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PAGE NO.
DATE 31 | 3 | 2021

Assignment #3: Renewable Energy - I

1\. (i) Nuclear energy produces 25.6 TWh/year.
Unused PV potential = 11 TWh/year

Given, 60% of unused PV potential is used to replace nuclear energy

$= \frac{6\cancel{0}}{10\cancel{0}} \times 11 \text{ TWh/year} = 6.6 \text{ TWh/year}$

$\therefore$ Remainder of Nuclear energy to be replaced $= (25.6 - 6.6)$ TWh/year $= 19.0$ TWh/year

1 natural gas power plant can produce $\left(\cancel{500}\text{ MW} \times \frac{85}{\cancel{100}}\right)$

$\therefore$ Number of Natural gas plants required $= \dfrac{19.0 \times 10^{12} \text{ Wh/year}}{(365 \times 24) \times (5 \times 85 \times 10^{6}) \text{ W}}$

$= 5.1034$

$\sim \underline{\underline{5}}$.

(ii) PV plant occupies 27000 hectare of land

$= 27000 \times 10^4 \text{ m}^2 = 2.7 \times 10^8 \text{ m}^2$

Panels occupy 30% of PV plant's area.

$\therefore$ Effective PV plant area $= \frac{3\cancel{0}}{100} \times \frac{2.7 \times 10^8}{\cancel{10}} = \underline{81 \times 10^6 \text{ m}^2}$

PAGE NO.
DATE: / /

Average daily solar radiation $= 2.1\ kWh/m^2$

Let efficiency of PV panel be $x\%$.

$\therefore$ Effective average solar radiation being utilised by panel $= \frac{x}{100} \times 2.1 \frac{kWh}{m^2} \times 81 \times 10^6 m^2$

$= 1.701 \left(\frac{x}{100}\right) \times 10^8$ kWh per day

$\therefore$ Annual Energy Production $= 1.701x \times 365 \times 10^8$ kWh/year

$= 620.865 \left(\frac{x}{100}\right) \times 10^8$ kWh/year

$\therefore$ to produce 11 TWh/year, this energy is required.

$\Rightarrow (0.6)(11)$ TWh/year $= 620.865 \left(\frac{x}{100}\right) \times 10^8$ kWh/year

$\Rightarrow x = \frac{0.6 \times 11 \times 10^{12} \text{ Wh/year} (\times 100)}{620.865 \times 10^8 \times 10^3 \text{ Wh/year}} = 10.632\%$

$= \underline{10.632\%}$

(iii) Let input solar energy be x

$\therefore x \times \left(\frac{17.72}{100}\right) \times 0.6 = (0.6)(11)$ TWh/year $\Rightarrow x = \frac{(11) \text{ TWh/year} \times \cancel{(0.6)}}{17.72 \times 10^{-2} \cancel{(0.6)}}$

$= 62.0767$ TWh/year

$= \underline{62.08}$ TWh/year

(iv) Total Installed PV capacity $= 9\% \times 11 \times 0.6$ TWh/year

$= 0.594$ TWh/year

2)(i) Energy demand per month = 1500 kWh

Lifetime of a PV cell array = 20 years = (20 × 12) months

$\therefore$ Total energy demand in 20 years = 1500 kWh/~~month~~ × (20 × 12) ~~months~~

= 3.6×10^5 kWh

Cost of solar cell = \$3 per W

Cost of solar cell (including cost of fabrication, maintenance and capital interest) = \$ 2 × 3 per W

Total Power generated = $\dfrac{1500 \text{ kWh}/\cancel{\text{month}}}{112 \text{ h}/\cancel{\text{month}}} = \left(\dfrac{1500}{112}\right)$ kW

$\therefore$ Cost of solar generated electricity = \$ $2 \times 3 \times \left(\dfrac{1500}{112}\right) \times 10^3$

= \$ 80.357142...

PAGE NO.
DATE: / /

$\therefore$ Cost of solar generated electricity per kWh $= \$ \dfrac{\frac{2 \times 3 \times 1320 \times 10^3}{112}}{3.6 \times 10^5}$ per kWh

$= \$ 0.2232$ per kWh

$= \underline{\underline{\$ 0.223 \text{ per kWh}}}$

(ii)

Present tariff of electricity $= \$ 0.07 / kWh$
Cost of solar generated electricity $= \$ 0.223 / kWh$

$\therefore$ Reduction in cost per kWh $= (\$ 0.223 - \$ 0.07) / kWh$

$= \underline{\underline{\$ 0.153 / kWh}}$

$\therefore$ Percentage of reduction $= \dfrac{\cancel{\$}\, 0.153 / \cancel{kWh}}{\cancel{\$}\, 0.223 / \cancel{kWh}} \times 100$

$= \underline{\underline{68.61 \%}}$