

Regn No: _____

Name: _____

(To be written by the candidate)

9th NATIONAL CERTIFICATION EXAMINATION – December, 2009 FOR ENERGY MANAGERS AND ENERGY AUDITORS

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

Date: 19.12.2009 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- Please check that this question paper contains **12** printed pages
- Please check that this question paper contains **64** questions
- The question paper is divided into three sections
- All questions in all three sections are compulsory
- All parts of a question should be answered at one place

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	To maximize the combustion efficiency, which of the following in the flue gas needs to be done? a) maximize O ₂ b) maximize CO₂ c) minimize CO ₂ d) maximize CO
2	Which of the following is not a primary energy source? a) electricity b) coal c) wood d) natural gas
3	Which one of the following is not an example of air pollution from furnace oil fired boilers and furnaces? a) sulphur dioxide (SO ₂) b) chloro-fluro carbons (CFC) c) nitrous oxide(NOX) d) carbon monoxide (CO)
4	Which industry among the following is not a designated consumer as per EC Act-2001? a) fertilisers b) chlor alkali c) cement d) nuclear power stations

Paper 1 –Set A Solutions

5	Propane is an example of a) nuclear energy b) radiant energy c) chemical energy d) thermal energy
6	The density of a fuel oil is 0.86. Its specific gravity will be a) 0.75 b) 0.86 c) 1.75 d) 0.0086
7	An indication of sensible heat content in air-water vapour mixture is a) wet bulb temperature b) dew point temperature c) density of air d) dry bulb temperature
8	The total mechanical energy of a body free falling in a vacuum a) increases b) decreases c) remains the same d) depends on the shape of the body
9	How much carbon emission will be reduced per year by replacing 60 Watt incandescent lamp with 15 Watt CFL Lamp, if emission per unit is 1 kg CO ₂ per kWh and annual burning is 3000 hours? a) 45 ton b) 3 ton c) 0.135 ton d) 183 ton
10	Which of the following is false? a) electricity is high-grade energy b) high grade forms of energy are highly ordered and compact c) low grade energy is better used for applications like melting of metals rather than heating water for bath d) the molecules of low grade energy are more randomly distributed than the molecules of carbon in coal
11	The present value of equipment is Rs. 10,000 and discount rate is 10%. The future value of the cash flow at the end of 2 years is: a) Rs. 10000 b) Rs. 12,100 c) Rs. 8100 d) Rs. 8264
12	What will be the energy saving if one 1500 watts, 25 liter water heater, which is normally put on for 20 minutes per day and 250 days in an year, is replaced with one 100 liter capacity solar water heater? a) 581units b) 750 units C) 125 units d) 169 units
13	An energy audit as defined in the Energy Conservation Act 2001 does not include a) action plan to reduce energy consumption b) verification, monitoring and analysis of use of energy c) submission of technical report with recommendations d) implementation of all the recommendations of energy audit
14	The difference between GCV and NCV of coal is a) the heat of vaporization of the moisture and hydrogen in coal b) the difference in calorific value with theoretical air and with allowable excess air c) difference in accounting the un-burnt content in the ash d) none of the above

Paper 1 –Set A Solutions

15	A public expression of organization's commitment to energy conservation would be a) reduce contract demand b) energy audit c) energy policy d) improve power factor
16	For calculating plant energy performance which of the following data is not required a) current year's production b) reference year's production c) reference year energy use d) capacity utilization
17	Which of the following is not applicable to liquid fuels? a) the viscosity of a liquid fuel is a measure of its internal resistance to flow. b) the viscosity of all liquid fuels decreases with increase in its temperature c) higher the viscosity of liquid fuels, higher will be its heating value d) viscous fuels need heat tracing
18	Non contact speed measurements can be carried out by a) odometer b) tachometer c) stroboscope d) oscilloscope
19	In the first two months the cumulative sum is 4 and 12 respectively. In each of the next two months $E_{\text{calculated}}$ is more than E_{actual} by 3. The energy savings at end of the fourth month would be a) -6 b) 0 c) 6 d) none of the above
20	The statement not applicable in the case of Sankey diagram a) useful tool to represent an entire input and output energy flow b) represents visually various outputs and losses c) depicts rejection and wastage of material flow d) helps energy manager to focus on finding improvements in a prioritized manner
21	The Designated National Agency (DNA) of India for Clean Development Mechanism (CDM) is a) Ministry of Environment and Forests (MoEF) b) Bureau of Energy Efficiency (BEE) c) Central Electricity Authority (CEA) d) Central Electricity Regulatory Commission (CERC)
22	Which among the following can be best implemented through an ESCO (Energy Service Company) route: a) coal procurement contract for captive power plant b) energy efficient design of a municipal lighting system c) large Waste Heat Recovery System in a large process plant, where external financing is sought d) energy and mass balance study of a Steel Plant
23	A CUSUM graph follows a random fluctuation trend and oscillates around a) 50% b) 100% c) 0 d) mean value
24	Statement not applicable to TOD (Time of the Day) in electricity tariff structure? a) higher energy charges during peak period b) it is an incentive to maximize off-peak consumption c) it is an incentive to minimize peak time power draw from the grid by consumers

Paper 1 –Set A Solutions

	d) it is a disincentive for Distribution Company
25	Which of the following will be true of load factor for a continuous process a) higher than batch process plants b) comparable to that of a five star hotel with 60% occupancy c) less than that of an energy efficient municipal lighting system d) closer to the regional grid load factor
26	In a heat treatment furnace the material is heated up to 800 °C from ambient temperature of 30 °C. Considering the specific heat of material as 0.13 kCal / kg °C, what is the energy content in one kg of material after heating? a) 700 kCal b) 250 kCal c) 350 kCal d) 100 kCal
27	In an industry the average electricity consumption is 4.6 lakh kWh for the period, the average production is 40000 tons with specific electricity consumption of 10 kWh /ton for the same period. The fixed electricity consumption for the plant is : a) 60000 kWh b) 46000 kWh c) 20000 kWh d) none of the above
28	The process by which Annex 1 countries can invest in the GHG mitigation projects in developing countries is called: a) green trading b) clean development mechanism c) conference of parties d) certified emission reduction
29	All the activities falling in the critical path of the PERT network will have a) ES = LS and EF = LF b) LF = LS and ES=EF c) only ES=LS d) only EF = LF
30	The cost of replacement of inefficient chiller with an energy efficient chiller in a plant was Rs. 10 lakh .The net annual cash flow is Rs 2.50 lakh .The return on investment is: a) 18% b) 20% c) 15 % d) none of the above
31	Condensation of saturated steam releases a) sensible heat b) super heat c) latent heat d) none of the above
32	Calorific Value of coal is measured by a device called a) bomb calorimeter b) calorifier c) infrared thermometer d) none of these
33	The first vital step in an energy management program is a) measurement b) setting goals c) energy audit d) top management commitment
34	The calorific value of coal is 5000 kCal /kg .Find out the oil equivalent of 200 kg of coal if the calorific value of oil is 10000 kCal/kg. a) 100 kg b) 108 kg c) 105 kg d) none of the above
35	Which gas has the least impact on global warming? a) carbon dioxide b) methane c) ozone d) carbon monoxide

Paper 1 –Set A Solutions

36	Which one is not an energy consumption benchmark parameter? a) kCal/kWh of electricity generated b) kg/ deg C. c) kW/ton of refrigeration d) kWh/kg of yarn
37	Calculate the amount of electricity required to heat 100 litres of hot water from 20 to 60°C a) 4.65 kWh b) 0.465 kWh c) 465 kWh d) 2 kWh
38	A person can do the following with wind energy a) destroy it b) convert it c) create it d) burn it
39	In a force field analysis in energy action planning, high price of energy acts as a) positive force b) negative force c) neutral forces d) none of the above
40	The four pillars of successful energy management are technical ability, monitoring system, top management support and _____ a) strategy plan b) energy audit plan c) quality plan d) financial plan
41	The 80/20 Rule in management means a) few (20%) are vital and many (80%) are trivial b) many (80%) are vital and few (20%) are trivial c) 80% of work is outsourced d) 20% of work is outsourced
42	The contractor provides the financing and is paid an agreed fraction of actual savings achieved. This payment is used to pay down the debt costs of equipment and/or services. This is known as a) traditional contract b) extended technical guarantee/service c) performance Contract d) shared savings performance contract
43	In project financing ,sensitivity analysis is applied because a) almost all the cash flow methods involve uncertainty b) of the need to assess how sensitive the project to changes in input parameters c) what if one or more factors are different from what is predicted d) all the above situation
44	One thousand liters of fuel oil cost Rs 20,000. How much does one kg of fuel oil cost if density is 0.98 a) 20.40 b) 20.0 c) 19.02 d) none of the above
45	Installed capacity of nuclear power plants in India as a % of total installed capacity is a) 10% b) 25% c) 3% d) 55%
46	Name the sector which is the biggest consumer of commercial energy a) industry b) agriculture c) transport d) residential
47	To calculate internal rate of return , the net present value is set to a) 1 b) 0 c) 10 d) 100

Paper 1 –Set A Solutions

48	Project management technique which uses three time estimates. a) PERT b) CUSUM c) CPM d) none of the above
49	One Certified Emission Reduction (CER) is equivalent of CO ₂ emission is a) 1 ton of CO₂ b) 1 kg of CO ₂ c) 10 kg of CO ₂ d) 10 ton of CO ₂
50	A system uses 100 kg of raw material A, 200 kg of raw material B and 220 kg of raw material C. The mix is heated to 220°C. The air is blown to cool which carries away on an average 60% of raw material A and 30% of raw material B through the chimney. The output product would be a) 520 kg b) 400 kg c) 312 kg d) 208 kg

..... 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 Explain the difference between contract demand and maximum demand.

Ans

Contract Demand

Contract demand is the amount of electric power that a customer demands from utility in a specified interval. Unit used is kVA or kW. It is the amount of electric power that the consumer agreed upon with the utility. This would mean that utility has to plan for the specified capacity.

(2.5 Marks)

Maximum Demand

Maximum demand is the highest average kVA recorded during any one-demand interval within the month. The demand interval is normally 30 minutes, but may vary from utility to utility from 15 minutes to 60 minutes. The demand is measured using a tri-vector meter / digital energy meter.

(2.5 Marks)

S-2 An induction motor draws 8 kW with a lagging reactive power of 4 kVAr. Calculate the operating power factor of the motor.

Ans. Power factor =
$$\frac{kW}{\sqrt{(kW)^2 + (kVAr)^2}}$$

(2 Marks)

$$= \frac{8}{\sqrt{(8)^2 + (4)^2}}$$

= 0.905

(3 Marks)

S-3 What are the environmental impacts of combustion of fossil fuels?

Ans Sulphur dioxide (SO₂), nitrous oxide (NO_x) and carbon monoxide (CO) and Carbon Dioxide are major emissions from combustion of fossil fuels. SO₂ and NO_x lead to acid rain. CO is unstable and toxic. CO₂ is a green house gas, which leads to global warming.

(5 Marks)

S-4 Fuel substitution may not always result in energy savings. Explain with an example.

Ans Let us say we are replacing an oil fired boiler by a wood fired boiler for economic reasons. The losses in wood fired boiler may be more and hence to compensate for that we need to supply more energy for the same output. Thus it will increase the energy consumption.

(5 Marks)

S-5 What parameters are measured with the following instruments?

- a) Pitot tube
- b) Stroboscope
- c) Fyrite
- d) Lux meter
- e) Power analyser

Ans

- a. Pitot tube - static, dynamic and total pressure
- b. Stroboscope - speed, RPM
- c. Fyrite - CO₂ or O₂
- d. Lux meter - Light levels in Lux (lumens/m²)
- e. Power analyser - kW, kVA, Power factor, V, A etc

(1 Mark each)

S-6 The initial temperature of 150g of ethanol was 22°C. What will be the final temperature of the ethanol if 3240 J was needed to raise the temperature of the ethanol? (Specific heat capacity of ethanol is 2.44 J/g°C).

Ans $q = m \times C_g \times (T_f - T_i)$
 $q = 3240 \text{ J}$
 $m = 150\text{g}$
 $C_g = 2.44 \text{ J/g}^\circ\text{C}$
 $T_i = 22^\circ\text{C}$
 $3240 = 150 \times 2.44 \times (T_f - 22)$
 $3240 = 366 (T_f - 22)$
 $8.85 = T_f - 22$
 $T_f = 30.9^\circ\text{C}$ (5 Marks)

Paper 1 –Set A Solutions

S-7 Explain the importance of TOD (time of the day) tariff and its advantage to utilities and to users. List some of the Industries where TOD benefits can be fully utilised.

Ans Many electrical utilities like to have flat demand curve to achieve high plant efficiency. They encourage user to draw more power during off-peak hours (say during night time) and less power during peak hours. As per their plan, they offer TOD Tariff, which may be incentives or disincentives. Energy meter will record peak and non-peak consumption separately by timer control. TOD tariff gives opportunity for the user to reduce their billing, as off peak hour tariff charged are quite low in comparison to peak hour tariff.

(3 Marks)

- a. Operation of additional Cement Mills in Night periods
- b. Operation of Melting furnaces in night shift
- c. Heat treatment furnace operation in Night shift
- d. Storage pump operation in large complex in night shift

(2 Marks)

S-8 Explain why a project with a high IRR is not necessarily more attractive than a project with lower IRR?

Ans The IRR can not be distinguished between lending and borrowing and hence a high IRR is not necessarily a desirable feature.

Also the NPV is the increase in shareholder or companies wealth through the project. It therefore can happen that a project A has a very high IRR but low NPV; while another Project B has low IRR but High NPV .In this case B should be selected

(5 Marks)

..... **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 Steam flow from a water tube boiler is measured by measuring the feed water tank levels. In two hours there is a drop of 200 cm in level. The cross sectional area of the tank is 9 m². Assuming no blowdown, calculate the steam flow rate. The enthalpy of steam is 662 kCal/kg and feed water temperature is 80°C. The calorific value of fuel used in the above boiler was measured by a continuous flow calorimeter. The following data were obtained.

Mass of fuel	: 2.25 kg
Inlet water temp	: 30°C
Quantity of water	: 360 litres

Paper 1 –Set A Solutions

Outlet water temp : 84°C
% heat transferred to water in bomb calorimeter : 85 %

(a) Calculate the calorific value of the sample (kCal/kg).

(b) If the efficiency of the boiler is 85% find out the fuel firing rate (kg/hr).

Ans To calculate the calorific value of the fuel

(a) Heat carried by water = 360 x 1x 54

$$= 19440 \text{ kcal}$$

Calorie released by fuel = 19440/0.85

$$= 22871 \text{ kcal}$$

$$= 10,164 \text{ kcal/kg}$$

(5 Marks)

(b) Volume of flow in 2 hours = 9 x 2m

$$= 18 \text{ m}^3$$

Steam flow rate = 18/2 = 9 TPH

Fuel firing rate = 9000 kg/hr x (662-80)/(0.85 x 10164)
= 606.29 kg/hr

(5 Marks)

L-2 Investment for a set of interrelated energy efficiency projects identified in a medium size process plant works out to Rs.12.00 lakh. Annual savings for the first four consecutive years are Rs. 300,000, Rs. 400,000, Rs. 400,000 and Rs. 450,000, respectively. The cost of capital is 12% p.a.

What is the net present value (NPV)? And as per NPV, suggest whether the plant can go ahead with the projects.

Ans. NPV= (-) 12,000,00/(1.12)⁰+3,50,000/(1.12)¹+4,00,000/(1.12)²+4,00,000/(1.12)³+ 4,50,000/(1.12)⁴

$$= (-)12,00,000+12,02073 = \text{Rs. } 2073$$

(8 Marks)

Hence the decision rule associated with the net present value criterion is: "Accept the project if the net present value is positive and rejects the project if the net present value is negative".

Therefore the project is acceptable.

(2 Marks)

L-3 What is Energy Security? Mention few strategies countries adopt to ensure this?

Ans. The basic aim of energy security for a nation is to reduce its dependence on the imported energy sources for its economic growth.

(2 marks)

Paper 1 –Set A Solutions

Some of the strategies for energy security are:

Building Stock Piles

Diversification of energy supplies sources.

Increased capacity of fuel switching

Demand restraint.

Development of renewable energy sources.

Energy Efficiency.

Sustainable development

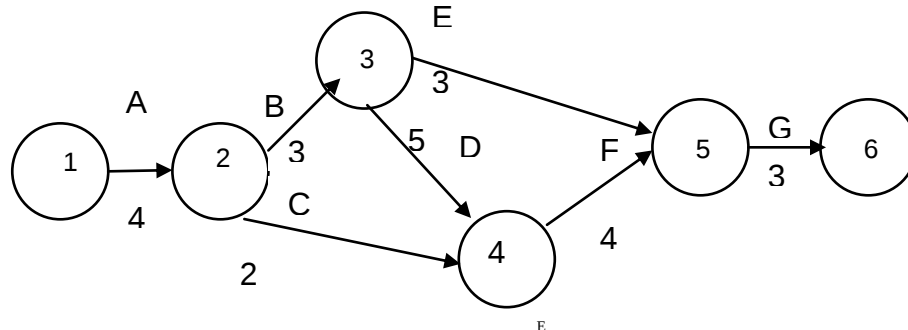
(8 marks, 2 marks for each for any four points)

L-4 (a) Construct a PERT Chart diagram for the data given below

(b) Identify the critical path and compute the project duration. Also compute the earliest start, earliest finish, latest start & latest finish of all activities

Activity	Precedent	Time, weeks
A		4
B	A	3
C	A	2
D	B	5
E	B	3
F	C,D	4
G	E,F	3

Ans (i)



[3 marks]

D1 and D2 are dummy activities

ii) Critical Path

A- B- D- F- G

Total time on critical path: 19 weeks

[1 mark]

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

Paper 1 –Set A Solutions

S.no	Activity	Duration	ES	EF	LS	LF
1	A	4	0	4	0	4
2	B	3	4	7	4	7
3	C	2	4	6	10	12
4	D	5	7	12	7	12
5	E	3	7	12	13	16
6	F	4	12	16	12	16
7	G	3	16	19	16	19

(6 marks)

L-5 A 500 MW coal plant based on conventional pulverized fuel has a gross efficiency of 38%. The Gross calorific value of the coal used is 4000 kCal/kg with 40% total carbon. A supercritical unit of 500 MW replaces the plant with a gross efficiency of 40% using the same characteristic coal. Calculate the following

(a) Specific coal consumption after replacement

(b) Amount of coal and carbon di-oxide saved during a year if the plant works for 8000 hours.

Ans Case (a) Before replacement

$$\text{Heat rate} = \frac{860}{0.38} = 2263 \text{ kcal/kwh}$$

$$\text{Specific coal consumption} = \text{heat rate} / \text{GCV} = 2263/4000 = 0.565 \text{ kg/kwh}$$

[3 marks]

Case (b) After replacement

$$\text{Heat rate of the plant} = \frac{860}{0.40} = 2150 \text{ kcal/kWh}$$

$$\begin{aligned} \text{Specific coal consumption} &= \text{heat rate} / \text{GCV} \\ &= 2150/4000 = 0.537 \text{ kg/kWh} \end{aligned}$$

$$\text{Saving in Coal consumption} = 0.565 - 0.537 = 0.028 \text{ kg/kWh}$$

$$\text{Amount of power generated in kWh} = 500 \times 1000 \times 8000 = 4 \times 10^9$$

$$\begin{aligned} \text{Amount of coal saved in a year} &= 0.028 \text{ kg/kWh} \times 4 \times 10^9 \\ &= 112000 \text{ tonnes} \end{aligned}$$

$$\text{Amount of CO}_2 \text{ saved} = 44/12 \times 112000 \times 0.40 = 164267 \text{ tonnes}$$

[7 marks]

Paper 1 –Set A Solutions

L-6 (a) When the same quantity of heat is added to the same mass of Iron and copper pieces, the temperature of Iron piece rises by 15°C . Calculate the rise in temperature of Copper piece, if the specific heat of Iron is $470 \text{ J/kg}^{\circ}\text{C}$ and that of Copper is $390 \text{ J / kg }^{\circ}\text{C}$?

(b) The input to a textile dryer is 60 kg of wet cloth per hour with 55% moisture. If it is dried to 10% in a dryer, estimate the moisture removed per hour.

Ans **Mass of Iron x Sp. Heat Iron x 15°C = Mass of Copper x Sp. Heat Copper x (Rise in Temp of Copper $^{\circ}\text{C}$)**

Since mass of Iron = Mass of Copper

Sp. Heat Iron x 15°C = Sp. Heat Copper x (Rise in Temp of Copper $^{\circ}\text{C}$)

Sp. Heat of Iron = $470 \text{ J / kg }^{\circ}\text{C}$

Sp. Heat of Copper = $390 \text{ J / kg }^{\circ}\text{C}$

**Hence, Rise in Copper Temp. = $(470 \times 15) / 390$
= 18.08°C**

[5 marks]

Ans **60 kg of wet cloth contains, $60 \times 0.55 \text{ kg water} = 33 \text{ kg moisture}$,
(b) **and $60 \times (1-0.55) = 27 \text{ kg bone dry cloth}$.****

As the final product contains 10% moisture,

If m is the moisture in kg, $[m/(27+m)] = 0.1$

$m = 2.7 + 0.1m$

$0.9m = 2.7$

$m = 2.7/0.9$

the moisture in the product is $27/9 = 3 \text{ kg}$

And so Moisture removed / hr = $33 - 3 = 30 \text{ kg/hr}$

[5 marks]

..... End of Section – III