**MEMORANDUM**

EUGENE WATER & ELECTRIC BOARD

Rely on us.

TO: Commissioners Brown, Carlson, Barofsky, McRae and Schlossberg

FROM: Megan Capper, Energy Resources Manager; Ben Ulrich, Senior Energy Resource Analyst; John Crider, Senior Energy Resource Analyst

DATE: November 4, 2022

SUBJECT: Reference Modeling Results in the 2022 IRP

OBJECTIVE: Information and Board Discussion

**Issue**

Board organizational goals for 2022 state that by year end, staff will complete a public draft of an Integrated Resource Plan (IRP) in order to gather feedback during a public comment period in early 2023. This memo presents a "calculated reference case" establishing a baseline for further iteration and public discussion.

**Background**

IRP modeling assesses different combinations of resources to create an electricity supply portfolio to meet EWEB's long-term energy needs. As part of the 2022 IRP process, staff have worked throughout the year to inform and engage the Board about key IRP topics, including EWEB's needs as well as new resource options. For the November Board Workshop, staff are providing information on Calculated Reference Case modeling assumptions and results, and will be seeking initial feedback on sensitivities and further analysis.

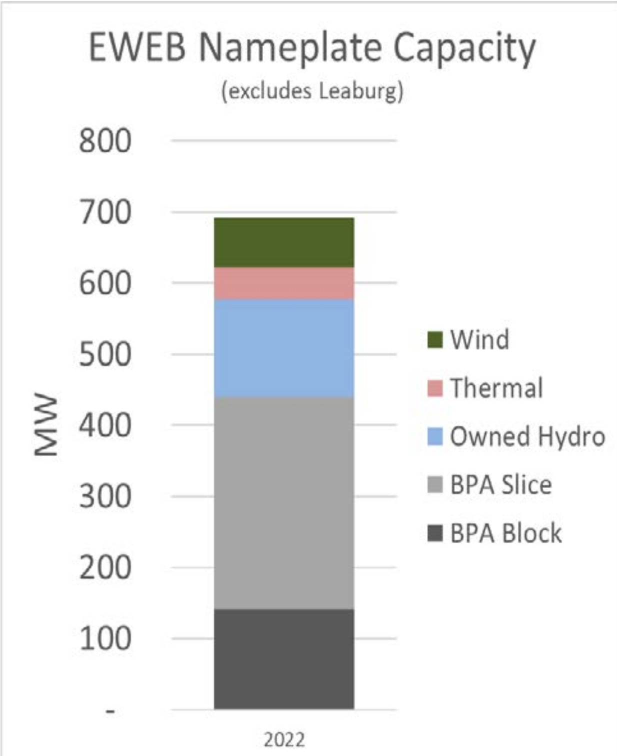
**Discussion**

## Key Takeaways

- Calculated Reference Case modeling results establish a benchmark comparison point for further portfolio sensitivity analysis in 2023.
- Due to plant retirements and expiring contracts, EWEB will have resource decisions to make over the next two to five years regardless of uncertainty about load growth and electrification
- Starting in 2030, unmanaged electric vehicle charging begins to increase peak capacity needs at 2% per year, driving increased portfolio costs for the following 10 years.
- To supplement BPA contracts, the model selected primarily wind, batteries, demand response and energy efficiency resources throughout the study period.

**The Calculated Reference Case** is a suggested portfolio based on modeling results and certain inputs and assumptions. These results are not EWEB's preferred or expected portfolio, but instead are computed results which act as a benchmark for further iteration, informing EWEB's future strategic decisions. The modeling results discussed herein are the beginning of a process and discussion.

## Existing EWEB Resources

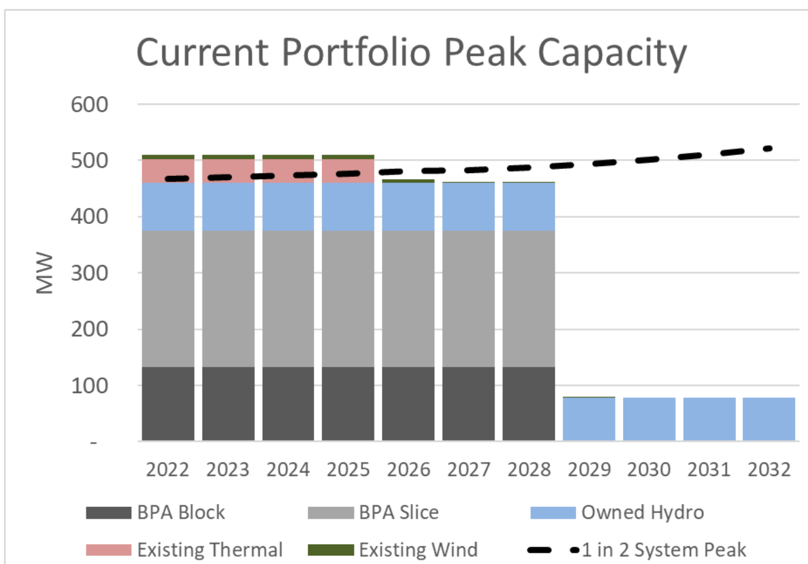



Over eighty percent of EWEB's power currently comes from hydro resources. These include EWEB-owned hydro projects on the McKenzie River, one project on the Clackamas River, as well as contracted power from the Bonneville Power Administration (BPA), a federal agency that manages and markets the generation from federal dams in the Columbia River System. In addition to these hydro resources, EWEB has contracts and ownership agreements for several wind farms, as well as biomass and co-generation facilities.

Due to the composition of this existing portfolio, EWEB's resource-based carbon emissions are a fraction of the state and national average. Depending on water conditions and hydro generation, EWEB's portfolio is currently about 90% carbon-free, with the majority of emissions coming from market purchases.

There are several recent and upcoming events that will shape EWEB's portfolio in the future:

- Expiration of EWEB's power contract with BPA in 2028, and upcoming decisions on whether to renew that contract going forward, and if so which products/options to select.
- Licensing requirements and structural issues at several of EWEB's owned hydro plants that have or could lead to these being removed from generation.
- Expiration of additional power contracts between 2026 and 2029.




Peak capacity represents the amount of a resource's nameplate capacity that is expected to be available to serve load during EWEB's single hour winter system peak.

Due to these changes, EWEB will have resource decisions to make over the next two to five years regardless of uncertainty about load growth, electrification, regulations, or other factors.

## Role of Modeling in IRP Analysis

EWEB's planning team uses energy supply modeling software, including Aurora, in addition to other tools and analysis, to explore EWEB's resource needs and portfolio options. This practice is standard across the energy industry, as it allows for more granular and sophisticated examination of different scenarios and uncertainties. Modeling allows staff to look at resource performance under a variety of conditions, as well as create 'optimized' solutions that reduce both cost and risk based on the assumptions used.

The purpose of this memorandum is to discuss the Calculated Reference Case modeling results for the 2022 IRP, which will establish a comparison point for further sensitivity analysis in 2023. In addition, the attached appendix provides more details about the specific model that EWEB uses, as well as the assumptions and inputs staff used in modeling work.

## Calculated Reference Case Summary

The Calculated Reference Case refers to the portfolio of future resources that the Aurora model has arrived at through simulation. The goal of the Calculated Reference Case is to provide a reasonable data point against which to compare other sensitivities and portfolios. The Calculated Reference Case relies on a variety of assumptions, and generally represents 'business as usual' constraints. These assumptions are substantial drivers of the resources selected throughout the study. While there are too many variables in the model to list in this memo, staff have provided a list of key assumptions for the Calculated Reference Case in the Appendix. Any assumption can be explored in sensitivity analysis, and staff have started identifying potential future sensitivity analysis (see 2023 Sensitivity Analysis section).

***Peak Load Planning Standards**

- Utility planners use "1-in-2" to refer to the likelihood of a specific event occurring. A 1-in-2 peak event is an 'average' peak, expected to occur once every two years – in other words, it has a 50% chance of occurring in any given year.
- A planning reserve margin (PRM) is the procurement of additional resources beyond 1-in-2 or other standards as a 'safety net' to ensure that if an unexpected outage or other event occurs, the utility will have enough resources to serve load.
- EWEB will test the impact of using a 1-in-10 (10% likelihood) planning standard or larger PRM on EWEB's forecasted portfolio needs and cost.

### Key Assumptions

- The Calculated Reference Case modeling is constrained to select just enough resources to meet a winter 1-in-2 peak load event*, but nothing more (0% Planning Reserve Margin).
- Results assume typical planning conditions, including median water years.
- EWEB's BPA contract is assumed to continue throughout the study period (post-2028), with cost adjustments for inflation starting in 2027.
- EWEB's portfolio is constrained to meet Board policy SD15, such that it will be 95% carbon-free by 2030.
- Additional assumptions are listed in the Appendix (e.g. transmission availability, resource costs).

# Calculated Reference Case Modeling Results

## Initial Modeling Results

- Using a 1-in-2 planning standard, EWEB does not have a need to acquire resources until 2026, when existing thermal and wind resource contracts (Seneca and International Paper) expire, and 14 MW of peak capacity are needed.
- Consistent with modeling parameters, EWEB's surplus capacity declines from 7% in 2022 to 0% in 2026.
- Starting in 2030, forecasted unmanaged electric vehicle charging begins to increase peak capacity needs at 2% per year, driving increased portfolio costs.
- The continuation of BPA Block and Slice is the primary driver of total portfolio costs throughout the study period. The assumption that BPA products will be similar in price and design to today is a key factor in least-cost Calculated Reference Case results. Future BPA contract options will be modeled in 2024 IRP.)
- Calculated Reference Case portfolio additions are primarily batteries, wind, demand response and energy efficiency throughout the study period.
- 10 MW of Small Modular Nuclear is added in the final year of the study period, 2042.

The table below shows the peak capacity of resources selected in the Calculated Reference Case. Peak capacity refers to a resource's ability to generate energy during the peak hour of EWEB's load each year. In the Calculated Reference Case, EWEB's peak hour occurs mid-December under load assumptions that mirror a 1-in-2 winter cold front.

| Peak Capacity (MW) | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | …2042 |
|---|---|---|---|---|---|---|---|
| **Existing Portfolio** | 509 | 467 | 462 | 461 | 454 | 453 | 465 |
| **Conservation** | | 1 | 2 | 3 | 4 | 5 | 18 |
| **Demand Response** | | 2 | 3 | 4 | 4 | 4 | 7 |
| **Wind** | | 4 | 8 | 10 | 10 | 10 | 50 |
| **Batteries (4 hour)** | | 7 | 7 | 10 | 22 | 30 | 100 |
| **Nuclear (SMR)** | | | | | | | 10 |
| **Total Peak Capacity** | **509** | **481** | **482** | **488** | **494** | **502** | **650** |
| **1-in-2 Peak Load*** | **477** | **481** | **482** | **488** | **494** | **502** | **650** |

The 2022 IRP is focused on two central questions: How much energy and capacity does EWEB need; and what resources are the "best fit" for EWEB? As shown in the chart above for 2025, given current assumptions, EWEB's current portfolio is surplus to 1-in-2 peak capacity needs, and the model replaces only enough capacity to meet peak needs in 2026. However, EWEB's long-term energy and capacity needs are expected increase with electrification. As this occurs, EWEB's portfolio and total costs grow.

The model generally selected "best fit" resources that provide winter energy or within-day flexibility and capacity. These characteristics help EWEB to meet winter peaks and shape energy into the times of day when EWEB's loads are highest.

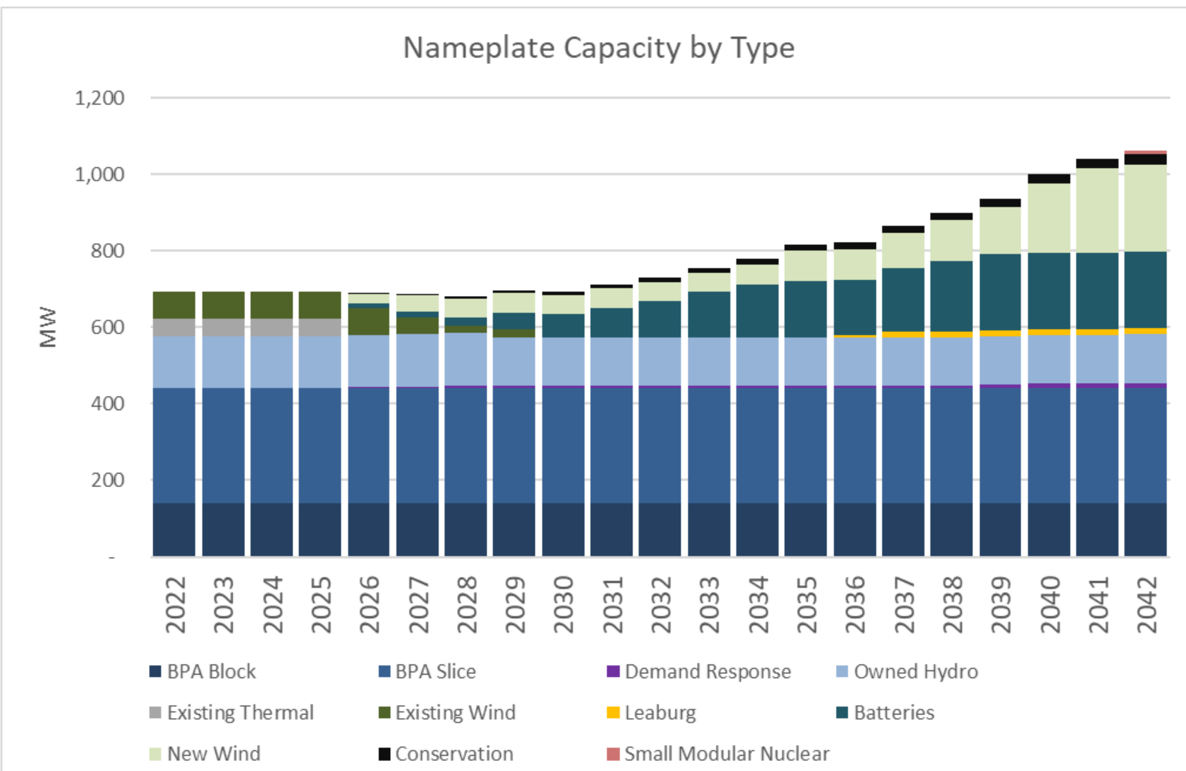
### Refresher on EWEB's needs

1. EWEB is a winter peaking utility. Our greatest needs occur on cold days between December and February, and the typical summer peak is 80% of the typical winter peak.
2. EWEB's loads fluctuate throughout the year and can vary by over 100 MWs within a 24-hour period. These shifts in load are driven primarily by customer behavior and temperature changes.

## Reference Portfolio Discussion

### Calculated Reference Case Nameplate Capacity

The Calculated Reference Case portfolio nameplate capacity is shown in the chart below. Nameplate capacity refers to the maximum amount of energy a resource can produce. For variable renewable resources like wind and solar facilities, or peaking thermal plants, nameplate capacity is typically higher than the average amount energy a resource produces during the year.

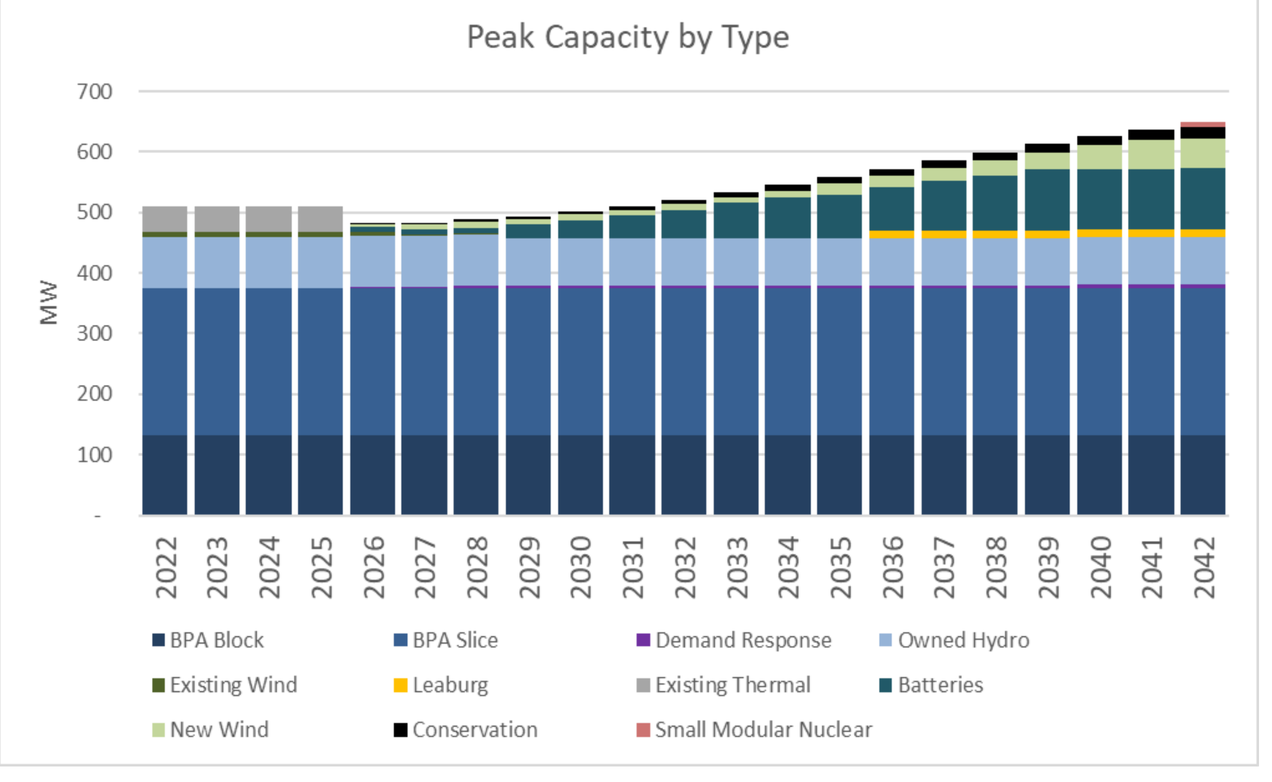



The Calculated Reference Case portfolio changes over the years as existing contracts expire and new ones are added. The modeling study begins in 2022 with EWEB's existing portfolio, which consists of BPA Slice and Block, owned hydro (excluding Leaburg until 2036), contracts with International Paper and Seneca thermal plants, and existing wind resources. As discussed in greater detail in the *BPA in the Calculated Reference Case* section below, EWEB's BPA contract is assumed to continue throughout the study period.

In the mid to late 2020's, existing wind and thermal contracts expire and are replaced with batteries, wind, and small amounts of low-cost energy efficiency and demand response programs. Resource acquisition picks up pace beginning about 2030 in response to expected electrification – primarily driven by the adoption of electric vehicles. 10 MW of small modular nuclear reactor (SMR) capacity is added in 2042. In general, nameplate capacity additions to the Calculated Reference Case are key portfolio cost drivers, as many of the selected resources have high up-front costs, but low operational and marginal costs.

### Reference Portfolio Capacity

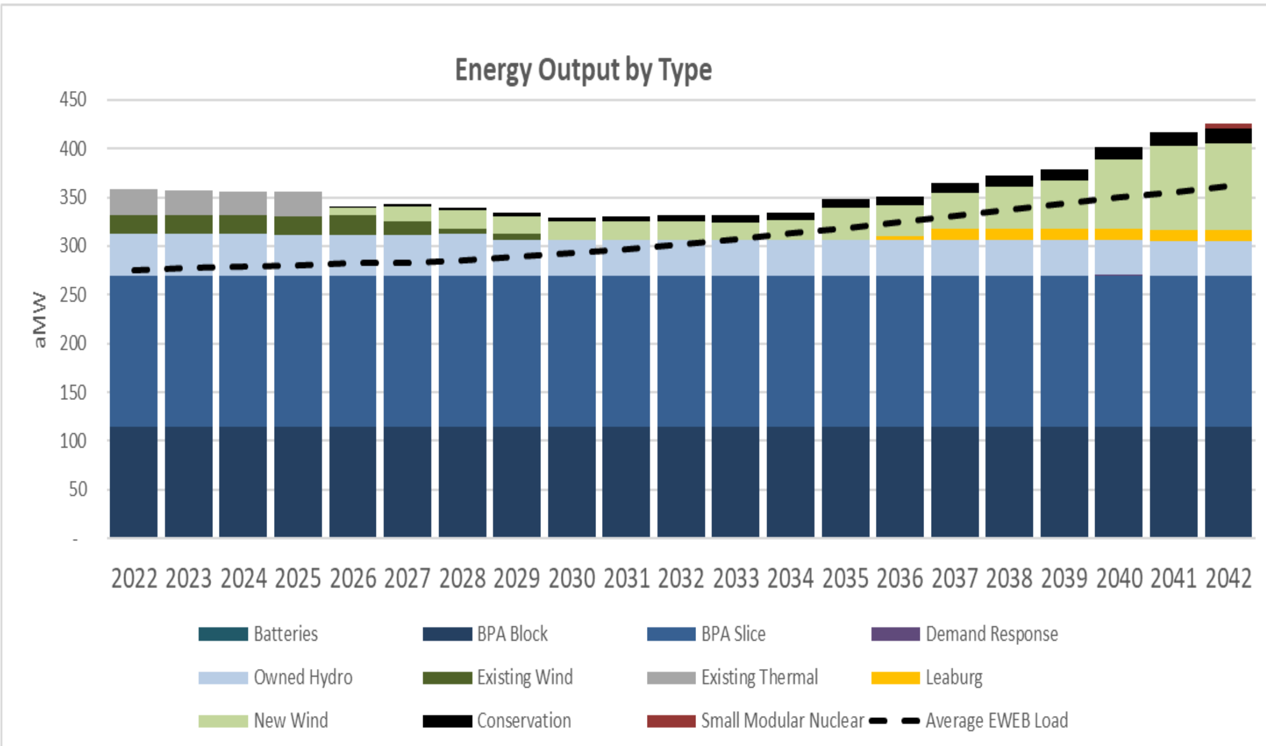
The Calculated Reference Case modeling results for peak capacity are shown below. Peak capacity represents the amount of a resource's nameplate capacity that is expected to be available to serve load during EWEB's single hour winter system peak. Peak capacity is less than, or in rare cases equal to, the nameplate capacity for a resource. Wind and solar patterns, planned and unplanned outages, fuel supply issues, and other operational uncertainties can result in capacity not being available at certain times in the year. The end result is that EWEB's portfolio will always have a nameplate capacity greater than its peak capacity.




The Calculated Reference Case portfolio's peak capacity decreases in 2026 as existing contracts expire and EWEB does not have additional capacity needs to meet a 1-in-2 standard. In the 2030's the total peak capacity of the portfolio then increases incrementally to keep pace with expected load growth. In general, for the 2022 IRP, peak capacity is a key driver of modeling results, as staff have required the model to match EWEB's 1-in-2 peak winter needs. Staff chose the 1-in-2 standard as a starting point because it represents a reference point to cover normal peak conditions. Exploring the appropriateness of a 1-in-2 standard, and the cost impacts of increasing reserve margins, will be part of the broader IRP process.

### Calculated Reference Case Portfolio Energy

The Calculated Reference Case portfolio energy production is shown below. Although energy production varies throughout each year, average energy gives an indication of long-term trends.




The Calculated Reference Case modeling assumes that EWEB's average energy need is approximately 270 aMW in 2022, growing to 361 aMW by 2042. Throughout the study period, the portfolio produces between 30-80 aMW of energy that is 'surplus' to EWEB's average energy needs (the area above the dotted line). This is because EWEB plans to meet *peak capacity* needs rather than *average energy* needs. To the extent that peak needs are met with renewable resources (including hydro and wind) that produce zero marginal cost energy at other times of the year, EWEB will always have surplus energy. This is a trait of EWEB's current portfolio, which is managed by selling and buying energy to realign with EWEB's needs.

From 2026 until the early 2030's, given the assumptions in the Calculated Reference Case portfolio, EWEB would actually have less surplus energy than it does now. This is largely due to the addition of batteries to EWEB's portfolio in 2026. Rather than generate more power, batteries shape energy into times that are more useful for EWEB, resulting in fewer hours of surplus energy. Batteries do not appear on the *Energy Output* chart above because they do not create energy.

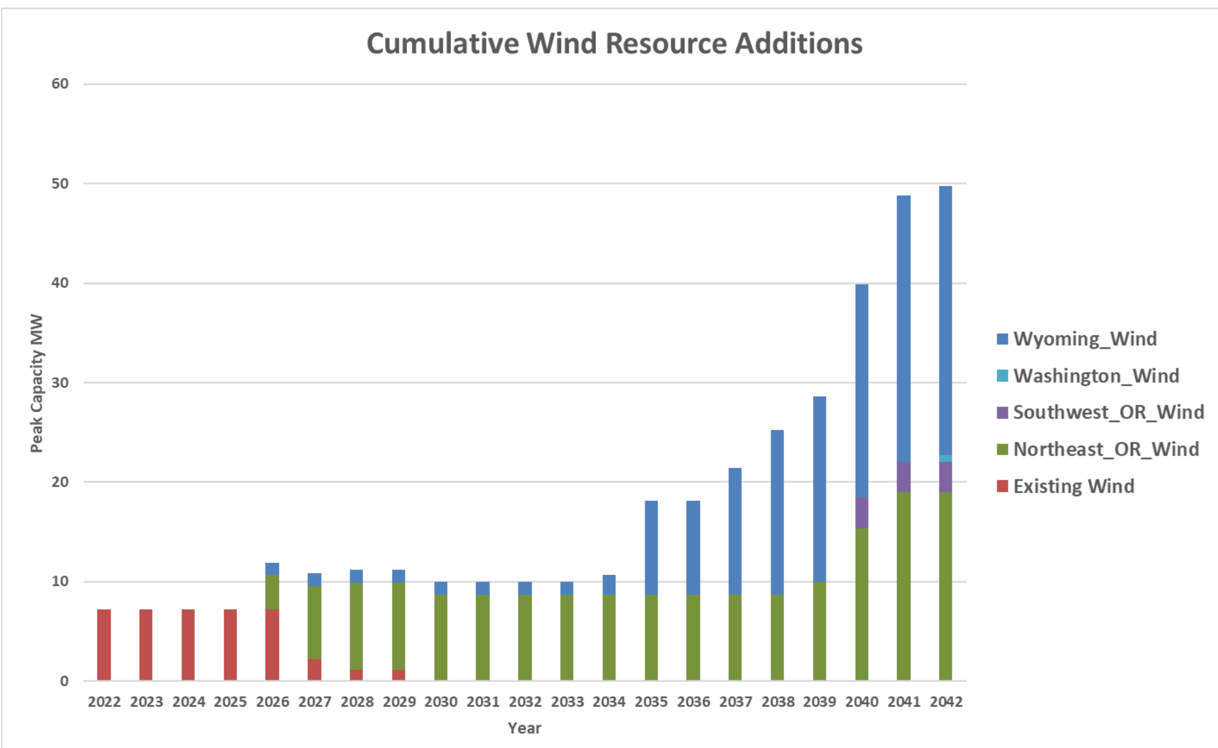
## Resource Specific Discussion

*BPA in the Calculated Reference Case*

Through early modeling tests and analysis, staff have found that continuing the BPA power contract post-2028 appears to be one of EWEB's least cost portfolio options. As such, the Calculated Reference Case assumes that EWEB will renew its BPA contract post-2028. This approach maintains 'business as usual' and provides a baseline against which to compare alternate portfolios. The Calculated Reference Case assumes that BPA's costs and products are similar to today, and future BPA contracts escalate at the rate of inflation starting in 2027. Because of this, changes to EWEB's total portfolio cost are primarily driven by resource additions to meet forecasted load growth from electrification. Once staff have more information about future BPA product options and costs, these will be included in the model.

*Wind*

Wind has been part of EWEB's portfolio for some time, as tax incentives, RPS requirements, and wind potential in the Northwest made it a desirable resource. Given current cost trajectories and other assumptions, the Calculated Reference Case portfolio includes meaningful amounts of wind acquisition throughout the next several decades. The specific resources selected tend to have winter peaking profiles, which makes them more likely to contribute to meeting EWEB's peak winter needs.




Northeast Oregon wind was selected to replace existing wind and thermal contracts in the mid to late 2020's, and Wyoming wind was selected to meet load growth later in the 2030's. However, the Calculated Reference Case does not substantially limit transmission availability for these resources, and transmission is a large risk factor. Due to this, there is potential that EWEB would not be able to access these resources even if they were determined to be least-cost, best-fit. The *Transmission Sensitivity* (discussed below) and analysis in the IRP will provide further information about transmission cost, availability, and risk.

*Demand Response*

Demand response (DR) is a set of programs that allow EWEB to partner with its customers to shift energy usage from times of high demand to off-peak hours, reducing the need for steel-in-the-ground supply-side resources and infrastructure investments. Demand response has a variety of costs and energy profiles depending on the specifics of the program. In the Calculated Reference Case, residential demand response programs that cost below $12/KW-month were selected in 2026-2028. These programs included residential Time of Use (TOU) rates, Critical Peak Pricing rates, and Residential Space & Water Heating Direct Load Control programs.

However, after 2028, batteries appear to displace additional investments in DR programs. Utility-controlled managed electric vehicle charging is a more expensive demand response program to implement ($19/KW-month), and was only selected in 2039, 2040 and 2042. However, it is possible that demand-side pricing programs like Time of Use rates may create voluntary managed EV charging behavior, thus diminishing the need for utility-controlled EV charging programs. Further study of customer behavior and characteristics could refine DR cost and availability information and better shape EWEB's demand-side management strategy.

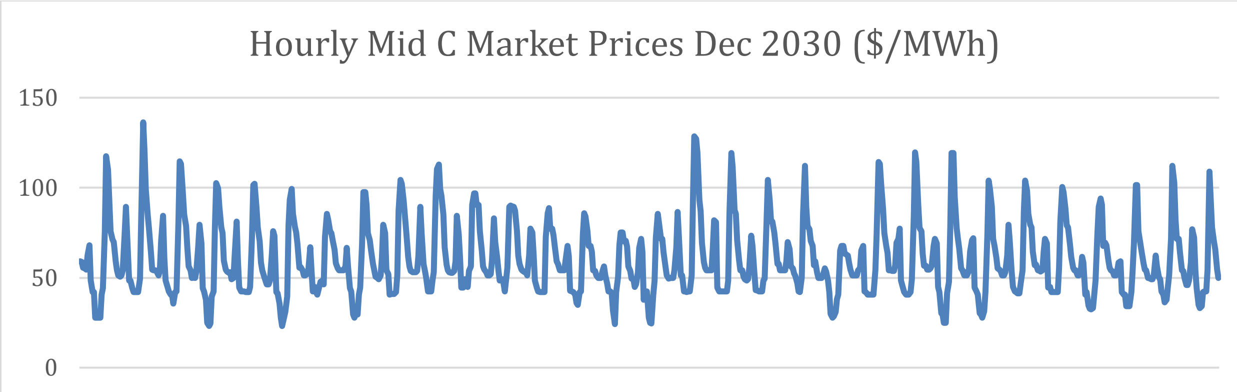
*Batteries*

EWEB staff modeled 4-hour lithium-ion batteries in the Calculated Reference Case. These types of batteries are becoming fairly standard as utility-scale resources, and longer-duration storage has not yet been demonstrated to be commercially viable. 4-hour batteries do not have enough energy storage to be useful for long-term, long-duration storage. Instead, they are typically used for within-day energy shaping to meet morning or evening peak loads.

The cost-effectiveness of these batteries depends on daily price spreads, as the battery will be charged during hours that are cheaper and discharged when prices are high. EWEB's Calculated Reference Case shows large within-day price variations by the late 2020's, when the model selects batteries as part of the portfolio. The chart below shows the daily prices at the Mid-Columbia trading hub where EWEB often transacts to buy and sell power. The chart demonstrates that prices fluctuate by $50-$75/MWh every day, creating a pricing arbitrage opportunity for batteries.

Battery Nameplate Capacity vs Energy

- Nameplate capacity is the maximum power the battery can deliver at once.
- Energy is the total amount of power a battery can deliver.
- A 4-hr 100 MW battery can deliver 100 MW of energy for four hours, at which point it will need to recharge.




*Energy Efficiency*

Energy efficiency has been a key part of EWEB's resource strategy for the past decade. However, energy efficiency supply curves are becoming more expensive, and renewable resources are becoming a less-expensive source of clean energy. In the Calculated Reference Case, energy efficiency programs with a levelized cost of $15/MWh and below were selected throughout the study period, whereas conservation higher than $45/MWh was not selected until 2040.

However, energy efficiency has very clear local benefits such as reduced needs for infrastructure upgrades, and equity impacts for customers whose bills are reduced or homes made more comfortable. Additionally, unlike many supply-side resources, energy efficiency does not have transmission risk, and has limited capital or build risk because it is local and small-scale. Sensitivities on transmission availability may show increased value for energy efficiency or other local resources. Future studies of customer characteristics could inform conservation potential in EWEB's service territory and help to better define programs.

*Small Modular Reactor*

The Calculated Reference Case selects 10 MW of a Small Modular Reactor resource (SMR) late in the study period. SMR's are dispatchable, have a high peak capacity accreditation, and do not have carbon emissions. This indicates that EWEB's system sees a need for these attributes as EWEB and the regional grid transition to a greater penetration of renewable resources. In the Calculated Reference Case, SMRs are being used as a stand-in for non-energy-limited, dispatchable, clean resources. The actual technology that can provide these characteristics may change over the course of the next 15-20 years. For example, other alternatives to SMR, such as hydrogen generation or multiple-day energy storage, may become commercially available by the time EWEB needs this capacity. The specific technology choice of a small nuclear reactor is less important than the attributes the model calculates are needed to assemble a least-cost portfolio in 2042.

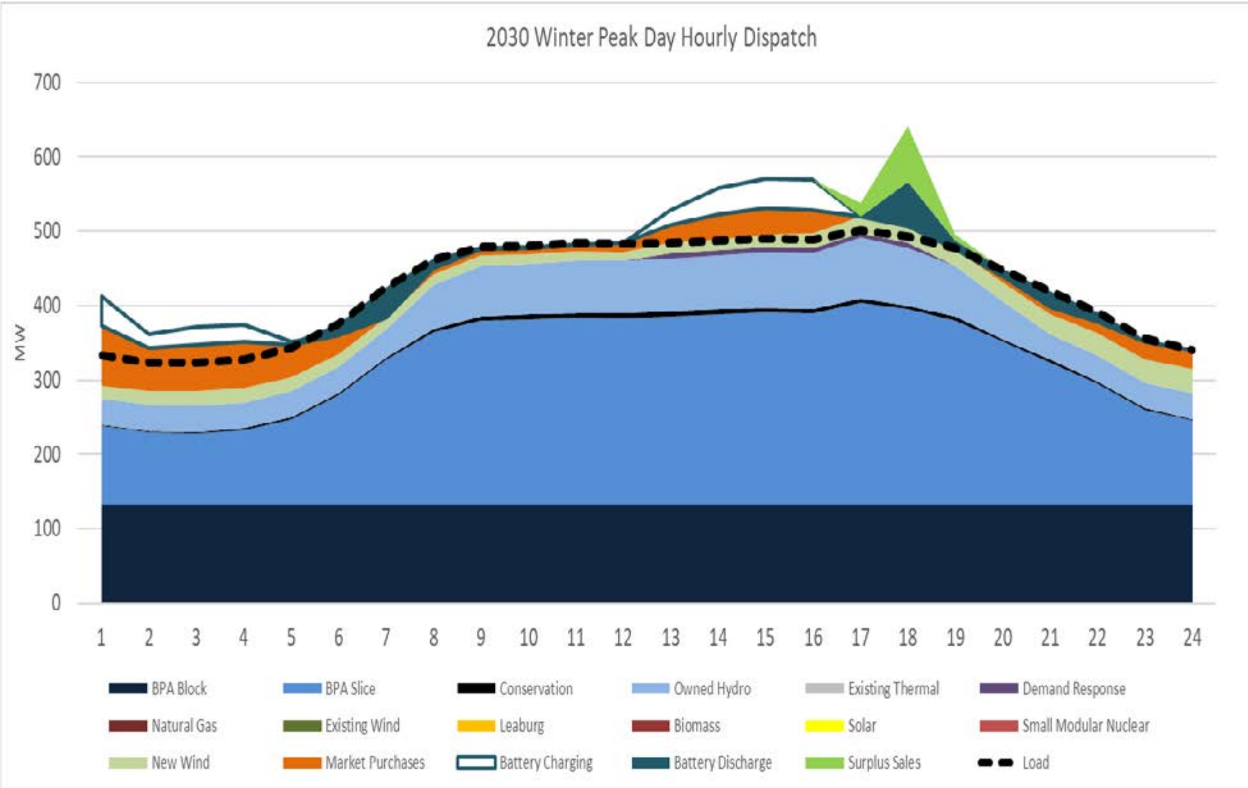
*Solar*

The Calculated Reference Case did not select solar as a resource for EWEB. This does not mean that there might not be a role for solar in EWEB's portfolio, or that other sensitivities will not select solar. As discussed in the August Board Memo, solar is a cost-effective resource for energy, but it is one of the more expensive resources for providing peak winter capacity. Changes in assumptions about EWEB's load or resource needs, or inclusion of metrics beyond cost may bring solar forward as an option.

*Portfolio Dispatch*

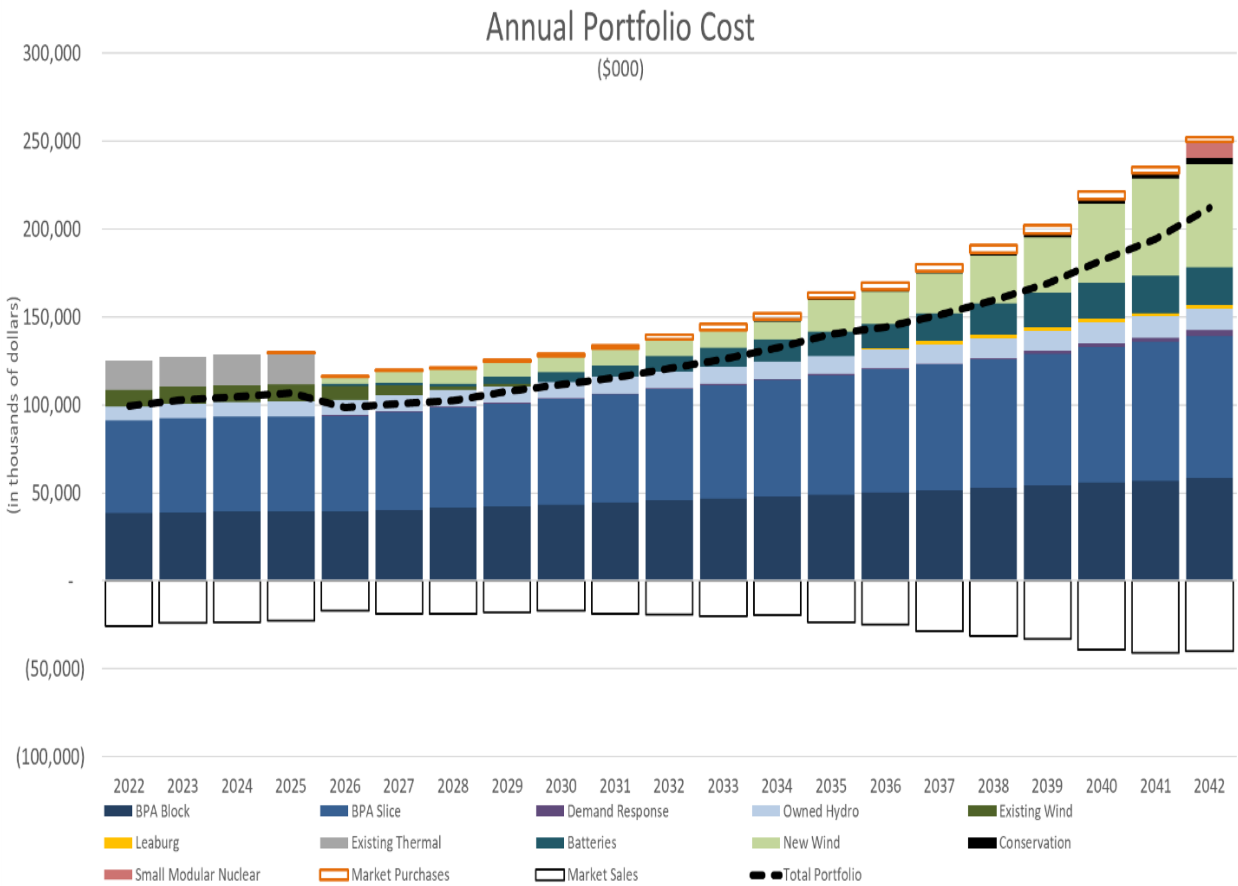
The chart below shows the dispatch of EWEB's portfolio during EWEB's peak winter day in 2030. In 2030, batteries, new DR, energy efficiency, and wind have all been added to the existing portfolio. The flat navy blue at the bottom of the stack is BPA Block, followed by Slice and EWEB-owned hydro in lighter blue (with conservation sandwiched between). New wind, market purchases, batteries, and demand response are on top of these. Battery charging is shown in the blue outline at the top of the image, with discharge shown by the dark blue section to the right of these. Market purchases are in orange towards the top of the stack, and market sales are in bright green at the very top right. EWEB's load is represented by the dotted line towards the top of the stack.

On this peak day in 2030, EWEB's load reaches a high of 502 MW in hour 17. In general, BPA Slice and EWEB hydro are shaped to follow EWEB's load. Wind resources provide energy during the 24-hour period, but their peak output is late at night (to the far right on the graph). Batteries charge at night and late afternoon and are dispatched in the morning ramping period between 6AM and 8AM, as well as Hours 17-22, to meet load or generate sales.



## Reference Portfolio Cost

The Calculated Reference Case portfolio cost estimate is shown below. These results are in nominal dollars and include the influence of an assumed inflation rate of 2.5%.



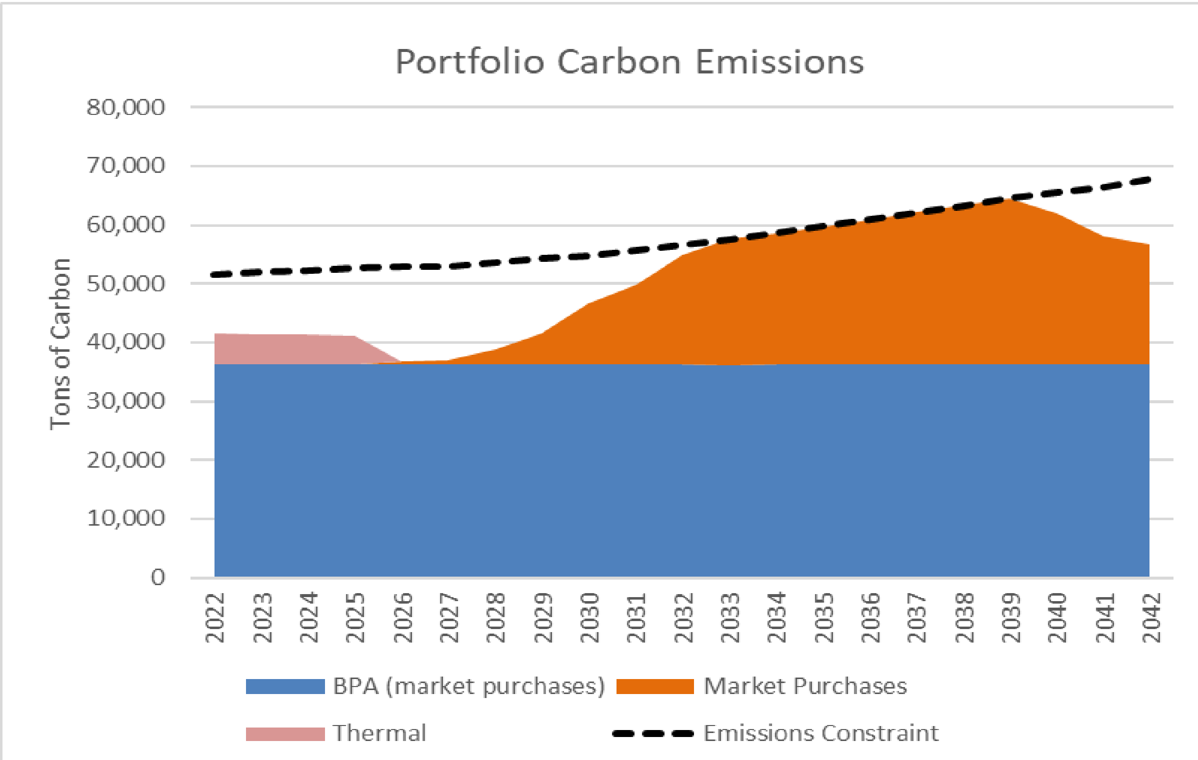

In the chart above, EWEB's portfolio cost remains relatively stable through the 2020's, despite some retirements of existing contracts for wind and biomass. During this time period, EWEB expects relatively flat or small load growth, which keeps the need for additional resources, and by proxy additional cost, to a minimum. However, increases in annual load due to vehicle electrification begin in the early 2030's. This increase in turn drives the need for more energy and capacity resources to serve the load, raising portfolio costs throughout the 2030's. Starting in 2033, the portfolio also begins to make market purchases of approximately 10 aMW instead of building more resources. This indicates that market purchases may be part of EWEB's least-cost portfolio strategy starting in 2033.

Over the study period, total portfolio costs increase an average of 4% annually, which includes both the impacts of load growth from electrification (2% growth per year) and inflation, indicating that portfolio costs relative to load would remain relatively flat.

As discussed in the *Portfolio Energy* section above, a key aspect of meeting growing demand with intermittent renewable generation is the generation of surplus energy. EWEB's ability to create revenue from this energy is an important part of reducing total portfolio costs. Throughout the study period, sales of excess energy averaged approximately $60/MWh and generated an average annual benefit of $25 million per year.

**Carbon Emissions and RPS**

EWEB has committed to have a portfolio that is 95% carbon-free on a planning basis by 2030. The carbon emissions constraint in the Aurora model assumed a "carbon budget" (in tons) equivalent to 5% of EWEB's energy needs being served by a carbon-emitting generator (like natural gas). The model is constrained by this limit between 2033 and 2042.




Today, the vast majority of EWEB's portfolio emissions are attributed to BPA, which provides the majority of EWEB's energy. While BPA's resources are mostly carbon-free, the market purchases that BPA makes have an assumed carbon emissions rate, because market purchases (unless otherwise specified) are assumed to come from natural gas generators which often set the price for market-based electricity. Early in the study period, there are some calculated emissions from EWEB's existing thermal contracts (IP and Seneca), but after these contracts are assumed to expire in 2025, there are no new carbon-emitting resources selected by the model. Hence, market purchases and BPA products are the only source of carbon emissions in the modeling results. Making a different assumption about the carbon intensity of BPA or future markets could allow the model to select alternative emitting resources, or show a reduction in EWEB portfolio emissions.

All of the portfolios constructed by the model comply with the Oregon Renewable Portfolio Standards, which require that 20% of EWEB's power come from renewable sources. Because of EWEB's legacy hydro exemptions and the addition of wind energy in the Calculated Reference Case, this portfolio will have sufficient renewable energy to meet the RPS targets throughout the study period.

## 2023 Sensitivity Analysis

EWEB's Calculated Reference Case does not represent EWEB's preferred or expected portfolio. Instead, the Calculated Reference Case is an output of a specific set of assumptions and modeling choices based upon best available information and geared towards a 'business as usual' outcome. There is uncertainty around many of these inputs, and further analysis is required to understand the risk or drawbacks to different portfolio approaches. Hydro and gas risk are treated separately from other sensitivities, as they are key inputs that will impact portfolio performance under all outcomes. Staff will conduct Aurora Risk modeling on several, if not most, portfolios to examine how fluctuations in water conditions and natural gas prices impact portfolio costs.

Below, staff have identified three key assumptions which will be explored through further sensitivity analysis. These sensitivities will be included in the Final IRP document in June 2023 and will inform EWEB's 2022 IRP Action Plan. Staff is also seeking feedback from the Board, as well as information gathered through public outreach, to inform additional IRP sensitivities. Potential topics for these sensitivities are listed below those that staff is already planning to conduct.

*Staff will conduct sensitivity analysis on the following three key assumptions:*

- **Transmission availability and cost**: There is almost no transmission availability for new resources across key East-West pathways that would connect EWEB to high value wind and solar, including those selected in the Calculated Reference Case. Staff believe that sensitivities on transmission cost and availability will be important for understanding portfolio alternatives and costs if access to these resources is limited.
- **EWEB Load Growth Trajectory**: The Calculated Reference Case assumes that EWEB's load will grow due to electrification. However, there is substantial uncertainty around this. Sensitivities would explore resource acquisition strategies for both faster growth and flatter load.
- **Planning Reserve Margin:** The Calculated Reference Case assumes that EWEB will build enough resources to meet 1-in-2 peak loads and nothing more. However, regional developments such as the Western Resource Adequacy Program (WRAP) may require EWEB to procure additional resources to meet a planning reserve margin (PRM). This sensitivity would explore the costs of procuring resources to meet WRAP standards.

*Staff will be seeking guidance and input on additional sensitivity analysis. Potential topics include:*

- **Solar**: The Calculated Reference Case did not select solar as a least-cost option, likely because it performs poorly during EWEB's peak winter load events. Sensitivities could explore the impact of adding solar to the portfolio, or test whether solar is selected if EWEB's summer needs increase. For example, while the current modeling assumes that EWEB will continue to be a winter-peaking utility, climate change and heat pump (air conditioning) penetration could result in EWEB becoming a dual-peaking utility, where summer and winter needs both drive resource decisions.

- **Carbon Limitations:** Analysis of resource selection under deep decarbonization can inform portfolio strategy.
- **Resource cost trajectories:** Resource cost trajectories, whether for renewables like wind and solar, or for emerging technologies like long-duration storage, are likely to diverge from current forecasts. For example, the Inflation Reduction Act created substantial tax incentives and other funding mechanisms that would reduce costs for a wide range of future resources.
- **Other:** Additional sensitivities as identified by staff, the Board, or public feedback can be included in IRP analysis, time permitting. (e.g. policy changes, market price changes, etc.)

*Hydro and gas risk analysis will be conducted for multiple sensitivities listed above.*

- **Hydro and Gas Risk:** Water conditions and natural gas prices are key drivers of portfolio costs, and both of these inputs are subject to a high degree of uncertainty. Aurora Risk analysis can provide information about portfolio costs under a wide range of gas and hydro inputs.

## Board Feedback and Guidance

The Calculated Reference Case portfolio represents the starting point of the 2022 IRP analysis and can be used to inform next steps. Staff will be seeking guidance from the Board on several topics, including:

- What types of analysis or information has not been covered to date that you would like to see?
- What sensitivities do you believe should be included in the final 2022 IRP?
- What types of information can staff gather from public outreach that would help inform your decisions for a future Action Plan?

Staff will continue to work on analysis and supporting materials for the IRP over the coming months in preparation to release the Final IRP in June of 2023.

# Appendix

## Aurora Model

EWEB's planning group uses a modeling program called Aurora to forecast market prices and inform future portfolio strategies. Aurora is also used by many utilities and other regional planning authorities, like the Northwest Power and Conservation Council. Aurora simulates load, generation, and transmission of the entire western interconnected power grid on an hourly basis. For each hour of the simulation, Aurora chooses the most economical generators to meet loads, given policy and system constraints. This hourly 'dispatch logic' allows Aurora to create simulated market prices based on the marginal generating unit for any given hour. Aurora then uses these market price forecasts and resource dispatch information to select the least-cost new resource options under a specific set of circumstances. By changing inputs such as transmission constraints or natural gas prices, analysts can test tipping points and tradeoffs between different resource strategies, while letting the model solve for the least-cost portfolio based on those inputs.

## Calculated Reference Case Assumptions and Modeling Inputs

- **Peak Planning Standard –** EWEB's resource needs are calculated using a peak planning standard of a P50 or 1-in-2, single hour system peak. In 2022, this is 467 MW which is the highest hour of load forecasted in a 'typical' year. To account uncertainty, some utilities use other planning standards around less frequent peaks like 1-in-10 or 1-in-25. Peak planning standards combine with planning reserve margins to calculate resource needs to for the utility.
- **Planning Reserve Margin –** The Calculated Reference Case does not assume any planning reserve margin in addition to the peak planning standard. Sensitivities will test different reserve margins, which could be necessary to meet future requirements of the Western Resource Adequacy Program.
- **New Resource Costs –** Various: Assumptions were developed in partnership with E3 consulting and presented in the August Board meeting. Costs for renewables and battery storage tend to decline over time with assumed supply chain and technology improvements.
- **Peak Capacity Credit –** The peak capacity credit for new resources reflects a resource's ability to help meet EWEB's peak load. For the Reference Case, this is reflective of December generation profiles given the specific data samples provided by E3 for use in the model.
- **BPA 2028 Contract Pricing –** The Calculated Reference Case assumes no rate increases through 2025, consistent with the current BPA BP-24 rate settlement. From 2026, BPA rates are assumed to increase with inflation.
- **Median Water Year –** The results shown in the Calculated Reference Case use median hydrological conditions and do not assume an increase or decrease in the performance of hydro generation. This assumption should be evaluated as part of portfolio risk analysis (understanding how a given portfolio may vary in cost based on hydrological conditions,

which can change each year due to precipitation).

- **Leaburg Return to Service –** The 15.9 MW nameplate capacity of Leaburg hydro generation is assumed to return to service in October 2036 and assumes historic operating costs. However, there are significant investments required at Leaburg in order to return to service and the Board is evaluating this decision using a Triple Bottom Line analysis. The Calculated Reference Case can be updated based on the Board's decision and the modeling can use updated cost assumptions from the Leaburg TBL analysis as needed.
- **Transmission Costs –** Transmission costs for existing transmission are based on published OATT rates. Costs for future transmission is a composite estimate based on staff research and analysis.
- **Inflation Reduction Act (IRA)–** The cost of solar, wind, batteries, and small modular nuclear reactors are expected to be lower as the result of the Inflation Reduction Act. The tax credits approved as part of the IRA are not yet reflected in the new resource cost assumptions for wind, solar and batteries which comes from E3. EWEB staff did reduce the cost assumptions for small modular nuclear to try to estimate the impacts, but a more thorough analysis will be required to estimate the cost reductions for these carbon-free technologies and update the model new resource cost assumptions.
- **Transmission and New Resource Build Limits–** Annual build limits of 100 MW were placed on each of the new renewable resource options in the Calculated Reference Case. Staff considers this a 'relaxed' assumption, and sensitivities will further constrain or add costs to resources outside of EWEB's area to reflect the uncertainty around building or upgrading transmission lines in the future.
- **EWEB Existing Resources –** Various: Owned plant assumptions are based on historical EWEB generation data and costs. Contracts are assumed to expire at their end dates, except for International Paper, which is assumed to be extended through 2025. The Calculated Reference Case assumes median hydro conditions.
- **Carbon Constraints –** EWEB's portfolio is constrained to be 95% carbon-free, meaning that roughly 5% of EWEB's annual load could be served by carbon-emitting resources throughout the study period. Individual resource emissions are included in the August memo. Market purchases are assumed to have emissions of 'average' regional generation, which is expected to decrease over time.
- **Carbon Pricing –** Carbon pricing is assumed for future years, consistent with CA and WA cap and trade programs.
- **RPS Constraint –** EWEB's future annual load (in MWh) must be served by either exempt or RPS compliant resources. This constraint ensures that all portfolios developed by the model comply with RPS requirements.
- **Natural Gas Prices –** The Calculated Reference Case assumes prices decline over time from current highs near $6/mmBTU to roughly $4/mmBTU at Henry Hub, with seasonal variations. Assumptions were developed in partnership with E3 consulting. IRP sensitivities will test various gas prices.
- **Inflation –** This is assumed to be 2.5% for the study period. Although there is uncertainty in future inflation rates, this factor would be applied equally to costs incurred under a resource strategy, reducing some variability due to inflation rate changes.
- **Discount Rate –** Not applicable. All financial data presented in the 2022 IRP is in nominal dollars and has not been discounted or presented in real dollars.
- **Market Limitations –** EWEB's simulated area is allowed 150 MW of imports and 150

MW of exports to exchange with BPA's area at all hours of the study period. Further, the import of energy is limited to approximately 25 aMW for each month of the study period. These market access limits were added to ensure that the calculated portfolio in the simulation does not routinely lean on the market to meet EWEB's energy needs. Sensitivities can test this assumption and be used to understand how different levels of market availability can impact EWEB's ideal mix of resources.

- **Load Forecast –** The Calculated Reference Case assumes load growth due to economic and population growth, as well as base case electrification expectations from the Phase 2 Electrification Study in 2021. This was covered in greater detail in the April 2022 Board memo entitled "EWEB's Electricity Consumption Profile and Forecasting". Sensitivities can be used to better understand low load growth and/or high electrification scenarios.
- **Unmanaged Electric Vehicle Peak Growth** - The peak forecast assumes unmanaged EV charging as a key driver of peak load growth. A managed charging demand response program to offset some of that peak load growth was modeled as a potential supply-side resource option.
- **WECC Build –** The Calculated Reference Case Western electric system buildout comes from E3's most recent Aurora price forecast and includes load increases from electrification and the impact of regional policies. This is discussed further in the Regional Environment section below.
- **Climate Change –** The Calculated Reference Case does not include specific climate change modeling. Sensitivities can test increased or decreased summer and winter loads to account for this, and future IRPs may include more comprehensive climate change analysis, pending Board direction and feedback.

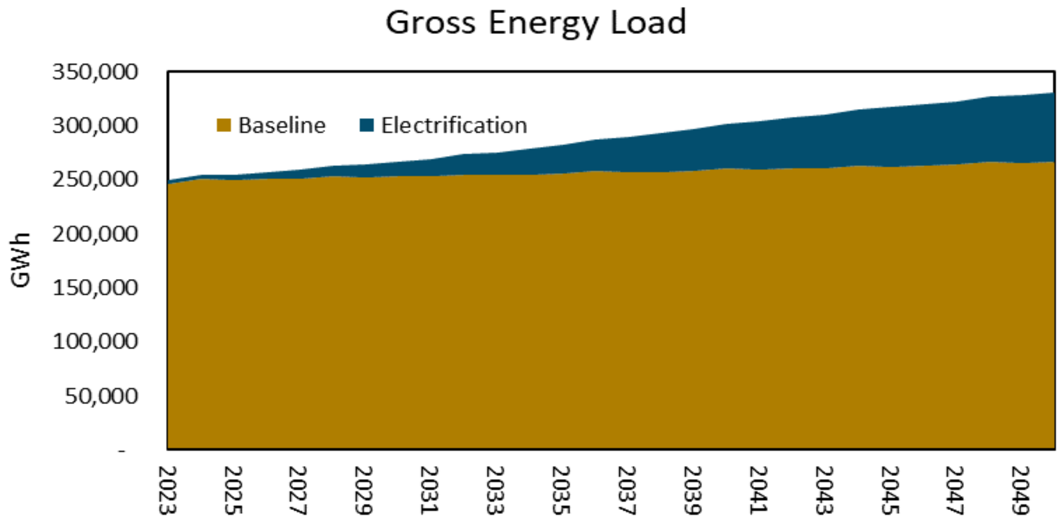
## Key Context: Pacific Northwest Energy Market Forecast

Resource selection and portfolio optimization are a balancing act between EWEB's specific needs and the broader electric system. If market prices are high, it is beneficial for EWEB to build resources and sell surplus energy on the market. If market prices are low, it is more cost-effective for EWEB to rely on the market rather than make large capital investments. To examine these interactions, EWEB partnered with E3 to incorporate their latest market price forecast and regional outlook into the 2022 IRP.

E3's forecast feeds modeling inputs and serves as the foundation for the Calculated Reference Case results. However, although the E3 view of the future electric system is informed by best available information and practices, as with any forecast, there is uncertainty. Future analysis will build upon the work with E3 and provide opportunities to explore multiple futures.

### *E3 Northwest Load Forecast*

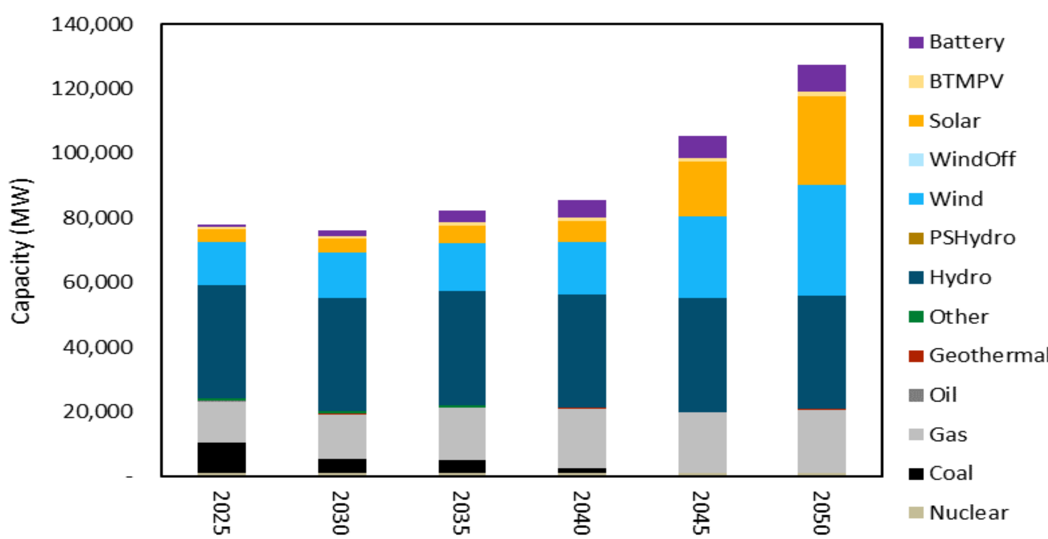
As with EWEB's load forecast, E3 expects that the primary driver of increased load in the future will be electrification. This is not expected to be impactful until closer to 2030, and in that year would represent roughly five percent of total annual load. In comparison, impacts of electrification in 2045 could be between fifteen to twenty percent of total annual load.




*E3 Northwest Resource Build*

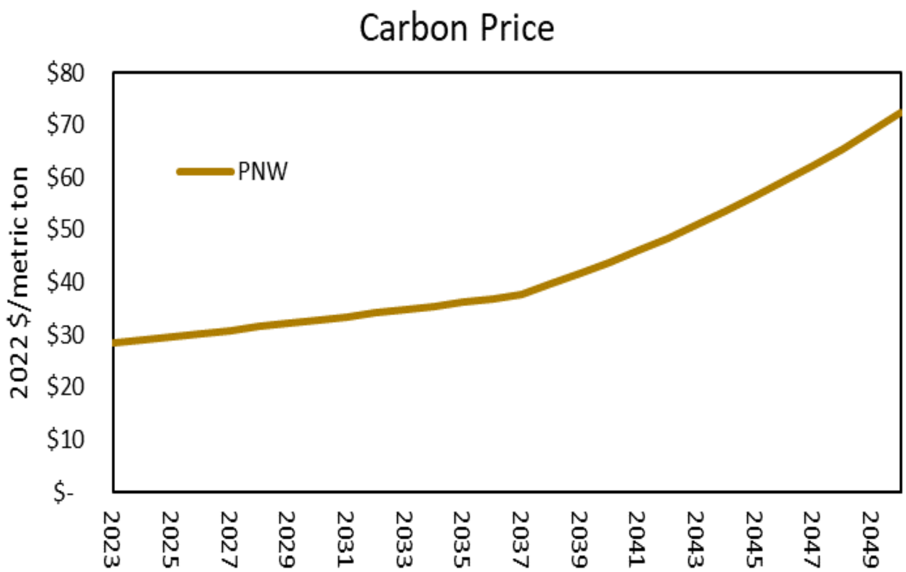
E3's analysis incorporates planned resource retirements, as well as policy constraints and resource cost projections. As the table below shows, this leads to a reduction in coal capacity in the Northwest, which is replaced over time primarily by a mix of wind, solar, and battery storage. The amount of solar expected in the region is not as substantial as in areas like the desert Southwest that have growing peak summer needs, fewer existing clean energy resources, and higher solar capacity factors. Batteries are not expected to make up a material portion of the Pacific Northwest portfolio until after 2030.

E3 Northwest Buildout



In general, because the Northwest already has a number of low-carbon hydro resources, E3's modeling does not predict substantial new resource builds to meet carbon policies before 2040; instead, a retention of firm capacity and new resource builds keep pace with growing peak and energy demands. This resource build forecast aligns with the IRPs of every major utility, where wind, solar and batteries make up the vast majority least-cost, best fit options.

*E3 Carbon Pricing*




E3's model includes a price on carbon, which influences resource build decisions and dispatch. With the passage of Washington State's Climate Commitment Act, a cap-and-trade program, carbon pricing is quickly becoming a reality in the Northwest. Regardless of whether Oregon passes a carbon pricing bill, Washington and California cap-and-trade programs will impact market liquidity and pricing. Washington State has already revised its initial forecast of carbon prices since allowances went from $18.80/ton in May 2021, to $27/ton in August 2022. Because natural gas plants are often the marginal generating unit, especially in evening hours and seasons when hydro and renewable generation is less abundant, carbon prices increase overall market prices.

E3 Market Prices: Mid-C Prices –

Electricity market price forecasts are useful for estimating the future price of electricity as traded on the wholesale, short-term (spot) market at the Mid-Columbia trading hub. This forecasted price represents the marginal cost of electricity at the trading hub based on the economic dispatch of resources and transmission constraints between other trading hubs. Aurora simulates both load and generation dispatch for the entire WECC[1] and the market price formation in each region is based on economic dispatch logic for the full system. The cost to run the last unit that is dispatched to meet regional load determines the spot market price.

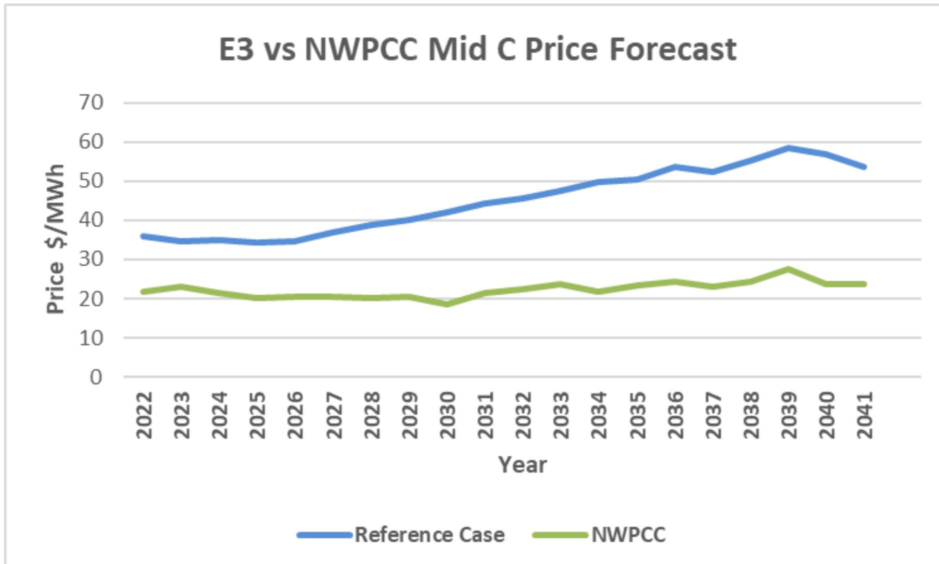
Spot markets are typically where power is sold after utilities secure enough resources to meet their loads. Utilities do not choose to build resources solely for their value in the spot market, but also consider other value streams like capacity value and their ability to generate renewable

1 WECC is the Western Electrical Coordinating Council. It coordinates reliability for the Western Interconnect.

energy certificates. Below is a comparison between the price forecast for the Calculated Reference Case and price forecasting from the 2021 Power Plan from the Northwest Power and Conservation Council (NWPCC). The Calculated Reference Case portfolio valuation estimates the value of market purchases and sales for the calculated portfolio using these Mid-C prices.

The primary causes for differences among price forecasts are related to:

1) the amount of new renewable generation developed in the future.
2) the amount and type electricity generation needed to maintain grid reliability.
3) the estimated future loads in the Pacific Northwest based on population changes, electrification, and conservation.




The NWPCC 2021 Power Plan forecast is substantially lower due to overbuilding renewables assumed to be needed to meet the various policy requirements put on Western electric utilities. This overbuild creates an oversupply of electricity and depresses market prices. EWEB's Calculated Reference Case Mid-C forecast, on the other hand, does not anticipate the same oversupply of electricity. Instead, rising demand for electricity keeps gas on the margin and carbon pricing puts upward pressure on the cost of electricity in the spot market.