Northwest **Power** and **Conservation** Council

April 4, 2017

MEMORANDUM

TO: **Power Committee Members**

FROM: **John Fazio, Senior Systems Analyst**

SUBJECT: **How Council Coordinates Hydro Unit Outages for Adequacy Modeling**

BACKGROUND:

Presenter: John Fazio

Summary: This briefing details how maintenance and forced outages on hydroelectric units are accounted for in the Council's adequacy assessments. Planned and (average) forced outage durations are combined for each hydroelectric project to determine the percent of time each is unavailable to generate. This percentage is used to derive monthly generating availability factors for each project.

For the hourly operation simulation, the sustained-peaking capability of the hydroelectric system is calculated accounting for four different maintenance and forced outage conditions. This adds an element of uncertainty with respect to the availability of future peaking capability. The sustained-peaking capability is also adjusted for hydro balancing reserves (incremental reserves, which are used when expected wind generation doesn't materialize and decremental reserves, which is hydro generation that can be turned off if more than expected wind generation appears).

Relevance: The GENESYS model is used annually to assess the adequacy of the power supply five years into the future to ensure that the region will continue to provide an adequate supply. It is critical that generating resources (and demand reduction actions) be accounted for accurately.

This means that both scheduled maintenance and unforeseen forced outages must somehow be accounted for in the assessment of adequacy. The method described above to implement the effect of outages on hydroelectric facilities works well with the current version of GENESYS but will have to be reassessed during the redevelopment of the model.

Workplan: N/A

Background: Generation from hydroelectric facilities in the Pacific Northwest serves about two-thirds of the region's energy needs, on average. It is imperative that the availability of these facilities to generate is simulated in a realistic manner, to the extent possible. In the past, the Northwest has historically been an energy limited region, meaning that it had sufficient generating capacity but was fuel (water) limited. Over the past decade or so, with increasing amounts of wind resources, more constraining operations on the hydroelectric system and increasing peak demands, planners now must also face peak-hour shortfalls. Because of this, it becomes even more important to accurately reflect the hourly capability of the hydroelectric system. The following section describes BPA's process for updating outage data.

Overview of BPA's Monthly Outage Assessment Process

Monthly availability forecasts are produced annually in January. They are the result of two separate forecasts – forced outage forecasts and scheduled outage forecasts. A forced outage forecast is projected by plant and by year for the next five years. An initial projection is made by the FCRPS Performance Committee based on the historical trend of plant performance and hydro industry average performance as reported by NERC's Generating Availability Data System (GADS). That projection is then adjusted as needed by each plant manager based on any known equipment issues that could produce higher than expected normal rates (age of equipment, design flaws, history of failures, etc.).

The scheduled outage forecast is produced based on the five-year outage plan. This plan is submitted by each plant annually in November, and contains all known generator outages due to routine maintenance, non-routine maintenance, capital investments, fish work, transmission work, or any other reason. Each outage is submitted with a start date, end date, and reason among other things. During the month of November, BPA analyzes the outage plans to determine any periods of time when the amount of unavailable capacity in the plan would severely restrict BPA's ability to meet its operational objectives. Problematic outages are flagged for further discussion at the Annual Outage Coordination conference call which is normally held in the first week of December. At that meeting, each plant will take turns calling in to discuss their outage plans with subject matter experts from power operations, water management, transmission planning, fish & wildlife program management, capital

investment planning, and other areas from BPA, the Corps, and Reclamation. In addition to responding to BPA's requests to move outages to more opportune time periods, the group will also discuss the outage plans to ensure that all known work is represented on the plan. It will also attempt to identify any potential conflicts or opportunities to combine work and reduce outage impacts.

After any changes are made to the outage plan as a result of the coordination call, scheduled outage factors are calculated. This is done using calculations provided by IEEE 762, an international standard which provides the basis for NERC GADS reporting. Scheduled outage factors are calculated for each plant by month and by reason for the next five years. The results of these projections are then checked against historical scheduled outage factors and some corrections are made. The most common correction is for expected capital investment work. Because of the development and approval cycle for capital investments, outage impacts for those investments are often not identified until two years prior to construction. So in the five-year outage plan, years three through five do not reflect the full expected outage impact of FCRPS capital investments.

The monthly scheduled outage projections are added to annual forced outage projections and subtracted from 100% to get net monthly availability by plant. BPA then adjusts the availabilities for incremental reserve requirements.

More Info: Please contact John Fazio (jfazio@nwcouncil.org)

Modeling Hydroelectric Maintenance and Forced Outages

John Fazio, Senior Systems Analyst
Power Committee Meeting
Missoula, Montana
April 11, 2017

Two Distinct Time Periods

- Monthly Regulation
  - Forced outages and maintenance combined
  - Monthly project availability is calculated as a percentage of nameplate capacity
- Hourly Simulation
  - Currently done using a 1-dam model
  - Sustained-peak vs. monthly energy curves are adjusted for forced and planned outages and for balancing reserves (INC and DEC)

Major Planned Outages

- Grand Coulee's Third Powerhouse Project
  - Mechanical Overhaul of Units G-23, and G-24 (done by 2018-2019)
  - Overhaul of Units G-19, G-20, G-21 (work from 3/2021 to 10/2028)
- Maintenance related to fish passage can be found in the US Army Corps of Engineers' report, ***2015 Fish Passage Plan***
  http://www.nwd-wc.usace.army.mil/tmt/documents/fpp/2015/final/FPP15_Final_110415.pdf
- Other scheduled maintenance can be found at each hydroelectric project's website or through the NW Power Pool (collecting data for the Pacific NW Coordination Agreement)

BPA's Monthly Outage Assessment[1]

- Outage data updated every January
- Unplanned outage forecast based on GADS and individual plant performance
- Planned outage forecast based on expected maintenance and improvements
- Unplanned and planned outages are combined
- A table of monthly availability factors (%) for each facility is created based on the total duration of forecast outages

[1]See cover memo for more information

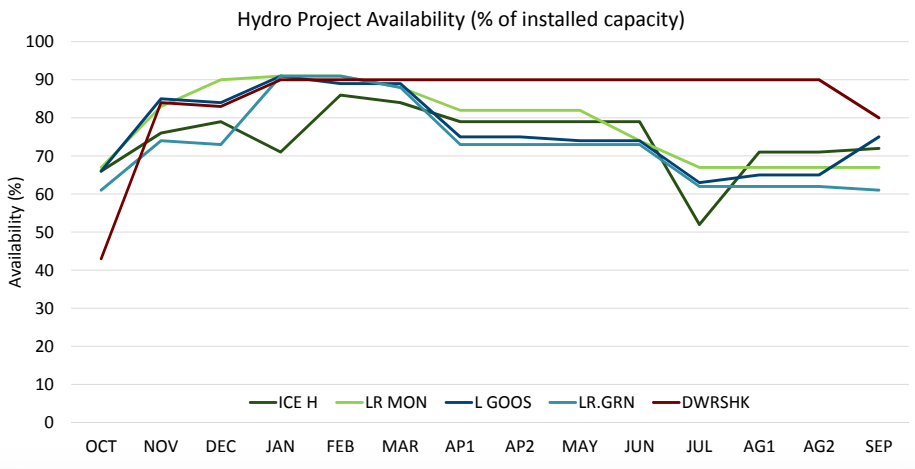
Council Adjustments

- The Council removes the effects of incremental balancing reserve requirements from BPA's monthly hydro availability data
- Because the INC requirements are applied in the hourly simulation in the GENESYS model
- For the Council's adequacy assessment, both the INC and DEC reserve requirements are accounted for in the sustained-peak vs. energy curves

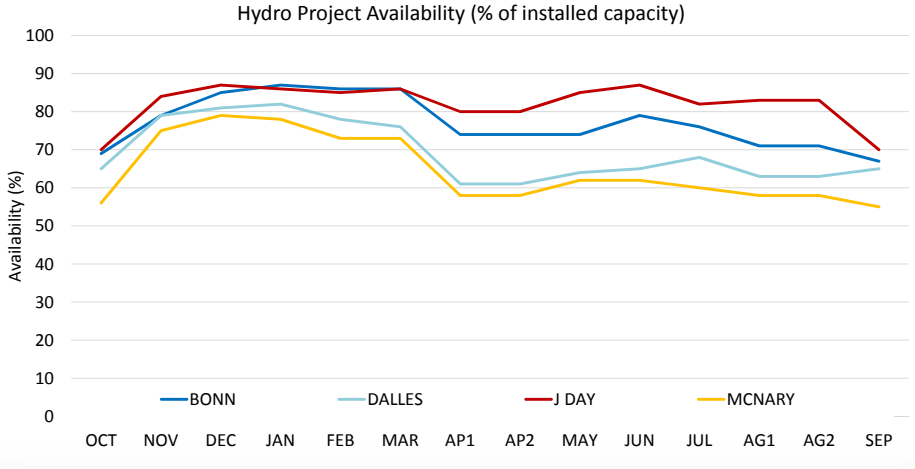
Monthly Hydro Availability (%)

PROJ	OCT	NOV	DEC	JAN	FEB	MAR	AP1	AP2	MAY	JUN	JUL	AG1	AG2	SEP
BONN	69	79	85	87	86	86	74	74	74	79	76	71	71	67
DALLES	65	79	81	82	78	76	61	61	64	65	68	63	63	65
J DAY	70	84	87	86	85	86	80	80	85	87	82	83	83	70
MCNARY	56	75	79	78	73	73	58	58	62	62	60	58	58	55
ICE H	66	76	79	71	86	84	79	79	79	79	52	71	71	72
LR MON	67	83	90	91	91	88	82	82	82	74	67	67	67	67
L GOOS	66	85	84	91	89	89	75	75	74	74	63	65	65	75
LR.GRN	61	74	73	91	91	88	73	73	73	73	62	62	62	61
DWRSHK	43	84	83	90	90	90	90	90	90	90	90	90	90	80
BRNLEE	100	100	100	100	100	100	100	100	100	100	100	100	100	100
PRIEST	100	100	100	93	90	96	100	100	100	100	100	100	99	90
WANAP	90	90	90	90	90	90	90	90	90	99	100	91	90	90
ROCK I	88	88	90	96	88	88	88	88	88	89	88	96	96	92
R RECH	90	90	90	90	90	90	90	90	90	84	90	90	90	90
CHELAN	100	100	100	100	100	63	35	35	88	100	100	100	100	100
WELLS	87	92	92	92	92	92	92	92	100	100	100	92	92	82
CH JOE	88	93	94	92	91	89	94	94	96	98	96	95	95	88
COULEE	71	62	56	65	69	68	70	70	69	60	73	72	72	60
H HORS	74	74	74	77	74	74	74	74	74	74	77	75	75	74
LIBBY	98	98	98	82	95	84	98	98	98	93	74	83	83	85

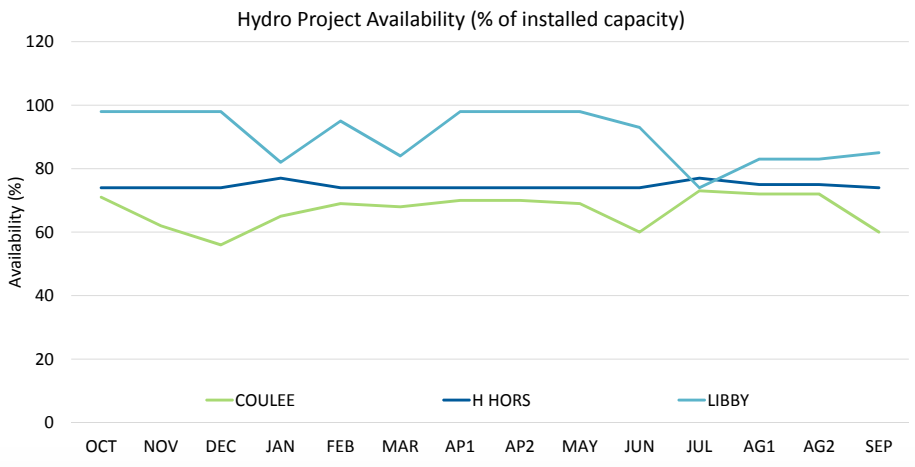
Monthly Hydro Availability
Snake



Monthly Hydro Availability
Lower Columbia



Monthly Hydro Availability Upper Columbia



For the Hourly Simulation

- One-dam hydro model used in GENESYS
- Hourly peaking capability is assessed via sustained-peak vs. monthly energy curves
- Sustained peak is calculated for different peak durations (2, 4 and 10 hours) and
- for 4 different maintenance and forced outage combinations (see next slide)

- GENESYS shapes monthly hydro energy to meet hourly loads without violating sustained-peak limits

Sustained-Peaking Forced Outage & Maintenance

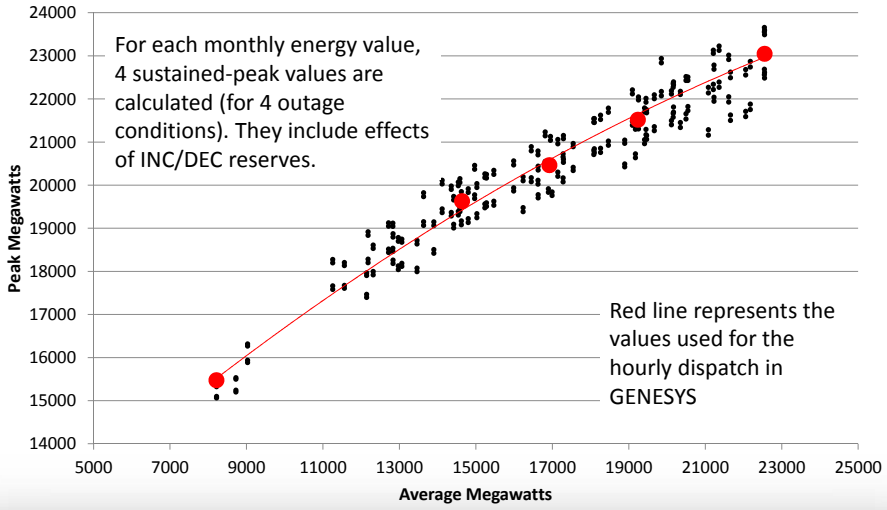
- Forced outage distribution
  - Define an average forced outage rate (~2.4%)
  - Apply a Normal distribution to the average FOR to extract the low and high conditions (see below)

- 4 outage states to assess sustained peaking
  1. High maintenance and high forced outage
  2. High maintenance and low forced outage
  3. Low maintenance and high forced outages
  4. Low maintenance and low forced outages

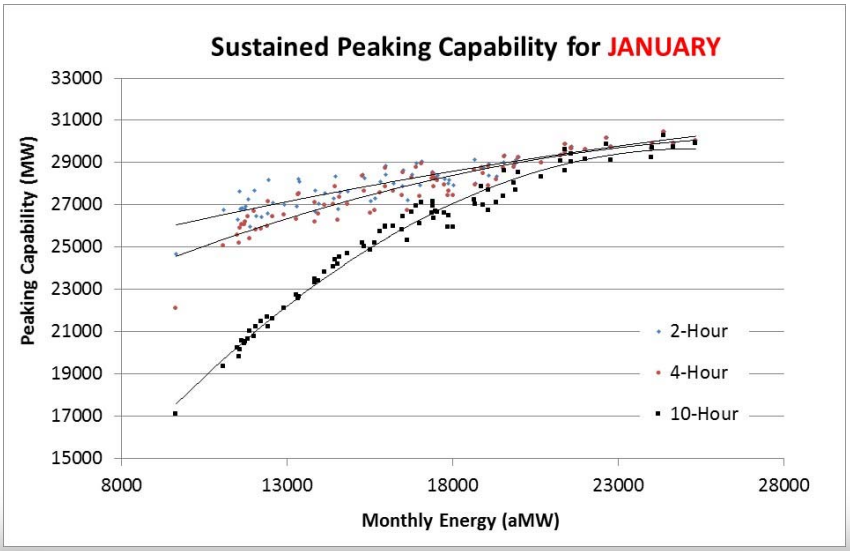
Range of Maintenance Uncertainty

Period	Low Maintenance	High Maintenance
1	.078	.111
2	.088	.109
3	.055	.083
4	.028	.048
5	.023	.027
6	.034	.044
7	.052	.063
8	.037	.081
9	.037	.081
10	.064	.080
11	.056	.069
12	.062	.088
13	.078	.108
14	.078	.108

4-Hour Sustained-Peaking Capability



Sustained-Peaking depends on Duration



Summary

- Hydro maintenance and forced outages for monthly simulations are implemented as availability factors by month by project
- For hourly simulations (because we use a 1-dam model), sustained-peak vs. energy curves are used to shape monthly hydro energy to meet hourly demands
  - The sustained-peak values account for 4 different outage states (combinations of high and low maintenance and forced outage)
  - INC and DEC requirements are included in the assessment of sustained-peak values