EVS ASSGN - 3

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Q1.

(i) Unused PV potential of Switzerland = 11 TWh/year

Nuclear energy of Switzerland = 25.6 TWh/year

We use 60% of PV potential to replace nuclear energy = 0.6 × 11 TWh/year

= 6.6 TWh/year

∴ The remaining to be met by natural gas plants

= 25.6 − 6.6

= 19 TWh/year

Now, the annual supply of gas power plant with capacity factor of 85%

$= 500\ MW \times 0.85 / year$

$= 3.72\ TWh / year$

$\therefore$ Number of gas power plants reqd

$$= \frac{19\ TWh/yr}{3.72\ TWh/yr}$$

$$= \lceil 5.107 \rceil$$

$$= 6$$

$\therefore$ 6 power plants are required.

(ii) Maximum land that can be occupied

$= 27000$ hectares

$= 2.7 \times 10^8\ m^2$

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

Occupied area $= 30\%$ of total

$= 0.3 \times 2.7 \times 10^8 = 81 \times 10^6\ m^2$

Now, let the efficiency be α, then, the solar radiation ~~utilized~~ utilized by the panels

$$= 2.1 \times 10^3 \times \alpha \ Wh/m^2$$

According to question, applying area constraint

$$\Rightarrow \frac{0.6 \times 11 \ TWh/yr}{2.1 \times 10^3 \times \alpha \times 365 \ Wh/m^2.yr} \leq 81 \times 10^6$$

$$\Rightarrow \frac{11 \times 10^{12} \times 0.6}{2.1 \times 10^3 \times \alpha \times 365} \leq 81 \times 10^6$$

$$\Rightarrow \alpha \geq \frac{11 \times 10^{12} \times 0.6}{2.1 \times 10^3 \times 365 \times 81 \times 10^6}$$

$$\Rightarrow \alpha \geq 0.177 \times 0.6$$

$$\Rightarrow \boxed{\alpha \geq 0.1062}$$

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$\Rightarrow$ Minimum efficiency needed
$= 10.62\,\%$

(iii) To achieve full potential with the efficiency same as in part (ii), we require say 'x' TWh/year solar energy. Then,

$$(x)(\alpha) = 0.6 \times 11 \text{ TWh/yr}$$

$$\Rightarrow \quad x = \frac{0.6 \times 11 \text{ TWh/yr}}{0.177 \times 0.6}$$

$$\Rightarrow \quad x = 62.147 \text{ TWh/year}$$

Therefore, we require $\boxed{62.147 \text{ TWh/yr}}$ solar energy.

(iv) The total installed PV capacity assuming a capacity factor of $9\% = \dfrac{0.6 \times 11 \text{ TWh/yr}}{0.09}$

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$= 73.3\bar{3}\ TWh/yr$

$$= 0.6 \times 122.22 \times \frac{1}{8760}\ TW$$

$= 0.6 \times 13.95\ GW$ power

$$= \boxed{8.37\ GW}$$

Q2. (i) Energy demand = 1500 kWh/month
Solar isolation available for 112 hours /month

⇒ Solar power produced by PV cells

$$= \frac{1500\ kWh/month}{112\ h/month}$$

$= 13.39\ kW$

To produce 1 W cost is \$3.

Cost of fabrication, maintainence & interest on capital = \$6

Total cost $= \$13.39 \times 6 \times 10^3$

$= \$\,80.34 \times 10^3$

Now, Energy produced for 20 years

$= 1500\ kWh \times 12 \times 20$

$= 3.6 \times 10^5\ kWh$

$\therefore$ Cost of solar generated electricity

$$= \frac{80.34 \times 10^3}{36 \times 10^4}$$

$$= \boxed{\$\,0.223\ /kWh}$$

PTO

(ii) Current tariff of electricity = $\$0.07/\text{kWh}$

The reduction in cost of solar generated electricity needed

$$= \$0.223 - \$0.07$$

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

Let new price be x \$/W.

$\therefore$ Total cost calculated with all power produced in 20 years

$$= \$\, 13.39 \times 10^3 \times (x)$$

$$\therefore \quad 13.39 \times 10^3 \times (x) = 2.52 \times 10^4$$

$$\Rightarrow \quad x = \frac{\$\, 25.2}{13.39} /\text{W}$$

$$= \boxed{\$\, 1.882/\text{W}}$$

Current cost per W $\rightarrow$ \$ 6

Hence, reduction reqd

$$= \$ (6 - 1.882) \text{ per } W$$

$$= \boxed{\$ 4.118/W}$$

in order to be competitive