Problem 1

A power plant of 210 MW installed capacity has the following particulars:
Capital cost = Rs. 18,000/kW installed
Interest and depreciation = 12%
Annual load factor = 60%
Annual capacity factor = 54%
Annual running charges = 200 $x10^6$
Energy consumed by power plant auxiliaries = 6%
Calculate the cost of power generation per kWh.

Solution to Problem 1

$$\frac{\text{Load Factor}}{\text{Capacity Factor}} = \frac{\text{Average load}}{\text{Maximum demand}} \times \frac{\text{Capacity of the plant}}{\text{Average Load}}$$

$$\frac{0.60}{0.54} = \frac{210\ MW}{\text{Maximum } demand}$$

Maximum Demand = 210 x 0.54/0.6 = 189 MW

Reserve capacity = 210 – 189 = 21 MW

Average load = Load factor x Maximum demand

= 0.6 x 189 = 113.4 MW

(365 days x 24 hrs)

Energy produced per year = 113.4 x 10^3 x $\underline{8760}$ = 993.384 x 10^6 kWh

Net energy delivered = (1 - energy consumed by auxiliaries) x (energy produced per year)
= (1 - 0.06) x 993.384 x 10^6 = 933.781 x 10^6

(Must be substituted in kW)

Annual interest and depreciation (fixed cost) $= 0.12 \times 18000 \times \underline{210 \times 10^3}$

$= \text{Rs. } 453.6\ 10^6$

Total Annual cost = Fixed cost + Running cost

$= 453.6 \times 10^6 + \underline{200 \times 10^6}$

(Annual running charges given in the problem)

$= \text{Rs. } 653.6 \times 10^6$

$$\text{Cost of power generation} = \frac{Rs.653.6 \times 10^6}{933.781 \times 10^6}$$

$$\boxed{\text{cost of power generation} = \text{Rs. } 0.70 \text{ or } 70 \text{ paise}}$$

Problem 2

Two possible routes for laying a power line are under study. Data on the routes are as follows:

	Around the lake	**Under the lake**
Length	15 km	5 km
First cost (Rs.)	1,50,000/km	7,50,000/km
Useful life (years)	15	15
Maintenance cost (Rs.)	6000/km/yr	12,000/km/yr
Salvage value (Rs.)	90,000/km	1,50,000/km
Yearly power loss (Rs.)	15,000/km	15,000/km

If 15% interest is used, should the power line be routed around the lake or under the lake?

Solution to Problem 2

In this problem, a comparison to be made for the routing the power line between two cases:

1. Around the lake and
2. Under the lake

Around the lake:

First cost = 1,50,000 x 15 = Rs. 22,50,000

Maintenance cost /year = 6,000 x 15 = Rs. 90,000 → (A)

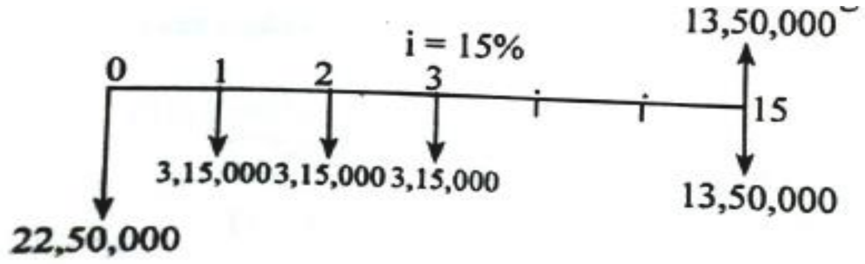
Power loss / year = 15,000 x 15 = Rs. 2,25,000 → (B)

(A) + (B) = Rs. 3,15,000

Salvage Value = 90,000 x 15 = Rs. 13,15,000

The annual equivalent cost expression is given by

$$\boxed{\text{AE(i\%) = First cost (A/P,i\%,n) + (Maintenance cost +Power cost) – Salvage Value(A/F,i\%,n)}}$$



The annual equivalent cost expression of the above cash flow diagram is:

$AE_1(15\%) = 22{,}50{,}000(A/P,15\%,15) + 3{,}15{,}000 - 13{,}50{,}000(A/F,15\%,15)$

$AE_1(15\%) = 22{,}50{,}000(0.1710) + 3{,}15{,}000 - 13{,}50{,}000(0.0210)$

$\boxed{AE_1(15\%) = \text{Rs. } 6{,}71{,}400}$

Under the lake

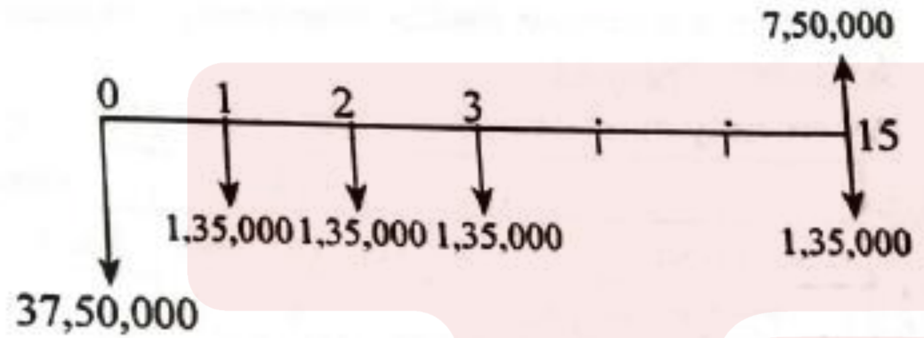
First cost = 7,50,000 x 5 = Rs. 37,50,000

Maintenance cost /year = 12,000 x 5 = Rs. 60,000 → (C)

Power loss / year = 15,000 x 5 = Rs. 75,000 → (D)

(C) + (D) = Rs. 1,35,000

Salvage Value = 1,50,000 x 5= Rs. 7,50,000



The annual equivalent cost expression of the above cash flow diagram is:

$AE_2(15\%) = 37{,}50{,}000(A/P,15\%,15) + 1{,}35{,}000 – 7{,}50{,}000(A/F,15\%,15)$

$AE_2(15\%) = 37{,}50{,}000(0.1710) + 1{,}35{,}000 – 7{,}50{,}000(0.0210)$

$\boxed{AE_2(15\%) = \text{Rs. } 7{,}60{,}500}$

By comparing the values of AE_1 and AE_2, we select the route around the lake for laying the power line.

(Note: for compound interest tables, please click the following link https://global.oup.com/us/companion.websites/9780199778126/pdf/Appendix_C_CITables.pdf)

15% Compound Interest Factors i= 15%

	Single Payment		Uniform Payment Series				Arithmetic Gradient		
n	Compound Amount Factor Find F Given P F/P	Present Worth Factor Find P Given F P/F	Sinking Fund Factor Find A Given F A/F	Capital Recovery Factor Find A Given P A/P	Compound Amount Factor Find F Given A F/A	Present Worth Factor Find P Given A P/A	Gradient Uniform Series Find A Given G A/G	Gradient Present Worth Find P Given G P/G	n
1	1.150	.8696	1.0000	1.1500	1.000	0.870	0	0	1
2	1.322	.7561	.4651	.6151	2.150	1.626	0.465	0.756	2
3	1.521	.6575	.2880	.4380	3.472	2.283	0.907	2.071	3
4	1.749	.5718	.2003	.3503	4.993	2.855	1.326	3.786	4
5	2.011	.4972	.1483	.2983	6.742	3.352	1.723	5.775	5
6	2.313	.4323	.1142	.2642	8.754	3.784	2.097	7.937	6
7	2.660	.3759	.0904	.2404	11.067	4.160	2.450	10.192	7
8	3.059	.3269	.0729	.2229	13.727	4.487	2.781	12.481	8
9	3.518	.2843	.0596	.2096	16.786	4.772	3.092	14.755	9
10	4.046	.2472	.0493	.1993	20.304	5.019	3.383	16.979	10
11	4.652	.2149	.0411	.1911	24.349	5.234	3.655	19.129	11
12	5.350	.1869	.0345	.1845	29.002	5.421	3.908	21.185	12
13	6.153	.1625	.0291	.1791	34.352	5.583	4.144	23.135	13
14	7.076	.1413	.0247	.1747	40.505	5.724	4.362	24.972	14
15	8.137	.1229	.0210	.1710	47.580	5.847	4.565	26.693	15
16	9.358	.1069	.0179	.1679	55.717	5.954	4.752	28.296	16
17	10.761	.0929	.0154	.1654	65.075	6.047	4.925	29.783	17
18	12.375	.0808	.0132	.1632	75.836	6.128	5.084	31.156	18
19	14.232	.0703	.0113	.1613	88.212	6.198	5.231	32.421	19
20	16.367	.0611	.00976	.1598	102.444	6.259	5.365	33.582	20
21	18.822	.0531	.00842	.1584	118.810	6.312	5.488	34.645	21
22	21.645	.0462	.00727	.1573	137.632	6.359	5.601	35.615	22
23	24.891	.0402	.00628	.1563	159.276	6.399	5.704	36.499	23
24	28.625	.0349	.00543	.1554	184.168	6.434	5.798	37.302	24
25	32.919	.0304	.00470	.1547	212.793	6.464	5.883	38.031	25

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