Given Data:

$$\text{Reservoir Area, } A = 2.4\,\text{km}^2 = 2.4 \times 10^6\,\text{m}^2,$$
$$\text{Reservoir Capacity, } V = 5 \times 10^6\,\text{m}^3,$$
$$\text{Effective Head, } H = 100\,\text{m},$$
$$\text{Efficiencies: } \eta_p = 0.95,\ \eta_t = 0.90,\ \eta_g = 0.85,$$
$$\text{Total Efficiency, } \eta = \eta_p \cdot \eta_t \cdot \eta_g = 0.95 \cdot 0.90 \cdot 0.85 = 0.72675,$$
$$\text{Gravitational Acceleration, } g = 9.81\,\text{m/s}^2,$$
$$\text{Load Supplied: } P = 15000\,\text{kW} = 1.5 \times 10^7\,\text{W},$$
$$\text{Time Supplied: } t = 3\,\text{hours} = 3 \cdot 3600 = 10800\,\text{s}.$$

Part i: Total Electrical Energy Generated

The total energy is calculated as:

$$E = \eta \cdot \rho \cdot g \cdot H \cdot V,$$

where $\rho = 1000\,\text{kg/m}^3$.

Substitute the values:

$$E = 0.72675 \cdot 1000 \cdot 9.81 \cdot 100 \cdot (5 \times 10^6).$$

$$E = 3.56 \times 10^{12}\,\text{J}.$$

Convert joules to kilowatt-hours:

$$E_{\text{kWh}} = \frac{E}{3.6 \times 10^6} = \frac{3.56 \times 10^{12}}{3.6 \times 10^6} = 988,541.67\,\text{kWh}.$$

Answer: The total electrical energy generated is:

$$E = 988,541.67\,\text{kWh}.$$

Part ii: Fall in Reservoir Level

The energy consumed is:

$$E_{\text{consumed}} = P \cdot t = 1.5 \times 10^7 \cdot 10800 = 1.62 \times 10^{11}\,\text{J}.$$

The volume of water used is:

$$V_{\text{used}} = \frac{E_{\text{consumed}}}{\eta \cdot \rho \cdot g \cdot H}.$$

Substitute values:

$$V_{\text{used}} = \frac{1.62 \times 10^{11}}{0.72675 \cdot 1000 \cdot 9.81 \cdot 100}.$$

$$V_{\text{used}} = 2.28 \times 10^4\,\text{m}^3.$$

The fall in reservoir level is:

$$\text{Fall in Level} = \frac{V_{\text{used}}}{A} = \frac{2.28 \times 10^4}{2.4 \times 10^6}.$$

$$\text{Fall in Level} = 0.0095\,\text{m} = 9.5\,\text{mm}.$$

Answer: The fall in reservoir level is:

$$\text{Fall in Level} = 9.5\,\text{mm}.$$

Hydroelectric Plant Discharge and Capacity Estimation

The weekly discharge of a typical hydroelectric plant is as follows:

Day	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Discharge (m^3/s)	500	520	850	800	875	900	546

The plant has an effective head of 15 m and an overall efficiency of 85%. The plant operates at a 40% load factor.

i. Average Daily Discharge

The average daily discharge is calculated as:

$$\text{Average daily discharge} = \frac{\text{Sum of daily discharges}}{\text{Number of days}}$$

$$\text{Average daily discharge} = \frac{500 + 520 + 850 + 800 + 875 + 900 + 546}{7} = \frac{4491}{7} = 641.57\,\text{m}^3/\text{s}$$

ii. Pondage Required

Pondage refers to the storage required to regulate the flow variations across days. First, calculate the deviations from the average daily discharge:

$$\text{Deviation for each day} = \text{Discharge for that day} - \text{Average discharge}$$

For positive deviations:

$$\text{Pondage required (m}^3\text{)} = \text{Sum of positive deviations} \times \text{Seconds per day}$$

For each day:

$$\text{Sun:} \quad 500 - 641.57 = -141.57 \quad \text{(negative, ignored)}$$

$$\text{Mon:} \quad 520 - 641.57 = -121.57 \quad \text{(negative, ignored)}$$

$$\text{Tue:} \quad 850 - 641.57 = 208.43 \quad \text{(positive deviation)}$$

$$\text{Wed:} \quad 800 - 641.57 = 158.43 \quad \text{(positive deviation)}$$

$$\text{Thu:} \quad 875 - 641.57 = 233.43 \quad \text{(positive deviation)}$$

$$\text{Fri:} \quad 900 - 641.57 = 258.43 \quad \text{(positive deviation)}$$
$$\text{Sat:} \quad 546 - 641.57 = -95.57 \quad \text{(negative, ignored)}$$

Total positive deviation:

$$208.43 + 158.43 + 233.43 + 258.43 = 858.72\,\mathrm{m^3/s}$$

Pondage required:

$$\text{Pondage required} = 858.72 \times 86400 = 74,177,612.8\,\mathrm{m^3}$$

iii. Installed Capacity of Proposed Plant

The installed capacity is calculated using the formula for power:

$$\text{Power (W)} = \rho \cdot g \cdot Q \cdot H \cdot \eta$$

Where:

$$\rho = 1000\,\mathrm{kg/m^3} \quad \text{(density of water)}, \quad g = 9.81\,\mathrm{m/s^2} \quad \text{(gravity)},$$
$$Q = 900\,\mathrm{m^3/s} \quad \text{(maximum discharge)}, \quad H = 15\,\mathrm{m}, \quad \eta = 0.85$$

Substituting the values:

$$\text{Power (W)} = 1000 \cdot 9.81 \cdot 900 \cdot 15 \cdot 0.85 = 112,569,750\,\mathrm{W}$$

Converting to MW:

$$\text{Power (MW)} = \frac{112,569,750}{10^6} = 112.57\,\mathrm{MW}$$

Considering the load factor:

$$\text{Installed Capacity (MW)} = \frac{\text{Power}}{\text{Load factor}} = \frac{112.57}{0.40} = 281.43\,\mathrm{MW}$$

i. Average Daily Discharge

The average daily discharge is calculated as:

$$\text{Average daily discharge} = \frac{\text{Sum of daily discharges}}{\text{Number of days}}$$

Substituting the values:

$$\text{Average daily discharge} = \frac{500 + 520 + 850 + 800 + 875 + 900 + 546}{7} = 713\,\mathrm{m^3/s}$$

ii. Pondage Required

Pondage refers to the storage required to regulate the flow variations across days. First, calculate the deviations from the average daily discharge:

$$\text{Deviation for each day} = \text{Discharge for that day} - \text{Average discharge}$$

For positive deviations:

$$\text{Pondage required (m}^3\text{)} = \text{Sum of positive deviations} \times \text{Seconds per day}$$

For each day:

$$\text{Sun:} \quad 500 - 713 = -213 \quad \text{(negative, ignored)}$$

$$\text{Mon:} \quad 520 - 713 = -193 \quad \text{(negative, ignored)}$$

$$\text{Tue:} \quad 850 - 713 = 137 \quad \text{(positive deviation)}$$

$$\text{Wed:} \quad 800 - 713 = 87 \quad \text{(positive deviation)}$$

$$\text{Thu:} \quad 875 - 713 = 162 \quad \text{(positive deviation)}$$

$$\text{Fri:} \quad 900 - 713 = 187 \quad \text{(positive deviation)}$$

$$\text{Sat:} \quad 546 - 713 = -167 \quad \text{(negative, ignored)}$$

Total positive deviation:

$$137 + 87 + 162 + 187 = 573\,\text{m}^3/\text{s}$$

Pondage required:

$$\text{Pondage required} = 573 \times 86400 = 49,507,200\,\text{m}^3$$

iii. Installed Capacity

The installed capacity is calculated using the formula for power:

$$\text{Power (W)} = \rho \cdot g \cdot Q \cdot H \cdot \eta$$

Where:

$$\rho = 1000\,\text{kg/m}^3 \quad \text{(density of water)}, \quad g = 9.81\,\text{m/s}^2 \quad \text{(gravity)},$$

$$Q = 900\,\text{m}^3/\text{s} \quad \text{(maximum discharge)}, \quad H = 15\,\text{m}, \quad \eta = 0.85$$

Substituting the values:

$$\text{Power (W)} = 1000 \cdot 9.81 \cdot 900 \cdot 15 \cdot 0.85 = 112,569,750\,\text{W}$$

Converting to MW:

$$\text{Power (MW)} = \frac{112,569,750}{10^6} = 112.57\,\text{MW}$$

Considering the load factor:

$$\text{Installed Capacity (MW)} = \frac{\text{Power}}{\text{Load factor}} = \frac{112.57}{0.40} = 281.43\,\text{MW}$$