Incorporating INC/DEC into Hydro Peaking

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Ben Kujala

Incremental reserves on a hydro system are reflected by making sure the system has the machine capacity to increase generation in response to within-hour variations in system conditions during the peak hours of the day. In other words, during a peak-load hour, if expected wind generation suddenly drops (or if load suddenly increases), the hydro system can make up for this temporary shortfall by using its INC reserves. It is generally assumed for modeling purposes that incremental reserve deployments are energy neutral from hour to hour because the model does not have the precision to simulate sub-hourly actions. While this assumption may not be exactly true, it should be sufficient for the Council's hourly hydro optimization model (the Trapezoidal Model or TRAP).

Decremental reserves are reflected in the same manner, that is, the hydro system should have sufficient running generation during the light-load hours to decrease some of that generation should expected wind generation suddenly increase. Decremental reserves are also assumed to be energy neutral across all hours. Because of these assumptions, the TRAP model does not need to be altered to model water consumption for incremental or decremental reserves.

TRAP is fundamentally a water flow model, whereas incremental reserves are a capacity value, i.e. in units of megawatts. Thus to implement a reserve restriction in the model, the megawatts of INC or DEC have to be translated into flow using the HK factor (power is equal to the turbine flow times the HK factor, in units of MW/KCFS). For the INC reserve, we want to reduce the maximum turbine flow by an amount equivalent to the INC reserve capacity in megawatts. This ensures that the hydro system can produce additional short-term generation within each hour, if needed. This restriction will be put into terms of the maximum flow, or full gate flow (Q_{max}), and the turbine flows (T_{on} and T_{off}) for the computation. This reduction in maximum turbine flow will be done for both on-sustained-peak and off-sustained-peak variables, though in most cases the constraint will likely only be binding in the on-sustained-peak variables.

Similarly for decremental reserves we want to increase the minimum turbine flow by an amount equivalent to the DEC reserve capacity in megawatts. The restriction should again be in terms of the turbine flows (T_{on} and T_{off}) and the minimum flow (Q_{min}).

This memo is proposing that to implement incremental reserves we add a constraint limiting the difference between the maximum flow, Q_{max}, and the turbine flow, T_{on} or T_{off}, multiplied by the HK curve to be greater than the incremental reserves, INC. That is, for on-sustained-peak, e.g.

$$\Sigma(HK * Q_{max} - HK * T_{on}) > INC$$

Rearrangement gives us

$-\Sigma(HK * T_{on}) > INC - \Sigma(HK * Q_{max})$

For decremental reserves, the difference between the turbine flow, T_{off}, and the minimum flow, Q_{min}, multiplied by the HK curve should be greater than the decremental reserves, DEC. e.g.

$\Sigma(HK * T_{off} - HK * Q_{min}) > DEC$

or

$\Sigma(HK * T_{off}) > DEC + \Sigma(HK * Q_{min})$

By taking this approach, we are effectively eliminating the need to manually increase minimum turbine flows and to manually decrease maximum turbine flows at specified projects, thus allowing the model to provide both INC and DEC in the optimization process.

These restrictions could be applied to a subset of the plants to reflect that reserves are mostly held on certain projects. For the time being I would propose we implement this on the 5 federal hydro projects already indicated by the wind decremental flow tables: Grand Coulee, Chief Joe, McNary, John Day and The Dalles.

Results from Preliminary Studies:

Implementing INC reserves in the proposed manner had very little impact on the calculated 4-hour sustained peak capacity assessment. That is, the 5 projects listed almost always had room for the INCs. If we use this approach to implement INC reserves, however, we should be cautious to <u>not</u> additionally reduce hydro peaking capacity in any other way. More specifically, current practice is to adjust the hydro maintenance file to decrease hydro peaking capability equal to the INC amount. This should not be done if INC is implemented in the TRAP model. However, hydro maintenance still needs to be accounted for.

Implementing DEC reserves using this method (as opposed to the current practice of manually increasing minimum turbine flows) resulted in lower off-peak flows overall. In other words, DEC reserve requirements could be implemented by generating less during the off-peak hours. This implies that using the exogenously calculated minimum turbine flows is too conservative. And, as a secondary consequence, on-sustained-peak capacity increased.