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September 28, 2022

MEMORANDUM

TO: **Power Committee**

FROM: **John Ollis, Manager of Planning and Analysis**

SUBJECT: **Update on Hydro Operations in GENESYS**

BACKGROUND:

Presenters: John Ollis and Dor Hirsh Bar Gai

Summary: Staff has been undergoing an effort focused on revisiting assumptions to better understand the operating limitations of the Northwest hydro system. This effort was split into three parts.

The first part of this project was to document in detail all the known operating limitations and capabilities on the system represented in the GENESYS on a project-by-project basis. The second part is to holistically validate and interpret of the constraints within the context of the GENESYS model. The third part is tp vet the revised limitations and capabilities and review the simulated operations from GENESYS with operators, stakeholders and regional experts to prepare the model for the upcoming adequacy assessment and further work.

The first and second part of this project are complete and the third part is ongoing and scheduled to wrap up in October of 2022

Relevance: The GENESYS model is one of the major quantitative tools used to develop the Council's regional power plan and annual adequacy

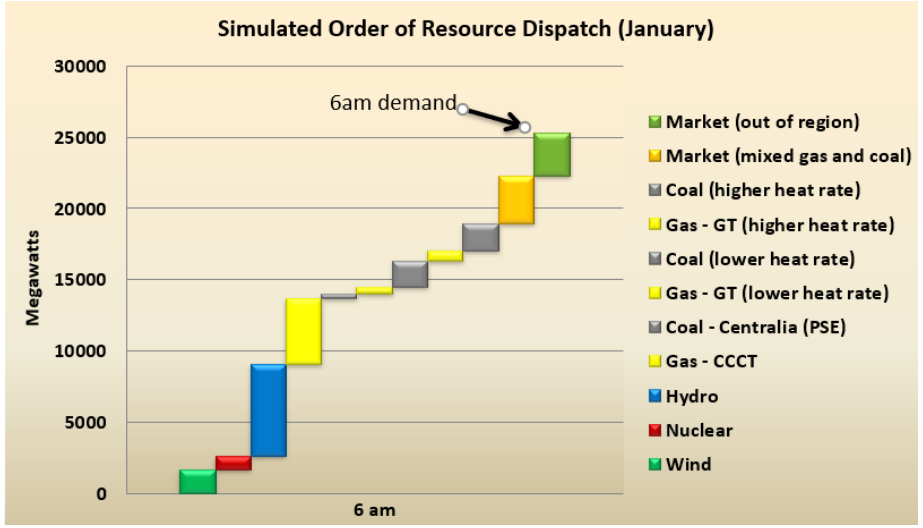
assessments. GENESYS is primarily used to assess the adequacy of the regional power supply, but it also provides hydroelectric system output to both the AURORA model and the Council's Regional Portfolio Model. In addition, GENESYS is used to validate that the power plan's resource strategy will produce adequate supplies. Because of the critical role that GENESYS plays in developing the Council's power plan, the model was evaluated and enhanced in the lead up to the 2021 Power Plan to improve forecasting reliability as well as to improve its data management capabilities and to make it less cumbersome to use.

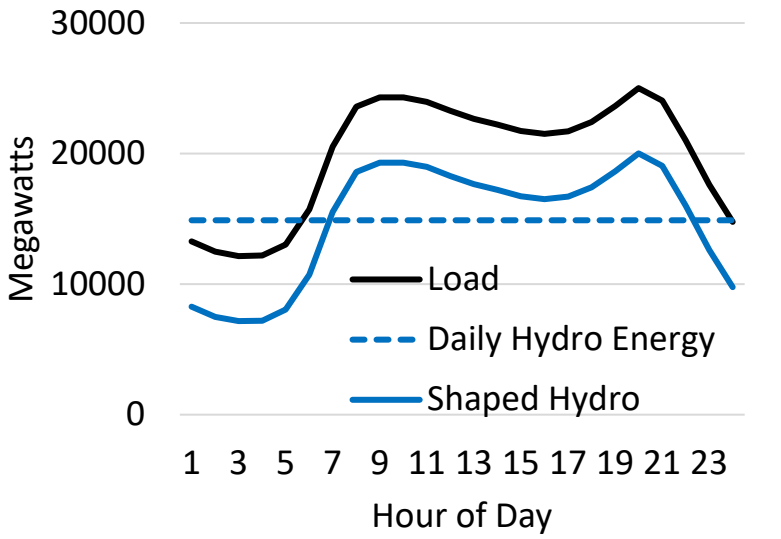
Background: Leading up to the plan staff had attempted to vet the GENESYS model and the underlying assumptions with stakeholders. Many of the assumptions were locked in early in the planning time period with not enough time to revisit them during the plan. As staff learned more about the actual system operations it became clear that some of those planning assumptions would need to be refined to better represent the hydro system operations on a project-by-project basis.

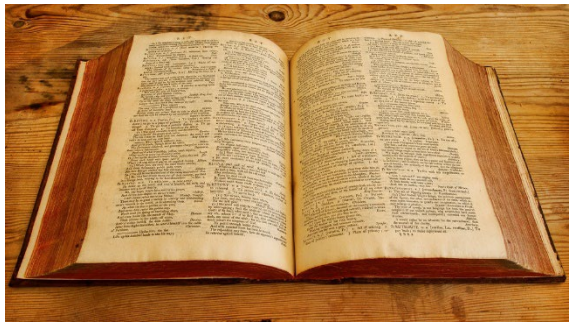
During the late stages 2021 Power Plan, there was limited capability and time to make drastic assumption changes in the model. However, it was deemed valuable during the plan to hold a technical workshop to walk through hydro system on a project-by-project basis with regional stakeholders. After the plan, an effort was made set aside time to revisit feedback from stakeholders and assumptions in the model on a more holistic basis to better understand limitations and capabilities of the regional hydro system.

More Info: GENESYS Technical Workshop

GENESYS Home Page







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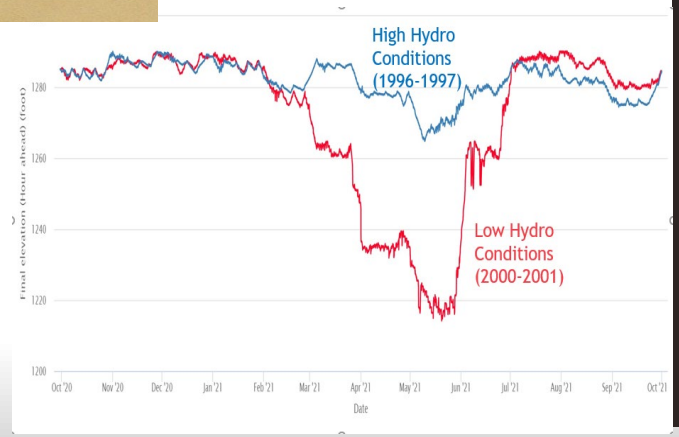
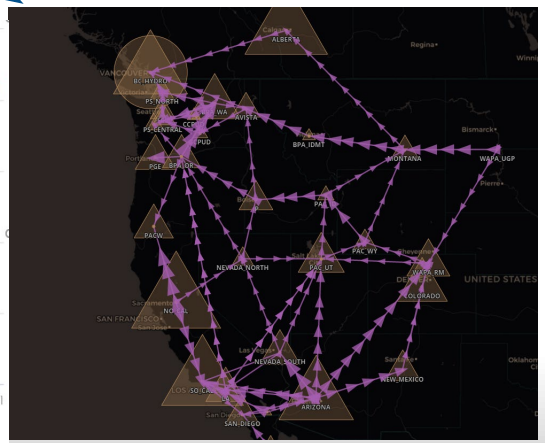
Update on Hydro Operations Review



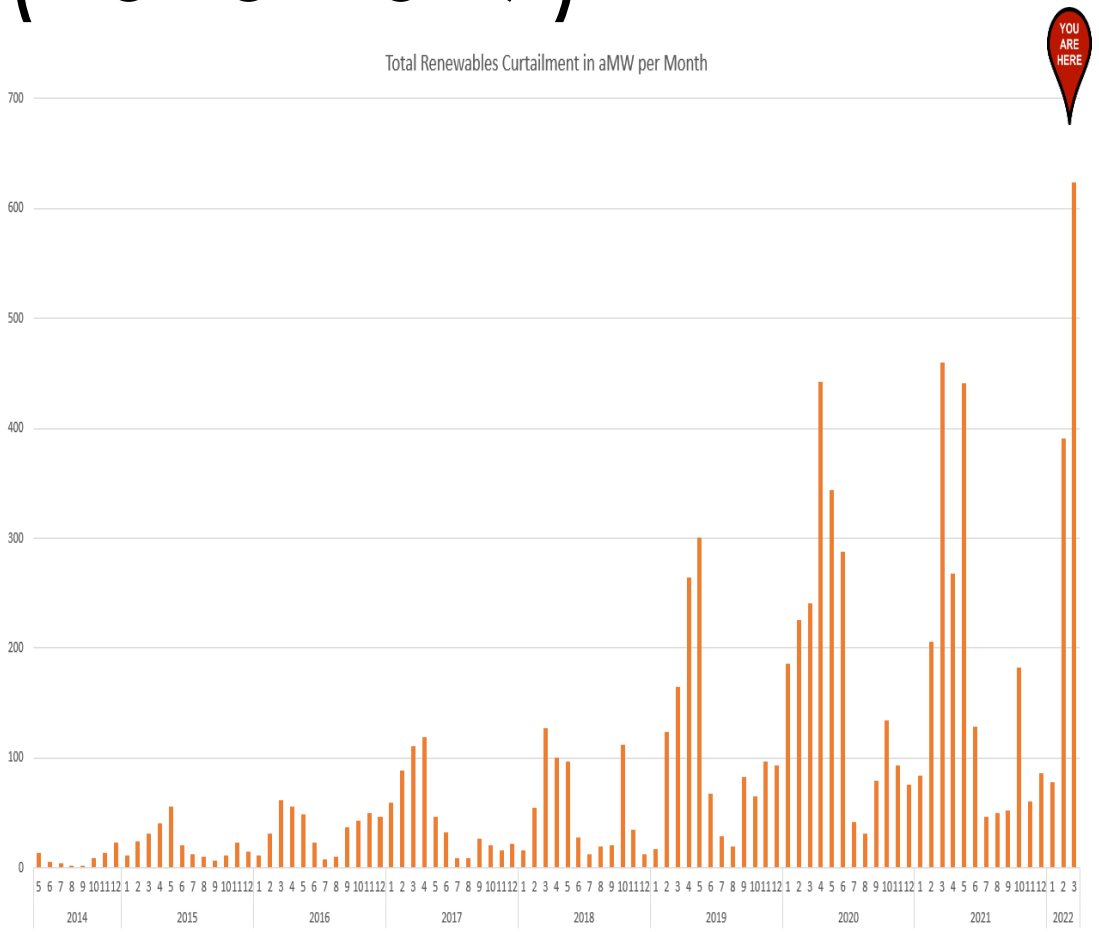


Update Highlights

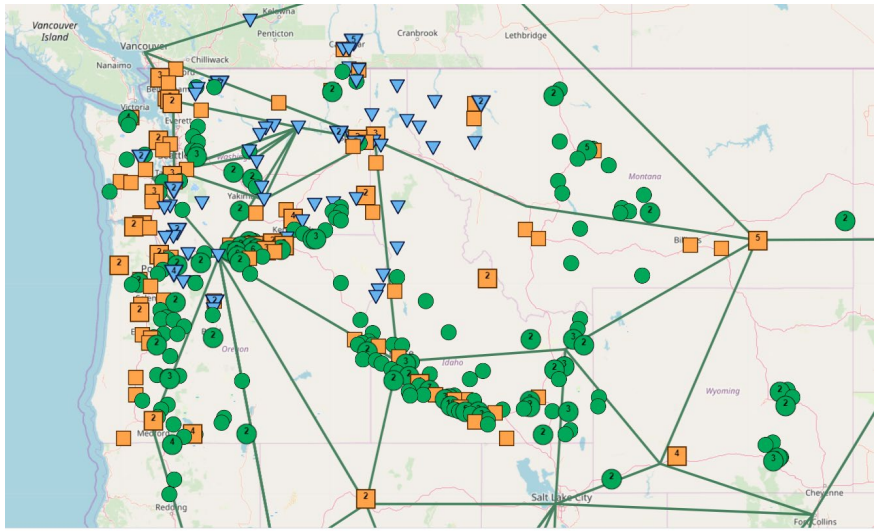
- Review model development and model improvement process
- Balancing planning and operational considerations, talking to hydro project operators and planners, understanding different objectives…
- Wrapping up this phase of model development and focus

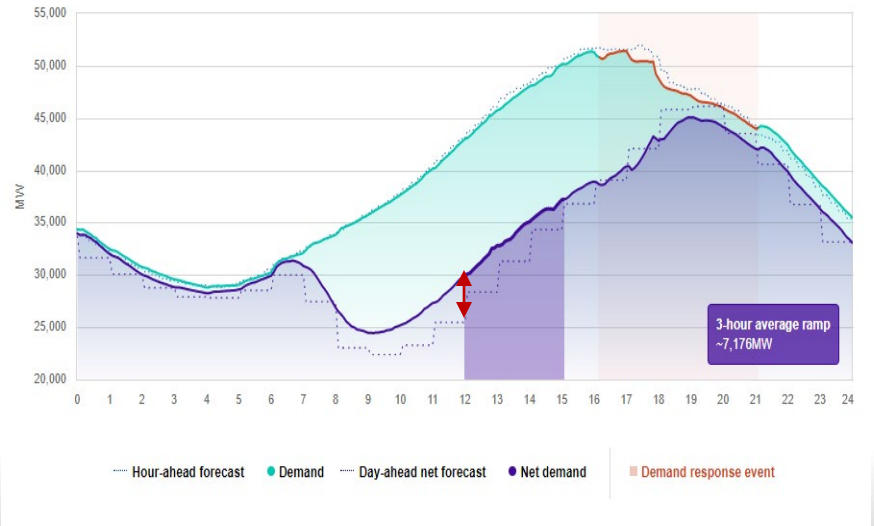
Where We Were Before the Redevelopment (2016-2019)

- Seventh Power Plan identified via two action plan items that the classic GENESYS model should be redeveloped by the next power plan
- Recognized a need to have an adequacy and hydro operations model that acknowledged the operational challenges of changing market fundamentals due to high variable energy resource penetration
  - In 2015, California Senate Bill 350 kicked off a cascade of policies throughout the WECC mandating more renewable resources.



Functionality Enhancements

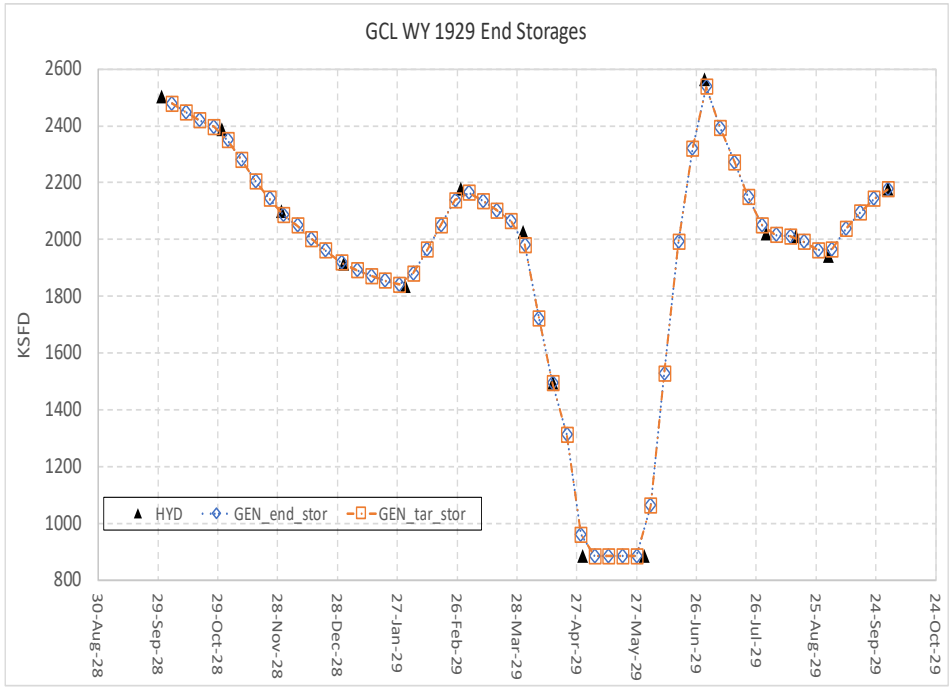




Attribute	Classic GENESYS	Redeveloped GENESYS
Hydro Resources	Modeled in aggregate hourly, modeled individually monthly	Modeled individually for all stages
Topology	Regional resources and demand in two nodes and external market supply is one node	Multiple market and regional nodes with loads, resources and seasonal transfer limits
Energy and Reserves	Balancing reserves on hydro system only. Contingency reserve check	Co-optimized dispatch of energy and all reserves
Forecast Error	No error other than Thermal FOR	Forecast error for load and renewable resources affects unit commitment and market position, and thermal FOR
Value of Hydro	Input by user. Hydro block pricing relative to operating costs of specific resources	Future value of hydro explicitly calculated
Fuel Accounting	Modeled in aggregate hourly per sustained peaking limits, modeled individually monthly	For hydro, battery and gas plants on an individual basis.
Emergency Resources	Modeled in aggregate	Modeled individually

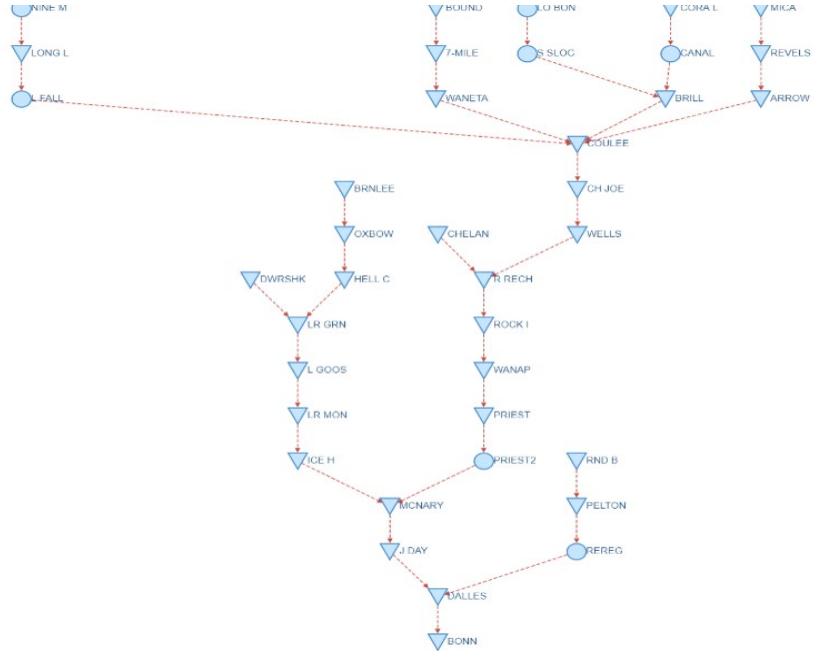
Where We Were During the Plan (2019-2021)

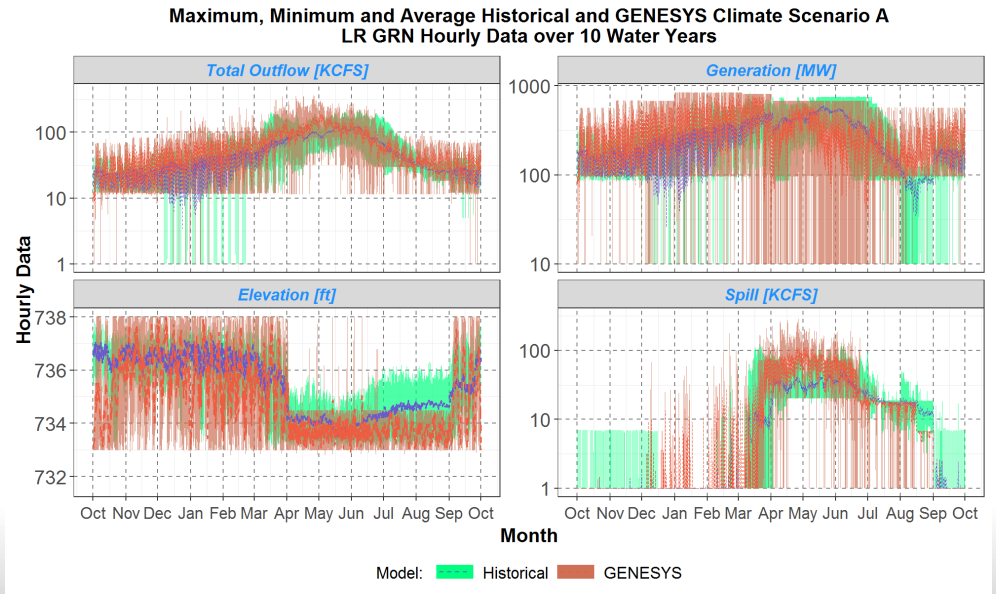
- Finished primary model development at end of 2019.
- Made an **assumption** to *align with HydSim water balances* on a weekly basis as a way ensure consistency on an energy basis (target storage methodology)
- Validated that model could perfectly align with HydSim targets before hourly constraints and operational data incorporated



GENESYS Technical Workshop

- In response to stakeholder concerns from advisory committee process about hydro operations in redeveloped GENESYS model, staff scheduled a three-day technical conference to walk through 55 individual hydro projects.
  - https://www.nwcouncil.org/meeting/raac saac-adequacygenesys-technical-conference-august-4-2021
- Regional stakeholders made some very specific suggestions about the modeling.





Where We Been Spending Time – Hydro Operations

Checking all constraints implied by treaty and non-treaty agreements, licenses, current fish passage and water management plans and reconciling with HydSim assumptions

1. Reevaluating constraints and priorities for each dam ★
2. Cataloguing modeling choices into a data repository ★
3. Validating modeling choices with operators and experts – Almost complete

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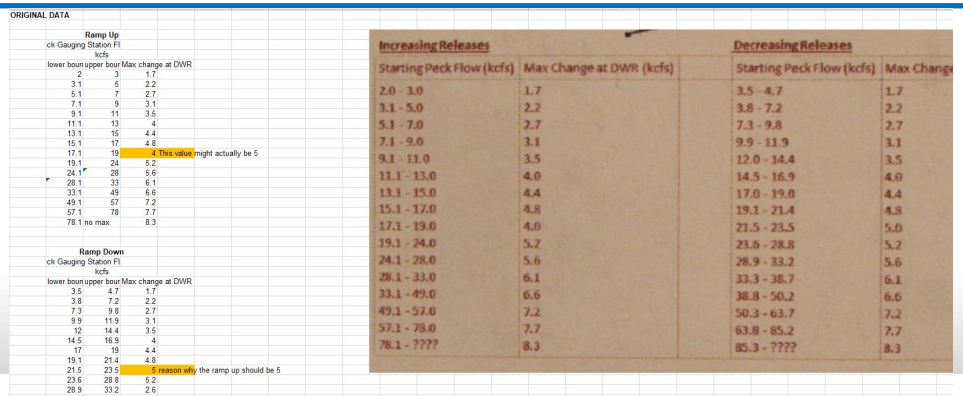

ORIGINAL DATA

Ramp Up

ck Gauging Station Fl kcfs		
lower boun	upper bour	Max change at DWR
2	3	1.7
3.1	5	2.2
5.1	7	2.7
7.1	9	3.1
9.1	11	3.5
11.1	13	4
13.1	15	4.4
15.1	17	4.8
17.1	19	4 This value might actually be 5
19.1	24	5.2
24.1	28	5.6
28.1	33	6.1
33.1	49	6.6
49.1	57	7.2
57.1	78	7.7
78.1	no max	8.3

Ramp Down

ck Gauging Station Fl kcfs		
lower boun	upper bour	Max change at DWR
3.5	4.7	1.7
3.8	7.2	2.2
7.3	9.8	2.7
9.9	11.9	3.1
12	14.4	3.5
14.5	16.9	4
17	19	4.4
19.1	21.4	4.8
21.5	23.5	5 reason why the ramp up should be 5
23.6	28.8	5.2
28.9	33.2	2.6

Increasing Releases		Decreasing Releases	
Starting Peck Flow (kcfs)	Max Change at DWR (kcfs)	Starting Peck Flow (kcfs)	Max Change
2.0 - 3.0	1.7	3.5 - 4.7	1.7
3.1 - 5.0	2.2	3.8 - 7.2	2.2
5.1 - 7.0	2.7	7.3 - 9.8	2.7
7.1 - 9.0	3.1	9.9 - 11.9	3.1
9.1 - 11.0	3.5	12.0 - 14.4	3.5
11.1 - 13.0	4.0	14.5 - 16.9	4.0
13.1 - 15.0	4.4	17.0 - 19.0	4.4
15.1 - 17.0	4.8	19.1 - 21.4	4.8
17.1 - 19.0	4.0	21.5 - 23.5	5.0
19.1 - 24.0	5.2	23.6 - 28.8	5.2
24.1 - 28.0	5.6	28.9 - 33.2	5.6
28.1 - 33.0	6.1	33.3 - 38.7	6.1
33.1 - 49.0	6.6	38.8 - 50.2	6.6
49.1 - 57.0	7.2	50.3 - 63.7	7.2
57.1 - 78.0	7.7	63.8 - 85.2	7.7
78.1 - ????	8.3	85.3 - ????	8.3

What have we found along the way so far…

- **HydSim represents limitations and capabilities on the system very differently than GENESYS**
  - Prioritized constraints solved iteratively rather than simultaneously.

- **We now only use the source constraints underlying HydSim rather than information from HydSim results.**
  - This meant that staff reviewed and catalogued over 15,000 constraints in HydSim
  - Many of these constraints contained redundant information for the purposes of GENESYS (or HydSim specific information), just over 3,000 are now translated to GENESYS.
  - Over 100 instances of project specific operations data that was not represented in HydSim also incorporated into GENESYS

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- **Many projects are modeled as having zero storage capability in HydSim actually have storage capability on a weekly or daily basis and our previous modeling underrepresented available system storage.**
  - However, in many places on the river the operation is severely constrained by license, BiOp or downstream constraints.

To Whom Are We Talking

Entity	Meetings
BPA Planners/Operators	8/22 and 9/2
USACE Operators	9/2
Idaho Power Planners/Operators	8/26
Seattle City Light Planners/Operators	9/9
Tacoma Power Planners/Operators	9/12
Portland General Electric Planners/Operators	9/20
Avista Planners/Operators	9/28
Grant/Chelan/Douglas County PUDs Operators	10/4
BC Hydro Planners/Operators	10/13*

<u>High-level Takeaways</u>:

- Entities have been very generous with their time, willing to get into details, and feedback has been positive.
- Certain pieces of the river were looking pretty good compared to today's operations
- For almost every operation that seemed to be something unexpected, we have found we were missing a piece of operational information or our interpretation of a constraint needed tweaking. This was especially the case on some smaller projects that were not in HydSim.
- Different entities sometimes within the same organization can have very different perspectives on priorities of plant operations.

Examples of Questions About Straddling the Fine Line Between a *Planning and Operations* Model

(1) Flow limitations at XX plant
- Modeled as XX plant
- Is that the correct interpretation?

(2) Downstream flows usually are important, we may have not found everything.
- Local flood control?
- Spill requirements?
- Flows for fish and wildlife?

(3) Are there any major constraints that we missed?
- Target elevations for recreation, flood control, etc.

Follow-up Conversations via Email or Virtual Meetings as Necessary

- This process has taken a considerable amount of time and effort, with each step requiring:
  - Implementing and testing new parameters
  - Seeing if there are any larger effects on other parts of the river system
  - Following up with questions on results when necessary

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Model Improvements and Stakeholder Relationships

The biggest successes of the project have been as follows:

(1) Engaging with stakeholders to better understand hydro operations

(2) Creating a clearinghouse of publicly available regional river system data honed by operator experience

(3) Tuning simulated hydro operations in GENESYS to better represent actual operations via the actual river constraints

Preliminary Hydro Flexibility Investigations: Present vs Plan

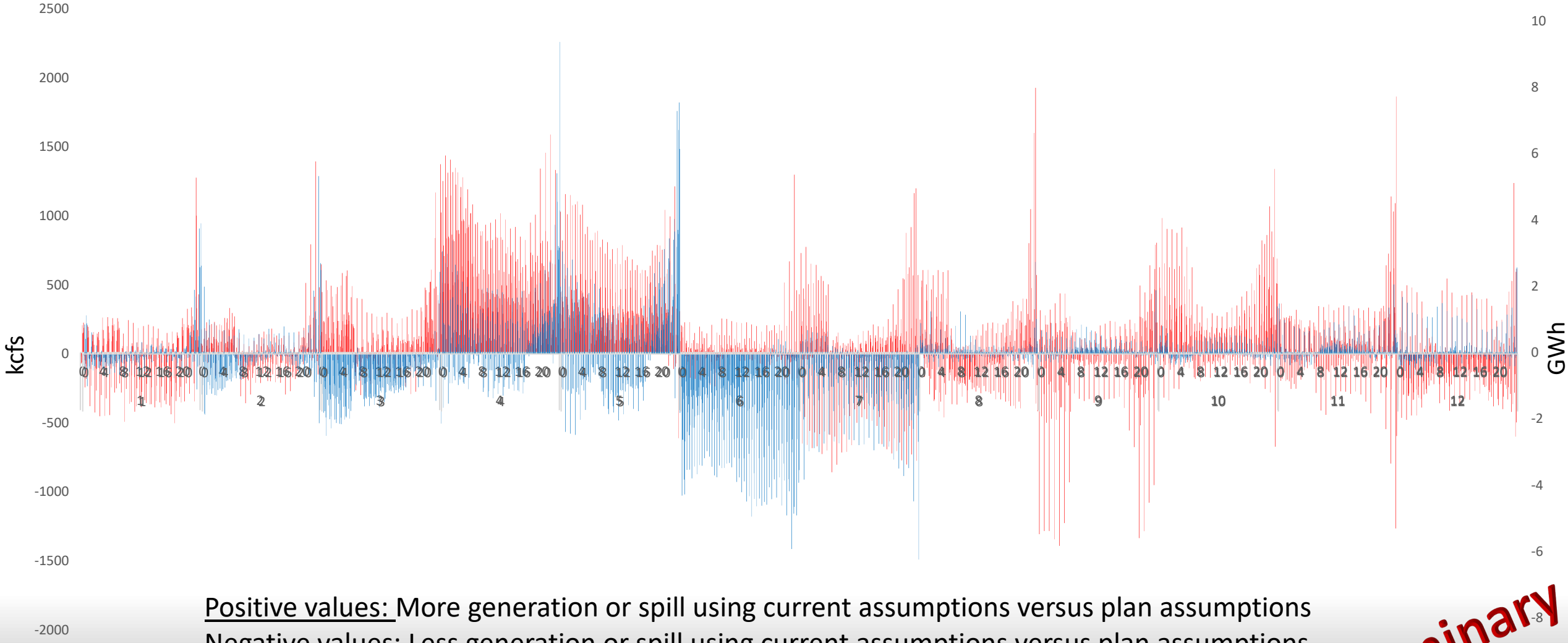
Preliminary

- Hydro Generation
  - Spring (Mar-May) - present modeling consistently generates more
  - Summer (Jul-Sep) - present modeling tends to show less generation, varies by climate year
  - Winter (Nov-Jan) – less observed differences, varies by climate year
- Spill
  - Present modeling consistently spills more throughout the year, except Mar, Jun, and Jul
- Flexibility (swing)
  - Daily swing is defined as the difference between the highest and lowest generation in a day and hourly swing is the change in generation between two consecutive hours
  - Greater daily swing in present modeling, except in Spring (Apr-Jun)
    - Magnitude varies by climate year
  - Hourly swing shows greatest difference during ramp hours, but varies by climate year

Drivers for Observed Changes

- Significant quantity of new information about summer recreational constraints
- New information about fish spill constraints
- A more nuanced interpretation of licenses and operations
- Reevaluation of certain HydSim priorities based on operator input
  - "what is more important, maintaining flows or storage targets?"

Difference in Hourly Generation and Spill

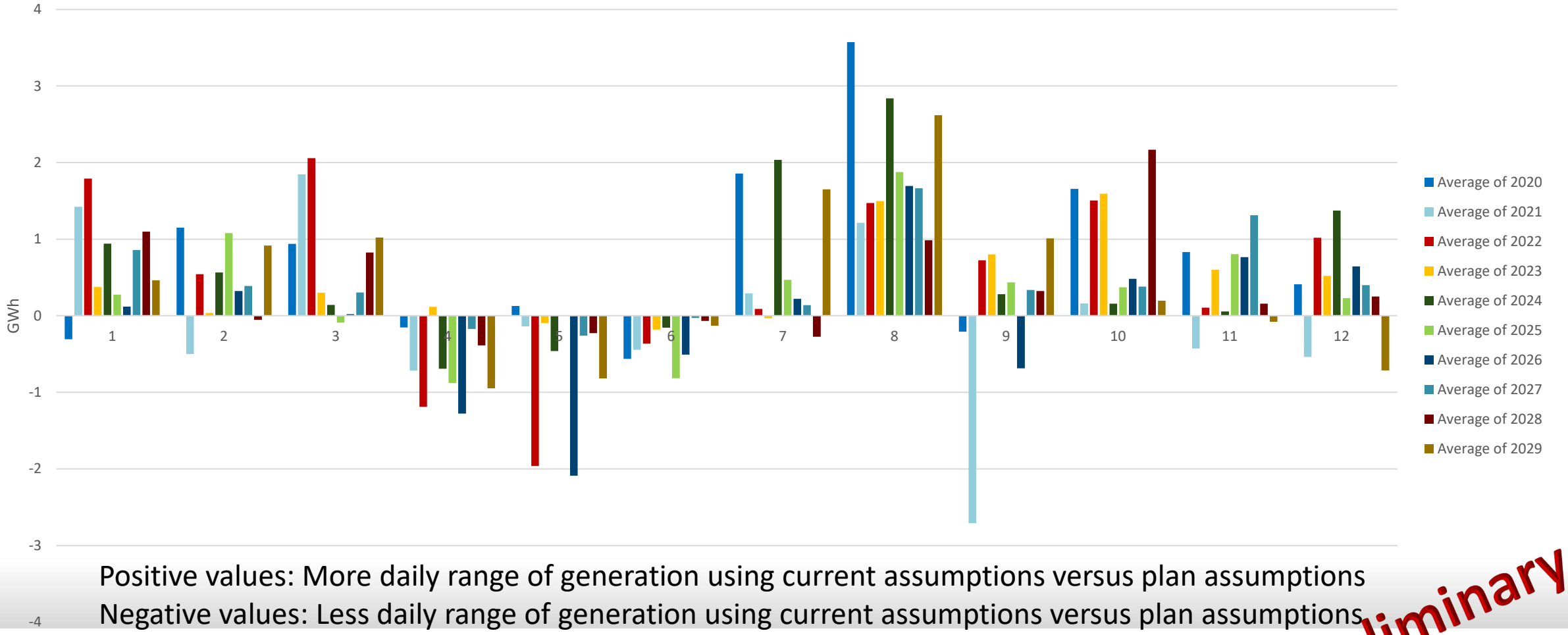


Positive values: More generation or spill using current assumptions versus plan assumptions

Negative values: Less generation or spill using current assumptions versus plan assumptions

Preliminary

Difference in Average Daily Swing



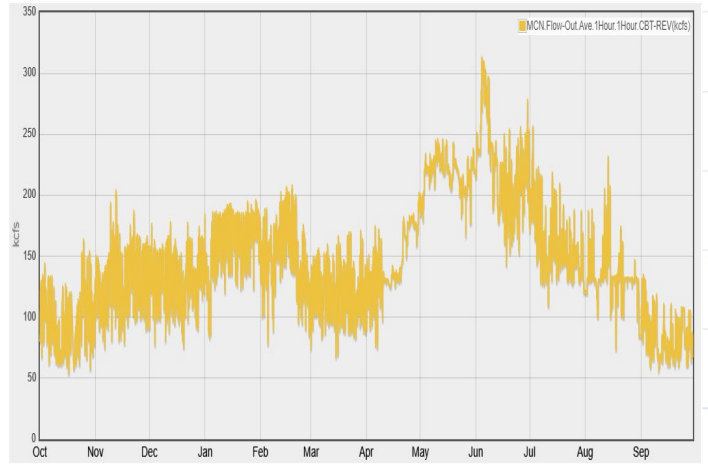
Positive values: More daily range of generation using current assumptions versus plan assumptions

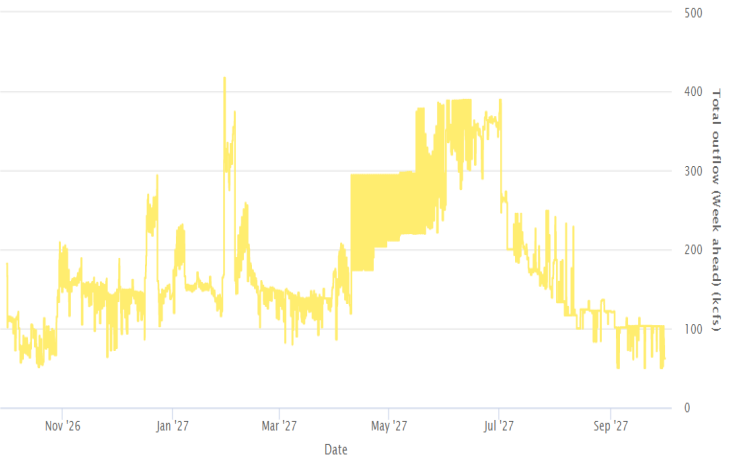
Negative values: Less daily range of generation using current assumptions versus plan assumptions

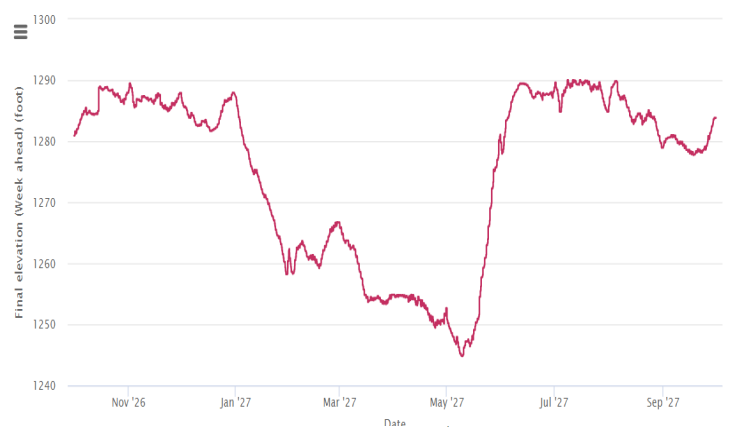
Preliminary

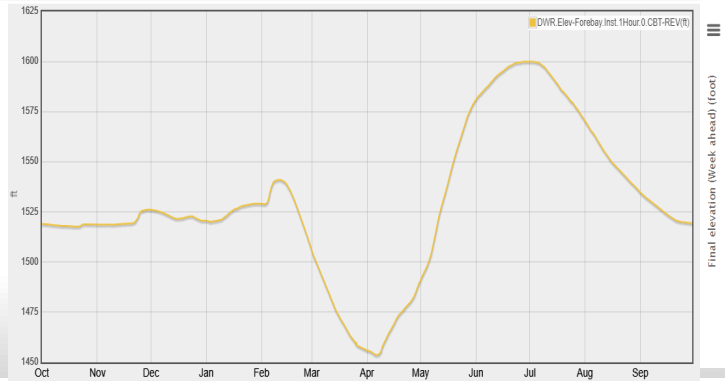
Planned Next Steps

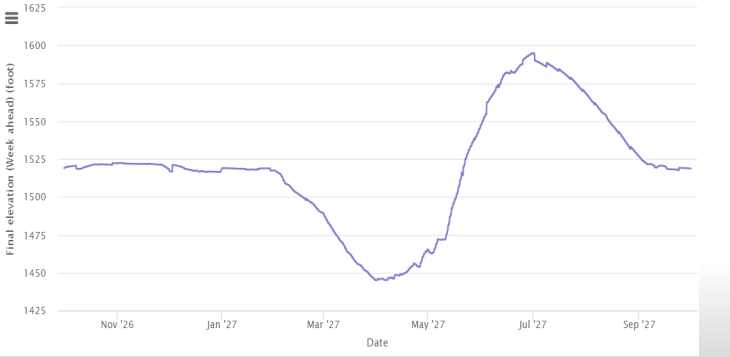
- Continue discussions with a broader group of stakeholders
- Have a second technical conference similar to the one last August but to highlight changes made since the plan comparing to actuals
- Continue to incorporate as much feedback as possible before the adequacy assessment, but continue to catalogue potential improvements for ongoing work











Timeline of Next Steps

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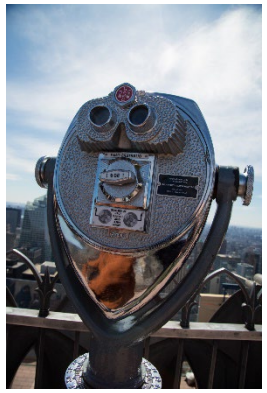


Target completion of next iteration of hydro operations review by staff by end of Q2 2022

Vet any assumptions changes with stakeholders one-on-one, in advisory committees and/or forums by beginning of Q4

Continue to collaborate with stakeholders in an open process about model assumptions and capabilities in future adequacy assessments and other studies.

Use updated model for Adequacy Assessment in Q4 2022

Questions

- John Ollis - jollis@nwcouncil.org
- Dor Hirsh Bar Gai - dhirshbargai@nwcouncil.org
- GENESYS Information

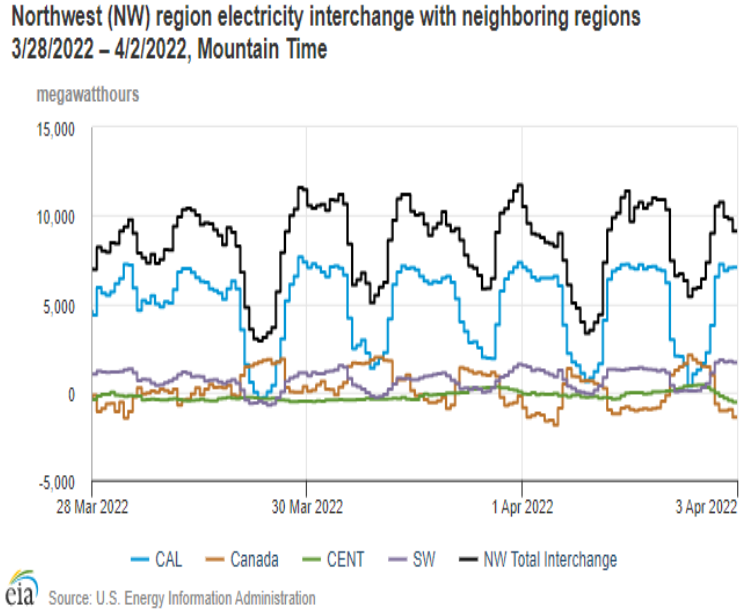
- 2021 Plan Info

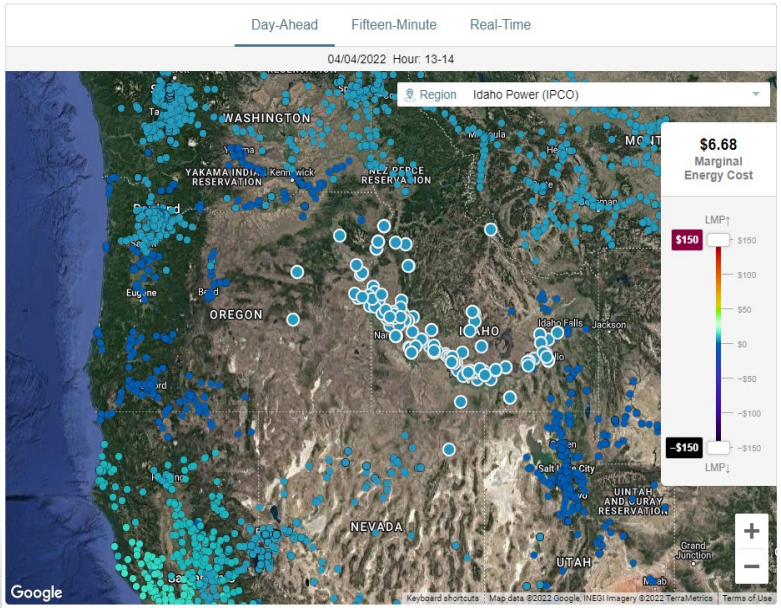
Extra Slides for Reference

Where We Are Going Next – Market Fundamentals

Stakeholders identified three main areas of concern when adding the market limitation

1. Input renewable and hydro resources throughout WECC (capture impacts of more forecast error and fuel uncertainty)
2. Investigate risks around transmission availability (planned and unplanned outages, congestion)
3. Understand more about thermal unit commitment challenges WECC-wide





Classic GENESYS – Technical Capabilities

- Chronological modeling of regional hydro system operations and constraint prioritization
  - Examples of condition-dependent and independent prioritized system constraints include the following:
    1. Minimum and maximum spill outflow, elevation and storage requirements,
    2. Discharge rate and forebay elevation ramp limitations,
    3. Minimum generation requirements,
    4. Tailwater constraints,
    5. Maintenance operations
  - Regional hydro system sustained peaking calculations accounting for water travel times.

Classic GENESYS – Technical Capabilities

- Detailed multi-stage simulation dispatching all regional resources
  - Currently has one market resource (purchase ahead and spot)
- Capable of simulating many future load, wind and hydro runoff conditions
  - Current setup focuses on climate change datasets but can be run with historical or simulated future data as well.
- Detailed resource variable costs (fuel), hydro reserve capability, efficiency curves (heat rates or H/K tables), very simple unit commitment requirements.

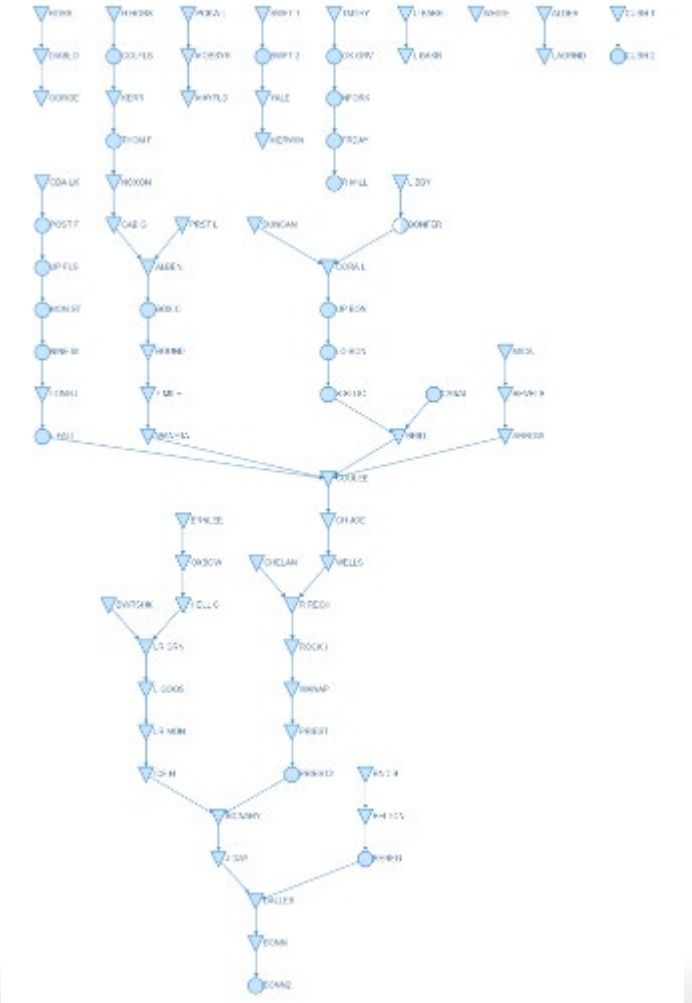
Key Limitations of Classic GENESYS

The classic model could evaluate many risks but unfortunately was not well set up to help understand the following:

- Interregional market fundamentals interaction with adequacy
  - Market resource/availability must be informed by outside the region information
- Implications of flexibility challenges on individual hydro plants
  - Limitations on reserve/flexibility modeling with aggregate hydro representation

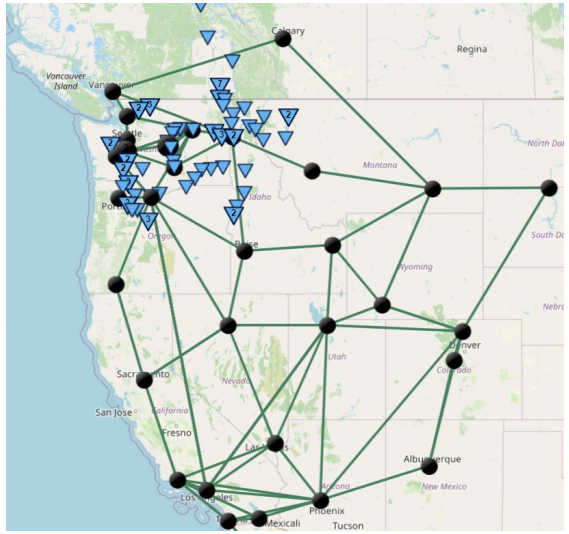
GENESYS –Technical Capabilities (Part 1)

- Chronological modeling of regional and some Canadian hydro system operations and constraint prioritization
  - Examples of condition-dependent and independent prioritized system constraints include the following:
    1. Minimum and maximum spill outflow, elevation and storage requirements,
    2. Discharge rate and forebay elevation ramp limitations,
    3. Minimum generation requirements,
    4. Tailwater constraints,
    5. Maintenance operations
  - 55 reservoirs with usable storage are simulated using constraints, detailed fuel accounting and water travel times.

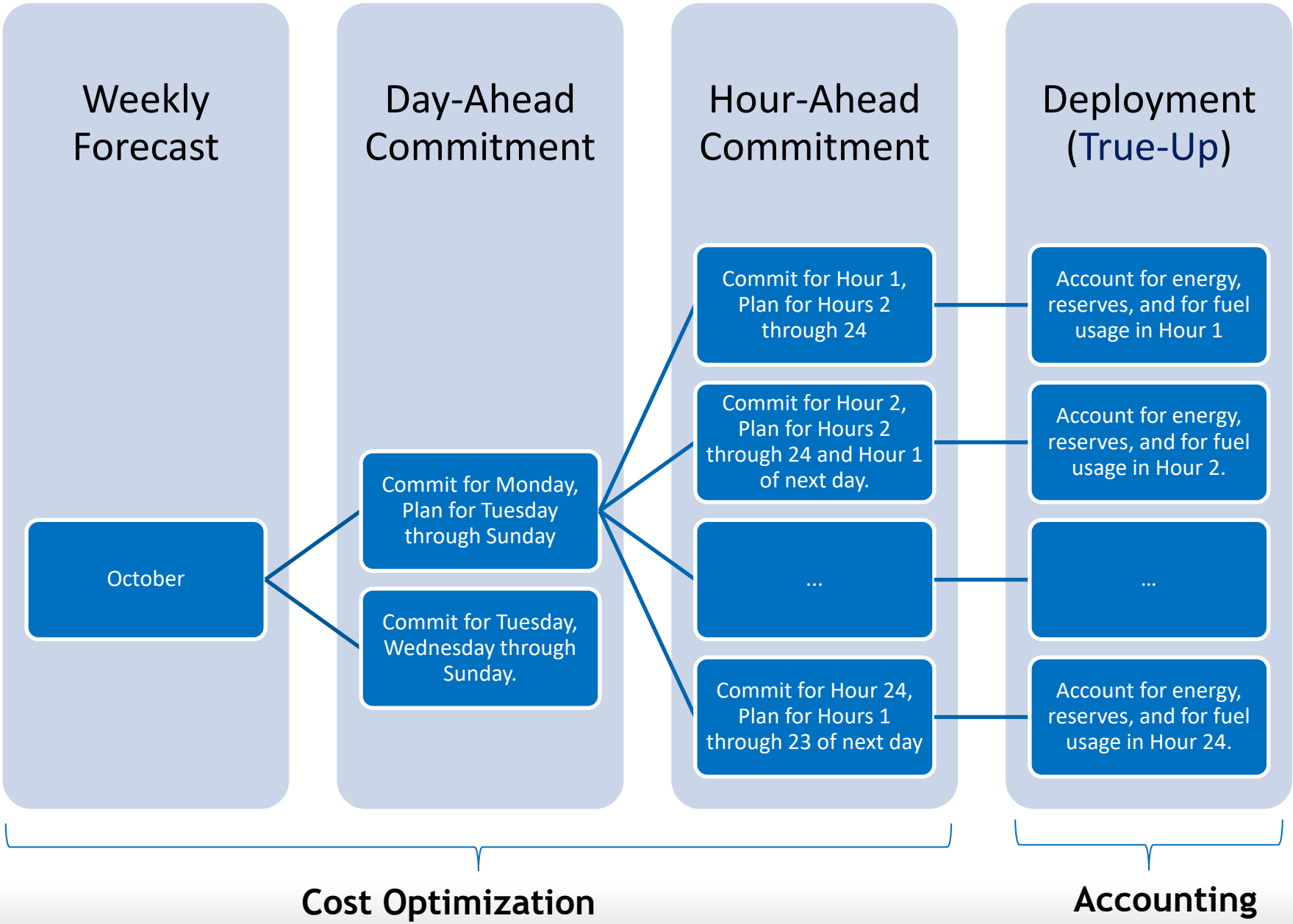


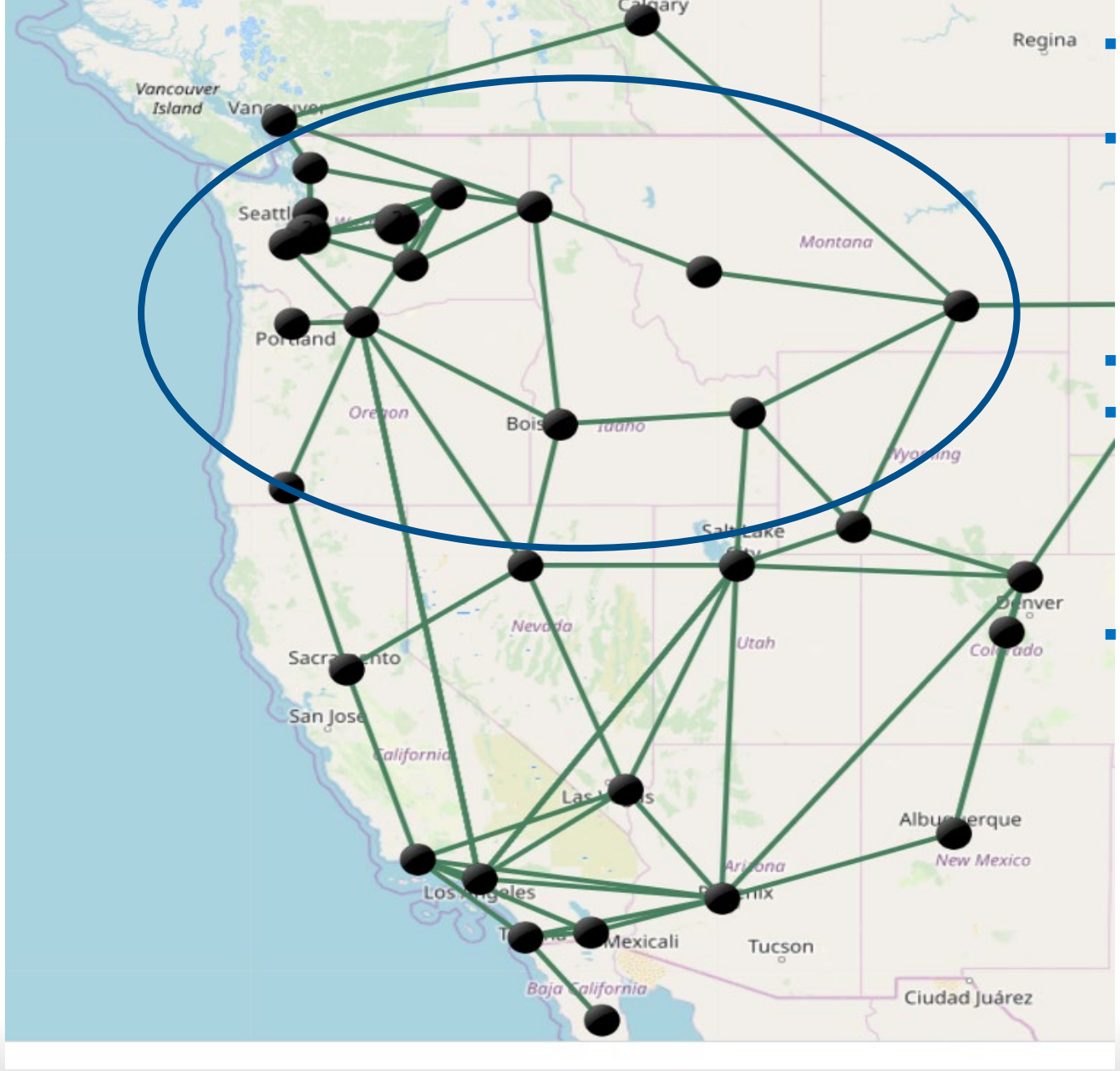
GENESYS –Technical Capabilities (Part 2)

- Detailed multi-stage simulation co-optimizing least cost resource generation and reserve provision with forecast error and fuel accounting
  - Current setup focuses on primarily on the region, but WECC market fundamentals and transmission limitations are represented.
  - Formulated as a mixed integer program
- Capable of simulating many future load, wind and hydro runoff conditions
  - Current setup focuses on climate change datasets but can be run with historical or simulated future data as well.
- Detailed resource variable costs (fuel, REC/Clean credit pricing, etc.), fueling requirements, reserve capability, emissions rates, efficiency curves (heat rates or H/K tables), ramp rates, unit commitment requirements.
  - Zonal transport representation of the WECC transmission system with detailed representation of utilities and balancing areas for reserve analysis.



Example: How Does Redeveloped GENESYS Simulate Hourly Operation?

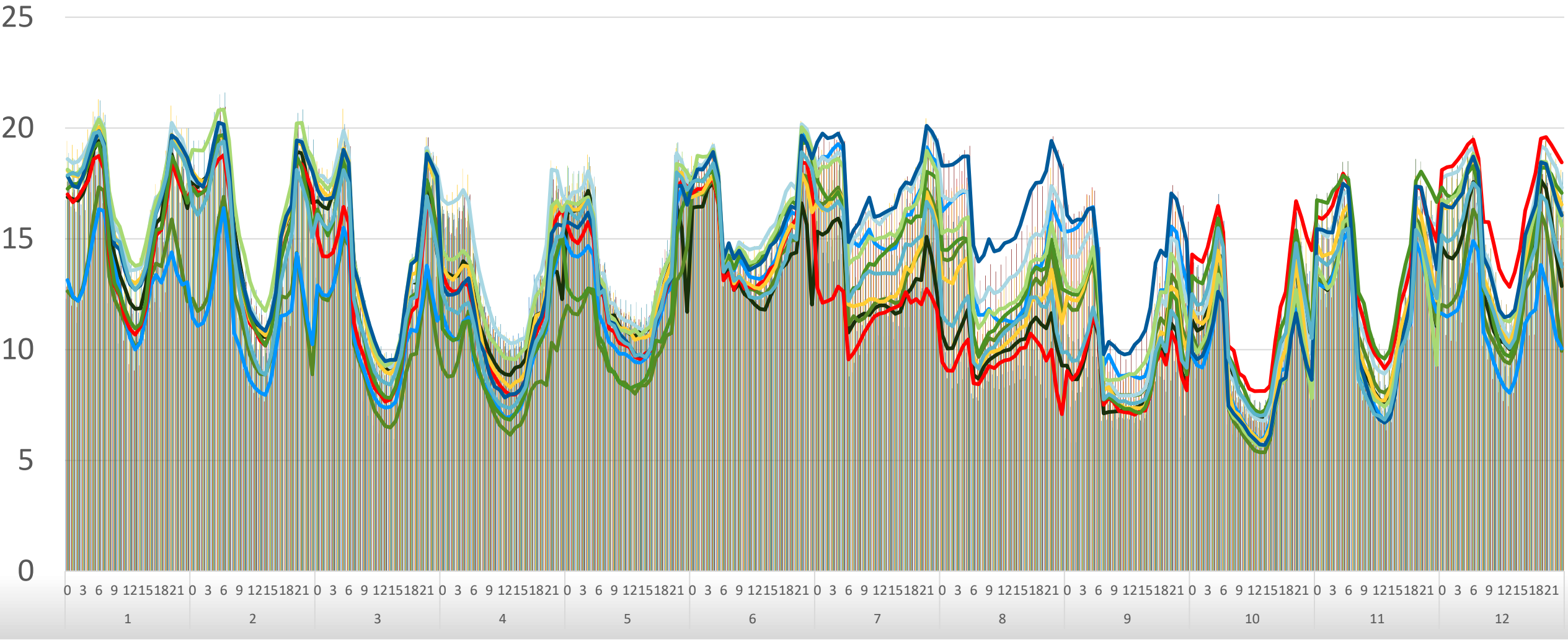




- More detailed transmission topology
- Each "bubble" represents a balancing authority, multiple balancing authorities or part of a balancing authority depending on transmission constraints.
- Hourly loads for each bubble.
- Resources in each bubble represented by bins of the amount of market resource available at a price (hourly) OR as a individually modeled resource.
- Currently, most of the resources in the region are represented as individual resources and most external to the region are represented as bins of market resource.

Expanded External Market Modeling Capability

Average Hourly Hydro Generation (GWh)



Average Hourly Spill (kcfs)