Alternative Energy
Chapter 3 Part 2
Photovoltaic Cell/Module Performance

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Chapter Description

- Expected Outcomes
  - understand the factors that effect to PV cell/module performance

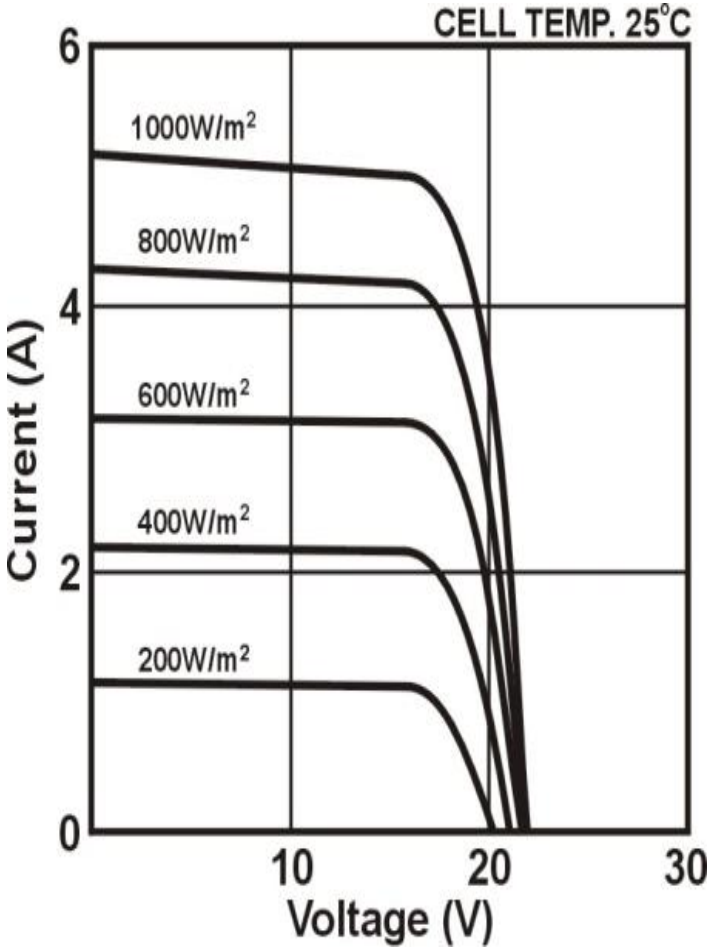
- References
  - Grid-connected Solar Electric Systems: The Earthscan Expert Handbook by Geoff Stapleton and Susan Neill, 2010.
  - Stand-alone Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation by Mark Hankins, Earthscan, 2010.

PV Output

- Power output of a module depends on:
  - Number of cells in the module
  - Type of cells
  - Total surface area of the cells
- The power output of a module changes depending on:
  - Amount of solar radiation
  - PV cells temperature

Effect of Solar Irradiance

- Current output of a PV module is highly dependent on irradiance
- Voltage output does not change dramatically
- Power significantly increases with the increase of solar irradiance



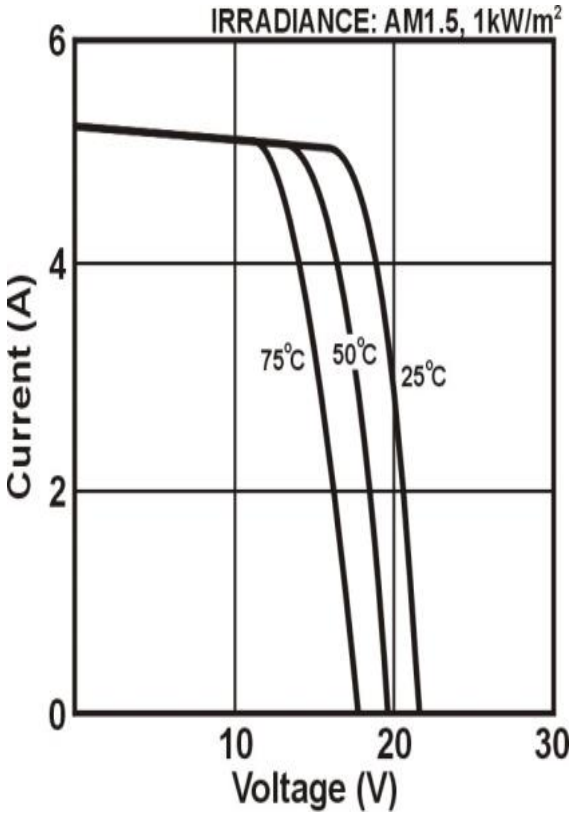
Effect of Temperature

- The output of a PV cell or module depends on its operating temperature
- The module's temperature gets elevated when exposed to the sun
- Thus it is imperative that the operating cell temperature of a module is determined when designing the system

Effect of Temperature

The output of a PV module is related to temperature as follows:

- Current marginally increases with an increase in module temperature.
- Voltage significantly decreases with an increase in module temperature.
- Power significantly decreases with an increase in module temperature



The V_{mp} decreases by approximately 0.5% per ºC as the PV cell temperature increases above 25ºC

Cell Operating Temperature

- The empirical formula for calculating the cell or module temperature during operation when exposed in the field is:

$$T_{cell} = T_{amb} + \left[\left(\frac{NOCT - 20}{800\ Wm^{-2}}\right) \times G\right]$$

NOCT – Nominal operating cell temperature (given by manufacturer)

T_{amb} – Average maximum ambient temperature

G – Irradiance at that ambient temperature

- In case NOCT is not available, the approaximate value of cell temperature is $T_{cell} = T_{amb}$+ 25°C

PV Module Specification

- Datasheet provides technical information required to design and install PV array
- Useful for user to compare different types of PV modules as it provides basic information about efficiency, rated power and physical size
- The electro-physical output rating of PV cells and modules are given at specific conditions
- These conditions are called as Standard Test Conditions (STC)

Testing Standards

- Standard Test Condition (STC) is defined as follows:

PARAMETER	SYMBOL	VALUE
Irradiance at normal incidence	G	1,000 Wm^{-2}
Cell temperature	T	25°C
Solar Spectrum (Air Mass)	AM	1.5

- All PV cell/module manufacturers provide their datasheet at this conditions

Testing Standards

- Nominal Operating Cell Temperature (NOCT) gives a more practical indication of the probable operating cell temperature in real conditions.
- The NOCT conditions are defined as:

PARAMETER	SYMBOL	VALUE
Irradiance at normal incidence	G	800 Wm^{-2}
Cell temperature	T	20°C
Solar Spectrum (Air Mass)	AM	1.5
Wind Speed	ws	1.0 ms^{-1}

PV Module Specification

Electrical Characteristics

	SX 160B	SX 150B	SX 140B
Maximum power (P_{max})	160W	150W	140W
Voltage at P_{max} (V_{mp})	35.0V	34.5V	34.0V
Current at P_{max} (I_{mp})	4.57A	4.35A	4.11A
Warranted minimum P_{max}	150W	140W	130W
Short-circuit current (I_{sc})	4.85A	4.75A	4.5A
Open-circuit voltage (V_{oc})	44.0V	43.5V	42.8V
Temperature coefficient of I_{sc}	(0.065±0.015)%/°C		
Temperature coefficient of voltage	-(160±20)mV/°C		
Temperature coefficient of power	-(0.5±0.05)%/°C		
NOCT	47±2°C		
Maximum series fuse rating	15A		
Maximum system voltage	600V (U.S. NEC rating) 1000V (TÜV Rheinland rating)		

Output at STC

Temperature coefficient

Nominal operating cell temperature

Courtesy of BP Solar


THANK
YOU