Hydro Peak Shave Logic

Description

This document describes Aurora's mathematical formulation of hydro peak shaving. The Peak Shaving hydro logic is used to model flexible hydro resources by optimally scheduling the monthly hydro energy across the highest demand periods within each month. The logic seeks to do this whil e also ensuring that the ordering of the periods based on demand net of the hydro allocation is the same as the ordering based on the original demand. To employ the logic f or a given hydro s et, the Peak Shave Only column in the Hydro Vectors table s hould be populated. Val id entries are:

- 1 – The model will do peak shaving over the entire month.
- 2 – The model will do peak shaving over each week, with each week getting the same amount of hydro energy allocated.
- 0/blank/NULL – The model will default to original hydro logic.

The purpose of this document is to describe how the LP algorithm is formulated to determine the hourly or sub-hourly hydro capability when peak shaving is used.

Introduction

The model uses a linear program (LP) to determine the best way to allocate the hydro energy across each month or week. The decision variables are hydro allocations for each hour or sub-hour period. The model creates an objective function that gives more weight to higher demand periods. This function is maximized subject to instantaneous min and max inputs, ordering constraints, and the total energy target. The ordering constraints require that the sorted order of the periods based on demand levels reduced by hydro energy stays the same as the order of the periods based on the original demand. The energy constraint ensures that the total hydro energy allocated for the month or week is honored. The total hydro energy available is based on the Hydro Monthly table inputs as well as the capacity, forced outage, and maintenance values of resources in the hydro set.

Mathematical Framework

Notation

Let $i \in \{1, ..., n\}$ be an integer index representing the time periods ordered by the demand values, such that $i = 1$ corresponds to the period of the week or month with lowest demand, and $i = n$ corresponds to the period with highest demand. The time periods represent either hourly or sub-hourly time steps. Note that in the mathematical notation below (with the exception of subscripts), all lower-case letters represent decision variables and all upper-case letters represent data input by the user or derived beforehand by the model. Define the following:

h_i = hydro allocation for period i (decision variables)
D_i = total demand for period i
U_i = maximum energy for hydro in period i
L_i = minimum energy for hydro in period i
E = total hydro energy available for month or week

Formulation

The model creates the following objective function by weighting hydro allocations according to their demand ordering:

$$h_1 + 2h_2 + ... + nh_n \tag{1}$$

Capacity constraints ensure that maximum and minimum energy requirements are obeyed. That is, for all i:

$$L_i \leq h_i \leq U_i \tag{2}$$

Ordering constraints require that ordering according to demand is preserved. That is, for all $i < n$: (3)

$$D_i - h_i \leq D_{i+1} - h_{i+1}$$

The energy constraint requires that allocations not exceed total available energy: (4)

$$\sum_{i=1}^{n} h_i = h_1 + h_2 + ... + h_n \leq E$$

To summarize, the model formulates the following LP and finds the vector $\boldsymbol{h}$ of hydro allocations for each time period:

maximize	$h_{1n} + 2h_2 + ... + nh_n$	
subject to	$L_i \leq h_i \leq U_i$	for all i
	$D_i - h_i \leq D_{i+1} - h_{i+1}$	for all $i < n$
	$\sum_{i=1} h_i = h_1 + h_2 + ... + h_n \leq E$	