Integrated Resource Planning

ROUNDTABLE 21-3

MAY 2021






MEETING LOGISTICS

Electronic version of presentation:

https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning/irp-public-meetings

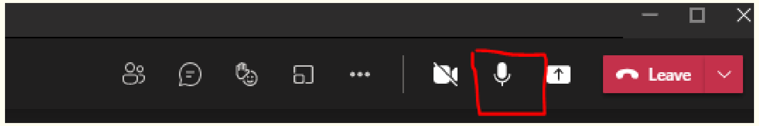
Teams Meeting

Please click the meeting link sent to your email or here:

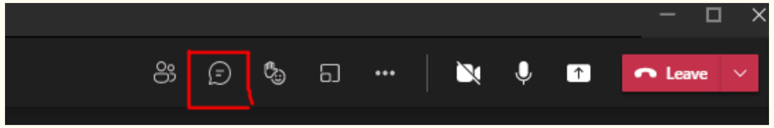
Join Microsoft Teams Meeting
+1 971-277-2317 (dial this number into your phone for best results)
PW: 111 848 255 2
*Please use Microsoft Edge or Google Chrome with Teams as it will give you the best experience

PARTICIPATION

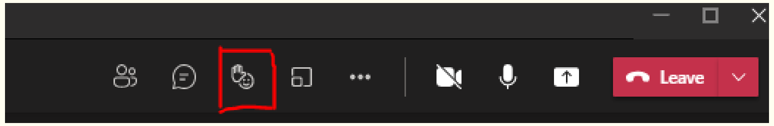
- Mute your mic while others are speaking; to unmute via phone press *6



- We will ask for comments and questions along the way
- Participate using the chat box or ask questions verbally



- Use the "raise hand" feature to signal you'd like to ask your question verbally



- Wait to be called on
- Please be polite and respect all participants on the webinar
- Please stay on topic; we may interrupt or shorten questions to meet the time commitment of the meeting

AGENDA

Welcome and introductions	15 minutes
Safety moment	5 minutes
IRP uncertainty	30 minutes
Price forecasts: part two	45 minutes
Capacity Assessment	45 minutes
Portfolio requests from participants	5 minutes

SAFETY MOMENT

Outdoor recreation safety

Warmer weather and indoor restrictions make hiking, biking, parks, and other outdoor recreation a popular choice. To stay safe, remember:

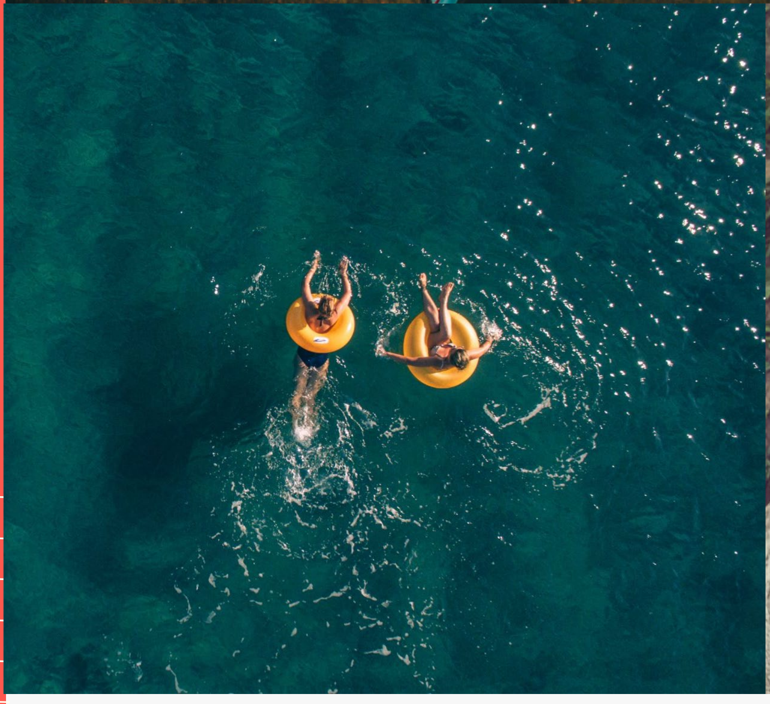
Hydration – drinking enough water is essential to outdoor safety in any season

Navigation – carry a detailed map of the area you are recreating in

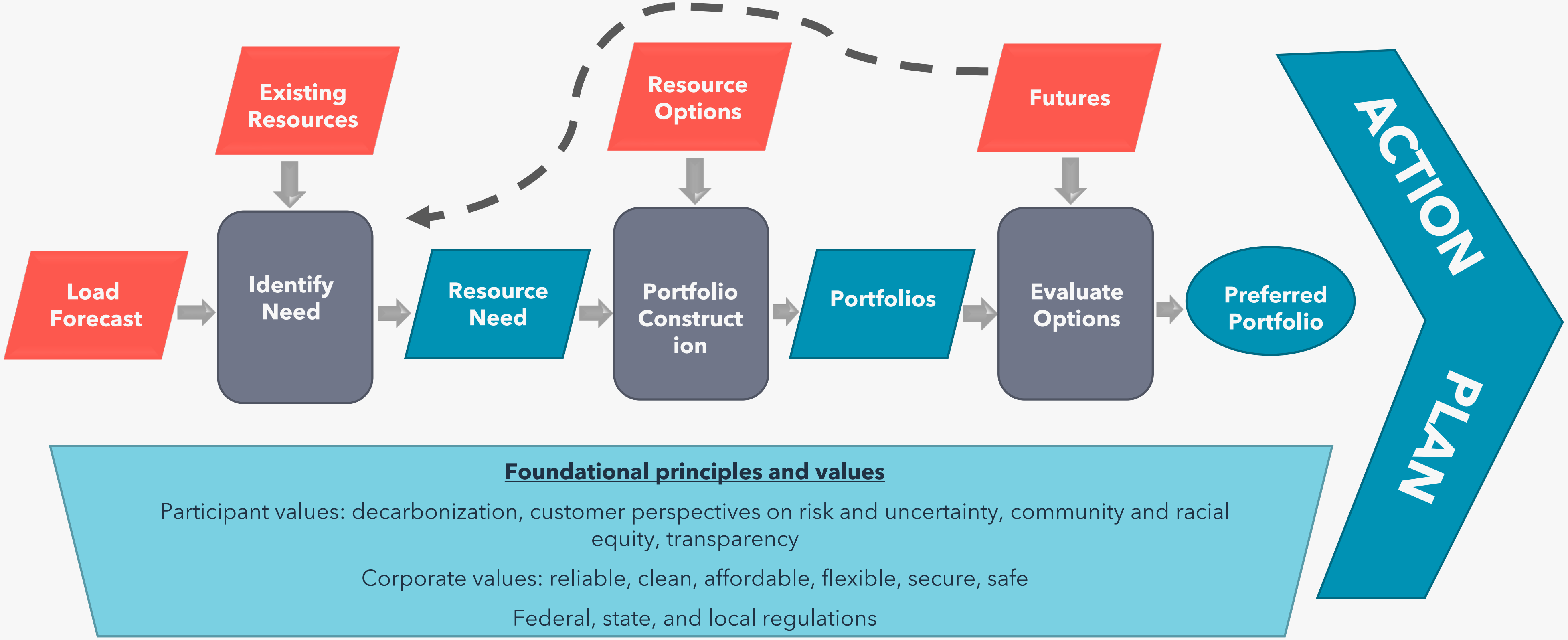
First aid kit – have the supplies you need to deal with minor and major injuries

Illumination – a light source is essential if you get caught out after dark

Sun protection – bring sunscreen, sunglasses, and hats for everyone in your party



IRP ANALYSIS PROCESS



IRP UNCERTAINTY

SETH WIGGINS

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Planning without uncertainty is easy

With no uncertainty, the IRP would be simple, as we would know:

- The size and timing of any changes to customer demand
- Generation from our existing and contracted resources
- The costs and benefits associated with all resource options
- The availability of the market
- The impacts to customers across classes caused by our decisions
- All applicable regulations

We'd simply select the least-cost option for any necessary resource additions

But there is so much we don’t know

- Market Conditions
- Demand
- Climate
- Planning Environment
- Existing Portfolio
- Supply Side Options
- Transmission
- Voluntary Programs
- Distributed Resources

2019 IRP attempts to model uncertainty

The 2019 IRP used two primary methods to incorporate uncertainty:

Futures: Portfolios were created and scored under changing market conditions

- Need: *reference, high, & low need*
- Technology Cost: *various renewable cost decline trajectories*
- Price: *reference, high, & low hydro conditions and carbon, gas prices, reference and high renewable buildouts*

Sensitivities: Key metrics were estimated varying specific inputs

- Voluntary renewable programs
- Direct access
- Qualifying Facilities

Planning trade-off

The ability to examine these alternate views (other than the reference case) presents an important trade-off:

- **Too few** alternate views of the future might not create a plan robust to future conditions
- **Too many** alternate views of the future might not be feasible, could obscure results, and slow modeling time

The IRP team seeks to balance this trade-off, efficiently creating a clear and robust resource plan

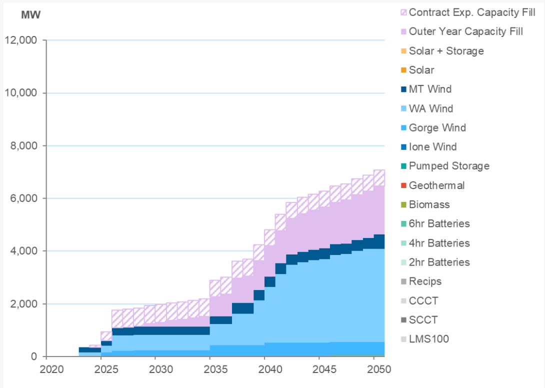
Answering questions

The IRP team includes alternative futures and sensitivities as *means* to the *end* of answering on specific questions

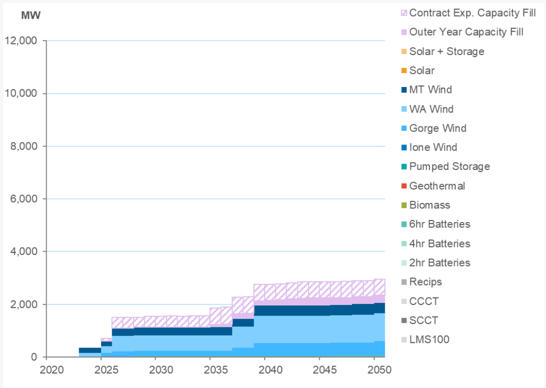
For example:

- ***Question:*** How will our resource plan change with lower load growth?
- ***Means:*** Include low need future in portfolio analysis
- ***Answer:*** In the IRP (and IRP Update, shown below), we were able to show resource buildouts by load future

Reference Case



Low-Need Case



We are seeking participant input

Determining which questions are most informative is a challenge.

We're evaluating those from the 2019 IRP and are thinking ahead.

We're also looking at the methods used/being developed.

- *Are there questions you want to see us evaluate at in the next IRP?*
- *Were the means we've used effective at answering your questions?*
- *Are there any questions you think are no longer appropriate?*

We're interested in participant feedback and requesting responses by June 24 at IRP@pgn.com

QUESTIONS & COMMENTS

We're seeking your feedback!

PRICE FORECASTS: PART TWO

SILVIA MELCHIORRI, ROBERT BROWN, KATE VON REIS BARON

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Electricity price forecasts

The 2019 IRP established methods to develop the forecasted prices

We've followed a similar set of procedures to develop initial draft price forecasts based on more recent inputs

An important component of evaluating these draft forecasts is participant input

We are open to feedback at this meeting and/or via IRP@pgn.com

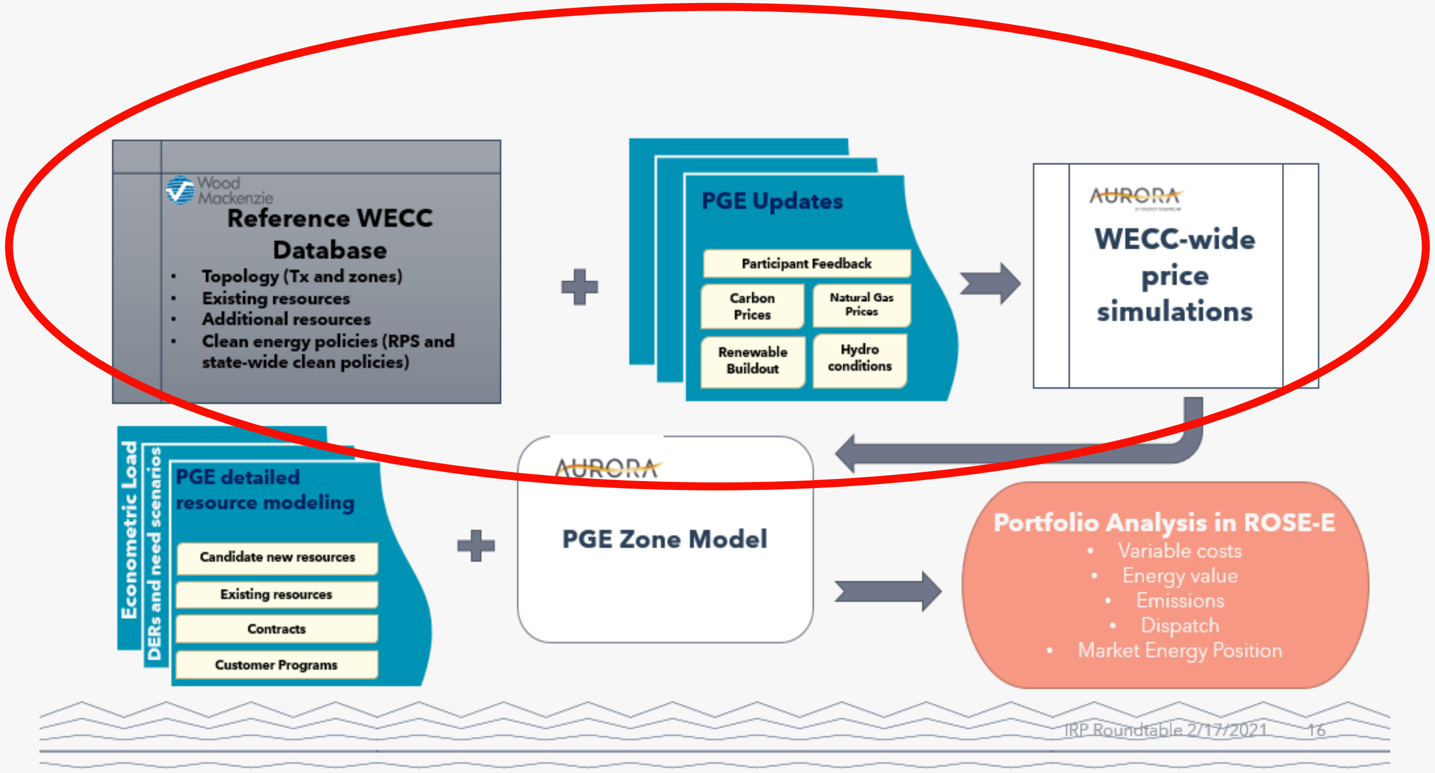
Electricity price forecast: Basic approach

Part I presented in Roundtable 21-1 on Feb. 17, 2021

Goal: simulate LONG-TERM electricity prices for the Pacific Northwest that capture reasonable range of uncertainty

Methodology:

1. Software: Aurora with WECC database by Wood Mackenzie (WM)
2. PGE updates to database: gas, carbon, etc.
3. Simulate electricity prices for reference case and futures
4. Input simulated PNW prices into PGE resource dispatch model (PZM)



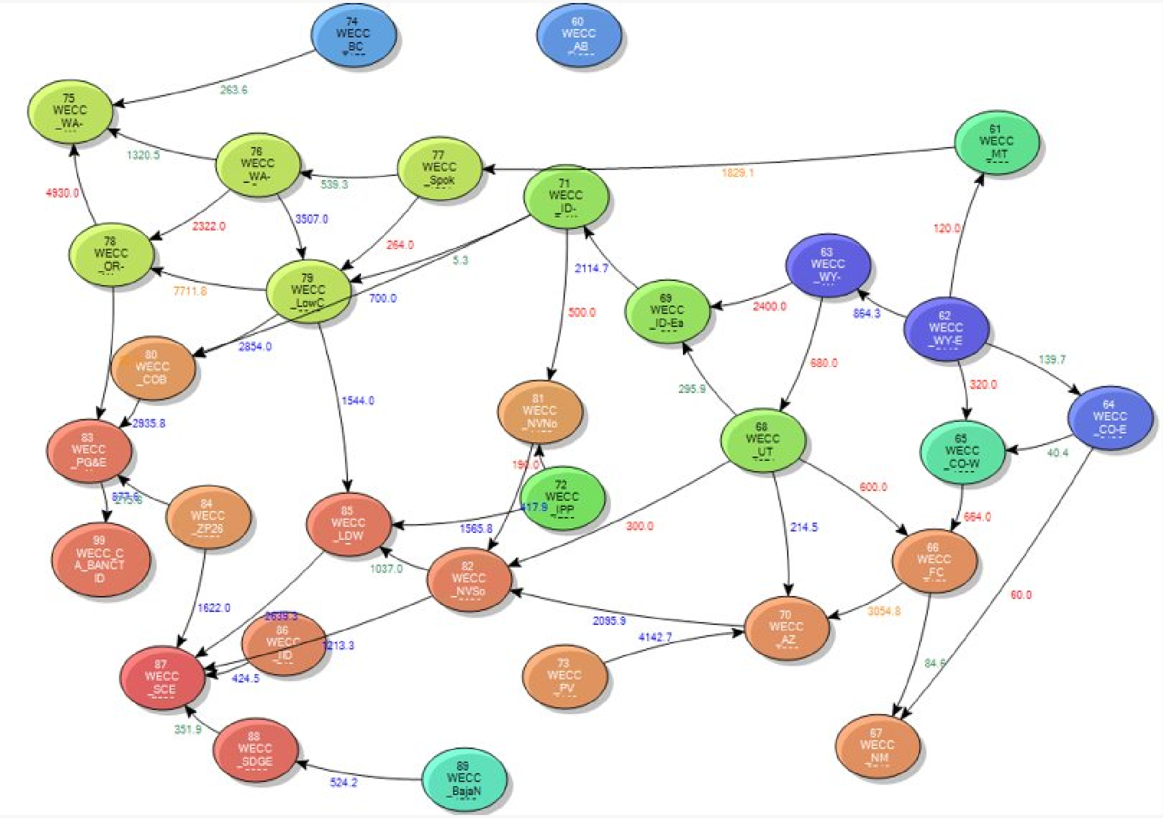
Electricity price forecast Wood Mackenzie disclosure

The data and information provided by Wood Mackenzie should not be interpreted as advice and you should not rely on it for any purpose. **You may not copy or use this data** and information except as expressly permitted by Wood Mackenzie in writing. To the fullest extent permitted by law, Wood Mackenzie accepts no responsibility for your use of this data and information except as specified in a written agreement you have entered into with Wood Mackenzie for the provision of such of such data and information.

Electricity price forecast: WECC model

- Software: Aurora, version 13.5.1057 with GUROBI optimizer
- Data: Wood Mackenzie WECC data base 2020H2 (released in Spring 2021). It collects information on:
    - Load and resources by geographical area (bubbles). Resources are both existing and new additions to meet forecasted load
    - Transmission: capacity, constraints, wheeling costs, and carbon hurdle rates
    - Macroeconomic data: fuel prices, environmental costs, inflation, etc.
    - Calibration of resource behavior and optimization parameters

Illustrative snapshot in time of the Wood Mackenzie (WM) WECC-wide topology as seen in Aurora



This pictures was obtained from a product of Wood Mackenzie.

Electricity price forecast: What's new in the 2022 IRP WECC model

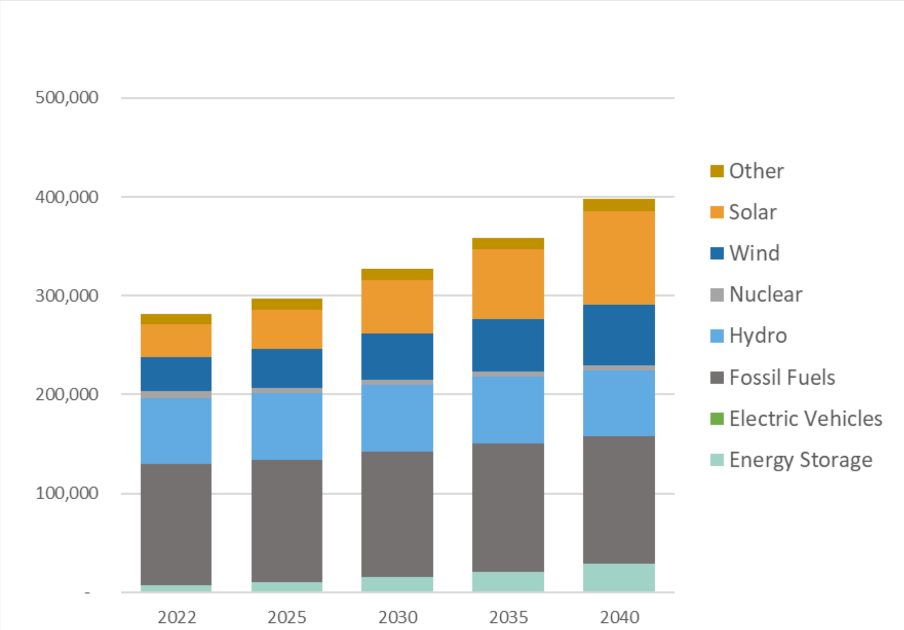
- WM 2020H2 embraces the view of future additions being mainly renewables + storage (see next slide)

- WM extended its forecasts to 2050. For IRP purposes, we need at least 20 years of forecasts. 2023-2045 is our draft proposed timeframe for price forecast

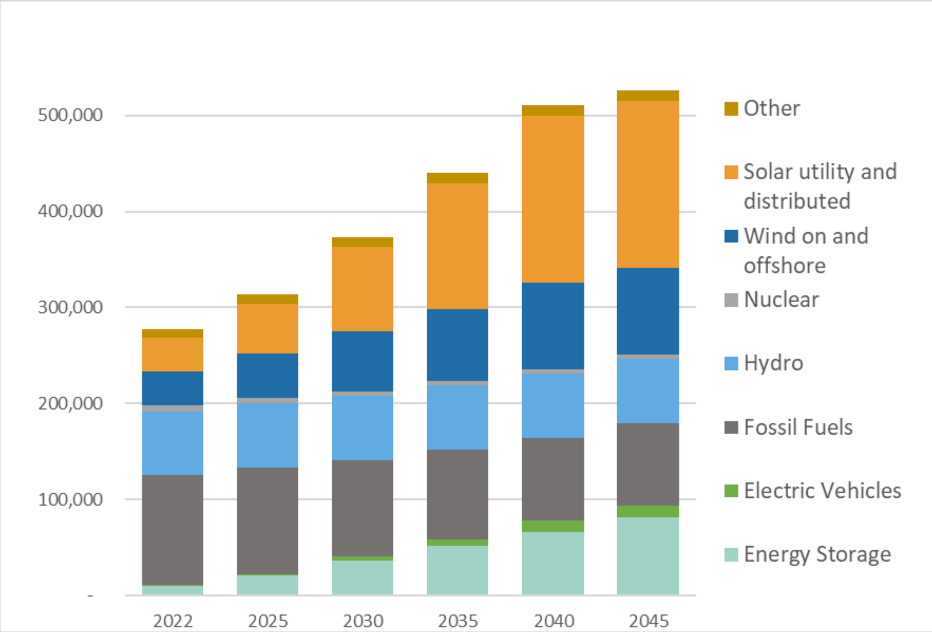
- Resource dispatch logic highly enhanced by Energy Exemplar, the vendor of Aurora
  - Traditional commitment with MOSEK optimizer: 2019 IRP
  - Optimized commitment with GUROBI optimizer: 2022 IRP
  - Both good; however, optimization with GUROBI is exceptional at finding the least cost solution in heavily constrained systems
  - Solution: meet WECC load at minimum cost, given constraints

Electricity price drivers: 1) WECC resource mix

- Overall net additions in WECC are massive (over 200 GW by 2040) in order to meet load and reserve requirements
- By 2040, solar + wind + storage meet half of the WECC energy need in the 2022 IRP draft simulations vs. one third in 2019 IRP



2019 IRP Resource mix (MW)



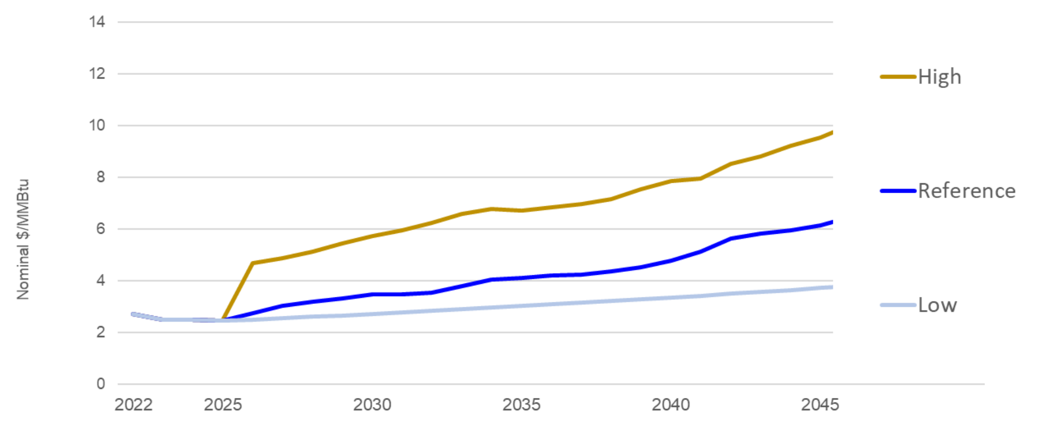
2022 IRP DRAFT Resource mix (MW)

These charts were obtained from the North America Power & Renewables Service &Tool – WECC, a product of Wood Mackenzie.

Electricity price drivers: 2) Gas price futures

- No changes to the methodology proposed in Roundtable 2021-1
- Updated reference per WM 2020H2. Gas prices are lower than IRP Update after 2030 for Sumas and after 2037 for AECO
- Reference case: TC to 2025, 2026 interpolation, 2027 forward WM
- Updated low per PGE-TC Feb. 2021
- Updated High per 2021 EIA-AEO
- Further updates will depend on availability of new forecast by this summer

Sumas gas price forecast

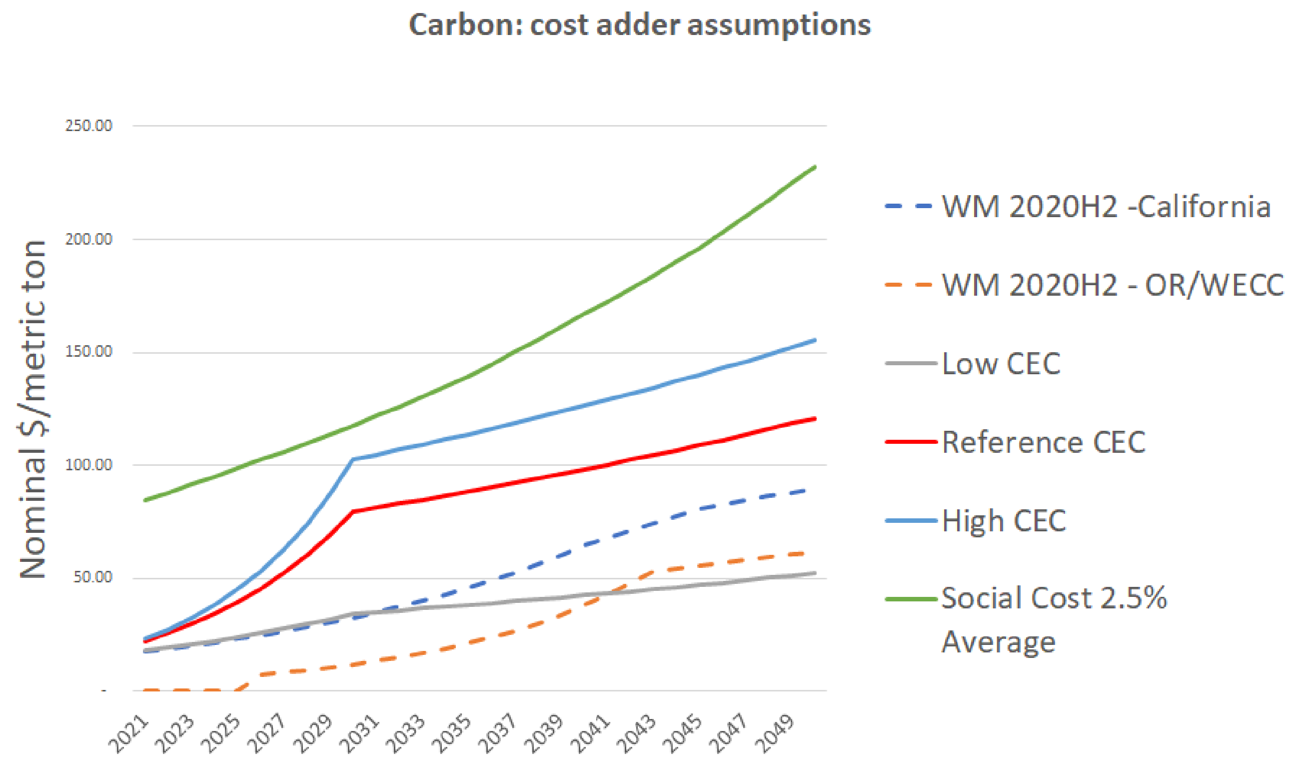


This chart was obtained from EIA, PGE, and from the North America Power and Renewables Service – WECC, a product of Wood Mackenzie

Electricity price drivers: 3) Carbon assumption

- Convenient modeling carbon regulation as a cost adder to fossil fuel dispatch cost
- PGE inputs (see also RT 21-1):
    - CA: 2019 Integrated Energy Policy Report (IEPR)
    - OR and WA: same as CA starting in 2022
    - Rest of WECC: default WoodMac
    - Suggestions?

Discuss: use CEC for low and ref; and Social cost with 2.5% discount rate for high

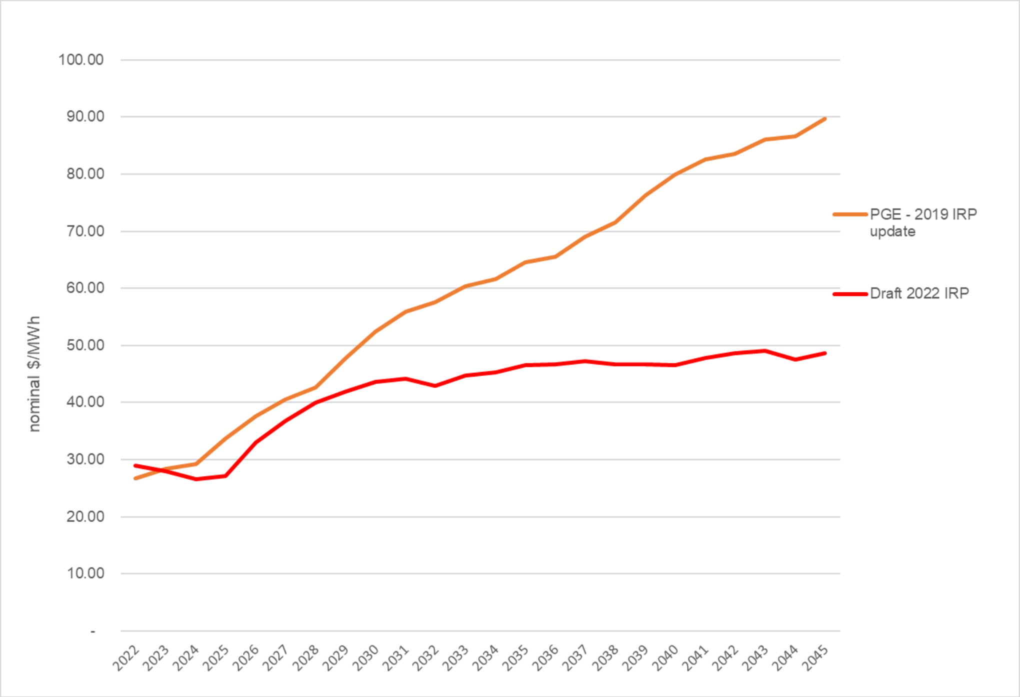


This chart was obtained from CEC public data and from the North America Power & Renewables Service – WECC, a product of Wood Mackenzie.

Electricity price forecast: Draft reference price for PNW

- Build-out: default WM 2020H2
- Updated Aurora software
- Adopted GUROBI optimization
- Carbon - 2019 IRP update assumptions to start with (need feedback)
- Gas – 2020H2 WM
- Hydro – default WM
- Long-term inflation: 2.10%
- Aurora price = the marginal cost of the most expensive resource dispatched in the zone

PNW: reference electricity draft price



Electricity price forecast: Impact of high share of renewables

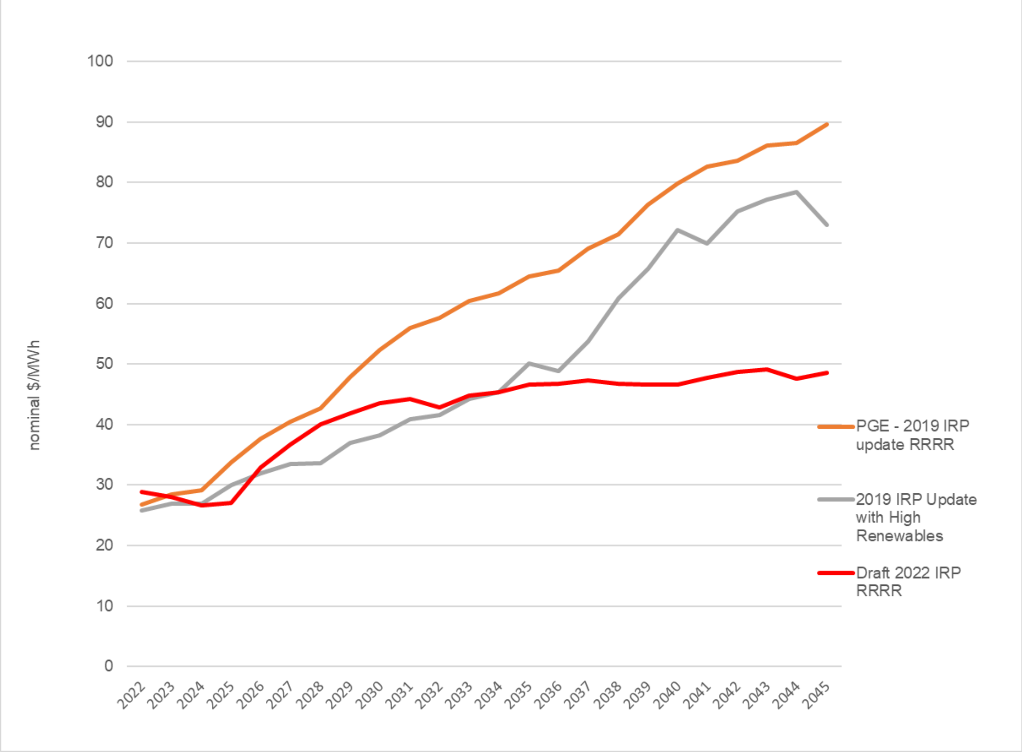
Why does the new database simulate prices so differently from HRRR?

- ST: pretty close
- MT: still not that different and within expected modeling variations
- LT: divergent. HRRR was using:
  - Aurora traditional commitment;
  - limited curtailment ability;
  - and somewhat lower storage

The combo made it difficult for Aurora to find a solution. Prices suffered from high volatility as initially uncommitted resources had to turn on with penalties

- Current RRRR uses Gurobi optimizer, optimal commit logic, more RES curtailment, storage

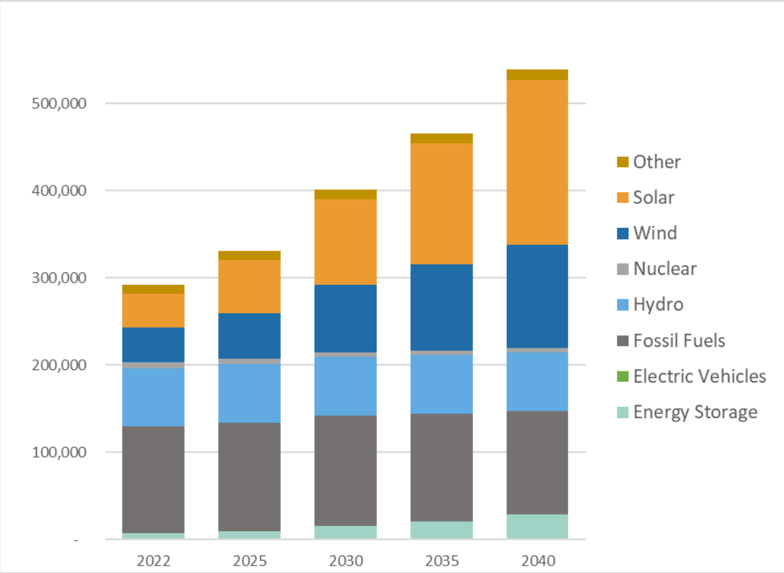
PNW: comparison of electricity draft price with RRRR and HRRR



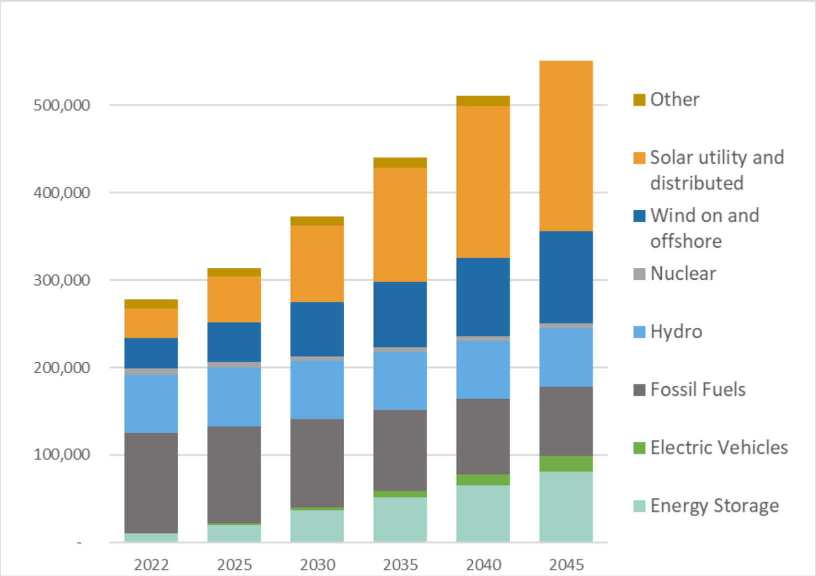
Electricity price forecast: Impact of high share of renewables

Why does the new database simulate prices so different from HRRR?

- Insight: prices depend not only on the resource mix but on the model ability to guess right in committing the right mix to follow intermittent resources generation
- New database has more flexibility built in



2019 IRP HRRR Resource mix (MW)

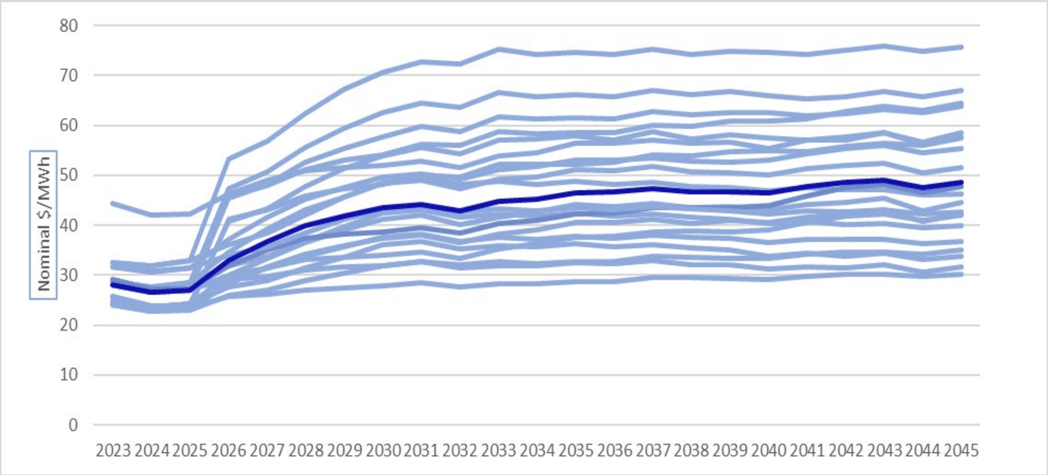


2022 IRP DRAFT Resource mix (MW)

These charts were obtained from the North America Power & Renewables Service &Tool – WECC, a product of Wood Mackenzie.

Electricity price forecast:
Evaluate options for price futures

PNW: draft futures simulations



2019 IRP	2022 IRP draft
Three gas futures: Ref., Low, High	Keep
Three carbon price futures: Ref., Low, High	Discuss
Three hydro futures: Ref., Low (-10%), High (+10%)	Keep
2 WECC build-out: Ref. ; high VER	Discuss
---	Consider new futures for uncertainty analysis: Stress optimization, Modify VER, load, etc.
Total of 54 futures	27+ futures if we keep the 3 carbon futures

WECC-wide market price: Next steps

1. Ongoing: IRP team continuing to review inputs & assumptions to validate draft results
2. We're interested in participant feedback on price scenarios and requesting responses **by June 24** at IRP@pgn.com
3. Review feedback and determine final price futures

Goals:

- Share final draft prices with participants
- Lock WECC model and generate PNW hourly prices for 2022 IRP

QUESTIONS & DISCUSSION

CAPACITY ASSESSMENT

KATE VON REIS BARON

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Capacity Assessment – May 2021

Some review and some new information

- References to prior discussions
- Sequoia model intro/review
- Update model: hybrid/storage resources
- Update inputs: load simulation tool
- Capacity need visualization: heatmaps
- Capacity Contribution (ELCC)
- Upcoming to-dos

Capacity assessment – review

- RT 20-1: high-level introduction to capacity assessments and the Sequoia model
- RT 20-3: Additional details about Sequoia's initial structure and dispatch logic
- RT 20-5: Information from a preliminary baseline exercise for Sequoia
- 2019 IRP Update: Sequoia information in Section 3.4.1 and Appendix K

Previous roundtable slides: https://portlandgeneral.com/about/who-we-are/resource-planning/irp-public-meetings

2019 IRP Update: https://portlandgeneral.com/about/who-we-are/resource-planning

Capacity adequacy means that a system has sufficient resources to meet a reliability standard (e.g., a loss-of-load probability of one day in ten years).

Capacity need is the quantity of additional resources needed to achieve the adequacy standard.

Capacity assessment process

Update model
hybrids, DER

→

Update inputs
load, existing resources, new resource options

→

Capacity Need Assessment

→

Capacity contribution (ELCC) study

Sequoia
capacity assessment model

- **Improved treatment of energy-limited resources**
- **Improved process efficiency**

- A loss-of-load probability model that estimates the capacity need of a system and estimates the capacity contribution of potential incremental resources for long-term planning
- A **Monte Carlo module** constructs thousands of plausible weeks of load and resource conditions (Python)
- Each week is evaluated independently in a **dispatch module** that optimizes all dispatchable resources across all hours of the week to minimize an objective function (GAMS with Gurobi solver)
- Model has perfect foresight
- Resolution is hourly
- Objective function is to minimize the sum of the average unserved energy across the week and the maximum unserved energy in a single hour of the week (not economic dispatch)
- There may be multiple solutions that achieve the same objective function value, especially in weeks with excess generation (these may not look "logical")
- Sequoia expresses capacity need in terms of theoretical perfect capacity (always available)

Monte Carlo Module

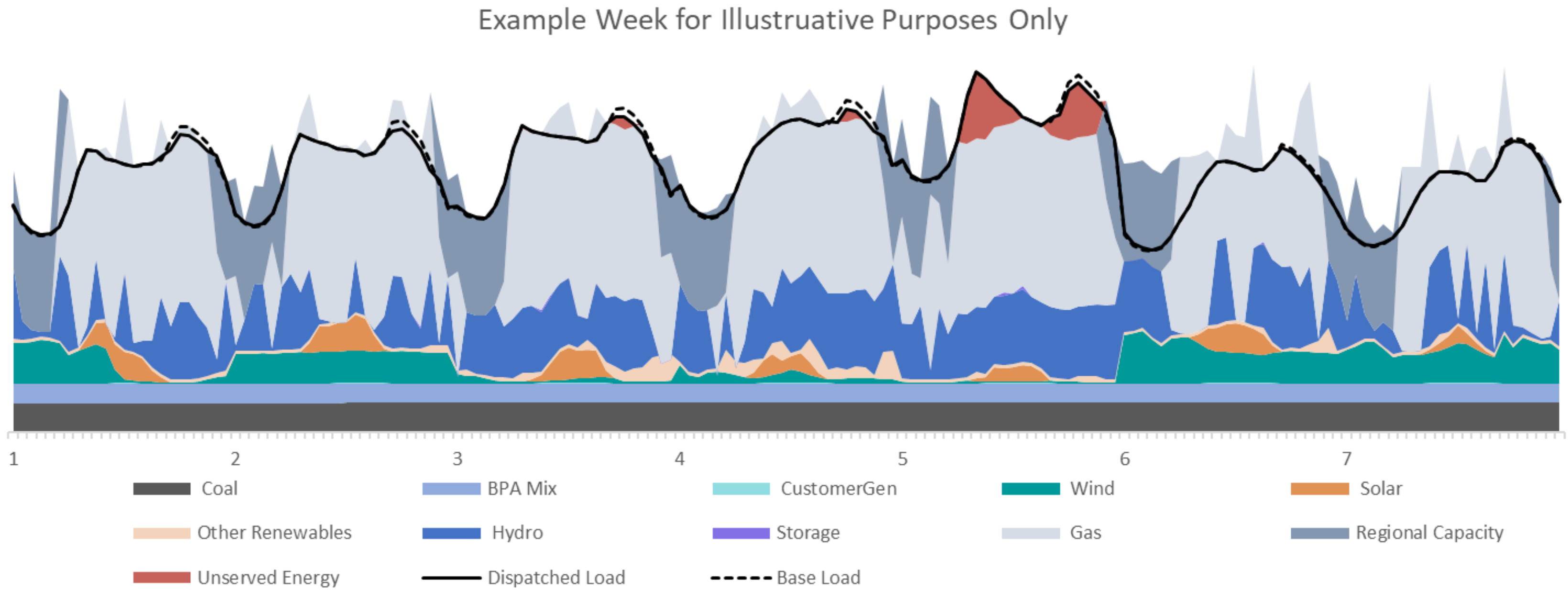
- Constructs thousands of weeks of plausible load and resource characteristics

- Simulation begins by randomly drawing seven sequential days and identifying the month, weekend/weekday, and weather day types for each day
- The model currently uses load as a proxy for weather conditions
- For each day of the week, the load is drawn from the distribution of days in the assigned day-type/weather bin (a similar process is applied for resources with hourly profiles such as wind and solar)
- For hydro with storage, a hydro year is randomly drawn and this, combined with the month, establishes the hydro conditions
- Assembles deterministic information corresponding to the day types for each day (e.g., thermal plant ratings) as well as other deterministic characteristics (e.g., capability to provide contingency reserves)
- Simulates random forced outages for thermal and storage resources based on inputs for forced outage rates, mean time to repair, and partial outage distributions
- For many dispatch types, the information is aggregated

Dispatch Module

- Optimizes each week to minimize the objective function
- Optimizes all hours and resources simultaneously
- Single stage - model has perfect foresight

- Given the inputs from the Monte Carlo module for a week and the constraint equations for each dispatch type, resources are optimized to minimize the objective function
- If there aren't sufficient resources to serve load and contingency reserves, unserved energy is reported
- The objective function is to minimize the sum of the average unserved energy in the week and the maximum unserved energy in a single hour of the week

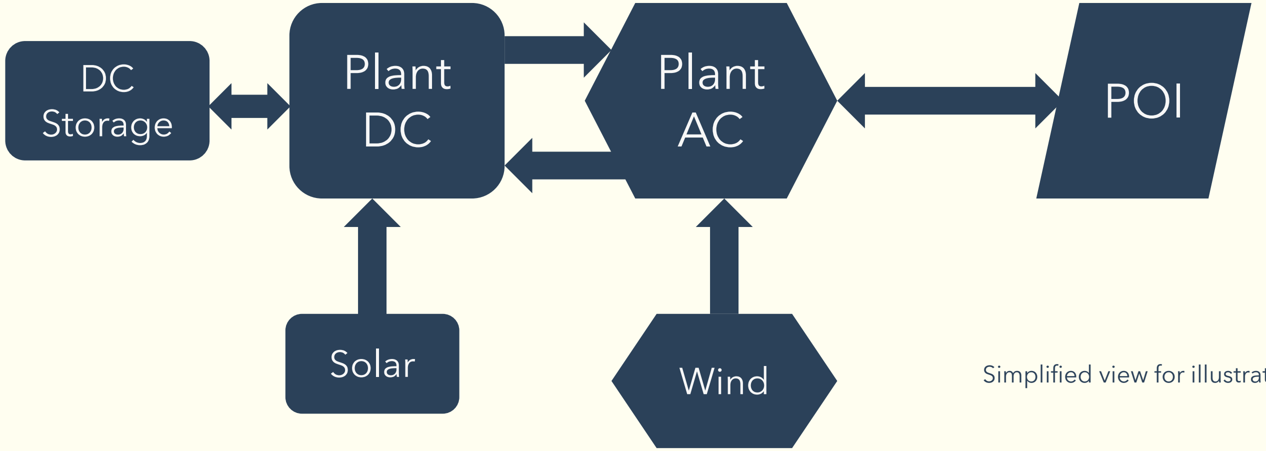


Update Model

- Hybrid and storage resource dispatch (see next slide)
- DER resource dispatch (upcoming)
- Additional considerations (e.g., functionality to consider impact of emission constraints, functionality to improve user operation and efficiency, improvements to hydro characterization, improvements to output reporting)

Update model: Hybrid/storage resources

- IRP Team is finishing improvements to the modeling of hybrid resources in Sequoia
- Accommodates DC and AC storage resources paired with generation (DC and/or AC) and/or grid charging
- Will allow for modeling of daily cycling limitations, grid charging limitations
- Hybrid logic used for stand-alone storage resources
- Hybrid/storage resources no longer aggregated



Simplified view for illustration

Update Inputs

- Econometric load forecast
- Baseline Portfolio (contracts, existing resource updates, DER, regional capacity)
- New resource options (supply-side, incremental EE and DER)
- Information for Low and High Need Futures
- Information for sensitivities

Update inputs: Load simulation tool

- One of the foundational pieces of input data for a resource adequacy model is the hourly econometric load forecast with weather variation
- The Load Simulation Tool is a Python based machine learning model developed for PGE by the Cadmus Group for creating hourly profiles of load response to weather
- IRP Team will be working to incorporate the output into Sequoia for the next IRP

Improved learning and calibration by customer revenue class

Improved weather simulation and ability to update weather information

Improved efficiency for updating to new load forecasts

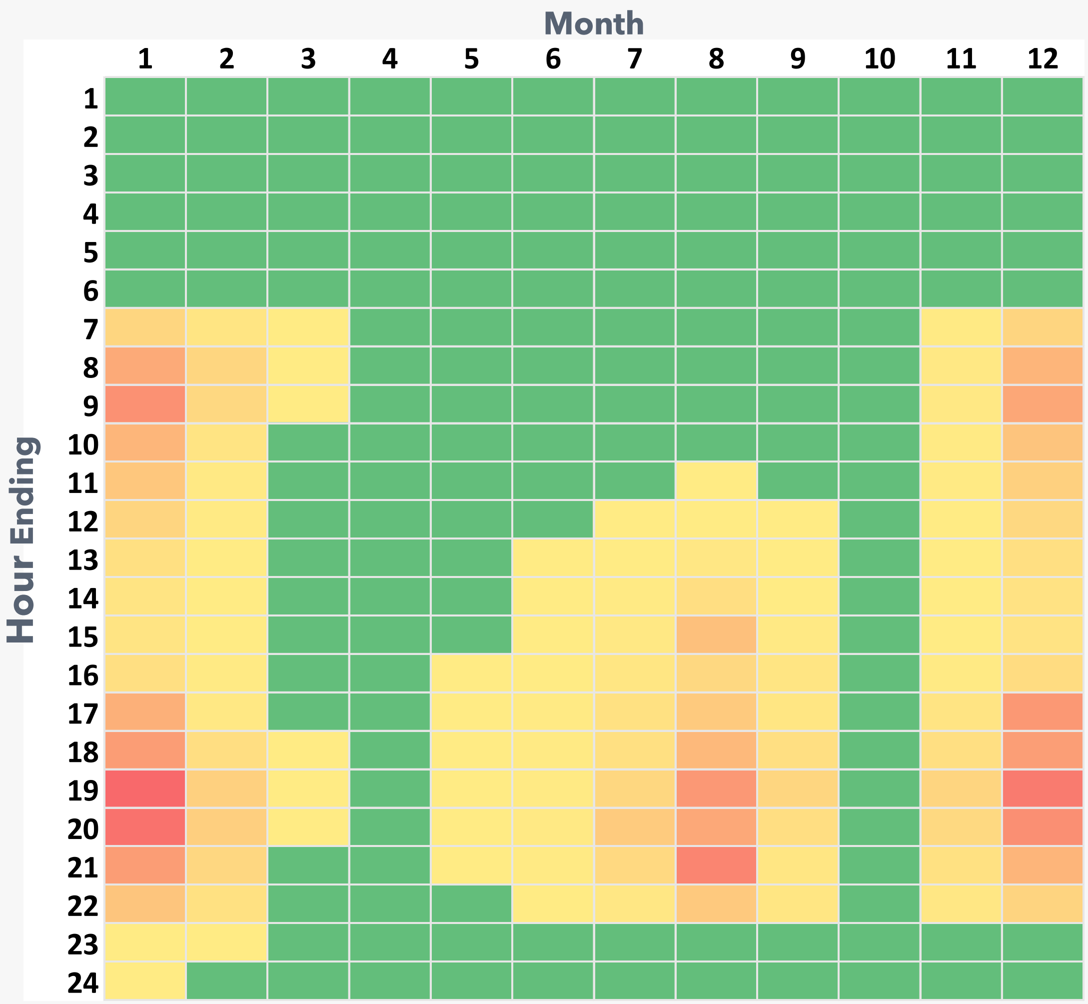
Capacity Need

- Assess capacity needed to achieve reliability standard in each year for each Need Futures and for sensitivities
- Examine outputs to learn about nature of need

Capacity need visualization: LOLE heatmap

- Loss-of-load expectation (LOLE) heatmap is useful for considering the seasonal and diurnal nature of when the system is forecast to have higher probability of capacity shortages
- Does not differentiate by magnitude
- Additional complexity can be viewed with Sequoia

2019 IRP Update LOLE Heatmap for 2025



Additional views

- While images do not capture the full complexity of the analysis, Sequoia allows for additional views that provide more information about the nature of the capacity need
- Can examine the seasonal and diurnal nature of the hours of greatest need
- We are working to determine additional views that may be useful and possible with Sequoia. **We appreciate your feedback on what you would find informative!**

Percentage of hours with greatest need by month
(2019 IRP Update, 2025)

1	2	3	4	5	6	7	8	9	10	11	12
31%	7%	0%	0%	0%	0%	2%	23%	2%	0%	2%	34%

	6	7	8	9
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	3	0
15	0	0	42	0
16	0	2	4	7
17	0	4	12	3
18	0	4	41	11
19	0	9	116	18
20	1	14	77	7
21	0	6	205	2
22	0	1	39	1
23	0	0	0	0
24	0	0	0	0

Count of summer hours with greatest need by month/hour
(2019 IRP Update, 2025)

ELCC study

capacity contribution

- For test year, prepare marginal ELCC curves for candidate new resources
- Examine portfolio effects
- ELCC values by year (Order No. 21-129) – discuss options with participants

Upcoming capacity to-dos

- Complete improvements to hybrid modeling
- Examine options for improved treatment of dispatchable DER, options for considering availability impact of emission constraints
- Update inputs, including implementing load simulation tool, incorporating new DER study, and adding new candidate supply-side resources
- Coordinate with participants to prioritize requests for analysis, including additional areas of ELCC analysis

QUESTIONS & DISCUSSION

PORTFOLIO REQUESTS FROM PARTICIPANTS

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PORTFOLIO REQUESTS

- Our portfolio optimization model ROSE-E has flexibility to evaluate any specific resource/size/year combination
  - For example, we could estimate the portfolio effects of adding 235 MW of SE Washington wind in 2036 and/or 150 MW of 6-hr batteries in 2026
  - In the 2019 IRP, we used this capability to evaluate the size and timing of 16 different renewable additions MW/year combinations
  - Carbon constraints

- We are open to any suggestions for portfolio questions to be evaluated
  - Please contact us (email: IRP@PGN.com)

QUESTIONS & DISCUSSION

NEXT STEPS

Submit feedback on **WECC-wide market price** and **IRP uncertainties** by June 24

By August roundtable PGE will provide final draft of WECC-wide market price to participants

A recording from today's webinar will be available on our website within a week
https://portlandgeneral.com/about/who-we-are/resource-planning/irp-public-meetings

THANK YOU

CONTACT US AT:
IRP@PGN.COM

ATTACHMENT A: ACRONYMS

CEC: California Energy Commission

DB: database

DER: distributed energy resource

EIA AEO: energy information administration annual energy outlook

ELCC: effective load carrying capability

GAMS (General Algebraic Modeling System): a programming language used for optimization programs

GUROBI: a commercial optimization solver for linear, quadratic, quadratically constrained, mixed integer linear, mixed-integer quadratic, and mixed-integer quadratically constrained programming.

GW: gigawatt

HRRR: high renewable WECC buildout

IRP: integrated resource plan

LUCAS, ROM, PGE-zone, Sequoia, ROSE-E, and AURORA: models PGE uses for IRP analysis (see Appendix I: 2019 IRP Modeling Details from the 2019 IRP)

MOSEK: a software package for the solution of linear, mixed-integer linear, quadratic, mixed-integer quadratic, quadratically constraint, conic and convex nonlinear mathematical optimization problems.

POI: Point of Interconnect

PNW: pacific northwest

RRRR: reference case price future

RT: roundtable

WECC-wide: Western Interconnection (today- the generators, transmission lines, and other facilities that comprise the Western Interconnection electrical grid, which is a NERC region)

WM: Wood Mackenzie