Integrated Resource Planning

Roundtable Meeting #20-3

May 20, 2020

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 the phone number rather than clicking the link)**
    - Conference ID: 470 342 140#
  - Please use Microsoft Edge or Google chrome with Teams as it will give you the best experience
  - During the presentation all attendees will be muted; to unmute yourself via computer click on the microphone that appears on the screen when you move your mouse
  - To unmute yourself over the phone press *6
  - If you call in using your phone in addition to joining via the online link, please make sure to mute your computer audio
  - There is now a meeting chat feature rather than a Q&A feature. Pull this up on the menu bar when you move your mouse and look for the little message icon

SAFETY MOMENT

- Computer work: Ergonomics at home
  - Make sure your monitor is eye level, that means you are looking straight ahead at the top third of your screen
  - Schedule breaks; they improve your ability to focus
  - Adjust your chair to fit your needs; add a pillow, a rolled towel for lumbar support, or a box for foot support

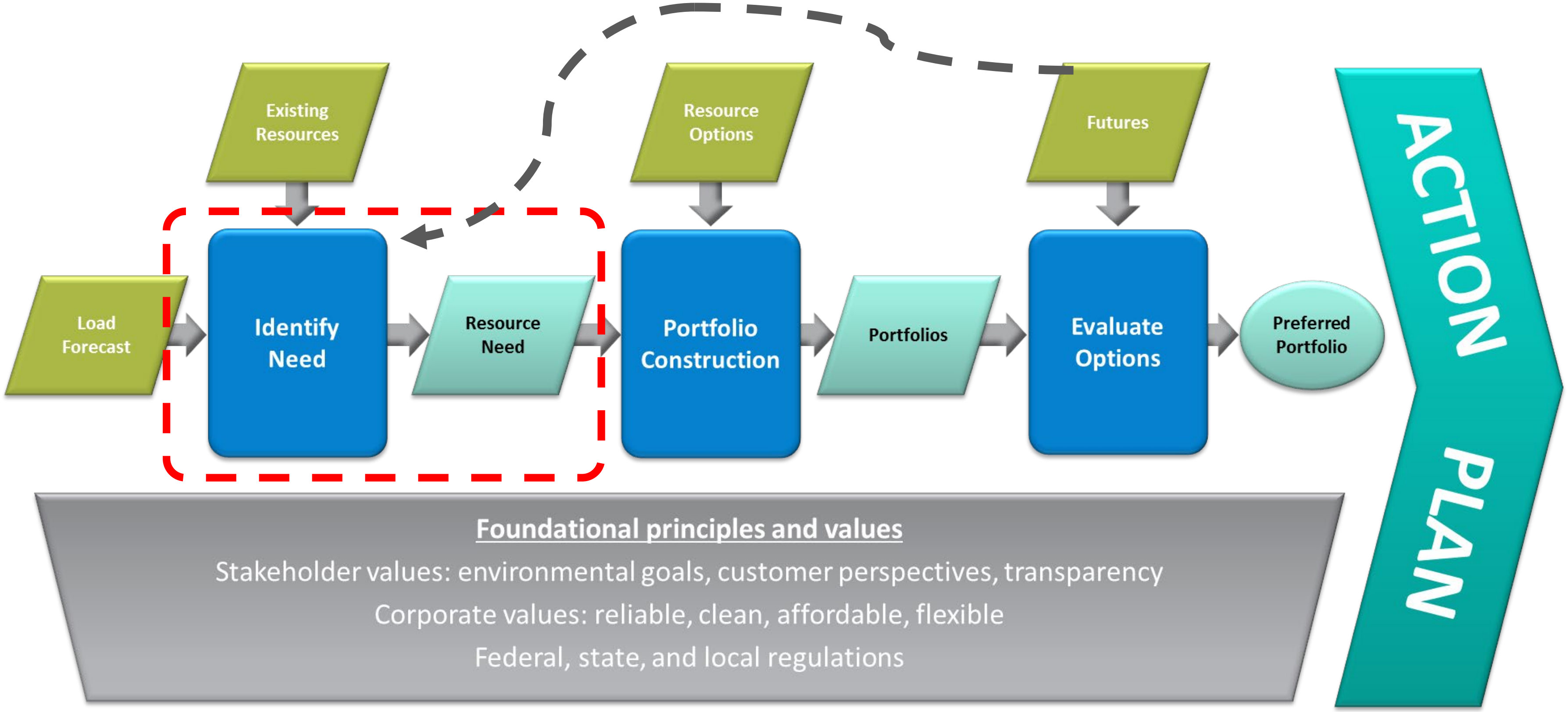
AGENDA

- Welcome and Introductions
- Capacity Assessment: Preliminary Model Development Workshop
    - 60 minutes
    - Discussion of preliminary model development
- Climate adaptation enabling study
    - 30 minutes
    - Stakeholder input for design/scoping

Capacity Assessment: Preliminary Model Development Workshop

Kate von Reis Baron, Elaine Hart

Need Assessment Analysis



Roundtable 20-1 Capacity Assessment Review

- The discussion included a capacity assessment high-level introduction and an introduction to the Sequoia model. The slides from RT 20-1 are available at:

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

Capacity Review

- **Capacity adequacy** means that a system has sufficient resources to meet a reliability standard (e.g., a loss of load probability of one event in ten years).
- **Capacity need** is the amount of additional resources needed to achieve the adequacy standard.
- **Capacity contribution** is the reduction to capacity need from adding an incremental resource. It is dependent both on the new resource characteristics and the characteristics of the system.

Sequoia

A Monte Carlo time-sequential capacity assessment model that calculates capacity need and capacity contribution of incremental resources.

Key objectives:

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

Sequoia Component Overview

#1 Input Data → #2 Monte Carlo Module → #3 Dispatch Module → #4 Output Metrics

Sequoia
Phase 1 Goals

- Improve treatment of energy-limited resources
- Improve process efficiency

Sequoia Monte Carlo Module

- For a single test year run, Sequoia builds thousands of weeks of load and resource information from the input data
- Each week's data set is drawn independent of the other weeks
- In the preliminary model, for a given week, the simulation:
  - ❑ Randomly draws a set of seven consecutive historical days and a historical hydro year
  - ❑ Identifies the types of days that were drawn in terms of month, weather conditions, and weekday/weekend classification
  - ❑ Randomly selects variables or hourly shapes corresponding to the day types for each day (e.g., load, wind, solar shapes)
  - ❑ Randomly selects variables that are independent of day type (e.g., plant forced outages)
  - ❑ Pulls weekly hydro conditions corresponding to the hydro year and month
  - ❑ Pulls deterministic (or non-probabilistic) information corresponding to the day types for each day (e.g., thermal plant ratings and simplified resource shapes)

Sequoia Component Overview

#1 Input Data → #2 Monte Carlo Module → #3 Dispatch Module → #4 Output Metrics

Sequoia Dispatch Module

Sequoia Phase 1 Goals

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

- Sequoia passes information for the thousands of drawn weeks from the Monte Carlo module to a dispatch simulation module
- Each week is examined independently
- The dispatch module has perfect foresight of load and resources across a week (no forecast error)
- For a given week, the module:
  - Optimizes all resource dispatch in order to minimize a linear reliability objective (e.g., unserved energy, maximum capacity shortage)
  - Determines the amount of resources needed to remove unserved energy in that week
- Capacity contribution values for new resource options can be determined by testing multiple scenarios within a single run

Dispatch Simulation

The dispatch simulation determines the availability of resources in each hour.

Both RECAP and Sequoia simulate availability. What is different about Sequoia, and why?

RECAP	SEQUOIA	Why?
Time-Independent Availability in each hour is fixed based on independent stochastic variables for all resources.	**Time-dependent** Availability in one hour may change for dispatchable resources based on dispatch decisions in other hours.	**Energy constraints** Time-dependent simulation allows us to better characterize resources that are constrained over time (e.g., storage hydro and energy storage).
Independent Resources Availability of each resource has no bearing on the availability of others.	**Co-optimized Resources** Dispatchable resources "see each other" and may coordinate to better avoid lost load.	**Portfolio effects** Dispatching the entire system together allows us to better capture interactive effects between resources (e.g., renewables and energy storage).
Exogenous Estimates Heuristics and outboard calculations are used to estimate the impacts of energy limitations.	**Endogenous Calculations** Energy-limitations and interactions between resources are solved for by the model endogenously.	**Accuracy and Process Efficiency** Endogenous treatment is more accurate, reduces the number of calculations, reduces the amount of input data, and reduces the likelihood of human error.

Sequoia Dispatch Simulation

Sequoia solves for resource dispatch in each hour over the course of each week (i.e., Monte Carlo draw) using an optimization model

Objective Function

Minimize total unserved energy ($\sum_t UE_t$) or the maximum capacity shortage ($max(UE_t)$) across the week

Constraints

Dispatch Constraints are specific to each *Dispatch Type*

- Fixed Resources
- Hydro with Storage
- Natural Gas
- Energy Storage
- Flexible Load
- Energy-limited generic

Load Balance Constraint

$$\sum_R D_t^R + UE_t \geq L_t$$

Total dispatch ($\sum_R D_t^R$) plus unserved energy (UE_t) must exceed load (L_t)

Note: this representation is simplified and focuses on a single transmission zone

Optimization Considerations

The nature of Resource Adequacy modeling is such that we're most interested in tail (e.g., unlikely) events.

Converging on the likelihood of an unlikely event requires that you consider A LOT of potential conditions (likely tens of thousands of draws)

Simulating dispatch in each draw therefore has to happen very quickly to avoid untenable runtimes

Optimization problems may be quite slow, depending on how they are designed

Optimization problem design is key to model convergence

Optimization Considerations

How have we designed the Sequoia dispatch optimization to meet the runtime requirements of a resource adequacy study?

- Everything is linear (linear objective function and linear constraints)
  - Cannot represent non-linear phenomena (e.g., a hydro efficiency curve)
- Everything is continuous (no integer or binary variables)
  - Cannot represent unit commitment decisions (i.e., every unit is assumed to be on if not on outage)
- Everything is aggregated (resources are aggregated by dispatch type to solve for fleet-wide dispatch and are reported by dispatch and resource type)
  - Cannot report specific resource dispatch behavior, but aggregated behavior by resource type
  - May overestimate the ability to coordinate energy-limited resources within a dispatch type

What is the result?

- Recent tests simulated 40,000 draws in about 1.5 hours (using Gurobi Solver on a desktop computer)
- With additional efficiencies in run structure and optimized parallelization, we expect the suite of simulations required for the IRP to require on the order of the same amount of time as RECAP

Related implications

- Will dramatically improve visibility into the circumstances driving resource adequacy challenges and ability to vet findings
- Running the model requires a Gurobi license and significant computing resource

Sequoia Dispatch Types and Resource Types

Dispatch Type – identifies how a resource can be dispatched

Resource Type – identifies the energy source of the resource (e.g., wind, natural gas)

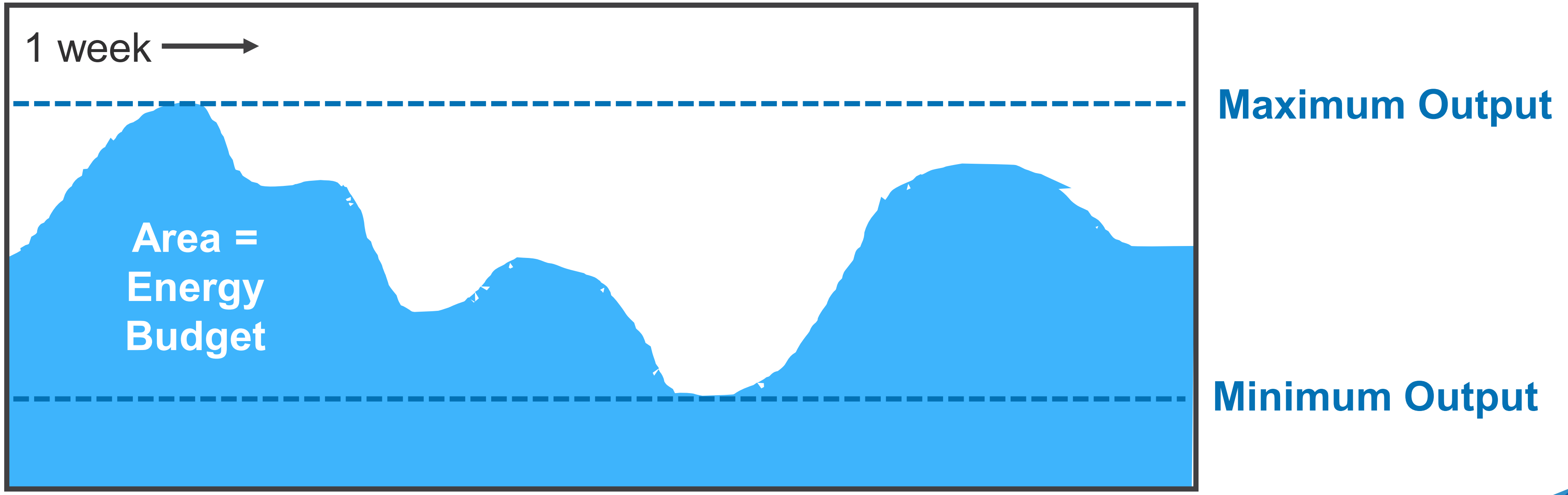
		Dispatch Types				
		Generic Fixed	Hydro w/ Storage	Natural Gas	Energy Storage	Generic Energy-Limited
Example Resource Types	Wind	X				
	Solar	X				
	Other Renewables	X				X
	Customer Generation	X				
	Storage				X	
	Hydro	X	X			
	Natural Gas			X		
	Coal	X				
	Contract or Other	X	X	X	X	X

Deeper Dive: Hydro with Storage

Hydro resources that have storage capability (e.g. Pelton Round Butte, Mid-C contracts, excludes run-of-river plants)

Stochastic Inputs	Max. output, min. output, and weekly energy budget based on hydro year and month
Deterministic Inputs	None
Aggregation	Dispatch aggregated by hydro zones

Dispatch Constraints



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Dispatch Constraints

Maximum Output

Total hydro generation (D_t^H) in hour *t* and hydro zone *H* must not exceed the sum of the maximum output levels ($D_{R,W}^{max}$) of all hydro resources in the zone based on the month and hydro year

$$D_t^H \leq \sum_{R \in H} D_{R,W}^{max}$$

Minimum Output

Total hydro generation (D_t^H) in hour *t* and hydro zone *H* must exceed the sum of the minimum output levels ($D_{R,W}^{min}$) of all hydro resources in the zone based on the month and hydro year

$$D_t^H \geq \sum_{R \in H} D_{R,W}^{min}$$

Weekly Energy Budget

Total hydro generation (D_t^H) across week *W* in hydro zone *H* must equal the sum of the weekly hydro budgets ($E_{R,W}$) for hydro resources in the zone, based on the month and hydro year.

$$\sum_{t \in W, R \in H} D_t^H = \sum_{R \in H} E_{R,W}$$

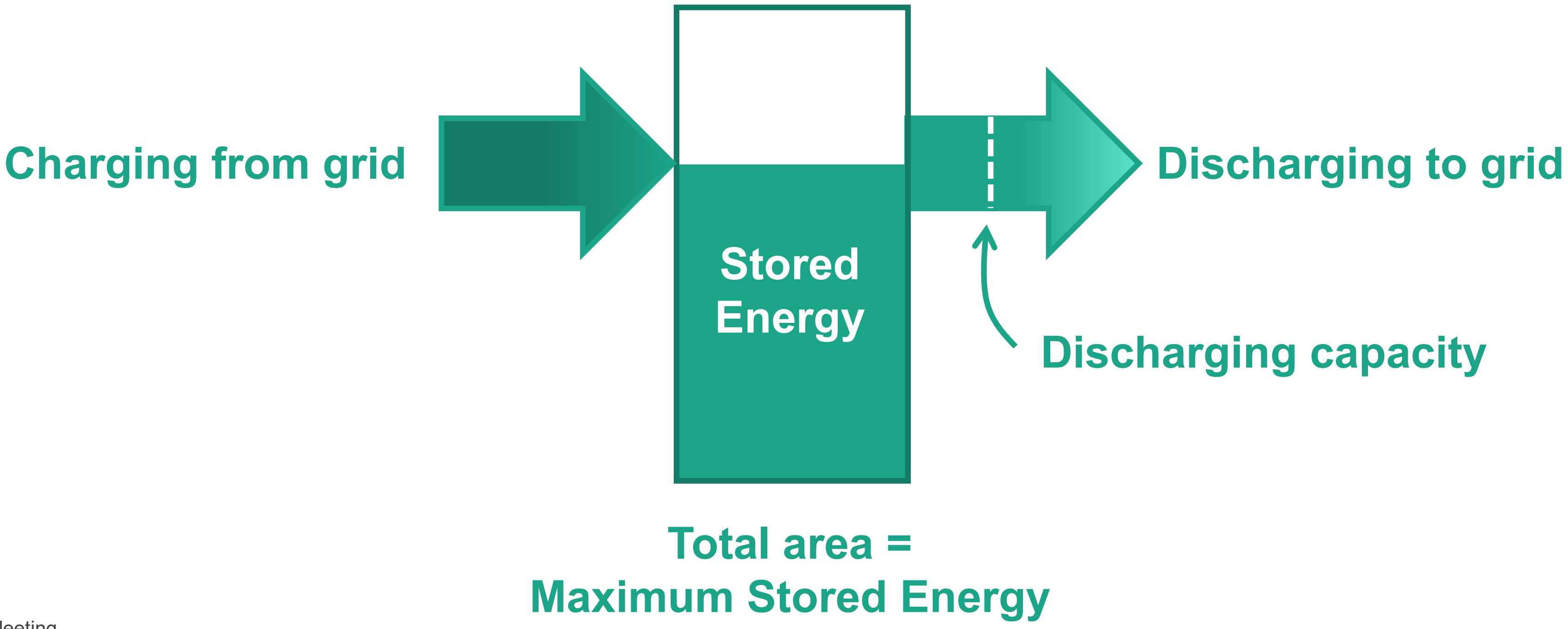
Note: this representation is simplified and focuses on hydro in a single transmission zone

Deeper Dive: Energy Storage

Stand-alone energy storage resources, (e.g., batteries and pumped storage)

Stochastic Inputs	Unit forced outages
Deterministic Inputs	Installed charge/discharge capacity, storage duration, and roundtrip efficiency
Aggregation	Dispatch aggregated by transmission zones

Dispatch Constraints



Deeper Dive: Energy Storage

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Stochastic Inputs	Unit forced outages
Deterministic Inputs	Installed charge/discharge capacity, storage duration, and roundtrip efficiency
Aggregation	Dispatch aggregated by transmission zones

Dispatch Constraints

Energy balance

The stored energy (S_t) in time *t* must equal the stored energy in time *t*-1 plus the charging from the grid (C_t^S), minus the energy discharged to the grid D_t^S, both adjusted for losses.

$$S_t = S_{t-1} + \sqrt{\eta} C_t^S - \frac{D_t^S}{\sqrt{\eta}}$$

Maximum Charging and Discharging

Both the charging from the grid and discharging to the grid must not exceed the sum of the storage discharging capacity (D_R^{max}) from available units ($u_{R,t}$) in transmission zone *T* after accounting for forced outages.

$$D_t^S \leq \sum_{R \in T} u_{R,t} D_R^{max}$$

$$C_t^S \leq \sum_{R \in T} u_{R,t} D_R^{max}$$

Maximum Stored Energy

The stored energy must not exceed the sum of the storage capacity (S_R^{max}) from available units ($u_{R,t}$) in transmission zone *T* after accounting for forced outages and adjusted for losses.

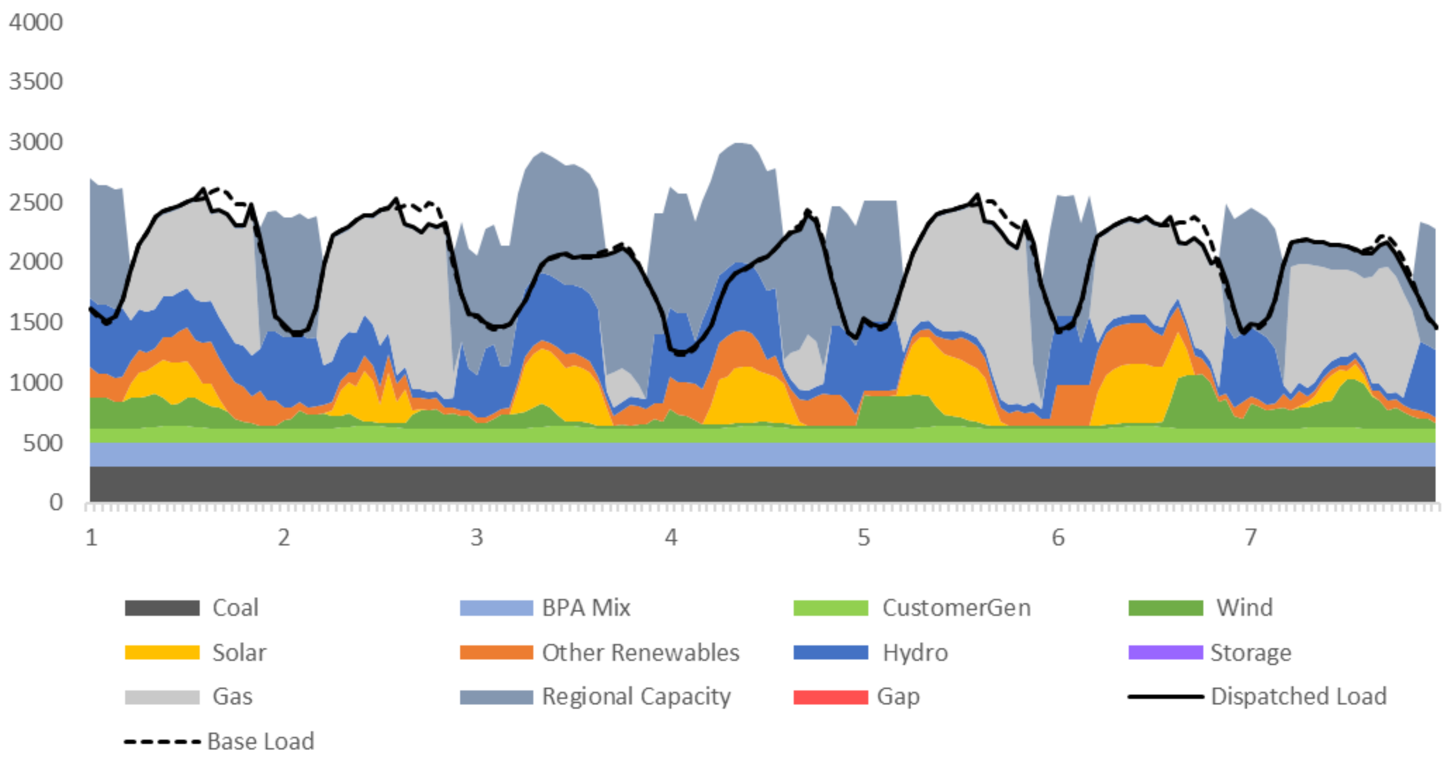
$$S_t \leq \frac{\sum_{R \in T} u_{R,t} \eta_R S_R^{max}}{\sum_{R \in T} \eta_R}$$

Where η_R is the roundtrip efficiency of storage resource *R*, and η is the weighted average roundtrip efficiency of all storage resources in the transmission zone:

$$\eta = \frac{\sum_{R \in T} \eta_R S_R^{max}}{\sum_{R \in T} S_R^{max}}$$

Sequoia Dispatch Example #1

A week without unserved energy…



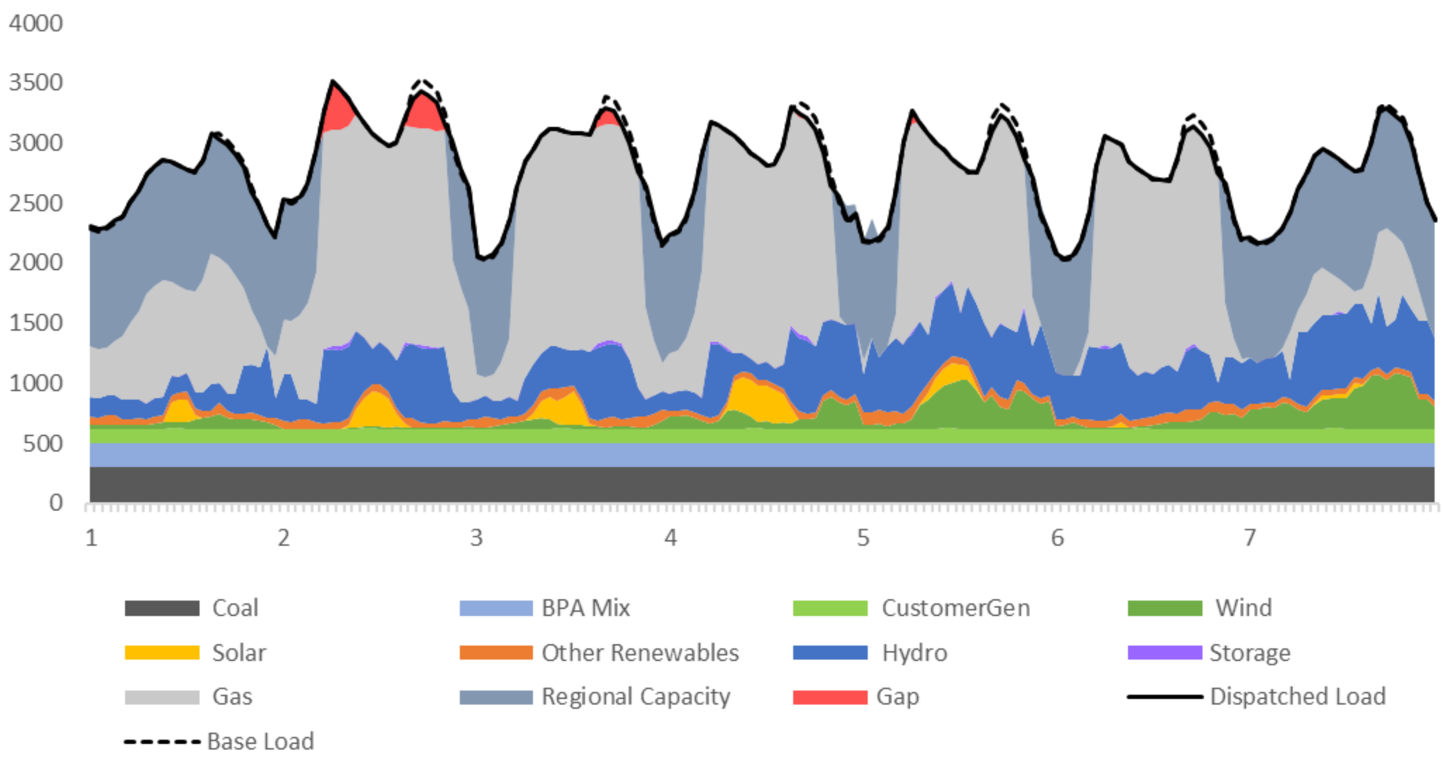
*Graph reflects actual simulation with placeholder input data

On weeks without unserved energy, resource availability for dispatchable resources may be unintuitive.

This is because there are multiple solutions that minimize the objective (unserved energy) and no one of those solutions is better than the others.

Sequoia Dispatch Example #2

A week with unserved energy…



*Graph reflects actual simulation with placeholder input data

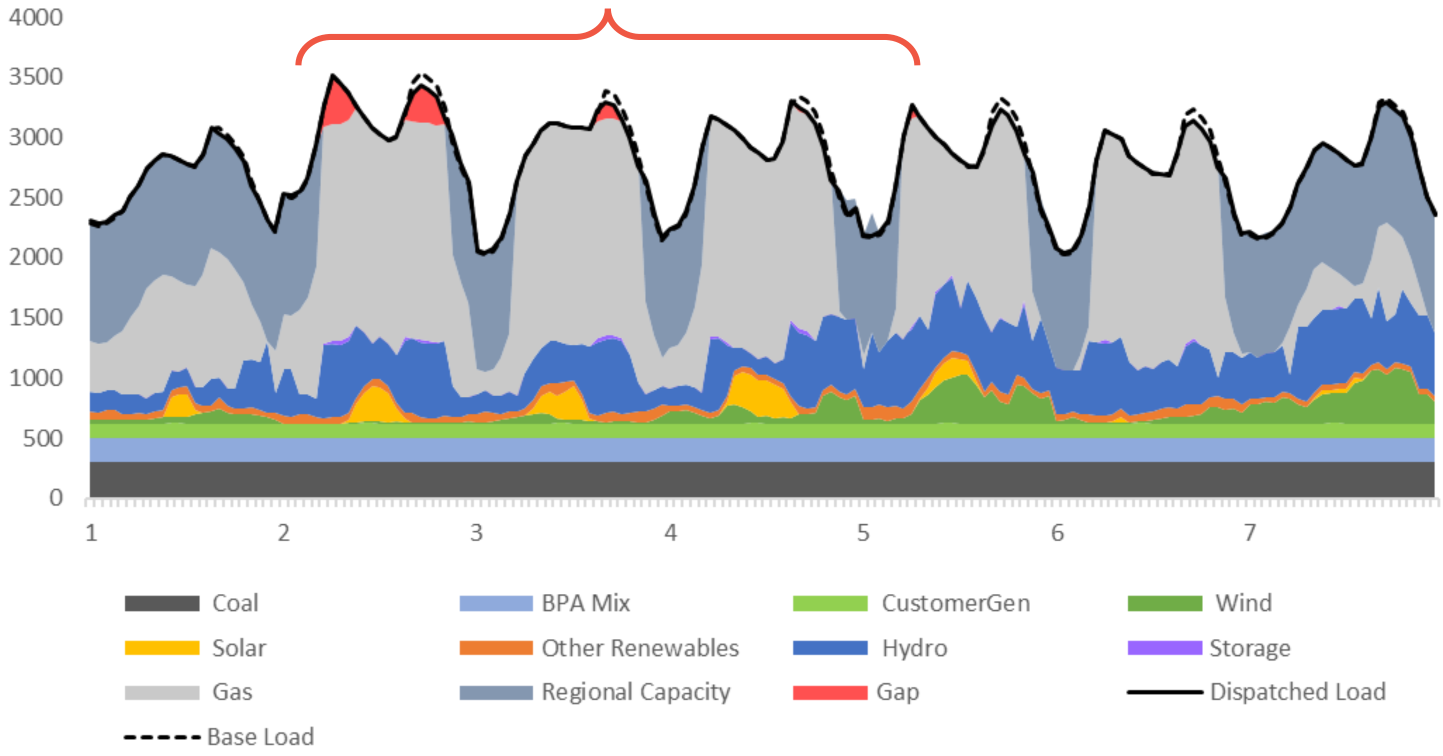
On weeks with unserved energy, resource availability for dispatchable resources makes more sense – the resources are used when they are needed most.

Note that multiple solutions may still exist if the week is only energy-constrained.

…these are the weeks we focus on

Loss of load metrics

Unserved Energy (USE or UE):
The total area shaded red (2,867 MWh)



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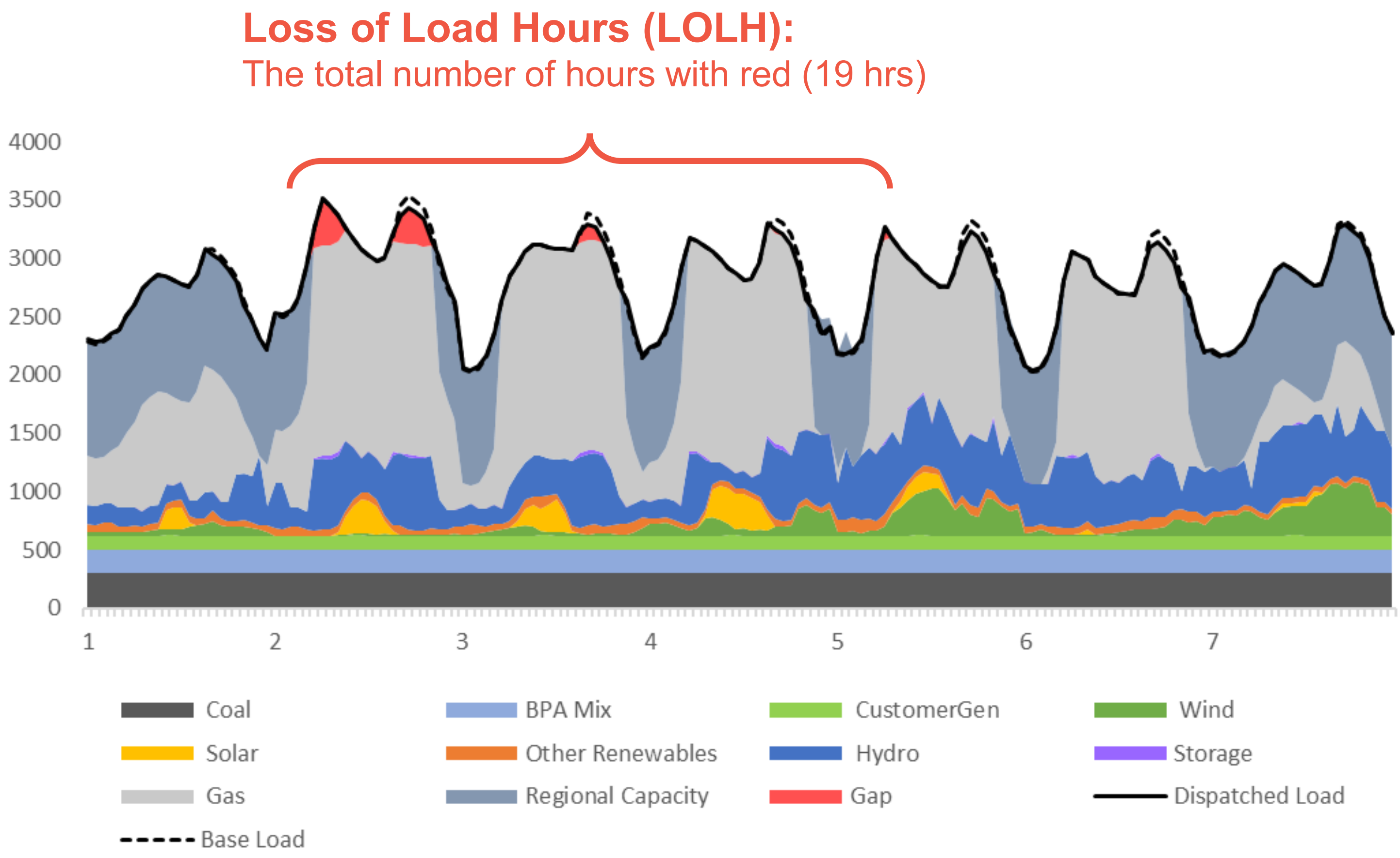
Loss of load metrics



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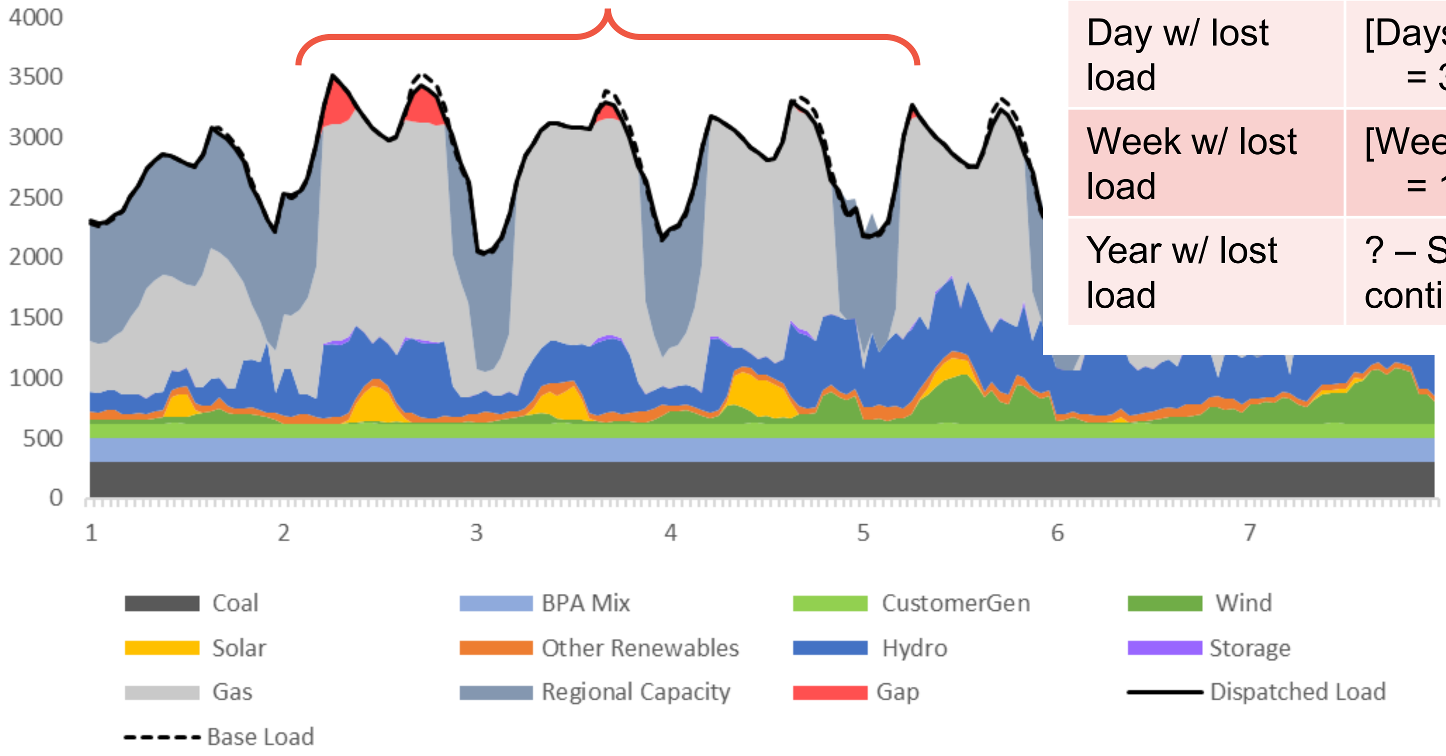
Loss of load metrics

Loss of Load Probability (LOLP):
It depends on how you define a loss of load event



*Graph reflects actual simulation with placeholder input data

Event	LOLP Definition
Hour w/ lost load	LOLH/[Total hours] = 19/(Dx168)
Day w/ lost load	[Days with lost load]/[Total days] = 3/(Dx7)
Week w/ lost load	[Weeks with lost load]/[Total weeks] = 1/D
Year w/ lost load	? – Sequoia does not model continuous years, but NWPCC does

D = Total number of draws

Sequoia Component Overview

#1 Input Data → #2 Monte Carlo Module → #3 Dispatch Module → #4 Output Metrics

Sequoia Input Data

Sequoia Phase 1 Goals

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

- Sequoia will have multiple input data types to capture load and resource characteristics
- Sequoia will build on inputs from RECAP with improvements to achieve Phase 1 goals
- The preliminary model is using placeholder data for some inputs as input data is being developed over the upcoming months
- Some placeholders were also created for fields that may be used in Phase 2 (e.g., transmission zones)
- Sequoia is a resource adequacy model, not an economic dispatch model. There are no inputs for market prices or resource costs

Sequoia Input Data: Load

- One of the foundational pieces of input data for a the resource adequacy model is the hourly econometric load forecast with weather variation
- A load simulation tool is being developed for PGE by the Cadmus Group to improve the development of the hourly load profile
- PGE will be reviewing the draft tool this month

Load Simulation Tool

- Improved efficiency for updating to new load forecasts
- Improved weather simulation and ability to update for more recent weather information
- Improved calibration by customer revenue class

Sequoia Input Data: Load Simulation Tool

- The load simulation tool is a Python based program that will create thirty years of weather-simulated hourly load by customer revenue class, and then calibrate the values to the customer revenue class forecast for the test year
- Cadmus is examining hourly weather variables (current and lagged), machine learning and regression methods, testing the training period, and testing calibration methodologies
- The tool is designed to allow PGE to update the model going forward with additional weather information, historical load, and updated econometric load forecasts

Sequoia Next Steps

Sequoia Phase 1 Goals

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

- Work with Cadmus to finalize the Load Simulation Tool
- Populate additional input data (hydro, DER)
- Continue refining code, optimizing run time, validation
- Develop output reports and documentation
- Share additional learnings and preliminary results at an upcoming Roundtable

QUESTIONS/ DISCUSSION?

Climate Adaptation Enabling Study

Seth Wiggins

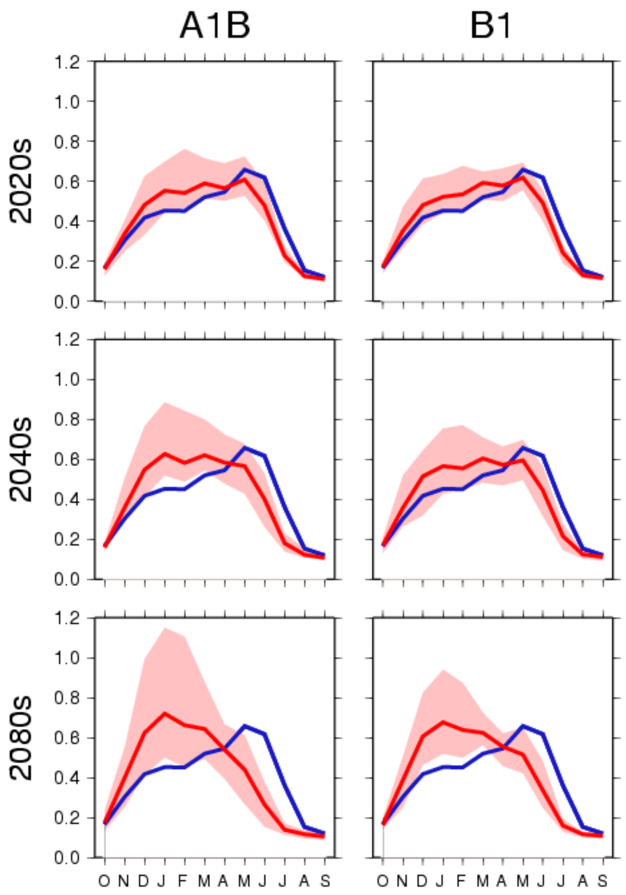
Prior climate adaptation work: 2016 IRP

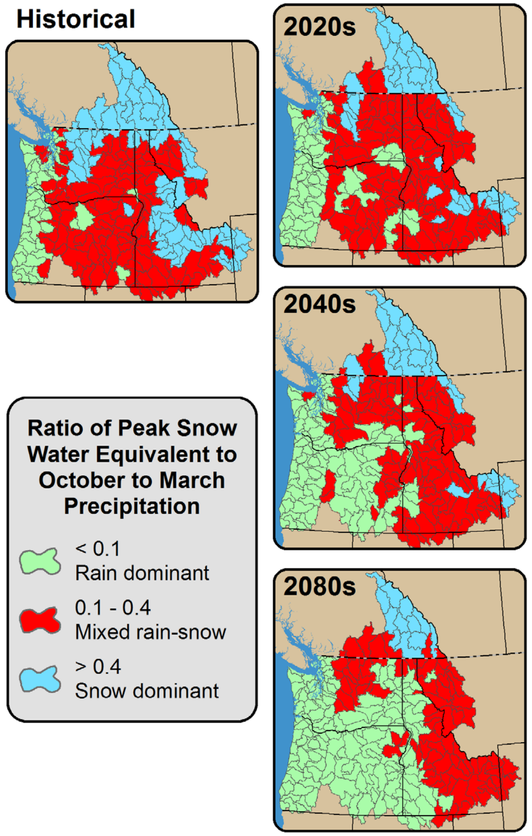
PGE commissioned OSU's Oregon Climate Change Research Institute (OCCRI)

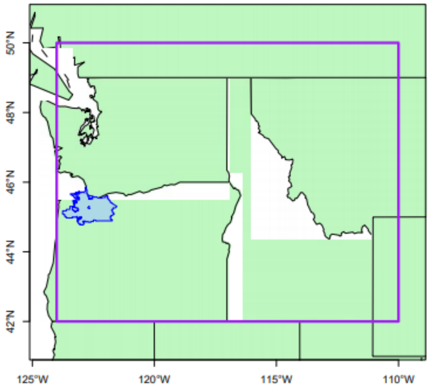
Scope:

- Regional impacts to weather, including temperature and precipitation and potential impacts to streamflows
- High level discussion of potential impacts to other factors including cloud cover, wind speeds, wildfire risk

Study did not estimate specific impacts to PGE loads and resources nor investigate climate adaptation options







Prior climate adaptation work: 2019 IRP

PGE commissioned Evolved Energy Research to evaluate economy-wide deep decarbonization

Study Scope:

- Investigate pathways to achieve 80% reduction below 1990 levels of energy-related CO2 emissions
- Evaluate common themes among these pathways as well as the trade-offs between them

Some results from this study were incorporated into a deep decarbonization scenario that was investigated in the IRP.

Figure 13 Three Pillars of Decarbonization

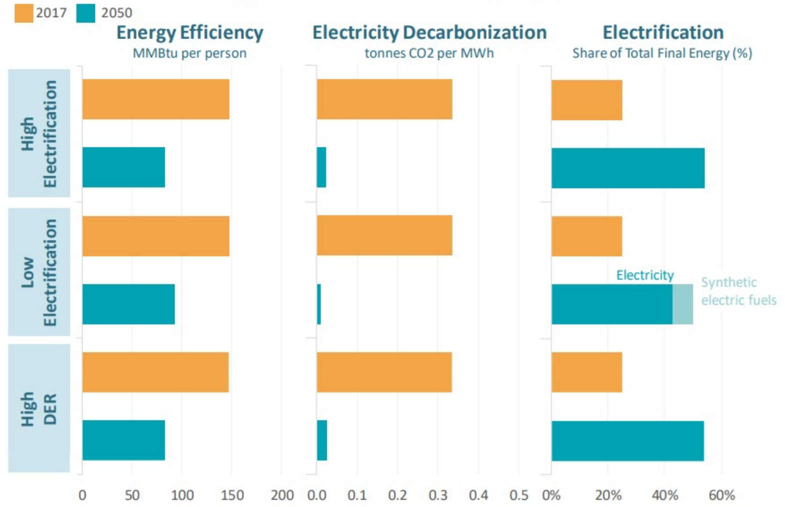
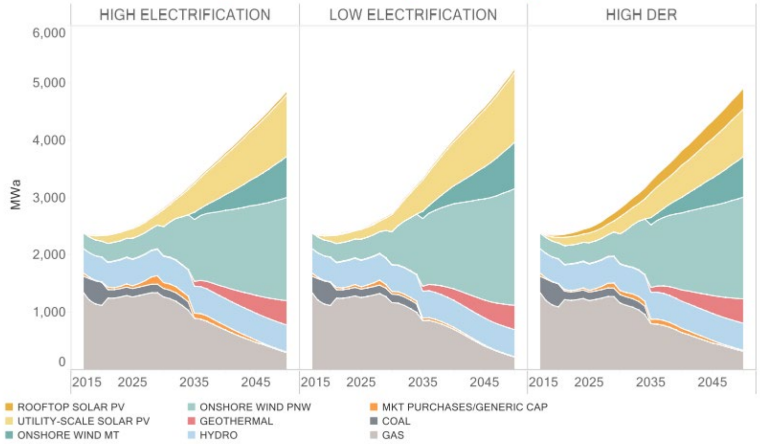


Figure 33 Generation by Resource Type

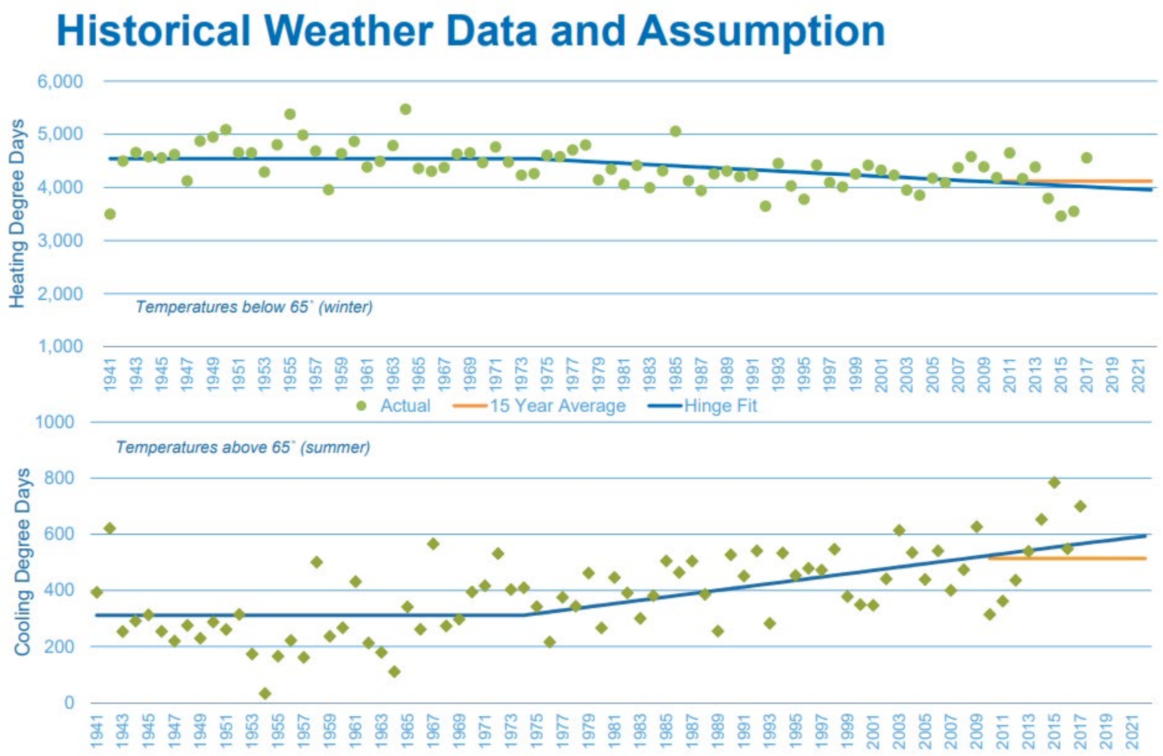


Prior climate adaptation work: Load Forecasts

Since the 2018 GRC (UE 335), PGE's load forecast has included a trended-weather assumption

Methodology first presented in PGE's 2017 GRC (UE 319)

- A main input to both average and peak load forecasts is weather
- Forecasts relied on historic averages of weather to describe 'normal' conditions
- To capture the effects on demand of regional warming, the load forecast included a 'trended-normal' assumption
    - This increased temperature forecasts by a linear trend starting in 1975 and continuing forward
    - This trend is included in long-term energy models



Current IRP

PGE plans to engage an external consultant to support the Climate Adaption Study

We welcome feedback on the scope of the study. Potential items in scope:

- **Best practices:** *What can we learn from other studies?*
- **Resource Demand**: *How could customer loads change?*
- **Resource Supply**: *How could generation availability change?*
- **Engagement:** *Could we be more inclusive in our climate resilience planning?*

QUESTIONS/ DISCUSSION?

THANK YOU

Contact us at:

IRP@pgn.com