Course: Sustainable Energy Technology-1
12150310

Title: PV Technology-L3

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Photovoltaics Characteristics

PV module output power:

$$P_{PV\text{-}gen} = P_{mp\text{-}STC} \times (G/G_{STC}) \times [1 + K_T(T_{cell} - T_{STC})]$$

$$T_{cell} = T_{amb} + (((NOCT\text{-}20)/800) \times G)$$

Or $T_{cell} = T_{amb} + 0.0256 * G$

$P_{mp\text{-}STC}$ is the rated power of the PV module (given by manufacturer)

G_{STC} is the radiation at standard test conditions 1000 W/m2

T_{STC} is the temperature at standard test conditions 25 C

NOCT is the Normal Operating Cell Temperature (given by manufacturer)

Photovoltaics Characteristics

Normal Operating Cell Temperature (NOCT):

It depends on PV construction.

Finned Aluminum Substrate 40 C

Glass substrate 41 C

Al substrate 43 C

Fiber glass substrate 47 C

Photovoltaics Characteristics

PV Power Systems:

A- Isolated (Standalone) PV systems:

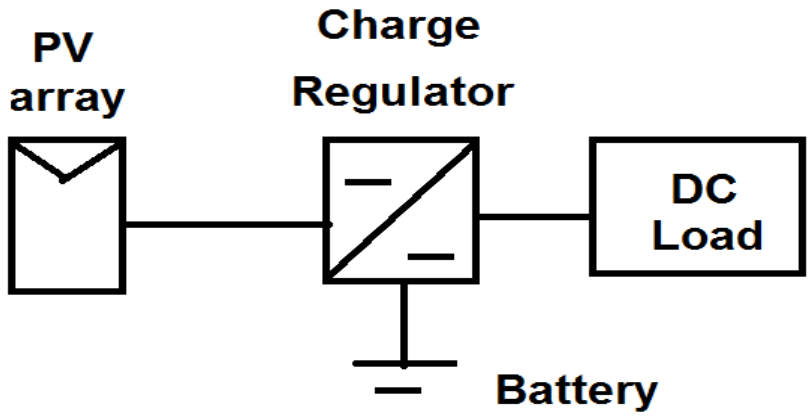
1- DC decentralized: (DC loads)

2- AC decentralized : (AC loads)

3- AC centralized: (Ac loads)

B- On-grid (Grid-tied) PV systems.

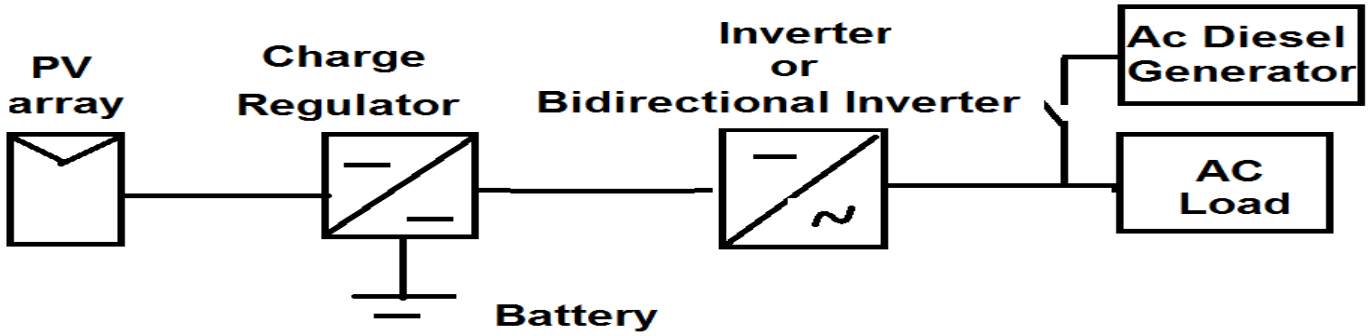
1- DC decentralized systems



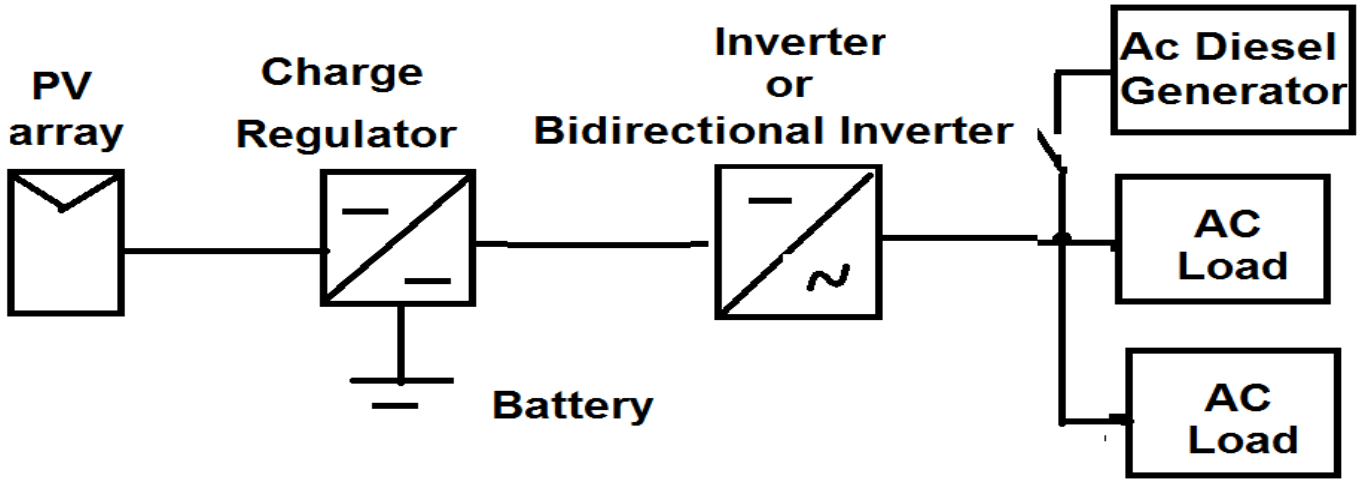
Photovoltaics Characteristics

PV Power Systems:

2- AC decentralized systems (For each consumer)

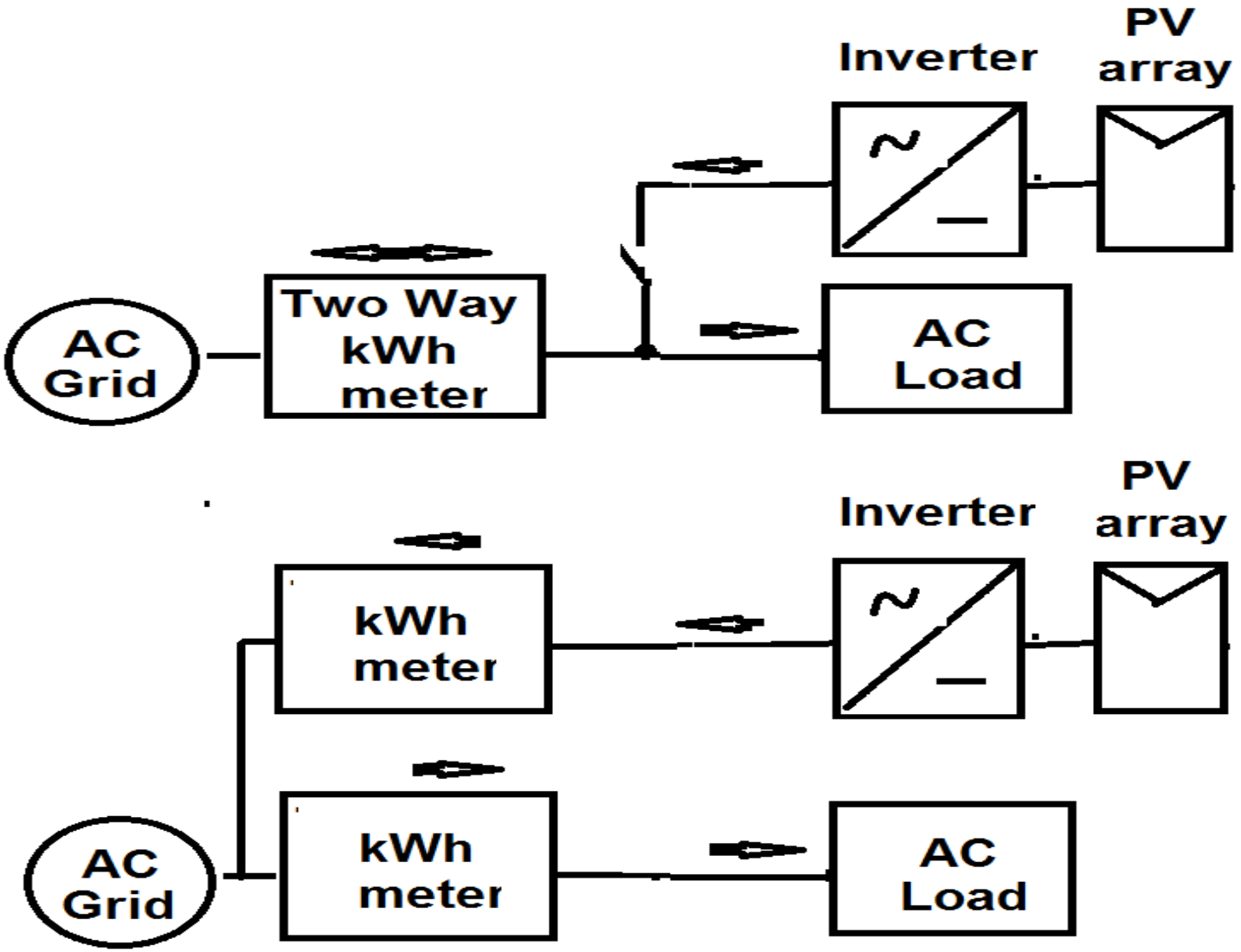


3- Ac centralized systems: The same as AC decentralized but the same PV system for the multi customers



Photovoltaics Characteristics

On-grid PV systems:



Photovoltaics Characteristics

Some rules of thumb regarding selection of the appropriate PV system type:

If P_{PV} < 600 Wp--------- Use DC decentralized

If 600 Wp< P_{PV} < 2200 Wp ------- Use Ac -1ph decentralized

If 2200 Wp< P_{PV} < 5000 Wp ----- Use Ac -3ph decentralized

If P_{PV} > 5000 Wp ------Use AC centralized (3-Ph)

If P_{PV} < 5000 Wp ------ Use AC centralized (1-ph)

If P_{PV} < 600 Wp-------Use 12 V DC bus system

If 600 Wp <P_{PV}<1500 Wp--- Use 24 V DC bus system (regular)

If 1500Wp <P_{PV}---------- Use 24 V DC or higher bus system (Block)

Photovoltaics Systems components

Charge regulators:

Regulate voltage to charge battery since the output of the PV module is not constant.

Functions:

- Prevents reversal of power
- Protect battery against excessive overcharge or deep discharge
- Switches off the battery when it is fully charged.
- Its ratings are selected to suit $V_{battrery}$, P_{pv}, V_{pv}

Photovoltaics Systems components

Storage batteries:

To supply isolated systems

1- Nickel Cadmium NiCd 2- Lead Acid cells 3- Lithium batteries

1- Nickel Cadmium NiCd : 1.2 V/cell ; low efficiency; high toxic; long life; deep discharge; high discharge rate; low energy density.

(biomedical equipment, professional video cameras and power tools)

- **Nickel Metal Hydrate (NiMH)**: Higher energy density compared to the NiCd; Reduced cycle life; NiMH contains no toxic metals.

(Applications include mobile phones and laptop computers).

2- Lead Acid batteries:

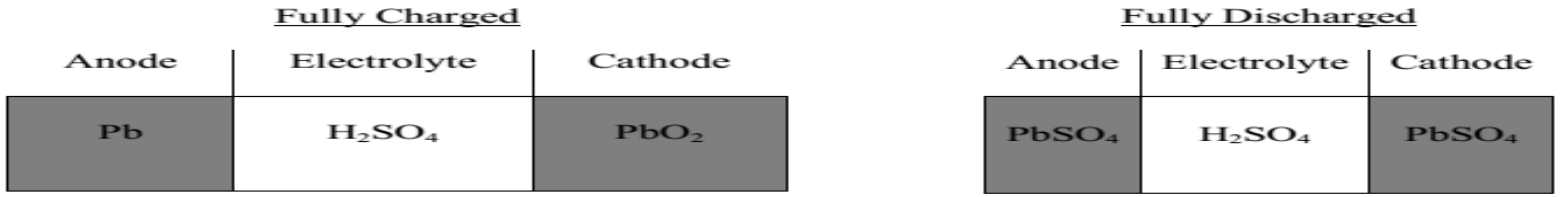
1.75-2.4 V per cell; higher efficiency; lower cost; less toxic w.r.t NiCd; less life; Most economical for larger power applications where weight is of little concern;

The lead acid battery is the preferred choice for hospital equipment, wheelchairs, emergency lighting and UPS systems.

Photovoltaics Systems components

Lead Acid batteries (Wet (Flooded) + Sealed (valve regulated)):

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} 2PbSO_4(s) + 2H_2O(l) \quad E\_cell=2.05V$$



I- Regular batteries: 6 cells; 12 V (10.8 -14.4); It is not the best for solar system; 70 $/kWh; 100 Ah

PV systems requires high cycling stability and very deep discharge

II- Block batteries: One cell per each; 2 V; stationary;

More than 10 years; high cycling stability; more efficient; higher cost; 140 $/kWh; 260-1000 Ah

Battery Capacity:

CWh = CAh * V

C10 = 1000 Ah means I discharge = 100 A at 10 hours

C20 = 100 Ah means I discharge = 5A at 20 hours

C5 = 100 Ah means I discharge = 20 A at 5 hours