Optimization Enhancements in Modeling Hydropower: Regulation and Integer Programming

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Overview

- Power Regulation
  - Simultaneous optimization with generation
  - System Value of Hydropower Regulation
    - Similar to existing modeling of generation
  - Modeling Regulation for an Individual Reservoir
  - Details of Modeling Regulation
- Integer Programming for Hydropower

RiverWare Optimization

- Optimization followed by Simulation.
- Preemptive Linear Goal Program
  - Piecewise-linear approximation of nonlinear functions
  - Physical equations: mass balance, routing, sloped storage, hydropower, etc.
  - Prioritized water policy constraints
  - Hydropower Objective – maximize system value of generation
  - Plant level modeling of hydropower

Hydropower Objective:

- *Maximize* Power Value
- Block costs, an example
  - System value of the first 50 MW of hydropower,
  - System value of the second 50 MW, etc. (Decreasing values)
  - 100 blocks for each 6-hour time period

Ancillary Services

- Regulation and Frequency Support
- Spinning Reserve
- Non-spinning Reserve

Typical Objective Function

- Maximize:

  regulation value – regulation operating costs

  + generation value

  + cumulative value of stored water

- Value is system wide
  - System value of regulation
  - Block costs for each time period.
    - Based on market and/or thermal system
- May require iteration with thermal system.

Modeling Regulation at a Reservoir

- $\text{Generation}_t + \text{Regulation}_t \leq \text{Maximum Power}_t$
- $\text{Generation}_t - \text{Regulation}_t \geq \text{Minimum Power}_t$
- $\text{Regulation Cost} = \text{coef}_r * \text{Regulation}_t$

Summary

- Simultaneous optimization with generation
  - Additional services possible
- System Value of Hydropower Regulation
  - Block values for each time period
  - Still a loop with ESO
- Model at each reservoir:
  - Interaction with Generation
  - Regulation Costs

Integer Programming for Hydropower Optimization

- Task for this FY
- Discrete operating points – esp. zero and minimum power.
- Avoidance of "holes" and "spikes"
- Model with 0-1 variables
- Also needed for regulation

Current Hydropower Optimization

- Piecewise approximation of nonlinear function, continuous
- Manual adjustment
  - Well intentioned
  - Potentially violate water constraints
  - Potentially far from optimal

Rounding Heuristic

- Exact optimization is likely difficult:
  - Many combinations of 0-1 variables
  - Many near optimal solutions
- Exact optimization isn't worth it given fluctuations in data.
- Instead, sequentially round up or round down variables.
- Remaining variables are reoptimized.
- Preserves feasibility, likely to be near optimal