

# NS POWER 2020 IRP UPDATED MODELING RESULTS RELEASE

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SEPTEMBER 2, 2020

UPDATED SEPTEMBER 18, 2020

# REVISIONS

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## SEPTEMBER 11

- Scenario 2.0C – corrected a typo in the 25-yr NPVRR (was previously reported as \$12,224 – corrected to \$12,234)
  - Updated on slides 13, 41, 43, & 45

## SEPTEMBER 18

- For certain sensitivity runs, the metric *Total CO<sub>2</sub> Emissions 2031-2045 (MT)* was incorrectly reported in the summary tables in the previous release. The *Total CO<sub>2</sub> Emissions 2021-2030 (MT)* and *Total CO<sub>2</sub> Emissions 2021-2045 (MT)* metrics were not affected, and the CO<sub>2</sub> Emissions graphs and CO<sub>2</sub> Emissions data in the Modeling Results Tables are correct.
  - Updated figures are shown in **purple text** on slides 35, 37, 39, 41, 45, 47, 51, 57, 59, & 63

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FINAL PORTFOLIO STUDY RESULTS

SENSITIVITY ANALYSIS RESULTS

# FINAL PORTFOLIO STUDY RESULTS SCENARIO RESULTS

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# FINAL PORTFOLIO STUDY

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- The following slides provide the Final Portfolio Study results from PLEXOS for the key scenarios (full capacity expansion runs in PLEXOS LT, and Generation / Production Cost results from PLEXOS MT/ST hourly simulations)
- The section includes detailed outputs of each scenario including energy mix, nameplate capacity installation, emissions compliance, achieved Planning Reserve Margin (PRM), several metrics of partial NPV of revenue requirement (NPVRR), average annual partial rate impact, and scenario notes
- NPVs presented in these results are partial revenue requirements that consider modeled costs (i.e. production, O&M, abatement, sustaining capital, and capital investment) and specific costs considered outside of the long-term model optimization (e.g. energy efficiency costs)

# FINAL PORTFOLIO STUDY - METRICS

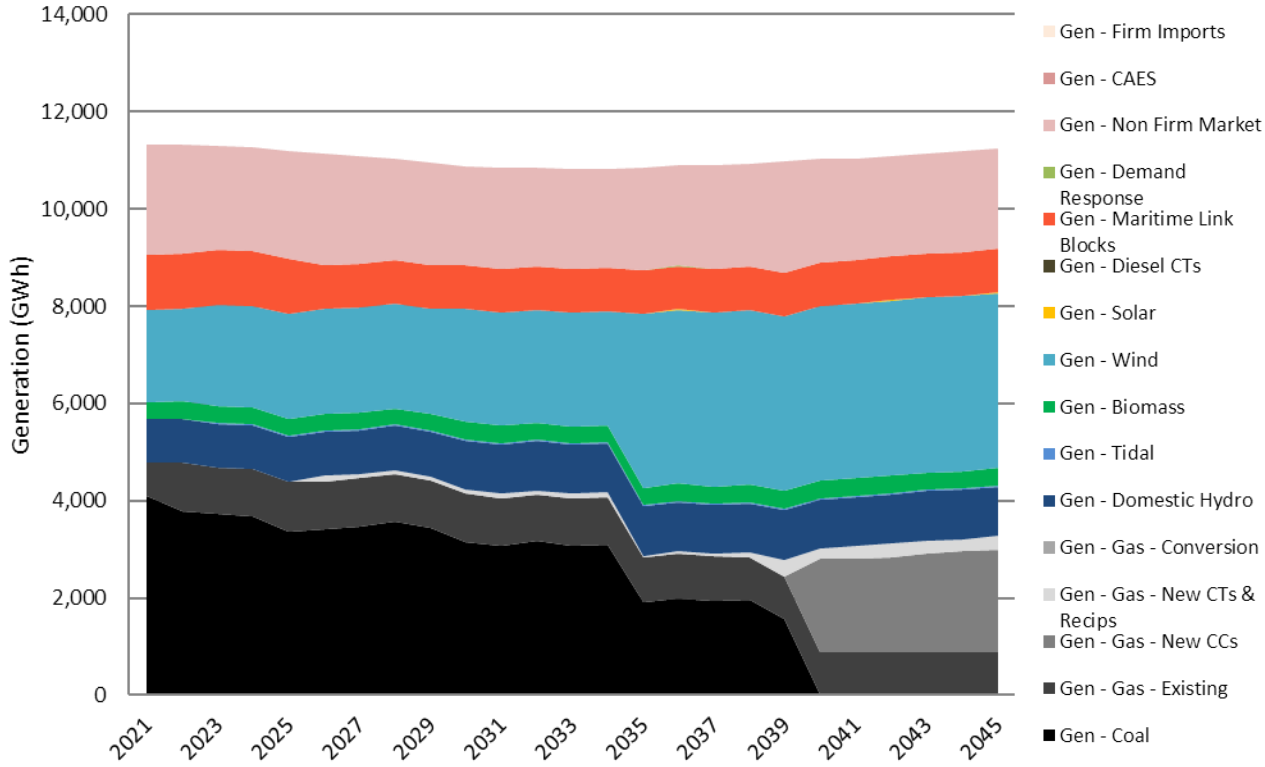
The following metrics are being used to evaluate each portfolio studied; updates from the Scenarios and Modeling Plan release based on ongoing work and stakeholder feedback are shown in **purple text**.

Metric	Description
Minimization of the cumulative present value of the annual revenue requirements over the planning horizon (with and without end-effects adjustment)	25 year NPV Revenue Requirement Average Annual Partial Rate Impact - 25-yr
Magnitude and timing of electricity rate effects	10 year NPV Revenue Requirement Average Annual Partial Rate Impact - 10-yr
Reliability requirements for supply adequacy	Evaluation of PRM, resource capacity adequacy, operating reserve requirements, etc.
Provision of essential grid services for system stability and reliability	Quantitative and qualitative assessment of the status of essential grid services provision for each portfolio. <b>Many plans are similar in this respect, so only key differences will be noted at this time.</b>
Plan robustness (the ability of a plan to withstand plausible potential changes to key assumptions)	Magnitude of the plan's exposure to changes in key assumptions (via sensitivity analysis) as well as resiliency to risks
Reduction of greenhouse gas and/or other emissions	Quantitative reductions as output by Plexos; <b>total emissions over planning horizon.</b>
Flexibility (limitation of constraints on future decisions arising from the selection of a particular path)	Qualitative assessment of timing of investments

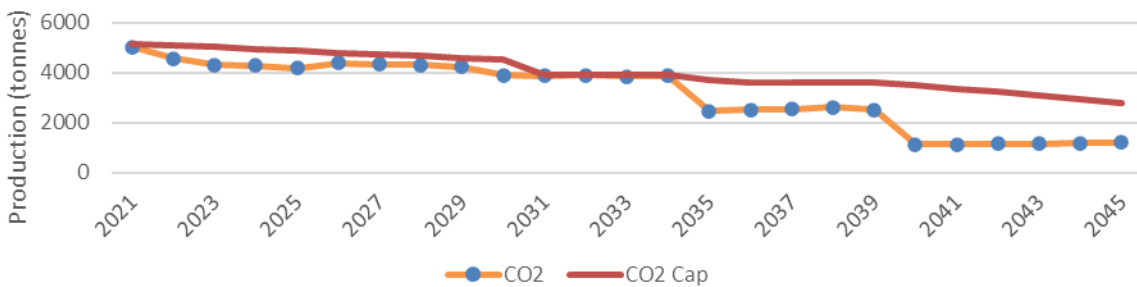
# 1.0A

## LOW ELEC. / BASE DSM / COMPARATOR EMISSIONS / CURRENT LANDSCAPE

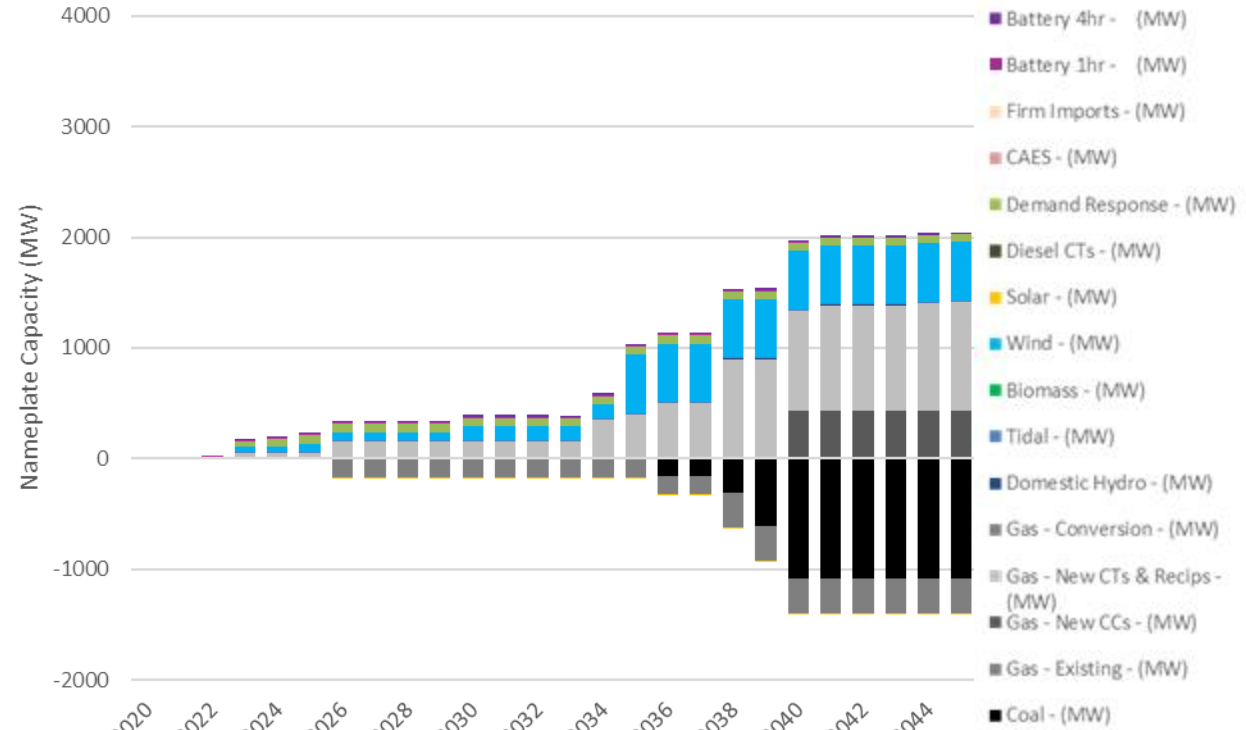
Energy Balance



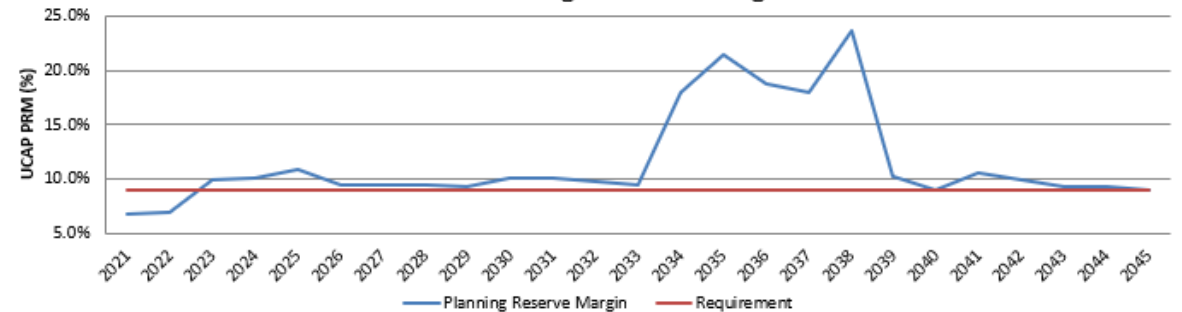
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 1.0A

## LOW ELEC. / BASE DSM / COMPARATOR EMISSIONS / CURRENT LANDSCAPE

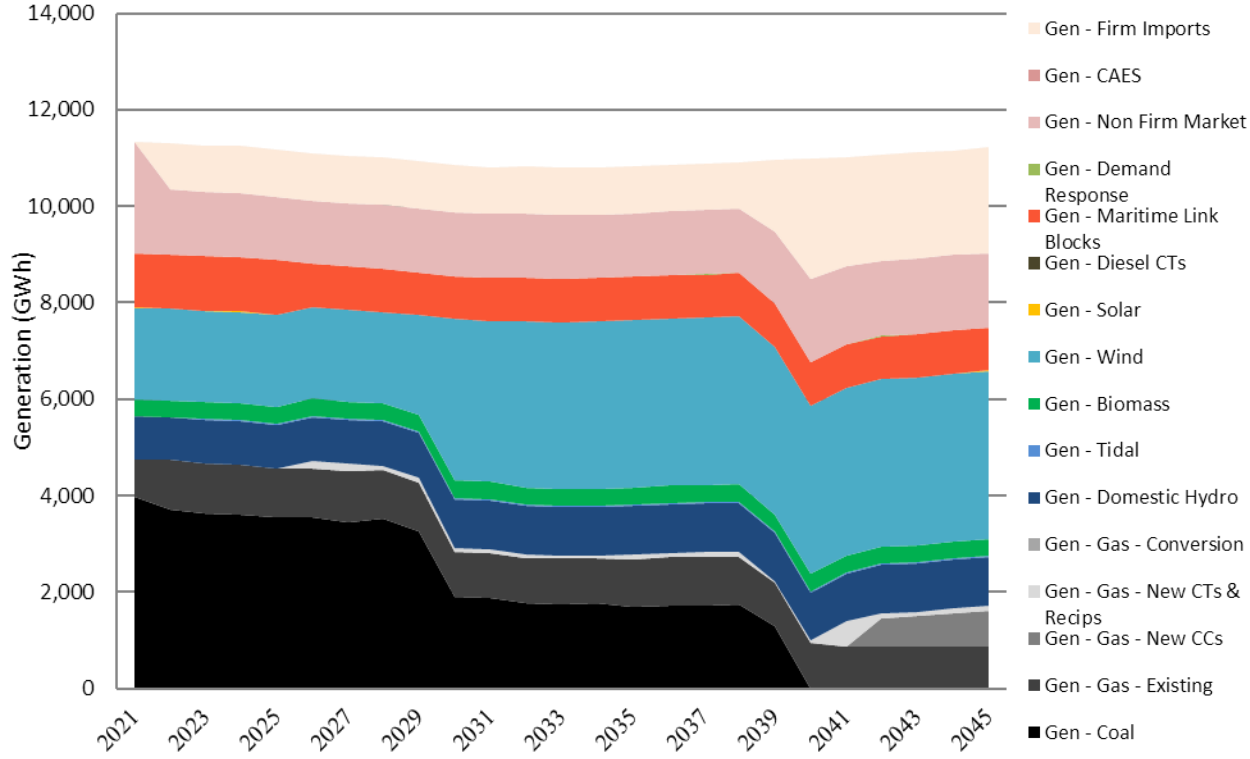
Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$12,419	<u>General Notes</u> <ul style="list-style-type: none"><li>Coal capacity replaced with new gas CCGT and CT units in late 2030s</li><li>Reliability Tie is built and enables additional economic wind generation in 2035</li></ul>
25-yr NPVRR with End Effects (\$MM)	\$16,692	<u>Essential Grid Services</u> <ul style="list-style-type: none"><li>Essential Grid Service requirements are met as modeled</li></ul>
10-yr NPVRR (\$MM)	\$6,850	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"><li>Reliability Tie: 2035</li><li>Regional Integration: n/a</li></ul>
Average Annual Partial Rate Impact		<u>Plan Robustness &amp; Flexibility</u>
2021-2030 (%)	0.8%	<ul style="list-style-type: none"><li>No reliance on firm import energy or capacity</li></ul>
2021-2045 (%)	1.0%	<ul style="list-style-type: none"><li>Not compliant with Sustainable Development Goals Act</li><li>More exposure to natural gas prices with 435MW NGCC capacity in 2040s</li></ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	43.5	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	35.0	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	78.5	



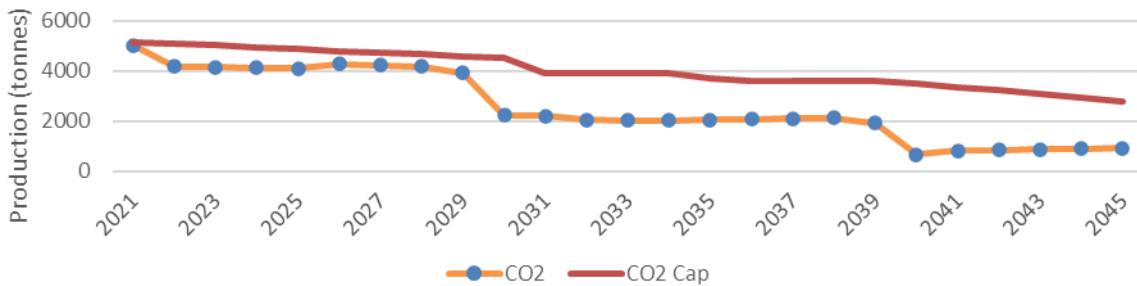
# 1.0C

## LOW ELEC. / BASE DSM / COMPARATOR EMISSIONS / REGIONAL INTEGRATION

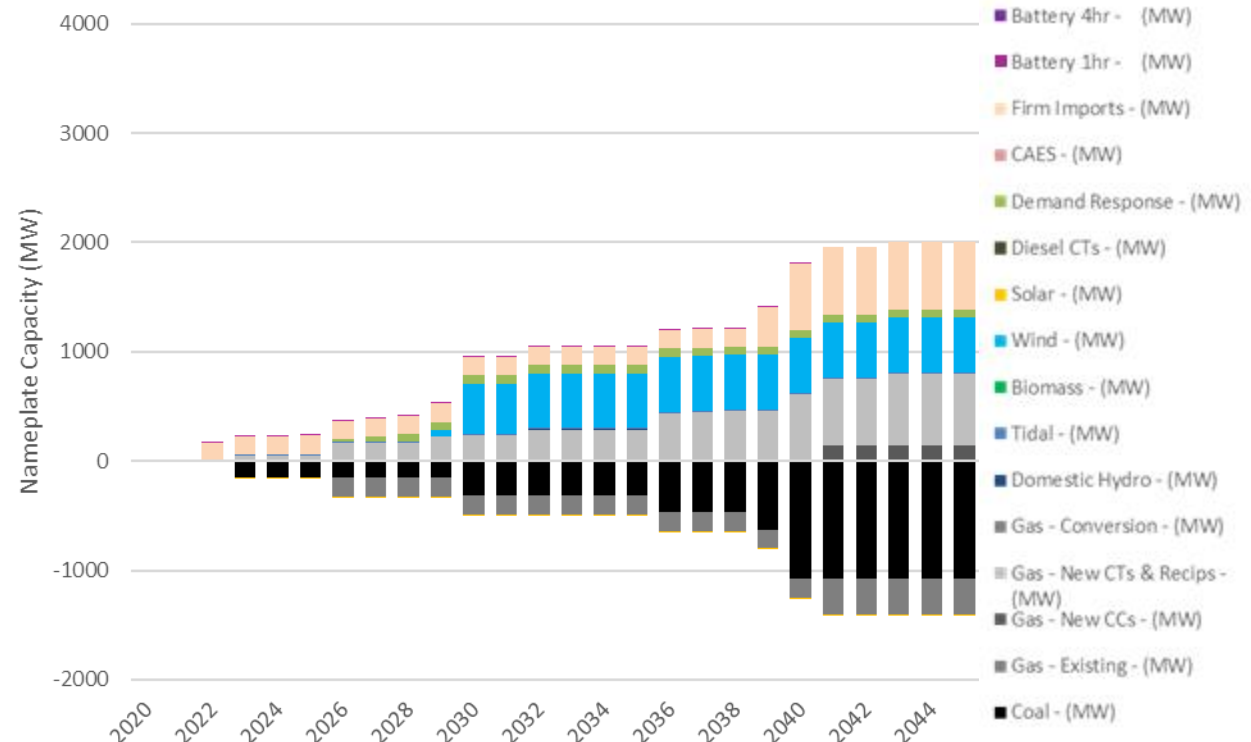
Energy Balance



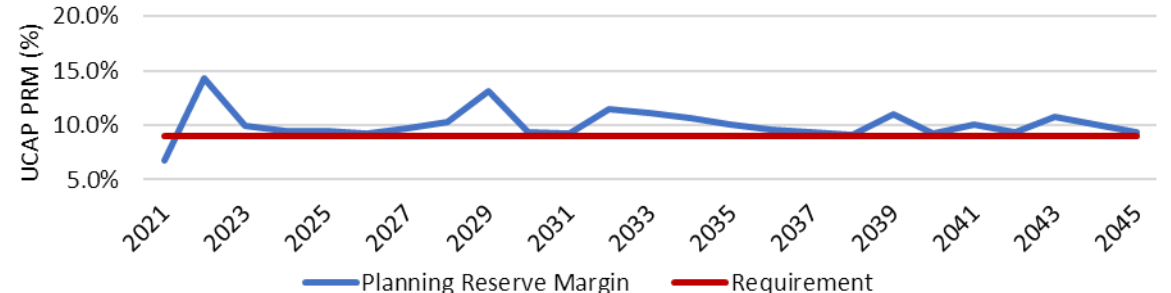
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 1.0C

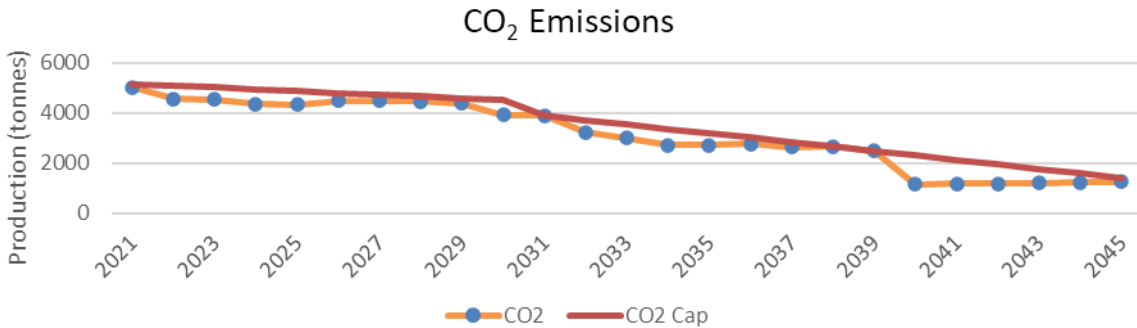
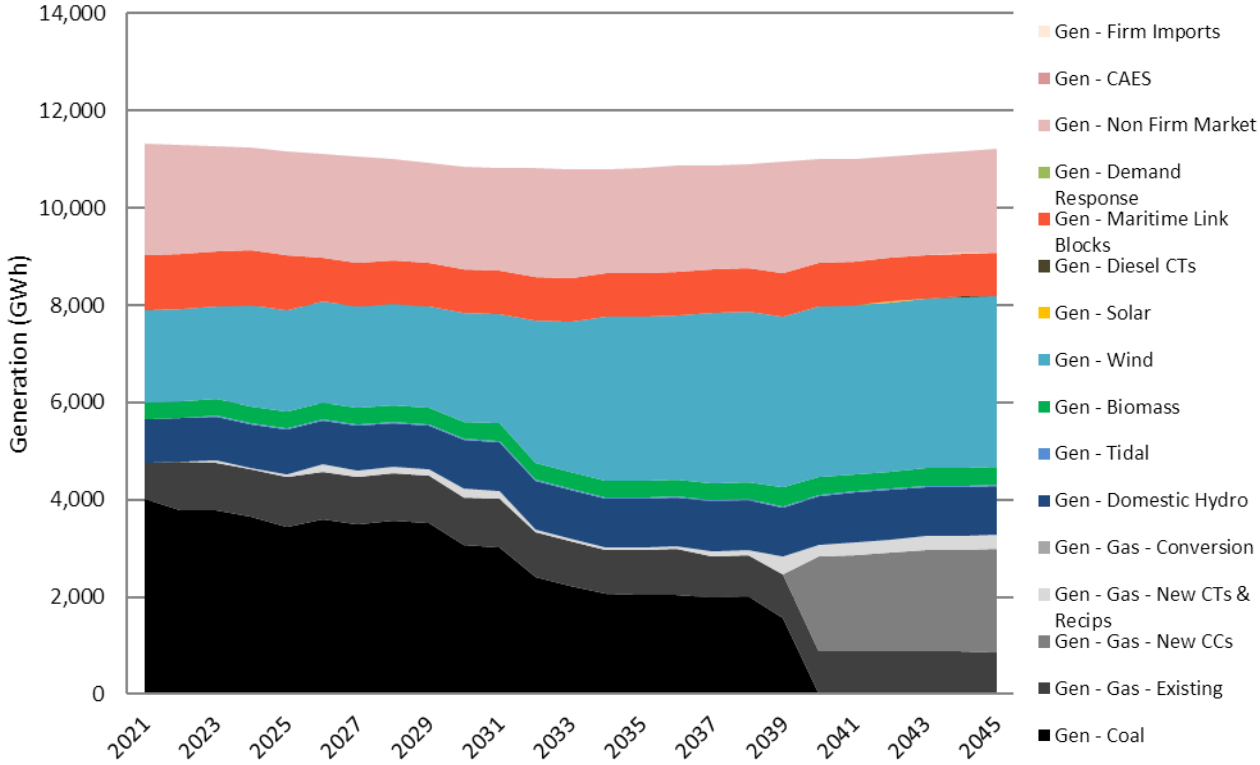
## LOW ELEC. / BASE DSM / COMPARATOR EMISSIONS / REGIONAL INTEGRATION

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$12,190	<u>General Notes</u> <ul style="list-style-type: none"><li>Incremental firm imports enable an economic coal unit retirement in the 2020s</li><li>Reliability Tie in 2030 enables additional wind integration earlier than seen in previous results</li><li>Regional Interconnection constructed in 2039 allows remaining coal retirements</li></ul>
25-yr NPVRR with End Effects (\$MM)	\$16,167	
10-yr NPVRR (\$MM)	\$6,811	
Average Annual Partial Rate Impact		<u>Essential Grid Services</u> <ul style="list-style-type: none"><li>Essential Grid Service requirements are met as modeled</li></ul>
2021-2030 (%)	0.9%	
2021-2045 (%)	0.8%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"><li>Reliability Tie: 2030</li><li>Regional Integration: 2039</li></ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	40.4	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	23.5	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"><li>Not compliant with Sustainable Development Goals Act</li><li>Regional Integration provides flexible ability to meet emissions constraints</li></ul>
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	63.8	

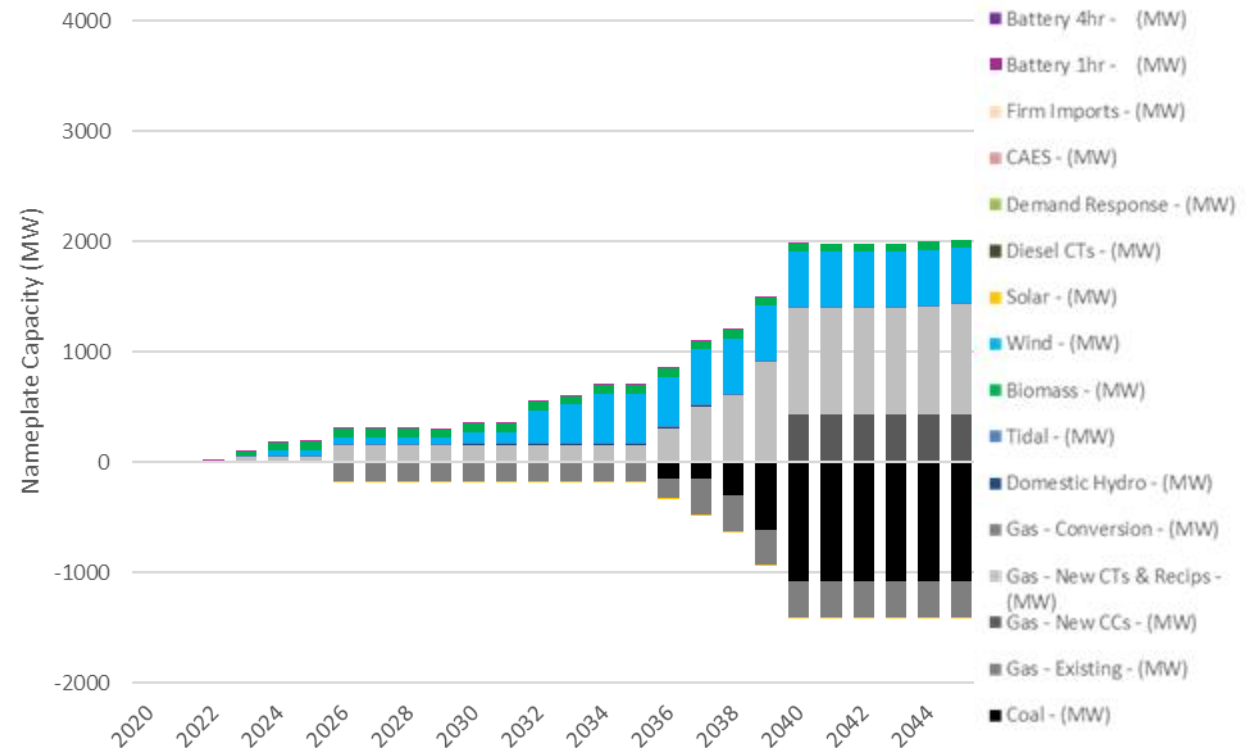
# 2.0A

## LOW ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

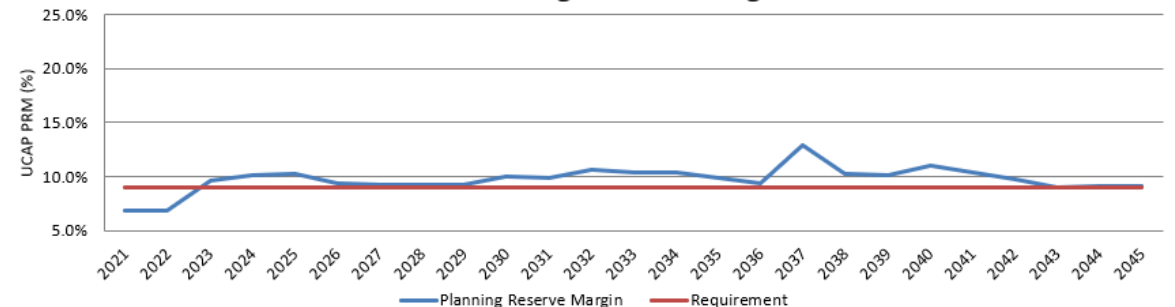
Energy Balance



New Installed Capacity



UCAP Planning Reserve Margin



# 2.0A

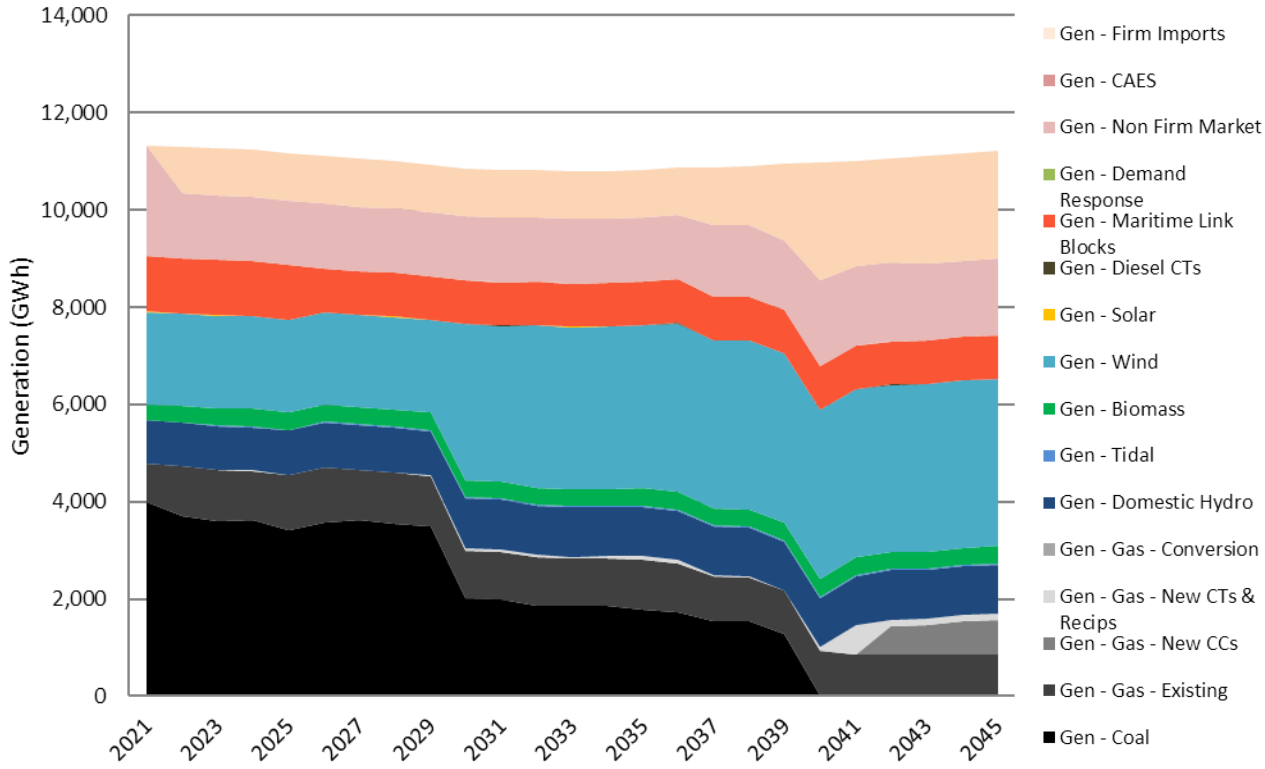
## LOW ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$12,351	<u>General Notes</u> <ul style="list-style-type: none"><li>Reliability Tie built in 2030 enables wind integration; does not provide firm capacity or energy access</li></ul>
25-yr NPVRR with End Effects (\$MM)	\$16,609	<u>Essential Grid Services</u> <ul style="list-style-type: none"><li>Essential Grid Service requirements are met as modeled</li></ul>
10-yr NPVRR (\$MM)	\$6,831	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"><li>Reliability Tie: 2032</li><li>Regional Integration: n/a</li></ul>
Average Annual Partial Rate Impact		<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"><li>No reliance on firm import energy or capacity</li><li>More exposure to natural gas prices with 435MW NGCC capacity in 2040s</li></ul>
2021-2030 (%)	0.9%	
2021-2045 (%)	1.0%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	44.5	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	33.2	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	77.7	

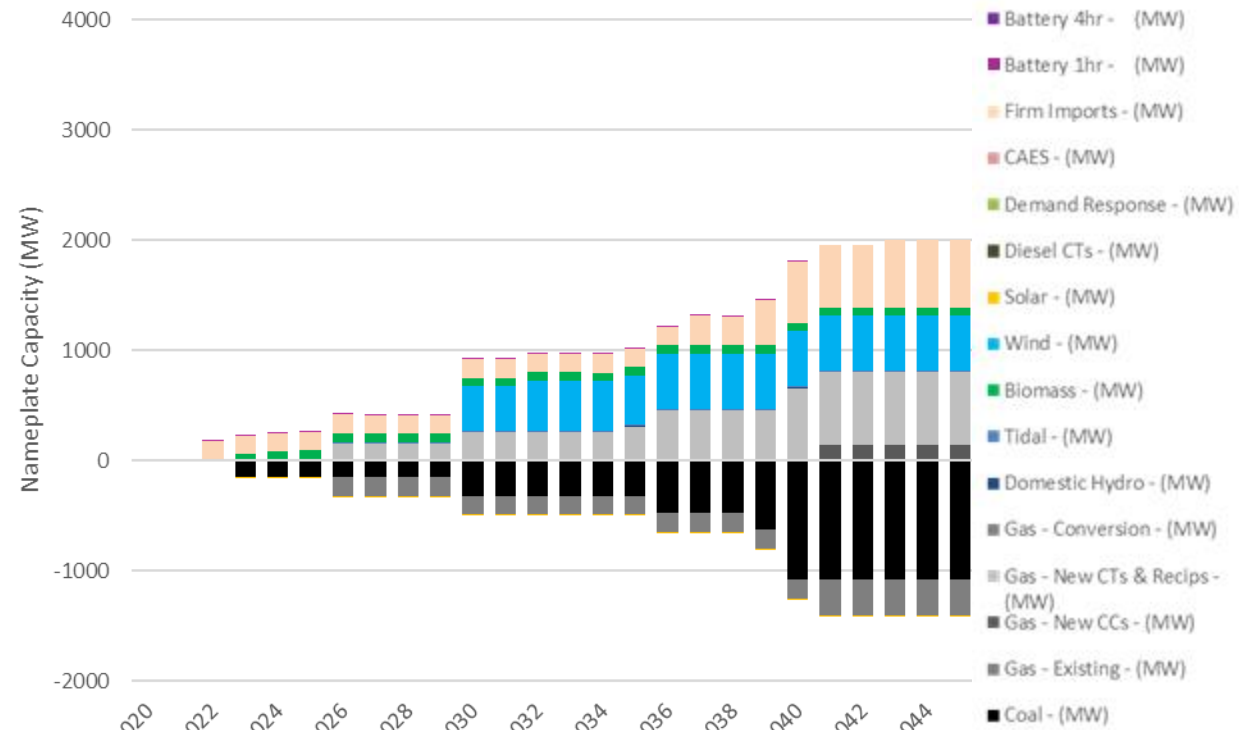
# 2.0C

LOW ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

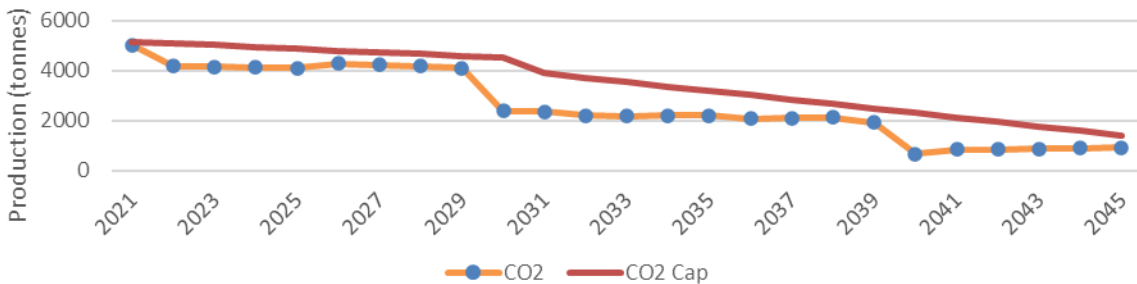
Energy Balance



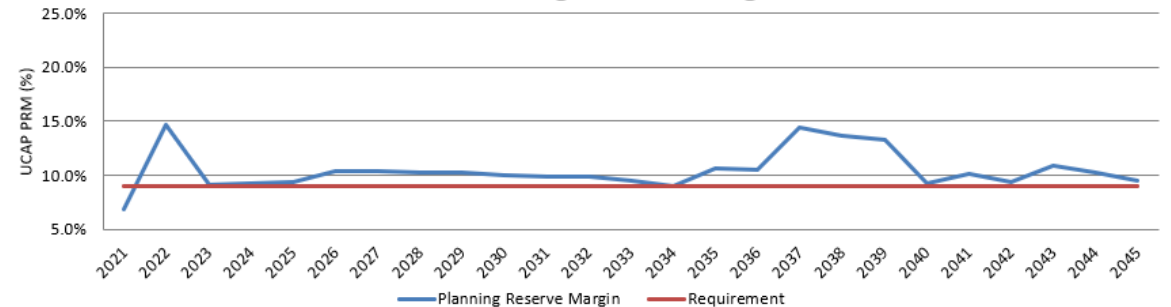
New Installed Capacity



CO<sub>2</sub> Emissions



UCAP Planning Reserve Margin



# 2.0C

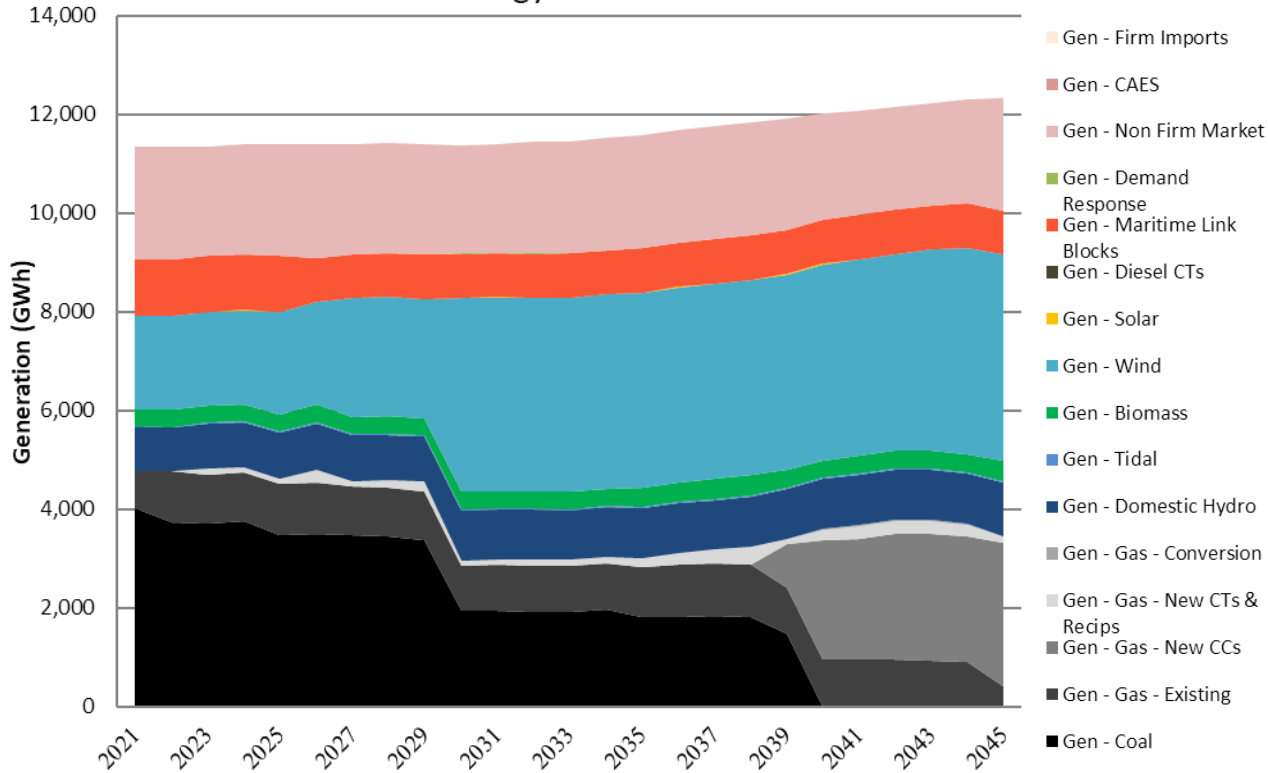
## LOW ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$12,234	<u>General Notes</u> <ul style="list-style-type: none"><li>Capacity expansion and generation are very similar to 1.0C case but with SDGA compliant GHG curve</li></ul>
25-yr NPVRR with End Effects (\$MM)	\$16,241	<u>Essential Grid Services</u> <ul style="list-style-type: none"><li>Essential Grid Service requirements are met as modeled</li></ul>
10-yr NPVRR (\$MM)	\$6,820	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"><li>Reliability Tie: 2030</li><li>Regional Integration: 2037</li></ul>
Average Annual Partial Rate Impact		<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"><li>Regional Integration provides flexible ability to meet emissions constraints</li></ul>
2021-2030 (%)	0.9%	
2021-2045 (%)	0.9%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	40.7	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	24.3	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	65.0	

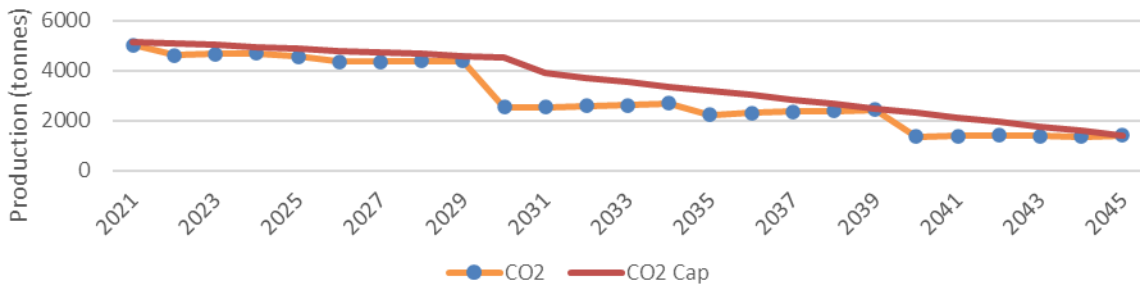
# 2.1A

## MID ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

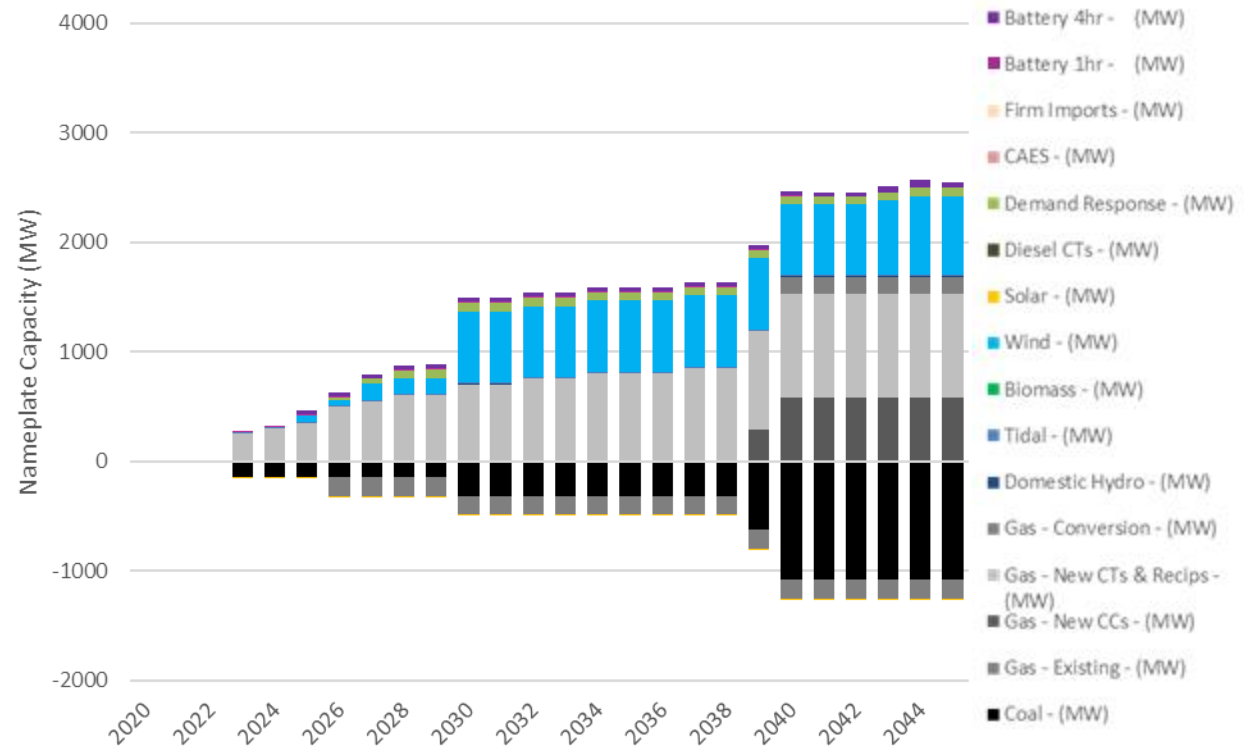
Energy Balance



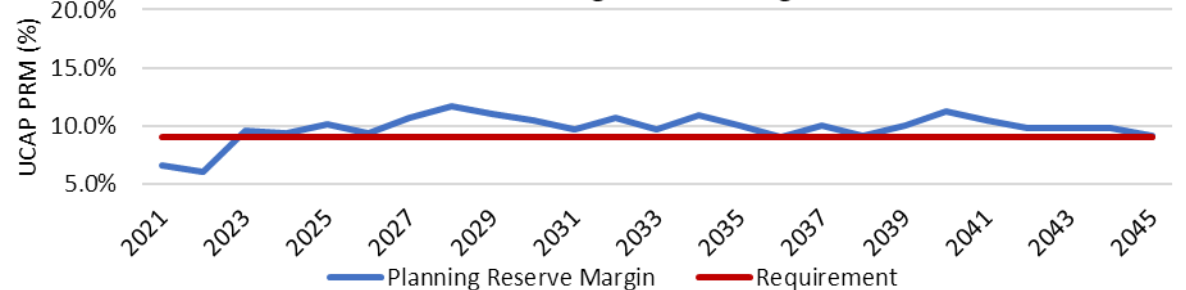
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 2.1A

## MID ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

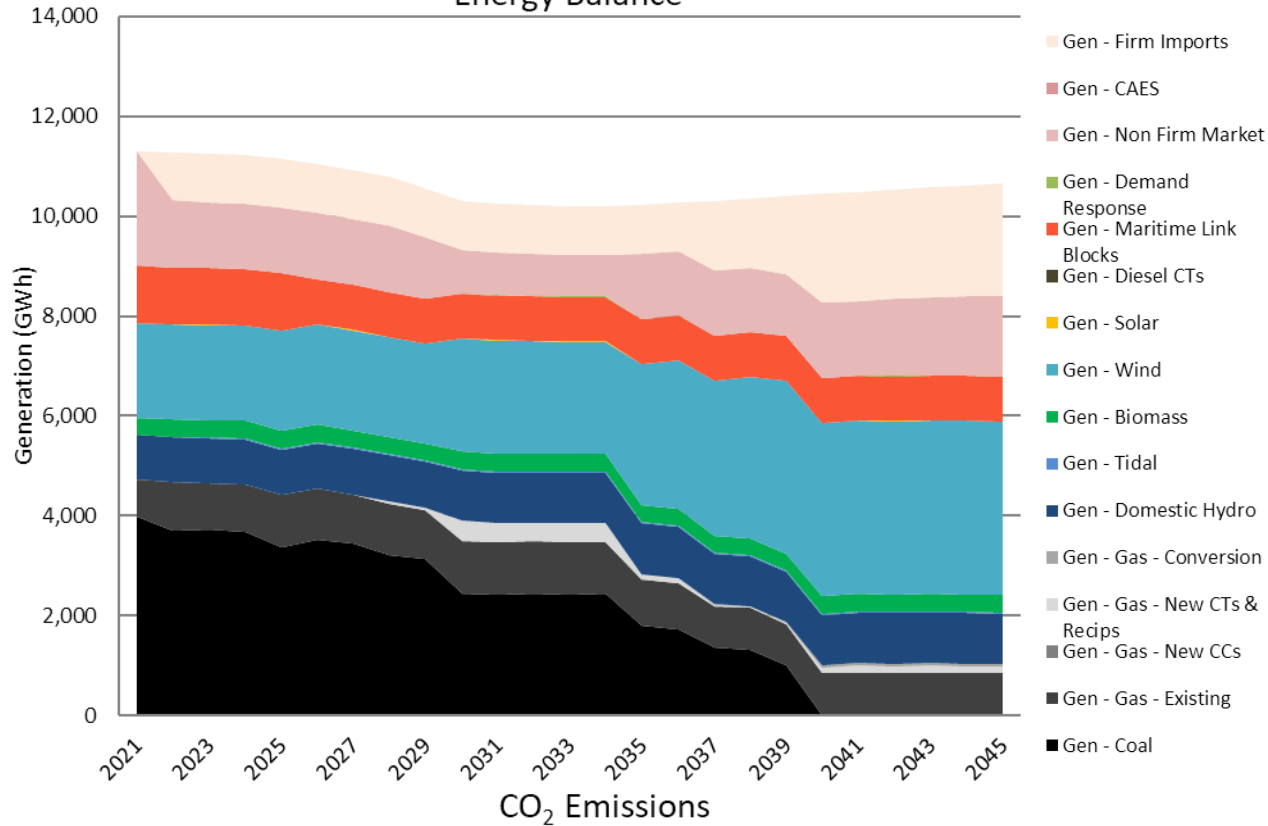
Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$13,353	<u>General Notes</u> <ul style="list-style-type: none"> <li>Reliability Tie built in 2031 enables wind integration but does not provide firm capacity or energy access</li> <li>Gas CT builds provide capacity to support early electrification load growth; energy is supplied by wind and non-firm imports, and CCGT when coal units retire</li> <li>1 coal unit converted to gas in 2040</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$18,264	
10-yr NPVRR (\$MM)	\$7,100	
Average Annual Partial Rate Impact		<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Essential Grid Service requirements are met as modeled</li> </ul>
2021-2030 (%)	0.8%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2030</li> <li>Regional Integration: n/a</li> </ul>
2021-2045 (%)	0.8%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	43.6	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No reliance on firm import energy or capacity</li> <li>More exposure to natural gas prices with 435MW NGCC capacity in 2040s</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	30.3	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	73.9	



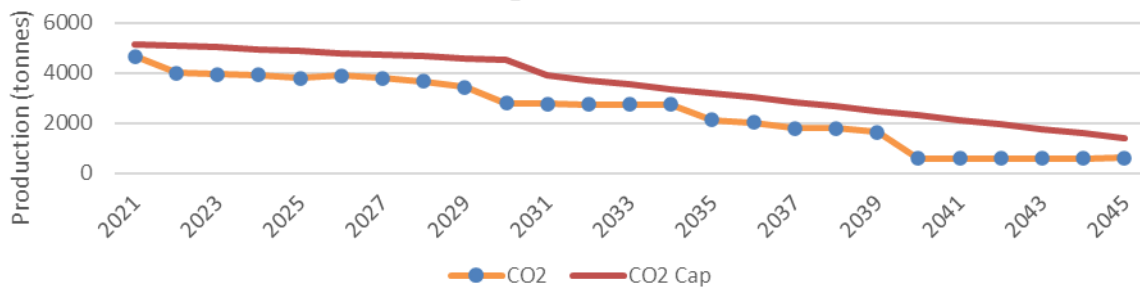
# 2.1B

## MID ELEC. / BASE DSM / NET ZERO 2050 / DISTRIBUTED RESOURCES

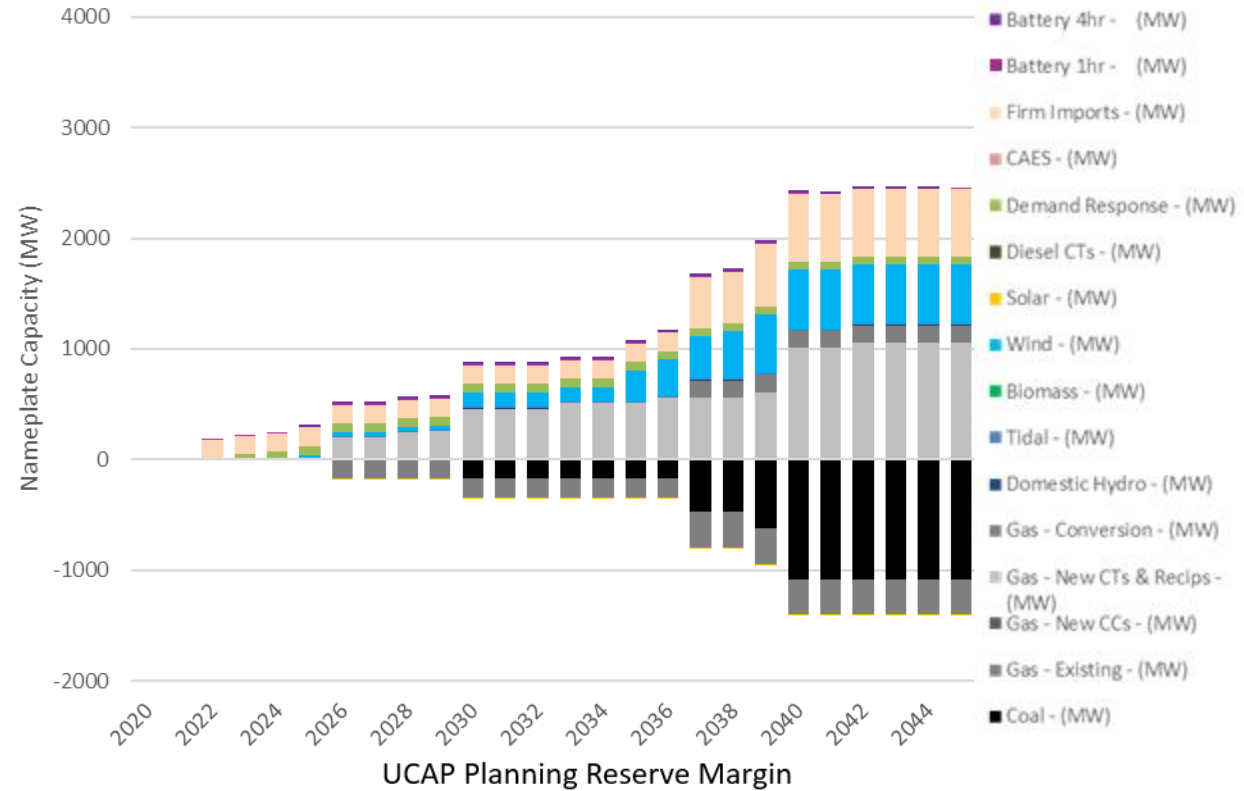
Energy Balance



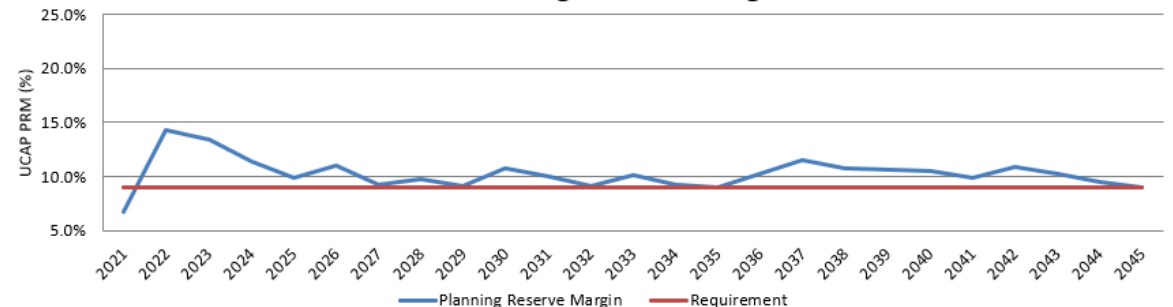
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 2.1B

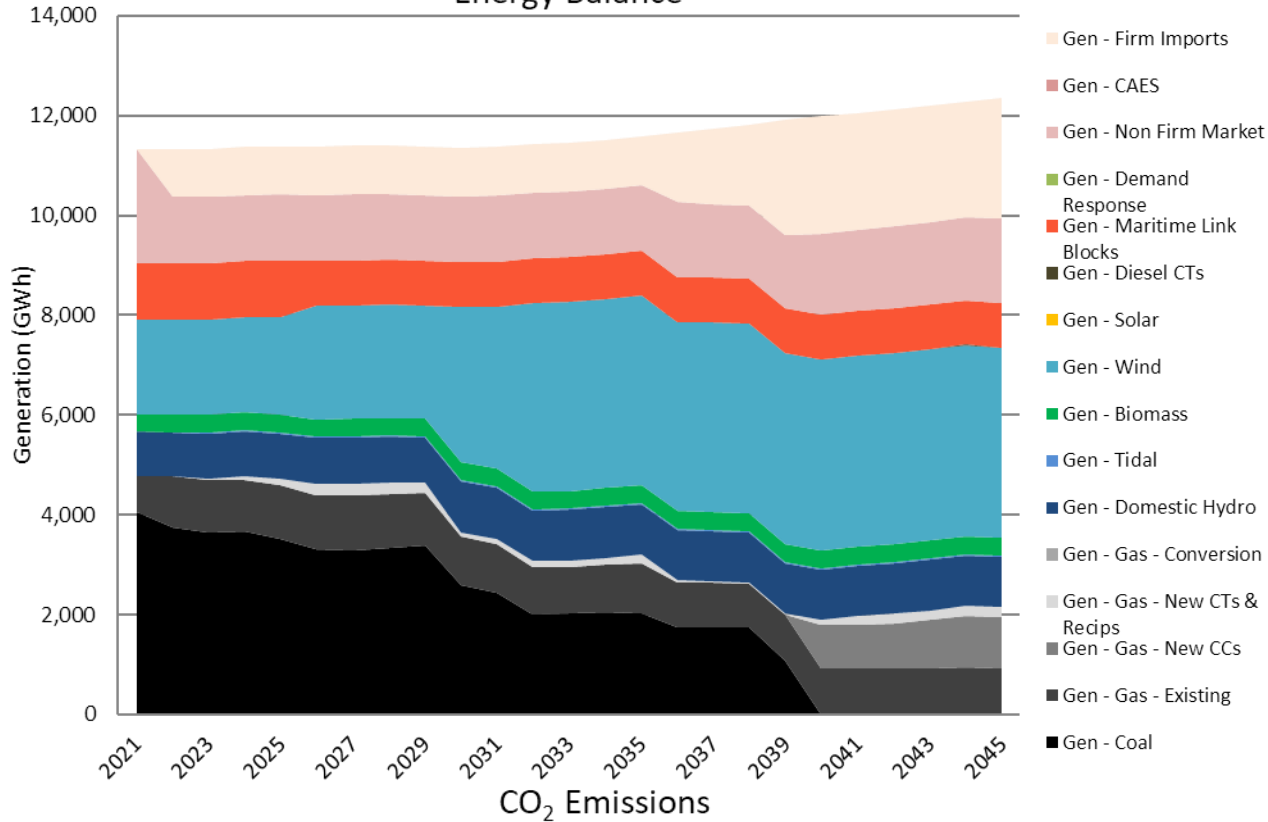
## MID ELEC. / BASE DSM / NET ZERO 2050 / DISTRIBUTED RESOURCES

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$12,479	<u>General Notes</u> <ul style="list-style-type: none"><li>DER is modeled as a load reduction; cost of DER resources not included in NPV calculations (\$1.6B - \$2.5B)</li><li>1 coal unit converted to gas in 2037</li></ul>
25-yr NPVRR with End Effects (\$MM)	\$16,573	
10-yr NPVRR (\$MM)	\$6,949	<u>Essential Grid Services</u> <ul style="list-style-type: none"><li>Essential Grid Service requirements are met as modeled</li></ul>
Average Annual Partial Rate Impact		<u>Resource Adequacy &amp; PRM</u>
2021-2030 (%)	1.9%	<ul style="list-style-type: none"><li>Reliability Tie: 2035</li><li>Regional Integration: 2037</li></ul>
2021-2045 (%)	1.2%	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"><li>Regional Integration provides flexible ability to meet emissions constraints</li></ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	37.9	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	23.8	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	61.7	

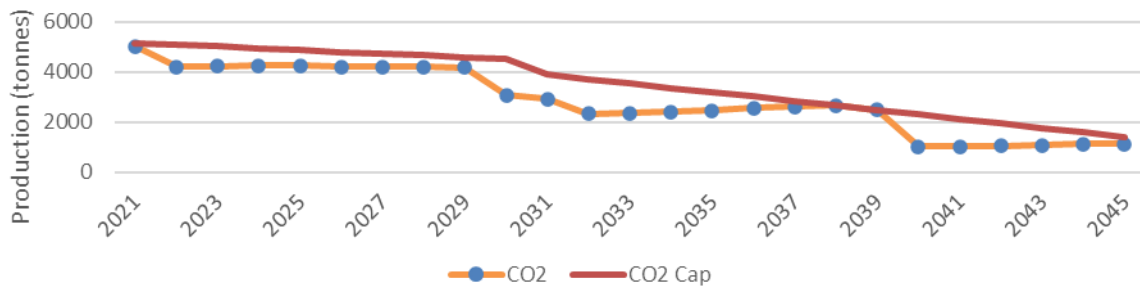
# 2.1C

## MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

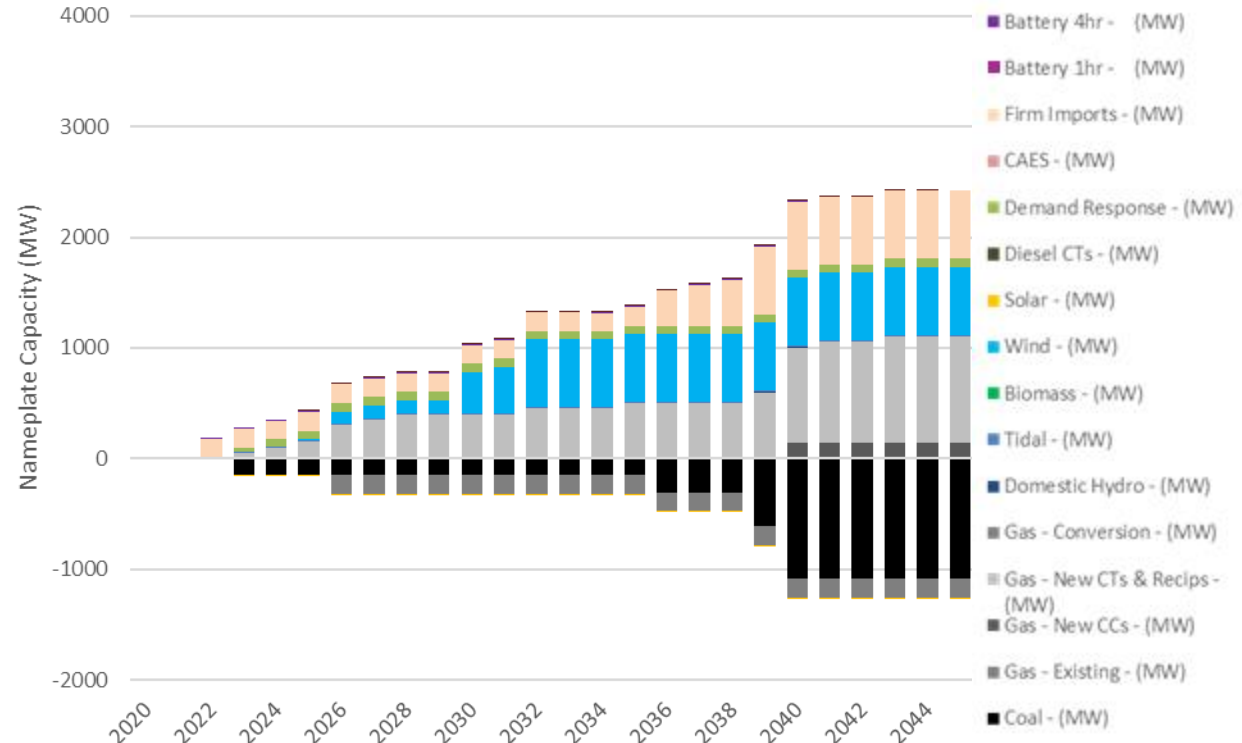
Energy Balance



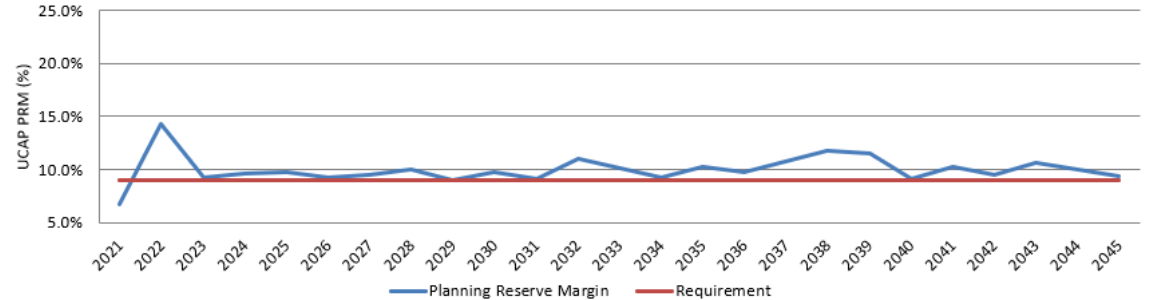
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 2.1C

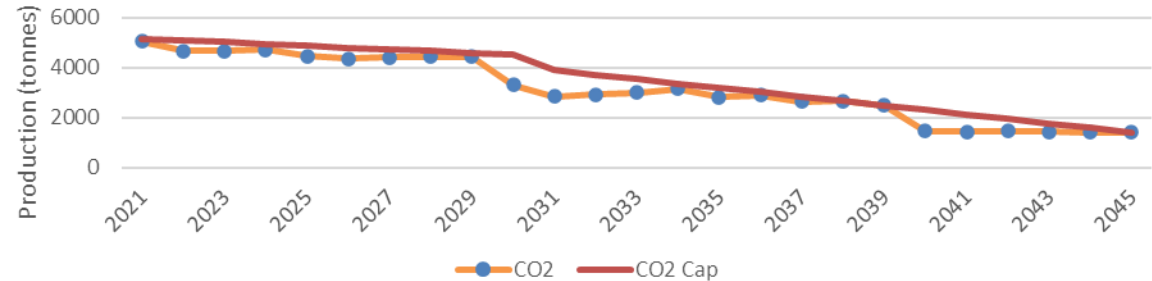
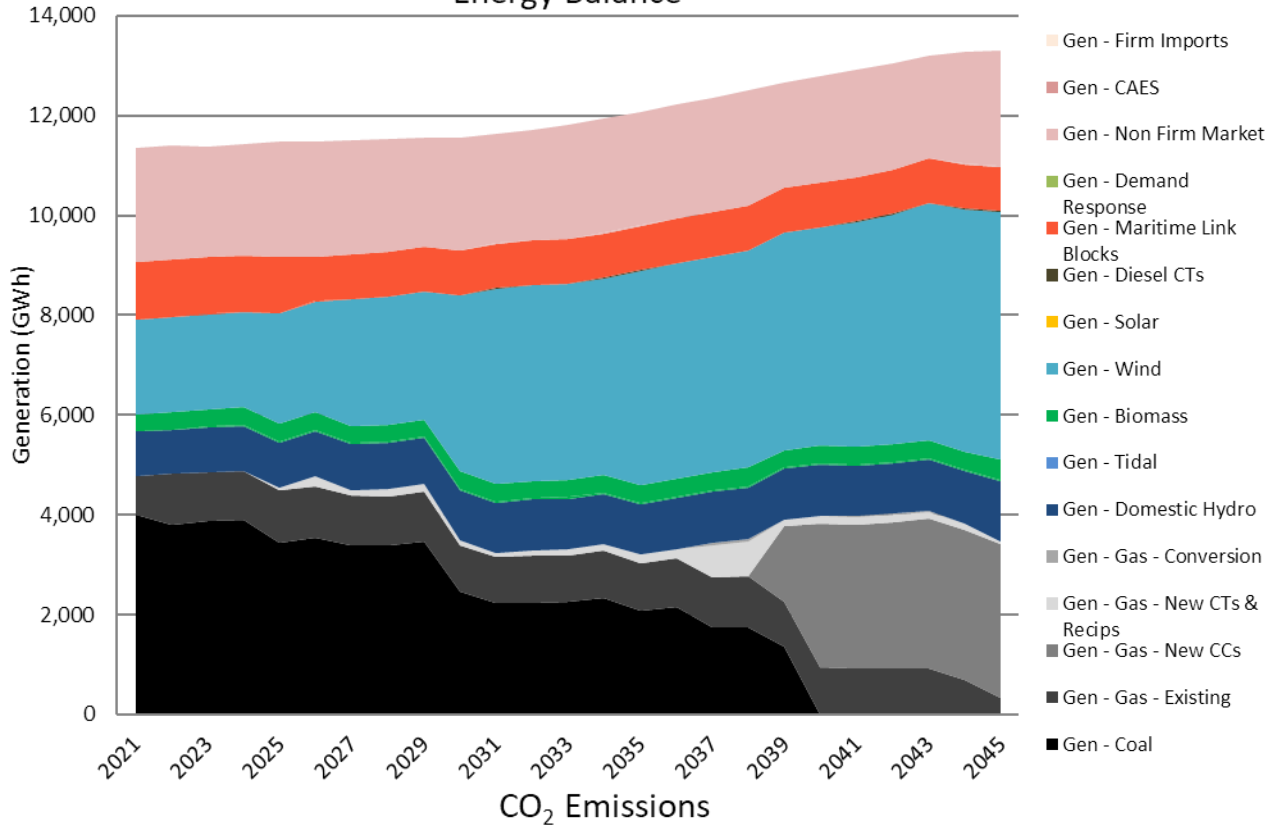
## MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$13,141	<u>General Notes</u> <ul style="list-style-type: none"><li>Reliability Tie built in 2031 (earlier than previous runs) enables wind integration</li><li>1 coal unit retired economically in 2020s</li><li>1 less combined cycle unit in 2040 than seen in previous runs</li></ul>
25-yr NPVRR with End Effects (\$MM)	\$17,767	
10-yr NPVRR (\$MM)	\$7,067	
Average Annual Partial Rate Impact		<u>Essential Grid Services</u> <ul style="list-style-type: none"><li>Essential Grid Service requirements are met as modeled</li></ul>
2021-2030 (%)	0.6%	
2021-2045 (%)	0.7%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"><li>Reliability Tie: 2030</li><li>Regional Integration: 2036</li></ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	41.8	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"><li>Regional Integration provides flexible ability to meet emissions constraints</li></ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	70.9	

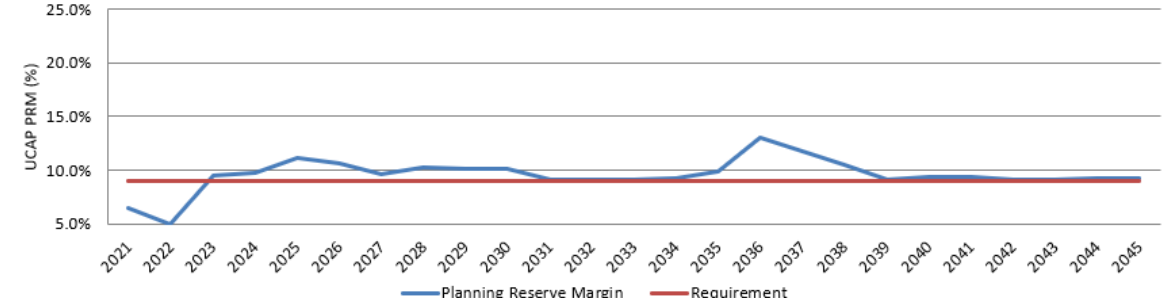
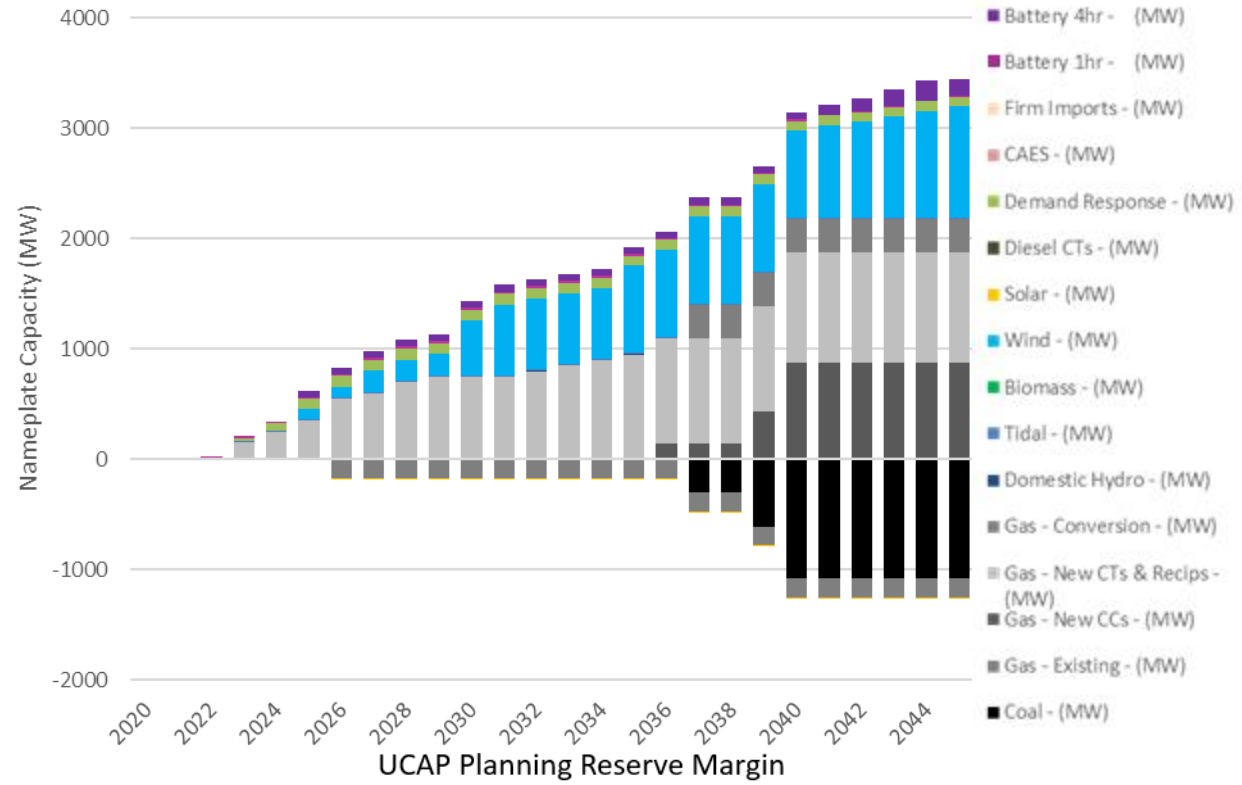
# 2.2A

## HIGH ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

Energy Balance



New Installed Capacity



# 2.2A

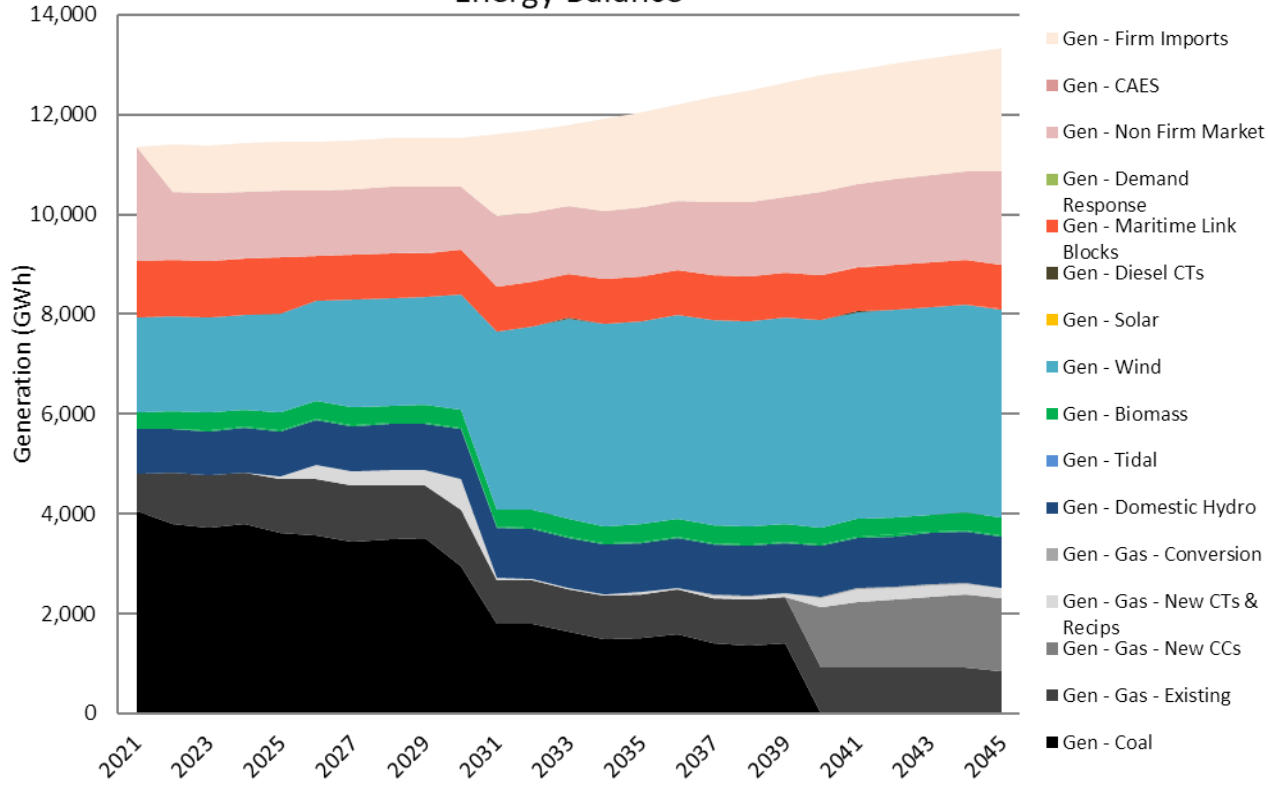
## HIGH ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$15,656	<u>General Notes</u> <ul style="list-style-type: none"> <li>• Early load growth served by incremental gas CTs and non firm import energy</li> <li>• Reliability Tie built in 2030 (earlier than previous runs) enables wind integration</li> <li>• Additional wind is integrated with local mitigation</li> <li>• 2 coal units converted to gas in 2037</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$21,627	
10-yr NPVRR (\$MM)	\$8,232	
Average Annual Partial Rate Impact		<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>• Essential Grid Service requirements are met as modeled</li> </ul>
2021-2030 (%)	1.4%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>• Reliability Tie: 2030</li> <li>• Regional Integration: n/a</li> </ul>
2021-2045 (%)	1.0%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	44.4	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>• No reliance on firm import energy or capacity</li> <li>• Significant exposure to natural gas prices with NGCC and gas conversion builds</li> <li>• Limited ability to adjust sources of supply as existing import options are maximized</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	33.9	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	78.3	

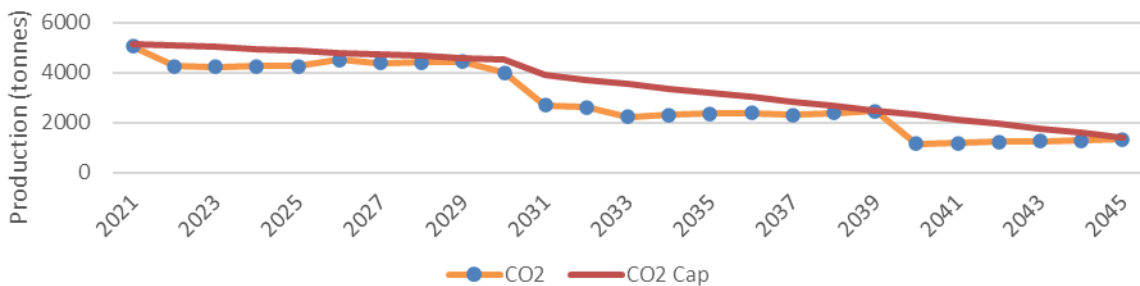
# 2.2C

## HIGH ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

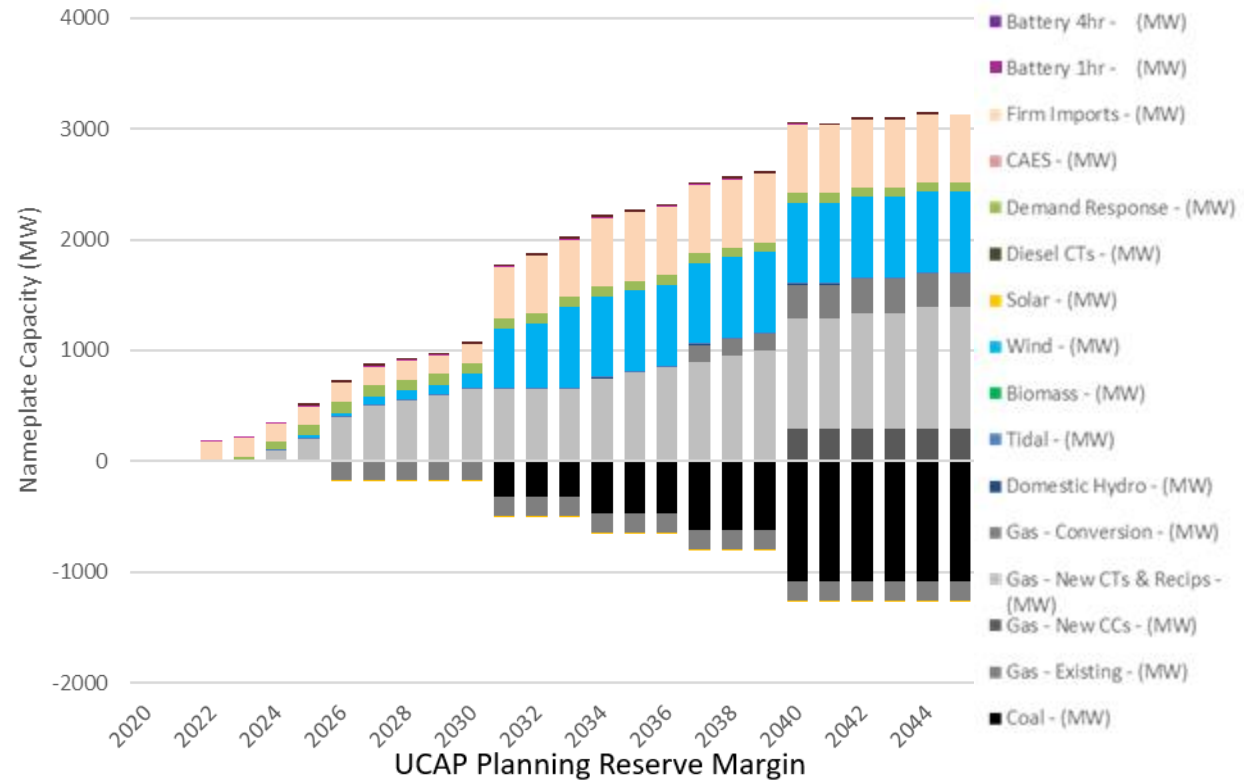
Energy Balance



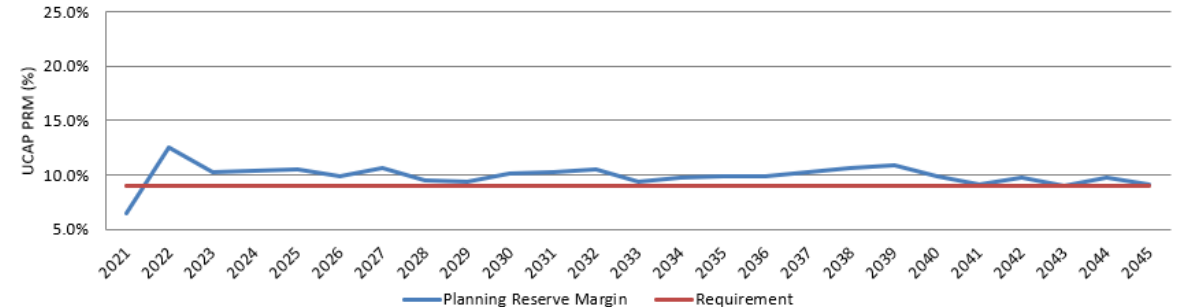
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 2.2C

## HIGH ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

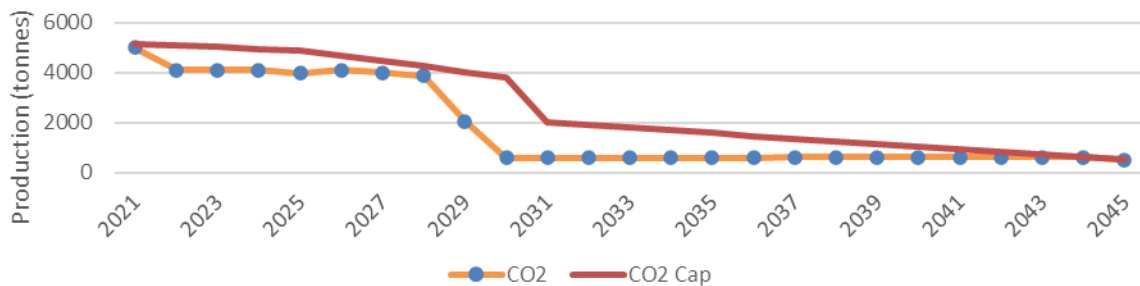
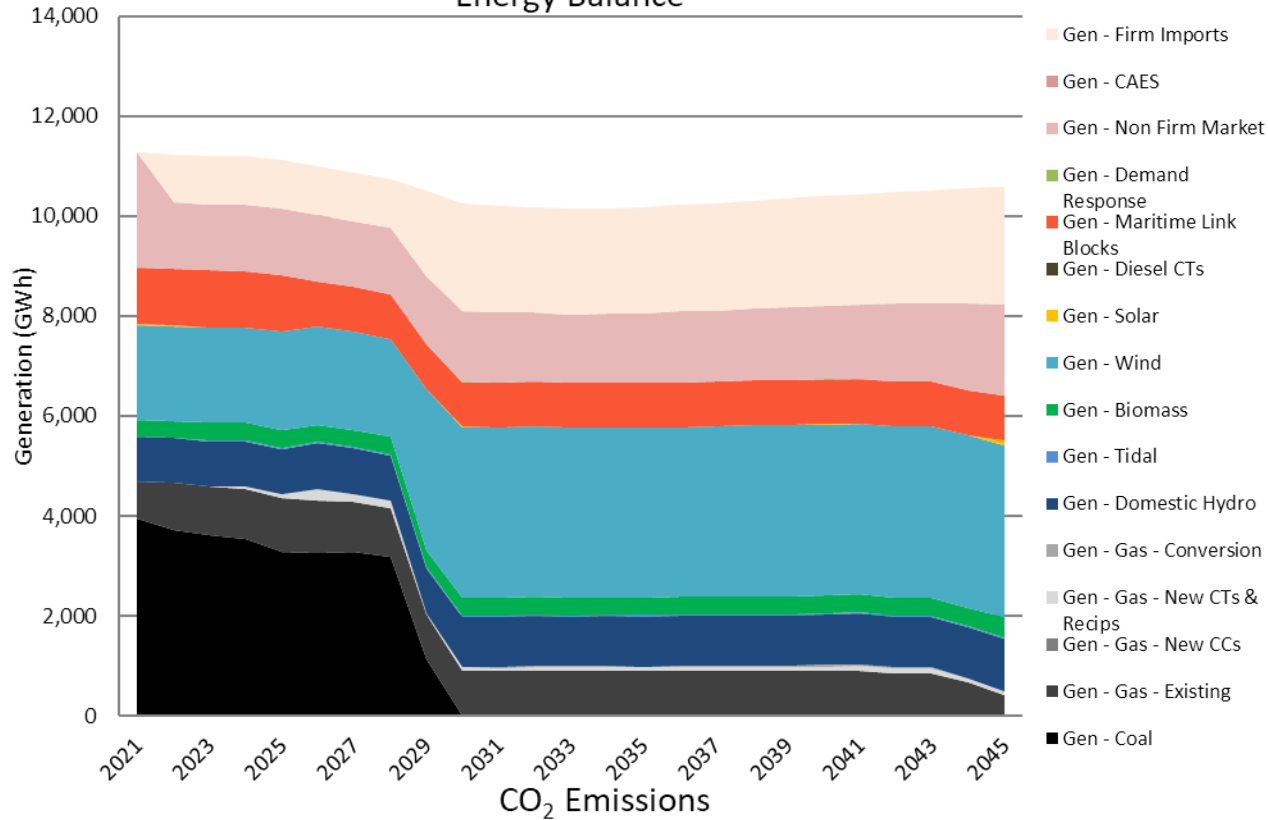
Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$15,380	<u>General Notes</u> <ul style="list-style-type: none"> <li>Reliability Tie &amp; Regional Interconnection built in 2031 (earlier than in previous runs)</li> <li>2 coal to gas conversions in 2037 &amp; 2040</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$20,945	<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Essential Grid Service requirements are met as modeled</li> </ul>
10-yr NPVRR (\$MM)	\$8,201	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2031</li> <li>Regional Integration: 2031</li> </ul>
Average Annual Partial Rate Impact		<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Regional Integration provides flexible ability to meet emissions constraints</li> </ul>
2021-2030 (%)	1.3%	
2021-2045 (%)	0.8%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	43.7	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	29.0	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	72.7	



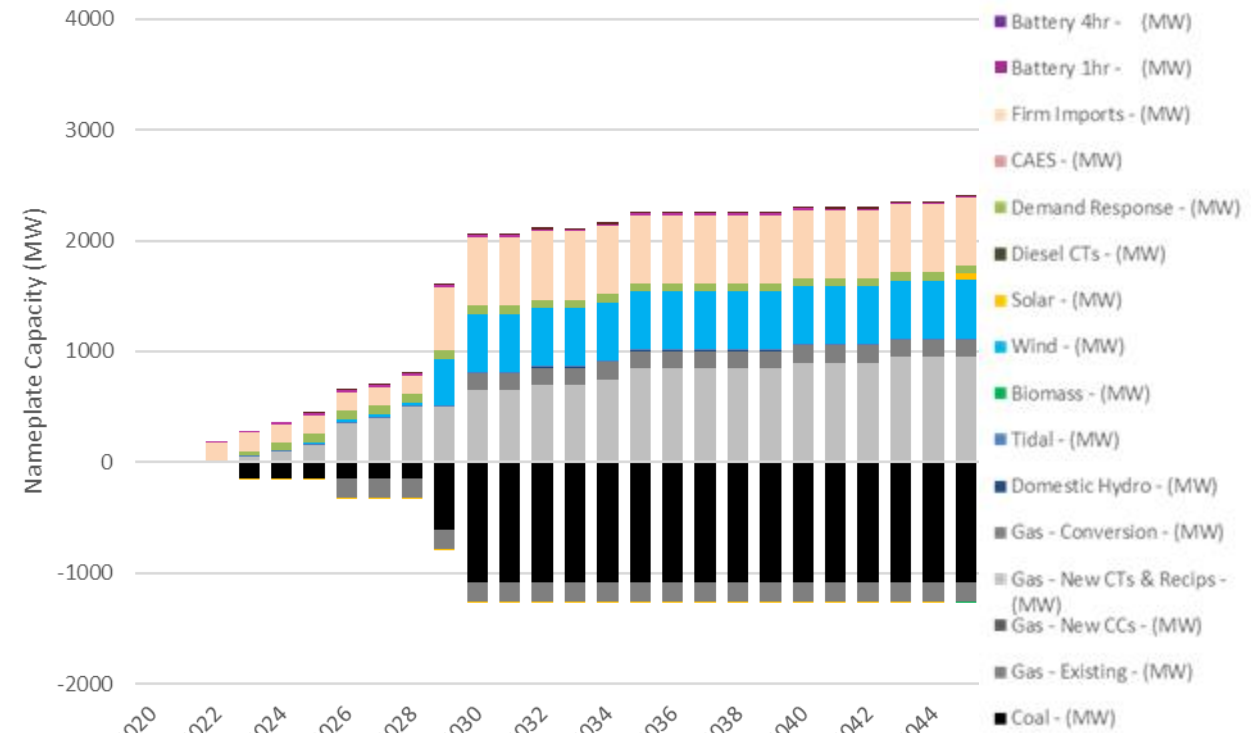
# 3.1B

## MID ELEC. / BASE DSM / ACCEL. NET ZERO 2045 / DISTRIBUTED RESOURCES

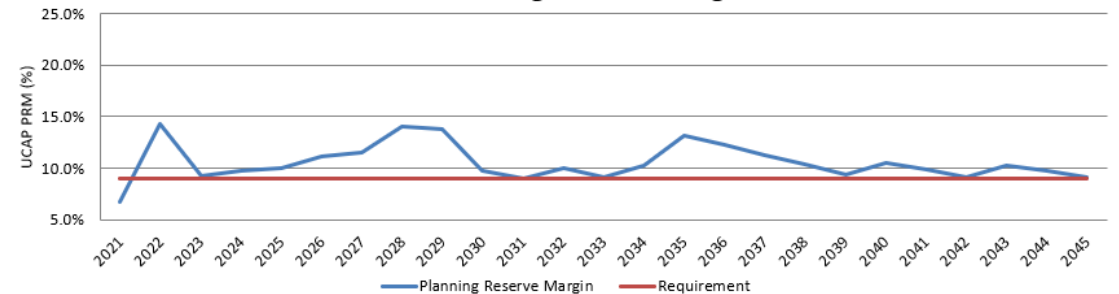
Energy Balance



New Installed Capacity



UCAP Planning Reserve Margin



# 3.1B

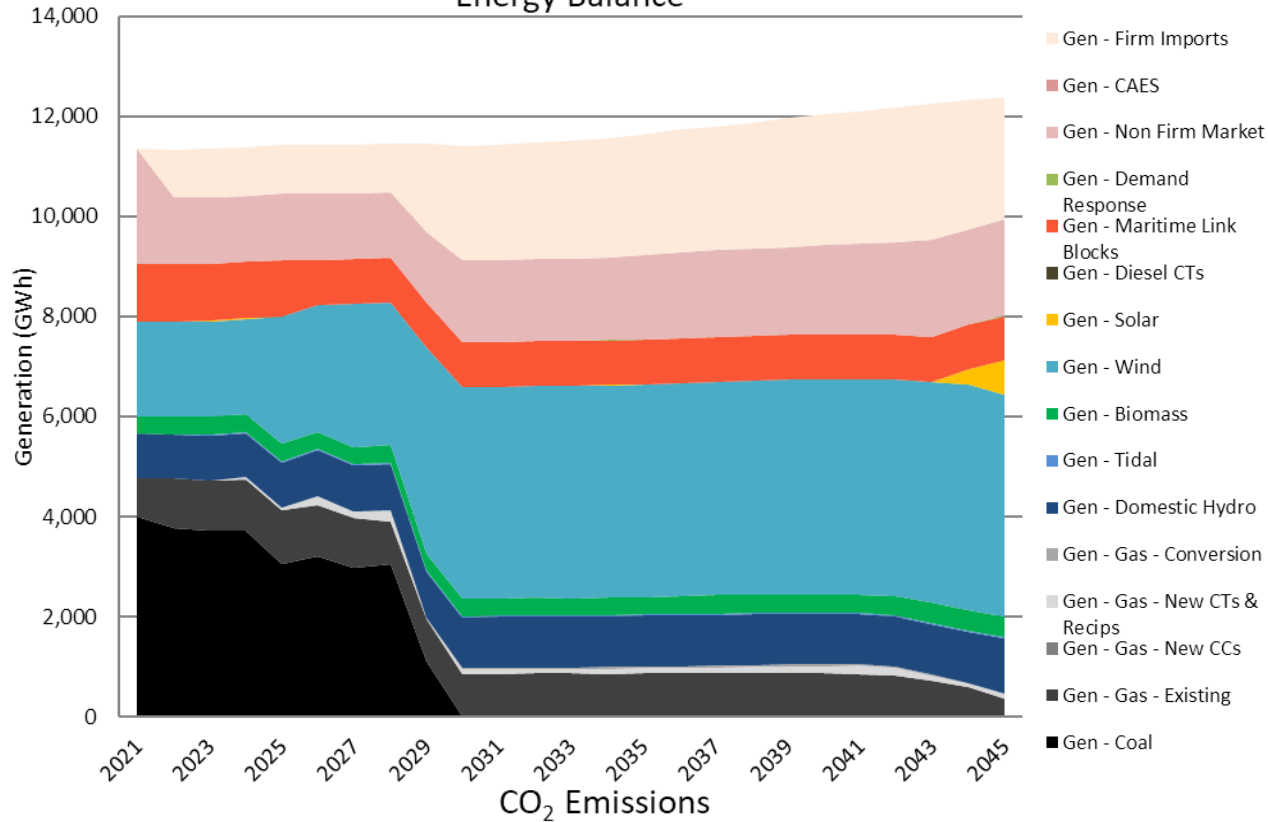
## MID ELEC. / BASE DSM / ACCEL. NET ZERO 2045 / DISTRIBUTED RESOURCES

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$12,698	<u>General Notes</u> <ul style="list-style-type: none"> <li>DER is modeled as a load reduction; cost of DER resources not included in NPV calculations (\$1.6B - \$2.5B)</li> <li>Reliability Tie and Regional Interconnection built in 2029 (earlier than in previous simulations) offsets build of NGCC assets seen in previous modeling results</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$16,754	
10-yr NPVRR (\$MM)	\$6,950	<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Essential Grid Service requirements are met as modeled</li> </ul>
Average Annual Partial Rate Impact		<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2029</li> <li>Regional Integration: 2029</li> </ul>
2021-2030 (%)	2.3%	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Regional Integration provides flexible ability to meet emissions constraints</li> </ul>
2021-2045 (%)	1.2%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	35.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	8.8	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	44.7	

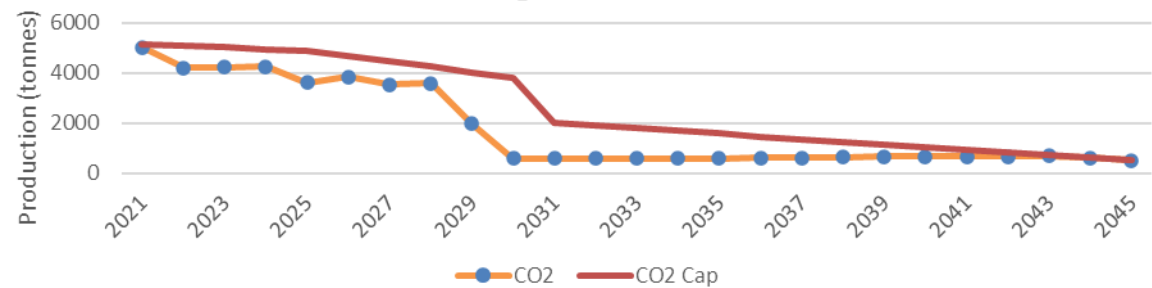
# 3.1C

## MID ELEC. / BASE DSM / ACCEL. NET ZERO 2045 / REGIONAL INTEGRATION

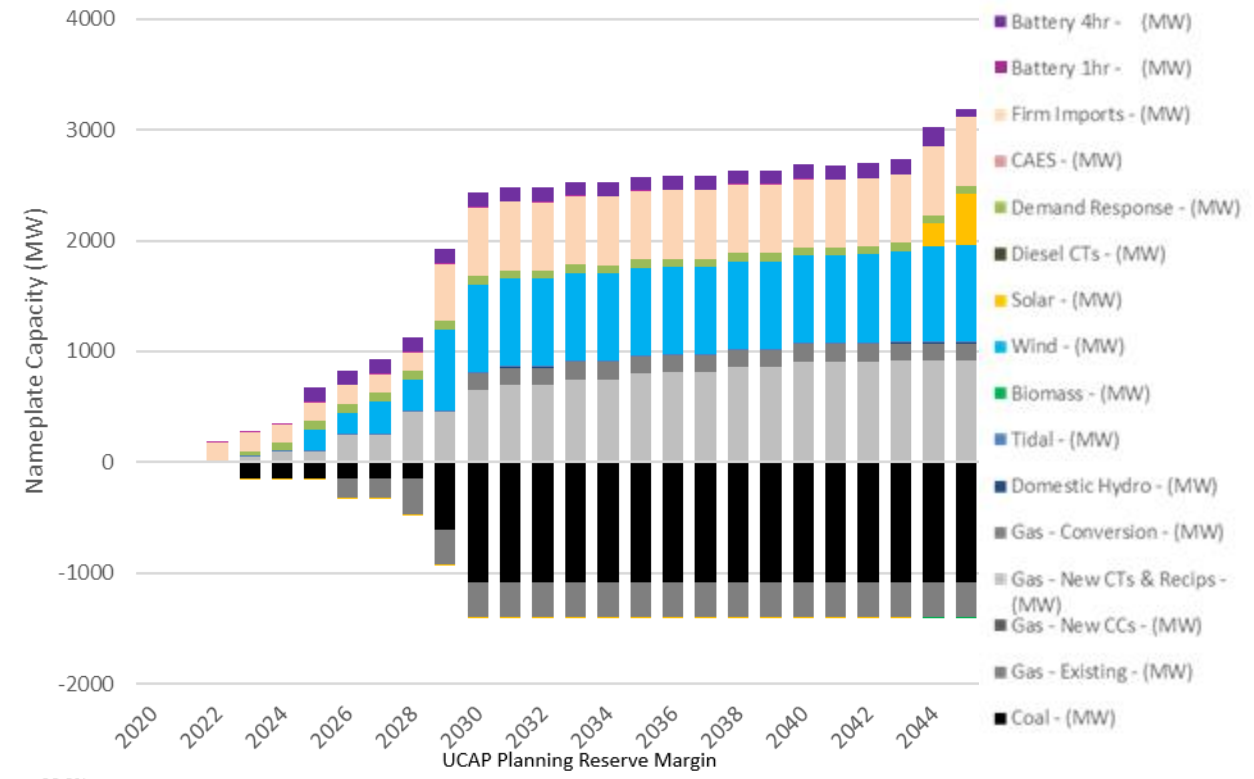
Energy Balance



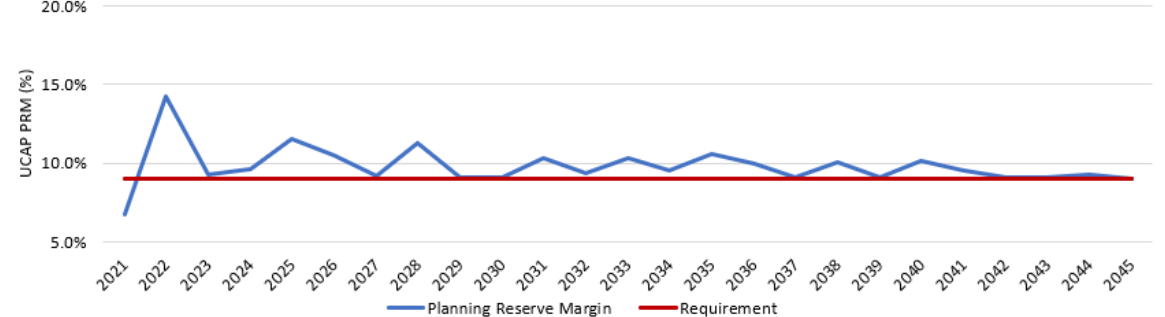
CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 3.1C

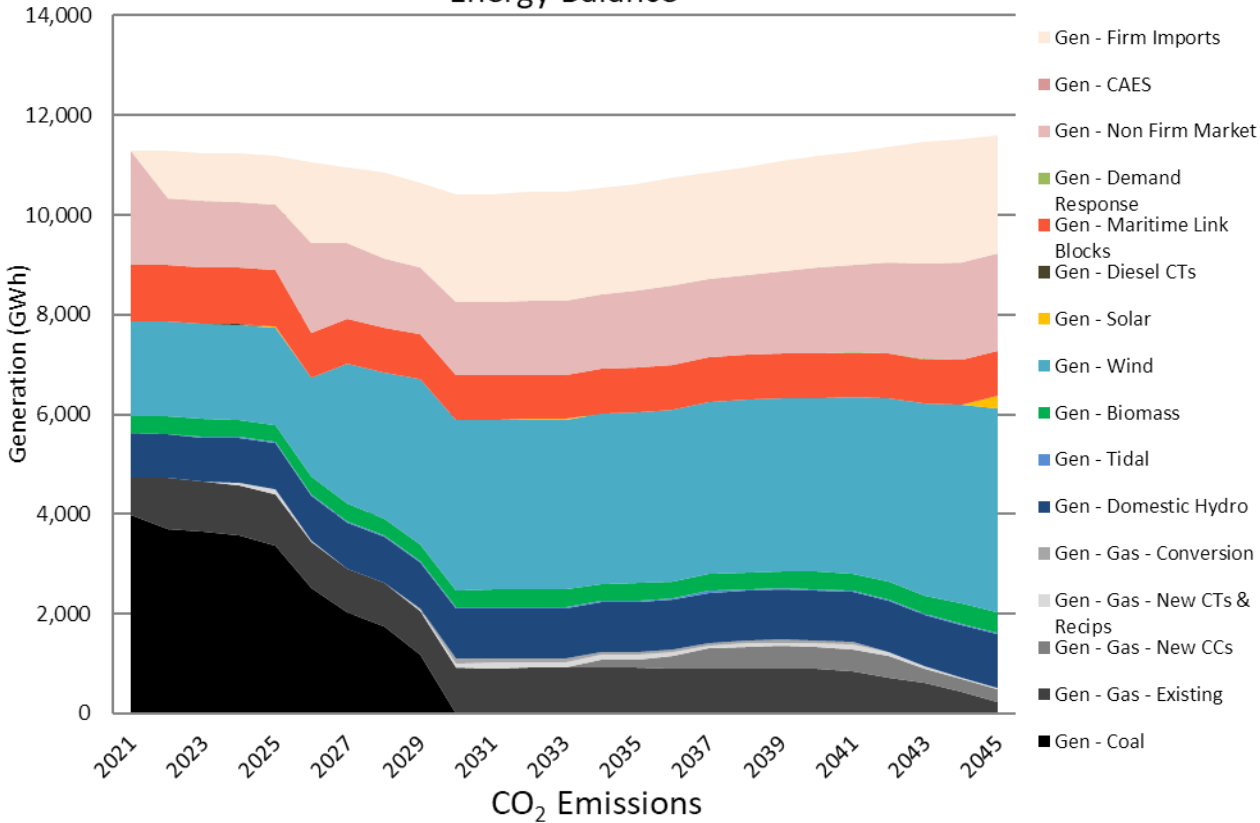
## MID ELEC. / BASE DSM / ACCEL. NET ZERO 2045 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$13,734	<u>General Notes</u> <ul style="list-style-type: none"> <li>1 coal to gas conversion in 2030</li> <li>Regional Interconnection build in 2029</li> <li>Solar is added late in the period (2044) as an energy resource</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$18,409	
10-yr NPVRR (\$MM)	\$7,224	
Average Annual Partial Rate Impact		<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Essential Grid Service requirements are met as modeled</li> </ul>
2021-2030 (%)	1.4%	
2021-2045 (%)	0.7%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2029</li> <li>Regional Integration: 2029</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	34.8	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Regional Integration provides flexible ability to meet emissions constraints</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	9.2	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	44.0	

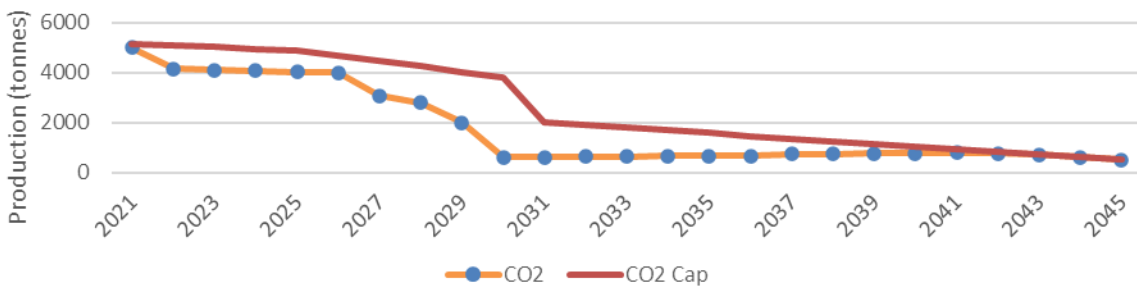
# 3.2B

## HIGH ELEC. / MAX DSM / ACCEL. NET ZERO 2045 / DISTRIBUTED RESOURCES

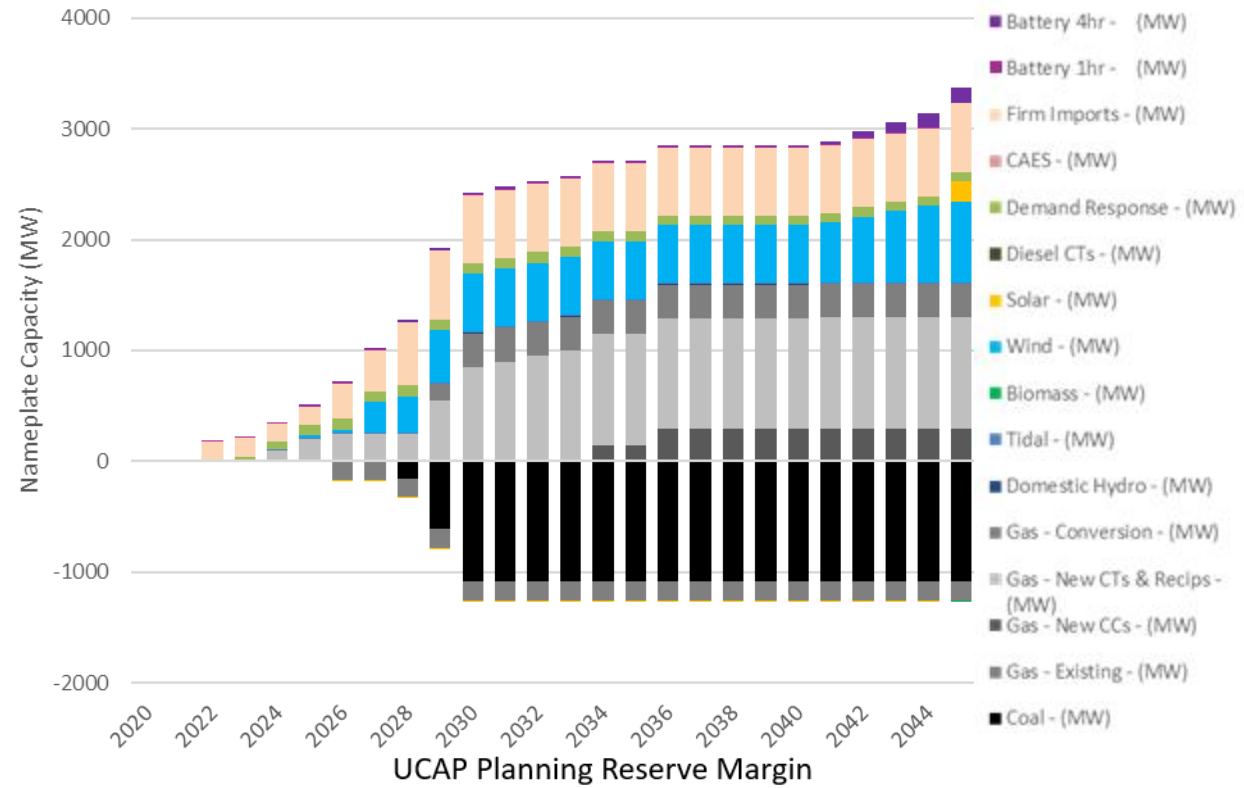
Energy Balance



CO<sub>2</sub> Emissions



New Installed Capacity



UCAP Planning Reserve Margin



# 3.2B

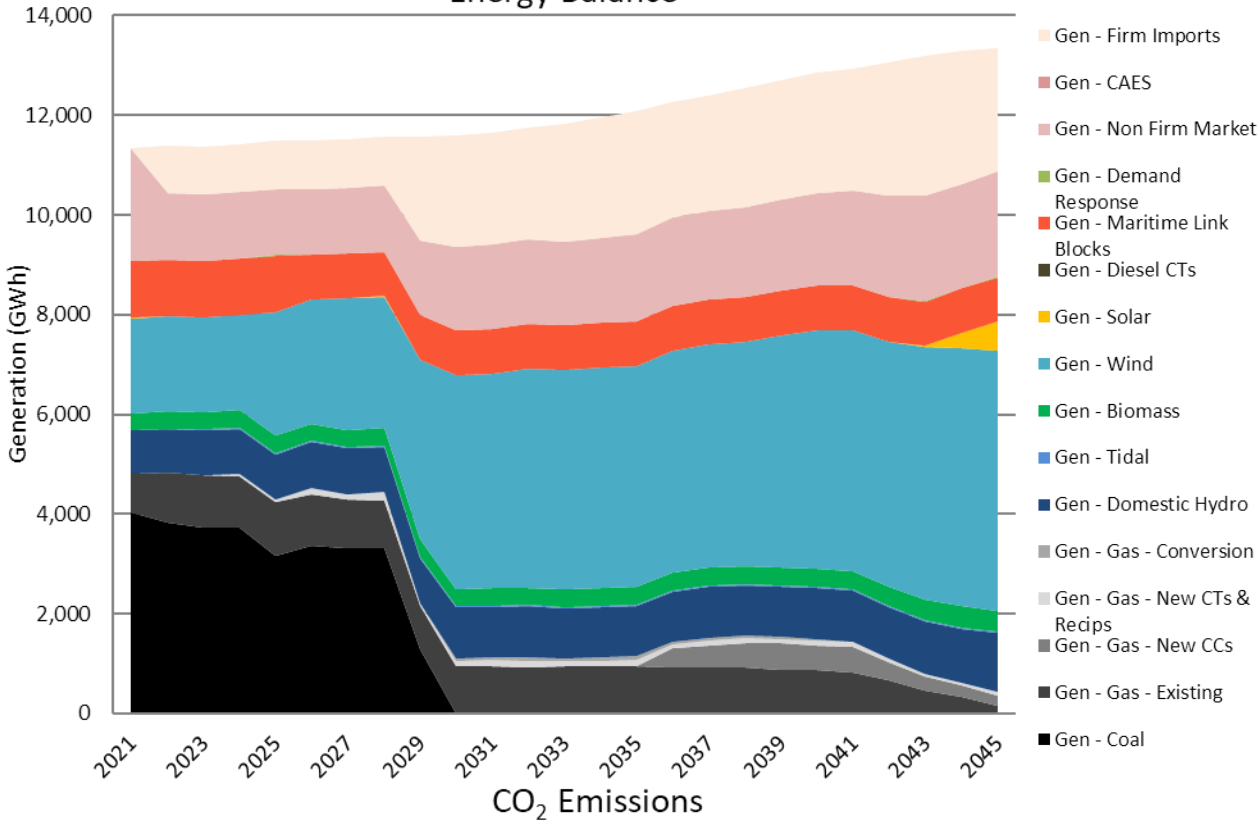
## HIGH ELEC. / MAX DSM / ACCEL. NET ZERO 2045 / DISTRIBUTED RESOURCES

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$15,045	<u>General Notes</u> <ul style="list-style-type: none"> <li>DER is modeled as a load reduction; cost of DER resources not included in NPV calculations (\$1.6B - \$2.5B)</li> <li>2 coal to gas conversions (2029 &amp; 2030)</li> <li>Solar is added late in the period (2045) as an energy resource</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$20,176	
10-yr NPVRR (\$MM)	\$8,125	<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Essential Grid Service requirements are met as modeled</li> </ul>
Average Annual Partial Rate Impact		<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2026</li> <li>Regional Integration: 2026</li> </ul>
2021-2030 (%)	2.9%	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Regional Integration provides flexible ability to meet emissions constraints</li> </ul>
2021-2045 (%)	1.3%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	33.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	10.2	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	44.0	

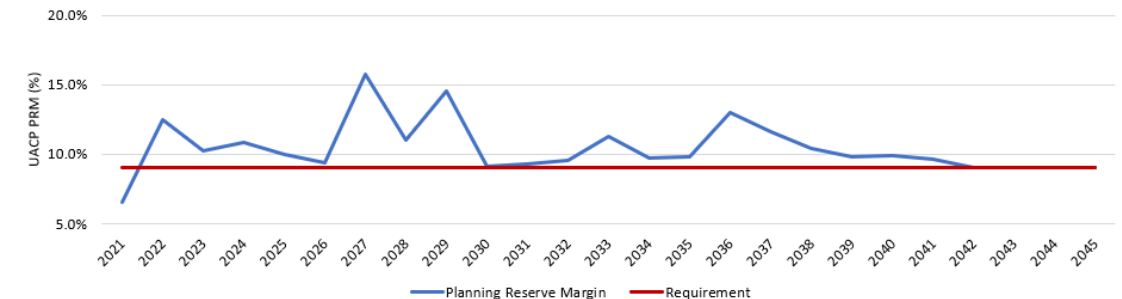
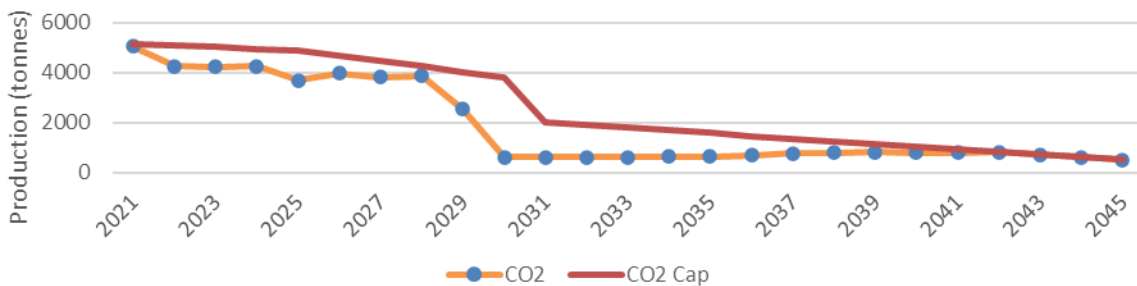
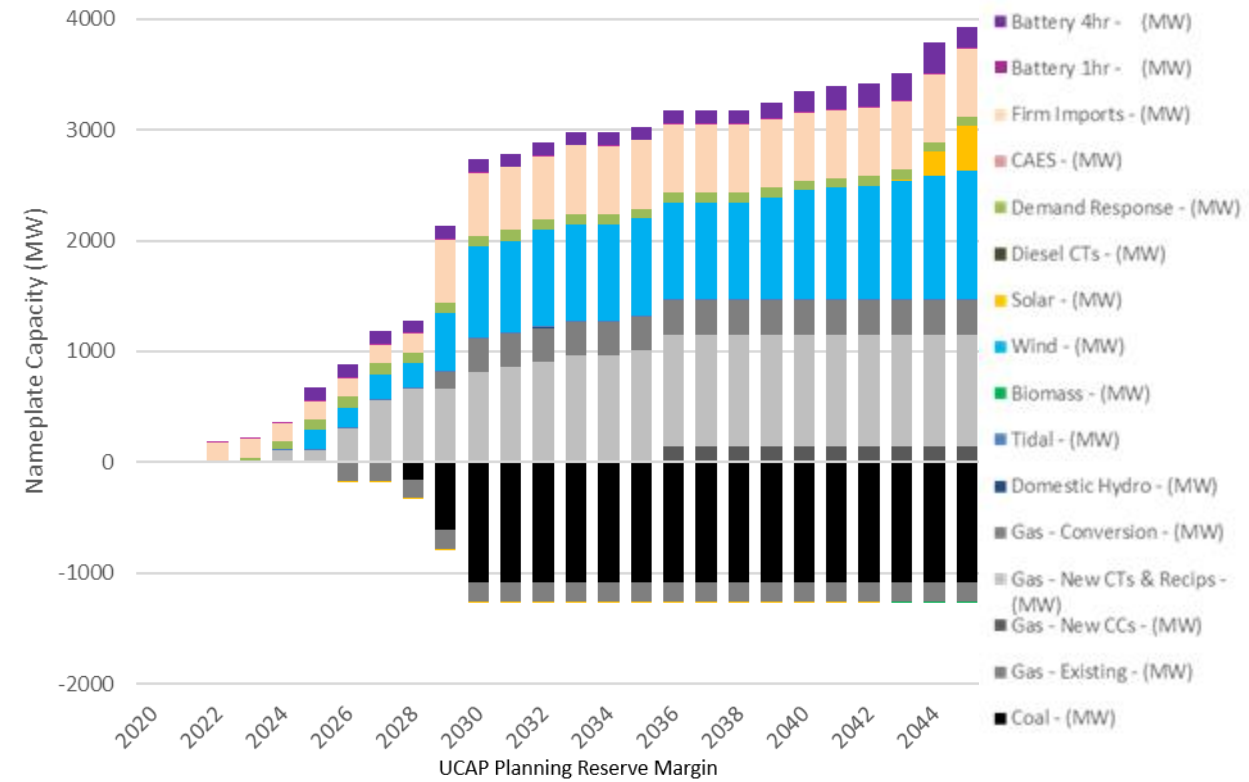
# 3.2C

## HIGH ELEC. / MAX DSM / ACCEL. NET ZERO 2045 / REGIONAL INTEGRATION

Energy Balance



New Installed Capacity



# 3.2C

## HIGH ELEC. / MAX DSM / ACCEL. NET ZERO 2045 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation		
25-yr NPVRR (\$MM)	\$16,049	<u>General Notes</u> <ul style="list-style-type: none"> <li>Gas CT builds and incremental firm imports support early load growth</li> <li>Increased firm import energy relative to previous runs offsets NGCC generation (now see 1 unit rather than 3 in previous modeling results)</li> </ul>
25-yr NPVRR with End Effects (\$MM)	\$21,770	
10-yr NPVRR (\$MM)	\$8,355	
Average Annual Partial Rate Impact		<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Essential Grid Service requirements are met as modeled</li> </ul>
2021-2030 (%)	2.0%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2029</li> <li>Regional Integration: 2029</li> </ul>
2021-2045 (%)	0.9%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	36.2	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Regional Integration provides flexible ability to meet emissions constraints</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	10.3	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	46.5	



# SENSITIVITY ANALYSIS RESULTS

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# SENSITIVITY ANALYSIS OVERVIEW

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In addition to the Final Portfolio Study, a series of model sensitivities has been studied to understand how model outputs will vary with adjustments to key input parameters of interest.

On the following slides, results are provided for each sensitivity run and are also compared to the corresponding base case in order to evaluate the impact of the change in model inputs.

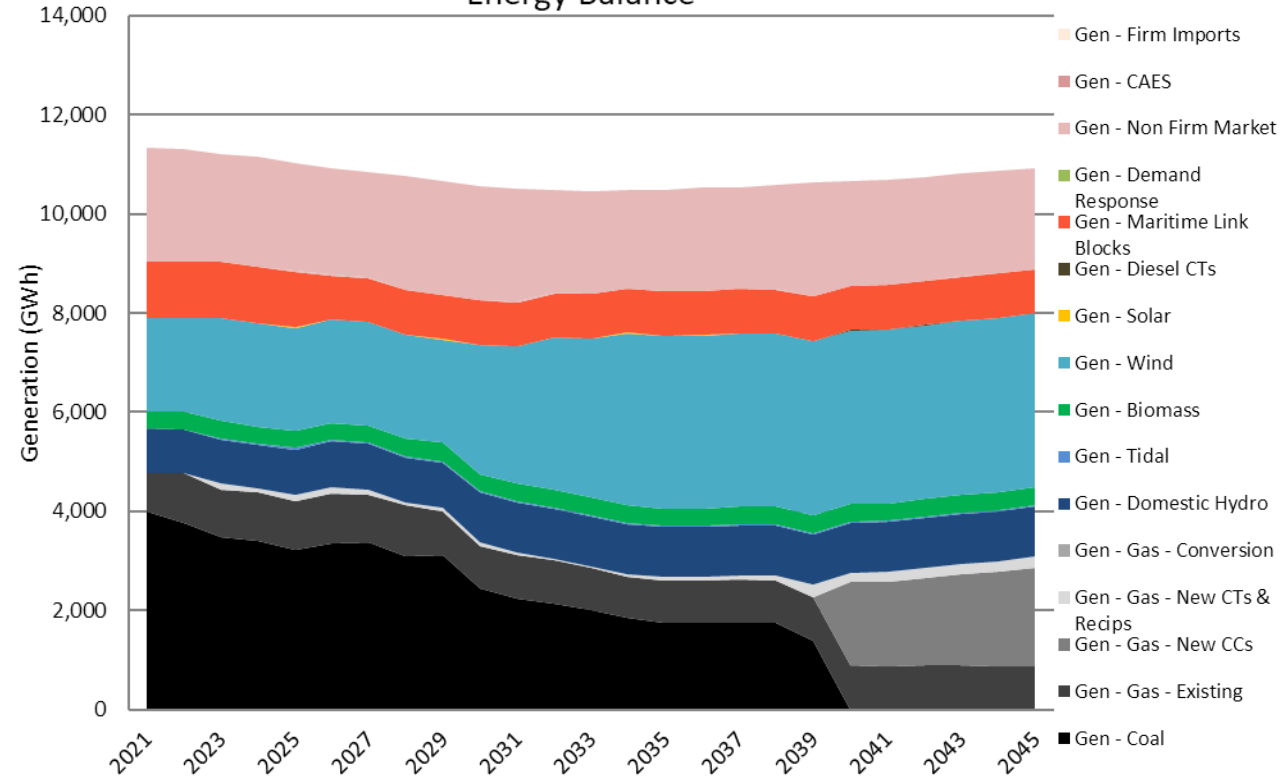
Sensitivities that are included in this results release are listed below:

2.0A.DSM-1	Low Electrification / Mid DSM
2.1C.DSM-2	Mid Electrification / Mid DSM
2.2C.DSM-3	High Electrification / Mid DSM
2.0C.DSM-4	Low Electrification / Low DSM
2.0C.DSM-5	Low Electrification / Mid DSM
2.0C.DSM-6	Low Electrification / Max DSM
3.1C.DSM-7	Mid Electrification / Mid DSM / 2030 Coal Retirement
2.1C.Wind-1	Low Wind Cost
2.1C.Wind-2	Low Wind + Low Battery Cost
2.1C.Wind-3	Low Inertia
2.1C.Wind-4	No Inertia / No Wind Integration Requirements
2.1C.Mersey	Mersey Hydro Retired
2.1C.Import-1	Limited Non-Firm Imports
2.0A.Import-2	Current Landscape case without Reliability Tie
2.1C.Import-3	Limited Reliability Tie Inertia (provides 50% of inertia requirement)

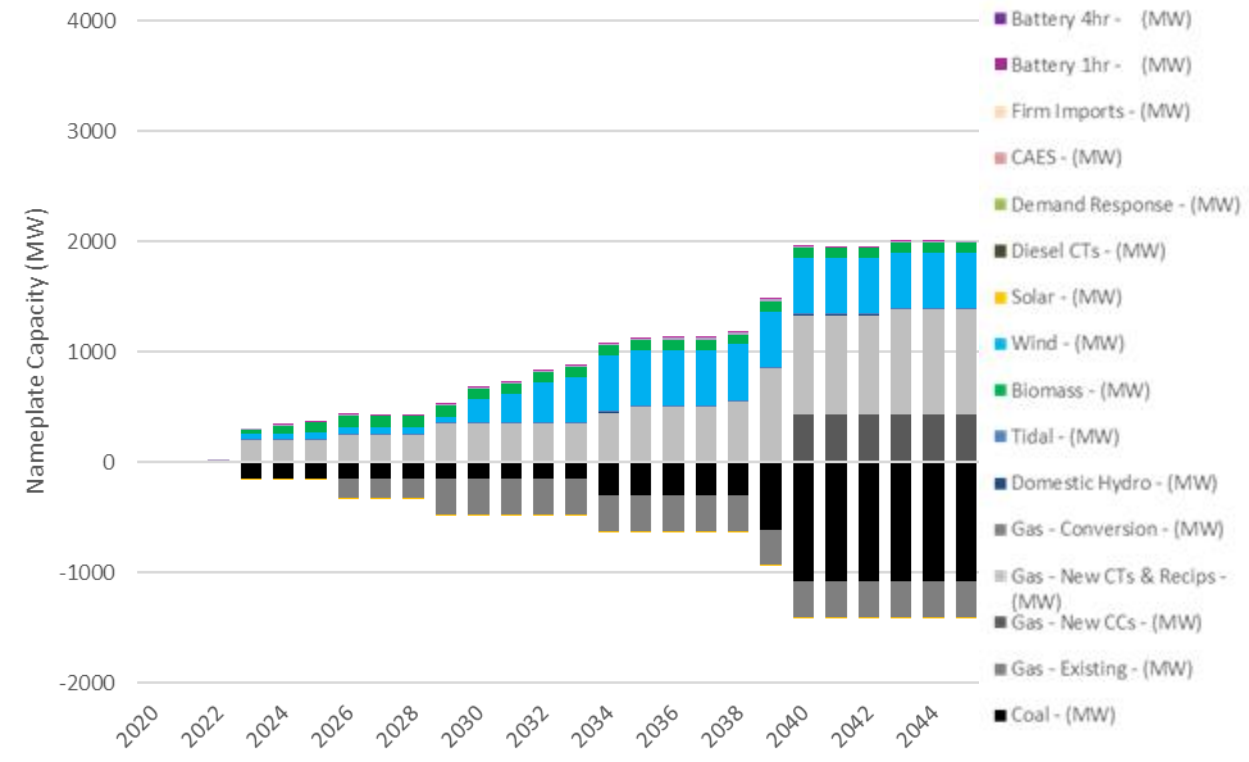
# 2.0A.DSM-1 (MID DSM)

LOW ELEC. / MID DSM / NET ZERO 2050 / CURRENT LANDSCAPE

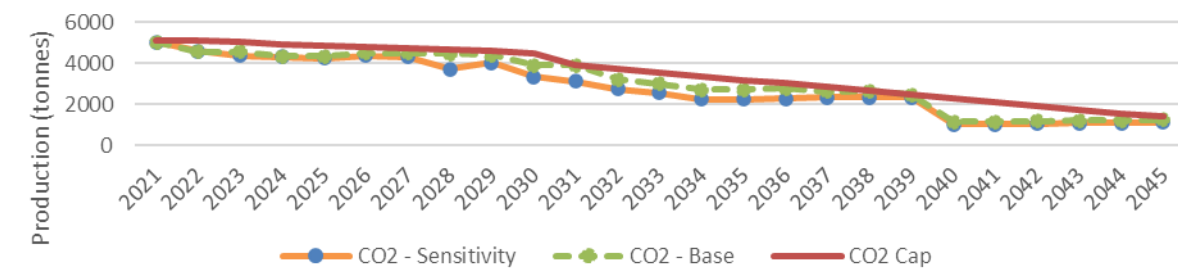
Energy Balance



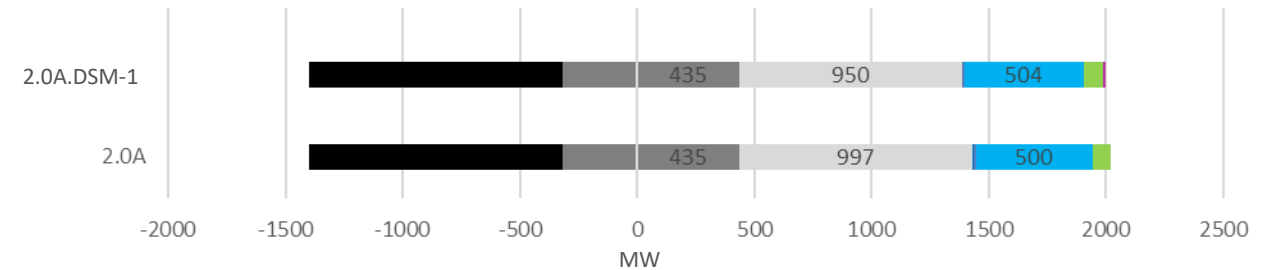
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.0A.DSM-1 (MID DSM)

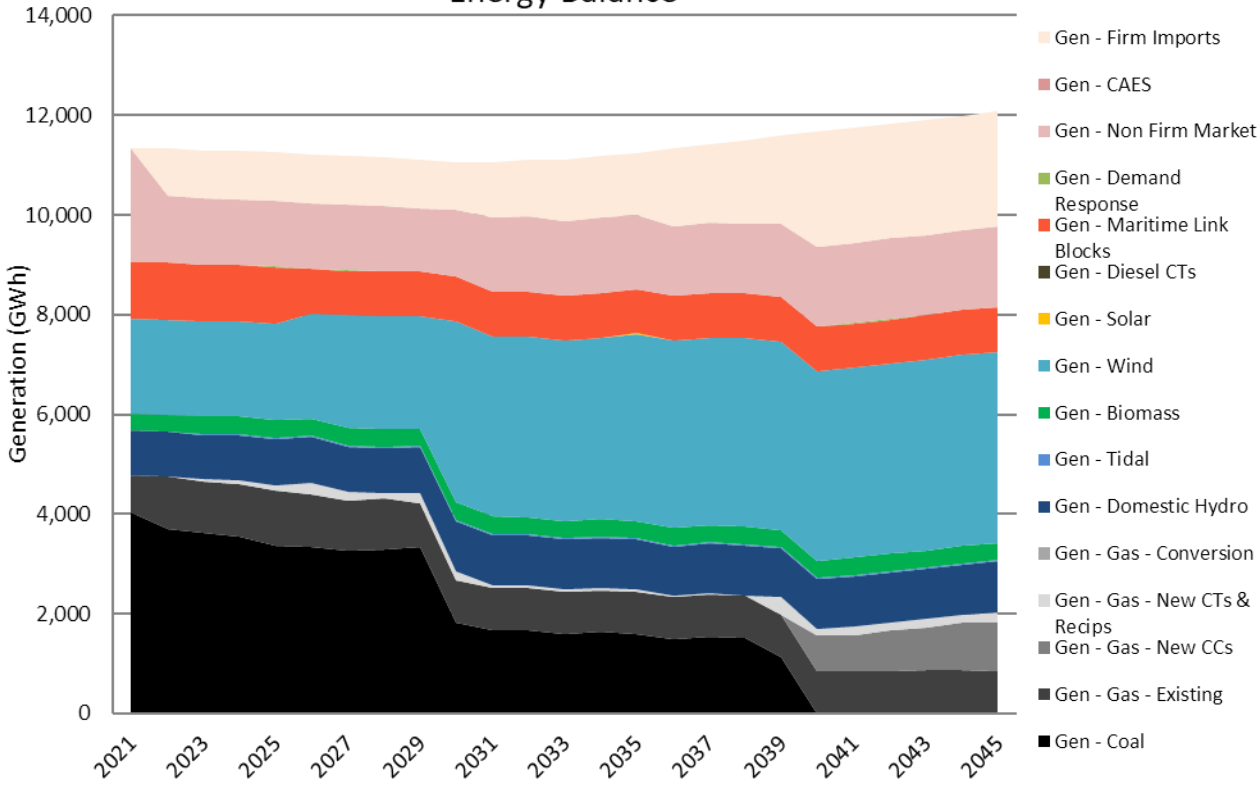
LOW ELEC. / MID DSM / NET ZERO 2050 / CURRENT LANDSCAPE

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.0A)	
25-yr NPVRR (\$MM)	\$12,711	\$12,351	<u>General Notes</u> <ul style="list-style-type: none"> <li>Relative to 2.0A (which includes Base DSM), 47MW fewer CT resources are built due to the reduction in peak load from the higher level of DSM and the higher capacity contribution of the DR program associated with Mid DSM (DR economically selected in both models)</li> <li>NPVRR is increased relative to Base DSM case for all three time periods</li> </ul> <u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No significant change relative to 2.0A</li> </ul> <u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2028</li> <li>Regional Integration: n/a</li> </ul> <u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No significant change relative to 2.0A base</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$16,888	\$16,609	
10-yr NPVRR (\$MM)	\$7,199	\$6,831	
Average Annual Partial Rate Impact			
2021-2030 (%)	1.5%	0.9%	
2021-2045 (%)	1.1%	1.0%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	42.2	44.5	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	28.6	33.2	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	70.7	77.7	

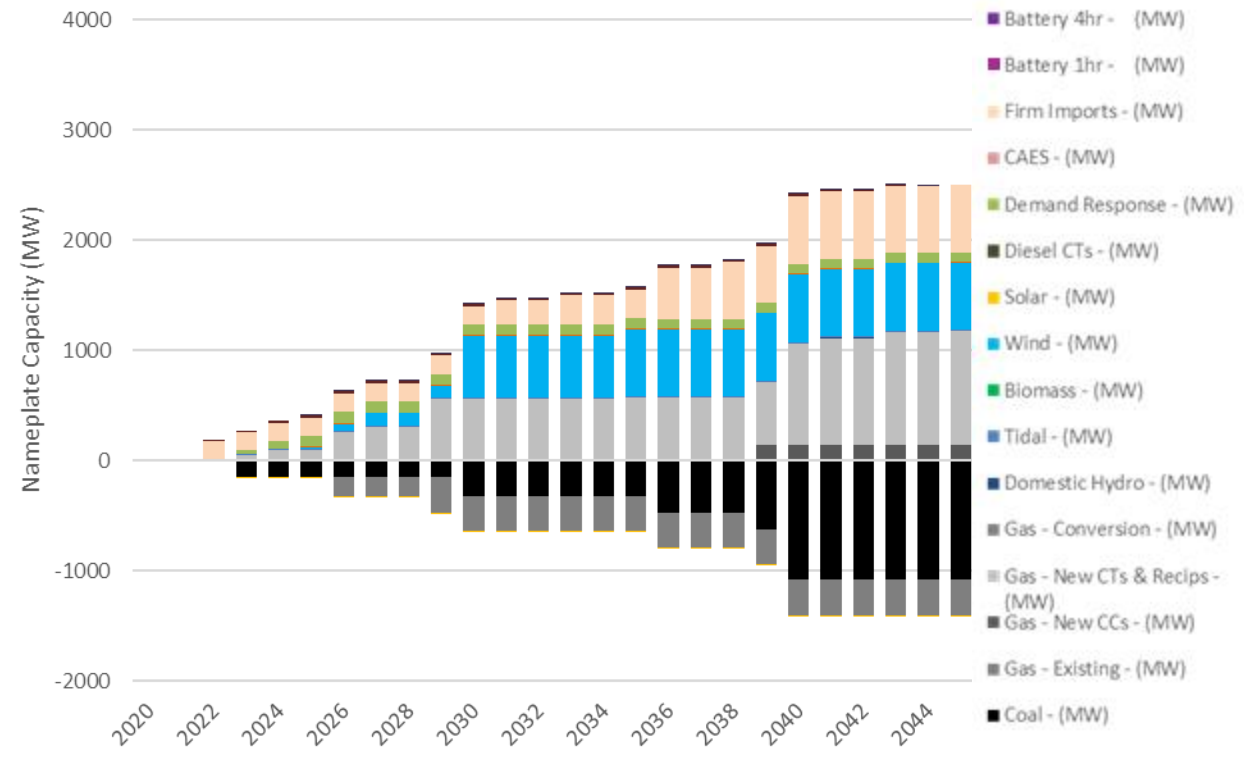
# 2.1C.DSM-2 (MID DSM)

MID ELEC. / MID DSM / NET ZERO 2050 / REGIONAL INTEGRATION

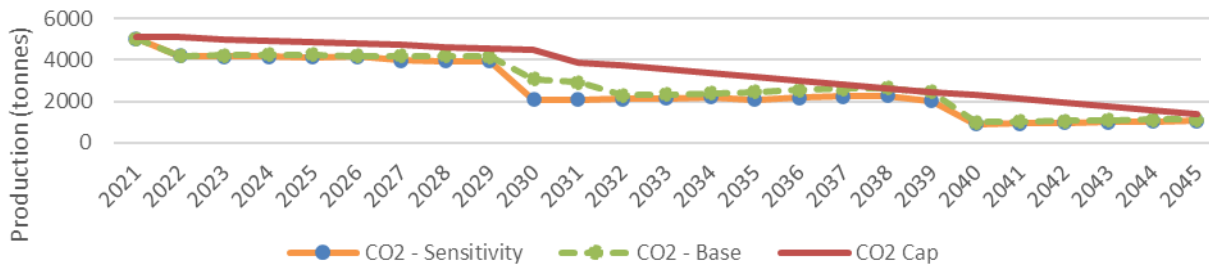
Energy Balance



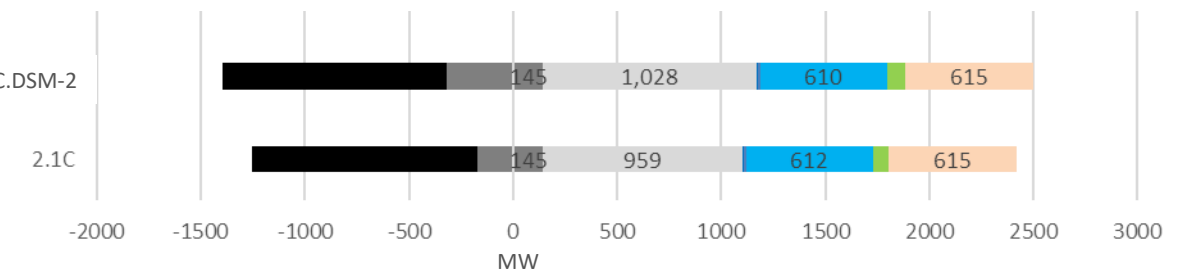
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.DSM-2 (MID DSM)

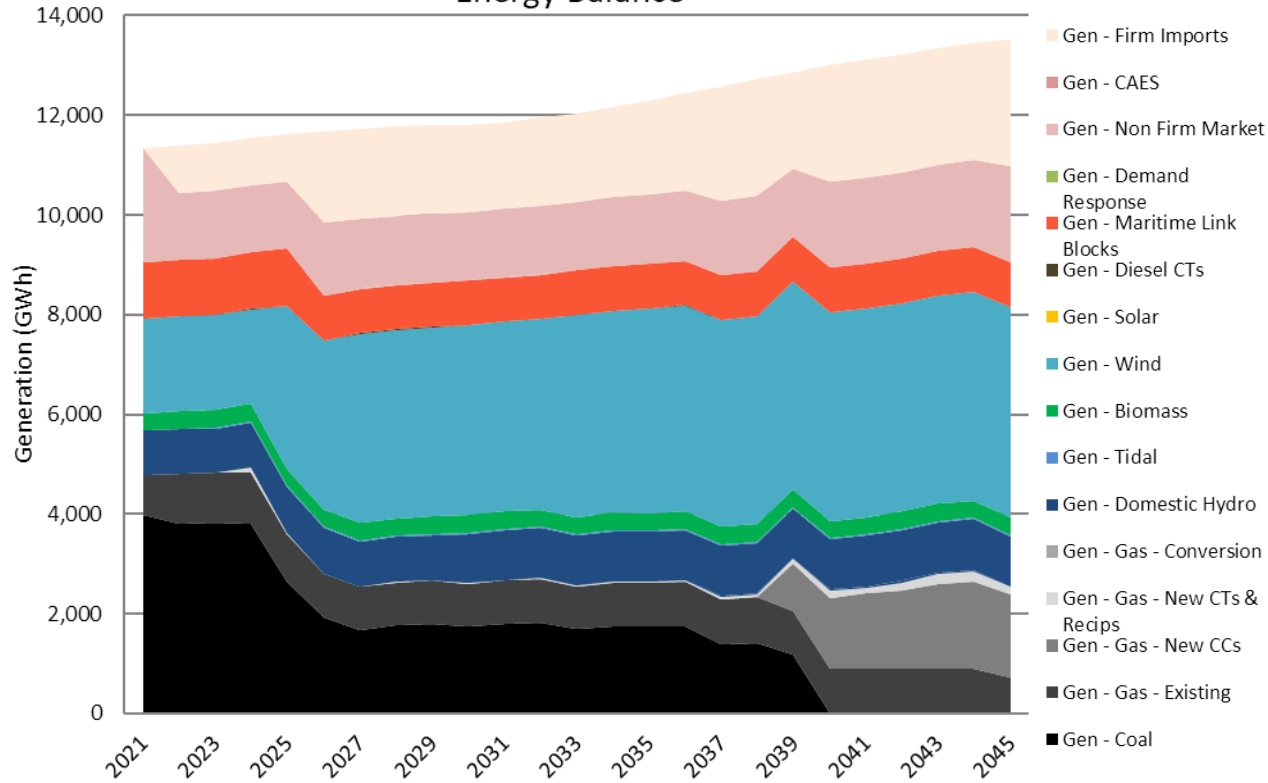
MID ELEC. / MID DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,468	\$13,141	<u>General Notes</u> <ul style="list-style-type: none"> <li>1 coal unit is retired earlier than in 2.1C Base; remainder of resource plan very similar</li> <li>Mid DSM case retires one additional gas steam unit vs. 2.1C Base DSM by 2045; capacity is replaced via a combination of decreased firm peak due to incremental DSM, additional combustion turbine capacity, and the higher capacity contribution of the DR program associated with Mid DSM</li> <li>NPVRR is increased relative to Base DSM case for all three time periods</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$18,013	\$17,767	
10-yr NPVRR (\$MM)	\$7,396	\$7,067	
<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No change relative to 2.1C</li> </ul>			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2030</li> <li>Regional Integration: 2031</li> </ul>
<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No change relative to 2.1C Base</li> </ul>			
Average Annual Partial Rate Impact			
2021-2030 (%)	1.2%	0.6%	
2021-2045 (%)	0.8%	0.7%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	39.9	41.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	25.2	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	65.1	70.9	

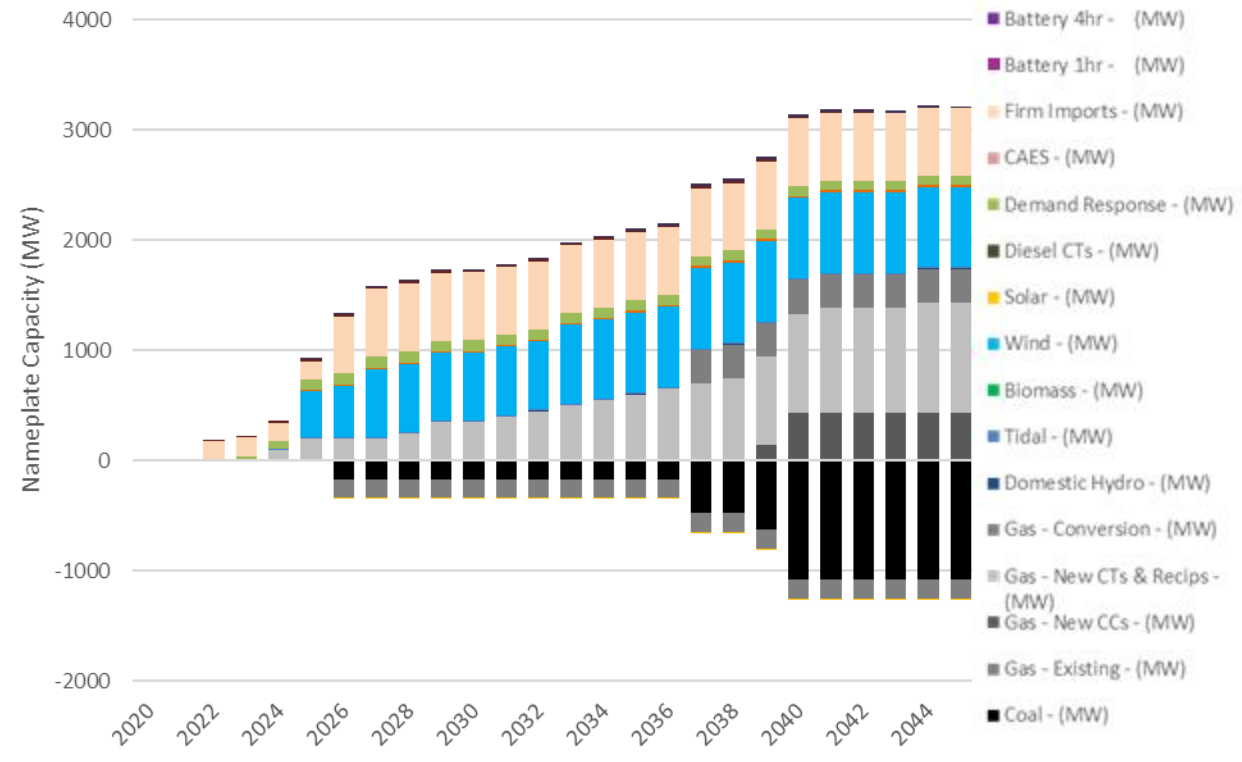
# 2.2C.DSM-3 (MID DSM)

HIGH ELEC. / MID DSM / NET ZERO 2050 / REGIONAL INTEGRATION

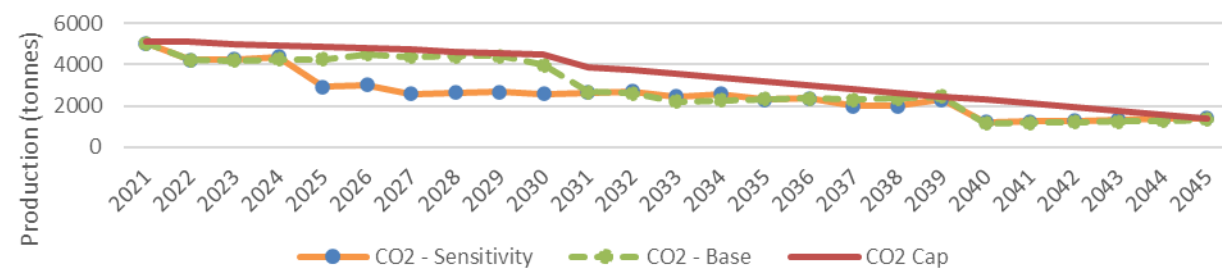
Energy Balance



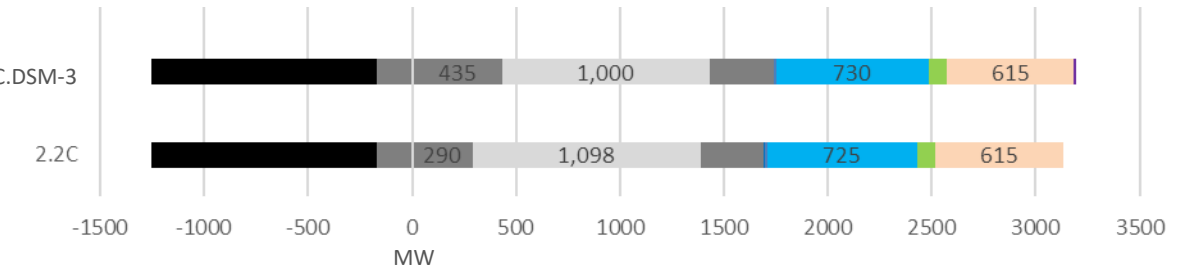
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.2C.DSM-3 (MID DSM)

HIGH ELEC. / MID DSM / NET ZERO 2050 / REGIONAL INTEGRATION

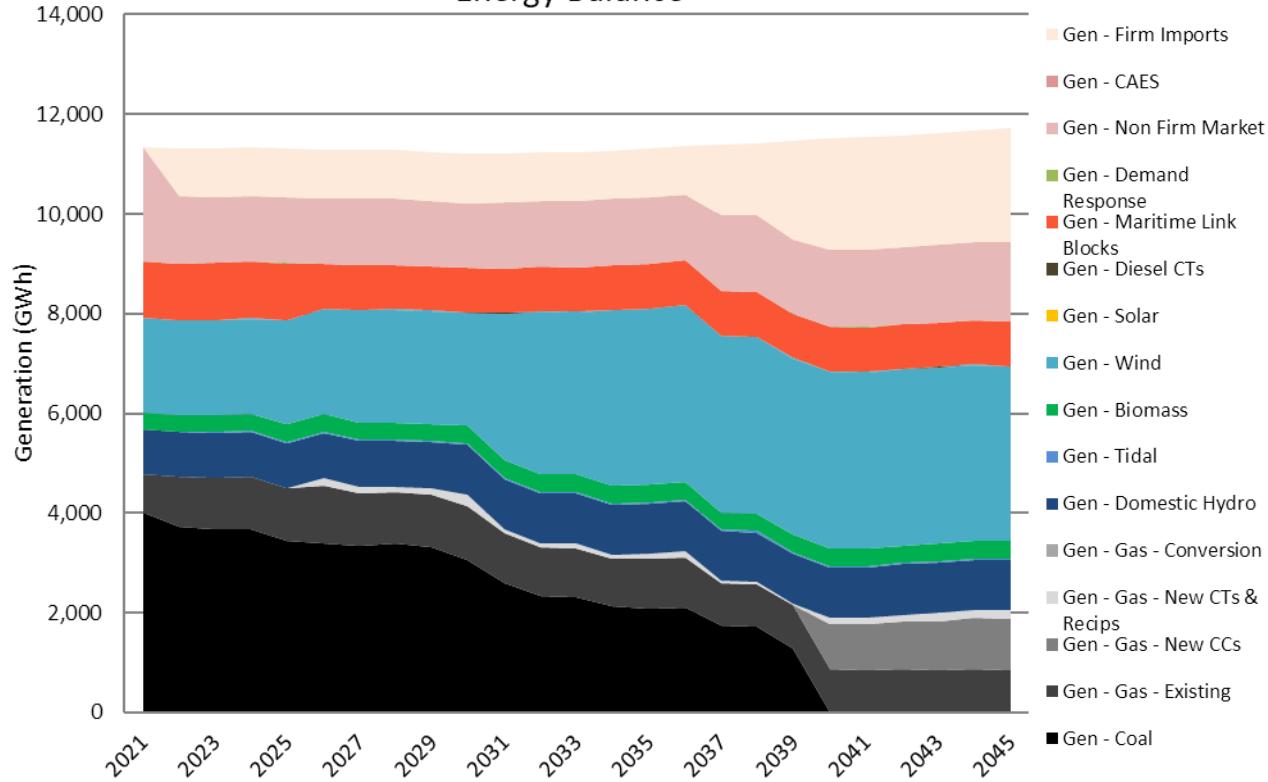
Scenario Metrics & Evaluation			
	Sensitivity	Base (2.2C)	
25-yr NPVRR (\$MM)	\$14,901	\$15,380	<u>General Notes</u> <ul style="list-style-type: none"> <li>Under the High Electrification / Mid DSM sensitivity, the Regional Interconnection is built 5 years earlier than 2.2C base case (which uses the Max DSM profile); this enables 1 earlier coal retirement in the 2030s economically and significantly reduces GHG emissions over the planning horizon</li> <li>By 2045, Mid DSM case has 1 additional NGCC unit and fewer combustion turbines for a net capacity difference of +47MW, very closely matching the firm peak increase of 41MW due to the change in DSM level</li> <li>NPVRR is decreased relative to 2.2C Max DSM case for all three time periods</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$20,366	\$20,945	
10-yr NPVRR (\$MM)	\$7,871	\$8,201	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No significant change from 2.2C</li> </ul>
2021-2030 (%)	0.8%	1.3%	
2021-2045 (%)	0.6%	0.8%	
			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2025</li> <li>Regional Integration: 2026</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	34.4	43.7	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>One additional NGCC increases exposure to gas prices; total gas generation limited by emissions constraints in model scenarios</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	29.2	29.0	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	63.6	72.7	



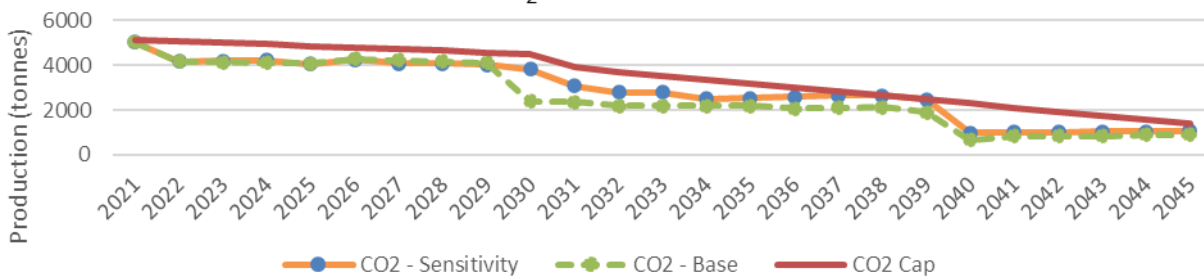
# 2.0C.DSM-4 (LOW DSM)

LOW ELEC. / LOW DSM / NET ZERO 2050 / REGIONAL INTEGRATION

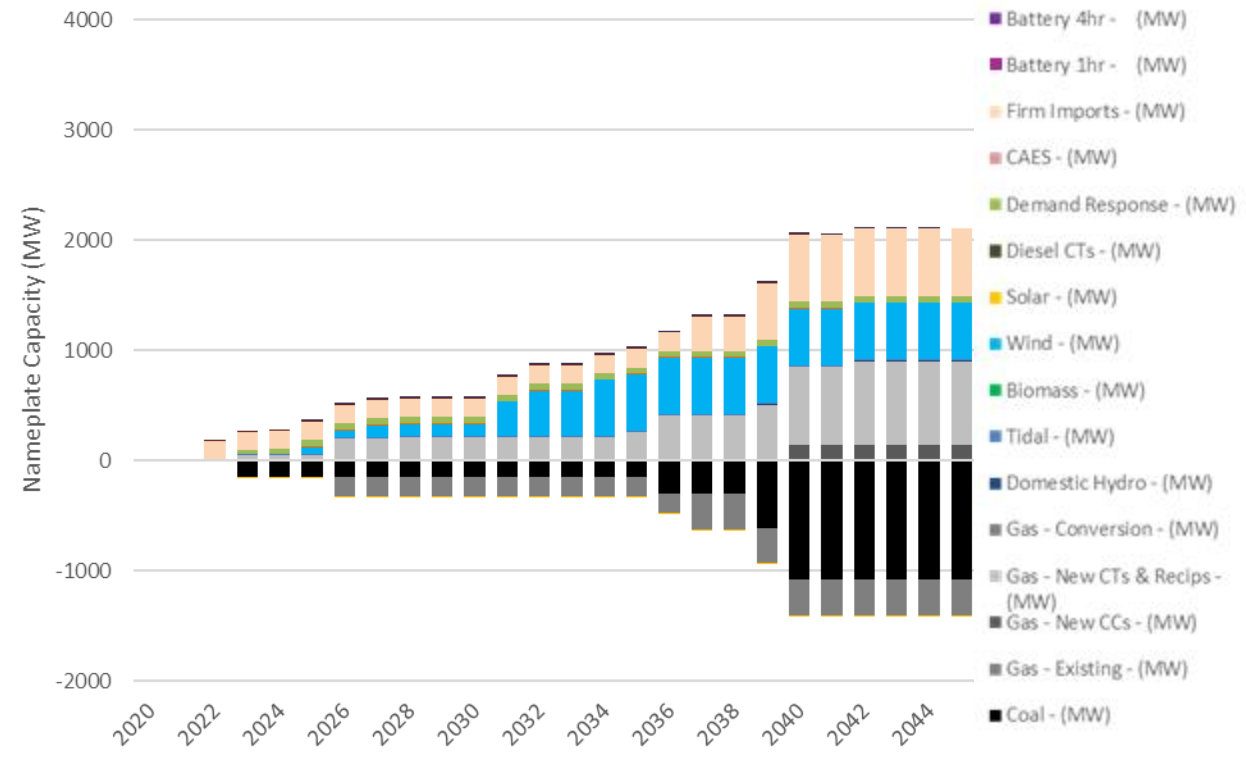
Energy Balance



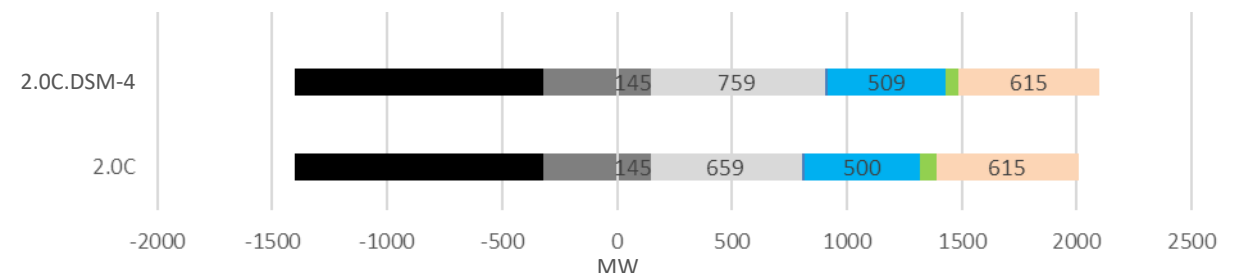
CO<sub>2</sub> Emissions



New Installed Capacity



New Installed Capacity Comparison (2045)



# 2.0C.DSM-4 (LOW DSM)

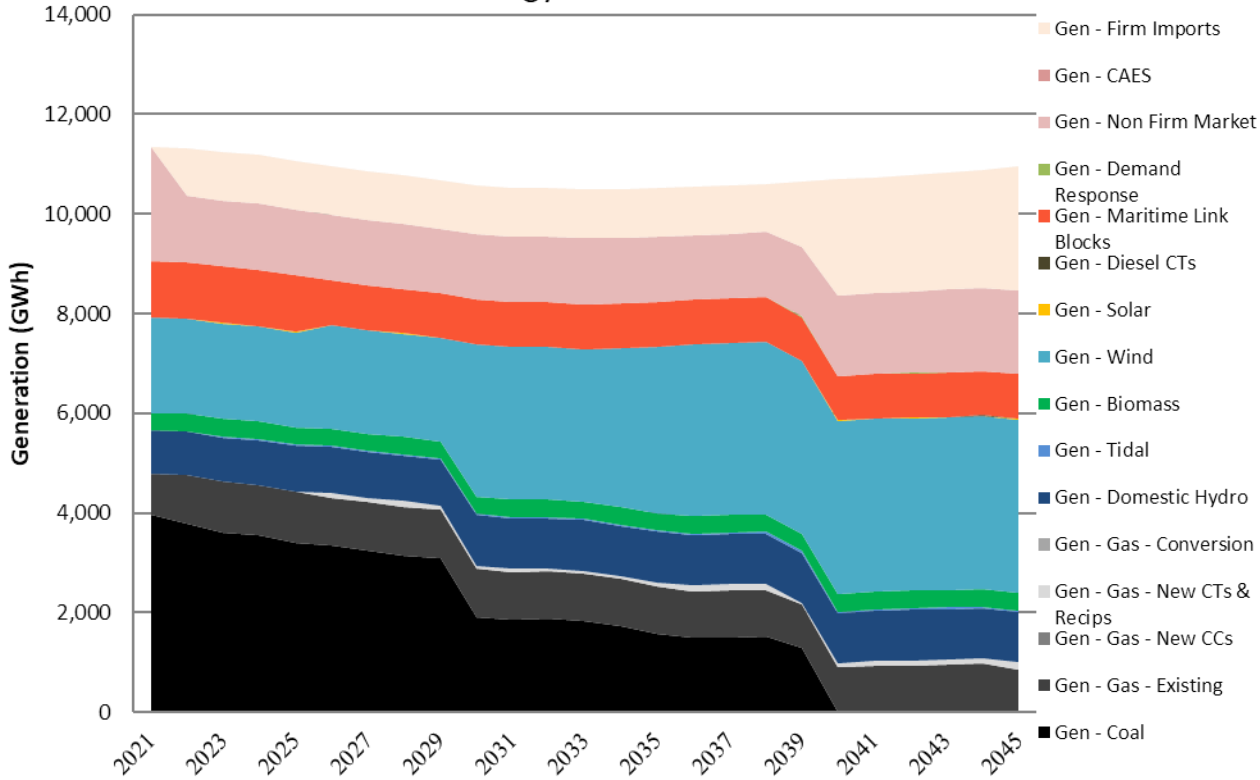
LOW ELEC. / LOW DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.0C)	
25-yr NPVRR (\$MM)	\$12,206	\$12,234	<u>General Notes</u> <ul style="list-style-type: none"> <li>• Similar resource plan overall to 2.0C Base DSM; 1 economic coal retirement is delayed later into 2030s due to increased load which leads to an increase in CO<sub>2</sub> emissions in the 2030s</li> <li>• By 2045 the Low DSM sensitivity adds 100MW incremental combustion turbine resources relative to Base DSM, closely matching the firm peak increase of 86MW (plus the associated PRM increase)</li> <li>• NPVRR is decreased over the first 10 years, very similar over 25 years, and increased when end effects are considered relative to 2.0C Base DSM indicating the solutions are very close economically</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$16,350	\$16,241	
10-yr NPVRR (\$MM)	\$6,676	\$6,820	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>• No change relative to 2.0C</li> </ul>
2021-2030 (%)	0.3%	0.9%	
2021-2045 (%)	0.7%	0.9%	
			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>• Reliability Tie: 2031</li> <li>• Regional Integration: 2037</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	41.9	40.7	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>• No change relative to 2.0C</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	30.2	24.3	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	72.1	65.0	

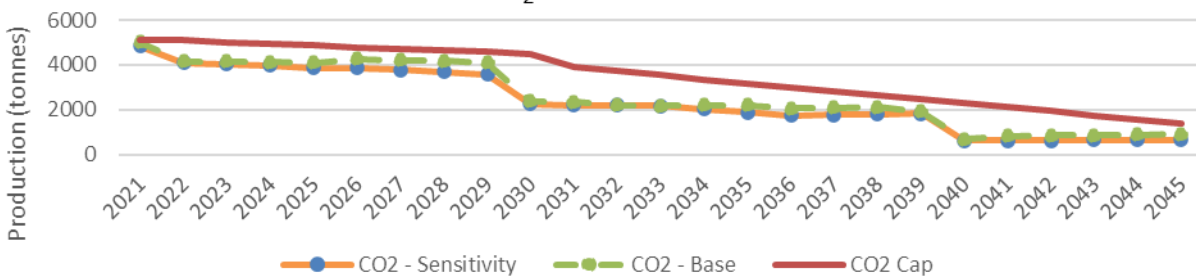
# 2.0C.DSM-5 (MID DSM)

LOW ELEC. / MID DSM / NET ZERO 2050 / REGIONAL INTEGRATION

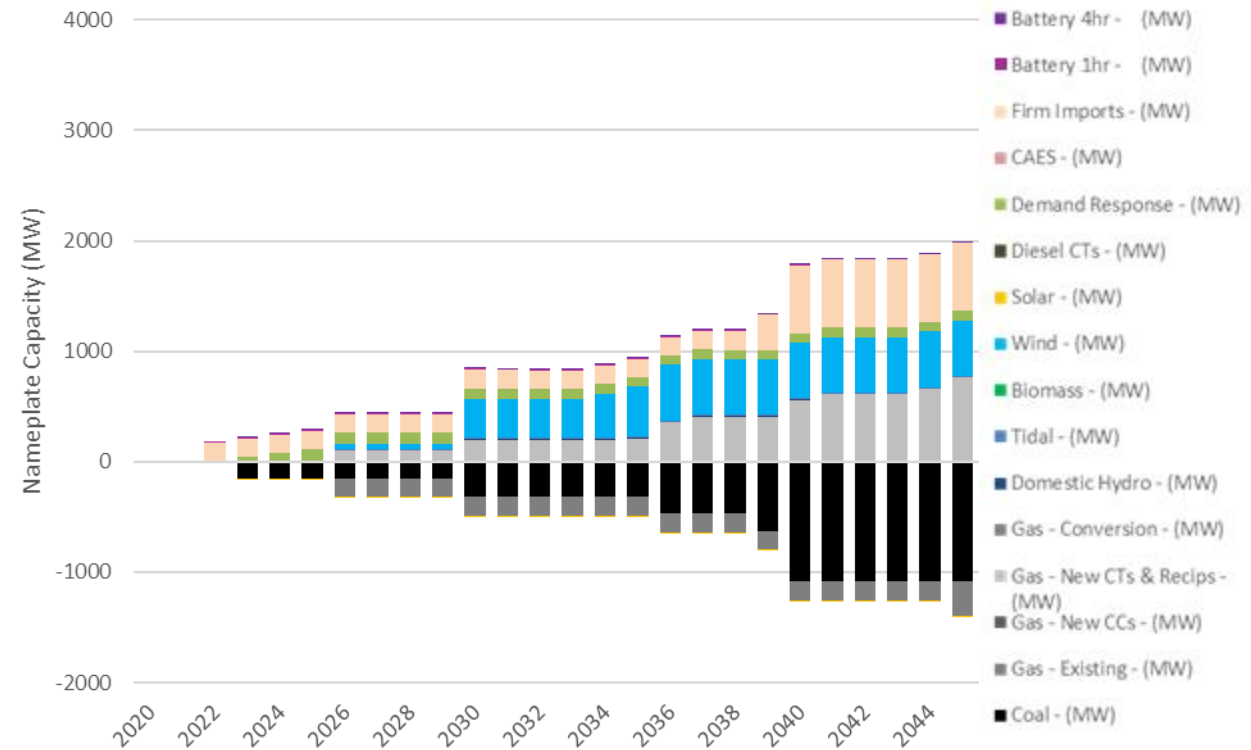
Energy Balance



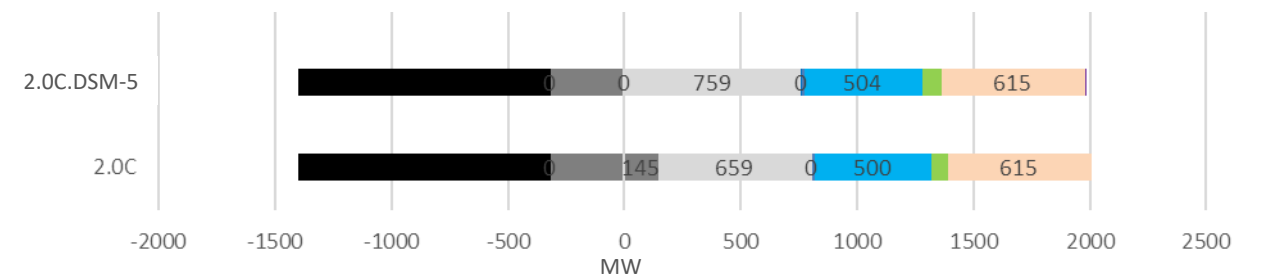
CO<sub>2</sub> Emissions



New Installed Capacity



New Installed Capacity Comparison (2045)



# 2.0C.DSM-5 (MID DSM)

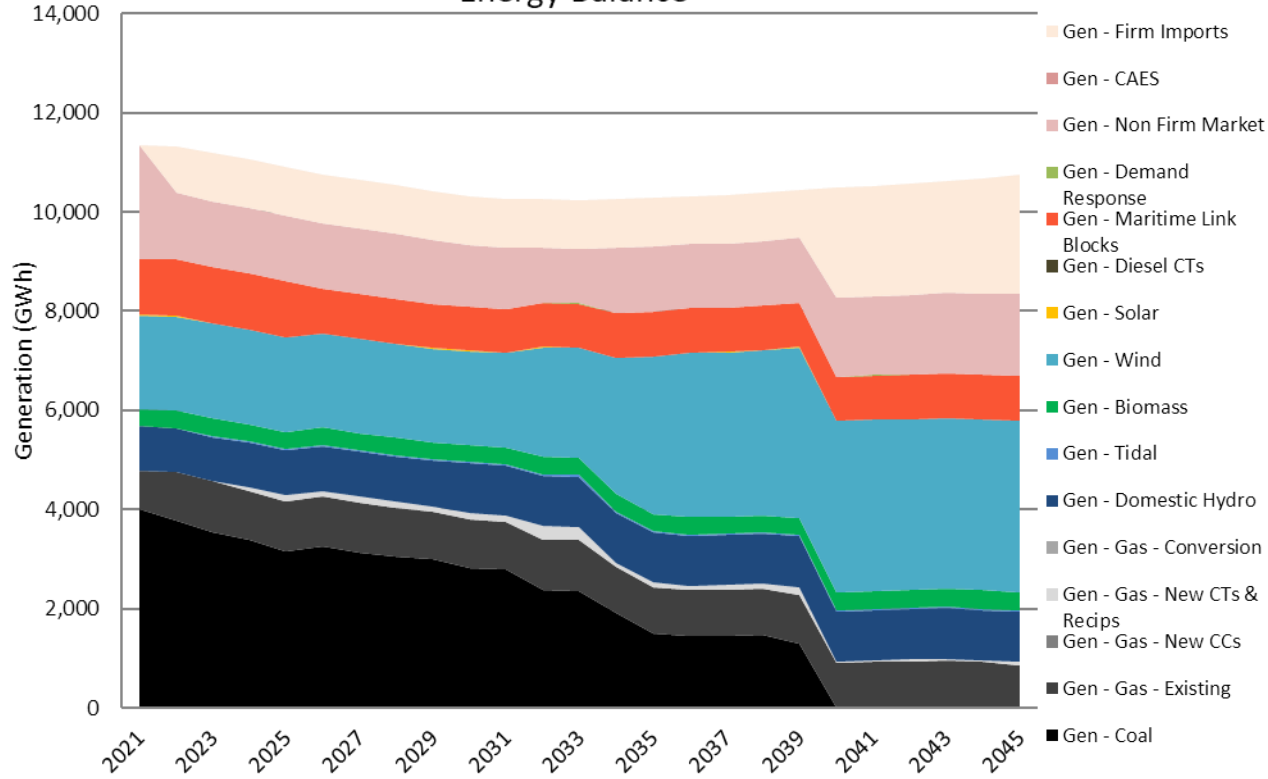
LOW ELEC. / MID DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.0C)	
25-yr NPVRR (\$MM)	\$12,556	\$12,234	<u>General Notes</u> <ul style="list-style-type: none"> <li>• Generally a similar resource plan to 2.1C</li> <li>• Increased level of DSM in this sensitivity deferred Regional Integration to 2039 from 2037.</li> <li>• A net of 45MW of gas generation capacity is avoided (100 MW additional combustion turbines and 145MW less NGCC relative to 2.0C Base DSM)</li> <li>• NPVRR is increased relative to Base DSM case for all three time periods</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$16,561	\$16,241	
10-yr NPVRR (\$MM)	\$7,164	\$6,820	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>• No change relative to 2.0C</li> </ul>
2021-2030 (%)	1.4%	0.9%	
2021-2045 (%)	1.0%	0.9%	
			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>• Reliability Tie: 2030</li> <li>• Regional Integration: 2039</li> </ul>
			<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>• No change relative to 2.0C</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	38.0	40.7	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	21.5	24.3	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	59.4	65.0	

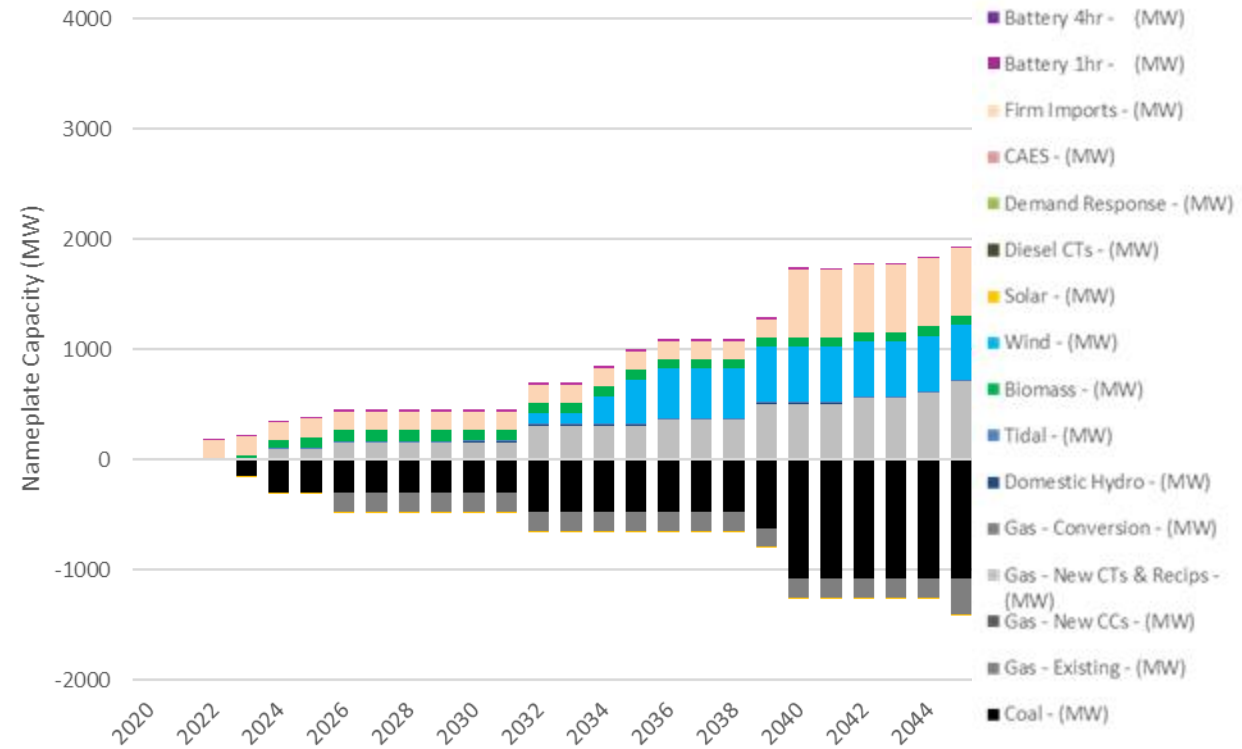
# 2.0C.DSM-6 (MAX DSM)

LOW ELEC. / MAX DSM / NET ZERO 2050 / REGIONAL INTEGRATION

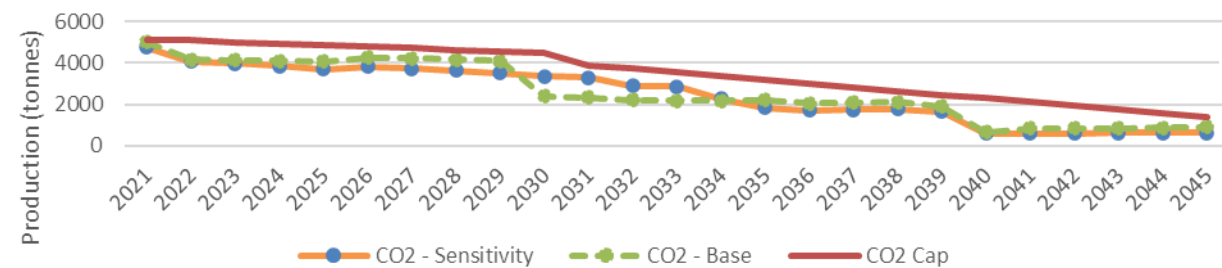
Energy Balance



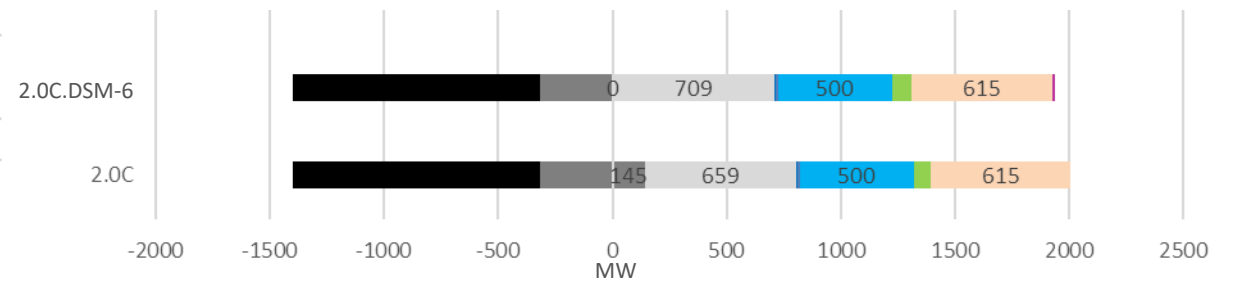
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.0C.DSM-6 (MAX DSM)

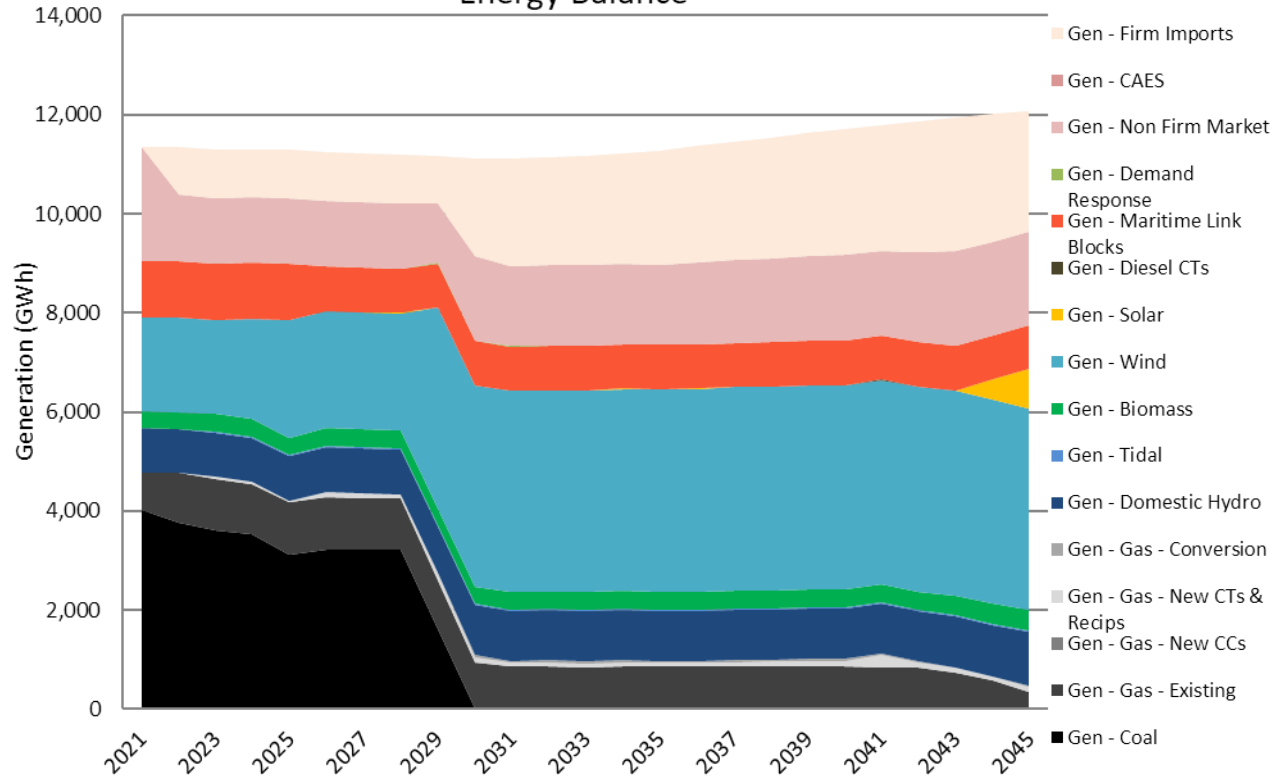
LOW ELEC. / MAX DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.0C)	
25-yr NPVRR (\$MM)	\$13,066	\$12,234	<u>General Notes</u> <ul style="list-style-type: none"> <li>Increased level of DSM deferred Reliability Tie to 2034 from 2030, and Regional Integration to 2040 from 2037.</li> <li>A net of 95MW of gas generation capacity is avoided (50 MW additional combustion turbines and 145MW less NGCC relative to 2.0C Base DSM)</li> <li>1 additional coal unit is retired in the 2020s economically and wind build is delayed</li> <li>NPVRR is increased relative to Base DSM case for all three time periods</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,153	\$16,241	
10-yr NPVRR (\$MM)	\$7,570	\$6,820	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No change relative to 2.0C</li> </ul>
2021-2030 (%)	1.8%	0.9%	
2021-2045 (%)	1.2%	0.9%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2034</li> <li>Regional Integration: 2040</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	38.4	40.7	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	23.7	24.3	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	62.1	65.0	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No change relative to 2.0C</li> </ul>

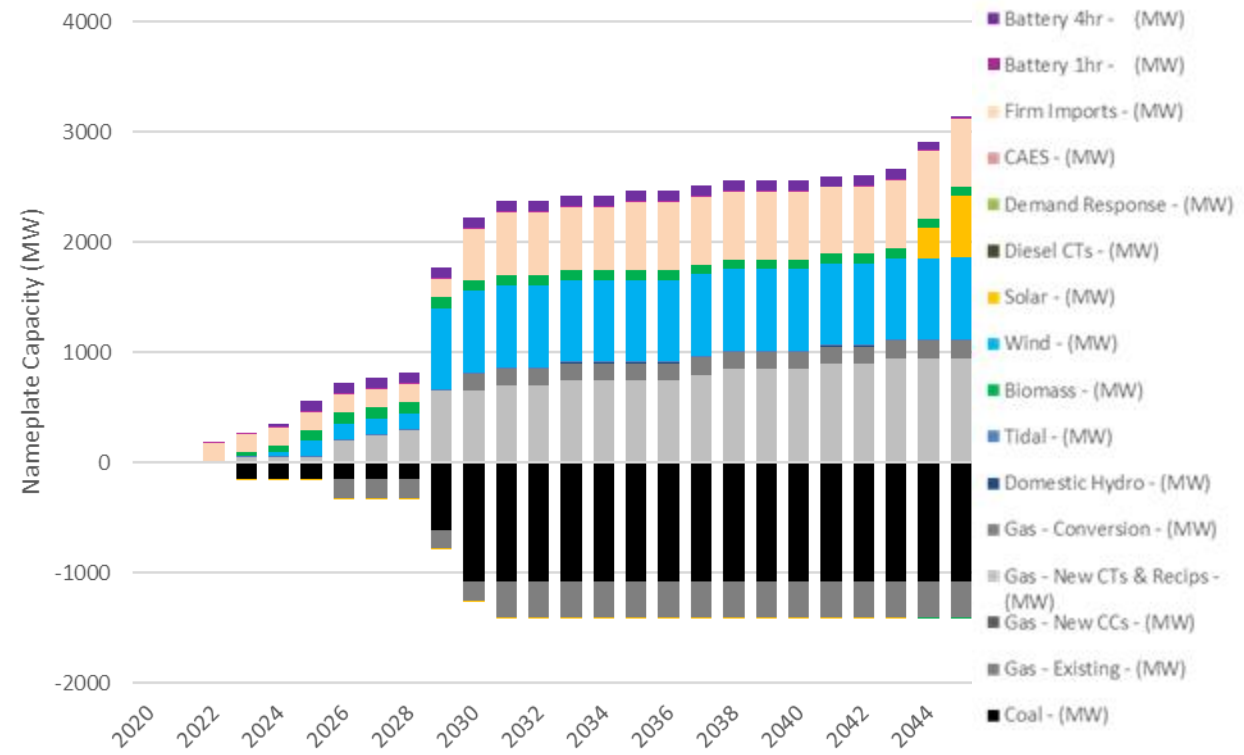
# 3.1C.DSM-7 (MID DSM)

MID ELEC. / MID DSM / ACCEL. NET ZERO 2045 / REGIONAL INTEGRATION

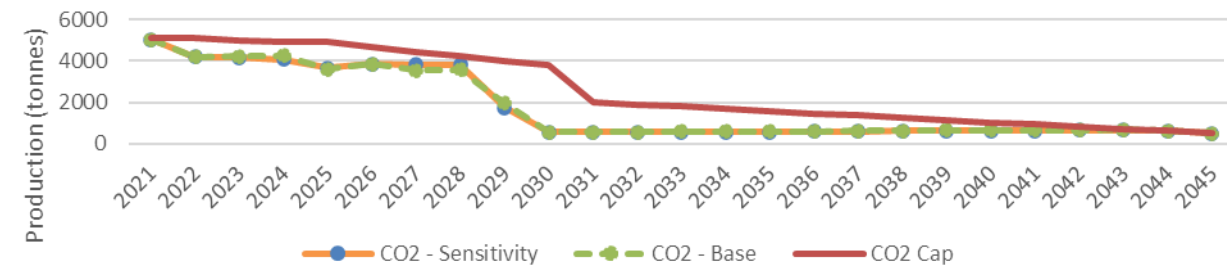
Energy Balance



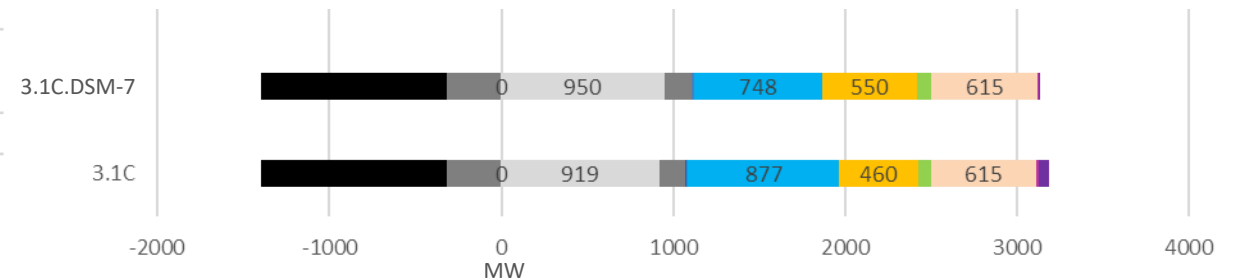
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 3.1C.DSM-7 (MID DSM)

MID ELEC. / MID DSM / ACCEL. NET ZERO 2045 / REGIONAL INTEGRATION

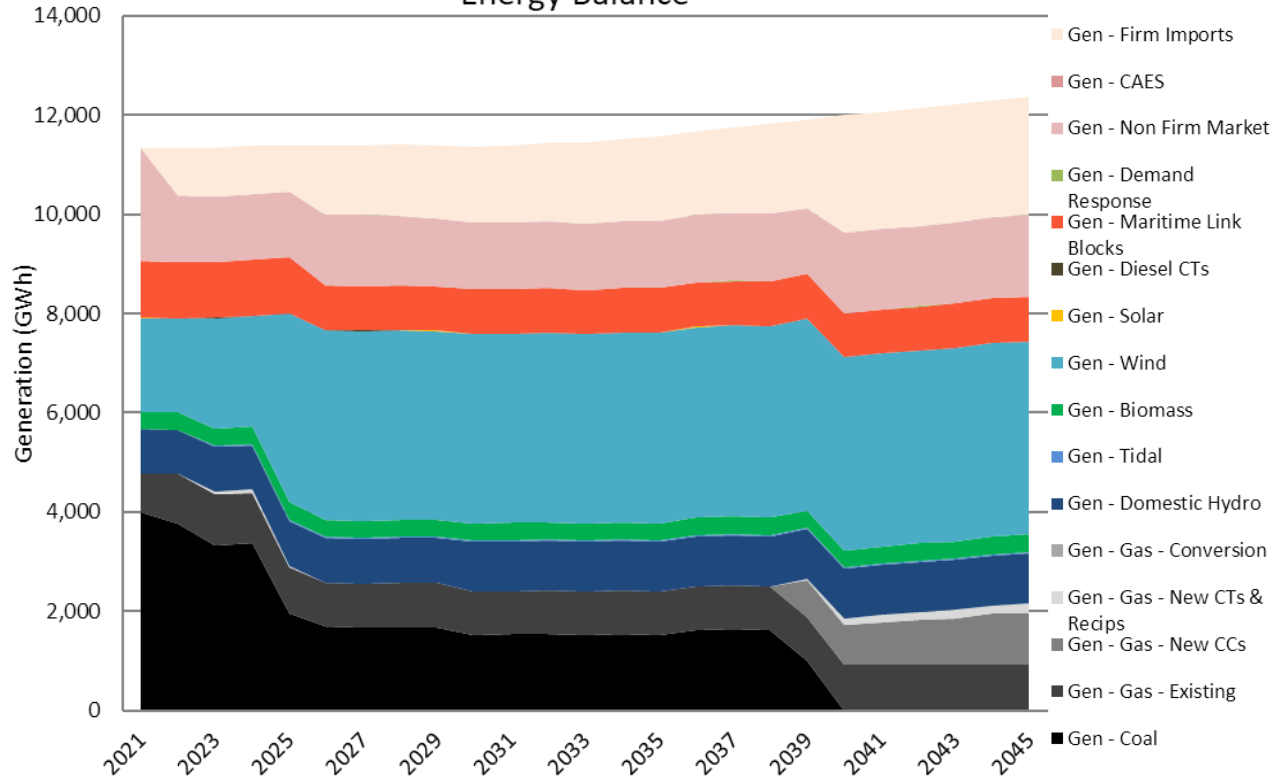
Scenario Metrics & Evaluation			
	Sensitivity	Base (3.1C)	
25-yr NPVRR (\$MM)	\$13,996	\$13,734	<u>General Notes</u> <ul style="list-style-type: none"> <li>Resource plan is largely unchanged between 3.1C and 3.1C with Mid DSM</li> <li>Slightly fewer batteries are built through the planning horizon due to lower firm capacity requirements (firm peak is 28MW lower by 2045 under Mid DSM vs. Base DSM)</li> <li>NPVRR is increased relative to Base DSM case for all three time periods</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$18,633	\$18,409	
10-yr NPVRR (\$MM)	\$7,524	\$7,224	
			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No change relative to 3.1C</li> </ul>
			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2029</li> <li>Regional Integration: 2030</li> </ul>
Average Annual Partial Rate Impact			<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No change relative to 3.1C</li> </ul>
2021-2030 (%)	1.9%	1.4%	
2021-2045 (%)	0.8%	0.7%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	34.9	34.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	8.9	9.2	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	43.9	44.0	



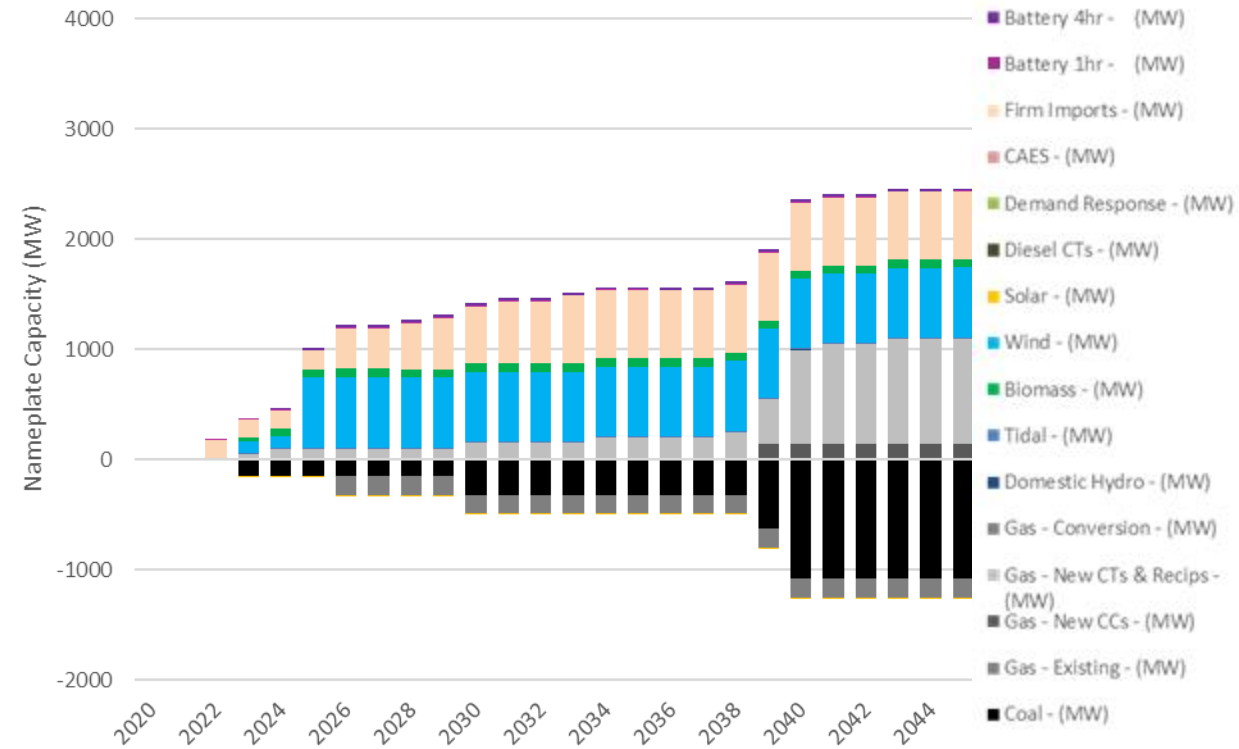
# 2.1C.WIND-1 (LOW WIND COST)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

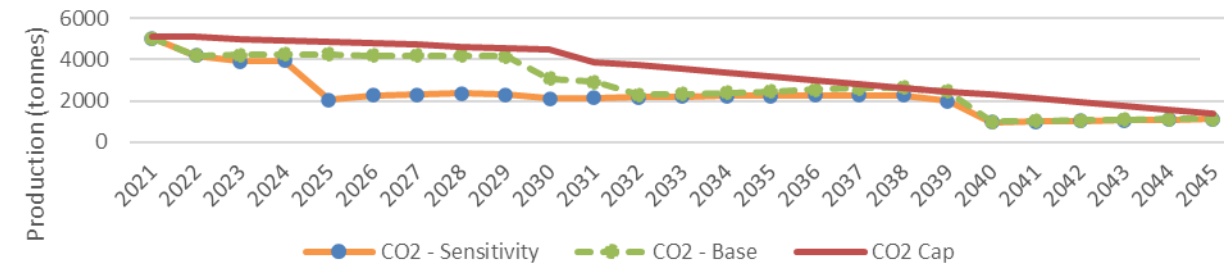
Energy Balance



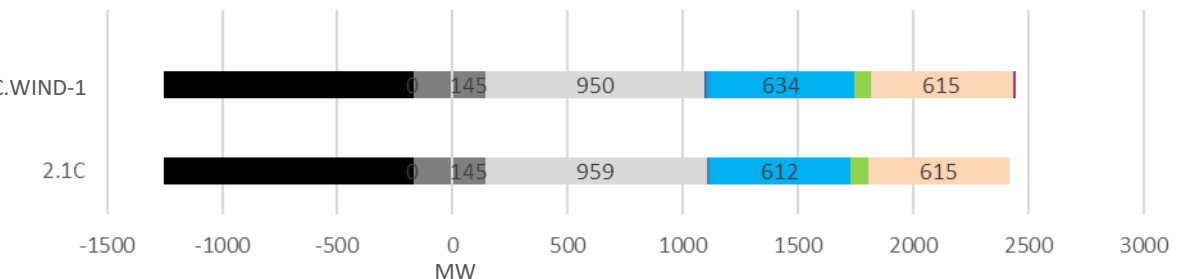
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.WIND-1 (LOW WIND COST)

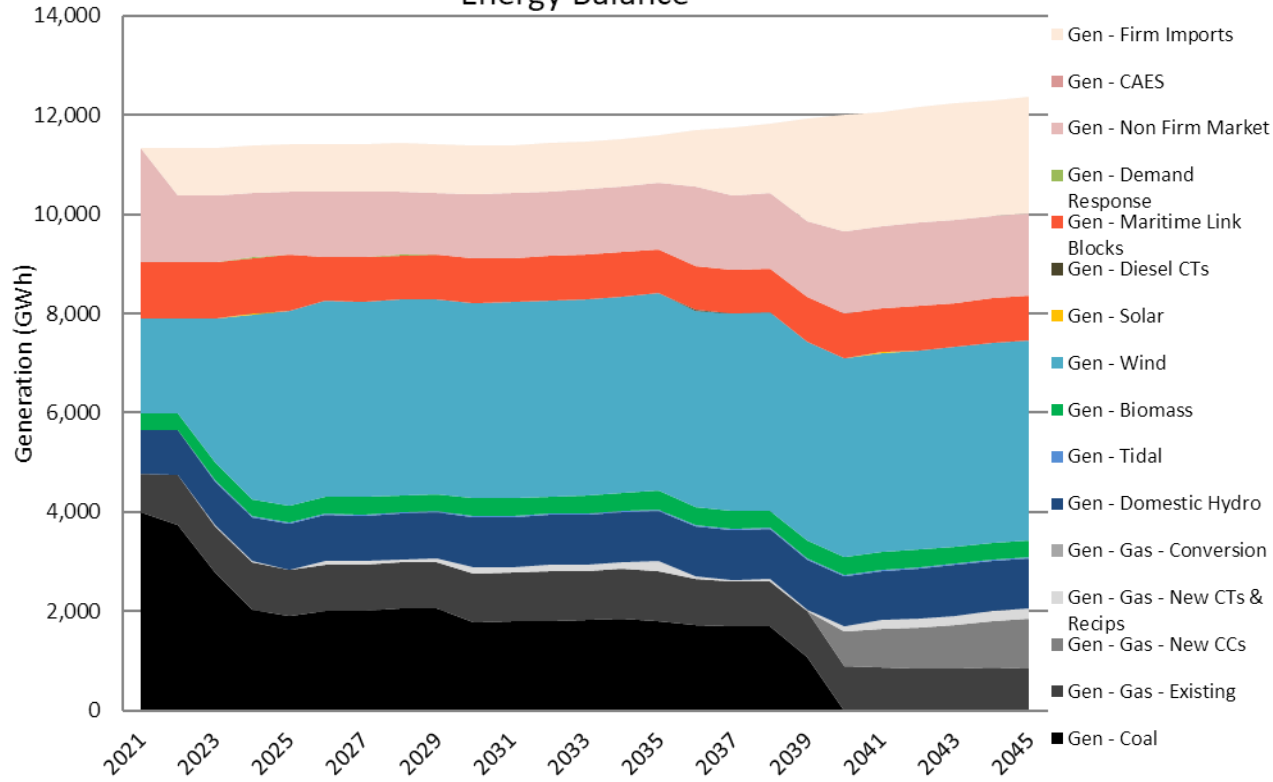
MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$12,978	\$13,141	<p><u>General Notes</u></p> <ul style="list-style-type: none"> <li>• Low wind price advances build of significant wind quantities from 2030 in base case to 2025; Reliability Tie is advanced as well to enable integration</li> <li>• Earlier build of Regional Interconnection relative to 2.1C allows procurement of firm capacity and delays some combustion turbine builds</li> <li>• Additional wind energy enables an additional coal unit retirement in 2030 relative to 2.1C (advanced from 2036)</li> <li>• Increased wind generation and earlier Regional Interconnection enables significantly reduced CO<sub>2</sub> emissions in the 2020s; emissions in 2031-2045 are largely unchanged</li> <li>• 2045 resource plans are effectively the same</li> <li>• NPVRR is reduced relative to 3.1C in two of three metrics, slightly higher in 10-yr NPV due to advancement of investment</li> </ul> <p><u>Essential Grid Services</u></p> <ul style="list-style-type: none"> <li>• No change relative to 2.1C</li> </ul> <p><u>Resource Adequacy &amp; PRM</u></p> <ul style="list-style-type: none"> <li>• Reliability Tie: 2025</li> <li>• Regional Integration: 2026</li> </ul> <p><u>Plan Robustness &amp; Flexibility</u></p> <ul style="list-style-type: none"> <li>• Need further consideration on flexibility of import energy to balance increased wind capacity in the near term</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,460	\$17,767	
10-yr NPVRR (\$MM)	\$7,132	\$7,067	
Average Annual Partial Rate Impact			
2021-2030 (%)	0.5%	0.6%	
2021-2045 (%)	0.6%	0.7%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	30.5	41.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	26.1	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	56.6	70.9	

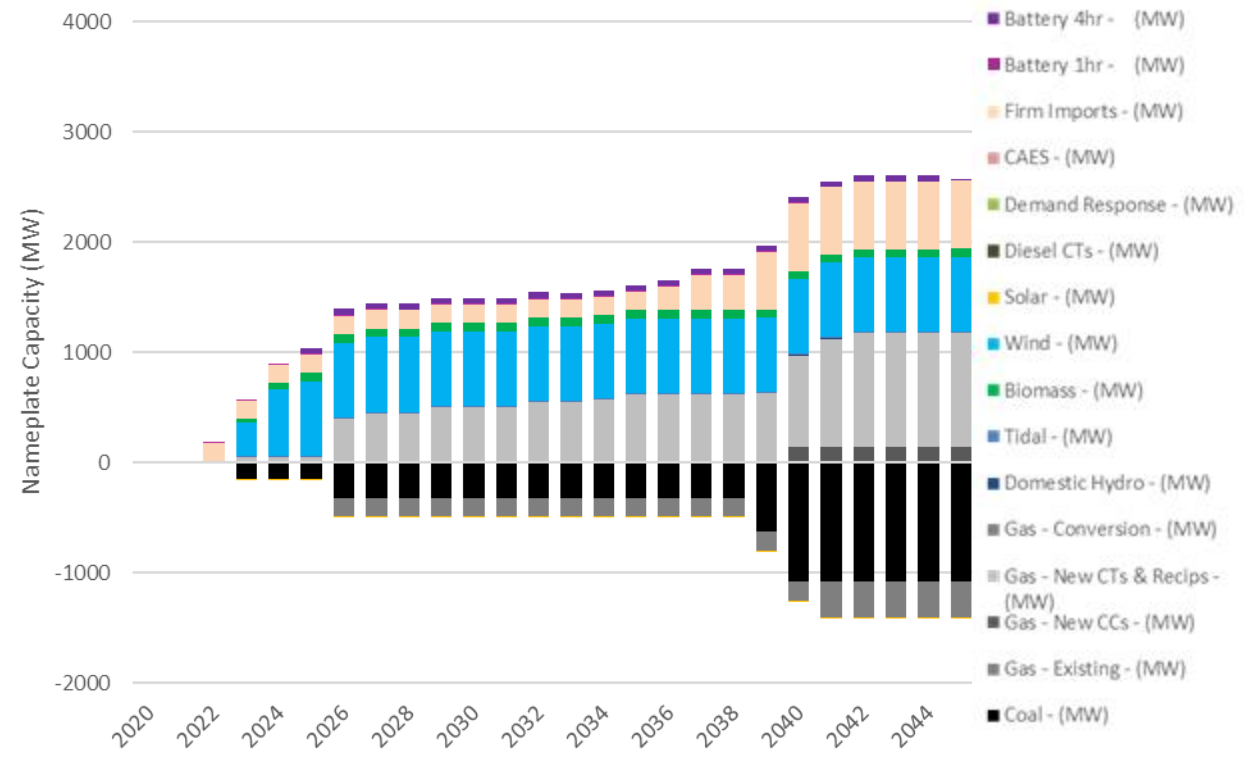
# 2.1C.WIND-2 (LOW WIND & BATTERY COST)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

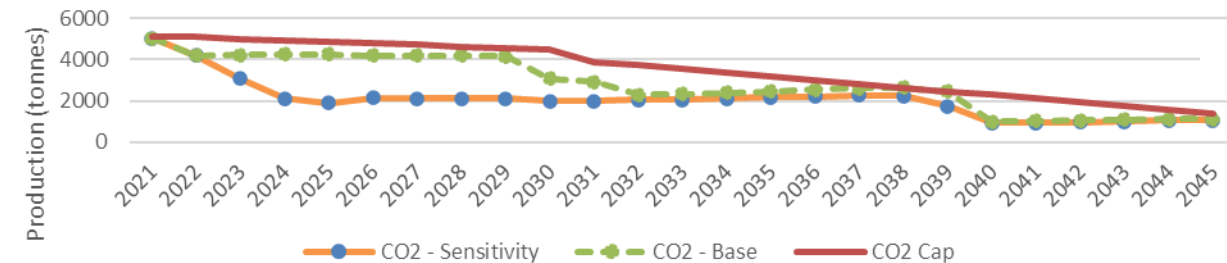
Energy Balance



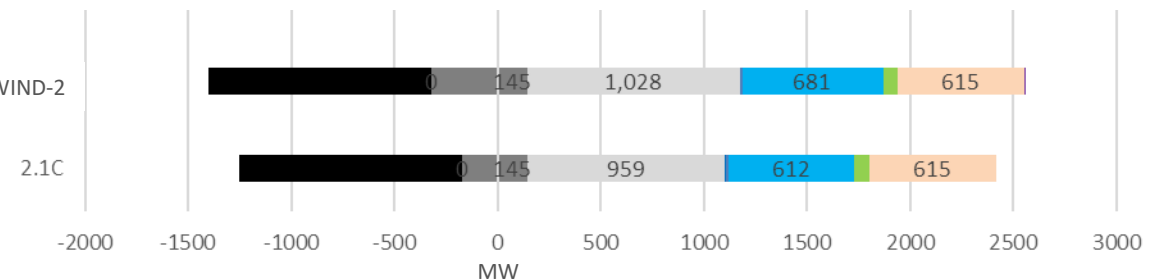
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.WIND-2 (LOW WIND & BATTERY COST)

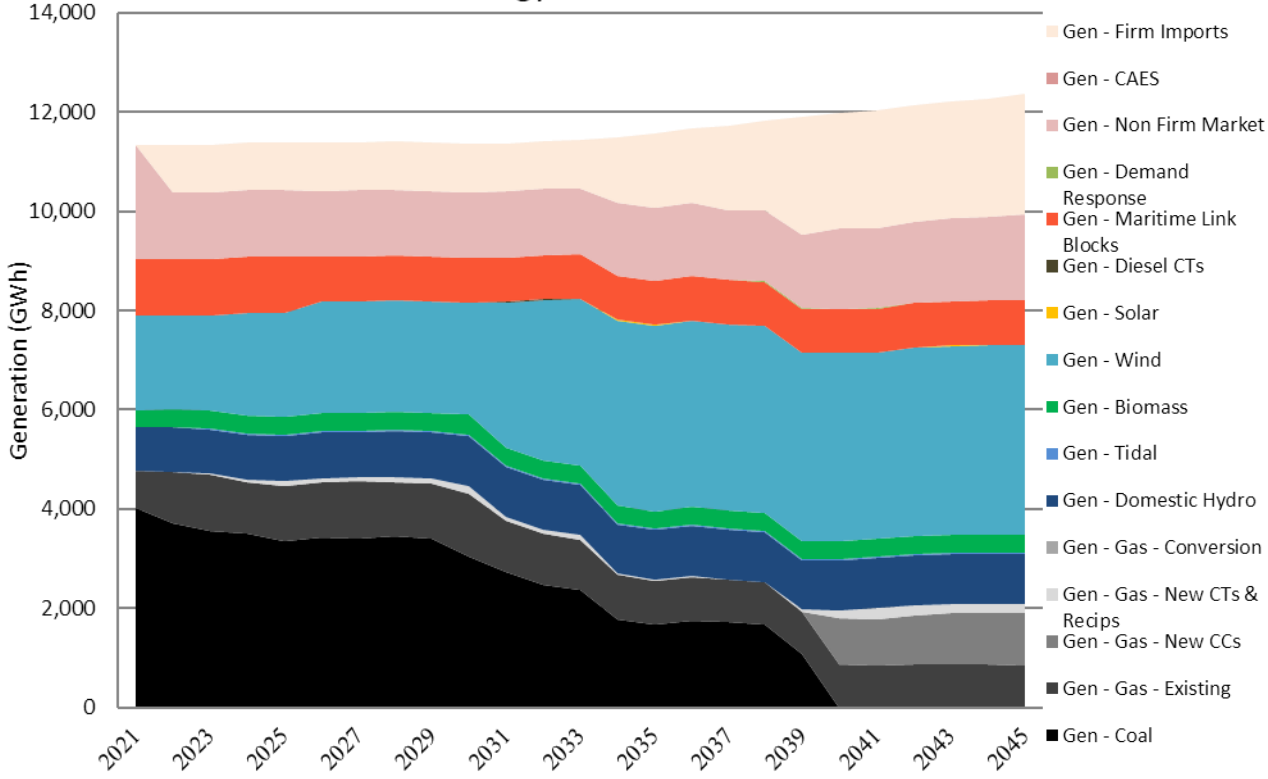
MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,086	\$13,141	<p><u>General Notes</u></p> <ul style="list-style-type: none"> <li>In general, resource plan changes are similar to what is seen in 2.1C.WIND-1 sensitivity but more pronounced</li> <li>Low wind and battery prices advance build of significant wind quantities from 2030 in base case to 2024; Reliability Tie is advanced as well to enable integration along with additional integration provided by batteries</li> <li>Regional Integration is unchanged relative to 2.1C at 2036</li> <li>Additional wind energy enables an additional coal unit retirement in 2026 relative to 2.1C (advanced from 2036)</li> <li>Increased wind generation enables significantly reduced CO<sub>2</sub> emissions in the 2020s; emissions in 2031-2045 are largely unchanged</li> <li>2045 resource plans show more wind and more CTs, and 1 additional retired gas steam unit</li> <li>NPVRR is reduced relative to 3.1C in two of three metrics, slightly higher in 10-yr NPV due to advancement of investment</li> </ul> <p><u>Essential Grid Services</u></p> <ul style="list-style-type: none"> <li>No change relative to 2.1C</li> </ul> <p><u>Resource Adequacy &amp; PRM</u></p> <ul style="list-style-type: none"> <li>Reliability Tie: 2023</li> <li>Regional Integration: 2036</li> </ul> <p><u>Plan Robustness &amp; Flexibility</u></p> <ul style="list-style-type: none"> <li>Need further consideration on flexibility of import energy to balance increased wind capacity in the near term</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,519	\$17,767	
10-yr NPVRR (\$MM)	\$7,177	\$7,067	
Average Annual Partial Rate Impact			
2021-2030 (%)	0.5%	0.6%	
2021-2045 (%)	0.6%	0.7%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	26.8	41.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	24.9	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	51.7	70.9	

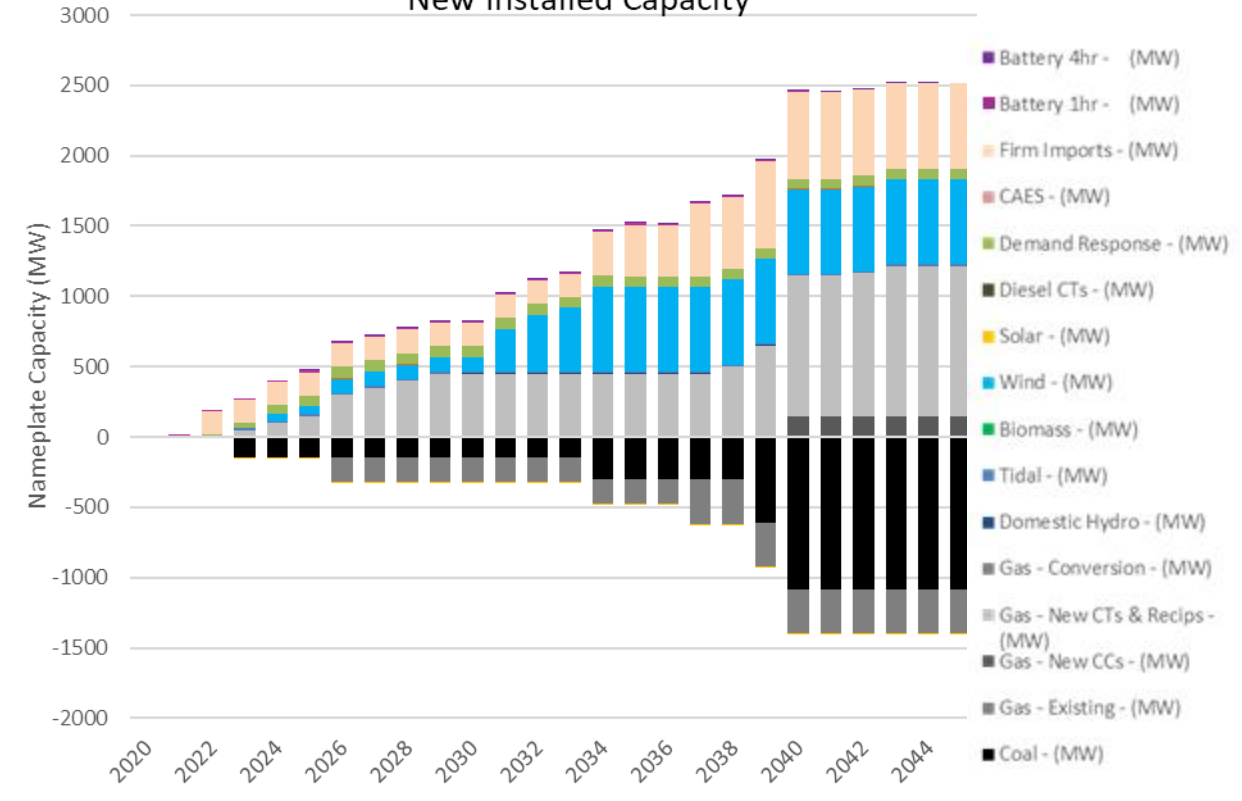
# 2.1C.WIND-3 (LOW INERTIA CONSTRAINT)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

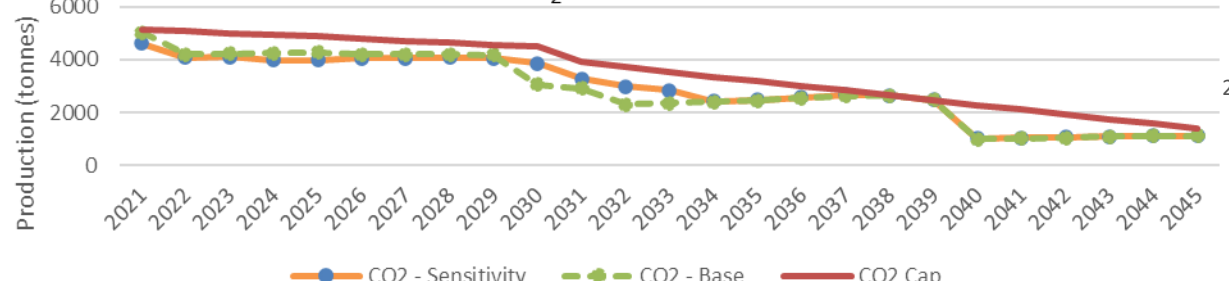
Energy Balance



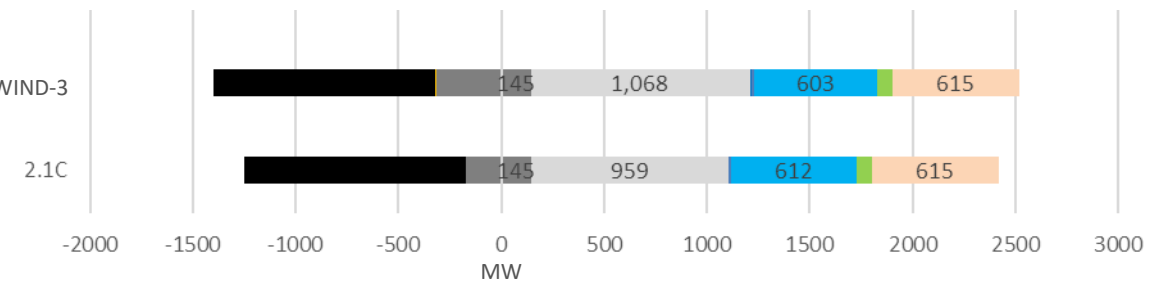
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.WIND-3 (LOW INERTIA CONSTRAINT)

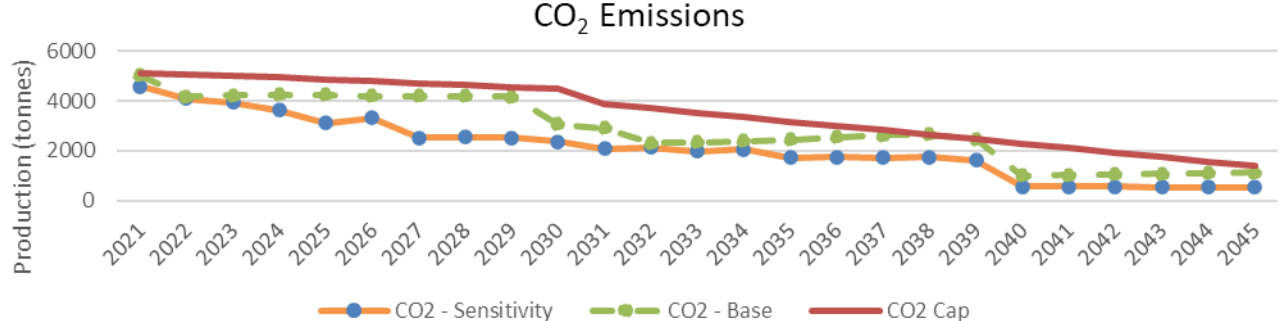
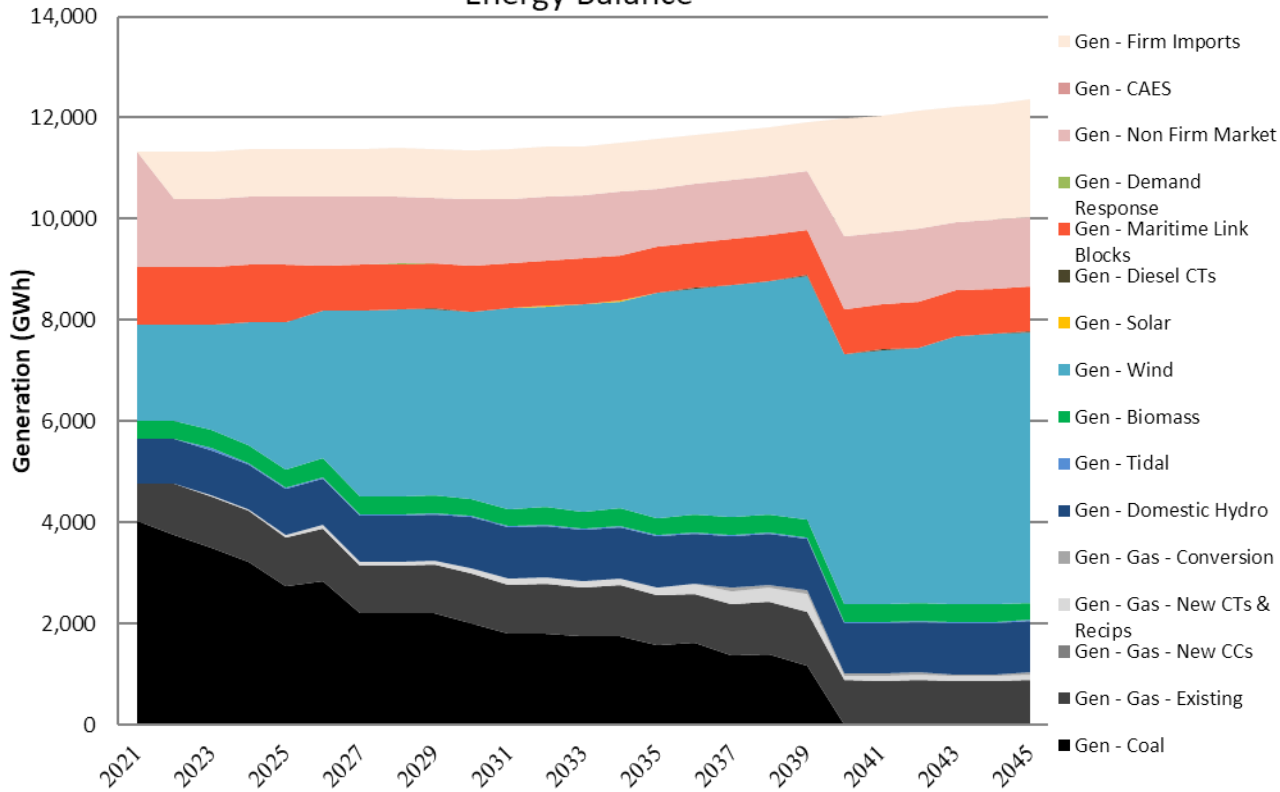
MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,059	\$13,141	<p><u>General Notes</u></p> <ul style="list-style-type: none"> <li>Inertia constraint is lowered from base of 3266 MW.sec to 2200 MW.sec in all hours</li> <li>Slight change to wind profile build is observed:                             <ul style="list-style-type: none"> <li>Initial no integration build is 50MW 2024 / 50 MW 2026, vs. 100MW 2026 in 2.1C</li> <li>Reliability Tie is built one year later and 500MW wind build is staged from 2031-2034 rather than 2030-2032 as seen in 2.1C</li> <li>In both cases relatively little wind build via local integration option</li> </ul> </li> <li>Incremental production cost savings are achieved via fewer thermal units online in early years of planning horizon; potential that this slightly delays the Reliability Tie build</li> <li>One additional gas steam unit is retired and replaced with incremental CT capacity</li> <li>Results suggest that lowering the inertia constraint in isolation has a limited impact on overall resource plan optimization</li> <li>Cost differences are small over all three NPV metrics</li> </ul> <p><u>Essential Grid Services</u></p> <ul style="list-style-type: none"> <li>Current studies indicate that 2200MW.sec of online kinetic inertia is not sufficient to reliably operate the NS Power system today; additional stability studies required to confirm potential impacts and mitigations, or dynamic operating constraints based on system state</li> </ul> <p><u>Resource Adequacy &amp; PRM</u></p> <ul style="list-style-type: none"> <li>Reliability Tie: 2031</li> <li>Regional Integration: 2034</li> </ul> <p><u>Plan Robustness &amp; Flexibility</u></p> <ul style="list-style-type: none"> <li>No change from 2.1C</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,653	\$17,767	
10-yr NPVRR (\$MM)	\$7,000	\$7,067	
Average Annual Partial Rate Impact			
2021-2030 (%)	0.5%	0.6%	
2021-2045 (%)	0.7%	0.7%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	40.8	41.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	30.9	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	71.7	70.9	

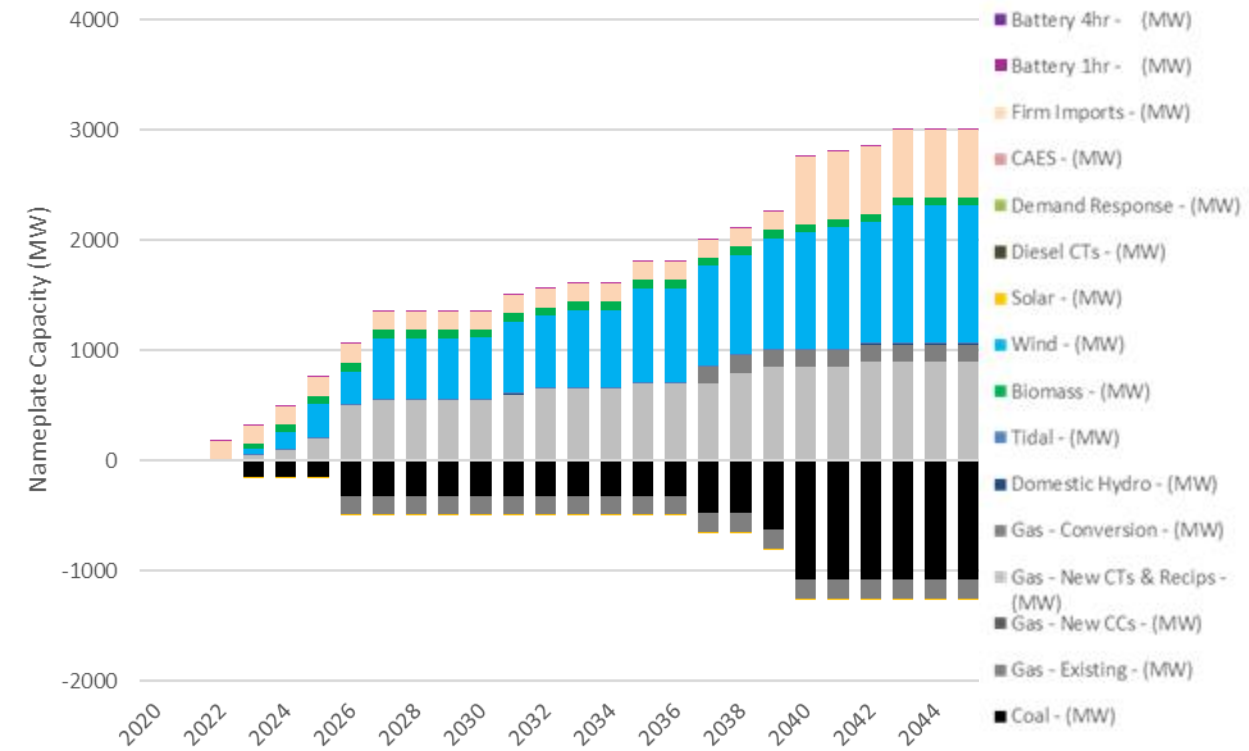
# 2.1C.WIND-4 (NO INERTIA / NO INTEGRATION)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

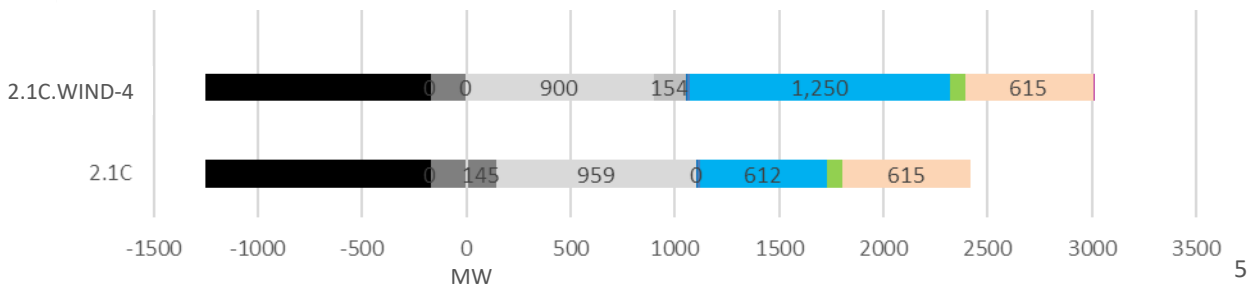
Energy Balance



New Installed Capacity



New Installed Capacity Comparison (2045)



# 2.1C.WIND-4 (NO INERTIA / NO INTEGRATION)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

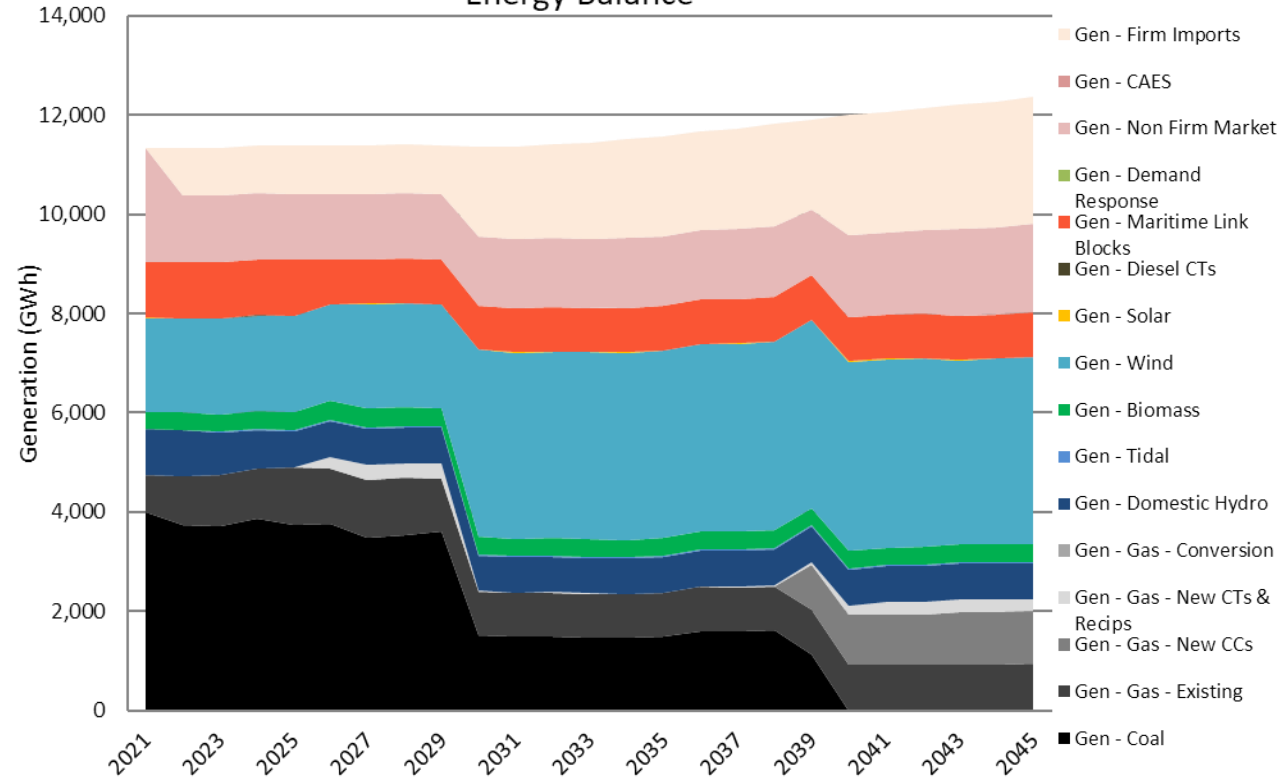
Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,076	\$13,141	<u>General Notes</u> <ul style="list-style-type: none"> <li>Model builds more wind relative to base case, with 200MW incremental added by 2030 and 250MW incremental by 2035, and 638MW incremental in 2045</li> <li>1 coal to gas conversion is selected, replacing a NGCC unit from the base case</li> <li>PLEXOS MT/ST simulations show that curtailment reached 828 GWh in 2045 (13.4%), vs. 208 GWh in 2045 (5.2%) in the 2.1C base case</li> <li>Due to curtailment and replacement energy costs, NPVs incorporating MT/ST Production Costs are not significantly lower than the base scenario 2.1C</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,734	\$17,767	
10-yr NPVRR (\$MM)	\$7,049	\$7,067	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>This run is intended as a test case to understand how the model will perform with no inertia constraint and no integration requirements for wind (i.e. Reliability Tie or Local Integration options); it is not a feasible resource plan but rather an extreme bookend</li> </ul>
2021-2030 (%)	0.4%	0.6%	
2021-2045 (%)	0.7%	0.7%	
			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2040</li> <li>Regional Integration: 2040</li> <li>Reliability Tie was built economically as part of Regional Integration to access firm capacity and energy; not required in this run for wind</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	32.7	41.8	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Significant wind penetration could be challenging to operate under some conditions</li> <li>The plan has retained flexibility of supply by adding the Regional Integration resource</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	20.1	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	52.8	70.9	



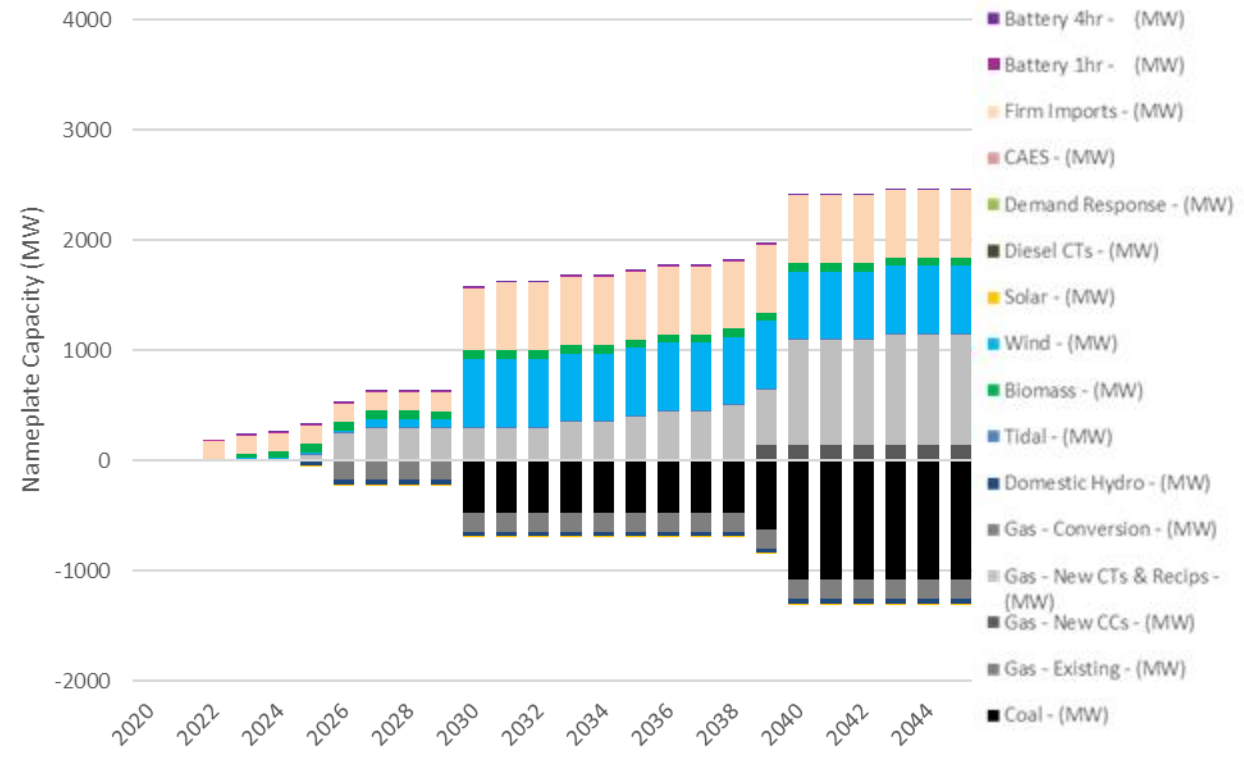
# 2.1C.MERSEY (MERSEY HYDRO RETIRED)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

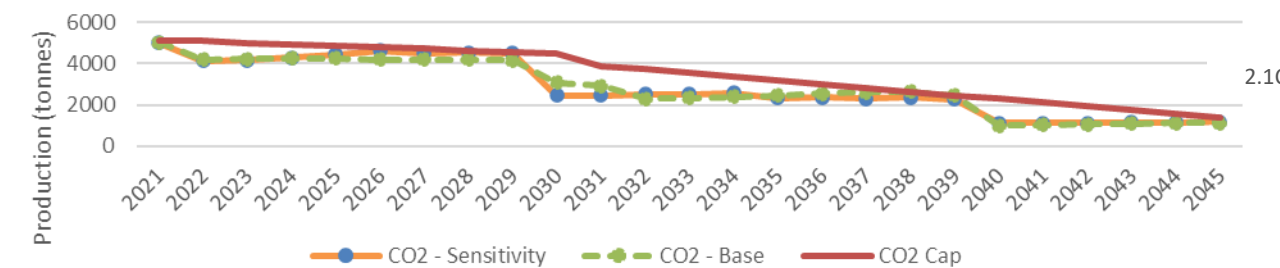
Energy Balance



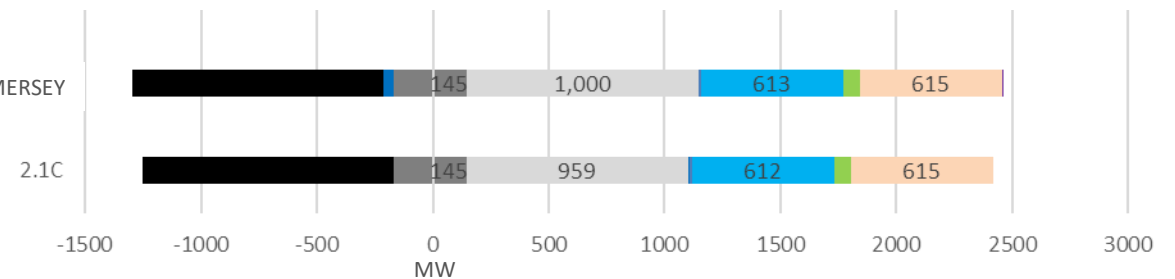
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.MERSEY (MERSEY HYDRO RETIRED)

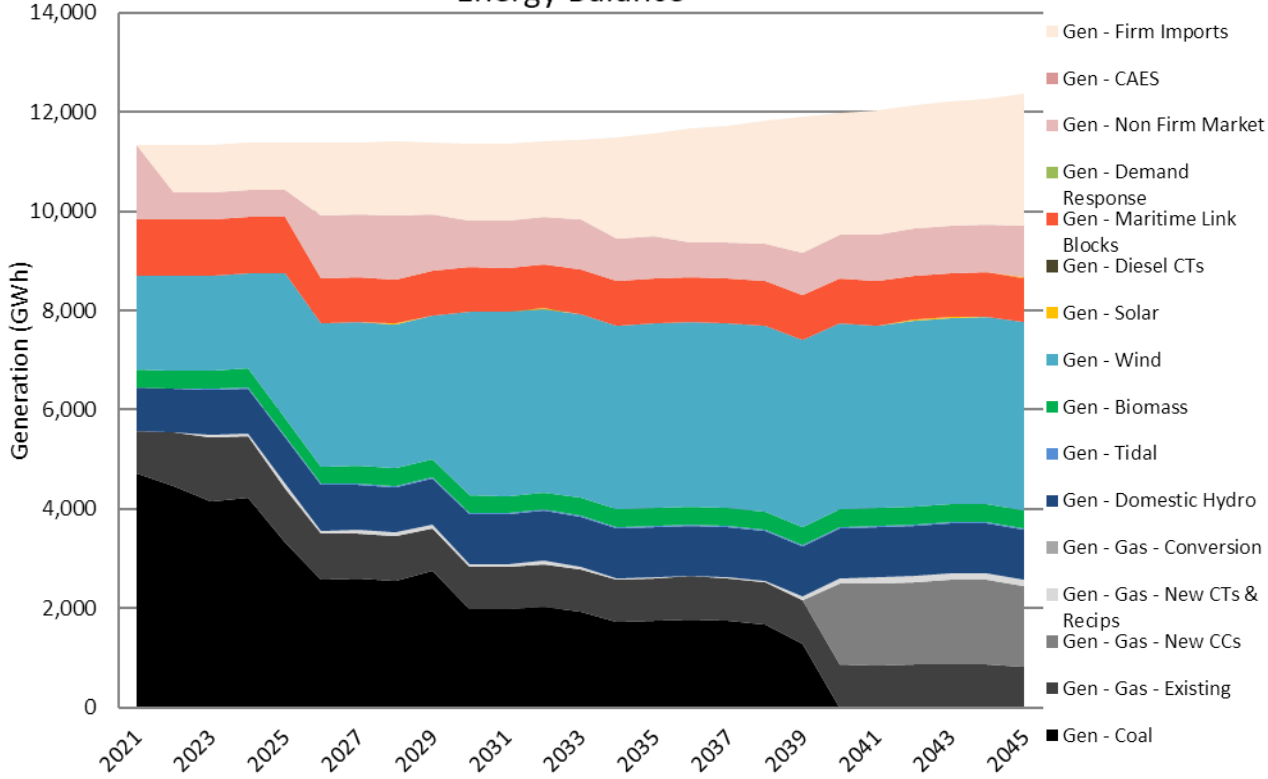
MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,097	\$13,141	<u>General Notes</u> <ul style="list-style-type: none"> <li>While the Mersey system was economically retained in the screening phase, this sensitivity was completed in order to understand how capacity and energy would be replaced</li> <li>Mersey Hydro is assumed to retire in 2025 in this scenario</li> <li>Regional Integration build is advanced from 2036 to 2030, and significant wind build occurs in 2030 rather than 2032</li> <li>By the end of the planning horizon, the build is similar but with 40MW of incremental combustion turbine capacity accounting for the retirement of Mersey Hydro</li> <li>Mersey Decommissioning Cost (\$227MM) is external to PLEXOS but included in Sensitivity NPV and Rate Impact results as an extrinsic cost</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,845	\$17,767	
10-yr NPVRR (\$MM)	\$6,885	\$7,067	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>Decommissioning of Mersey Hydro system would require system stability studies for the Western region of Nova Scotia due to changes in essential grid service provision; cost of any mitigation not included in decommissioning NPV</li> </ul>
2021-2030 (%)	0.6%	0.6%	
2021-2045 (%)	0.7%	0.7%	
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	42.7	41.8	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2030</li> <li>Regional Integration: 2030</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	28.5	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	71.2	70.9	
			<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>Hydro assets are not subject to fuel price volatility and are located locally in Nova Scotia</li> </ul>

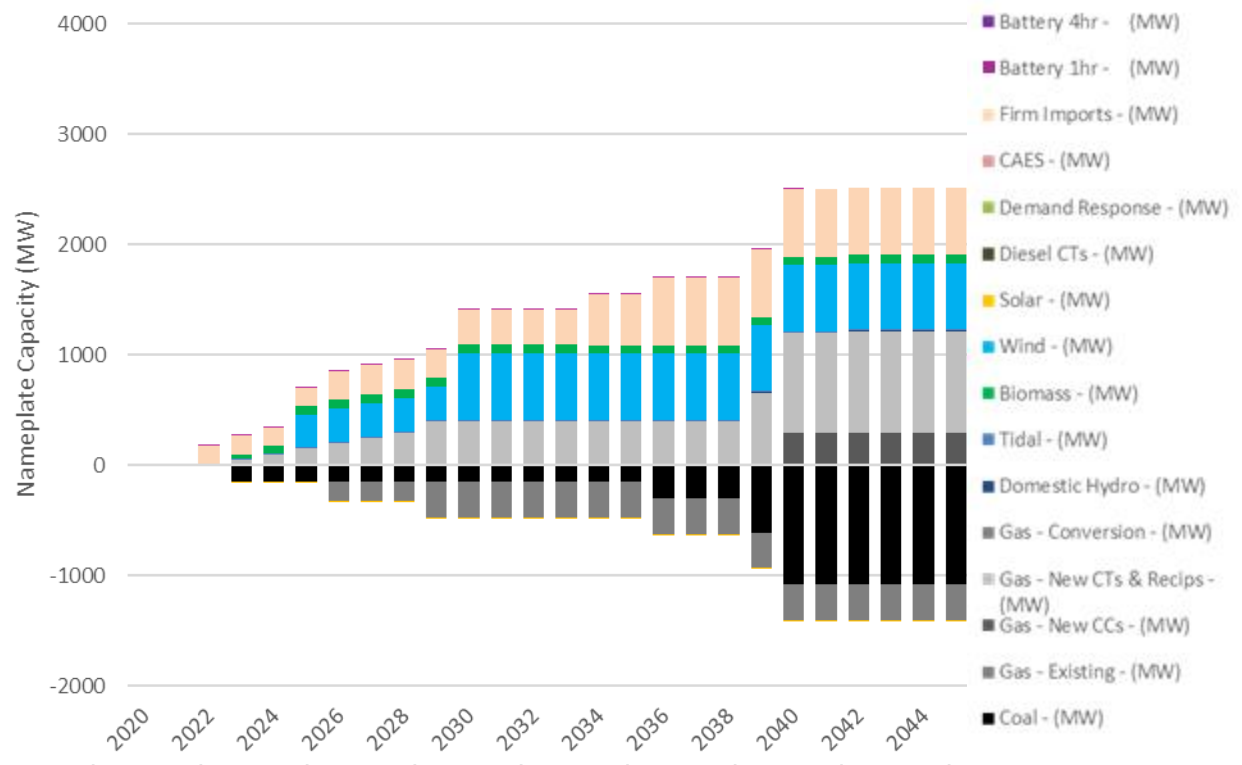
# 2.1C.IMPORT-1 (LIMITED NON-FIRM IMPORTS)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

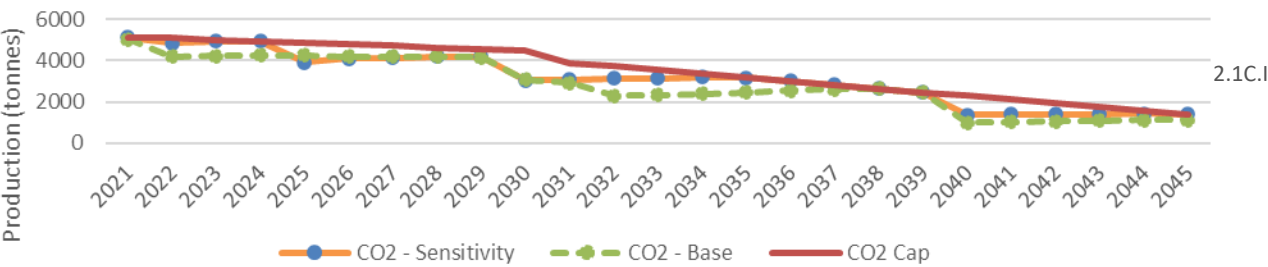
Energy Balance



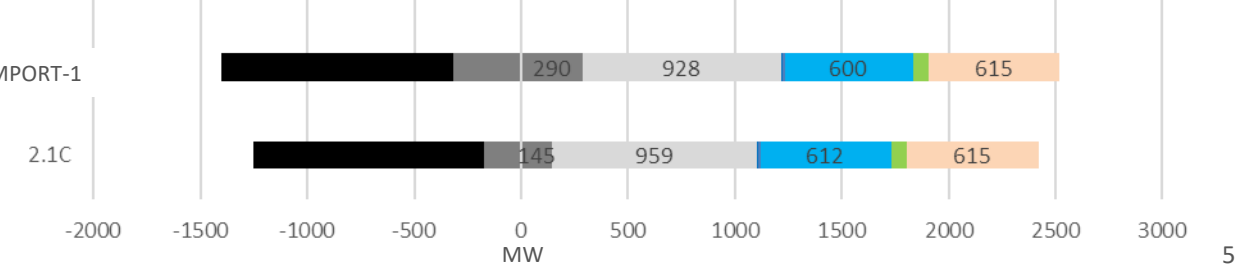
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.IMPORT-1 (LIMITED NON-FIRM IMPORTS)

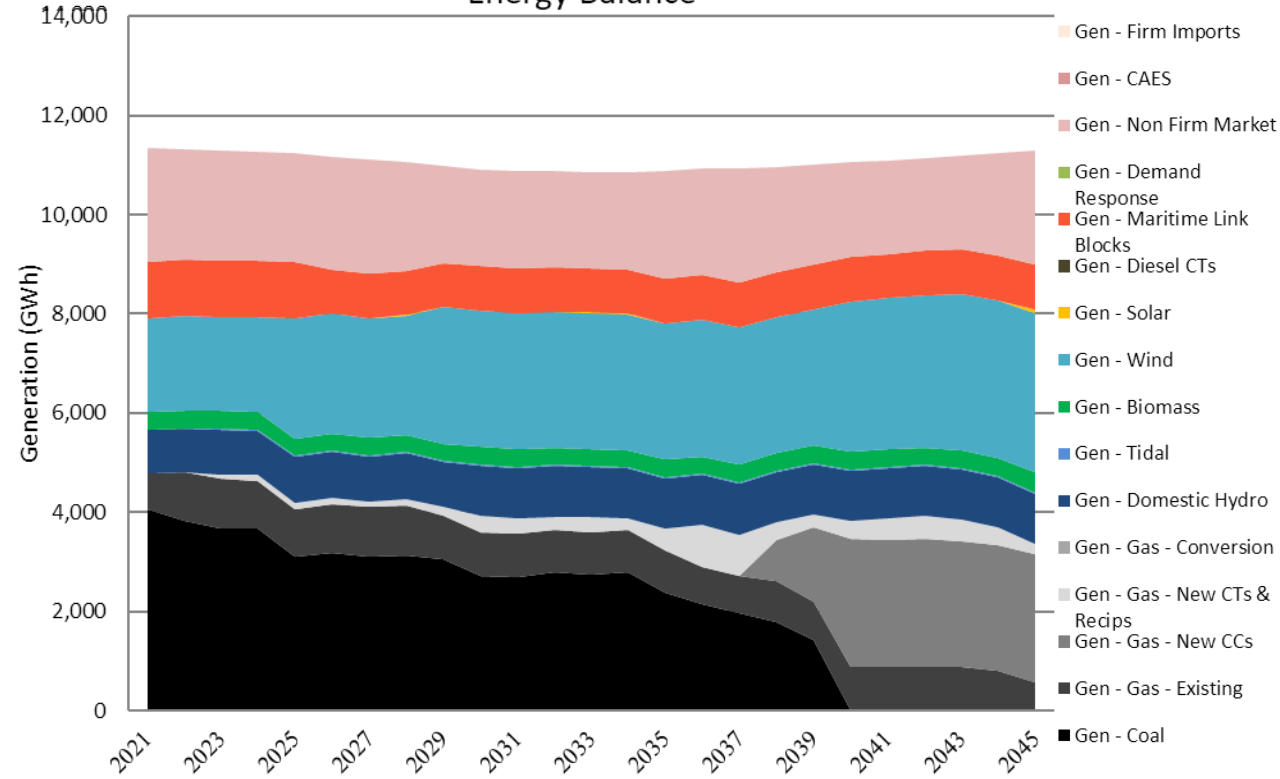
MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,543	\$13,141	<u>General Notes</u> <ul style="list-style-type: none"> <li>Sensitivity reduces the maximum quantity of non-firm imports from all sources available to the model by 0.8TWh</li> <li>Model builds wind earlier in late 2020s</li> <li>Sensitivity case builds one additional NGCC and retires one additional gas steam unit but remainder of 2045 resource mix largely unchanged; generation mix sees additional procurement of firm imports to offset reduction in non-firm availability</li> <li>In general the 2.1C base resource plan is robust to a reduction in non-firm imports, but replacement energy does come at a higher cost</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$18,176	\$17,767	
10-yr NPVRR (\$MM)	\$7,373	\$7,067	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No change relative to 2.1C</li> </ul>
2021-2030 (%)	0.9%	0.6%	
2021-2045 (%)	0.7%	0.7%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2024</li> <li>Regional Integration: 2026</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	43.5	41.8	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	35.1	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	78.6	70.9	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No change relative to 2.1C</li> </ul>

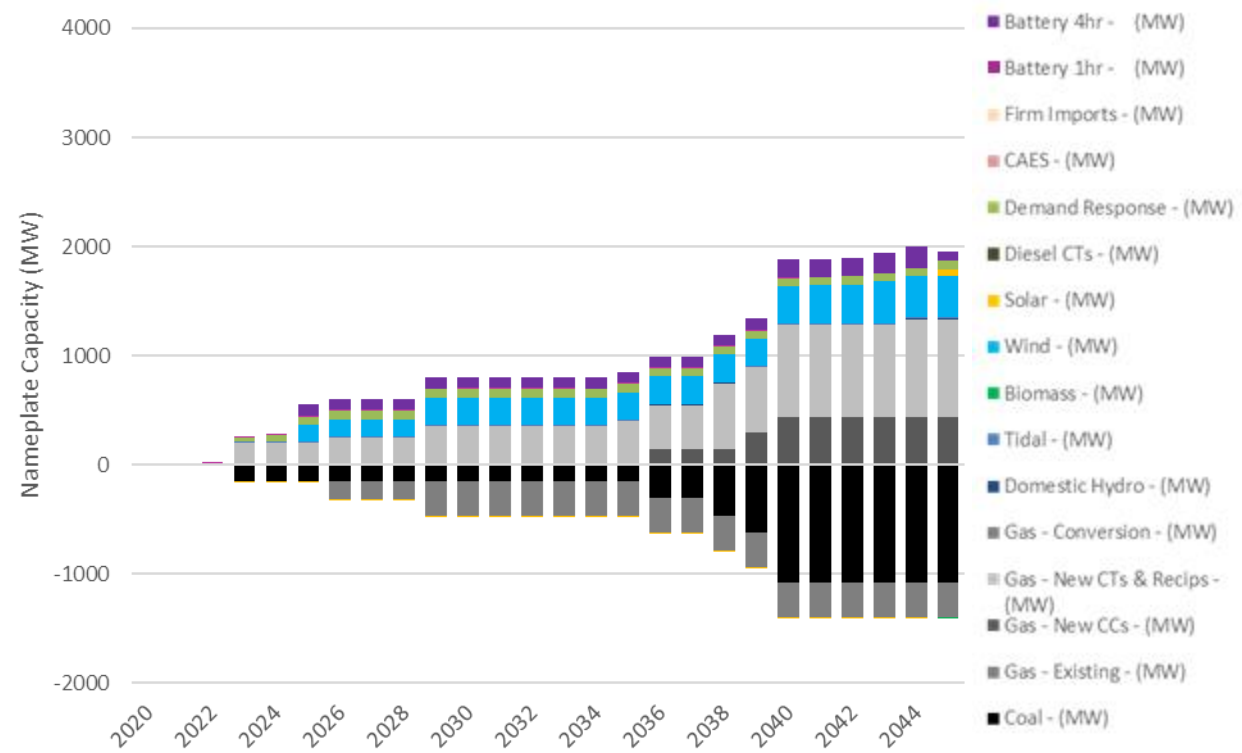
# 2.0A.IMPORT-2 (NO RELIABILITY TIE)

MID ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

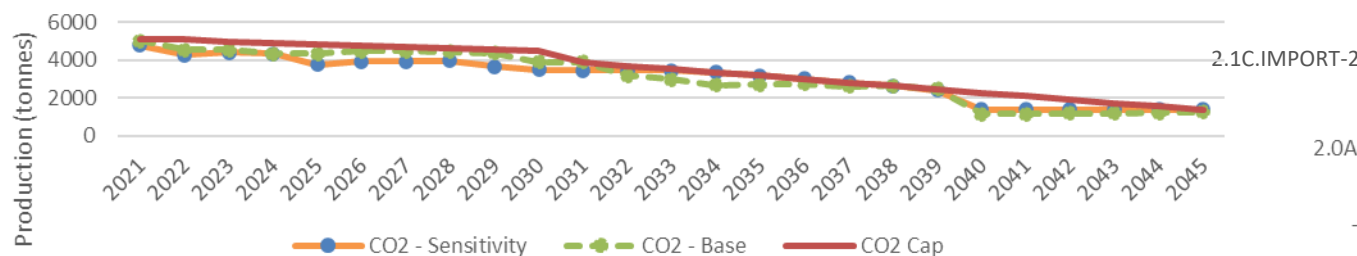
Energy Balance



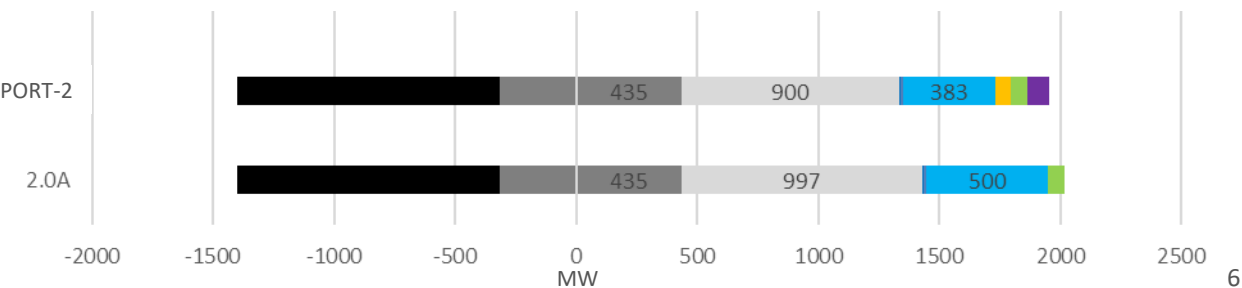
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.0A.IMPORT-2 (NO RELIABILITY TIE)

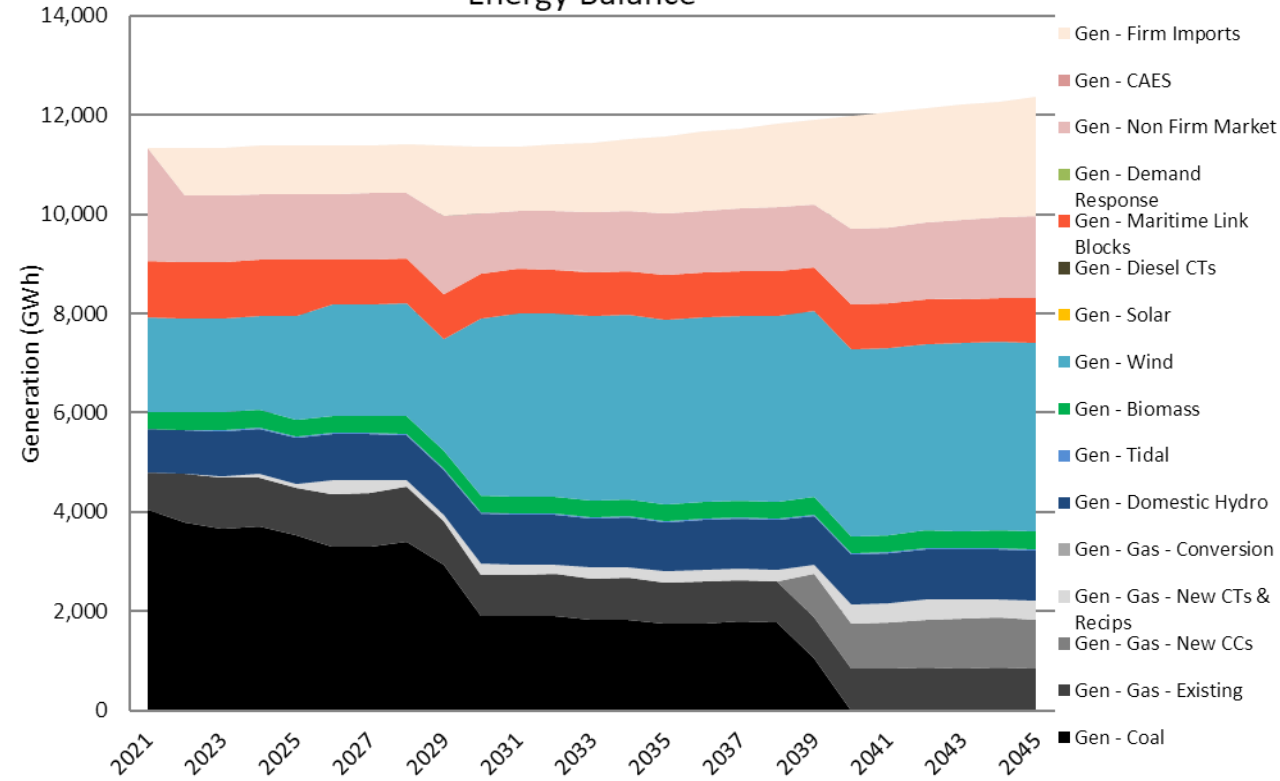
MID ELEC. / BASE DSM / NET ZERO 2050 / CURRENT LANDSCAPE

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.0A)	
25-yr NPVRR (\$MM)	\$12,628	\$12,351	<u>General Notes</u> <ul style="list-style-type: none"> <li>Without the ability to build the Reliability Tie, wind is built via the local integration option (batteries + synchronous condensers), which also contribute to system inertia requirements</li> <li>Total quantity of wind built is less and batteries are added for wind integration; remainder of resource plan is similar</li> <li>Costs are higher than the base 2.0A scenario for all NPV metrics</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$16,965	\$16,609	
10-yr NPVRR (\$MM)	\$6,951	\$6,831	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>High inertia synchronous condensers contribute kinetic inertia in addition to online thermal generation</li> </ul>
2021-2030 (%)	1.0%	0.9%	
2021-2045 (%)	1.1%	1.0%	<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: n/a</li> <li>Regional Integration: n/a</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	40.6	44.5	
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	36.2	33.2	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No change relative to 2.0A</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	76.8	77.7	

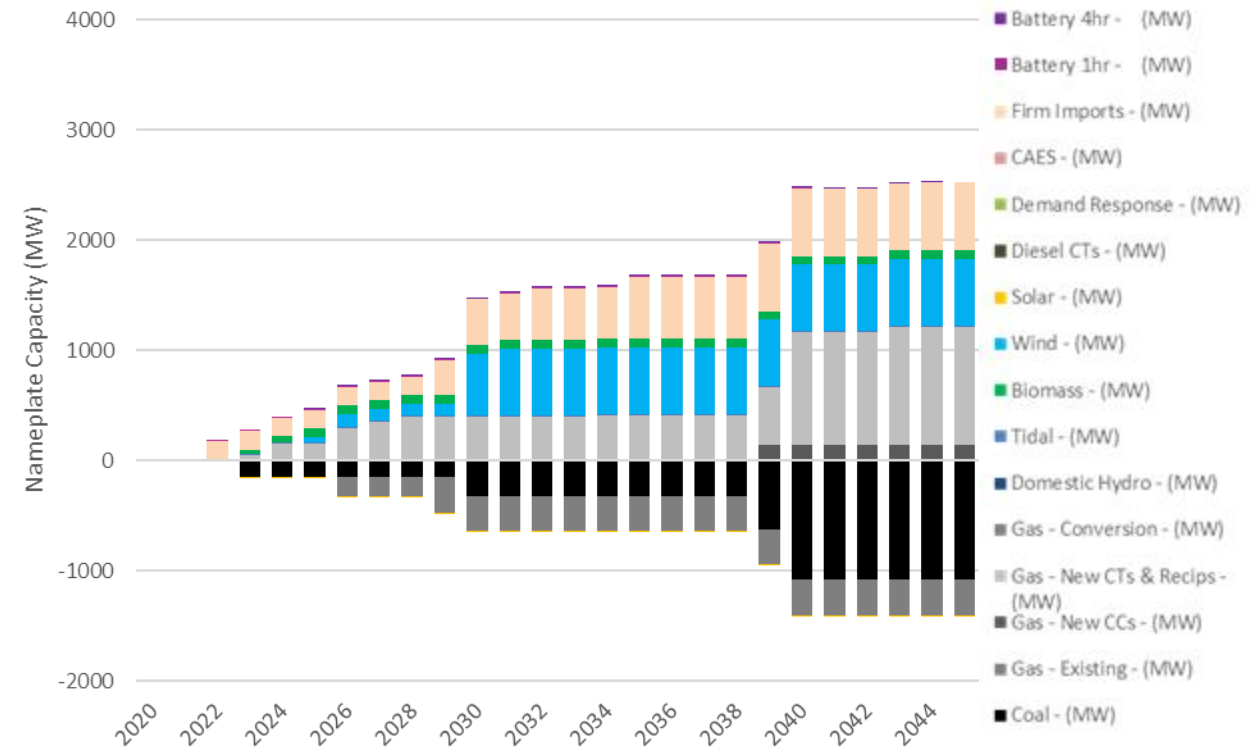
# 2.1C.IMPORT-3 (LIMITED RELIABILITY TIE INERTIA)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

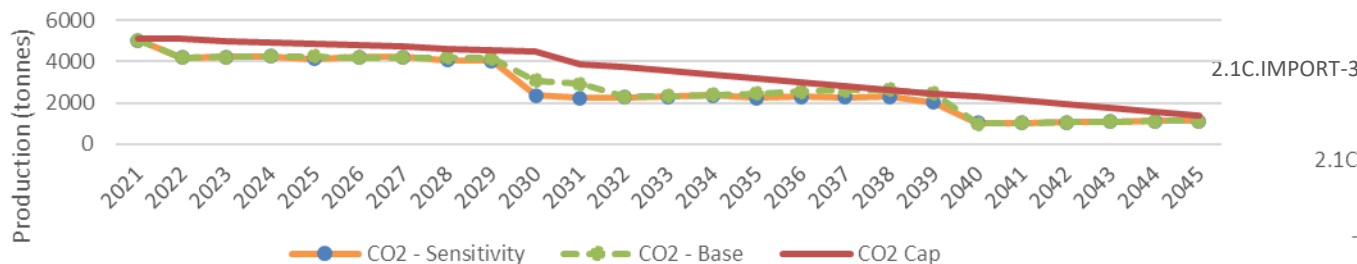
Energy Balance



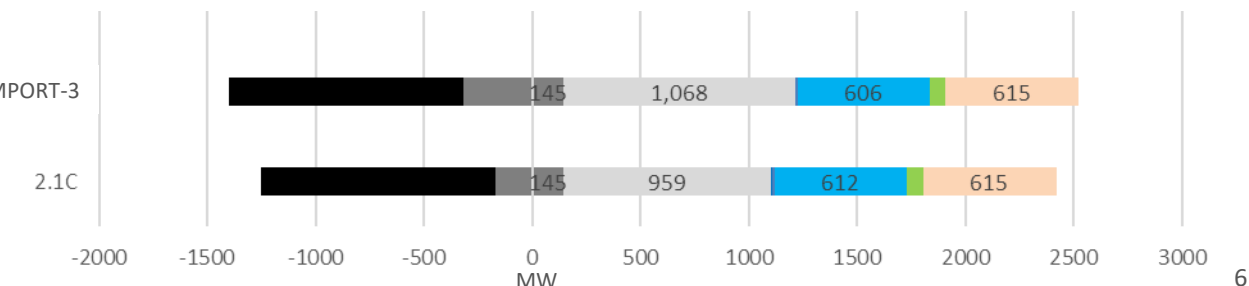
New Installed Capacity



CO<sub>2</sub> Emissions



New Installed Capacity Comparison (2045)



# 2.1C.IMPORT-3 (LIMITED RELIABILITY TIE INERTIA)

MID ELEC. / BASE DSM / NET ZERO 2050 / REGIONAL INTEGRATION

Scenario Metrics & Evaluation			
	Sensitivity	Base (2.1C)	
25-yr NPVRR (\$MM)	\$13,225	\$13,141	<u>General Notes</u> <ul style="list-style-type: none"> <li>In this scenario the Reliability Tie contributes only 50% of required system inertia once built (i.e. 1633 MW.sec); intention of scenario is to test robustness of the assumption that Reliability Tie can supply all system inertia requirements</li> <li>Reliability Tie and Regional Integration are built slightly earlier in this scenario, with some accompanying earlier retirements as well, likely because more flexible units are easier to satisfy the remaining inertia requirement with</li> <li>Generation mix is generally unchanged from 2.1C on an annual basis</li> <li>Costs are relatively close to 2.1C on all NPV metrics</li> </ul>
25-yr NPVRR w/ End Effects (\$MM)	\$17,842	\$17,767	
10-yr NPVRR (\$MM)	\$7,111	\$7,067	
Average Annual Partial Rate Impact			<u>Essential Grid Services</u> <ul style="list-style-type: none"> <li>No change from 2.1C</li> </ul>
2021-2030 (%)	0.8%	0.6%	
2021-2045 (%)	0.7%	0.7%	
			<u>Resource Adequacy &amp; PRM</u> <ul style="list-style-type: none"> <li>Reliability Tie: 2028</li> <li>Regional Integration: 2029</li> </ul>
Total CO <sub>2</sub> Emissions 2021-2030 (MT)	40.8	41.8	<u>Plan Robustness &amp; Flexibility</u> <ul style="list-style-type: none"> <li>No change from 2.1C</li> </ul>
Total CO <sub>2</sub> Emissions 2031-2045 (MT)	26.8	29.1	
Total CO <sub>2</sub> Emissions 2021-2045 (MT)	67.6	70.9	



