Department of Water Resources & Environmental Engineering, NTUA

Course: Renewable Energy & Hydroelectric Works

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Exercise 2: Simulation of hydroelectric reservoir operation

Attached are the monthly observed inflows at Ilarion dam, for hydrological years 1962-63 to 2011-12. The minimum and maximum pool levels of the reservoir are +365.0 and +403.0 m, respectively, while the outlet elevation of the power station is +293.0 m. The storage curve of the reservoir is approximated by the power function:

$$s = 2.392\ (z/z_0)^{16.376}$$

where s is the water volume (hm^3), z is the water level of the reservoir (m), and z_0 = +290.0 m is the elevation of the river bed at the dam site.

The monthly energy generation is estimated by:

$$E = 0.00238\ V\ h$$

where E is the energy (GWh), V is the monthly water release through the turbines (hm^3), and h is the gross head (m).

The monthly capacity of the penstock is 430 hm^3, which is considered, for simplicity, constant (i.e., independent of the head).

Apart from energy production, the reservoir fulfills the maintenance of a constant environmental flow 4.5 m^3/s downstream of the dam, which is released through an independent intake.

For the given data, formulate the monthly simulation model of the reservoir (in spreadsheet), assuming that this serves a constant energy demand of 20 GWh. According to the model results:

- Plot the monthly time series of simulated water level, reservoir storage, outflows through the turbines, spill losses and generated hydroelectric energy.
- Compute and plot the power-duration curve.
- Estimate the mean annual benefit from the reservoir operation, assuming firm energy price 0.10 €/kWh, secondary energy price 0.05 €/kWh, and penalty cost for energy deficit 1.0 €/kWh.
- Estimate the monthly energy target that maximizes the aforementioned profit.
- Repeat calculations assuming alternative values of the maximum pool level between +370 and +430 m, and provide a scatter plot of the useful storage capacity and the maximized profit from hydropower generation.