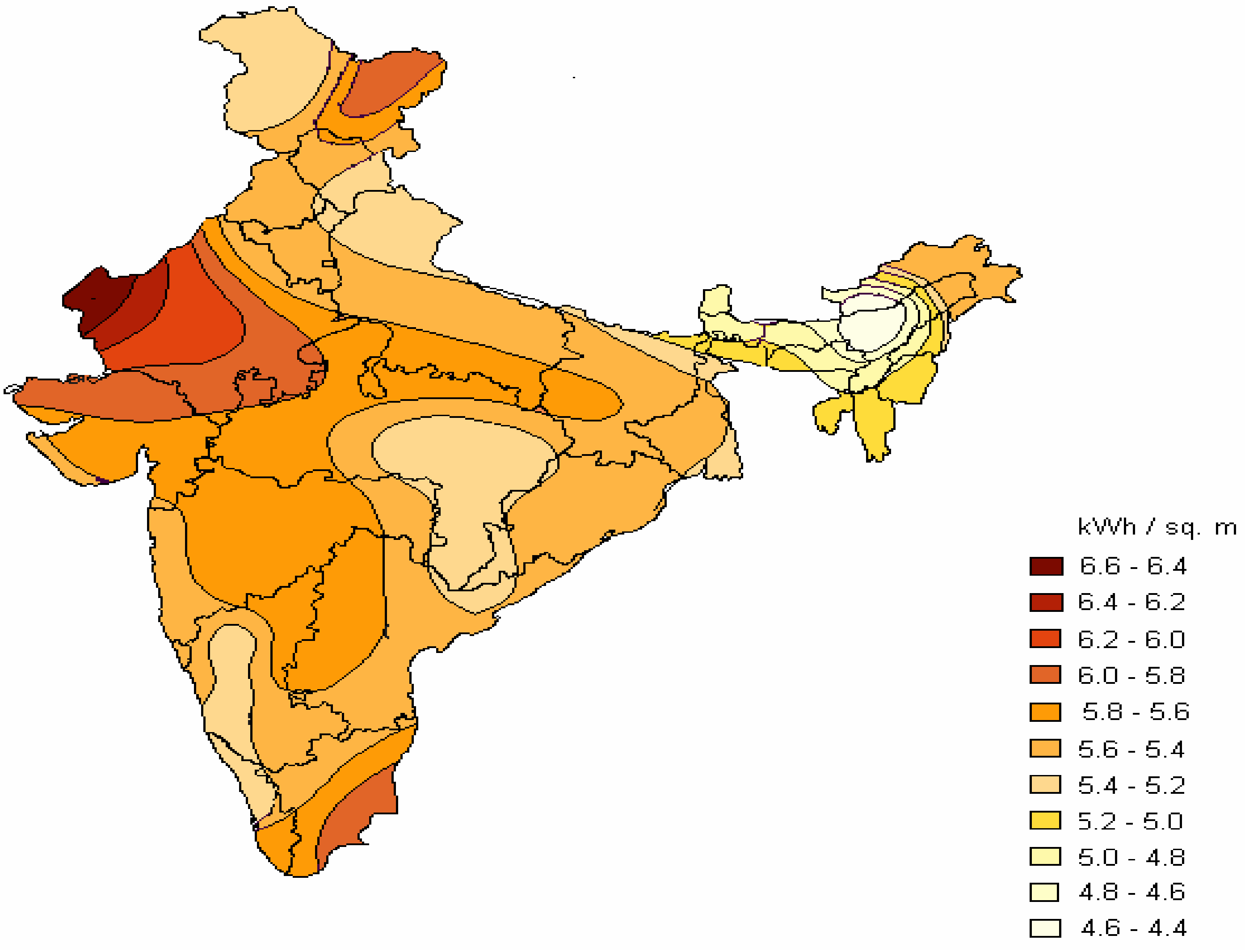
Overview of Solar cell Technologies

Solar Energy

- Most readily available and free source of energy
- It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year.

- India receives solar energy in the region of 5 to 7 kWh/m^2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilometre land area.

Solar Map


kWh / sq. m
6.6 - 6.4
6.4 - 6.2
6.2 - 6.0
6.0 - 5.8
5.8 - 5.6
5.6 - 5.4
5.4 - 5.2
5.2 - 5.0
5.0 - 4.8
4.8 - 4.6
4.6 - 4.4

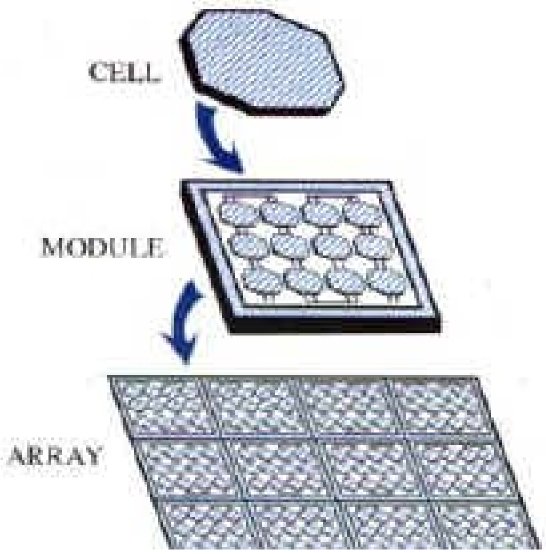
- Solar energy can be utilised through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes.
- **Solar thermal -**route uses the sun's heat to produce hot water or air, cook food, drying materials etc.
- **Solar photovoltaic-** uses sun’s heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting.

Solar Photovoltaic (PV)

- PV cells are usually made of silicon, an element that naturally releases electrons when exposed to light.
- The magnitude of the electric current generated depends on the intensity of the solar radiation, exposed area of the solar cell, the type of material used in fabricating the solar cell, and ambient temperature.

- Typically, one cell produces about 1.5 watts of power. Individual cells are connected together to form a solar *panel* or *module*, capable of producing 3 to 110 Watts power

- Panels can be connected together in series and parallel to make a solar *array*
- Modules are usually designed to supply electricity at 12 Volts. PV modules are rated by their peak Watt output at solar noon on a clear day.



PV tracking systems

- Positioning of solar panels or collectors can greatly influence the system output, efficiency and payback.
- Tilting mechanisms provided to the collectors need to be adjusted according to seasons (summer and winter) to maximise the collector efficiency.

- PV tracking systems is an alternative to the fixed, stationary PV panels. PV tracking systems are mounted and provided with tracking mechanisms to follow the sun as it moves through the sky. These tracking systems run entirely on their own power and can increase output by 40%.

Silicon Wafer

- Silicon is the basic raw feedstock material for PV cell
- The primary source of silicon is Quartzite, found in ordinary sand
- It takes a lot of energy to make a pure silicon wafer, on which a solar cell is grown. Silicon is purified, melted and crystallized into ingots. The ingots are then sliced into wafers to make individual cells. Some quantity of precious silicon material is also lost during wafer production. Silicon , after processing doesn’t come cheap, so it is important to use lesser quantity of silicon

- The thickness of the wafer is quite important in determining the cost of a solar cell. The average thickness of wafer has been reduced from 0.32 mm in 2003 to around 0.18 mm
- To avoid wastage of precious silicon wafer lost during production, ribbon sheet technology is used. It involves pulling thin wafers from the melt, thus eliminating the wastage.

Common Types of PV cells- Crystalline type

- Single crystal (Mono-crystalline) silicon
- Polycrystalline silicon
- Ribbon silicon
  - Individual cells are attached to a base called a back-plane, which is usually a layer of a metal used to physically reinforce the cells and provide electrical contact at the bottom.
  - Polycrystalline cells are manufactured by a similar process using relatively less pure silicon.
  - In case of ribbon type PV cells, molten silicon is drawn into the form of ribbon.

Thin film cells

- As pure silicon is very expensive material, continuous efforts are on to produce cells with very little or no quantity of silicon. This type of technology is known as thin film technology.
- Thin film modules are made by depositing very thin layers of photosensitive materials on a low cost backing. Typical inexpensive substrates used for the purpose are made of glass, stainless steel or even plastic.

- Three types of thin films are commercially available:
  - Amorphous silicon
  - Cadmium telluride
  - Copper indium diselenide
- These have active layers in the thickness range of less than a few microns and are suitable for large scale production.
- One of the unique advantage of amorphous silicon is that it can be moulded into many different shapes. However, thin film cell technologies possess lower solar to electric conversion efficiencies in comparison to crystalline silicon cell technologies.
- Crystaline silicon is the most dominant cell technology at present with market share of 90%

Currently available module efficiencies

Technology	Module Efficiency	Remarks
Single crystal silicon	13--15	Highest efficiencies but more expensive
Polycrystalline silicon	12-14	Slightly less efficient but no distinct advantage
Amorphous silicon	6-7	Very low efficiency but cheaper fabrication cost
Cadmium telluride	8-10	Moderately efficient, just beginning to make market impact
Copper indium diselenide	10-11	Most efficient amongst rest of thin films, negligible market share

Approximate share of cell technologies

Technology	Share (%)
Single crystal silicon	43.4
Polycrystalline silicon	46.5
Ribbon sheet (crystalline silicon)	2.6
Amorphous silicon	4.7
Cadmium telluride	2.7
Copper indium diselenide	0.2

Comparison between thick(crystalline silicon) and thin film (amorphous silicon for example)

Crystalline Silicon	Amorphous silicon
High quality of cells with no change in performance levels	Not very stable under outdoor light conditions (loses some power initially)
High solar to electric conversion efficiency	Very low efficiency
Long life (about 25 years)	Short life (< 10 years)
Occupies market share of more than 90%	Market share less than 5%

Average area requirements for different types of solar modules

Technology	Average Area requirement (per KWp)
Single crystal silicon	7 sq mt
Polycrystalline silicon	8 sq mt
Amorphous silicon	15 sq mt
Cadmium telluride	11 sq mt
Copper indium diselenide	10 sq mt


Thank You!