UNIT-06

"RENEWABLE ENERGY HYBRID SYSTEM"

6.1 Need for Hybrid Systems

- The combinations of two or more different types of power systems are called **hybrid systems.**
- Such systems are needed to overcome the shortcomings (inherent problems) associated with one system by combining with another system.
- For example, solar based power system cannot operate at night since solar energy is not available.
- While the wind power generation is low during day time because wind velocities are low whereas the wind power generation is higher at night because of higher wind velocity.
- Thus, the combination of solar based power system with wind power system can ensure the continuous power supply.
- There could be many hybrid systems which may be exploited and used to improve the other renewable energy systems which are not fully utilized in remote and rural areas e.g. micro hydel system can be combined with biomass or PV systems.
- There could be many types of hybrid systems, however only few of the hybrid systems have been dealt in this chapter.

6.2 Integration of Renewable Energy Sources (RES) with Grid

- An **electric grid** is a network of synchronized power providers (power plants) and the interconnected group of connected loads (consumers of power) connected by transmission and distribution lines.
- There are large number of power plants operating on renewable sources of energy. These power plants needs to be integrated with the grid.
- **The advantages of integration of RES power plants with grid are :**
  1. It reduces the reserve capacity of power plant.
  2. It reduces the energy losses.
  3. Decrease in reserve capacity reduces the capital cost and the cost power generation.
  4. Power system becomes more reliable.
  5. It can easily meet the variable load demand.
  6. Seasonal variations of power production by renewable sources are offset.

6.2.1 Types of Hybrid Systems

Various hybrid systems for power supply which are relevant to Indian conditions are :

(i) Wind - Solar
(ii) Wind - Biogas
(iii) Biogas - Solar thermal
(iv) PV - diesel
(v) Wind - diesel
(vi) Biomass - Solar
(vii) Microhydel - PV or wind

The schematic diagram showing the components of a hybrid system for integration of renewable energy sources with the gird is shown in Fig. 6.2.1.

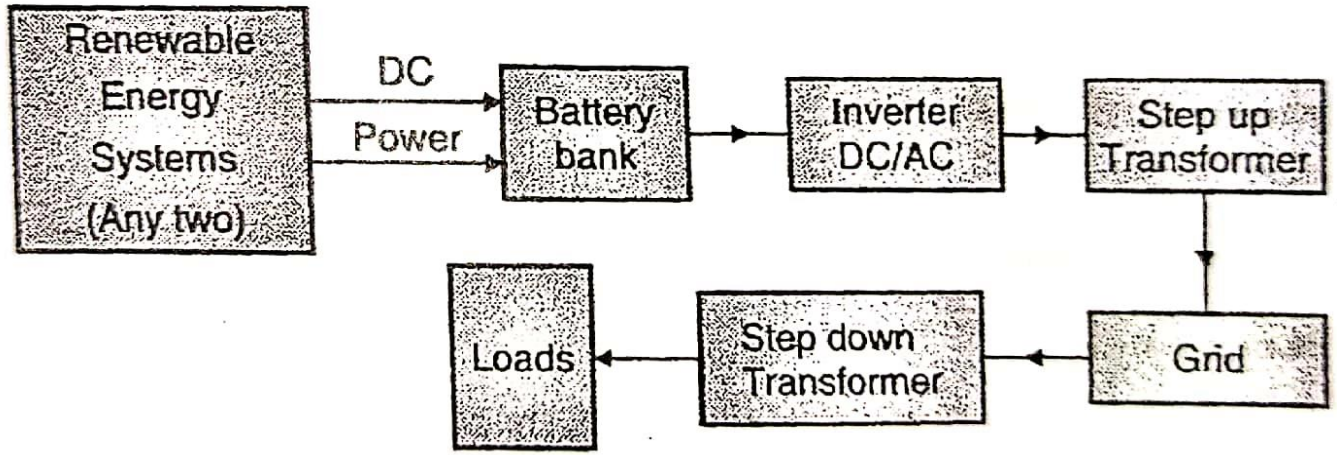


Fig. 6.2.1 : Schematic diagram for hybrid power system

As can be seen from Fig. 6.2.1, the basic components of hybrid systems are the renewable energy power systems which supplies the DC power to battery bank an inverter to convert DC to AC, step up transformer and the power grid.

6.3 Solar Wind Hybrid Power System

A system using the combination of wind power and solar power is called the **solar wind hybrid power system.**

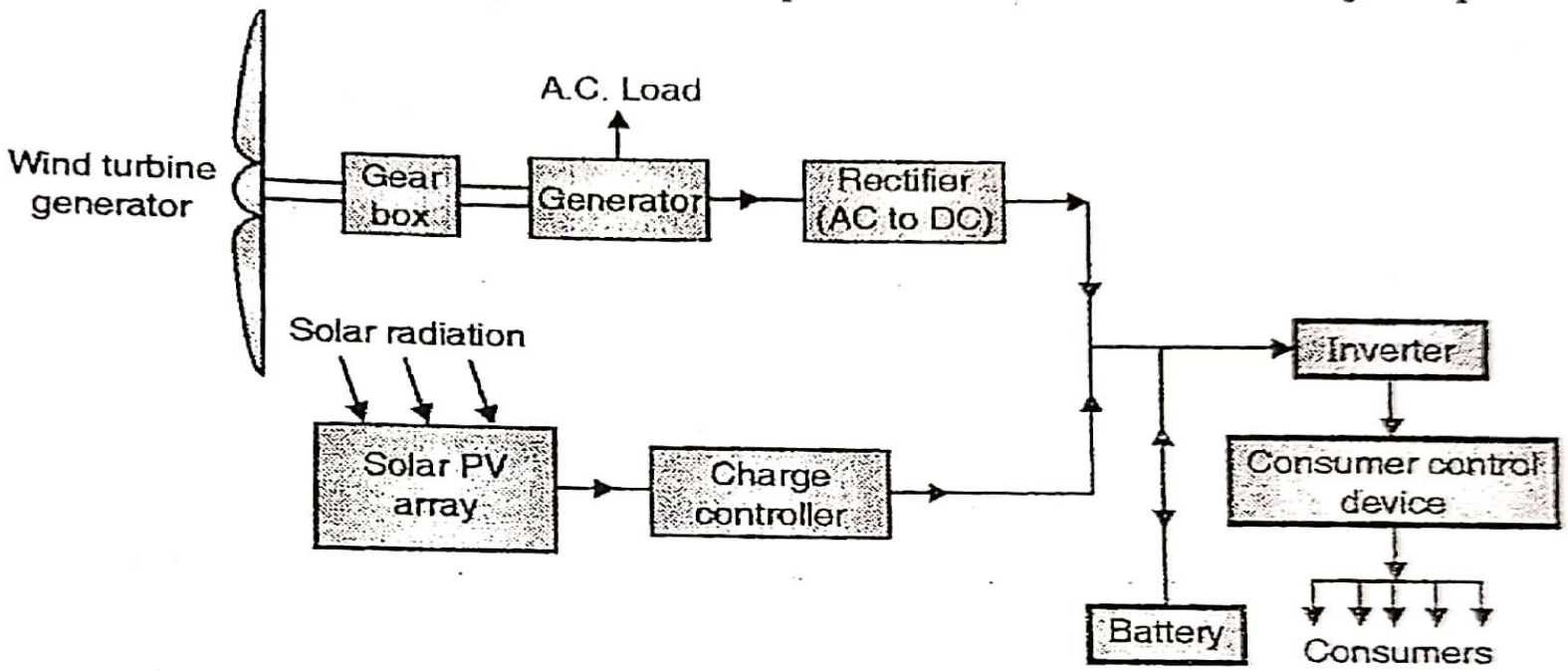


Fig. 6.3.1 : Solar-Wind Hybrid Power System

- These systems are under development. Such a system can be located in vast flat open terrains away from forests and tall buildings at locations where both the solar radiations and wind speeds are available for several months.
- In most locations, the wind often blows when sun is not shining while the wind velocities are low when the sun is shining.
- Therefore, the intermittent supply of wind power can be supplemented by solar power or by other means like diesel generating sets.
- Therefore, the solar wind hybrid power system ensures the continuous supply of power at remote locations where grid is not available.

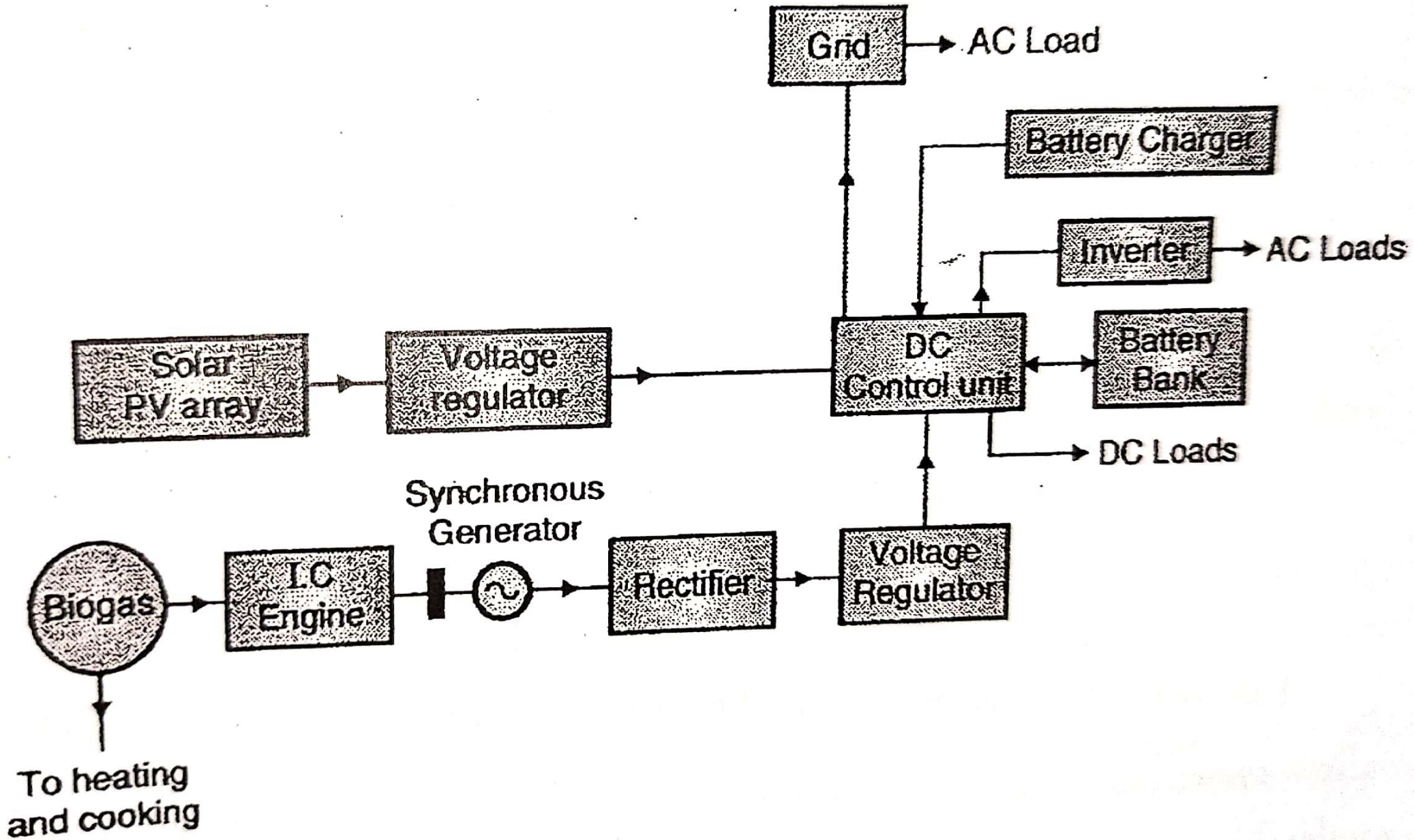
- A block diagram of solar-wind hybrid power system for an isolated location is shown in Fig. 6.3.1.
- During favourable wind period, the wind turbine generator generates AC power.
- It may be used directly and connected to AC loads. The excess AC power is converted into DC by rectifier and stored in bank of batteries.
- During the day time and favourable sun shine, the solar photovoltaic (PV) system converts the solar radiations received by it directly into DC power. It is stored in the bank of batteries.
- The DC power is converted into AC by an inverter. This power is supplied to various consumers, street lighting, pumping etc. through the consumer control devices.
- Battery acts storage system. It stores the excess power when demand of energy by consumers is less than the power produced by the solar-wind system.
- When the power produced by the system is less, the additional energy needed by the consumers is supplied from the battery.

Advantages of Solar-Wind Hybrid Power System are

1. Ensures continuous power supply.
2. System can be used at remote locations where transmission lines are not available.
3. It reduces the size of large energy storage (battery) needed individually for solar power system and wind power systems.

6.4 Solar-Biogas Power System

- Many remote rural areas in India are characterized with low energy demand with low population density. It results into high cost of power generation and transmission.
- However, many rural areas are bestowed with renewable sources of energy that can be converted into usable energy. It would meet their energy needs with poverty reduction.
- Biogas is a renewable sources energy. Its feed stock is human, animal and poultry manures which are easily and readily available in most rural areas. This feed stock can be easily converted into biogas. Advantage of biogas production is reduction in use of firewood for cooking and smoke in houses which is the causes of many respiratory diseases. Apart from this the residue from biogas plant is a valuable fertilizer which can be used in their fields for organic farming.
- On the other hand, solar energy which is available 270 days a year in India can generate both heat and electric power. It can be used for solar drying, water heating and provide electricity for lighting, operation of TV and radio, water pumping etc. Use of solar PV system for generation of electricity can improve quality of life in villages.
- Therefore, in the **biogas-solar hybrid system,** the biogas will cater for the thermal needs like heating and cooking and also the needs of lighting or rural community. Whereas, solar energy can be used for battery charging and supplimentary need of electric power.
- These hybrid systems can be implemented both for individual requirement as well for the community as a whole.
- Atleast two cows are needed for biogas generation to meet the individual needs of a household for heating and cooking requirement with availability of manure.
- Alternately, the ministry of renewable sources are promoting biomass gasifiers power plants based on locally available biomass like wood chips, rice husk, cotton and arhar dal stalks and other agro-residues in rural areas. It has taken up project for grid connected power plant upto 2 MW capacity.
- A solar-biogas hybrid system with gird is shown in Fig. 6.4.1.


Grid
AC Load
Battery Charger
Inverter
AC Loads
Solar PV array
Voltage regulator
DC Control unit
Battery Bank
DC Loads
Synchronous Generator
Biogas
IC Engine
Rectifier
Voltage Regulator
To heating and cooking

- The power generated by PV array during day time and the electric output of biogas I.C. engine is stored in the battery bank.
- The energy stored in the battery bank is drawn by electrical AC loads through the inverter which converts the DC in AC power.
- The inverter has the in-built protection against short circuits, overheating, low battery voltage and overloads.
- The battery banks is so designed that it can meet the loads upto a certain number of days when there is no solar power available. If it is a grid connected system, then it draws power from the grid.
- A petrol engine can run 100 % on biogas. If using diesel engines, it is modified so that it can operated both on bio-gas and diesel as per the requirement.

❖ WIND-BIOGAS HYBRID SYSTEM

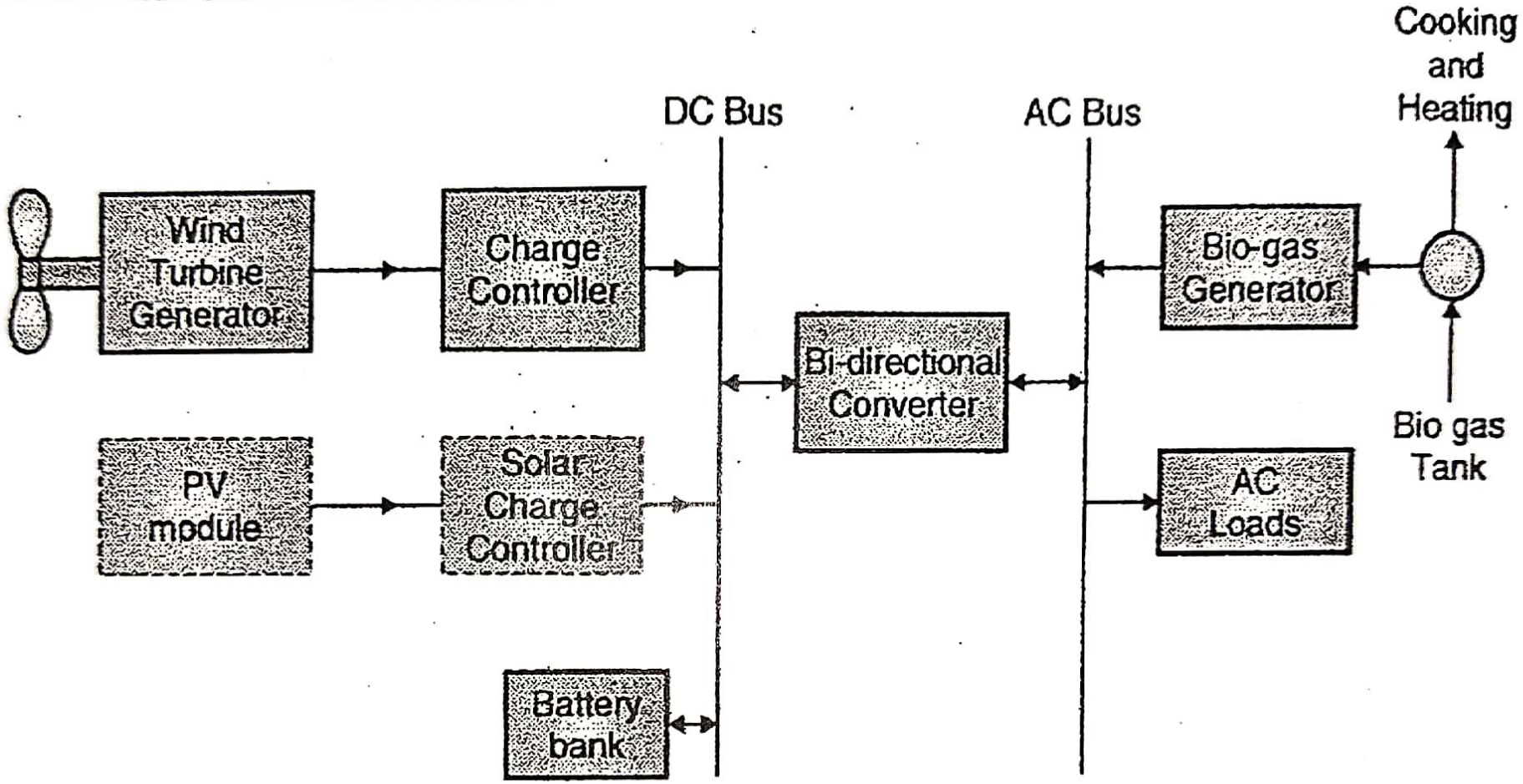


Fig. 6.5.1 : Circuit diagram of wind-biogas hybrid systems

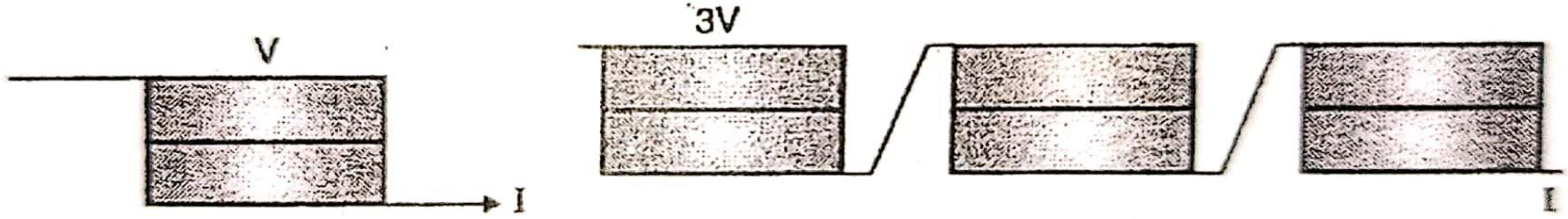
6.6.2 Power Output of Solar Photo Voltaic (SPV)

- A single PV cell of a standard size has a voltage of about 0.45V and capacity 0.33 W. It can provide 1.2 Ampere of current when exposed to full sun light.
- PV cells are arranged in series and parallel. If V is the voltage of a single cell and A is the current then,

  mV = Voltage produced when 'm' cell are connected in series

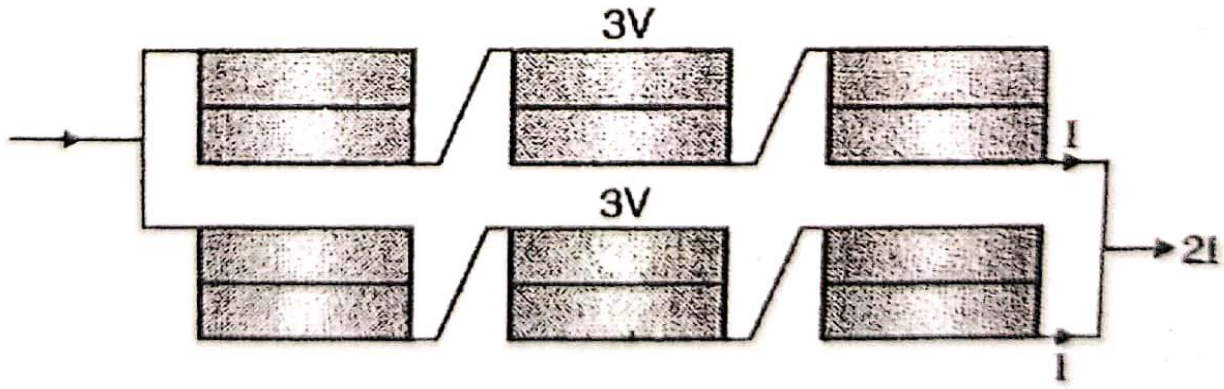
  nA = Current produced when 'n' rows of cells are arranged in parallel

- The arrangement of PV cells to form a module and array is shown in Fig. 6.6.1.

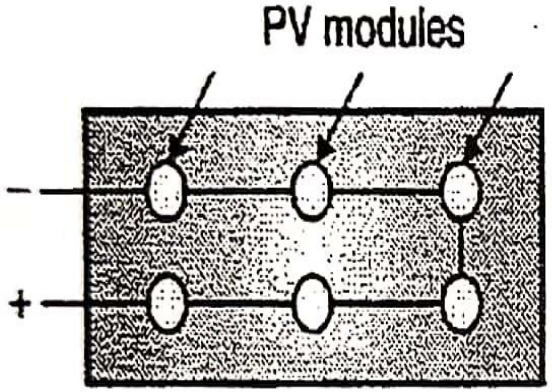


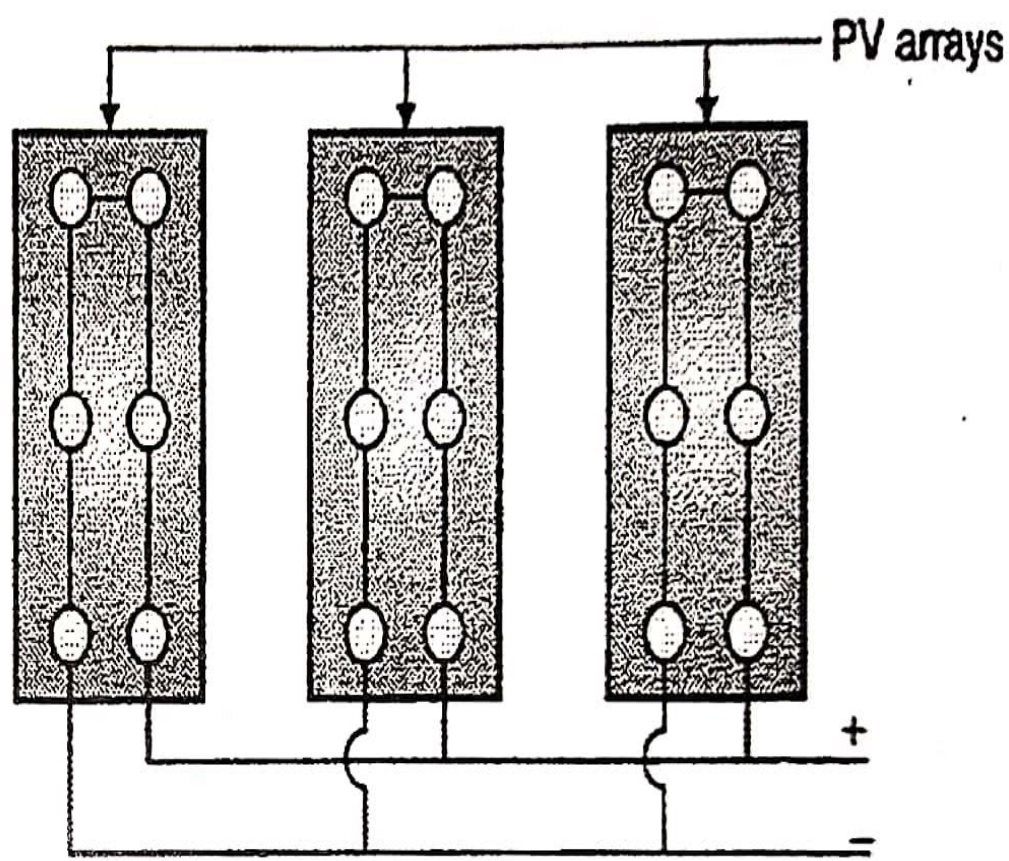
(a) Single cell

(b) Three cells in series(3V, I)



(c) Two rows in parallel with 3 cells in series in each row(3V, 2I)





(d) PV-Array(PV modules in series and parallel) (e) PV arrays in parallel

Fig. 6.6.1 : Connection of PV cells, modules and arrays

- As defined earlier, a **module** is the arrangement of solar cells in parallel and series.
- When several modules are connected in series and parallel they form an array.

Power produced by 1 module

Let P_c = Power produced by one cell (W)

x = no. of cells in a module having 'm' cells in series and n cells in parallel

$= m \times n$

P_m = Power produced by 1 module (W)

Then, $P_m = x \times P_c = m \times n \times P_c$

Power produced by Array

Let y = No. of modules in series and parallel

P_a = Power produced by an array.

Then, $P_a = y \times P_m = y \times x \times P_m$

6.7 Installation Procedure of Wind Solar PV Hybrid System

- The hybrid wind-solar PV system can provide an effective solution to electrical power needs to a residential premises or a group of residences or small complexes or in the remote village areas.
- The wind mill and the solar PV system after designing are installed separately. The method of installation of the hybrid system are as follows :

1. Installation of small Wind Mill

(i) Wind mill must be installed at least at 10m height clear from the ground and free from trees/obstructions/debris, etc. for free flow of wind.

(ii) Usually the design of foundation is provided by the supplier of wind mill and the foundation must be constructed accordingly.

However, build the foundation using plum (stones) concreting in which large sized stones are filled with concrete. Ensure that while concreting no air pockets are created in the foundation. It should be built atleast 2 to 3 m height from ground level.

(iii) The curing of the foundation must be done atleast (2-4) weeks in order to provide strong and stable foundation.

(iv) If the wind mill is to be installed at the roof top for individual needs, prepare the foundation according to supplier's design and specifications.

(v) Install a pole with anti-corrosion point of 10 cm to 15 cm diameter for wind mills upto the capacity of 10 kW. It should be atleast 4m to 5m height to receive uninterrupted wind to turbine blades.

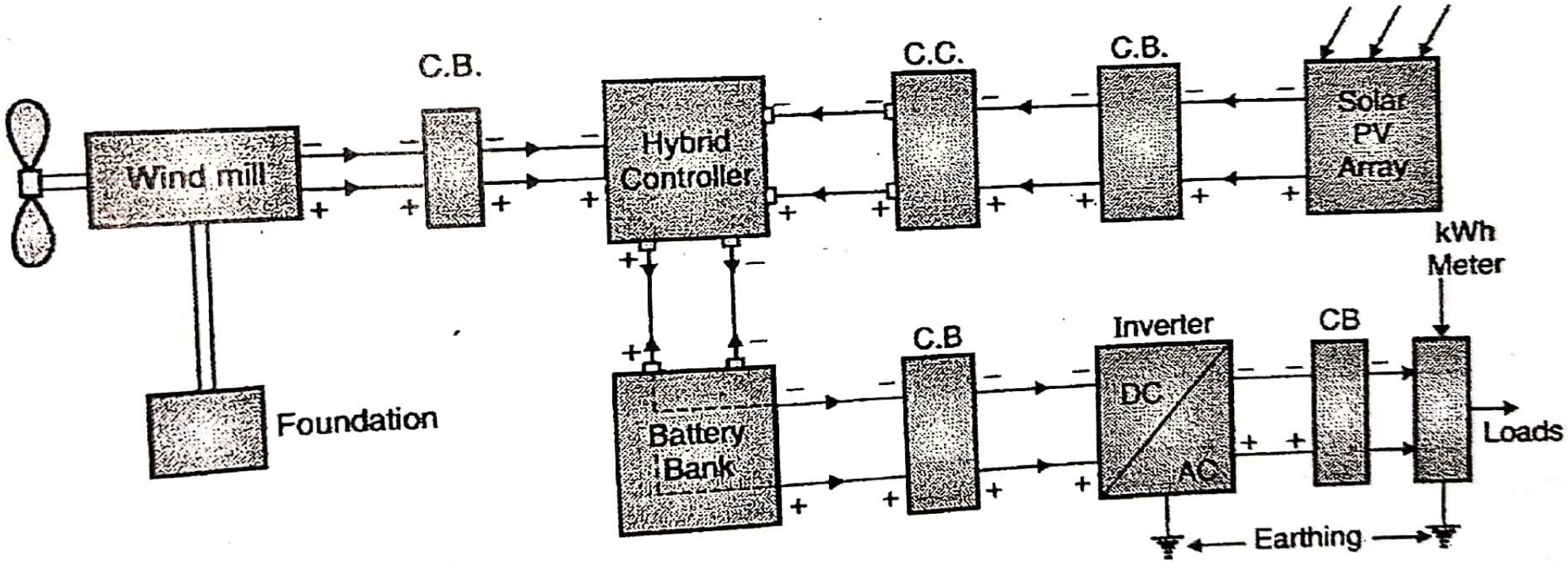
(vi) Install the wind mill horizontal platform at the top of pole with nut and bolts and stay wires and carryout the needed wiring.

2. Installation of Solar PV System

(i) Install solar PV panels at the roof top on stands made of MS or Aluminium channels with corrosion resistant paints on them.

(ii) The solar collectors may be installed at an angle equal to the latitude towards south.

(iii) Do the wiring with the insulated wires as shown in Fig. 6.7.1. The purpose of various components is described below :



(a) **C.B. (Circuit Breaker) :** A switch which shuts-down when a certain amount of current exceeds the amount of current passes through it.

(b) **C. C. (Charge Controller) :** An electronic device that regulates the voltage and current of the solar PV array. It gives steady output which is used by the hybrid controller.

(c) **Hybrid Controller :** It controls the voltage and current supplied by both PV array and wind mill. It makes it suitable for charging the batteries.

(d) **Inverter :** An electronic device which converts a low voltage DC into high voltage AC output e.g. it can convert 12 V or 24 V DC of battery into 220 V AC to take up the loads.

(iv) Red colour PVC wires be used to connect positive terminals, black colour wires to connect negative terminals and green wire for earthing.

6.9 Costing of Renewable Energy Systems

- There are various method to compare the costing of renewable energy system. Few of the methods are described below:

6.9.1 Unit Cost of Energy Method

- The operating cost of a project is calculated based on the fixed and variable cost. These are :

1. Fixed cost

- Fixed cost are those costs which are not dependent on the output or a process of a plant for example this cost is incurred even when the power generation or power output is zero in case of power producing plants or there is no production in case of an industry.
- In other words, fixed cost does not change though output is zero.
- Fixed cost includes the following
  - (i) Interest on capital investment
  - (ii) Depreciation
  - (iii) Insurance premium
  - (iv) Taxes
  - (v) Salaries of management and clerical staff.

2 Variable cost

- Variable costs also called as running cost are those costs which varies directly with the output of a plant or production process.

  Variable cost includes the following

  (i) Cost of fuel and lubricant

  (ii) Cost of oil water and grease

  (iii) Cost of operating and maintenance labour

  (iv) Cost of spares and repairs

- **Total cost** or **Annual cost** is the sum of fixed cost and the variable cost.

Example

- Consider a power producing plant with following details :

  C = Capacity of power plant or kW rating of power plant

  E = Energy generated in kWh / year

  UC = Unit cost of energy

- The cost of electrical energy generated per unit can be calculated as follows :

Unit cost of energy,

$$(UC) = Rs\left[\frac{\text{Annual fixed cost}}{C} + \frac{\text{Annual running cost}}{E}\right]$$