CMR INSTITUTE OF TECHNOLOGY

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Internal Assesment Test – 2

Sub: Solar and Wind Energy (Professional Elective)				Code: 15EE654
Date: 17/04/2018	Duration: 90 mins	Max Marks: 50	Sem: 6	Section: B [EEE]

Answer ANY FIVE full questions. Explain your notations explicitly and clearly. Sketch figures wherever necessary. Good luck!

		Marks	OBE	
			CO	RBT
Q1.	With a neat diagram, explain the Trombe Wall method of solar passive space heating.	[10]	CO654.4	L3
Q2.	Explain with a neat diagram the principle of conservation of solar energy into heat employed in liquid flat plate collectors.	[10]	CO654.4	L3
Q3.	Explain box type solar cooker.	[10]	CO654.4	L3
Q4.	What are the major advantages and disadvantages of a solar PV system?	[10]	CO654.5	L2
Q5.	Describe the classification of solar cells based on the active material used.	[10]	CO654.5	L3
Q6.	Describe the working principle of solar PV cell. With the help of a block diagram, explain the working of a grid tied solar PV system.	[10]	CO654.5	L3
Q7.	A PV system feeds a dc motor to produce 1 hp power at the shaft. The motor efficiency is 85%. Each module has 36 multicrystalline silicon solar cells with cell size of 125 mm x 125 mm and cell efficiency of 12%. Calculate the number of modules required in the PV array. Assume global radiation incident normally to the panel is 1 kW/m^2. 1 HP = 746 W.	[10]	CO654.5	L3
Q8a.	List various applications of solar PV systems.	[6]	CO654.5	L2
Q8b.	Define: (ii) Fill Factor; and (ii) Conversion Efficiency.	[4]	CO654.5	L2

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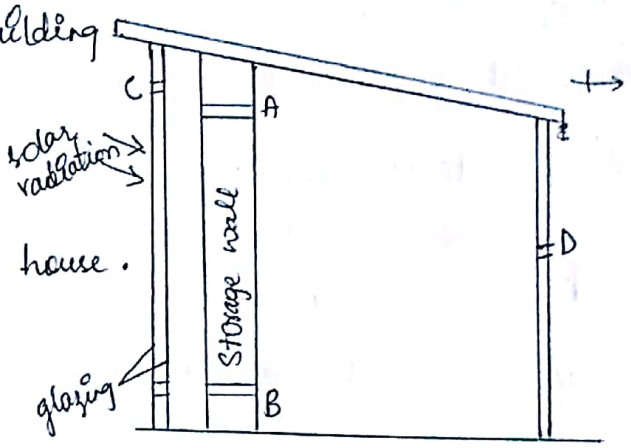
Assignment #02

Solar & Wind Energy

1) With a neat diagram, explain the Trombe wall method of solar passive space heating.

Ans:

i) Passive heating/cooling restricts building design to have natural heat flow possibility.



ii) Such building is called solar house.

iii) Passive does not require mechanical devices.

iv) The wall is made of concrete, adobe, stone or composite of brick blocks & sand.

v) Wall absorbs radiation & serves as thermal storage.

vi) Vents A & B are provided at top & bottom of the wall & can be kept open or close.

vii) Whole unit containing storage wall, vents & glazing is called Trombe wall.

viii) During day vents A & B are kept open.

ix) Air between inner glazing & wall get heated & enter in living room through vent A.

x) Thus natural circulation takes place.

xi) Thus transfer can happen due to radiation & convection from inner surface of storage wall.

xii) In summer vents B, C, D are kept open & A is closed.

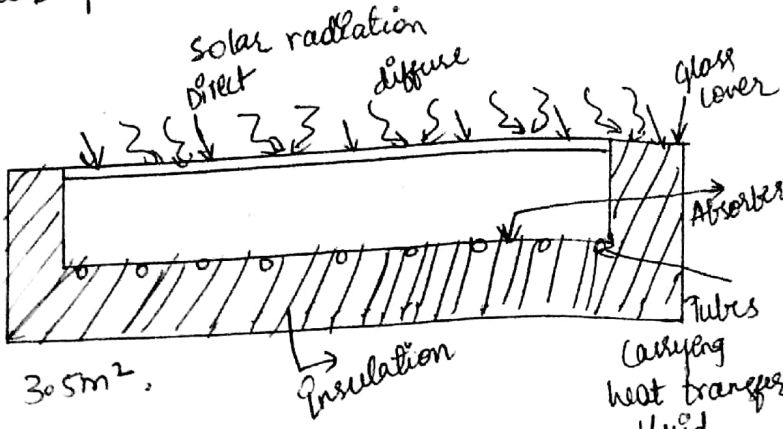
xiii) This causes air to be pulled from vent B.

xiv) Vent D should be located near cool & shaded area.

xv) Movable insulation is used to cover glazing to reduce heat loss from storage wall in night.

2) Explain with a neat diagram the principle of conversion of solar energy into heat employed in liquid flat plate collectors.

Ans



1) Surface area of each collector
   $2m^2$ (2m x 1m)
2) Typical collector dimension is
   2m x 1m x 15cm.
3) Flat/roof area required per collector $3.5m^2$.
4) Optimum tilt angle of collector is equal to latitude of the location with $\pm 10^\circ$ to $\pm 15^\circ$ variation.
5) For solar cooling latitude -10°
6) For solar heating latitude $+10^\circ$

Working: 1) Solar radiation strikes the absorber through glazing
2) The temperature of the absorber plate increases.
3) Heat which is trapped by the glass cover is transferred to heat transfer liquid circulating in risers tubes.
4) The header tube of diameter 2cm to 2.5cm leads the water in & out of collector through tubes.
5) Heated water is collected in a storage tank.
6) Attains temperature of 60°C to 100°C.

3) Explain box type solar cooker.

Ans:- 1) Well insulated box.
2) Double glass lid.
3) Reflector cover on inside.
4) Simple in construction & operation.
5) Angle of reflector is adjusted accordingly.
6) With addition of reflector temperature rise of 15° to 25°C is achieved
7) Box cover traps heat due to green house effect.
8) Cooking is faster in summer than in winter.

9) Electrical backup is provided to use during non sun shine hours.
10) Cost varies between Rs. 5000/- to Rs. 62901/- depending on type, size quality & electrical backup facility.
11) Keeps food warm in afternoon & evening.
12) Most widely used.

4) What are the major advantages & disadvantages of solar PV system.

Ans:-

Advantages:

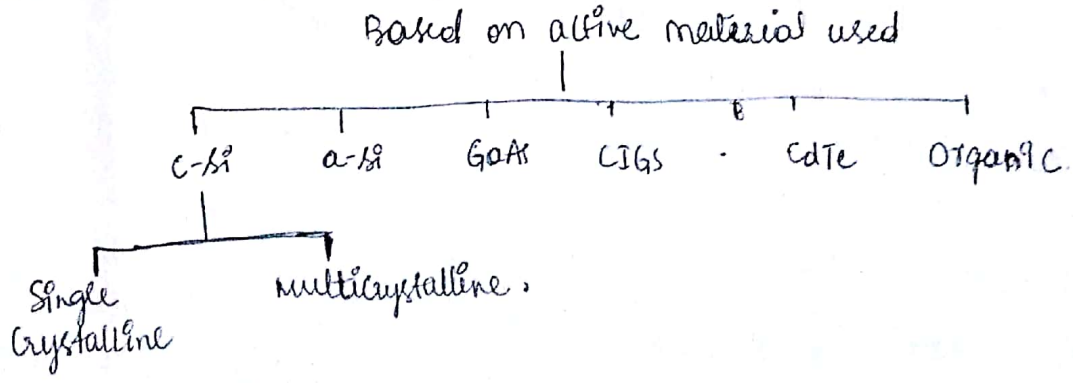
1) Converts sunlight to electricity directly.
2) No moving parts.
3) Reliable.
4) Durable.
5) Maintainance free.
6) Modular.
7) Noiseless operation.
8) Compatible with all environments.
9) Long life span.
10) Universally available.

Disadvantages:

1) High cost.
2) Low efficiency.
3) Larger space for high generation.
4) Requires storage system due to intermittent nature of sunlight.
5) Storage system in turn makes the system more expensive.

5) Describe the classification of solar cells based on active material used.

Ans:



i) c-Si technology:

→ 80% crystalline market.
→ 25 years lifetime.
→ Upto 20% efficiency of polycrystalline cells.

ii) Amorphous Silicon (a-Si):

→ Cheaper & uses thin film technology.
→ The cell is manufactured by chemical vapour deposition technique.
→ Stops degradation after initial exposure
→ Less efficient.

iii) GaAs:

→ GaAs has direct band gap of 1.43 eV.
→ Fill factor is about 80%.
→ Very expensive.

iv) CdTe:

→ CdTe has direct band gap of 1.5eV.
→ EVA is used for encapsulation.
→ Efficiency is about 10% with V_{OC} of 0.8 V.

v) Organic PV cell:

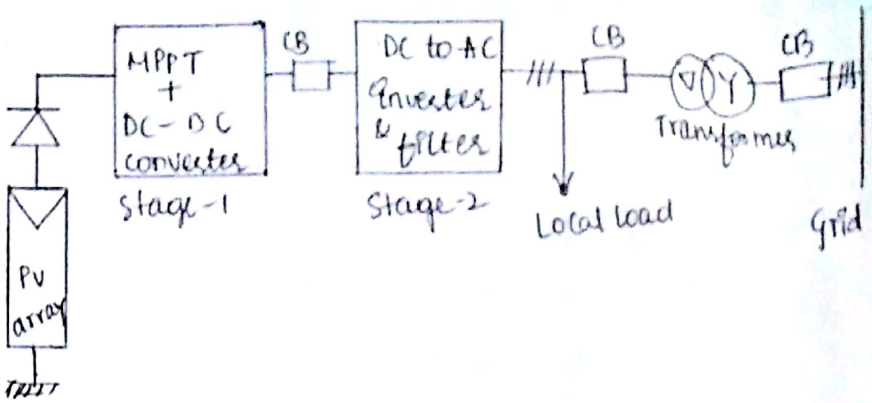
→ Fabricated out of carbon based dyes & organic polymers.
→ Flexible & hence can be bent without breaking.
→ Light weight, cheap & rugged.
→ Low efficiency.

6) Describe the working principle of solar PV cell. With the help of a block diagram, explain the working of a grid tied solar PV system.

Ans:- Solar cells

→ Operates on photoelectric principle – effect of releasing electrons by absorbing photons of light.
→ These free electrons are captured to generate electricity.
→ Made of special semiconductors.
→ Efficiency lies between 10 to 25%.
→ 25 years lifetime of solar panel.
→ Long lasting.
→ Reliable.

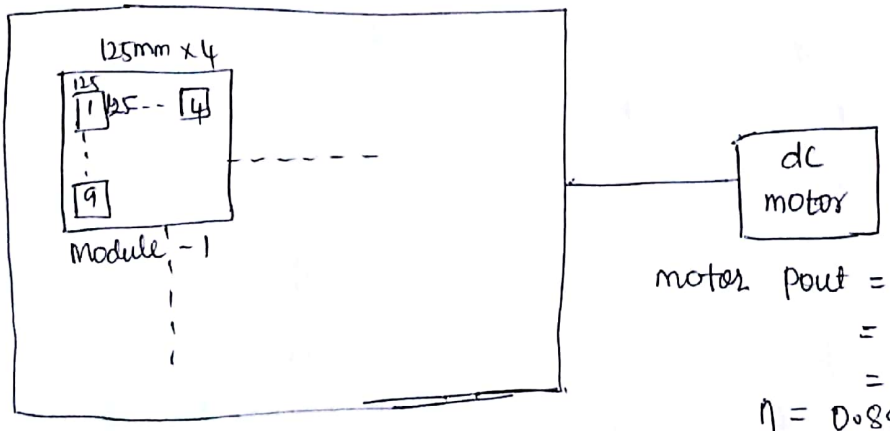
* Grid tied solar PV system:



1) Connected to the utility grid with two way metering system.
2) During day time it meets demand of house & feeds excess to grid.
3) Does not contain a battery back up.
4) Grid acts as infinite source or sink of energy.
5) First stage tracks maximum power while second stage inverts this dc to high quality ac.

7) A pv system feeds a dc motor to produce 1hp power at the shaft. The motor efficiency is 85%. Each module has 36 multicrystalline silicon solar cells with cell size of 125mm x 125mm & cell efficiency of 12%. Calculate the number of modules required in the PV array. Assume global radiation incident normally to the panel is $1KW/m^2$. $1HP = 746W$.

Ans:-



motor pout = 1 Hp.
= 1 x 746
= 746 W.

$\eta = 0.85$

$P_{in} = P_o \times \eta$

$P_{in} = 877.6\ W$

Area of one module $= 125 \times 10^{-6} \times 125 \times 9 \times 4$
$= 0.5625\ m^2$

Area of PV array having n-modules
$S = 0.5625n\ m^2$

Solar radiation $E = 1KW/m^2 = 1000\ W/m^2$

$P_{in} = E \times S = 1000 \times 0.5625n$

$P_{in} = 562.5n$

∴ output power of array

$P_a = P_{in} \times \eta_{cell} = 0.13 \times 562.5 n$

$P_a = 67.5$

as $P_a = (P_{in})_m$

$67.5n = 877.6$

$\boxed{n = 13}$

8) a) List various applications of solar pv systems.

b) Define i) Fill factor. & ii) Conversion efficiency.

Ans :- a) Applications :

1) Solar water pumps.
2) Solar vehicles.
3) Solar lanterns.
4) Cathodic protection systems.
5) Telecommunication & remote monitoring systems.
6) Water treatment systems.

b) i) Fill factor (FF)

→ Defines behaviour or quality of solar cell.
→ Value lies between 0 & 1
→ Good solar cells will have a FF value of 0.8.

$FF = P_{max} / (V_{OC} \times I_{SC}) = (V_{mp} \times I_{mp}) / (V_{OC} \times I_{SC})$

ii) Conversion efficiency :

It is the ratio of maximum power output of the cell (in W) to the product of input light power & the surface area of the solar cell under standard conditions.

$\eta = V_m I_m / P_i = P_{max} / (E \times S)$

$\eta = (FF \times V_{OC} \times I_{SC}) / (E \times S)$