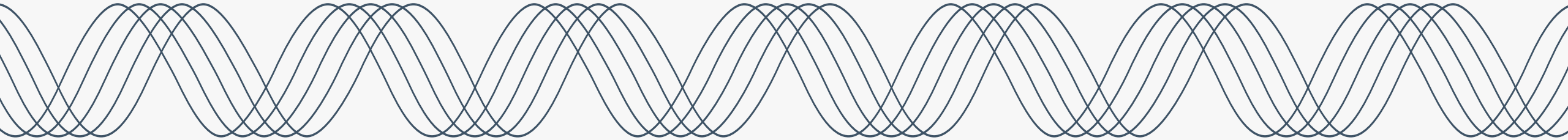
Integrated Resource Planning

ROUNDTABLE 23-2
MARCH 2023



March 8, 2023 – Agenda

8:30 – 8:45	Welcome, introductions, meeting logistics
8:45 – 9:30	Data center energy efficiency opportunities (with Energy Trust of Oregon)
9:30 – 9:50	Price futures
9:50 – 10:00	*Break*
10:00 – 1:00	Draft portfolio analysis results & preferred portfolio part II
1:00 – 1:30	*Break*
1:30 – 2:00	Draft Action Plan part II
2:00 – 2:30	Initiation of request for proposals

Meeting Details

1

Electronic version of presentation

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

2

Zoom meeting details

- Join Zoom Meeting https://us06web.zoom.us/j/84391255924?pwd=RDQ2VFpUZERVSEcraU5CZWw3VDhQZz09
- Meeting ID: 843 9125 5924
  Passcode: 108198

3

Participation

Use the raise hand feature to let us know you have a question

Unmute with microphone icon or *6 on phones

MEETING LOGISTICS

Focus on learning & understanding

Team members will take clarifying questions during the presentation
Attendees will not have access to the chat feature during the meeting in order to streamline taking feedback
Attendees are encouraged to "raise" their hand to ask questions

Questions & answers

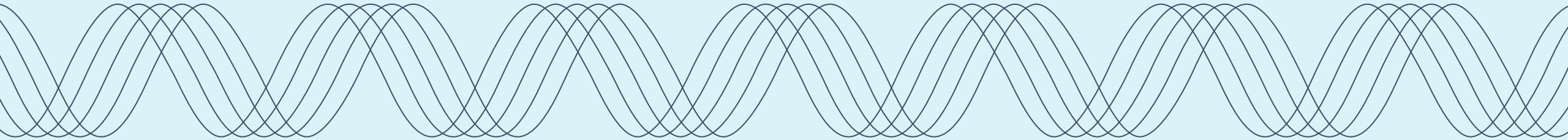
Time will be dedicated at the end of each presentation to address questions and comments

Follow up

If we don't have time to cover all questions, we will provide answers via the monthly published feedback form

DATA CENTER ENERGY EFFICIENCY OPPORTUNITIES

ANDY EIDEN, PGE



Background – PGE

OPUC issued a directive to PGE in its 2019 IRP acknowledgement Order (Order 20-152) which stated: "[b]efore the next IRP, PGE and Energy Trust will conduct a workshop regarding data center load and energy efficiency measures…"

PGE is experiencing strong and continued growth in data center customer sector, particularly concentrated in the western part of our service area

PGE & Energy Trust worked over a series of meetings in 2021-22 to identify opportunities for alignment and additional energy efficiency (EE) opportunities within data centers

This presentation will cover a brief overview of load growth trends followed by treatment of energy efficiency potential for data centers

Types of Data Centers

What is a data center

- It is a physical space or facility that centralizes an organization's shared IT operations and equipment for the purposes of storing, and processing data
- It can be as small as a closet
- Or it can be as large as an entire building or series of buildings spanning several acres

Three Data Center Types

- **On Premise:** Located onsite to support that company's business functions
- **Co-location:** Large facilities that offer data center services to multiple clients in the same facility
- **Hyperscale:** Large facilities typically owned and operated by the company it supports or co-location provider with a hyperscale client as a tenant (hyperscale client is a single large customer that takes the entire data center or multiple data centers, such as social media and technology companies)

Why are Data Centers Coming to Hillsboro?

Transpacific Cable Access

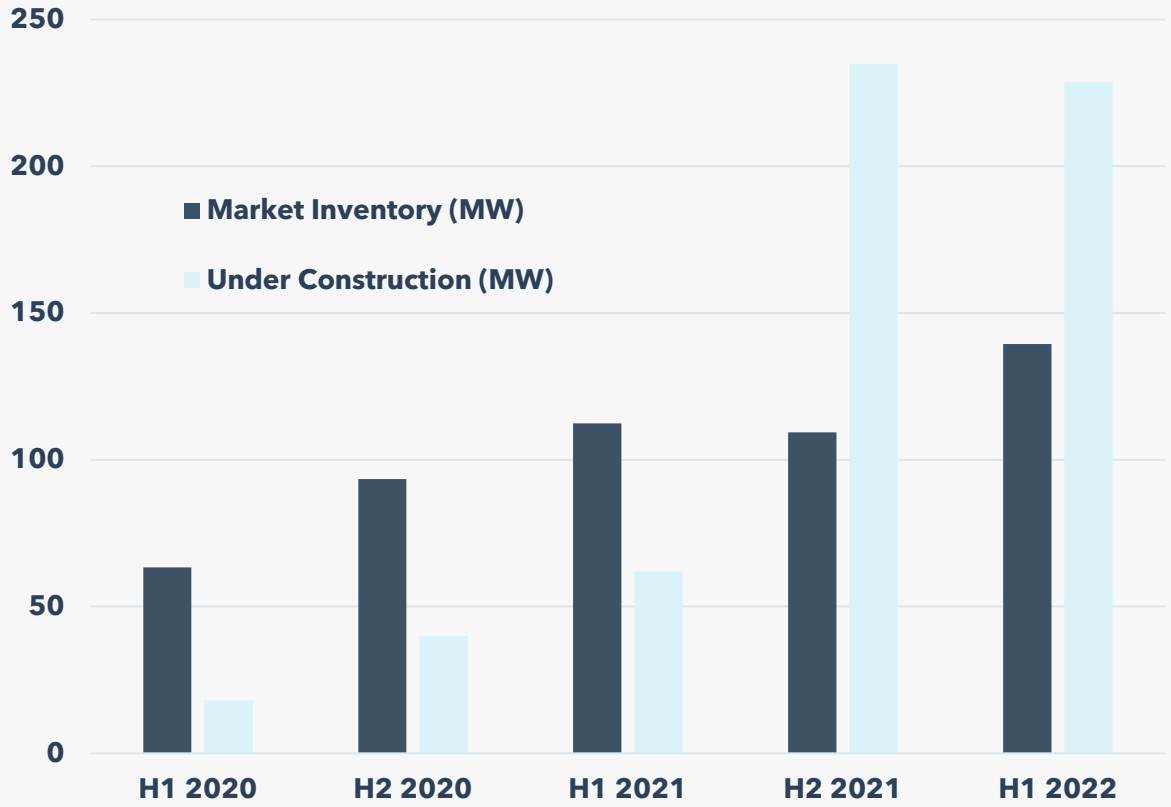
Clean Energy & Renewable Power Options

Favorable Weather Climate

Cost of Living & Education

Data Center Clustering

Hillsboro Data Center Market



Commercial real estate market reports have highlighted rapid growth in the Hillsboro data center market in recent years

Market inventory has increased, and construction activity implies this trend will continue

Source: Community based renewable energy (CBRE) Research, Semi-annual North America Data Center Market Trends Report , available online: https://www.cbre.com/insights/reports/north-america-data-center-trends-h1-2022

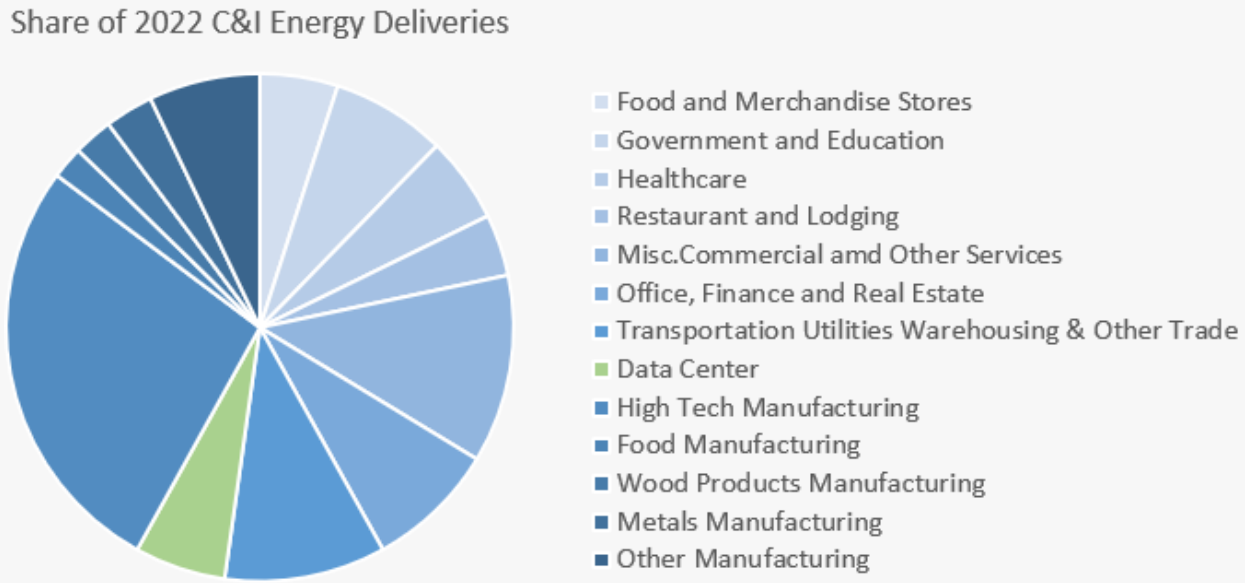
PGE Commercial & Industrial Energy Deliveries

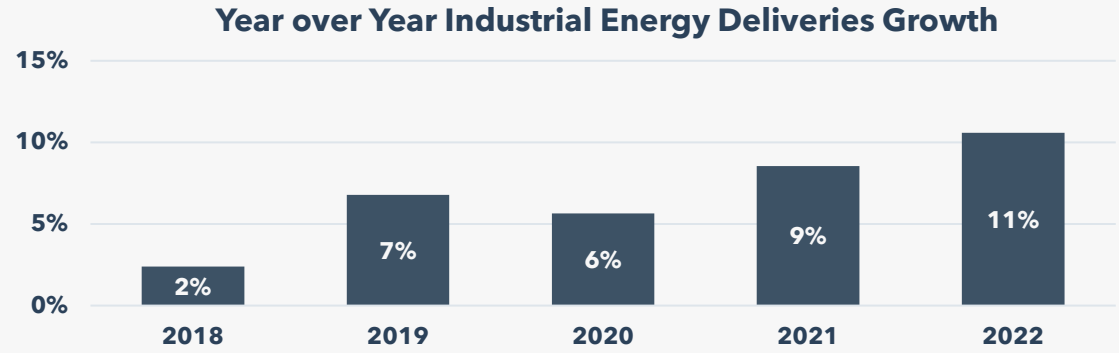
PGE has experienced rapid industrial energy deliveries growth in recent years

High tech manufacturing remains PGE's largest segment

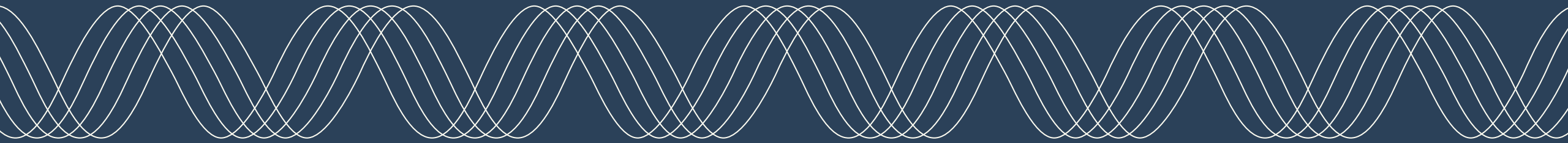
The data center market is emerging as an increased share of total commercial and industrial (C&I) deliveries

*** While the North American Industry Classification System (NAICS) considers data centers to be a commercial sector, PGE uses Industrial to refer to customers receiving service above Secondary Service Voltage, which includes many large data centers**





Energy Efficiency in Data Centers: Energy Trust of Oregon



Energy Trust EE Forecast for PGE IRP

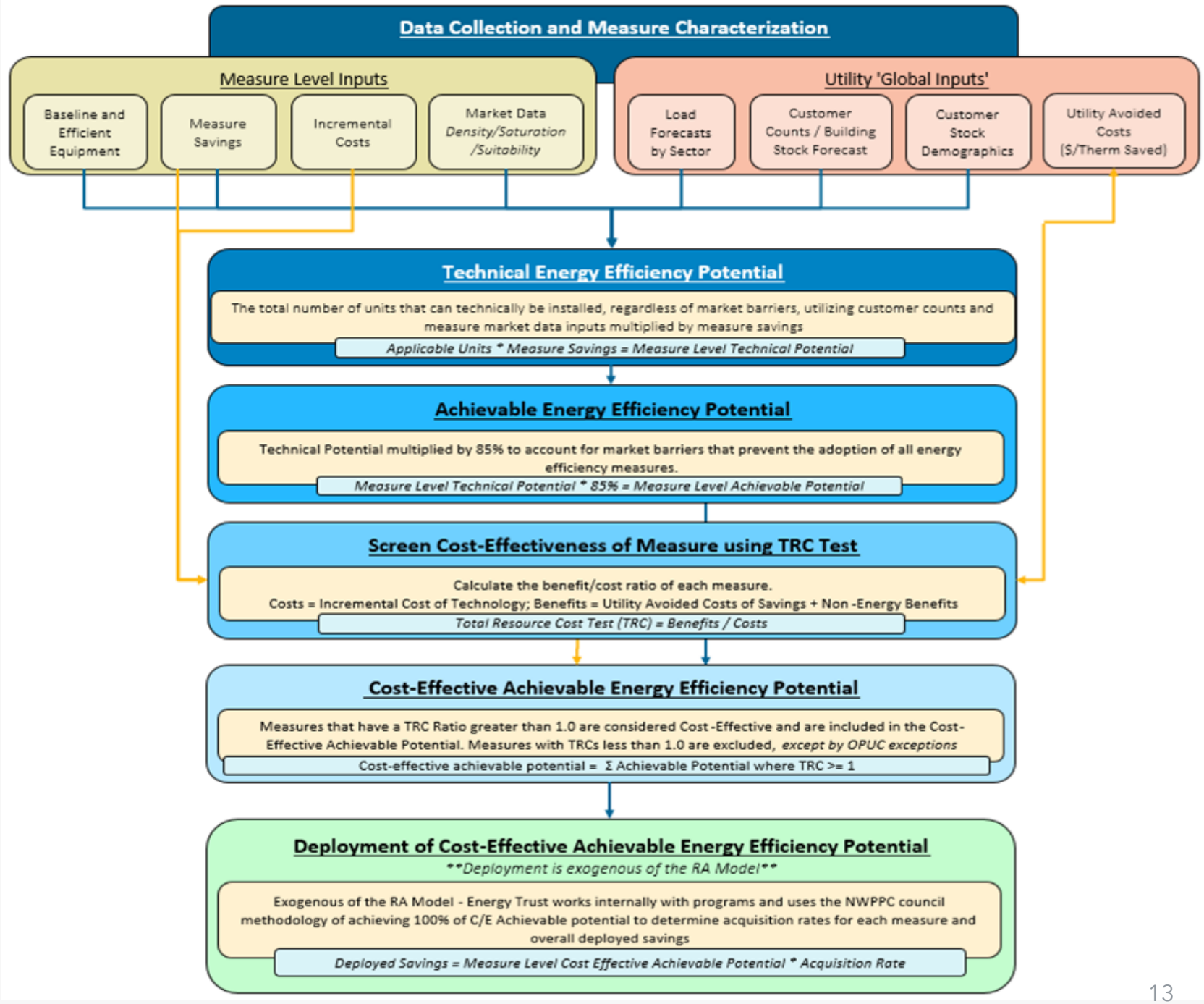
Energy Trust provides PGE with energy efficiency cost-effective achievable potential forecasts to support utility integrated resource planning

Forecast provides estimates of 20-year EE potential and the associated load reduction

Helps PGE to strategically plan future investment in both demand and supply side resources

Supports Energy Trust forecasts of future savings

EE Forecast Model Process



Data Centers in Energy Efficiency Forecast

Forecast model uses energy use intensity (EUI - measured as kWh/sq ft) for commercial and industrial measures

Current and historical EE forecast models use 542 kWh/sq. ft. for Data Centers

Energy use from HVAC pumps and chillers, lighting, computer loads, power supplies, ventilation

Will work with PGE in future to better refine application of data center load data in EE forecast model as needed

Data Center Energy Savings Calculations – The History

Prior to 2020, savings were calculated based on a combination of energy code and standard practice baseline.

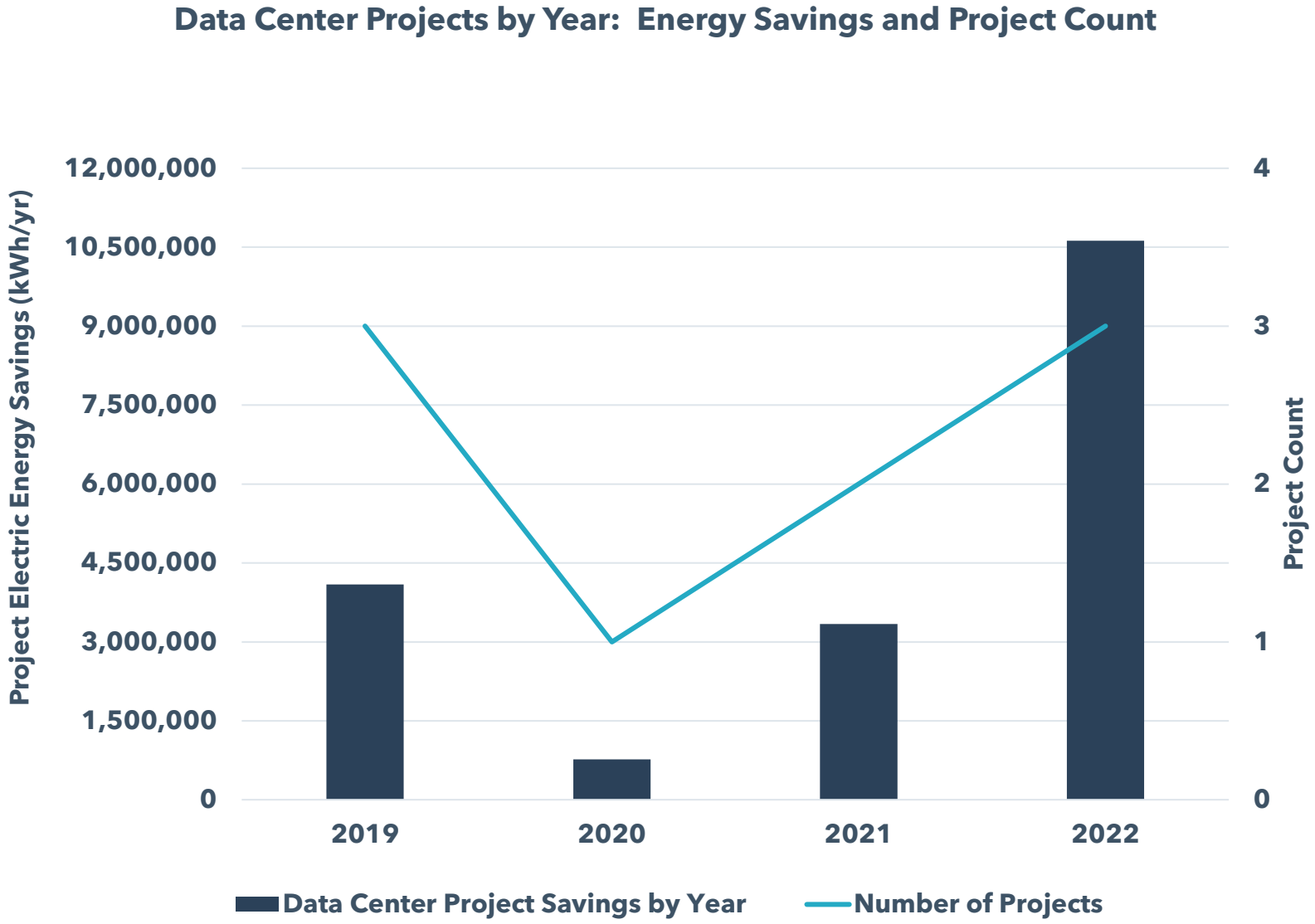
- Early studies conducted to understand data center market, including technology options
- Baseline periodically revised based on energy code updates and other documents supporting changes in standard practice (such as improvements in UPS efficiency)
- Data center project evaluation in 2019 suggested using the new ASHRAE Standard 90.4-2016 as baseline

At one time, there were approved measure calculators for distribution system efficiency (e.g., site-level transformers), high-efficiency UPS and high-efficiency servers.

Added a small savings measure for mini-split system for cooling data closets (limited to no greater than 4.5-ton cooling units); measure is still active.

In 2019, Oregon moved to a commercial energy code based on ASHRAE Standard 90.1. This paved the way for the 2021 Oregon energy code which included ASHRAE Standard 90.4 for data centers.

Historical Data Center Project Savings



Note: Only projects closing in 2022 were enrolled in the current data center offering

Data Center Energy Savings Calculations – The Present

Current offering is based on ASHRAE 90.4 which is a design standard – sets minimum performance levels based on mechanical and electrical system efficiency at 4 loadings (25%, 50%, 75%, and 100%).

Energy Trust offering uses a calculator to estimate annual energy savings from performance at different loadings, applied to the estimated two-year loading schedule.

Primary offering is a whole building offering, with savings coming from efficiencies in the mechanical and electrical systems. There are no savings opportunities associated with the Information Technology Equipment (ITE) load itself.

Based on larger data center projects currently enrolled in the program, energy savings are averaging around 400,000 kWh per MW of ITE design load.

Past Project Savings Based on Load

	Project 1	Project 2	Project 3	Project 4	Project 5
IT Design Power (kW)	45	80	72,255	22,968	35,300
Savings (kWh)	12,265	11,755	54,196,070	6,280,502	20,443,386
Savings per MW (kWh/MW)	**361,444**	**146,938**	**750,067**	**273,446**	**579,133**

Notes:

- Not all projects are in the PGE service territory
- All projects were enrolled under the newest data center offering

Participation Trends in New Buildings Offerings

Existing providers expanding but facing headwinds

- Technological advancements are causing some customers to reconsider their designs, causing construction delays
- Supply chain issues continue to impact construction and loading

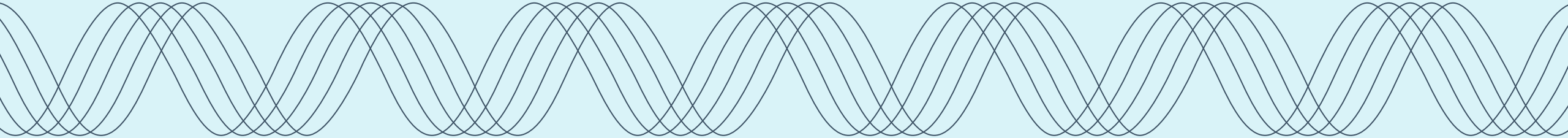
Future participation in New Buildings program is uncertain

- New incentive offering is gaining traction
- Other factors lead to low participation, including privacy concerns and lack of staff to support the process

Questions

PRICE FUTURES

RAINBOW WONG, PGE



Evolution of Price Future Creation

Today's price future update is focused on discussing PGE's carbon policy assumptions to reflect existing carbon tax legislations in WECC.

Below timeline is a summary of PGE's price future creation methodology.

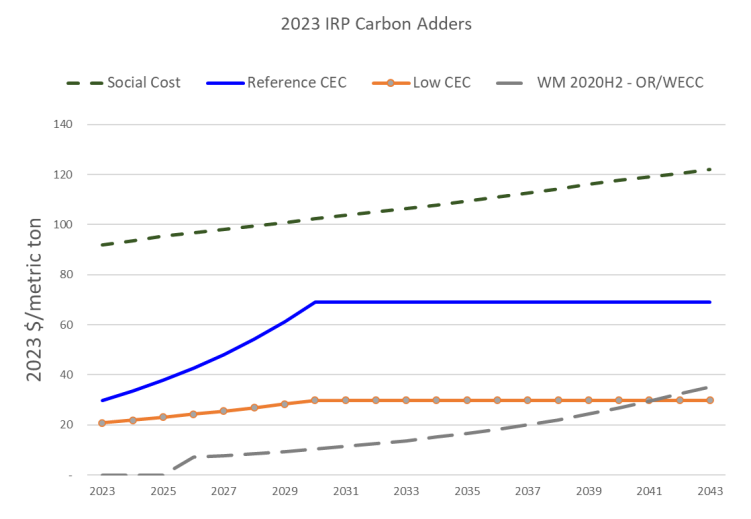
Risk Component	April 2022 Roundtable 22-4	July 2022 Roundtable 22-7	November 2022 Roundtable 22-11	Roundtable 23-2 March 2023
WECC buildout forecast	Wood Mackenzie's High Renewable and Storage WECC outlook			
Carbon policy	• Applied carbon adders to carbon-emitting resources located in CA, OR, and WA for reference case price futures • Applied carbon adders to only CA carbon-emitting resources in low carbon price future • Applied social cost to all high carbon price futures		Created 24 additional futures where there are no carbon adders in WECC	• Apply carbon adders to carbon-emitting resources in CA and WA only for reference price futures • Removed carbon adders to carbon-emitting resources in OR and rest of WECC in low carbon price futures
Gas price	Wood Mackenzie 2021H2 gas price forecast	Updated gas price forecast to 2022H1 Wood Mackenzie forecast		
Hydropower condition	Low, reference, and high hydropower conditions	Created 8 additional futures to align to hydropower conditions futures for modeling in ROSE-E		
Scarcity premium	Created price futures with start-up costs applied to individual resource dispatch costs			
Net-load commitment error	Created price futures with +/-15% wind capacity applied randomly to a day of each month			
Total price futures	**31**	**39**	**42**	**39**

Notes: Specific locations where price futures were discussed are: Roundtable 22-4: slides 45-52; Roundtable 22-7: slides 44-50; and Roundtable 22-11: slides 31-34.

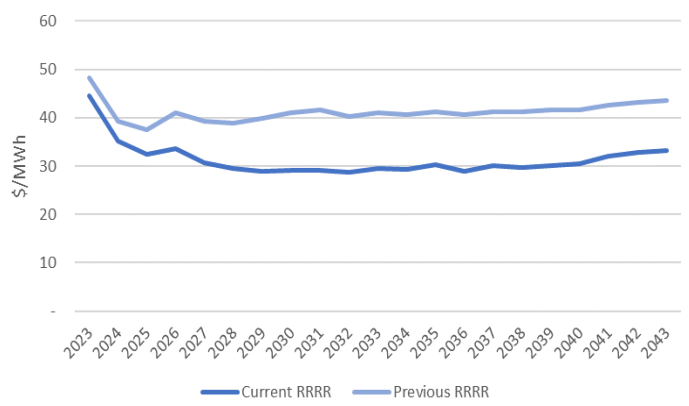
PGE's price future creation methodology and comparison to previous IRP were discussed in Roundtables 21-1, 21-3, and 21-8.

Impacts of Carbon Policy Changes on PNW Electricity Prices

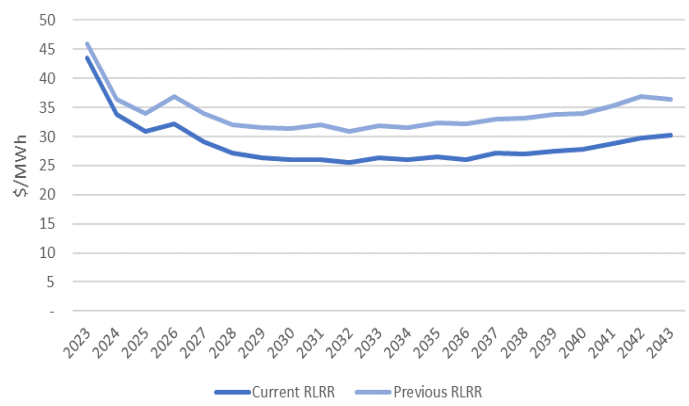
The updated carbon policy assumptions to the Western Electricity Coordinating Council (WECC) region reduced the simulated Pacific Northwest electricity prices for the Reference and Low Carbon price futures as no carbon adder is applied to Oregon and the rest of WECC.



	CA	WA	OR	WECC	BC, Alb
Previous RRRR	Ref CEC	Ref CEC	Ref CEC	WM 2020H2	tax
Current RRRR	Ref CEC	Ref CEC	none	none	tax



	CA	WA	OR	WECC	BC, Alb
Previous RLRR	Low CEC	Low CEC	Low CEC	WM 2020H2	tax
Current RLRR	Low CEC	Low CEC	none	none	tax



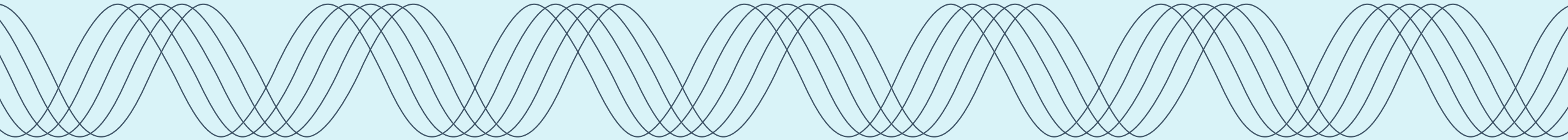
Notes:

- California Energy Commission (CEC)
- Wood Mackenzie (WM) . WM is an independent power research consultancy. PGE incorporates WM's industry expertise to IRP modeling assumptions.
- Reference case price future (RRRR). This price future sets:
  - **R**eference WECC buildout outlook
  - **R**eference case carbon adder
  - **R**eference case gas price forecast
  - **R**eference case hydropower generation
- RLRR is a price future that has the same reference case components of RRRR, with the exception of having Low carbon adder

Questions

DRAFT PORTFOLIO ANALYSIS RESULTS & PREFERRED PORTFOLIO PART II

ROB CAMPBELL AND NIHIT SHAH, PGE

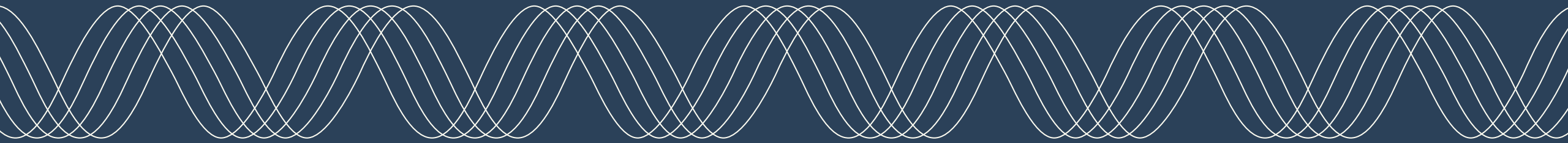


Recap and Previous Meetings

We have presented on portfolio analysis in the last four meetings	January 2023 – Draft results and preferred portfolio – link
	December 2022 – Draft results – link
	November 2022 – Proposed portfolios for analysis - link
	October 2022 – Transmission constraint approach - link

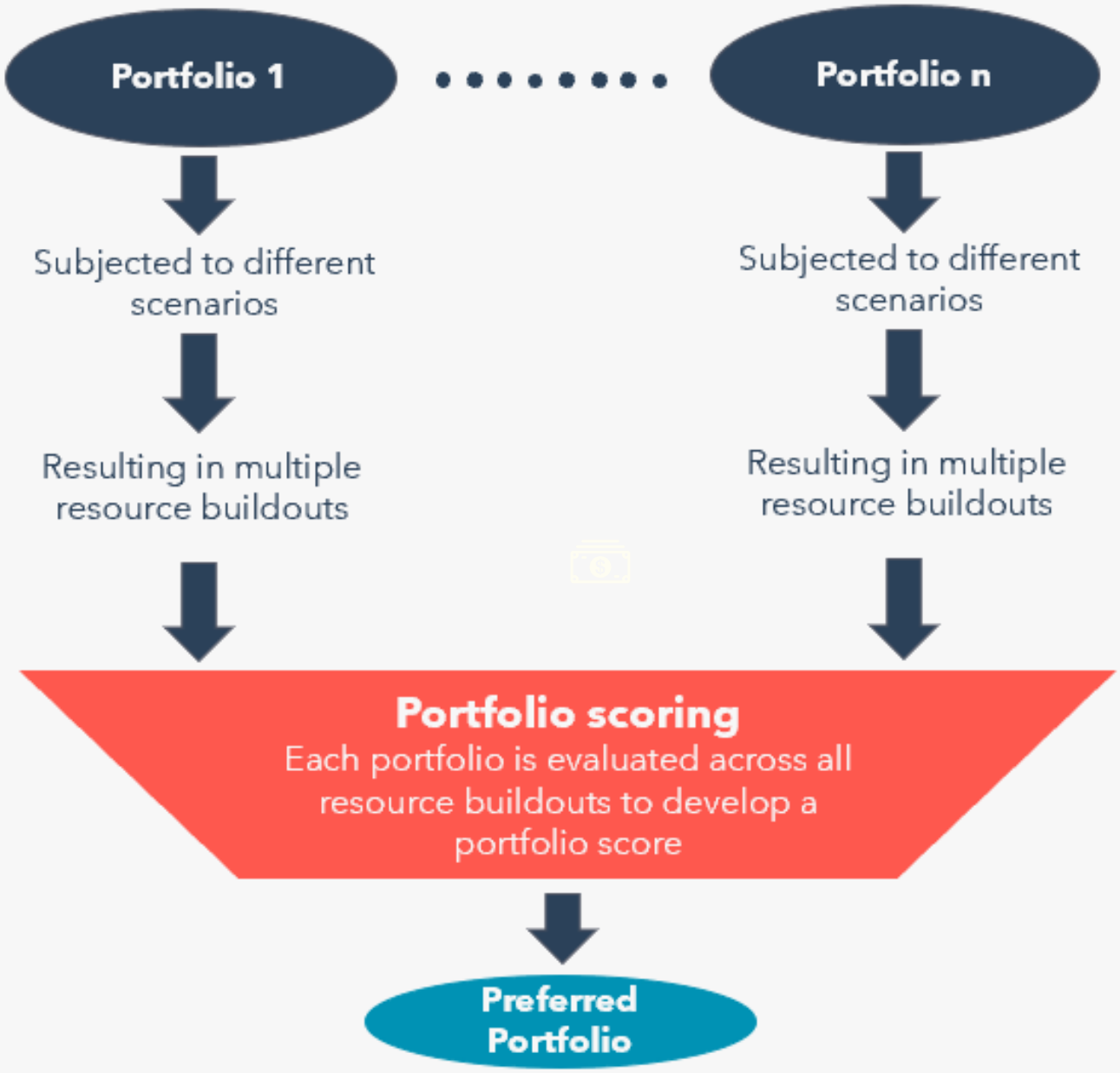
Today's presentation will cover:	Analysis Approach
	Design Requirements
	Draft Results
	Preferred Portfolio
	Yearly Price Impacts
	Resource Buildout Robustness
	Sensitivities

Portfolio Analysis Approach



From a Portfolio to the Preferred Portfolio

- **Portfolio**: A fixed set of resource decisions designed to test the impact of specific constraints or resource additions.
- **Preferred Portfolio**: A portfolio used to inform the Action Plan, designed based on key insights and common themes identified from the analysis of many portfolios.



Portfolio Analysis in this IRP

PGE has addressed key questions through portfolio analysis, such as:

- What should be the pace of emission reductions?
- Which resource actions maximize community benefit?
- Will community-based renewables (CBREs) lower system costs?
- Should PGE pursue additional EE and DR to what was previously planned?
- Is there sufficient transmission available to meet HB 2021 2030 targets?
- Do transmission expansion options provide a way for PGE to meet system needs at the lowest cost?

Answering these questions provides key insights on how to balance cost, risk, rate of GHG reduction, and community benefits

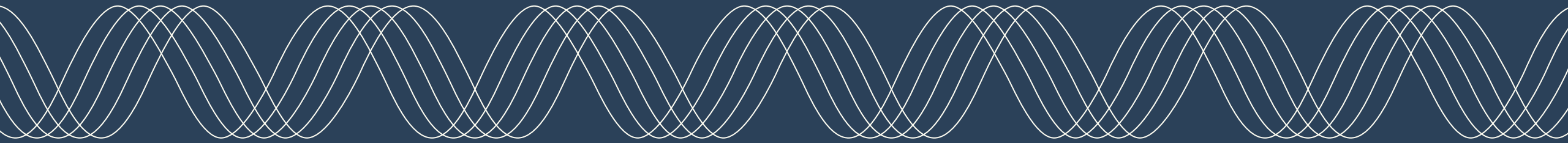
PGE has developed the draft preferred portfolio based on these key insights

Portfolio Categories

PGE has evaluated 40 portfolios across 7 portfolio categories

Decarbonization Glidepath	Explored the relationship between the rate of emissions reduction to serve retail load, cost, and risk
Transmission	Studied the need for transmission, the timing of this need, and the corresponding magnitude needed over time to reliably decarbonize
CBRE	Explored the relationship between costs, risk, and community benefits
Additional EE and DR	Determined if and how the role of these resources could change with the changing planning environment
Optimized	Effect of optimization assumptions
Targeted policy	To inform stakeholder discussions on specific policy questions
Emerging Technology	Understand the impact of emerging technologies

Portfolio Design Requirements



Key Assumptions in Portfolio Analysis

Parameter	Base Assumption (unless modified by portfolio design)
Emissions	Must comply with HB 2021 GHG emissions reduction targets
Resource procurement	Opportunities for incremental resource actions are available starting in 2026
Energy position	Starting in 2026, portfolio cannot be long more than 100 MWa
Contract expiration	200 MW of contract extension through 2030
RPS	Portfolios comply with RPS obligations
Transmission	Portfolios subject to Transmission constraint based on BPA contractual landscape

Updated Methodology: Generic Resources

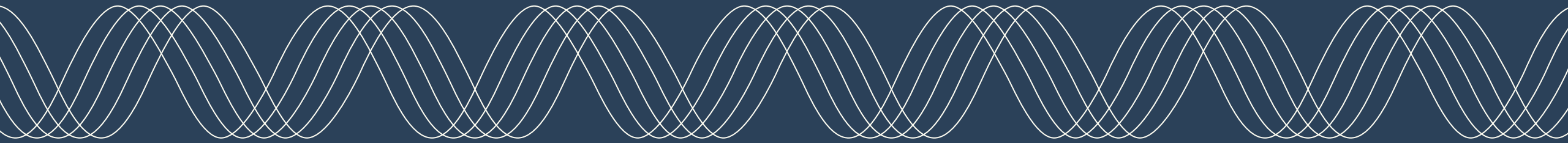
Previous method

- One Generic non-emitting resource providing capacity and energy
- Available in 2031 as default, with earlier-access made available for portfolios with otherwise insufficient resources
- Real-levelized fixed costs = $1000/kW-year cost

Current method

- Two Generic non-emitting resources
- **Generic capacity resource**: 100% ELCC, 0% capacity factor
- **Generic VER resource**: ELCC and capacity factor = weighted average of proxy resources
- Available in 2026 in all portfolios
- Real-levelized fixed costs = 105% of NV Transmission proxy resource

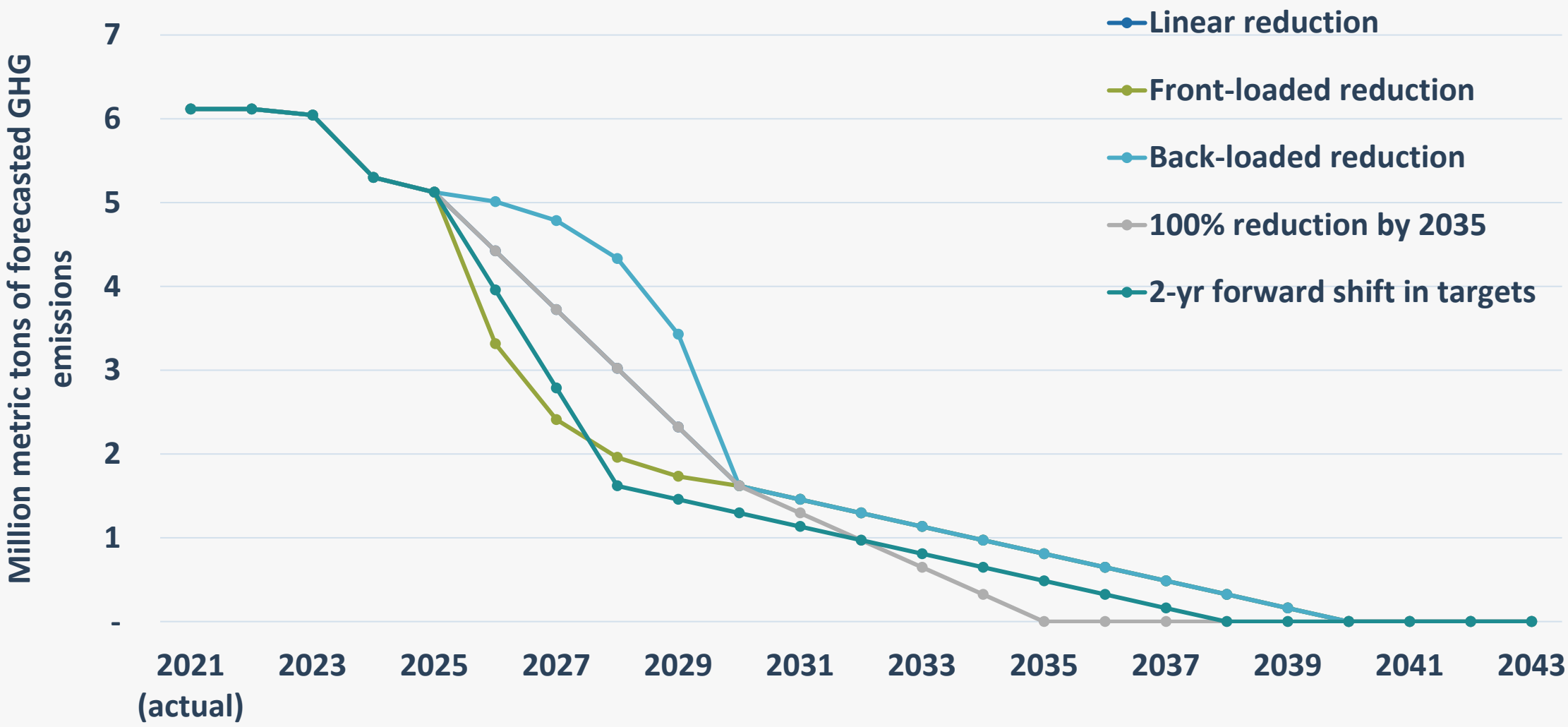
Draft Portfolio Results



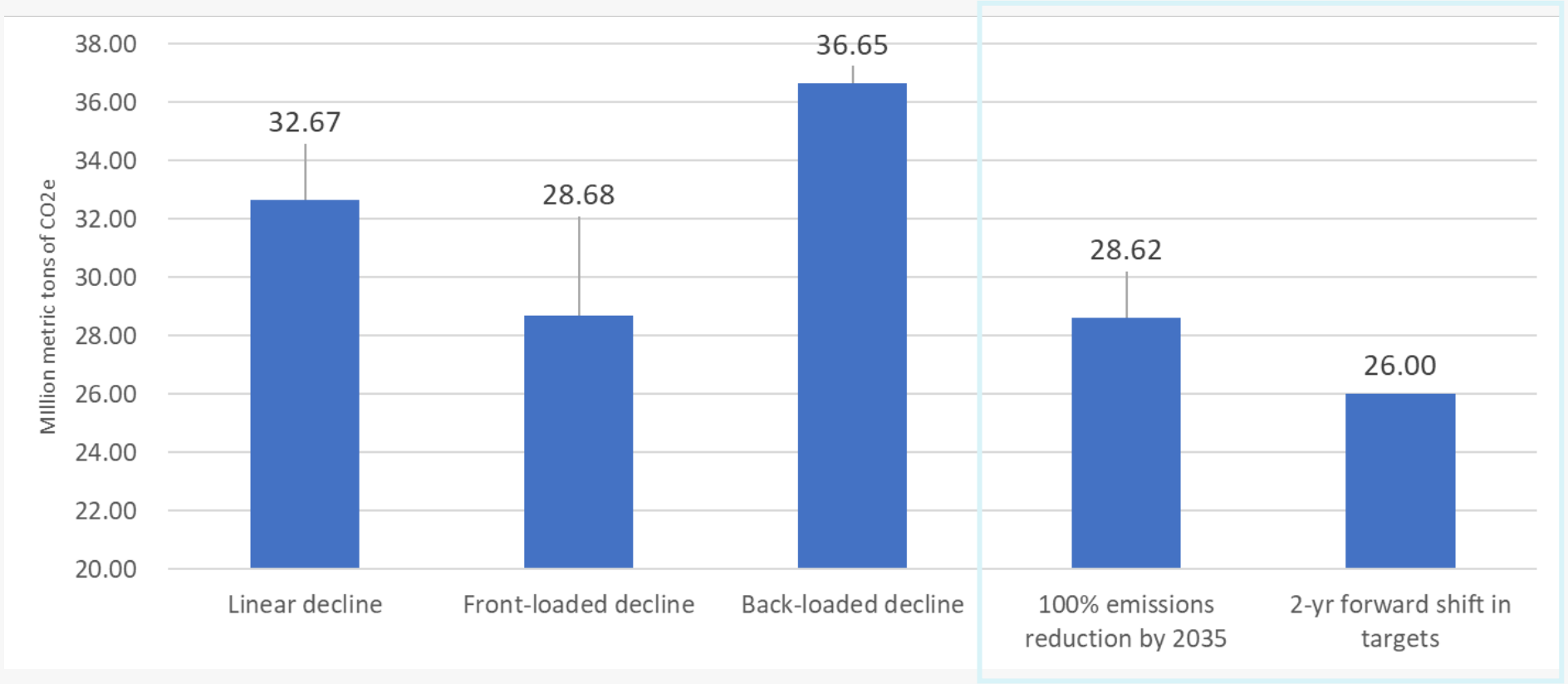
Decarbonization Glidepath Portfolios

Portfolios	Portfolio Condition
Linear reduction	Meeting 2030 targets by adopting a linear path in emissions reduction
Front-loaded reduction	Meeting 2030 targets by front loading emission reduction
Back-loaded reduction	Meeting 2030 targets by rear loading emission reduction
Accelerated Decarbonization Portfolios (achieving targets ahead of HB 2021)	
100% reduction by 2035	Achieving 100% emissions reduction by 2035
2-yr forward shift in targets	Achieving each emissions target 2 years ahead of schedule - 80% by 2028, 90% by 2033 and 100% by 2038

Decarbonization Glidepath Portfolios



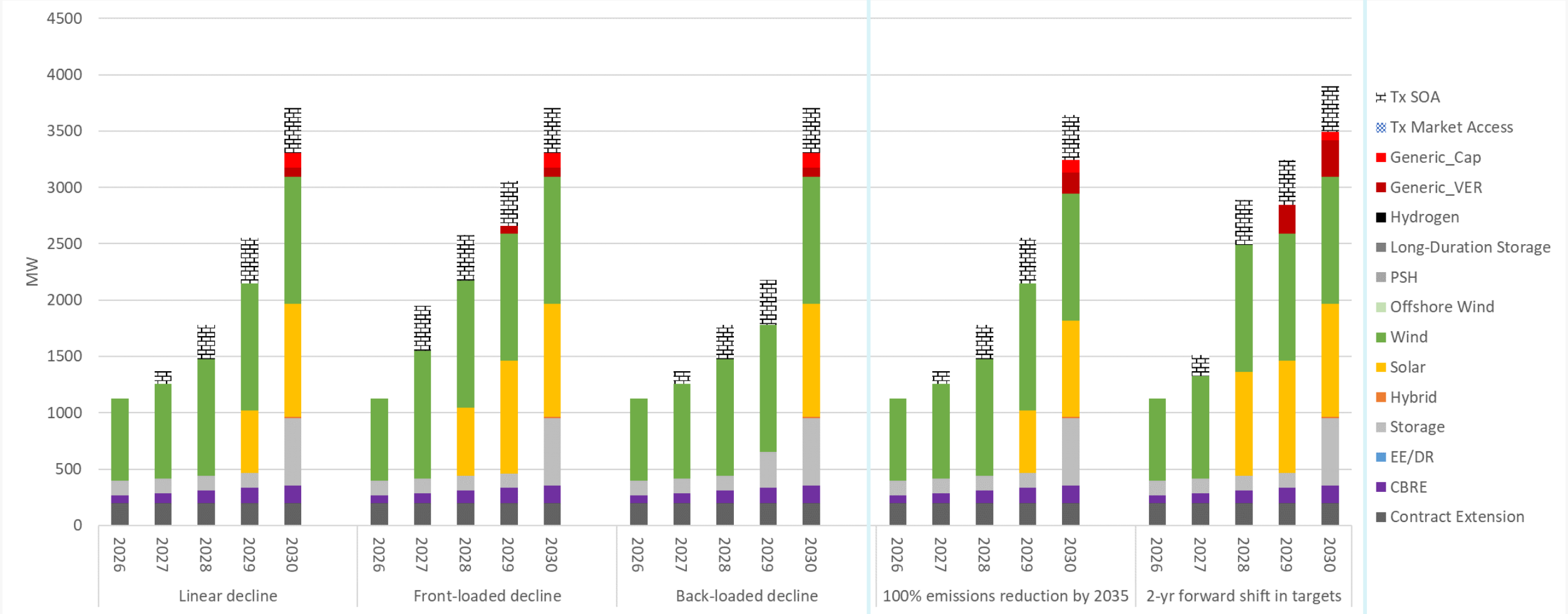
Decarbonization Glidepath Portfolios: Cumulative Emissions



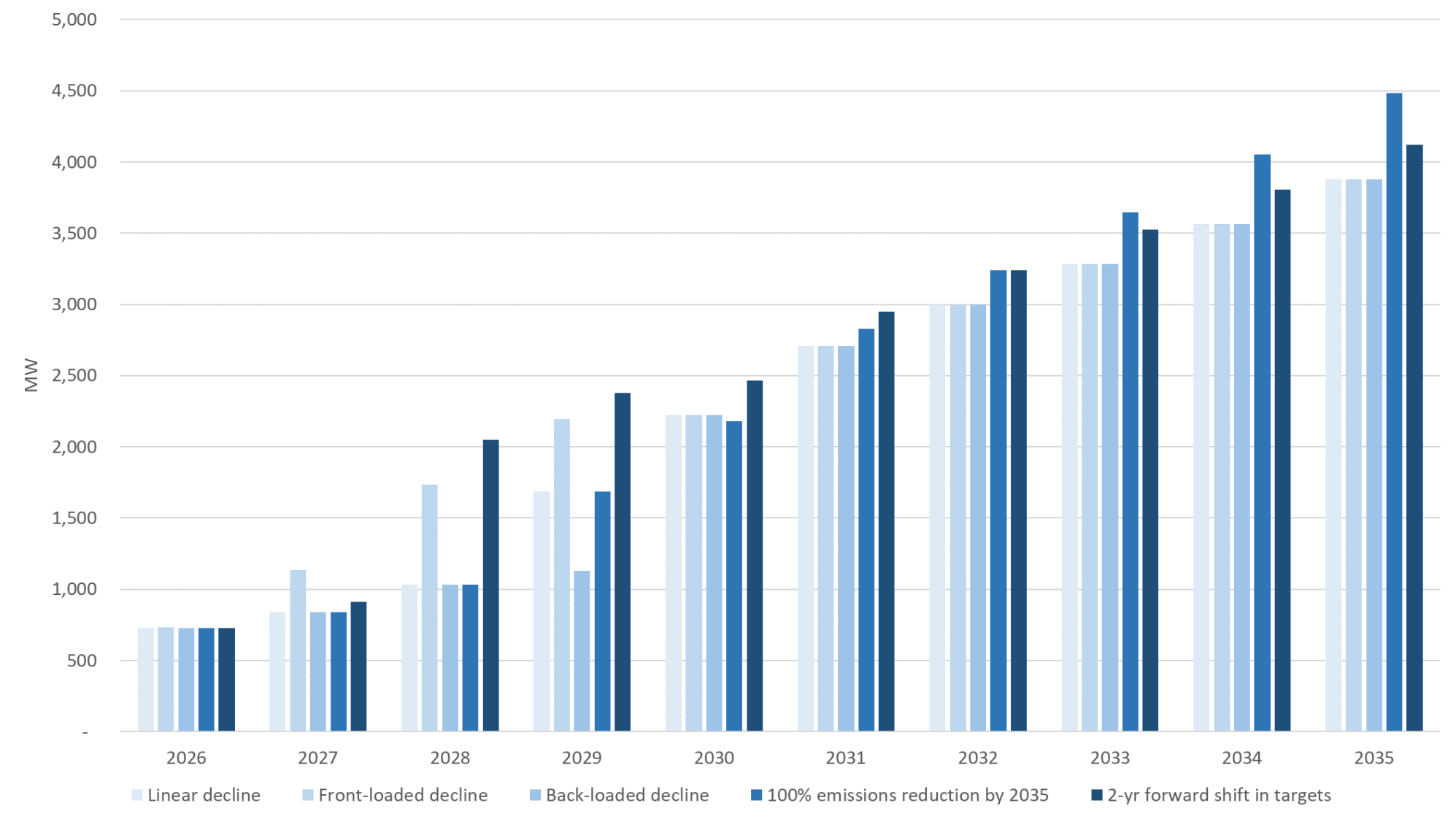
Accelerated decarbonization portfolios

Decarbonization Glidepath Portfolios: Resource Buildouts

Accelerated decarbonization portfolios



Decarbonization Glidepath Portfolios: Renewable Resource Buildouts

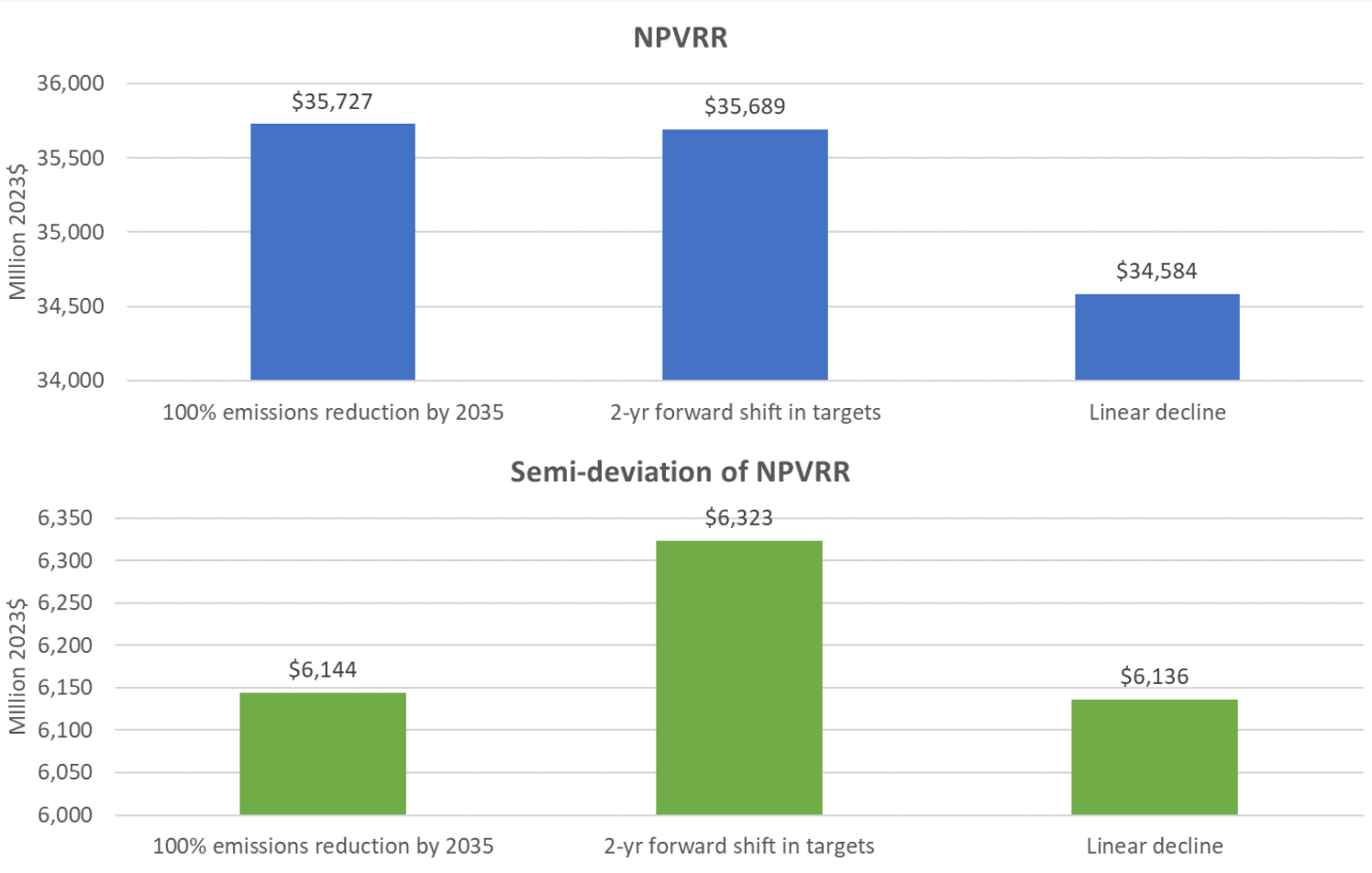


Decarbonization Glidepath Portfolios: Insights (1/2)

Achieving HB 2021 targets earlier than currently mandated (*100% reduction by 2035 and 2-yr forward shift in targets*) lowers cumulative emissions but increases system costs and risk

Accelerated decarbonization increases procurement risk and dependence on new transmission options or emerging technologies

Meeting HB 2021 targets as currently mandated best balance GHG reductions, risk, and cost



Note: While resource buildouts are shown through 2030 in most cases, cost and risk metrics throughout presentation are based on full 2024-2043 time-horizon.

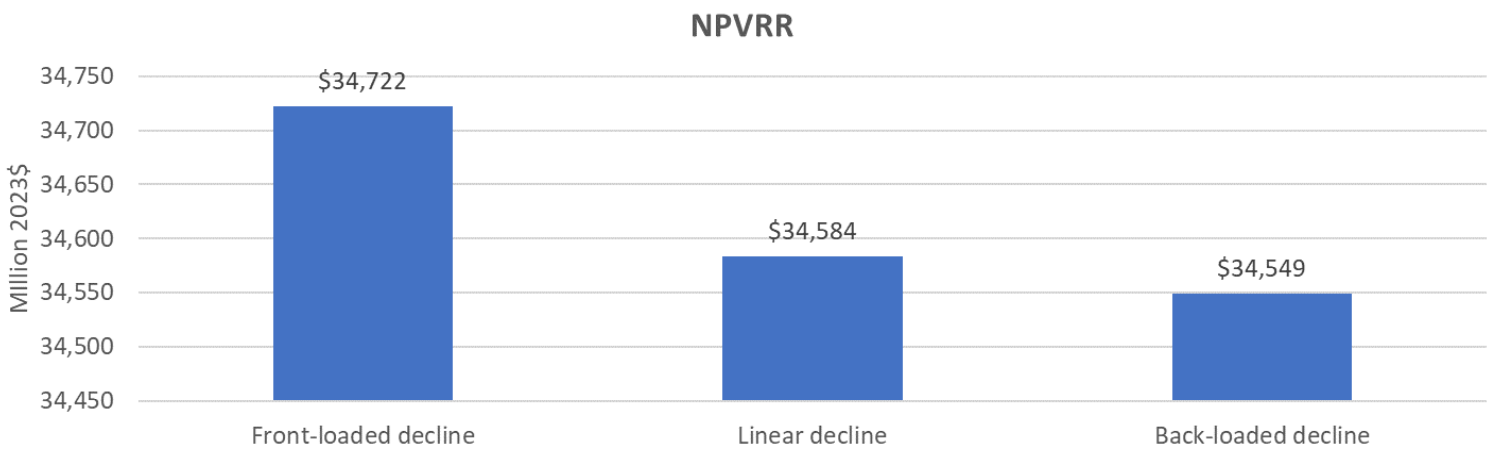
Decarbonization Glidepath Portfolios: Insights (2/2)

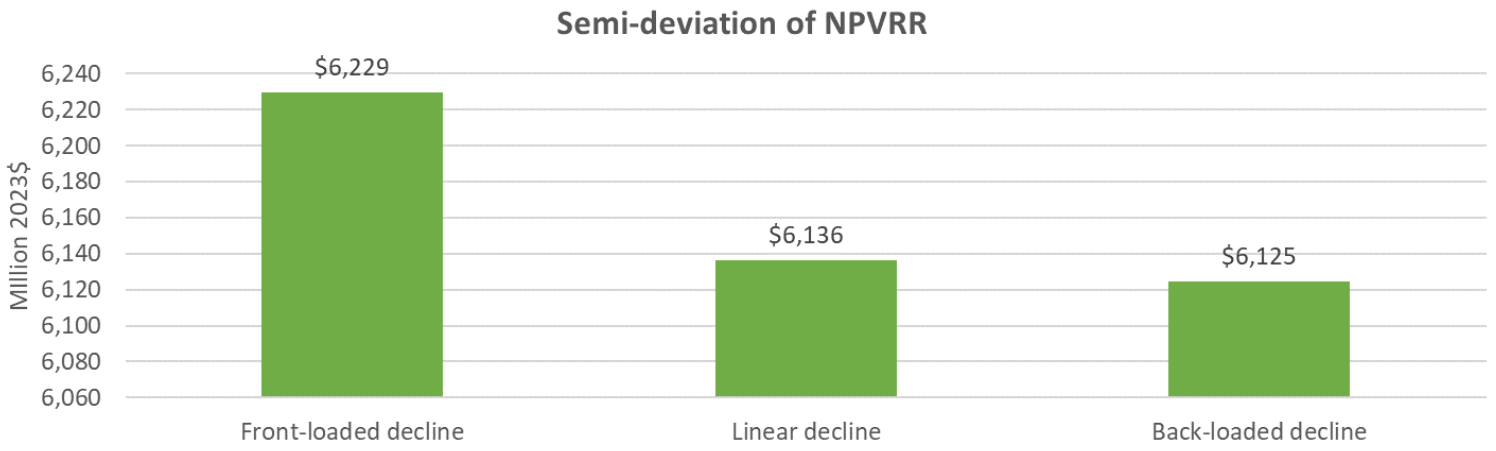
Cumulative emissions of *Linear decline* are close to the average of *Front-loaded decline* and *Back-loaded decline*, but costs are closer to *Back-loaded decline*

Back-loaded decline is lowest cost but increases risks such as:

- Increased uncertainties in available transmission inventory
- Procurement delays and other supply chain constraints
- Operational risks associated with adding large quantities of resources in a small amount of time
- Regulatory delays of approval processes

Key takeaway – PGE should use a linear reduction path through 2030 in the preferred portfolio

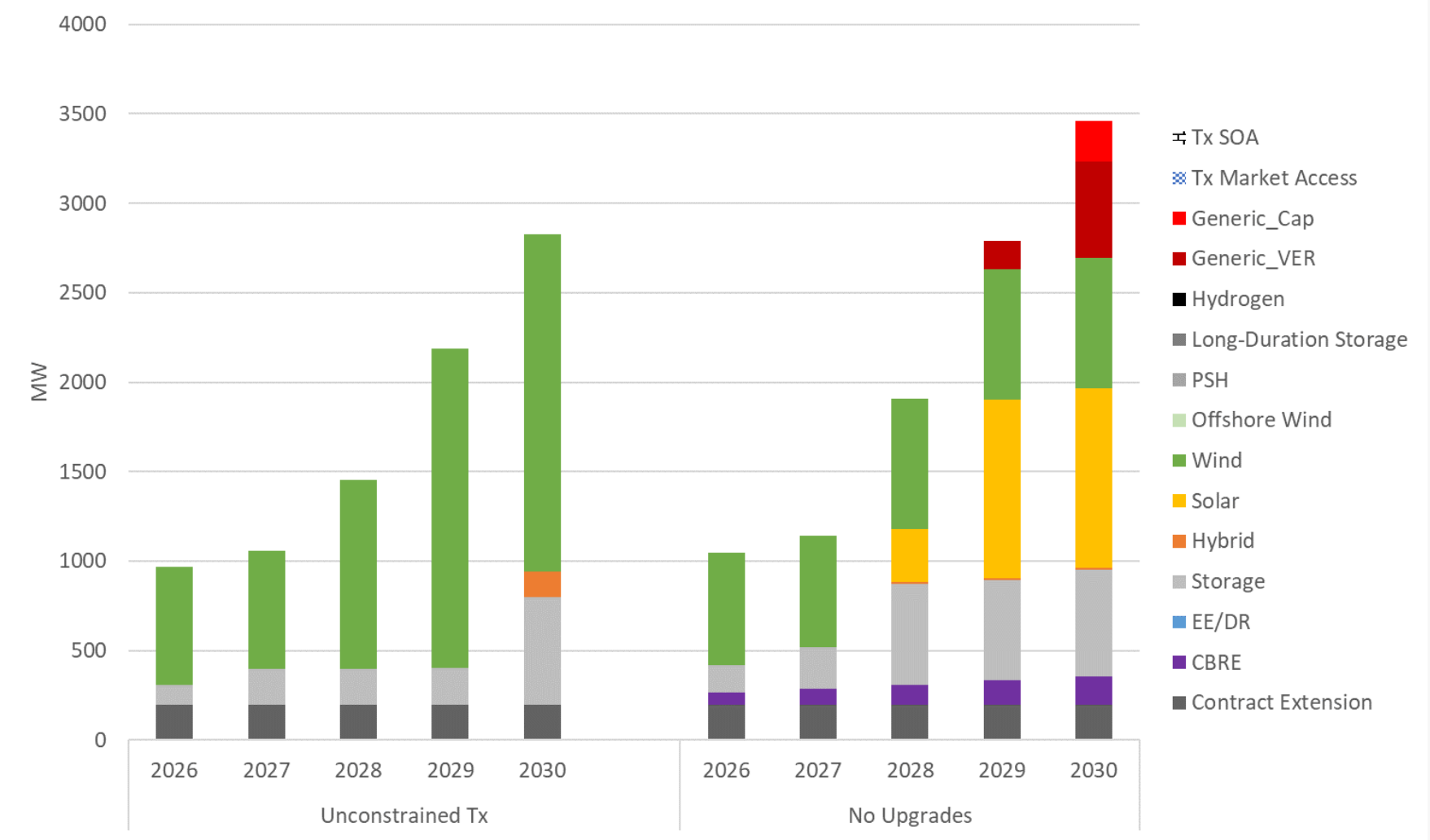




Transmission Portfolios

Portfolios	Subcategory	Portfolio Condition
No Tx constraints	Informational	No transmission constraints
No upgrades		No transmission upgrades or built options are available.
Unconstrained SoA	Transmission diversity	Unlimited South of Allston transmission access beginning in 2027
Unconstrained SoA plus other options		Unlimited South of Allston transmission access beginning in 2027 New transmission options to WY and NV are available in 2026
SoA in 2027 plus	Transmission timing	South of Allston upgrade unlocks 400MW of IRP proxy resources in the PNW in 2027 New transmission options 400 MW each to WY and NV are available in 2026
SoA in 2027		South of Allston upgrade unlocks 400MW of IRP proxy resources in the PNW in 2027
SoA in 2029		South of Allston upgrade unlocks 400MW of IRP proxy resources in the PNW in 2029
WY in 2026		New transmission option 400 MW to Wyoming in 2026
NV in 2026		New transmission option 400 MW to Desert Southwest in 2026
WY in 2028		New transmission option 400 MW to Wyoming in 2028
NV in 2028		New transmission option 400 MW to Desert Southwest in 2028

Informational Transmission Portfolios



Informational Transmission Portfolios: Insights

Transmission is the single largest factor impacting the economics and timing of resource additions in this IRP

Transmission need is significant and required for PGE to reliably decarbonize and meet the 2030 targets of HB 2021

Transmission needs arise by 2029 at the latest assuming no constraints on distribution connected resources

Year	Generic VER	Generic capacity	Potential transmission needed (MW)
2026	-	-	-
2028	-	-	-
2029	159	-	159
2030	541	228	541-768
2035	2199	807	2,199-3,005
2040	4285	3183	4,285-7,468
2043	5057	3362	5,057-8,419

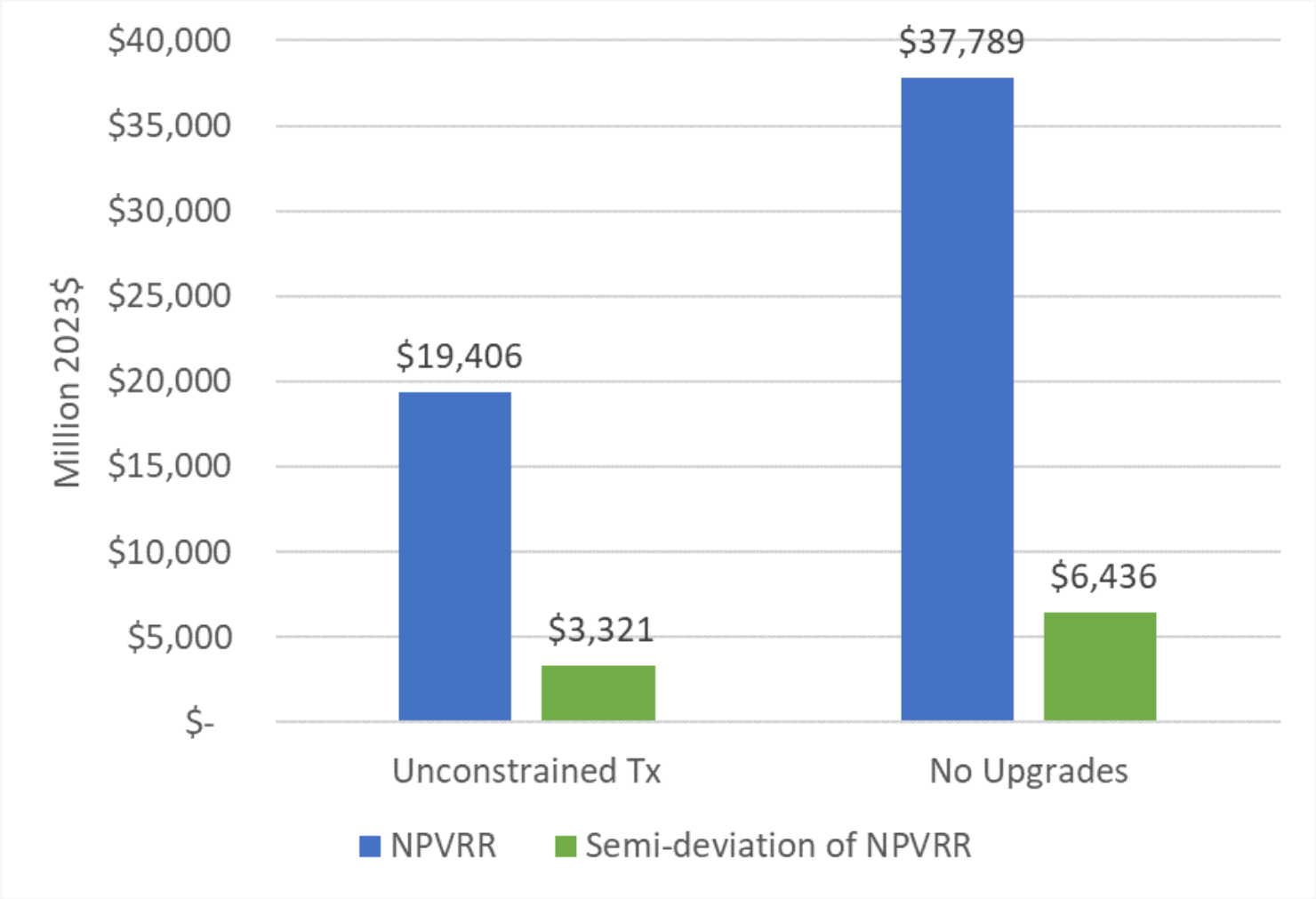
Informational Transmission Portfolios: Insights

Without transmission constraints, CBREs are not selected

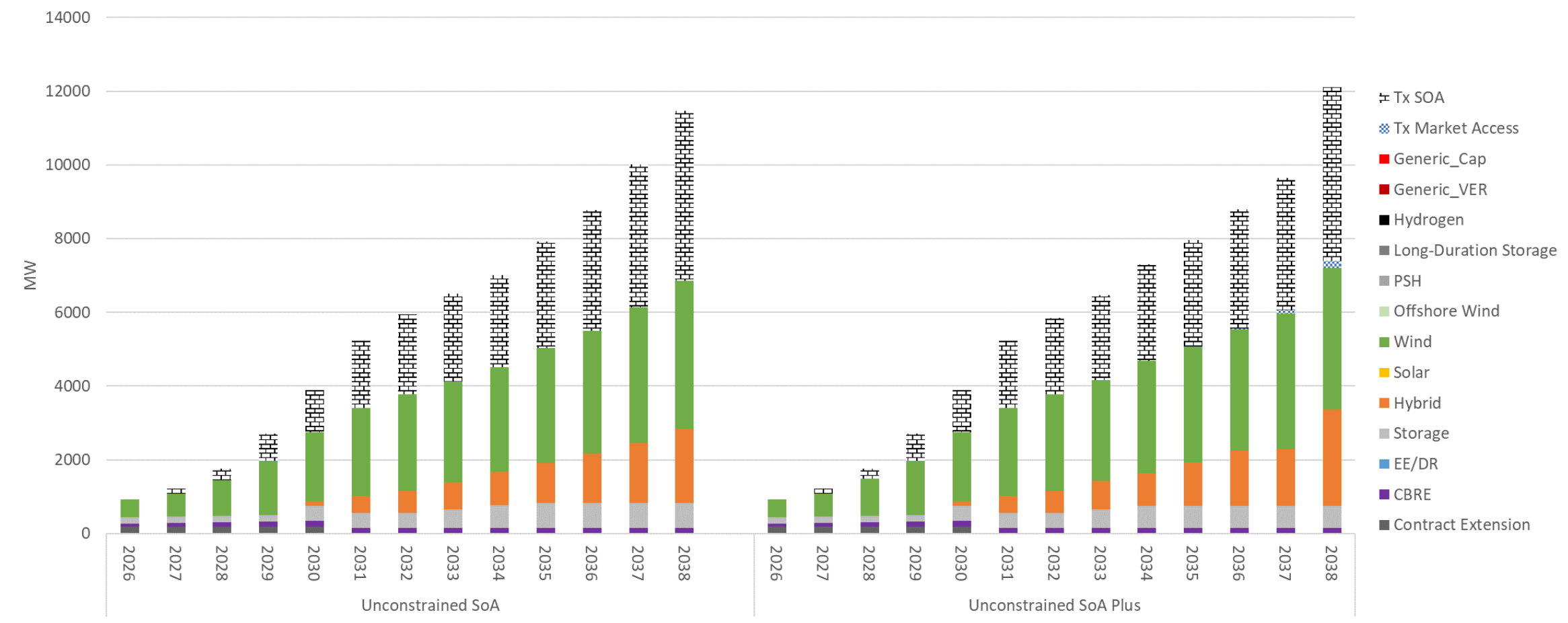
Introducing transmission constraints makes CBREs more competitive

Not investing in transmission significantly increase portfolio costs

Transmission needs by 2030 is between 541-768MW based on resource quality and location growing rapidly over 2,000 MW by 2035



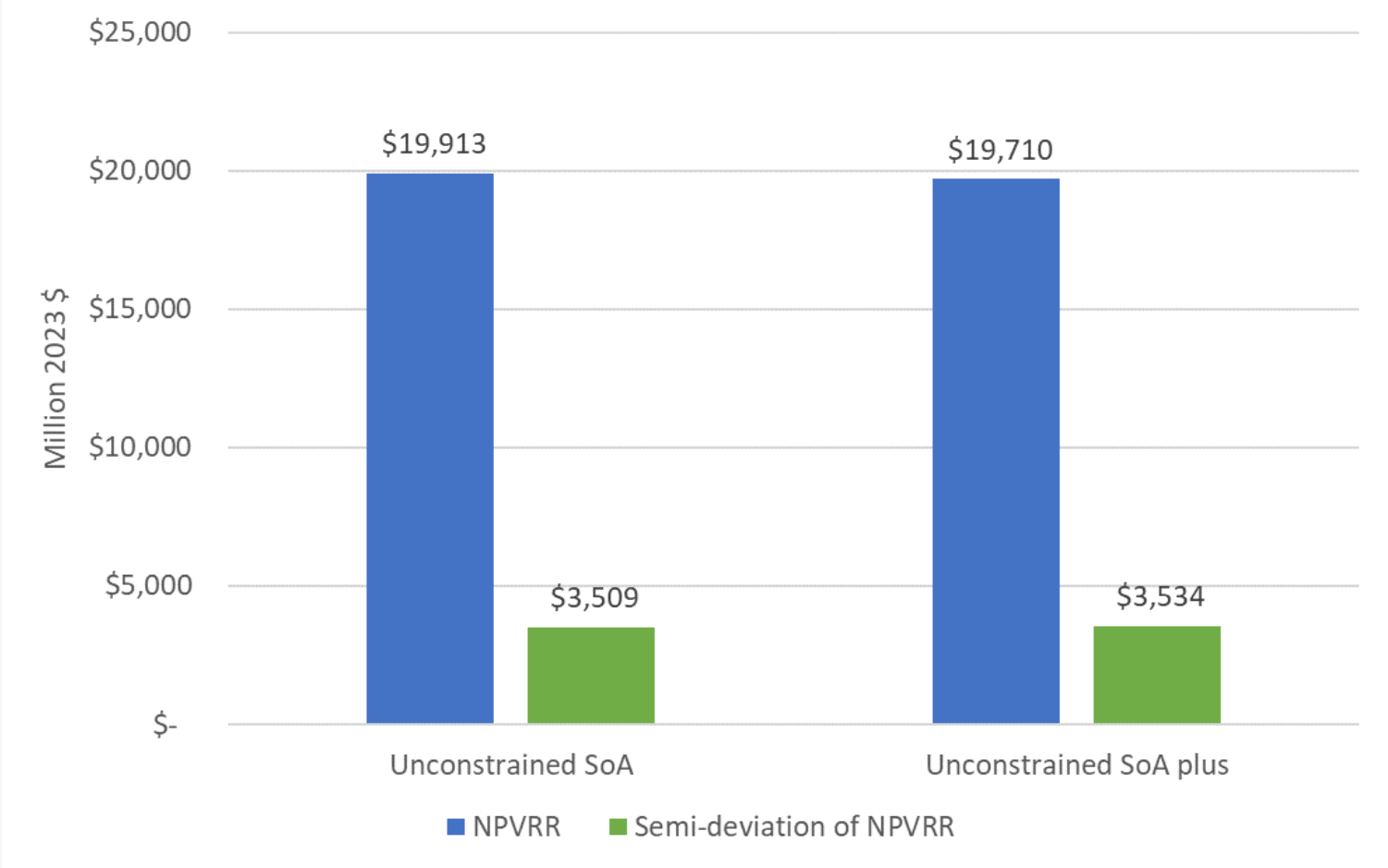
Transmission Diversity Portfolios



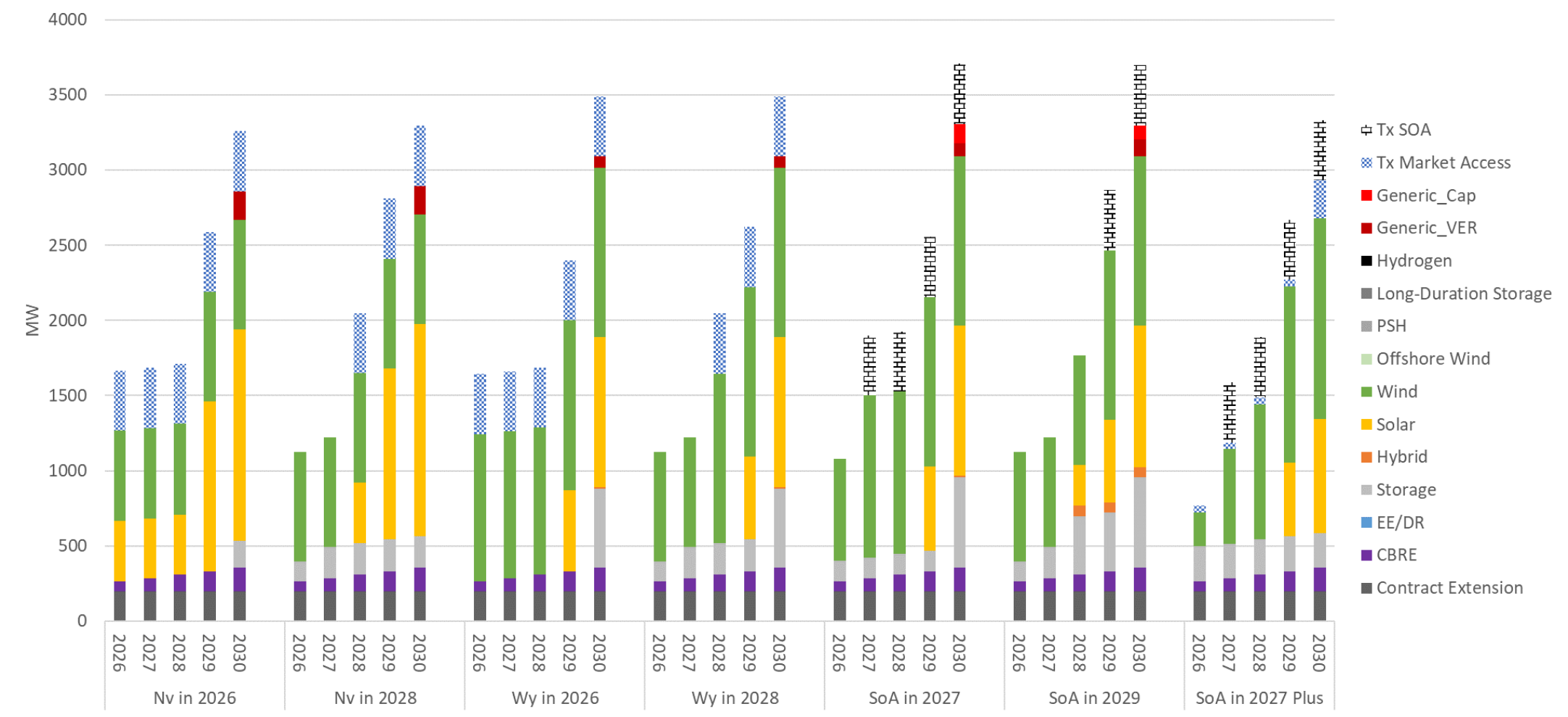
Transmission Diversity Portfolios: Insights

Increasing access to current PNW proxy resources through BPA is a sufficient condition to decarbonize reliably

Investing in additional transmission options beyond the BPA choices can reduce costs



Transmission Timing Portfolios

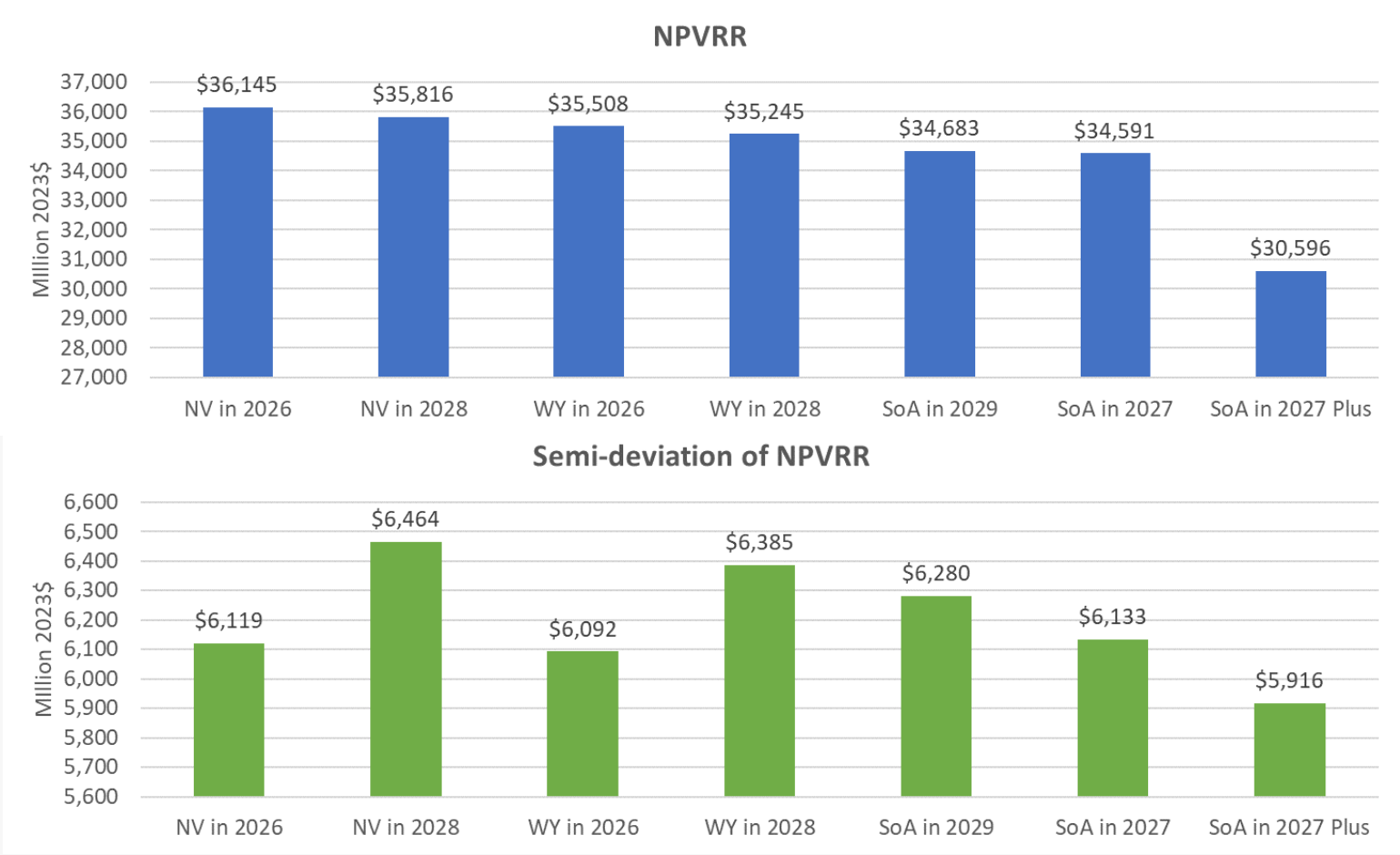


Transmission Timing Portfolios: Insights

After implementing all transmission constraints:

- Actions to increase access to IRP proxy resources and explore new transmission options result in least cost and least risk portfolio that meets HB2021 targets
- Adding NV or WY Tx is more expensive in 2026 than 2028, but the earlier additions decreases risk

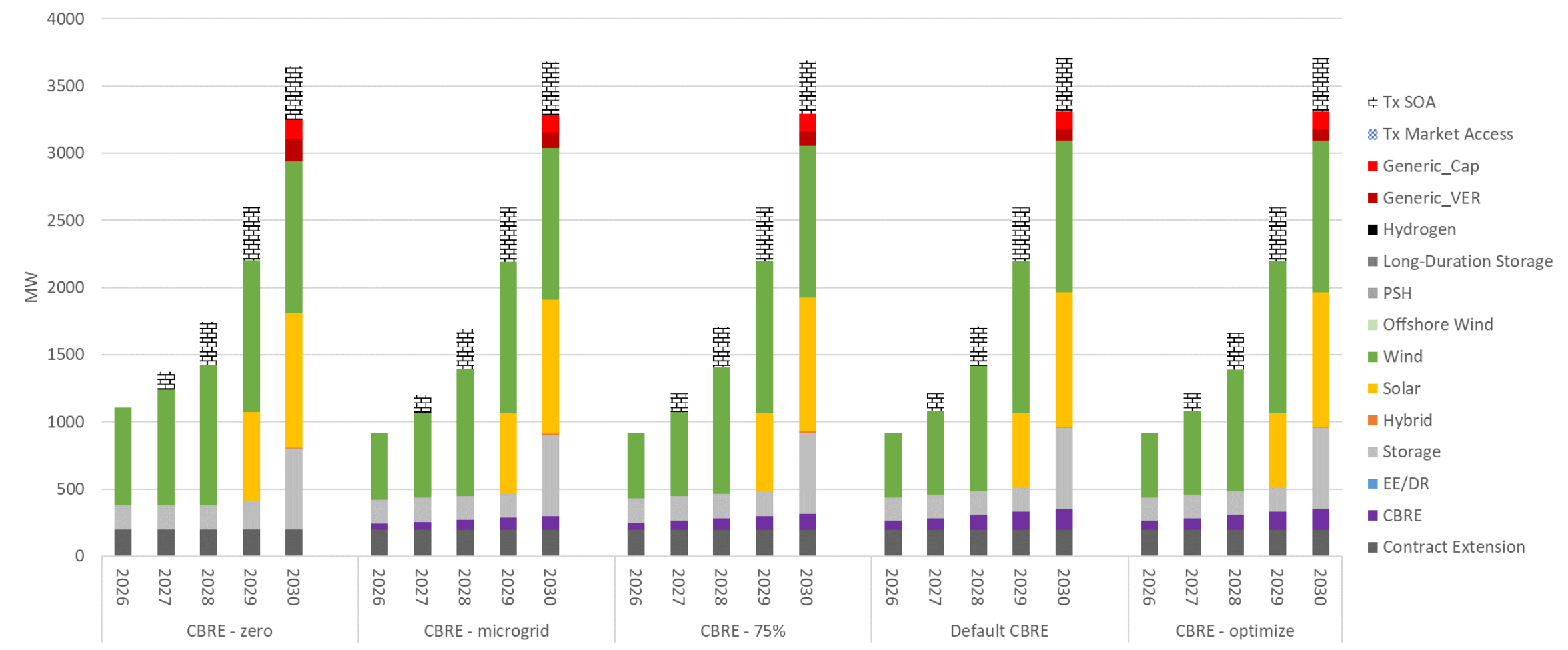
Key takeaway – The Preferred Portfolio should pursue all opportunities to increase access to current proxy resources in 2027 and include access to new transmission options in 2026 to minimize cost and risk



CBRE Portfolios

Portfolios	Portfolio Condition
Default CBREs	100% of CBRE achievable potential is selected
CBRE: 75%	75% of CBRE achievable potential is selected
CBRE: Unavailable	CBREs are unavailable
CBRE: Microgrids	Only Microgrid CBREs are available
Optimized CBREs	CBREs compete economically

CBRE Portfolios



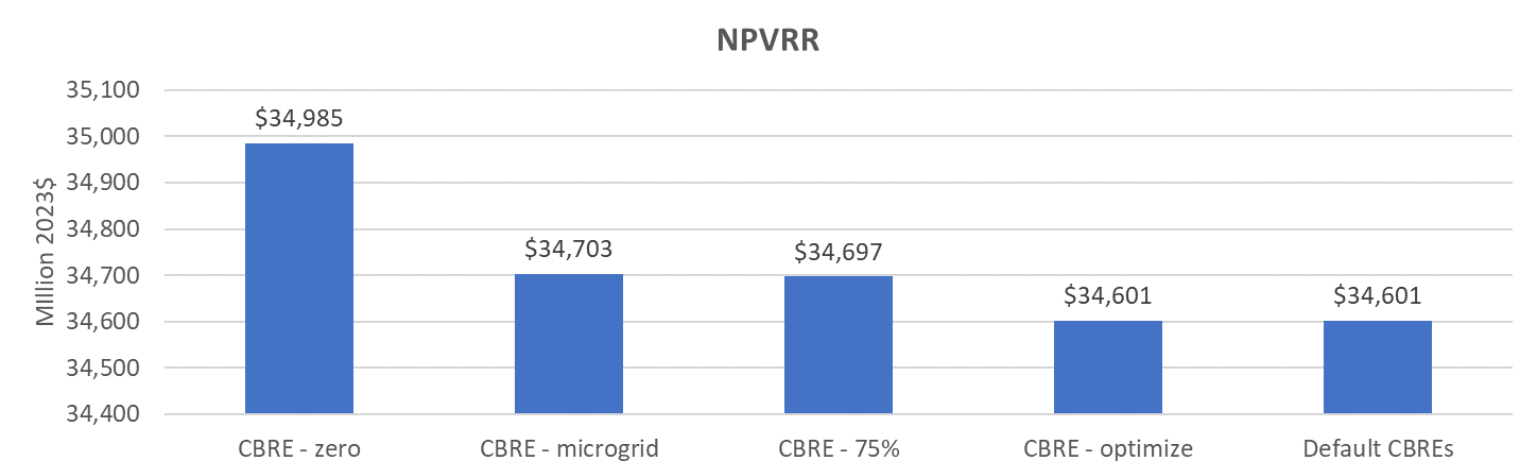
CBRE Portfolios: Insights

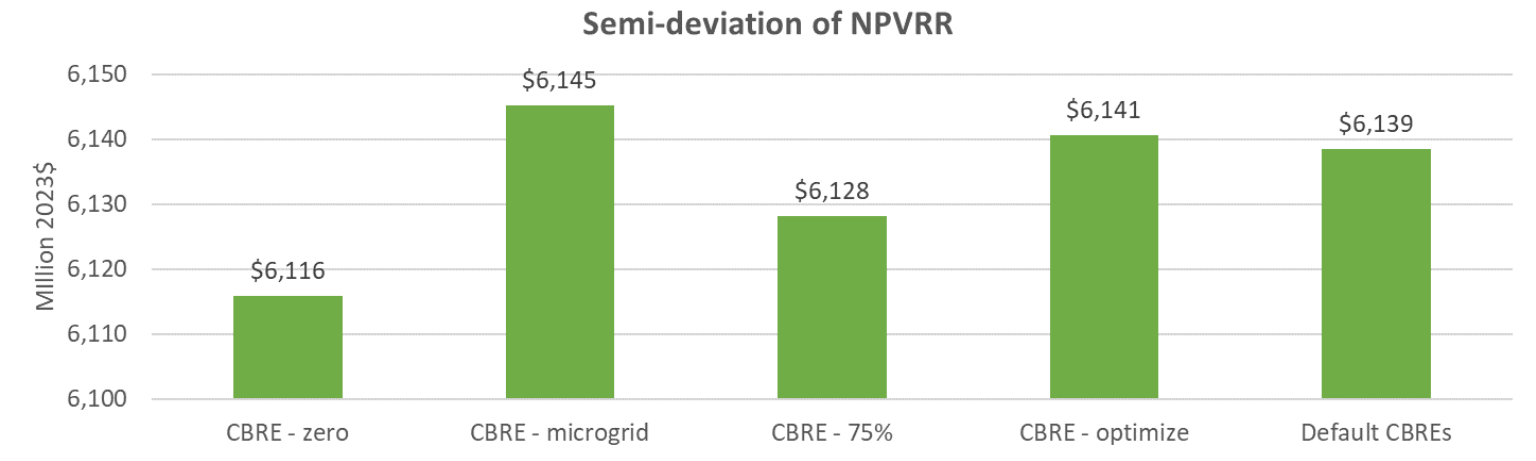
rCBI benefits and transmission constraints result in selecting 100% of the distribution and sub-transmission connected CBRE potential

The Default CBRE and Optimized CBRE portfolios provide the most community benefits based on pCBI findings

Thus, selecting 100% of CBREs would both maximize community benefits and reduce cost

Key takeaway – The Preferred Portfolio should include 100% of CBRE potential to ensure a least cost portfolio that maximizes community benefits



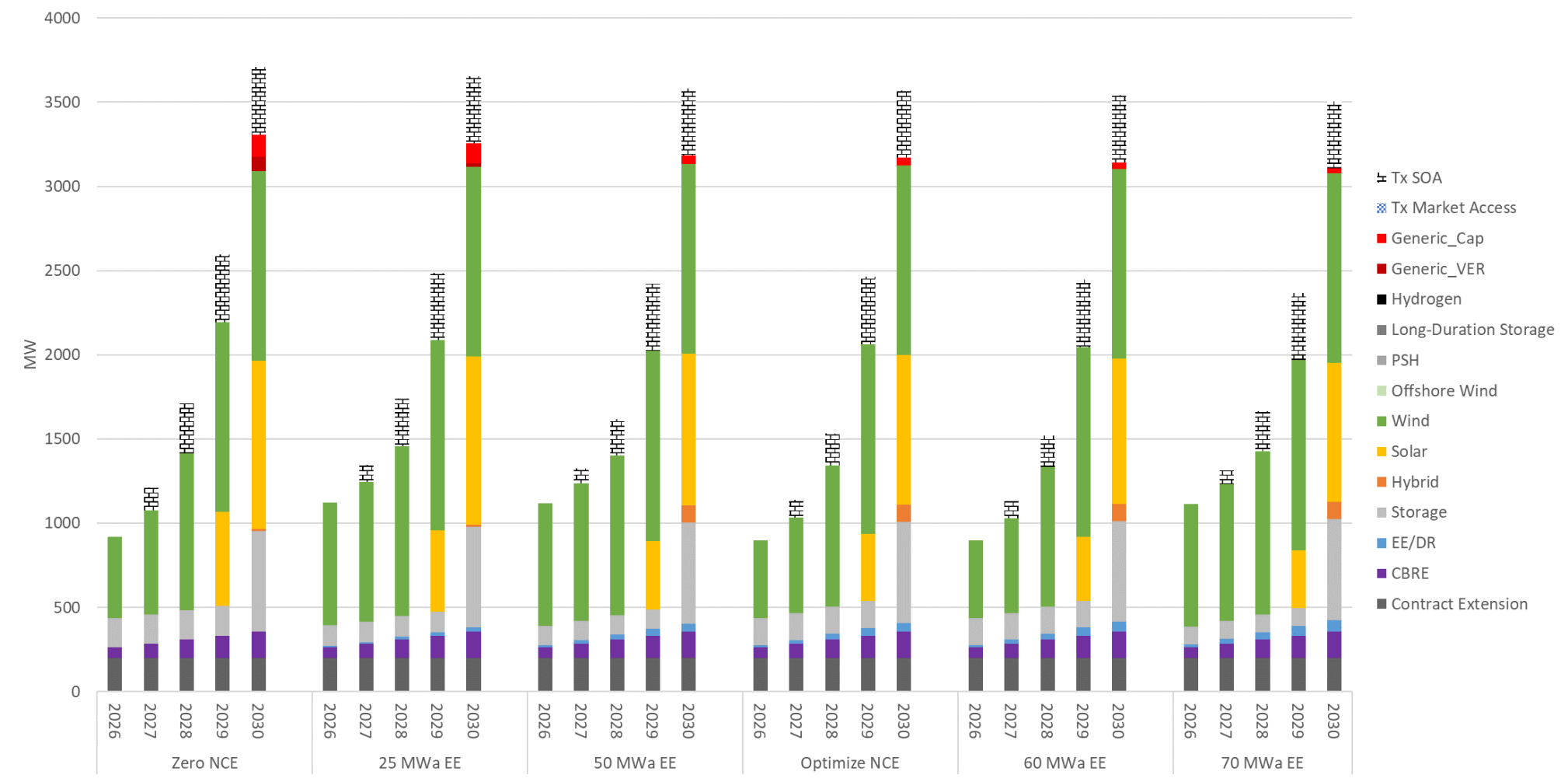


Portfolios	pCBI
Default CBREs	155
CBRE: 75%	116
CBRE: Unavailable	0
CBRE: Microgrids	100
Optimized CBREs	155

Additional EE and DER Portfolios

Portfolios	Portfolio Condition 2026 - 2030
Zero NCE	No NCE DERs available
25 MWa EE	5MWa of NCE EE included each year
50 MWa EE	10MWa of NCE EE included each year
60 MWa EE	12MWa of NCE EE included each year
70 MWa EE	15MWa of NCE EE included each year
Optimize EE	15MWa of NCE EE available each year

Additional EE and DER Portfolios



Additional EE and DER Portfolios: Insights

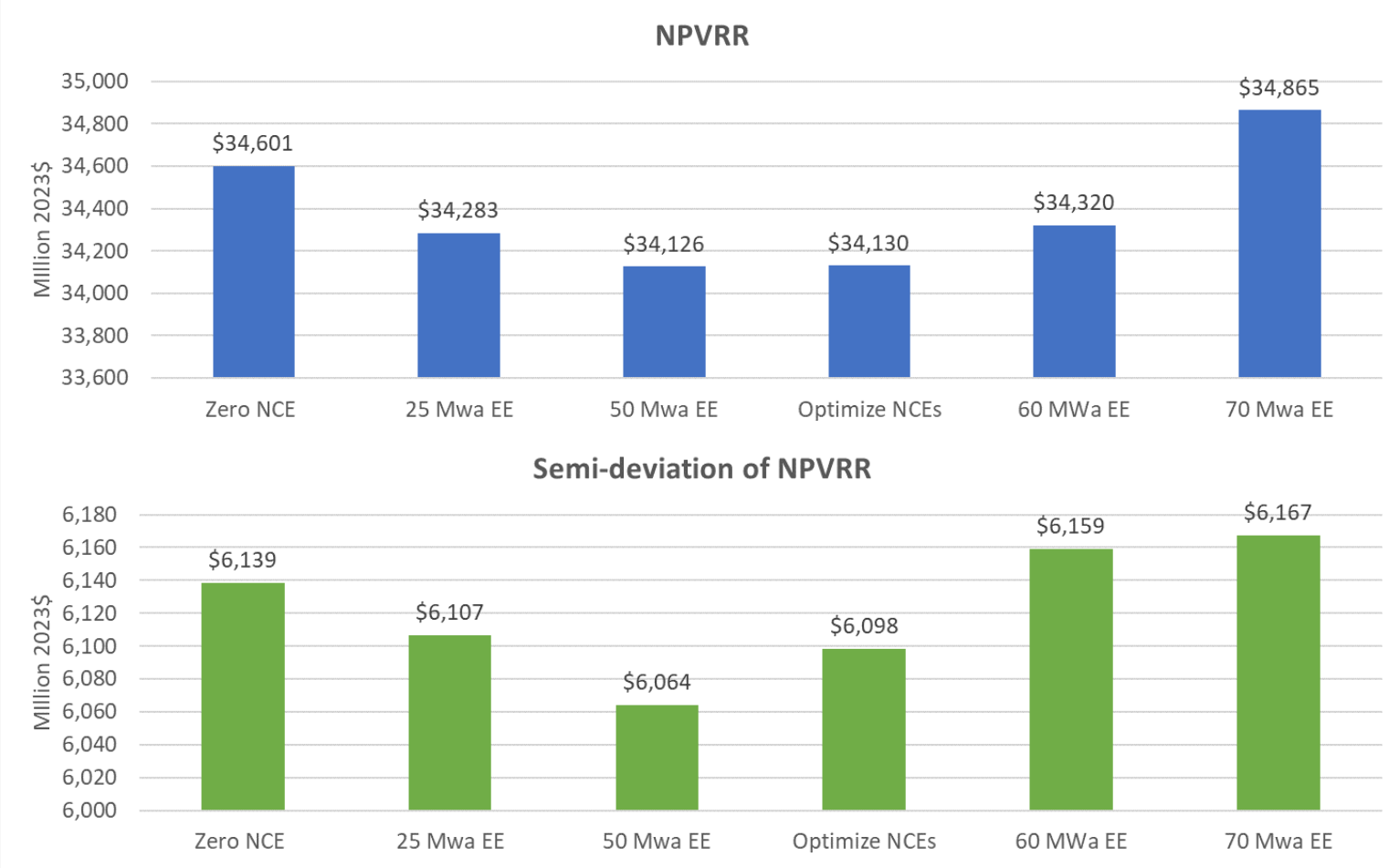
Given transmission constraints, additional EE could be an effective strategy to decrease costs and risk

Additional demand response is not chosen due to current costs

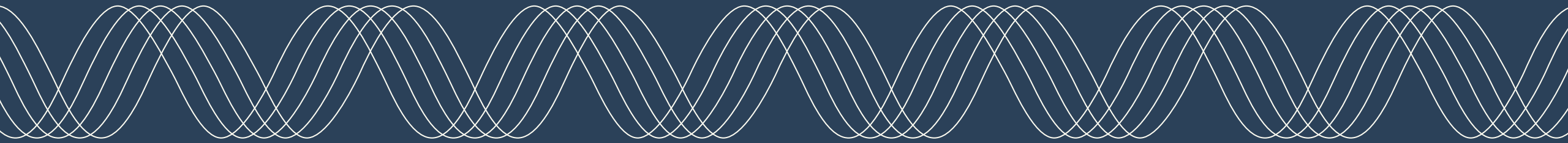
There is procurement risk and cost pressure associated with additional quantities of EE (covered below)

Key takeaway – Preferred portfolio should include the cost-effective levels of additional EE

Forecasted to be 150MWa by 2028



Preferred Portfolio



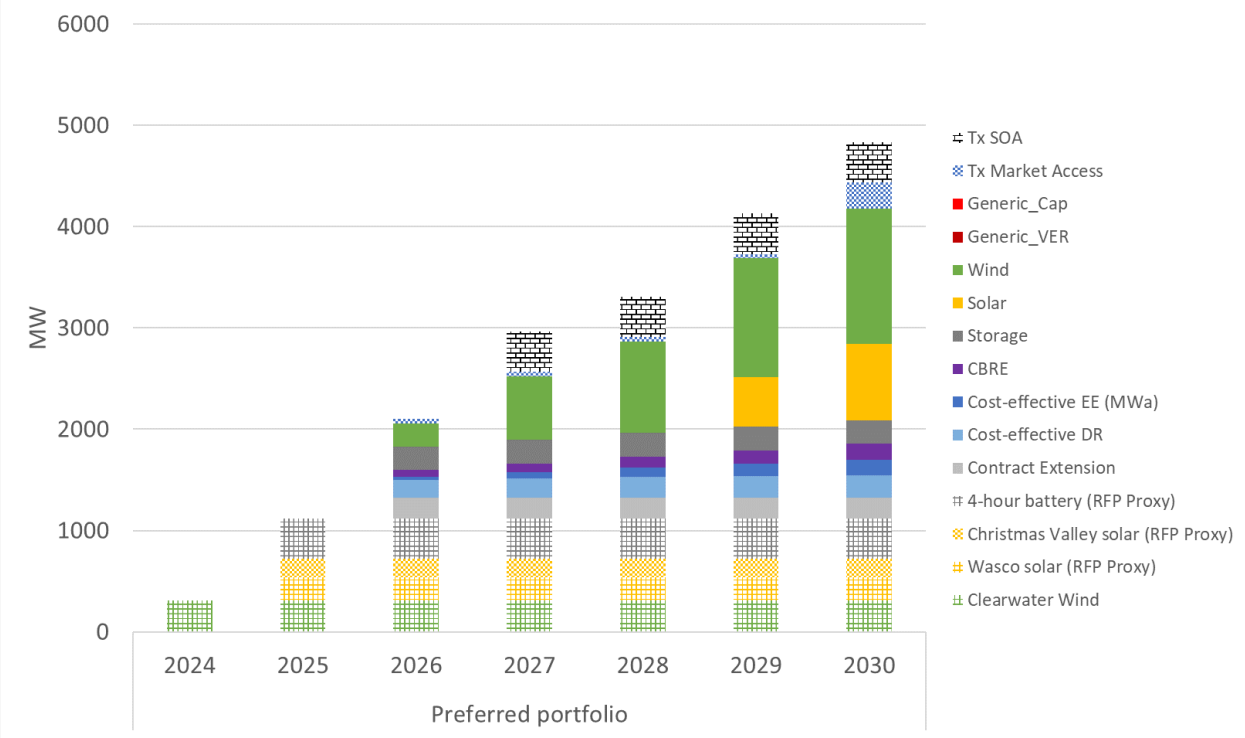
Preferred Portfolio

Created based on key insights gained through analysis of 39 portfolios:

Linear decarbonization glidepath from 2026-2030	Balances costs & risk & the rate of GHG reductions
Select 100% of CBREs available	Minimizes cost & maximizes community benefit
Incorporates “cost-effective” quantities of EE & DR	Minimizes cost & risk
400 MW of South of Allston congestion relief in 2027	Minimizes cost & ensures reliability
Access to 400 MW each of NV and WY Tx starting in 2026	Minimizes cost & risk

Preferred Portfolio: Resource Build

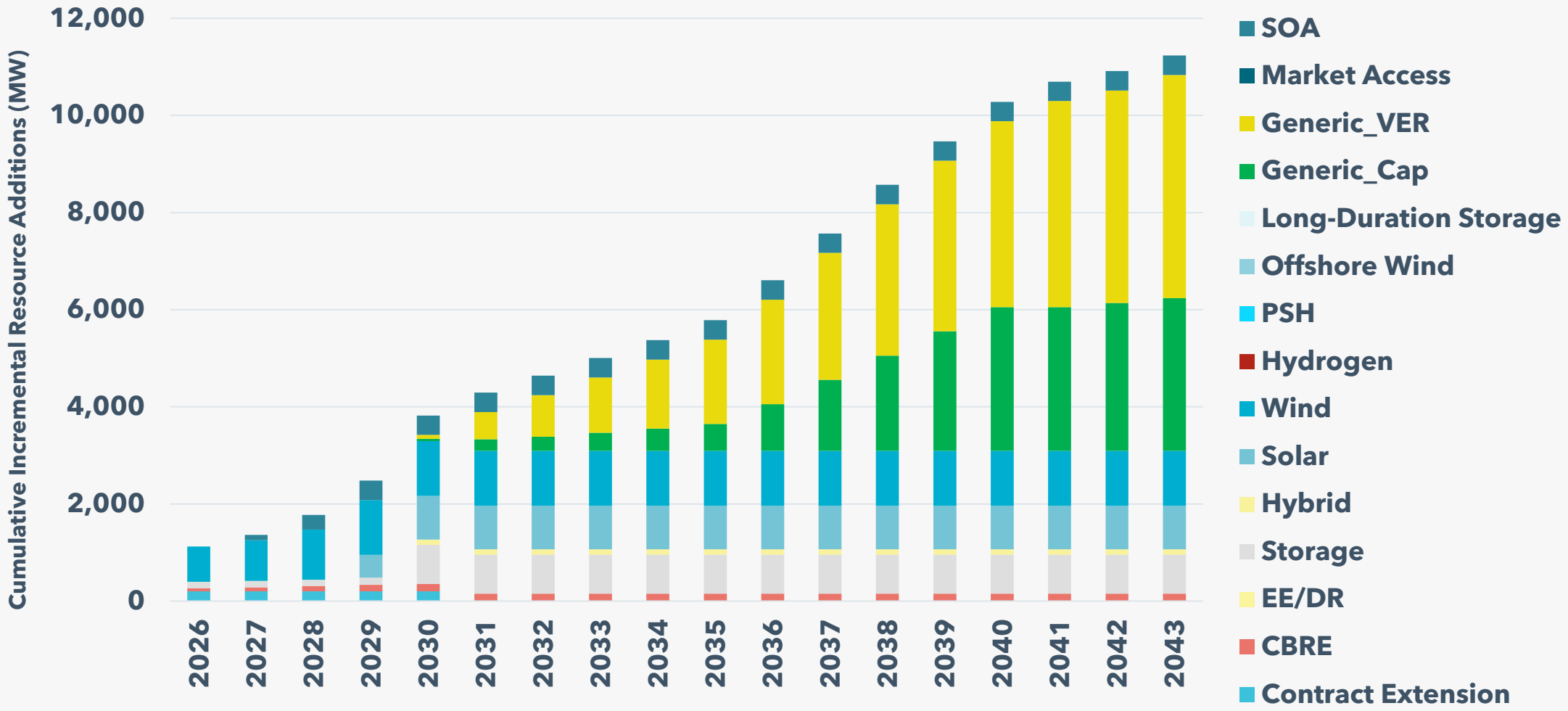
Cumulative Resource Additions (MW)							
	2024	2025	2026	2027	2028	2029	2030
Wind	0	0	227	627	901	1172	1334
Solar	0	0	0	0	0	490	756
Storage	0	0	232	232	232	232	232
CBRE	0	0	65	84	110	133	155
NV Tx	0	0	0	0	0	0	49
WY Tx	0	0	44	44	44	44	206
Tx SOA	0	0	0	400	400	400	400
Contract Extension	0	0	200	200	200	200	200
Clearwater Wind	311	311	311	311	311	311	311
Wasco solar (RFP Proxy)*	0	230	230	230	230	230	230
Christmas Valley solar (RFP Proxy)*	0	180	180	180	180	180	180
4-hour battery (RFP Proxy)*	0	400	400	400	400	400	400
Cost-effective EE (MWa)**	30	60	90	120	150	183	216
Cost-effective DR**	133	162	183	199	211	218	228



** RFP proxy resources represent expected additions acquired through the 2021 RFP*

*** Estimates of system need have already incorporated forecasts of cost-effective EE & DR – these are shown here for informational purposes*

Preferred Portfolio: Resource Build



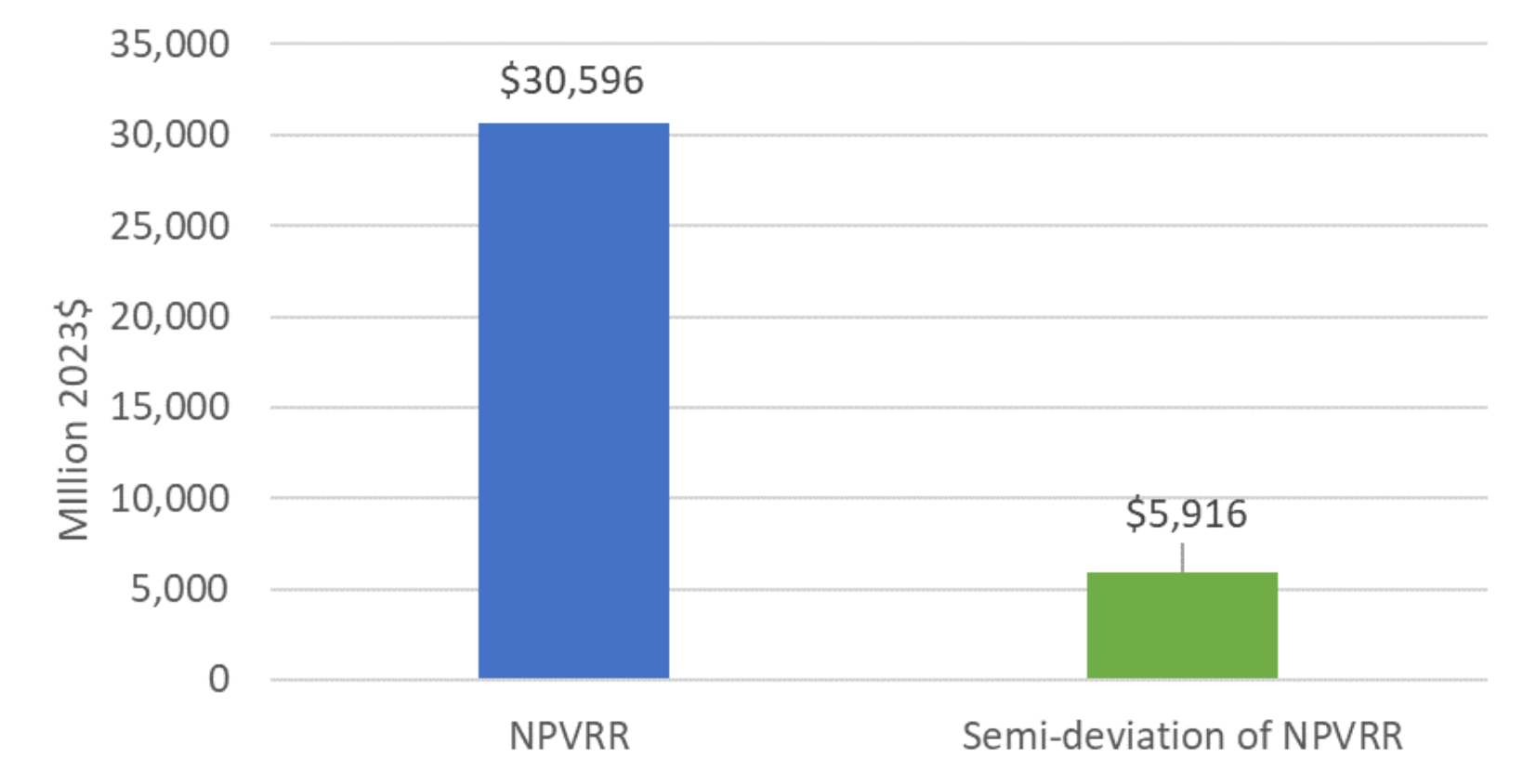
** Estimates of system need have already incorporated forecasts of cost-effective EE & DR – these are shown here for informational purposes*

Preferred Portfolio: Resource Build

Resources	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Wind	0	0	227	627	901	1172	1334	1419	1528	1528	1528	1528	1528	1528	1528	1528	1528	1528	1528	1528
Solar	0	0	0	0	0	490	756	1267	1410	1410	1410	1410	1410	1410	1410	1410	1410	1410	1410	1410
Hybrid	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage	0	0	232	232	232	232	232	232	232	232	232	332	400	500	600	700	800	800	800	800
EE/DR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CBRE	0	0	65	84	110	133	155	155	155	155	155	155	155	155	155	155	155	155	155	155
Market Access	0	0	44	44	44	44	255	548	800	800	800	800	800	800	800	800	800	800	800	800
SoA*	0	0	0	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Contract Extension	0	0	200	200	200	200	200	0	0	0	0	0	0	0	0	0	0	0	0	0
Generic_Cap	0	0	0	0	0	0	0	0	0	0	0	13	321	821	1321	1821	2321	2321	2371	2470
Generic_VER	0	0	0	0	0	0	0	0	48	330	615	933	1353	1820	2320	2711	3031	3445	3577	3801
Cost-effective EE (MWa)**	30	60	90	120	150	183	216	251	285	317	348	377	404	429	452	471	487	503	514	523
Cost-effective DR**	133	162	183	199	211	218	228	242	252	261	270	272	287	296	303	310	306	314	330	336

** SoA represents transmission upgrades that allow access to additional resources, not a resource that provides energy or capacity directly.*
*** Estimates of system need have already incorporated forecasts of cost-effective EE & DR – these are shown here for informational purposes*

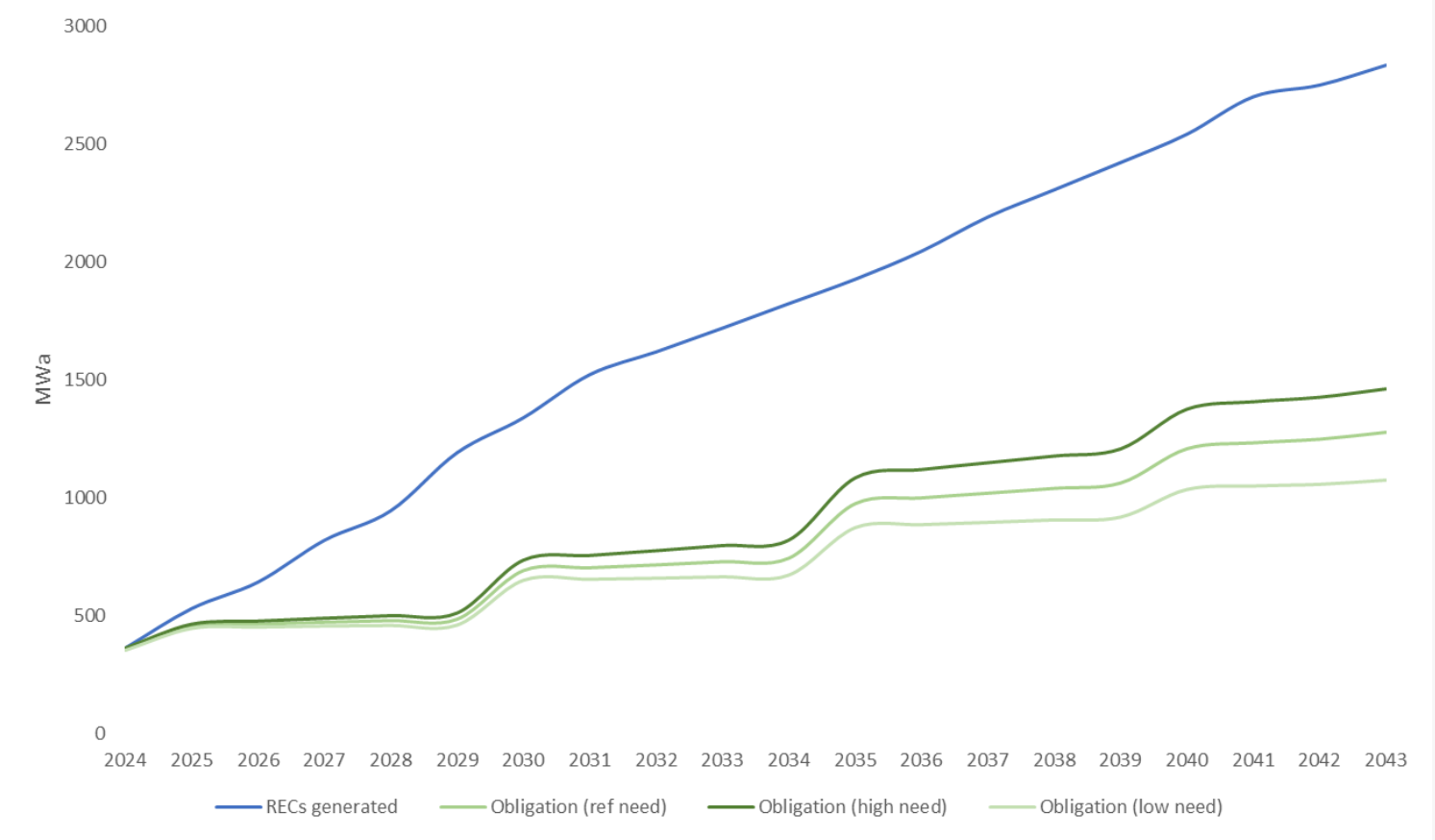
Preferred Portfolio: Cost and Risk Metrics



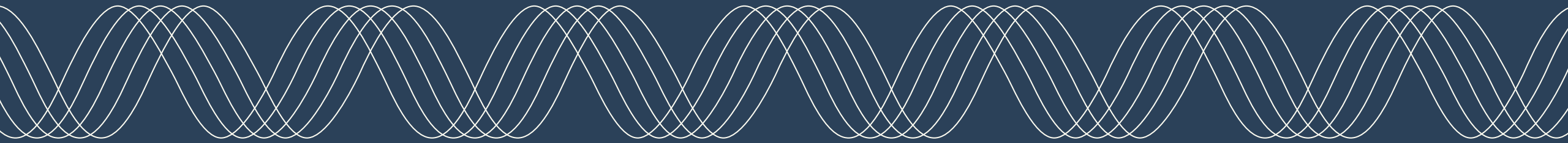
Preferred Portfolio: Resulting RPS Position

Generation of RECs from existing and incremental RPS resources in the Preferred portfolio is forecasted to enable PGE to be compliant with RPS requirements.

Because of the need to build new non-emitting resources to comply with HB 2021, the number of RECs forecast to be generated by PGE's portfolio will exceed RPS requirements.



Yearly Price Impacts



Annual Rev. Req. Tool (ART)

ART enables the comparison of the yearly price impacts of different portfolios

Estimates include both PGE's existing portfolio and planned proxy new resource additions by portfolio

Limitations of ART and yearly price impact analyses within the IRP

- ART does not include costs from the rest of the company such as grid modernization, A&G, wildfire mitigation, or T&D costs
- Yearly price impacts do not reflect actual customer prices because they do include proxy resource generation costs and do not incorporate cost changes across PGE
- Applying percentages to these changes will not represent actual customer price changes because they do include proxy resource generation costs and do not incorporate cost changes across PGE
- Yearly prices are highly sensitive to assumptions of generic resources costs

Annual Rev. Req. Tool (ART)

All costs are in nominal terms

The model uses proxy resource costs and associated operating characteristics

The model incorporates the impact of market sales and market purchases on an annual basis consistent with ROSE-E and the GHG model

Assumes 50% PPA and 50% PGE ownership of all new resources

Assumes 100% PPA for remaining 2021 RFP resources
Clearwater wind project included from 2024

Assumes Colstrip exit in 2029

Assumes energy efficiency and demand response is not financed (consistent with current treatment)

Results are specific for the reference case scenario (reference need, reference prices, reference cost future)

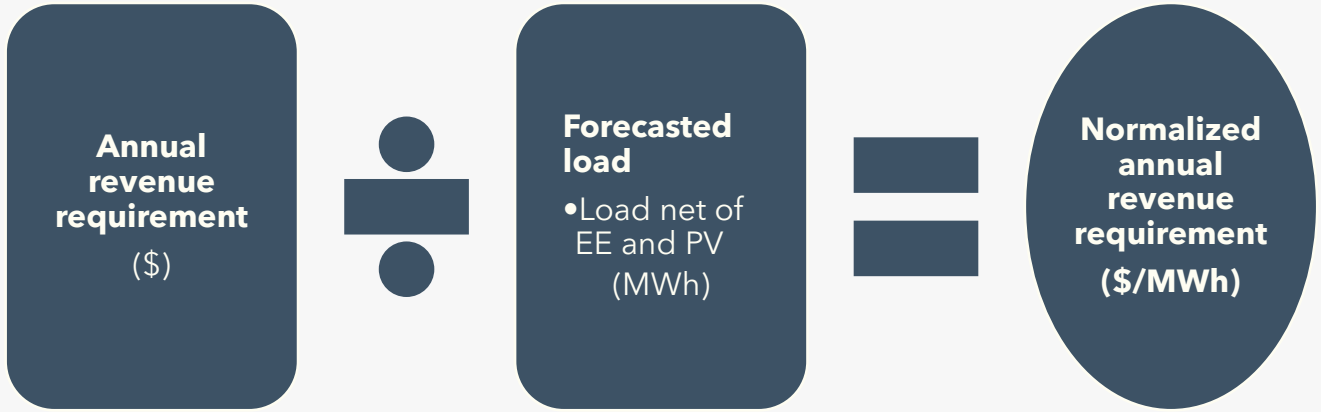
Why Create the ART?

ROSE-E	ART
Costs: Existing and new resource related fixed, variable, and integration costs based on 100% PPA assumption	**Costs**: Existing and new resource related fixed, variable, and integration costs based on ownership structure
Benefits: Resource energy value, flexibility value, rCBI	**Benefits**: Market sales of excess generation
All values are expressed in levelized terms which may not reflect actual yearly costs due to ownership structure and tax credit implications	**All values are based on expected impact each year of the planning horizon, and are representative of the cost changes associated with existing and incremental generation**

Estimating Yearly Price Impacts

Estimating the annual price impact

Estimating the annual normalized price impact

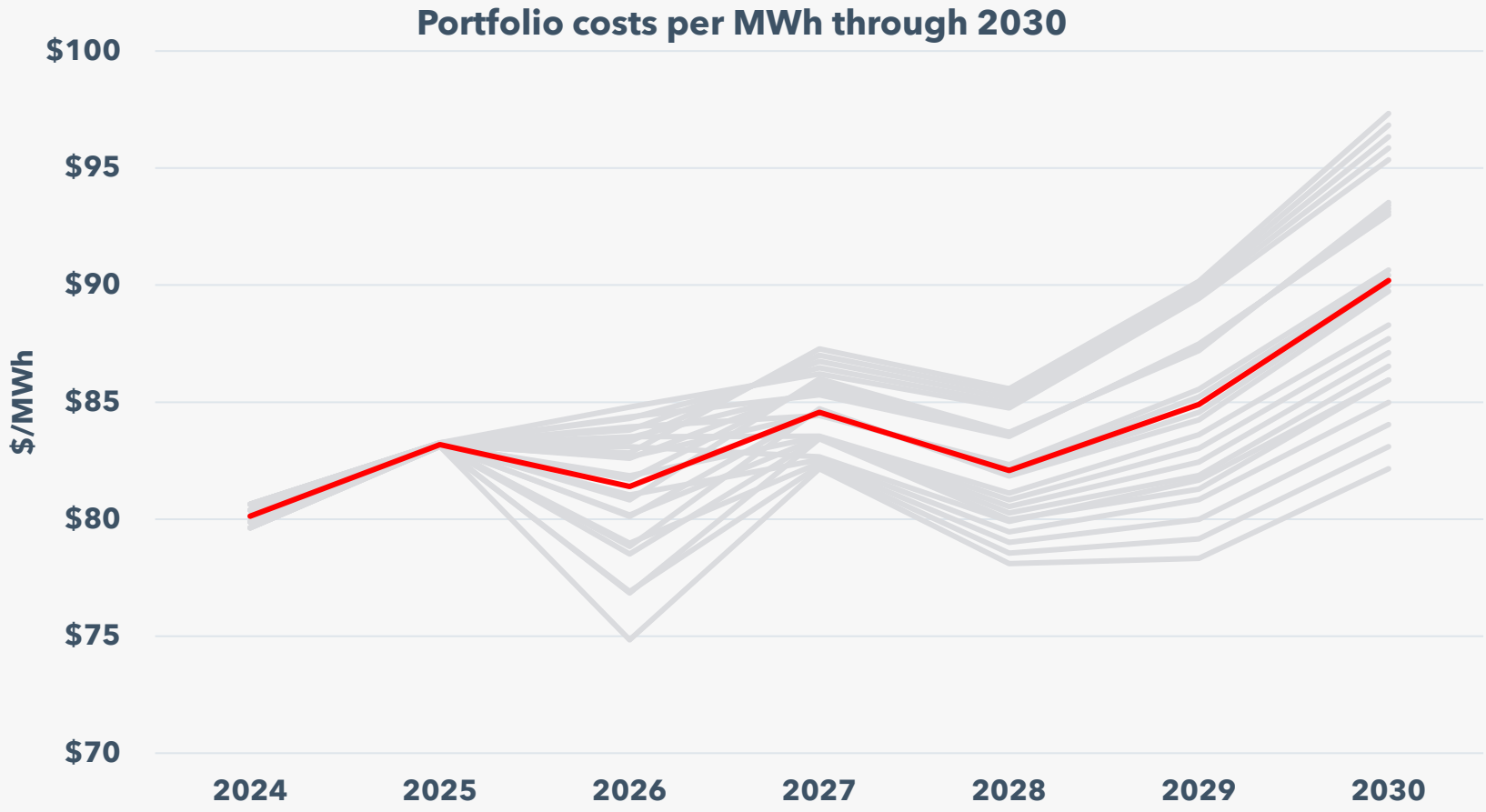


Yearly Impact – Preferred Portfolio

Ownership structure and tax credits significantly impact annual price impact.

Tax credits assumed in ROSE-E and 50% PPA/50% PGE ownership assumption highlighted in **red**

Results are highly sensitive to assumptions about generic resource cost and buildout



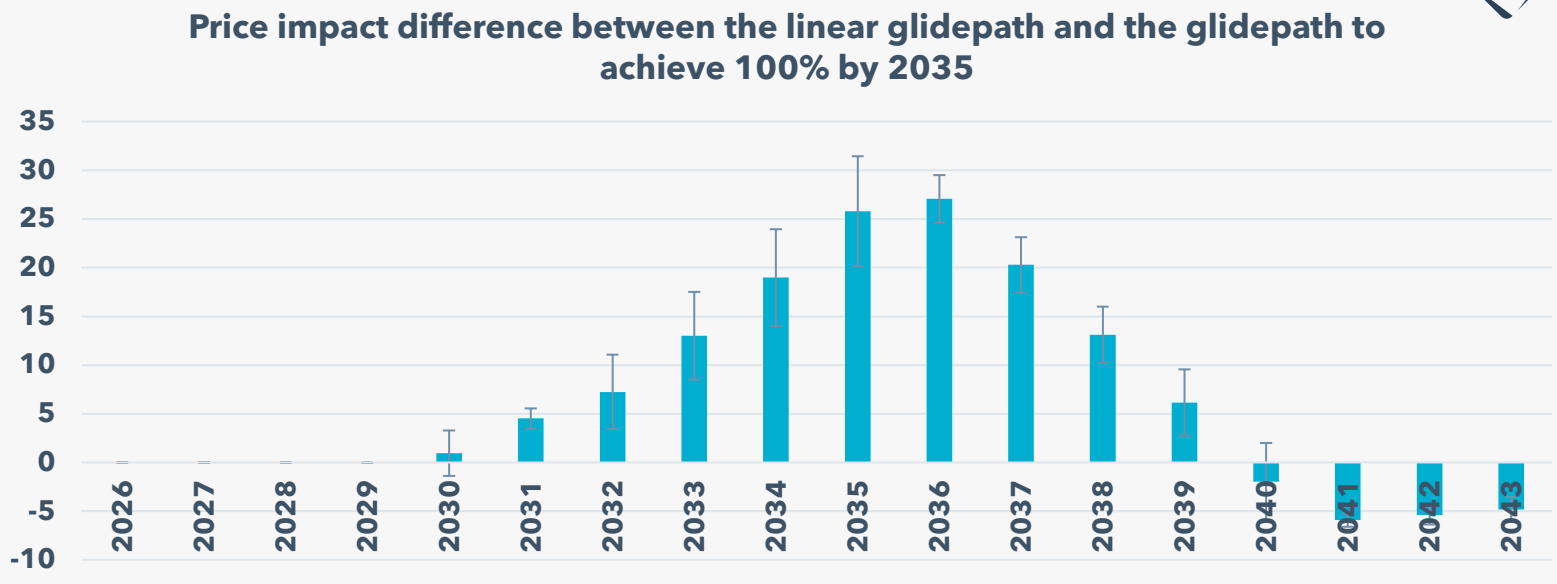
Each line represents a unique combination of ownership structure and tax credits.
Ownership structures: 0%, 25%, 50%, 75%, and 100% PPA
Tax credit range: +/-25% and +/-50% of base tax credit

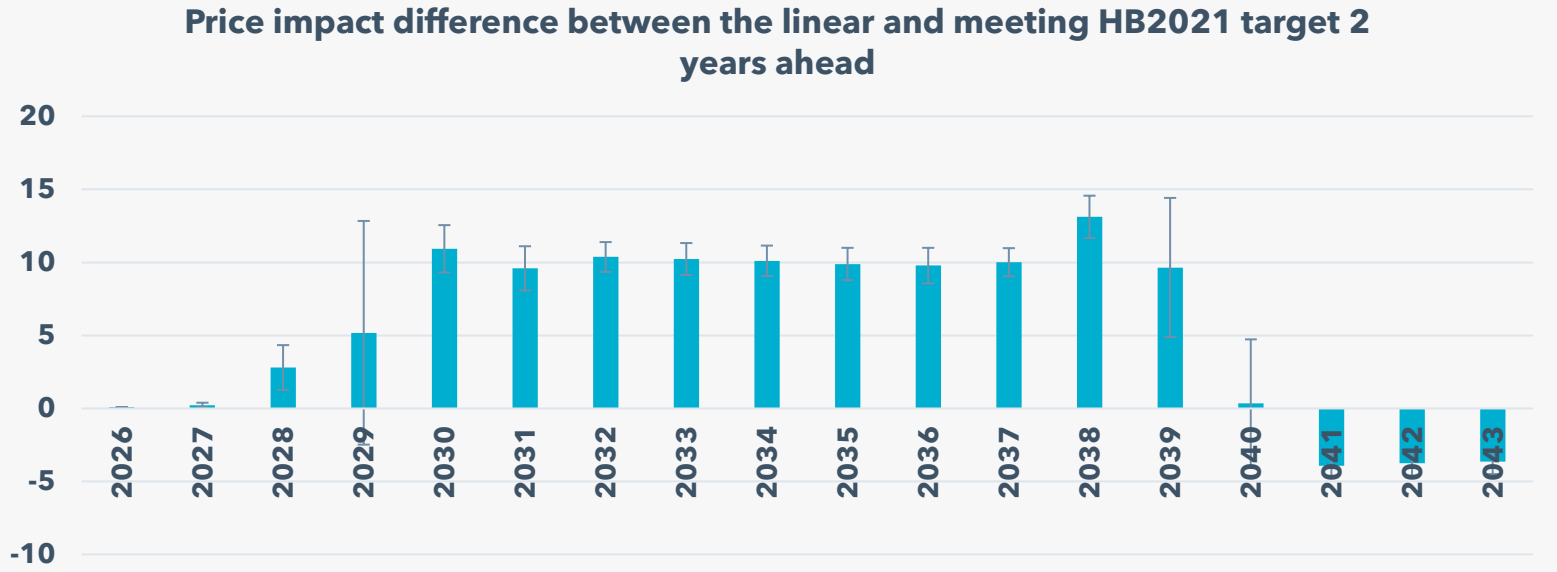
Yearly Impact – Accelerated Decarbonization Portfolios

Positive values indicate higher costs compared to linear glidepath

Error bars represent the standard deviation in the difference of costs across 25 unique ownership structure and tax credit combinations

Meeting emission targets increases cost across most years of the planning horizon



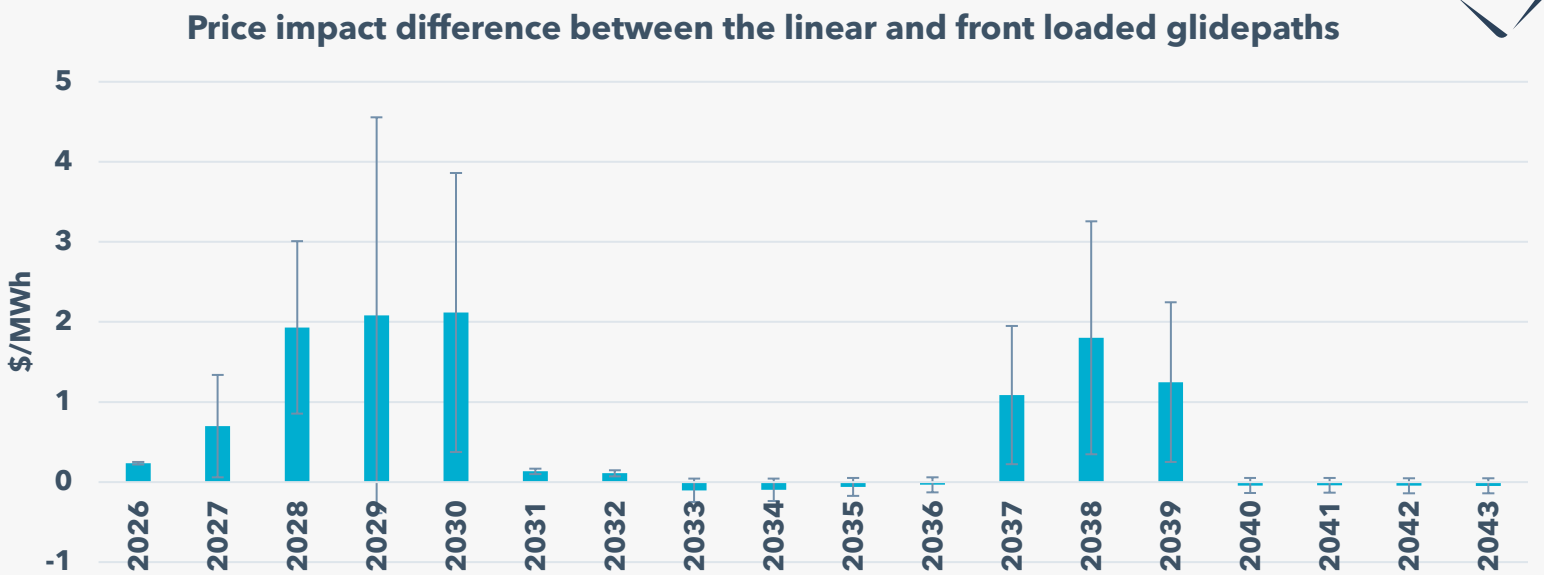


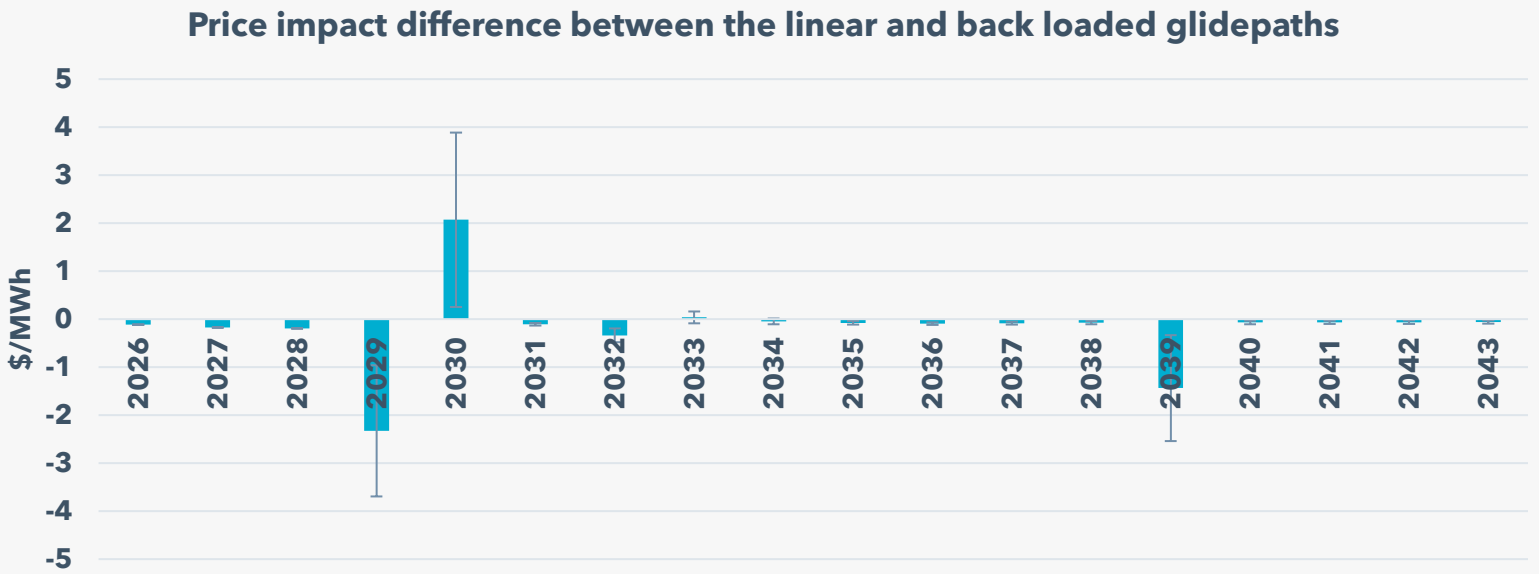
Yearly Impact – GHG Portfolios

The graph shows the underlying relationship between emission reduction and prices

Results generally indicate emission reductions increase annual system costs

Higher 2030 costs of the Back-loaded portfolio impacted by resource buildout

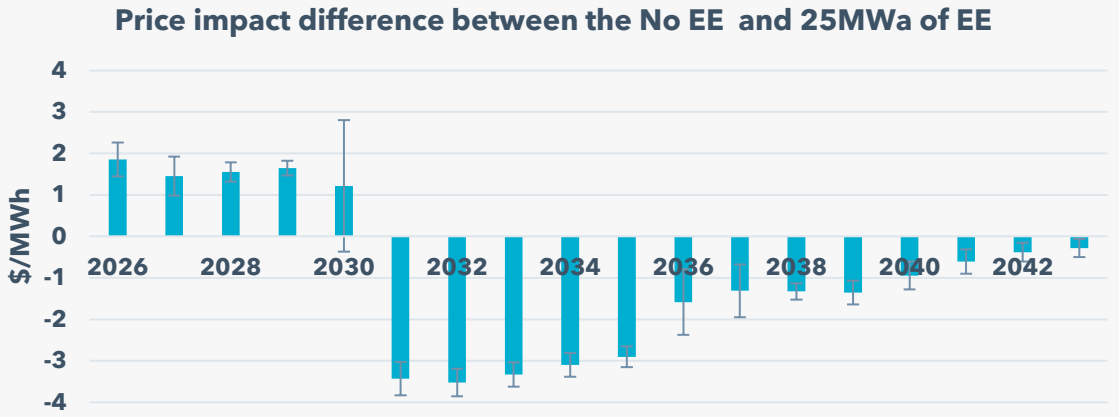


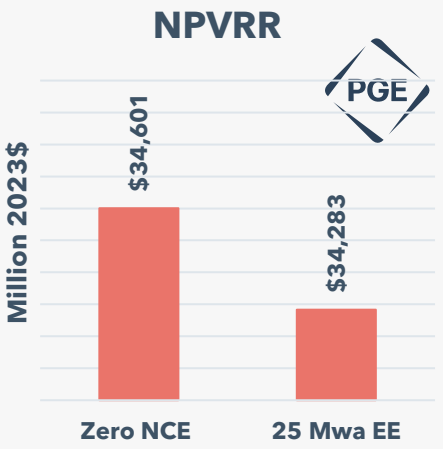


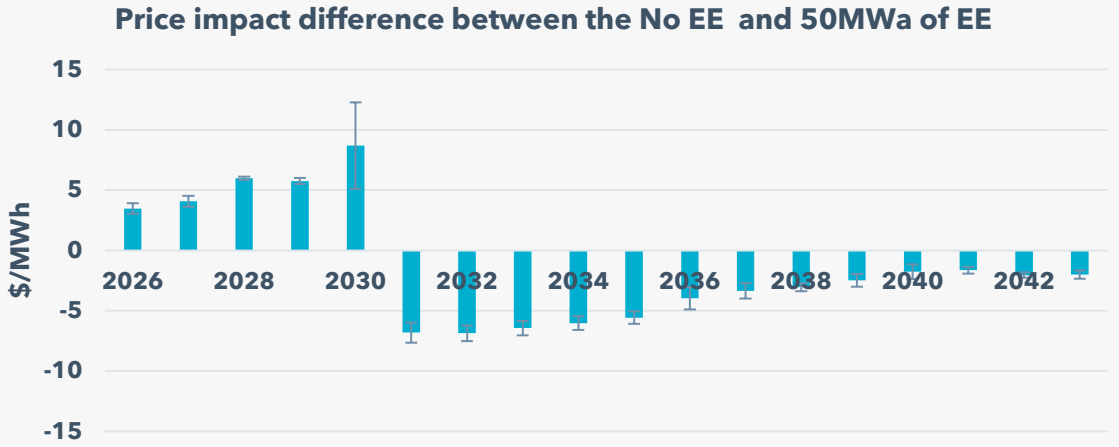
Yearly impact – Additional EE portfolios

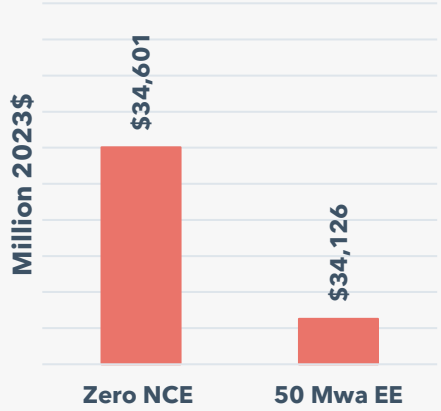
Current policy leads to near-term cost increases when additional EE is added

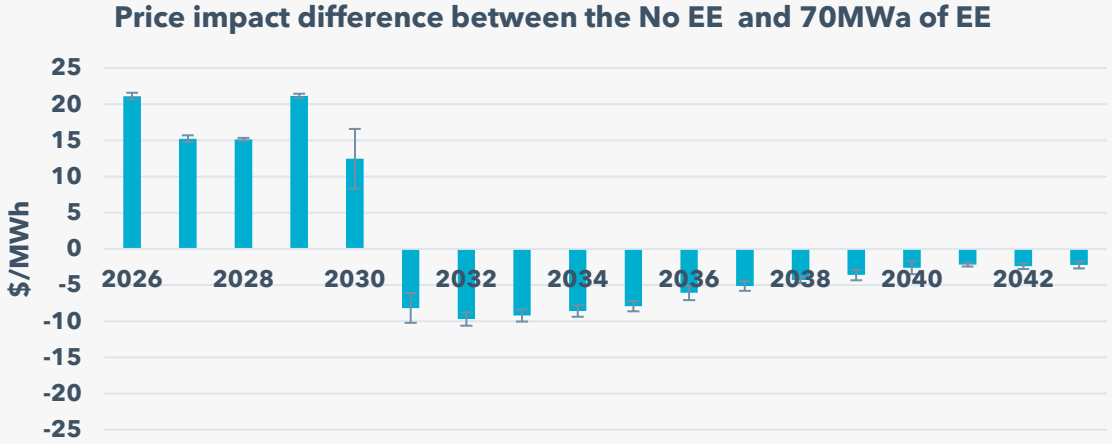
Larger quantities of additional EE results in larger yearly cost increases in the near term



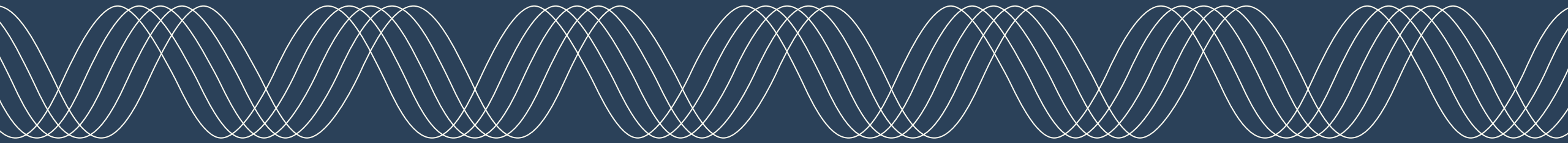








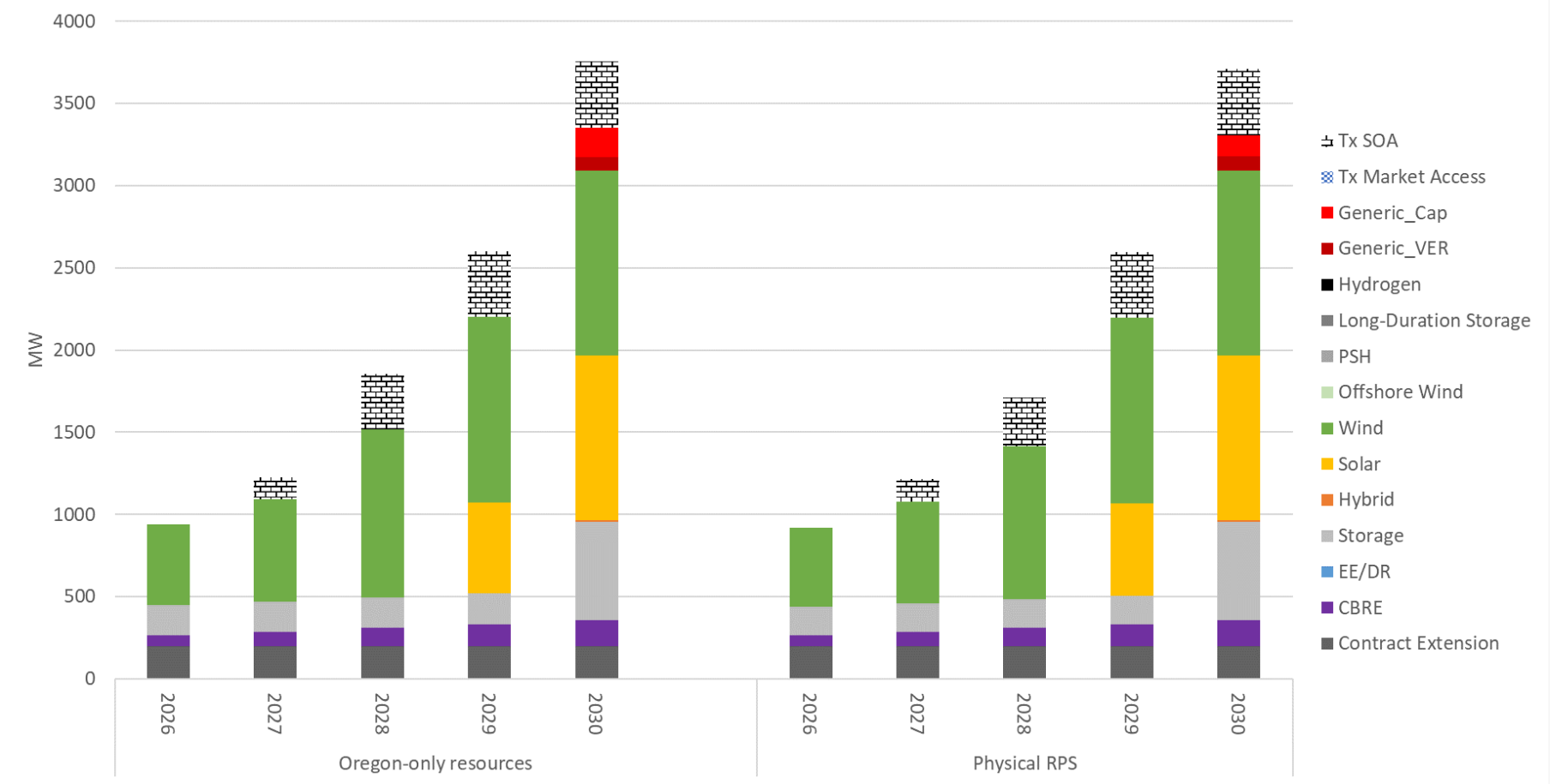
Additional Portfolios



Targeted Policy Portfolios

Portfolios	Portfolio Condition
Oregon-only resources	Limit resource availability to Oregon-sited only
Physical RPS	Enforce physical RPS compliance

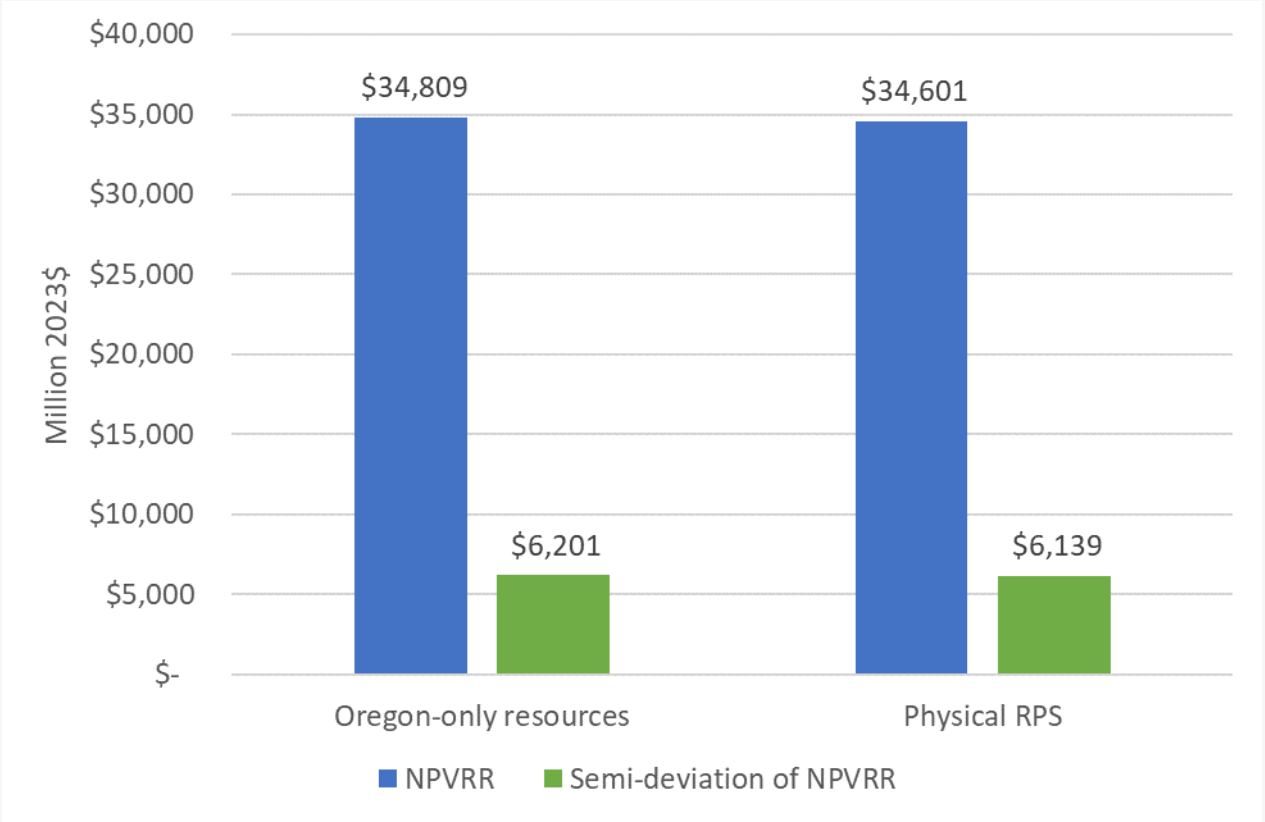
Targeted Policy Portfolios



Targeted Policy Portfolios: Insights

Reliance on Oregon-only resources increases costs and risk due to lower resource diversity

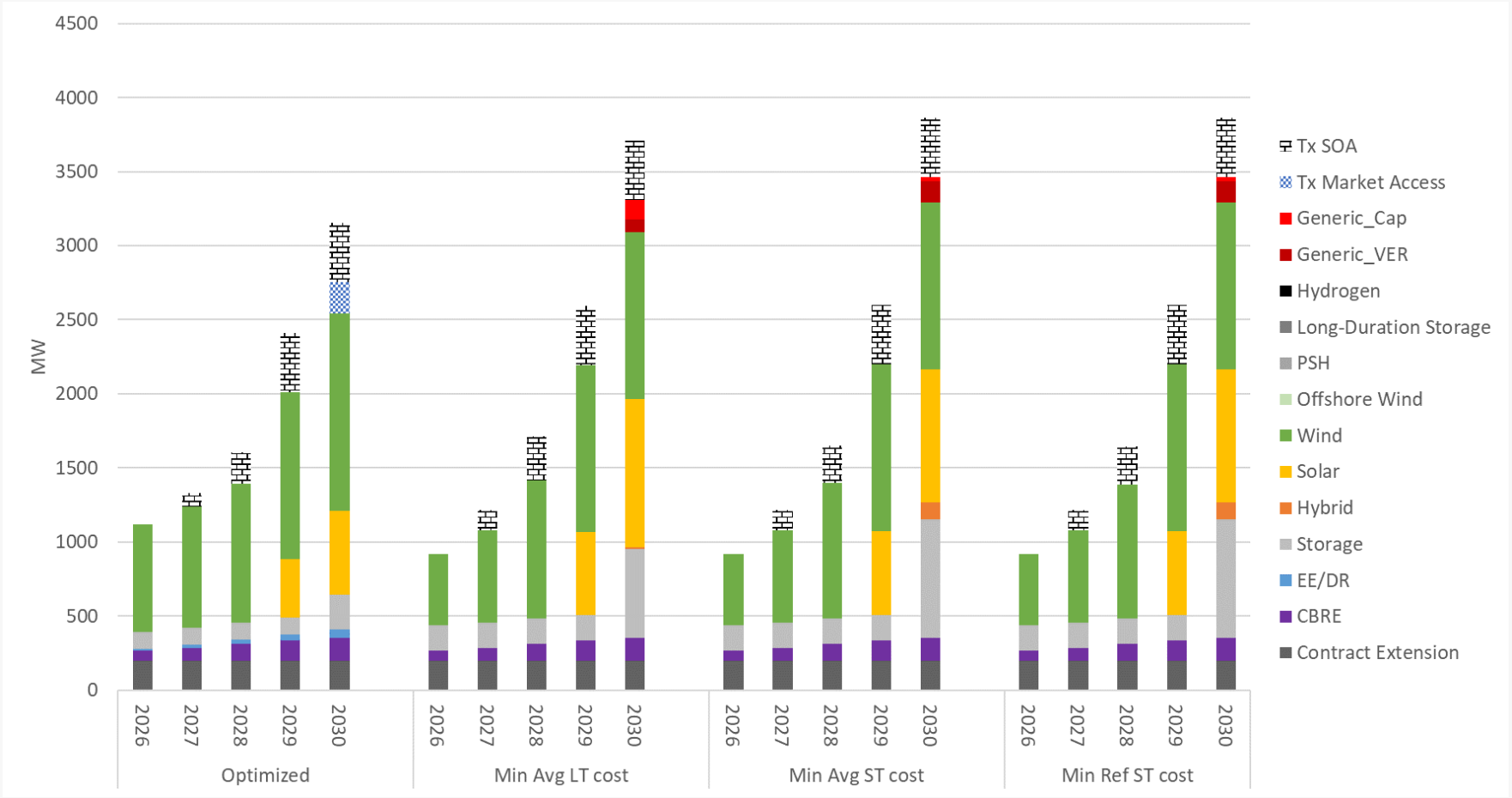
Physical RPS constraint is non-binding due to emission reduction targets from HB 2021 requirements



Optimization Portfolios

Portfolios	Portfolio Condition
Min Avg LT cost	Minimizing average long-term NPVRR
Min Avg ST cost (informational)	Minimizing average short-term NPVRR through 2030
Min Ref ST cost (informational)	Minimizing reference case short-term NPVRR through 2030
Optimized (informational)	Least constrained

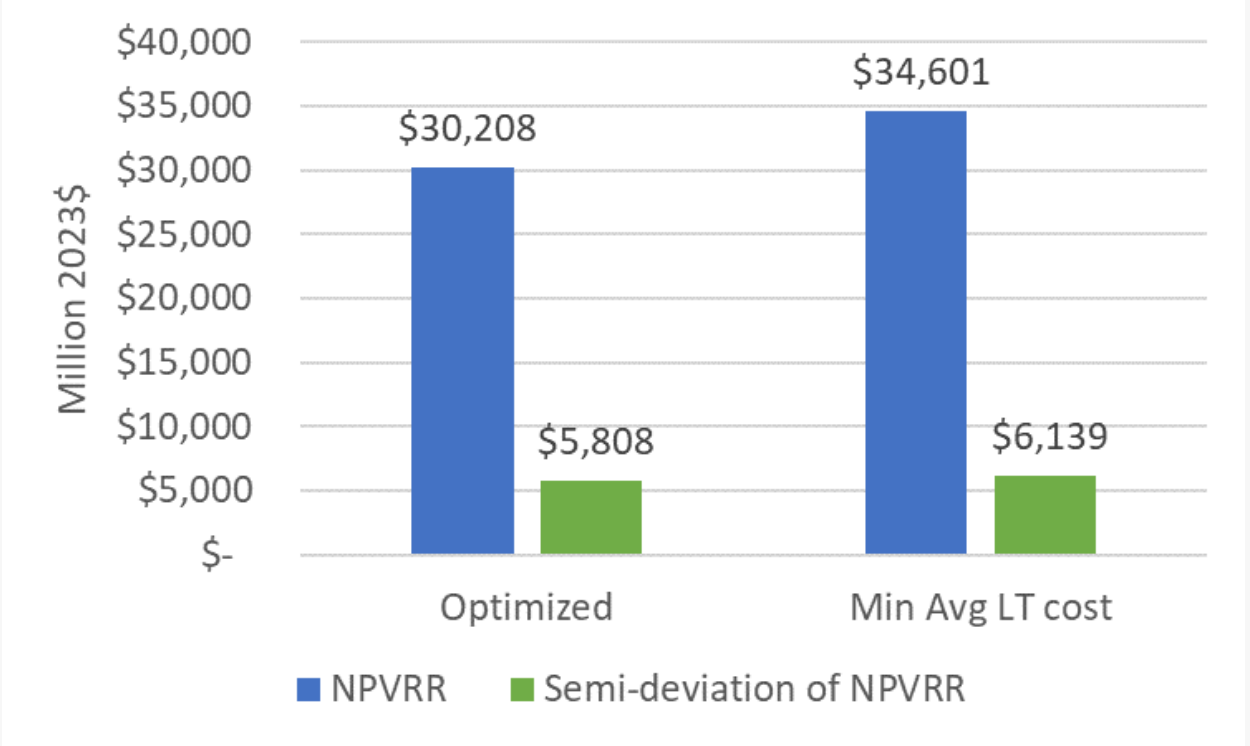
Optimization Portfolios



Optimization Portfolios: Insights

With the option to add CBREs and additional EE, the Optimized portfolio minimizes costs by adding all CBREs and 75% of available EE

Slight differences across portfolios that optimize only short-term vs. entire 20-year period demonstrate utility of long-term time planning horizon

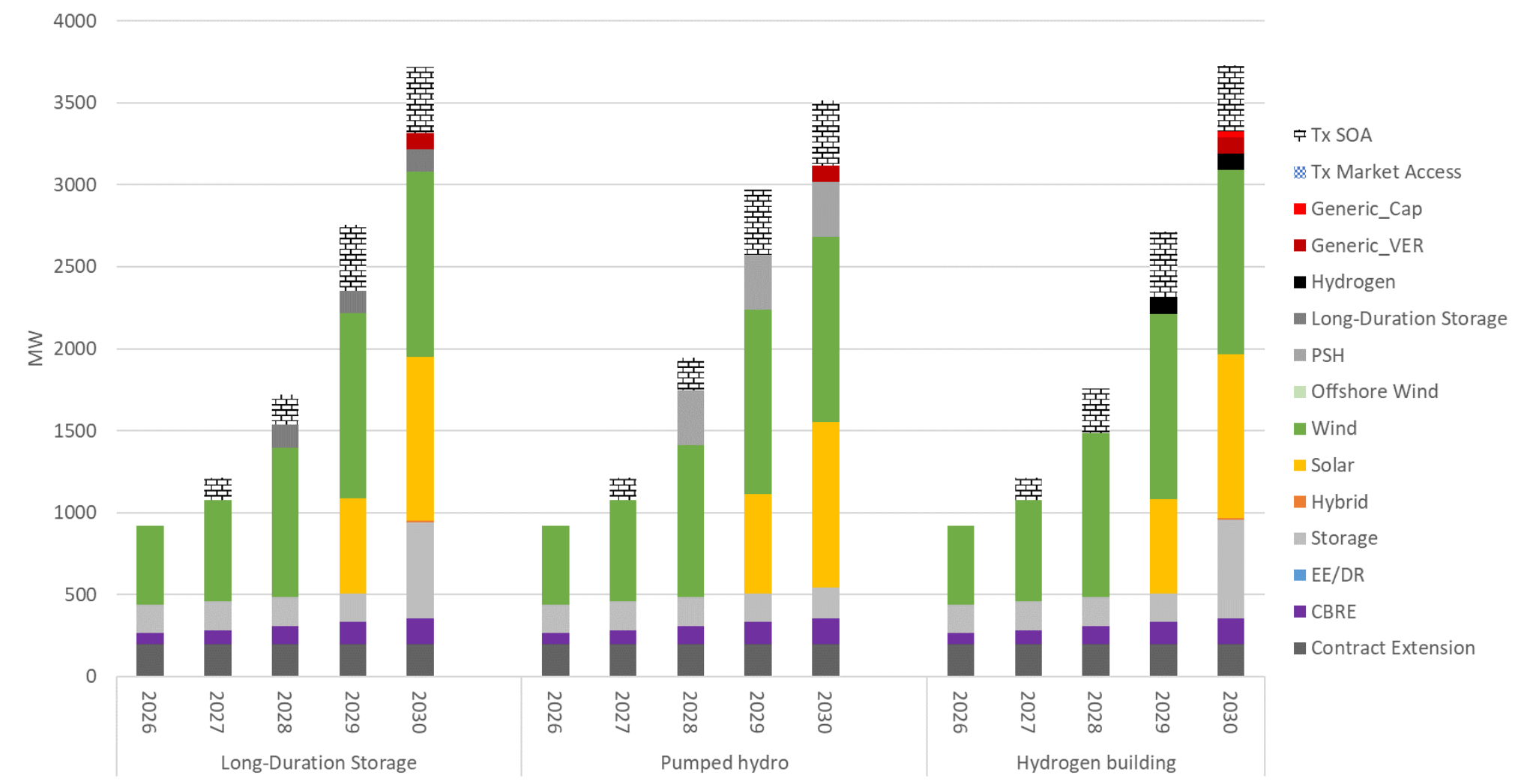


Because they are optimized over a shorter timeframe of 7 years compared to the standard 20 years for other portfolios, the cost and risk metrics of the 'Min Avg ST cost' and 'Min Ref ST cost' portfolios are not comparable to those of other portfolios.

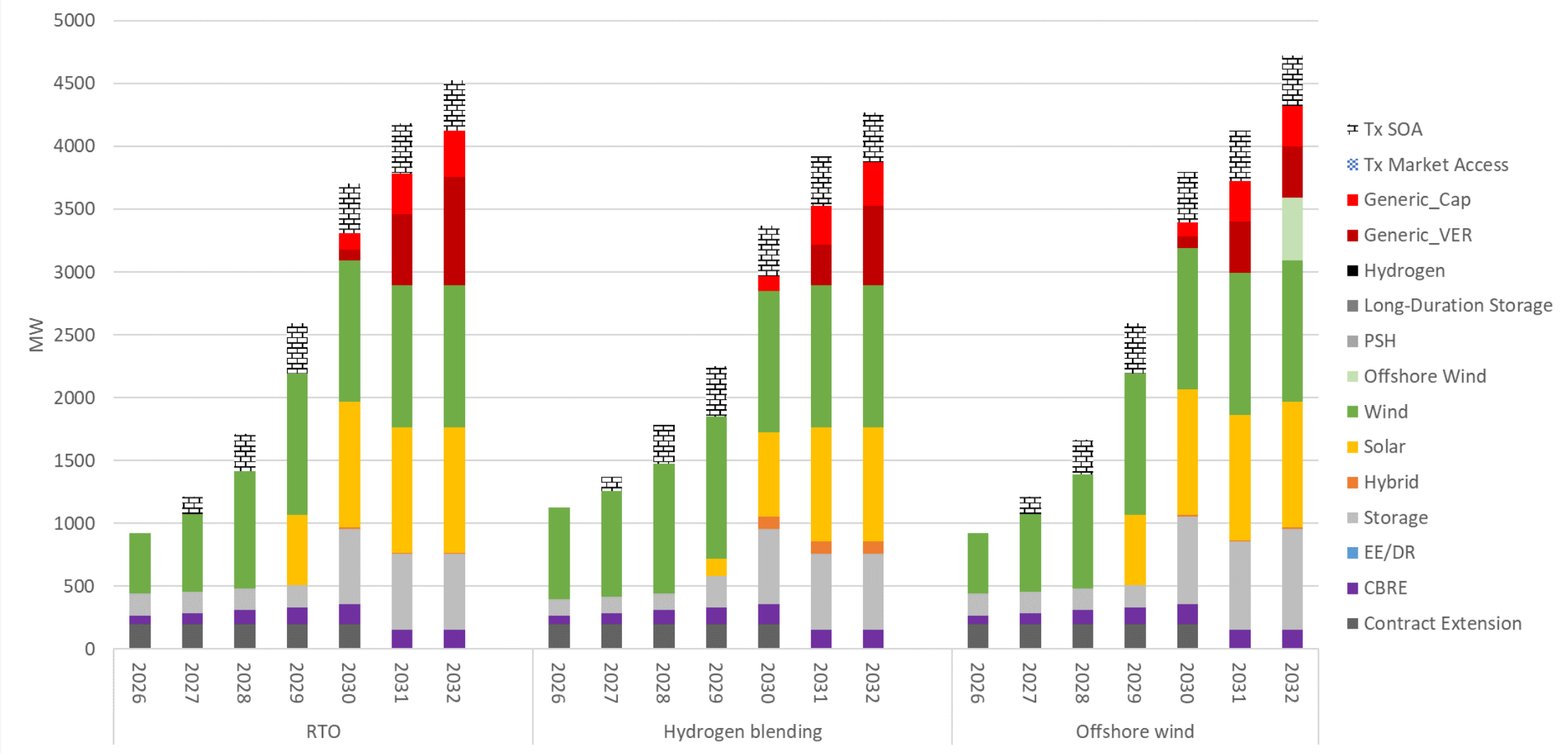
Emerging Technology Portfolios

Portfolios	Portfolio Condition
Pumped hydro	333 MW of PSH in 2028
Hydrogen blending	Blending of hydrogen at existing NG plants
Hydrogen building	100MW of hydrogen in 2027
Offshore wind – informational	500 MW of offshore wind in 2032
Long Duration Storage	139 MW of 24 hr battery in 2028
RTO - informational	200 MW Reduction in Capacity Need

Emerging Technology Portfolios: 1



Emerging Technology Portfolios: 2

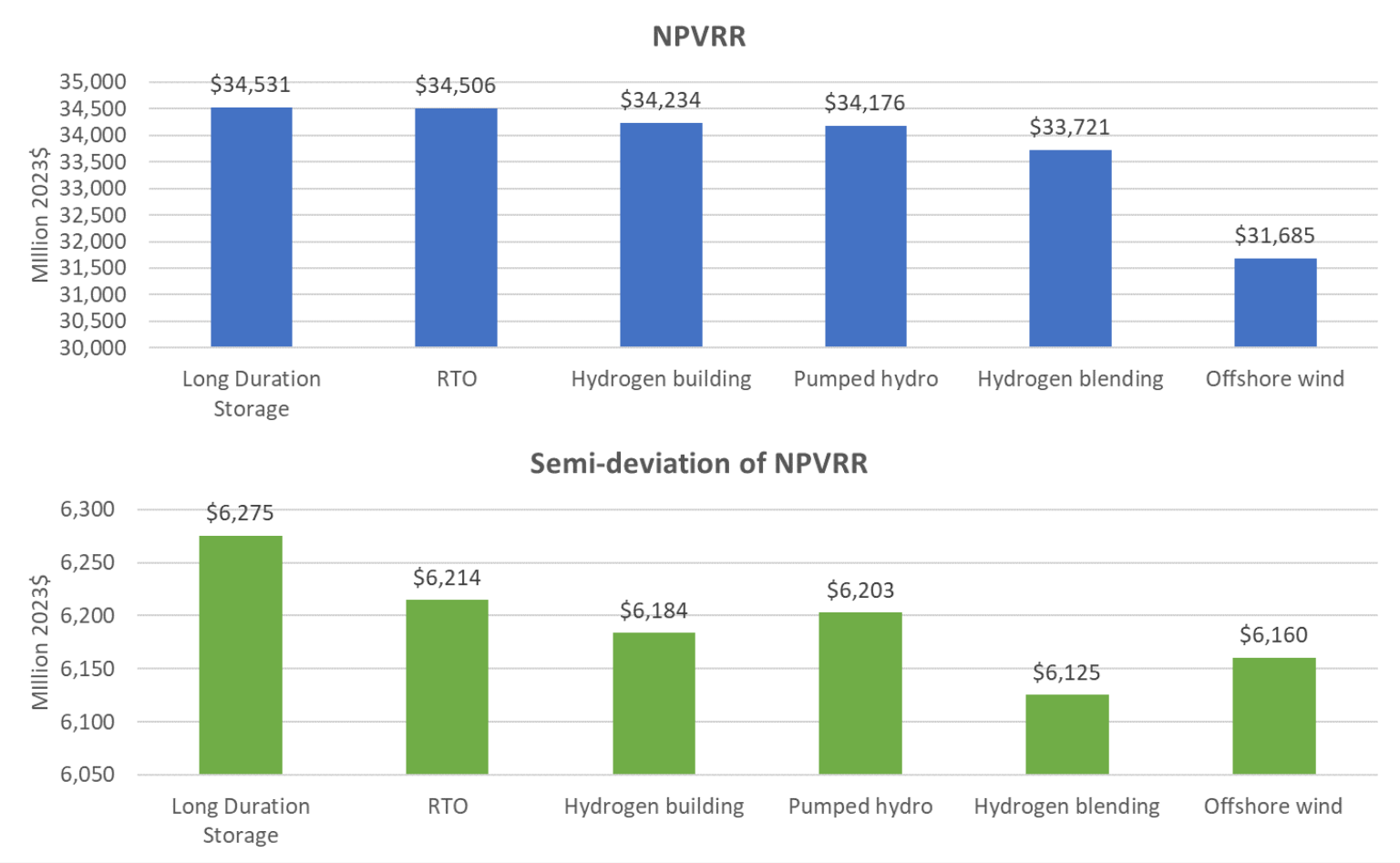


Emerging Technology Portfolios: Insights

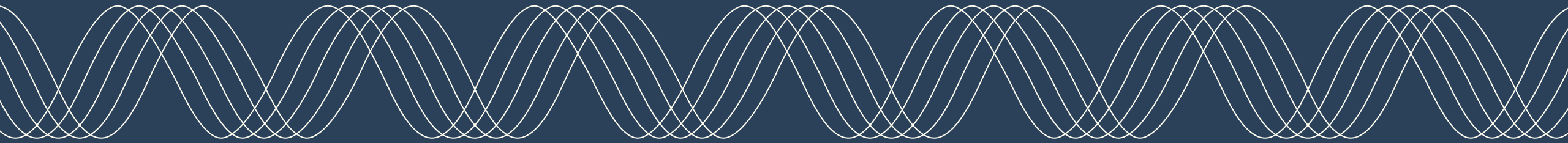
Transmission solutions are lower cost than emerging technologies reviewed

Emerging technologies can diversify transmission risks if available in time

Key takeaway – PGE should continue exploring emerging technology as part of potential risk mitigation strategies



Resource Buildout Robustness Analysis



Resource Buildout Robustness Analysis

Purpose – to test the robustness of the 2026-2030 resource build to future technological and economic development of emerging technologies

Method of analysis – vary cost and timing of availability of Generic emerging technology resource with 50% capacity factor and 100% ELCC

Year	Cost of Generic Emerging Resource			
	$100/kW-yr	$250/kW-yr	$500/kW-yr	$1000kW-year
2029	Case 1	Case 5	Case 9	Case 13
2030	Case 2	Case 6	Case 10	Case 14
2031	Case 3	Case 7	Case 11	Case 15
2032	Case 4	Case 8	Case 12	Case 16

All cases:

- Add 155 MW of CBREs
- Add 400 MW SoA in 2027
- Available 400 MW each of WY and NV Tx in 2026

Resource Buildout Robustness Analysis

Cost of Generic Resource	Results
$1000/kW-yr	Resource build is unaffected though 2030, regardless of year of availability
$500/kW-yr	• Generic emerging is selected as early as 2030 (52 MW) • Decrease in solar and Tx in action plan window
$250/kW-yr	• Generic Resource is added as early as 2030 (221 MW) • Decrease wind, solar, and Tx in action plan window • Increase in storage and hybrids in action plan window
$100/kW-yr	• Generic emerging resource is selected in first year of availability • Substantial impacts on resource build in action plan window

Resource Buildout Robustness Analysis Takeaways

Timing

- Resource actions within the action plan window (2026-28) is driven by needs and is minimally impacted by emerging technologies
- If costs are sufficiently low, emerging technologies available after the 2030 can impact the resource build prior to 2030

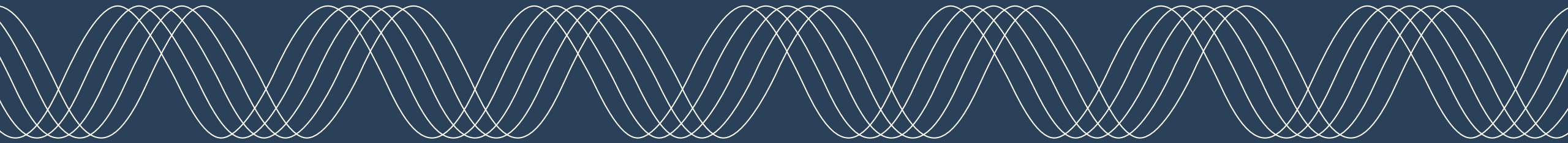
Cost

- For an emerging technology to enter the portfolio prior to 2030, a competitive price will need to be under $250 per kW-year
- A price of $100/kW-year could result in approximately 300MW of emerging technology added through 2030

Takeaway

Near-term resource additions (particularly within the action plan window) are relatively robust and are low/no regret options despite potential emerging technologies that may disrupt resource additions in the long-term

Preferred Portfolio Sensitivities



RFP Size and Timing Sensitivity Analysis

Purpose – to test the impact of alternative RFP cadences and magnitude of procurement on portfolio cost and risk

Method of analysis – subject preferred portfolio to resource procurement constraints to simulate alternative RFP cadences and magnitude of procurement

Year	Maximum Annual Resource Addition					
	RFP 2026 and 2029*		RFP Annually		RFP 2026, 2028, 2030	
	Renewables (MWa)	Storage (MW)	Renewables (MWa)	Storage (MW)	Renewables (MWa)	Storage (MW)
2026	1,000	800	180	133	400	267
2027	0	0	180	133	0	0
2028	0	0	180	133	400	267
2029	1,000	800	180	133	0	0
2030	0	0	180	133	400	267
2031	0	0	180	133	0	0

**Year of resource addition in ROSE-E is assumed to occur three years after an RFP is conducted. For example, 'RFP 2026' denotes an RFP initiated in 2023 and allowing the estimated time for an RFP docket, negotiation, and construction of the associated resources.*

RFP Size and Timing scenarios are not subjected to energy surplus constraint in order to accommodate larger annual resource additions where necessary to conform to procurement constraints.

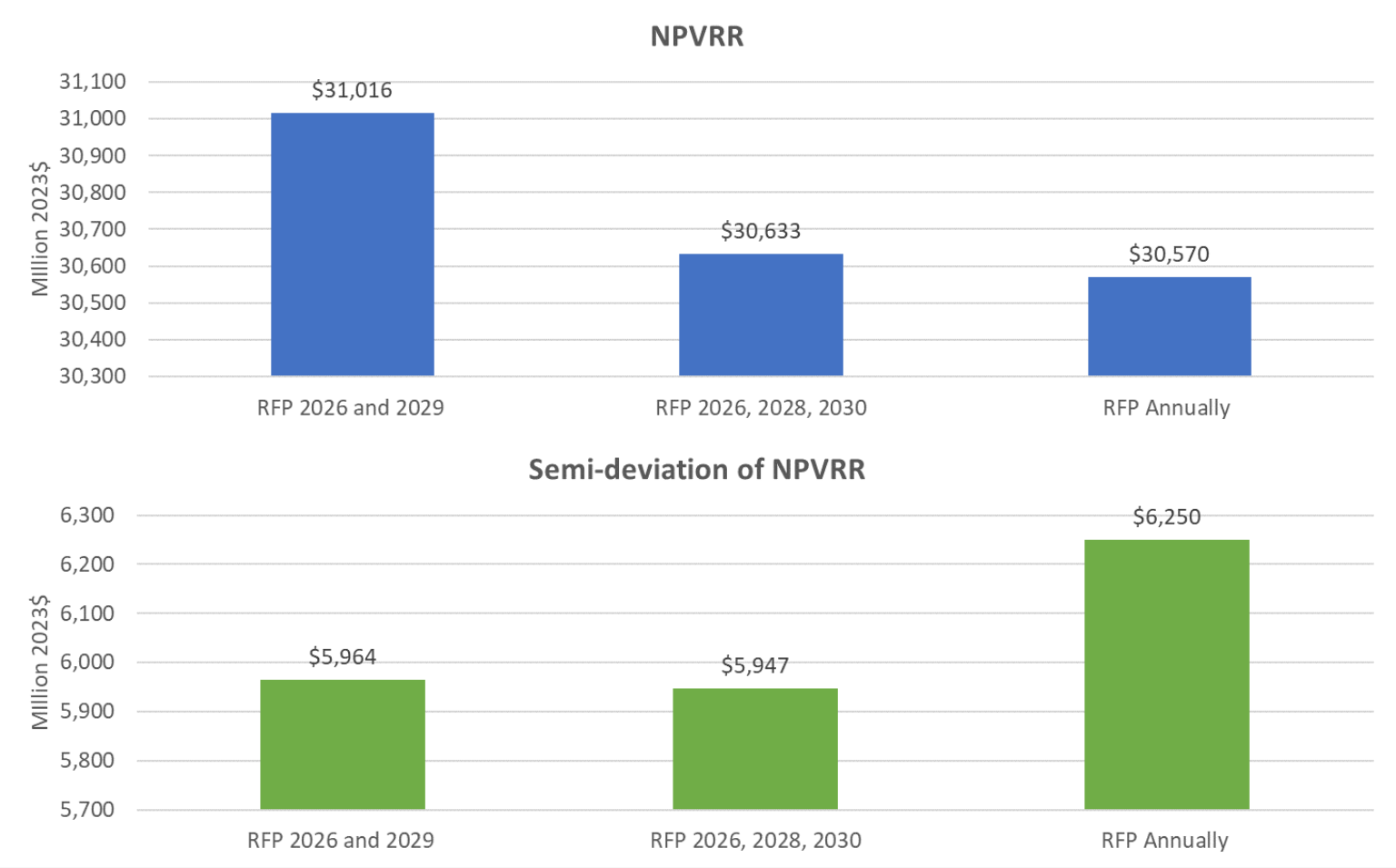
RPF Size and Timing: Insights

Constraining the number of years in which resources may be procured increases estimated portfolio costs

When acquisitions are limited to fewer years, resources are added earlier than otherwise needed, increasing costs as a function of:

1) Declining resource cost curves through time

2) Discounting in calculation of NPVRR



Supply Chain Sensitivity Analysis

Purpose – to test the impact of supply chain congestion on portfolio cost and risk

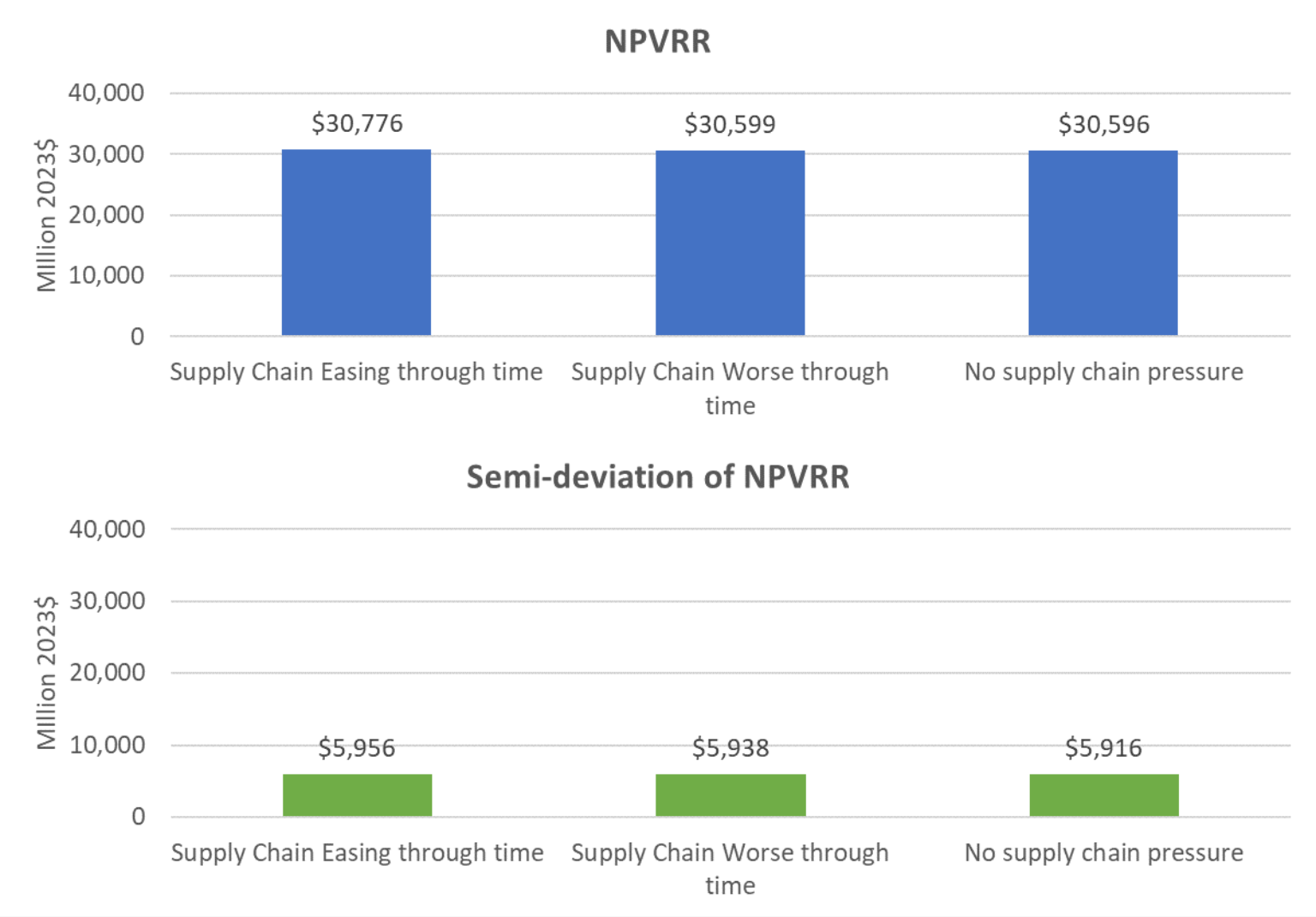
Method of analysis – Subject preferred portfolio to resource procurement constraints to simulate the impact of supply chain congestion that either A) eases though time, or B) increases through time

Year	Maximum Annual Resource Addition			
	Supply chain pressure easing		Supply chain pressure increasing	
	Renewables (MWa)	Storage (MW)	Renewables (MWa)	Storage (MW)
2026	150	38	400	228
2027	200	76	350	190
2028	250	114	300	152
2029	300	152	250	114
2030	350	190	200	76
2031	400	228	150	38

Supply Chain Sensitivity: Insights

Supply chain congestion increases portfolio costs and risk

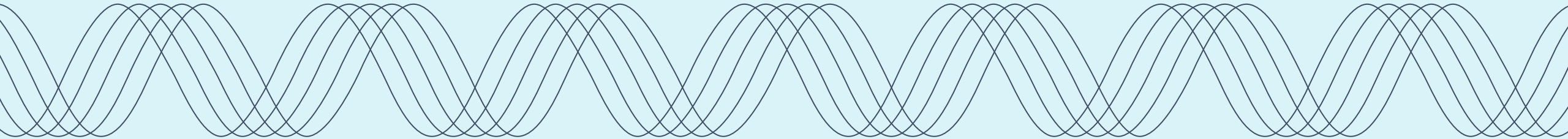
Near-term supply chain congestion has larger impact than congestion that occurs later in time



Questions

DRAFT ACTION PLAN PART II

TOMAS MORRISSEY, PGE



Recap & Previous Meetings

We first presented on the draft action plan in January 2023	January 2023 – five main components of the draft action plan Powerpoint (starts on slide 74); Recording (starts at minute 4:23:42)
	Today – updates and more details on those five components
	Action 3: Updated energy need
	Action 5: Updated transmission expansion approach

Five Components of IRP/CEP Action Plan

The IRP/CEP Action has five main components

1. Customer Actions
2. Community Based Renewable Energy Action
3. Energy Action
4. Capacity Action
5. Transmission Action

1. Customer Actions

i. Energy Efficiency

- Acquire all cost-effective EE - ETO forecasts a cumulative 150 MWa through 2028 (*estimates from ETO)*

ii. Demand Response

- Incorporate customer additions of 211/158 MW* of summer/winter DR by 2028 (*estimates from DSP pt. II*)

* Demand response values include existing programs

2. Community-Based Renewable Energy Action

CBREs are renewable energy systems that promote climate resilience and:

- Provide direct community benefit through a benefits agreement or ownership; or
- Result in increased resiliency or community stability, local jobs, economic development or direct energy cost savings to families and small businesses.

Conduct an RFP for community-based renewable energy resources (CBREs)

- Set up a new RFP process focused on CBREs procurement
- Evaluation and scoring of projects led by communities
- Community benefits are a key element of the scoring matrix

Action plan target is 66 MW in 2026

Our target is to achieve 155 MW of CBREs by 2030

- Aligned with Multnomah County and City of Portland goals

3. Energy Action

Conduct an RFP for non-emitting energy resources

Current Reference Case 2030 energy need: **905** MWa

Assuming a consistent yearly acquisition, PGE needs to add **181** MWa (**905** MWa/5 years) per year

- This action assumes the forecasted cost-effective levels of EE and DR will materialize

CBRE additions could reduce this 2030 need by up to a total of ~30 MWa (to ~875 MWa)

4. Capacity Action

Initiate an RFP to meet 2026 capacity needs

Current reference 2026 capacity need: **506** MW summer, **430** MW winter

This will take a staged approach. Simultaneously, PGE will:
1. Pursue cost-competitive options in the bilateral market
2. Acquire and incorporate customer and CBRE resources

Then, PGE will:
3. Conduct RFP for remaining 2026 capacity needs

The capacity action will aim to maintain near-term resource adequacy

5. Transmission Expansion

Pursue options to alleviate congestion on the SoA flowgate

Current estimates of existing transmission system suggest insufficient transmission capacity available to support the acquisition of off-system resources required for 2030 and beyond

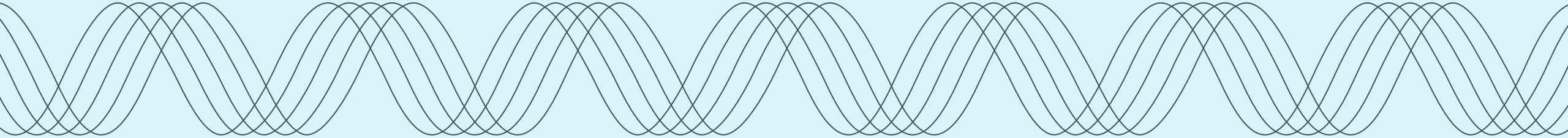
Explore the upgrade of the Bethel-Round Butte line (from 230 to 500 kV)

This option provides near-term relief to transmission constraints and opens access to a diverse set of resources for future PGE load service

Questions

2023 ALL-SOURCE REQUEST FOR PROPOSALS (RFP)

SHIRAZ BENGALI, PGE



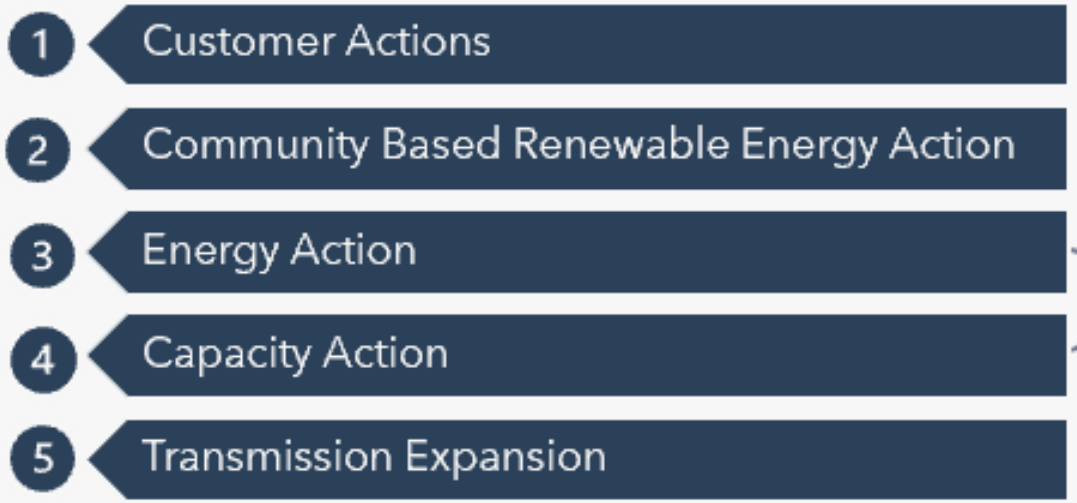
INTRO

1. The 2023 IRP introduces a high likelihood of both non-emitting capacity and non-emitting energy needs within the action plan window.

2. PGE filed to initiate a 2023 All-Source RFP on January 31, with a request to streamline the acquisition process in a way that retains a robust regulatory process while working toward HB 2021 targets.

3. Actual procurement volume will align with the 2023 IRP action plan once acknowledgment decision is made by the Commission.

Alignment with 2023 IRP process



We anticipate that the RFP will seek products that meet both the 2026 capacity need and add renewable energy resources to make continual progress toward HB 2021 targets.

Total actual procurement volume will align with acknowledged 2023 IRP action plan and reflect all actions taken up until IRP acknowledgment.

Timing of RFP to meet action plan needs

Maintaining alignment with the IRP action plan requires immediate initiation of 2023 RFP...

Proposal to Streamline

Independent Evaluator

PGE has proposed extension of Bates White as the independent evaluator (IE).

Most recent IE competitive solicitation was less than two years ago.

Scoring and Modeling Methodology

Proposed to waive the procedural requirement to seek approval of Scoring and Modeling Methodology in advance of draft RFP.

Would likely use the scoring and modeling methodology from UM 2166 as a base, with robust opportunity to review and provide feedback on any changes.

Draft RFP

Would seek review of the structure of the solicitation (including scoring and modeling).

Would specify product type and minimum requirements.

Volume to procure would remain flexible and will align with acknowledged 2023 IRP action plan.

If approved, proposed changes would remove 4-6 months from procedural schedule while retaining robust opportunity for review.

Next steps

1. Commission determination on Waiver request and establish a procedural schedule in UM 2274.

2. IRP/CEP filed March 31.

3. Parallel review of PGE's RFP structure and IRP/CEP, with PGE goal to issue draft RFP in April and have approved RFP to market by Q3 2023.

Questions

NEXT STEPS

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

Upcoming Roundtables:

- March 30, 2023

Upcoming IRP Filing Date:

- March 31, 2023

Thank you

Contact us at
IRP@PGN.COM

An

kind of energy

ACRONYMS

CBI (iCBI, rCBI, pCBI): community benefit indicators

CEP: clean energy plan

ETO: energy trust of Oregon

CBRE: community based renewable energy

RFP: request for proposal

MYP: multi-year plan

DSP: distribution system plan

EJ: environmental justice

EE: energy efficiency

GHG: greenhouse gas

ODOE: Oregon department of energy

CBIAG: community benefits and impacts advisory group

LOLH: loss of load hours

DR: demand response

HB2021: House Bill 2021

MW: megawatt

ELCC: effective load carrying capacity

MWa: mega watt average

kW: kilowatt

RPS: renewable portfolio standard

Tx: Transmission

BPA: Bonneville Power Administration

NCE: non-cost effective

NPVRR: net present value revenue requirement

PSH: pumped storage hydro

NG: natural gas

SoA: South of Allston

REC: renewable energy credit

VPP: virtual power plant

C&I: commercial and industrial

EUI: energy use intensity

NAICS: North American industry classification system

UPS: uninterruptible power supply

ITE: information technology equipment

DC: direct current

WECC: western electricity coordinating council

IE: independent evaluator

LT/ST: long term/ short term

ITC: investment tax credit

T&D: transmission and distribution

PPA: power purchase agreement

RTO: regional transmission organization

RRRR: reference case price future

RLRR: low carbon price future

VER: variable energy resources

PV: photovoltaic

ART: annual revenue-requirement tool

CEC: California energy commission


9:45 – 10:00 Break


12:15 – 12:45 pm Break