April 27, 2021

MEMORANDUM

TO: **Council Members**

FROM: **John Ollis, Manager of Planning and Analysis**

SUBJECT: **Greenhouse Gas Tipping Point Scenario Findings**

BACKGROUND:

Presenter: John Ollis and Ben Kujala

Summary: This scenario explores the impacts of greenhouse gas (GHG) emissions regulations and explicit emissions pricing in the region and throughout the west. Some of the explorations look at implications of a WECC-wide GHG emissions pricing, impact of limitations by fuel type per regulation, and peak emissions reductions capability of particular demand response resources. We have been assessing the implied changes in regional needs and analyzing resource strategies to highlight potential risks and benefits or different markets.

Relevance: Greenhouse gas emissions pricing policies and mechanisms have been employed in different parts of the United States and throughout the world as a means of reducing emissions in the power sector. Since the emissions damages are considered in many of the scenarios in this plan, this scenario explores the impact of emissions pricing on operations.

Additionally, regulatory barriers and policies throughout the west have made it increasingly more difficult to invest in natural gas builds to meet load growth or backfill retiring units. This is a fairly new paradigm, and has consequences for the number of resources that will need to be built to maintain appropriate reserve margins.

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Workplan: A.6.1 Complete scenario analysis for the plan

More Info: Simulation results related to this scenario were discussed at the following recent meetings:

April 14th SAAC

April 21st Power Committee Webinar

Greenhouse Gas Tipping Point Scenario

Power Committee

April 21st, 2021

Ben Kujala, John Ollis

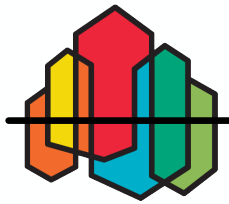
THE 2021
NORTHWEST
POWER PLAN

FOR A SECURE & AFFORDABLE
ENERGY FUTURE

Scenario Description

- Look at thresholds where the resource strategy changes based on responding to a price on greenhouse gas emissions and/or regulations related to reducing emissions.
  1. Limitations around building gas plants WECC wide (*No Gas Build Limits*)
  2. Explicit pricing of greenhouse gas emissions in dispatch (*GHG Pricing*).
  3. Magnitude of damage cost of greenhouse gas emissions in resource decision making

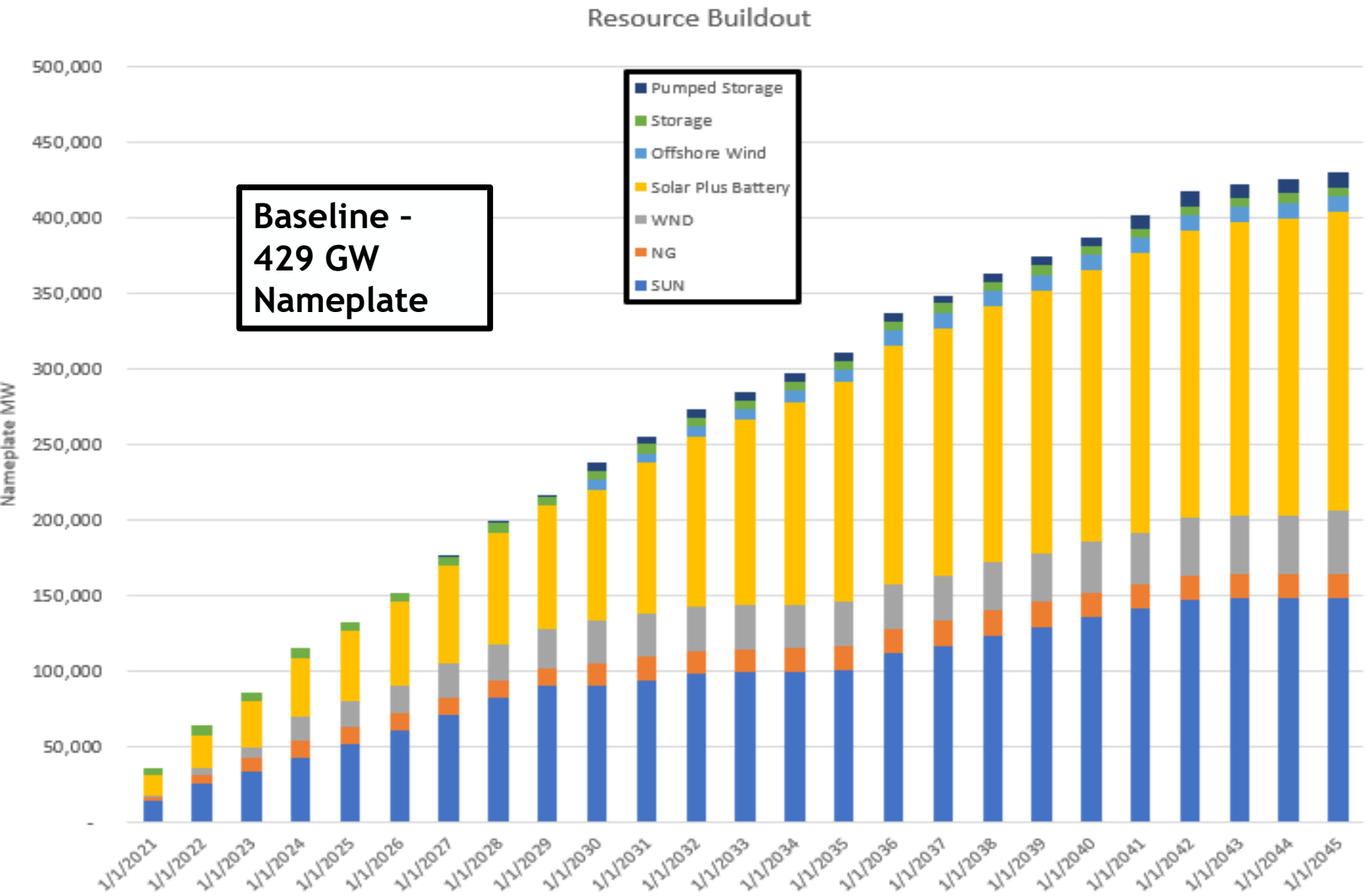
- Explore other emissions reduction strategies like re-binning demand response programs to avoid peaking emissions.



Buildout Discussion

- No Gas Build Limit buildout has 67 GW of gas at the end of the study, and overall build is 165 GW less than baseline.
- Buildout with GHG pricing in the dispatch WECC-wide is 33 GW larger than the baseline, and leans even more heavily on solar and short duration storage.
- Both sensitivities are almost as adequate as the baseline, but the No Gas Build Limit sensitivity does not achieve clean policies as often.

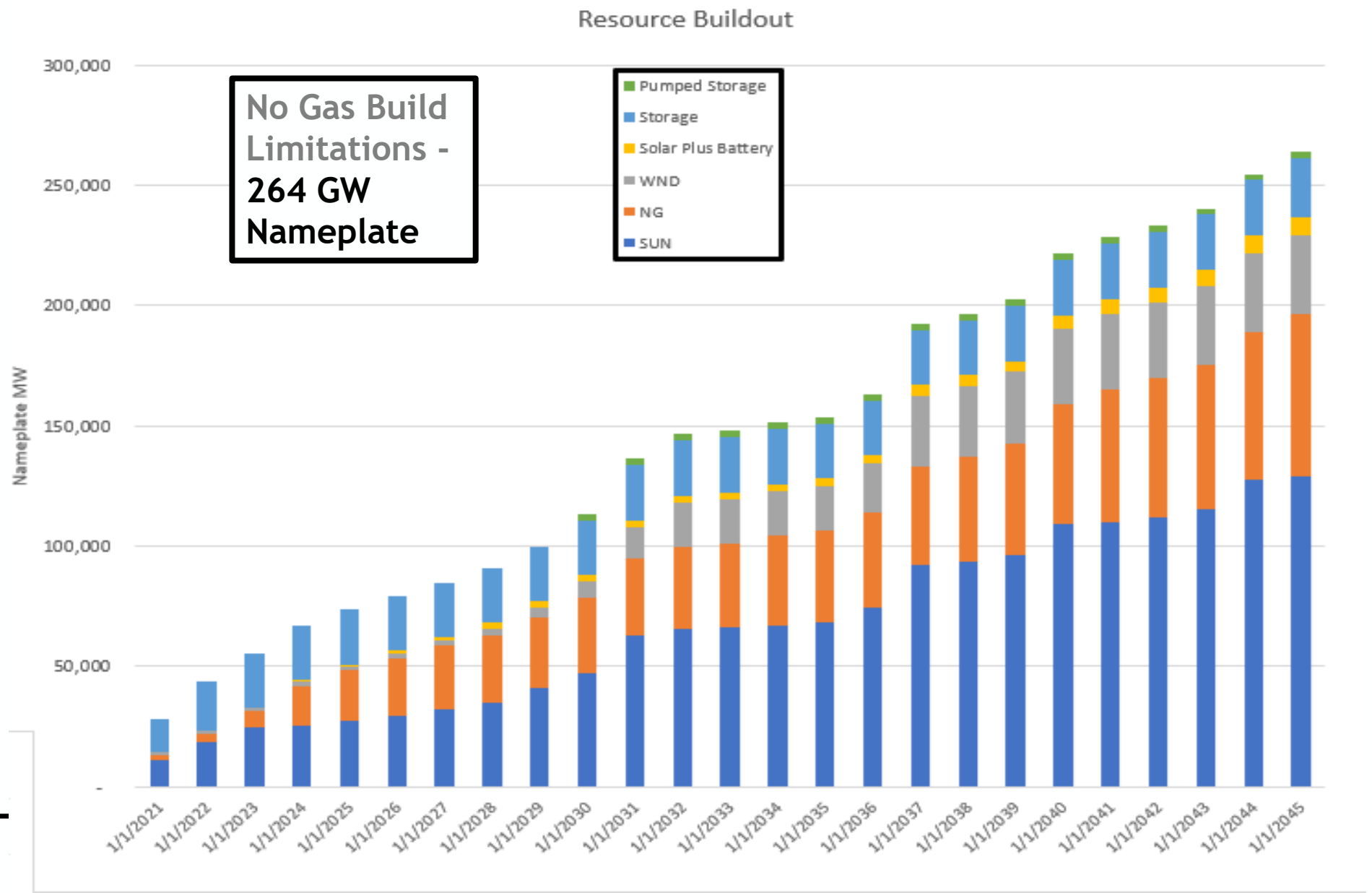
Baseline



1. Planning reserve margins are mostly met
2. Clean/RPS Policies met until 2037

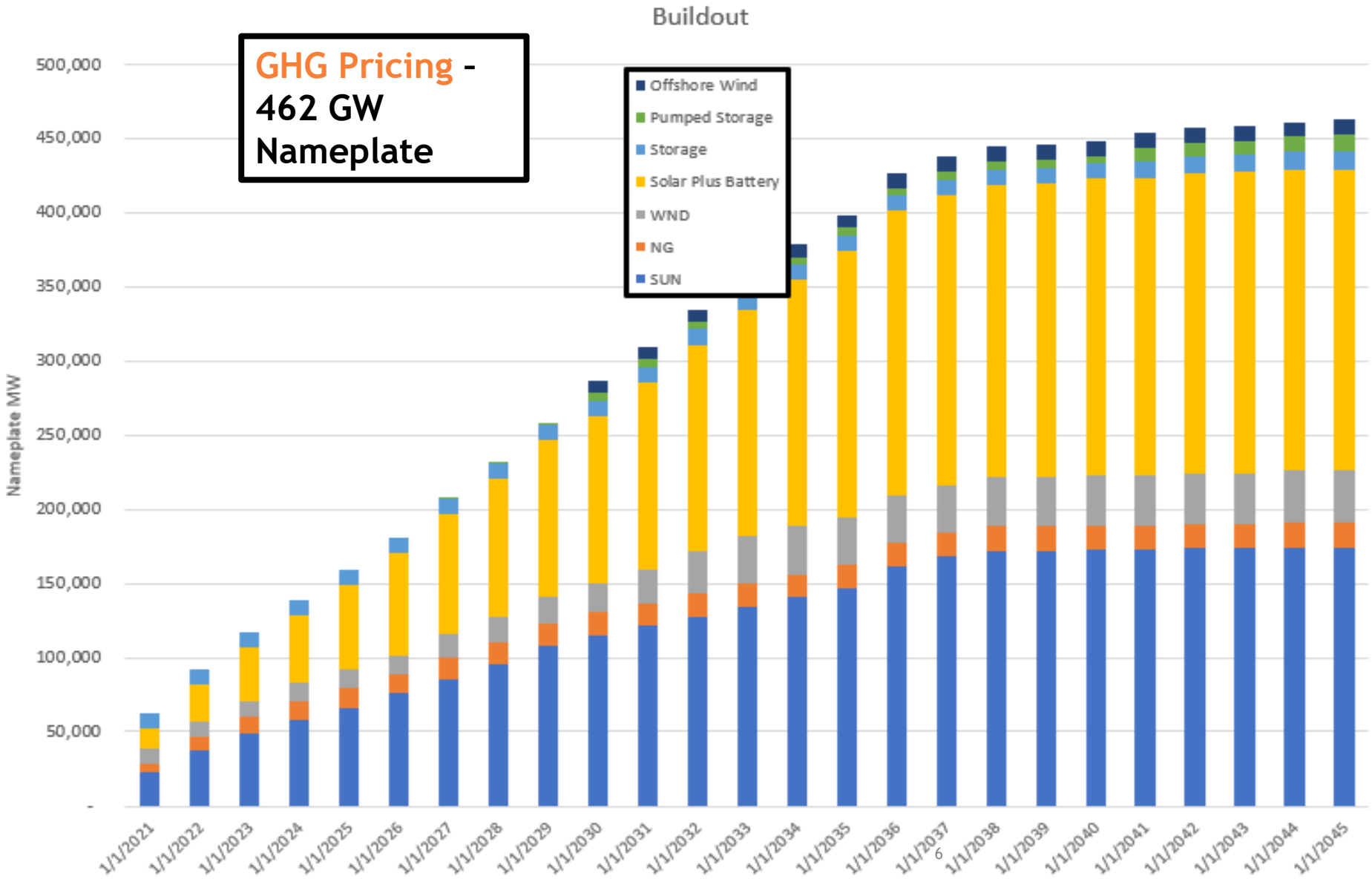
No Gas Build Limitations

1. Planning reserve margins are met consistently
2. Clean/RPS Policies met until 2030
3. Gas stays on the margin more often.



GHG Pricing

GHG Pricing - 462 GW Nameplate

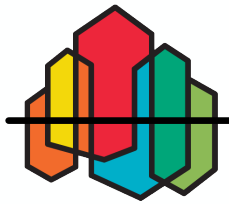


1. Planning reserve margins are mostly met
2. Clean/RPS Policies met until 2037

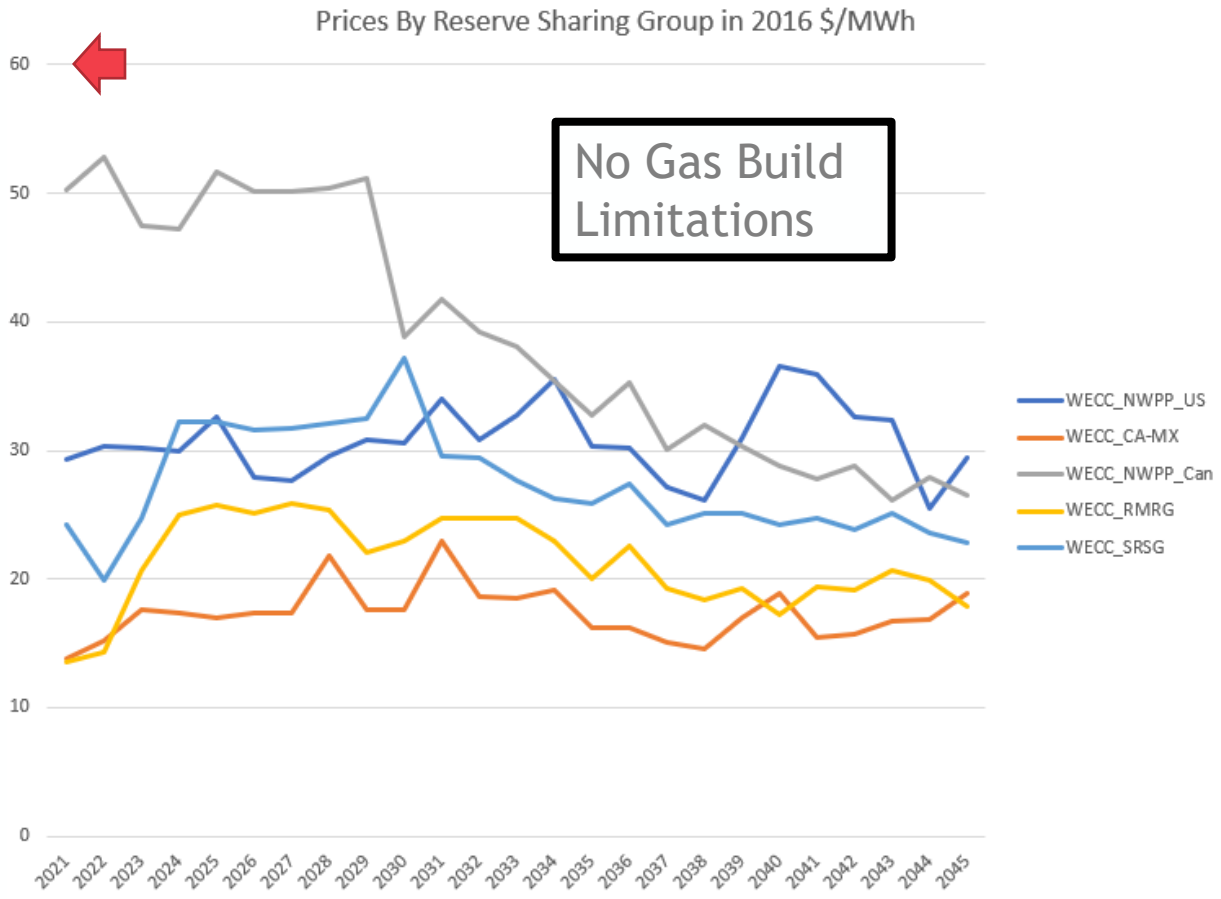
Detailed Comparison of GHG Pricing Sensitivity to Baseline

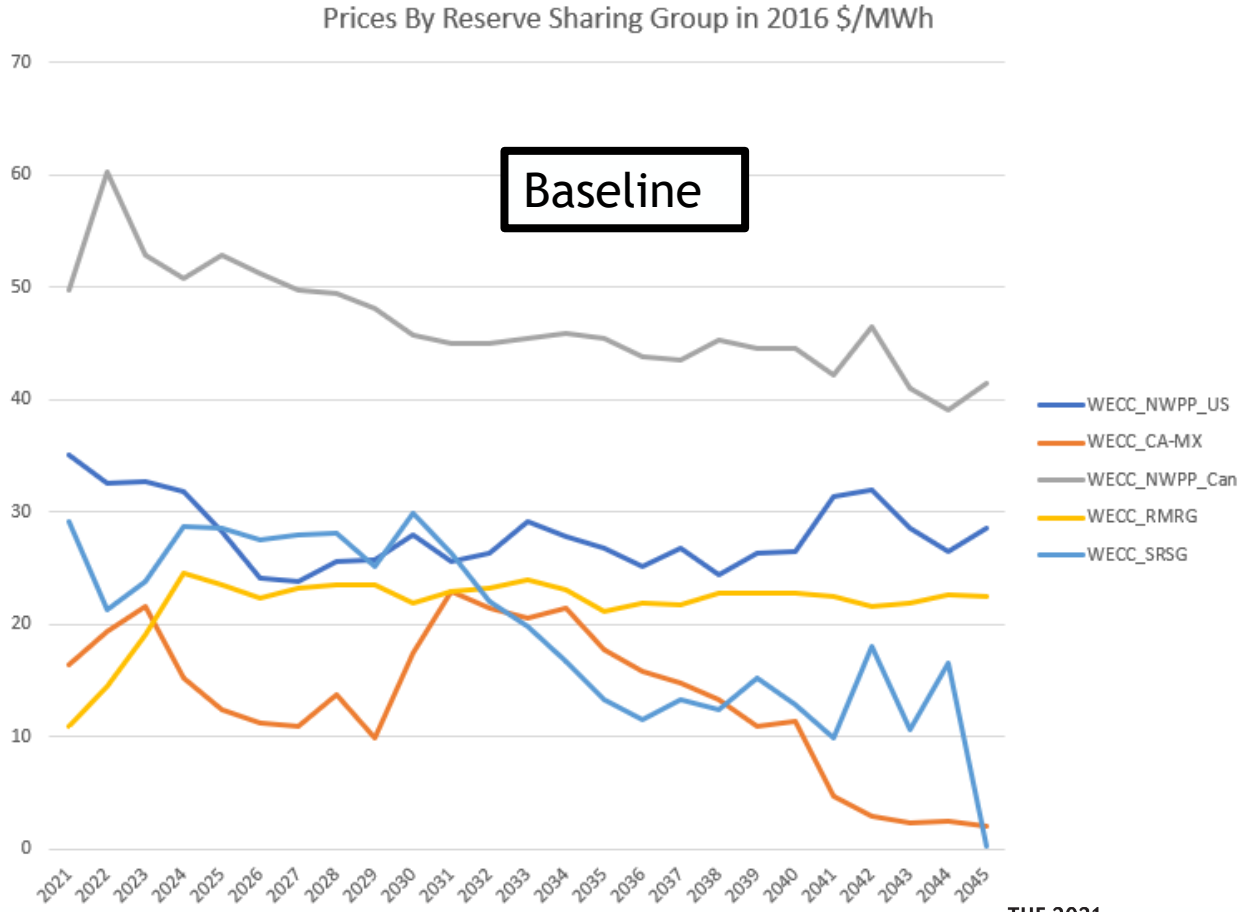
What are some of the effects of assuming the WECC has a GHG emissions price?

- Mid-C Prices are higher, especially in summer when thermal units are marginal more of the time than in the baseline.
- Avoided CO2e Emissions Rates are lower than in the baseline, especially off-peak.
- Needs go up in the region later in the study due to more builds inside the region removed than the baseline removed for the needs assessment.

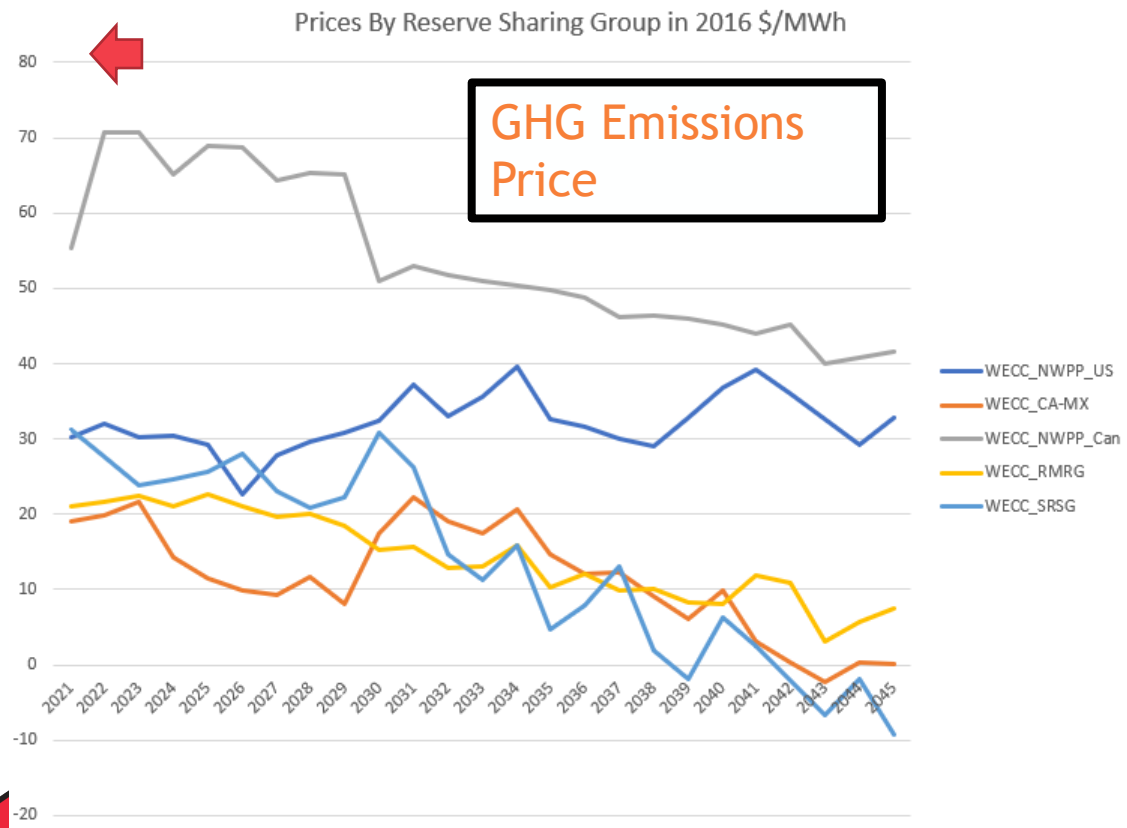


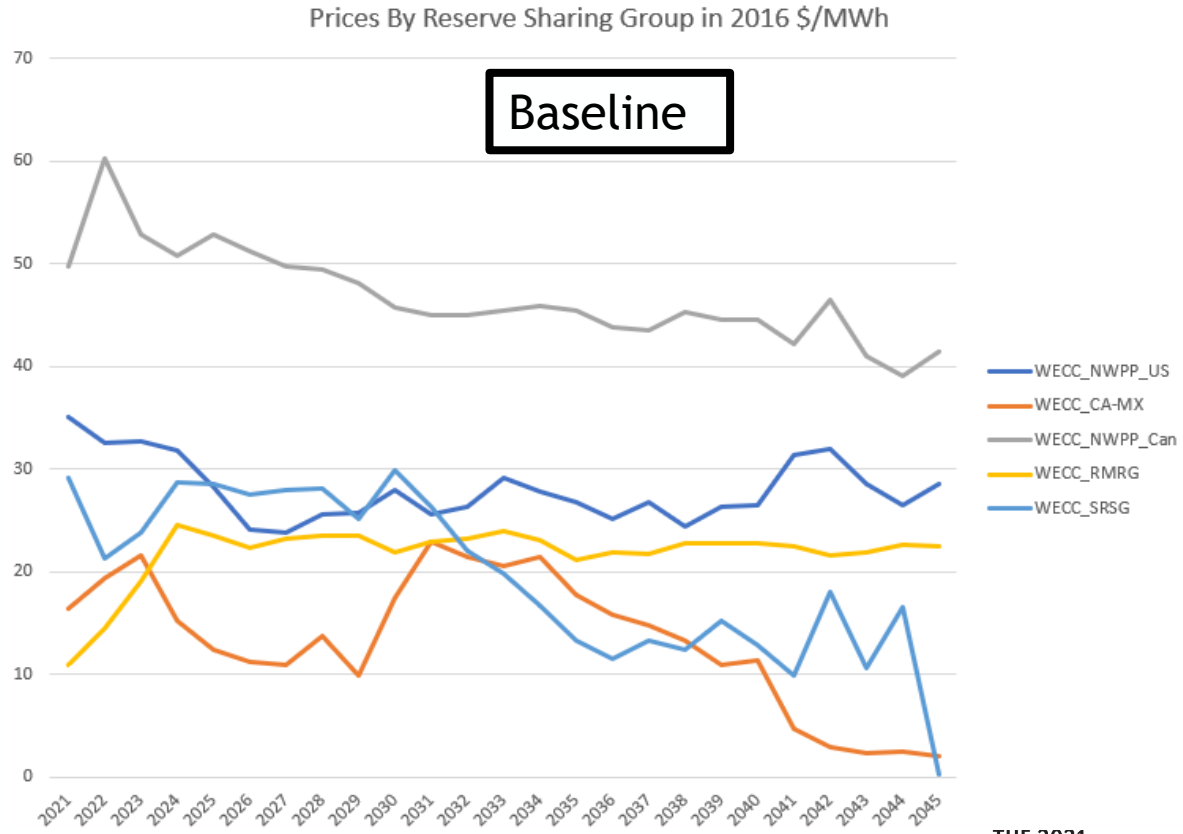
Higher prices WECC-wide with thermal units more often on the margin than in the baseline

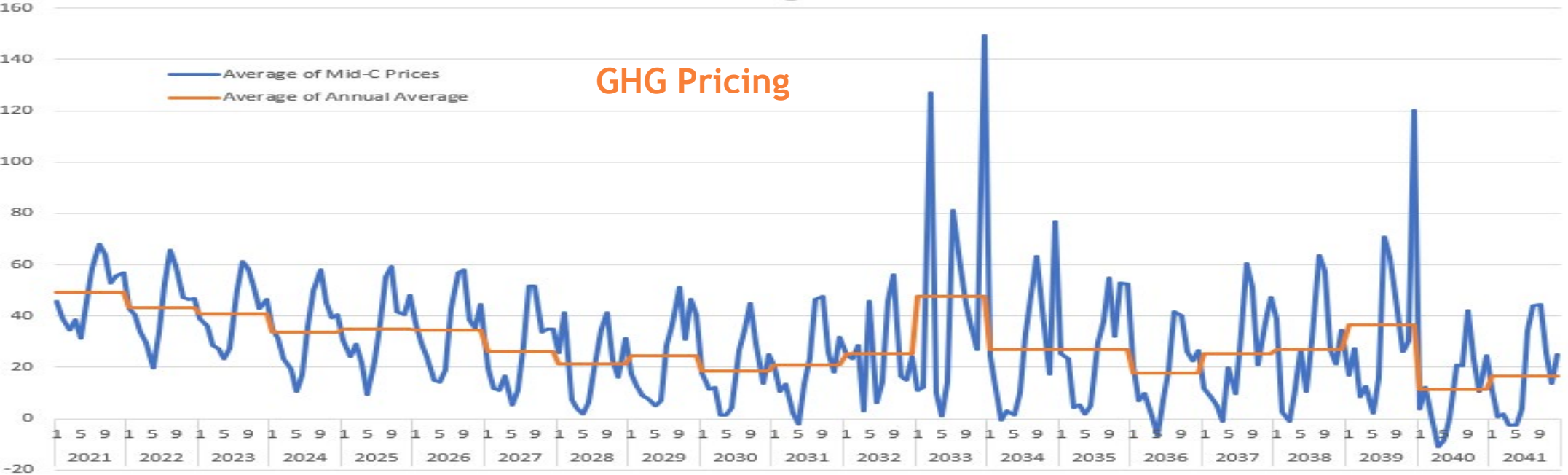




Higher prices initially due to marginal coal units, but lower prices by the end of the study in comparison to the baseline.






Average of Mid-C Prices
Average of Annual Average
GHG Pricing
160
140
120
100
80
60
40
20
0
-20
2021
2022
2023
2024
2025
2026
2027
2028
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2036
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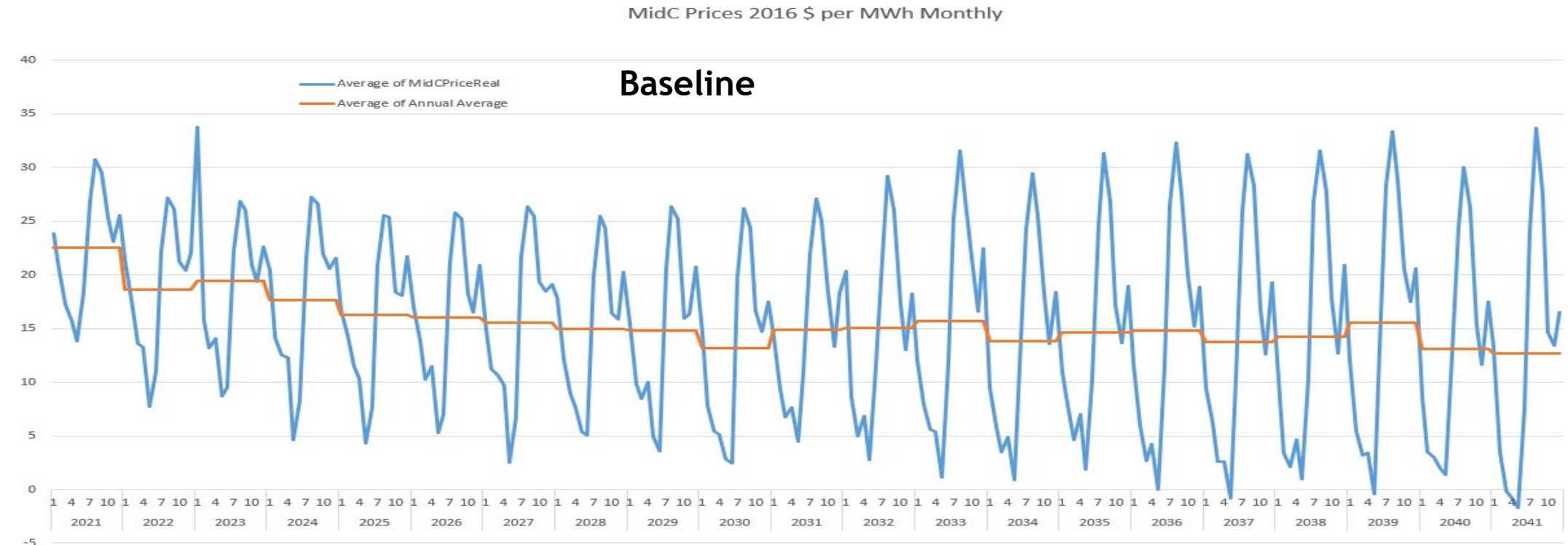
2039
2040
2041


MidC Prices 2016 $ per MWh Monthly
Average of MidCPriceReal
Average of Annual Average
Baseline
40
35
30
25
20
15
10
5
0
-5
2021
2022
2023
2024
2025
2026
2027
2028
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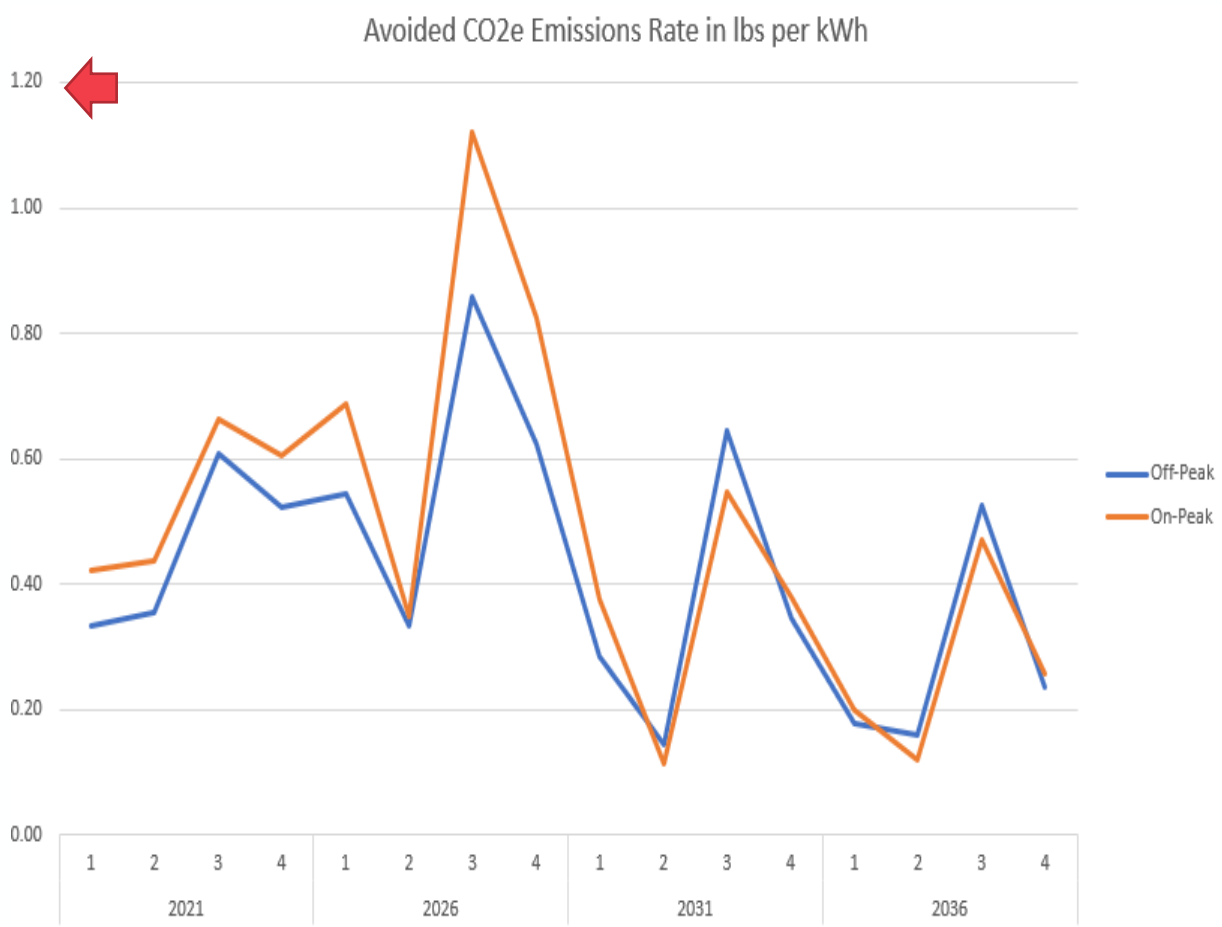
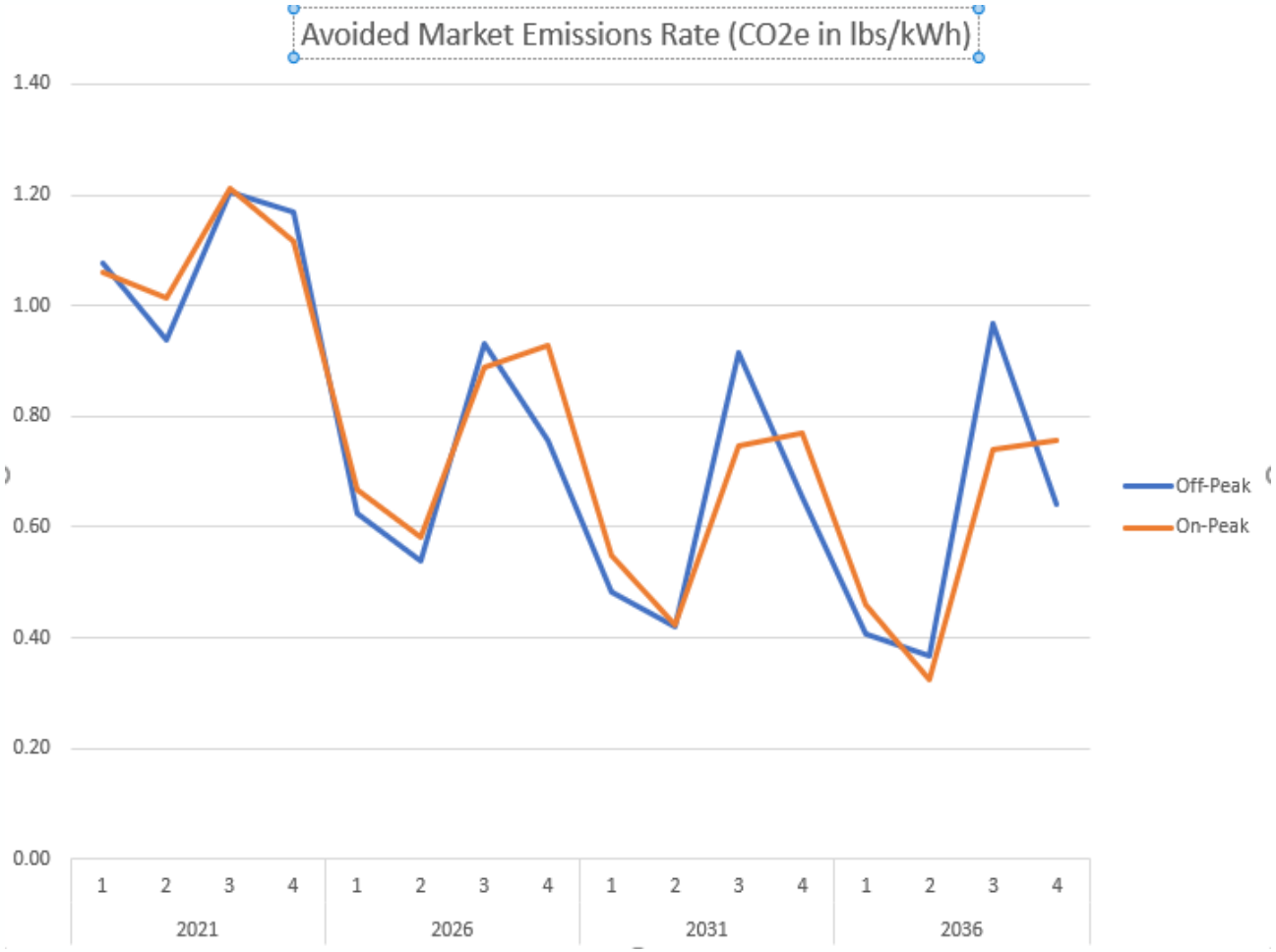


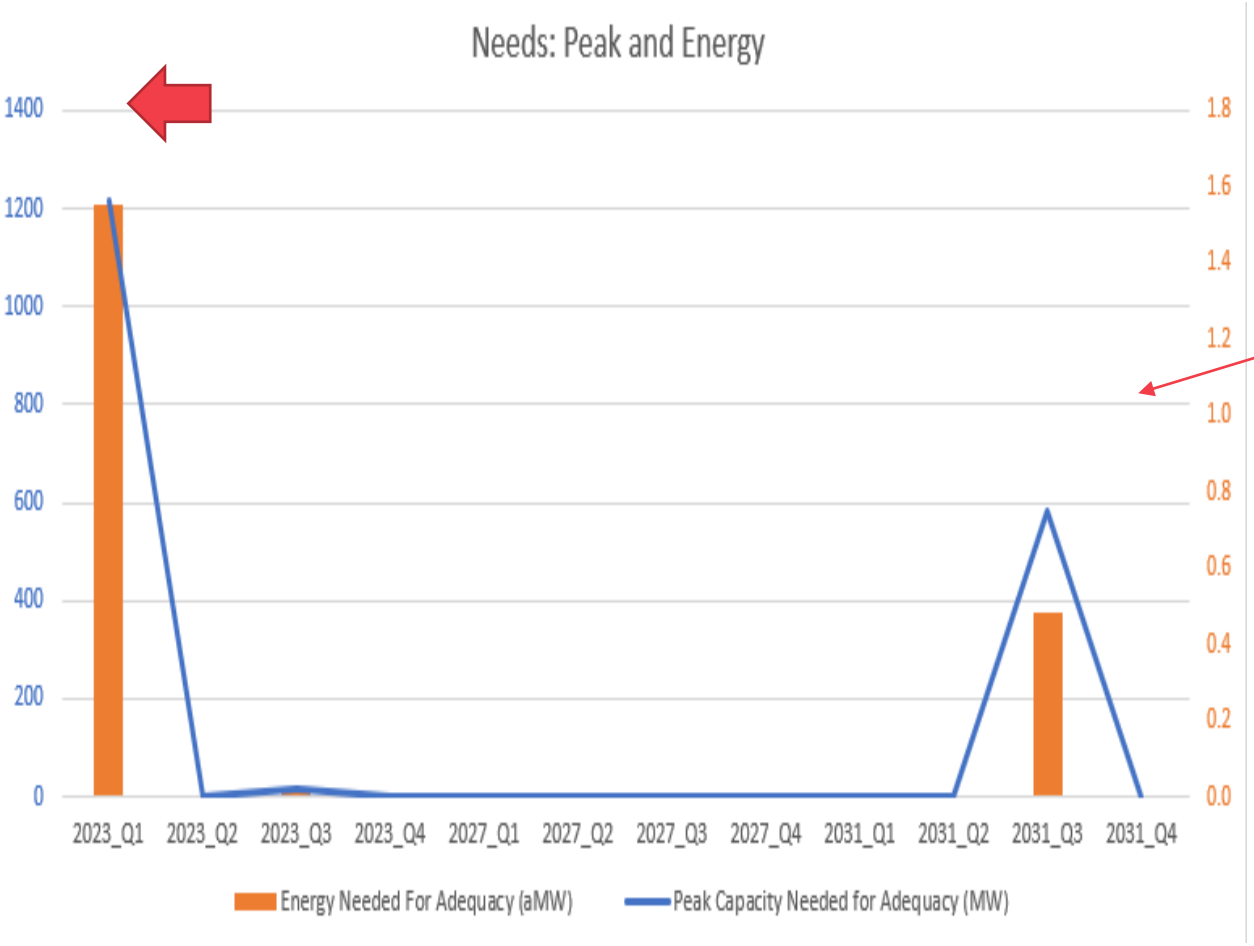


GHG Pricing

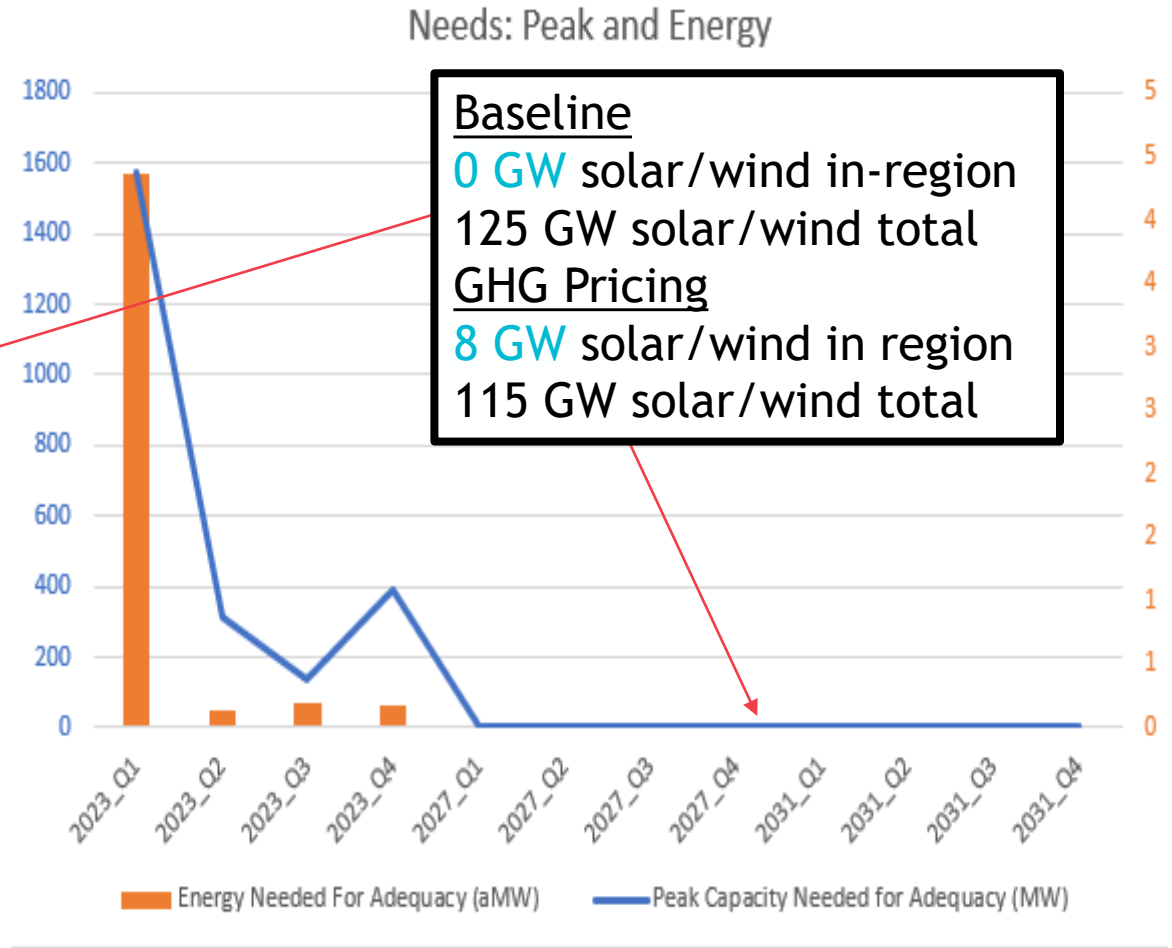
Baseline

1) Emissions rate is almost always lower than baseline.
2) On-peak avoided emissions rate almost always stays below emissions rate of combined cycle gas units.
3) Off-peak avoided emissions is always lower than the baseline late in the study. (Almost all WECC-wide coal dispatch is off the margin)

Peak needs are lower earlier, and higher later *in GHG Pricing* sensitivity than in the *Baseline*.
Significant regional builds identified in AURORA removed for needs assessment, which changes the regional needs.



GHG Pricing



Baseline
0 GW solar/wind in-region
125 GW solar/wind total
GHG Pricing
8 GW solar/wind in region
115 GW solar/wind total

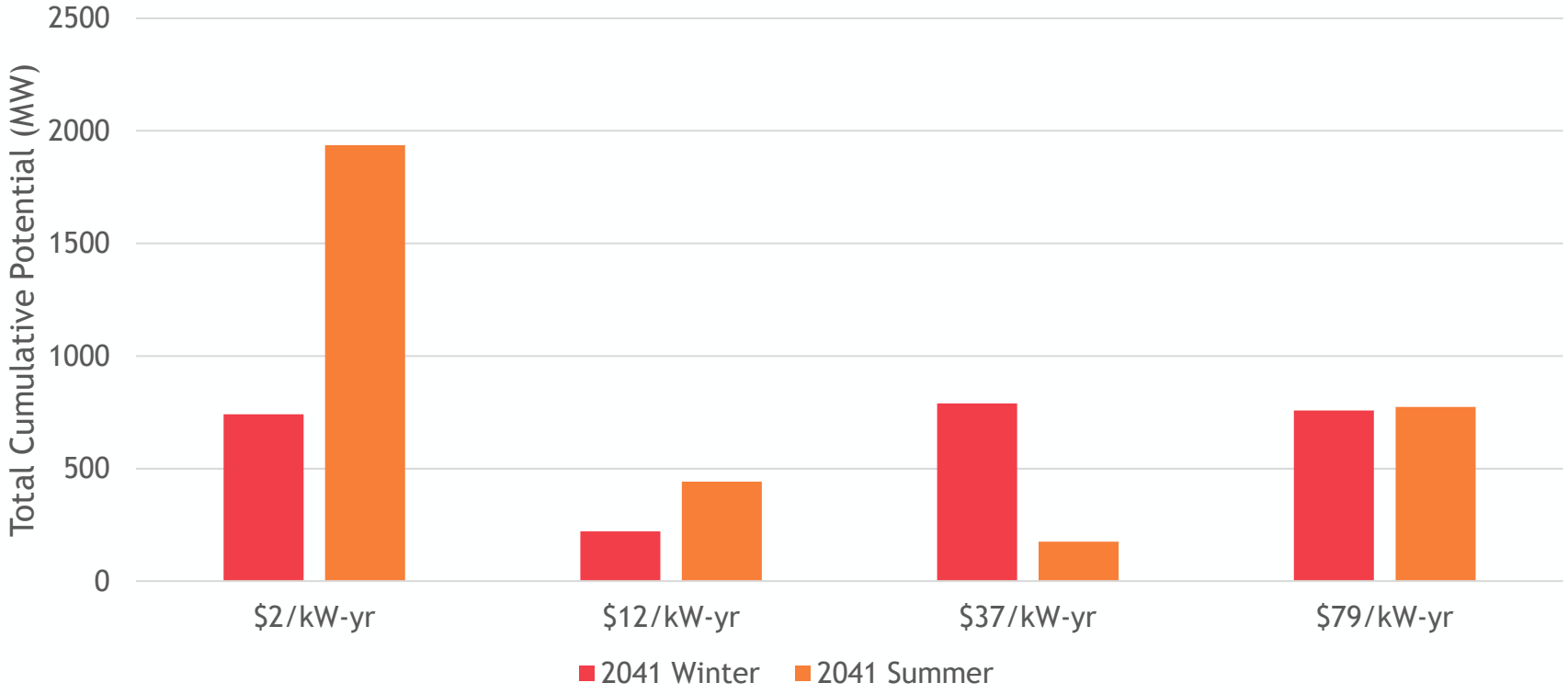
Baseline

Demand Response Re-Binning Sensitivity

Reduce peak emissions by changing binning strategy

Binning Strategy for Demand Response

- An earlier decision was to bin DR products by price. This resulted in combining different seasonal products or other characteristics into one bin. How might this impact results?

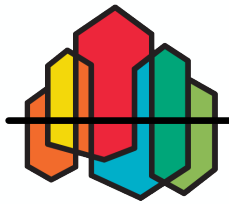


Findings so far

- Regional Portfolio Model picks resources that do the following:
  A. Avoid emissions
  B. Compete with low market prices
  C. Are dispatchable
  D. Have low fixed cost investment
- Why so little DR?

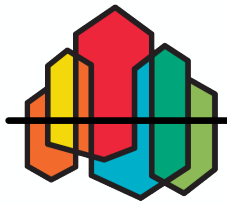
Reconfiguring Bin 1 for Sensitivity

- Sensitivity test – Changing bin designation by dispatchability
  - Dispatchability to meet daily variation is important. DR products that could be dispatched more frequently would have more value; namely ***Demand Voltage Reduction*** (DVR) and ***Time Of Use*** (TOU) programs
  - Assumption – DVR and TOU could be dispatched 4 hours **every** peak day (M-Sa 6pm-10pm)
  - Re-create bin 1 so that it only contains DVR and TOU, all former bin 1 products are now grouped with bin 2
  - Since these programs often are used persistently without dispatch cost, consider dispatch cost as 0$/MWh

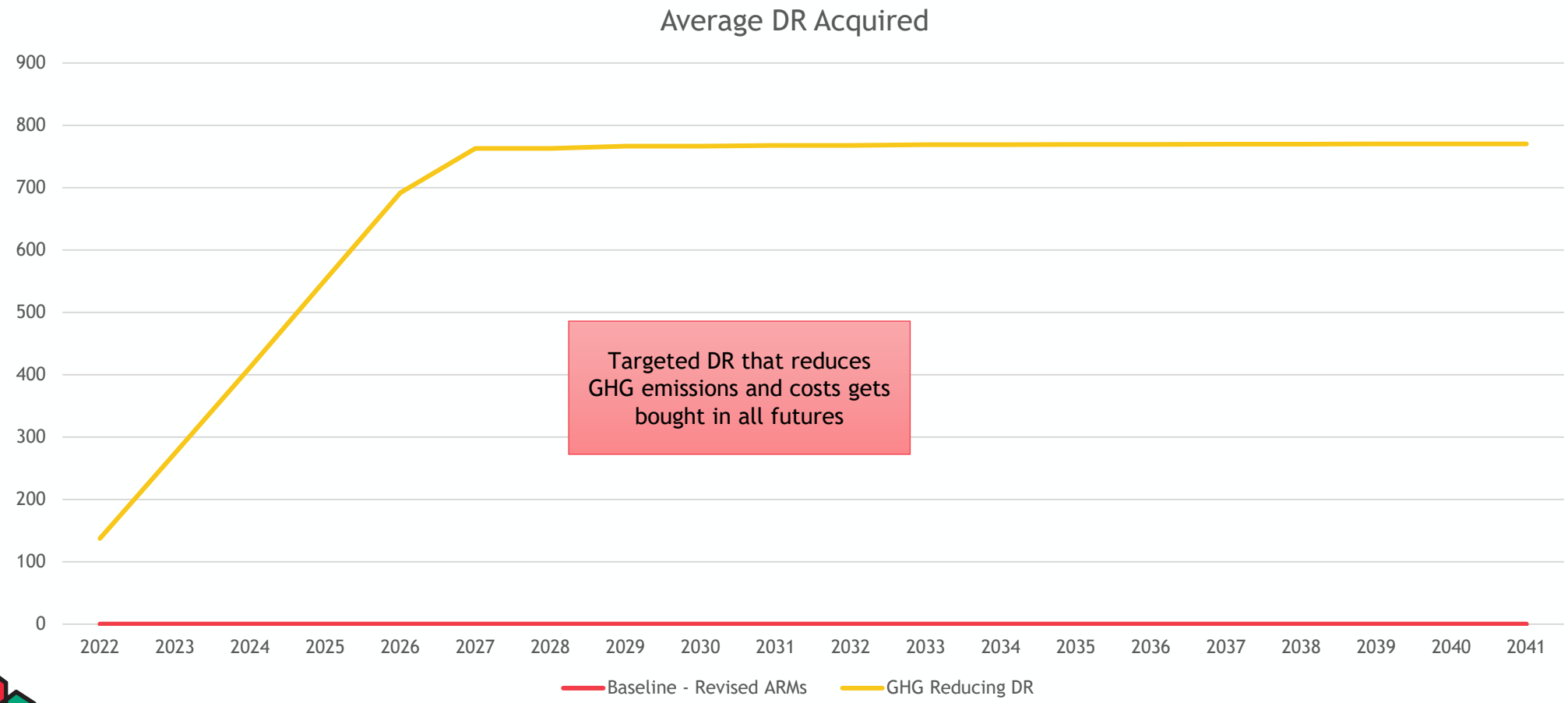


High-level Results

- Reduces cumulative Greenhouse Gas Emissions by 1.4 MMT
- Reduces system cost by 1.87% and residential bills by 0.1%
- No substantive change in EE, Renewable, or Thermal builds from the baseline
- Substantial increase in DR build relative to baseline conditions



Significant Increase in Average DR Build from Baseline Conditions



High Level Takeaway

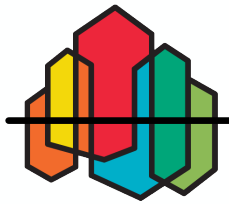
- Low fixed cost demand response programs which can be used often at little cost with no change in customer experience can be designed to be effective at not just meeting adequacy needs but also
  1. Reducing energy costs associated with meeting peak times
  2. Reducing emissions associated with meeting peak times

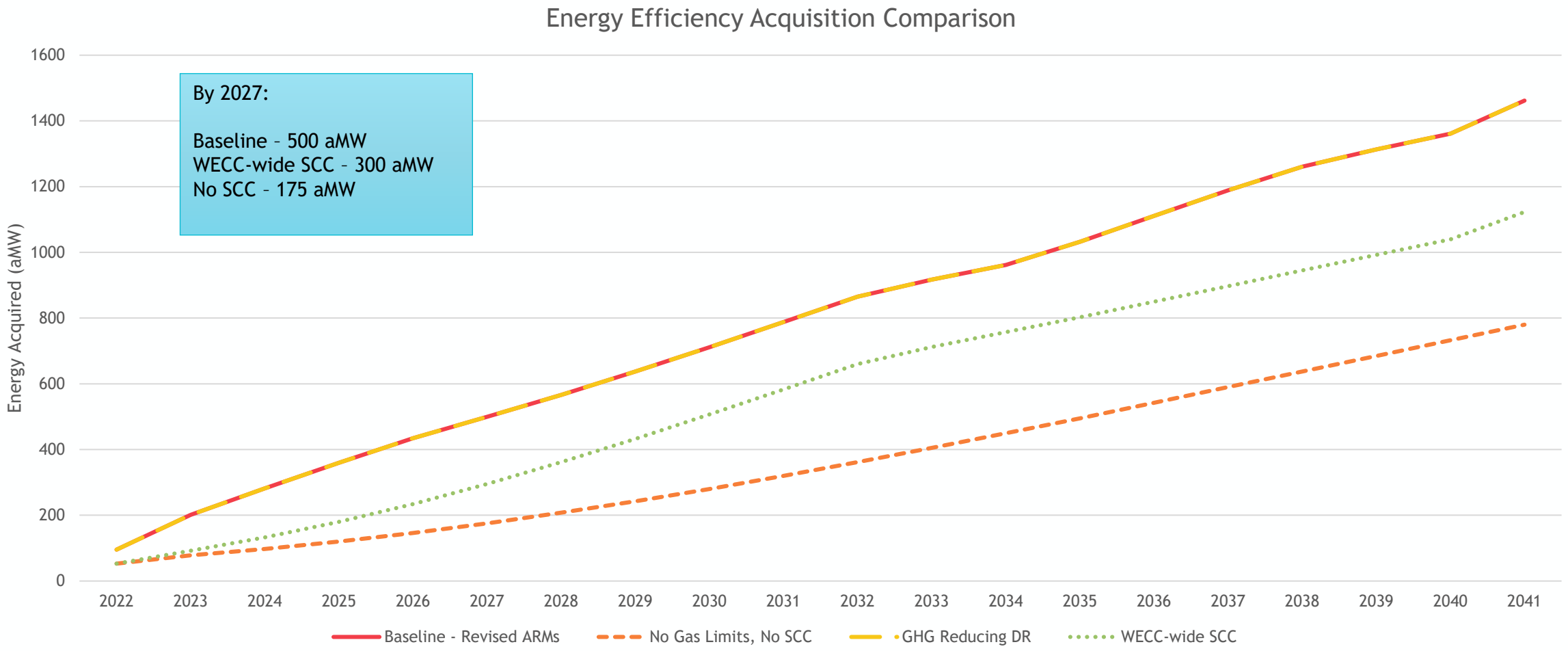
GHG Tipping Points – With and Without Social Cost of Carbon

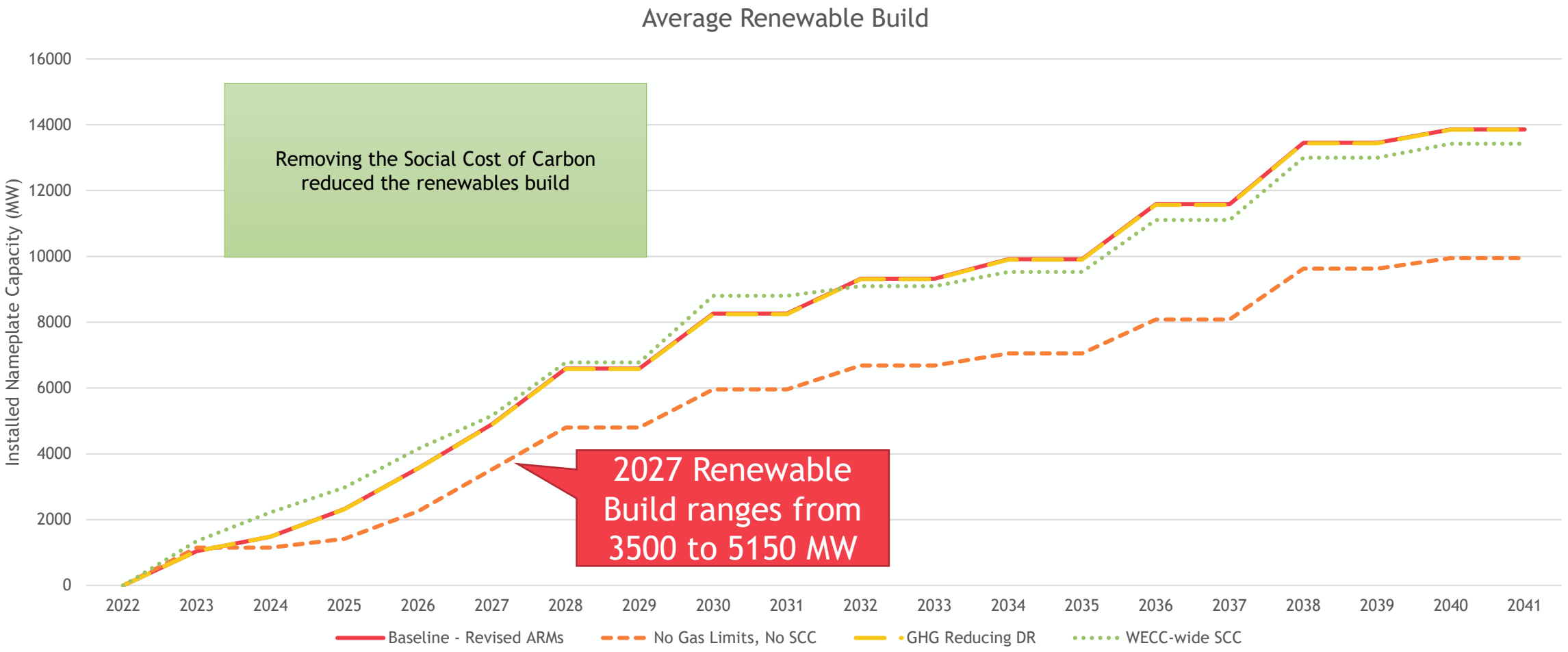
Preliminary Resource Strategy Findings

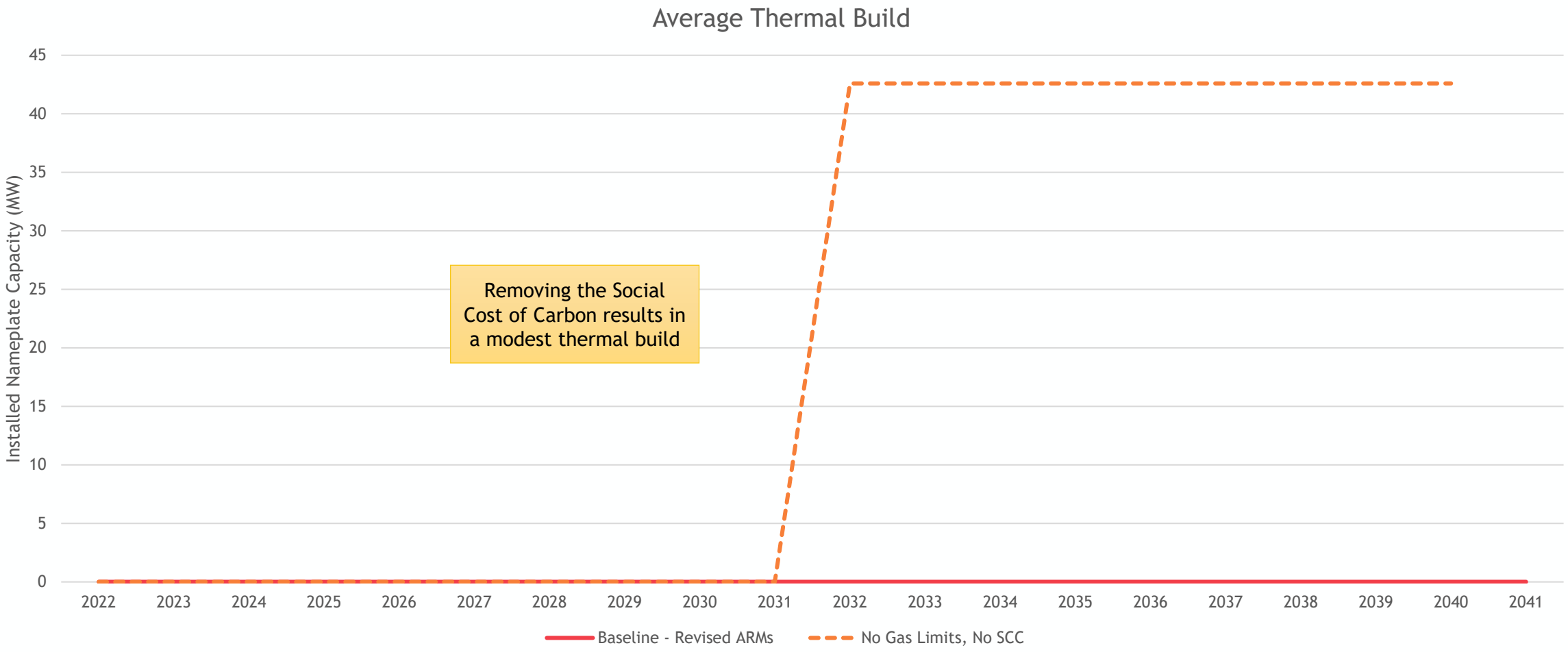
High-level Take-aways

- Neither including or excluding the Social Cost of Carbon increased energy efficiency acquired
- Dispatching with the Social Cost of Carbon included substantially reduces emissions – especially in the early part of the study
- Renewables are sensitive to inclusion of the Social Cost of Carbon but still a substantial part of the strategy either way




Energy Efficiency Acquisition Comparison
By 2027:
Baseline – 500 aMW
WECC-wide SCC – 300 aMW
No SCC – 175 aMW
Energy Acquired (aMW)
1600
1400
1200
1000
800
600
400
200
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Baseline - Revised ARMs
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC


Average Renewable Build
Installed Nameplate Capacity (MW)
16000
14000
12000
10000
8000
6000
4000
2000
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Removing the Social Cost of Carbon reduced the renewables build
2027 Renewable Build ranges from 3500 to 5150 MW
Baseline - Revised ARMs
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC


Average Thermal Build
Installed Nameplate Capacity (MW)
45
40
35
30
25
20
15
10
5
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
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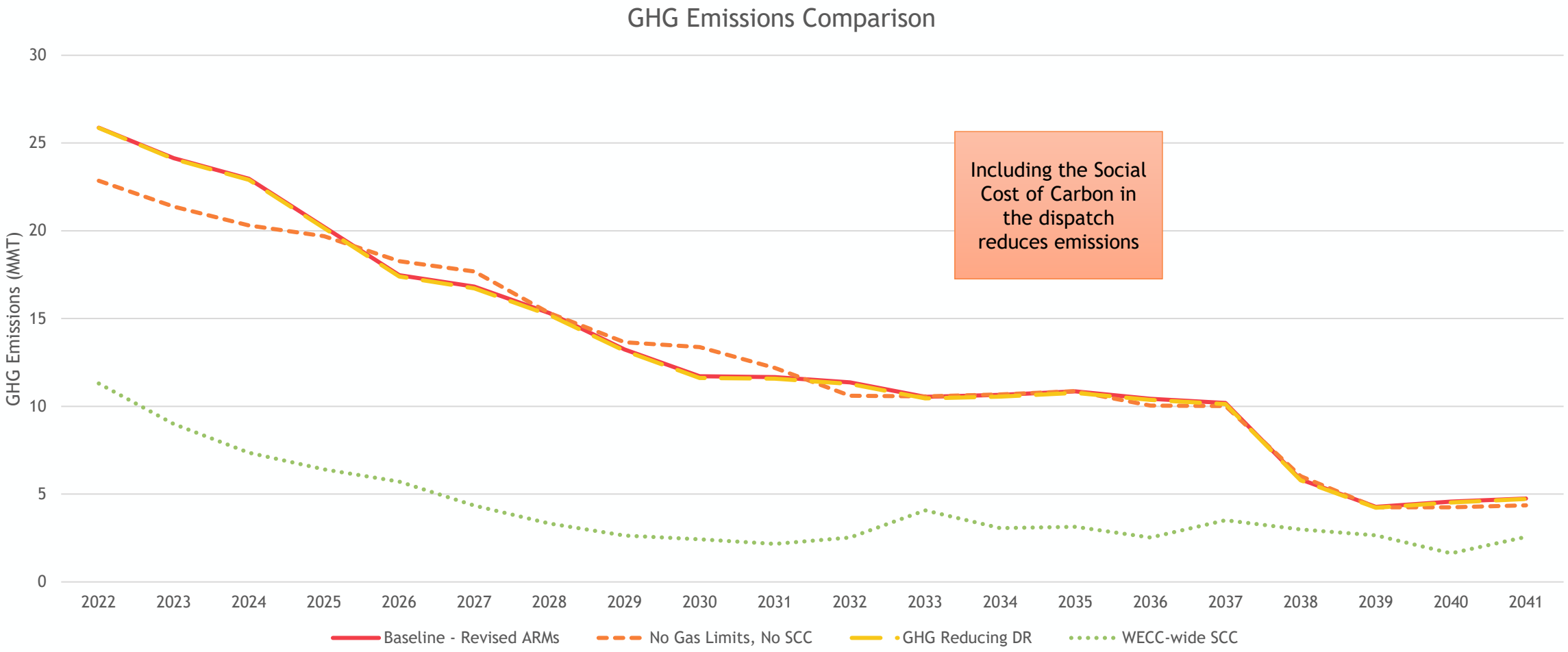
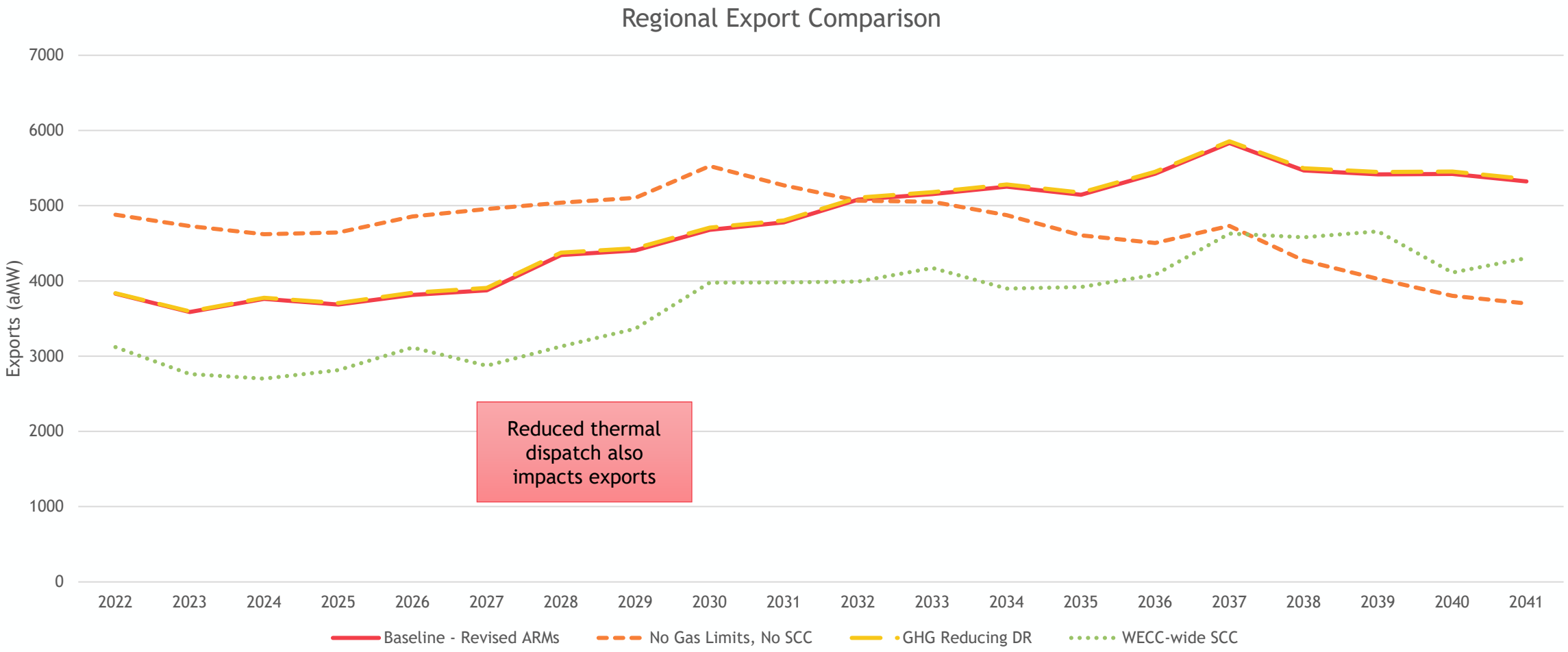
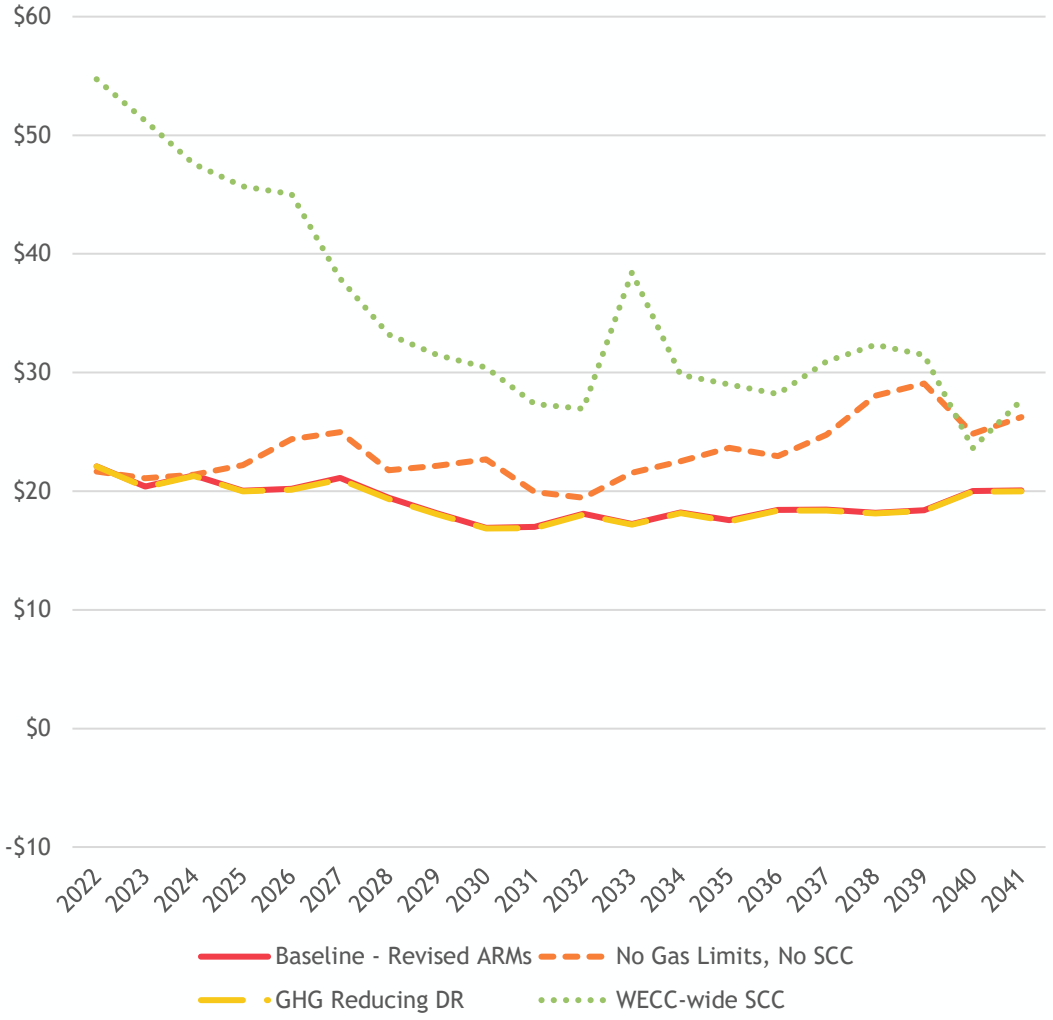
2039
2040
2041
Removing the Social Cost of Carbon results in a modest thermal build
Baseline - Revised ARMs
No Gas Limits, No SCC

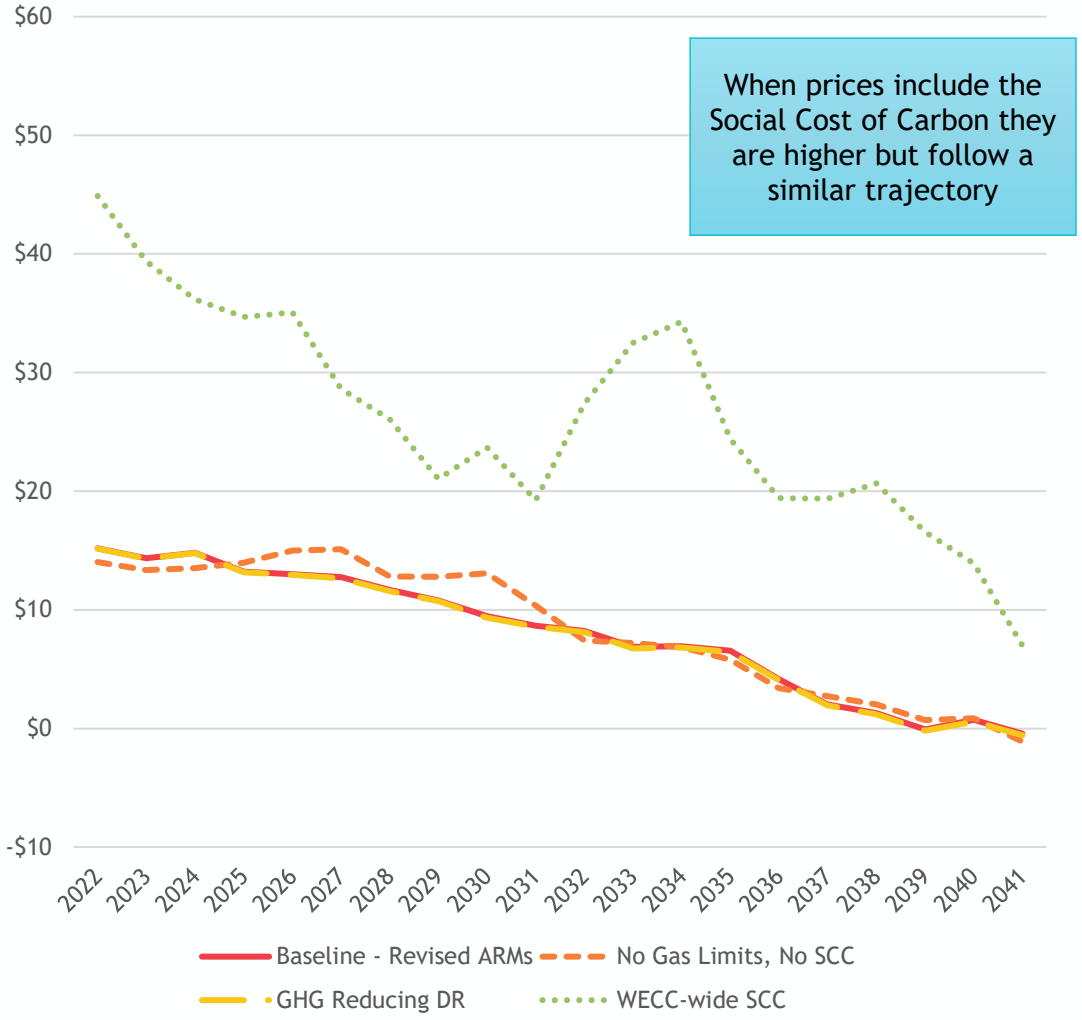

GHG Emissions Comparison
GHG Emissions (MMT)
30
25
20
15
10
5
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Including the Social Cost of Carbon in the dispatch reduces emissions
Baseline - Revised ARMs
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC


Regional Export Comparison
Exports (aMW)
7000
6000
5000
4000
3000
2000
1000
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Reduced thermal dispatch also impacts exports
Baseline - Revised ARMs
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC

On-Peak Internal Electricity Prices



Off-Peak Internal Electricity Prices



When prices include the Social Cost of Carbon they are higher but follow a similar trajectory


Questions

Extra Slides

Get A Strategy

AURORA Buildout

Gas Build Limits
GHG Pricing

Long term capital expansion for the WECC ensures that price simulations in AURORA are informed by an ***adequate system*** that ***meets policies***

AURORA Price Runs

Hourly market capability is needed for GENESYS to provide ***a good adequacy signal for the NW*** informed by changing market fundamentals

Hourly WECC-wide price simulations inform ***market prices*** and ***associated emissions*** in the RPM, both can significantly impact ***regional resource strategy economics***

Gas Build Limits
GHG Pricing

GENESYS

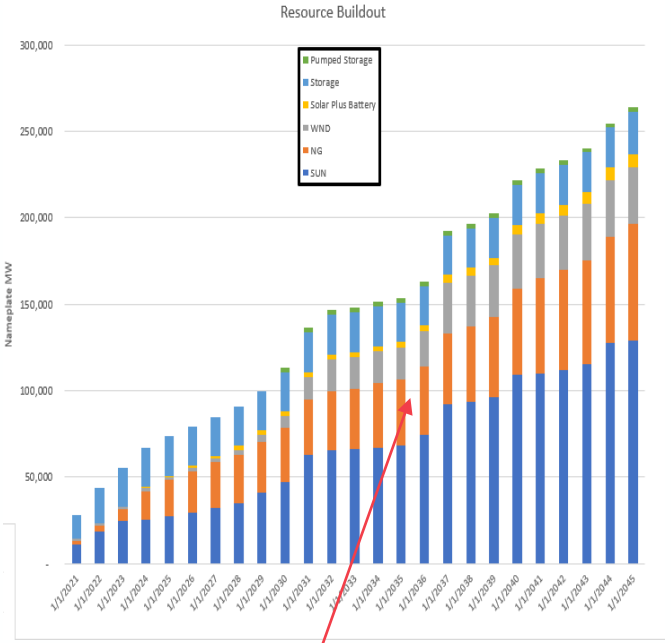
RPM

Gas Build Limits
GHG Pricing

Hourly analysis in GENESYS creates quarterly ARMs and ASCCs, which the RPM uses ***to select an adequate resource strategy***

Comparisons of Buildout

- WECC-wide and PNW builds
- By Nameplate MW's by fuel type
- Color coding of table should align (almost) with previous graphs
- Wind includes onshore and offshore wind *in CA only*



Year	Baseline
2025	
2030	

Solar and Solar Plus Storage Build Comparisons

Year	Baseline	GHG Price	No Gas Limit
2025	51,538	66,477	27,183
2030	89,838	115,100	47,270
2035	100,357	146,152	68,357
2040	135,054	172,529	109,221
2045	147,554	174,159	128,886

Year	Baseline	GHG Price	No Gas Limit
2025	46,600	56,906	1,041
2030	86,600	112,458	2,445
2035	145,500	179,351	2,954
2040	179,800	199,725	6,008
2045	198,000	202,663	7,167

Battery and Pumped Storage Build Comparisons

Year	Baseline	GHG Price	No Gas Limit
2025	6,004	13,025	22,846
2030	6,004	19,800	22,846
2035	6,004	32,000	22,846
2040	6,004	33,717	22,846
2045	6,055	35,680	24,773

Year	Baseline	GHG Price	No Gas Limit
2025	0	0	0
2030	4,900	5,300	0
2035	5,650	5,300	2,700
2040	6,050	5,300	2,700
2045	9,690	11,140	2,700

Wind and Gas Build Comparisons

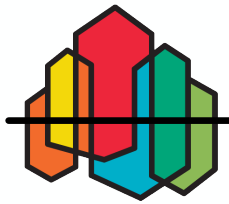
Year	Baseline	GHG Price	No Gas Limit
2025	16,775	12,400	1,600
2030	35,175	19,800	7,069
2035	37,063	32,000	18,354
2040	43,657	33,717	31,481
2045	51,481	35,680	32,959

Year	Baseline	GHG Price	No Gas Limit
2025	11,351	13,025	21,003
2030	14,873	15,121	31,154
2035	16,058	16,069	38,118
2040	16,532	16,306	49,407
2045	16,532	16,306	67,605

Solar and Solar Plus Storage Build Comparisons

Year	Baseline	GHG Price	No Gas Limit
2025	0	7,744	8,090
2030	0	8,165	12,992
2035	0	8,165	19,116
2040	459	8,165	27,366
2045	459	8,187	28,444

Year	Baseline	GHG Price	No Gas Limit
2025	0	0	0
2030	0	0	0
2035	0	0	0
2040	0	0	690
2045	0	0	690



Battery and Pumped Storage Build Comparisons

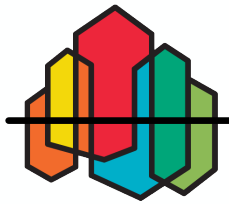
Year	Baseline	GHG Price	No Gas Limit
2025	2,248	3,721	2,005
2030	2,248	3,721	2,005
2035	2,248	3,721	2,005
2040	2,248	3,721	2,005
2045	2,248	3,721	2,005

Year	Baseline	Organized	No Gas Limit
2025	0	0	0
2030	400	800	0
2035	400	800	0
2040	800	800	0
2045	2,900	3,600	0

Wind and Gas Build Comparisons

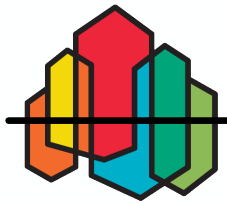
Year	Baseline	GHG Price	No Gas Limit
2025	0	0	0
2030	0	0	0
2035	0	0	0
2040	0	0	0
2045	0	1,000	0

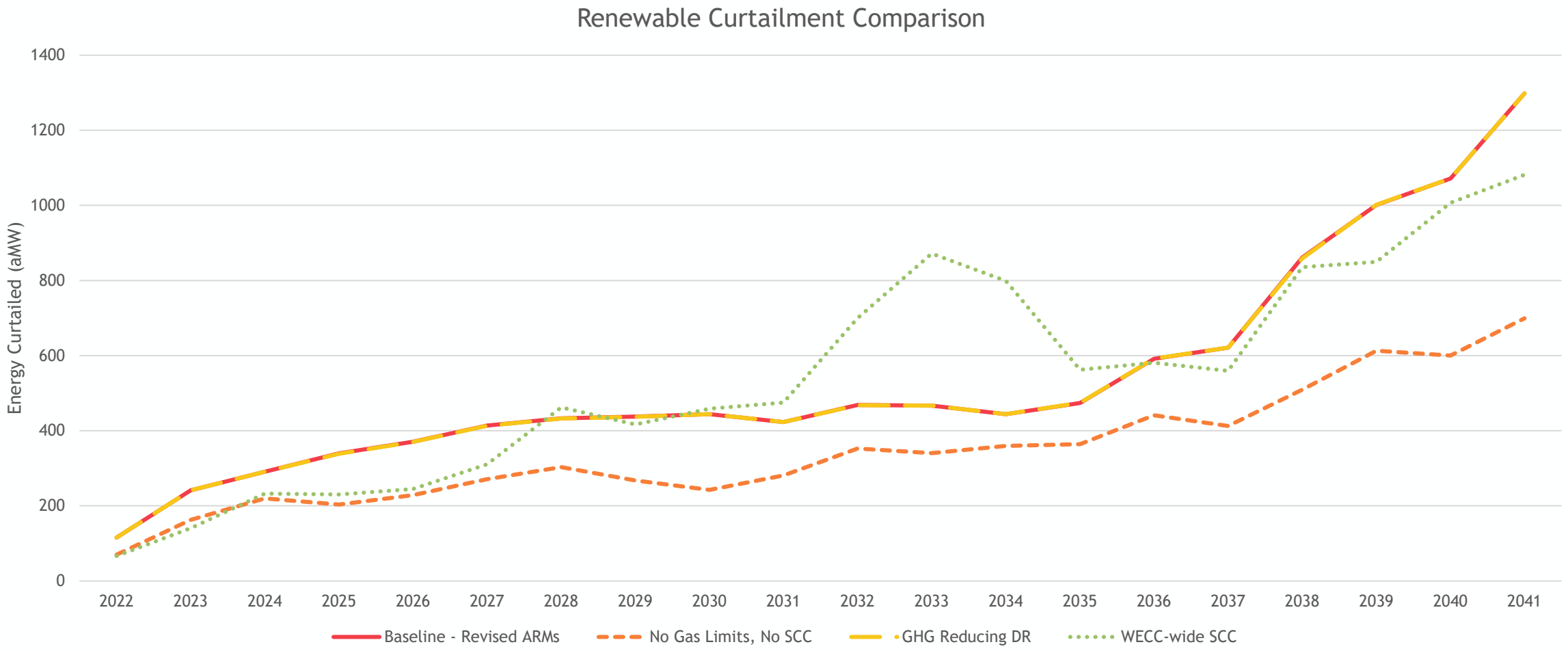
Year	Baseline	GHG Price	No Gas Limit
2025	100	0	1,659
2030	100	0	1,949
2035	100	0	1,949
2040	100	0	1,949
2045	100	0	5,381

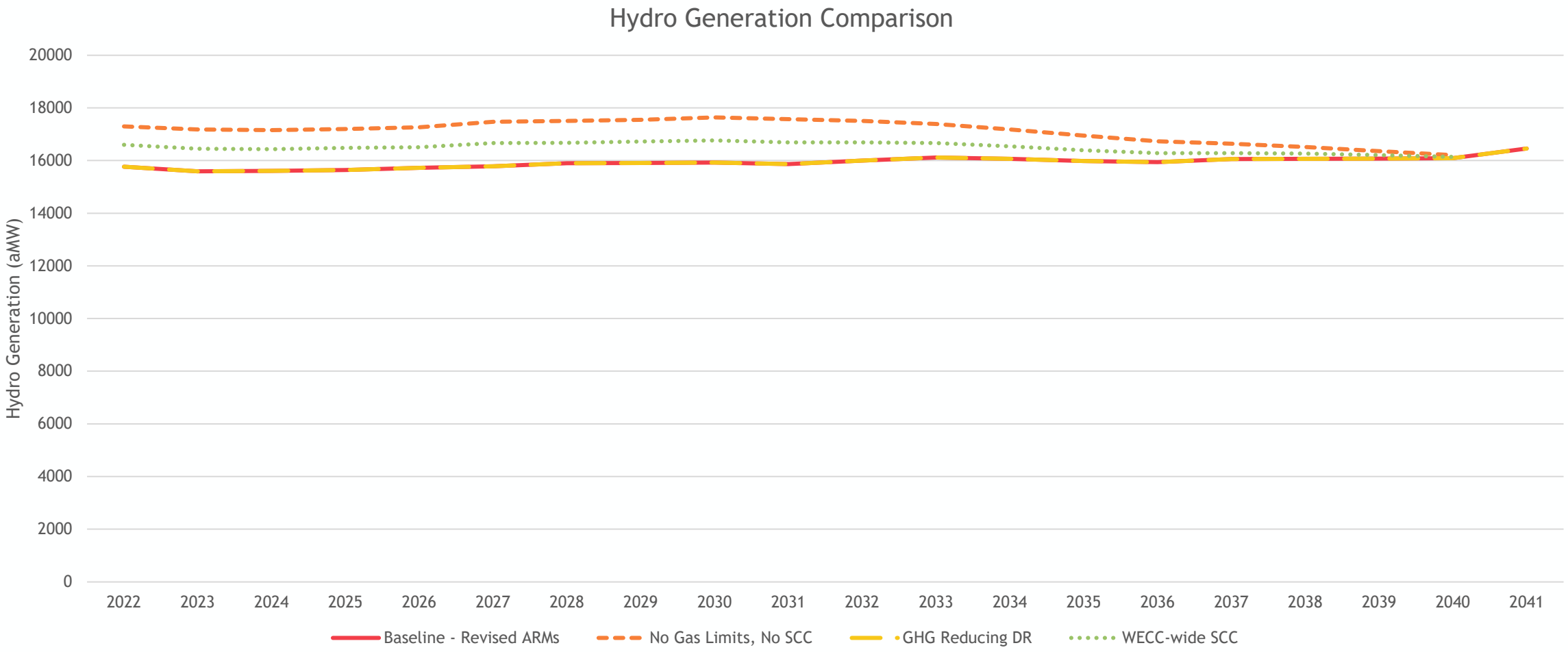


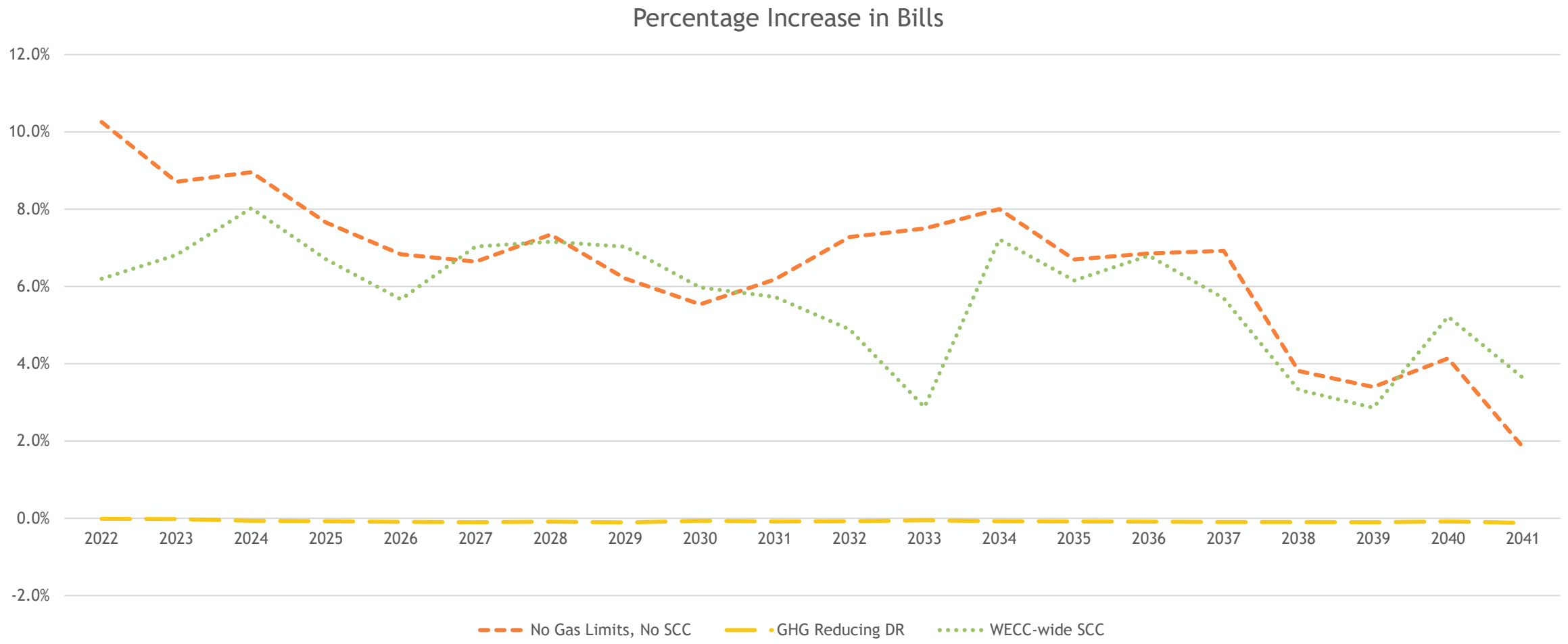
Regional Build Assumption

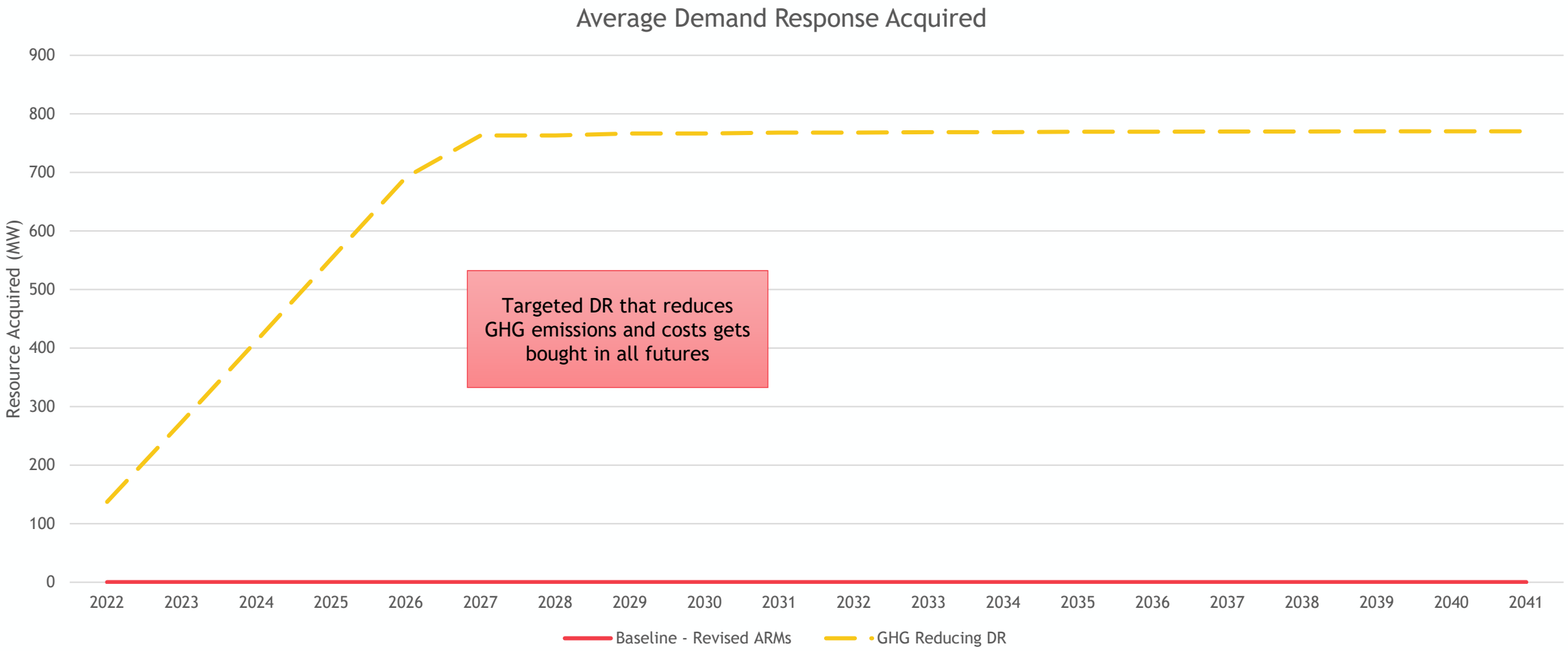
- Same build as the external market without limits on new natural gas generation (from the external market scenario)
- Prices include current emissions costs from AURORA in California and BC
- No portfolio carbon cost
- Similarly limited needs from GENESYS




Renewable Curtailment Comparison
Energy Curtailed (aMW)
1400
1200
1000
800
600
400
200
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Baseline - Revised ARMs
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC

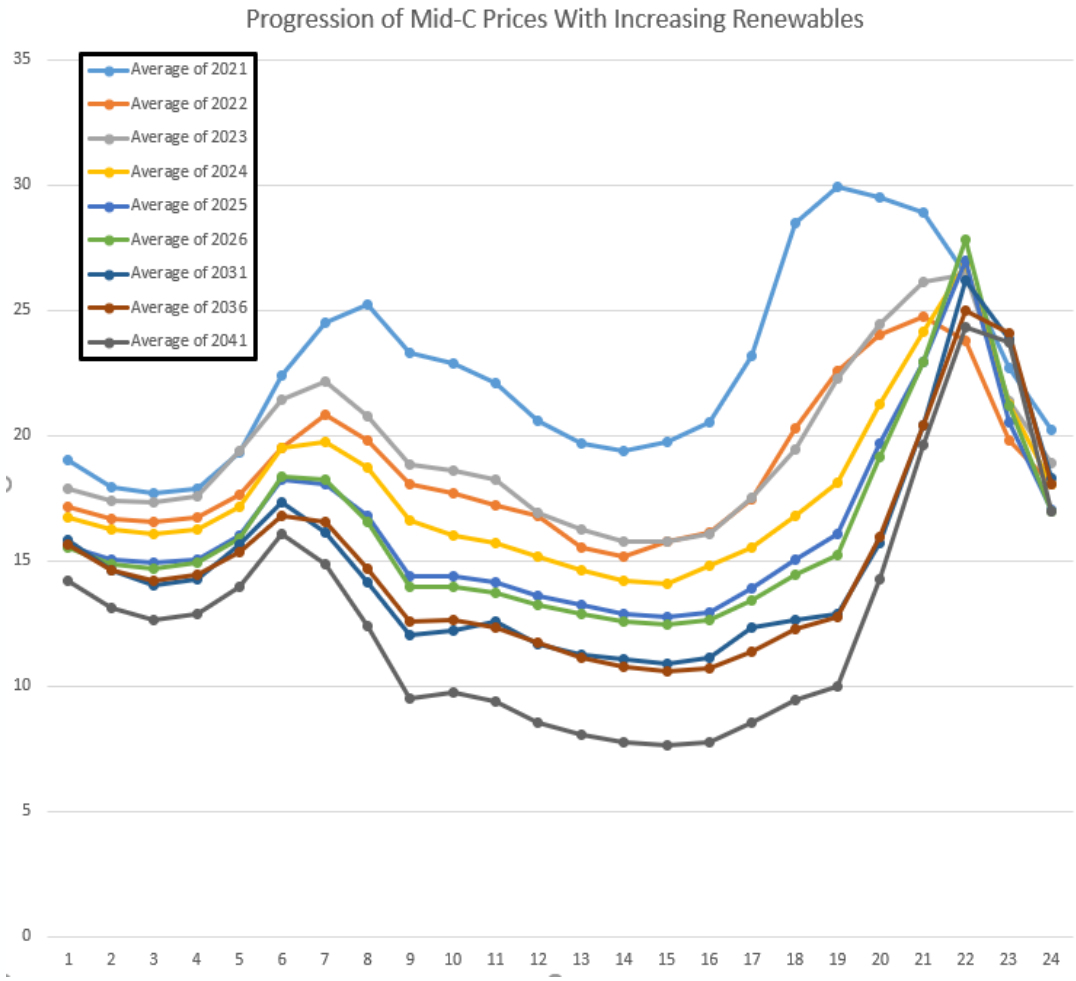

Hydro Generation Comparison
Hydro Generation (aMW)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Baseline - Revised ARMs
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC


Percentage Increase in Bills
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
-2.0%
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
No Gas Limits, No SCC
GHG Reducing DR
WECC-wide SCC


Average Demand Response Acquired
Resource Acquired (MW)
900
800
700
600
500
400
300
200
100
0
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
Targeted DR that reduces GHG emissions and costs gets bought in all futures
Baseline - Revised ARMs
GHG Reducing DR

Observations on Demand Response and 2021 Power Plan Fundamentals

- Demand response in 7th Power Plan was part of the resource strategy primarily to meet adequacy needs.
- Due to the effects of changing price fundamentals in the October 2019 AURORA price forecast and recent history, the decision was made early on to change the definition of on-peak in the Regional Portfolio Model to best capture intraday price variability
  1. From hour ending 700 to 2200 on-peak aligned with traditional heavy load hours
  2. To hour ending 1900 to 2200 on-peak aligned with evening ramp when sun goes down.



High Probability of DR Builds