Alternative Energy

Chapter 6 Part 1: PV Grid-Connected System Design

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Chapter Description

- Expected Outcomes
  - Design a grid-connected PV system
  - To apply the system sizing based on design criteria

- References
  - Grid-connected Solar Electric Systems: The Earthscan Expert Handbook by Geoff Stapleton and Susan Neill, 2010.

Site Survey

A site survey is required before designing the system. So, it important to determine :

1. the solar access for the site.
   - whether any shading will occur and estimate its effect on the system.
   - Estimate the solar resource at the site.
2. the available area to install the solar array.
   - whether the roof/structure is suitable for mounting the array.
   - How to mount the PV modules on the roof.
3. components location to be installed
   - where the inverter will interconnect to the grid.
   - where to locate the array junction box, inverter and kWh meter
   - the cabling route and therefore estimate the length of the cable

Selecting Inverter

- ✓ **There are several types of inverter:**
  1. **Central**
  2. **Multi-string**
  3. **String**
  4. **Modular**

- ✓ **Things to consider when selecting an inverter are:**
  - i. **The peak rating of the PV array**
  - ii. **Whether all the solar modules are in the same plane (the same tilt angle and direction)**
  - iii. **The type of shading that occurs on the array**
  - iv. **The capital costs of the different inverters**
  - v. **The average annual energy yield**

System Sizing

In general, a PV Grid-Connected system can be designed based on the following limiting design criteria:

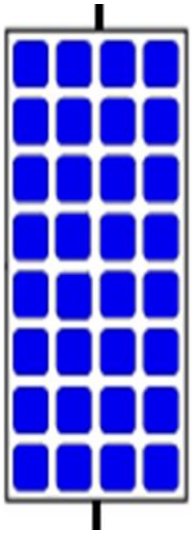
i. **to fit on available roof area** - determine the total number of modules that can be mounted on the roof.

ii. **to meet yearly energy requirements** - determine the PV array capacity to meet the energy requirement.

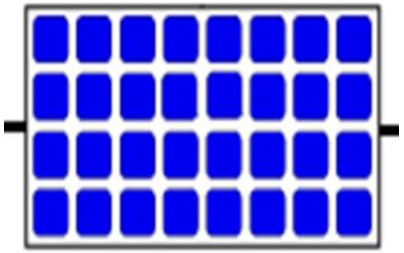
iii. **to meet a specific budget** - determine the PV array capacity that fits within the budget constraint.

Designed to fit on available roof area

- ✓ The possible number of PV modules that can fit on an area or roof is limited by the actual width and length of the module compared with the width and length of the available space.
- ✓ A PV module has two fixed dimensions which are the width and length, in general modules are in a rectangular shape.
- ✓ The PV modules could then be installed either mounted in length wise up or in length wise across



Length-wise up



Length-wise across

Designed to meet yearly energy requirements

Consider the Sub-System Losses due to the following:

- ✓ Inverter efficiency
- ✓ Cable losses (transmission efficiency)
- ✓ Average yearly irradiation for the tilt angle and the orientation of the PV modules
- ✓ Manufacturing and mismatch tolerance of the PV modules
- ✓ Temperature effects
- ✓ The effects of dust or dirt on the PV modules

Designed to meet yearly energy requirements

The total number of PV module required is

$$N_{total} = \frac{E_{system}}{P_{mod\_STC} \times PSH_{pa} \times f_{temp} \times f_{mm} \times f_{dirt} \times \eta_{pv\_inv} \times \eta_{inv}}$$

E_{system} annual energy requirement (kWh)

P_{mod_STC} peak rating of the PV array at STC (kWp)

PSH_{pa} PSH for the specified tilt angle over one year (h)

f_{temp} derating factor for temperature

f_{mm} derating factor for manufacture tolerance and mismatch

f_{dirt} derating factor for dirt

η_{pv_inv} cabling efficiency between the PV and the inverter

η_{inv} energy efficiency of the inverter

Designed Based on Budget

The systems designer shall consider all the various activities and items that incur costs to make up a complete PV system, such as: consultation and design work, hardware equipment, installation, test and commission and all relevant costs and fees.

Typically the size of the complete PV system ¡s accounted for in terms of the installed price per installed PV array capacity.

$$N_{total} = \frac{Budget}{f_{cost}}$$

- *Budget is sum of money allocated for the investment*
- f_{cost} *is cost factor for PV system (RM per kWp)*

Conclusion

- In this module we have determined the total number of PV modules that is required based on the selected sizing criteria
- The final number will be dependent on the selection of the Inverter and the specific number of modules that can be connected in series and parallel to that inverter. This will be covered in the next module…

Thank You