Paper -1 Set A Solutions

13th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2012

PAPER – 1: General Aspects of Energy Management & Energy Audit

Date: 15.09.2012 Timings: 09:30-12:30 Hrs Duration: 3 Hrs Max. Marks: 150

Section - I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

(i) Answer all **50** questions
(ii) Each question carries **one** mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or HB pencil, as per instructions

1.	The primary energy content of fuels is generally expressed in terms of ton of oil equivalent (toe) and is based on the following conversion factor a) 1 toe=10x10^6 kCal b) 1 toe=11630 kWh c) 1 toe=41870 MJ d) **all the above**
2.	Largest share of global primary energy consumption is from which of the following fuels: a) oil and natural gas **b) coal and oil** c) oil and nuclear d) coal and nuclear
3.	1 kg of wood contains 15% moisture and 7% hydrogen by weight. How much water is evaporated from wood during complete combustion of 1 kg of wood ? **a) 0.78 kg** b) 0.22 kg c) 0.15 kg d) 0.63 kg
4.	**A power utility distributed 1 million 15 Watt CFLs for Rs 15 million, replacing 60 Watt incandescent lamps under Bachat Lamp Yojna. What will be the drop in power in the evening on the demand side, if 80% of the lights are on at that time, assuming similar numbers of incandescent lamps were switched on during the same period?** a) 360 kW b) 12 MW c) **36 MW** d) 60 MW
5.	Which of the following with respect to fossil fuels is true? a) Reserve / Production (R/P) ratio is a constant once established b) R/P ratio varies every year with only changes in production c) R/P ratio varies every year with only changes in reserves

	d) R/P ratio varies every year with changes in both production and reserves
6.	From rated V, A and PF given in the name-plate of a motor , one can calculate: **a) rated input Power** b) rated output Power c) both a & b d) none of these
7.	Air velocity in the ducts can be measured by using _____ and manometer a) orifice meter b) Bourden gauge c) **Pitot tube** d) anemometer
8.	One certified emission reduction (CER) is equivalent to: a) one kg of carbon b) one kg of carbon dioxide c) one ton of carbon d) **one ton of carbon dioxide**
9.	Speed measurement (RPM) of an electric motor is measured with a **a) stroboscope** **b)** ultrasonic meter c) lux meter d) rotameter
10.	How much power generation potential is available in a run of river mini hydropower plant for a flow of 40 liters/second with a head of 24 metres. Assume system efficiency of 60% ? **a) 5.6 kW** **b)** 2.4 kW c) 4.0 kW d) 2.8 kW
11.	A process requires 10 kg of fuel with a calorific value of 5000 kCal/kg. The system efficiency is 80% The losses then will be **a) 10000 kCal** **b)** 45000 kCal c) 40000 kCal d) 20000 kCal
12.	Ratio of average load (kW) to maximum load (kW) is termed as **a) load factor** **b)** demand factor c) form factor d) utilization factor
13.	The ISO standard for Energy Management System is a) ISO 9001 b) **ISO 50001** **c)** ISO 14001 d) none of the above
14.	Material and energy balance is used to quantify **a) material and energy losses** **b)** profit c) cost of production d) all of the above
15.	Which is not a part of " Energy Audit" defined as per the Energy Conservation Act, 2001 a) monitoring and analysis of energy use **b) ensuring implementations of recommended measures followed by review** c) submission of technical report with recommendations d) verification of energy use
16.	Which of the following statements regarding ECBC are correct?

	i) ECBC defines the norms of energy requirements per sq. metre of area taking into account climatic region where building is located ii) ECBC does not encourage retrofit of Energy conservation measures iii) ECBC prescribes energy efficiency standards for design and construction of commercial and industrial buildings iv) One of the key objectives of ECBC is to minimize life cycle costs (construction and operating energy costs) a) i & ii b) i & iii c) ii & iii **d) <u>i & iv</u>**
17.	Which of the following statements regarding BLY (Bachat Lamp Yojana) are correct ? i) BLY aims at large scale replacement of all fluorescent lamps of poor lumen intensity with CFL of high lumen intensity ii) CDM is used as a tool to recover market price difference between lower cost replaced incandescent lamps of 60 W and higher cost CFLs of 11 W iii) BLY involves public, private partnership and DISCOM partnerships iv) DSM is used as a tool to recover market price difference between lower cost replaced incandescent lamps of 60 W and higher cost CFLs of 11 W a) i & ii b) i & iii **c) <u>ii & iii</u>** d) i & iv
18.	The average gross efficiency of thermal power generation on all India bases is about a) **<u>30 – 34%</u>** b) 36 – 38% c) 39 - 41% d) 25 - 28%
19.	Which of the following is not the activity related to restructured APDRP? a) separate feeders for agricultural pumps b) energy auditing at distribution transformer level c) GIS mapping of the network and consumers **d) <u>establishing targets for reducing power consumption</u>**
20.	Assuming total conversion of electrical energy to heat energy, how much heat is produced by a 200 W heater in 5 minutes? a) 200 kJ b) 40 kJ c) 1000 kJ d) **<u>60 kJ</u>**
21.	Which of the following statements regarding DSM is incorrect? a) potential areas for DSM thrust activity are agriculture, domestic and municipalities b) savings accrued through DSM can be treated as new power addition on supply side **c) <u>under DSM, demand can be shifted from off-peak to peak hours thereby avoiding imported power during off peak hours</u>** d) DSM programs may result in demand as well as energy reduction

22.	A motor with 10 kW rating in its name plate, will draw Input power of____ a) 10 kW at full load b) **more than 10 kW at full load** c) less than 10 kW at full load d) 10 kW at 110% of full load
23.	Which of the following statements is not true regarding Maximum Demand Control? a) Maximum demand control offers a way of 'shaving' the peaks and 'filling' the valleys in the consumer load diagram **b) Maximum demand control is carried out by concerned utility at customer premises** c) Maximum demand control focuses on critical load for management d) All of the above
24.	Which of the following statements is false? a) reactive current is necessary to build up the flux for the magnetic field of inductive devices **b) some portion of reactive current is converted into useful work** c) Cosine of the angle between kVA and kW vector is called power factor d) power factor is unity in a pure resistive circuit
25.	Steam leak reduction program can be best achieved through a) Small Group Activities b) Autonomous Maintenance c) TPM d) **All of the above**
26.	Consider two competitive projects A and B each entailing investment of Rs.85,000/- . Project A returns Rs.50,000 at the end of each year, but Project B returns Rs.115,000 at the end of Year 2. Which project is superior? a) project A since it starts earning by end of first year itself and recovers cost before end of two years b) project B since it offers higher return before end of two years c) both projects are equal in rank **d) insufficient information to assess the superiority**
27.	Which of the following statements regarding Internal Rate of Return (IRR) is correct? a) IRR distinguishes between lending and borrowing **b) Internal rate of return is the discount rate at which net present value is equal to zero** c) if the IRR is higher than current interest rate, the investment is not attractive d) between two alternative projects, the project with lower internal rate of return would be considered more attractive

28.	Global warming will not result in a) melting of the ice caps b) increasing sea levels **c) increasing the size of the hole in the ozone layer** d) unpredictable climate patterns
29.	The ozone layer found in the stratosphere: **a) protects against the sun's harmful UV rays** b) can react with atmospheric pollutants to form smog c) is toxic to plants d) is capable of disintegrating fabric and rubber on earth
30.	The process of capturing CO_2 from point sources and storing them is called _____ a) **carbon capture and sequestration** b) carbon sink c) carbon capture d) carbon absorption
31.	Which of the following statements is false regarding wind turbine? a) wind power does not vary as the cross-sectional area of the rotor b) wind power varies as cube of wind velocity c) cut-in wind speed is always less than rated wind speed d) theoretical maximum amount of energy in the wind that can be collected by wind turbine rotor is about 95%
32.	What percentage of the sun's energy falling on a silicon solar panel gets converted into electricity? a) 25% b) **15%** **c)** 75% d) 50%
33.	Which of the following fuels is non-renewable? a) LPG b) lignite c) nuclear d) all of the above
34.	India's share of world oil reserves is _____ a) 5% b) 2% c) **0.5 %** d) 3%
35.	Nuclear power development in India is constrained by a) low % of Uranium in the ore b) inadequate supply of Uranium c) constraints in import of Uranium d) **all of the above**
36.	In a contract when all or part of the savings are guaranteed by contractor, and all or part of the costs of equipment and/or services are paid out of savings as they are achieved, is termed as

	a) traditional contract b) **guaranteed saving performance contract** c) shared saving performance contract d) extended technical guarantee contract
37.	A fuel cell is a) an electromagnetic cell b) a magnetic cell c) **an electrochemical device** d) none of the above
38.	If 3350 kJ of heat is supplied to 20 kg of ice at 0^o C, how many kg of ice will melt into water at 0^o C (latent heat of melting of ice is 335 kJ/kg) a) 1 kg b) 4.18 kg **c) 10 kg** d) 29 kg
39.	If oxygen rich combustion air (25% vol oxygen) is supplied to a furnace instead of normal air (21% vol oxygen), the % CO_2 in flue gases will a) reduce **b) increase** c) remain same d) will become zero
40.	The return on investment (ROI), is expressed as a) annual cost / capital cost b) (first cost / first year benefits) x 100 c) NPV / IRR **d) (annual net cash flow x 100) / capital cost**
41.	The time between its earliest and latest start time, or between its earliest and latest finish time of an activity is a) delay time **b) slack time** c) critical path d) start time
42.	In project management work breakdown structure defines a) temporary endeavour undertaken to create unique product or service **b) the activities to be completed in the projects** c) how realistic were the assumptions underlying the project d) none of the above
43.	The empirical relationship used to plot Production Vs Energy consumption is…… (where Y= energy consumed for the period; C = fixed energy consumption; M = energy consumption directly related to production; X= production for same period). a) X=Y+MC **b) Y=MX+C** c) M=CX+Y d) Y= MX-C
44.	The main constituent of greenhouse gases (GHG) in atmosphere is

	a) CO_2 b) SOx c) nitrogen d) water vapor
45.	The Global Warming Potential (GWP) of nitrous oxide (N_2O) is a) 1 b) 23 c) **300** d**)** 5700
46.	In project management, the critical path in the network is a) the path where activates have slack b) the shortest path c) **the path where no activities have slack** d) none of the above
47.	The cost of a new heat exchanger is Rs. 1.0 lakh. The simple payback period in years considering annual savings of Rs 60,000 and annual operating cost of Rs. 10,000 is a) 0.50 b) 1.66 **c) 2.00** d) 6.00
48.	Of the total natural gas used in India**,** the largest share goes to_____sector. a) petrochemicals b) fertilizers **c) power** d) domestic
49.	What is the future value of Rs. 1000/- after 3 years if the interest rate is 10% ? **a) 1331** **b)** 3000 c) 3300 d) 2420
50.	If the asset depreciation is considered, then net operating cash inflow would be a) higher **b) lower** c) no effect d) none of these

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	Explain the concept of Bachat Lamp Yojana (BLY)?
ANS	BLY aims at the large scale replacement of inefficient incandescent bulbs in households by Compact Fluorescent Lamps (CFLs). It seeks to provide CFLs to households at the same price to that of incandescent bulbs. Clean Development Mechanism (CDM) is used to recover the cost difference between the market price of the CFLs and the price at which they are sold to households.

	BLY involves public-private partnership between the Government of India, private sector CFL suppliers and State level Electricity Distribution Companies (DISCOMs).
S-2	Briefly explain 'Renewable Purchase Obligation (RPO)' and means by which this requirement can be met ?
ANS	RPO is **Renewable Purchase Obligation** requires each retail seller of electricity to include in its resource portfolio a certain proportion of power is from **renewable sources** such as wind, solar, small hydro or various forms of biomass energy. The retailer can meet this requirement by **owning a renewable energy facility and producing power** or **purchasing power** from another renewable energy facility.
S-3	Give a short description about Availability Based Tariff (ABT).
ANS	Introduction of availability based tariff(ABT) and scheduled interchange charges for power introduced in 2003 for interstate sale of power , have reduced voltage and frequency fluctuation (any three) • It is performance-based tariff system for the supply of electricity by generators owned and controlled by the central government. • It is also a new system of scheduling and despatch, which requires both generators and beneficiaries to commit to day ahead schedule. • It is a system of rewards and penalties seeking to enforce day ahead pre-committed schedules, though variations are permitted if notified one and a half hours in advance. • The order emphasis prompt payment of dues , non-payment of prescribed charges will be liable for appropriate action *Any other relevant points as appropriate may also be given marks*
S-4	In a process plant , an evaporator concentrates a liquor containing solids of 6% w/w (weight by weight) to produce an output containing 30% solids w/w. Calculate the evaporation of water per 400 kgs of feed to the evaporator.
ANS	Inlet solid contents = 6 % Output solid contents=30% Feed=400kgs Solid contents in kg in feed =400 x 0.06 = 24 Kg Outlet Solid contents in kg =**24 kg** quantity of water evaporated=[400 – {(100) x 24}] = 320 30 *Also right* = *24x400/30* = ***320***
S-5	In the management of financial aspects, state what are micro and macro factors and list three factors in each, which influence sensitivity analysis?

ANS	**Micro factors are variables related to the project being implemented and can be influenced** Any three in the following list ü Operating expenses (various expenses items) ü Capital structure ü Costs of debt, equity ü Changing of the forms of finance e.g. leasing ü Changing the project life **Macro factors are variables that affect the operation of industry of which the company operates and cannot be changed by the company management.** Any three in the following list ü Changes in interest rates ü Changes in the tax rates ü Changes in the accounting standards e.g. methods of calculating depreciation ü Changes in depreciation rates ü Extension of various government subsidized projects e.g. rural electrification ü General employment trends e.g. if the government changes the salary scales ü Imposition of regulations on environmental and safety issues in the industry ü Energy Price change
S-6	A plant is using 6 ton/day of coal in a boiler to generate steam at 72% boiler efficiency. The gross calorific value of coal is 3300 kCal/kg. The cost of coal is Rs. 4200/ton . The plant substitutes coal with agro-residue , as a boiler fuel, which has a gross calorific value of 3100 kCal /kg and costs Rs. 1800/ton. The boiler efficiency reduces to 68%. Calculate the annual cost savings for 300 days of operation with agro residue as fuel.
ANS	Useful energy to generate steam by 6 tonnes of coal per day = 6000 x 3300 x 0.72 = 14256000 kcal/day To deliver 14256000kcal/day , daily amount of agro residue required $= \frac{14256000}{3100 \times 0.68}$ **= 6763 kg/day** Daily saving = $\frac{6000}{1000} \times 4200 - \frac{6763}{1000} \times 1800$ = 25200-12173 = Rs 13027/-

	Annual saving =13027 x 300 **=Rs 39,08,100/-**
S-7	Based on local pollution control department norms the maximum limit of dust in the gas stream leaving the industry should not exceed one ton per day. A bag filter was installed to reduce the pollution from the exhaust gas stream. Find out the dust collected in ton per day if the gas stream to the dust collector was entering at the rate of 130,000 m^3 per hour containing 6 g/m^3 and leaving at the rate of 150,000 m^3 per hour, inclusive of ingress of air) containing 300 mg/m^3. Also find out whether, the industry met the pollution norms if the plant operates for 24 hours a day at same capacity.
ANS	Amount of Dust in the inlet stream = 130,000 x 6 = 780,000 grams/hour Amount of Dust in the outlet stream = 150,000 x 0.30 g/hr = 45,000 grams/hour Amount of Dust in the Bag Filter = 780,000 - 45,000 = 735,000 grams/hour x $24/10^6$ = <u>17.64 Tonnes/day</u> Amount of dust leaving the Industry = 45,000 grams / hour x $24/10^6$ = 1.08 Tonnes / day <u>Since it is more than 1 tonne/ day, the industry does not meet the pollution norms</u>
S-8	In an industry the existing winding of a motor has burnt out. Calculate the annual energy savings and simple payback for replacing the burnt out motor with an energy efficient motor of the same capacity instead of rewinding. The data given are • Efficiency after rewinding of burnt out motor - 86% • Cost of rewinding - Rs 7500 • Efficiency of energy efficient motor - 94% • Cost of new energy efficient motor - Rs 42000 • Operating hours/year - 6900 hours • % loading of motor - 82% • Energy cost - Rs 5.2/kWh • Name plate rating of motor - 22 kW
ANS	Energy cost saving (Rs / year)

	=[(kW) x (% loading) x [(1/efficiency of rewound standard motor) - (1/ Efficiency of energy efficient motor)] x (HRS/annum) x (Rs/kwh) =22 x 0.82 x 6900 x 5.2 [(100/86) – (100/94)] =Rs 64055 Simple payback period = [(42000-7500)/64055] =6.5 months

------- End of Section - II ---------

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1	An oil fired reheating furnace heats steel billets from 40°C to 1220°C at a furnace efficiency of 28%. The furnace operates for 4700 hours per annum. The GCV of furnace oil is10,000 kCal /kg and density is 0.94kg/litre. The cost of furnace oil is Rs.45 /liter. The specific heat of billets is 0.12 kCal/kg°C. a. Calculate the amount of energy necessary to heat 12 tons of steel billets per hour b. Calculate liters of furnace oil fired per tons of steel billets. c. If the efficiency of the furnace is improved from 28% to 30% by adopting ceramic fibre insulation, calculate the hourly furnace oil cost saving d. What is the simple payback period if the investment is Rs. 20 lakhs ? e. How large could be the investment to improve the efficiency at an internal rate of 16% and per year over 6 years.
ANS	: a) Amount of energy necessary to heat 12 tons of steel billets = m x cp x△t = 12000 Kgs x 0.12 x (1220- 40) kCals/hr **= 16,99,200 Kcals/hr** B) Litres of furnace oil fired per ton of steel billet = [(1699200/12)] = 141600 Kcal/ tonne of billet Input energy per ton of billet = 141160/0.28 = 505714 kcal/ tonne of billet Furnace oil required in kg = 505714 / 10,000 = 50.57 Kg/ tonne of billet Furnace oil required in litres = 50.57 / 0.94 **= 53.79** litres/ tonne of billet

c). Hourly furnace oil cost savings/ton

= 53.79 x [1 – (0.28/0.30)] * Rs 45

= Rs 161.37/tonne

Hourly furnace oil cost savings for 12 tons

= Rs 161.37 *12

=Rs 1936/hr

d). Simple payback period @ 4700 hrs of operation

=20,00,000/1936*4700

= 0.352 yrs or 4.2 months

e) Net cash inflow per annum= 1936*4700

= Rs 91.0 lakhs

$$\text{Investment} = 91.0 \left[\frac{1}{1.16} + \frac{1}{(1.16)^2} + \frac{1}{(1.16)^3} + \frac{1}{(1.16)^4} + \frac{1}{(1.16)^5} + \frac{1}{(1.16)^6} \right]$$

= 91.0 [0.862+ 0.743+0.641+0.552+0.476+0.410]

= Rs. 3.35 crores

L-2

The Energy- production data (for Jan-June, 2011) of an industry follows a relationship : Calculated energy consumption = 0.5 P +220.

A Waste heat recovery system was installed at end of June 2011 and further data was gathered up to December 2011.

Using CUSUM technique, calculate energy savings in terms of ton of oil equivalent (toe) and the reduction in specific energy consumption achieved with the installation of waste heat recovery system.

The plant data is given in the table below.

2011-Month	Actual Energy Consumption, toe/month	Actual production, ton/month
Jan	620	760
Feb	690	960
Mar	635	790
Apr	628	830
May	545	610
Jun	540	670
July	**590**	**760**
Aug	**605**	**820**
Sep	**670**	**940**
Oct	**582**	**750**
Nov	**512**	**610**
Dec	**540**	**670**

ANS

The table below gives values of actual energy consumption Vs. calculated (predicted)

energy consumption from July –Dec. 2011.

Specific energy consumption monitored Vs predicted for each month. The variations are calculated and the Cumulative sum of differences is calculated from Jan-June-2011.

2011-Month	Eact.	Ecal 0.5P+220	Eact - Ecal	CUSUM
July	**590**	600	-10	-10
Aug	**605**	630	-25	-35
Sept	**670**	690	-20	-55
Oct.	**582**	595	-13	-68
Nov.	**512**	525	-13	-81
Dec.	**540**	555	-15	-96

Energy savings achieved = **96 toe**

Reduction in specific energy consumption = 96/4550 = 0.021 toe/tonne of production
(Production for 6 months = 760+820+940+750+610+670 = **4550 tonnes**)

L-3 A proposed energy efficiency improvement project requires an initial investment of Rs.5,00,000 and generates cash flow as given below:

Savings in year	Cash flow (Rs.)
1	120000
2	115500
3	130000
4	116500
5	117250
6	200000

Calculate IRR of the project by interpolation method by taking initial discount rate as 11%.

ANS a) NPV at 11% = $-500000 + 120000/(1+0.11)^1 + 115500/(1+0.11)^2 + 130000/(1+0.11)^3 + 116500/(1+0.11)^4 + 117250/(1+0.11)^5 + 200000/(1+0.11)^6$

= 50157.88

NPV at 16% = $-500000 + 120000/(1+0.16)^1 + 115500/(1+0.16)^2 + 130000/(1+0.16)^3 + 116500/(1+0.16)^4 + 117250/(1+0.16)^5 + 200000/(1+0.16)^6$

= -25176.29

NPV is between 11% and 16%

	IRR with Linear Interpolation I_L = 11% NPV_L = 50157.88 I_U= 16% NPV_U = -25176.29 $IRR = I_L + \frac{(I_U - I_L) \times NPV_L}{(NPV_L - NPV_U)}$ = 0.11 + (0.16-0.11) (50157.88) / [(50157.88 – (- 25176.20)] = 0.11 + (0.05 x 50157.88) / 75334.17 = 0.11 + 2507.894 / 75334.17 = 0.11 + 0.0333 = 0.1433 **= 14.33%**
L-4	Write short notes on **any two** of the following a)BEE's Standards and Labeling programme for equipment and appliances b)Role of ESCOs c)Evacuated tube collector for solar energy applications
ANS	**a) Standards & Labeling** Standards and Labeling would ensure that only energy efficient equipment and appliances would be made available to consumers. Main provisions of S&L are: • Evolve minimum energy consumption and performance standards for notified equipment and appliances • Prevent manufacture, sale and import of equipment which do not meet the standards • Introduce a mandatory labeling scheme for notified equipment and appliances to enable consumers to make informed choices • Spread information on benefits to consumers For establishing standards, agreed testing procedures are defined and values of energy performance are measured.

Energy labels are the best way to implement the standards. They are information affixed to manufactured products to describe the product's energy performance usually in form of energy use or efficiency. These give data to consumers to make informed purchases.

b) Role of ESCOs

Conduct of Investment grade energy audit

Arranging finance

Purchase, installation and maintenance of installed energy efficient equipment

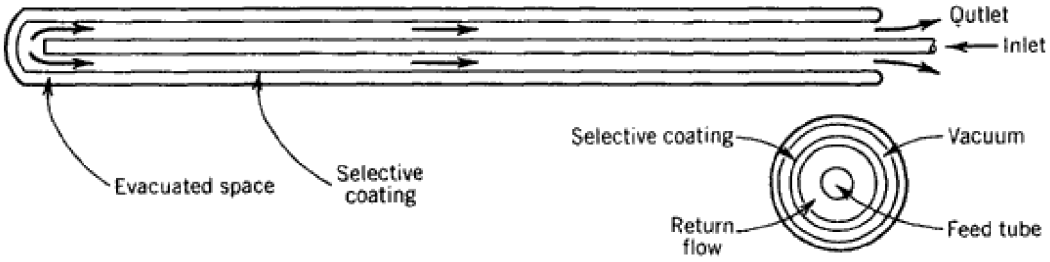
Operation & Maintenance training

Monitoring of operations and energy savings

c) Evacuated Tube Collector

Evacuated tube collector comprises of two concentric glass tubes fused in the ends. The air is evacuated from the gap between the tubes. The evacuated double-walled glass tube provides thermal insulation similar to that of thermally insulated "Thermos" bottle. The outer glass tube is clear, and the surface of the inner glass tube is coated with a special heat material that absorbs the sun's energy.

Sun rays penetrate the outer clear glass and heat energy is absorbed by the inner coated glass. The vacuum permits the heat radiation to enter the outer tube. The absorbent coating on the inner tube converts short wave radiation to long wave radiation thus preventing re-radiation to atmosphere. Since conduction cannot take place in vacuum, heat loss due to conduction back to atmosphere is also prevented. Because of this principle, more heat is trapped compared to a flat plate collector. The heat loss in Evacuated tube collector is less than 10% compared with 40% for a flat plate collector. Water flows in through a third, innermost concentric feeder tube and hot water flows out in the annulus outside the feeder tube in contact with the absorber tube surface. This type of solar collector can reach high temperatures upto 150°C.



L-5

a) Explain in brief the process of gasification of biomass.

b) Find out the conversion efficiency of a gasifier, if 20 kg of wood (having a calorific value of 3200 kCal / kg) produces 46 m^3 of producer gas having an average calorific value of 1000 kCal / $Nm^{3.}$

ANS

a) **Gasification of Biomass**

Biomass contains Carbon, Hydrogen and Oxygen molecules. Complete combustion of Biomass would produce Carbon Dioxide and water vapour, whereas combustion under controlled conditions ie partial combustion produces Carbon Monoxide and Hydrogen, which are combustible gases. The biogas produced through gasification is called as Producer Gas.

Gasification is a partial oxidation of biomass and takes place at temperature of about 1000^{o}C. Partial oxidation is facilitated by supplying air less than the stoichiometric requirements. The products of combustion are gases like Carbon Monoxide, Hydrogen and traces of Methane and non- useful products like tar & dust. The production of these gases is by reaction of water vapour and Carbon Dioxide through a glowing layer of charcoal.

A gasification system consists of 4 main steps:

- § Feeding of Feedstock
- § Gasifier reactions where gasification takes place.
- § Cleaning of resultant gas
- § Utilization of cleaned gas

Biomass Gasifier is a thermo-chemical convertor / reactor where various physical and chemical reactions take place. Biomass is passed through following zones before being converted to high quality producer gas:

- Drying Zone
- Distillation Zone
- Pyrolysis zone
- Combustion Zone
- Reduction Zone

The following reactions take place:

$C + O_2 = CO_2$

$H_2 + ½ O_2 = H_2O$

$C + O_2 = 2CO$

$C + H2O = CO + H_2$

$CO_2 + H_2 = CO + H2O$

$C + 2 H_2 = CH_4$

The Producer gas has relatively a low calorific value ranging from 1000 to 1200 kCal/Nm^3. The conversion efficiency of Gasifier is in the range of 60 – 70%. It can be used for combustion in

a reciprocating engine.

b) Heat Input in the Gasifier = 20 x 3200
= 64000 kCal

Heat Output as Producer gas = 46 x 1000
= 46000 kCal

Conversion efficiency of Gasifier = Heat Output / Heat Input
= 46000 x 100 / 64000
= 71.88 % **Ans**

L-6

a) Construct a PERT/CPM network diagram for a project for which the data is given below

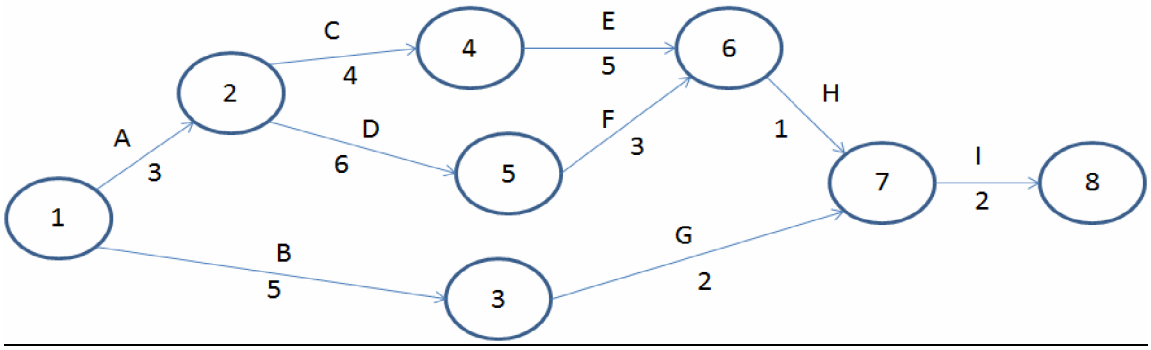
b) Compute the earliest start, earliest finish, latest start, latest finish and slack for all the activities

c) Also compute the project duration, identify critical activities and the critical path(s)

Activity	Predecessor	Time in weeks
A	-	3
B	-	5
C	A	4
D	A	6
E	C	5
F	D	3
G	B	2
H	E,F	1
I	G,H	2

ANS

(a) PERT/CPM Network Diagram



b) **Early start (ES), Early Finish (EF), Latest start (LS), Latest finish (LF)**

Activity	**Duration** (weeks)	**ES**	**EF**	**LS**	**LF**	**Slack**
A	3	0	3	0	3	0
B	5	0	5	6	11	6
C	4	3	7	3	7	0
D	6	3	9	3	9	0
E	5	7	12	7	12	0
F	3	9	12	9	12	0
G	2	5	7	11	13	6
H	1	12	13	12	13	0
I	2	13	15	13	15	0

c) Critical Paths

Two critical paths exist. They are

A-C-E-H-I & **A-D-F-H-I**

Project duration : 15 weeks