2020 Resource Program

March 6, 2020
BPA Resource Program

The Resource Program:

- Begins with a forecast of BPA load obligations and existing resources and then determines needs
- Identifies and evaluates potential solutions to meeting those needs
  - Energy efficiency, demand response, market purchases, wind, solar, gas plants, etc.
- Identifies least-cost method of meeting future needs

The Resource Program is not:

- A decision or policy document such as an Administrator’s Record of Decision
- A requirement of law or a regulating body such as FERC or NERC
2018 Resource Program Process Overhaul

- Red boxes are significant changes in 2018 from prior Resource Programs
- 2020 is a “Refresh” of some underlying data
2020 Preserved the 2018 Process

- The 2020 refresh serves as a pulse check
- To accomplish the refresh, certain inputs were updated:
  - Needs Assessment
  - Load Forecasts
  - Resource Forecasts
  - Market Price Forecast
  - Conservation Potential Assessment
  - Resource costs
Key Findings in 2020

- Each of these will be addressed in more depth later in the presentation

- Changes from the 2018 Resource Program (RP) to the 2020 Refresh
  - The load forecast declined
  - Changes to modeled hydro operations had variable impacts across months on BPA’s forecast for Federal energy and capacity
  - The Needs Assessment showed a general decline in BPA’s need for resources to meet its obligations
    - Including a flip from a forecast summer capacity deficit to a surplus
  - The market price forecast declined
Implications

- At the intersection of all of these changes to model inputs, the results of the optimization suggest that BPA can meet its obligations in a reliable and least-cost manner with Energy Efficiency (EE) and market purchases.

- The 2020 RP Refresh results are generally consistent with the results from the 2018 RP:
  - BPA does not anticipate any major changes to its EE acquisition strategy based on the 2020 results.
  - Demand response is now not in the least cost portfolios.

- We will now hear from the relevant SMEs about their planning processes that feed into the Resource Program.
Load Forecast
Implementing End-Use Forecasting

- Goal: Implement End-Use forecasting to provide a frozen efficiency forecast for the BPA Resource Program with
  - Process that is transparent to and involves our customers
  - Consistency with the Council forecast data
  - Representative of the BPA service territory
  - Integrates in with our other BPA forecasting and planning activities

- Status: Moving forward as planned
  - Of 148 customers, 27 have end-use (SAE) models
  - Continuing to use existing process on pre-conservation energy for those not converted
  - Will be doing a frozen efficiency and expected case forecast each year
Updated Forecast Results

- Used the spring 2019 forecast (same as BP 2020 rate case)
  - Major reductions from delay in large site additions
  - Some new major facilities were canceled
  - Some new facilities use less load than expected when finished
- Remaining conditions were basically unchanged
  - Minor ups and downs resulting in little difference from prior forecast
Needs Assessment – Obligations, Resources and Needs
Needs Assessment - Overview

- The 2019 Needs Assessment studies rely on the same models, methodologies, and metrics as past Needs Assessments
- Include routine forecast updates
- Obligations:
  - Spring 2019 forecasts (BP20 Rate Case expected case)
  - Expected Case Forecasts increased by factors, to Frozen Efficiency obligations
    - Factors derived from Frozen Efficiency vs Expected Case forecasts from 2017 Needs Assessment
- Resources:
  - Hydro based on the same base studies as BP20, re-ran to include the 125 Flexible Spill
    - Not the CRSO Preferred Alternative hydro study
- Results in general show less deficits
Needs Assessment - Obligation Updates

- No Frozen efficiency forecast produced in 2019:
  - Expected Case Forecasts increased by factors
  - Factors based on 2017 vintage Total Retail Load differences

- Significant Obligation changes between 2017 and 2019 Needs Assessments:
  - Above High Water Mark load service election changes \( (reduced \text{T2\hspace{1pt}obligation}) \)
  - Alcoa contract termination \( (reduced\hspace{1pt}obligation) \)
  - PGE capacity sales \( (increased\hspace{1pt}obligation) \)
  - Flattened/reduced load forecast for RD customers \( (reduced\hspace{1pt}T1\hspace{1pt}obligation) \)
Needs Assessment - Resource Updates

- Regulated hydro projects
  - Hydro based on the same base studies as BP20,
  - Re-ran to include the 125 Flexible Spill Operation
  - Treaty operations (2020-2024 Assured Operating Plans)

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Needs Assessment - Metrics

- **Annual Energy**
  - Evaluates the annual energy surplus/deficit under 1937-critical water conditions

- **P10 Heavy Load Hour**
  - Evaluates the 10\textsuperscript{th} percentile (P10) surplus/deficit over heavy load hours by month, given variability in hydro generation, loads, and Columbia Generating Station output

- **P10 Superpeak**
  - Evaluates the P10 surplus/deficit over the six peak load hours per weekday by month, given variability in hydro generation, loads, and Columbia Generating Station output

- **18-Hour Capacity**
  - Evaluates the ability to meet the six peak load hours per day over three-day extreme weather events assuming median water conditions
Results: Annual Energy

- **Annual Energy** deficits of 150 aMW in fiscal year (FY) 2022, growing to 300 aMW by FY 2025, recovering to a deficit of 50 aMW in FY2026 growing to 300 aMW again by FY2031

- The larger deficits in odd years represent Columbia Generating Station maintenance/refueling outages
- Change between 2025 and 2026 is the expiration of contracts
Results: P10 Heavy Load Hour

- The largest P10 Heavy Load Hour deficits occur in winter (Dec/Jan), and the second half of April
- Change from 2017: 1-5 year average needs decreased by 110 aMW, 5-10 year average needs decreased by 440 aMW

- Spill operation causes shift in largest deficit to shift to second half of April in low water conditions
  (becomes surplus at P24)
- Inventory position shifts between 2025 and 2026 is driven by expiration of contracts
Results: P10 Superpeak

- The largest P10 Superpeak deficits occur in winter, the second half of April

- The P10 Superpeak deficits are smaller than the P10 Heavy Load Hour deficits across the study period

- Spill operation causes shift in largest deficit to shift to second half of April in low water conditions
  (becomes surplus at P24)

- Inventory position shifts between 2025 and 2026 is driven by expiration of contracts
Results: 18-Hour Capacity

- **Winter 18-Hour Capacity** – 2017 Needs Assessments showed surplus' over the study horizon
- **Summer 18-Hour Capacity** – 2019 Needs Assessment shows a surplus of 450 aMW in FY 2025, the 2017 Needs Assessments showed summer deficit of 350 aMW in FY 2025.

- Change from 2017 - Eliminated capacity shortfall shown in 2017, now see a capacity surplus
- The summer 18-Hour Capacity deficits are smaller than the P10 Superpeak and P10 HLH deficits
Aurora Market Prices and Purchase Limits
Aurora Refresher

- Aurora is a third party production cost model used globally by utilities, regulators, system operators, planning entities, consultants, and investment firms to model the economics of wholesale electricity grids.
- BPA has used Aurora to forecast electricity prices in every rate case since 2000.
- Aurora uses a linear program to minimize the cost of meeting load in the Western Interconnection on an hourly basis, subject to a number of operating constraints. Given the solution (an output level for all generating resources and a flow level for all interties), the price at any hub is the cost, including wheeling and losses, of delivering a unit of power from the least-cost available resource. **It is assumed that the marginal cost of producing and delivering electricity approximates the price.**

**Limitations**

- No market design differentiation (no: forward curves / contracts / forecast error & day-ahead vs real-time markets/ source & sink/local commitment considerations), **all of the WECC is effectively modeled as a single ISO**
- No behavioral components of power markets (in reality, bids may differ from actual marginal cost)
- No AC flows / nodal prices, and transmission system is fixed (Aurora has the capability, not yet implemented)
- No ancillary services (again, Aurora has the capability, not yet implemented)
- No thermal resource duct firing / peak heat rate

**AURORA is a deterministic model, we produce a distribution of price forecasts** by using a Monte Carlo of input distributions using historical variation for: loads, hydro generation, gas prices, transmission capability, wind generation, and CGS availability.
BPA Uses Aurora Price Forecasts for:

- Net secondary revenue forecast in the rate case
- Resource program (prices and market depth)
- CRSO and other fish operations
- Outage planning
- Competitiveness analysis
- Treaty negotiations
- Other one-off analysis
Market Price Forecast
About half of the downward pressure is due to lower natural gas prices.

Notice 2030 price deltas tend to coincide with expected solar generation profile (largest decreases in the summer)
Aurora Resource Build: LT Capacity Expansion

- First step in an Aurora price forecast is to generate a long-term resource build
  - Start with existing resources
  - Lock in high likelihood builds and retirements over the duration of the next rate period
  - Allow AURORA to build and retire additional resources based on economics, ensuring pool planning reserve margins are satisfied and all relevant, modeled state policies (primarily Renewable Portfolio Standards) are met
- Default planning reserve margins are about 15%
State Policies

- Renewable Portfolio Standards (RPS), 2030 goals (updates since 2018 RP in red):
  - CA 60% (formerly 50%)
  - NV 50% (formerly 25%)
  - NM 50% (formerly 20%)
  - OR 50% by 2040 (effectively closer to 35%)
  - Alberta 30%
  - CO 30%
  - WA 20%
  - AZ 15%
  - MT 15%

- WA CETA (2030: 80% zero emission, 20% subject to penalties if not zero emission)
- Other, longer-term low or zero carbon emission mandates are not modeled

Other Aurora Updates

The 2020 RP market price forecast was generated in September 2019 and is mostly consistent with BP-20 FP Aurora assumptions. Updates since the 2018 RP forecast:

- New natural gas price forecast (accounts for roughly half of the declines in forecast prices)
- New transmission risk model
- New Aurora version that accounts for renewable curtailment in buildout
- Updated thermal resource minimum generation levels
Renewable Energy

Total Annual WECC Solar and Wind Generation

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Hourly Generation May 2030

Note that the graphic is from a different presentation, RC2019 is the resource build used for the RP 2020 market price forecast.
Hourly Generation
August 2030

The strange shape of CA solar is driven by curtailments

Bonneville Power Administration
Mid-C Average Hourly Prices, 2030

May

August

$\text{MWh, nominal}$

Old RP (2018)

RP2020

HE
Key Uncertainties

- Policy and technology are fundamentally altering the electricity landscape; the associated range of price uncertainty should not be underestimated.

- While this is a solar heavy build, it is likely underestimating future solar buildout:
  - Assumes zero rooftop solar outside of the Desert Southwest
  - Assumes zero new Carbon / RPS legislation

- Timing of RPS build could change: acceleration to capture tax credits / delay for reliability?

- Hydro shaping and storage resources:
  - Likely dampen the extreme impacts

- New technologies (offshore wind, hydrogen, new storage, seasonal storage, something else?)

- Negative price severity depends on:
  - Storage / hydro shaping
  - Policy relaxation
  - Alternative new technologies

- Potential climate change impacts not modeled

- The resource build reflects one load forecast
Market Limits
RP2020 AURORA Average Monthly HLH Market Limits*

This study was not refreshed for the 2020 RP, values are the same as the 2018 RP.

*In our analysis, no loss of load events occurred in LLH
Assessing Market Liquidity & Reliance Limits

Old

- Trading floor looked back at recent scarce conditions and assessed how much more energy the market could have sustained using a number of techniques
- Conservative values from the lookback are then projected forward to set limits on average monthly HLH energy in winter and summer months

New

- Leverage assumptions about future resource builds and retirements used in our AURORA setup to produce the market price forecast
- Minor modifications are made to assess loss of load events and allocate potential liquidity to BPA
- Details provided in the following slides
Market Limits in Aurora

Given longer duration of this Resource Program and expected evolution of resource mix over the planning horizon, we adopted a method that relies on AURORA. In order to ascertain market depth:

1. Start with our base resource build used to project future marginal costs of meeting load (market prices), this meets a ~15% planning reserve margin in the PNW

2. Simulate scarcity conditions by reducing PNW hydro generation to monthly p10 level and allow all other risk models to operate normally (loads, transmission, wind, CGS, and natural gas prices)

3. Add incremental load increases to approximate greater resource retirements / fewer resource additions associated with higher levels of regional market reliance

4. On a monthly basis, determine level at which greater market reliance causes region to exceed 5% LOLP (as roughly approximated with AURORA)

5. Allocate a share of the market reliance to BPA and accept this as our market reliance limit
Start with baseline loads and resources

This approach focuses on physical load-resource balance across the system, no modifications have been made to reflect frictions / improvements driven by changing market structures

Incrementally increase PNW regional loads until loss-of-load events exceed threshold (5% LOLP proxy)

Determine BPA's share (proportional to BPA load obligation / PNW regional loads) and use this as our market reliance limit
LOLP runs in AURORA

- 20 year (2020-2039) study with 3200 AURORA iterations, all iterations have PNW hydro fixed at monthly p10 levels

- PNW Loads are incrementally increased by 5%, 10%, 12.5%, 15%, … 40%
  - Achieved by a flat load increase in each PNW AURORA zone
  - For example, if the BPA Washington zone has 3,000 aMW in a month, the iterations testing a 10% increase would have an additional 300 MW of load for every hour of the month

- Each increased load level gets randomly assigned to 200 AURORA iterations
Example, December 2030
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Shaded cells indicate 5% LOLP exceeded
Example, December 2030

Region 5% LOLP proxy exceeded with a 17.5% load increase (~4,800 aMW)

We set regional market depth one level below that (15% = 4,117 aMW)

Finally, we allocate a share of the regional market depth to BPA. BPA’s December 2030 load is ~23% of the region, so BPA’s corresponding market reliance limit becomes 951 aMW (0.23 * 4,117)
Resources in the Optimization
Energy Efficiency
BPA Conservation Potential Assessment

- Developed in 2017
- Based on Council’s 7th Plan, adjusted for BPA territory specific attributes
- Data provided to Resource Program

Key Findings

1. The results were mostly as we expected
2. We look slightly different from the region
3. We identified a significant amount of inexpensive energy efficiency
What we learned about public power

01 We have more electric heating load

02 We have 38% of all single family homes

03 We have 36% of all commercial sq footage

04 We have 48% of the industrial sales

05 We have 34% of all irrigated acres

06 We have 30% of substations > 40,000 MWh
2019 CPA Update

- Removed savings achieved in 2018-2019
- Removed forecasted savings for 2020-21
- No updates to measure specifics or available measure set
- New CPA developed in 2022 after release of 8th Plan
Demand Response
BPA Has Done Advance Work to Prepare for the Use of Demand Response

- BPA tested **164MW** of Demand Response (DR) in demonstrations from 2013 – 2018.
- Worked with **15+** power customer utilities and their end-consumers.
- Showed high reliability of demand response.
- Readied the organization for commercial roll-out, to be applicable when BPA and its power customers and the end-consumers have a compelling business case and cost effective price signal.

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In 2019, Cadmus Completed a DR Potential Study; This was an Input into the 2020 Resource Program

- Per Guidance of the Action Plan of the 7th Power Plan, BPA conducted a DR Potential study, contracting with Cadmus.
- The Cadmus Potential Study found 2,300 MW of achievable Summer and Winter DR with BPA’s public power customers.
- These supply curves were reviewed and vetted with Council staff and BPA’s Resource Program.
- The Resource Program modeling did not select DR based on the lack of a capacity need, nor did the model dispatch DR as an alternative to market purchases.
Other Resources
All Included Resources

- Resources to included in portfolio modeling
  1. Wind – $1,366/kW* in 2025 (in 2017 real $)
     1. GRAC had $1,450/kW
  2. Solar – $1,242/kW* in 2025 (in 2017 real $), single axis tracking
     1. GRAC has $1465 - $1350/kW, single axis tracking
  3. Natural gas (LMS100) – $1,047/kW in 2025 (in 2017 real $) + variable costs
     1. GRAC had LMS 100 at $1,000/kW, frame at $550/kW
  4. Market purchases
  5. EE – The CPA supply curves were updated to remove 90aMW of planned EE acquisitions in the 2020-2021 timeframe and 56aMW of market transformation and momentum savings
  6. DR – Biggest change: Correcting the methodology used to load DR costs into AURORA significantly increased the cost of DR, relative to the 2018 Resource Program
     1. DR costs have continued to be refined, for example, costs are now summer specific if targeting a summer capacity need

* Before tax credit
2020 Resource Program
Preliminary Results
Refresher: Portfolio Optimization

- **Step 1**: Find Portfolio 1, the “least-COST” mix of resources that meet P10 HLH Energy needs and don’t violate Market Purchase Limit.

- **Step 2**: Find Portfolio 40, the “least-RISK**” mix of resources that meet P10 HLH Energy needs and don’t violate Market Purchase Limit.

- **Step 3-40**: Incrementally add budget to Portfolio 1’s budget value and remix resources to find risk minimizing combination at given budget level.

**Where risk is measured as variance in the total cost of the portfolio across iterations, with market prices being the main source of said variance.**
Putting Two Pictures Together – MPLs and Needs in 2025

Needs vs Market Purchase Limits in FY 2025

- BPA's Market Purchase Limit
- P10 HLH Needs
EE Results in Portfolio Optimizer

- Each portfolio meets BPA’s needs while respecting the Market Purchase Limits

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Concurrent Planning Efforts

- The final draft of the 2021 Plan is scheduled to be published in 2021
  - The Northwest Power and Conservation Council is finishing up its draft EE supply curves right now

- 2020RP Portfolio 1’s EE Savings over 2021 Plan Timeline:

  Corresponding to NWPC2C 2021 Plan Timeline (Cumulative aMW of EE)

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<td>2020 Port 1</td>
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<td>111</td>
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</tr>
</tbody>
</table>

- The 2022 Resource Program plans to use EE supply curves from the 2021 Plan