19th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS – SEPTEMBER, 2018

PAPER – 1: GENERAL ASPECTS OF ENERGY MANAGEMENT & ENERGY AUDIT

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 **HB pencil only**, as per instructions

1.	Which among the following is not a renewable source of energy? a) Bagasse b) Rice husk c) **Nuclear** d) Wind
2.	What is shale Oil? a) **Sedimentary rock containing solid bituminous materials** b) Heavy black viscous oil combination of clay, sand, water and bitumen c) A form of naturally compressed peat d) combustible brownish-black sedimentary rock
3.	Which of the following has the lowest energy content in terms of MJ/kg a) LPG b) Diesel c) **Bagasse** d) Furnace oil
4.	_____ and _____ consume major share of Natural Gas consumption in India. a) Domestic sector and Transport sector b) Transport sector and Fertilizer Industry c) **Power Generation and Fertilizer Industries** d) Domestic Sector and Fertilizer Industries
5.	The sector consuming major share of energy in India a) Agriculture Sector b) Transport Sector c) **Industrial Sector** d) Domestic Sector
6.	Which of the following designated consumer has the lowest energy intensity? a) **Aluminium** b) Iron and Steel c) Cement d) Chlor alkali
7.	Which of the following is not a Demand Side Management measure? a) Implementing Time of the Day (ToD) Electricity Tariff b) **Maximizing fossil fuel based energy utilization** c) Replacement of inefficient electrical appliances d) Use of ice bank system
8.	Which of the following does not meet the Designated Consumer criteria? a) Pulp and Paper Industries with minimum annual energy consumption of 30,000 TOE. b) Cement Industries with minimum annual energy consumption of 30,000 TOE. **c) Chlor- Alkali Industries with minimum annual energy consumption of 7500 TOE.**

	d) Textile Industries with minimum annual energy consumption of 3000 TOE.
9.	The kW or HP of a motor given on the name plate indicates a) The shaft output of the motor at part load b) **The shaft output of the motor at full load** c) The input power to the motor at the best efficiency point d) The input power to the motor at any load
10.	Which of the following has the highest Specific Heat? a) Steel b) Aluminium c) Copper d) **Water**
11.	Heat transfer in an air cooled condenser occurs predominantly by a) conduction b) **convection** c) radiation d) none of the above
12.	Definition of Energy Audit as per EC Act does not include: a) **Creation of an Energy Management System (EnMS)** b) evaluation of Techno-economics c) Verification, monitoring and analysis of energy use d) Action plan required for energy saving
13.	The ISO standard for Energy Management System is a) ISO 14001 b) **ISO 50001** c) ISO 9001 d) ISO 18001
14.	To arrive at the relative humidity at a point we need to know_____of air a) dry bulb temperature b) wet bulb temperature c) enthalpy d) **both a & b**
15.	As per Energy Conservation Act, 2001 appointment of BEE Certified Energy Manger is mandatory for a) all State designated agencies b) all large Industrial consumers c) **all designated consumers** d) all commercial buildings
16.	A waste heat recovery system requires Rs. 50 lakhs investment and Rs. 2 lakhs per year to operate and maintain. If the annual savings is Rs. 22 lakhs, the payback period will be a) 2.28 years b) **2.5 years** c) 3 years d) 10 years
17.	~~What is the heat content of the 200 liters of water at **500ºC** in terms of the basic unit of energy in Kilo Joules~~ ~~a) 30000 b) 23880~~ ~~c) 10000 d) 41870~~ **Note: 1 Mark is awarded to all candidate who have attempted this question.**
18.	Which of the following GHGs has the longest atmospheric life time a) CH4 b) SF6 c) CFC d) **PFC**
19.	Which of the following is used for non-contact measurement of temperature a) Thermocouples b) **Infrared Thermometer** c) Leaf type contact probe d) All of the above
20.	The force field analysis in energy action planning considers a) Positive forces only b) negative forces only c) **Both negative and positive forces** d) no forces

21.	Which of the following equation is used to calculate the future value of the cash flow? a) NPV $(1 - i)^n$ b) NPV / $(1 - i)^n$ c) **NPV $(1 + i)^n$** d) NPV/ $(1 + i)^n$
22.	For investment decision, ROI must always be _____ prevailing interest rate. a) Lower than b) **Higher than** c) Equal to d) No relation
23.	Large scattering on production versus energy consumption trend line indicates a) **Poor process control** b) Inefficient equipment c) Inefficient process d) None of the above
24.	Frequency of energy audit for designated consumers is_____ a) once in a year b) once in two years c) **once in three years** d) Once in five years
25.	The rotor axis is aligned with the wind direction in a wind mill by _____ control a) **yaw** b) pitch c) disc break d) all of the above
26.	Producer gas basically comprises of a) **CO, H_2 and CH_4** b) Only CH_4 c) CO and CH_4 d) Only CO and H_2
27.	The lowest theoretical temperature to which water can be cooled in a cooling tower is a) Difference between DBT and WBT of the atmospheric air b) Average DBT and WBT of the atmospheric air c) DBT of the atmospheric air d) **WBT of the atmospheric air**
28.	In a solar thermal power station Molten salt is preferred as it provides an efficient low cost medium to store _____ energy a) Electrical b) **Thermal** c) Kinetic d) Potential
29.	From Voltage, Amps and Power factor given in the name plate of a motor, one can calculate _____. a) Rated output power b) Shaft power c) **Rated input power** d) Both (b) & (c)
30.	RPM of an electric motor is measured using ___. a) Ultrasonic meter b) **Stroboscope** c) Lux meter d) Rotameter
31.	If asset depreciation is considered, then net operating cash inflow would be a) **lower** b) higher c) no effect d) none of the above
32.	Which of the following comes under Capital cost in a project? a) Design cost b) Installation cost c) Commissioning cost d) **All of the above**
33.	Energy consumption per GDP is termed as ___. a) Energy factor b) **Energy intensity** c) Energy Efficiency index d) All of the above
34.	A three phase induction motor is drawing 10 Ampere at 440 Volts. If the operating

	power factor of the motor is 0.9 and the efficiency of the motor is 95%, then the mechanical shaft power of the motor is a) 3.76 KW b) 4.18 KW c) **6.51 KW** d) 7.21 KW
35.	For an activity in a project, Latest start time is 8 weeks and Latest finish time is 12 weeks. If the earliest finish time is 9 weeks, Slack time for the activity is ____. a) **3 weeks** b) 4 weeks c) 1 week d) none of the above
36.	The amount of CO_2 produced in complete combustion of 18 Kg of Carbon is _____. a) 50 b) 44 c) **66** d) 792
37.	Which mode of heat transfer does not require medium? a) Natural convection b) Forced convection c) **Radiation** d) Conduction
38.	If the fixed energy consumption of a company is 2000 kWh per month and the line slope of the energy (y) versus production (x) chart is 0.3, then the energy consumed in kWh per month for a production level of 60,000 tons/month is _____. a) 16,000 KWh b) 18,000 KWh c) 22,000 KWh d) **none of the above**
39.	Which technique takes care of time value of money in evaluation? a) payback period b) IRR c) NPV d) **Both (b) & (c)**
40.	The heat rate of a power plant is expressed as a) kWh/kg of steam b) **kCal/kWh** c) kg of steam / kg of fuel d) kWh / kVA
41.	Which equipment does not come under mandatory labelling program? a) Room Air conditioners b) Frost free refrigerator c) **Induction motors** d) Distribution transformer
42.	Furling speed of wind turbine indicates ____ a) **Cut out speed** b) Cut in speed c) Rated speed d) None of the above
43.	One Silicon cell in a PV module typically produces a) **0.5 V** b) 1 V c) 2 V d) 12 V
44.	The input to a fuel cell is. a) Electricity b) **Hydrogen** c) Oxygen d) All of the above
45.	The production factor is defined as the ratio of a) **current year production to the reference year production** b) current year production to the reference month production c) reference month production to the current month production d) reference year production to the current year production
46.	To reduce the distribution losses within a plant, the capacitors should be located a) **Closest to the load** b) Farthest from the load c) In the substation d) Before the billing meter
47.	Absolute pressure is measured as a) Gauge pressure – Atmospheric pressure

	b) **Gauge pressure + Atmospheric pressure** c) Gauge pressure / Atmospheric pressure d) none of the above
48.	The dryness (x) fraction of superheated steam is taken as a) x= 0 b) x= 0.9 c) x= 0.87 d) **x= 1**
49.	When the evaporation of water from a wet substance is zero, the relative humidity of the air is likely to be a) 0% b) **100%** c) 50% d) unpredictable
50.	Which of the following type of collector is used for low temperature systems? a) **Flat plate collector** b)Line focusing parabolic collector c) Parabolic trough collector d) None of the above

……. End of Section – I ……..…..

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

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

S-1	List five equipment and appliances covered under Standards and Labelling program.
Ans	**Refer BEE Guide Book 1- Page No 37**
S- 2	State true or false (each carries 1 mark) a) When it is raining, there is a substantial difference between the dry and wet bulb temperatures. b) The specific gravity of light diesel oil is given in kg/m^3 c) The major constituent of LNG is propane d) Evaporative cooling of space requires use of refrigerant R134a e) HSD needs preheating to increase viscosity
Ans	a) False b) False c) False d) False e) False
S – 3	For installing a recuperator in a furnace, the plant has assessed the following time estimates Optimistic Time : 2.5 weeks Most Likely Time : 3 weeks Pessimistic Time : 3.5 weeks Find out the "Expected Time", "Standard Deviation" and "Variance" to complete the activity (**2 +1.5+1.5 Marks**)

Ans	Expected time = (Optimistic Time + 4 X Most Likely Time + Pessimistic Time) / 6 = (2.5 + 4 x 3 + 3.5)/ 6 = 3 Standard Deviation = (3.5-2.5)/6 = 1/6 = 0.167 Variance = {(PT-OT/6)} ^{2} = 1 / 36 = 0.0278
S-4	A thermal power plant uses 0.72 kg of coal to generate one KWh of electricity. If the coal contains 38% carbon by weight, calculate the amount of CO_2 emission/KWh under complete combustion.
Ans	Amount of carbon present in coal = 0.72 * 38/100 = 0.2736 kg As per chemical reaction, C + O_2 = CO_2 1 kg of carbon generates 44/12 kg of carbon dioxide (CO2) under complete combustion Amount of CO2 generation while generating one KWh of electricity = 0.2736 * 44/12 = 1.0032 Kg/KWh
S-5	A solar photovoltaic power plant is installed with 350 Watts panel of size 1.5 m x 1.5 m in roof top area of a building having dimension of 9 m x 10m. If solar insolation is 1,000 W/m^2, calculate the panel conversion efficiency?
Ans	Area of solar cell = 1.5 x 1.5 = 2.25 m^2 Efficiency = (350 /(2.25 x 1000)) x 100 = 15.6 %
S – 6	A paint drier requires 75.4 m^3/min of air at 93°C, which is heated in a steam-coil unit. How many kg of steam at 4 bar does this unit require per hour? The density of air is 1.2 kg/m^3 and specific heat of air is 0.24 kcal/kg°C. The ambient temperature is 32°C.

Pressure bar	Temperature °C	Enthalpy kcal/kg		
		Water	Evaporation	Steam
4	143	143	510	653

Ans	Solution: Air flow rate = 75.4 m^3/min * 60 = 4524 m^3/hr Air flow rate = 4524 * 1.2 = 5428.8 kg/hr Sensible heat of air = m * Cp * ΔT = 5428.8 * 0.24 * (93-32) = 79477.6 kcal/hr Latent heat of Steam = 510 Kcal/kg Steam required = 79477.6 / 510 Steam required = 156 kg/hr

S – 7	An ESCO company is required to invest in a waste heat recovery project, which is expected to yield an annual saving of Rs.10,00,000 and the life of the equipment is 7 years. If the ESCO expects 30% IRR on this project, calculate the investment required to be made.
Ans	The PV of the Annual Savings of Rs.1,000,000 per year: $0 = -\frac{\text{Investment}}{(1+0.3)^0} + \frac{1000000}{(1+0.3)^1} + \frac{1000000}{(1+0.3)^2} + \frac{1000000}{(1+0.3)^3} + \frac{1000000}{(1+0.3)^4} + \frac{1000000}{(1+0.3)^5} + \frac{1000000}{(1+0.3)^6} + \frac{1000000}{(1+0.3)^7}$ or Investment = Rs.1,000,000/year (P/AIN Factor) = Rs.1,000,000/year (2.8021) = Rs. 2,802,100 Thus, we can pay Rs.2,802,100 for the Waste Heat Exchanger and still have a positive NPV.
S – 8	In a textile plant monthly energy consumption is 7,00,000 kWh of electricity , 40 kL of furnace oil (specific gravity=0.92) for thermic fluid heater, 360 tonne of coal for steam boiler and 10 kL of HSD (specific gravity= 0.885) for material handling equipment. Compute the energy consumption in terms of Metric Tonne of Oil Equivalent (MTOE) for the plant. Given Data: (1 kWh = 860 kcal, GCV of coal= 3450 kCal/kg, GCV of furnace oil= 10,000 kcal/kg, GCV of HSD= 10,500 kcal/kg, GCV of rice husk= 3100 kcal/kg, 1 kg oil equivalent = 10,000 kcal)
Ans	Aggregate Energy Use= (40000 x0.92x 10000) + (360000 x 3450) + (7, 00,000 x 860) + (10,000x 0.885 x 10,500). MTOE = $\frac{(36.8 \times 10^7) + (124.2 \times 10^7) + (60.2 \times 10^7) + (9.2925 \times 10^7)}{10^7}$ = 230.5 Metric Tonnes of Oil Equivalent per month Energy consumption of the textile plant = 230.5 x 12 = 2766 MTOE

……. 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

<table>
<tr><td>L - 1</td><td>Describe the stages of Gasification of Biomass process with a pictorial diagram and reaction equations?</td></tr>
<tr><td>Ans</td><td>Refer BEE Guide Book 1- Page No 275-276</td></tr>
<tr><td>L – 2</td><td>a. Explain briefly three types of Performance Contracting? (6 Marks)
b. What are the drawbacks of ESCO? (4 Marks)</td></tr>
<tr><td>Ans</td><td>Refer BEE Guide Book 1- Page No.178</td></tr>
<tr><td>L - 3</td><td>a) Write down the steps for computing energy savings using CUSUM over a period. (4 Marks),
b) Develop a table using a CUSUM technique to calculate energy savings for 8 months period for a production level of 2000 MT per month. Refer to field data given in the table below. (6 marks)
<table>
<tr><th>Month</th><th>Actual SEC kWh/MT</th><th>Predicted SEC kWh/MT</th></tr>
<tr><td>May</td><td>1225</td><td>1250</td></tr>
<tr><td>June</td><td>1227</td><td>1250</td></tr>
<tr><td>July</td><td>1240</td><td>1250</td></tr>
<tr><td>Aug</td><td>1245</td><td>1250</td></tr>
<tr><td>Sep</td><td>1238</td><td>1250</td></tr>
<tr><td>Oct</td><td>1257</td><td>1250</td></tr>
<tr><td>Nov</td><td>1248</td><td>1250</td></tr>
<tr><td>Dec</td><td>1264</td><td>1250</td></tr>
</table></td></tr>
<tr><td>Ans</td><td>a) Steps for CUSUM analysis:
Refer BEE Guide Book 1 Page No. 229

b) Estimate the savings accumulated from use of the heat recovery system.
<table>
<tr><th>Month</th><th>Actual SEC kWh/MT</th><th>Predicted SEC kWh/MT</th><th>Difference (Actual SEC - Predicted SEC) kWh/MT</th><th>CUSUM Savings kWh/MT</th></tr>
<tr><td>May</td><td>1225</td><td>1250</td><td>-25</td><td>-25</td></tr>
<tr><td>June</td><td>1227</td><td>1250</td><td>-23</td><td>-48</td></tr>
</table></td></tr>
</table>

	July	**1240**	**1250**	**-10**	**-58**
	Aug	**1245**	**1250**	**-5**	**-63**
	Sep	**1238**	**1250**	**-12**	**-75**
	Oct	**1257**	**1250**	**+7**	**-68**
	Nov	**1248**	**1250**	**-2**	**-70**
	Dec	**1264**	**1250**	**+14**	**-56**

Positive savings i.e. savings in energy consumption over a period of eight months are 56 x 2000 = 112,000 kWh

L – 4 In a Chlor-Alkali plant, an evaporator was designed to concentrate 500 kg of liquor containing solids of 7% w/w (weight by weight) to 45% solids w/w in the output. Presently the output from evaporator has 30% solids w/w. The energy manager suggested overhauling the evaporator to achieve the design rate of solids w/w in the output. Calculate the percentage improvement in water removal in the evaporator after overhauling of the evaporator.

Ans

Amount of feed (input) to the evaporator = 500 Kg
Concentration of solids in feed = 7 wt%
Amount of solids in feed (input) = 500 * 7 /100
= 35 Kg

<u>Present scenario :</u>
Concentration of solids in product (output) = 30 wt% = 0.3
<u>Mass balance across the evaporator :</u>
Amount of product (output) from the evaporator = 35 / 0.3
= 116.7 Kg

Water vapour removed from the evaporator is = 500 – 116.7
= 383.3 Kg

<u>Design scenario :</u>
Concentration of solids in product (output) = 45 wt% = 0.45
<u>Mass balance across the evaporator :</u>
Amount of product (output) from the evaporator = 35 / 0.45
= 77.8 Kg

Water vapour removed from the evaporator is = 500 – 77.8
= 422.2 Kg

Incremental water removal achieved is = 422.2 – 383.3
= 38.9 Kg

% increase in water removal = 38.9 / 383.3 * 100
% improvement in water removal after overhaul = 10.14 %

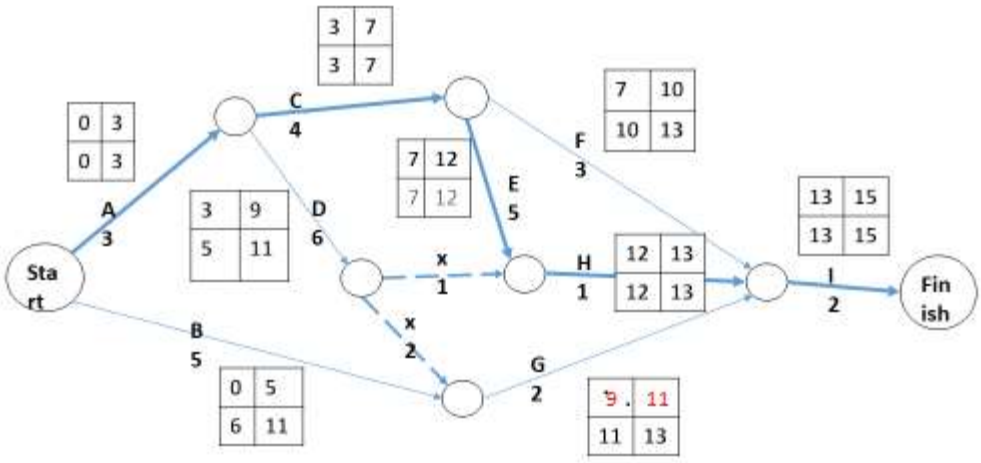
L -5 A process plant is planning to implement a waste heat recovery project. The various activities from procurement to commissioning are given in the table below along with their duration and dependency.

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

a) Construct a PERT/CPM network diagram for the above project. **(5 Marks)**
b) Compute the earliest start, earliest finish, latest start, latest finish and slack for all the activities **(3 Marks)**
c) Compute the project duration. **(1 Mark)**
d) Identify the critical activities and the critical path(s). **(1 Mark)**

Ans

a) PERT/CPM network diagram for a project



b) Early start (ES), Early Finish (EF), Latest start (LS), Latest finish (LF) and slack for all the activities.

Activity	Duration	ES	EF	LS	LF	Slack (LS-ES) or (LF-EF)
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	5	11	2
E	5	7	12	7	12	0

F	3	7	10	10	13	3
G	2	9	11	11	13	2
H	1	12	13	12	13	0
I	2	13	15	13	15	0

X1 and X2 are dummy activities

c) Critical Path : A- C- E- H- I

d) Total time on critical path (project duration) : 15 weeks

L- 6

A medium size chemical plant receives electricity from grid and also generates electricity from coal based Captive Power Plant (CPP). Coal is also used for process requirements. The fine coal from CPP is sold to neighboring plant. The annual energy details are given below:

Electricity purchased from grid	5 MU
Electricity exported to grid	11 MU
Power generation from CPP	36 MU
Power Supplied from CPP to Process plant	25 MU
Fine coal sold to neighboring unit	1000 ton
Coal used for process plant	5000 ton
GCV of coal	4500 kcal/kg
Heat rate of CPP	3500 kcal/kWh
Annual Operating Hours	7200

Calculate

a. Energy usage in TOE (Tons of oil equivalent) (5 Marks)
b. Coal used in CPP (3 Marks)
c. Calculate the CPP operating power in MW. (2 Marks)

Ans

Energy usage in TOE (Tons of oil equivalent)

- Grid electricity Imported = (5 x 10^6 kWh)x (860 kcal/kWh) = (+) 43 x 10^8 kcals/year
- Power generated from CPP = (36 x 10^6 kWh)x (3500 kcal/kWh) = (+) 1260 x 10^8 kcals/year
- Coal imported for process = (5000 x 10^3 kg)x (4500 kcal/kg) = (+) 225 x 10^8 kcals/year
- Power exported to grid = (11 x 10^6 kWh)x (3500 kcal/kWh) = (-) 385 x 10^8 kcals/year
- Coal fines exported to neighbour = (1000 x 10^3 kg)x (4500 kcal/kg) = (-) 45 x 10^8 kcals/year
- Net annual energy consumption = (43+1260+225)-(385+45) = (+) 1098 x 10^8 kcals/year

a. Energy usage in TOE = (1098 x 10^8 kcals/year) / (10^7) = 10980 MTOE
(1 MTOE = 10^7 kcals)

b. Coal used in CPP = ((36 x 10^6 kWh)x (3500 kcal/kWh)) / (4500 kcal/kg)
= 28 x 10^6 kgs Coal/ Year
= (28 x 10^6)/10^3 = 28000 Tons Coal/ Year

c. Calculate the CPP operating MW = (36 x 10^6 kWh/year)/ (7200 hrs/year)
= 5000 kW
= 5 MW

……. End of Section – III ……