PAPER-1 COLOR C0DE : GREEN

25th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS- SEPTEMBER 2025

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

Date:27.09.2025 Timings:09:30-12:30HRS Duration: 3 HRS Max.Marks:150

General instructions:

- *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:50x1=50**

(i) Answer all **50** questions
(ii) Each question carries **one** mark

1.	Energy saving through DSM is treated as equivalent to: a) A reduction in electricity tariff **b) New additions on the supply side in MWs** c) Import of cheaper electricity d) Government subsidies
2.	What is the main aim of the Accelerated Power Development and Reform Programme (APDRP)? a) To eliminate subsidies for agricultural consumers b) To privatize all power plants in India c) To promote only renewable energy in the power sector **d) To cut AT&C losses by audits and system improvements**
3.	Resistance of 250 V incandescent lamp drawing 0.5 A: a) 5,000 Ω **b) 500 Ω** c) 50 Ω d) 5 Ω
4.	A process receives 1000 kg/hr of raw material. The hourly outputs are 700 kg of product, 200 kg of waste, and 50 kg stored. What is the unaccounted loss? a) 100 kg/hr b) 150 kg/hr c) 200 kg/hr **d) 50 kg/hr**
5.	A boiler receives 100 MJ of fuel energy. The steam output is 70 MJ, the flue gas loss is 20 MJ and the radiation plus unaccounted loss is 10 MJ. What is the boiler efficiency? a) 65% b) 60% **c) 70%** d) 75%
6.	1 tonne of oil equivalent =: **a) 41,868 MJ** b) 1,000 kcal c) 1,000 kWh d) 1,000 BTU
7.	Maximum specific heat among the following: **a) Water** b) Lead c) Mercury d) Iron
8.	Ozone depletion is mainly due to: a) Oxygen b) Methane **c) Chlorofluorocarbons** d) Carbon dioxide
9.	The first step in an energy action plan is: a) Recognition of achievements b) Designing monitoring reports c) Selecting new technologies **d) Top management commitment**
10.	Heat required for Cooling 2000 kg of water for ΔT of 10°C _____ a) 2,000 kcal

	b) 20,000 kcal c) 200 kcal d) 2×10^5 kcal
11.	Calculate the quantity of water evaporated when 100 kg of feed containing 6% solids is concentrated to 30% solids. a) 600 kg b) 180 kg **c) 80 kg** d) 800 kg
12.	In force field analysis, which approach is usually more effective for achieving a goal? a) Strengthening forces that are already positive **b) Minimising negative forces that act as barriers** c) Ignoring external factors and focusing only on internal ones d) Changing the organisational goal
13.	Which of the following is NOT a conventional financing option? a) Debt financing b) Performance contracting c) Retained earnings **d) Stock buyback**
14.	Two projects: X (IRR=40%, NPV= Rs 50,000/-) and Y (IRR=30%, NPV= Rs 1,20,000/-) having same life, no finance limit. Choose the best project. a) X **b) Y** c) Cannot decide d) Question invalid
15.	Term for asset value decrease over time: a) Discounting b) Inflation **c) Depreciation** d) Compounding
16.	In Total Productive Maintenance (TPM), which of the following is not one of the six big losses that lower equipment efficiency? a) Breakdowns b) Idling and minor stoppages c) Reduced speed **d) Excessive overtime hours**
17.	Fixed energy consumption can be determined from: a) Bar chart b) Vertical line chart c) Pie chart **d) XY coordinate system**
18.	Carbon capture from point sources and storage is called: **a) Carbon sequestration** b) Carbon sink c) Carbon capture d) Carbon adsorption
19.	Why is an energy baseline established in Monitoring and Targeting (M&T)? a) To record only monthly electricity bills **b) To fix a reference point for measuring energy performance improvements** c) To eliminate the need for energy performance indicators d) To avoid sharing information with managers and stakeholders
20.	Life-cycle costing is better than simple purchase cost because it: **a) Includes operation, maintenance and energy costs over life** b) Ignores maintenance costs c) Forces single-supplier bidding d) Cuts down procurement cycle time
21.	Producer gas consists of: a) CO, H_2, CH_4 b) CO, CH_4 **c) CO, H_2**

	d) Only CH_4
22.	Work Breakdown Structure (WBS) is mainly used for: a) Combining small tasks into one large project **b) Dividing complex projects into simpler, manageable tasks** c) Preparing cost estimation only d) Eliminating tasks from the project
23.	What is a major limitation of the Gantt chart in project management? a) It does not show the duration of activities **b) It does not clearly show logical dependencies between activities** c) It cannot be used for construction projects d) It requires advanced statistical methods for preparation
24.	In a project network diagram, why is a dummy activity used? a) To represent an activity with very small duration **b) To show logical dependency between activities with the same start and end nodes** c) To reduce the total project duration d) To allocate additional resources to critical activities
25.	Solar radiation consists of: a) X-rays, Gamma rays, and Microwaves **b) Ultra-violet, Visible, and Infra-red radiation** c) Visible, Infra-red, and Radio waves d) Ultra-violet, X-rays, and Cosmic rays
26.	Which of the following are basic objectives of sustainable development? a) Economic security and prosperity b) Social development and advancement c) Environmental sustainability **d) All of the above**
27.	Select the correct statement about the Critical Path Method (CPM): **a) CPM is a deterministic model that does not take into account variation in completion time** b) CPM is a probabilistic model that takes into account variation in completion time c) CPM is a probabilistic model that does not take into account variation in completion time d) CPM is a deterministic model that takes into account variation in completion time
28.	Acceptable delay time (slack time/float) is equal to: a) Time between Earliest Finish and Latest Finish b) Time between Earliest Start and Latest Start **c) Both a and b** d) None of the above
29.	The objectives of Standards & Labeling (S&L) programme aim to: a) Set sulphur standards for coal-fired power plants **b) Provide informed choice about energy saving** c) Enforce penalties on renewable obligation non-compliance d) Fix tariff slabs for power-intensive industries
30.	Is the activity critical, given ES = 8 days and LS = 10 days? a) Yes **b) No** c) More details required d) Next activity details required
31.	The relation between gauge pressure (pg), system pressure (ps), and atmospheric pressure (pa) is: a) pg = ps + pa **b) pg = ps − pa** c) ps = pg − pa d) pa = ps + pg
32.	Availability Based Tariff (ABT) was introduced in India to: a) Encourage solar roof-top for industries b) Reduce dependence on oil imports c) Subsidise rural electrification **d) Improve grid discipline and frequency control**
33.	In a 'Guaranteed Savings' ESCO project, the ESCO company would not be involved in: a) Project design b) Project finance

	c) Project implementation **d) Verifying energy savings**
34.	The Reserves-to-Production (R/P) ratio of coal in India is high compared to oil and gas. This implies: **a) Coal reserves can provide secure supply for decades** b) India has surplus oil reserves to meet its demand c) Natural gas is India's most secure long-term option d) India's coal imports will vanish completely
35.	The use of Purchasing Power Parities (PPPs) in energy intensity calculations ensures that: a) GDP comparisons reflect only exchange rate fluctuations **b) GDP of all countries is valued at a uniform price level, showing only differences in real economic volume** c) GDP is measured exclusively in domestic currency terms d) GDP comparisons ignore differences in goods and services consumed
36.	Which statement best describes the relationship between energy conservation and energy efficiency?: a) Energy conservation and energy efficiency are identical and interchangeable terms **b) Energy efficiency refers to reducing energy intensity per unit of output, while energy conservation refers to reducing overall consumption.** c) Energy efficiency requires lowering comfort levels, while energy conservation does not d) Energy conservation excludes energy efficiency measures from its scope
37.	"Designated Consumers" under EC Act are classified mainly because: a) They are exempted from energy audits b) They focus only on renewable generation c) They represent small artisan industries **d) They are users of energy in an energy intensive industry**
38.	Sankey diagrams help energy managers by: **a) Prioritizing improvements based on visualized energy losses** b) Reducing the need for energy audits c) Replacing thermodynamic calculations d) Eliminating the use of performance indicators
39.	Which instrument measures power factor directly? a) Ammeter b) Wattmeter c) Lux meter **d) Power analyzer**
40.	What is the mission of the Bureau of Energy Efficiency (BEE) under the Energy Conservation Act 2001? a) To regulate electricity tariffs at the national level b) To promote renewable energy by providing capital subsidies **c) To develop policies and strategies that reduce the energy intensity of the Indian economy** d) To license only energy auditors and energy managers
41.	What is the main purpose of the Energy Conservation Building Code (ECBC)? **a) To set minimum energy efficiency standards for commercial buildings** b) To fix electricity tariffs for buildings c) To mandate use of only renewable energy in construction d) To regulate real estate prices
42.	"Daylight harvesting" in lighting systems means: a) Collecting solar energy for night lighting b) Using flat plate collectors for heating **c) Adjusting artificial lighting based on natural daylight** d) Storing energy in battery banks
43.	In a cumulative sum chart, a horizontal graph indicates: a) Nothing can be said b) Energy consumption is reduced c) Specific energy consumption is increasing **d) Actual and calculated energy consumption are the same**
44.	Which of the following is non-commercial energy? a) Lignite b) LPG

	c) Solar energy for water heating d) Hydro power
45.	Power rating of an electrical heater consuming 12,000 J/min is: a) 12 W b) 100 W **c) 200 W** d) 12,000 W
46.	Moles of water in 54 grams: **a) 3** b) 4 c) 5 d) 6
47.	The main purpose of Performance Measurement and Verification (PMV) is to: a) Establish new project costs **b) Ensure that guaranteed savings have been achieved** c) Increase the baseline consumption d) Eliminate the need for utility bills
48.	ROI for an investment of Rs 1,00,000 with an annual return of Rs 20,000 per year is_____ a) 1% b) 10% **c) 20%** d) 200%
49.	Biomass gasifier using 1 kg wood (4,000 kCal/kg) producing 2 m^3 gas (1,000 kCal/m^3). What would be the efficiency? a) 25% **b) 50%** c) 75% d) 100%
50.	Mean molecular weight of air (77% N_2, 23% O_2 by weight) is _____grams. a) 26.8 b) 27.8 **c) 28.8** d) 29.8

.....End of Section I.....

Section–II: SHORT DESCRIPTIVE QUESTIONS **Marks:8x5=40**

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

S-1	A continuous centrifuge separates 36,000 kg of whole milk containing 4% fat in 6-hour period into skim milk with 0.40% fat and cream with 40 % fat. Find out the flow rates of whole milk, cream and skim milk using mass balance.
S-1 Ans	Mass inlet: Total mass flow of whole milk = 36000/6 = 6000 kg per hour. Fat per hour = 6000 x 0.04 = 240 kg/hr. Therefore, Water plus solids other than fat = (6000-240) kg per hr. = 5760 kg per hr. Mass outlet: Let the mass of cream be X kg then its total fat content is 0.40X. The mass of skim milk is (6000- X) and its total fat content is 0.0040 (6000 - X) Material balance on fat: Fat in = Fat out 6000 x 0.04 = 0.0040(6000 - X) + 0.40X; solving this, X = 545 kg/hr So that the flow of cream is 545 kg/hr and skim milk (6000- 545) = 5455 kg/hr.
S-2	a) Define energy intensity. Explain what low and high energy intensity indicate about a country's economy. **3 Marks** b) Country A consumes 2000 toe of energy and has a GDP of US$ 100 million. Country B consumes 2500 toe of energy and has a GDP of US$ 140 million. Calculate the Energy

P1P

	Intensity of both countries in toe per US$ million GDP and indicate which country is more efficient in its use of energy? **2 Marks**
S-2 Ans	a) Refer guide book b)Energy Intensity (EI) = Energy Consumption (toe) / GDP (million US $) EI for Country A = 2000 / 100 = 20 EI for Country B = 2500 / 140 = 17.85 Country B consumes less energy per $. This, it is better in terms of energy efficiency.
S-3	What are the benefits of the Critical Path Method (CPM)? Also explain how the Program Evaluation and Review Technique (PERT) differs from CPM.
S-3 Ans	Refer guide book
S-4	The facility has a connected load of 500 kW and currently has a contract demand of 500 kVA. The monthly maximum demand recorded is consistently around 350 kW at 0.85 power factor. The utility imposes a penalty of ₹ 350 per excess kVA/month, if recorded demand exceeds contract demand. The demand charge is ₹ 300 per kVA/month. a) Determine current demand in kVA. **1 Mark** b) The minimum billing demand is 80% of contract demand. Calculate excess demand charges paid above minimum billing demand per month. **2 Marks** c) Calculate minimum power factor required to avoid payment of excess demand charges over minimum billing demand. **2 Marks**
S-4 Ans	a)Calculate actual kVA demand (1 marks) Actual Demand (kVA)=actual kW/Power Factor=350/0.85 =411.76 kVA b)Excess demand Charges per month (2 marks) Minimum billed demand = 500×0.8 = 400 kVA Excess demand Charges paid= (411.76-400) *300 = Rs.3528.00/month c)Minimum Power Factor Improvement Required (2 marks) To avoid excess demand charges = 350/400 = 0.875
S-5	A food processing unit uses the following per day: • LPG consumption: 200 kg/day (Calorific Value = 11,000 kcal/kg, rate ₹90/kg) • DG backup: 100 kWh/day when the grid fails, using diesel at ₹95/litre with a specific fuel consumption of 260 ml/kWh. (Calorific value = 10,000 kcal/litre) • Electrical energy: 1,200 kWh/day at ₹7.5/kWh **Calculate the following:** **Each 1 Mark** a) Convert the LPG energy to kWh equivalent. b) Calculate the thermal energy input (in kcal) required by the DG to produce 100 kWh. c) Calculate the daily energy cost from all 3 sources. d) Calculate the percentage contribution of each energy source to the total energy input (in kWh equivalent). e) Determine the cost share of each energy source in the total energy cost and identify the most economic source among grid power, LPG and DG power.

S-5 Ans

a) LPG to kWh
- Thermal energy = 200 × 11,000 = 2,200,000 kcal/day
- Convert to kWh: 2,200,000/860= 2,558.14 kWh

b) Diesel Energy Input for DG
- DG Output = 100 kWh
- Specific fuel consumption = 260 ml/kWh
  Input =100*260 /1000 = 26 litres
  Convert to kcal: 26 × 10000 = 260,000 kcal /day

c)Daily Energy Cost
- Electricity = 1,200 × ₹7.5 = ₹9,000
- LPG = ₹90/kg × 200 = ₹18,000
- Diesel = 26 × ₹95 = ₹2,470

Total Cost=₹9,000+₹18,000+₹2,470=₹29,470/day

d)Percentage contribution of each energy source (in kWh)

Source	kWh equivalent	% Share kWh
Grid power	1,200	=1200/3858.14 *100 = 31.1%
LPG	2,558.14	=2558.14/3858.14 *100 = 66.3%
DG output	100	=100/3858.14 *100 = 2.6%
Total	3,858.14 kWh	100%

e) Percentage cost share of each energy source

Source	Daily energy Cost	% Share Cost
Grid power	₹9,000	=9000/29470 *100 = 30.53%
LPG	₹18,000	=18000/29470 *100 = 61.07%
DG output	₹2,470	=2470/29470 *100 = 8.4%
Total	₹29,470/day	100%

LPG is more economic.

S-6

An energy audit conducted in a rubber processing unit identifies the following:
- A centrifugal pump (motor rating 30 kW) runs continuously for 16 hours/day, 300 days/year.
- Measured motor loading = 65%, Motor efficiency = 88%, with no flow control.
- A VFD retrofit is proposed, which is expected to reduce energy consumption by 10% due to optimized flow control.
- Power cost = ₹7.0/kWh
- VFD installation cost = ₹1,50,000

a) Calculate the current annual energy consumption of the motor. 2 Marks
b) Estimate the expected annual energy savings from the VFD. 1 Mark
c) Calculate the annual cost saving in ₹. 1 Mark
d) Determine the simple payback period for the investment. 1 Mark

S-6 Ans

Item	Calculation	Value
Annual energy use	= (30x 0.65 /0.88)x16x300	106,364 kWh
Energy saved	= 106,364 * 0.1	10,636.4 kWh
Annual ₹ savings	= 10,636.4 x7	₹74,454.8
Payback period	= 1,50,000/74454.8	2.01 years (~24.17 months)

S-7

A food dryer processes 1,000 kg/hr of wet material with an initial moisture content of 55% (wet basis) and dries it to a final moisture content of 10% (wet basis).

- Steam Flow: 2,500 kg/hr at 3.5 bar (enthalpy = 660 kcal/kg)
- Latent heat of water vaporization = 540 kcal/kg
- Specific heat of dry material = 0.45 kcal/kg°C

	• Drying temperature rise = 60°C • Ignore heat loss and assume 100% steam use for moisture removal and solid heating **Each 1 Mark** a) Calculate the mass of bone-dry solid in the feed b) Calculate the mass of water removed per hour c) Estimate the energy required to evaporate the moisture d) Estimate the energy required to heat the dry solids e) Calculate the total energy input from steam
S-7 Ans	a) Mass of bone-dry solid in the feed Moisture content (wet basis) = 55% Dry matter fraction = 1 – 0.55 = 0.45 Dry solid mass = 1000 × 0.45 = 450 kg/hr b) Mass of water removed per hour Initial water = 1000 – 450 = 550 kg/hr Final moisture content = 10% (wet basis) Let final product mass = M. Moisture = 0.10M, Dry solid = 0.90M. Dry solid remains constant at 450 kg. 0.90M = 450 → M = 500 kg/hr Final water = 500 – 450 = 50 kg/hr Water removed = 550 – 50 = 500 kg/hr c) Energy required to evaporate the moisture Qevap = mass of water removed × latent heat of vaporization Qevap = 500 × 540 = 270,000 kcal/hr d) Energy required to heat the dry solids Qsolid = mass of dry solid × specific heat × temperature rise Qsolid = 450 × 0.45 × 60 = 12,150 kcal/hr e) Total energy input from steam Qtotal = Qevap + Qsolid Qtotal = 270,000 + 12,150 = 282,150 kcal/hr Energy available from steam = mass of steam × enthalpy = 2500 × 660 = 1,650,000 kcal/hr Total energy demand = 282,150 kcal/hr Total energy supply = 1,650,000 kcal/hr
S-8	A medium-sized factory installs an energy-efficient air compressor system costing ₹6,00,000. An audit estimates that it will save ₹1,80,000 per year in energy bills for the next 3 years. Annual maintenance is expected to cost ₹10,000 starting from second year onward. Assume: Discount rate (cost of capital) is 10% and salvage value at the end of third year is ₹50,000. a) Calculate the net annual cash flow from Year 2 onward 2 Marks b) Compute the Net Present Value (NPV) of the investment 2 Marks c) Based on NPV, assess whether the project is economically acceptable 1 Mark
S-8 Ans	a) Net Annual Cash Flow from Year 2 Onward Annual saving = ₹1,80,000 Annual maintenance (from Year 2) = ₹10,000 Net = 1,80,000 – 10,000 = ₹1,70,000 Therefore, the net annual cash flow from Year 2 onward is ₹1,70,000. b) Cash Flow Table with Discounting (10% discount rate)

Year	Savings (₹)	Maintenance (₹)	Net Cash Flow (₹)	Salvage Value (₹)	Total Cash Flow (₹)	PV Factor @10%	Present Value (₹)
0	-	-	-	-	-6,00,000	1.000	-6,00,000
1	1,80,000	0	1,80,000	0	1,80,000	0.909	1,63,636
2	1,80,000	10,000	1,70,000	0	1,70,000	0.826	1,40,420
3	1,80,000	10,000	1,70,000	50,000	2,20,000	0.751	1,65,220

Total PV of inflows = 1,63,636 + 1,40,420 + 1,65,220 = 4,69,276
NPV = 4,69,276 – 6,00,000 = –1,30,724

c) Economic Acceptability
The NPV is negative (–₹1,30,724), meaning the project will not recover its investment cost within 3 years at a 10% discount rate. Therefore, the project is not economically acceptable under these conditions.

.....End of Section II.....

Section–III: LONG DESCRIPTIVE QUESTIONS **Marks:6x10=60**

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

L-1 (a) Construct a CPM diagram for the activities below: **4 Marks**

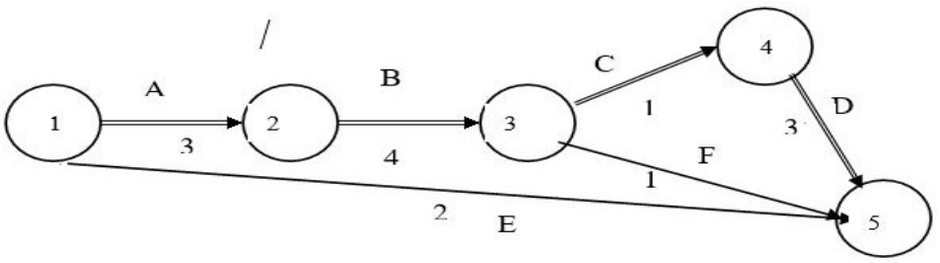
Activity	Precedence	Duration in weeks
A	Start	3
B	A	4
C	B	1
D	C	3
E	Start	2
F	B	1
Finish	D, E, F	--

(b) Compute the earliest start, earliest finish, latest start & latest finish of all activities. **3 Marks**

(c) Identify the critical path and its duration. **3 Marks**

L-1 Ans

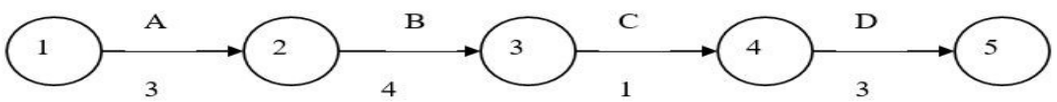
a)Network diagram (4 marks)



b)Early start (ES), Early Finish (EF), Latest start (LS), Latest finish (LF)-3 marks

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

c)Critical Path (3 marks)



Total time on critical path: **11 weeks**

L-2

A foundry operates an induction furnace with a capacity of 5 t/hr, having a specific electrical energy consumption of 620 kWh/t of liquid metal produced. The overall casting yield of the foundry is 60%.

After melting and casting, the products are heat treated in an oil-fired furnace which consumes 75 kg of fuel oil per tonne of castings. The gross calorific value of fuel oil is 10,000 kCal/kg. Additional information provided includes auxiliary connected electrical load of 50 kW, transformer efficiency of 98%, oil density of 0.88 kg/liter and average oil price of ₹80 per kg. Average castings produced is 45 tonnes per day and the plant is in continuous operation.

Using the above data,

a) Calculate the total energy consumption per tonne of finished product, expressed as oil equivalent (kg of oil per tonne of finished casting). **7 Marks**

b) The foundry is receiving additional order to produce 30 tonnes of casting per day. Assess whether the plant can handle additional demand. **3 Marks**

L-2 Ans

a)

Specific electric energy = 620 kWh per tonne of liquid metal. Casting Yield = 60%
Therefore, to produce 1 tonne of finished castings Luid metal required=1/0.60=1.67
Energy (electrical) per tonne of finished product: 620 kWh/t (liquid /0.6 = 1033.3 kWh/ t (finished)

Equivalent energy in kCal = 1033 x 860
= 8,88,380 kCal/T

Equivalent energy of auxiliary loads = (50/45)x24x860
= 22,933 kCal/T

	(Assuming auxiliaries operating at full load as not mentioned in the question) Total Equivalent electrical energy consumption = 8,88,380 + 22, 933 = 9,11,313 kCal/T Total Equivalent electrical energy with transformer losses = 9,11,313 /0.98 kCal/T = 9,29,911 kCal/T Heat required for heat treatment furnace = 75 x 10,000 = 7,50,000 Kcal/T Total kCals required per tonne of finished casting = 9,29,911 + 7,50,000 = 16,79,911 Kcals/T In terms of oil equivalent = 16,79,911 / 10,000 = 167.99 kg of oil/T of finished product b) Actual liquid metal production by induction furnace = (45/24)/0.6 = 3.125 TPH Addition castings production required = 30/24 =1.25 TPH Additional Liquid metal production required = 1.25/0.6 = 2.083 TPH Total Liquid metal production = 3.125 + 2.083 = 5.208 TPH, which is beyond the induction furnace capacity, therefore the plant will be unable to take-up additional production requirement.
L-3	Answer the following questions: **Each 2 Marks** a) Briefly explain the working principle of a solar PV system. b) If a 1 kW PV system in Chennai operates at an average of 5 peak sun hours/day with 15% efficiency, calculate the daily energy output. c) List the factors that affect the performance of a wind turbine. d) A wind turbine with rotor area 200 m^2 is installed in an area with average wind speed of 8 m/s. If air density is 1.2 kg/m^3, calculate the wind power available in the air stream. e) Briefly explain how biomass is used for electricity generation.
L-3 Ans	a) Solar PV works on the principle of the photovoltaic effect in which photons create electron-hole pairs at a p–n junction, generating DC electricity (or) Refer Guidebook b) Energy Output = 1 kW × 5 h = 5 kWh/day. c) Factors: wind speed, air density, rotor area, blade design, hub height, and site conditions. (or) Refer Guidebook d) Power = 0.5 × 1.2 × 200 × (8^3) = 61,440 W ≈ 61.44 kW. e) Biomass is combusted/gasified to generate heat or syngas, which drives turbines/engines to produce power (or) Refer Guidebook

L-4

In a chemical company, variable consumption was measured 2.2 times of the production, and the non-production consumption (fixed energy consumption) was observed 10000 kWh/Month. A company has implemented several energy saving initiatives during the previous financial year.

a) Calculate energy saving by preparing a CUSUM chart. The actual production and energy consumption observed during the current financial year for the first two quarters is as follows:

(8 Marks)

Month	Production (kg)	Actual Energy Consumption (Kwh)
April	75000	170000
May	78000	172000
June	85000	185000
July	72000	155000
Aug	71000	153000
Sept	76000	163000

b)Also mention four names of different financing options for industry. —--- **2 Marks**

L-4 Ans

Month	Production (kg)	Actual Energy Consumption ,kWh (EA)	Predicted Energy consumption, kWh (2.2P+10000) (EP)	Ea-Ep	CUSUM
April	75000	170000	175000	-5000	-5000
May	78000	172000	181600	-9600	-14600
June	85000	185000	197000	-12000	-26600
July	72000	155000	168400	-13400	-40000
Aug	71000	153000	166200	-13200	-53200
Sept	76000	163000	177200	-14200	-67400

Cumulative saving in six month is 67400 Kwh by implementing the energy saving measures.

b) Different financing options with the organization
- i) Debt financing
- ii) Equity financing
- iii) Retained earning
- iv) Capital lease
- v) True Lease
- vi) Performance contract

L-5

An industry is exploring two project development options as part of its pursuing energy efficiency strategy. Using the NPV concept, find out the better option. Consider 10% as the discount rate and 5 year as the project life.

Description	**Project A**	**Project B**
Capital cost	80,000	100,000
Year	Net Annual Savings (₹)	Net Annual Savings (₹)
1	+ 25,000	+ 35,000
2	+ 25,000	+ 35,000
3	+ 25,000	+ 35,000
4	+ 25,000	+ 35,000
5	+ 25,000	+ 35,000

L-5 Ans

$NPV = - CF_0/(1+r)^0 + CF_1/(1+r)^1 + CF_2/(1+r)^2 + CF_3/(1+r)^3 + ...$

Project A

$NPV = - 80,000/ (1+0.10)^0 + 25,000/ (1+0.10)^1 + 25,000/ (1+0.10)^2 + 25,000/ (1+0.10)^3 + 25,000/ (1+0.10)^4 + 25,000/ (1+0.10)^5$

= -80,000 + 22,727 + 20,661 + 18,783 + 17,075 + 15,522

= Rs 14,768

Project B

$NPV = - 100,000/ (1+0.10)^0 + 35,000/ (1+0.10)^1 + 35,000/ (1+0.10)^2 + 35,000/ (1+0.10)^3 + 35,000/ (1+0.10)^4 + 35,000/ (1+0.10)^5$

= -100,000 + 31,818 + 28,926 + 26,296 + 23,905 + 21,732

= Rs 32,677

Project B shall be preferable due to higher NPV.

L-6

In a chemical company, Natural Gas (NG) is being used to heat 15 kl/hr of water by 15°C. The company is planning to switch this heating process to steam, which is available from neighbouring industries.

a) Work out the feasibility of this option, considering annual operating hours of 6000 hrs. The effective heat of NG is 8500 kCal/m^3, the NG rate is ₹55/m^3, and the density of NG is 0.717 kg/m^3. The latent heat of steam is 540 kCal/kg, and the steam rate is ₹2.2/kg. **6 Marks**

b) Also, calculate the tonnes of CO_2 emission for both the options, if 0.2 kg of CO_2 is emitted per kg of steam consumed and the percentage of carbon in NG is 74%. **4 Marks**

L-6 Ans

a)Total heat requirement = 15000X15 = 225000 Kcal/Hr

Current Option : NG Consumption = 225000/8500=26.47 m^3/Hr

NG Consumption = 26.47 X 6000 = 158820 m^3/Year

Energy Cost = 158820 X 55/100000=87.35 Lakh/Year

Alternative Option : Steam consumption = 225000/540=416.67 kg/Hr

Steam Consumption = 416.67x 6000=2500020 Kg/Year

Energy Cost = 2500020 x 2.2/100000=55 Lakh/Year

It is suggested to go with an alternative option considering saving of INR 32.35 Lakh per year.

b)

CO_2 emission for using steam = 2500020 X 0.2/1000

=500 Tonne of CO_2 emission per annum

CO_2 emission for using NG = (158820 x 0.717 x 0.74 x (44/12))/1000

= 309 Tonne of CO_2 emission per annum

.....End of Section III.....