Economics of Generating Stations

- **Definition**
- **Factors affecting cost of generation**
- **Methods of determining depreciation**

Economics of power generating station is the art of determining the per-unit cost of electric energy production; (*Cost of one kWh*)

Main factors affecting cost of generation:

- ***Cost of land***
- ***Cost of equipment***
- ***Interest on capital investment***
- ***Depreciation of equipment***
- ***Cost of fuel, lubricants and maintenance***

Cost of generation:

Fixed cost: *Independent on maximum demand or generated units; includes Cost of central organization, interest on capital land cost & high officials' salaries*

Semi-fixed cost: *directly proportional to maximum demand but independent on generated units; related to annual interest and depreciation on capital investment of building and equipment, and salaries of management and clerical staff.*

Running cost: *dependent only on number of generated units; includes cost of fuel, lubricants, maintenance and repair*

Total annual cost of Energy = $A + B \times$ ***Maximum demand*** $+ C \times$ **Generated kWh per annum**

or approximately

Total annual cost of Energy = $A' \times$ ***Maximum demand*** $+ B' \times$ **Generated kWh per annum**

Depreciation of equipment:

Depreciation is the decrease in the value of the power plant equipment and building due to constant use.

Power station has a useful life ranging from fifty to sixty years. From the time the power station is installed, its equipment steadily deteriorates due to ***wear and tear*** so that there is a gradual reduction in the value of the plant. The reduction every year is known as ***annual depreciation***. Due to depreciation, the plant has to be replaced after its useful life. Therefore, suitable amount must be set aside every year so that by the time the plant retires, the collected amount standing for depreciation equals the cost of replacement. Accordingly, the cost of production must include annual depreciation charges.

Depreciation may be determined by either of the following methods:

- Straight line method
- Diminishing value method
- Sinking fund method

Straight line method

A constant depreciation <u>charge</u> is made every year on the basis of total depreciation and the useful life of the property.

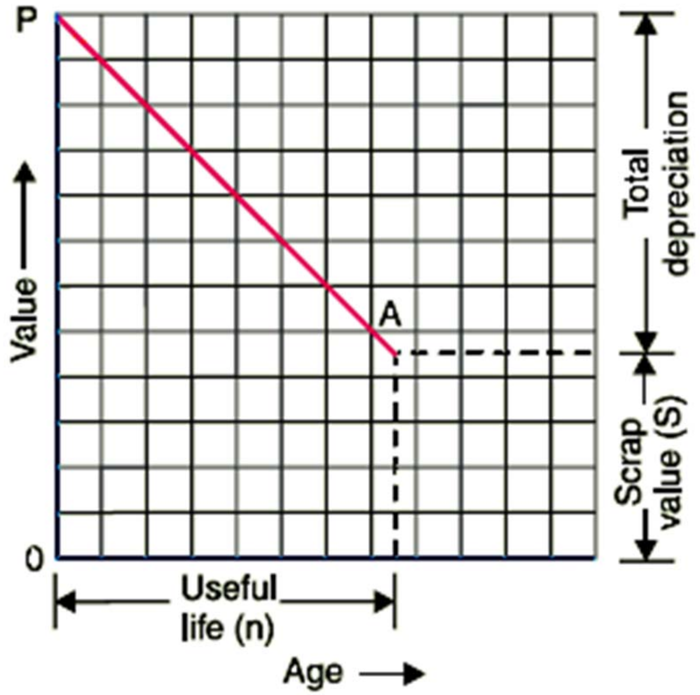
$$\text{Annual depreciation charge} = \frac{\text{Total depreciation}}{\text{Useful life}}$$

$$= \frac{\text{Initial or capital cost of equipment (P) - Scrap (salvage) value (S)}}{\text{Useful life in years (n)}}$$

<u>Disadvantages:</u>

-The assumption of constant depreciation charge every year is not correct.

- Doesn't account for the interest which may be drawn during accumulation.



Diminishing value method

A constant depreciation rate (χ) is applied every year to the diminishing value of plant as a basis of determining this year's depreciation and the relevant depreciation charge.

$$\text{Equipment value after a year} = \text{Equipment value at start of year} - \text{Annual depreciation}$$

$$\text{Equipment value after 1st year} = P\text{-}Px = P(1-x)$$

$$\text{Equipment value after 2nd year} = P(1-x) - P(1-x)x = P(1-x)^2$$

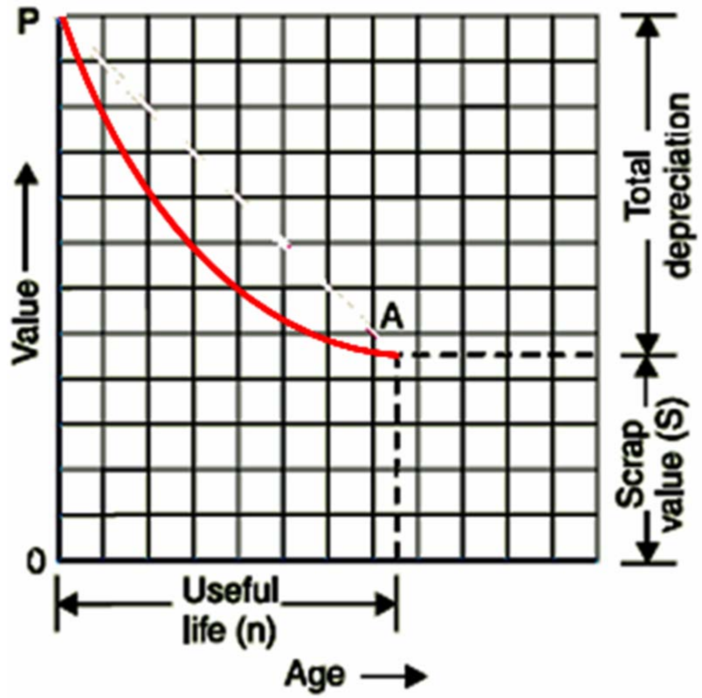
$$\text{Equipment value after n years} = P(1-x)^n = \text{Scrap value}(S)$$

$$\text{Depreciation rate}(x) = 1 - \left(\frac{S}{P}\right)^{1/n}$$

Disadvantages:

-Low depreciation charges in late years where maintenance and repair charges are heavy

- Doesn't account for the interest which may be drawn during accumulation.



Sinking fund method

A constant depreciation charge (q) is made every year on the basis of the cost of replacement (P-S) and an assumed constant annual interest rate ($\Re$).

$$\text{Amount } q \text{ deposited at end of 1st year becomes after } (n\text{-}1) \text{ years} \Rightarrow q(1+\Re)^{n-1}$$

$$\text{Amount } q \text{ deposited at end of 2nd year becomes after } (n\text{-}2) \text{ years} \Rightarrow q(1+\Re)^{n-2}$$

$$\text{Amount } q \text{ deposited at end of year } (n\text{-}1) \text{ becomes after last years} \Rightarrow q(1+\Re)$$

$$\text{Total fund collected with interest after } n \text{ years} = q\left\{(1+\Re)^{n-1} + (1+\Re)^{n-2} + \ldots + (1+\Re)\right\}$$

$$\text{Total fund collected with interest after } n \text{ years} = \frac{q\left\{(1+\Re)^{n} - 1\right\}}{\Re} = P - S$$

$$\Rightarrow \text{ Sinking fund or depreciation charge } q = (P-S)\left[\frac{\Re}{(1+\Re)^{n} - 1}\right]$$

Meeting the Load (*revisited as example of economic operation*):

Interconnecting two power stations(1, 2) the more efficient plant (***with lower running cost***) is assigned the base load, while the less efficient one (***with higher running cost***) is assigned the peak load.

$\Rightarrow$ ***Minimum cost of generation for a load supplied by 2 plants***

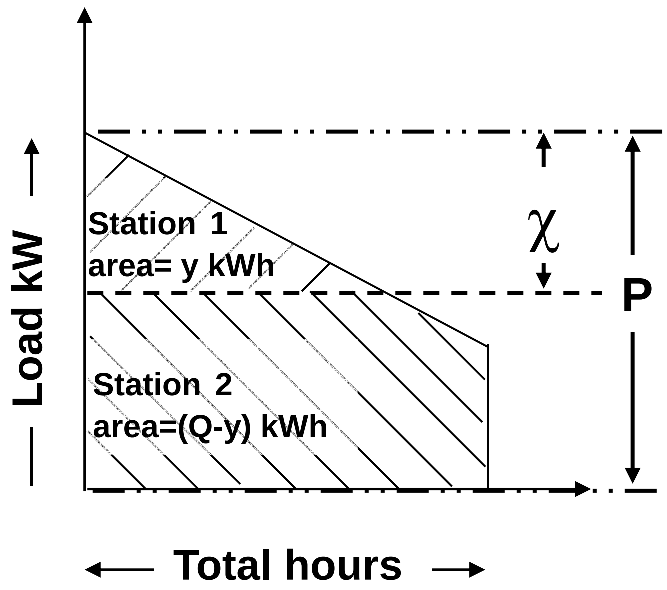
χ = peak load on station 1

y = kWh generated by station 1

P = Peak load on system

Q = Total number of units to be supplied

= Area of load duration curve



Annual cost of 1 = $A_1 + B_1 \times \chi + C_1 \times y$

Annual cost of 2 = $A_2 + B_2 \times (P - \chi) + C_2 \times (Q - y)$

Total cost = $Cost_1$+$Cost_2$

$= A_1 + B_1 \times \chi + C_1 \times y + A_2 + B_2 \times (P - \chi) + C_2 \times (Q - y)$

For minimum operating cost:

$$\frac{d(Cost)}{dx} = Zero \Rightarrow \frac{dy}{dx} = \frac{B_1 - B_2}{C_2 - C_1}$$

$$\& \because \frac{dy}{dx} = \text{hours of operation of peak station } (h)$$

$$\therefore h = \frac{B_1 - B_2}{C_2 - C_1}$$

- Knowing hours of operation of peak load station, its capacity χ and units generated y are found from curve.

- Substituting capacity χ and units generated y in total cost equation, the minimum cost is determined