Numerical (Unit-1 to 3)

Subject (EECA) ELO-412

1. The maximum demand of a consumer is 15 A at 230 V and his/her total energy consumption is 9000 kWh. If the energy is charged at the rate of Rs. 5 per unit for 600 h use of the maximum demand per annum plus Rs. 2 per unit for additional units, calculate (1) annual bill and (2) equivalent flat rate
2. A manufacturing industry plans to improve its energy performance under PAT through implementation of an energy conservation scheme. After implementation, calculate the Plant Energy Performance (PEP) with 2015-16 as the reference year. What is your inference?

Given that: • The current year (2016-17) Annual Production – 34000 T ,

• Current year (2016-17) Annual Energy Consumption– 27,200 MWh, •

Reference year (2015-16) production - 28,750 T,

Reference year (2015-16) Energy consumption - 23,834MWh.

Ans: Production factor (PF) = 34000 / 28750= 1.18

Ref year equivalent energy (RYEE) = Ref Year Energy Use (RYEU) x PF = 23834 x 1.18= 28124.12MWh PEP = (RYEE – current year energy)/RYEE = (28124.12 – 27200)/28124.12 = (+) 0.0329 ie (+) 3.3 %

Since the PEP is positive, it implies that the energy conservation measure had yield reduction in energy consumption. Action has to be taken to improve plant performance.

3. An industrial consumer charged with the scheduled tariff of Rs. 250/KVA per month for the maximum demand and 150 paisa per unit consumed for the load factor of 60% and 80%. Find overall cost per unit at (i) unity PF (ii) 0.9 PF consider maximum demand of 50 KVA.
4. A factory operates at 0.80 power factor lagging and has a monthly demand of 750 kVA. The monthly power rate is 8.50 per kVA. To improve the power factor, 250 kVA capacitors are installed in which there is negligible power loss. The installed cost of equipment is Rs. 20,000 and fixed charges are estimated at 10% per year. Calculate the annual savings effected by the use of capacitors.
5. For the tariff of Rs. 125/KVA of maximum demand and Rs. 3.00 per unit consumed; load factor 50%, find overall cost/unit at 0.8 p.f. consider maximum demand 10 KVA.
6. Deodorizer that costs Rs.60 lakhs to purchase and install, Rs.1.5 lakhs per year on an average to operate and maintain and is expected to save Rs. 20 lakhs by reducing steam consumption (as compared to batch deodorizers), calculate simple payback period?
7. The maximum demand of a consumer is 15 A at 230 V and his/her total energy consumption is 9000 kWh. If the energy is charged at the rate of Rs. 5 per unit for 600 h use of the maximum demand per annum plus Rs. 2 per unit for additional units, calculate (1) annual bill and (2) equivalent flat rate

8. A consumer has a maximum demand of 200 kW at 40% load factor. If the tariff is Rs. 100 per kW of maximum demand plus 10 paise per kWh, find the overall cost per kWh.

Solution:

$$\begin{aligned}
\text{Units consumed/year} &= \text{Max. demand} \times \text{L.F.} \times \text{Hours in a year} \\
&= (200) \times (0{\cdot}4) \times 8760 = 7{,}00{,}800\,\text{kWh} \\
\text{Annual charges} &= \text{Annual M.D. charges} + \text{Annual energy charges} \\
&= \text{Rs}\,(100 \times 200 + 0{\cdot}1 \times 7{,}00{,}800) \\
&= \text{Rs}\,90{,}080 \\
\text{Overall cost/kWh} &= \text{Rs}\,\frac{90{,}080}{7{,}00{,}800} = \text{Re}\,0{\cdot}1285 = \mathbf{12{\cdot}85\ paise}
\end{aligned}$$

9. The maximum demand of a consumer is 20 A at 220 V and his total energy consumption is 8760 kWh. If the energy is charged at the rate of 20 paise per unit for 500 hours use of the maximum demand per annum plus 10 paise per unit for additional units, calculate : (i)annual bill (ii) equivalent flat rate.

Solution:

Assume the load factor and power factor to be unity.

$$\therefore \quad \text{Maximum demand} = \frac{220 \times 20 \times 1}{1000} = 4 \cdot 4\,\text{kW}$$

$$\begin{aligned}
(i)\ \text{Units consumed in 500 hrs} &= 4{\cdot}4 \times 500 = 2200\,\text{kWh} \\
\text{Charges for 2200 kWh} &= \text{Rs}\ 0{\cdot}2 \times 2200 = \text{Rs}\,440 \\
\text{Remaining units} &= 8760 - 2200 = 6560\,\text{kWh} \\
\text{Charges for 6560 kWh} &= \text{Rs}\,0{\cdot}1 \times 6560 = \text{Rs}\,656 \\
\text{Total annual bill} &= \text{Rs}\,(440 + 656) = \mathbf{Rs.\,1096} \\
\text{Equivalent flat rate} &= \text{Rs}\,\frac{1096}{8760} = \text{Re}\ 0 \cdot 125 = \mathbf{12.5\ paise}
\end{aligned}$$

10. **For the tariff of 125/kVA of maximum demand and 3.00 per unit consumed; load factor = 50%, find overall cost/unit at (i) unity power factor (ii) 0.8 p.f consider maximum demand = 10 kVA.**

Ans:	Given: Tariff = Rs. 125/kVA of maximum demand + 3.00 per unit consumed Load factor = 50 %, M. D. = 10 kVA **Monthly total charges/bill:** MD charges per month = (M.D. KvA x M.D. Charges per KvA) = 10 x 125 = Rs. 1250.00 Energy charges per unit = Rs. 3/kWh. Energy consumed in a given time period is = (average active power) x (hours) Energy consumption charges per month: = average demand(kW) x (monthly hrs) x (charges per kWh) Average demand kW = (load factor) x (maximum demand) x pf. The number hours in a month is = 24 x 30 = 720. **i) At Unity Power Factor:** **Average demand kW =** (load factor) x (maximum demand) x pf. = 0.5 x 10 x 1 = 5 kW. -- **Energy consumption per month***:* = average demand (kW) x (monthly hrs) = 5 x 720 = 3600 kWh. **Energy consumption charges per month:** = (monthly energy consumed in kWh) x (charges per kWh) = 3600 x 3 = Rs. 10800 **Total billing =** MD charges + energy charges = 1250 + 10800 = Rs. 12050.

Overall cost per unit = (total bill) / (kWh for the month)

= 12050 / 3600

= Rs. 3.35/kWh.

ii) At 0.8 pf :

Average demand kW = (load factor) x (maximum demand) x pf.

= 0.5 x 10 x 0.8

= 4 kW

Energy consumption per month: = average demand(kW) x (monthly hrs)

= 4 x 720

= 2880 kWh.

Energy consumption charges per month:

= (monthly energy consumed in kWh) x (charges per kWh)

= 2880 x 3

= Rs. 8640

Total billing = MD charges + energy charges

= 1250 + 8640

= Rs. 9890

Overall cost per unit = (total bill) / (kWh for the month)

= 9890 / 2880

= Rs. 3.43 /kWh.

11. Simple payback period for a continuous Deodorizer that costs Rs.60 lakhs to purchase and install, Rs.1.5 lakhs per year on an average to operate and maintain and is expected to save Rs. 20 lakhs by reducing steam consumption (as compared to batch deodorizers), calculate simple payback period.

12. Formula for TIME VALUE OF MONEY

Future Value (FV) = NPV $(1 + i)^n$ or NPV = FV / $(1+i)^n$

Where FV = Future value of the cash flow

NPV= Net Present Value of the cash flow

i = Interest or discount rate

n = Number of years in the future

13. Return on Investment (ROI)

This is a broad indicator of the annual return expected from initial capital investment, expressed as a percentage:

$$ROI = \frac{Annual\ net\ Cash\ flow}{CApital\ cost} x\ 100$$

ROI must always be higher than cost of money (interest rate); the greater the return on investment better is the investment.

14. Net Present Value

Limitations

- It does not take into account the time value of money.
- It does not account for the variable nature of annual net cash inflows.

6.4.3 Net Present Value

The net present value (NPV) of a project is equal to the sum of the present values of all the cash flows associated with it. Symbolically,

$$NPV = \frac{CF_0}{(1+\kappa)^0} + \frac{CF_1}{(1+\kappa)^1} + \text{- - -} + \frac{CF_n}{(1+\kappa)^n} = \sum_{t=0}^{n} \frac{CF_t}{(1+\kappa)^t}$$

Where NPV = Net Present Value

CF_t = Cash flow occurring at the end of year 't' (t=0,1,….n)

n = life of the project

k = Discount rate

The discount rate (k) employed for evaluating the present value of the expected future cash flows should reflect the risk of the project.

15. Calculate the internal rate of return for an economizer that will cost Rs.500,000, will last 10

years, and will result in fuel savings of Rs.150,000 each year.

Find the i that will equate the following:

Solution: Rs.500,000 = 150,000 x PV (A = 10 years, i = ?)

To do this, calculate the net present value (NPV) for various i values, selected by visual inspection;

NPV 25% = Rs.150,000 x 3.571 - Rs.500,000

= Rs.35,650

NPV 30% = Rs.150,000 x 3.092 - Rs. 500,000

= -Rs. 36,200

For i = 25 per cent, net present value is positive; i = 30 per cent, net present value is negative.

Thus, for some discount rate between 25 and 30 per cent, present value benefits are equated to

present value costs. To find the rate more exactly, one can interpolate between the two rates as

follows:

i = 0.25 + (0.30-0.25) x 35650 / (35650 + 36200)

= 0.275, or 27.5 percent.

16. Cost of an heat exchanger is Rs.1.00 lakhs .Calculate simple pay back period considering annual saving potential of Rs.60,000/- and annual operating cost of Rs.15,000/-.
17. Investment for an energy proposal is Rs.10.00 lakhs. Annual savings for the first three years is 150,000, 200,000 & 300,000. Considering cost of capital as 10%, what is the net present value of the proposal?

18. As example, in an industry, if the drawl over a recording cycle of 30 minutes is :
2500 kVA for 4 minutes
3600 kVA for 12 minutes
4100 kVA for 6 minutes
3800 kVA for 8 minutes
The MD recorder will be computing MD as: (2500 x 4) + (3600 x 12) + (4100 x 6) + (3800 x 8) = 3606.7 kVA.
19. The utility bill shows an average power factor of 0.72 with an average KW of 627. How much kVAr is required to improve the power factor to .95 ?
Using formula Cos $\Phi1 = 0.72$,
tan $\Phi1 = 0.963$
Cos $\Phi2 = 0.95$,
tan $\Phi2 = 0.329$
kVAr required = P ($\tan\varphi1 - \tan\varphi2$) = 627 (0.964 – 0.329) = 398 kVA.

20.

∴ Capacitance of each capacitor = $4 \times 293 \cdot 4$ = **$1173 \cdot 6\ \mu F$**

Example 6.6. *The load on an installation is 800 kW, 0·8 lagging p.f. which works for 3000 hours per annum. The tariff is Rs 100 per kVA plus 20 paise per kWh. If the power factor is improved to 0·9 lagging by means of loss-free capacitors costing Rs 60 per kVAR, calculate the annual saving effected. Allow 10% per annum for interest and depreciation on capacitors.*

Solution.

$$\text{Load, } P = 800 \text{ kW}$$

$$\cos\phi_1 = 0 \cdot 8 \;;\quad \tan\phi_1 = \tan(\cos^{-1} 0 \cdot 8) = 0 \cdot 75$$

$$\cos\phi_2 = 0 \cdot 9 \;;\quad \tan\phi_2 = \tan(\cos^{-1} 0 \cdot 9) = 0 \cdot 4843$$

Leading kVAR taken by the capacitors

$$= P(\tan\phi_1 - \tan\phi_2) = 800\,(0 \cdot 75 - 0 \cdot 4843) = 212 \cdot 56$$

Annual cost before p.f. correction

Max. kVA demand = 800/0·8 = 1000

kVA demand charges = Rs 100 × 1000 = Rs 1,00,000

Units consumed/year = 800 × 3000 = 24,00,000 kWh

Energy charges/year = Rs 0·2 × 24,00,000 = Rs 4,80,000

Total annual cost = Rs (1,00,000 + 4,80,000) = Rs 5,80,000

Annual cost after p.f. correction

Max. kVA demand = 800/0·9 = 888·89

kVA demand charges = Rs 100 × 888·89 = Rs 88,889

Energy charges = Same as before *i.e.*, Rs 4,80,000

Capital cost of capacitors = Rs 60 × 212·56 = Rs 12,750

Annual interest and depreciation = Rs 0·1 × 12750 = Rs 1275

Total annual cost = Rs (88,889 + 4,80,000 + 1275) = Rs 5,70,164

∴ Annual saving = Rs (5,80,000 − 5,70,164) = **Rs 9836**

Example 6.7. *A factory takes a load of 200 kW at 0·85 p.f. lagging for 2500 hours per annum.*

21.

Example 6.8. *A factory operates at 0·8 p.f. lagging and has a monthly demand of 750 kVA. The monthly power rate is Rs 8·50 per kVA. To improve the power factor, 250 kVA capacitors are installed in which there is negligible power loss. The installed cost of equipment is Rs 20,000 and fixed charges are estimated at 10% per year. Calculate the annual saving effected by the use of capacitors.*

Solution.

Monthly demand is 750 kVA.

$$\cos\phi = 0 \cdot 8 \;;\ \sin\phi = \sin(\cos^{-1} 0 \cdot 8) = 0 \cdot 6$$

kW component of demand = kVA × cos φ = 750 × 0·8 = 600

kVAR component of demand = kVA × sin φ = 750 × 0·6 = 450

Leading kVAR taken by the capacitors is 250 kVAR. Therefore, net kVAR after p.f. improvement is 450 − 250 = 200.

$$\therefore \quad \text{kVA after p.f. improvement} = \sqrt{(600)^2 + (200)^2} = 632 \cdot 45$$

Reduction in kVA = 750 − 632·45 = 117·5

Monthly saving on kVA charges = Rs 8·5 × 117·5 = Rs 998·75

Yearly saving on kVA charges = Rs 998·75 × 12 = Rs 11,985

Fixed charges/year = Rs 0·1 × 20,000 = Rs 2000

Net annual saving = Rs (11,985 − 2000) = **Rs 9,985**