Alternative Energy

Chapter 4 Part 2:PV System Components

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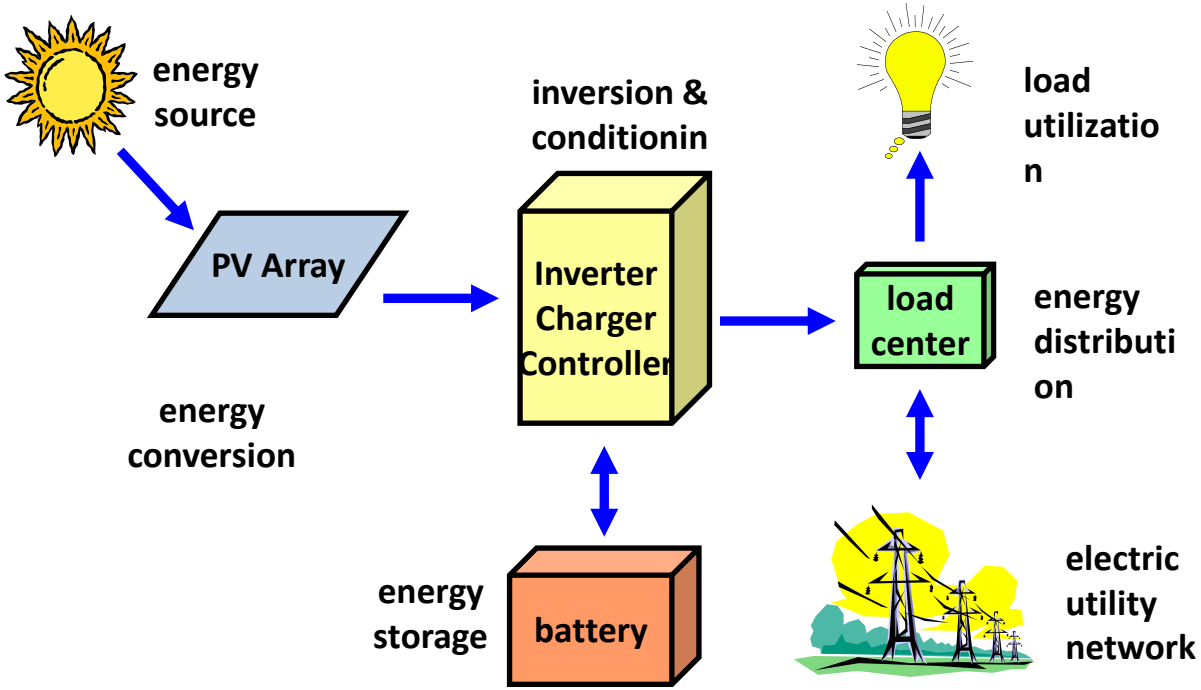
Chapter Description

- Expected Outcomes
  - understand about the main PV system components

- 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.

Photovoltaic System

The combination of all components and subsystems for converting the solar energy into electrical energy that is suitable for connection to a utilization load.



PV System Components

- ***PV Array***: An electrical assembly of PV modules that convert sunlight to DC electricity.
- ***Energy Storage:*** Electrical or other storage devices sometimes used to store energy produced by PV arrays for later consumption.
- ***Inverter:*** A device that converts DC power from batteries or PV arrays into utility-grade AC power.
- ***System Charge Controller:*** A device used to protect batteries from overcharge and over discharge, and sometimes to provide load control functions.
- ***Load:*** Energy consuming electrical appliances served by the system.
- ***Balance of System (BOS) Components:*** Other equipment required to control, conduct, protect, distribute power and structurally support the system.

Energy Storage

- Battery – commonly used for storing electrical energy
- Common type of rechargeable battery
  - Lead acid, nickel metal hydride, lithium-ion, lithium-polymer nickel cadmium and so on
- Lead acid batteries are used almost exclusively in PV system due to more cost effective and readily available.
- Battery Capacity – amount of energy that a battery can store (unit: amp-hours (Ah))

Charge Controller

- Function – to regulate the voltage and current coming from solar array to the battery
- Preventing from **overcharging** which causes plate corrosion, gassing and loss of liquid
- Preventing from **deep discharging** or discharging below their cut-off voltage which might cause permanent damage to the battery and loss of capacity

Type of charge controller

1. Series-type controllers:
   - rely on relays or electronic switches in series between the PV module and the battery.
   - Disconnect the PV module when the battery reaches a set voltage
2. Shunt-type controllers: parallel between the array and battery
   - Gradually reduce power from the PV module to the battery as the battery reaches full charge (short-circuiting back through the module)
   - Low cost, simple, well suited for small off-grid PV systems

Type of charge controller

3. Pulse-width modulation (PWM) controllers:
   - Send pulse of charges of charge to the battery that vary depending on its state of charge (SOC).
   - Battery with low SOC gets a wide pulse (high charge) and send increasingly narrow pulse as the battery gets fully charged.
4. Maximum power point tracker (MPPT) controller
   - Track for the maximum power point of the solar array and convert the extra power available (in the extra voltage) to provide extra current at the battery charge voltage.

Inverter

- Convert lower voltage DC electricity into higher voltage AC.
- PV array and inverter interface:
  - Stand-alone system
  - Grid-connected system

Inverter for Stand-alone system

- Two ways that the inverter can be used in stand-alone systems:
  - Small inverter to power a single appliance
  - Larger inverter to power entire circuits
- Typically about 90% efficiency
- Available in sizes ranging from 50W to thousands of watts

Inverter for Grid-connected system

- All grid-connected inverters perform these basic functions:
  - Convert DC from array to AC power and fed to the grid
  - Ensure power being fed into the grid is at the **appropriate frequency and voltage**. Otherwise it will not release the electricity to the grid.
  - Use MPPT to ensure that the inverter is finding the maximum power available from the PV array to convert to AC
  - Inbuilt **active and passive safety protections** to ensure that the inverter itself down when the grid is not operating within acceptable voltage and frequency tolerances

Inverter for Grid-connected system

Type of grid inverters may be different in a number of ways:

- With transformer or without transformer
- Switching frequency of the transformer used
- How the array and inverter interface with each other
- The inverter's rated capacity
- Whether the input has a single or multiple string inputs
- Whether it is designed for single phase or multiple phase power supplies

Choosing Inverter

- Type of inverter – grid-tied or stand-alone system
- Inverter Size (power rating)
- Input Voltage
  - Stand-alone : depend on system voltage (12V, 24V, 48V….)
  - Grid-connected: allowable input voltage ranges of the inverter
- Efficiency
- Safety and protection

Balance of System (BOS)

- The BOS components include mounting materials for the modules, wire and all wiring components, lightning protectors, grounding connections, combiner box and battery containers.
- Protection components: Circuit breaker, fuses, isolators, switch, Surge protective device, diodes (blocking and bypass)
- Other important components: energy meter, system monitoring

BOS

- Certain BOS components are regulated by codes or standards.
  - Array mounts, for example, must meet any wind loading requirements of applicable building codes (in Malaysia: MS1553 – code of practice on wind loading for building structure)
  - Cable sizes, voltage drop, protection devices, etc.. must comply with the standards (eg: Malaysian Standard MS1837:2010)

Thank You