

NATIONAL CERTIFICATION EXAMINATION 2005

FOR

ENERGY MANAGERS & ENERGY AUDITORS

Question Papers & Model solutions to the Question Papers

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

Date: 28.05.2005 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- Please check that this question paper contains **7** printed pages
- Please check that this question paper contains **65** 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) Put a (✓) tick mark in the appropriate box in the answer book

1.	Methane traps about ____ times more heat than Carbon Dioxide a) 7 b) 14 c) <u>21</u> d) 28
2.	One of the flexible instrument as stated in the Kyoto Protocol is a) CO ₂ adaptation b) <u>Clean Development Mechanism (CDM)</u> c) CO ₂ sequestration mechanism d) none of the above
3.	Which country was the latest to recently ratify the Kyoto Protocol a) USA b) Australia c) <u>Russia</u> d) Germany
4.	Which is a greenhouse gas a) Sulfur Dioxide b) Nitrogen c) <u>Nitrous Oxide</u> d) none of the above
5.	In an industry the electricity consumed for a period is 1,00,000 kWh. The production in this period is 10,000 tons with a variable energy consumption of 7 kWh/ton. The fixed kwh consumption of the plant is a) <u>30000</u> b) 23000 c) 7000 d) 10000
6.	In an CUSUM chart, if the graph is horizontal for two consecutive period then a) actual and calculated energy consumption are the same b) actual energy consumption is reduced c) specific energy consumption is the same d) <u>each one of the above may be true</u>

7.	Pie chart of a fuel mix on energy consumption represents a) percentage share of fuels based on costs b) percentage share of fuels based on energy bill c) percentage share of fuels based on volume content d) <u>percentage share of fuels based on common unit of energy</u>
8.	Drawing a Gantt chart does not require a) <u>to know cost of the activities</u> c) to know beginning of the activities b) duration of activity d) to know the interdependency of the tasks
9.	Critical path in a CPM network diagram a) <u>is the longest path in a network</u> b) is the shortest path in a network c) where all activities of long duration fall d) none of the above.
10.	PERT stands for _____ a) Project Evaluation Research Technique b) <u>Programme Evaluation & Review Technique</u> c) Power & Energy Reforms Techniques d) none of the above
11.	Benchmarking helps to a) track performance change over time c) <u>both a & b</u> b) compare with best/average performance d) none of the above
12.	One of the basic indicators of financial investment appraisal is a) risk assessment c) interest rate b) trending of fuel costs d) <u>simple payback</u>
13.	What does the concept of time value of money imply a) present value of money c) discounting of cash flows b) future value of money d) <u>all of the above</u>
14.	Return on Investment (ROI) as a fraction means a) annual return / initial investment c) <u>annual net cash flow / capital cost</u> b) annual cost / cost of capital d) none of the above.
15.	The net present value (NPV) is a) <u>equal to the sum of the present values of all cash flows</u> b) equal to the sum of returns c) equal to the sum of all cash flows d) none of the above
16.	The Internal Rate of Return (IRR), of an investment is calculated by a) selecting a discount rate so that $NPV = 0$ b) equating total discounted costs with total discounted benefits c) making sure the benefit / cost ratio equals unity d) <u>all of the above</u>

17.	Which one is not a macro factor in a sensitivity analysis? a) change in interest rates b) technology changes c) <u>cost of debt</u> d) change in tax rates
18.	Which service is normally not part of an ESCO contract? a) financing of measures b) engineering analysis and design c) project development and supervision d) <u>obtaining operation permits</u>
19.	In Project Management, what does the 80/20 Rule say? a) 20% is trivial and 80% is vital work b) <u>20% of work consumes 80% of time and resources</u> c) the first 20% of work consumes 80% of your time and resources d) none of the above.
20.	Which subject is not so important in the screening of projects in a need identification a) cost-effectiveness b) availability of technology c) sustainability of the savings d) <u>implementation period</u>
21.	A firm switches from a low ash and low moisture fuel to a less expensive high ash and high moisture fuel by retrofitting a furnace. The most likely impact of the measure is a) saves fuel cost and reduces energy consumption b) <u>saves fuel cost but increases energy consumption</u> c) increases fuel costs and energy consumption d) none of the above.
22.	The "superheat" of steam is expressed in a technical report as a) <u>degrees Centigrade above saturation temperature</u> b) critical temperature of the steam c) the temperature of the steam d) none of the above
23.	The rate of energy transfer from a higher temperature to a lower temperature is measured in a) kCal b) <u>Watt</u> c) Watts per Second d) none of the above.
24.	The electrical power unit Giga Watt (GW) may be written as a) 1,000,000,000 MW b) <u>1,000 x MW</u> c) 1,000 x kW d) 1,000,000 x W
25.	CO ₂ measurement with a Fyrite kit is based on a) weight basis (dry) b) <u>volume basis (dry)</u> c) weight basis (wet) d) volume basis (wet)
26.	A good coal has a Gross Calorific Value of 26,000 MJ/ton. Expressed in kCal/kg the Gross Calorific Value is a) 621000 b) 62100 c) <u>6210</u> d) 621
27.	The annual energy consumption of a plant in the reference year 2003/2004 was 1 Lakh GJ. In the next year 2004/2005 it was 1.1 Lakh GJ. Calculate the plant energy performance (PEP), assuming no change in product mix and output quantity. a) <u>-10%</u> b) 10% c) -9.1% d) none of the above

28.	An oil-fired furnace is retrofitted to fire coconut shell chips. Boiler thermal efficiency drops from 82% to 72%. How much more, or less energy, in percent is spent to generate same amount of steam. a) 10% more b) 12.2% more c) 13.9% less d) <u>13.9% more</u>
29.	Portable combustion analyzers may have built in chemical cells for measurement of stack gas components. Which combination of chemical cells is not possible? a) CO, SO _x , O ₂ b) <u>CO₂, O₂</u> c) O ₂ , NO _x , SO _x , CO d) O ₂ , CO
30.	Non contact flow measurement can be carried out by a) orifice meter b) turbine flow meter c) <u>ultrasonic flow meter</u> d) magnetic flow meter
31.	Two reactants A (200 kg) and B (200 kg) are used in a chemical process as reactants. If conversion is 50% and A and B reacts in equal proportion then calculate the weight of the product formed. a) 150 kg b) <u>200 kg</u> c) 250 kg d) 400 kg
32.	The Energy Conservation Act requires that all designated consumers should get energy audits conducted by a) Energy Manager b) <u>Accredited energy auditor</u> c) Certified Energy Auditor d) Designated agencies
33.	Which energy source is indirect in an overall energy balance in the generation of electricity by a photovoltaic cell? a) <u>commercial energy</u> b) wave energy c) sun light d) none of the above
34.	In the material balance of a process which compound will not be considered on the input side a) chemicals b) air and water c) recycled product d) <u>by-product</u>
35.	Which process emits the most CO ₂ per ton of coal burned a) cogeneration b) power generation c) <u>cement manufacturing</u> d) coal gasification
36.	Which task is not considered a major duty of an energy manager a) prepare an annual activity plan b) establish an improved data recording system c) <u>conduct mandatory energy audit</u> d) prepare information material
37.	Fill in the missing word. An energy policy provides the _____ for setting performance goal and integrating energy management into an organization's culture. a) budget b) delivery mechanism c) action plan d) <u>foundation</u>
38.	Which one is not a step in energy action planning a) make commitment b) implement action plan c) set goals d) <u>report result to designated agency</u>
39.	PERT/ CPM provides the following benefits a) graphical view of the project b) shows activities which are critical to maintaining the schedule c) predicts the time required to complete the project d) <u>all the above</u>

40.	What does normalization of data mean? a) comparing data with respect to performance of a specific year b) removing the impact of various factors on data c) indexing performance of process on data d) benchmarking performance
41.	Primary energy sources are, a) electricity b) converted into secondary energy sources c) used in diesel generator sets d) LPG, petrol & diesel
42.	Eighty percent of the worlds' population lives in developing countries and consumes approximately of the world's total energy consumption a) 80 % b) 60 % c) 40 % d) 20 %
43.	Energy consumption per unit of GDP is called a) energy ratio b) energy intensity c) per capita consumption d) all of the above
44.	Identify the wrong statement for a measure to reduce energy costs in a furnace by substitution of a fuel. a) fuel switching may improve energy efficiency b) fuel switching may reduce energy efficiency. c) fuel switching may reduce energy costs. d) fuel switching always reduces energy consumption.
45.	The Energy Conservation Act 2001 does not require all notified designated consumers to a) appoint/designate certified energy manager b) conduct an energy audit through an accredited energy auditor c) comply with energy consumption norms & standards d) invest in all energy conservation measures
46.	An energy audit as defined in the Energy Conservation Act 2001 includes a) verification, monitoring and analysis of use of energy b) submission of technical report with recommendations c) action plan to reduce energy consumption d) all of the above
47.	An example of stored mechanical energy is a) water in a reservoir b) an arrow in a stretched bow c) an air-borne aeroplane d) you on top of a mountain
48.	Mega Volt Ampere (MVA) in a three phase electrical circuit could be written as a) $\frac{\text{Voltage} \times \text{Ampere}}{1000}$ b) $\frac{\text{Voltage} \times \text{Ampere}}{1,000,000}$ c) Voltage x Ampere x1,000 d) none of the above
49.	When the current lags the voltage in an alternating current system, it is mainly due to a) resistive load b) capacitive load c) inductive load d) none of the above
50.	The phase change from solid state to a liquid state is called a) fission b) enthalpy c) latent heat d) fusion

----- End of Section - I -----

Section - II: SHORT DESCRIPTIVE QUESTIONS

Marks: 10 x 5 = 50

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

S-1 List 5 negative forces of a force field analysis, which are a barrier to the objective “reduce energy consumption per unit production”

- (i) Low price of energy
- (ii) Technology not available
- (iii) Top management not committed
- (iv) Energy is low component of product cost
- (v) No incentives for energy conservation available
- (vi) Firm makes enough profit
- (vii) Lack of awareness throughout company
- (viii) Absence of corporate energy policy
- (ix) Insufficient financial resources to find measure.

S-2 Define Latent Heat

It is the (i) change in (ii) heat (energy) content of a substance, when its (iii) physical state is changed (iv) without change in (v) temperature.

S-3 Distinguish between Gross Calorific Value (GCV) and Net Calorific Value (NCV) of a fuel.

The difference between GCV and NCV is the (i) heat of vaporization of the water that is either (ii) physically present in the fuel as moisture or (iii) formed from the Hydrogen in the fuel during the combustion process. (iv) NCV does not account for the heat of vaporization and is therefore always smaller than GCV if a fuel contains hydrogen or moisture.

S-4 During an air pollution monitoring study, the inlet gas stream to a bag filter was 100,000 m³ per hour. The outlet gas stream from the bag filter was a little bit higher at 120,000 m³ per hour. Dust load at the inlet was 5 gram/ m³, and at the outlet 0.2 gram/ m³. How much dust was in kg/hour was collected in the bag filter bin?

Dust (gas in) = dust (in gas out) + dust (in bin)
100,000 x 5 = 120,000 x 0.2 + x and it follows

$$x = 476,000 \text{ gram/hour} = \underline{476 \text{ kg/hour.}}$$

- S-5 (i) State two obvious measures which may reduce the ratio of energy consumption to gross domestic product (GDP) in the Indian economy.
(ii) What is roughly the ratio under present conditions?

(i) All energy efficiency measures and all national programmes to promote less energy-intensive sectors of the Indian economy will obviously lower energy intensity.

(ii) The present ratio is 1.5 based on Book 1 and any answer between 0.7 and 1.5 should be seen as correct.

- S-6 List 5 sources of greenhouse gases which are either naturally occurring or are caused by human activities.

(i) CO₂ (Carbon Dioxide), (ii) CH₄ (Methane), (iii) NO_x (Nitrous Oxides),
(iv) H₂O(g) (Water in vapor form), (v) HFCs (Hydro Fluor Carbons),
(vi) SF₆ (Sulfur Hexafluoride), (vii) PFCs (Pero Fluoro Carbons)

(OR)

Burning of fossil fuels, deforestation, agriculture, industry, transport.

- S-7 The company “Save Electricity the Smart Way” sells you a gadget that lowers voltage of your electric water storage heater by 10% and saves electricity by 10%. The heater is rated at 2 kW at 230 V. Do you agree with the claim of the company? Support your opinion.

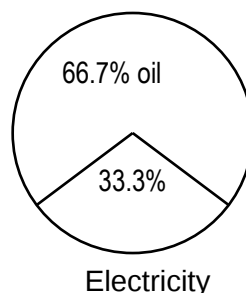
The answer is “No electricity is saved.” There are no calculations necessary. The given information about the water is not needed. Due to the lower voltage the kW load will go down. Therefore the process to heat the water will take longer based on the energy balance. Since the gadget to lower the voltage consumes itself electricity the electricity consumption in fact goes slightly up on paper.

- S-8 A company consumes 5,000 tons of furnace oil per year (GCV =10,200 kCal/kg), as well as 29,651 MWh of electricity per year. Draw the pie-chart of percentage share of fuels based on consumption in kCal (1kWh = 860 kcal)

$5,000 \text{ tonnes} \times 10,200 \text{ kCal} \times 1000 = 5.10 \times 10^{10} \text{ kCal}$

$29,651 \text{ MWh} = 29,651,000 \text{ kWh}$
 $= 29,651,000 \times 860 \text{ kCal}$
 $= 2.55 \times 10^{10} \text{ kCal}$

Total consumption $5.10 + 2.55 = 7.65 \times 10^{10}$ of which 2/3 (66.7%) is oil and 1/3 (33.3%) is electricity.



S-9 Define the Internal Rate of Return (IRR) and write its equation.

(i) The Internal Rate of Return is the discount rate d at which the net present value NPV becomes zero.

(ii) or,
$$NPV = \frac{C_0}{(1+d)^0} + \frac{C_1}{(1+d)^1} + \dots + \frac{C_n}{(1+d)^n} = 0$$

with C_i = Cash flow occurring in the year i ,
 n = life of project in years;
 d = discount rate as a fraction and not in %

S-10 State the key elements of an energy audit as defined in the Energy Conservation Act 2001.

There are six key elements mentioned in the original text of the Act.

“Energy audit” means the (i) verification, (ii) monitoring and analysis of use of energy, including (iii) submission of technical report, (iv) containing recommendations for improving energy efficiency with, (v) cost benefit analysis and an, (vi) action plan to reduce energy consumption.

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

Section - III: LONG DESCRIPTIVE QUESTIONS

Marks: 5 x 10 = 50

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

L-1 An energy auditor or an energy manager is trying to establish the power factor of a 7.5 HP induction motor. The instrument to measure electric parameters displays the three numbers 2.5 kW and 1 kVAr and PF = 92.9%. Do you fully agree with the instrument display and its correctness?

Right angle triangle and Pythagoras yields $(kVA)^2 = (kW)^2 + (kVAr)^2$.
Furthermore $PF = kW/kVA$, and consequently
 $kVA = \sqrt{(kVAr)^2 + (kW)^2} = \sqrt{(1)^2 + (2.5)^2} = 2.69$ and $PF = 2.5/2.69 = 0.928$

This calculation agrees with the display of 92.9%

However it is unlikely that a 5.5 kW motor operating at 50% load will ever achieve $PF = 0.929$. Consequently something is suspicious with the instrument. Therefore the answer is NO, because it is also unlikely that a 7.5 HP induction motor is compensated in such a way that this power factor is achieved at 50% load.

L-2 The following table shows the import bill of fossil fuels in million tonnes and its cost in Crores Rupees over the last eight years.

- (i) calculate the average annual percentage increase of fossil fuel imports
- (ii) calculate the average annual percentage increase of the import bill
- (iii) calculate the average costs for the last eight years, in Rs. Per metric ton of imported fossil fuels.

Import bill of fossil fuels		
Year	Quantity (MMT)	Value (Rs.Crore)
1996-97	33.90	18,337
1997-98	34.49	15,872
1998-99	39.81	19,907
1999-00	57.80	40,028
2000-01	74.10	65,932
2001-02	84.90	80,116
2002-03	90.00	85,042
2003-04	95.00	93,159

There are seven years to consider

- (i) $95 / 33.90 = 2.80236$ folded increase over 7 years. It follows to solve the equation $(1. x)^7 = 2.80236$ by introducing the exponent $1/7$ of each side we get $1.x = 2.80236^{1/7}$ or $1.x = 1.15859$ or 15.86%. By trial and error one should get close to the result as well. Any number between 15.5% and 16% should count as correct

Give 2 marks if the average is calculated as the arithmetic average by summation the increase over each year. Result is 16.67%

- (ii) $93,159 / 18,337 = 5.0804$ folded increase over 7 year. Similar to (i) it follows 26.14%. Any answer between 26.0% and 26.3% should count as correct.

Give 2 marks if the arithmetic average is formed out of the sum of yearly increases. The result is 29.37%

- (iii) The sum of all imports is 510 Million metric tons over this time period. The value is Rs 418,393 Crore. Consequently average costs are calculated as $(418,393 \times 10,000,000) / 510,000,000 = \underline{8,203.78 \text{ Rs}}$ per metric ton.

L-3 Fuel substitution from a high cost fuel to a low cost fuel is common to reduce energy bill. For the following situations calculate:

- (i) annual reduction in energy costs in Crore Rs .
- (ii) annual change in energy consumption in %. (Calorific value of fuels not required for calculations)

Before substitution:

Steam output = 5 tons/hour
 Fuel consumption = 1 ton oil per 13 tons of steam.
 Operating hours = 6000 / Year
 Fuel costs = Rs.13,000 /ton of oil
 Boiler thermal efficiency (yearly average)= 84%

After Substitution:

Steam output = 5 tons/hour
 Fuel consumption = 2.5 tons of shells per 13 tons of steam
 Fuel costs = Rs.2,800 / ton of shells
 Boiler thermal efficiency (yearly average) = 72%

Oil consumption before substitution was $5 \times 6000/13 = 2,307.69$ tons/y.
 The annual oil costs were $2,307.69 \times 13,000 = 29,999,970 = \text{Rs } 3 \text{ Crore}$

Shell consumption after substitution is $5 \times 6000 \times 2.5/13 = 5,769.23$ tons/y
 The annual shell costs are $5,769.23 \times 2,800 = \text{Rs } 1.615 \text{ Crore}$

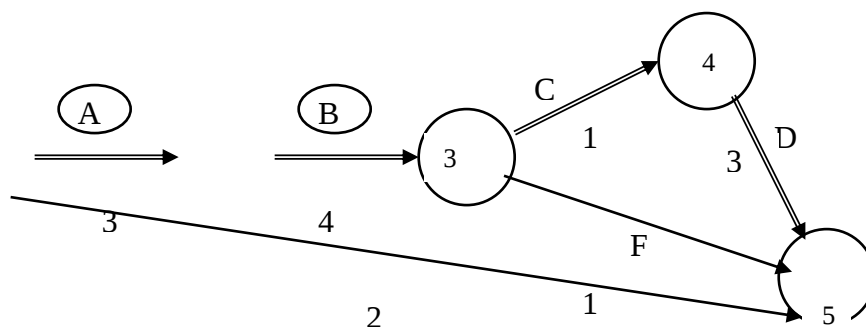
(i) The annual reduction in fuel costs is Rs 1.385 Crore.

(ii) More energy is used because the boiler efficiency drops
 the change is $100 \times (72-84)/72 = 16.7\% \text{ more energy}$

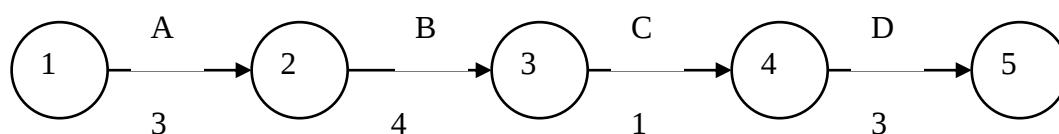
- L-4
- (i) Construct a CPM diagram for the example below
 - (ii) Identify the critical path. Also compute the earliest start, earliest finish, latest start & latest finish of all activities?

Activity	Precedent	Time, weeks
A	Start	3
B	A	4
C	B	1
D	C	3
E	Start	2
F	B	1
Finish	D, E, F	--

(i)



ii) Critical Path:



Total time on critical path: 11 weeks

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

S.no	Activity	Duration	ES	EF	LS	LF
1	A	3	0	3	0	3
2	B	4	3	7	3	7
3	C	1	7	8	7	8
4	D	3	8	11	8	11
5	E	2	0	2	9	11
6	F	1	7	8	10	11

L-5 A company invests Rs.6 lakhs and completes an energy efficiency project at the beginning of year 1. The firm is investing its own money and expects an internal rate of return, IRR, of at least 20% on constant positive annual net cash flow of Rs. 1 lakh, over a period of 10 years, starting with year 1.

- Will the project meet the firm's expectations?
- What is the IRR of this measure?

Solution

- Use the NPV formula with $d = 0.20$ and check to what extent $NPV > 0$ at $n = 10$ years.

$$(ii) \quad NPV = - 600,000 + \frac{100,000}{1.20^1} + \frac{100,000}{(1.20)^2} + \dots + \frac{100,000}{(1.20)^{10}} =$$

$$= - 600,000 + 83,333 + 69,444 + 57,870 + 48,225 + 40,188 + 33,490 + 27,908 + 23,257 + 19,381 + 16,151 = \text{Minus } 180,753$$

Since NPV is negative at 20%, the expectation of the project will not met the firm's expectations, because this means that the factor of 0.20 must be selected smaller in order to have NPV = 0

The IRR is 10.56%. Any result between 10.2% and 10.7 is valid

----- *End of Section - III* -----