Restructured Energy Market Report

Assessment of Market Outcomes & Efficiency of the Proposed REM Design

Sensitivity: May 22nd, 2025

Update: June 5th, 2025

Preliminary Results - June 5, 2025 Update

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Energy+Environmental Economics

Disclaimer

This modeling is based on the current REM proposal which remains under development and is subject to change.

E3 created the following forecasts and analyses using the best available public information and our expertise and knowledge of the relevant markets, along with commercially available 3rd party software models and proprietary in-house energy market price forecasting tools. However, the future is uncertain, and these forecasts (along with underlying market expectations) may change due to many factors, including unforeseen events, new technology adoption or inventions, new market structures, regulatory actions, and changes in both provincial and federal government policies. E3 makes no guarantees related to these forecasts or the information presented herein and should not be held liable for any economic damages associated with independent investment decisions.

Executive Summary

Preliminary Results - June 5, 2025 Update

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Updated REM Scenarios Overview

- **This report provides an analysis of updated REM parameters based on recent changes to the REM design**
- **Included are two scenarios that test higher offer caps in the energy market of $1,500/MWh and $2,000/MWh, with a price floor of $0/MWh**
  - The price cap of $3,000/MWh remains
    Smooth ORDC was applied from offer cap to price cap based on loss of load probability and VOLL consistent with previous studies
  - E3 utilized the strategic pricing model scaling up historical offer behaviour to increased ceiling
  - An R30 ramping reserve replacing the R10 and R60 products previously modeled
    R60 volumes calculated in previous runs were used as a proxy for the R30 volumes given limited data
- **The results show an improvement of revenue sufficiency and an increased reserve margin when compared to the Status Quo market design**
- **This report is a supplement to the E3 reports currently on the AESO Engage Website. All methodology, inputs, and supplemental data not contained in this presentation can be found here:**
  - E3 Preliminary Report November 14
  - December 13 Update
  - March 14 Update

Scenario & Inputs Overview

Scenario matrix for reference throughout presentation corresponds to table below

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

The matrix identifies how each scenario will be referred to as shorthand in charts and throughout the report

Design Feature	Value	Status Quo Dec-24	REM Dec-24	Status Quo Mar-25	REM Mar-25	REM Sensitivity I	REM Sensitivity II
		SQ190	PI381D	SQ190-95	PI381-95	PI3200ND-95	PI3150ND-95
Price Cap ($/MWh)	$3,000.00		X		X	X	X
Prcie Cap ($/MWh)	$1,000.00	X		X			
Price Floor ($/MWh)	$0.00	X		X		X	X
Price Floor ($/MWh)	($100.00)		X		X		
Offer Cap ($/MWh)	$2,000					X	
Offer Cap ($/MWh)	$1,500						X
Offer Cap ($/MWh)	$800.00		X		X		
Offer Cap ($/MWh)	$999.99	X		X			
Intertie Participation	Status Quo (SQ)	X		X			
Intertie Participation	Priced (PI)		X		X	X	X
ORDC	Smooth		X		X	X	X
Reserves	DAC		X		X		
Reserves	R10/R60		X		X		
Reserves	R30					X	X
Reserves	CR, RR	X	X	X	X	X	X
Border Node	Yes		X		X	X	X
Shortened Settlement	Yes		X		X	X	X
Mitigation	Yes		X		X	X	X
Strategic DAC	Yes				X		
New Build New Entrant	Yes			X	X	X	X
Net Zero Constraint	Yes	X	X				
Carbon Price $170	Yes	X	X				
Carbon Price $95	Yes			X	X	X	X
2035 Intertie Restoration	Yes			X	X	X	X

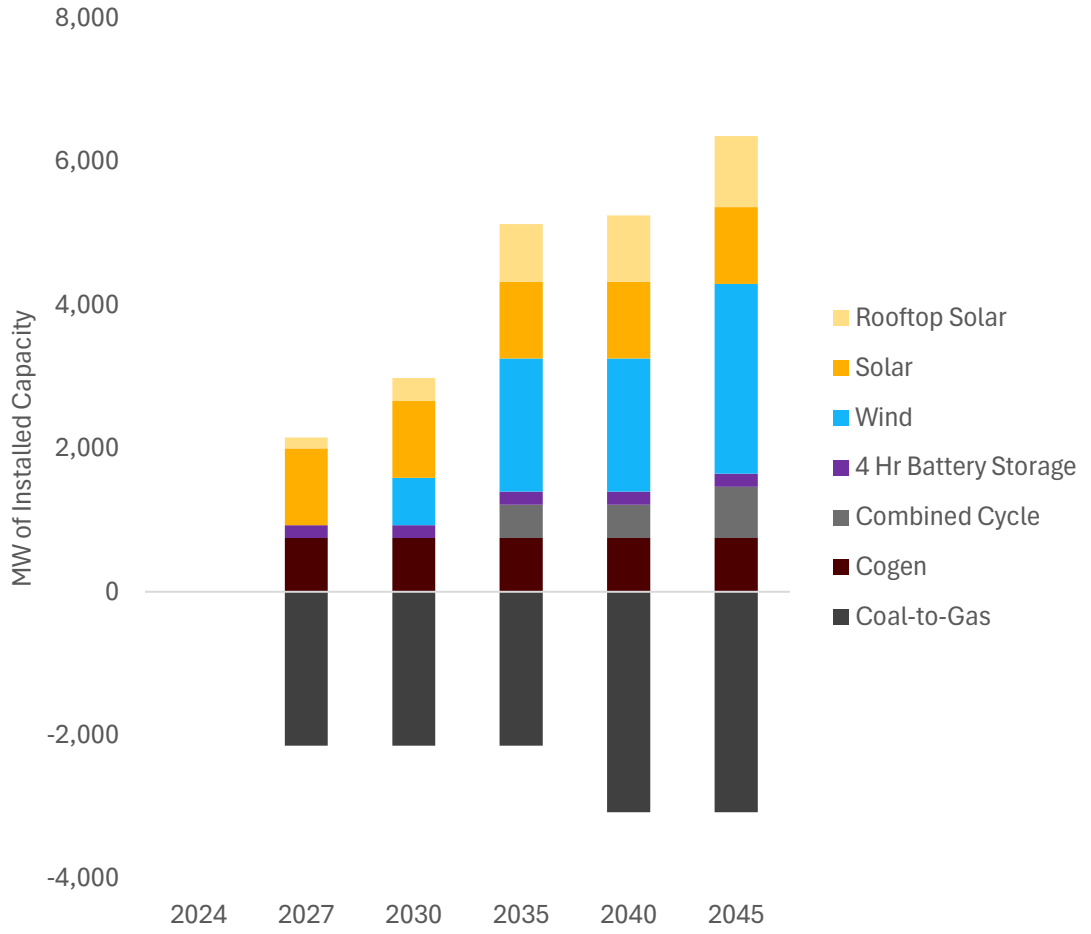
New Cases

Projected Build Under Previously Modeled Status Quo Elements (Scenario #3)

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

- **Under the current market design, Alberta will see continued changes in supply mix with wind still being an economic generation source. With a $999.99/MWh offer cap and without ORDC or DAC there is no investment in Storage, and CCGT additions are limited and occur later**
- **E3 forecasts the following additions to the current installed capacity over the study horizon under Status Quo market design**
  - 1.9 GW of additional solar generation from current (of which 990 MW of rooftop solar)
    - All additions currently under construction
  - 2.6 GW of wind
  - 0.2 GW of battery storage
    - All additions currently under construction
  - 0.7 GW of CCGT
  - 0.8 GW of Cogen
    - Currently energizing
  - 3 GW of coal-to-gas retirements

Status Quo (SQ190-195) Build Additions[1]



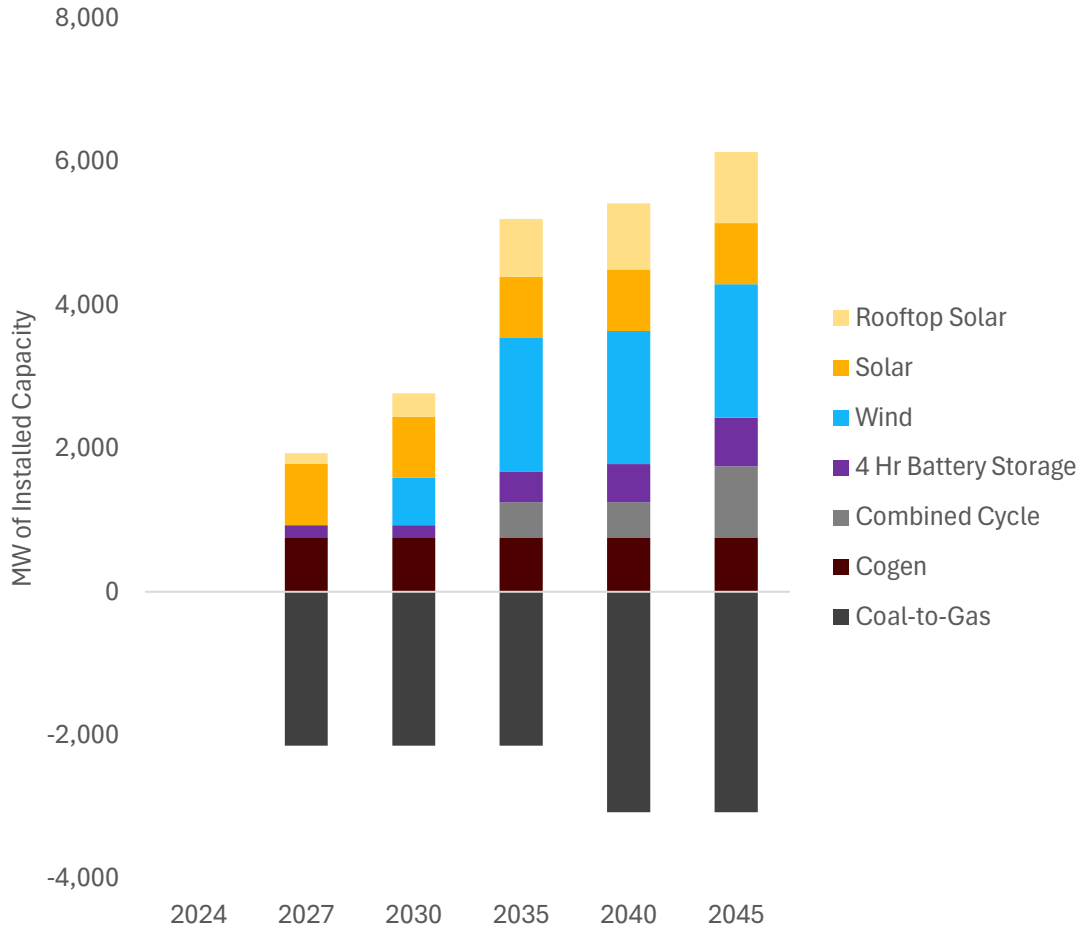
1. Incremental to 2024 EOY Installed Nameplate

Build For New REM Sensitivities (Scenarios #5-6)

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

- **When compared with the status-quo, the modeled REM design increases the amount of dispatchable generation on the system**
- **E3 forecasts the following additions to the current installed capacity over the study horizon for the REM sensitivities**
  - 1.9 GW of additional solar generation from current (of which 990 MW of rooftop solar)
    - All additions currently under construction
  - 1.9 GW of wind
  - 0.8 GW of battery storage
  - 1.0 GW of CCGT
  - 0.8 GW of Cogen
    - Currently energizing
  - 3 GW of coal-to-gas retirements

REM (PI3200ND & PI1500ND) Build Additions[1]



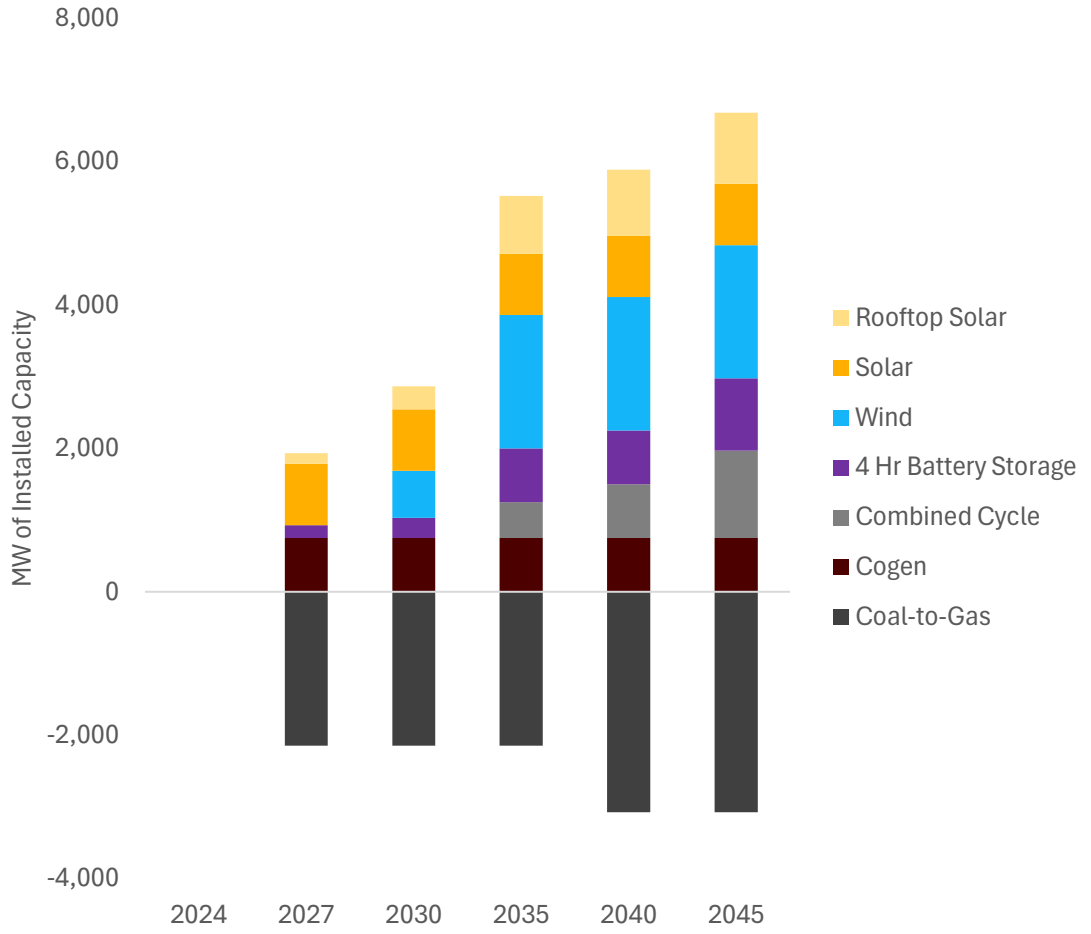
1. Incremental to 2024 EOY Installed Nameplate

Projected Build Under Previously Modeled REM Elements (Scenario #4)

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

- **For comparison, the previously published results (March 14 Report) are provided**
- **E3 forecasts the following additions to the current installed capacity over the study horizon for Scenario 4**
  - 1.9 GW of additional solar generation from current (of which 990 MW of rooftop solar)
    - All additions currently under construction
  - 1.9 GW of wind
  - 1.1 GW of battery storage
  - 1.2 GW of CCGT
  - 0.8 GW of Cogen
    - Currently energizing
  - 3 GW of coal-to-gas retirements

REM (PI381-95) Build Additions[1]



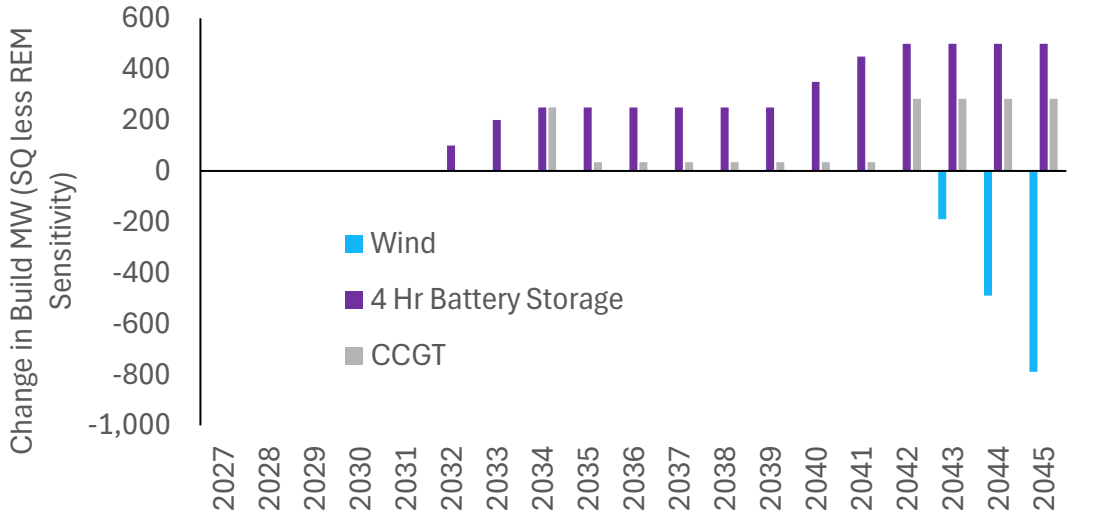
1. Incremental to 2024 EOY Installed Nameplate

Build Comparison (Scenarios #5-6 vs #3)

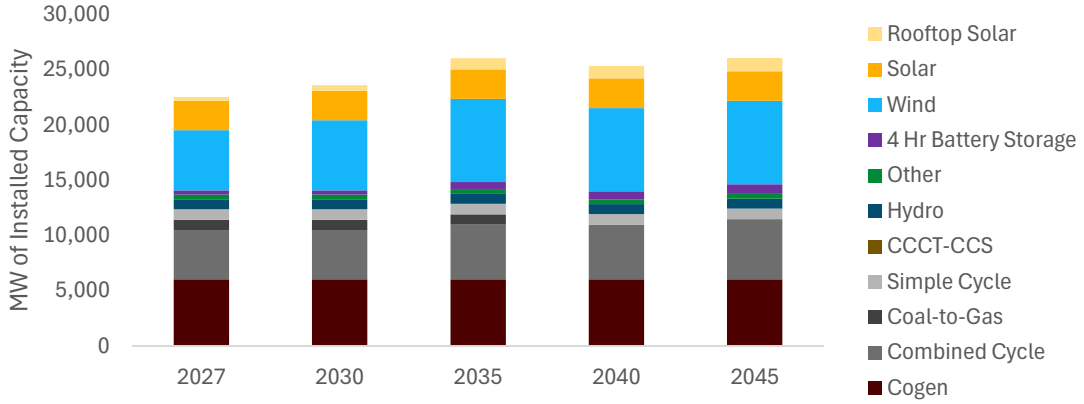
#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

Long-term expansion results indicate that the updated REM design (PI3200ND-95 & PI1500ND-95) attracts 280 MW more Combined Cycle Gas (CCGT) while also building earlier, and adds 500 MW more 4-Hr duration storage than the Status Quo (SQ190-95) by 2045

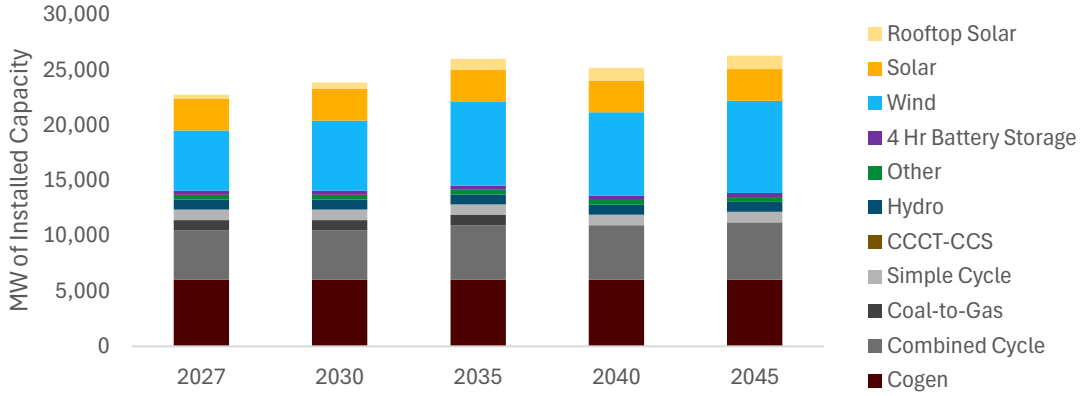
Cumulative Build Comparison (SQ minus REM Sensitivity)



REM Design – Long-term Build (PI3200ND-95& PI1500ND-95)



Status Quo – Long-term Build (SQ190-95)

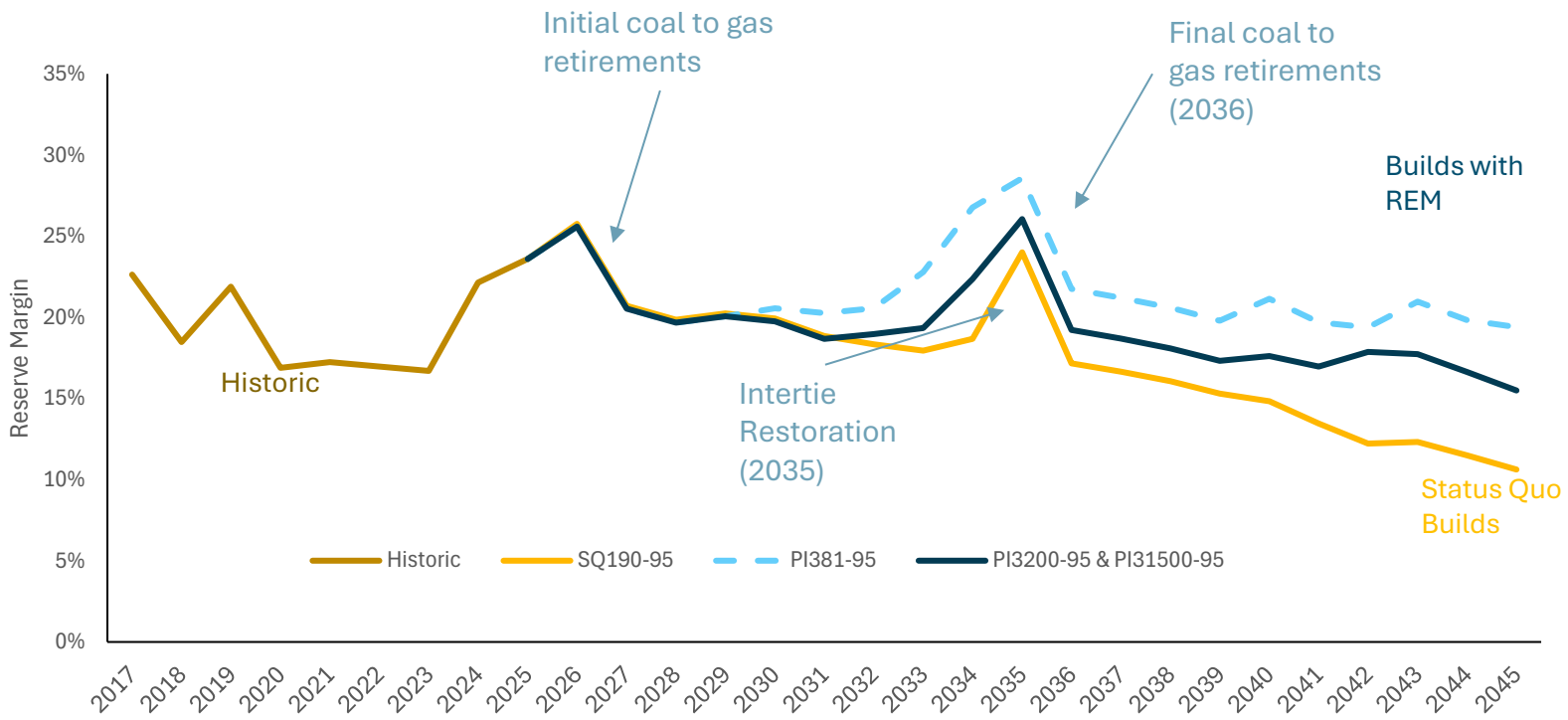


Additional REM Revenue Streams Increases Firm Generation

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

The ORDC and higher offer caps attract more firm resources than the Status Quo
Reserve margins stay flat with a slight decline to 2020-2023 levels in the 2040s

Change in Reserve Margin* with REM Components



Effective Capacity

Type	Effective Capacity
Rooftop Solar	5%
Solar	10%
Wind	10%
CCS	100%
Storage	100%
Hydro	67%
Other	100%
CCGT	95%
Cogen	100%
CTG	93%
Simple Cycle	100%
Intertie	50%

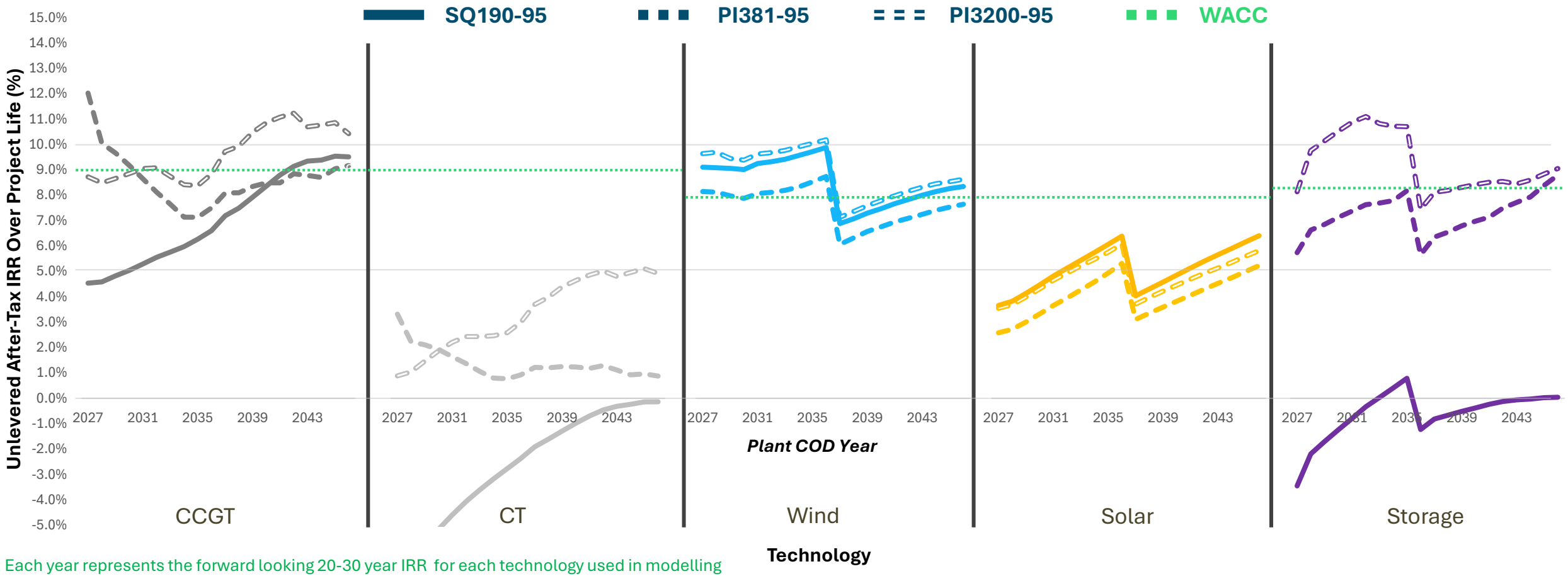
E3's effective capacity assumptions are for the purposes of the reserve margin calculation. Strictly for comparison purposes.

*Reserve margin is effective capacity divided by Peak load

Investment signals across technologies change over time as new generation is built and the ITC expires

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

REM Sensitivity components provide early investment signals for storage and CCGT. Wind also sees profitable entry which is challenged by the expiration of ITC in 2036. Tighter market conditions in the long-term drive increased returns across all technologies

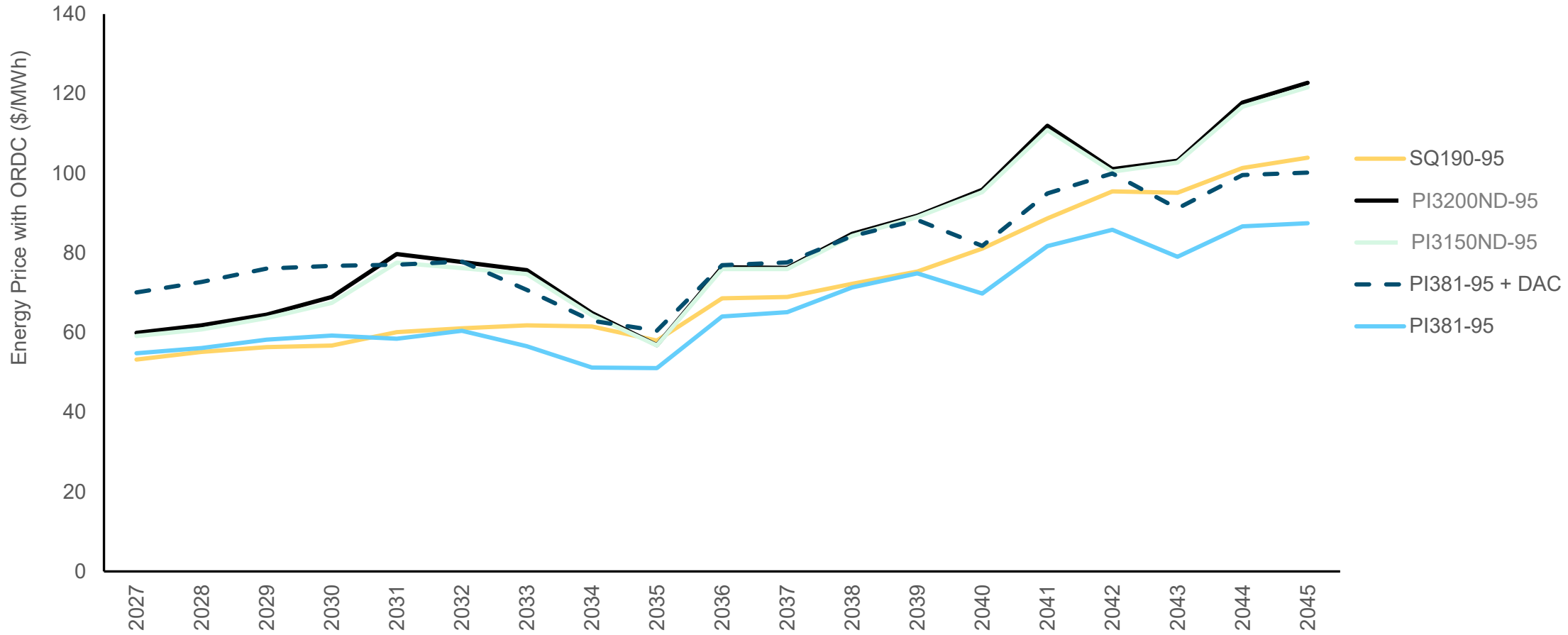


Each year represents the forward looking 20-30 year IRR for each technology used in modelling
WACC is a reference point, each project will have its own unique WACC

Energy Price Comparison – Annual Price incl ORDC

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

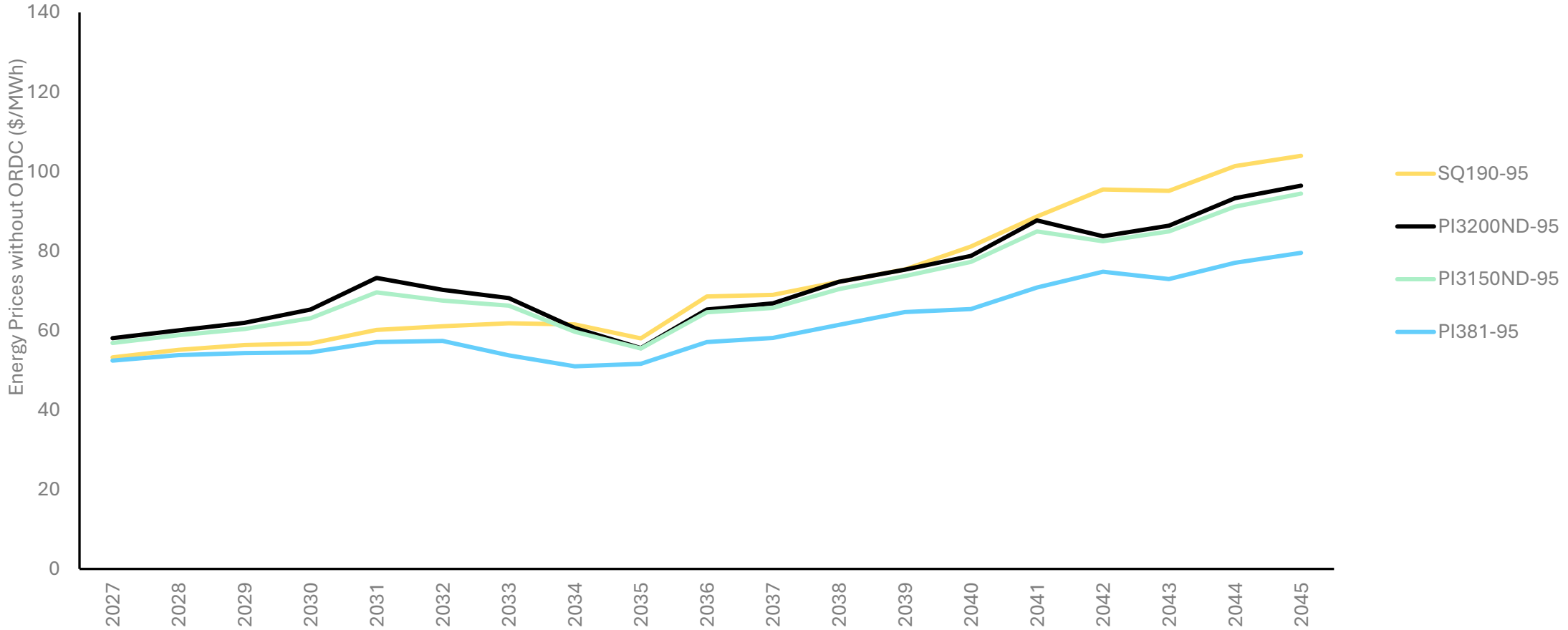
DAC removal results in strong cost savings 2027-2030. Increased offer cap with ORDC result in an increase in price compared to Status Quo, but less than the combined PI381-95 Case. In the outer years, ORDC and strategic bidding support new capacity economics



Energy Price Comparison – Annual Price excl ORDC

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

When ORDC impacts are removed, the difference in pricing between a $1500 and $2000 offer cap is more visible. Status Quo has higher energy prices in the long run as no ORDC provides less revenue resulting in the energy market providing more revenue

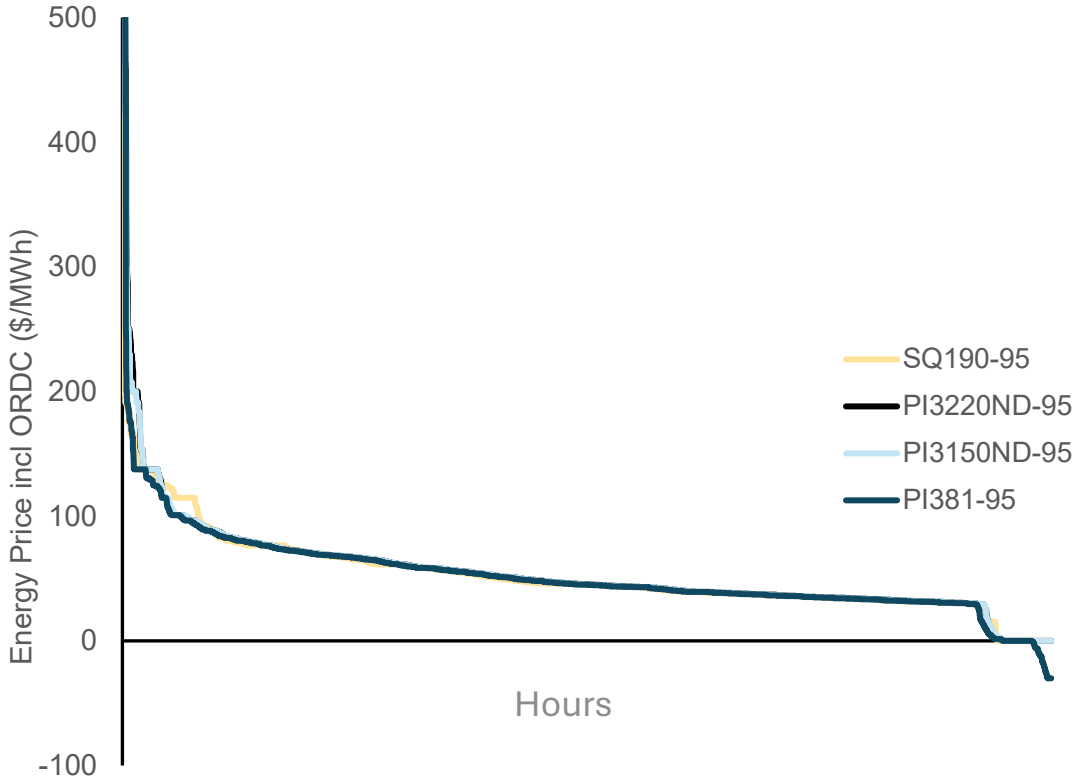


Energy Price Comparison – Duration Curves 2027

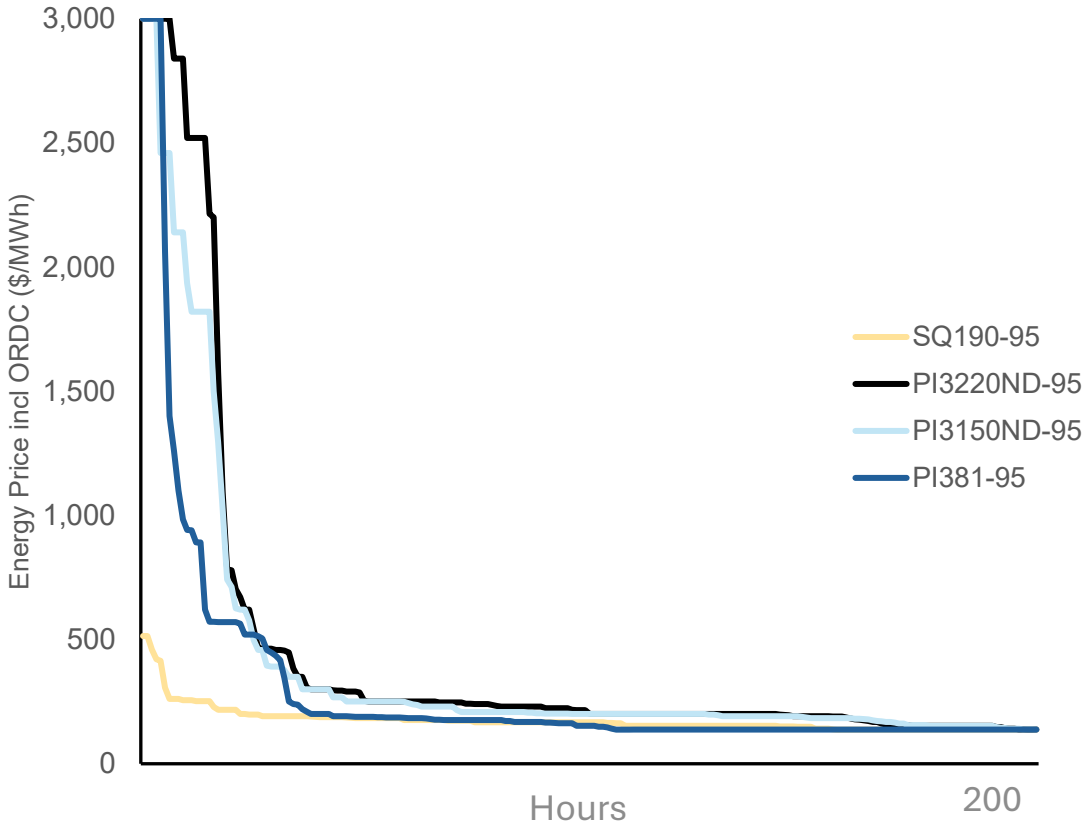
#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

In REM Sensitivity, resource revenues are concentrated in top energy price hours as revenues are supported by ORDC and higher offer caps instead of DAC

2027 Price Duration Curve (8760)



2027 Price Duration Curve Top 200 Hours

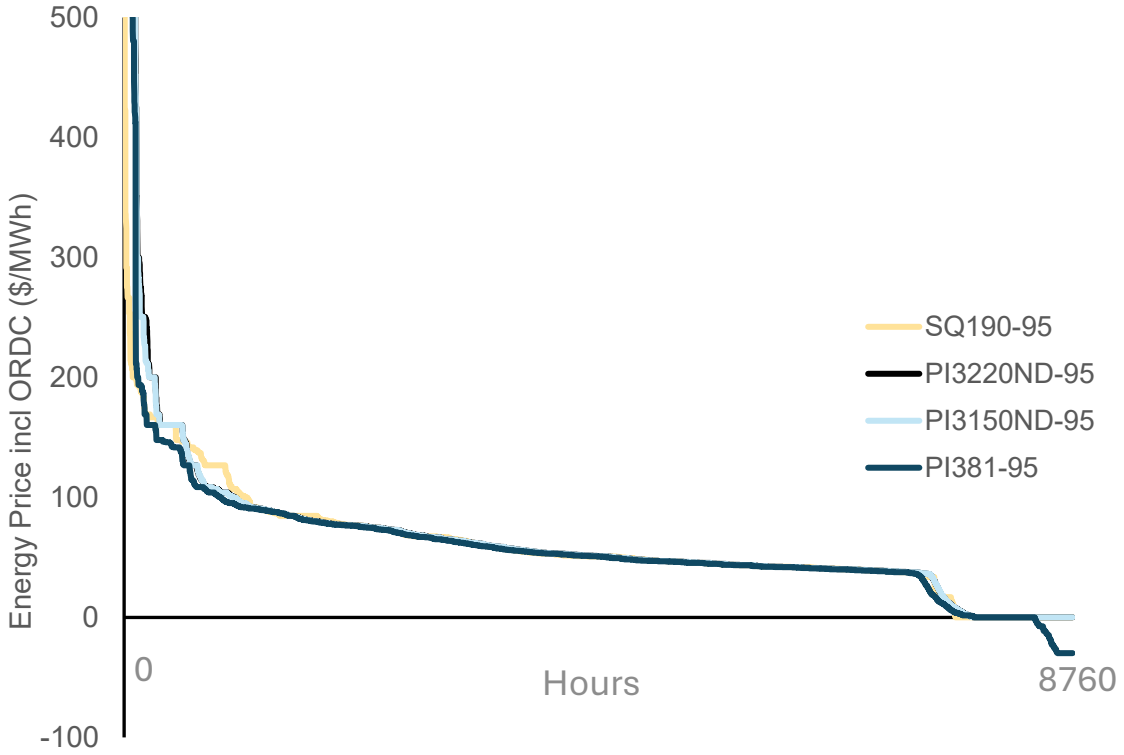


Energy Price Comparison – Duration Curves 2032

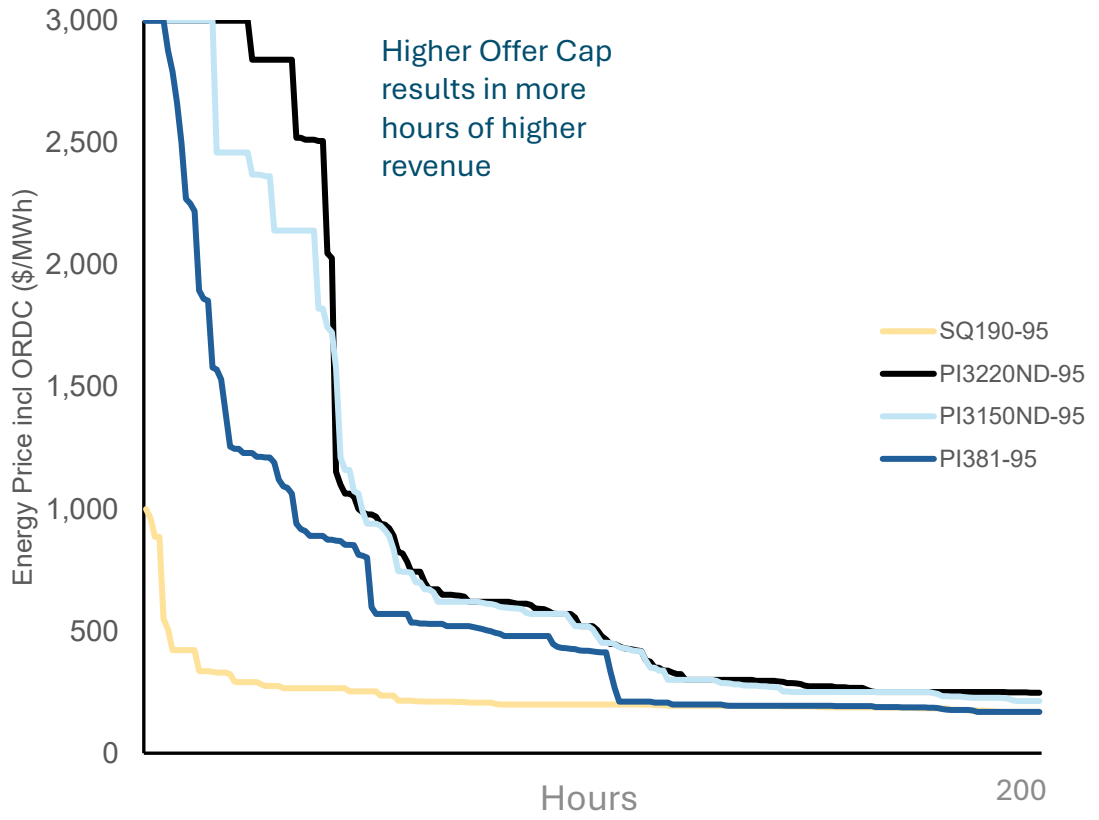
#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

In REM Sensitivity, resource revenues are concentrated in top energy price hours as revenues are supported by ORDC and higher offer caps instead of DAC

2032 Price Duration Curve (8760)



2032 Price Duration Curve Top 200 Hours

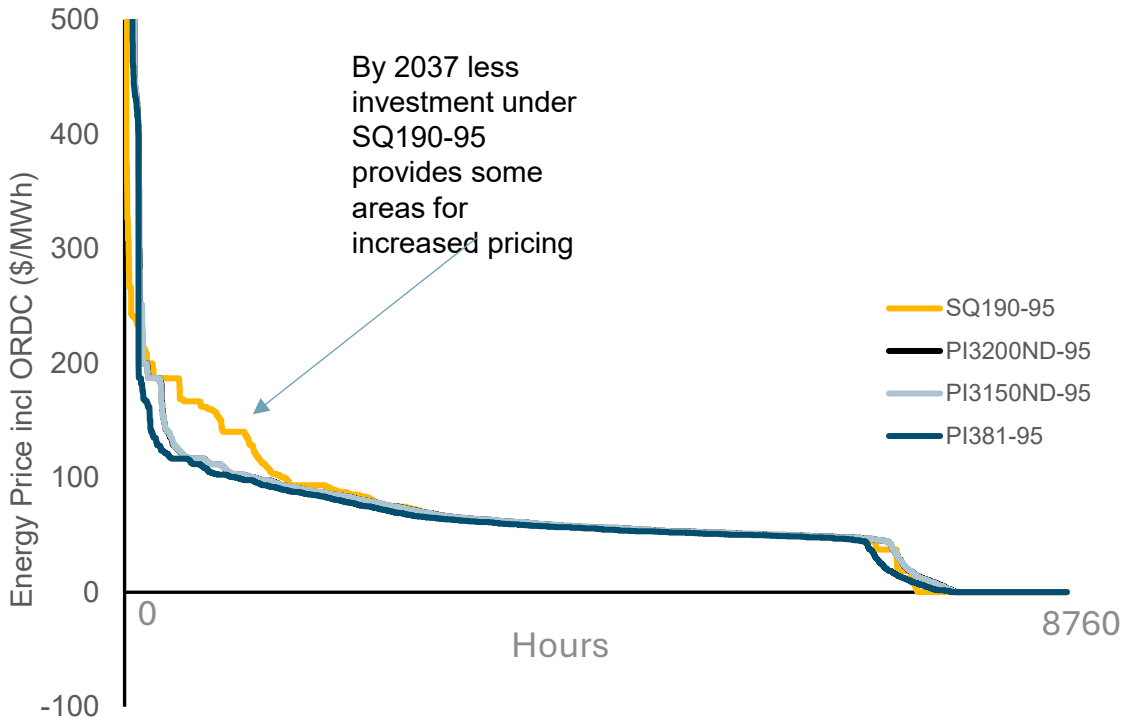


Energy Price Comparison – Duration Curves 2037

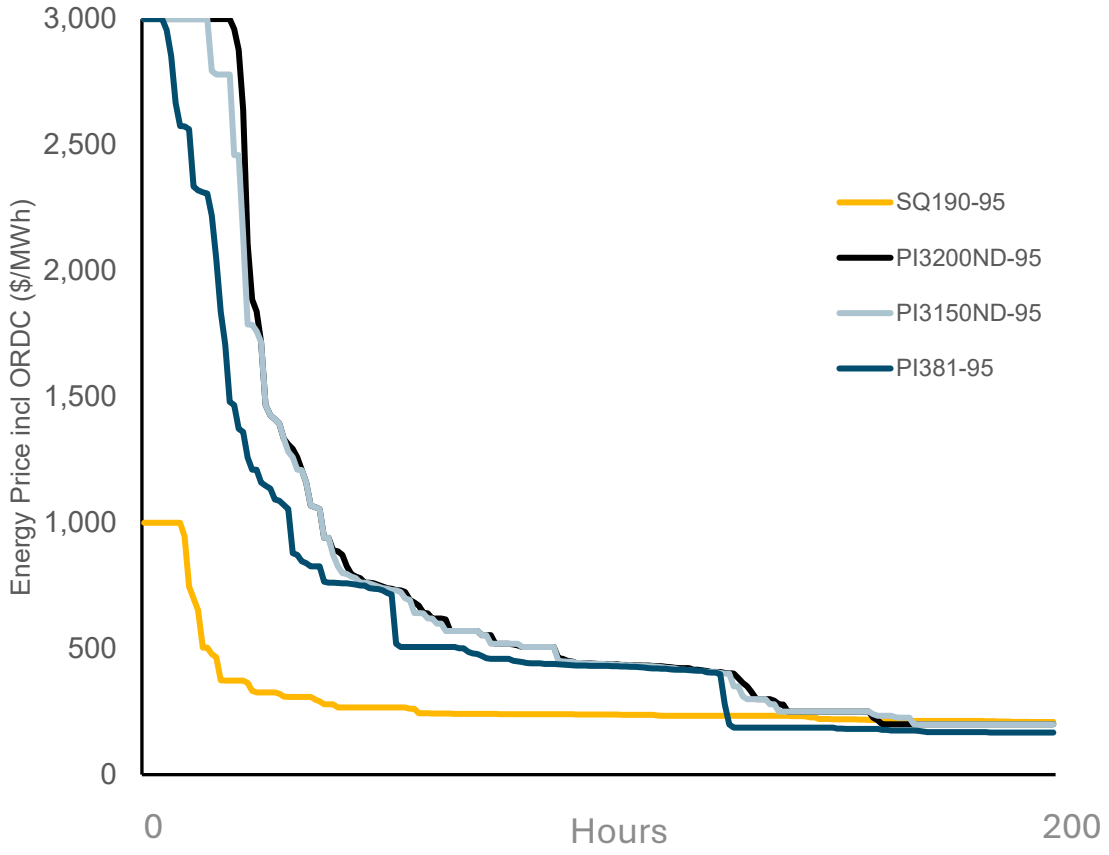
#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

In REM Sensitivity, resource revenues are concentrated in top energy price hours as revenues are supported by ORDC and higher offer caps instead of DAC. Tighter conditions in Status Quo begin to offer some revenue opportunities

2037 Price Duration Curve (8760)



2037 Price Duration Curve Top 200 Hours

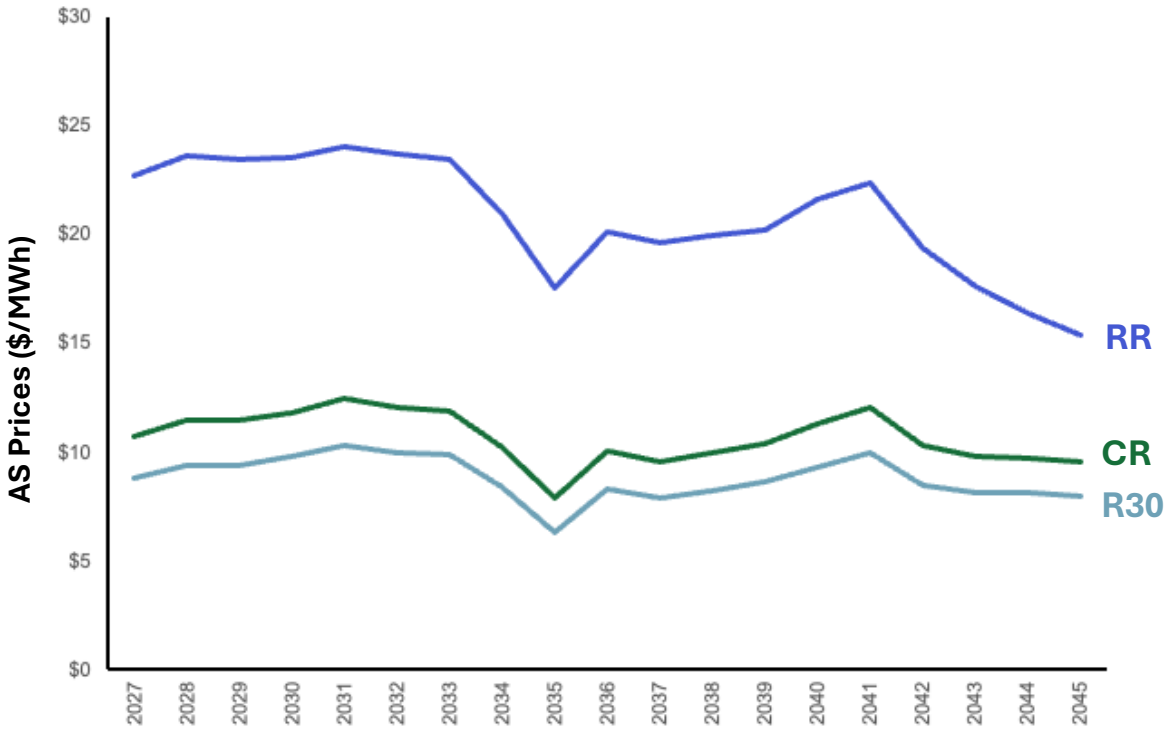


Ancillary Service Price Comparison – Annual Average

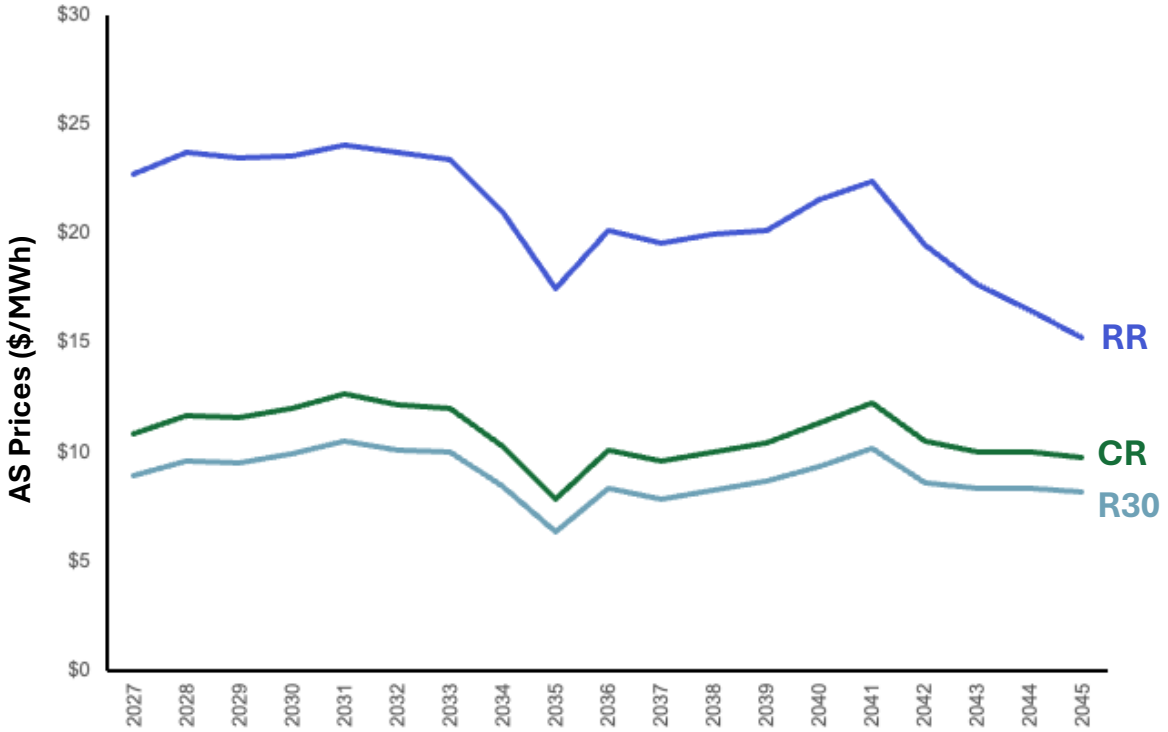
#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

Average Ancillary Service product prices remain relatively unchanged across REM Sensitivity Scenarios. Prices remain relatively stable over time with long-term decreases in Regulating Reserve price due to market saturation from increasing battery capacity

PI3150ND-95



PI3200ND-95



Forum Questions – Additional Information

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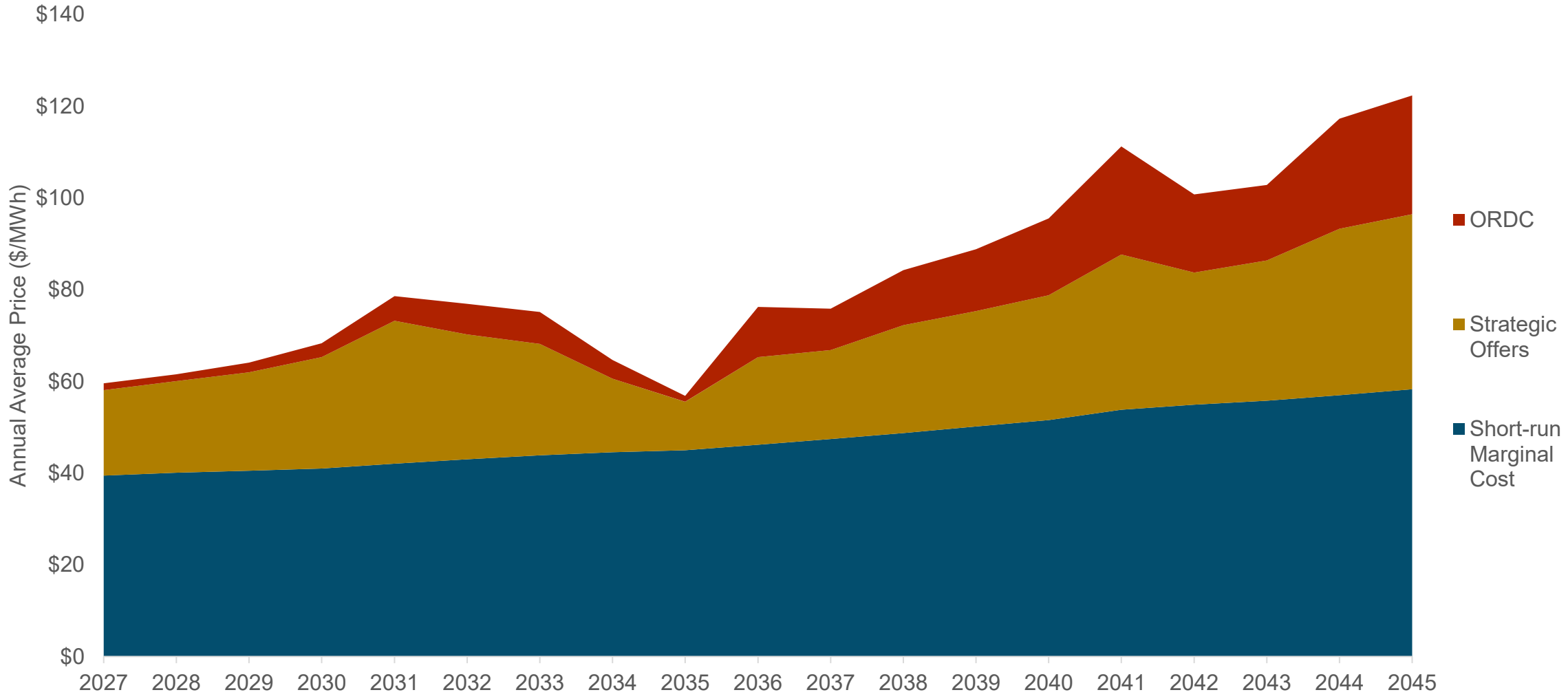
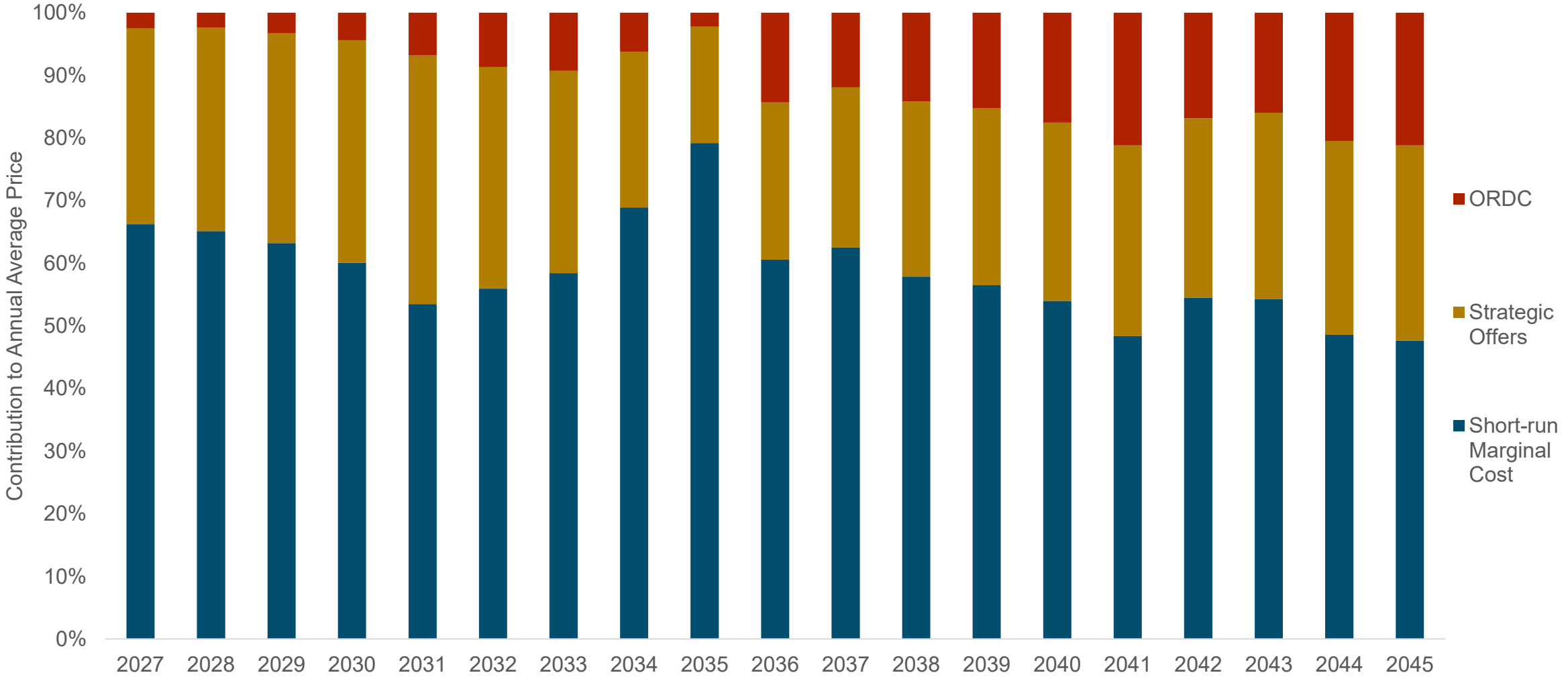
Annual Energy Price by Component – PI3200ND-95

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95



Annual Energy Price Proportion by Component

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

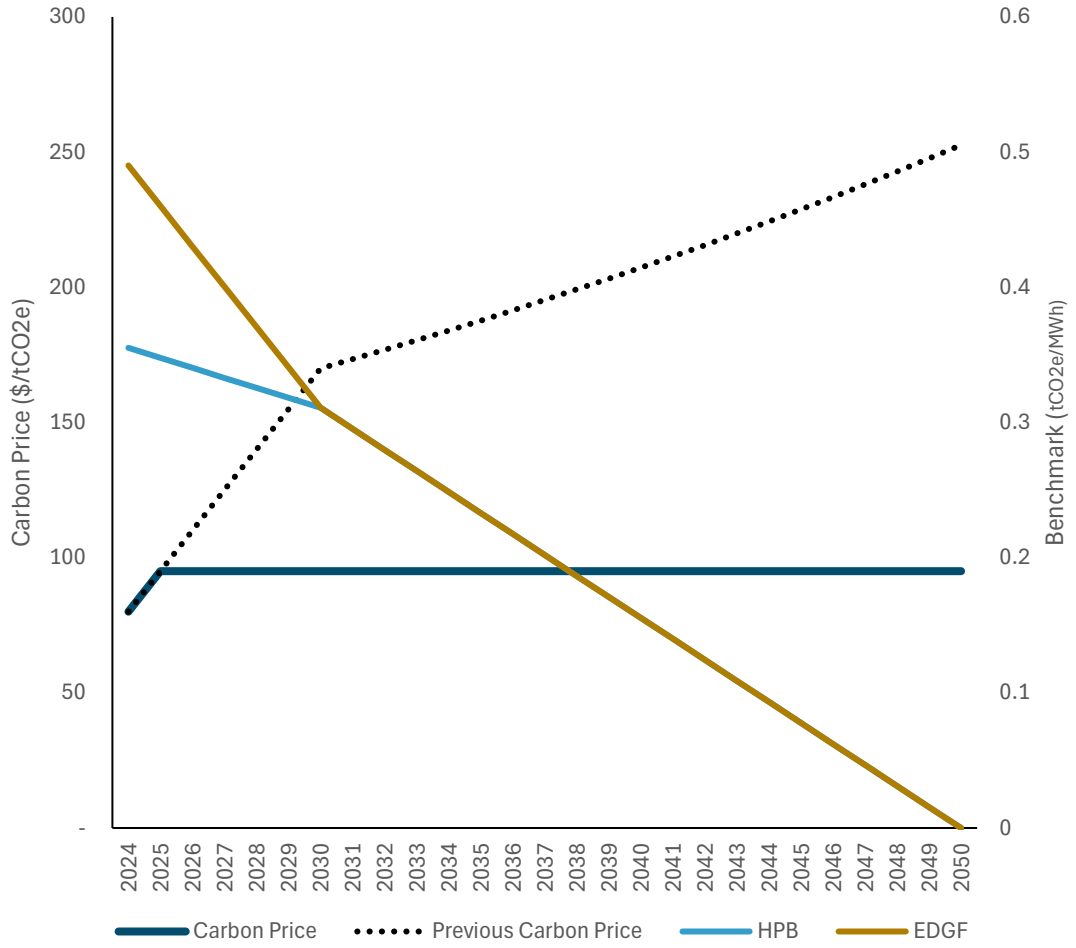


Carbon Pricing – Total Carbon Price

#	Scenario Name	Offer Cap	ORDC/DAC	Binding Net Zero	Carbon Price
1	SQ190	$999	N/N	Y	$170
2	PI381	$800	Y/Y	Y	$170
3	SQ190-95	$999	N/N	N	$95
4	PI381-95	$800	Y/Y	N	$95
5	PI3150ND-95	$1,500	Y/N	N	$95
6	PI3200ND-95	$2,000	Y/N	N	$95

- **E3 modelled the Alberta electricity system with modified carbon pricing as a sensitivity**
- **Carbon price follows the federal trajectory of increasing $15/t per year until reaching $95/t, after which it is held flat (held flat at $95/t nominal)**
- **The High-Performance Benchmark (HPB) aligns with the current trajectory under TIER out to 2030 and then exhibits a linear decline to 0t/MWh by 2050**
  - The Electricity Grid Displacement Factor (EGDF) also follows the current TIER trajectory until 2030, after which it decreases linearly in conjunction with the HPB, reaching 0t/MWh by 2050

Modelled Alberta Carbon Policy



Thank You

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