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June 2, 2021

MEMORANDUM

TO: Power Committee

FROM: Ben Kujala and John Ollis

SUBJECT: Scenario Findings and Further Modeling Results

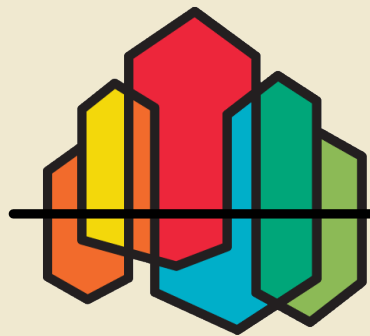
BACKGROUND:

Presenter: Ben Kujala and John Ollis

Summary: The committee has had many presentations on the scenario analysis for the 2021 Power Plan. In this presentation we will review all the scenarios and discuss what we've learned from the various analyses. We will also share any final modeling results.

The scenario analysis will be included in the draft of Section 5 that is anticipated to be ready for committee review at the June 30th webinar.

Scenario Findings and Further Modeling Results



THE 2021
NORTHWEST
POWER PLAN

FOR A SECURE & AFFORDABLE
ENERGY FUTURE



Full fathom five thy father lies;
Of his bones are coral made;
Those are pearls that were his eyes:
Nothing of him that doth fade,
But doth suffer a sea-change
Into something rich and strange.
Sea-nymphs hourly ring his knell:
Ding-dong.
Hark! now I hear them,—ding-dong, bell.

William Shakespeare - The Tempest

sea change

/ˈsiːˌtʃeɪnʃ/

noun

a profound or notable transformation.

"recent years have witnessed a sea change in the fortunes of car safety as a marketable quantity"

Similar:

transformation

change

alteration

modification

variation


conversion



Definitions from Oxford Languages

[Feedback](#)





JULY 2019

Scenario Approach Presented to Committee

What has changed in the region since the 7th Plan?

- Coal retirements:
 - Colstrip 1 & 2 retired by end of 2019
 - Valmy 1 retired by end of 2019
 - Discussion of retirement of Bridger 1 & 2 in Idaho Power and PacifiCorp draft IRPs
 - Oregon SB1547 no coal by wire 2030 provisions
 - Washington utility exit from coal by 2025 has an uncertain impact on Colstrip 3 & 4 in addition to uncertainty about fuel supply
- Clean Energy Targets & RPS:
 - California moved to 60% RPS and 100% clean
 - **California, Colorado, Maine, Nevada, New Mexico, New York and Washington** have all passed laws aimed at getting 100 percent of their electricity from carbon-free sources by midcentury¹
 - Oregon increased RPS to 50%

1. Plumber, B. (2019, June 26). As Coal Fades in the U.S., Natural Gas Becomes the Climate Battleground. Retrieved from <https://www.nytimes.com/2019/06/26/climate/natural-gas-renewables-fight.html>.



What has changed in the region since the 7th Plan?

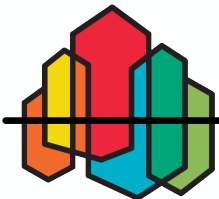


- Natural gas fired generation:
 - Enbridge pipeline + Jackson Prairie maintenance + Unusually cold March + DC scheduled maintenance lead to price spikes
 - Unlikely to expand in Washington
 - Corporate goals make it less likely to be pursued as a resource by Idaho Power and Avista
 - Portland General does not indicate in drafting IRP that natural gas generation is being pursued
 - California unlikely to expand natural gas fired generation after SB 100



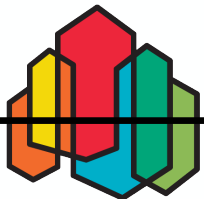
What has changed in the region since the 7th Plan?

- Bonneville contracts:
 - Concerns about Bonneville competitiveness have subsided a bit after market prices hit \$1000 but still remains a topic of discussion
 - Capacity and flexibility from the hydro system likely to be critical to a future without many natural gas fired generation additions
- Markets:
 - Expansion of the EIM has been rapid
 - Bonneville exploring entry in 2022
- Better understanding of climate change on hydro generation



Why do we develop scenarios?

- 4(e)(2) The plan shall set forth a general scheme for implementing conservation measures and developing resources
- “Certainty about the future does not come from the technical sophistication of the methods used to create a forecast. Instead, it comes from the flexibility and confidence one has in the number and types of resources available to meet any given condition. As times and conditions change, so must the region's plans.” – First Power Plan (1983)



Where we anticipate describing scenarios

Section 1: Executive Summary and

Section 2: Demand Forecast

Section 3: Forecast of Regional Reserve Requirements

Section 4: Energy Conservation Program

Section 5: Resource Development Plan

- Resource strategy (generation and conservation)
- **Analysis of Alternative Resource Strategies**
- Input and Analysis:
 - Existing resources and retirements
 - Economic and Financial Assumptions
 - Electricity and Fuel Price Forecasts
 - Transportation forecast
 - End-use natural gas forecast
 - Conservation resources (supply curves)
 - New generating resources potential
 - New demand response resources potential

Introduction

and Reliability

Section 6: Forecasts of Power Resources Required to meet BPA's Obligations

Section 7: Recommendation for Amount of Power BPA Should Acquire

Section 8: Analysis of Cost-Effective Methods for Providing Reserves

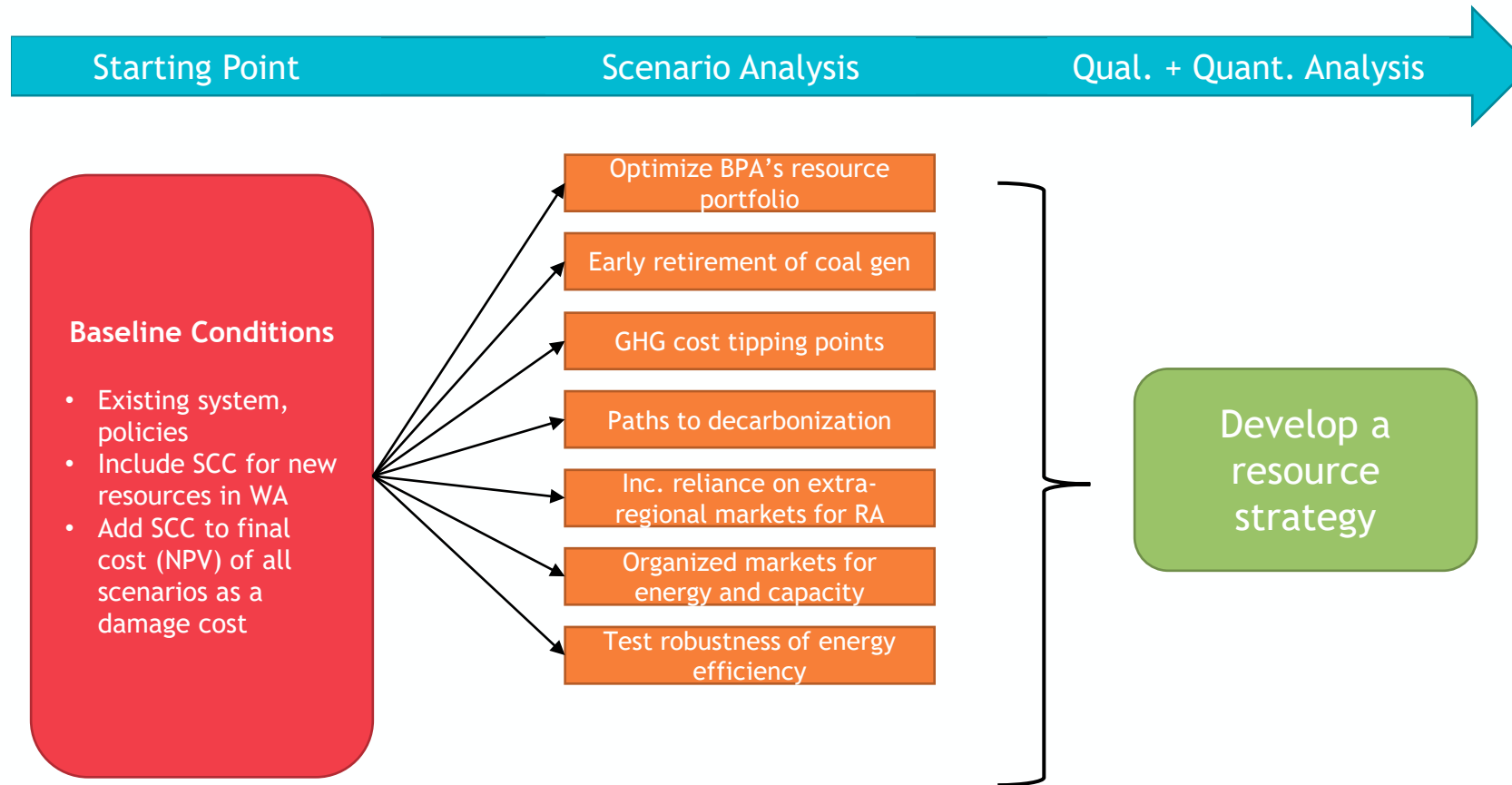
Section 9: Recommendations for Research and Development

Section 10: Methodology for Determining Quantifiable Environmental Costs and Benefits for Cost Effectiveness

Section 11: Fish and Wildlife Program



Building the 2021 Power Plan



Optimize Bonneville's resource portfolio

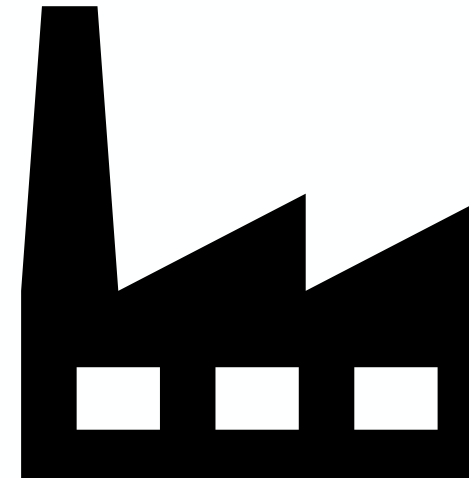


- Study Bonneville competitiveness
- Examine changes in how Bonneville might acquire resources and sell power
- Look for strategies that benefit Bonneville and its customers



Early retirement of coal generation

- Examine implications of early retirement of all regional coal plants – and to some extent the rest of the West
- Study resulting greenhouse gas emissions and reliability



Greenhouse gas cost tipping points

- Look at adding a regional price for greenhouse gas emissions in addition to existing policies
- Explore thresholds where the resource strategy changes based on responding to the carbon price



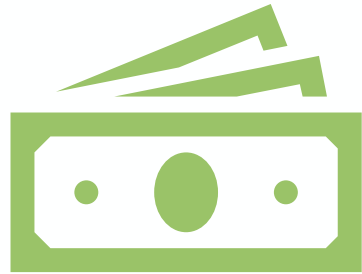
Paths to decarbonization



- Look at potential approaches to reducing greenhouse gas emissions both in the electric sector and in other economic sectors
- Quantify how emissions in the electric sector can be reduced and how that will net out with emissions in the other economic sectors like transportation and end-use of natural gas
- Explore the practical limits of how far emissions can be reduced, e.g. a percentage relative to 1990 emissions, and how quickly that reduction can be achieved



Increasing our reliance on extra-regional markets

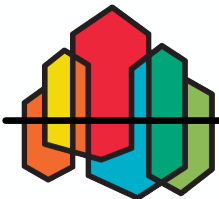


- Test relying more on resources outside our region being available when the region has an adequacy need
- Examine the depth of the supply as well as the ability to deliver the power to the region



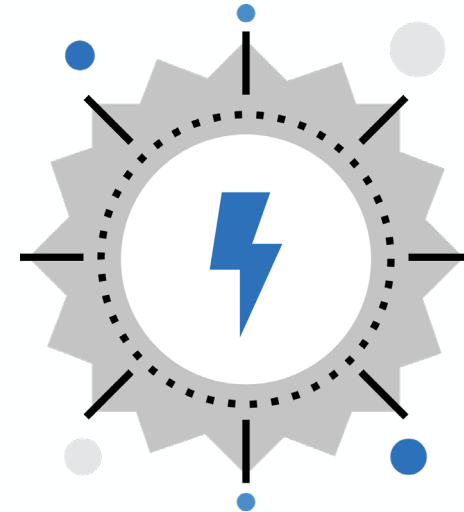
Organized markets for energy and capacity

- Look at the impact on the cost of new resources
- Estimate changes to adequacy and reserve requirements



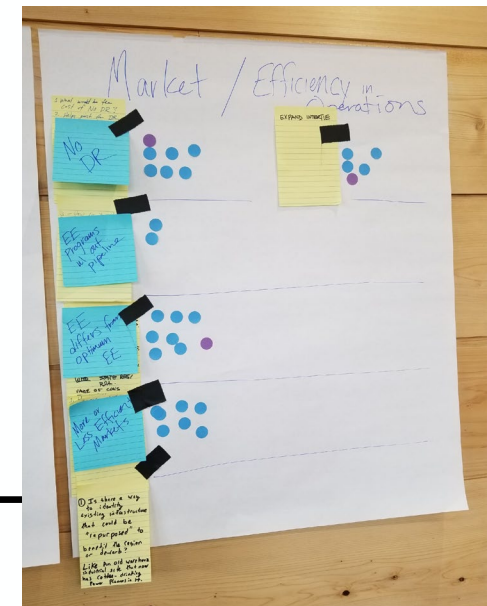
Test robustness of energy efficiency

- Test increasing and decreasing the supply and uptake of energy efficiency
- Examine impacts on regional cost and risk

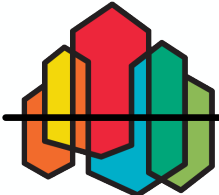
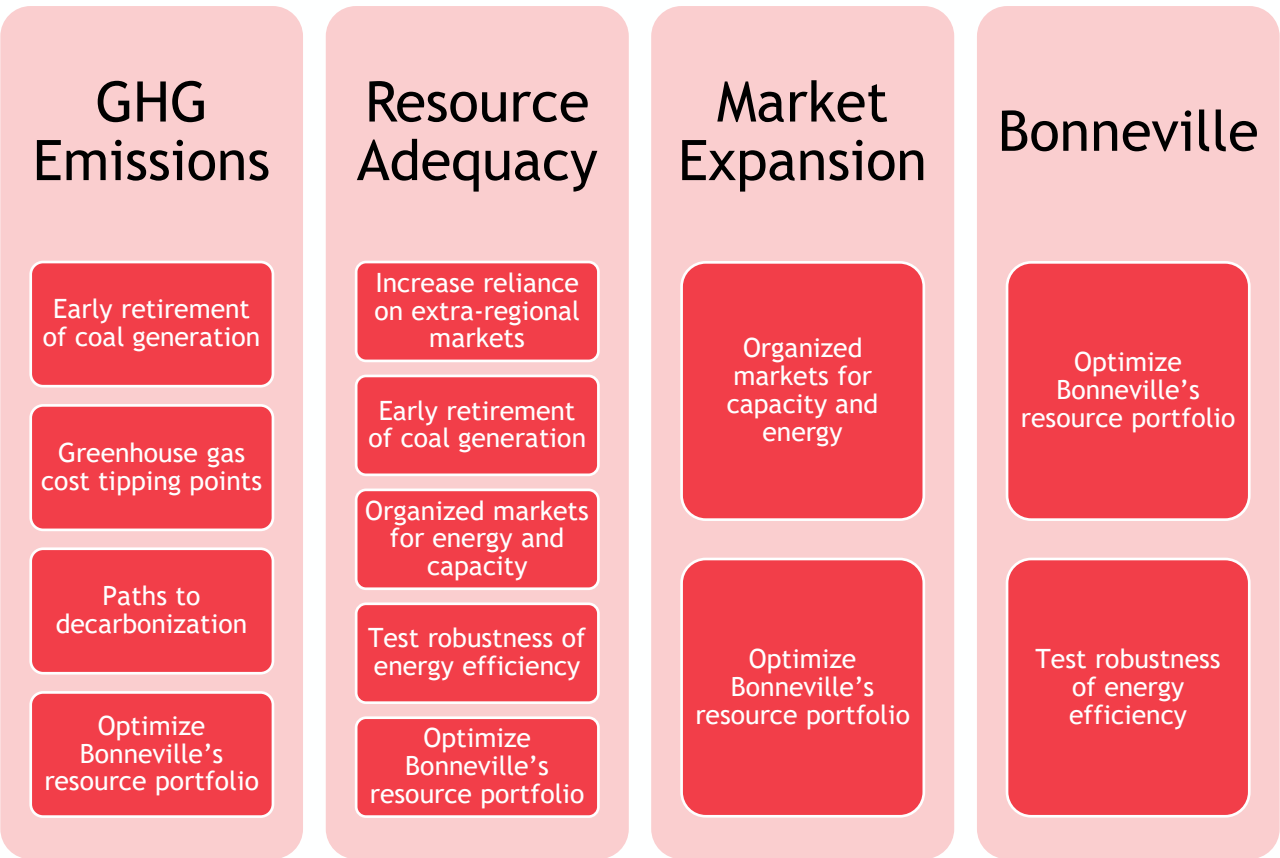


How we created the recommendation

1. Brainstorm all staff created ideas in small groups
2. Combined similar ideas into 37 different potential scenarios
3. Staff voted with 6 yes and 2 no dots at offsite meeting
4. The following week, staff reviewed transcription of brainstorm and eliminated 13 scenarios
5. The remaining 24 scenarios were then ranked based on difficulty
6. Scenarios that were determined to be too difficult to complete were dropped and scenarios with substantial overlap were combined to get to 16
7. Each staff selected 5 scenarios in priority order from the 16 and 6 scenarios were clearly at the top, the 7th (Increasing our reliance on extra-regional markets for resource adequacy) was marginal but after discussion was included



Primary connection to high-Level themes



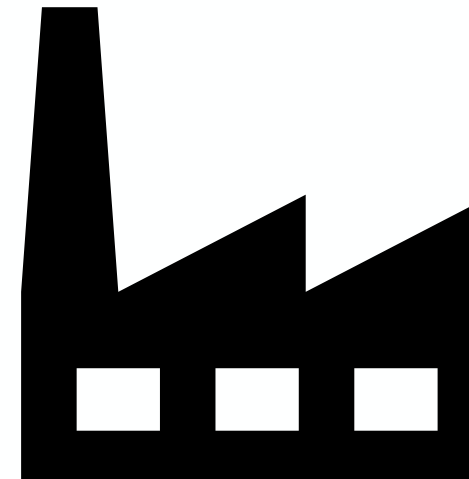
A scenic landscape of a mountain valley with a lake, partially obscured by white geometric overlays. The scene shows a valley with a lake in the foreground, surrounded by mountains and a layer of mist or low clouds. The image is overlaid with several white, semi-transparent geometric shapes, including triangles and rectangles, which create a layered, architectural effect. The text is centered in the lower half of the image.

January & February 2020

Further Refined Scenarios Scope

Early Retirement of Coal Generation

- Examine implications of early retirement of all regional coal plants – and to some extent the rest of the West
- Study resulting greenhouse gas emissions and reliability
- Plan implications:
 - Basis for comparison of emission reductions for other scenarios
 - Informs the Resource Development Plan
 - Examine impacts on cost-effective methods for providing reserves



Proposed In-Scope

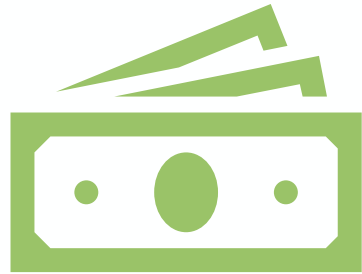
Coal Plant Unit	Announced/Existing Retirement Date (EOY)	Baseline Conditions*	Scenario: Early Retirement (EOY)
Colstrip Unit 1	2019	Retired	Retired
Colstrip Unit 2	2019	Retired	Retired
Boardman	2020	Retired	Retired
Centralia 1	2020	Retired	Retired
North Valmy 1	2021	2021	2021
Centralia 2	2025	2025	2025
North Valmy 2	2025	2025	2025
Jim Bridger 1	2023	2023	2022
Jim Bridger 2	2028**	2028	2026
Colstrip 3	2027**	2037	2025
Colstrip 4	2027**	2037	2025 (WA Legislation)
Jim Bridger 3	--	2037**	2026
Jim Bridger 4	--	2037**	2026

* Baseline conditions – announced retirement date or expected end-of-useful life estimate

** PAC and IPC still working out details of the accelerated retirement of Bridger 2, dates could be considered tentative. PAC announced in its 2019 IRP preferred portfolio that the most cost-effective strategy for PAC would be to end its involvement in Colstrip 3 and 4 in 2027. PAC is only 10% owner in these units so clearly this is not a formal retirement announcement, rather an indication of current analyses and discussions between owners to come. Jim Bridger 3 and 4 are currently assumed to operate until the end of their useful life, indicated as 2037 in the PAC 2019 IRP.



Change Reliance on Extra-Regional Markets for Resource Adequacy



- Test relying on availability of resources outside our region when the region has an adequacy need
- Examine the ability to deliver the power to the region
- Informs conversations regarding:
 - **The Council's resource adequacy standard**
 - Those considering differing market depths
 - Efforts to pool resource adequacy
 - Forecast of regional reserve and reliability requirements
 - Resource development plan



Proposed In-Scope

- Change Adequacy Reserve Margin / Planning Reserve Margin for the region
- Examine if incremental market reliance impacts Associated System Capacity Contribution of new resources
- *Potentially* examine impacts of wind and solar generation external to the region on available power for meeting regional peak load and the interaction of new and existing resources in the region with these external market dynamics
- Examine transmission limitations and outage likelihoods



Analyze the Bonneville Portfolio

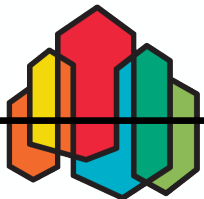


- Portfolio Analysis:
 - What is the Bonneville Portfolio?
 - Why should the Council analyze it?
 - What is the impact of the 2028 end of the regional dialogue contracts?



Proposed In-Scope

- Bonneville load based on expected obligation
 - Hourly forecast prior to 2028
 - Hourly forecast post-2028 including:
 - Higher obligation (e.g. all current customers plus 15 to 20%-ish)
 - Medium or persistent obligation
 - Lower obligation (e.g. reduce subscription by 35%-ish)
 - ~~Proportional assumptions or parameters to represent above high watermark obligations and the expected weekly/daily/hourly shape (flat or otherwise) of that obligation~~
 - Bonneville commercial contracts from 1+ to 20 years out - e.g. locked in power purchases whether tied to a resource or just a contract for delivery of unspecified power
 - Includes Bonneville's share of Canadian Entitlement



Proposed In-Scope

- Bonneville Load to Market Price Correlation - Intra-quarterly correlations used in RPM - e.g. should the hours where Bonneville's load is high be the same hours with high Mid-C prices?
- Bonneville market reliance limits - what is the amount of market power that is available to BPA to meet seasonal energy and capacity needs?
 - Should be consistent with post-2028 obligation levels



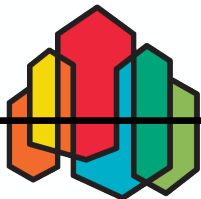
Proposed In-Scope

- Bonneville's transmission to market - beyond adequacy what is the maximum transmission that should be used for marketing opportunities when both purchasing and selling power?
- Bonneville-specific existing resource parameters – aggregate for RPM
 - Hydro – federal not regional
 - Columbia Generating Station
 - Wind PPAs
 - ~~Anticipated Hydro Upgrades~~
 - Other?
- State RPS / clean policy parameters - should Bonneville acquire resources to facilitate customer utility compliance with state policies?



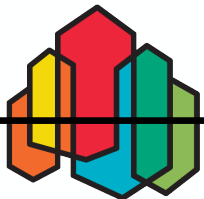
Proposed In-Scope

- ~~• Bonneville-specific market greenhouse gas emissions rate~~
- ~~• Bonneville-specific generating resource potential and cost (with BPA-specific debt assumptions)~~
- Bonneville EE Supply Curves
- Bonneville DR Supply Curves - assuming Bonneville can arrange a contract for any DR potential in a customer utility that would be dispatched for Bonneville needs



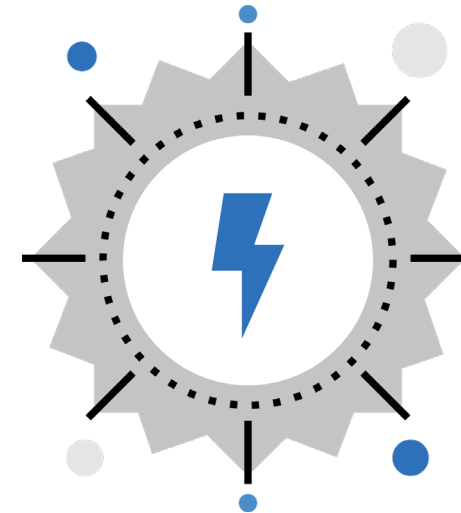
Proposed In-Scope

- Bonneville ASCC assumptions – *potentially* using federal GENESYS
- ~~Existing System Revenue Requirement – what is the current Bonneville portfolio revenue requirement?~~
- ~~Debt Balance and Payments~~
 - ~~What is the current debt and forecast payments?~~
 - ~~How would new acquisitions be financed and what would be the impact to Bonneville debt?~~



Test robustness of energy efficiency

- Test increasing and decreasing the supply and uptake of energy efficiency
- Examine impacts on regional cost and risk



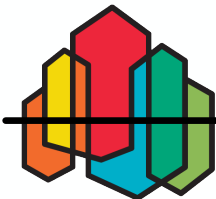
Proposed in-scope

- Test increasing EE supply and examine the impacts on portfolio cost
 - Use differing ramp rates reflecting accelerating/decelerating EE acquisition
 - Increase/decrease maximum achievable EE in 20-year horizon
 - Add in emerging EE measures to see impact of additional EE in later years or include >100% ramp rate on existing EE to emulate emerging tech
- Test varying the capacity contribution of EE
 - Change kW impact or load profile to see value of capacity contribution; potentially as a modifier to the ASCC
- Test the interaction between the availability of EE and the availability of DR
 - Modify potential and/or modify elasticity between EE and DR, as DR availability is tied to EE ramp rates



Organized / limited markets for energy and capacity

- Look at the impact on the cost of new resources
- Estimate changes to adequacy and reserve requirements



Proposed in-scope

- ~~• Change in Generating Resource Potential available to the region — in an organized market transmission would not limit the resource options available to the region~~
- Change in Wheeling Charges – these charges are based on charges to get in and out of balancing authorities and existing markets
- ~~• Change in market price caps — markets would implement price caps which could limit the value resources like DR get in the market. (CAISO uses \$1000 a MWh)~~
- Adjust regional Planning Reserve Margin (PRM) – simple adjustments to look at the impact of markets on reducing the resources needed for adequacy



Proposed in-scope

- Adjust market availability in GENESYS – probably most of the impact would be on the Adequacy Reserve Margin
- ~~• Change the peak hour of EE supply curves to match WECC-wide peak versus regional peak~~
- ~~• Change the supply curve ramp rates and maximum potential to reflect market signal for capacity from EE and DR~~
 - ~~• Increase program participation rates with increased marketing/incentive costs by utilities~~



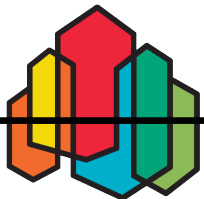
Greenhouse gas cost tipping points

- Look at adding a regional price for greenhouse gas emissions in addition to existing policies
- Explore thresholds where the resource strategy changes based on responding to the carbon price



Proposed in-scope

- ~~• Test a range of greenhouse gas prices for inside and outside the region~~
 - ~~• Market prices could impact the uptake of energy efficiency depending on how much is acquired in the baseline conditions~~
- Expand generating resource reference plant options / potential to give additional depth resources that do not emit greenhouse gases
- ~~• Examine change in retail price of electricity based on a carbon tax passed through to consumer~~
- Test for sufficient reserves and examine resources used to supply reserves



Paths to decarbonization



- Look at potential approaches to reducing greenhouse gas emissions both in the electric sector and in other economic sectors
- Quantify how emissions in the electric sector can be reduced and how that will net out with emissions in the other economic sectors like transportation and end-use of natural gas
- Explore the practical limits of how far emissions can be reduced, e.g. a percentage relative to 1990 emissions, and how quickly that reduction can be achieved



Proposed in-scope

- Natural Gas Price and related emissions
 - ~~Change in wholesale price based on reduced demand~~
 - Reduce upstream methane emission reductions
 - Test price based on blending natural gas to reduce emissions intensity of natural gas fuel
 - ~~Estimate impact of fuel switching on the retail price of natural gas~~
- Regional Transportation fuel consumption
 - Transportation fuel switching – test increase EV adoption
 - Increase gasoline efficiency – increase CAFÉ standards to 80 MPG or 100 MPG by 2050
 - Increase in alternative delivery methods (Policies to reduce miles travelled)
 - Evaluate alternative fuels (hydrogen, biofuel)



Proposed in-scope

- Consumption of Natural Gas (End-use)
 - ~~Natural gas retail price increase – reflecting emissions cost to consumers may impact consumer choice~~
 - Reduce greenhouse gas intensity of natural gas fuel – e.g. RNG blending
 - Evaluate alternative fuels (hydrogen, biofuel) for industrial processes
- Generating Resources
 - Accelerated retirements – coal and natural-gas-fired generation
 - Added resources – offshore wind, SMR, enhanced geothermal, etc.
 - Increased potential of non-GHG-emitting resources (i.e. conventional geothermal and pumped storage)



Proposed in-scope

- Load Forecast
 - Increase behind-the-meter solar and battery penetration (net zero homes)
 - Increase standards
 - Increase alternative fuels penetration – hydrogen & biofuel
 - Acquire EE outside electric load (e.g. in natural gas end-use)
 - Test no new gas/oil/coal consumption for residential and commercial sectors
 - Increase efficiency of use for both electricity and natural gas
 - Implement economy-wide consumer GHG pricing - test \$50 & \$100 per ton CO₂e



Proposed in-scope

- ~~California~~

- ~~• Fuel switching of load outside region — new and/or replace on burnout~~
- ~~• Estimate electrical loads as a result of deep decarbonization~~

- EE

- Increased units from fuel switch
- Increase availability a la EE Robustness
- Increased availability from emerging technologies
- Update with aggressive retrofits



Proposed in-scope

- DR
 - ~~Events based on highest GHG emission hours?~~
 - Increased potential from increased units/loads
 - Update potential based on changes in units and load forecast
- Greenhouse Gas Sink
 - Need supply curve, costs, and limitations
 - Inventory of potential policy initiatives
 - Supply curve is proxy for other reductions (expensive, not the first measure)



Proposed in-scope

- Estimate System Adequacy Requirements (GENESYS)
 - ~~Optimize Hydro & Regional Generation based on GHG emissions~~
 - ~~Review adequacy based on retirements and markets outside the region~~
- ~~Forecast Electricity Price (AURORA) & RPM~~
 - ~~WECC-wide carbon tax or carbon cap, restrict new resource options~~
 - ~~Expand 100 percent clean (accelerate)~~
 - ~~Dispatch based on GHG emissions~~
 - ~~Possible Time-Of-Use rate structure study~~





November 2020 to February 2021

First Look at Baseline Conditions

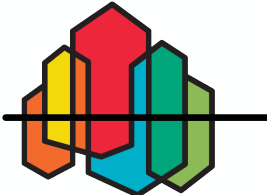
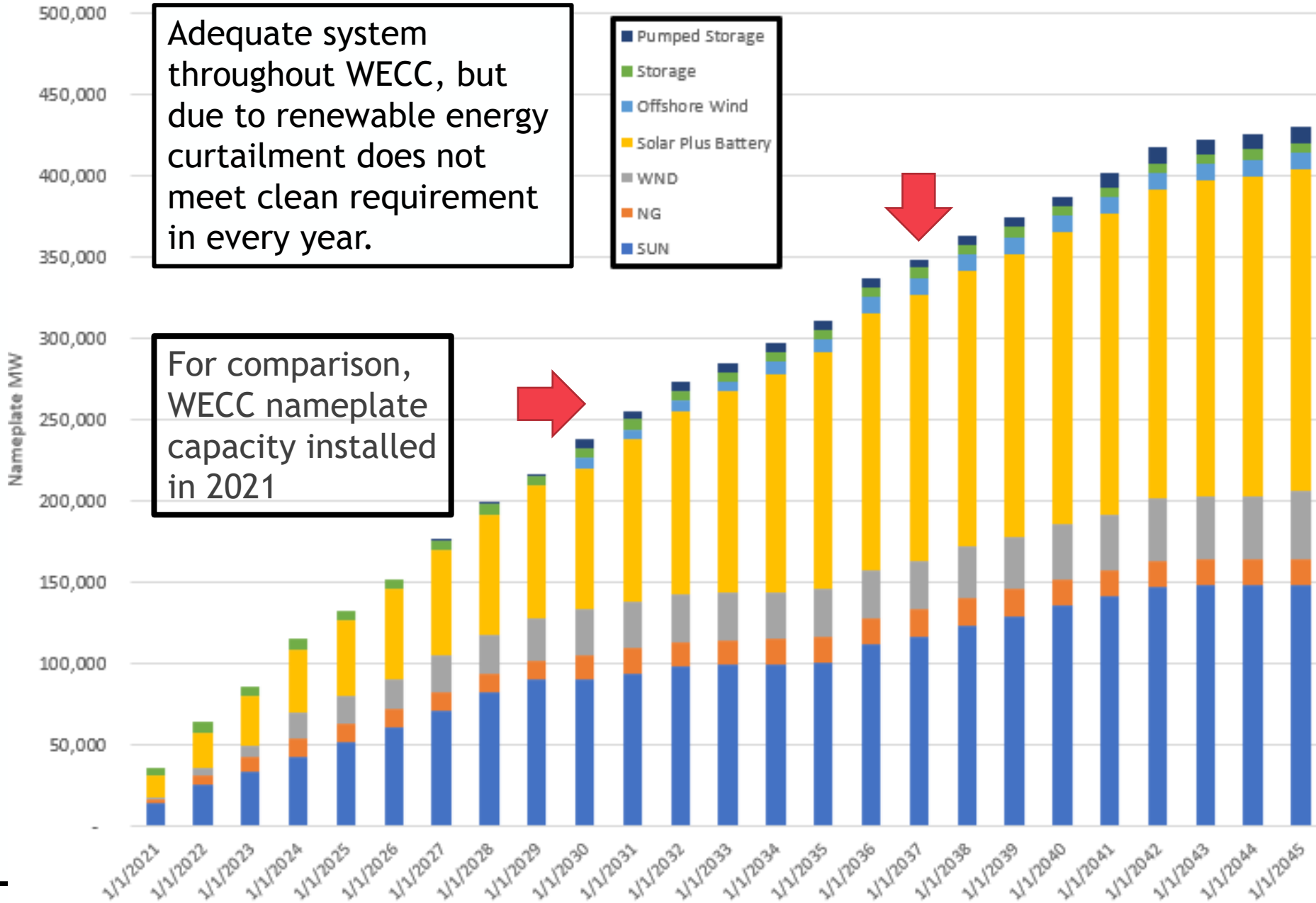
- Wholesale Electricity Price Forecast Challenges & Impacts
- Leaving the 7th Plan Behind

What are baseline conditions?

- Baseline conditions are a basis for comparison when developing scenarios
- Baseline conditions are assumptions that are common between 2 or more scenarios
- Baseline conditions are **not**:
 - Business as usual
 - Most likely scenario
 - Default forecast
 - Recommended regional resource strategy



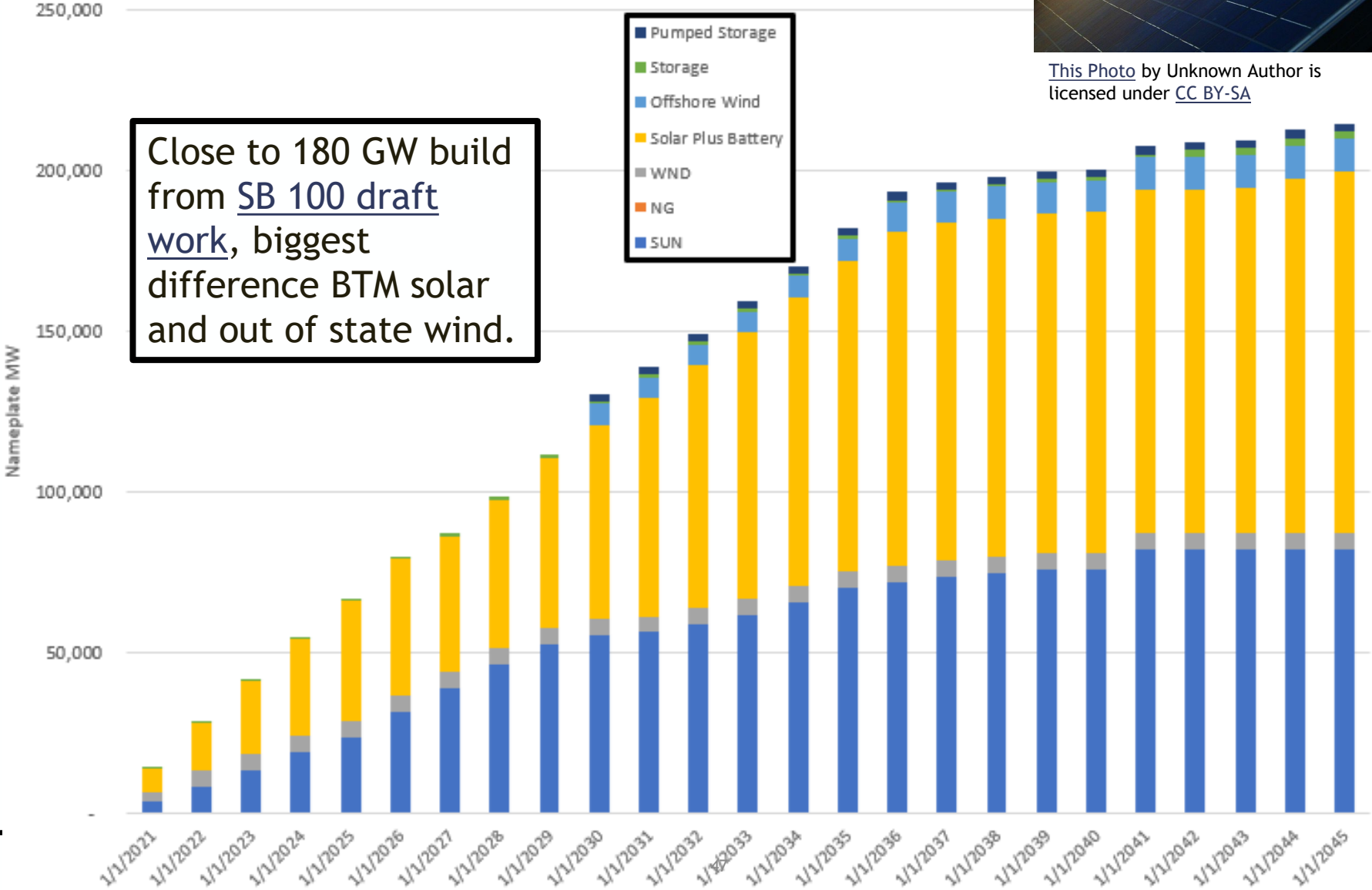
WECC Buildout



CA Buildout



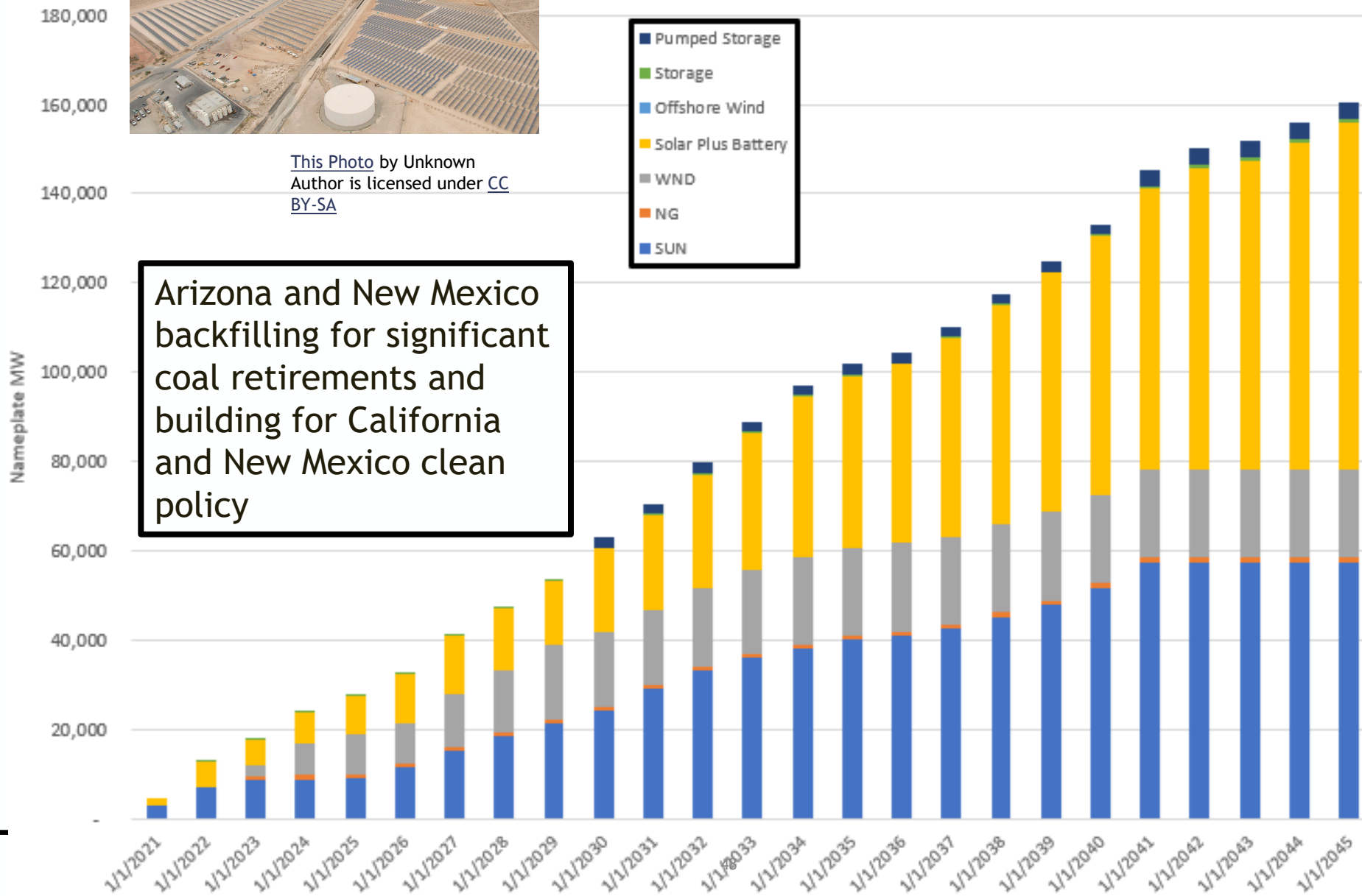
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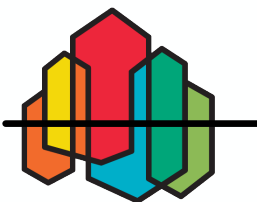


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Desert SW Buildout



Arizona and New Mexico backfilling for significant coal retirements and building for California and New Mexico clean policy

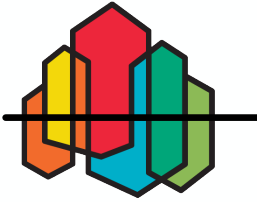
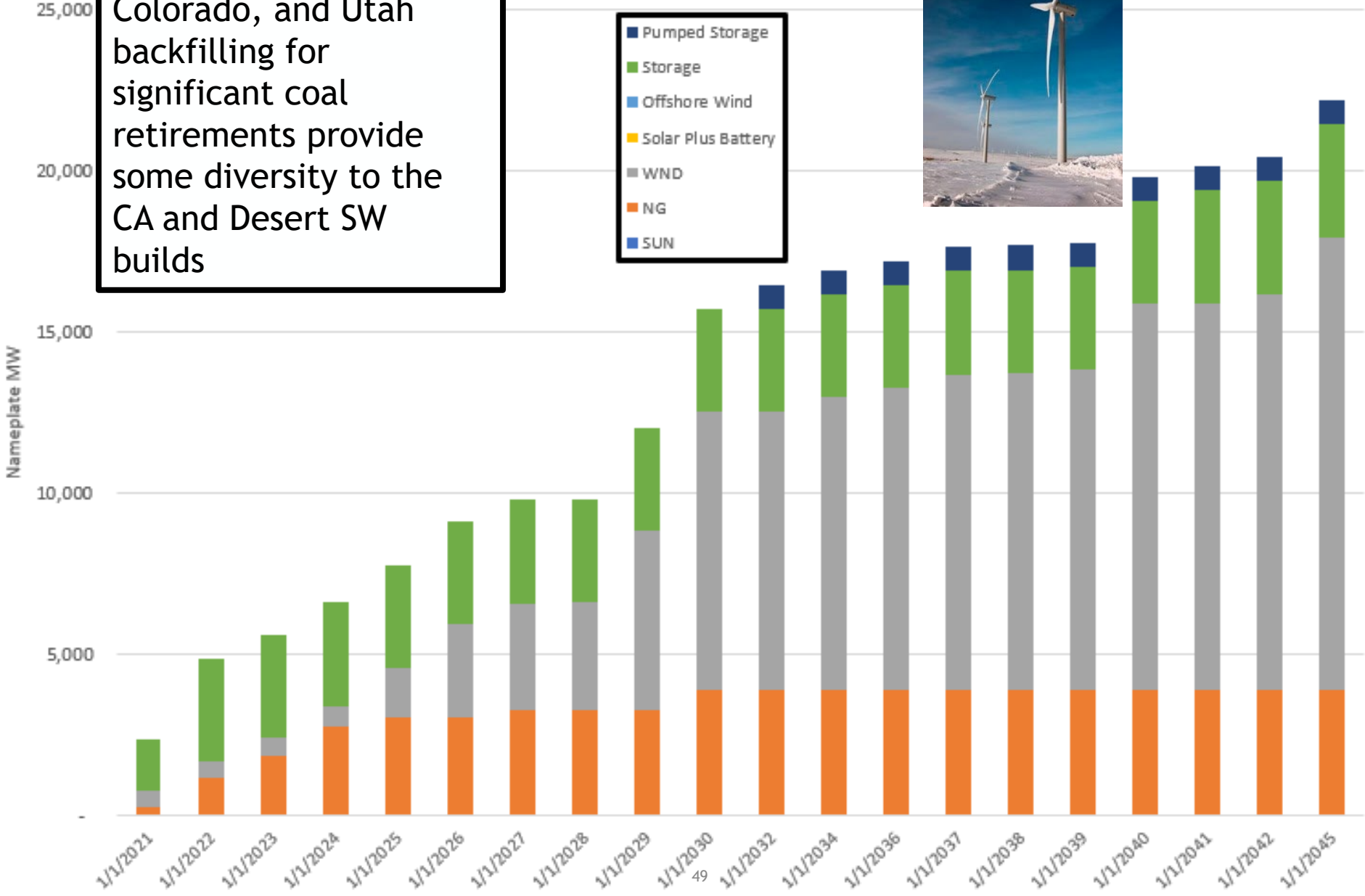


Nevada, Wyoming, Colorado, and Utah backfilling for significant coal retirements provide some diversity to the CA and Desert SW builds

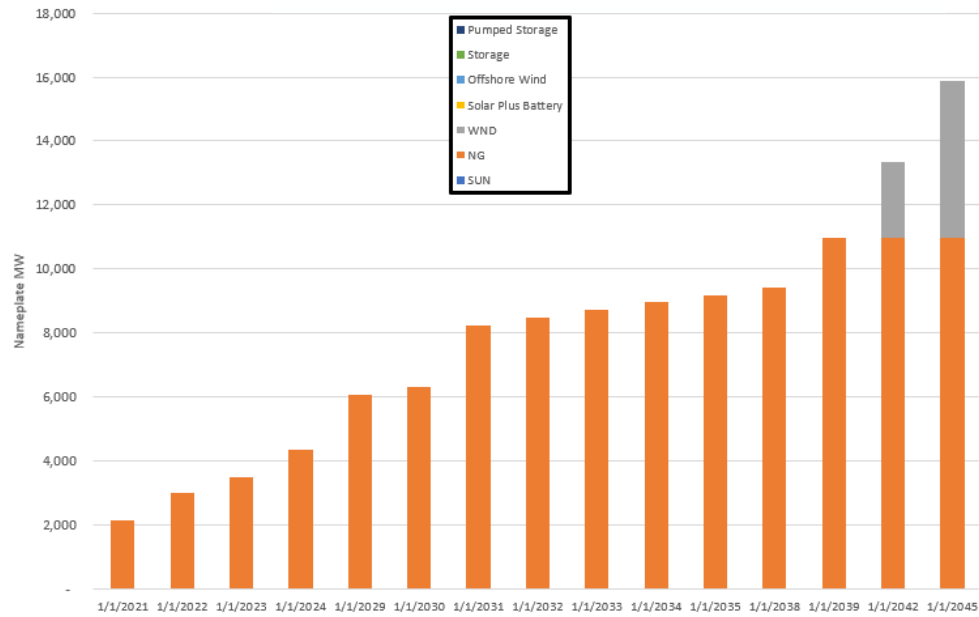
Mountain West Buildout



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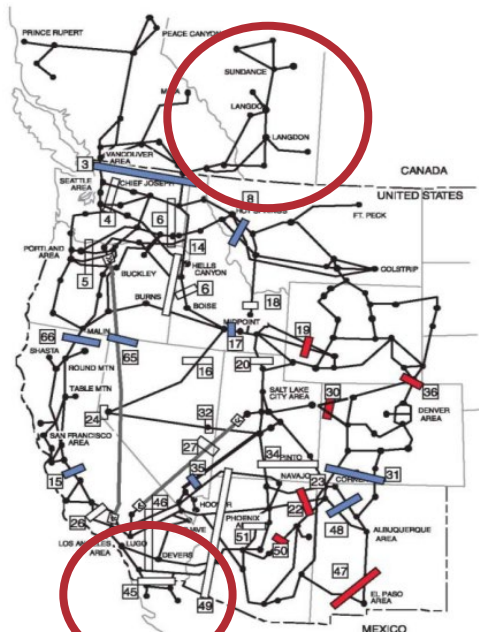


Alberta Buildout



All but 4 GW of natural gas builds in Alberta or Baja CA.

Both have fairly immediate needs and limited resource and transmission options.

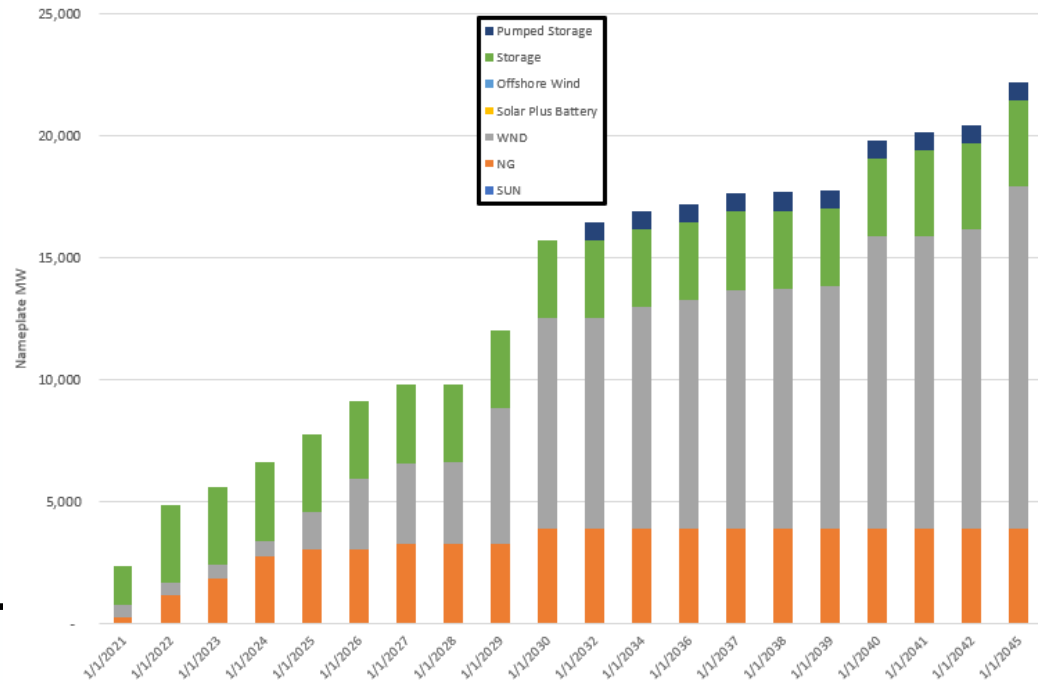


Transmission paths are shown as lines. The number alongside each bar is the WECC number for that path.

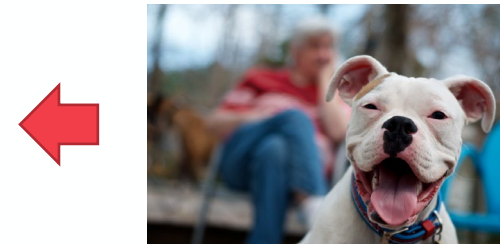
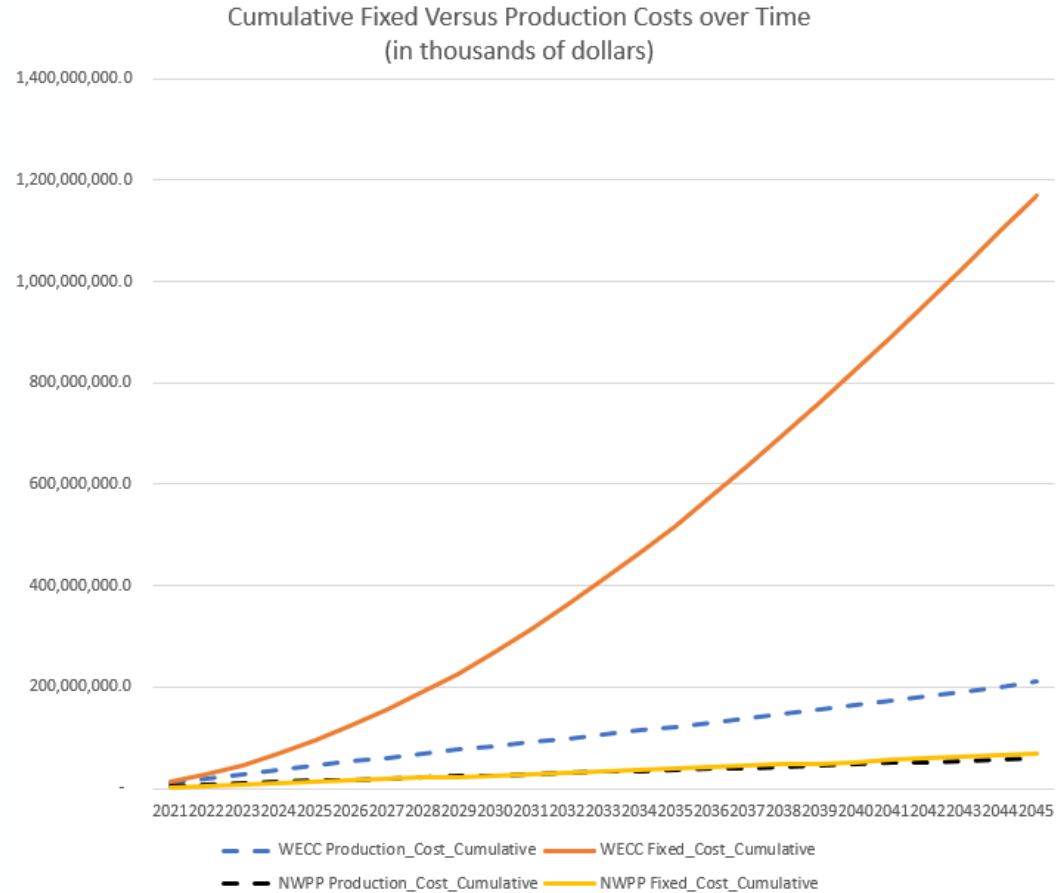
- Actual Flow > 75% of OTC greater than 50% of time on path
- Actual Flow > 75% of OTC between 25% and 50 % of time on path
- Actual Flow > 75% of OTC between 0% and 25% of time on path

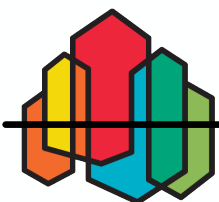
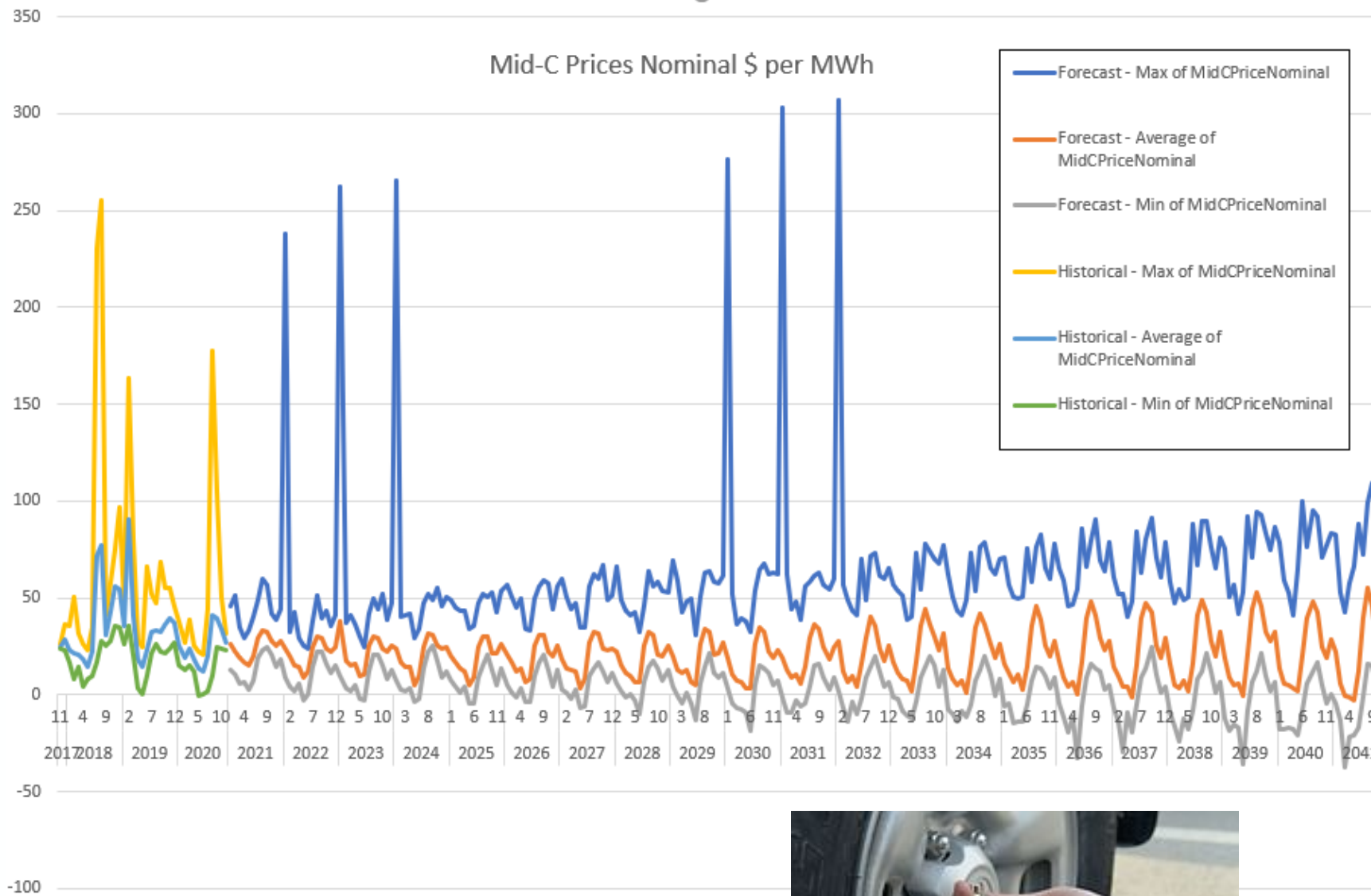
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Baja CA Buildout



Fixed costs more than **6 times** production costs for WECC, **NWPP** fixed and production costs stay similar.

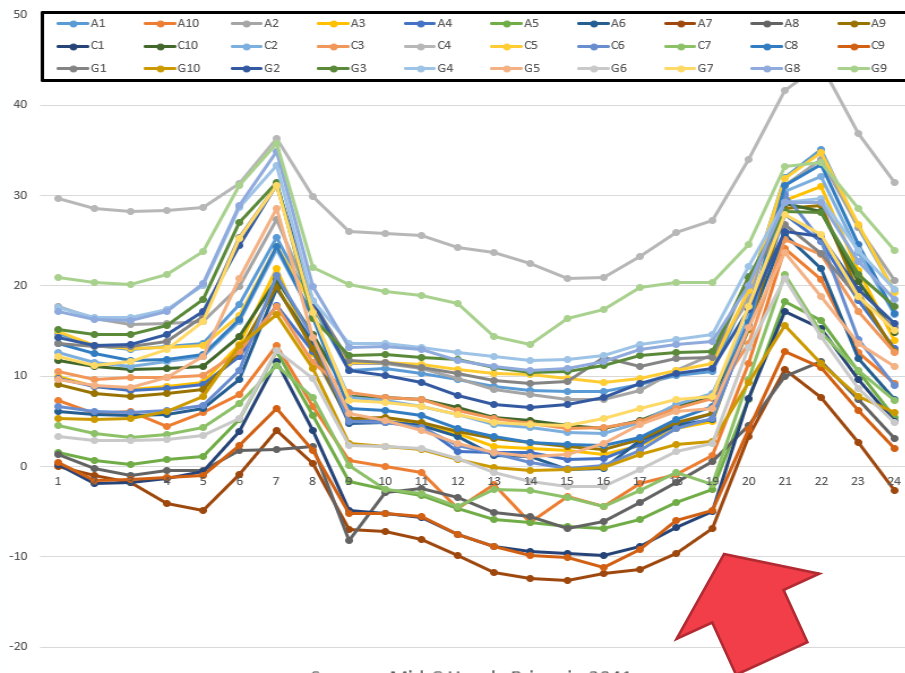




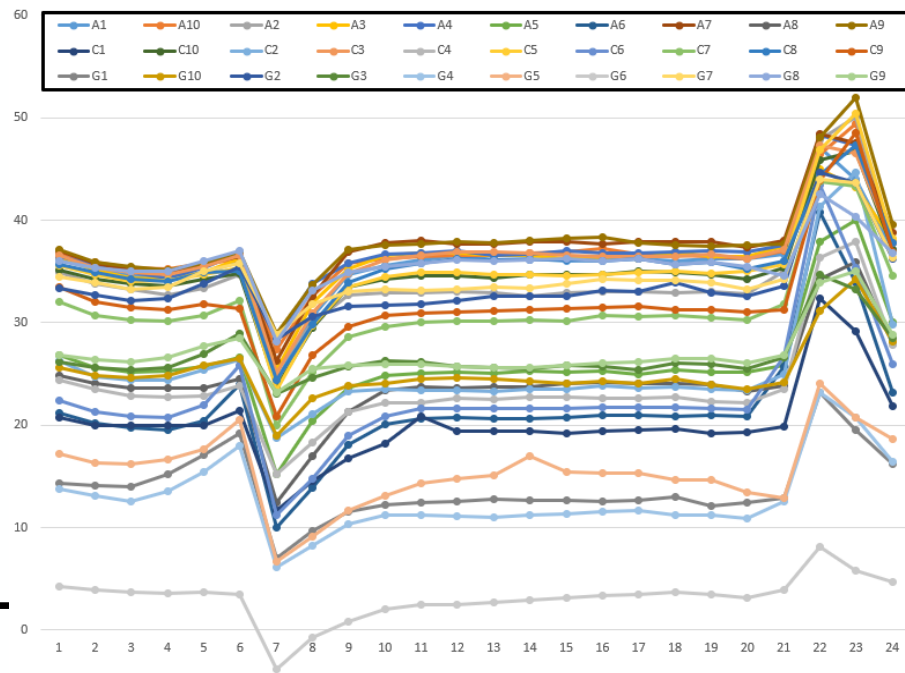
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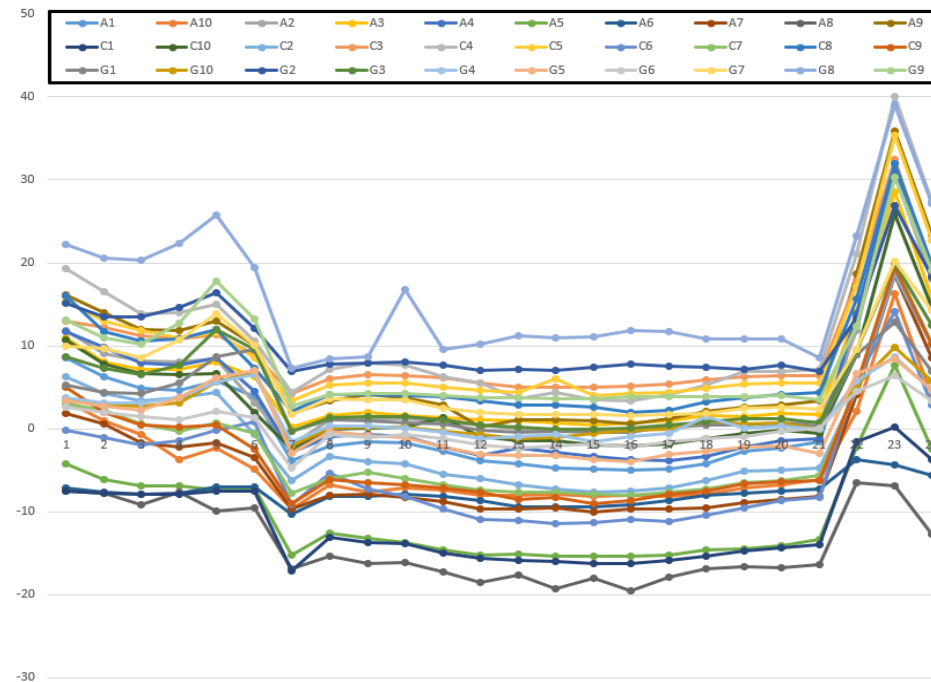
Winter/Fall Mid-C Hourly Prices in 2041



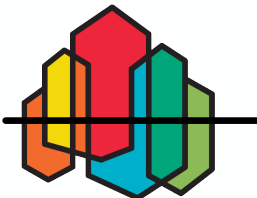
Summer Mid-C Hourly Prices in 2041



Spring Mid-C Hourly Prices in 2041



Prices by 2041 have persistent negative pricing seasonally for many hours mid-day.



Market Price Conclusions

More Price Spread in RPM

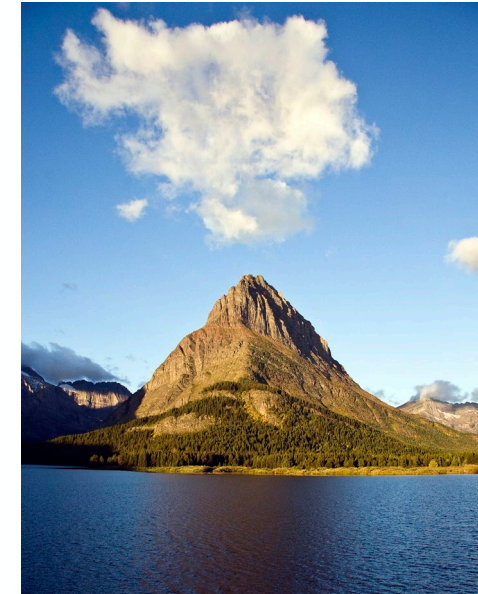
- RPM also looks at different gas price scenarios
- Those simulations are still running...

Daily Price Shape is Important

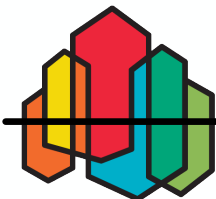
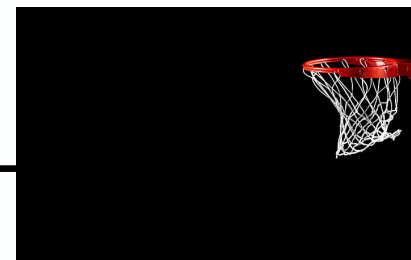
- **Net peak** driving prices more than peak.
- Resources that must run midday will be competing with extremely low market prices
- Maintaining reserves and ramping capability while undergoing persistent negative price periods could be a challenge for the WECC, and by the end of the study the NW.
- Resources with ramping capability with low must-run requirements will be more and more valuable.
- Hydro conditions still the major driver of price variability at Mid-C.



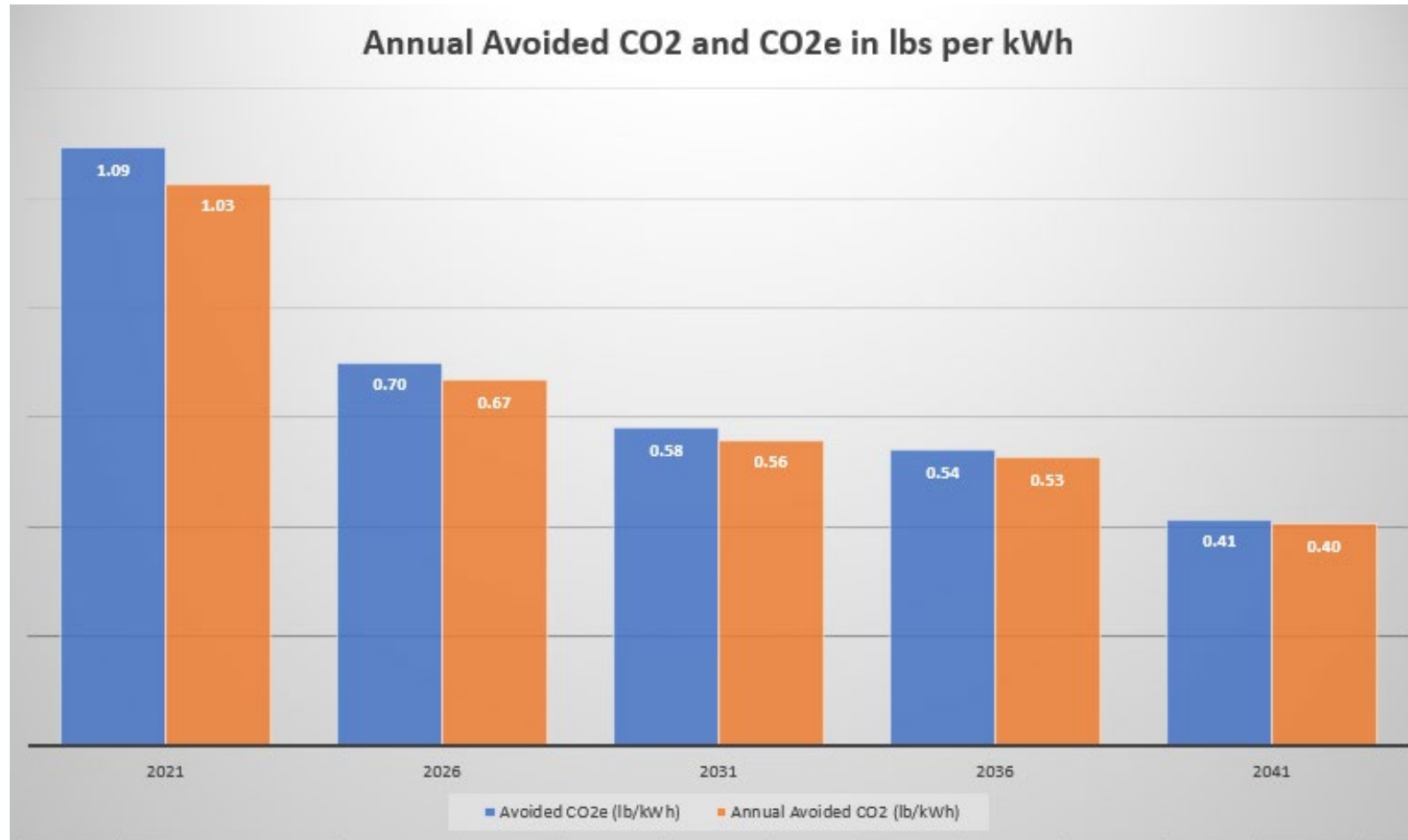
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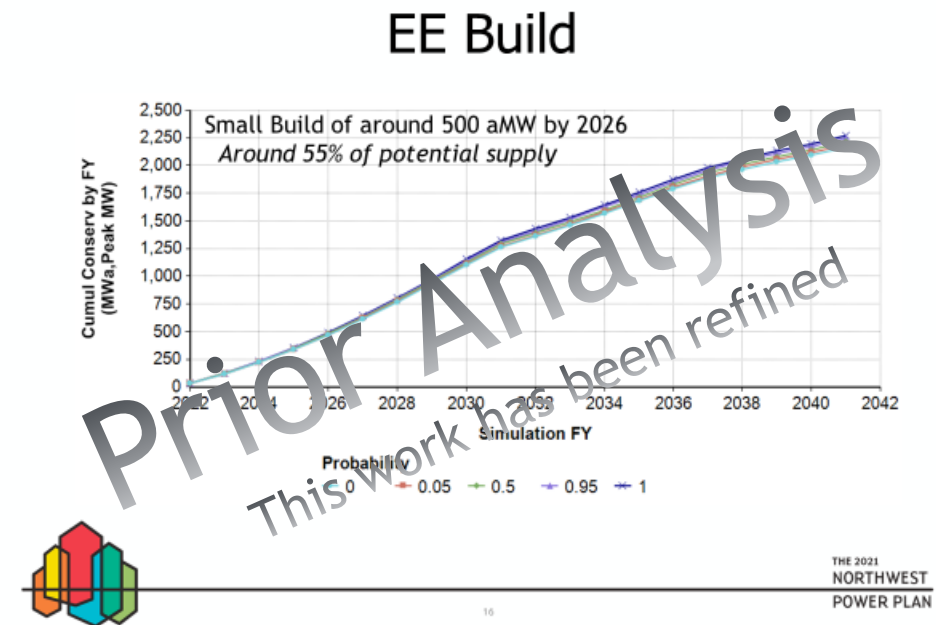


Avoided Market Emissions Rate Decreases Over Time



Unexpected Energy Efficiency Results

- Early analysis showed Energy Efficiency playing a very different role in the portfolio than previous plans
- Results were contrary to staff expectations coming in way below where we thought they would be



EE in 2021P World



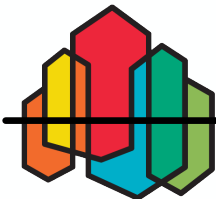
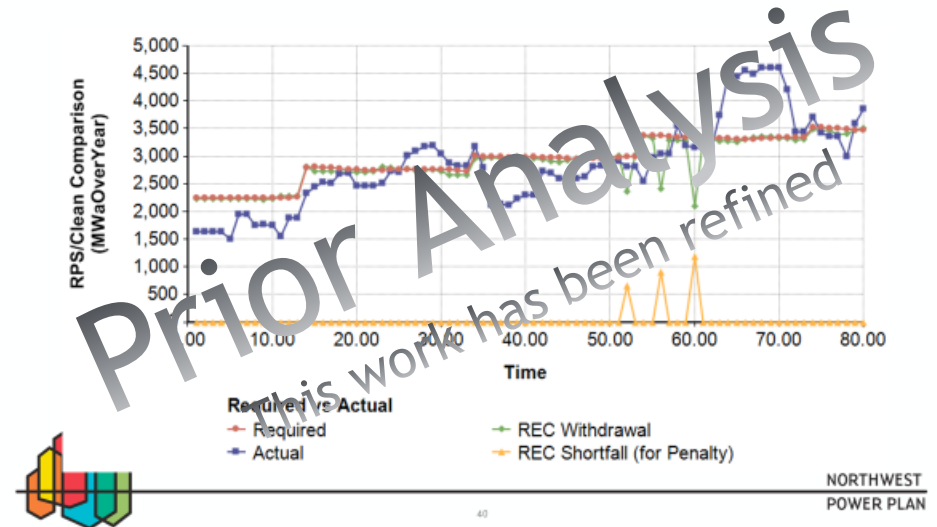
- Renewables are competing directly with EE
 - No carbon emissions
 - Low cost with additional benefits (ITC and RECs)
 - Interruptible
- Low market prices that are *decreasing* over time reduce value of EE as a hedge
 - Only first couple bins of EE show negative long-term energy value (when CO₂ prices are included)
- EE as an incremental build resource is less desirable than a immediate build generation resource



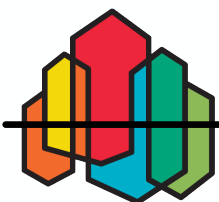
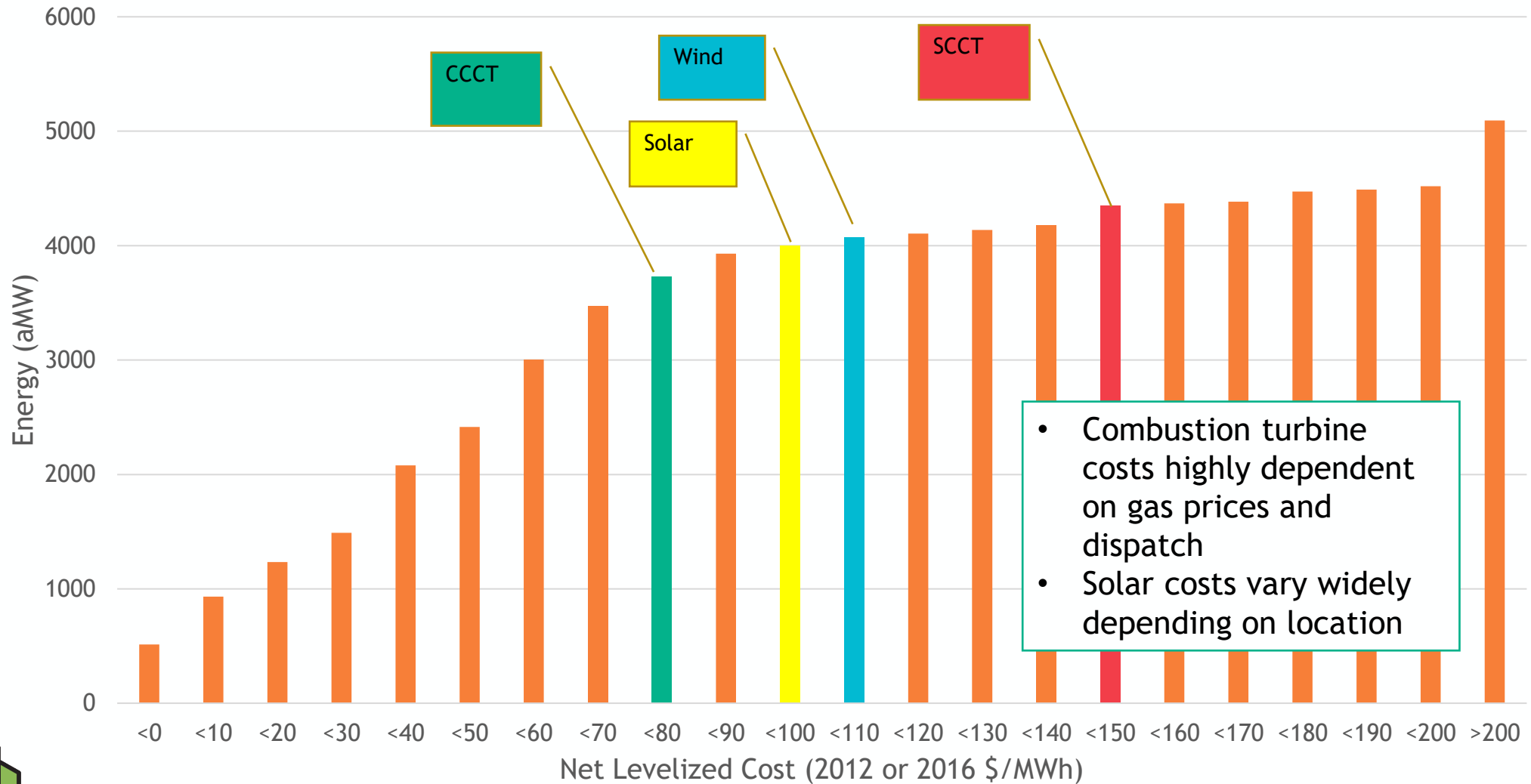
Renewables Stand Out

- Early on the role of renewables in the portfolio showed the sea change in policy and prices
- Renewables value in the plan analyses stood out because of:
 - Impact on reducing emissions
 - RECs and Clean Policy
 - Interruptibility
 - Levelized cost of energy

REC Shortfall Example



Comparing 2021P Energy Efficiency with 7th Plan Generation Resources Costs (examples)



Generation Resources: Seventh Plan vs 2021 Plan

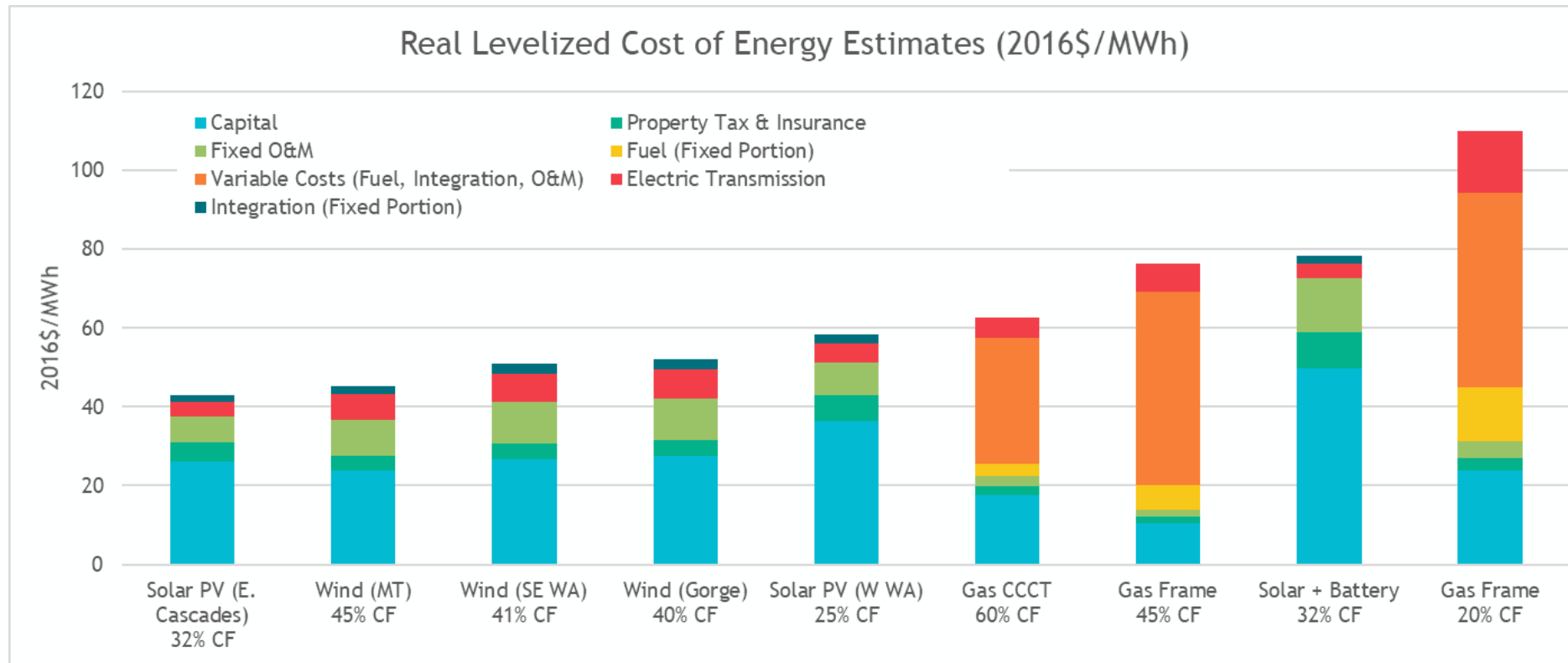
Resource	7P Capital Cost (2016\$/kW)	7P Mid-term (2016\$/kW)	2021P Capital Cost (2016\$/kW)
Combined Cycle Combustion Turbine (Gas)	\$1,220	\$1,100 - \$1,300	\$1,150
Simple Cycle CT (Gas) (Frame)*	\$859	\$500 - 650	\$550
Reciprocating Engine	\$1,382	\$1,250 - \$1,450	\$1,250
Wind	\$2,382	\$1,500 - \$1,700	\$1,450
Solar PV	\$1,792 (Low cost); \$2,566	\$1,350 - \$1,500	\$1,350 (E. Cascades); \$1,465 (W. WA)
Geothermal	\$4,575	--	\$5,400
Pumped Storage	--	--	\$2,300
Battery (4 hrs)	--	--	\$1,400
Solar + Battery	--	--	\$2,568

Solar and Geothermal receive the 10% Investment Tax Credit (ITC) - not included in the capital cost assumptions above

* Price difference also reflects a change in the reference plant technology class



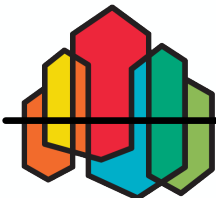
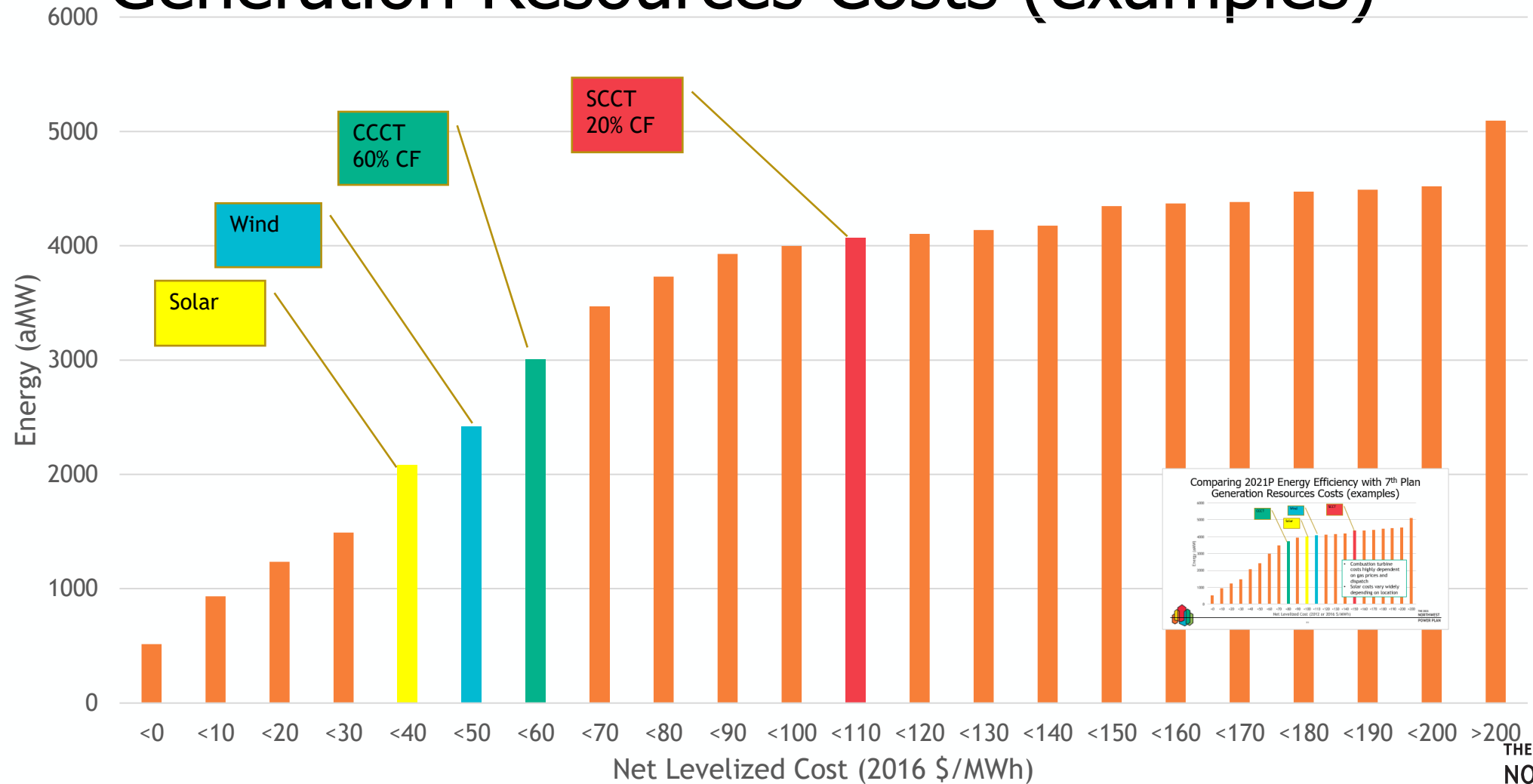
Draft 2021 Plan – LCOE Estimates of Select New Generating Resources*



*Based on draft 2021 plan generating resource reference plants (size, configuration, technology, location, etc.) and financial assumptions in MicroFin

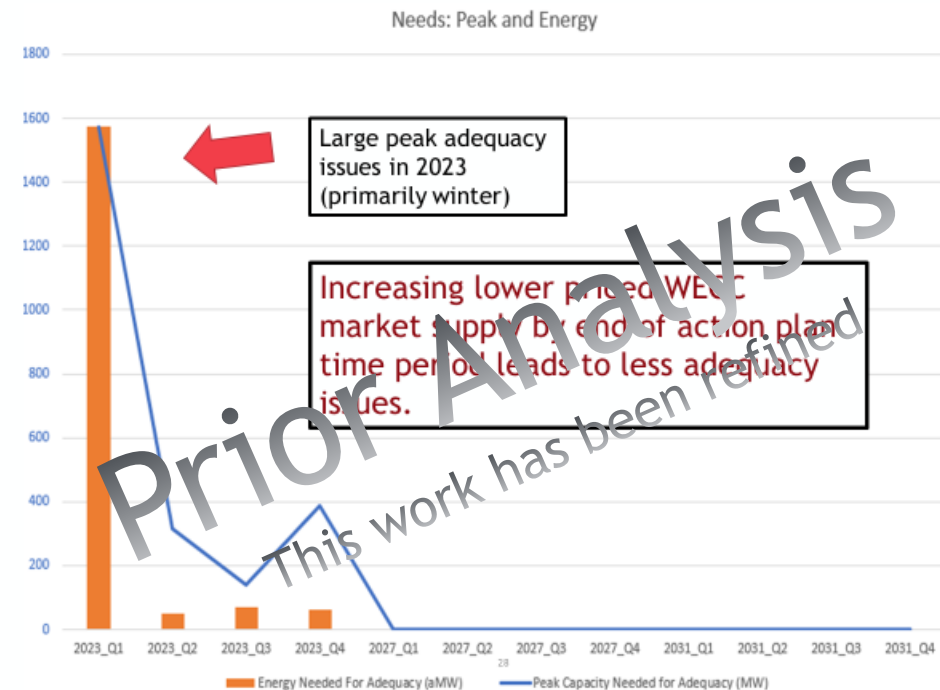



Comparing Energy Efficiency with 2021P Generation Resources Costs (examples)



Adequacy & Needs – Changing Perspective

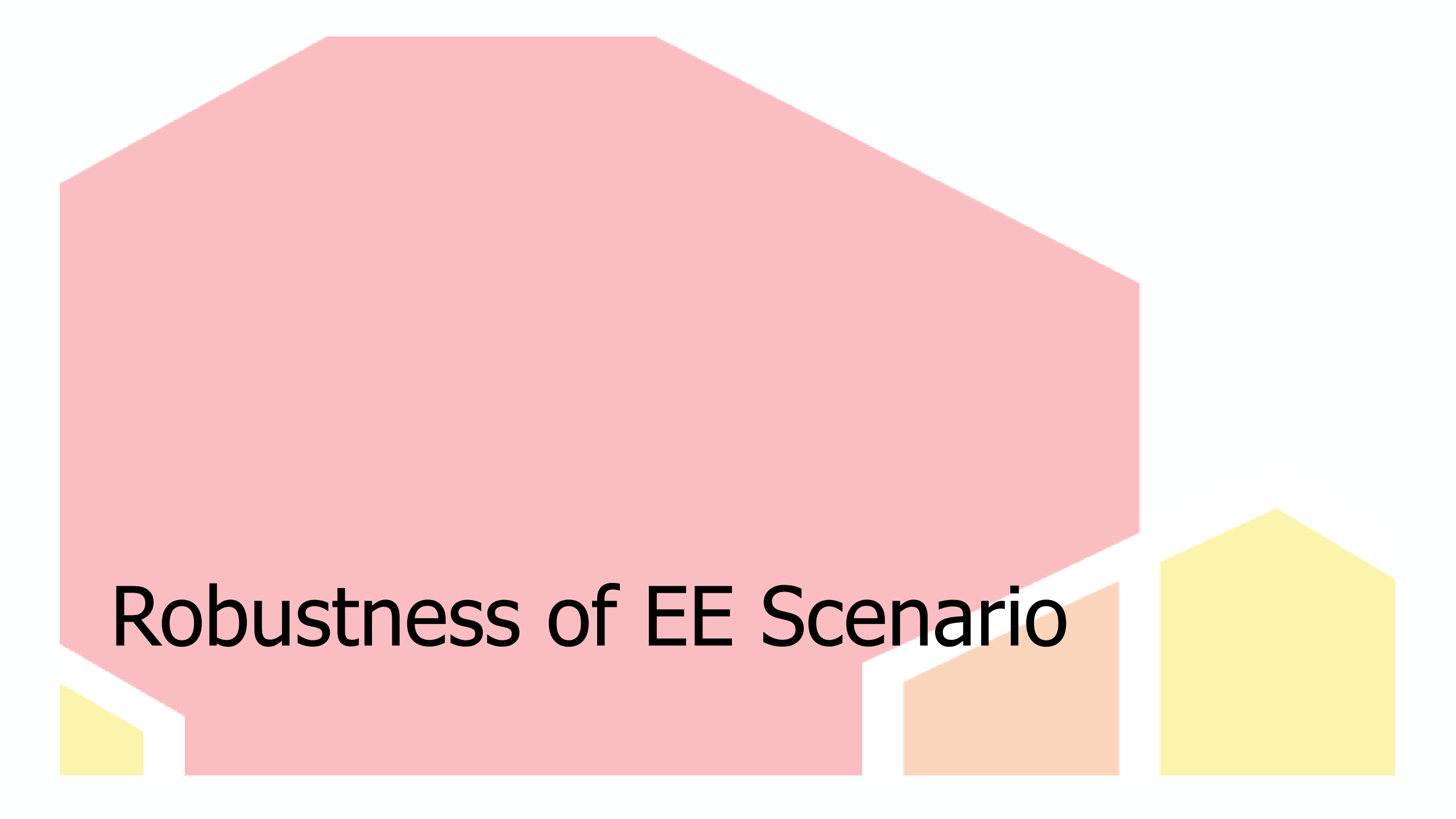
- Market Prices change import / export behavior
- Economics drive adequacy!
- Economics drive adequacy!
- Economics drive adequacy!



The background image shows a mountain valley with a lake, partially obscured by white geometric overlays. The text is overlaid on the left side of the image.

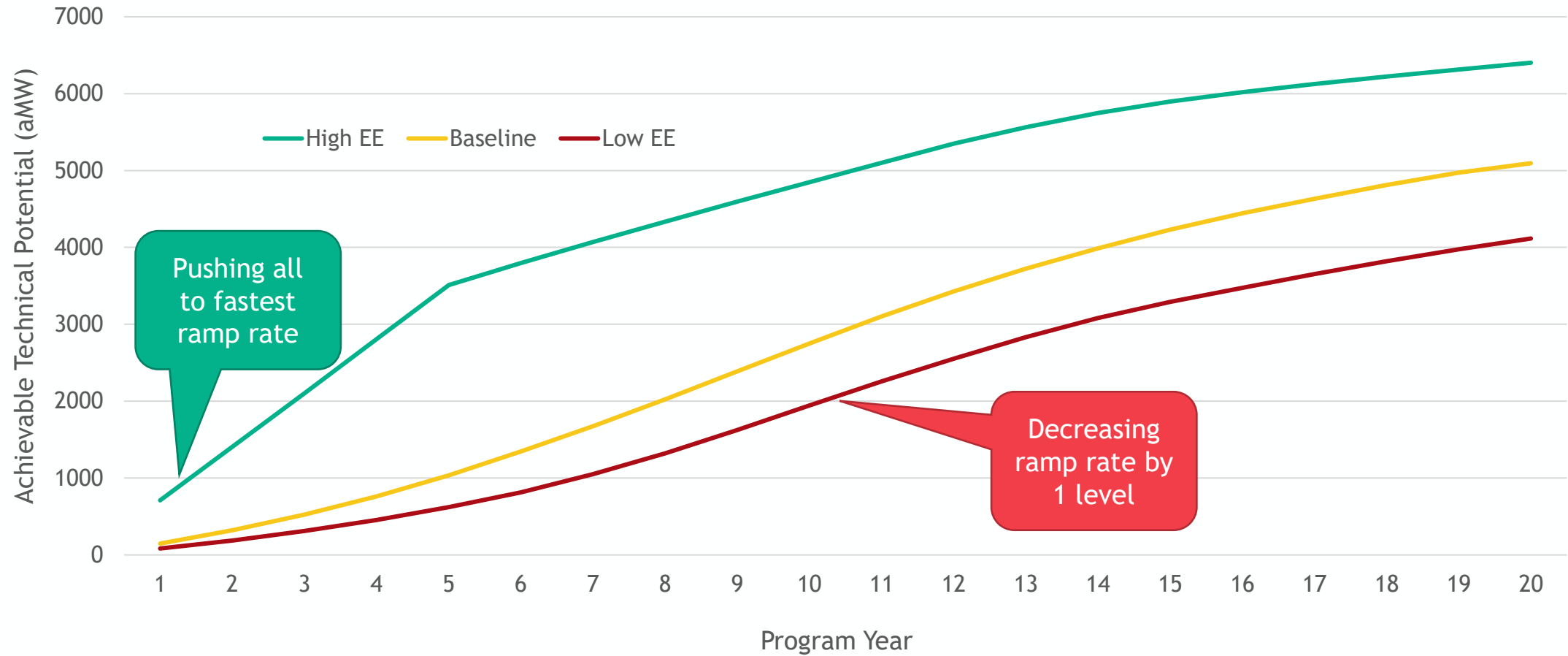
January to June 2021

Scenario Analysis Results and Vetting



Robustness of EE Scenario

Relative Rate of Acquisition 2021P draft



Robustness of EE – Early Findings from Ramp Rate Variations

- RPM is acquiring EE at similar costs to baseline
 - High cost bins early to meet adequacy need
 - Low cost bins later as renewables flood market and market price drops
- More findings will be presented at Feb Council meeting

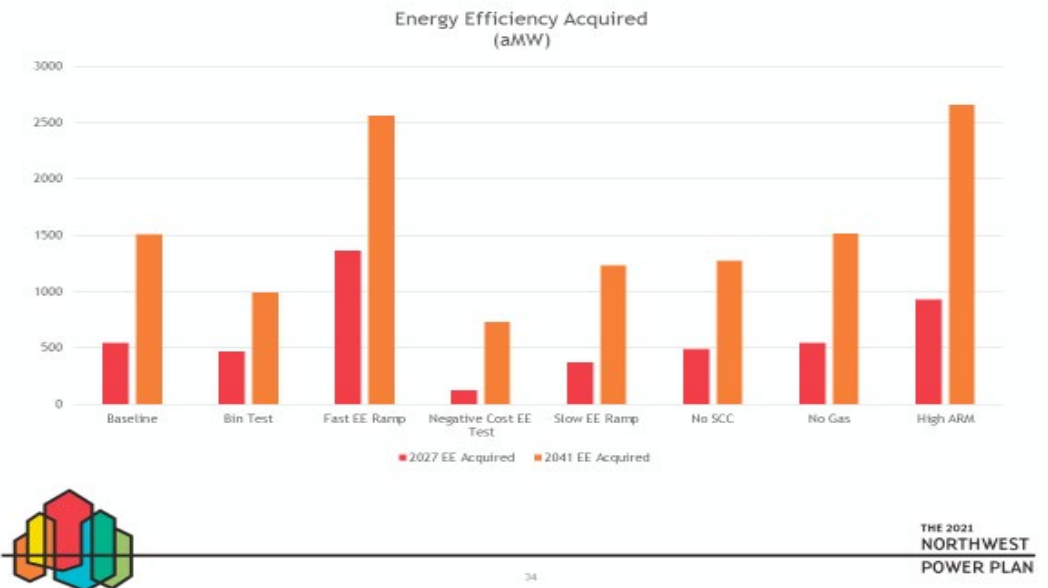
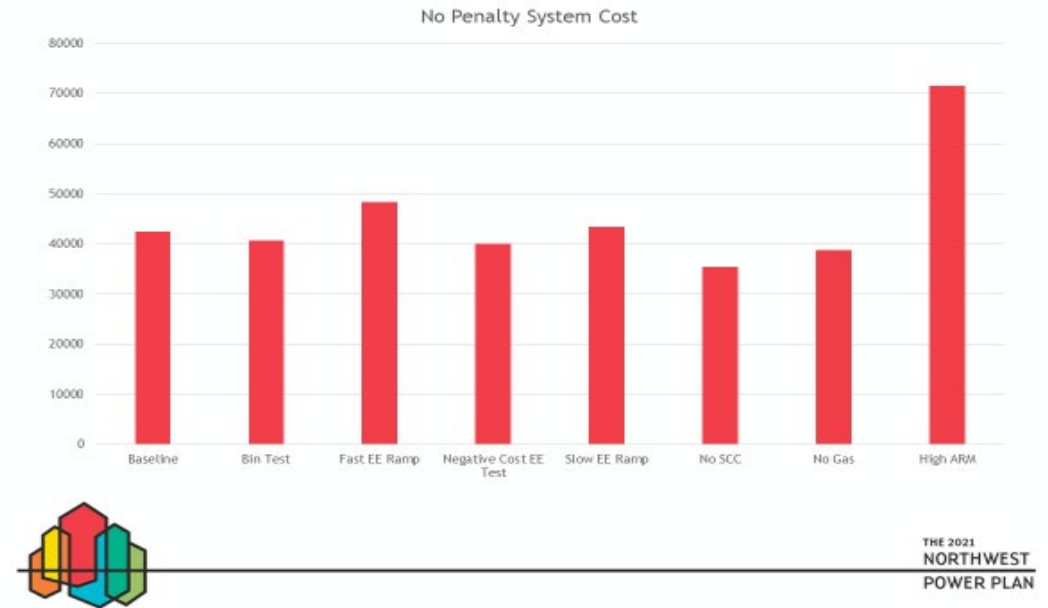
EE Level	2027 Acquisition	2041 Acquisition	Portfolio Cost (NPV)*
Low	342 aMW	1157 aMW	\$46.2B
Baseline	524 aMW	1501 aMW	\$46.4B
High	1606 aMW	2856 aMW	\$51.4B

*does not include adequacy penalties



Robustness of EE

- Increases in EE acquisition didn't reduce overall costs
- Many changes tested reduced acquisition, few increased it



Conclusions

- The amount of EE acquired is surprisingly sensitive to how the supply curves are assigned to bins and to how quickly the bins ramp
- Adequacy needs can drive higher EE acquisition but this tends to happen when other options have been exhausted in the current RPM setup
- System costs are extremely low, most of these NPVs translate to approximately 2 to 3 billion 2016 \$ fixed annual payment – the region currently spends around 14 billion 2016 \$ per year which includes some costs captured in these NPV figures
 - A similar calculation for the Seventh Plan scenario including the social cost of carbon translated to a 4.5 billion 2012 \$ fixed annual payment





Early Retirement of Coal Scenario

Proposed Coal Retirement Scenario: 2021 Power Plan

- Purpose: to analyze effect on resource strategies of 100% coal retirements in the region/WECC
 - What does this do to emissions, system cost?
 - What are the replacement resources?
 - How to maintain adequacy and reliability?
- High level parameters – Retire all coal by
 - **2027 for Region**
 - **2030 for WECC**

What is a **scenario** in the Council's Power Plan?



High-level questions help build a future **landscape** which we examine and compare to alternative outlooks to **learn** and create a narrative that informs the audience for the Power Plan



THE 2021
NORTHWEST
POWER PLAN



Region Assumptions: Retire all coal units by 2027

Coal Plant Unit	Nameplate Capacity (MW)	Announced/Existing Retirement Date (EOY)	Baseline Conditions*	Scenario: Early Retirement (EOY)
Colstrip Unit 1	358	2019	Retired	Retired
Colstrip Unit 2	358	2019	Retired	Retired
Boardman	601	2020	Retired	Retired
Centralia 1	730	2020	Retired	Retired
North Valmy 1	277	2019**/2021	Retired	Retired
Centralia 2	730	2025	2025	2025
North Valmy 2	289	2025	2025	2025
Jim Bridger 1	608	2023	2023	2022
Jim Bridger 2	617	2028***	2028	2026
Colstrip 3	778	--	2037	2025 (WA Legislation)
Colstrip 4	778	--	2037	2025 (WA Legislation)
Jim Bridger 3	608	--	2037	2026
Jim Bridger 4	608	--	2037	2026

Accelerated coal unit retirement

EOY = End of Year

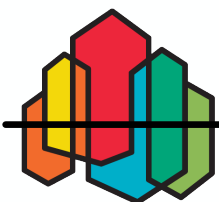
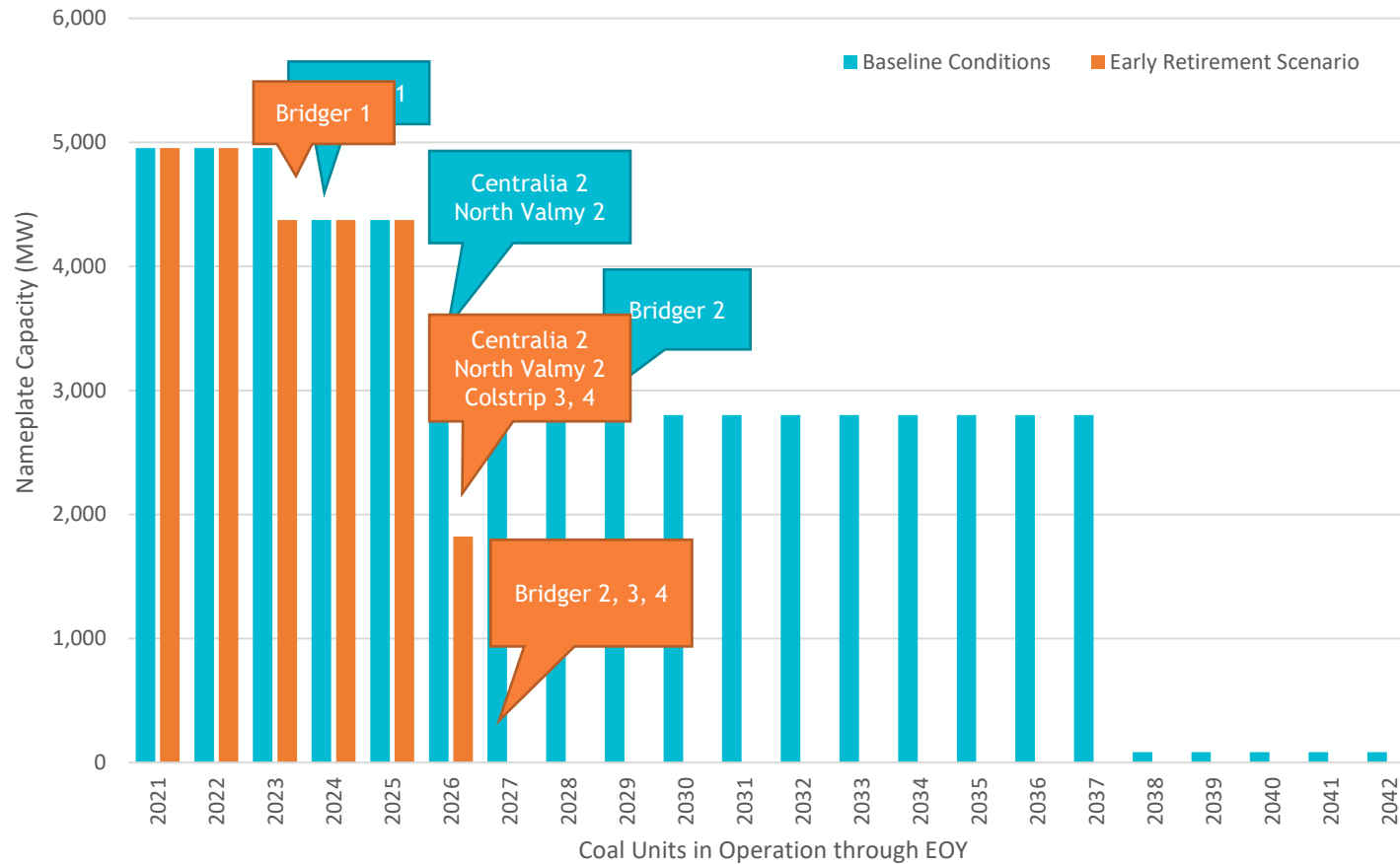
* Baseline conditions – announced retirement date or expected end-of-useful life estimate

** Idaho Power ended its participation in North Valmy 1 in 2019

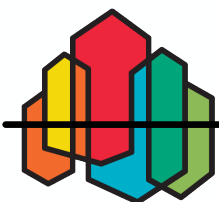
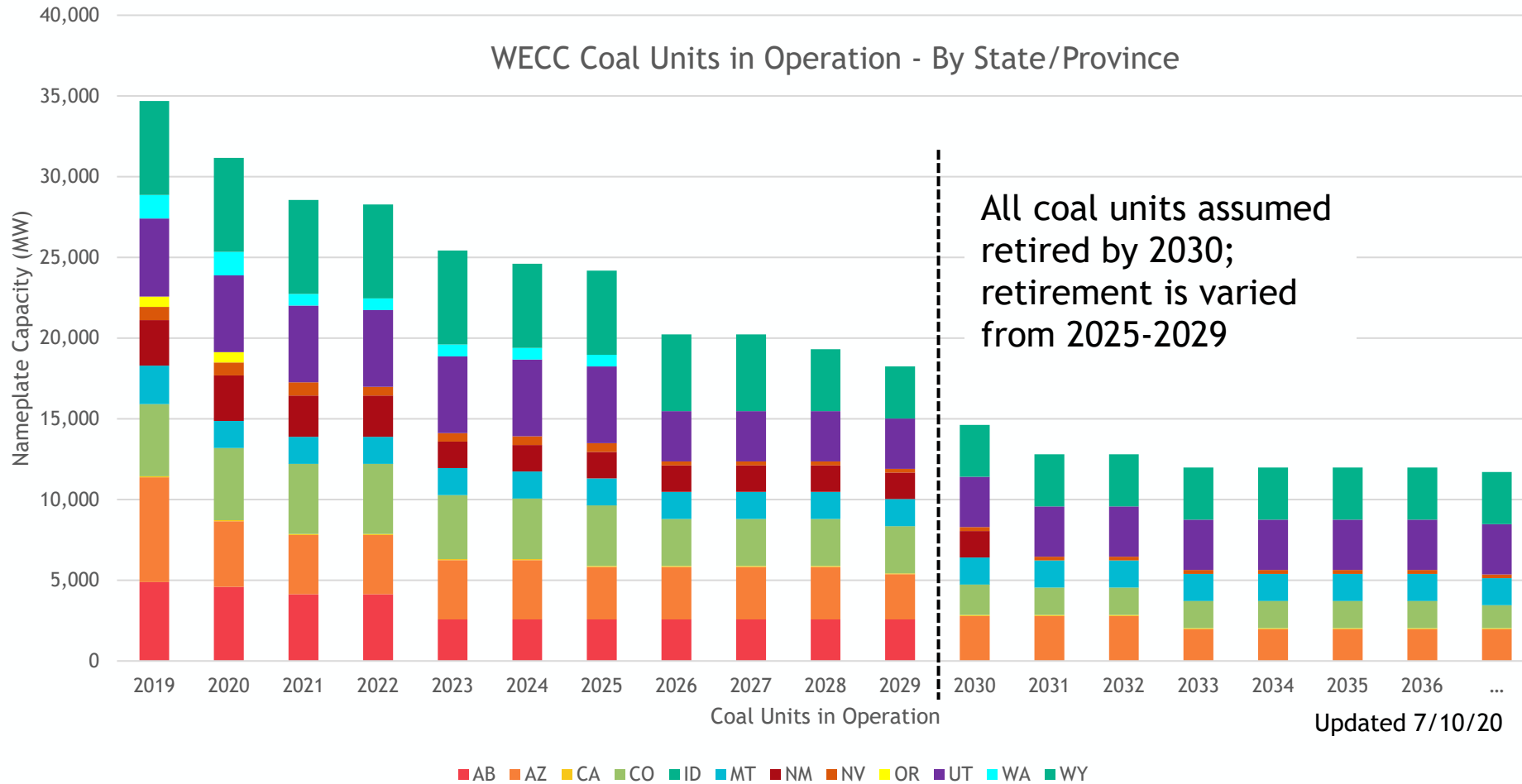
*** PAC and IPC still working out details of the accelerated retirement of Bridger 2, date could be considered tentative.



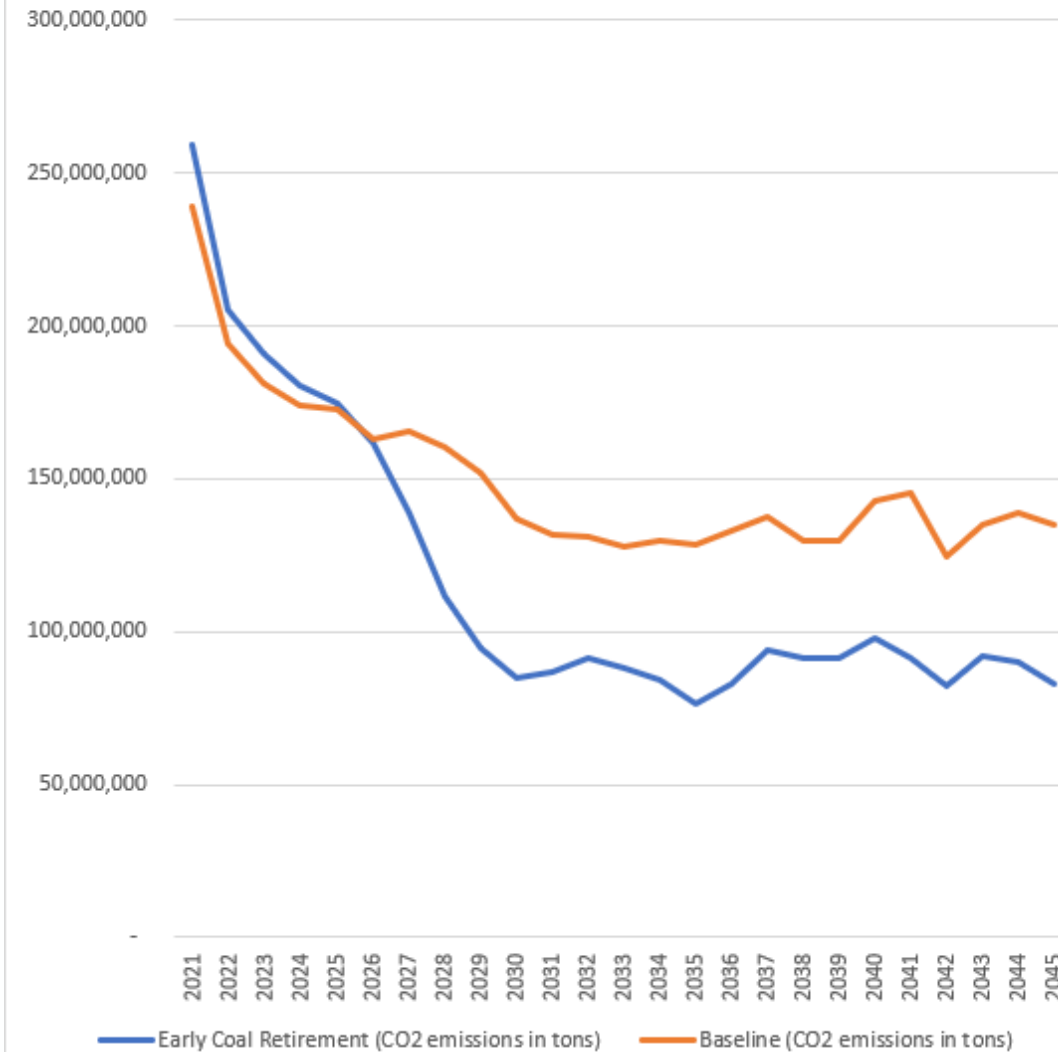
Coal Unit Retirements: Baseline Conditions vs. Early Retirement



WECC Assumptions: Retire all coal units by 2030



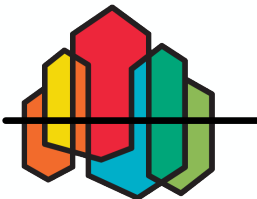
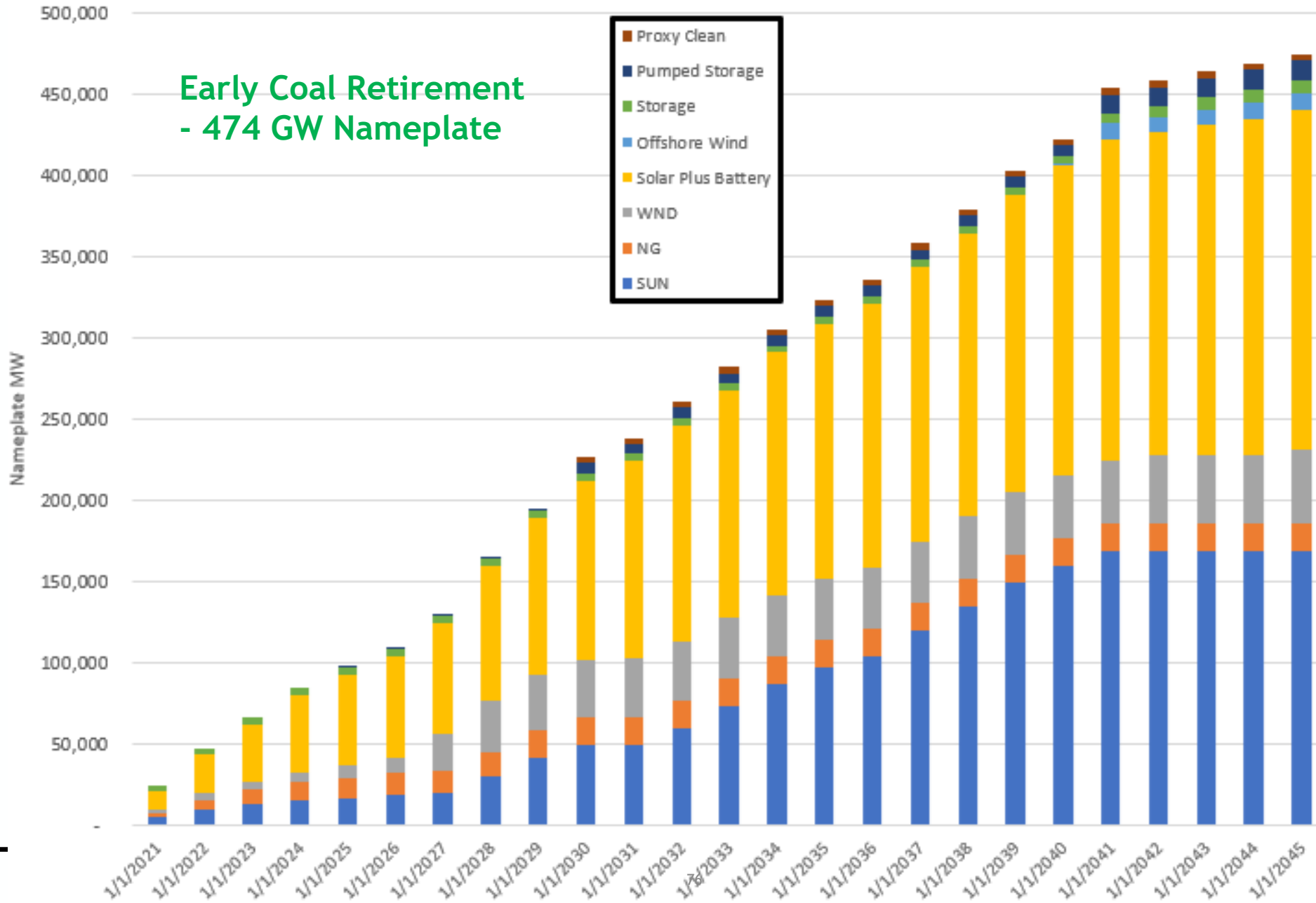
CO2 Emissions Comparisons



Emissions Drop By 38% in 2030 and by 39% in 2045



Buildout

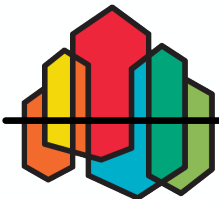
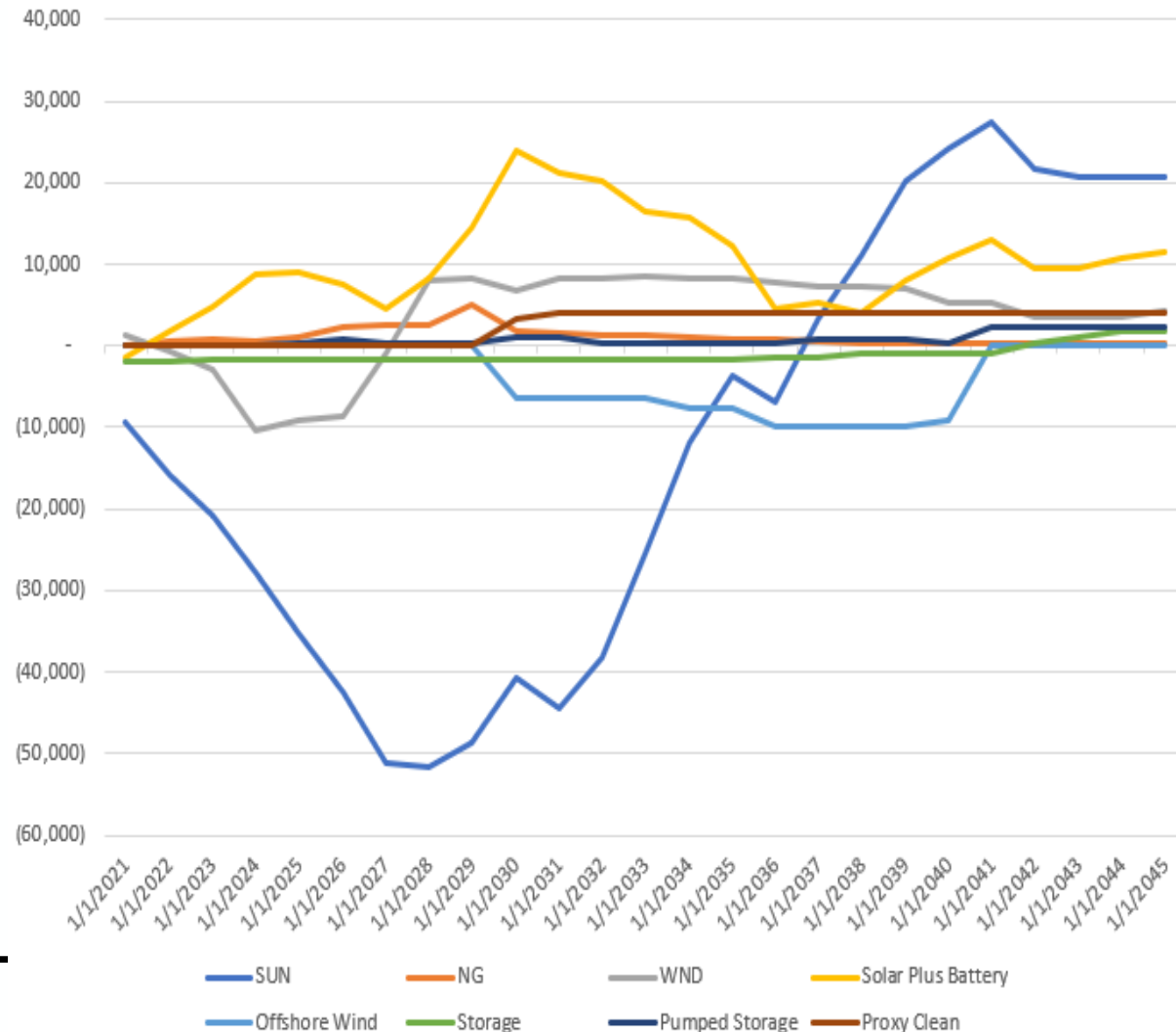


More Builds in a Coal Retirement Scenario

Observations:

1. Less solar early, more late, more solar plus battery.
2. Builds of offshore wind and storage deferred to later in study
3. Proxy clean resource builds in first year available.

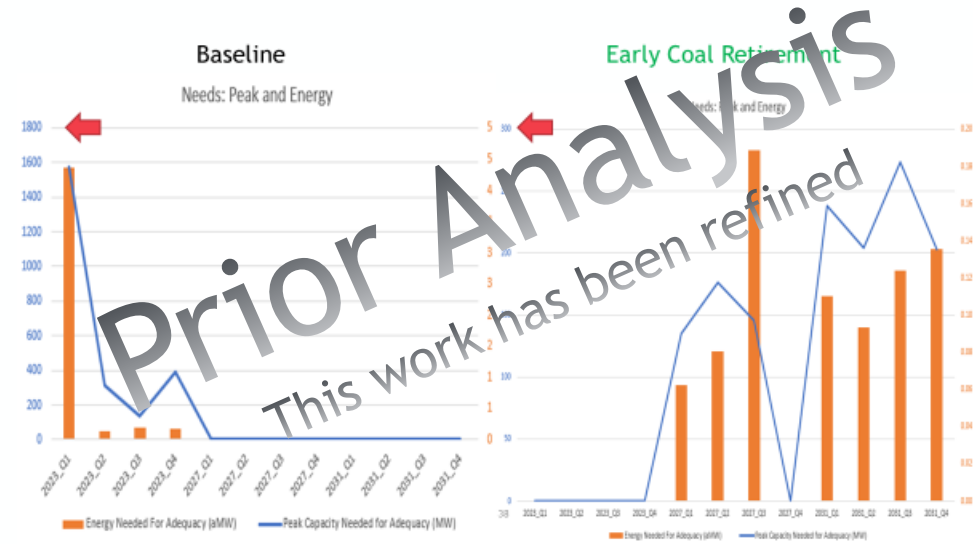
Buildout Comparison By Nameplate MW to Baseline



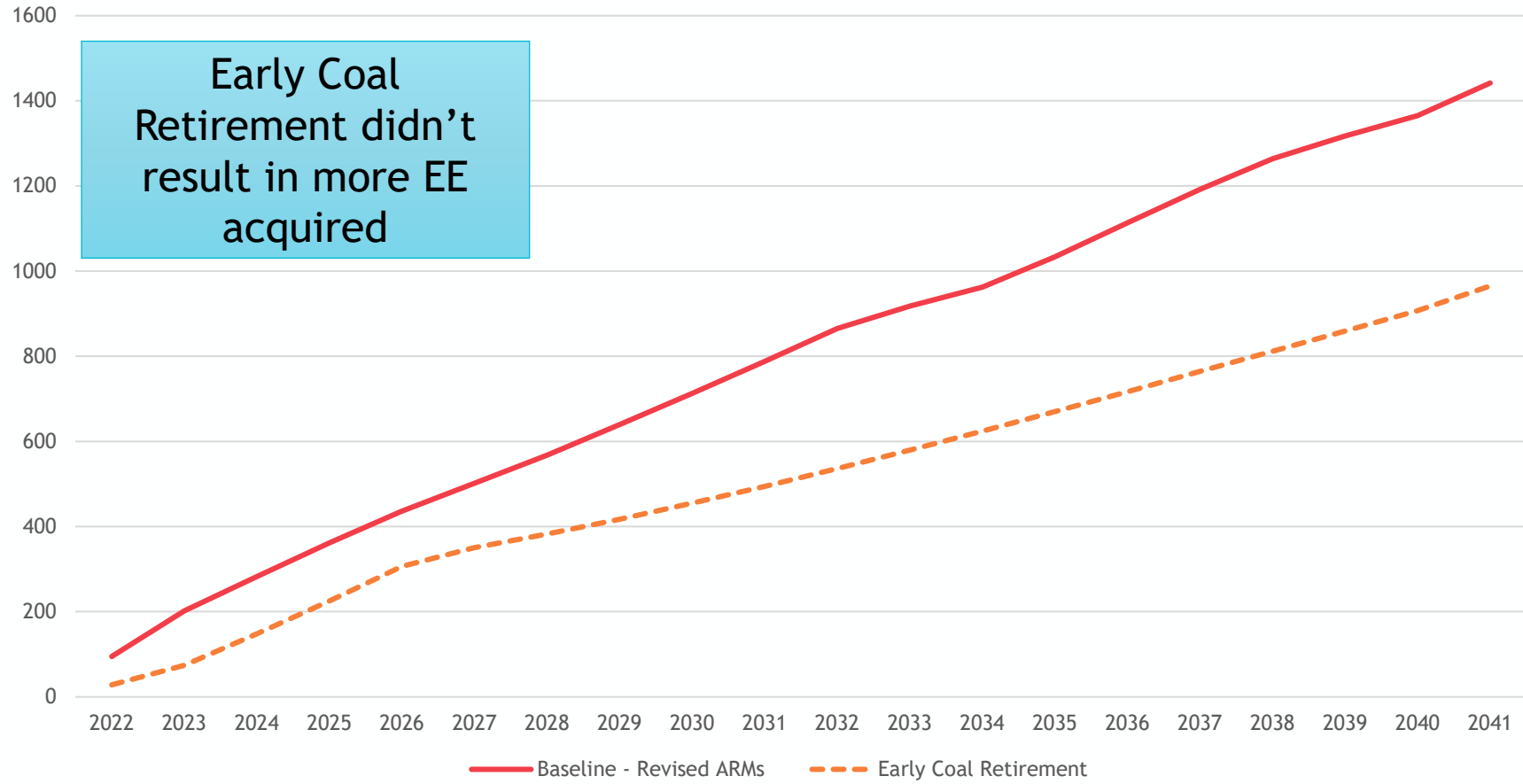
Retiring Coal Earlier Leads to Increased Resource Needs

- Additional resource needs in 2027 and 2031 relative to the baseline conditions
- Retirements external the region drive more renewables – but the difference to the region is likely not big because the baseline conditions build already represents a renewable saturated market

Decreased Needs Early, Increased Needs After Retirements



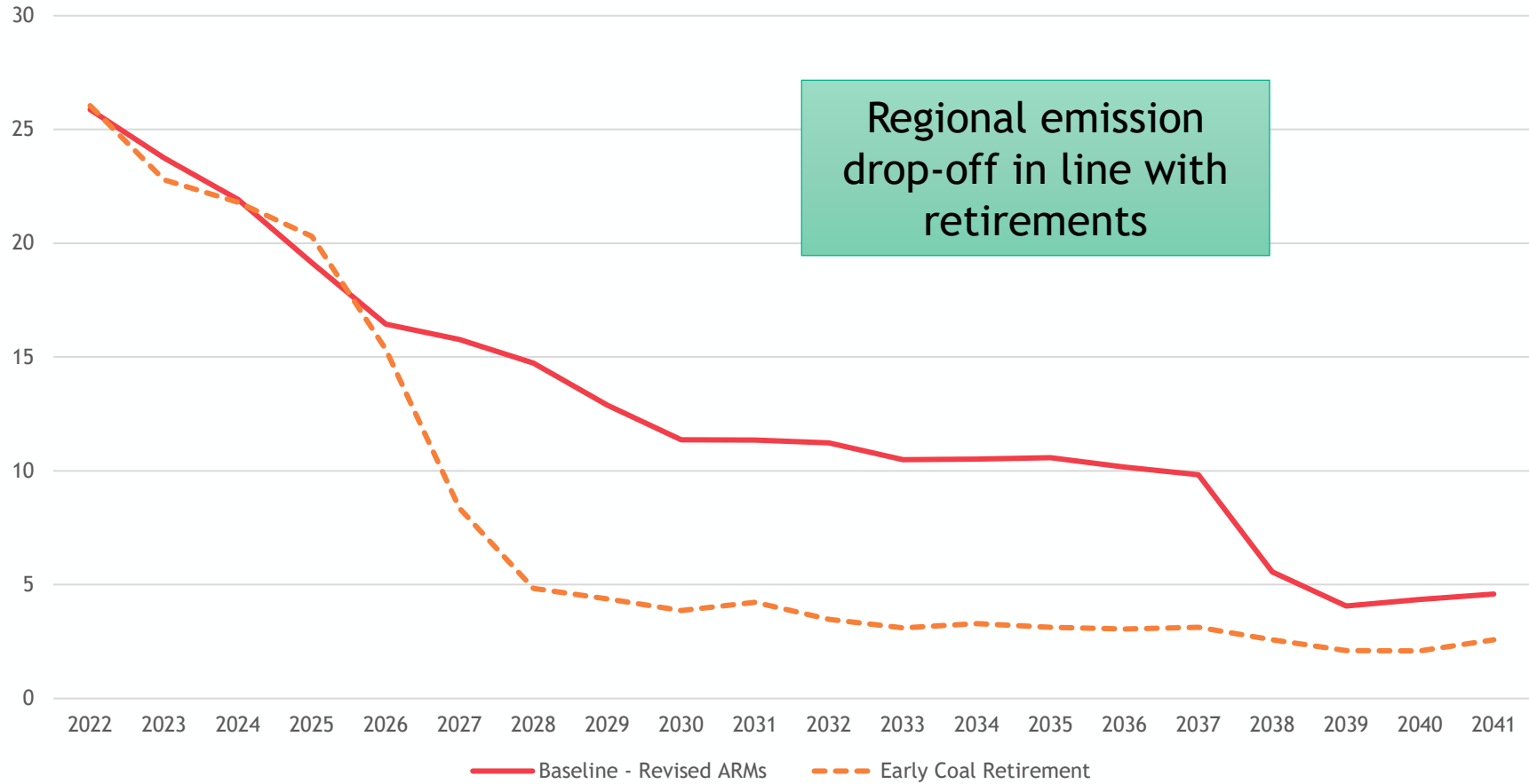
Average EE Acquired



Early Coal Retirement didn't result in more EE acquired



Average GHG Emissions (MMT)



The image features a large, light pink, irregular polygonal shape that dominates the upper and middle portions of the frame. Below this, there are three smaller, overlapping shapes: a small yellow trapezoid on the left, a medium orange trapezoid in the center, and a larger yellow trapezoid on the right. The text 'Increased Market Reliance' is centered horizontally across the lower part of the pink shape.

Increased Market Reliance

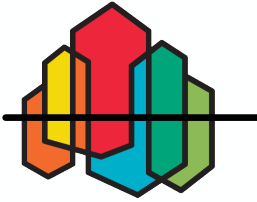
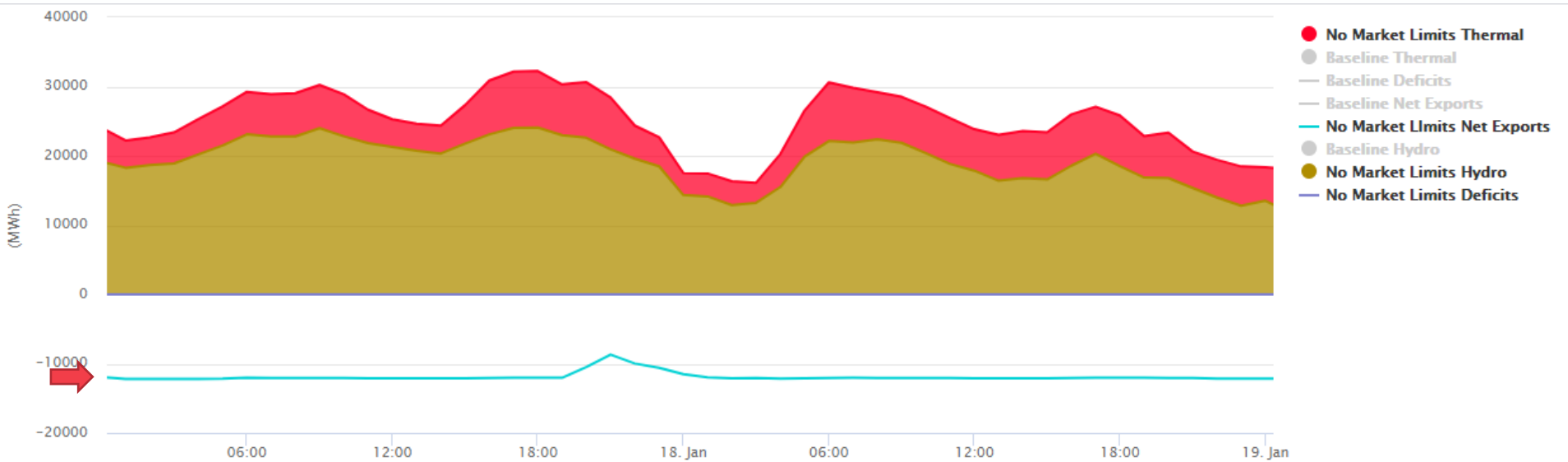
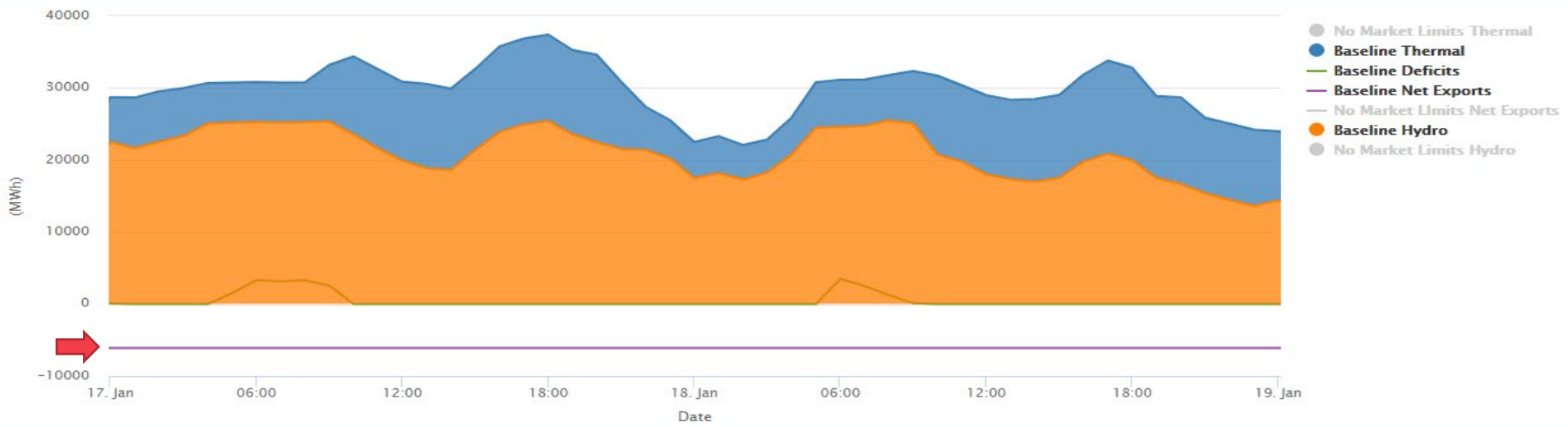
Increased Market Reliance Results

Increasing the regions reliance on the external market:

- Eliminates all regional needs due to adequacy*
- Decreases residential bills on average by 1.7%
- Decreases the no penalty NPV by 13.1%
- Substantial changes in resource builds tend to be in Demand Response and thermal resources

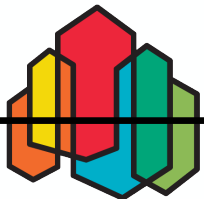
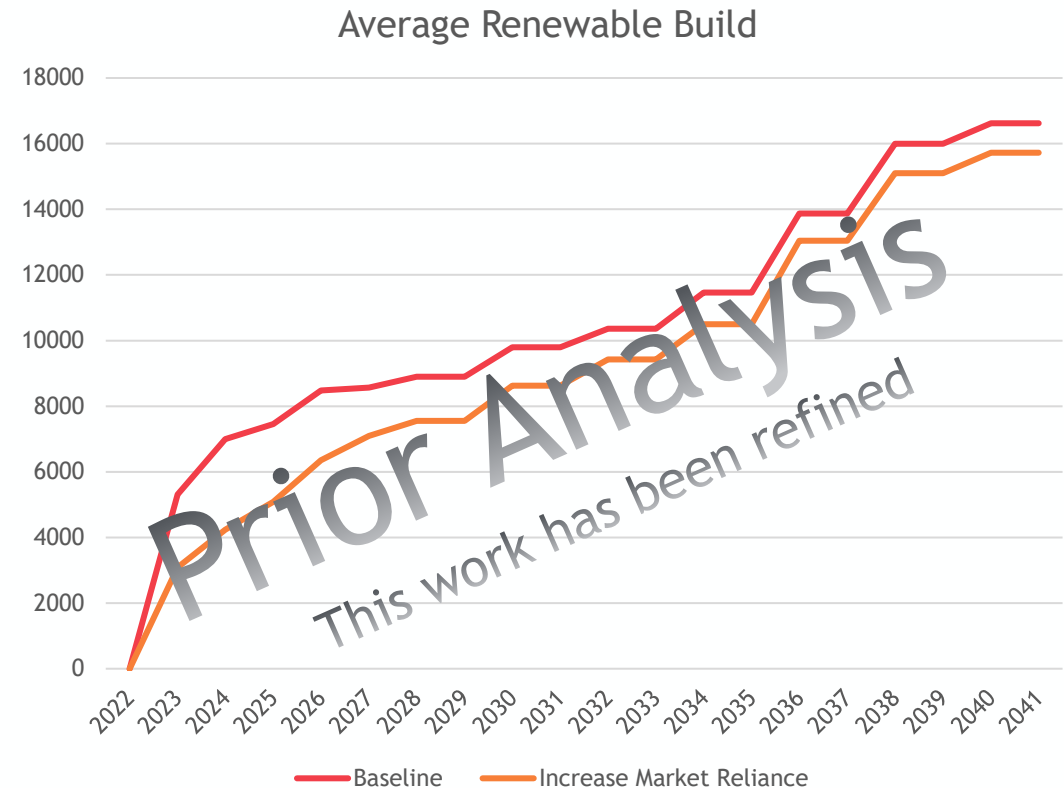


Winter Example: Increasing Market Reliance Reduces Deficits **Directly**



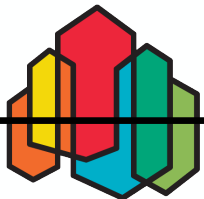
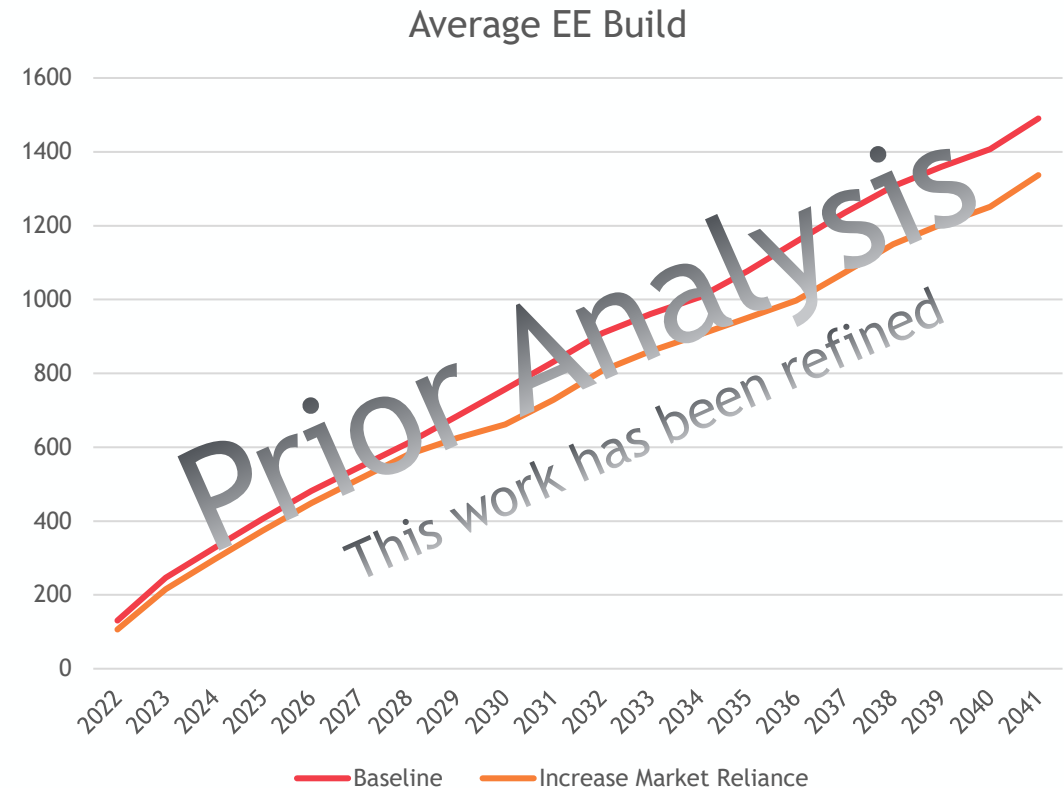
Increasing Reliance on the External Market Reduced Renewable Builds

- Limiting our reliance on other regions generally means we build more resource, this results was not surprising



Increasing Reliance on the External Market Also Slightly Reduced EE Acquired

- Also not surprising and consistent with similar results from the 7th Plan

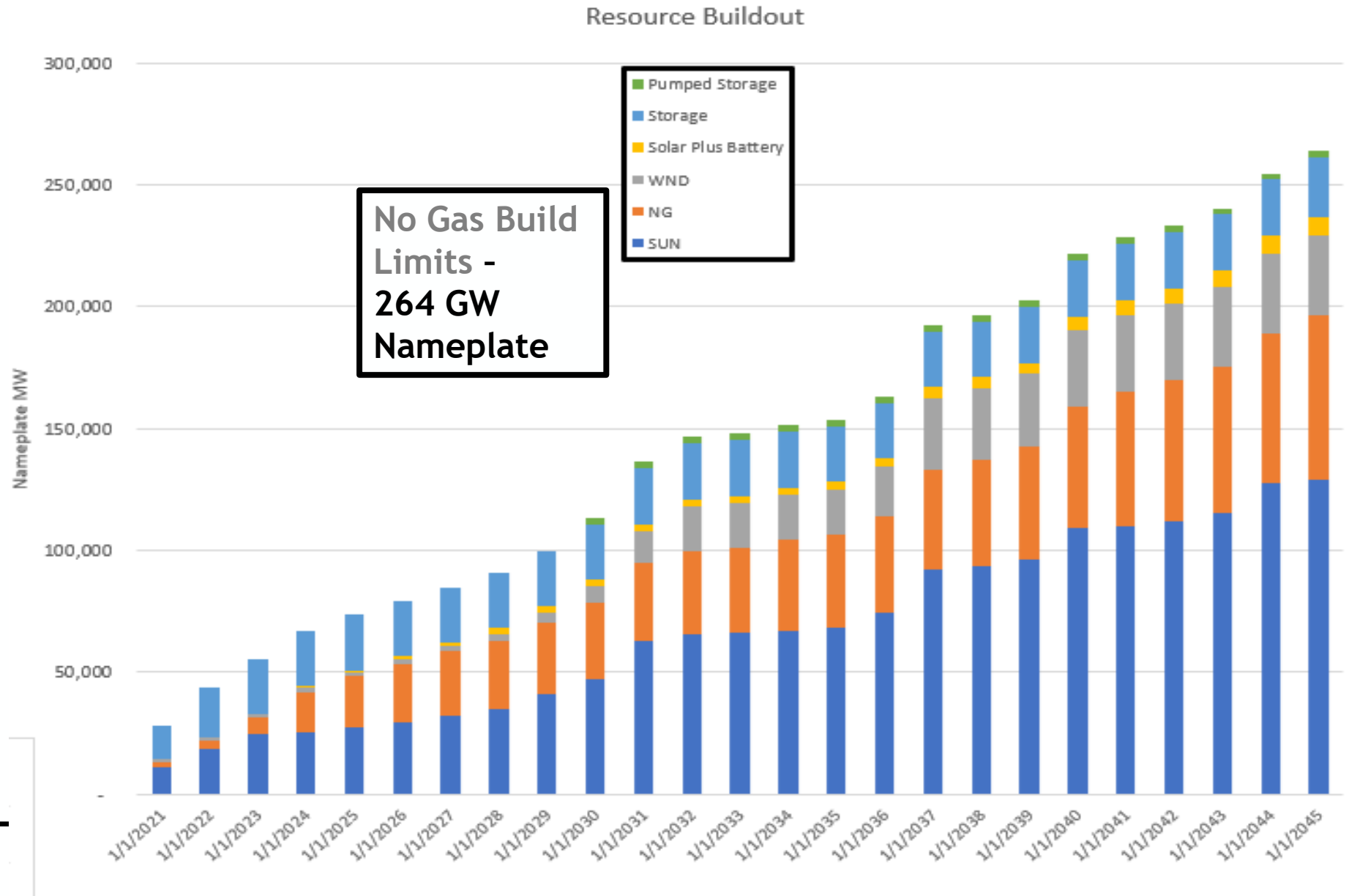




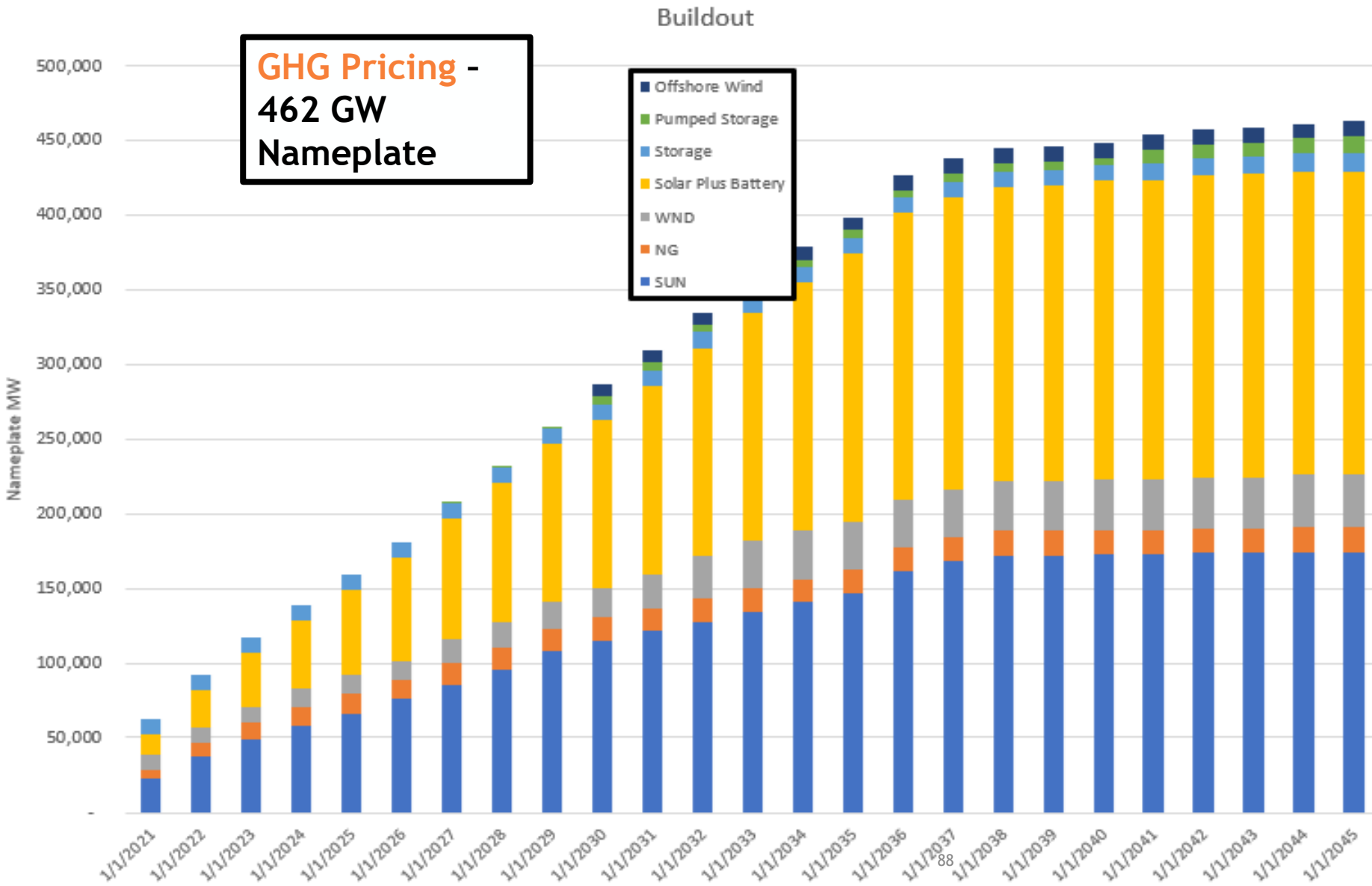
Greenhouse Gas Tipping Points

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



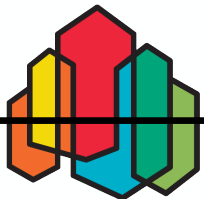
1. Planning reserve margins are mostly met
2. Clean/RPS Policies met until 2037

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

Solar shows up in a major way regardless of GHG inputs

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



WECC

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



WECC

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



Buildout Discussion

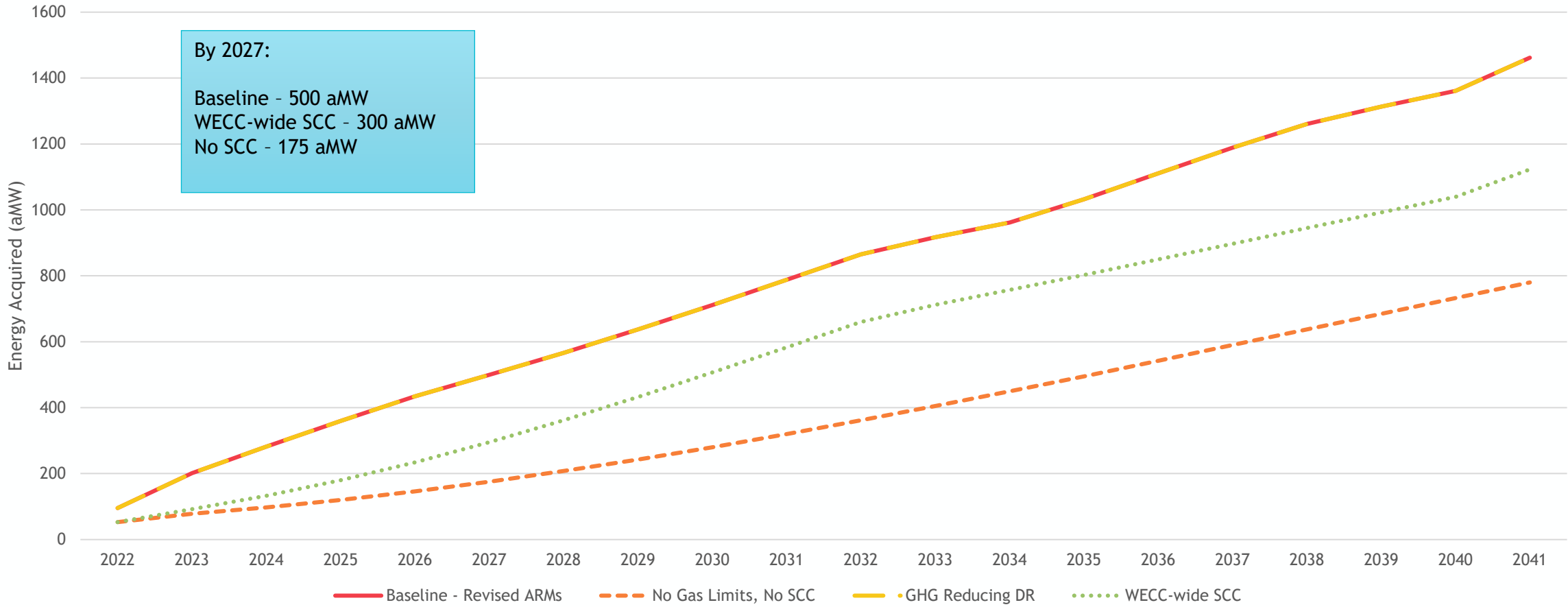
- No gas build limit buildout has 67 GW of gas at the end of the study, and overall build is 165 GW less than baseline.
- Buildout with **GHG pricing** in the dispatch WECC-wide is 33 GW larger than the baseline, and leans even more on solar and short duration storage.
- Both sensitivities are almost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



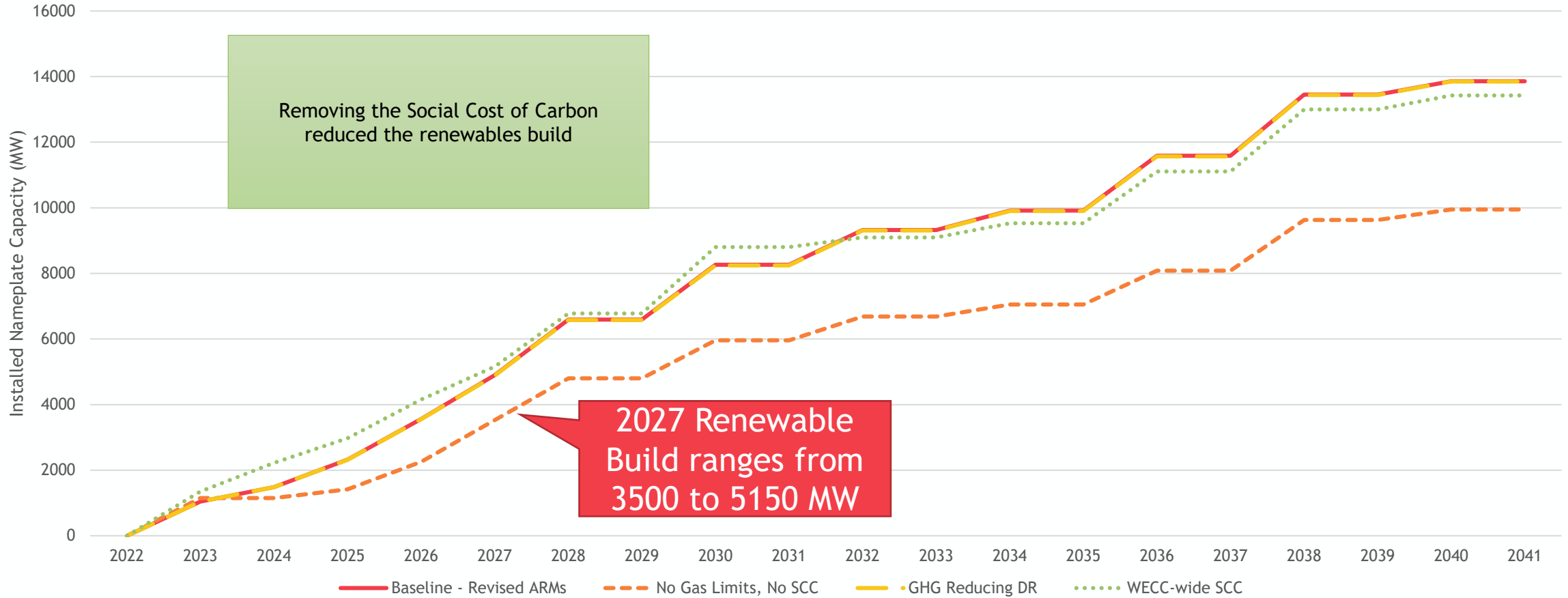
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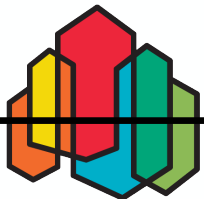
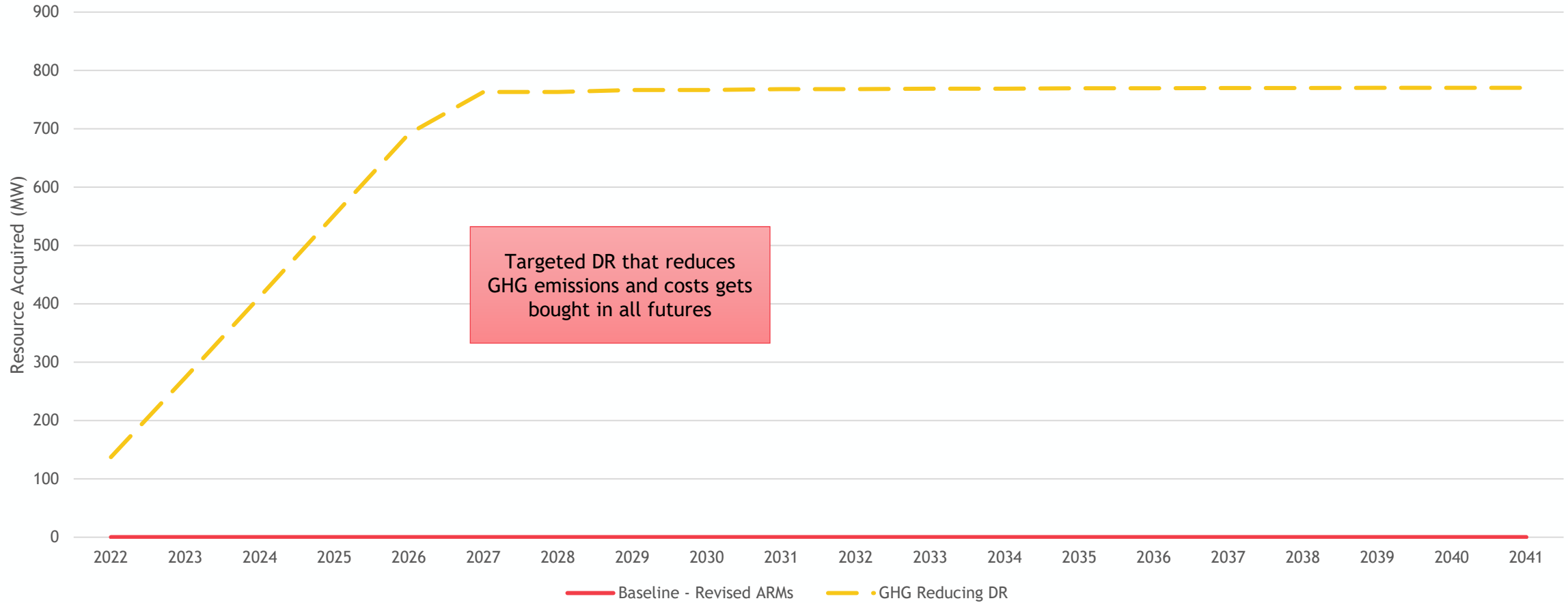
Energy Efficiency Acquisition Comparison



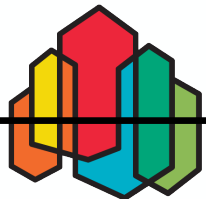
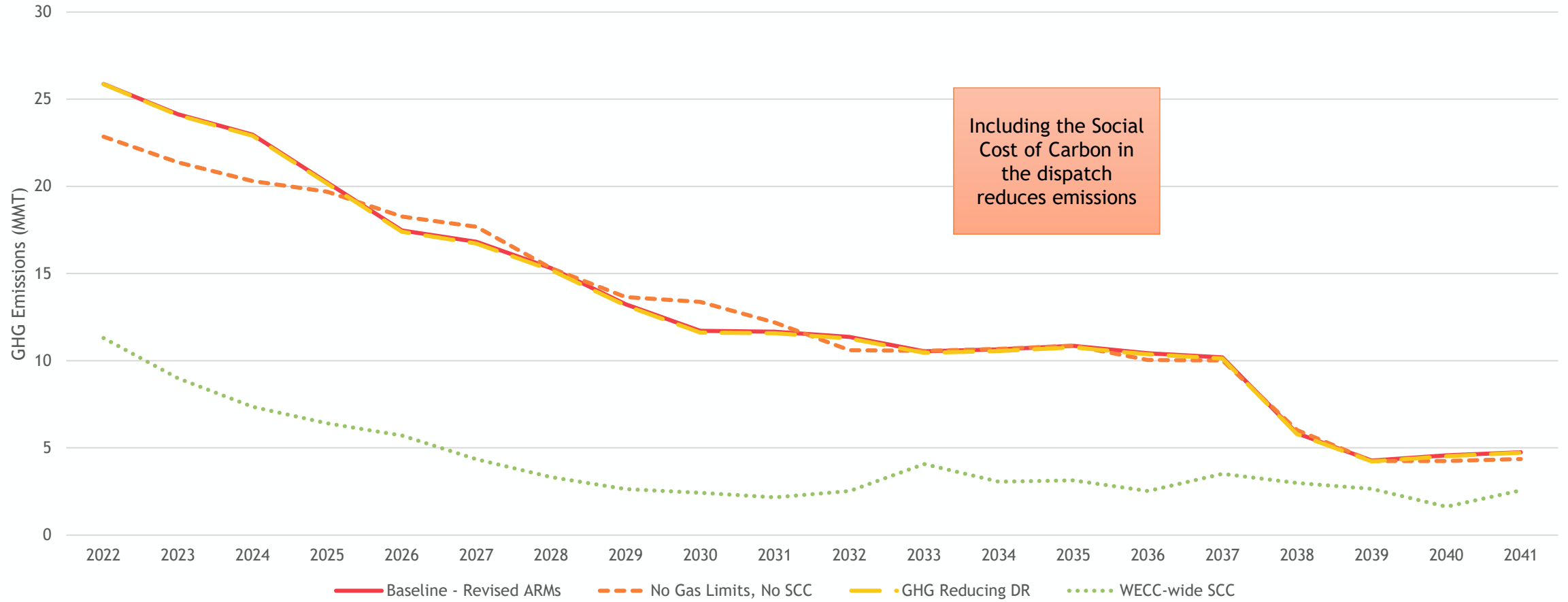
Average Renewable Build



Average Demand Response Acquired



GHG Emissions Comparison



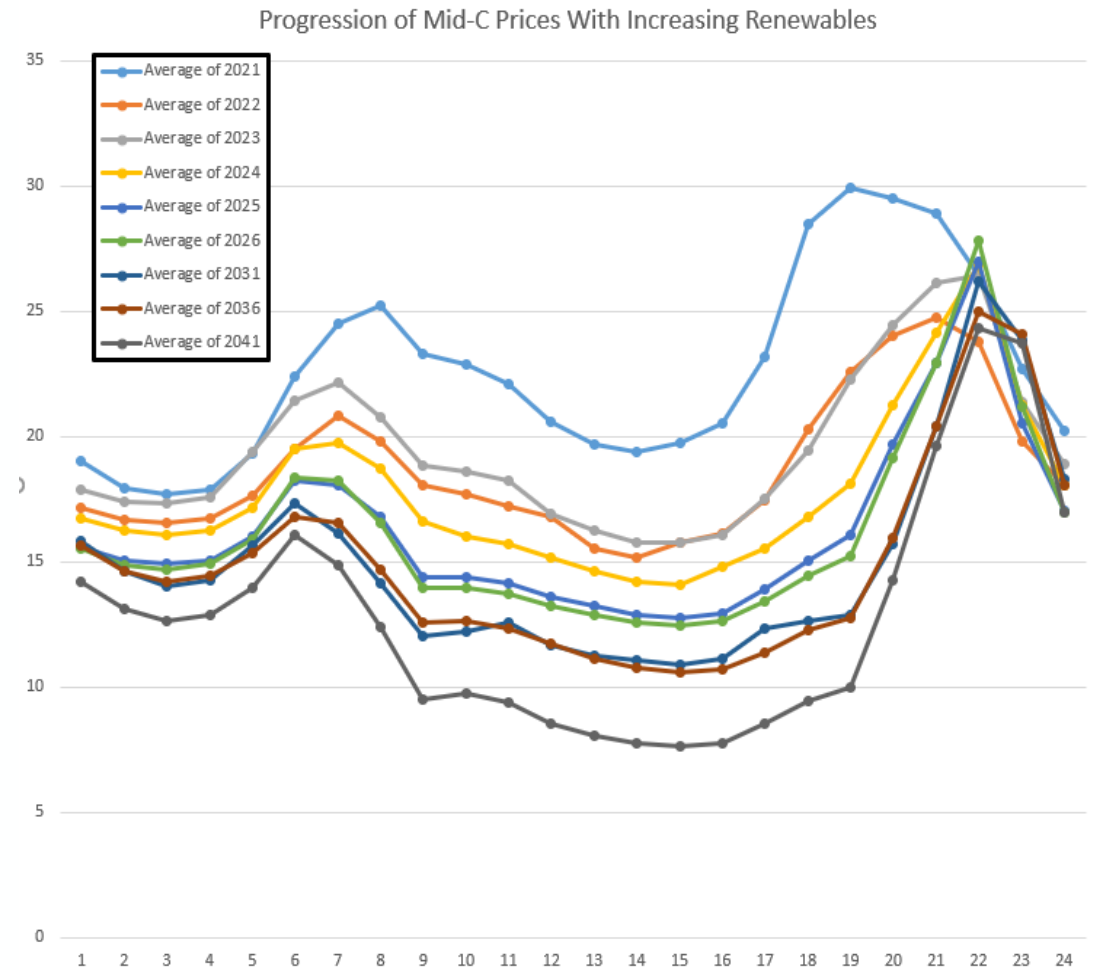


Demand Response Re- Binning Sensitivity

Reduce peak emissions by changing binning strategy

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.



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

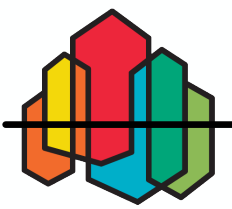
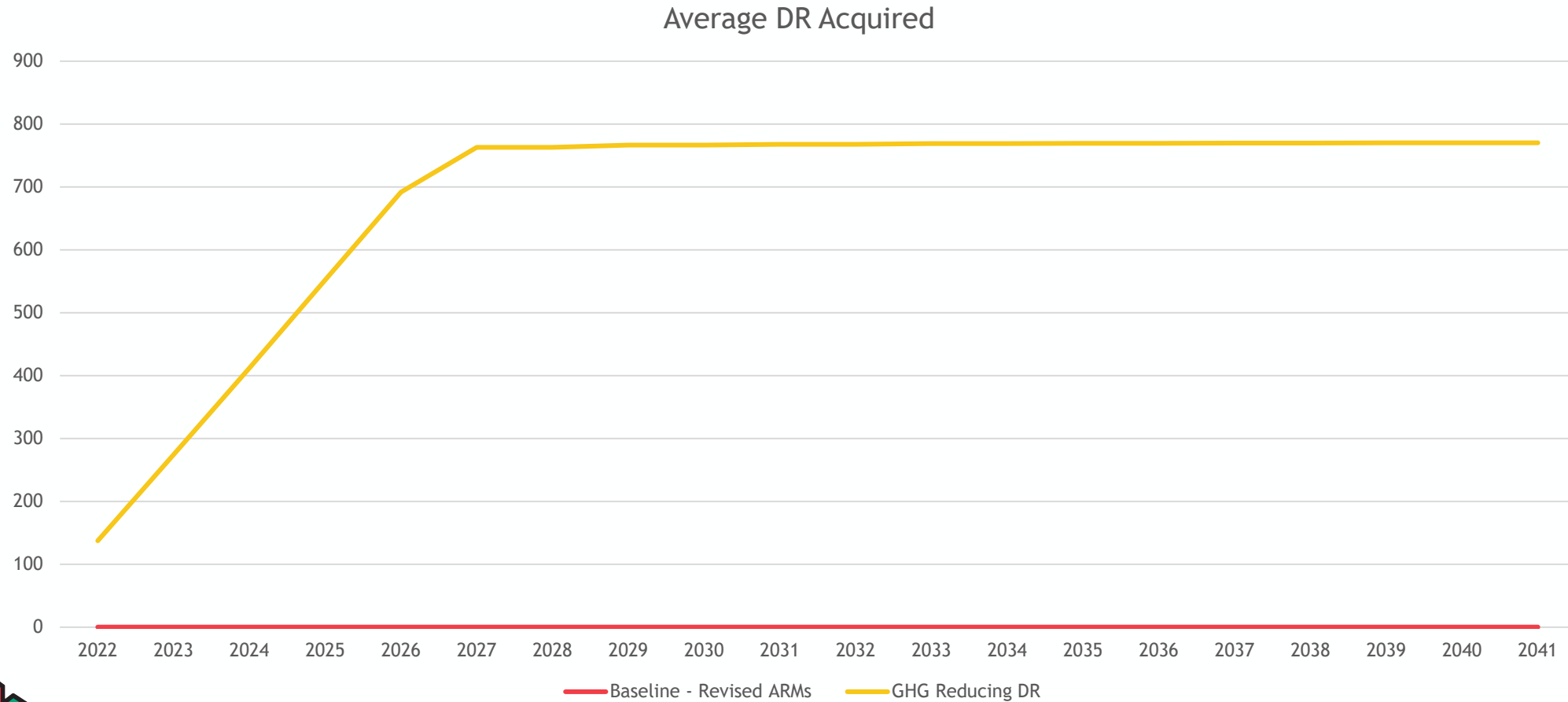


High-level Results

- 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



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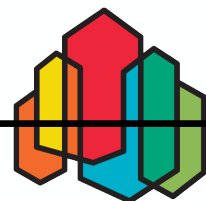
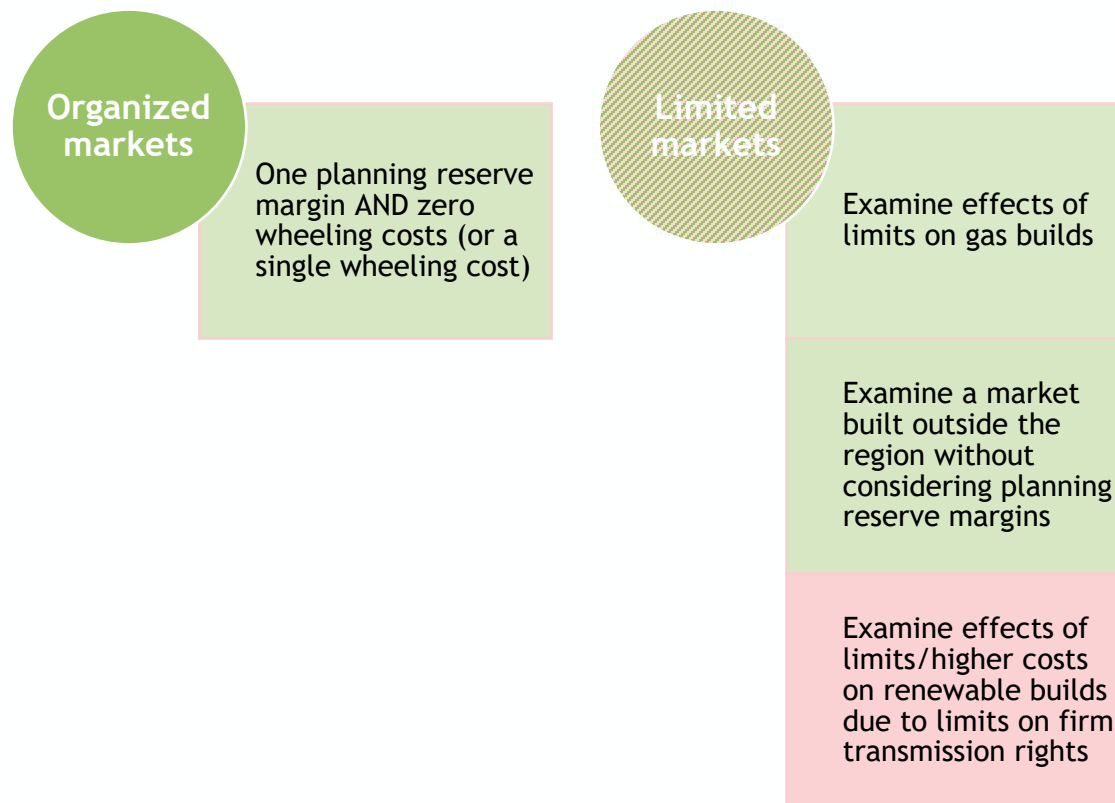




Markets for Energy and Capacity

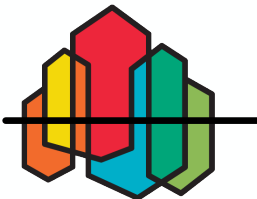
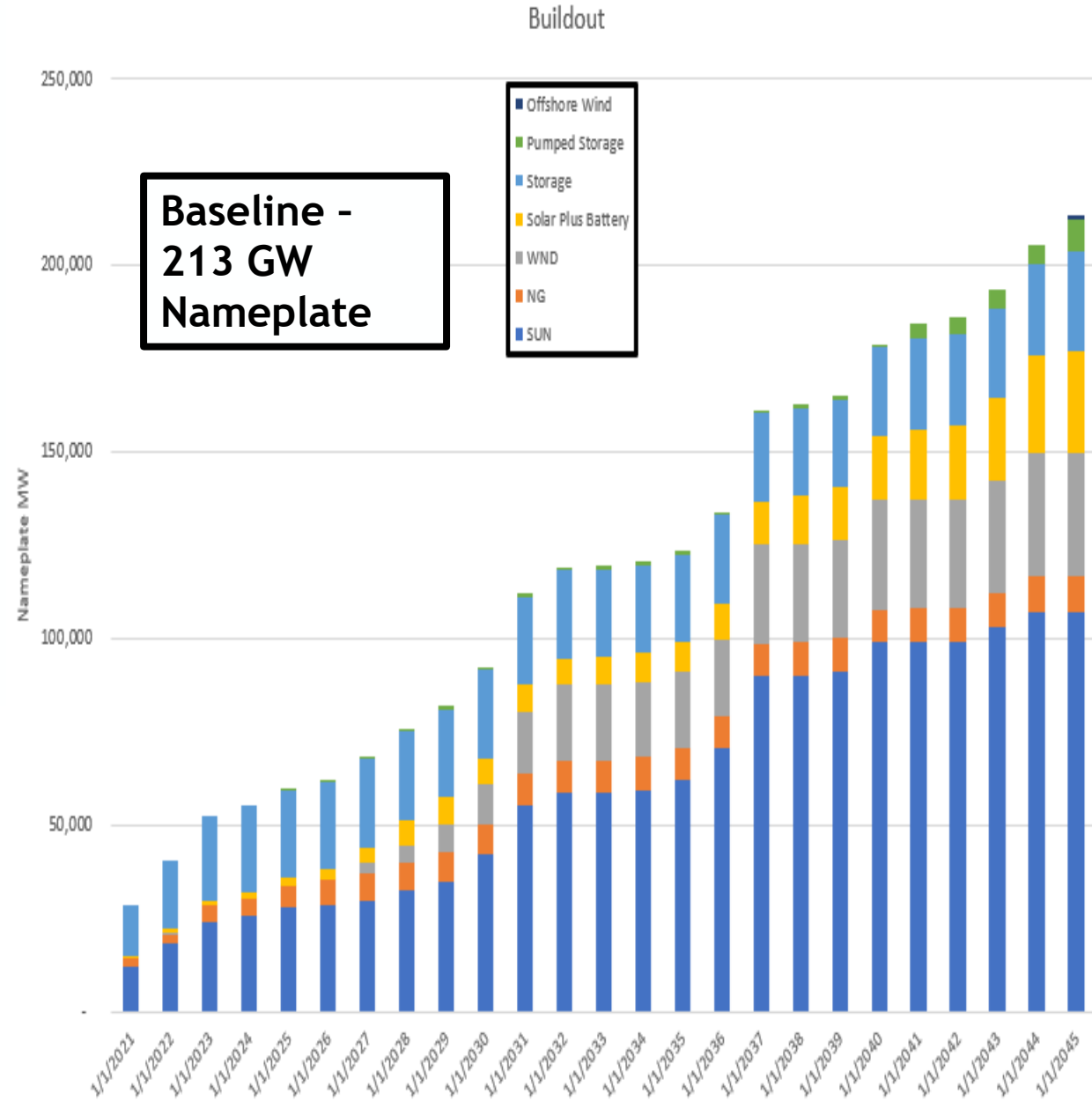
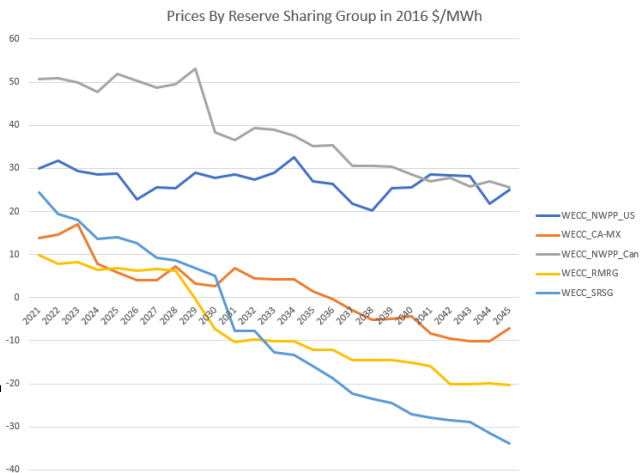
Scenario Description

- Examine the impact on the resource strategy of organized or limited markets under different fundamental, structural and regulatory assumptions.
- We will also estimate changes to adequacy, market and reserve requirements where appropriate.

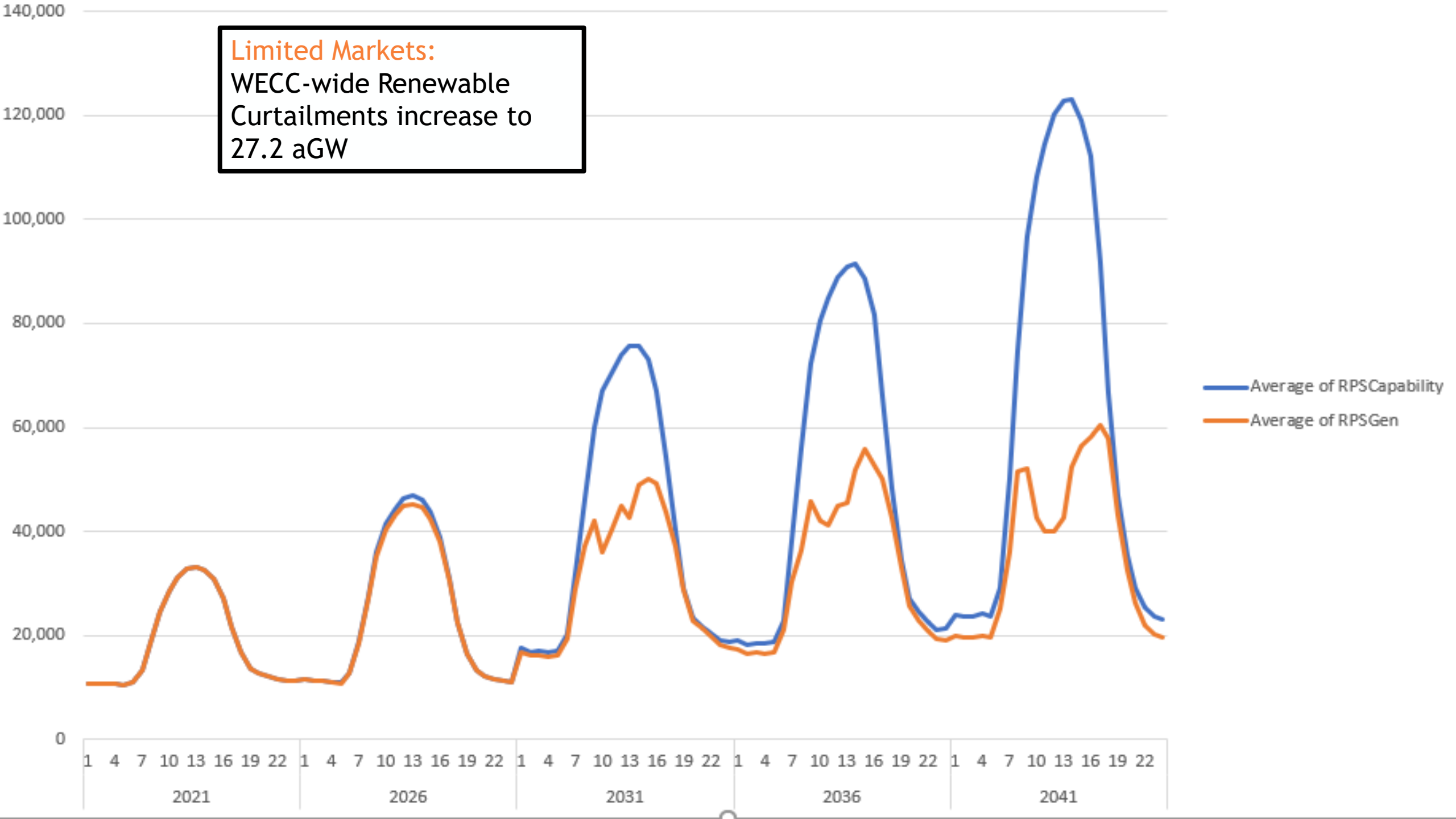


Limited Market (No PRM)

1. Planning reserve margins are missed nearly immediately primarily in California.
2. Clean/RPS Policies met until 2030
3. Prices are low in non-NWPP regions, but volatile

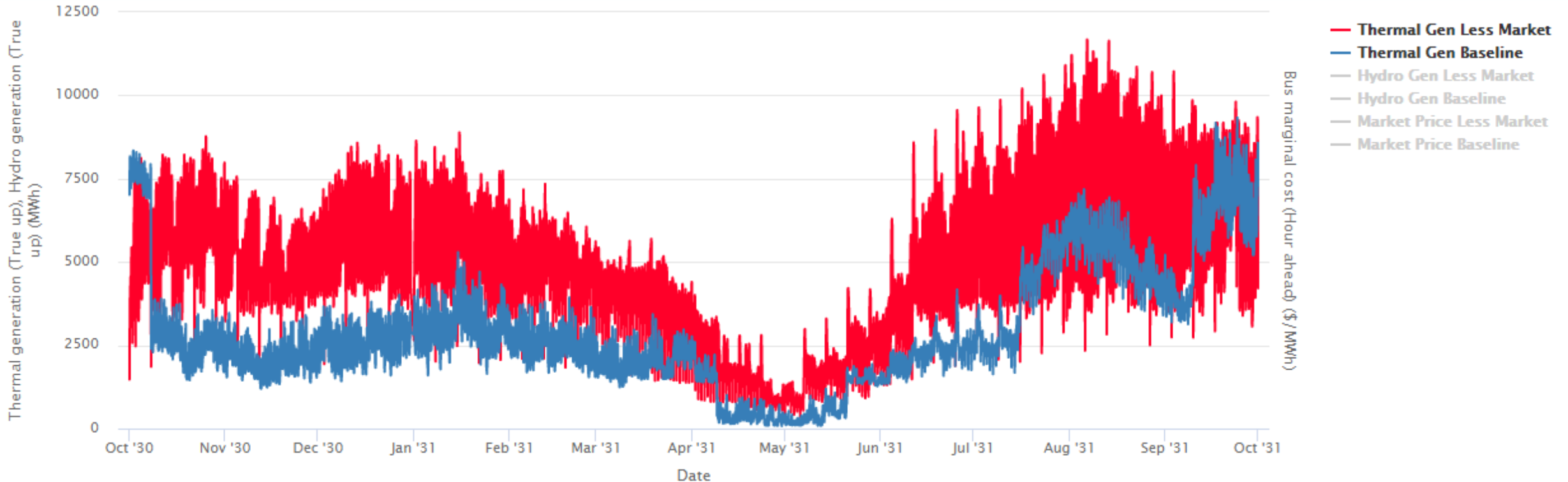


Limited Markets:
WECC-wide Renewable
Curtailments increase to
27.2 aGW

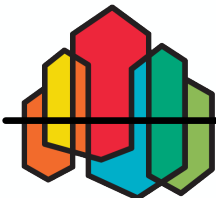


Why Did the Limited Market Not Have More Needs?

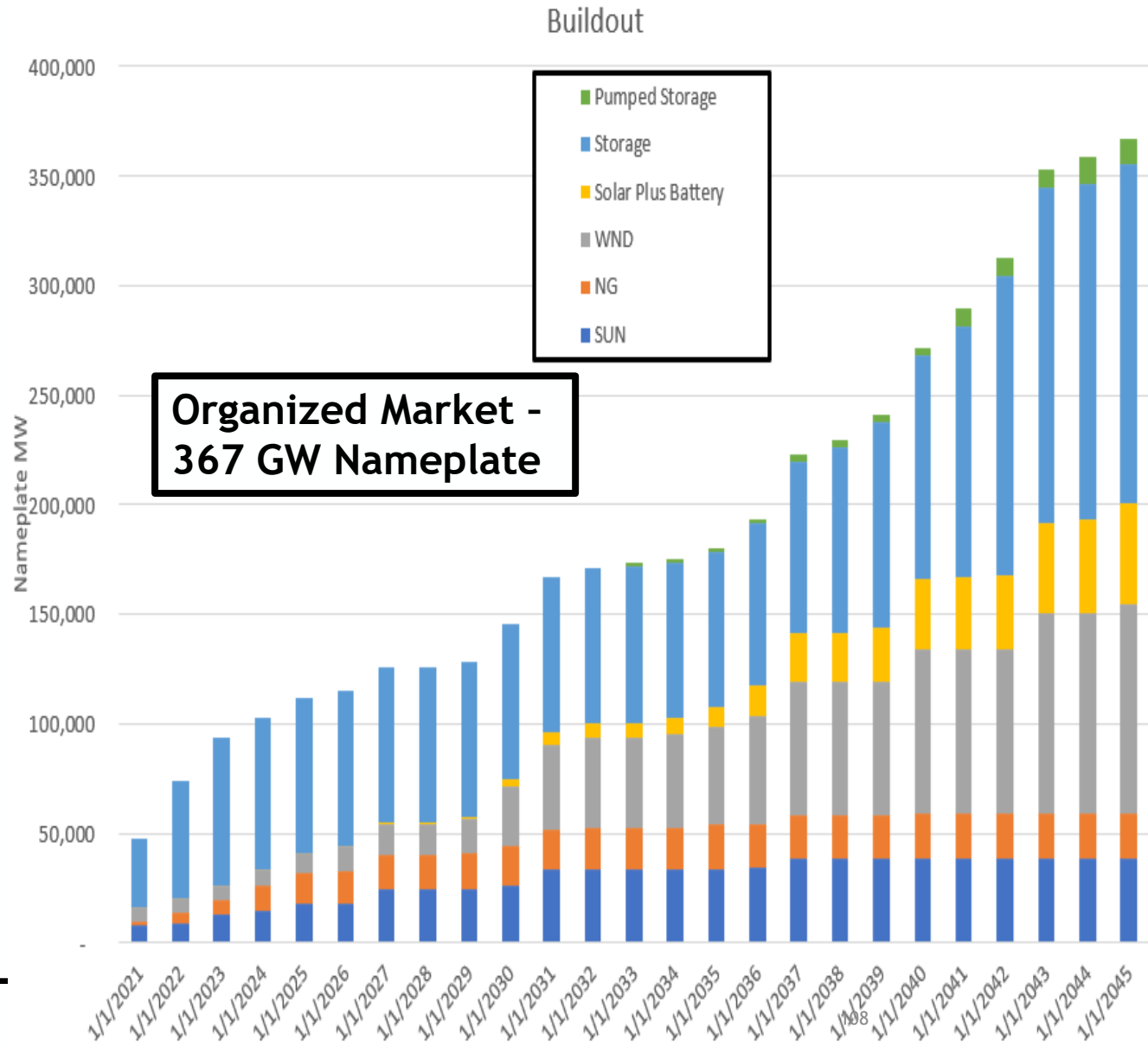
The Commitment of Thermals



Higher prices means more thermal units are committed, which positions the regional fleet better for adequacy issues.

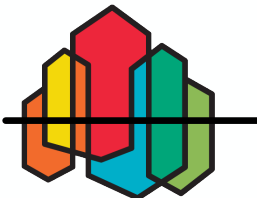
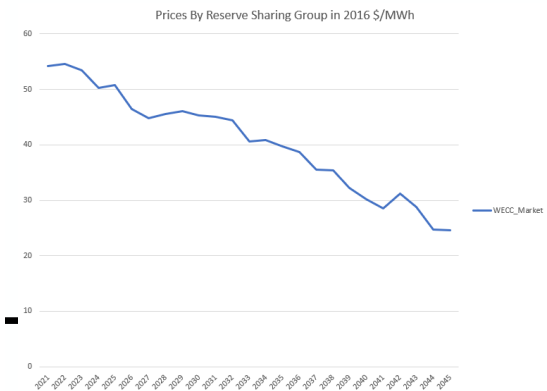


Organized Market (preliminary results)

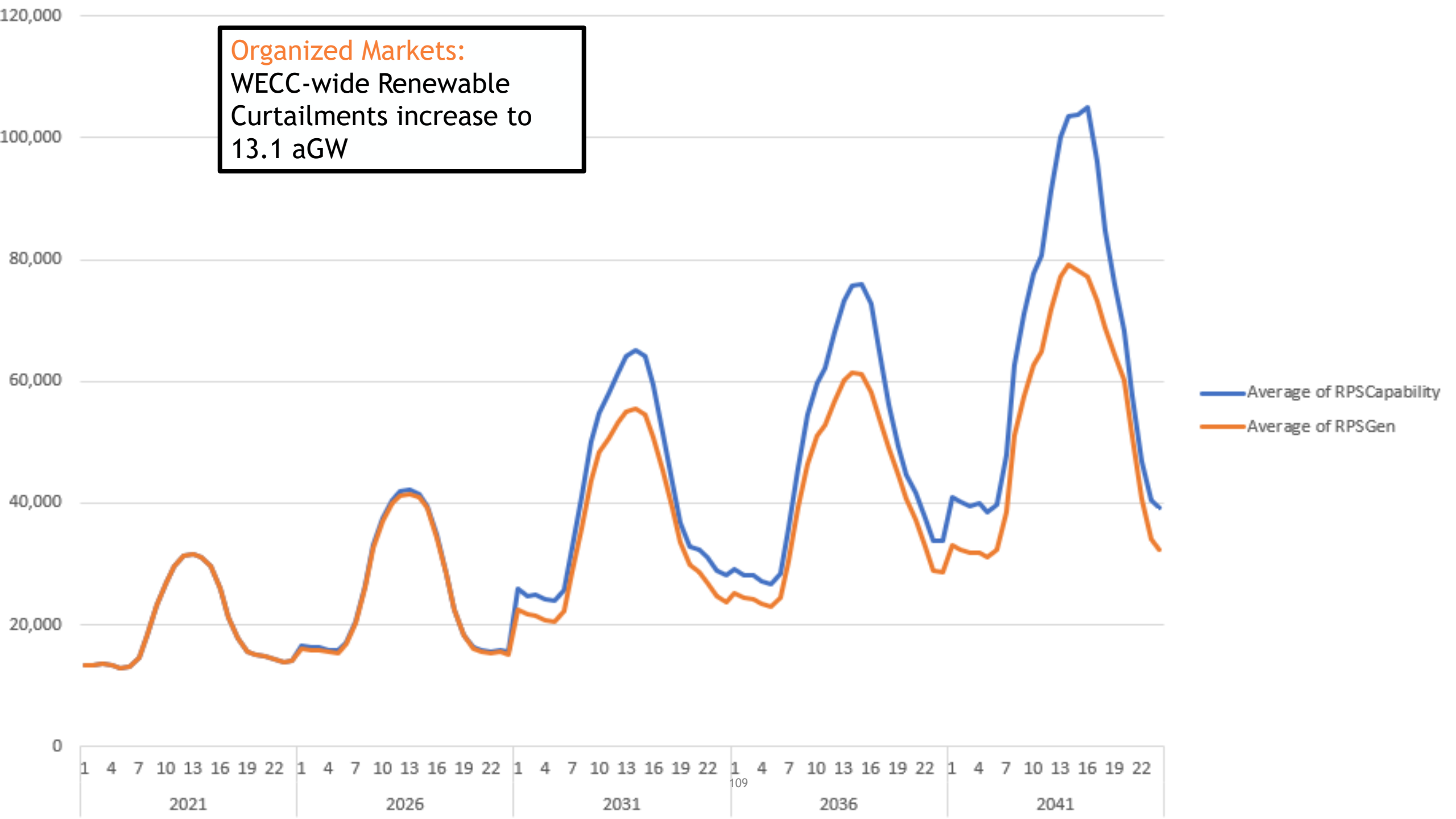


Simulated market starts in 2021

1. Planning reserve margins are met consistently, but system not adequate
2. Clean/RPS Policies met until late 2020s
3. WECC Prices drop

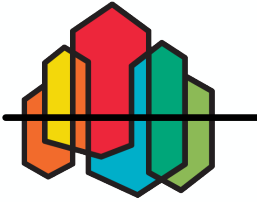
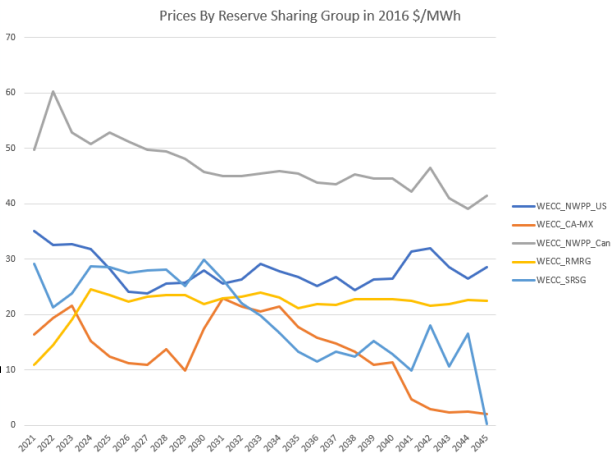
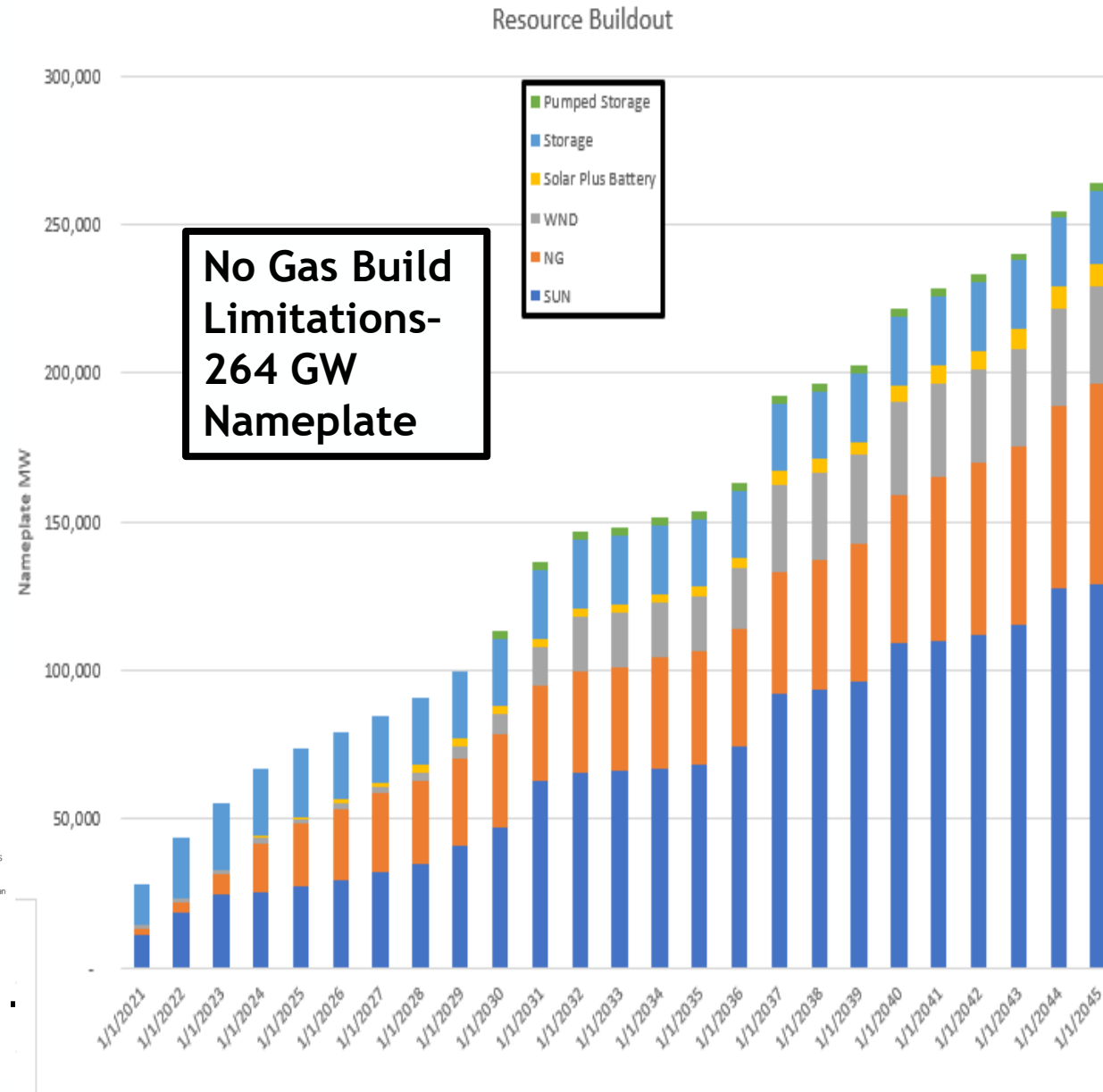


Organized Markets:
WECC-wide Renewable
Curtailments increase to
13.1 aGW



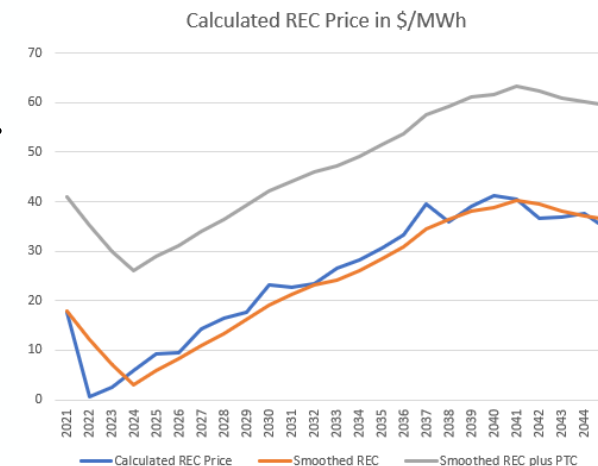
No Gas Build Limitations

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



Caveats About Market Studies

- Baseline build is adequate throughout study, all the rest of the builds are less adequate.
 - Adequate in the context of AURORA means minimal or zero load control events.
- Baseline build meets RPS and Clean constraints until late 2030's with current REC price forecast, the rest of the builds **have significant risk of missing clean targets persistently.**
 - Higher prices enforcing clean credit than RECs
 - Load shifting to time of clean energy use



Solar and Solar Plus Storage Build Comparisons

Year	Baseline	Organized	Limited	No Gas Limit
2025	51,538	17,878	27,742	27,183
2030	89,838	26,374	42,077	47,270
2035	100,357	34,003	61,830	68,357
2040	135,054	38,629	98,642	109,221
2045	147,554	38,631	107,032	128,886

Year	Baseline	Organized	Limited	No Gas Limit
2025	46,600	48	1,907	1,041
2030	86,600	3,018	7,098	2,445
2035	145,500	9,140	7,860	2,954
2040	179,800	32,512	17,041	6,008
2045	198,000	46,488	27,598	7,167



WECC

Battery and Pumped Storage Build Comparisons

Year	Baseline	Organized	Limited	No Gas Limit
2025	6,004	70,984	23,491	22,846
2030	6,004	70,984	23,558	22,846
2035	6,004	70,984	23,690	22,846
2040	6,004	101,951	23,974	22,846
2045	6,055	154,270	26,622	24,773

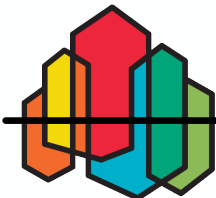
Year	Baseline	Organized	Limited	No Gas Limit
2025	0	0	400	0
2030	4,900	0	800	0
2035	5,650	1,500	800	2,700
2040	6,050	3,400	800	2,700
2045	9,690	11,940	8,440	2,700



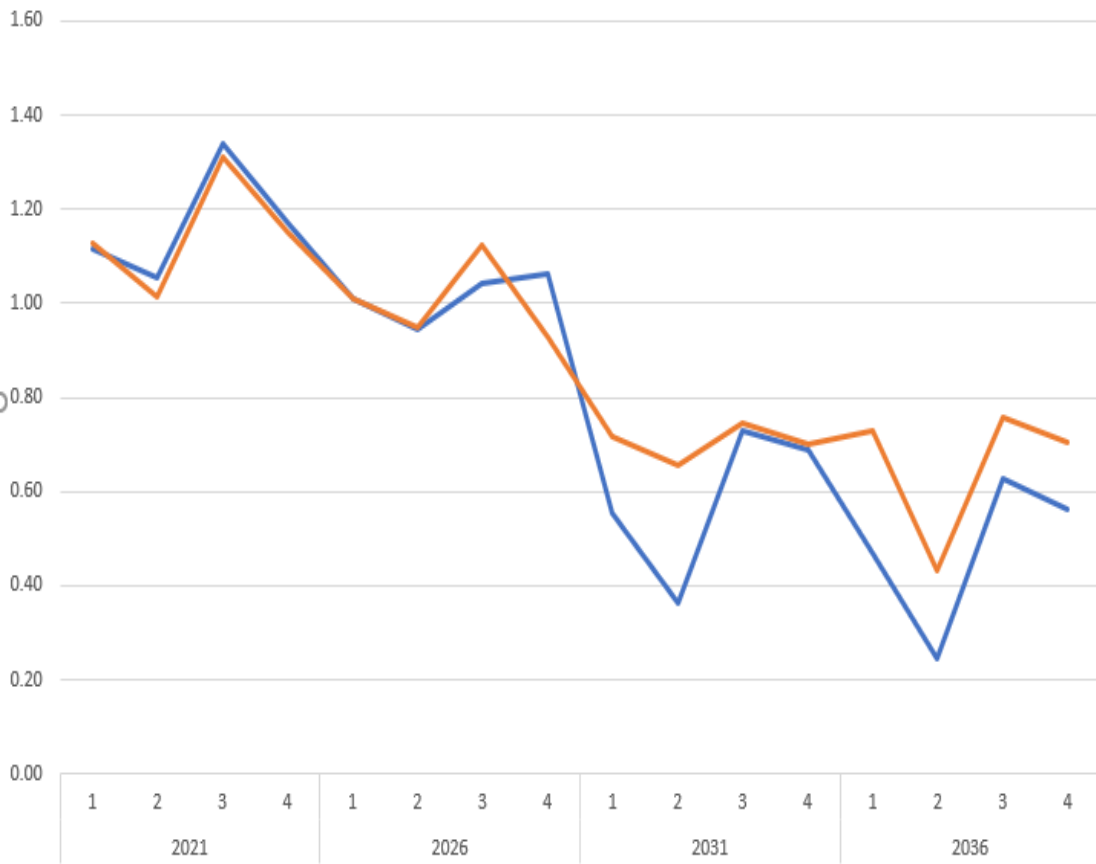
Wind and Gas Build Comparisons

Year	Baseline	Organized	Limited	No Gas Limit
2025	16,775	9,172	110	1,600
2030	35,175	27,526	10,425	7,069
2035	37,063	44,611	20,247	18,354
2040	43,657	74,737	29,255	31,481
2045	51,481	95,394	33,937	32,959

Year	Baseline	Organized	Limited	No Gas Limit
2025	11,351	13,716	5,904	21,003
2030	14,873	17,814	8,192	31,154
2035	16,058	19,824	8,666	38,118
2040	16,532	20,641	8,956	49,407
2045	16,532	20,641	9,536	67,605

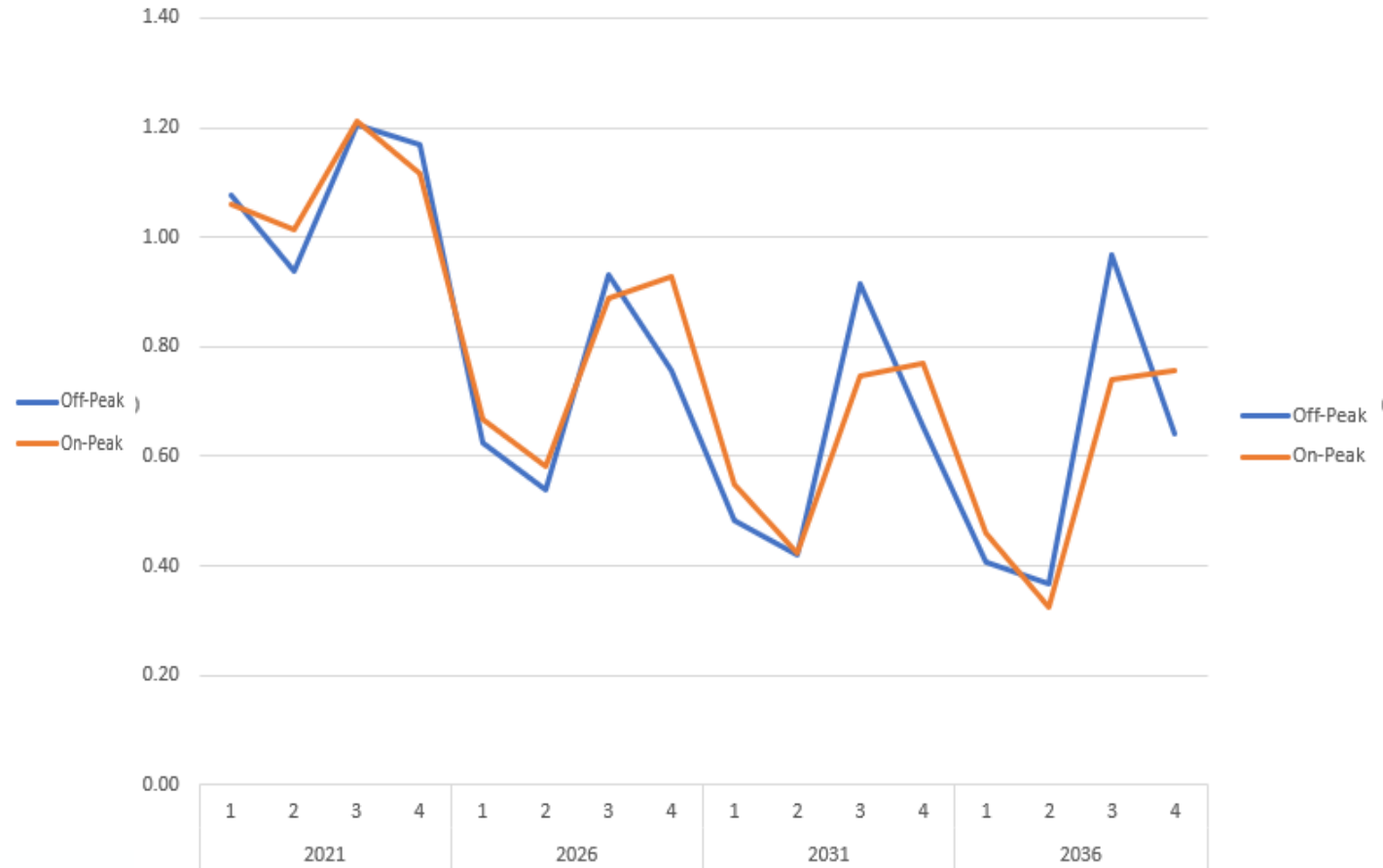


Avoided CO2e Emissions Rate in lbs per kWh



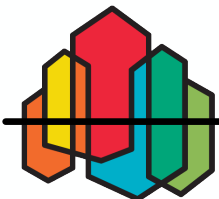
Organized Markets

Avoided Market Emissions Rate (CO2e in lbs/kWh)



Baseline

- 1) Emissions rate starts a little higher in summer, but goes lower than baseline
- 2) On-peak avoided emissions rate stays around emissions rate of combined cycle gas units.
- 3) Off-peak avoided emissions rate goes lower than the baseline late in the study. (Less thermal units providing flexibility due to large battery build)



The background features a series of overlapping, semi-transparent geometric shapes. On the left, a small light green trapezoid is partially visible. Next to it is a large teal pentagon. To the right of the teal shape is a light blue trapezoid. Further right is a large light green rectangle. The text 'Resource Strategy Results' is centered horizontally across the middle of these shapes.

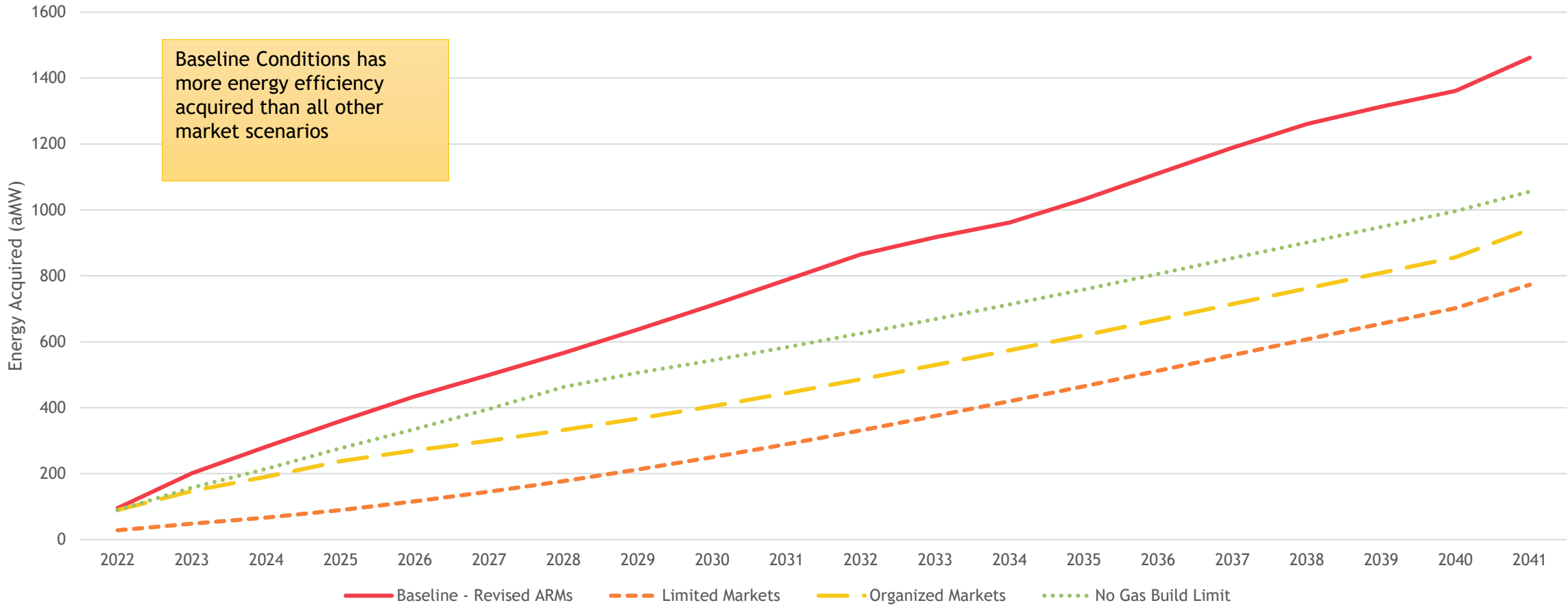
Resource Strategy Results

High-level Take-aways

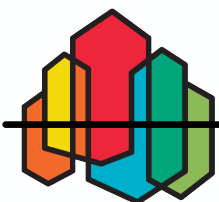
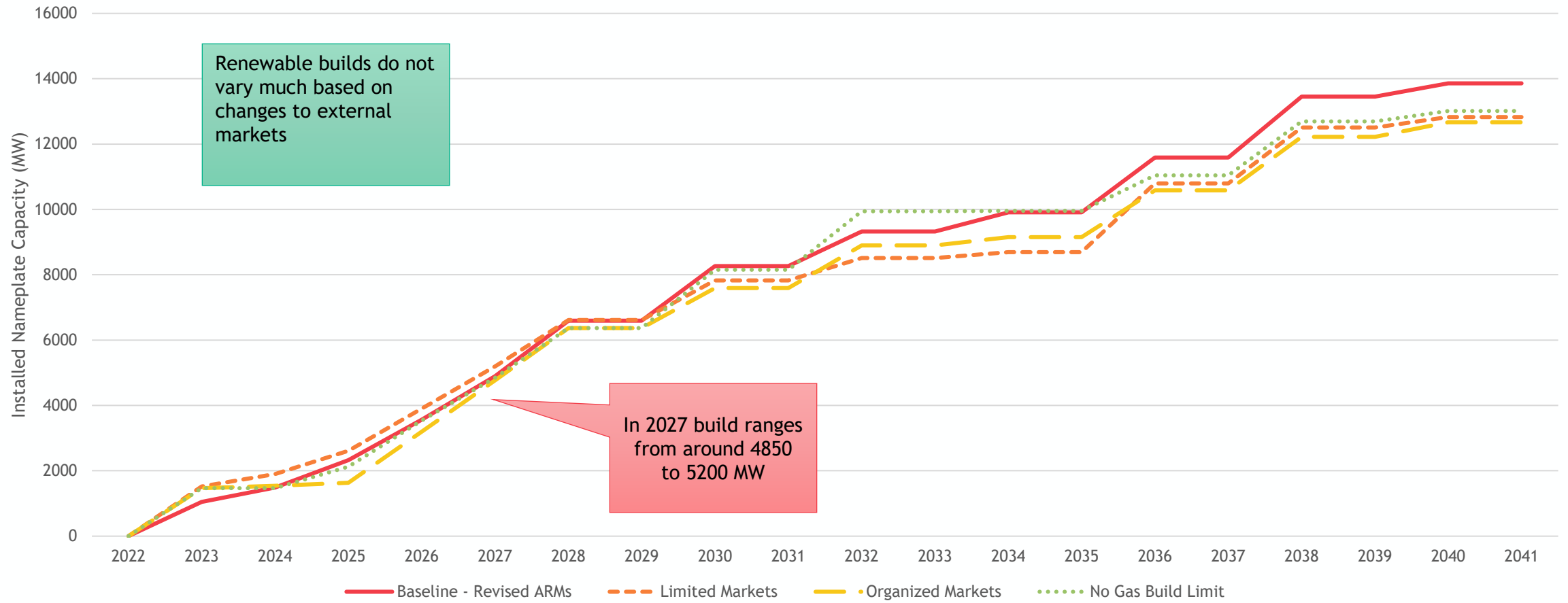
- Renewable builds are not sensitive to the different external market assumptions
- Energy efficiency acquisition does change based on different external market assumptions
- Electricity prices and residential bills do not substantially diverge based on external market assumptions
- Interactive effects with external markets are better captured by GENESYS - dynamic hydro is a big part of the picture



Energy Efficiency Acquisition Comparison



Average Renewable Build





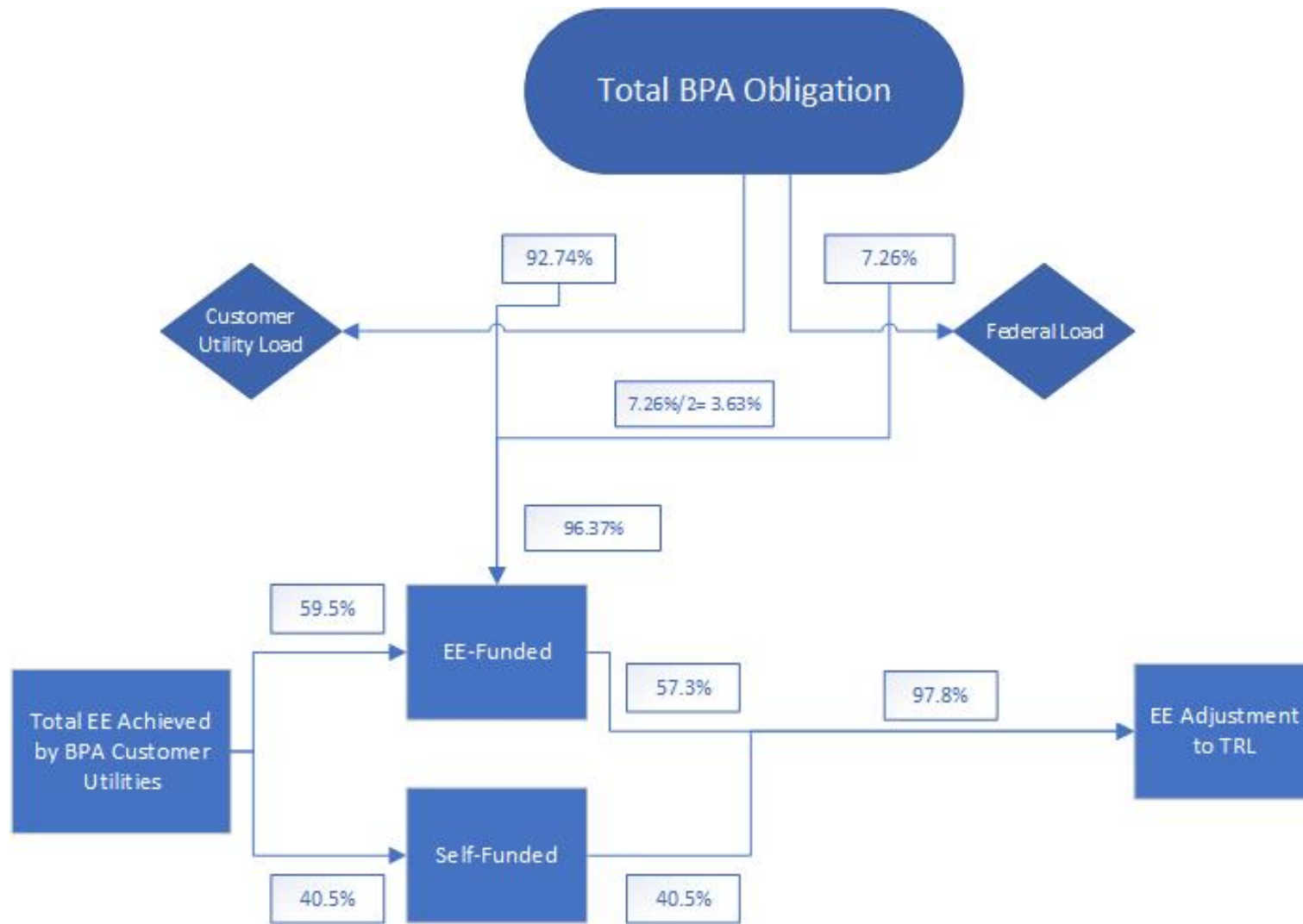
Analyze the Bonneville Portfolio

Analyze the Bonneville Portfolio



- What Resources are Required to Meet or Reduce the Administrator's Obligation?
- Portfolio costs are one factor of many that the Council will consider and balance as it formulates recommendations on amounts of power to acquire to the Bonneville Administrator
- Much of the information needed for this analysis we expect to be supplied under the existing December 2017 agreement on 4(c)(9) information sharing with Bonneville





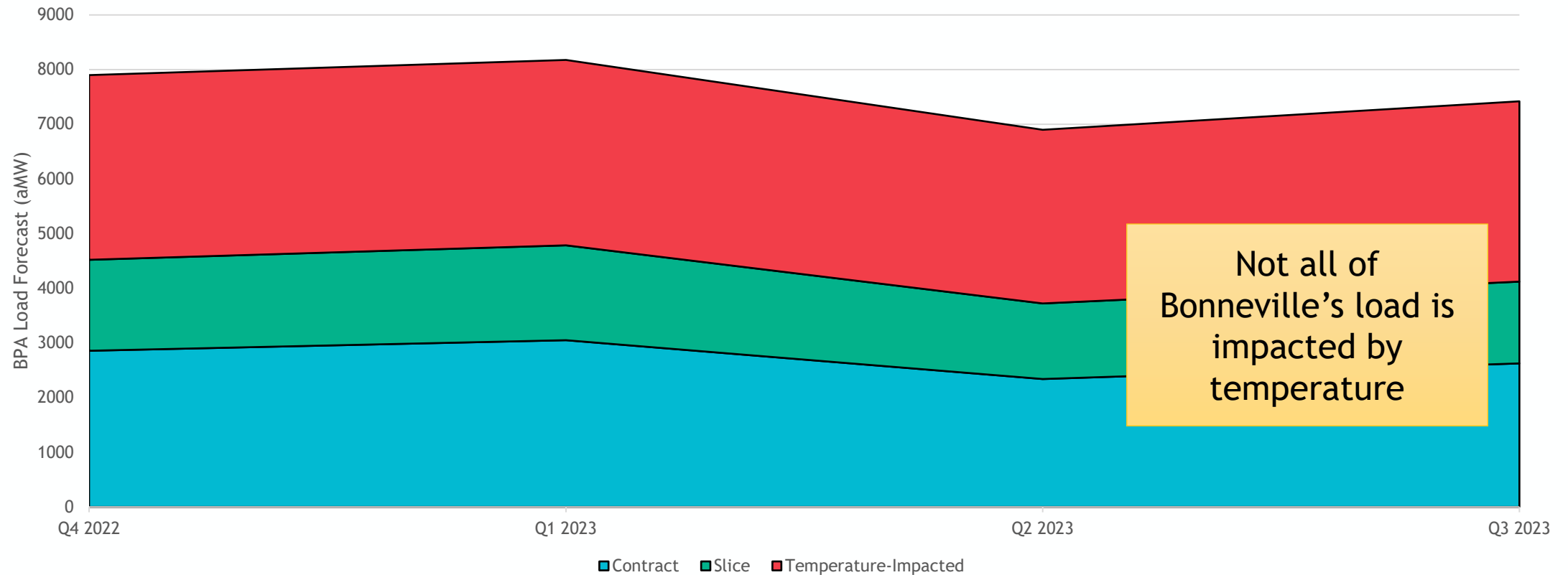
Estimated impact of EE on BPA's load obligation

Using the TRMbd Workbook with this adjustment we see EE changes the BPA obligation to serve load under the Regional Dialogue contracts anywhere from around 70% up to 92% based on how much EE acquired, on average EE changed the BPA obligation by **80.9%**.

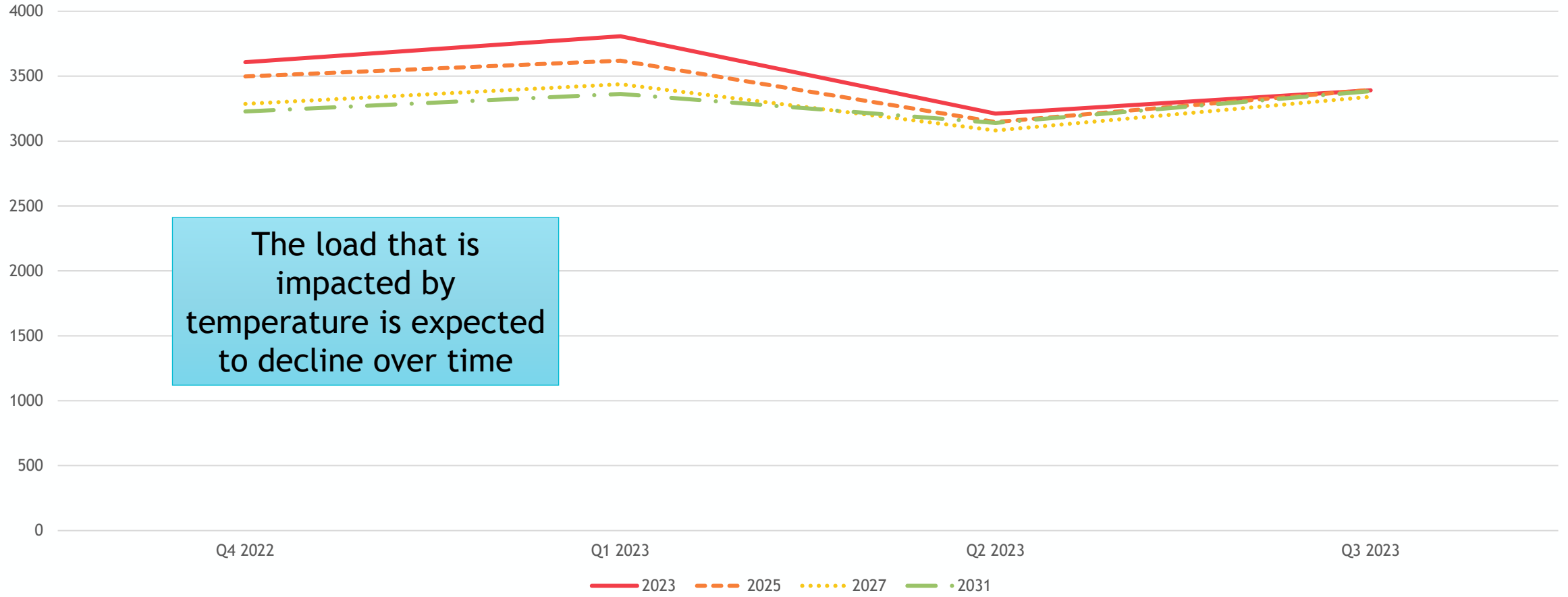
I.e. for 10 aMW of EE purchased from the supply curves, we estimate BPA's load is reduced by 8.09 aMW.



Components of Bonneville Adequacy Reserve Margin Load Calculation



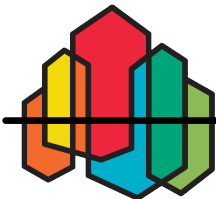
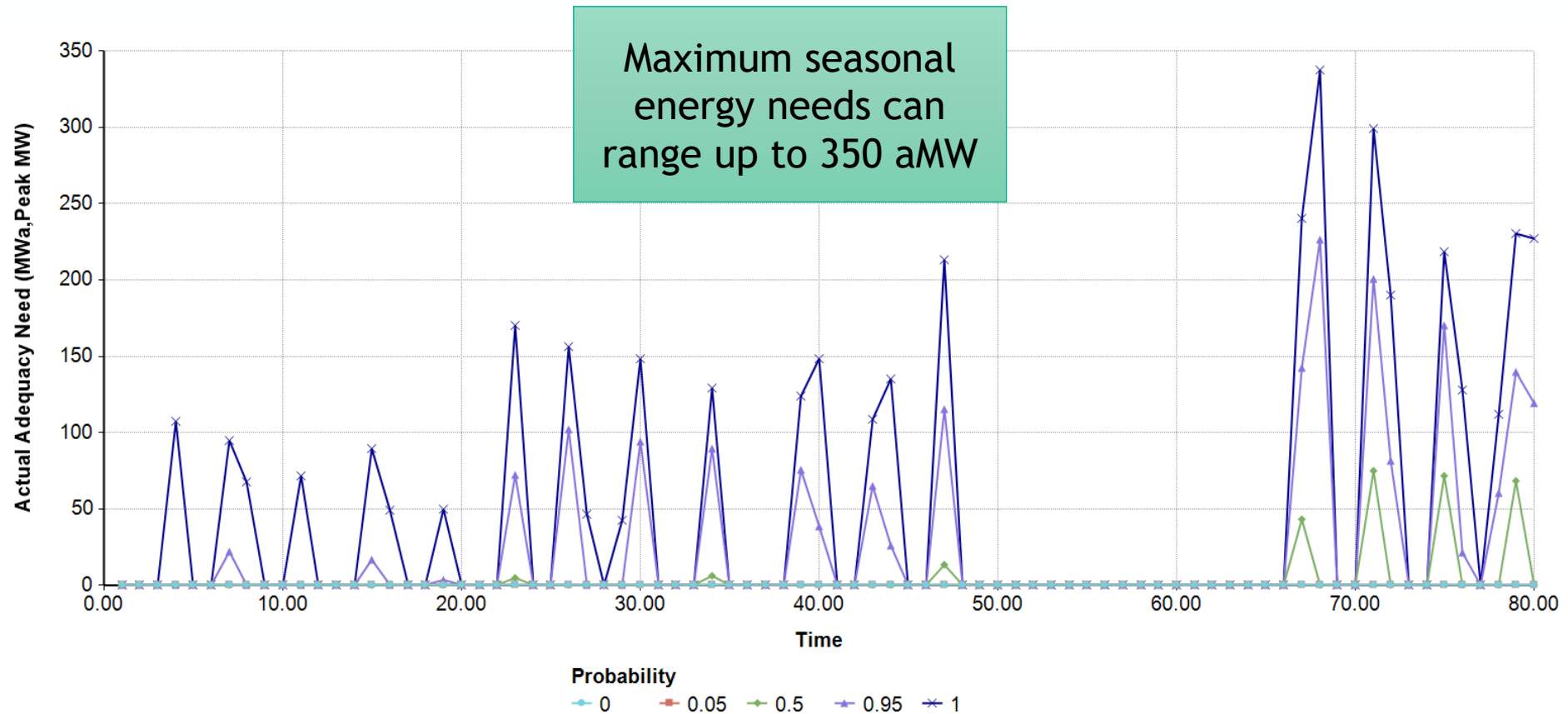
Temperature-Impacted Load



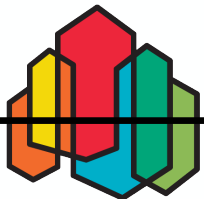
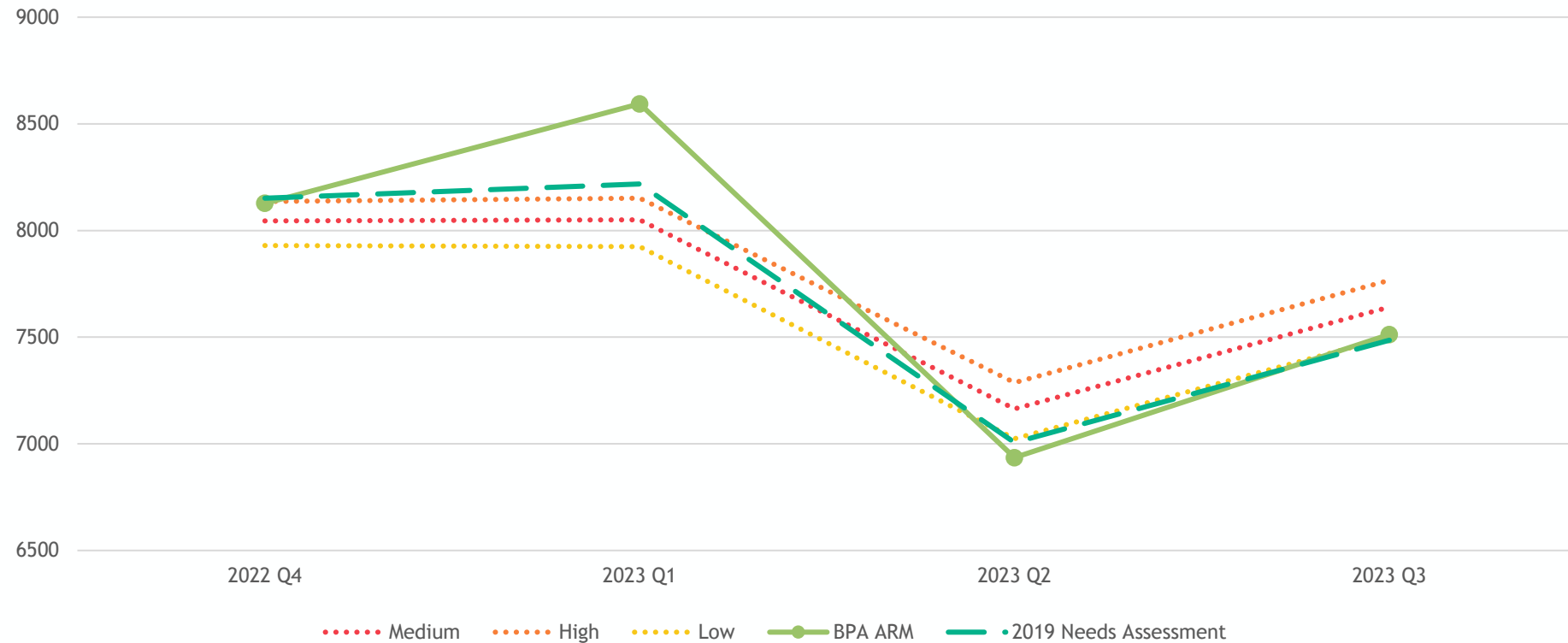
The load that is impacted by temperature is expected to decline over time



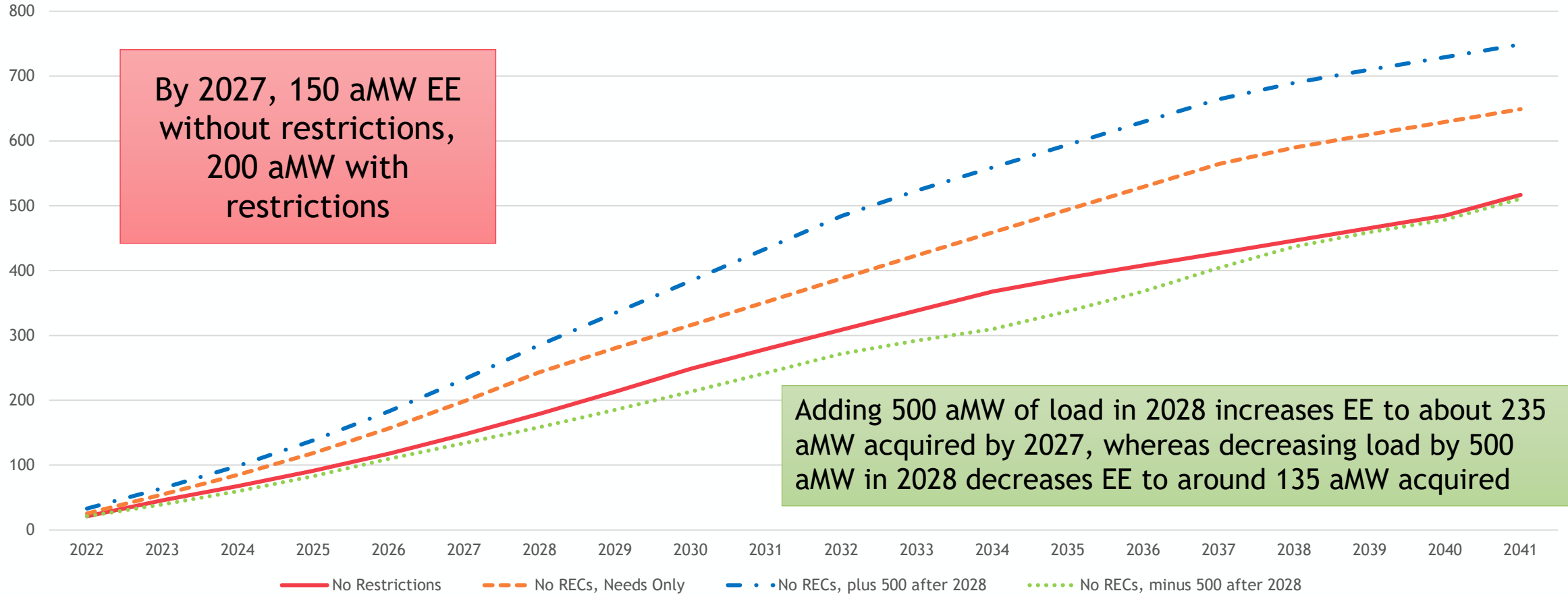
Energy Need with Updated Loads



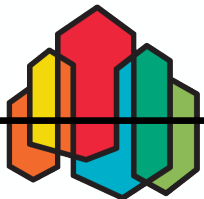
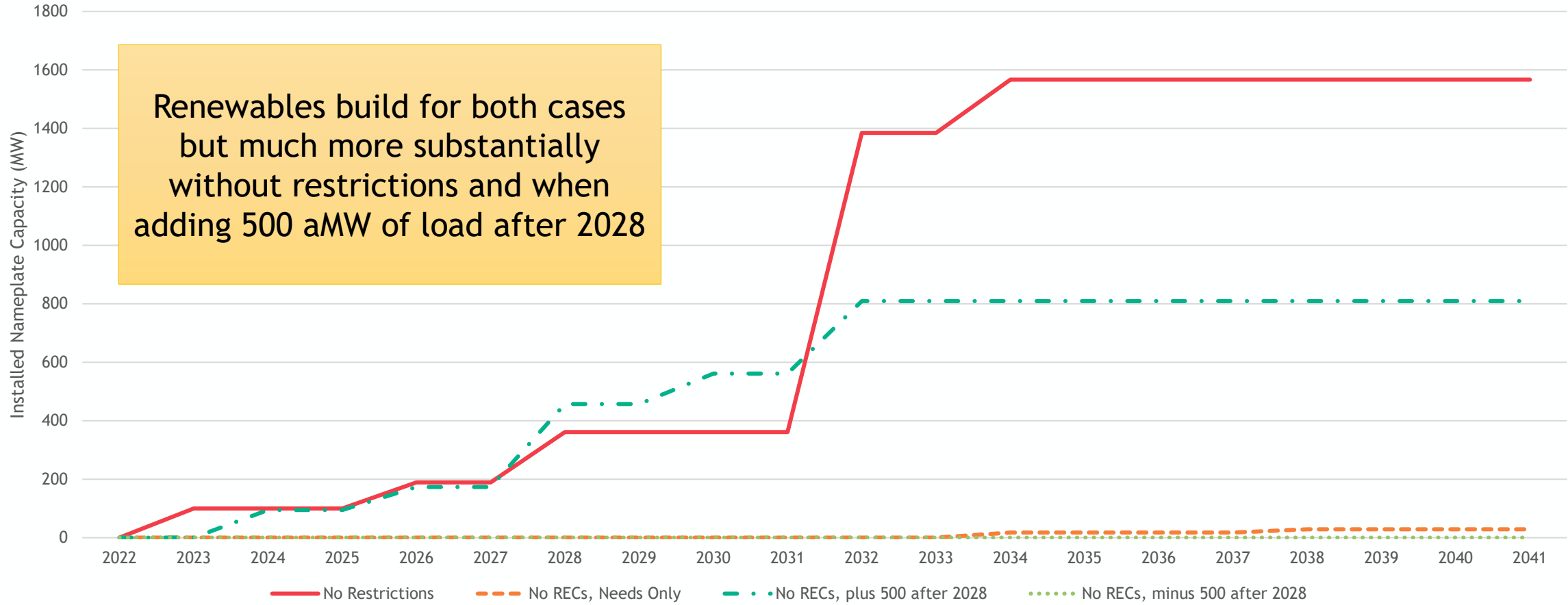
2021 Plan Updated BPA Forecast



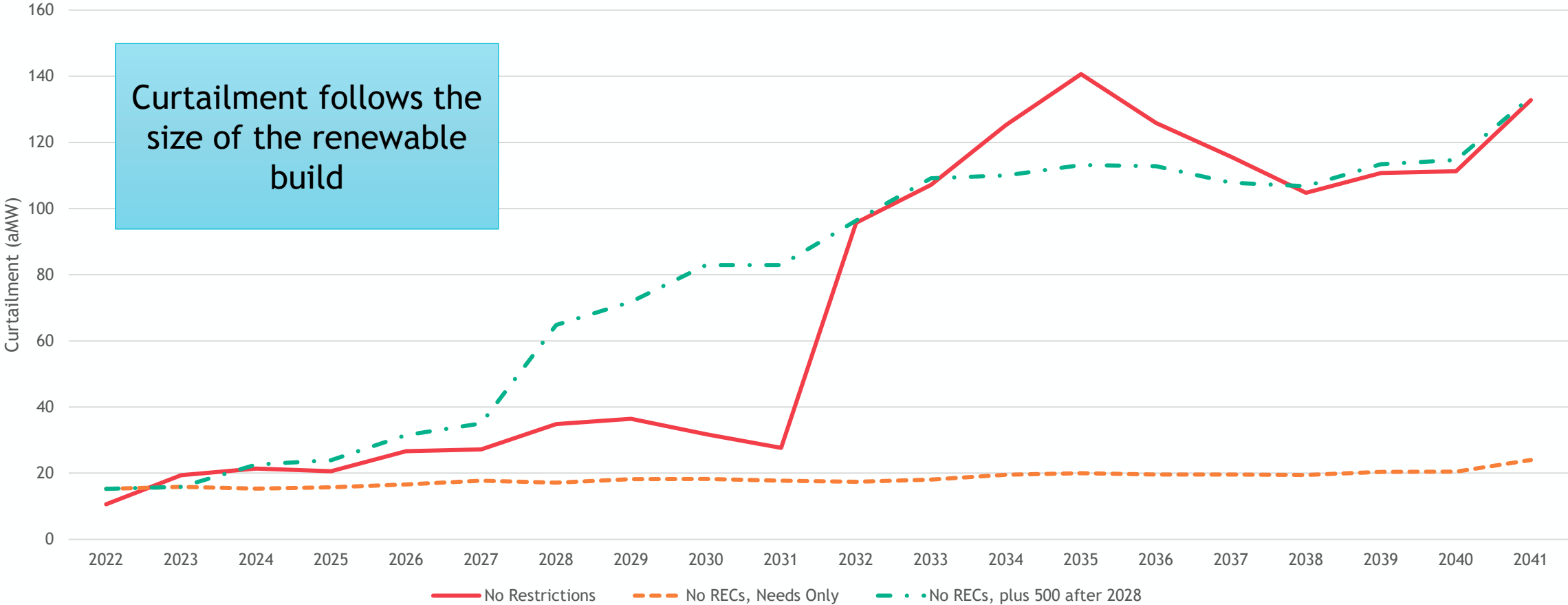
Energy Efficiency Acquired



Renewables Build

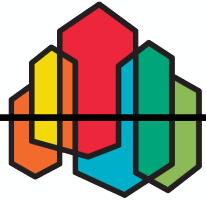
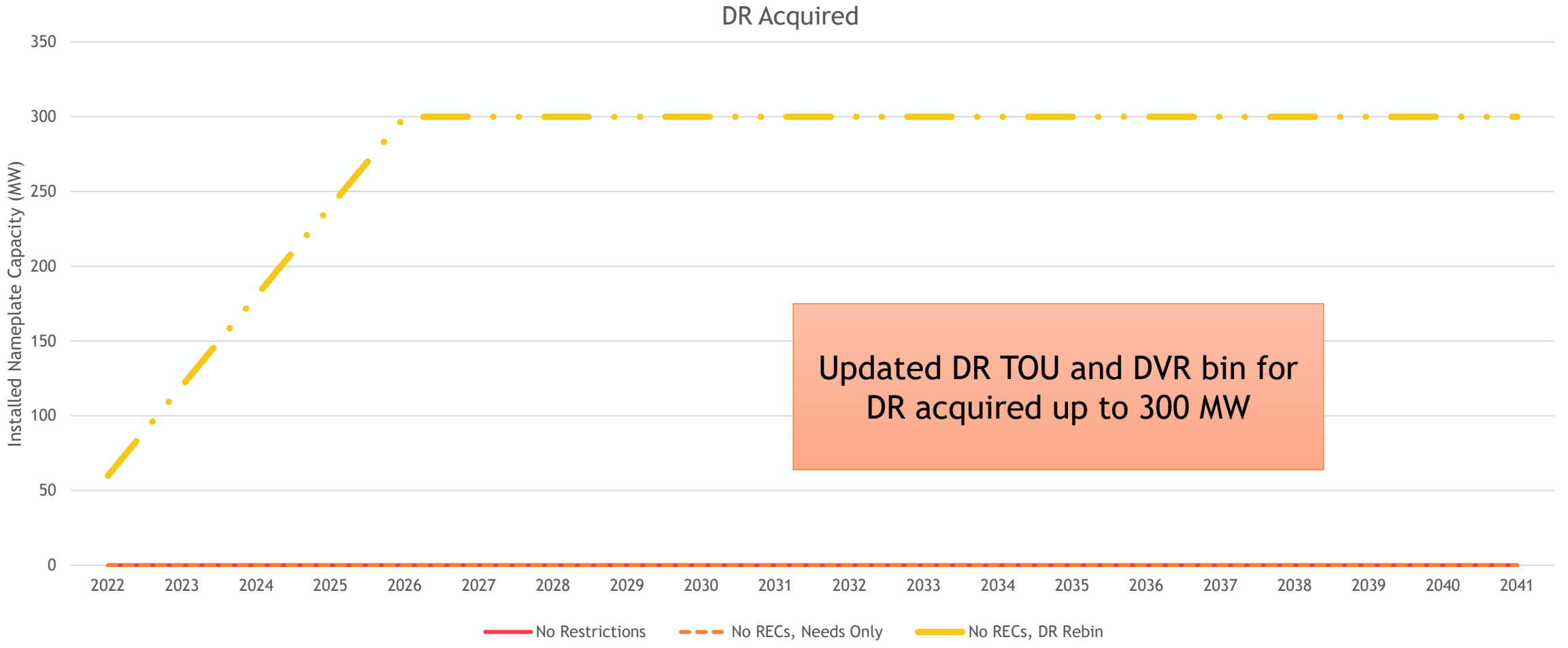


Renewables Curtailment



Curtailment follows the size of the renewable build





Challenges with Bonneville in RPM

- **Renewable builds likely overstated** - agent-based logic applied to an individual utility rather than the region overstates the forecast errors the “agent” would make and does not capture the partition
- **Load risk model doesn’t capture slice or subscription-like load dynamics** – fixed this load in the adequacy calculations but the cost impacts on the portfolio would be different with this logic implemented
- **Portfolio is more sensitive to REC forecast** – when RECs are included resource decisions change, the higher the REC price the more likely adding more renewables and less EE would reduce costs
- **No fidelity on hydro spill** – Bonneville adding renewables could impact hydro spill in ways that are not possible to capture in RPM
- **Assumes Bonneville’s contracts with customer utilities continue in a similar form**



Conclusions

- Bonneville has future needs which can be filled by EE, renewables, or some combination of the two
- Having all customer utility contracts end at the same date makes planning for resource acquisition and/or managing contract risk difficult
 - If obligation is added to the portfolio post-2028, adding resource before 2028 lowers portfolio cost
 - If obligation is removed post-2028, reducing resource acquisition before 2028 lowers portfolio cost
- Better fidelity on market interaction with Bonneville would likely reduce resource needs below what we see currently in the models and could change the value of renewable resources





Pathways to Decarbonization

Introduction

To combat climate change - the states of Oregon and Washington have set goals and limits on future greenhouse gas emissions from their respective states

Oregon

45 % below 1990 levels by 2035

80 % below 1990 levels by 2050

Washington

45 % below 1990 levels by 2030

70 % below 1990 levels by 2040

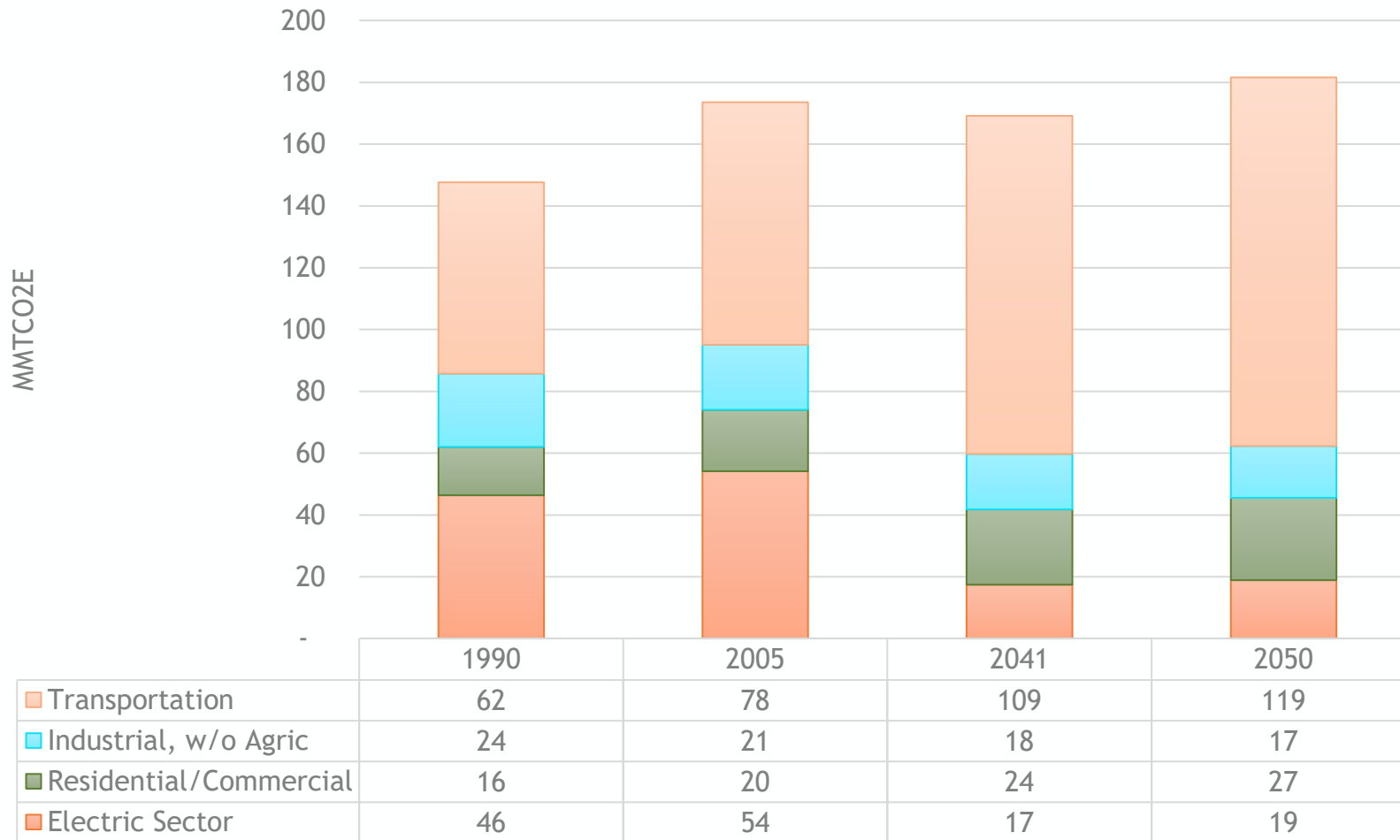
and 95 % below 1990 levels by 2050
net zero emissions

For the **2021 Power Plan** - in order to form a more comprehensive understanding of expected regional emissions - we expanded our forecasting out past the power sector to include the use of fuels for transportation, the home, the business and industry

The **Paths to Decarbonization Scenario** is an investigation into methods that can reduce greenhouse gas emissions from the **entire economy** - both energy related & non-energy related



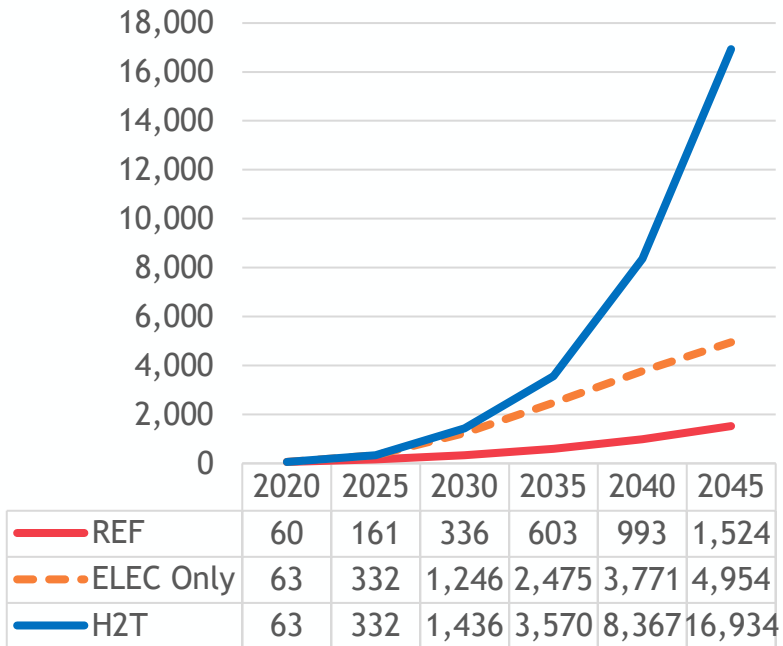
Baseline Conditions Emissions



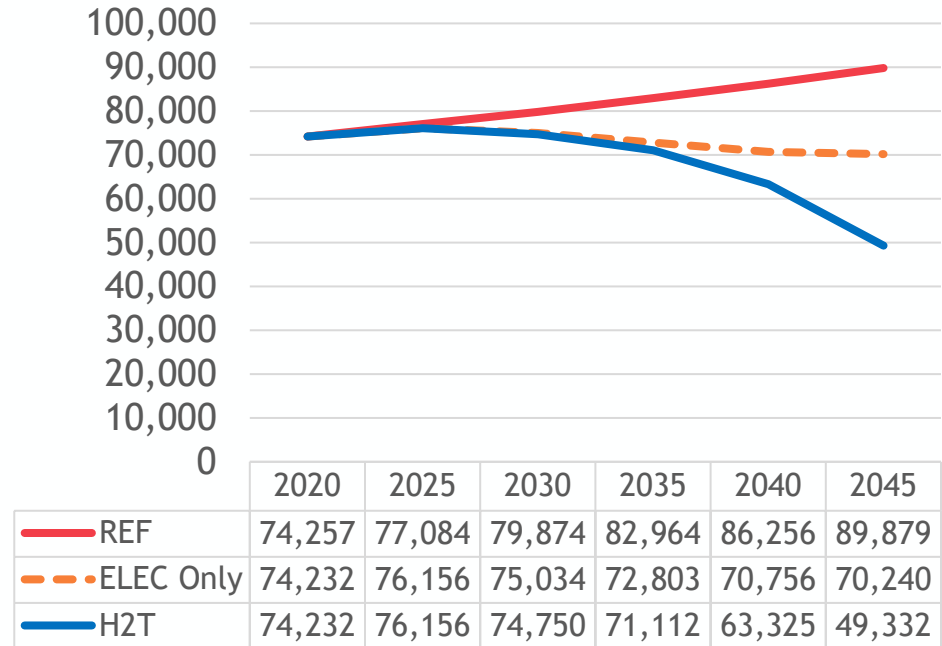
ELEC Only -
electrification
changes only -
no H₂

Results

Demand for Electricity
aMW

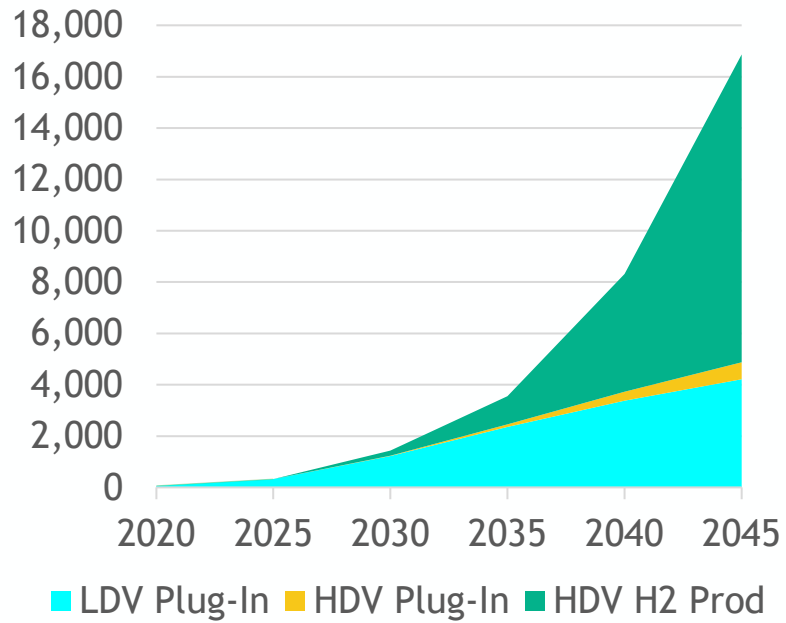


Tailpipe Emmissions
kTonne CO₂e

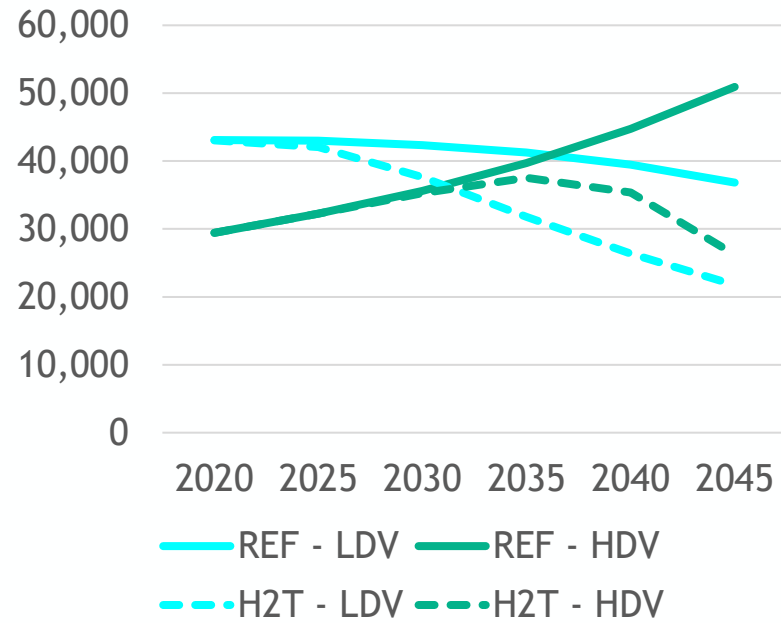


More Results

H₂T Case - Electricity Demand by Use
aMW

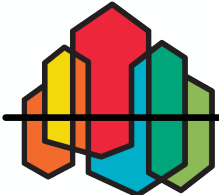
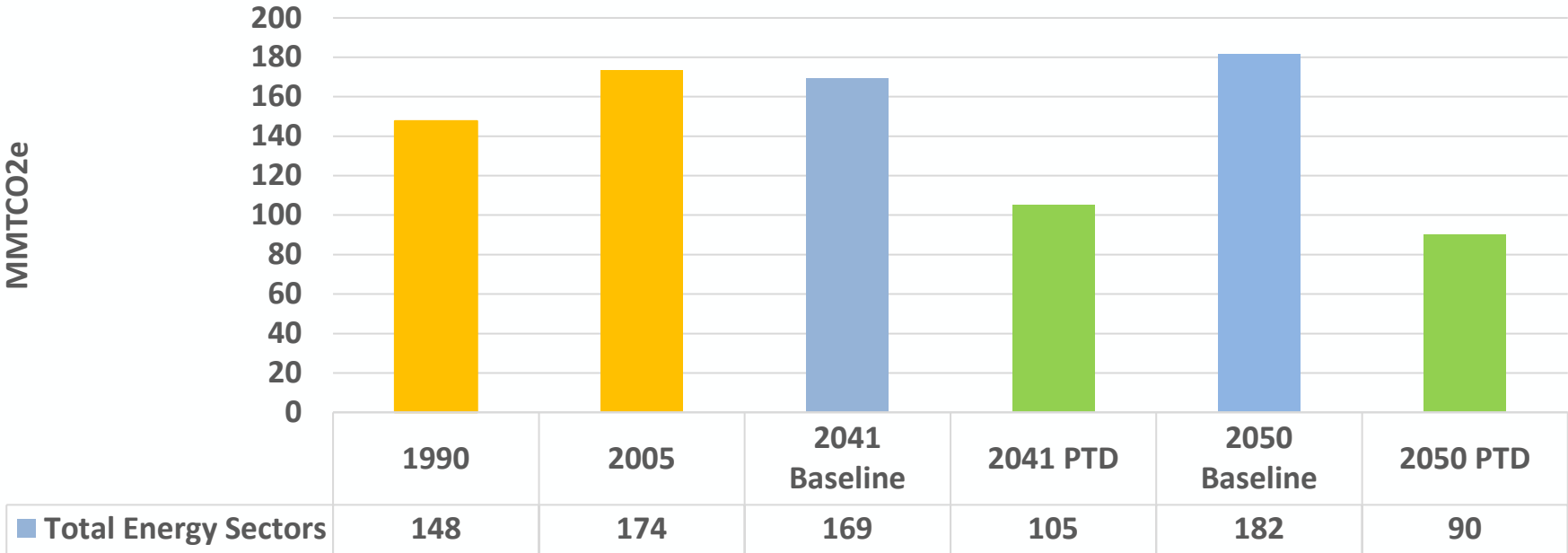


Tailpipe Emissions by Category
kTonne CO₂e

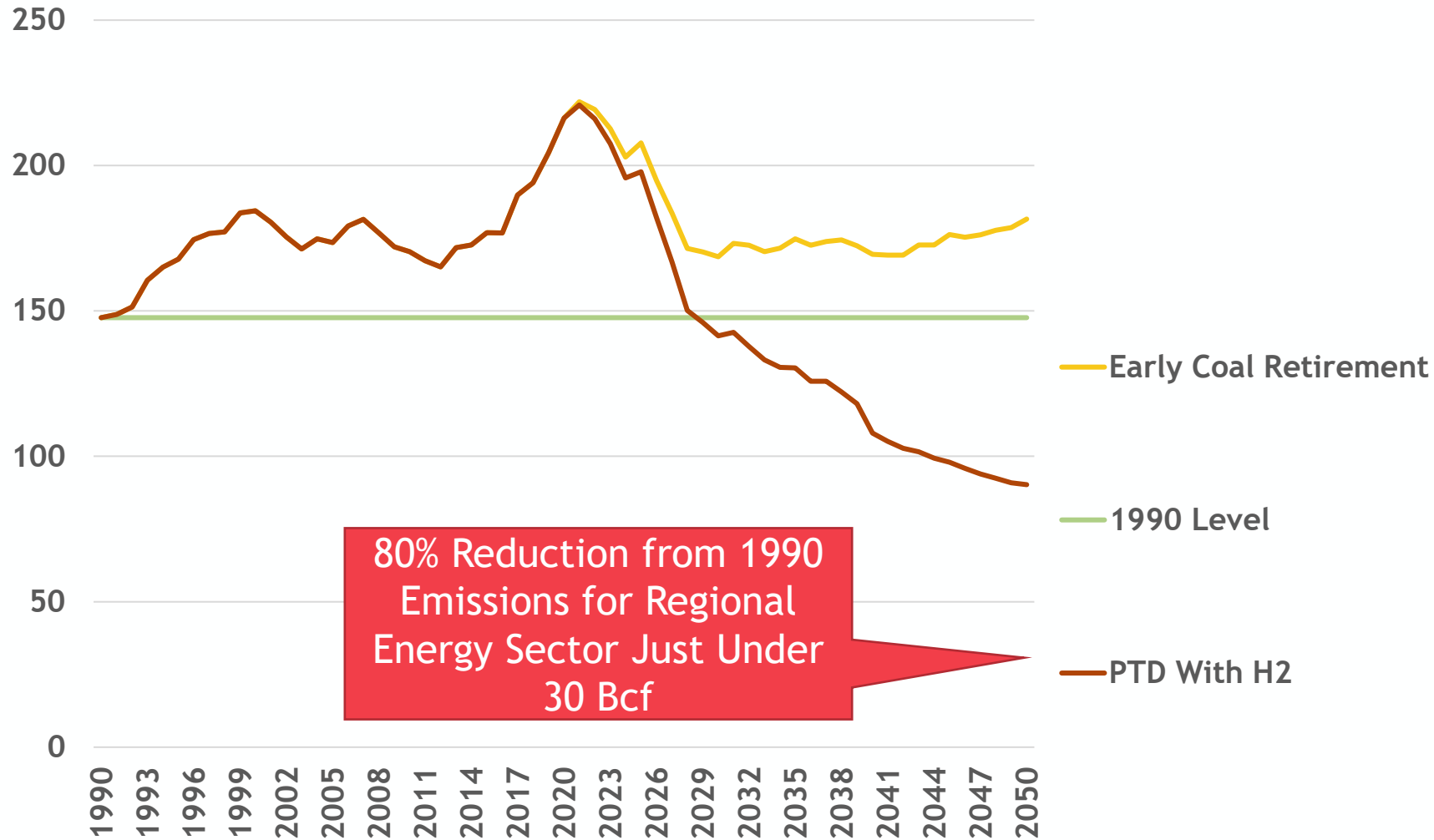


Where Does This Leave Us for Emissions from Energy Use in the Northwest?

GHG Emissions from Energy used in Residential, Commercial, Industrial, Agriculture and Electric Utilities



Decarbonization Looking at Energy Sector Falls Short of Targets



Partial Decarbonization

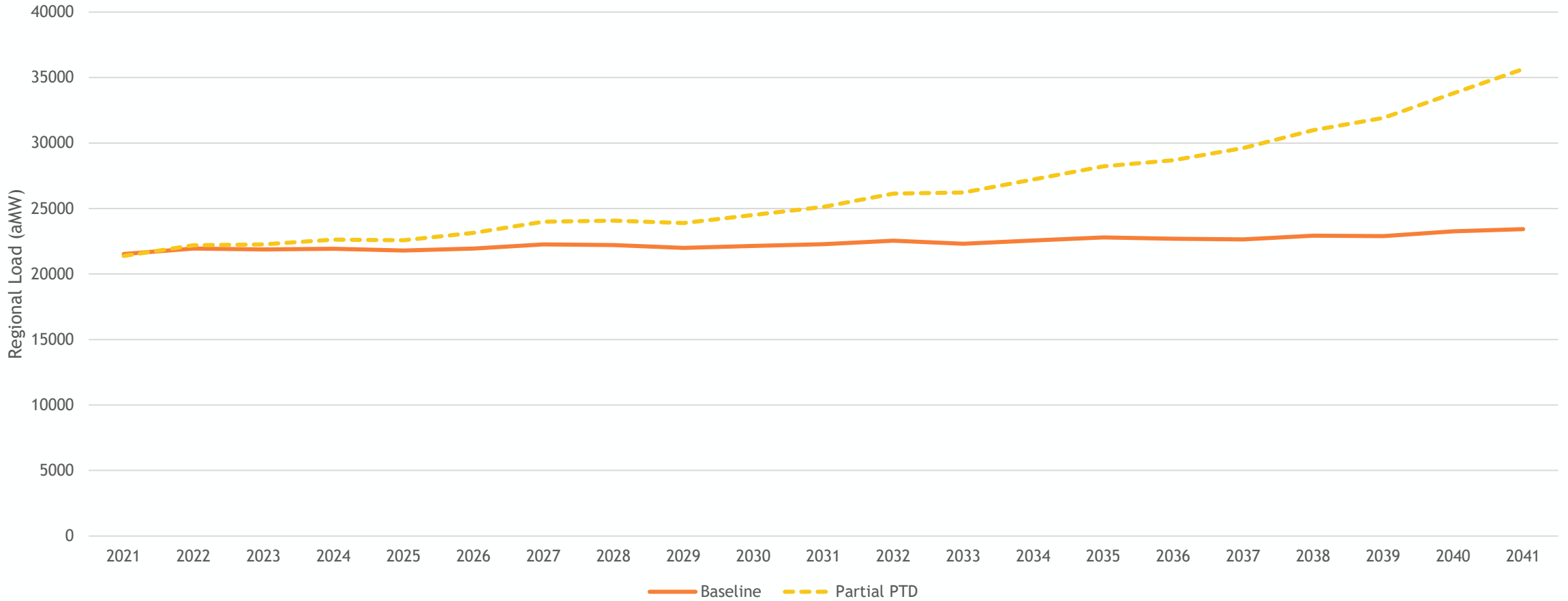
What if we see some but not all impacts on the electric sector?

1. Started with Early Coal Retirement Scenario
2. Removed all natural gas resource options
3. Added SMRs as an option
4. Increased loads consistent with electrification of new buildings and light-duty EV reaching 100 percent of sales by 2030
5. Run through RPM

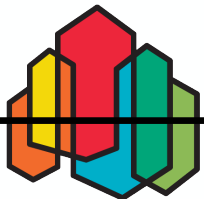
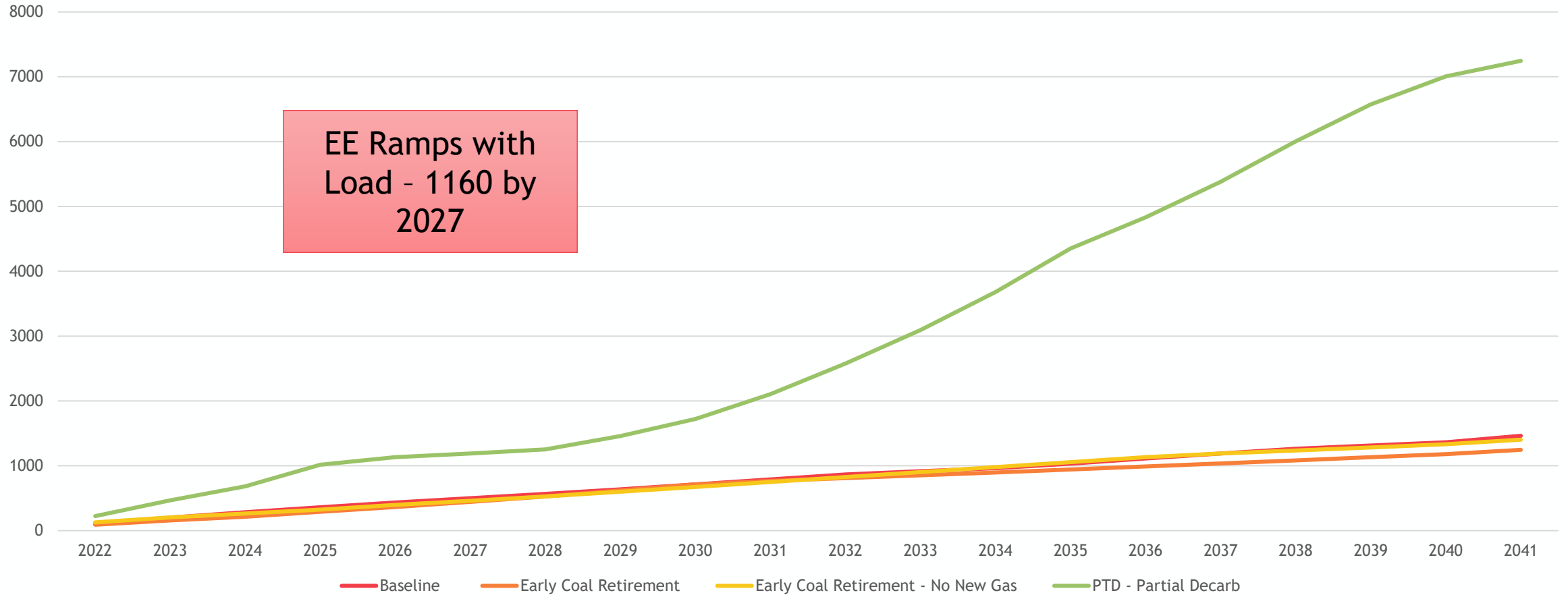
NOTE: this does **not** represent a system that meets current state goals



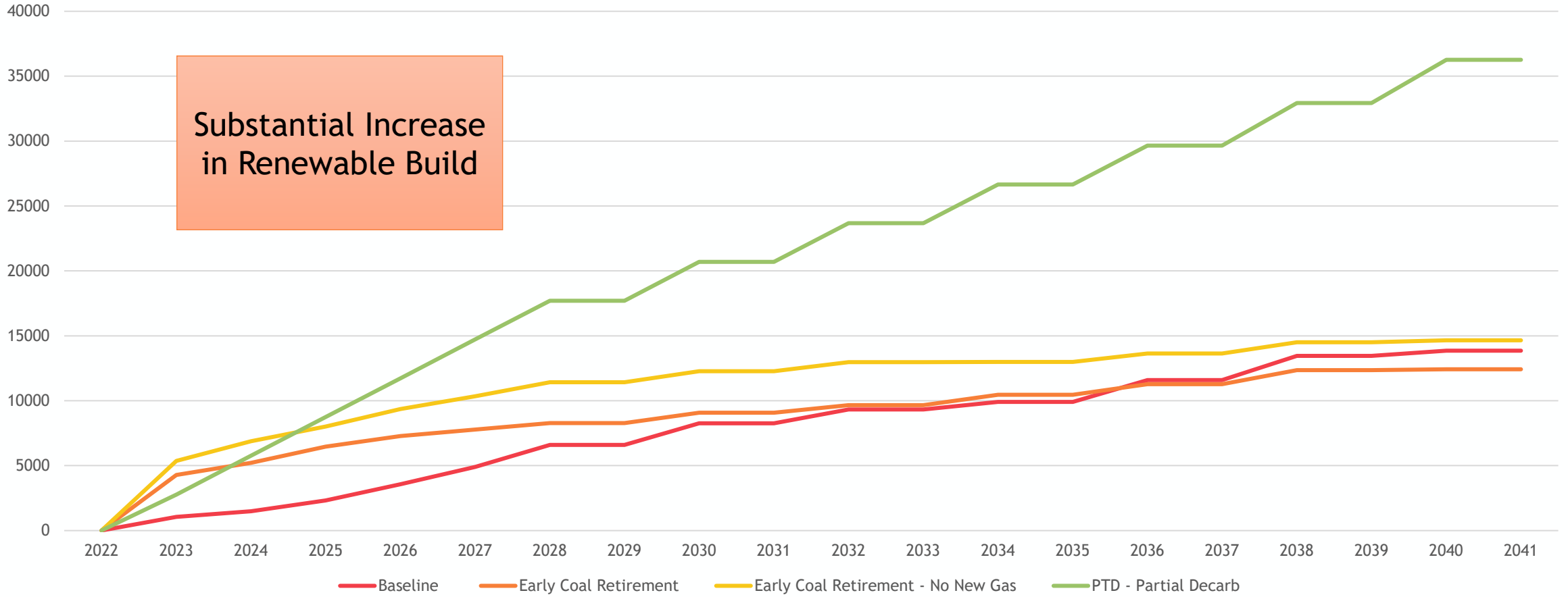
Increased Load for Partial Pathways to Decarbonization Analysis



Average EE Acquired



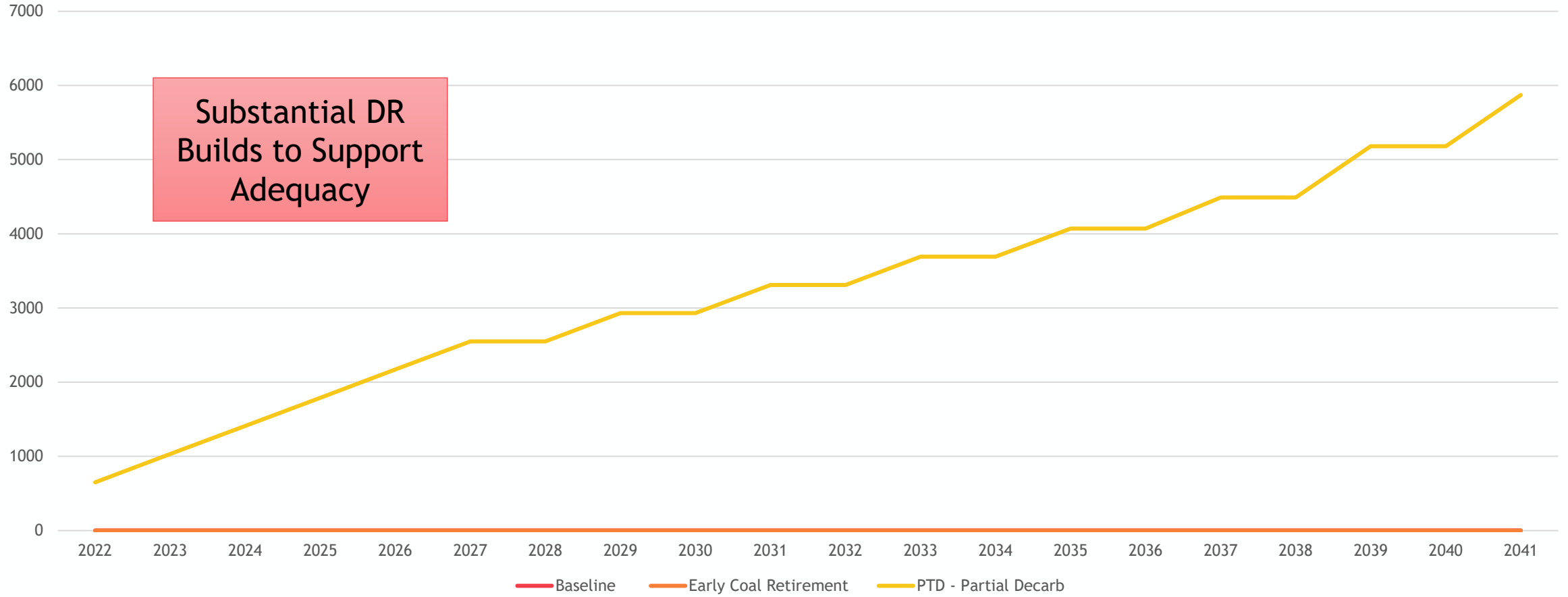
Average Renewable Build



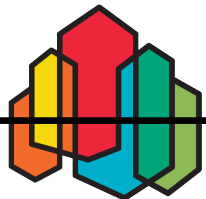
Substantial Increase
in Renewable Build



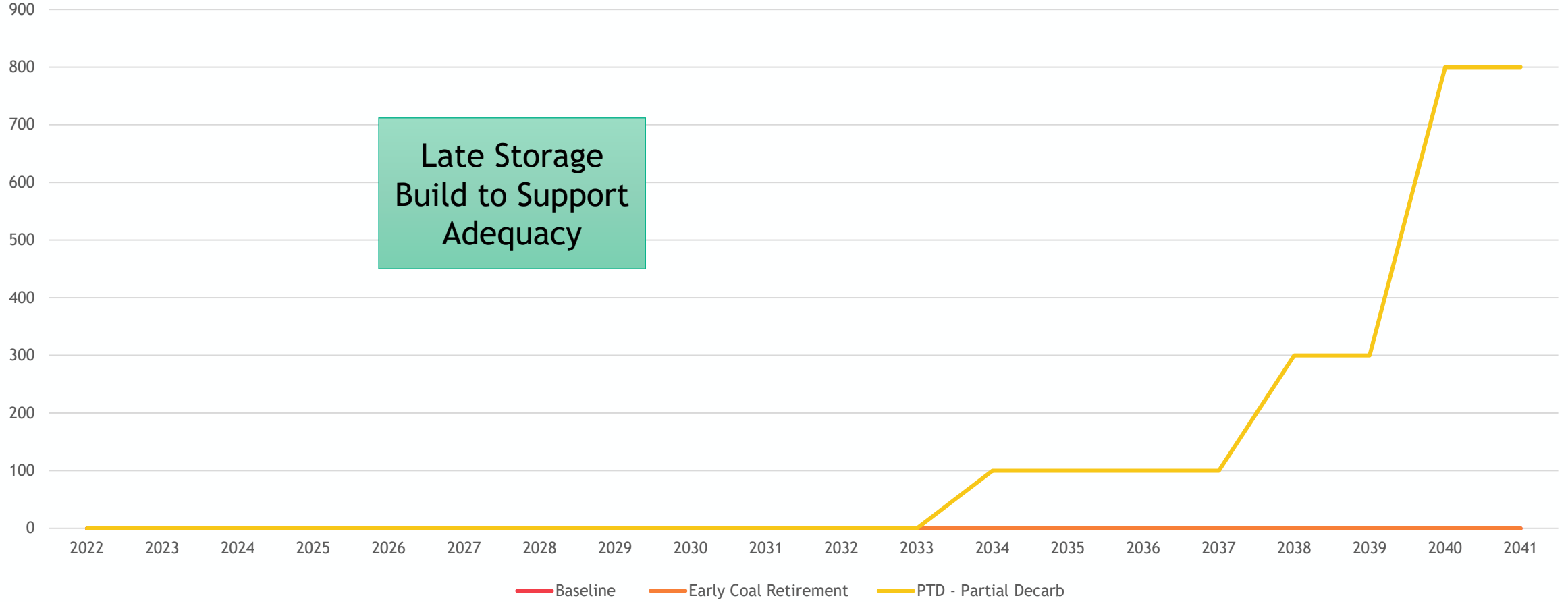
Average DR Acquired



Substantial DR Builds to Support Adequacy



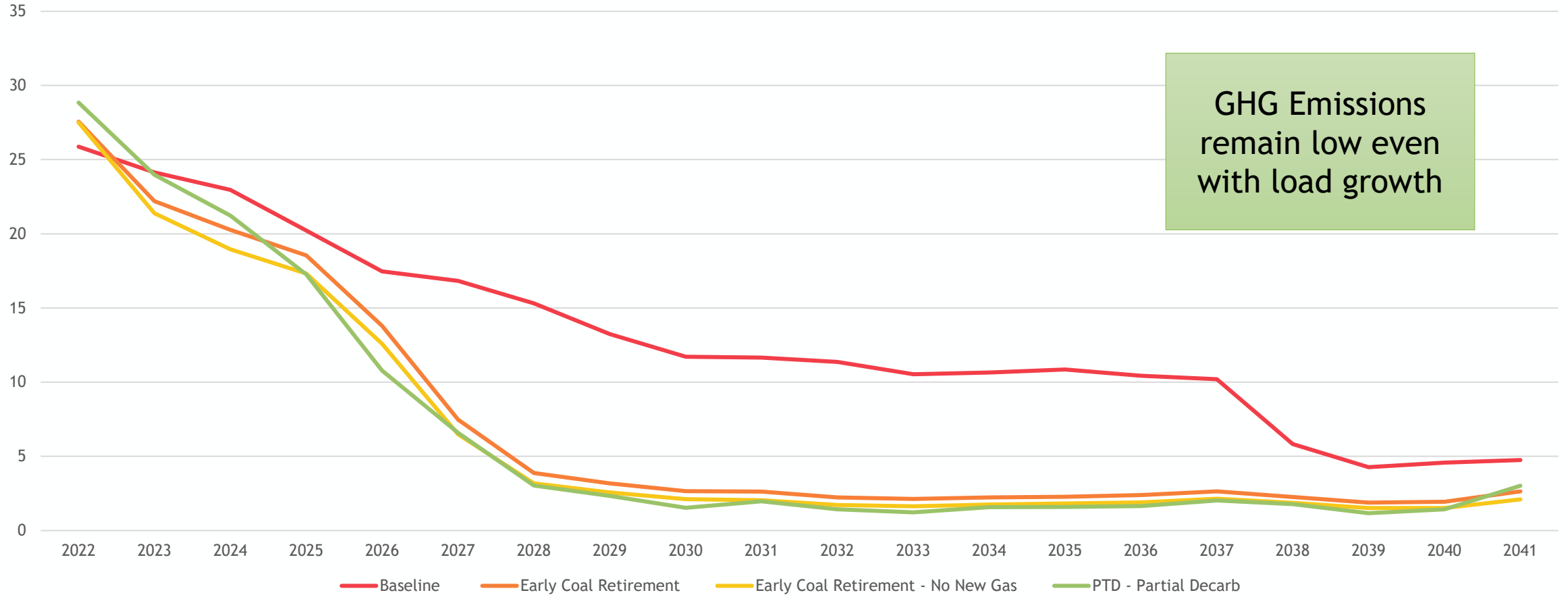
Average Storage Build



Late Storage Build to Support Adequacy



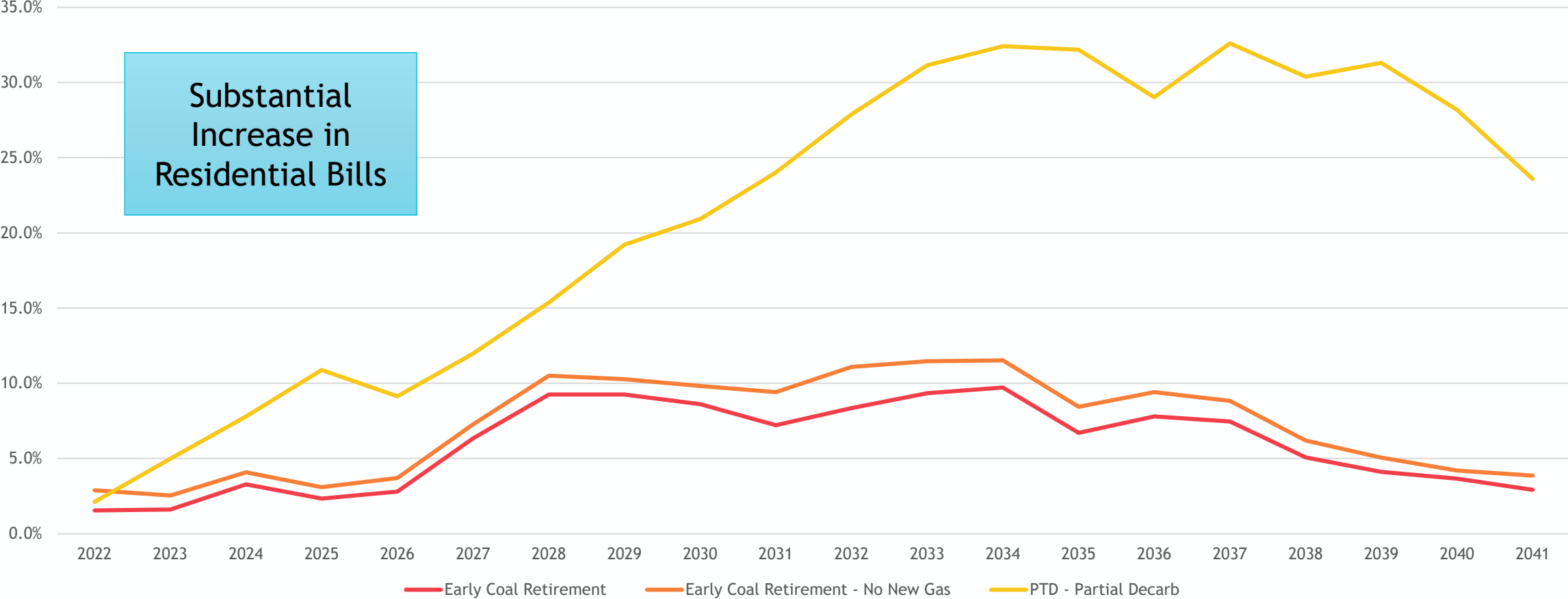
Average GHG Emissions (MMT)



GHG Emissions remain low even with load growth



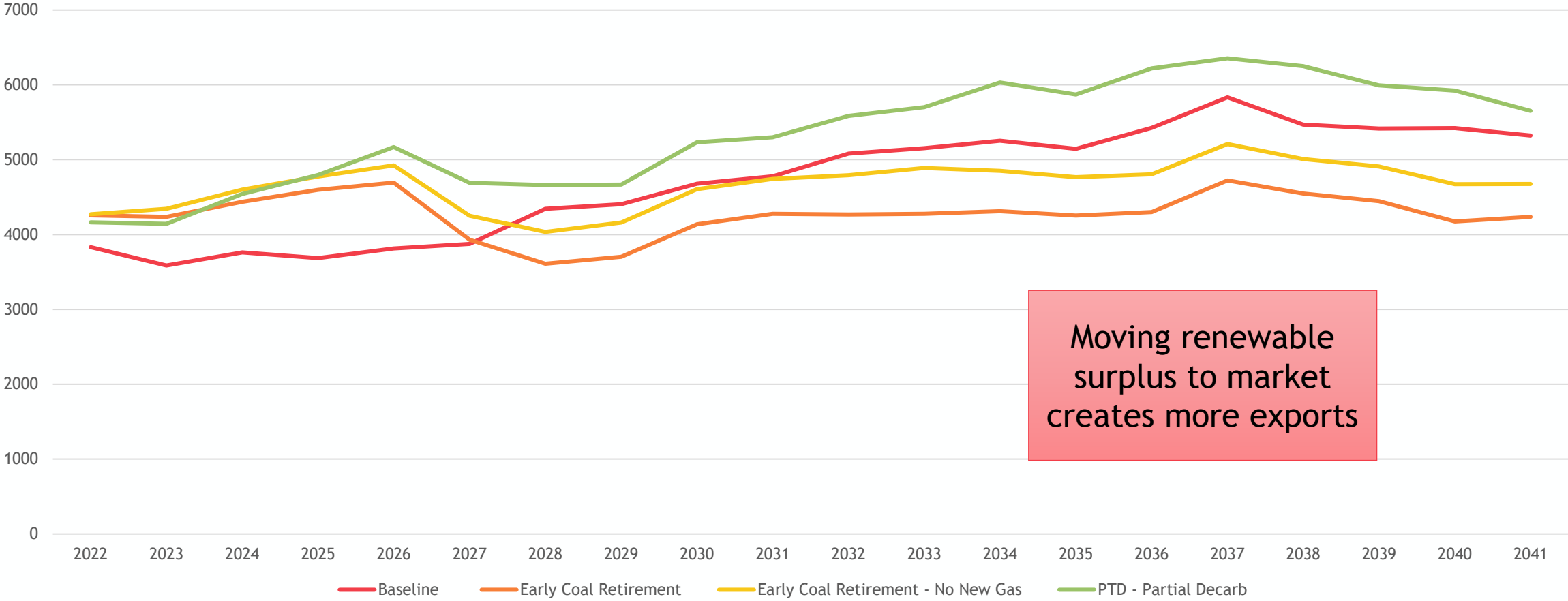
Percentage Increase in Bills



Substantial Increase in Residential Bills



Average Exports (aMW)



Moving renewable surplus to market creates more exports



Conclusions

- Increased EE tends to be really aggressive after the first decade
- Increasing load pushes renewables up
- No options for natural gas pushes storage and DR and a single geothermal plant into resulting strategy
- Reserves likely need to be adjusted to account for additional renewables – operability of the system is unclear



A scenic landscape of a mountain valley with a lake, partially obscured by white geometric overlays. The scene features a calm lake in the foreground, surrounded by rugged, rocky terrain and sparse vegetation. In the background, misty mountains rise against a pale sky. The image is overlaid with several white, semi-transparent geometric shapes, including triangles and polygons, which create a layered, architectural effect. The text 'June 2021' is prominently displayed in the lower-left quadrant, with 'What We've Learned' written below it in a smaller font.

June 2021

What We've Learned

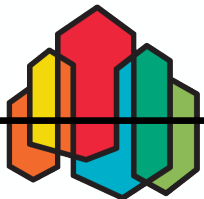
Energy Efficiency

- Competition and markets, both present and future, have altered the value proposition for EE
- The supply is more expensive and there are more alternative resources
- Accelerating EE doesn't result in a less expensive system
- Supply curves miss drivers that in retrospect are important like timing of the savings and resiliency
- EE is a fixed position in a portfolio, you get flexibility on the pacing of investment and build but don't have flexibility to curtail which does not work well with negative priced markets



Renewables

- Clean policies throughout the West are incredibly aggressive and impact the results substantially
- Solar is cheap and seems likely to saturate the Western electric grid regardless of decisions made in the region
- Overbuilding and curtailment are projected to grow going forward
- Market structure makes a big difference on the amount of renewables needed to achieve policy goals and maintain adequacy
- Renewables are part of a least-cost solutions for the regional resource strategy regardless of the assumptions made about emissions limitations and/or pricing



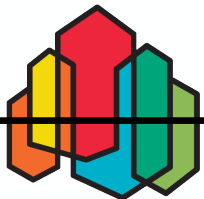
Thermals

- Coal in the generation stack still is the substantial driver in regional emissions
- Adding gas resources with renewables doesn't necessarily increase emissions
- Limiting new natural gas resources substantially increases the assumed renewable resource build
- Low capacity factors in almost every run shows challenging economics for thermals going forward



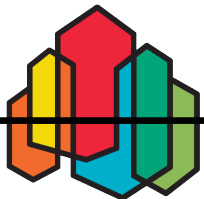
Markets

- Organized markets can substantially reduce the capital cost needed to achieve policy goals
- Limited markets have big implications throughout the Western electric grid and would impact regional economics, but don't move regional adequacy substantially
- Every market structure tested is substantially impacted by forecast solar builds with organized markets showing the lowest impact



Adequacy

- Resource adequacy is much more dynamic than expected – with a changing interaction with the external market being anticipated in every scenario tested
- Operational challenges are more likely to drive adequacy results than a lack of physical resources
- Hydro flexibility and assessment is fundamental to adequacy results
- Loss of Load Probability under improved assessment methods does not equate to either the size or severity of needs – it does not well delineate adequacy risks in a system with high renewable penetration
- How reserves are held determines system adequacy and can substantially change results under different assessments
- Capacity needs and reserve needs are not independent and to an extent exchangeable – this is particularly true with EE which can reduce the need to hold reserves



Hydro Generation

- Markets will likely push hydro operations to ramp more as solar generation penetration increases in the Western electric grid
- Flexibility in the region is likely a plant-by-plant consideration – substantially more focus needs to be spent on understanding operations under forecast future markets and water conditions
- Expected operations need to be considered as part of the next fish & wildlife program to see if they cause concern or provide opportunities



A scenic landscape of a mountain valley with a lake, partially obscured by a white geometric overlay. The word "Questions?" is written in large black font on the left side of the image.

Questions?