Förnyelsebar elproduktion och eltransporter (DAT460)

Hydropower Assignment

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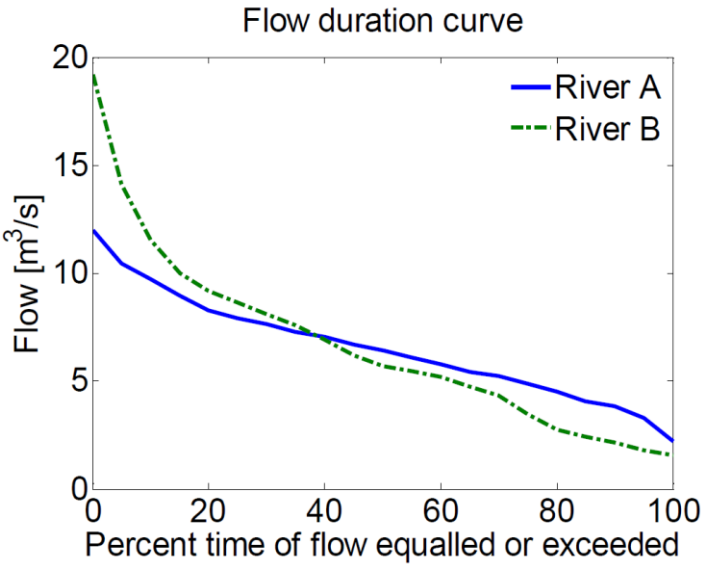
1. Introduction

This assignment is to provide basic knowledge on calculation of the hydropower potential and conversion. An Excel file is given for calculation.

2. Flow duration curve

Variation of river flow over a year can be expressed in a flow duration curve. Figure 1 shows a flow duration curve of river A and B. The river A data is given in the Excel file: Calculation 1, column B and column C. The river B data is given in the Excel file: Calculation 1, column G and column H.

Figure 1: Flow duration curve of river A and B.



Q1: Which river has more flow throughout a year? (Hint: you will need the number of total minutes per year. An average flow in each percent interval can be assumed.)

Q2: If you have to choose one of these two rivers for hydropower utilization, which river is more suitable (by assuming that all other variables of the two rivers are identical)? Explain your answer.

The maximum flow through a hydropower plant is denoted as designed flow.

3. Turbine efficiency

Hydro turbine efficiency varies depending on the flows. Normally, the maximum efficiency is located slightly below the designed flow. The efficiency data for different turbine types are provided in the Excel file: Calculation 2. And the efficiency curves are plotted in the Excel file: Plots, Curve 1 to Curve 3.

Typically, the dominant consideration factors in selecting turbine type are the available head and flow. Other considerations such as whether the turbine is expected to operate for partial flow in long duration is also another important factor.

Q3: Based on the given efficiency curve, which type of turbine will be likely to produce more energy if one would build a hydropower plant with:

a. Design flow of 3 $[m^3/s]$ on river A.

b. Design flow of 12 $[m^3/s]$ on river B.

Note that you don't need to perform calculation to answer this question, just give your estimation based on the efficiency curve. Don't forget to motivate your answer.

4. Generated power

Generated electric power P from a small hydropower plant can be calculated as follows

$$P = \rho \cdot g \cdot Q \cdot \left[H_g - \left(h_{hydr} + h_{tail}\right)\right] \cdot e_t \cdot e_g \qquad (1)$$

where

ρ is the density of water (1000 $[kg/m^3]$)

g is the gravity acceleration (9.81 $[m/s^3]$)

H_g is the gross head ($[m]$)

h_{hydr} and h_{tail} are the hydraulic losses and tailrace effect associated with the flow

e_t is the turbine efficiency at flow Q

e_g is the generator efficiency

Suppose a hydropower plant is built on river A. The plant has the following data:

Designed flow: 7.6 $[m^3/s]$, Plant availability: 0.96,

H_g : 110 $[m]$, Generator efficiency: 0.96,

Turbine type : Francis, h_{hydr} and h_{tail} are neglected,

Q4: What is the maximum power that can be delivered to the grid (the power capacity of the plant) in MW?

Q5: Calculated the power of river A with different flows in the Excel file: Calculation 1, column D. The power duration curve of the plant is plotted in the Excel file: Plots.

Q6: How much energy is delivered by the hydropower plant throughout a year?

5. Capacity Factor

The capacity factor of hydropower plant is given by

$$CF = \frac{E_{prod}}{hoursperyear * P} \qquad (2)$$

where E_{prod} is the total energy produced by the plant and P is the power capacity of the plant.

Q7: What is the capacity factor of the hydropower plant?