Step 1: Determination of the Average Load Demand

The absolute baseline for evaluating system capacity begins with finding the average power demanded from the facility over the course of the designated timeframe. Electrical energy consumption is a time-integrated product of power and duration. Therefore, to extract the steady-state continuous mathematical equivalent—defined as the **Average Load**—the annual energy generation must be divided by the total number of operational hours in a standard year:

$$\text{Average Load} = \frac{Total\ Energy\ Generated\ in\ Kilowatt-Hours\ (kWh)}{Number\ of\ Hours\ Considered}$$

Given an annual yield of 870 x 10^5 kWh and assuming a standard non-leap year containing 365 days (amounting to exactly 8,760 hours):

$$\text{Average Load} = \frac{87{,}000{,}000\ kWh}{8{,}760\ hrs} = 9,931.5068\ kW$$

Step 2: Isolation of the Total Installed Power Station Capacity

The **Capacity Factor** measures how intensively the total potential generator configuration is utilized over a prolonged operational period. It mathematically reflects the ratio of the average continuous output to the maximum nameplate rating of the plant:

$$\text{Capacity Factor} = \frac{Average\ Load}{Rated\ Plant\ Capacity}$$

Substituting our calculated average load and the given 25% target capacity baseline allows us to calculate the maximum capability of the installation:

$$0.25 = \frac{9{,}931.5068\ kW}{Plant\ Capacity}$$

$$Plant\ Capacity = 397,260.27\ kW$$

Step 3: Calculation of Peak Coincident Demand

The **Load Factor** indicates the relative volatility or flatness of consumer demand over a specified operational timeframe. It relates the continuous average load base to the highest short-duration instantaneous strain placed on the system—the **Peak Load**:

$$\text{Load Factor} = \frac{Average\ Load}{Peak\ Load}$$

Given that our facility runs under an annual load factor profile of30%, the maximum instantaneous usage is calculated as follows:

$$0.30 = \frac{9{,}931.5068\ kW}{Peak\ Load}$$

$$Peak\ Load = 33,105.023\ kW$$

<u>Step 4:</u> Quantifying the Total Reserve Load Margin

The safety envelope designed to shield utility networks from catastrophic blackouts during peak load events is known as the **Reserve Capacity** (or Reserved Load). This measures the surplus equipment potential kept online or synchronized above the maximum anticipated consumer spike:

Reserved Capacity = Plant Capacity - Peak Load = $397,260.27\ kW$ - $33,105.023\ kW$

Reserved Capacity = 66,155.25 kW

A Capacity Factor (25%) significantly lower than the Load Factor (30%) shows that the power plant remains under utilized. While this ensures excellent buffer margins, it means capital-intensive equipment sits idle for much of the year, which extends the financial payback period for investment capital.

Hydroelectric plants have unique operational profiles. The 66.2 MW reserve capacity calculated here serves as vital insurance. It can function as a "spinning reserve" that can ramp up instantly to handle sudden drop-offs on the grid, or provide a buffer for seasonal water flow variations.

Maintaining a reserve capacity that is nearly 20% of peak demand represents a classic engineering compromise. It balances the capital cost of keeping idle machinery online against the socio-economic necessity of maintaining absolute grid reliability and avoiding brownouts.