Integrated Resource Planning

ROUNDTABLE 22-6

JULY 2022

PGE

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

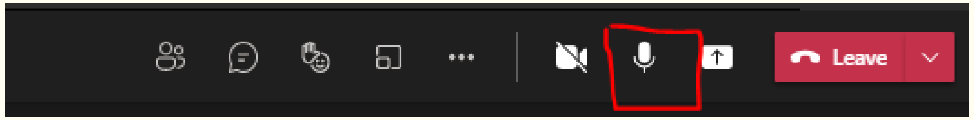
*Please use Microsoft Edge or Google Chrome with Teams as it will give you the best experience

+1 971-277-2317 (dial this number from your phone for best results)

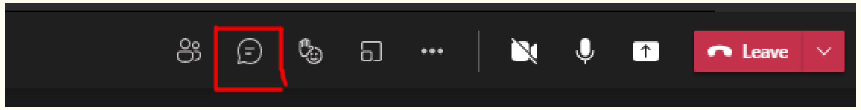
PW: 649 302 997#

PARTICIPATION

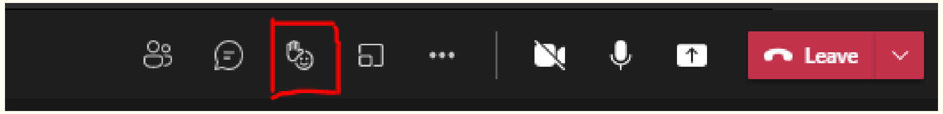
- Mute your mic while others are speaking; to unmute via phone press *6



- 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 would 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
Need Futures	30 minutes
Yearly Capacity Needs	30 minutes
Distributed Energy Resources	30 minutes
Updated WECC Pricing	30 minutes

SAFETY MOMENT

Summer heat

Practice summer safety to avoid common heat-related injuries

Heat Rash: an uncomfortable rash that can be caused by blocked sweat glands, which then causes inflammation

Heatstroke: caused when your body is overheating. Often, this is caused by prolonged exposure to the sun or working in hot temperatures.

Sunburns: burns on the skin and eyes caused by UV rays

Protect yourself by:

- Drink water every 15 minutes
- Wear sunscreen of 30 spf
- Work in the shade if possible
- Wear appropriate clothing

NEED FUTURES

NIHIT SHAH

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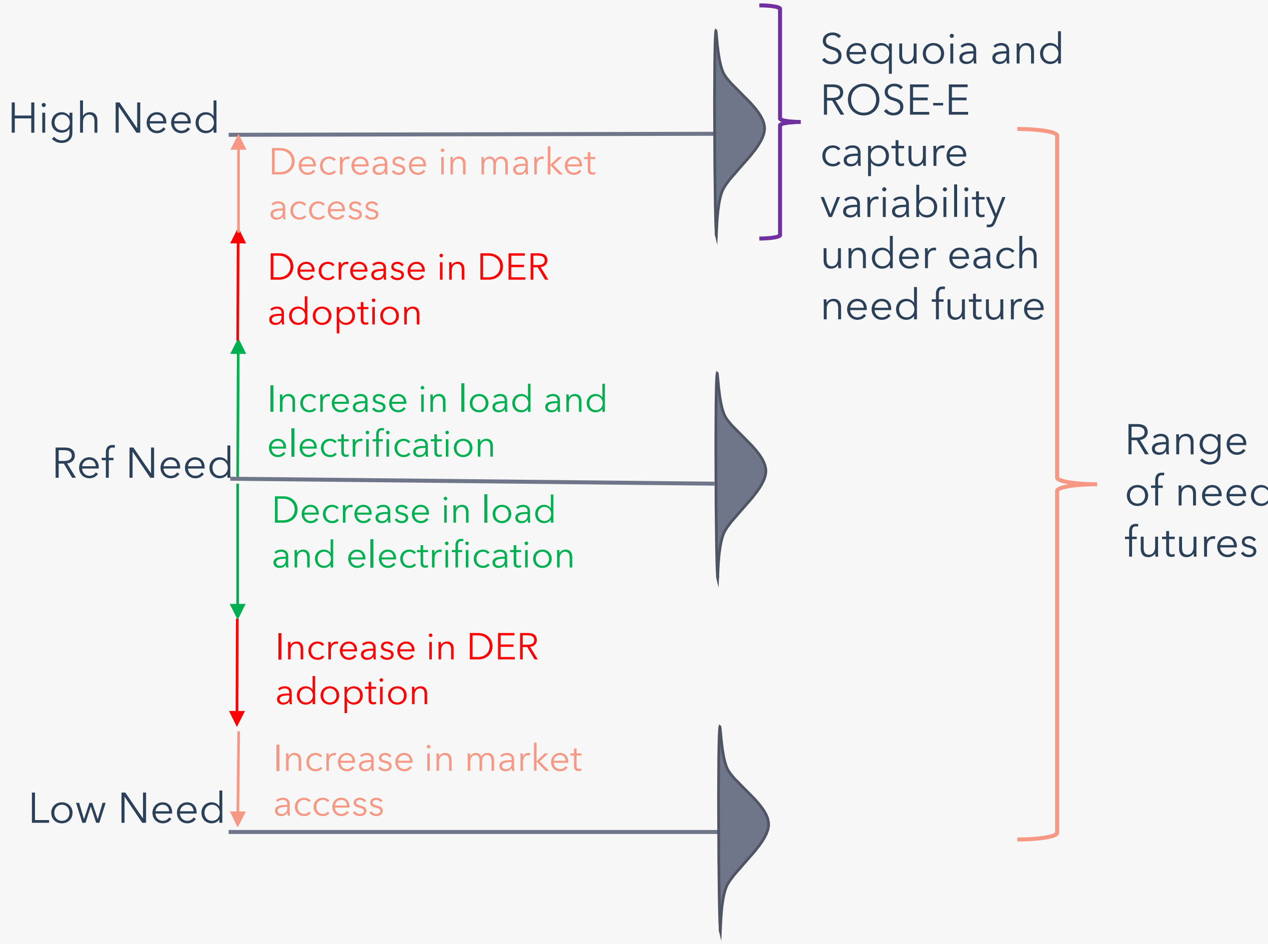
Capturing a Broad Range of Need Futures

Need futures set the upper and lower bounds for capacity needs

- ROSE-E builds to these broad range of need futures
- Resource selection across these need futures provide Insights on short-term additions of the preferred portfolio

To capture a wide range of futures, PGE considers the compounding impacts of:

- Load including electrification
- DER adoption
- Market access



2019 IRP Need Futures

2019 IRP	Low Need Future	Reference Need	High Need Future
Top-down Load Forecast	Low Growth	Reference	High Growth
Energy Efficiency	High EE	Reference	Reference
Distributed PV	High Adoption	Reference	Low Adoption
EV + DLCEV	Low Adoption	Reference	High Adoption
Demand Response	High Participation	Reference	Low Participation
Customer Battery Storage	High Adoption	Reference	Low Adoption
Market Capacity	High Availability	Reference	Low Availability

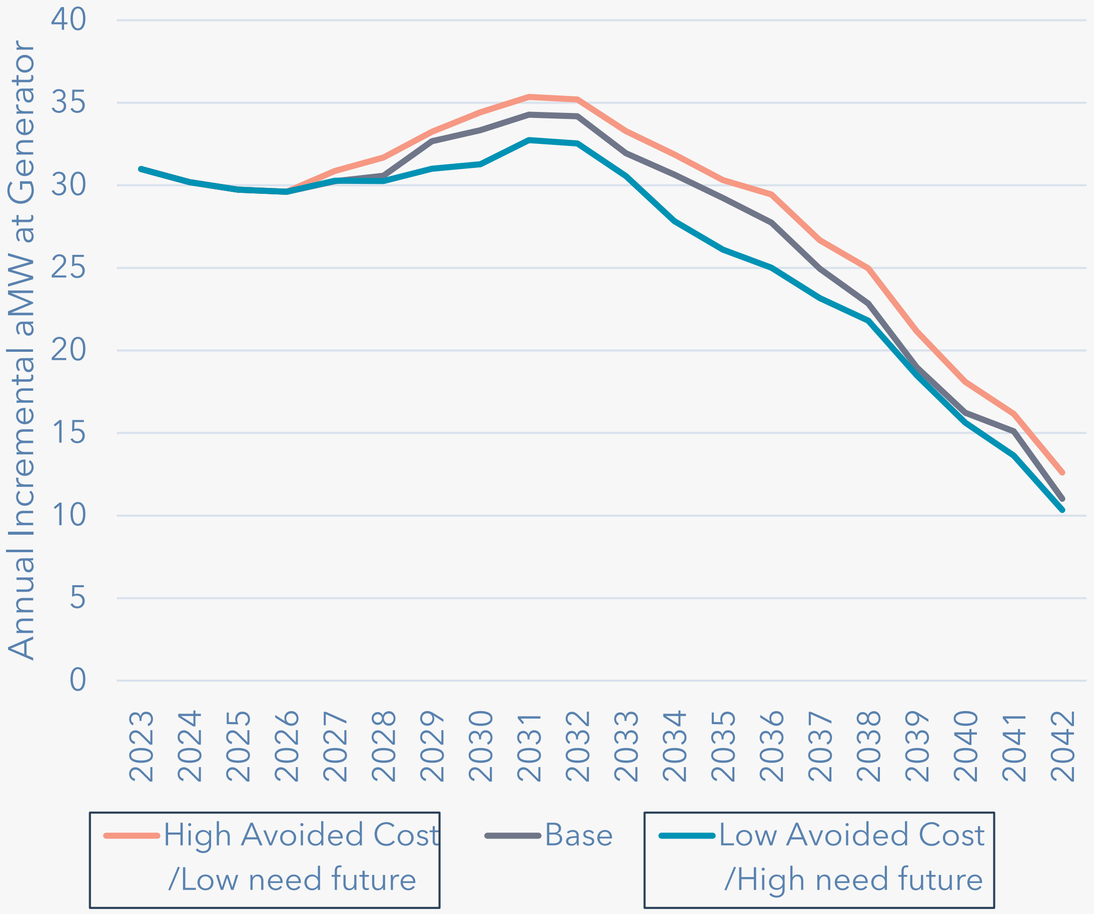
2023 IRP Need Futures – Recommendation

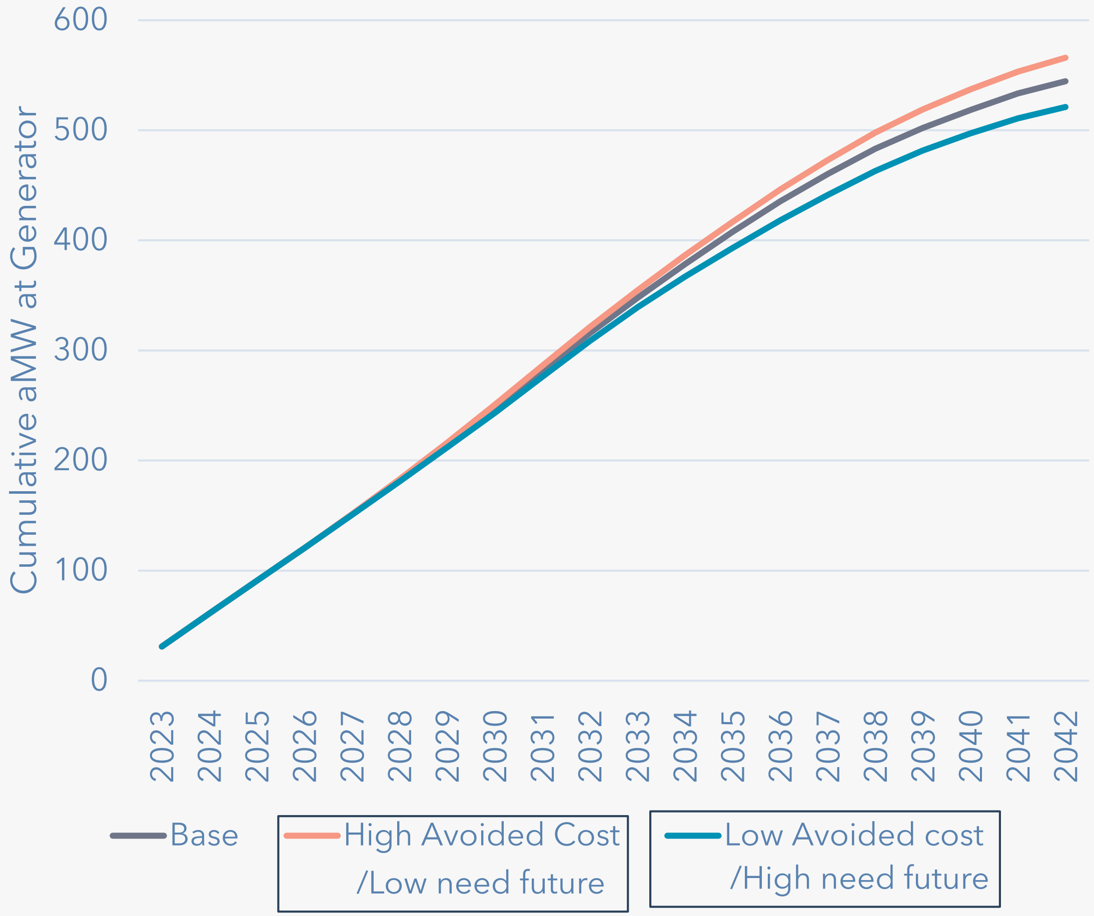
	Low Need Future	Reference Need	High Need Future	Roundtable Presentation Date
Top-down Load Forecast	Low Growth	Reference	High Growth	March 2022
Energy Efficiency	High EE	Reference	**Low EE**	July 2022
Distributed PV	High Adoption	Reference	Low Adoption	July 2022
EV load and associated DR programs	Low Adoption of EV load and **reference adoption of EV related DR programs**	Reference	High Adoption of EV load and **low adoption of EV related DR programs**	July 2022
Demand Response Programs	High Adoption	Reference	Low Adoption	July 2022
Customer Owned Battery Storage	High Adoption	Reference	Low Adoption	July 2022
Market Capacity	High Availability	Reference	Low Availability	June 2022 (updated in July 2022)
Building electrification and associated DR programs	**Low Adoption of BE loads and reference adoption of BE related DR programs**	**Reference**	**High Adoption of BE loads and low adoption of BE related DR programs**	July 2022

Changes from 2019 IRP reflected in **blue**

Visualizing the need futures

Energy Efficiency Scenarios

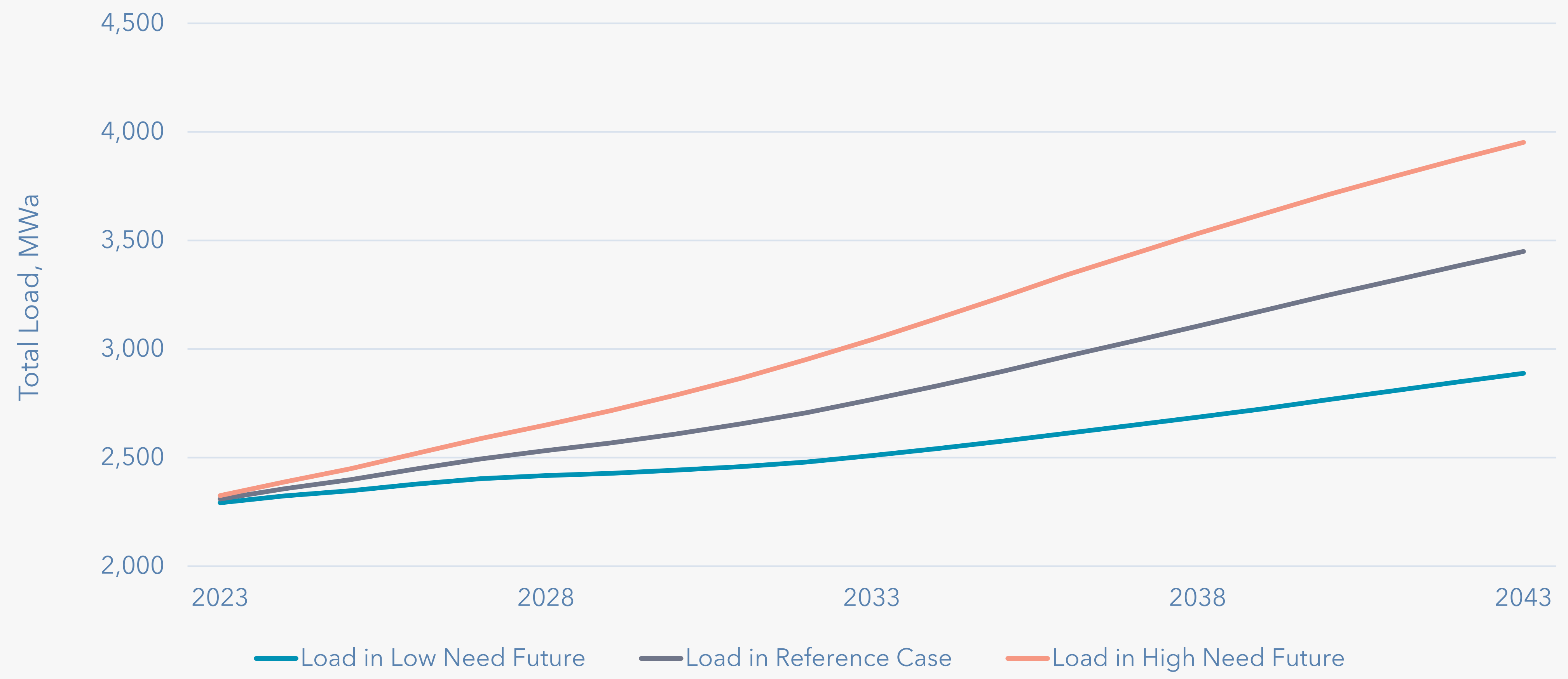




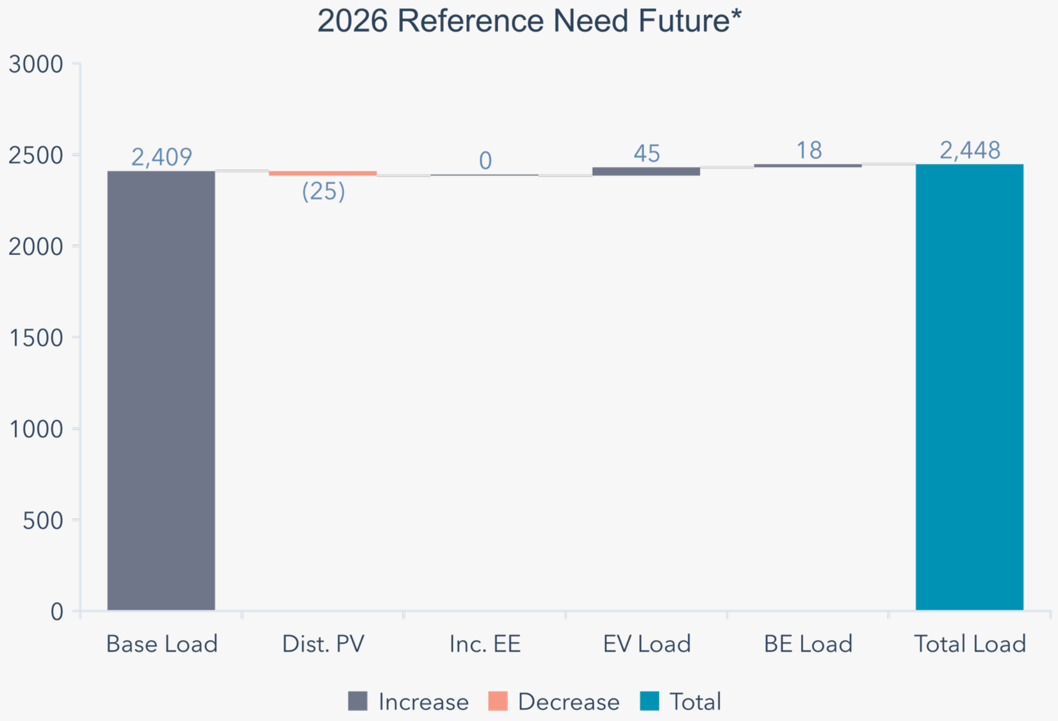
Market Access Assumptions

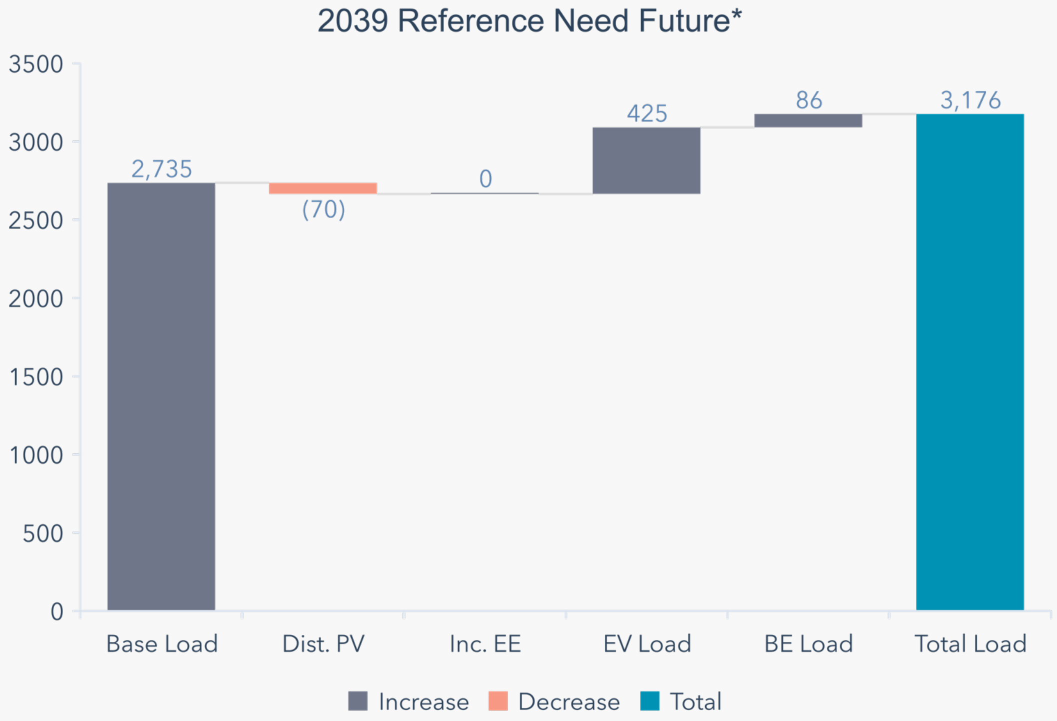
	Winter (HLH)		Summer (HLH)
	Before 2026	2026 and beyond	All years
Reference Future	200MW	100MW	0MW
High Need Future	150MW	0MW	0MW
Low Need Future	300MW	200MW	0MW

Load Across Need Futures



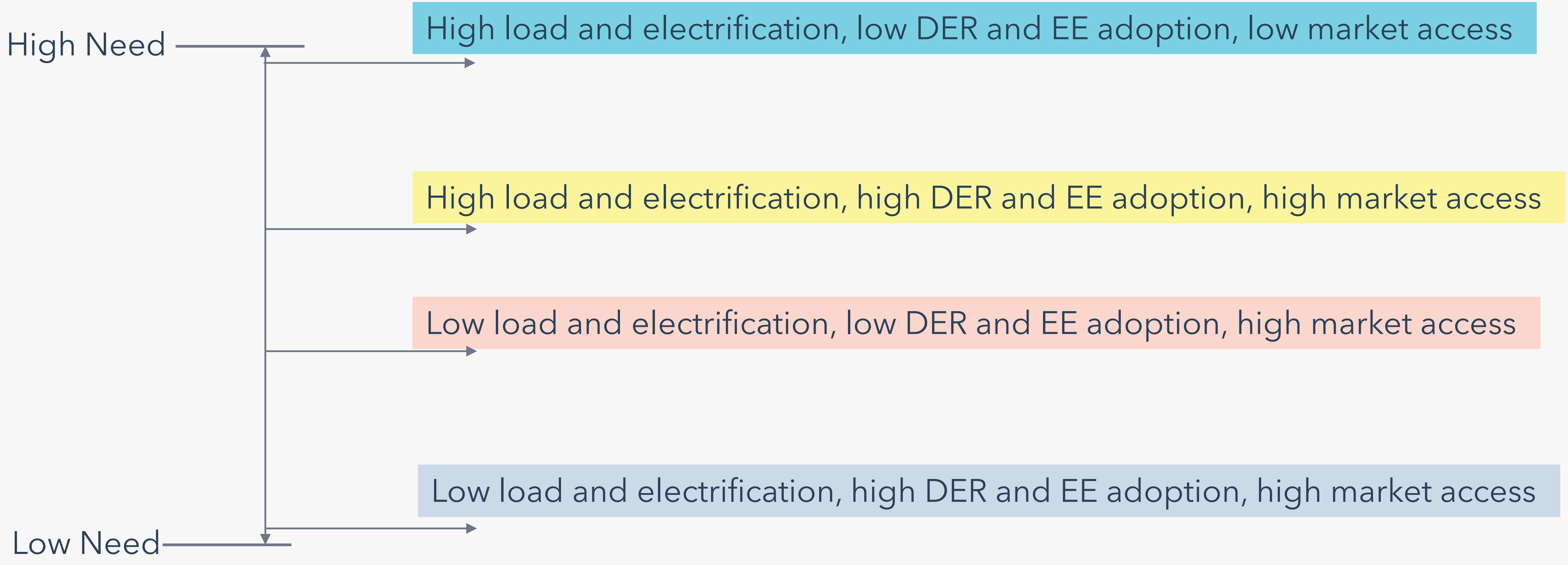
Net energy impact of passive components





*Existing (pre-2022) loads from electrification and load reduction from PV are included within the base load

Implicitly captured need futures



YEARLY CAPACITY NEEDS

TOMÁS MORRISSEY

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Sequoia – Model Basics

a) Hourly Monte Carlo adequacy model developed in-house after 2019 IRP
    a) Created to improve modeling of energy limited resources
    b) Has been used in the 2019 IRP Update, various PUC dockets, a PGE RFP, and discussed in in various IRP roundtable meetings

b) Targets an annual loss-of-load-hour metric of 2.4 hours / year

c) Creates synthetic weeks out of input data – currently simulating 50,000 weeks / year

d) Incorporates PGE resources, owned/contracted resources, and new proxy resources

Sequoia Model Tuning

- Model is final enough to start sharing some results

- We will likely see changes before publishing due to:
  - *RFP resources being signed (we have proxy resources in the model now)*
  - *Existing contracts being renewed*
  - *New contracts being signed*
  - *General model quality control*
  - *Major policy shifts*

- Big items that are locked
  - *Modeling methodology*
  - *Load forecast*
  - *DER inputs*
  - *New resources we are testing for ELCCs*

What Has Changed Since the RFP

In fall 2021 the RFP proxy need was 372 MW for year 2025

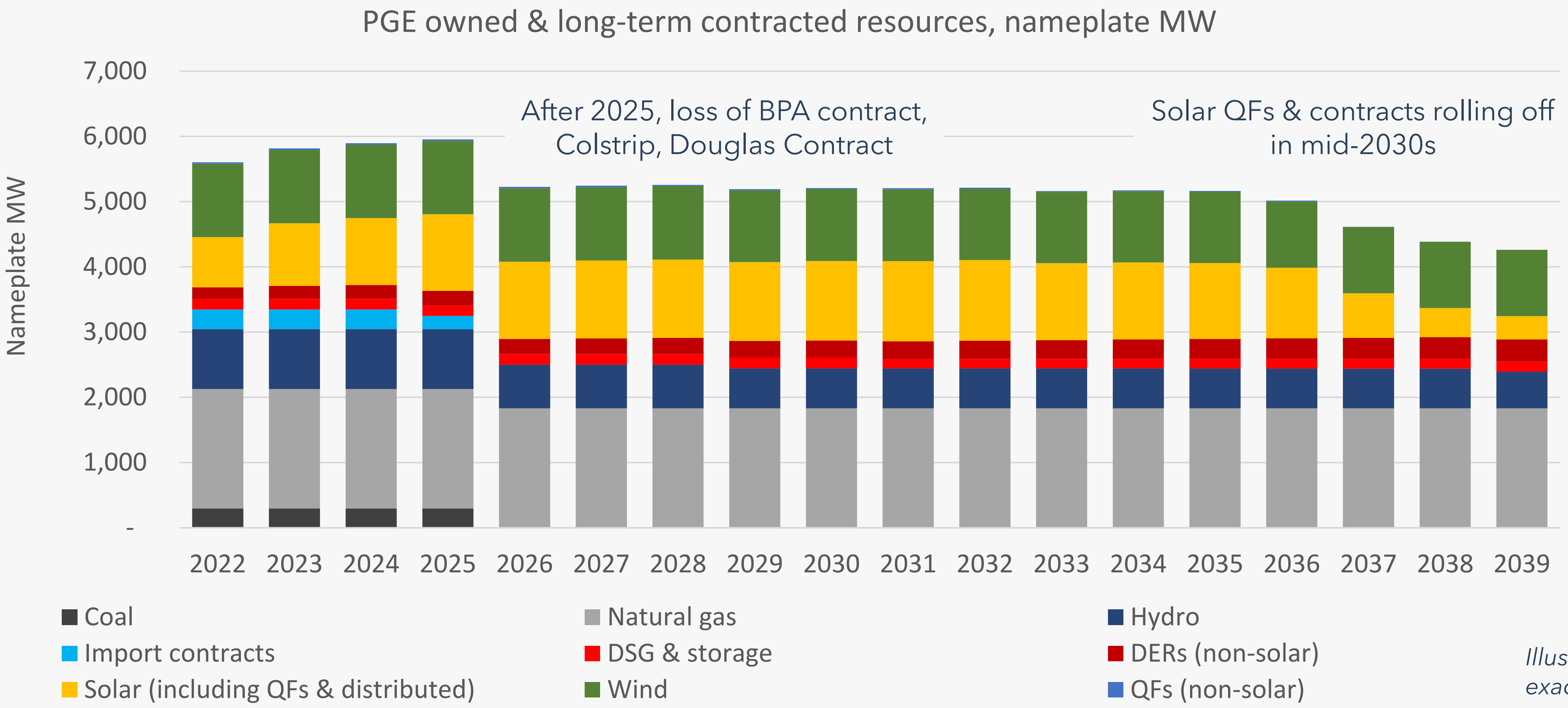
Items that Increase Need	Items that Decrease Need
Updated corporate load forecast	Inclusion of RFP proxy resources*
Inclusion of 2021 weather year	Increased market power (winter only)
Updated DERs (includes EV & BE load)	Updated QF forecast
	Updated thermal FOR

**Proxy resource is 250 aMW of wind & solar (even energy split, solar includes a hybrid) and enough 4hr battery to add ~375 MW of capacity. This may change if specific resources are signed and as the RFP discussion continues.*

2023 IRP Market Assumptions

- For summer/winter HLH:
  - Zero MW in summer
    - *No change in the high/low market cases*
  - 200 MW in winter through 2025, 100 MW after (reduction due to coal retirements, recently changed to reflect Jim Bridger converting to gas)
    - *300 MW through 2025 & 200 MW after in high market case, and 150 MW through 2025 & zero after in low market case*
- For spring/fall HLH:
  - 200 MW
    - *300 MW through 2025 in the high market case*
- For year round LLH:
  - 200 to 999 MW available depending on load

High Level Resource Snapshot



Illustrative example, exact values may vary

Gas Usage in Sequoia

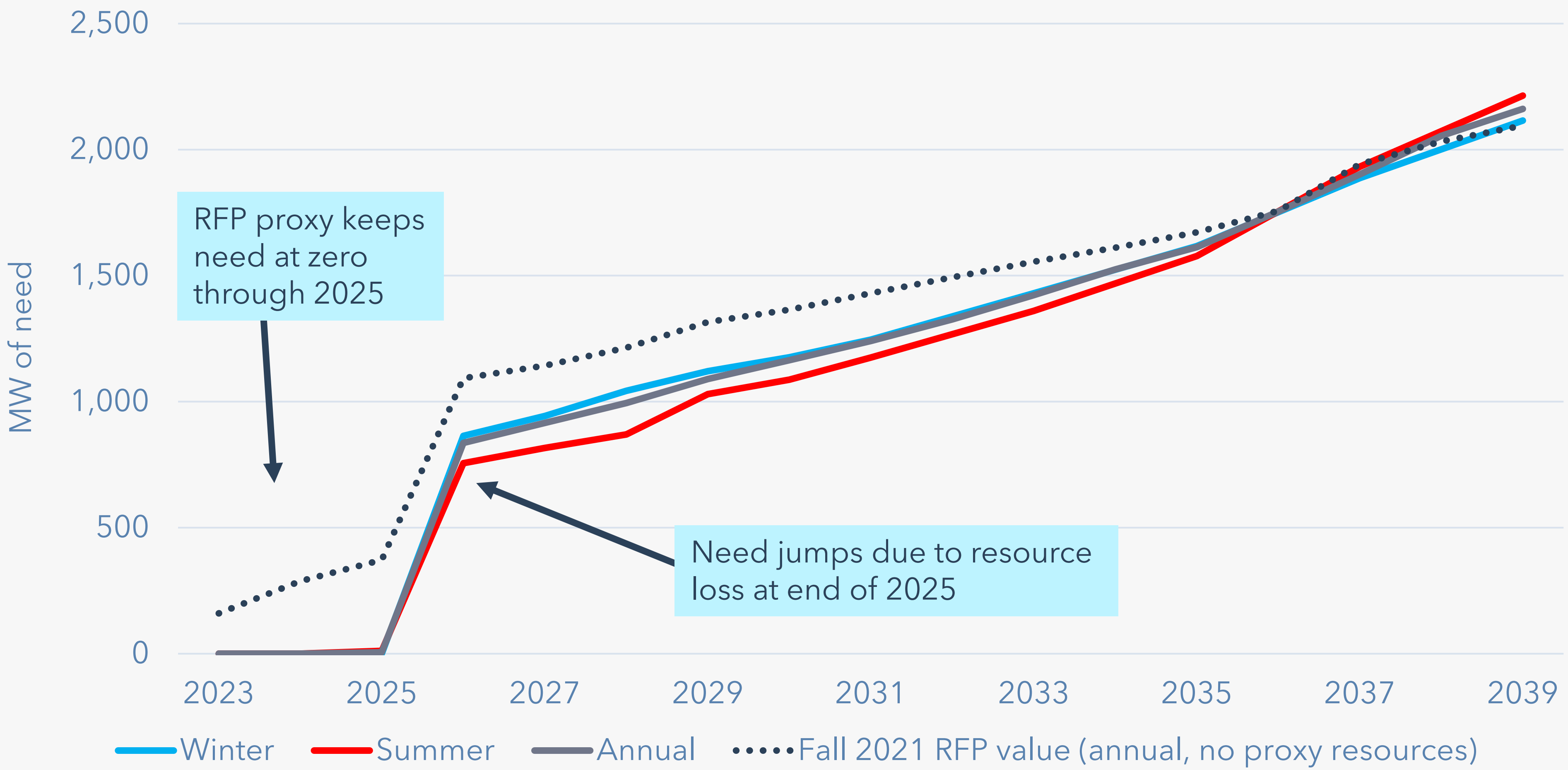
- Through 2039 we have a carbon budget and can run gas units. During high need hours the gas fleet may run at 100% provided it is offset later in the year.

- ROSE-E, the portfolio model, ensures that there is enough carbon free resources added to offset gas usage and meet carbon goals.

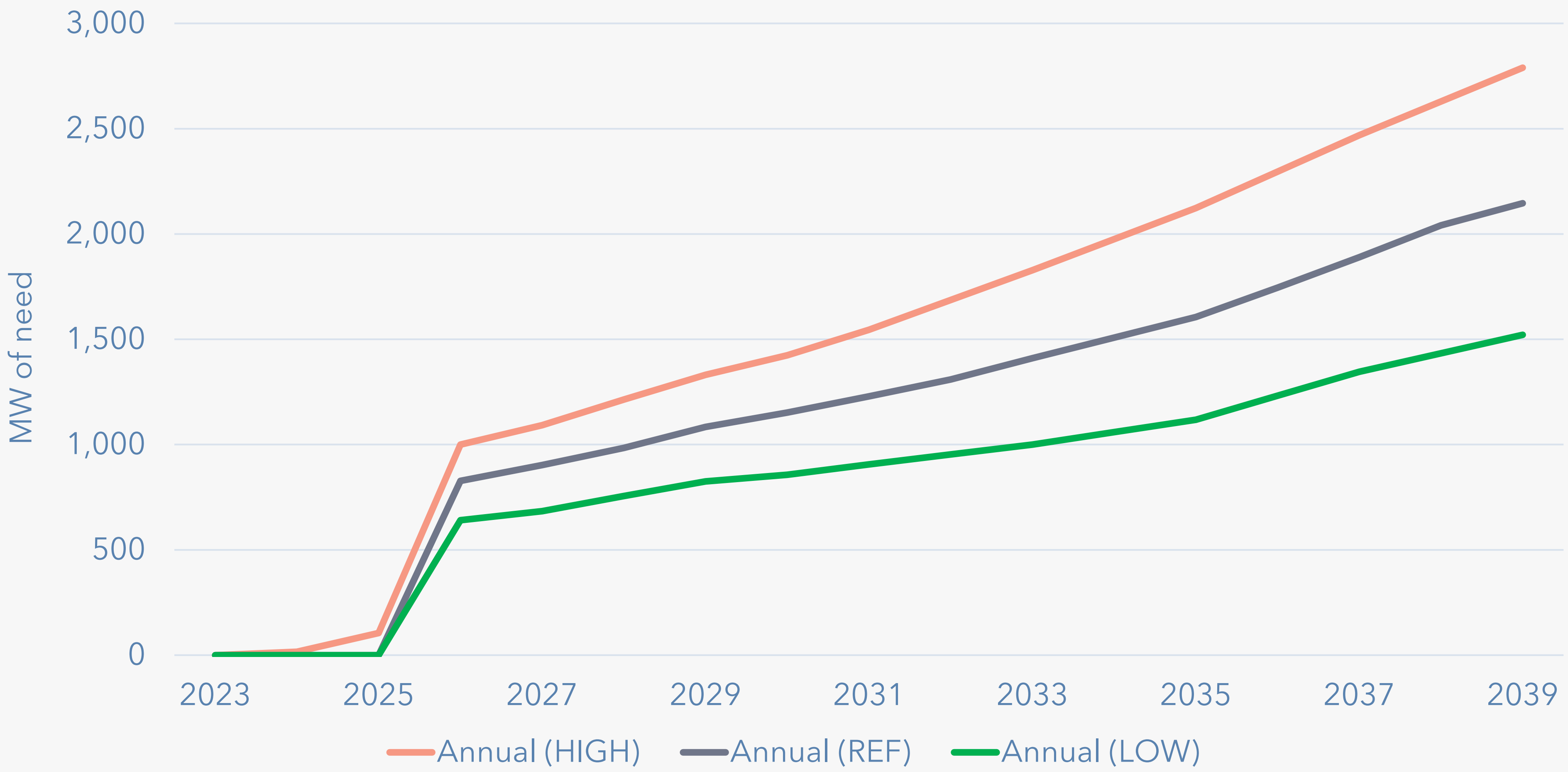
- Sequoia helps inform ROSE-E of the impact of extreme weather events (like colder or hotter than expected weather) and can adjust the carbon target ROSE-E sees to incorporate headroom for these events into the portfolio.

- After 2040 system adequacy is difficult to maintain with the current available resources, which is why we are discussing nascent/less common resource options in the IRP for the post 2030 time period (more info in June Roundtable slides).

2023 to 2039 Capacity Need, Ref Case



Low / Ref/ High Need Cases



Key Points

a) Resource needs starting in 2026 due to resource loss and load growth
    a) Resource need starts sooner and grows larger if current RFP is unable to contract ~375 MW of capacity

b) Contract renewals would reduce resource need, but are not assumed in the IRP

c) Capacity need growing faster than previous calculations due to load growth (including electrification)

d) Final need numbers may shift between now and March 2023

DISTRIBUTED ENERGY RESOURCES

ANDY EIDEN

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Objective

- Provide overview of DER Potential Study scope and methods
- Present final DER forecast results across different scenarios
- Provide venue for discussion and questions about DER forecast in the IRP

Past DER Forecast presentations

IRP Roundtable

- December 10, 2020 – IRP Roundtable 20-8, presentation on DER forecasting study overview (slides 15-30)
- August 25, 2021 – IRP Roundtable 21-7 (slides 7-70)

DSP Partner Monthly Meetings

- February 10, 2021 - DER Potential & Flex Load Assessment 101 (slides 31-45 & video)
- March 10, 2021 – DER and Flexible Load Study (slides & video)
- April 14, 2021 – DER Potential & Flex Load Analysis – Phase 1 (slides 12 -21 & video)
- May 12, 2021 – DER Forecast: Final Draft Results (slides 34-54 & video)
- Jan 13, 2022 – DER Forecast Updates (slides 41- 61 & video)
- Mar 10, 2022 – AdopDER Model Overview – OPUC TWG (slides)
- Apr 27, 2022 – DER Forecast – AdopDER Preliminary Updated Results

DER and Flex Load Study with DSP Part I

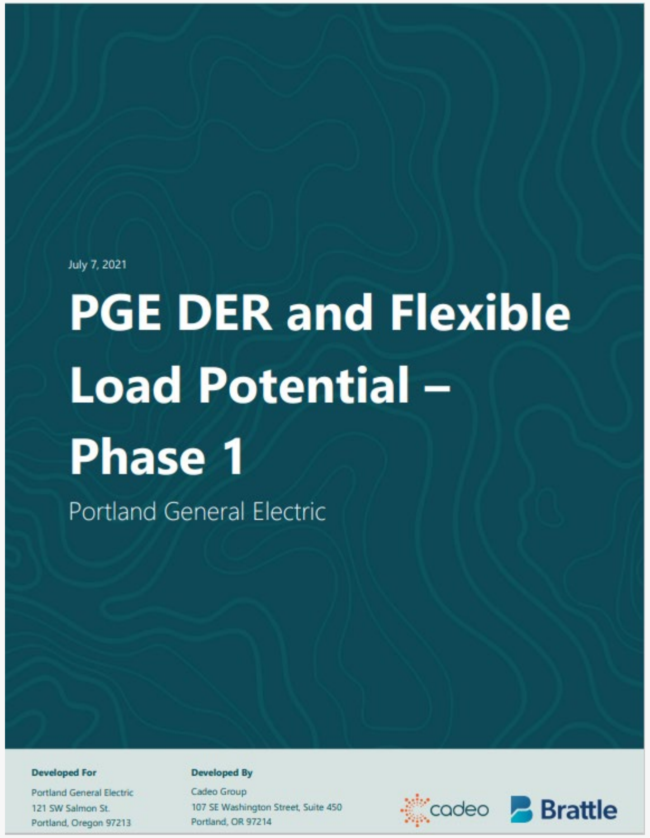
Full report with detailed methodology and findings available on PGE DSP website

- Cadeo and Brattle led the study development
- National expertise in flexible load modeling and resource assessments

Study covers forecast of the following distributed energy resources (DERs)

- Demand response / flex loads
- Distributed rooftop PV
- Distributed battery storage
- Electric vehicles and charging needs

Full study available online as Appendix G to the DSP Part I, available at: https://portlandgeneral.com/about/who-we-are/resource-planning/distribution-system-planning


July 7, 2021

PGE DER and Flexible Load Potential – Phase 1

Portland General Electric

Developed For
Portland General Electric
121 SW Salmon St.
Portland, Oregon 97213

Developed By
Cadeo Group
107 SE Washington Street, Suite 450
Portland, OR 97214

cadeo Brattle

Why a Potential Study?

Develop reliable estimates of capacity (MW) and energy (MWh) resources/needs from DERs

Evaluate impact on system at different timescales (hourly, daily, seasonal)

Assess costs and benefits compared to supply-side alternatives

From our perspective, a DER Potential Study helps inform utility resource planning, both long-term and short-term. Though it can inform program planning, it is not a detailed program planning exercise.

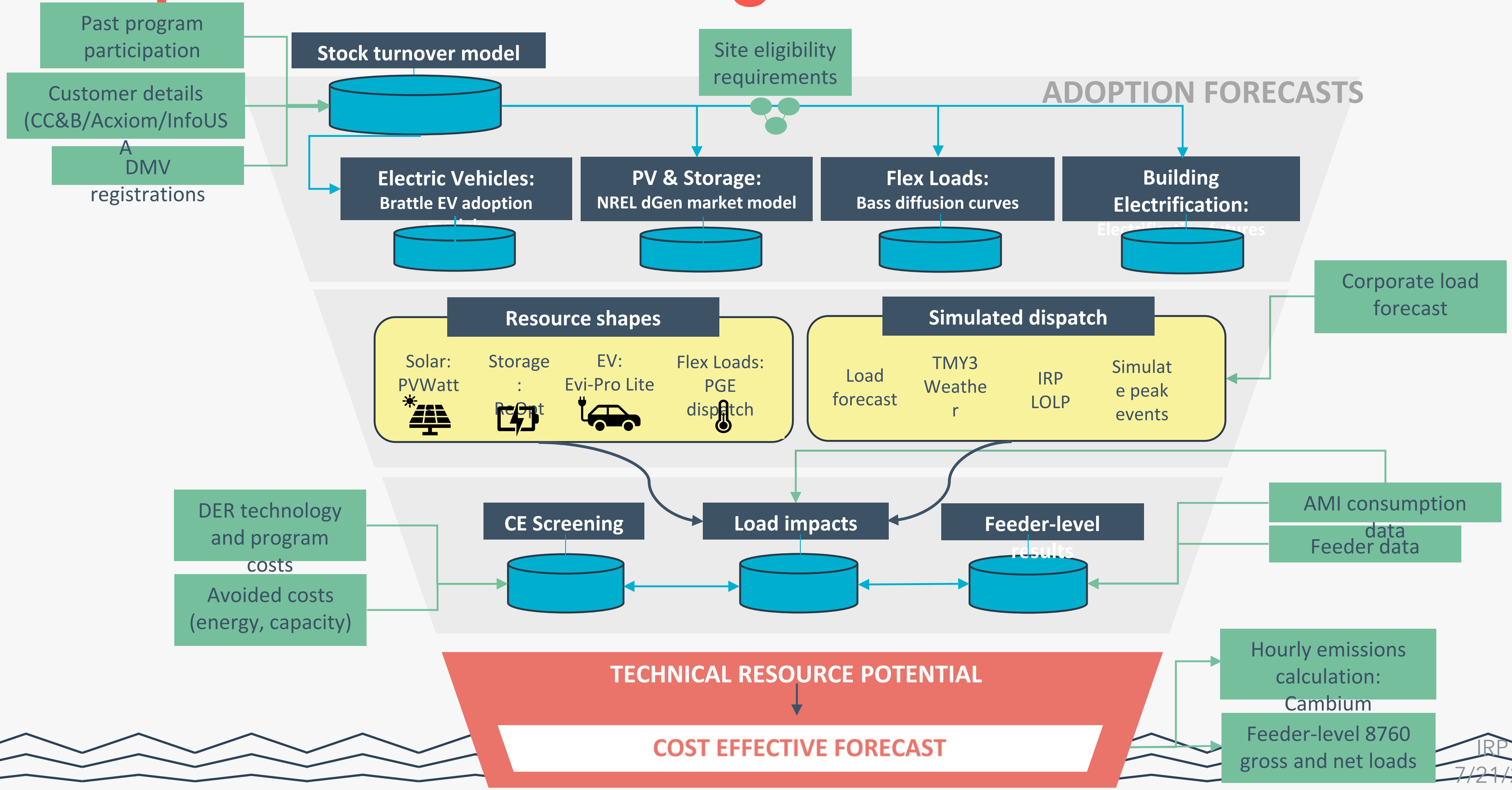
Integrated Resource Plan (IRP)

- The IRP analyzes energy, capacity, and reliability needs across a variety of need futures
- DERs fit into the portfolio of supply- and demand-side options to serve customer load
- IRP is focused on bulk-system impacts

Distribution System Plan (DSP)

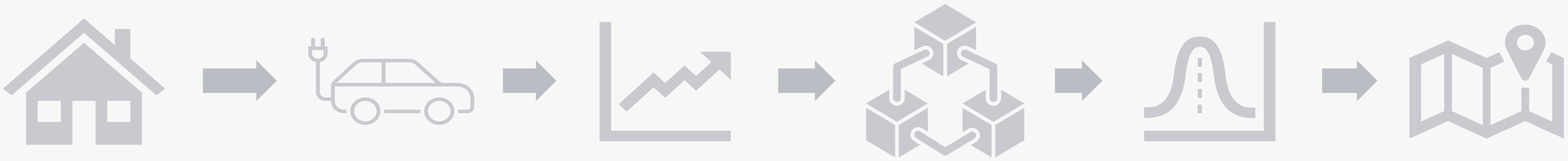
- Focused on parts of the system associated with final energy delivery to customers (substation to meter)
- More impacted by spatial differences in terms of grid assets and customer makeup
- Necessitates more granular planning efforts

AdopDER Flow Diagram



DER Study Methods Overview

Overall Workflow



Market Segmentation → DER Measure Inputs → Stock Turnover → Potential Model → Economic Screening / Adoption → Locational DER Adoption

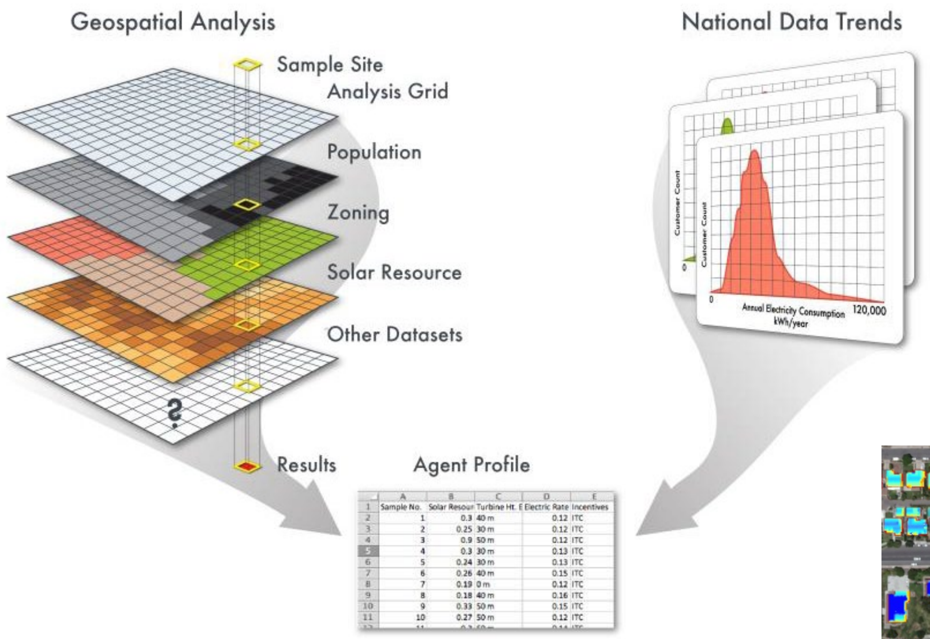
Modeled DER Technology Overview

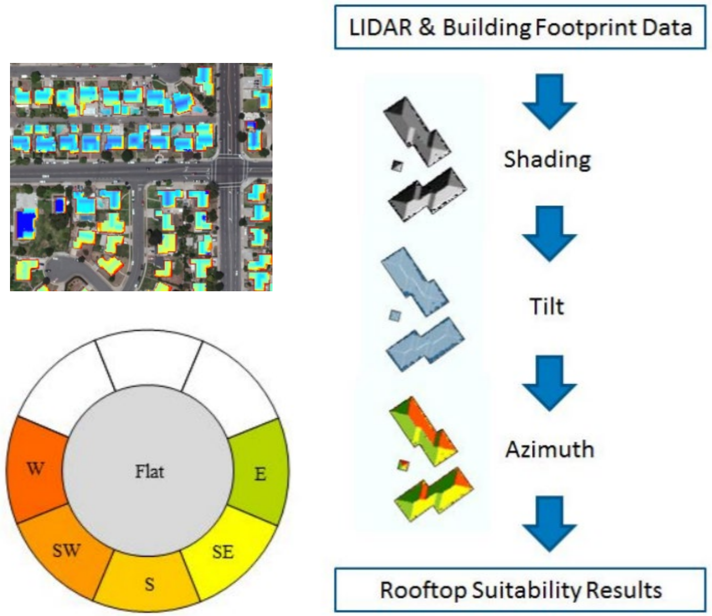
- **Solar and Storage**
  - Solar PV
  - Battery Energy Storage
  - Single-site microgrid
  - Campus microgrid
- **Electric Vehicles**
  - Light-Duty Vehicles
  - Medium-Duty Vehicles
  - Heavy-Duty Vehicles
- **Basic EVSE**
  - Res L2
  - Non-res L2
  - Non-res DCQC
- **Smart Charging**
  - Res Smart EVSE
  - Non-res Smart EVSE
- **Smart Water Heating**
  - ERWH retrofit switch
  - ERWH smart controls
  - Smart ERWH
  - HPWH smart controls
- **Smart HVAC**
  - Res smart tstat controls
  - Res line voltage tstat
  - Res DHP controls
- **C&I DR**
  - Commercial smart tstat
  - Irrigation load control
  - Large C&I tariff
  - Cold thermal storage
- **Non-firm DR**
  - Peak Time Rebates (PTR)
  - Time of Use (TOU) rates
  - EV-TOU

Modeling Solar + Storage

- NREL's dGEN tool forecasts adoption of distributed solar & storage by sector and county through 2050
- Agent-Based Model simulating consumer decision-making
- Incorporates detailed spatial and temporal data to understand regional adoption trends

NREL's dGEN tool example workflow





Combines solar resource data and adoption (above) with detailed rooftop suitability assessment (right)

Image credit: NREL

Modeling Electric Vehicles

- **Light-duty vehicles (LDV)**
  - Regression-based approach formulated on:
    - EV purchase price incentives
    - Relative price of electricity versus gasoline
    - State policies that are favorable to transportation electrification
    - Battery costs
    - High Occupancy Vehicle (HOV) lane access (combined with traffic density)
    - Vehicle model availability*
    - Range anxiety / charger coverage*
- **Medium- and Heavy-duty vehicle (MDHDV)**
  - Multi-round expert panel (Delphi approach) to estimate market adoption for short/medium/long term
  - Outputs fit to Bass diffusion using historical IHS Markit data and customer insights
- **EV charging requirements**
  - Using NREL's EVI-Pro Lite tool to analyze charging requirements of expected EV adoption

* Note: out of model adjustments

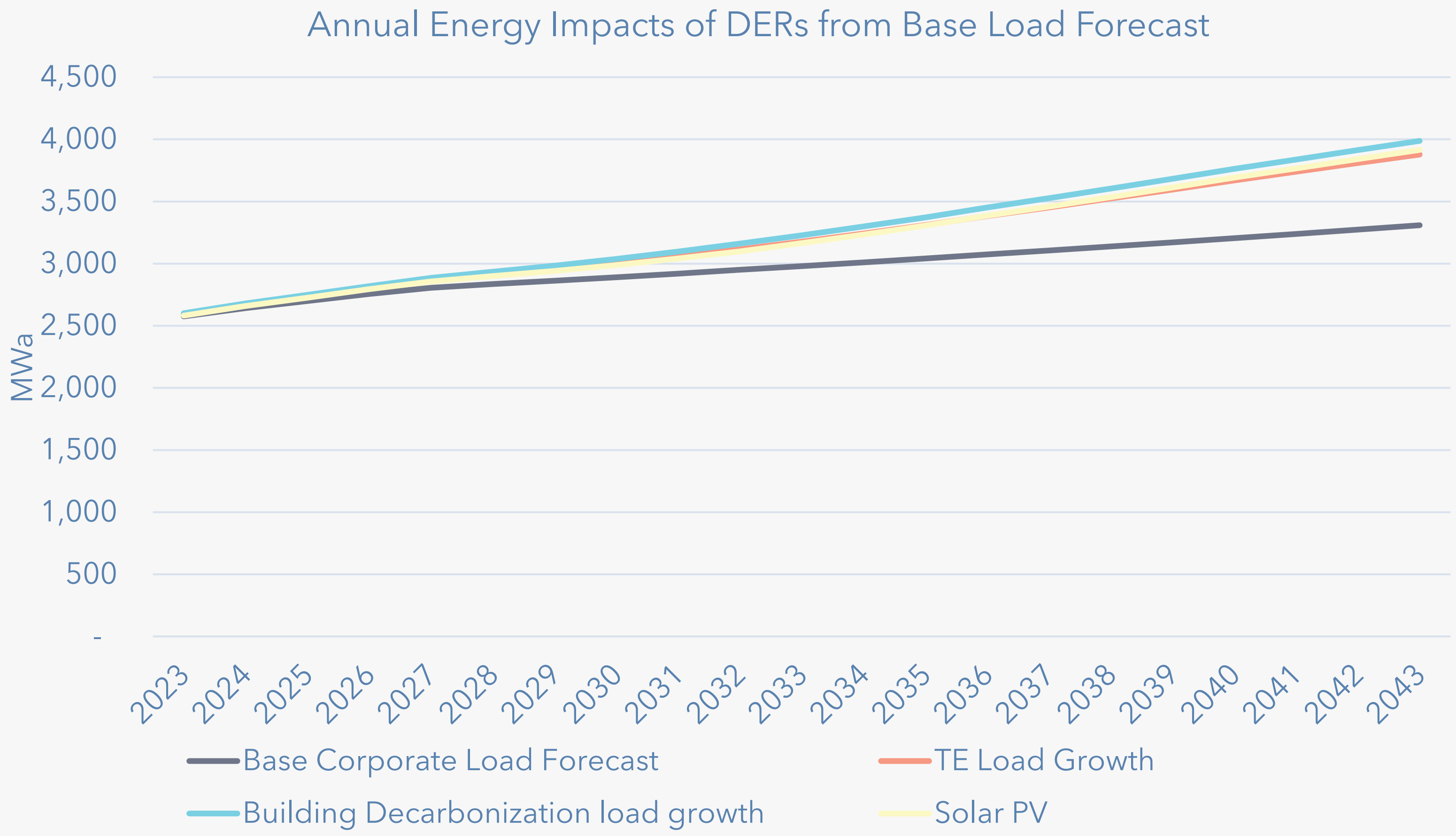
Modeling Demand Response

- Inherently a programmatic adoption question (i.e., requires aggregation and control)
- Resource cost-effectiveness determined by Total Resource Cost test.
  - Utilizes utility avoided costs for primary benefits stream
  - Leveraging PGE pilot experience for program costs and dispatch patterns
  - Working with IRP team to model additional flexibility of battery storage and water heaters
- Device functionality phased in over time
  - We expect industry standards to improve software/hardware and controls (e.g., CTA-2045 for grid-ready consumer appliances)
  - Accounted for in adoption rates and lower per-unit costs over time
  - Not including emerging technologies unless regional interest (line voltage thermostats)
- Study will result in "supply curve" showing amount of DR in terms of levelized $/MW
  - Will roll into PGE's 2022 IRP to study possible electric system needs for "non-cost effective" DR

DER Study – Final Inputs to IRP

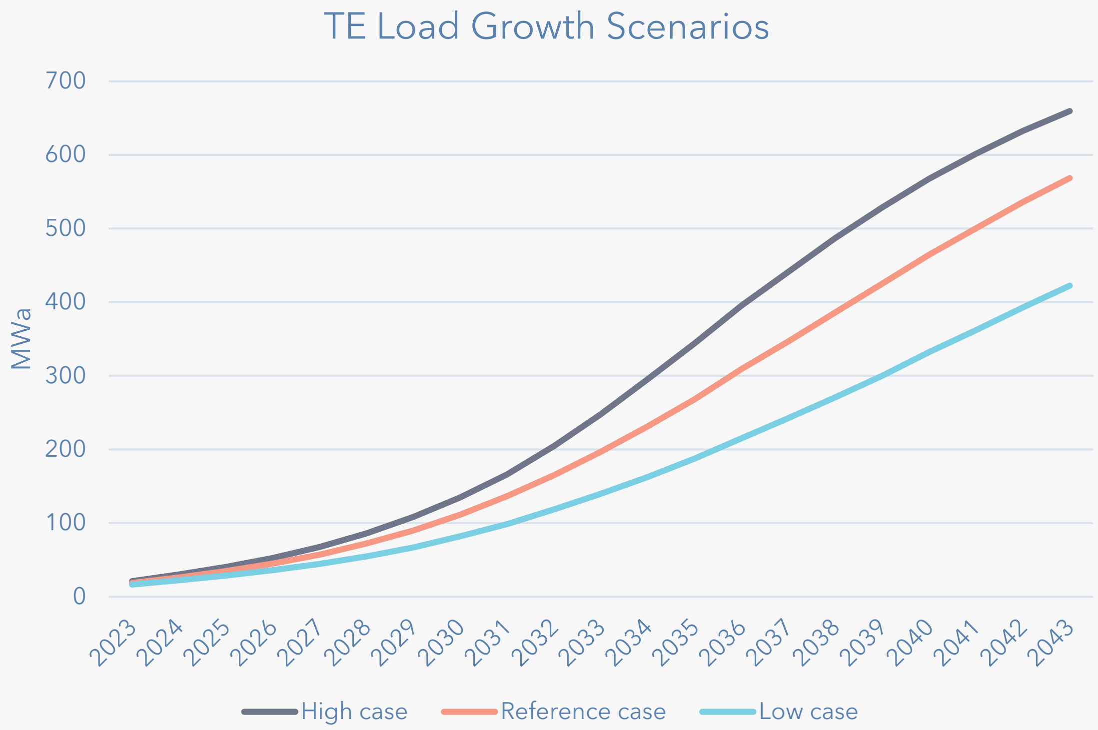
System-level energy impacts

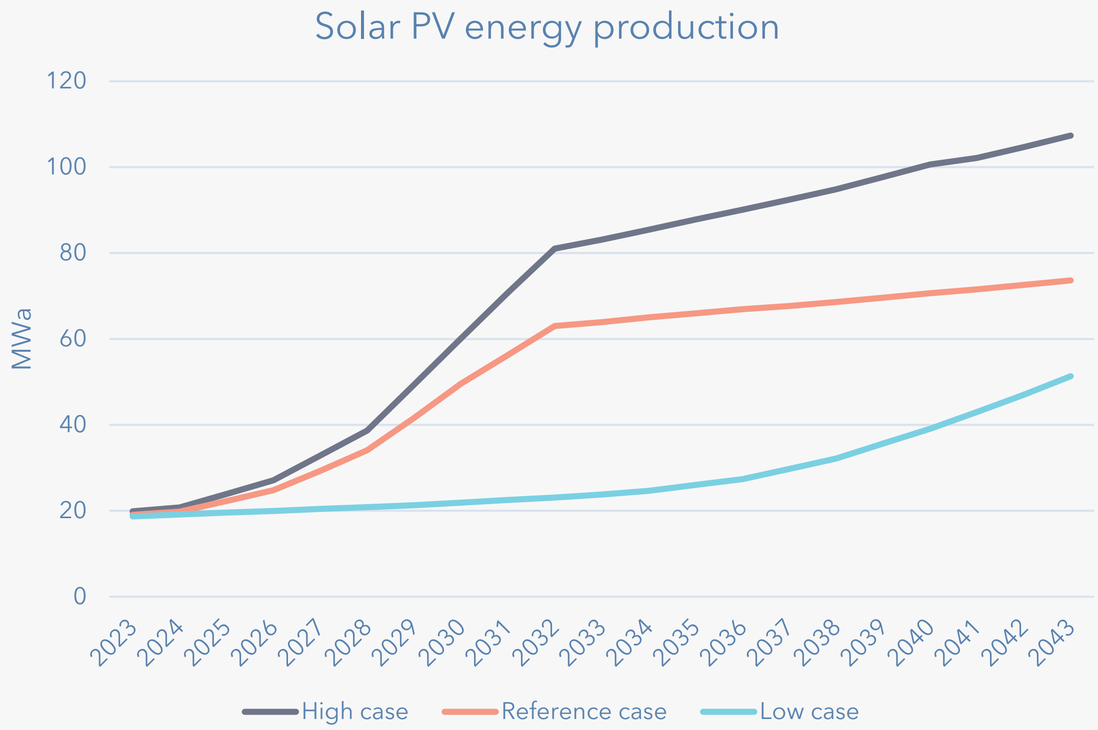
- Overall, energy impacts from DERs increase energy needs from the base Corporate forecast
- TE and BE add to this need, while solar PV reduces the need
- The net impacts are an increase of around 100 Mwa by 2030 and 500 MWa by 2040 (3% and 15% increase, respectively)



Scenario results for DER energy impacts

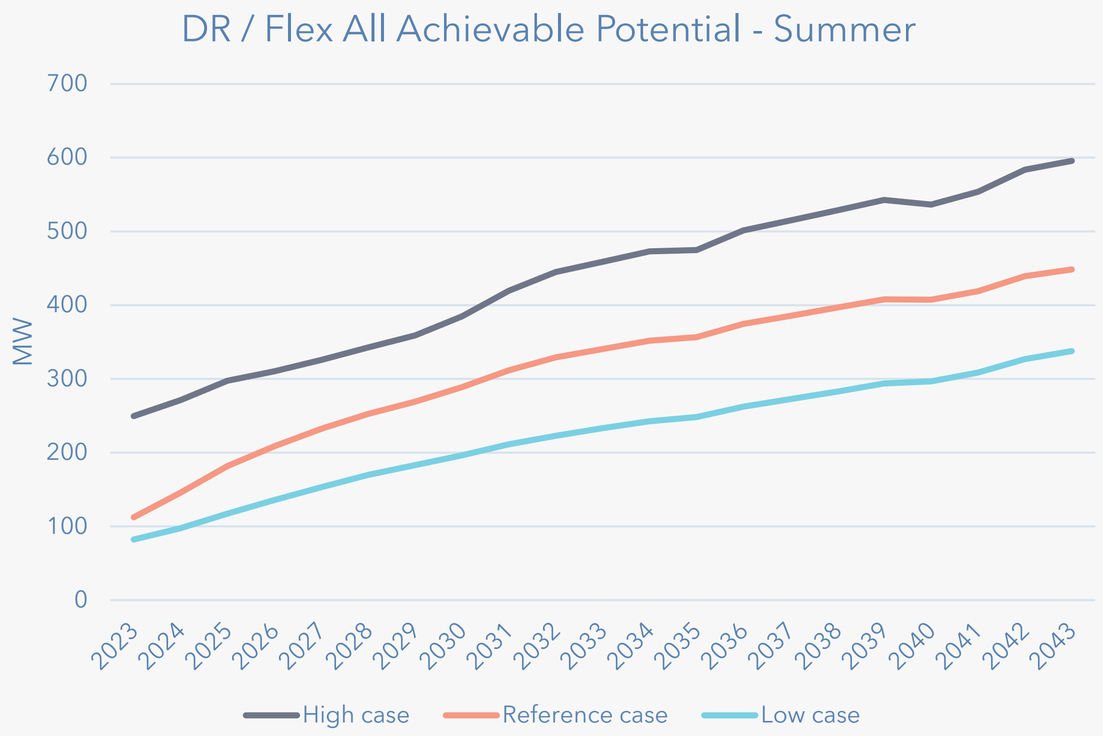
We investigated sensitivity scenarios for each DER type which influences the low-reference-high need futures of the IRP analysis

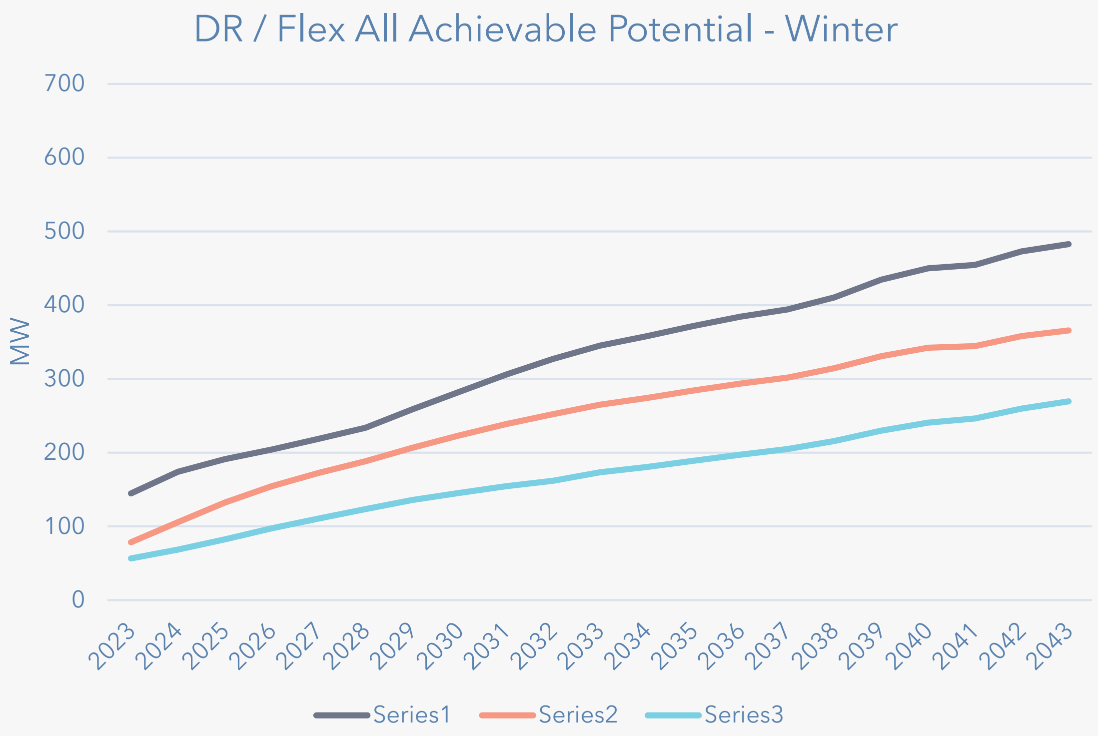




Demand response capacity impacts

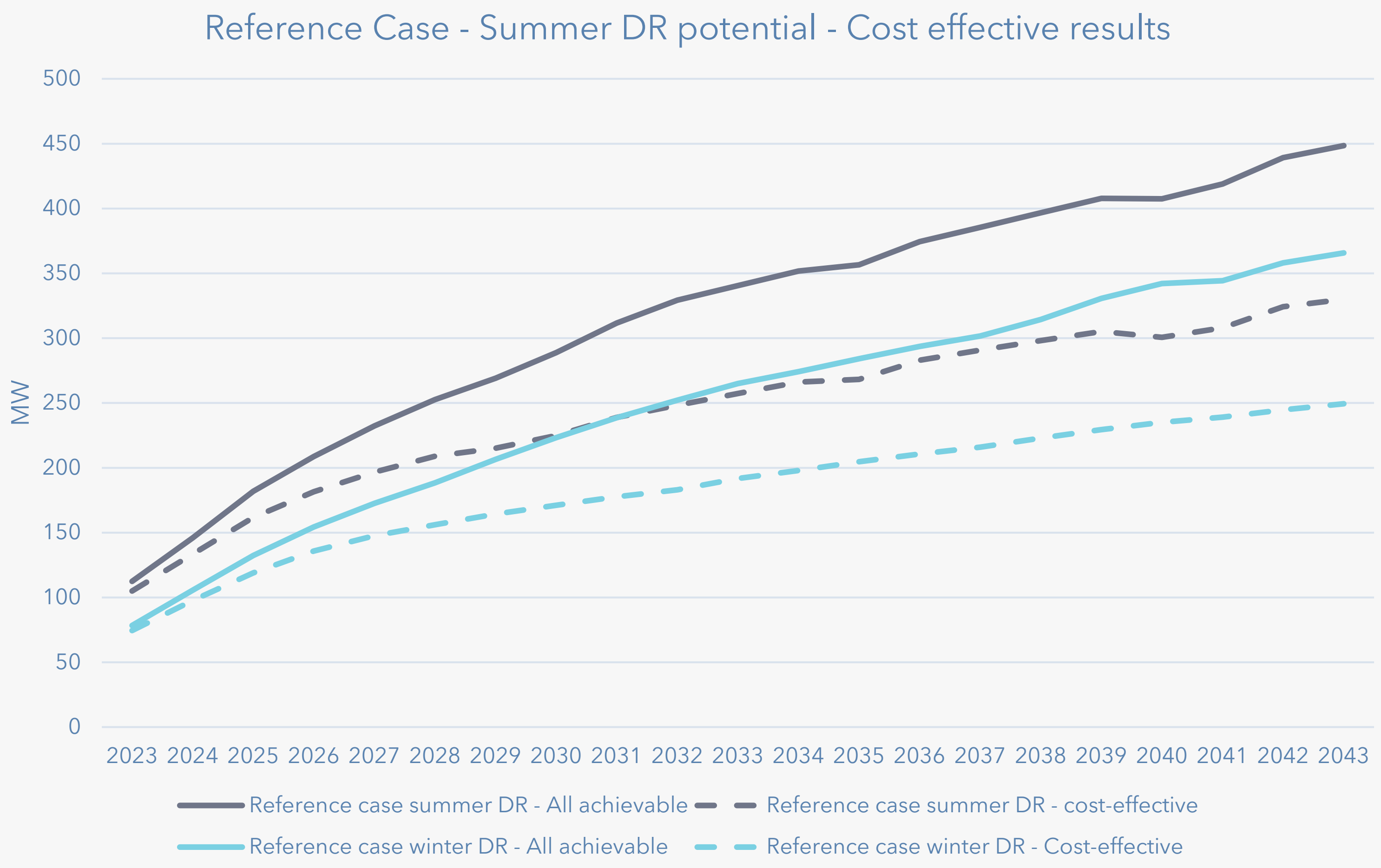
- By 2030 we've identified between 200-400 MW of achievable demand response and flex load potential for summer capacity, and 150-300 MW of winter capacity





Cost effective vs. non-cost effective

- Not all of the identified potential is cost-effective.
  - The IRP will evaluate supply curves of the non-cost-effective DR potential for any added portfolio benefits.
- Non-cost-effective measures primarily dispatchable storage and small commercial thermostats, along with some emerging tech



QUESTIONS/ DISCUSSION?

UPDATED WECC PRICING

RAINBOW WONG

ROUNDTABLE 22-6

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Electricity Price Forecast: *Updated* Final

***Updated* Final Price Forecast**

PGE presented a final gas price forecast in Roundtable 22-3 in April 2022 that was locked in. However, due to significant market movements in recent months, the IRP team updated the gas price forecast to reflect the current market.

- Though short-term price shocks did not impact the 20-year forecast, the IRP team captured the most recent market prices in the updated simulation.
- Wood Mackenzie (WM) 2022H1 gas price forecast was input into Aurora software to simulate WECC-wide prices. These prices are then input into PGE-PZM Aurora model for PGE portfolio dispatch.
- 8 additional futures were added to align to the hydro condition futures for modeling in ROSE-E.

Recap – PGE presented proposed methodology and comparison with previous IRP in:

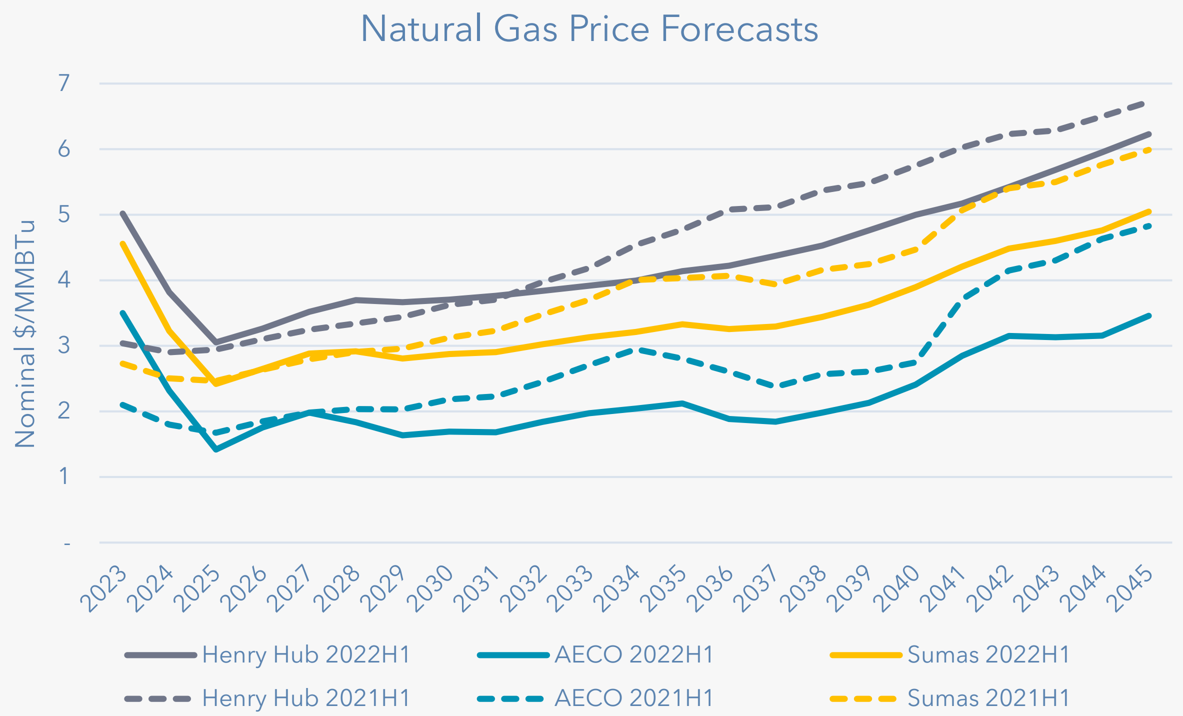
- Roundtable 21-1 in February 2021,
- Roundtable 21-3 in May 2021,
- Roundtable 21-8 in November 2021

Note: view prior roundtable presentations at PGE web site: https://portlandgeneral.com/about/who-we-are/resource-planning/irp-public-meetings

✓ Reference WECC Database | ✓ PGE Updates | ✓ WECC-wide price simulations (2Q22) | Input prices for PGE Portfolio Analysis (Now)

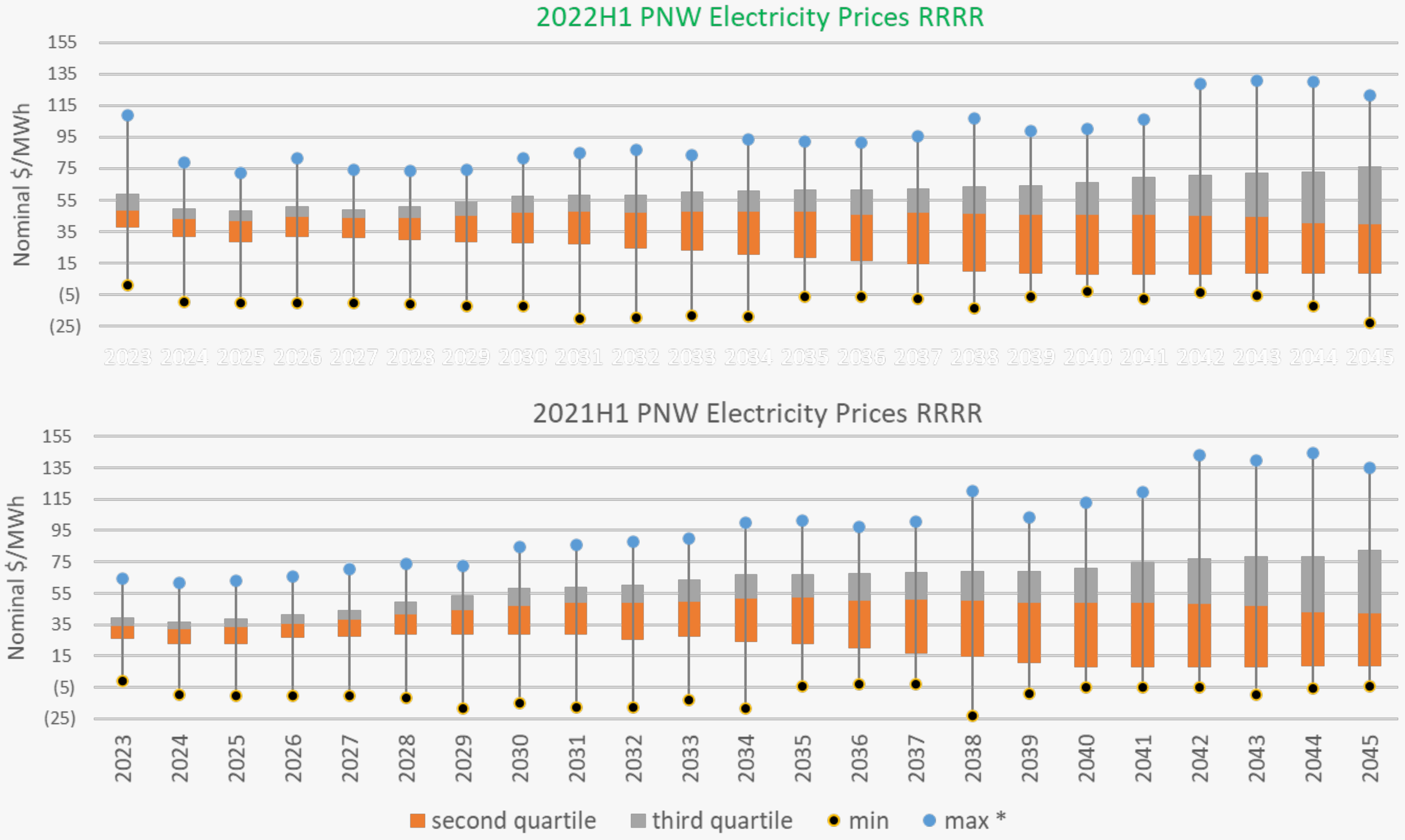
WECC MODEL: Updated gas price forecast to 2022H1

- Near term gas price forecast around $5/MMBTu as geopolitical affairs pose gas price volatility
- However, WM adjusted long-term gas prices downward from 2021H1 to reflect the optimism of the energy transition that is underway
- WM points to the long-term federal tax credit extensions and the national zero-emissions credit (ZEC) as optimism for continued clean energy investments
- Future gas contribution is forecast to minimize as States pursue terminal decarbonization with renewables and storage



Sources: 2023-26 gas prices are from PGE forward curve, 2027 gas prices are interpolated between forward curve and WM forecast, 2028-45 gas prices are from Wood Mackenzie, North America Power & Renewables Service & Tool - WECC

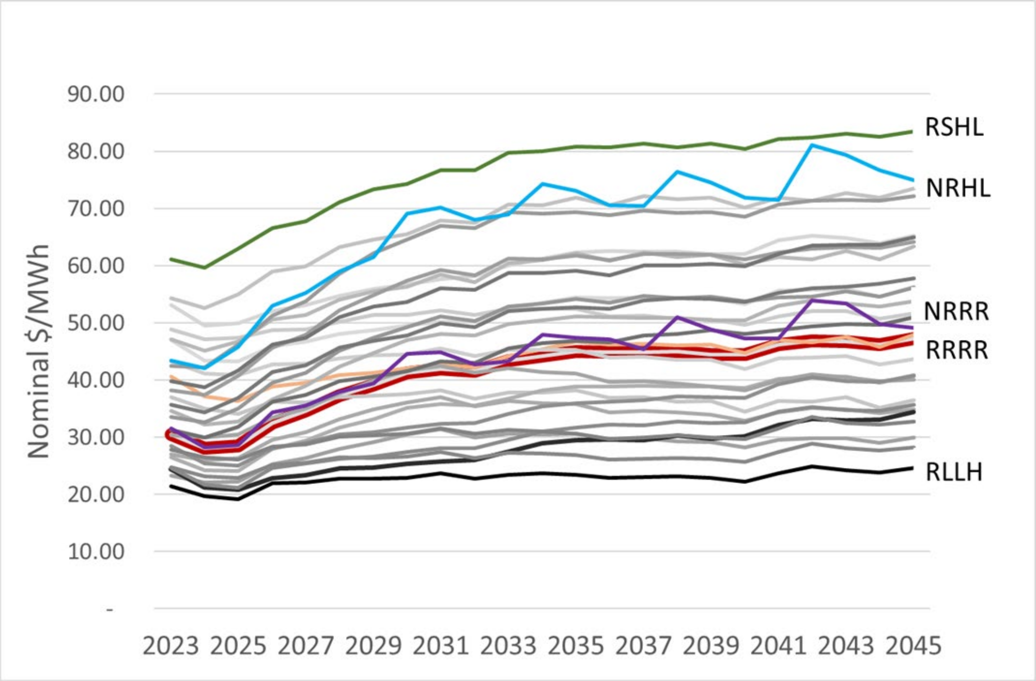
WECC MODEL RESULTS: Electricity price compare



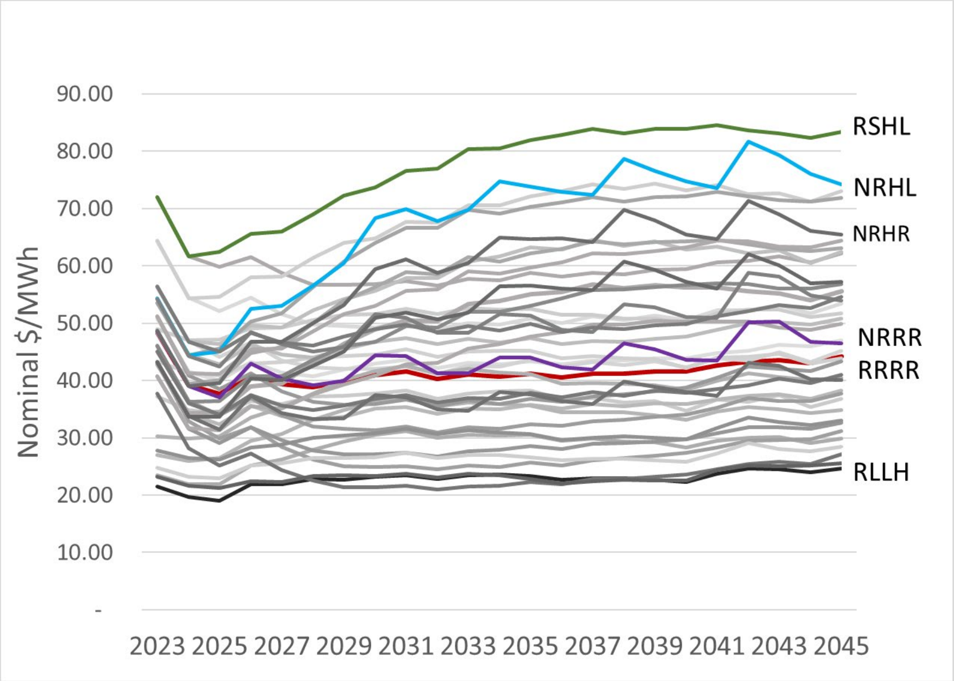
- 2023-27: Higher electricity price volatility as 2022H1 gas price forecast reflect current geopolitical shocks
- 2027-45: Electricity prices did not change dramatically from 2021H1 forecast simulation
- Prices are slightly lower in the updated forecast simulation, not exceeding $135/MMBTu

PNW ELECTRICITY PRICES ACROSS FUTURES

2021H1



2022H1



LIST OF SIMULATED ELECTRICITY PRICE FUTURES

Risk driver	How we proxy it
Commodity	Natural gas price: 1. Reference: PGE TC + Wood Mackenzie fundamentals 2. Low: estimate of historical minimum prices 3. High: EIA highest price forecast (from Annual Energy Outlook 2022, ***updated***) Hydro: 1. Reference 2. -10% in PNW 3. +10% in PNW
Carbon	Range of carbon adders: 1. Reference: California cap and trade projected prices for California, OR, WA 2. Low: low California price projection 3. High: Social cost with discount rate = 2.5% 4. No carbon adder, proxy for a future where tax credits might be used instead of carbon adders
Uncertainty	Modeled errors in the Aurora Gurobi-optized logic to simulate less-than-perfect commitment (proxy for lacking capacity at the right time): 1. Wind error + ref gas + ref hydro + ref carbon. Imposed price cap of $250/MWh 2. Wind error + high gas + Low hydro + ref carbon. Imposed price cap of $250/MWh
Scarcity	Scarcity premiums affecting prices. No easy way of doing this. Proxied it with: 1. Add start-up costs to on-peak hours. Future: Start-up cost + ref gas + ref hydro + ref carbon
Hydro conditions	8 additional futures were added to align to the hydro condition futures for modeling in ROSE-E: NRRL, SRRL, SRRH, RNRH, NRRH, NRHR, NRHH, RNRL

PRICE FUTURES COMBOS

PGE generated the following price futures:

- 27 combos of gas prices, carbon goals/policy, hydro conditions with default DB setup
- 3 futures are then simulated to capture uncertainty and scarcity due to intermittency of generation
- 1 future with reference gas and hydro but no additional carbon adder in WECC
- *8 futures were added to align to the ROSE-E hydro condition futures*

Futures are identified by the following 4 letter combo:

Variable >>	Aurora setup		Carbon adder		Natural Gas Price		PNW hydro gen	
	N	Net load commit error	L	CA cap and trade LOW for CA, OR and WA. Default for rest of WECC.	H	EIA-AEO 2022 highest gas price case	H	+10% PNW hydro generation
	R	Wood Mackenzie default	N	No carbon adder in dispatch	L	PGE estimate of Low historical gas	L	-10% PNW hydro generation
	S	Start up cost added to prices	R	CA cap and trade REF for CA, OR and WA. Default for rest WECC.	R	Wood Mackenzie default	R	Wood Mackenzie default
			S	Social Cost 2.5% discount rate for CA, OR and WA. Default for rest WECC.				
Example future name:	R	Wood Mackenzie default	R	CA cap and trade REF for CA, OR and WA. Default for rest WECC.	R	Wood Mackenzie default	R	Wood Mackenzie default

QUESTIONS/ DISCUSSION?

NEXT STEPS

A recording from today's webinar will be available in one week

Upcoming Roundtables:
August 18
September 15
October 20
November 16
December 15

THANK YOU

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ACRONYMS

aMW: average megawatt

BE: building electrification

BPA: Bonneville Power Administration

CE: cost effective

C&I DR: commercial and industrial demand response

DCQC: direct current quick charge

DER: distributed energy resource

DHP: ductless heat pump

DR: distributed resource

DSG: dispatchable standby generation

DSP: distribution system plan

EE: energy efficiency

ELCC: effective load carrying capacity

EVSE: electric vehicle service equipment

EV + DLCEV: electric vehicle + direct load controlled electric vehicle

FOR: forced outage rate

MMBTu: metric million British thermal unit

MW: megawatt

Solar PV: solar photovoltaics

QF: qualified facility

RFP: request for proposal

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

WECC: Western Energy Coordinating Council