Alternative Energy
Chapter 3 Part 1
Photovoltaic Principle

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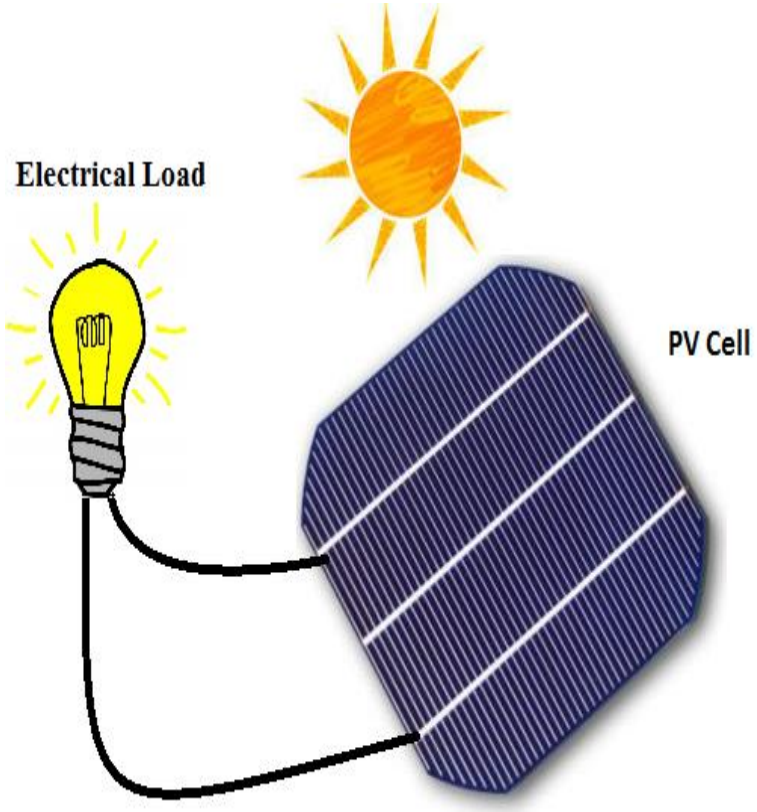
Chapter Description

- Expected Outcomes
  - understand PV cell characteristic

- References
  - Grid-connected Solar Electric Systems: The Earthscan Expert Handbook by Geoff Stapleton and Susan Neill, 2010.
  - Stand-alone Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation by Mark Hankins, Earthscan, 2010.

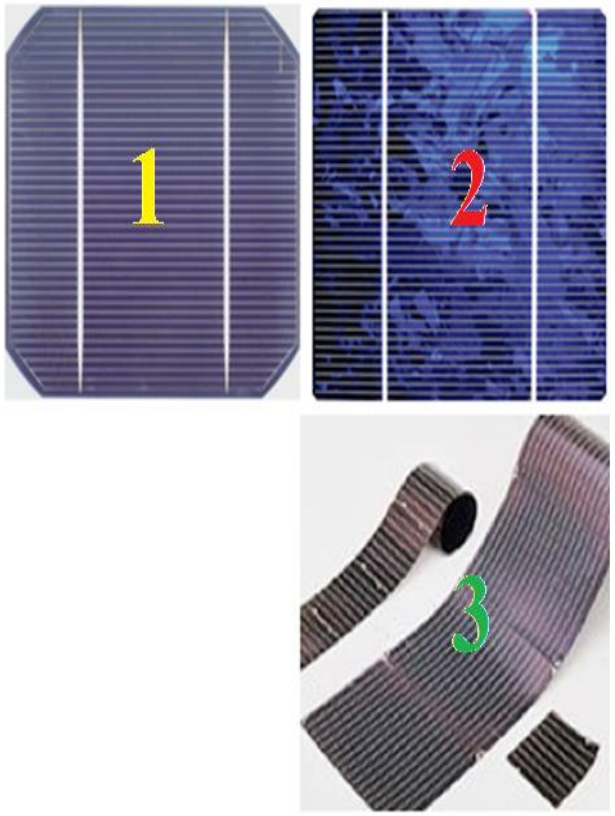
PV Cell

- Solar/PV cell convert sunlight to electricity based on ‘photo-electric effect’
- Made from semiconductor material (silicon)
- Silicon is the most widely used material in PV cell production.



Solar Cell Technology

1. **Monocrystalline silicon** - a single silicon seed crystal
2. **Poly/Multicrystalline silicon** - composed of many small crystals which grow in random orientations
3. **Amorphous silicon Thin film** - non-crystalline silicon that is deposited on the back of glass or substrate
4. **Heterojunction with intrinsic thin layer (HIT)** - use both crystalline silicon cells and amorphous silicon thin film technology



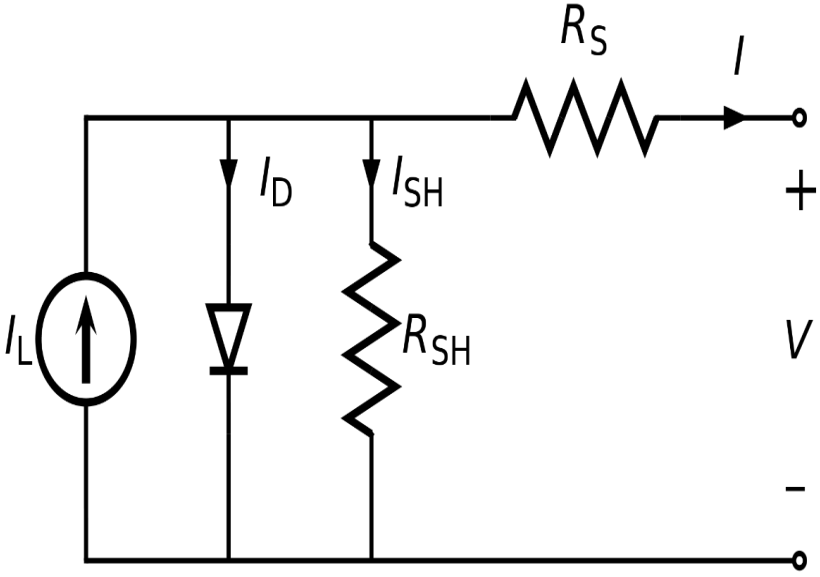
Solar Cell Technology

Type of PV Technology	Commercially Module Efficiency	Note
Monocrystalline	14-20%	The most efficient and expensive
Poly/Multicrystalline	13-15%	Lower efficiency than mono
Amorphous Silicon Thin Film	6-9%	Less expensive to manufacture

PV Cell Characteristic

PV cell can represented using an equivalent circuit diagram of a p-n junction (single diode model)

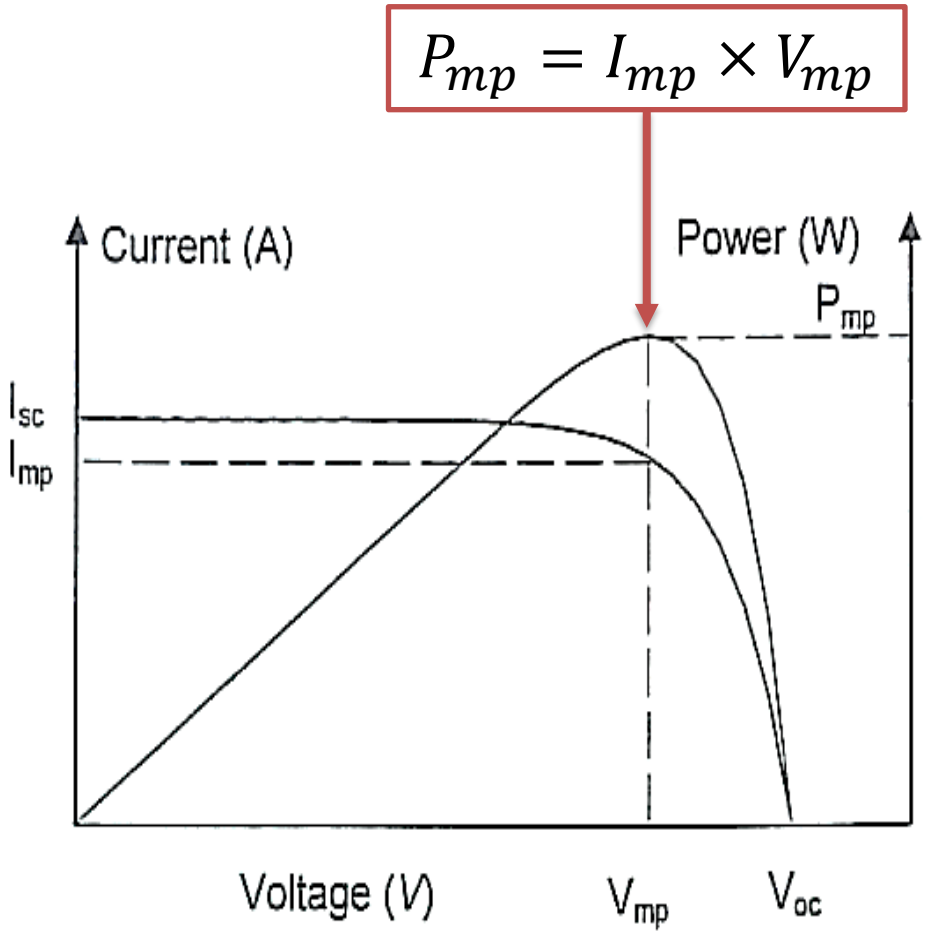
- I_L - light generated current
- I_D - diode current
- I_{SH} - shunt current
- R_{SH} - shunt resistor
- R_S - series resistor
- V – voltage across the PV cell



PV cell equivalent circuit

PV Cell Characteristic

- The characteristic of a PV cell can be presented in I-V curve
- Plot of current versus voltage at different resistances
- Power is 0W when either I or V is equal to zero.
- Maximum power ($\boldsymbol{P_{mp}}$) is produced when V= $\boldsymbol{V_{mp}}$ at which point the current is $\boldsymbol{I_{mp}}$



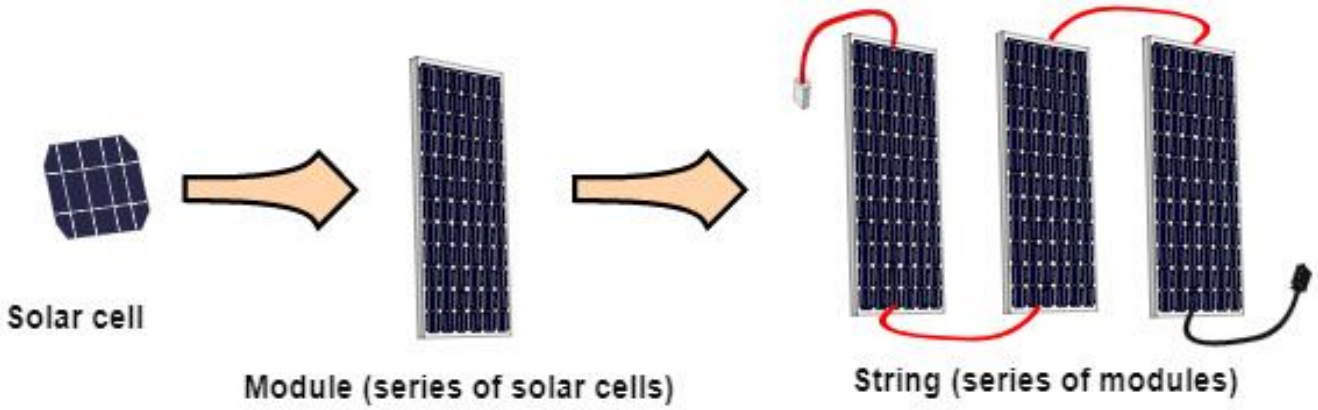
PV Cell Characteristic

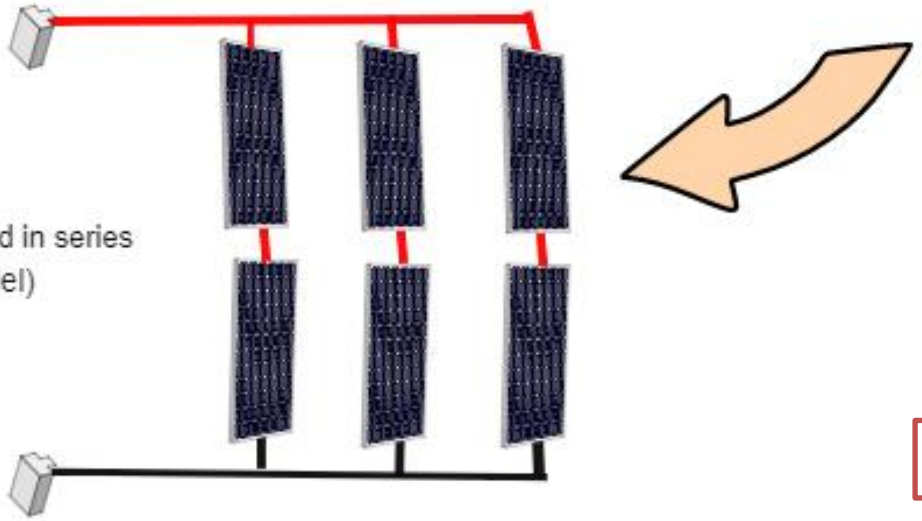
- Fill factor, $FF = \frac{I_{mp} \times V_{mp}}{I_{sc} \times V_{oc}}$
- Typical values of fill factor range between 0.6 and 0.7
- Conversion Efficiency,

$$\eta = \frac{\boldsymbol{P_{out}}}{\boldsymbol{P_{in}}} = \frac{I_{mp} \times V_{mp}}{\boldsymbol{G} \times \boldsymbol{A}} = \frac{I_{sc} \times V_{oc} \times \boldsymbol{FF}}{\boldsymbol{G} \times \boldsymbol{A}}$$

$\boldsymbol{P_{out}}$ – output from cell
G – solar irradiance
$\boldsymbol{P_{in}}$ – input from cell
A – active area of cell

PV Cell and Module Configuration





Array
(Modules connected in series and parallel)

From Cell to Array


THANK
YOU