

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.	Primary energy sources are, a) electricity b) converted into secondary energy sources c) used in diesel generator sets d) LPG, petrol & diesel
2.	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 %
3.	Energy consumption per unit GDP is called a) energy ratio b) energy intensity c) per capita consumption d) all of the above
4.	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.
5.	The Energy Conservation Act 2001 does not require 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

6.	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) <u>all of the above</u>
7.	An example of stored mechanical energy is a) water in a reservoir b) <u>an arrow in a stretched bow</u> c) an air-borne aeroplane d) you on top of a mountain
8.	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) <u>none of the above</u>
9.	When the current lags the voltage in an alternating current system, it is caused mainly due to a) resistive load b) capacitive load c) <u>inductive load</u> d) none of the above
10.	The phase change from solid state to a liquid state is called a) fission b) enthalpy c) latent heat d) <u>fusion</u>
11.	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
12.	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.
13.	The electrical power unit GigaWatt (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
14.	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)
15.	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
16.	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. The plant energy performance (PEP), assuming no change in product mix and output quantity in ____ a) <u>-10%</u> b) 10% c) -9.1% d) none of the above
17.	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>

18.	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) CO₂, O₂ c) O ₂ , NO _x , SO _x , CO d) O ₂ , CO
19.	Non contact flow measurement can be carried out by a) orifice meter b) turbine flow meter c) ultrasonic flow meter d) magnetic flow meter
20.	Two reactants A (200 kg) and B (200 kg) are used in a chemical process. If conversion is 50% and A and B reacts in equal proportion then the weight of the product formed is ____ a) 150 kg b) 200 kg c) 250 kg d) 400 kg
21.	The Energy Conservation Act requires that all designated consumers should get energy audits conducted by a) Energy Manager b) Accredited energy auditor c) Certified Energy Auditor d) Designated agencies
22.	Which energy source is indirect in an overall energy balance in the generation of electricity by a photovoltaic cell? a) commercial energy b) wave energy c) sun light d) none of the above
23.	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) by-product
24.	Which process emits the most CO ₂ per ton of coal burned a) cogeneration b) power generation c) cement manufacture d) coal gasification
25.	Which task is not considered as a duty of an energy manager a) prepare an annual activity plan b) establish an improved data recording system c) conduct mandatory energy audit d) prepare information material
26.	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) foundation
27.	Which one is not a step in energy action planning a) make commitments b) implement action plan c) set goals d) report results to designated agency of the state
28.	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) all the above
29.	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 data d) benchmarking performance

30.	Benchmarking helps to a) track performance change over time b) compare with best/average performance c) both a & b d) none of the above
31.	One of the basic indicators of financial investment appraisal is a) risk assessment b) trending of fuel costs c) interest rate d) simple payback
32.	What does the concept of time value of money imply a) present value of money b) future value of money c) discounting of cash flows d) all of the above
33.	Return on Investment (ROI) as a fraction means a) initial investment / annual return b) annual cost / cost of capital c) annual net cash flow / capital cost d) none of the above.
34.	The net present value (NPV) is a) equal to the sum of the present values of all cash flows b) equal to the sum of returns c) equal to the sum of all cash flows d) none of the above
35.	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) all of the above
36.	Which one is not a macro factor in a sensitivity analysis? a) change in interest rates b) technology changes c) cost of debt d) change in tax rates
37.	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) obtaining operation permits
38.	In Project Management, what does the 80/20 Rule say? a) 20% is trivial and 80% is vital work b) 20% of work consumes 80% of time and resources c) the first 20% of work consumes 80% of your time and resources d) none of the above.
39.	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) implementation period
40.	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) saves fuel cost but increases energy consumption c) increases fuel costs and energy consumption d) none of the above.

41.	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.
42.	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
43.	Drawing a Gantt chart does not require a) <u>to know cost of the activities</u> b) duration of activity c) to know beginning of the activities d) to know the interdependency of the tasks
44.	Pie chart of the 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>
45.	In an CUSUM chart, if the graph is horizontal for two consecutive periods 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>
46.	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
47.	Which is a greenhouse gas a) Sulfur Dioxide b) Nitrogen c) <u>Nitrous Oxide</u> d) none of the above
48.	Which country was the latest to recently ratify the Kyoto Protocol a) USA b) Australia c) <u>Russia</u> d) Germany
49.	One of the flexible instrument as stated in the Kyoto Protocol is a) CO₂ adaptation b) <u>Clean Development Mechanism (CDM)</u> c) CO₂ sequestration mechanism d) none of the above
50.	Methane traps about _____ times more heat than Carbon Dioxide a) 7 b) 14 c) <u>21</u> d) 28

----- 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 (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 low energy-intensive sectors of the Indian economy will obviously lower energy intensity.

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

- S-2 Define Dew Point.

It is the temperature at which condensation of water vapour from the air begins, as the temperature of the air-water vapour mixture falls.

- S-3 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.

- S-4 During an air pollution monitoring study, the inlet gas stream to a bag filter was 200,000 m³ per hour. The outlet gas stream from the bag filter was a little bit higher at 210,000 m³ per hour. Dust load at the inlet was 6 gram/ m³, and at the outlet 0.1 gram/ m³. How much dust in kg/hour was collected in the bag filter bin?

Dust (gas in) = dust (in gas out) + dust (in bin)
 $200,000 \times 6 = 210,000 \times 0.1 + x$ and it follows

$x = 1,179,000 \text{ gram/hour} = \underline{1,179 \text{ kg/hour.}}$

- S-5 List 5 positive forces of a force field analysis in support of the goal: “Reduce energy consumption per unit production”.

- (i) high price of energy
- (ii) energy efficient technology available
- (iii) top management commitment to energy conservation
- (iv) energy is high component of product cost
- (v) incentives for energy conservation available

S-6 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-7 List 5 steps in a PERT planning process

- (i) identify specific activities and milestones.
- (ii) determine the proper sequence of the activities
- (iii) construct a network diagram.
- (iv) estimate the time required for each activity.
- (v) determine the critical path
- (vi) update the PERT chart as the project progresses.

S-8 A company consumes 1.3×10^5 kWh of electricity and 11.18×10^7 kCal of furnace oil per month. Draw the pie chart of percentage share of fuels based on consumption in kCal. (1 kWh = 860 kcal)

The pie chart is split in half (50% oil and 50% electricity) because 1 kWh = 860 kCal and therefore $130,000 \times 860 = 11.18 \times 10^7$ kCal

S-9 The company "Save Electricity the Smart Way" sells a gadget that lowers voltage of your electric water storage heater by 20% and saves electricity by 20%. The heater is rated 2 kW at 230 V. Do you agree with the claim of the company? Support your opinion.

The answer is "No electricity is saved." (ii) 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-10 (i) Why is the Ozone layer important to plant, animal and human life on earth?
(ii) which substances are destroying it, and
(iii) by which process?

- (i) Ozone (O_3) is a filter for harmful Ultra Violet -B rays.
- (ii) Chlorine and bromine compounds, such as CFC's, and HCFC's are destroying Ozone.
- (iii) Ozone is highly reactive and can be easily broken down. If UV rays hit CFC's and HCFC's the chlorine (Cl) atom is separated from the carbon atom and this Cl atom reacts with Ozone, breaking it apart.

----- 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 The following table shows the import bill of fossil fuels in million metric tonnes (MMT) 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
- (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.
- (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 $(418,393 \times 10,000,000)/510,000,000 = \underline{8,203.78}$ Rs per metric ton.

- L-2 An energy manager or energy auditor is trying to establish the power factor of a 15 HP induction motor. The instrument to measure electric parameters displays the three numbers 5 kW and 2 kVA and PF = 92.8%. Do you fully agree with the instrument display and its correctness?

**Rectangular triangle and Pythagoras yields $(kVA)^2 = (kW)^2 + (kVA_r)^2$.
Furthermore $PF = kW/kVA$, and consequently
 $kVA = \sqrt{(kVA_r)^2 + (kW)^2} = \sqrt{(2)^2 + (5)^2} = 5.38516$ and $PF = 5/5.38516 = 0.928$**

This calculation agrees with the display of 92.8%.

However it is unlikely that a 10 kW motor operating at 50% load will ever achieve $PF = 0.928$. Consequently something is suspicious with the instrument. Therefore the answer is NO, because it is also unlikely that a 15 HP induction motor is compensated in such a way that this power factor is achieved at 50% load.

- L-3 Fuel substitution from a high cost fuel to a low cost fuel in boilers is common to reduce energy bill. For the following situations calculate:
- annual reduction in energy costs in Crore Rs.
 - annual change in energy consumption in %. (Calorific value of fuels not required for calculations)

Before substitution:

Steam output	=	6 tons/hour
Fuel consumption	=	1 ton oil per 13 tons of steam.
Operating hours	=	6400 / Year
Fuel costs	=	Rs.13,000 /ton of oil
Boiler thermal efficiency (yearly average)=		82%

After Substitution:

Steam output	=	6 tons/hour
Fuel consumption	=	3 tons of waste wood per 13 tons of steam
Fuel costs	=	Rs.2,000 / ton of waste wood
Boiler thermal efficiency (yearly average)	=	74%

**Oil consumption before substitution was $6 \times 6400/13 = 2,953.85$ tons/y.
The annual oil costs were $2,953.85 \times 13,000 = 38,400,050 = \text{Rs } 3.84 \text{ Crore}$**

**Wood consumption after substitution is $6 \times 6400 \times 3/13 = 8,861.54$ tons/y
The annual waste wood costs are $8,861.54 \times 2,000 = 1.77 \text{ Crore Rs.}$**

(i) The annual reduction in fuel costs is Rs 2.07 Crore.

**(ii) More energy is used because the boiler efficiency drops
the change is $100 \times (74-82)/74 = 10.8\% \text{ more energy}$**

L-4 A company invests Rs.10 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 26% on constant positive annual net cash flow of Rs.2 lakhs, over a period of 10 years, starting with year 1.

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

Solution

- (i) Use the NPV formula with $d = 0.26$ and check to what extent $NPV > 0$ at $n = 10$ years.

$$NPV = -1,000,000 + \frac{200,000}{1.26^1} + \frac{200,000}{(1.26)^2} + \dots + \frac{200,000}{(1.26)^{10}} =$$

$$= -1,000,000 + 158,730 + 125,976 + 99,981 + 79,350 + 62,976 + 49,981 + 39,668 + 31,482 + 24,986 + 19,830 = \text{MINUS } 307,040$$

Since NPV is negative at 26%, project will not meet the firm's expectations, because this means that the factor of 1.26 must be selected smaller in order to have $NPV = 0$ (7 marks)

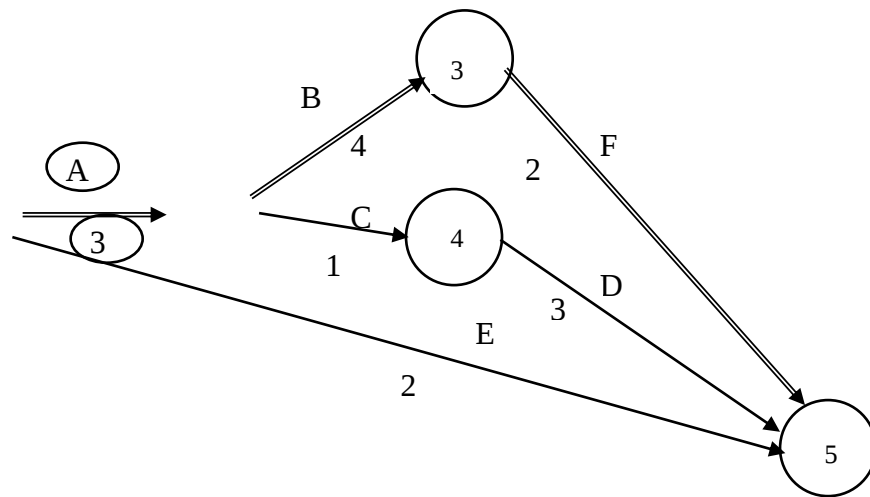
- (ii) The IRR is 15.1%. Any result between 14.5 and 15.5 is valid

- L-5
- (i) Construct a CPM diagram for the data given below
 - (ii) Identify the critical path. Also compute the earliest start, earliest finish, latest start & latest finish of all activities

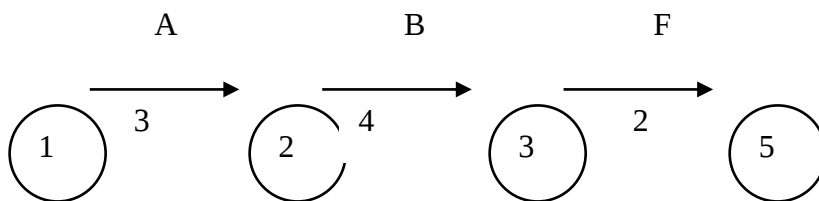
Activity	Precedent	Time, weeks
A	Start	3
B	A	4
C	A	1
D	C	3
E	Start	2
F	B	2
Finish	D, E, F	--

Solution

(i)



ii) critical Path



Total time on critical path: 9 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	3	4	5	6
4	D	3	4	7	6	9
5	E	2	0	2	7	9
6	F	2	7	9	7	9

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