2019 IRP Working Group

Meeting 12: March 27– 28, 2019


welcome

Safety Moment

Building Emergency Plan

Introductions

- Name
- Organization and Role

Agenda – March 27

11:30	**Lunch**	**Meeting Room 5**
12:30	**Welcome and Today's Meeting** **Recap Where we are in process**	**Jo Anne Lavender** **Brian Child**
1:00	**High Level Recap of IRP** **Public Comment Period Update** **Themes from Public Meetings**	**Hunter Hydas** **Amy Henry**
1:30	**Sensitivities**	**Jane Elliott and Roger Pierce / Scott Jones**
2:30	**Break**	
2:45	**Sensitivities – cont'd**	**Jane Elliott and Roger Pierce / Scott Jones**
4:00	**Group Breakout**	**Group**
5:00	**Wrap Up day 1**	**Jo Anne / Brian**
6:00	**Group Dinner**	

Agenda – March 28

RED text indicates confidential

7:15	***Breakfast – at hotel for guests - use voucher.*** ***Coffee / light refreshments in meeting room***	
8:30	**Welcome and Recap Day 1**	**Jo Anne / Brian**
9:00	**Recap Sensitivities**	**Jane Elliott**
9:30	**IRPWG Activity: Developing your recommendation**	**Jo Anne and Group**
10:00	**TVA Approach for Developing a Recommendation**	**Hunter Hydas**
10:30	**Group Break Out - Input on Developing a Recommendation**	**Jo Anne and group**
11:30	**Recap Meeting** **Review next steps and adjourn.**	
12:00	**Lunch**	**Meeting Room 5**

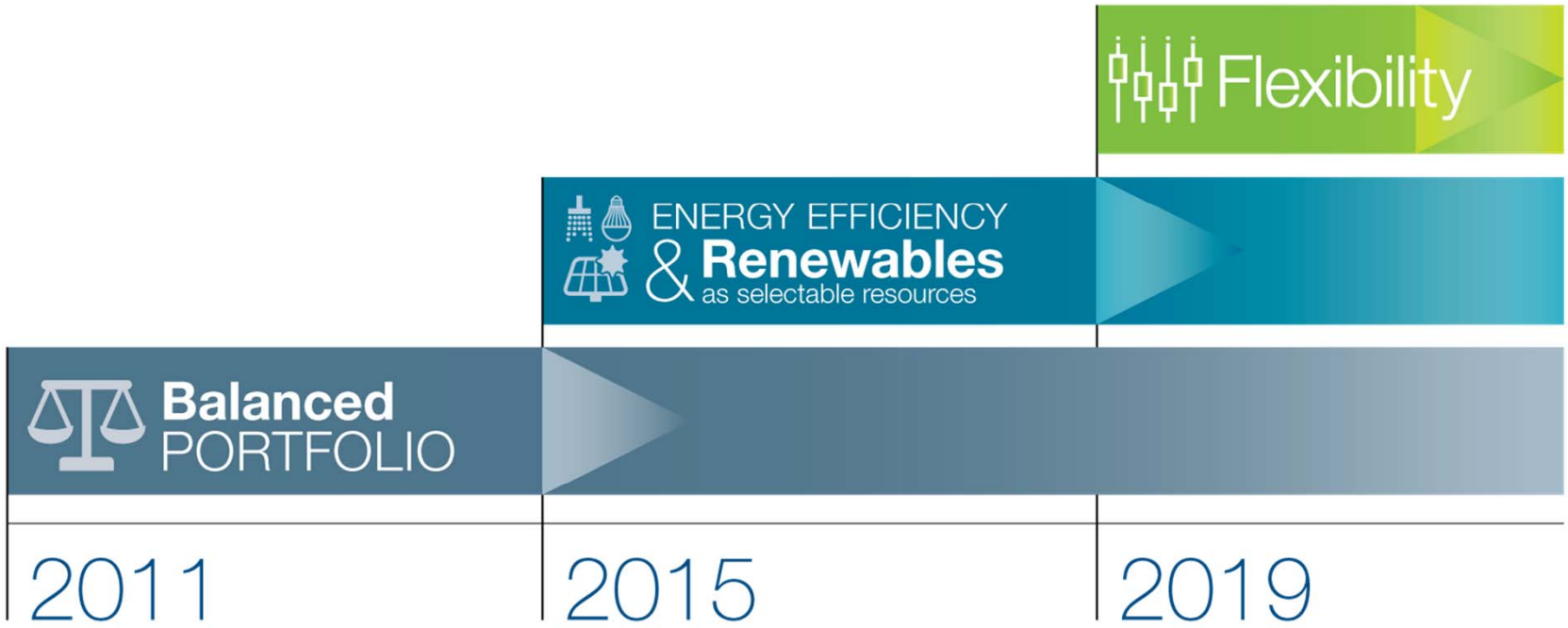
IRPWG Meeting 11 Recap

Brian Child

February Meeting Highlights

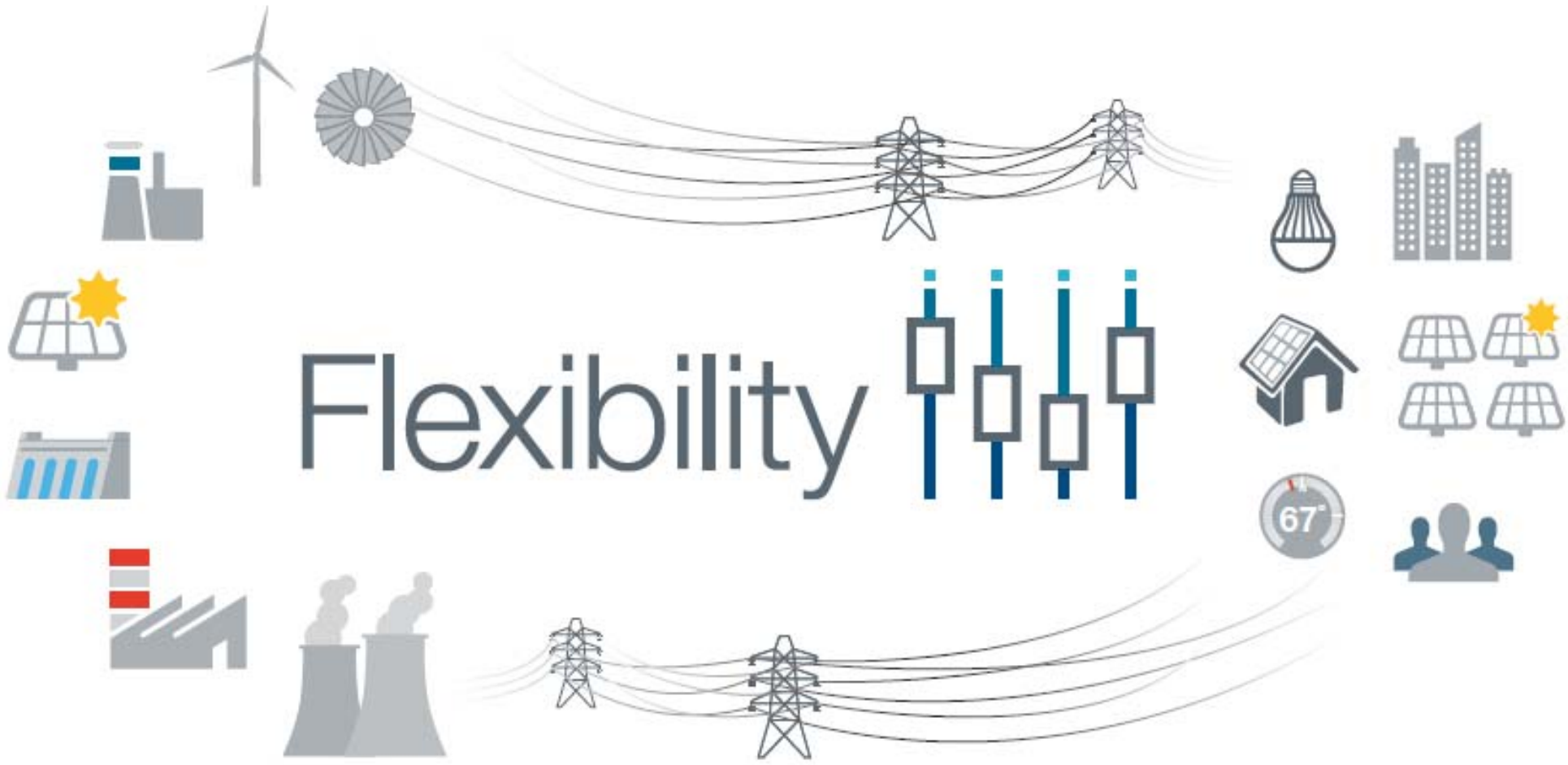
- Plans for public engagement on the Draft IRP
- Details on the EIS Metrics
- New Base Case overview
- First group of Sensitivity Results
- Discussion to prioritize additional Sensitivities to run

INTEGRATED Resource Plan 2019



2019 IRP Focus Areas

- System flexibility
- Distributed Energy Resources
- Portfolio diversity


Flexibility
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2019 IRP Schedule: Schedule & Milestones

The 2019 IRP Study Approach is intended to ensure transparency & enable stakeholder involvement

(** indicates timing of Valley-wide public meetings)

Key Tasks/Milestones in this study timeline include:

- Establish stakeholder group and hold first meeting (Feb 2018)
- System modeling (June - December 2018)
- Publish draft EIS and IRP (Feb 2019)
- Complete public meetings (March 2019)
- Board approval and final publication of EIS and IRP (expected Summer 2019)

IRP Working Group Meeting Objectives

February 28 – March 1	March 27 -28	May 12-13	June 25
• Updated Base Case • Sensitivities results so far • Discuss Sensitivities • Prioritize Sensitivities	• Sensitivity Results • Review public comment period • Early themes from public comments	• Final Sensitivity • Public Comments • Developing the Recommendation	• Final Recommendation

High Level Recap of IRP

Hunter Hydas

Public Comment Period Update and Themes from Public Meetings

Amy Henry

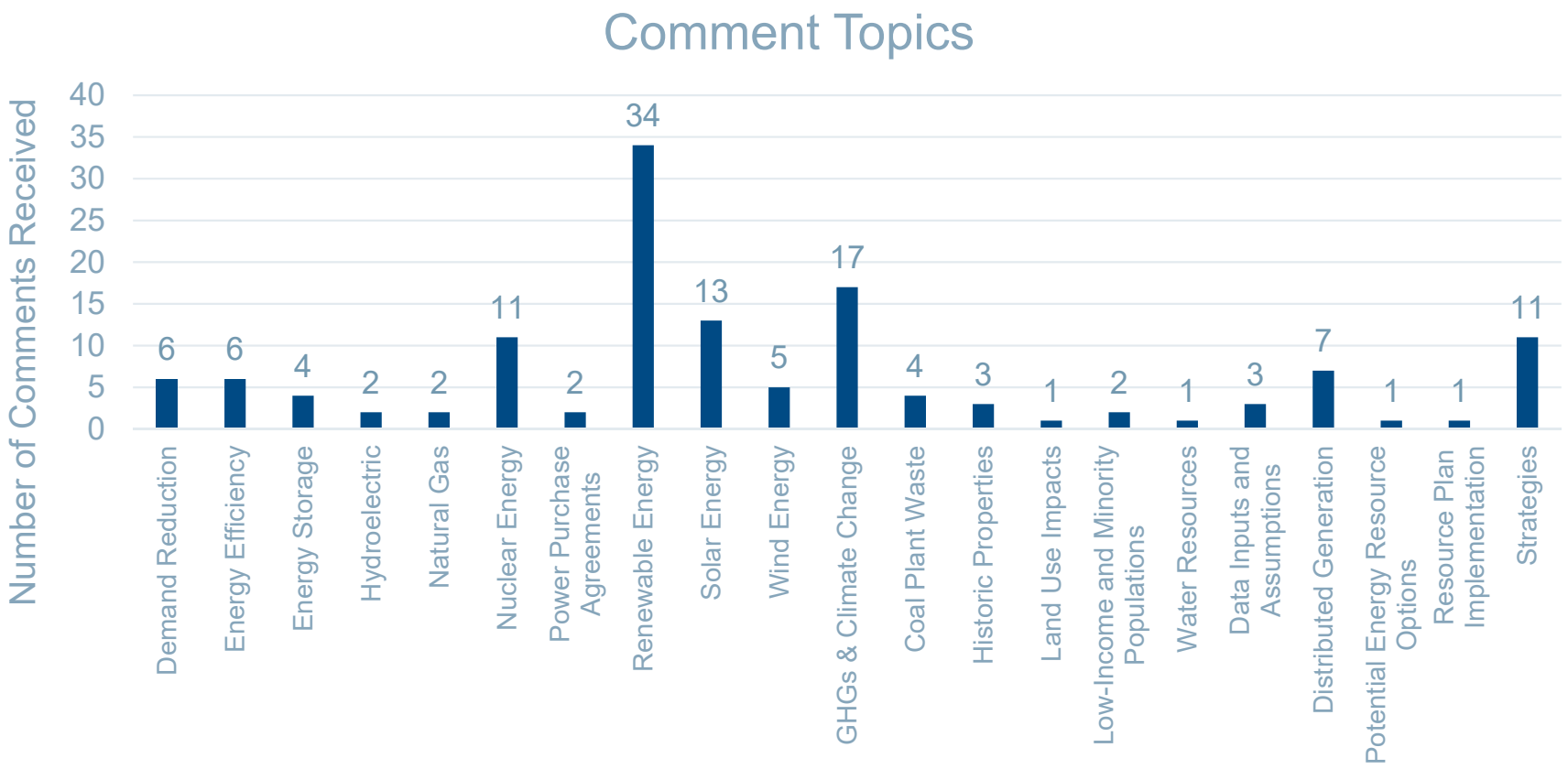
Draft IRP and EIS Comment Summary

- As of March 22, TVA has received 60 comments on the Draft IRP and EIS.
- Organizations that have responded include:
  - Kentucky State Clearinghouse
  - Mississippi Department of Archives and History Tennessee Historical Commission
  - Virginia Department of Historic Resources
  - Southern Renewable Energy Association Citizen's Climate Lobby, Knoxville Chapter
  - Conservation Fisheries, Inc.
  - Our Revolution
  - Private Attorney Generals (PAGs) Across America
  - Sunrise Movement, Knoxville
  - Universal Fibers Systems

Most Frequent Comments:

- **Increase the use of renewable energy**
- **More aggressively reduce CO_2 emissions**

Draft IRP and EIS Comment Summary



2019 IRP Public Meetings

- February 26 — Public Webinar (Almost 90 participants)
- February 27 — Knoxville (About 40 attendees)
- March 18 — Memphis (About 50 attendees)
- March 19 — Huntsville (About 50 attendees)
- March 20 — Chattanooga (About 40 attendees)
- March 21 — Nashville (More than 100 attendees)
- March 26 — Bowling Green (About xx attendees)

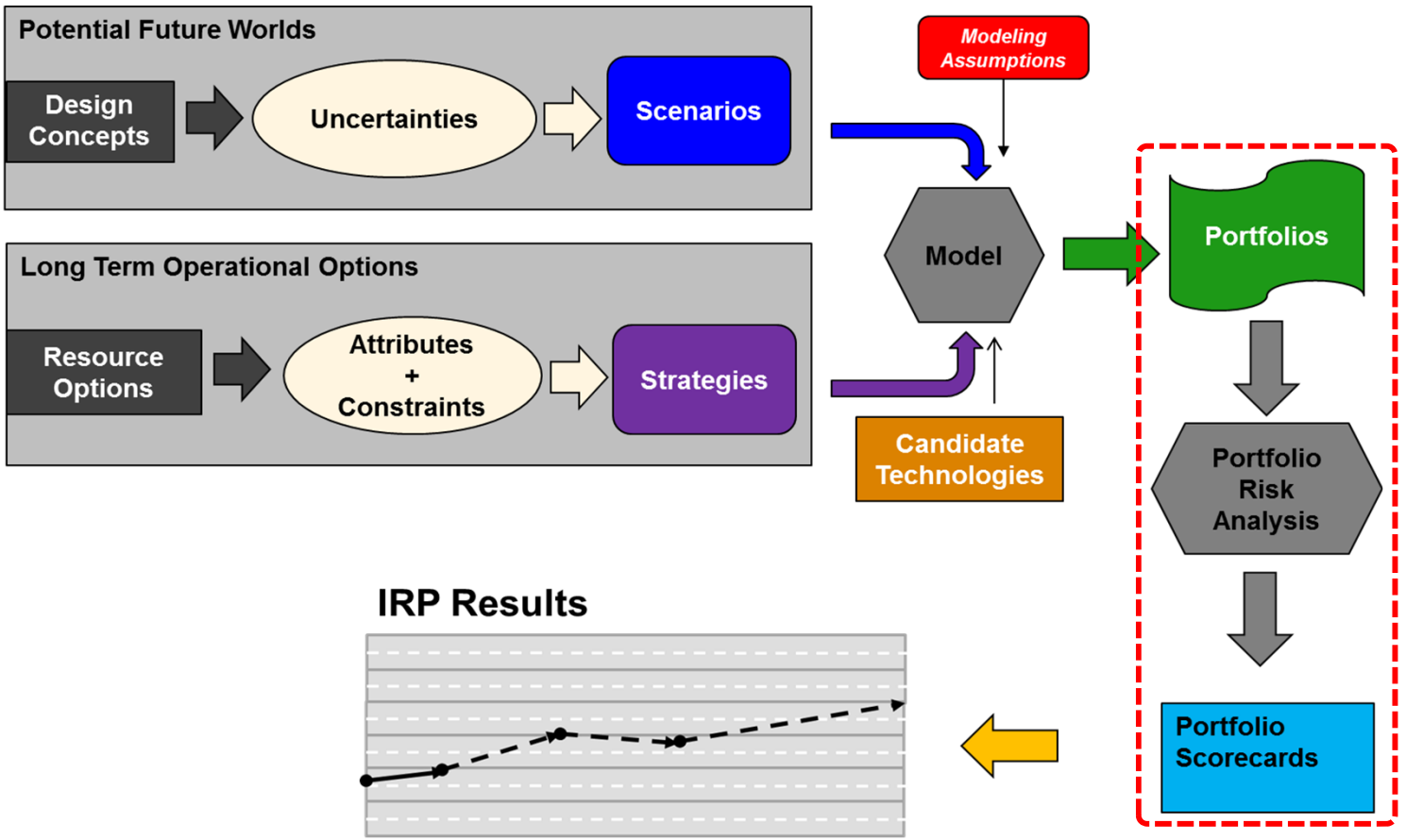
Commonly Asked Questions at the Public Meetings

- The Draft IRP shows no new solar resources added until 2023. How will TVA address renewable energy between now and then?
- Why is wind not added, since it seems to be reasonably priced?
- Is TVA eliminating Energy Efficiency programs?
- How is TVA addressing climate change in this IRP?
- What is TVA doing to ensure it will be providing the cleanest energy possible in the future?

IRP Sensitivity Analysis

Jane Elliott, Roger Pierce, Scott Jones
Resource Strategy

Sensitivity Analysis Informs Recommendation



The result of a strategy evaluated in a scenario

How uncertainty impacts the portfolio results

Standard metrics to compare portfolios

2019 IRP Scenarios and Strategies

Scenarios

1. *Current Outlook*
2. *Economic Downturn*
3. *Valley Load Growth*
4. *Decarbonization*
5. *Rapid DER Adoption*
6. *No Nuclear Extensions*

Strategies

A. *Base Case*
B. *Promote DER*
C. *Promote Resiliency*
D. *Promote Efficient Load Shape*
E. *Promote Renewables*

What is the Purpose of Sensitivity Analysis?

- Sensitivity analyses are performed to help answer questions meriting further evaluation
- Sensitivity analyses are typically run as variations from Case 1A, the Base Case strategy applied in the Current Outlook scenario, to isolate the impact of a change in one key assumption
- All sensitivities will be run off the updated Base Case reflecting recent plant retirement decisions made by the TVA Board
- Sensitivities will be considered, along with the balance of portfolio results, when developing the 2019 IRP recommendation

2019 IRP Sensitivities

Last Meeting

- ✓ Older Gas CT retirements
- ✓ Integration cost and flexibility benefit

Today

- ✓ High and low gas prices (two standard deviations)
- ✓ Solar acceleration and caps
- ✓ Breakeven analysis for storage, wind, CHP and SMR capital costs

Next Meeting

- More stringent carbon penalty (Double decarbonization scenario)
- Increasing ongoing operating costs for coal plants
- Extreme weather case (acute and chronic)
- Increased EE and DR market depth

Sensitivities Covered in the February IRPWG Meeting

Older Gas CT Retirements

Gas CT Retirement

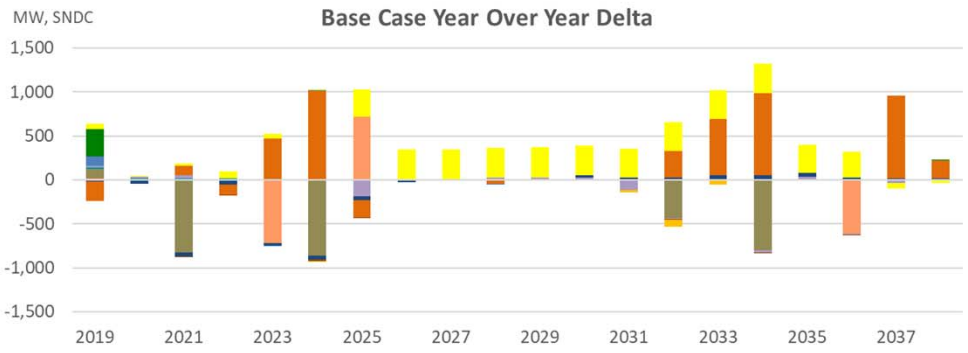
Objective: Perform a sensitivity bounding case to evaluate the potential impact of retiring older Gas CTs on IRP results.

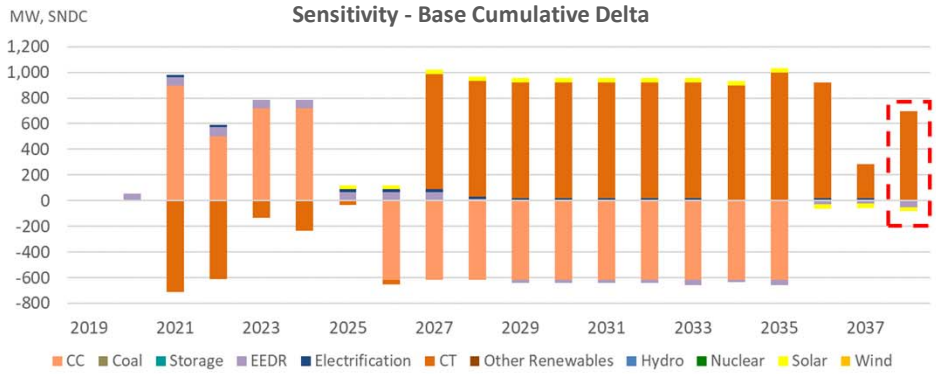
Approach: Assume all Gas CTs older than 40 years are retired at the earliest possible date (2020), then rerun models to derive impact on capacity expansion plan and metric results.

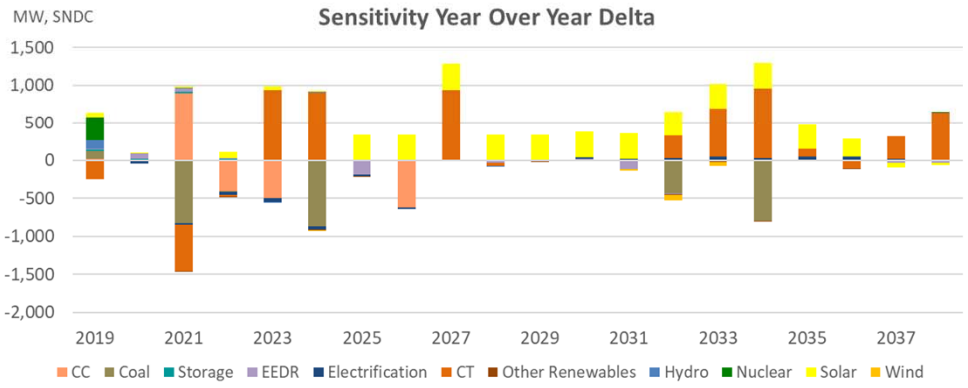
Gas CTs older than 40 years include:

- Allen CT Plant
- Colbert CT Plant
- Gallatin CT Units 1-4
- Johnsonville CT Units 1-16

Gas CT Retirement Case



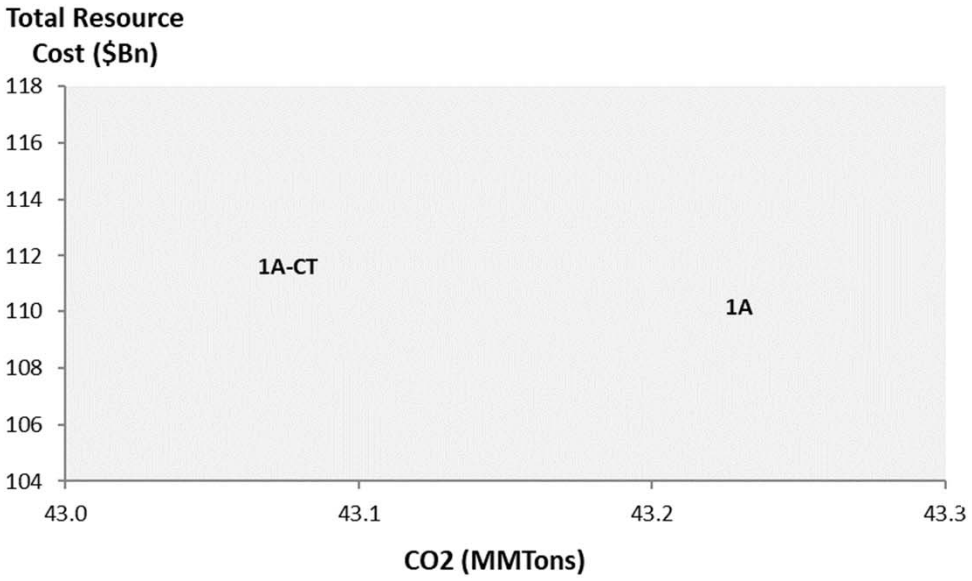


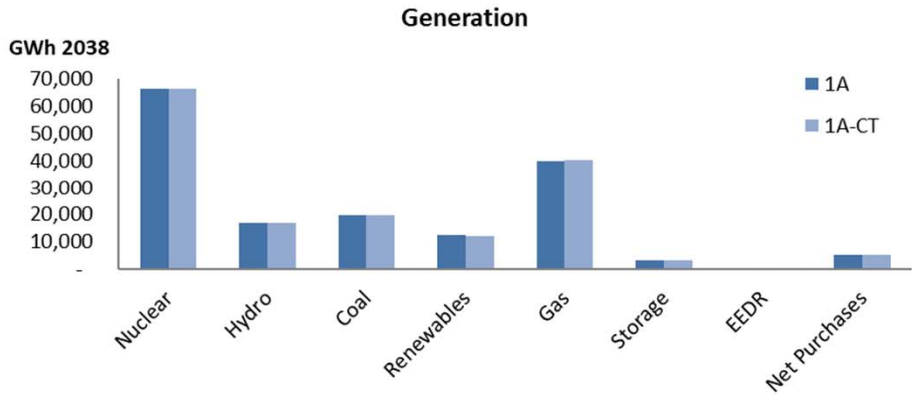


- The timing of CT capacity additions shift, and over the course of 20 years there is an increase of ~700 MW of CT capacity
- CT capacity replaces CC capacity starting in 2027 to meet peaking needs

Gas CT Retirement

Retiring older Gas CTs results in similar costs and carbon emissions, as older, higher maintenance CTs are replaced with newer, lower maintenance CTs. Generation largely remains the same.





Gas CT Retirement

Sensitivity Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income*	Percent Difference in Employment*
Gas CT Retirement Case	111	71	112	1.06	120	43	539	54,001	2,259	43,221	2.07	50%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	1.44	0.98	1.45	0.00	1.43	0	-1	-0,052	-10	-144	0.09	0%	0.00%	0.00%

**Economic analysis was not re-run for sensitivities*

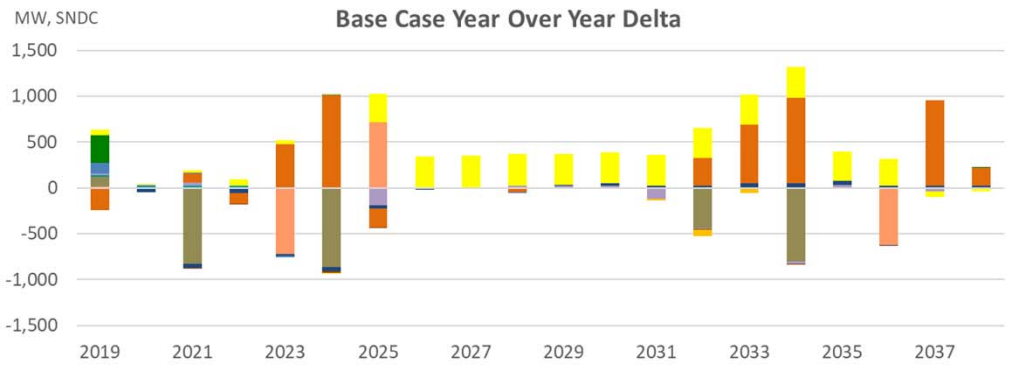
Integration Cost & Flexibility Benefit Case

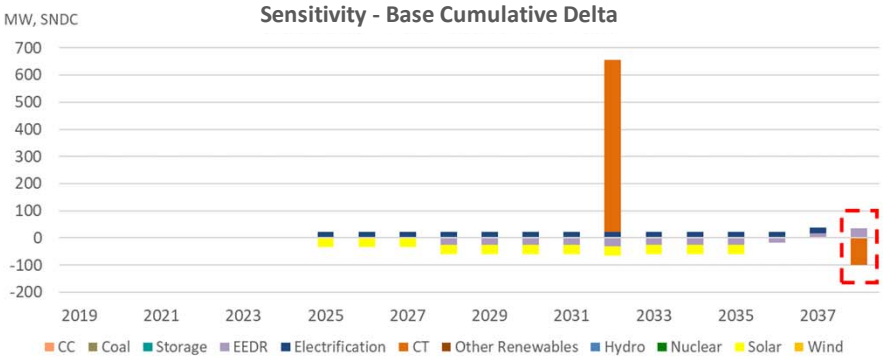
Integration Cost & Flexibility Benefit Case

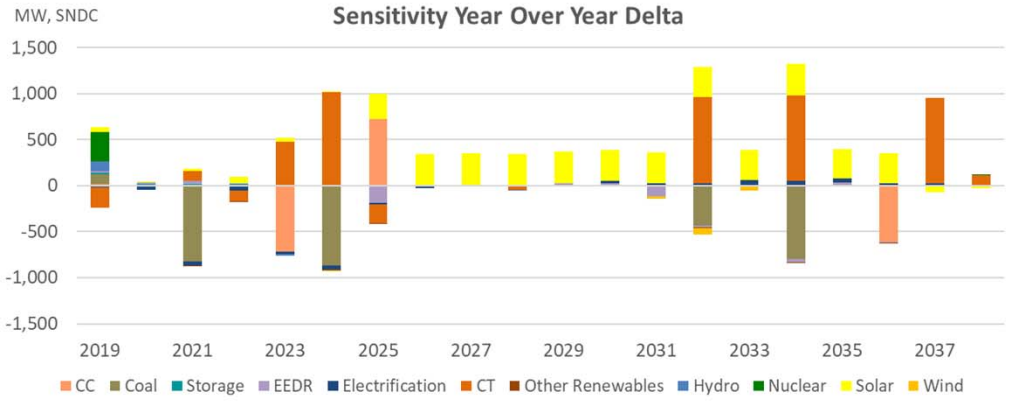
Objective: Perform a sensitivity case to evaluate the impact of removing integration costs and flexibility benefits on IRP results.

Approach: Remove solar & wind integration costs and aeroderivative CT & battery flexibility benefits, then rerun models to derive impact on capacity expansion plan and metric results.

Integration Cost & Flexibility Benefit Case



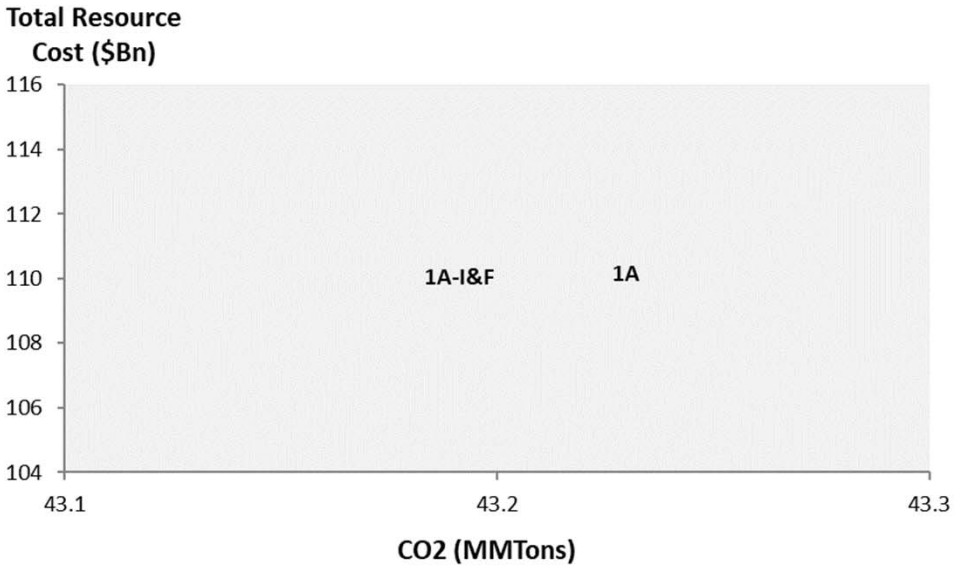


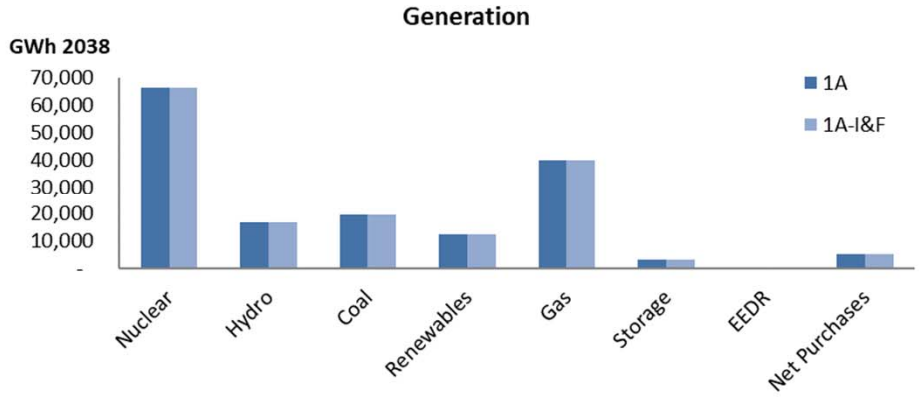


- Minimal impact on the capacity plan over time
- Removing integration costs and flexibility benefits drives timing differences in CT capacity additions but a very similar end result

Integration Cost & Flexibility Benefit Case

As removing integration costs and flexibility benefits has minor impact on capacity expansion plans, impacts on metric results overall from hourly models are also minor. However, it is important to understand integration costs and flexibility benefits in specific asset evaluations.





Integration Cost & Flexibility Benefit Case

Sensitivity Metric Results

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Integration Cost & Flexibility Benefit Case	110	70	110	1.06	119	43	541	54,037	2,267	43,365	1.97	50%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	-0.10	-0.02	-0.10	0.00	-0.11	0	0	-0,016	-2	0	-0.01	0%	0.00%	0.00%

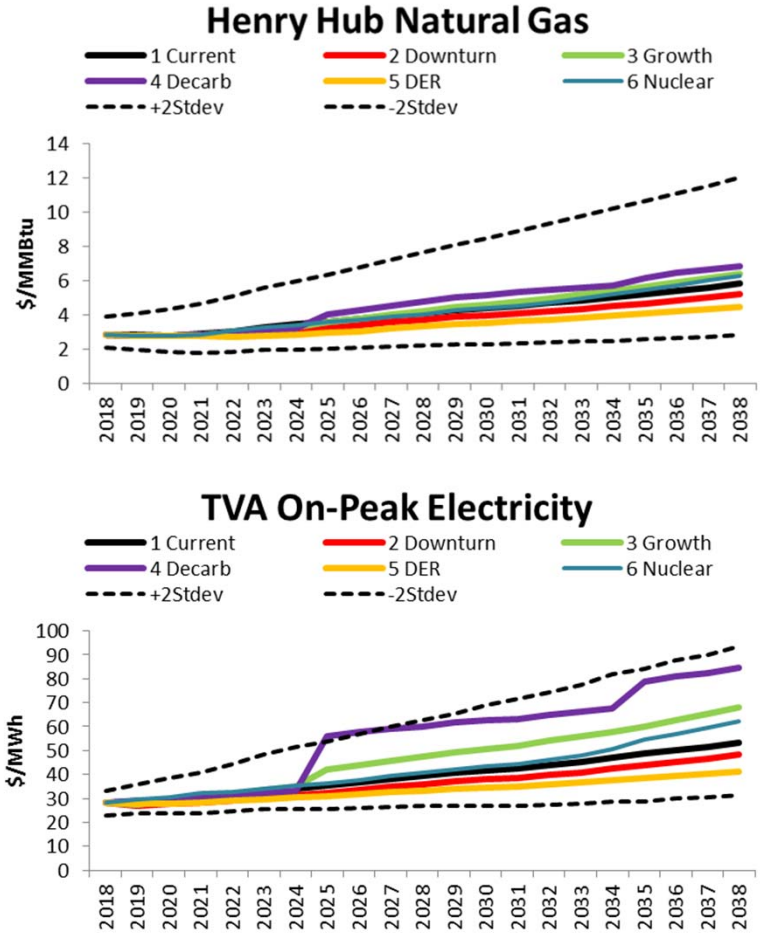
**Economic analysis was not re-run for sensitivities*

High and Low Gas Prices

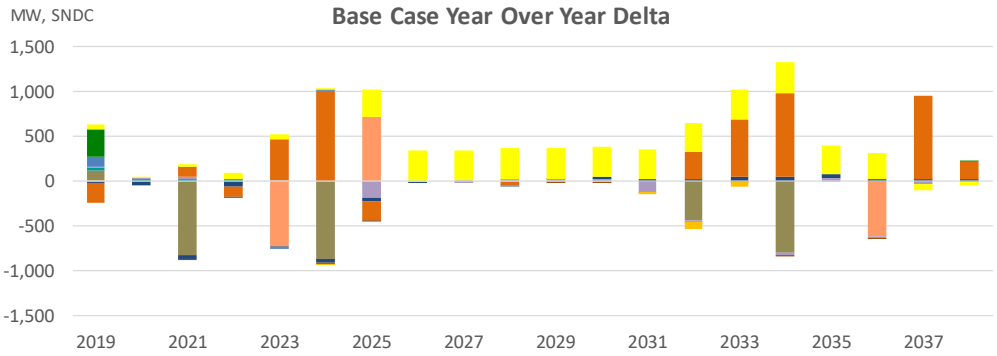
High & Low Gas Prices

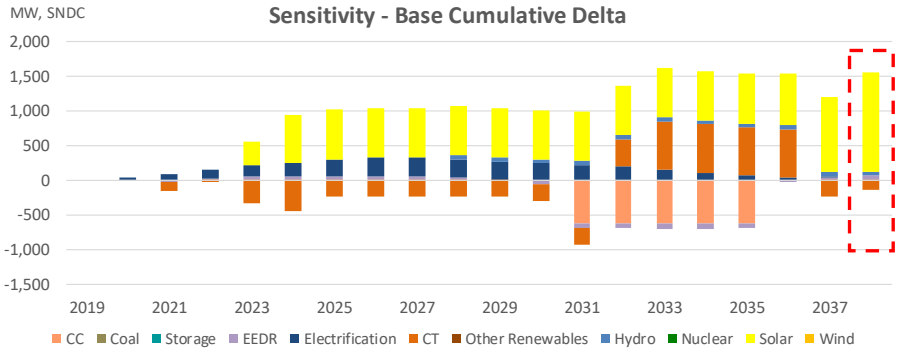
Objective: Perform a sensitivity bounding case to evaluate the potential impact of high and low gas prices.

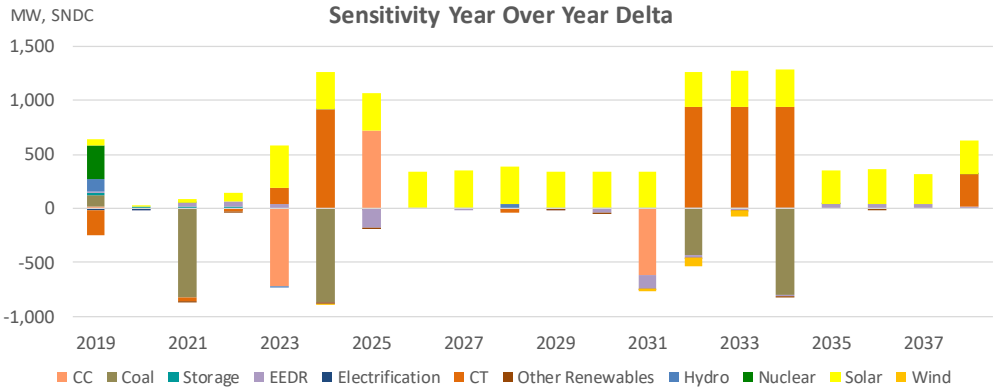
Approach: Assume additional sensitivities in which gas prices are two standard deviations below and two standard deviations above the fundamental forecast, then rerun models to derive impact on capacity expansion plan and metric results.



High Gas Prices



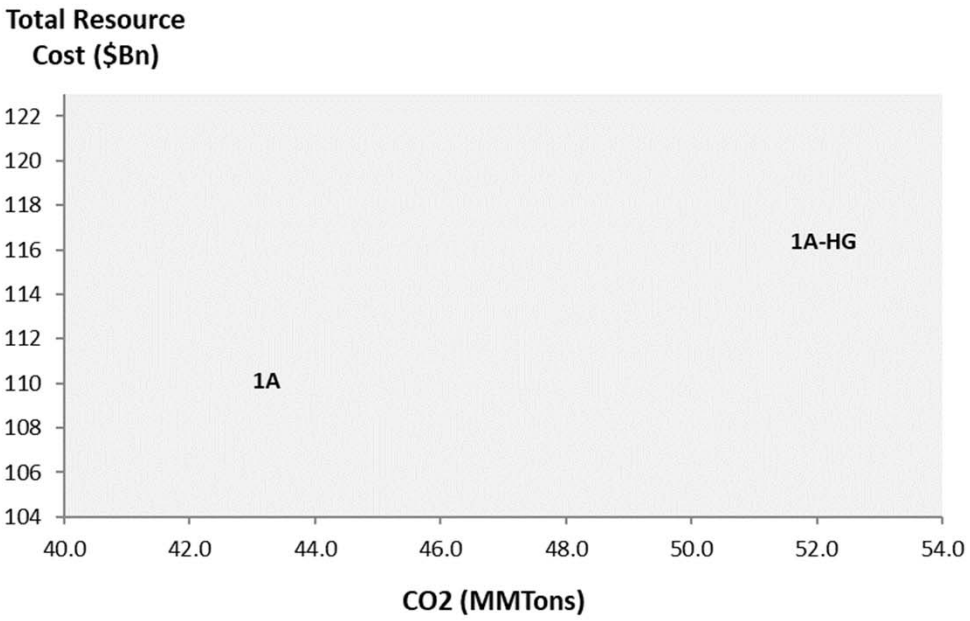


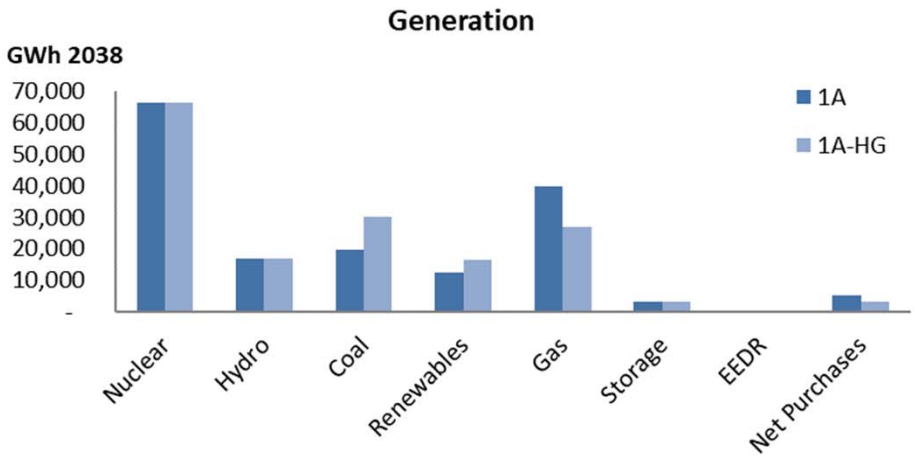


- By 2038, an additional ~1,400 MW of solar and ~55 MW of new hydro replace a small amount of CT capacity
- Electrification programs are reduced and CC capacity is swapped for CT builds earlier in the plan
- Gas is a significant component of total generation, so the avoided energy cost for alternate resources is higher in this sensitivity

High Gas Prices

High gas prices drive increased renewables capacity and coal generation along with lower gas capacity factors, resulting in higher carbon emissions overall.



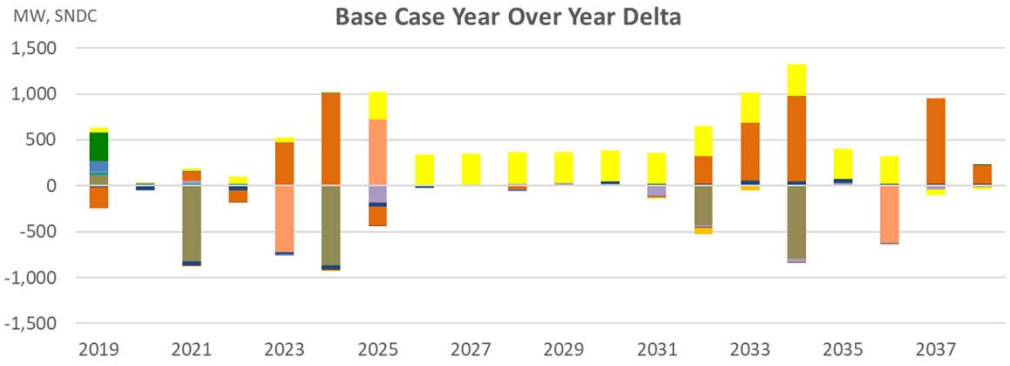


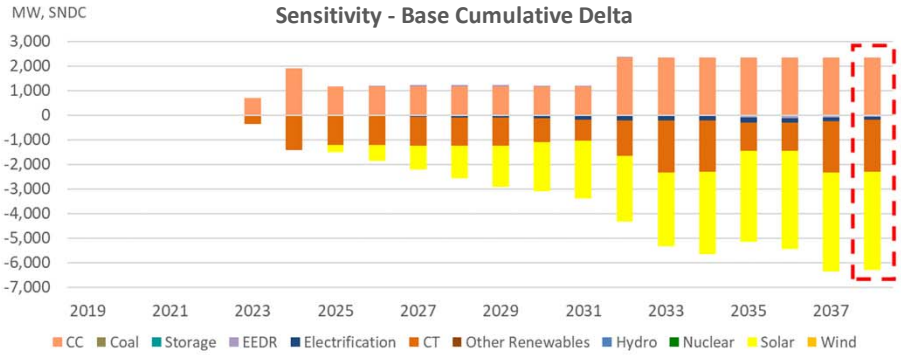
High Gas Prices

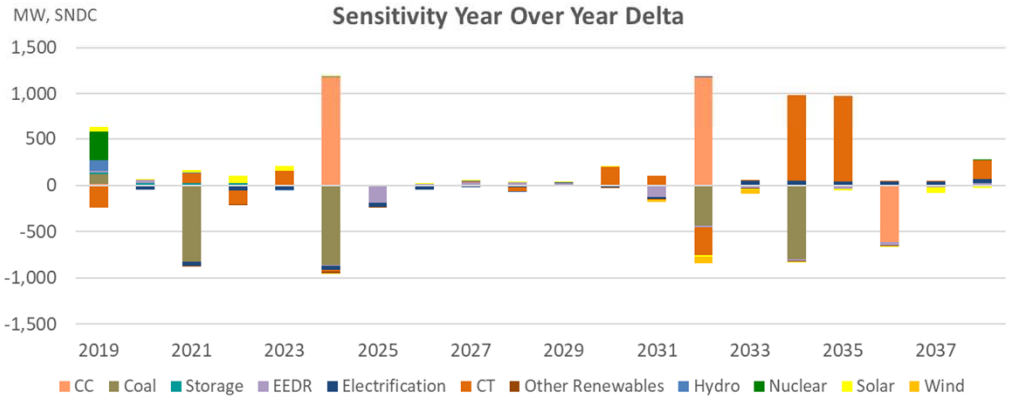
Sensitivity Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income*	Percent Difference in Employment*
High Gas Prices	116	75	116	1.10	128	52	658	56,902	3,296	58,695	1.70	53%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	6.27	4.66	6.25	0.03	8.88	9	117	2,849	1,028	15,330	-0.28	3%	0.00%	0.00%

Low Gas Prices



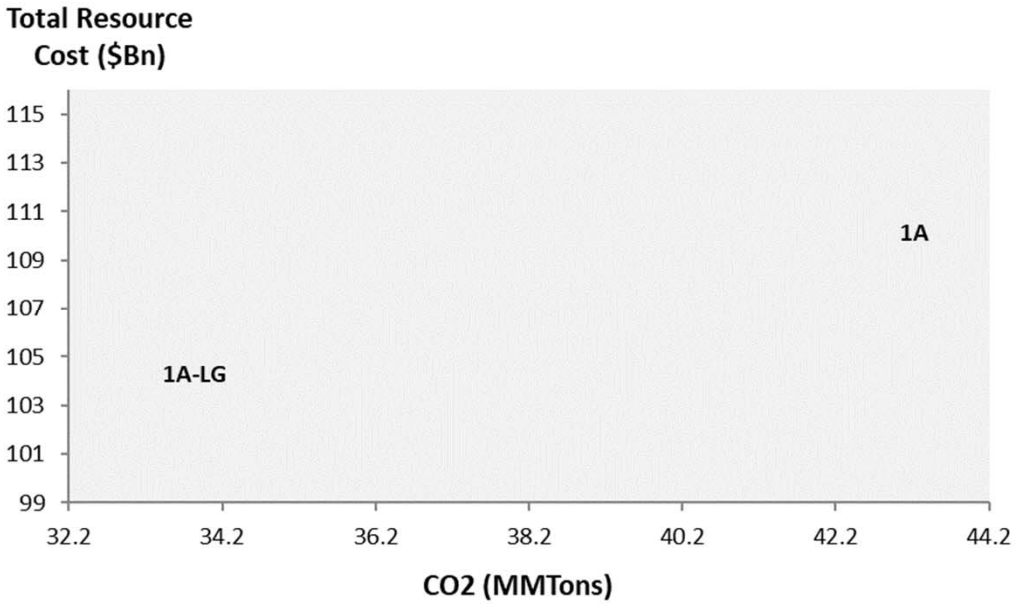


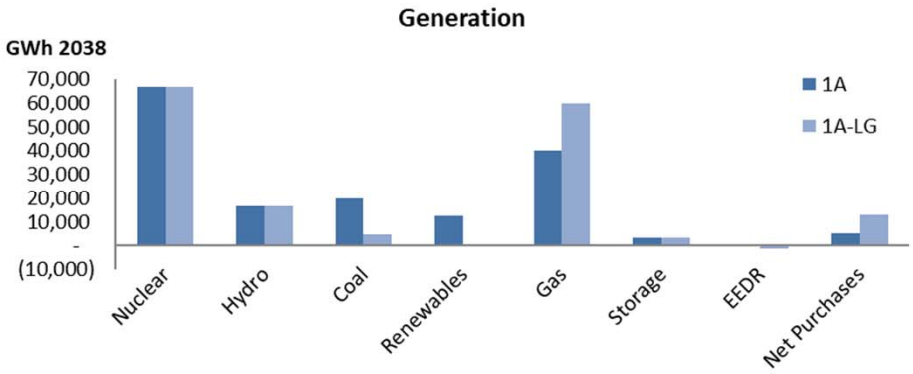


- By 2038, ~4 GW of solar and ~2 GW of CT capacity is replaced with CC capacity
- However, this sensitivity does not take into account customer demand for renewables and clean energy that would likely create a floor for renewable additions

Low Gas Prices

Low gas prices drive lower renewable capacity along with increased gas generation and lower coal capacity factors, resulting in lower carbon emissions overall.





Low Gas Prices

Sensitivity Metric Results

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Low Gas Prices	104	66	104	1.02	111	34	421	50,314	952	335	2.06	41%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	-5.87	-4.00	-5.85	-0.04	-7.72	-9	-120	-3,739	-1,316	-43,030	0.08	-9%	0.00%	0.00%

**Economic analysis was not re-run for sensitivities*

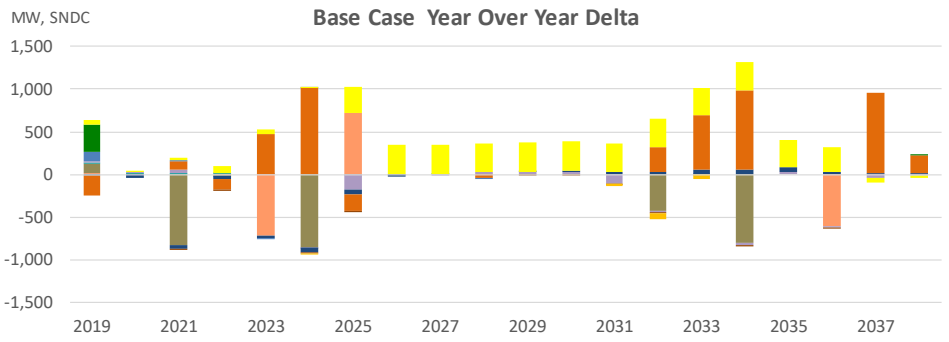
Solar Acceleration and Annual Caps

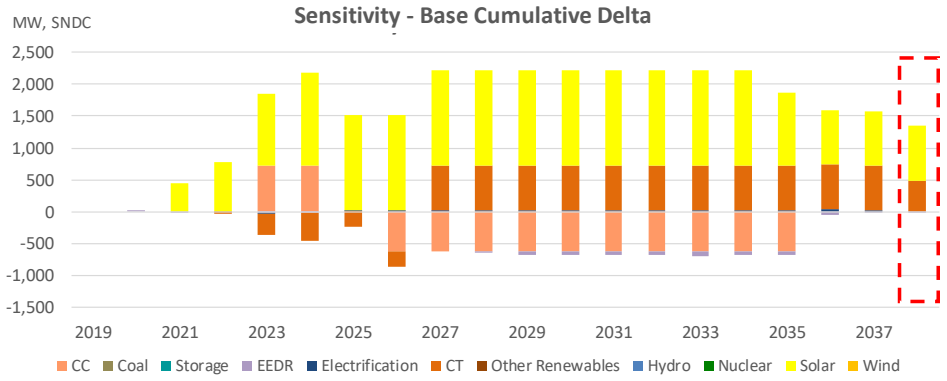
Accelerated Solar

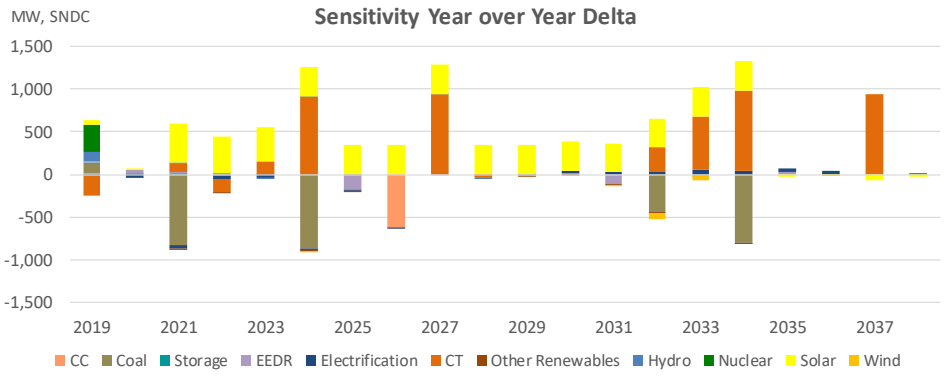
Objective: Perform a sensitivity case to evaluate the impact of accelerating solar builds to align with the potential timing of customer demand for renewables.

Approach: Reflect recent Facebook and Google solar signings of ~700 MW total scheduled to come online by 2021 and assume 500 MW per year accelerated solar additions thereafter until economic solar additions pick up in the mid-2020s, then rerun models to derive impact on capacity expansion plan and metric results

Accelerated Solar



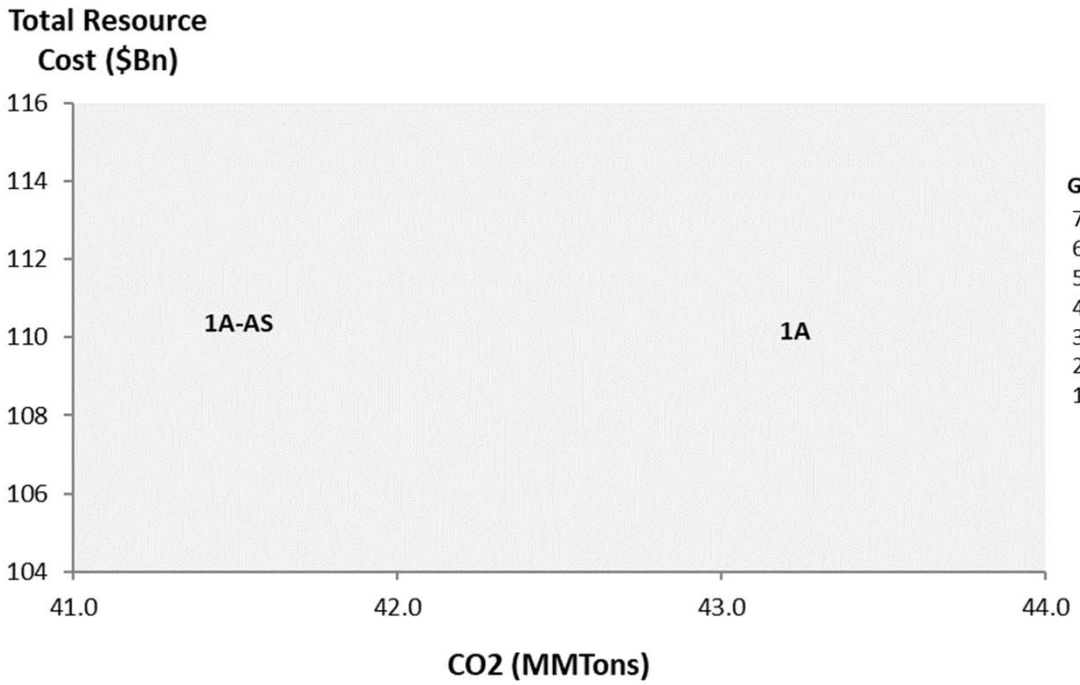


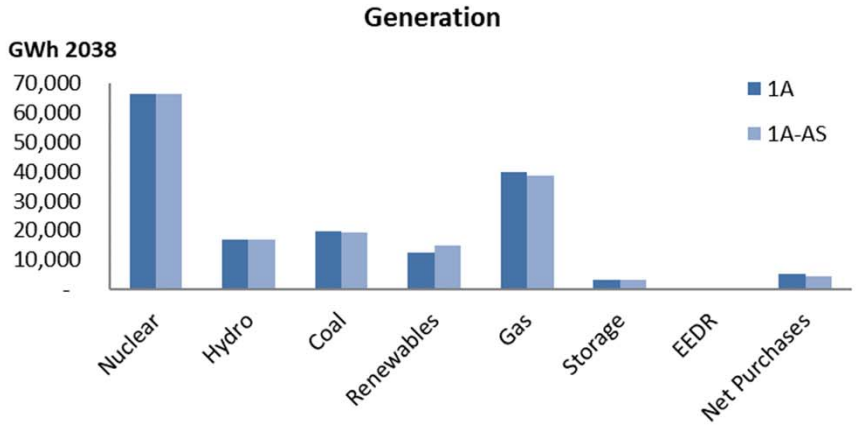


- Accelerating solar additions primarily has the effect of bringing the economic solar additions forward, resulting in an additional ~800 MW of solar by 2038 which is less than the total accelerated amounts
- Total nameplate MW of solar is below 10,000 MW in the both cases

Accelerated Solar

Given the overall impact on solar additions, renewable generation slightly displaces gas generation and leads to a reduction in carbon emissions.





Accelerated Solar

Sensitivity Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income*	Percent Difference in Employment*
Accelerated Solar	110	70	110	1.04	119	42	520	53,408	2,191	52,564	1.88	51%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	0.22	0.19	0.22	-0.03	-0.04	-2	-21	-645	-78	9,199	-0.10	2%	0.00%	0.00%

**Economic analysis was not re-run for sensitivities*

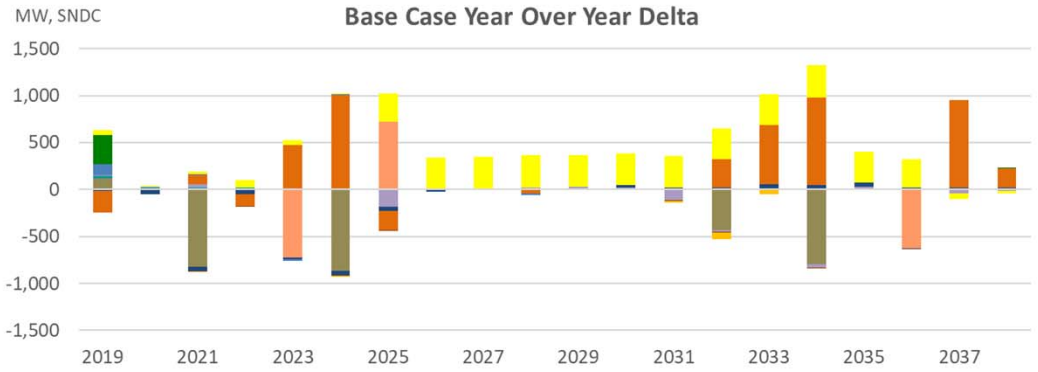
Double Annual Solar Cap

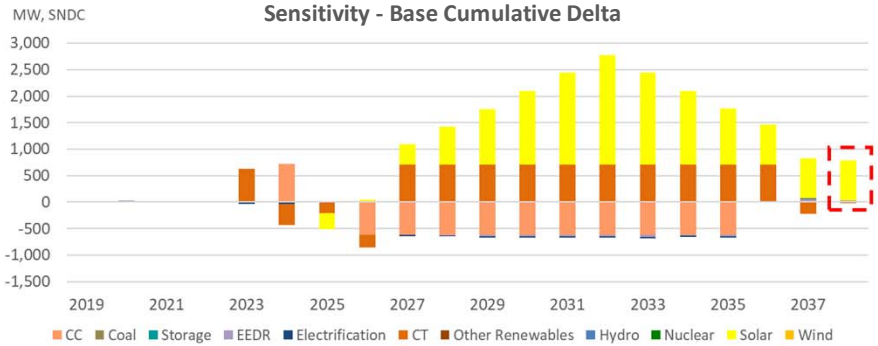
Objective: Perform a sensitivity case to evaluate the potential impact of increasing the annual cap on solar additions.

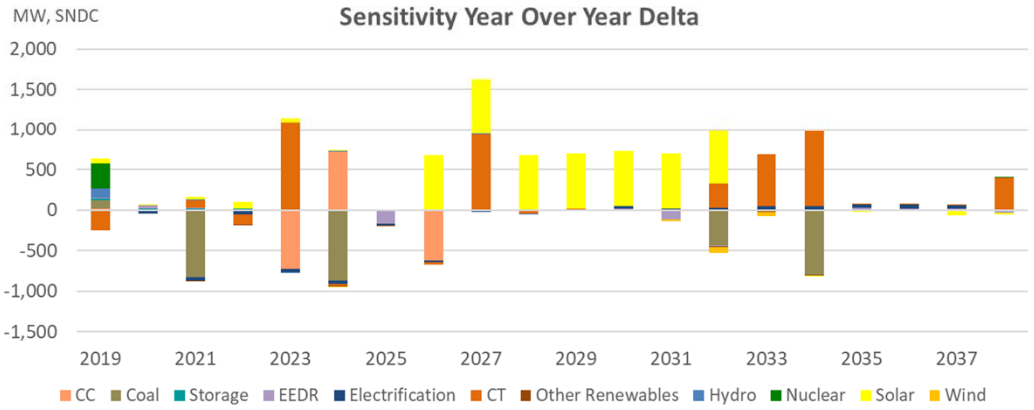
Approach: Double the annual solar cap to 1,000 MW and remove the cumulative cap on solar additions, then rerun models to derive impact on capacity expansion plan and metric results

Note: There are limitations on the timing of other resource additions, such as how many new builds can be planned for a given year, to reflect the practicality of when we have knowledge of the need and other project management considerations.

Double Annual Solar Cap



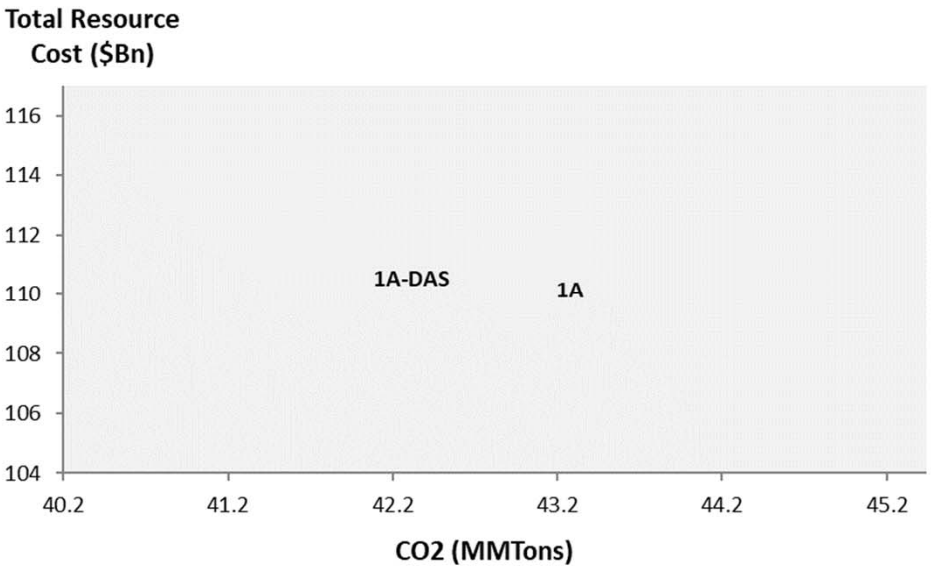


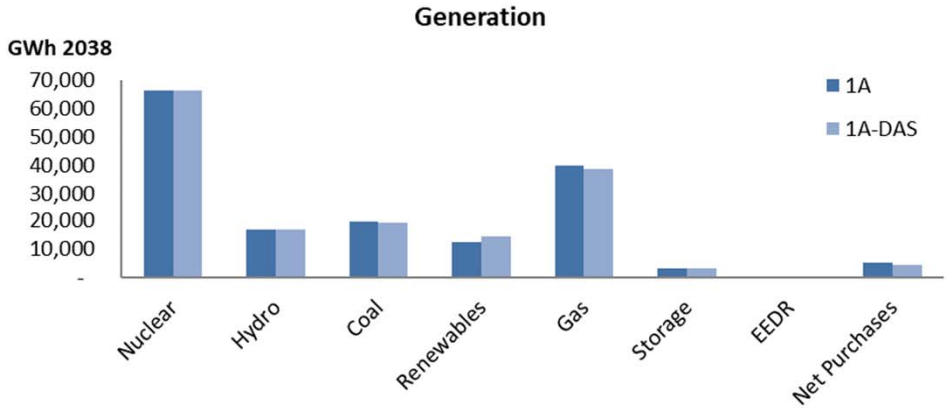


- In this case, solar capacity is accelerated due to favorable pricing in the mid to late 2020s
- By 2038, ~750 MW of additional solar capacity is added

Double Annual Solar Cap

Doubling the annual solar cap results in similar costs and lower carbon emissions, as renewable generation slightly displaces gas generation.





Double Annual Solar Cap

Sensitivity Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income*	Percent Difference in Employment*
Double Annual Solar Cap	110	70	111	1.05	119	42	528	53,703	2,228	51,395	1.83	51%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	0.37	0.20	0.38	-0.01	0.25	-1	-12	-350	-41	8,030	-0.14	1%	0.00%	0.00%

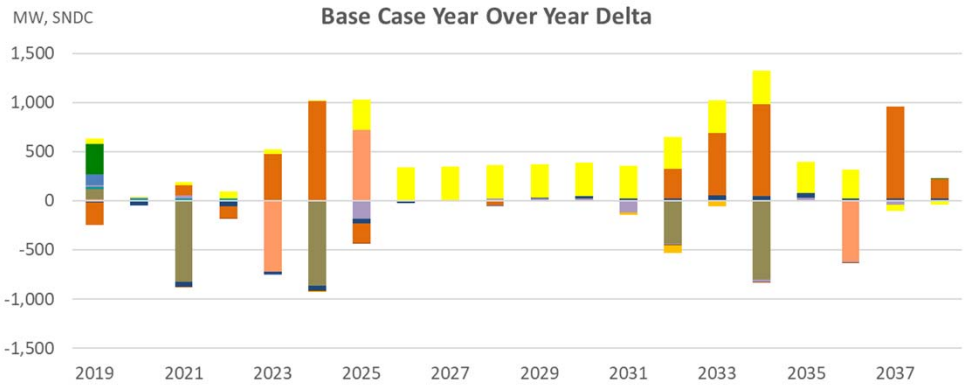
**Economic analysis was not re-run for sensitivities*

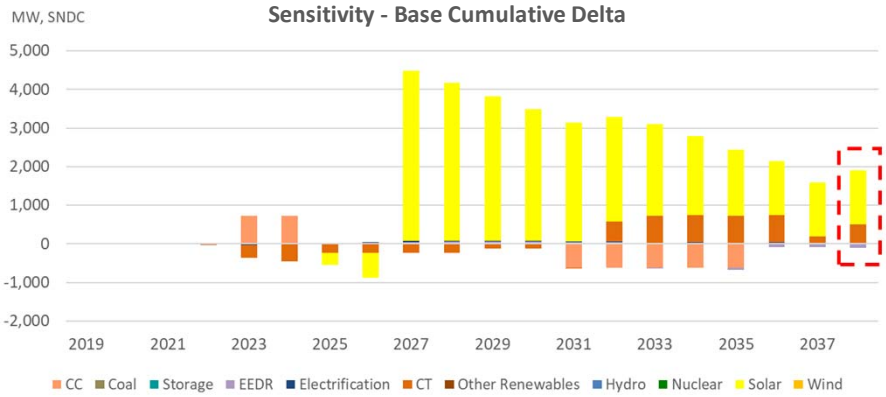
No Annual Solar Cap

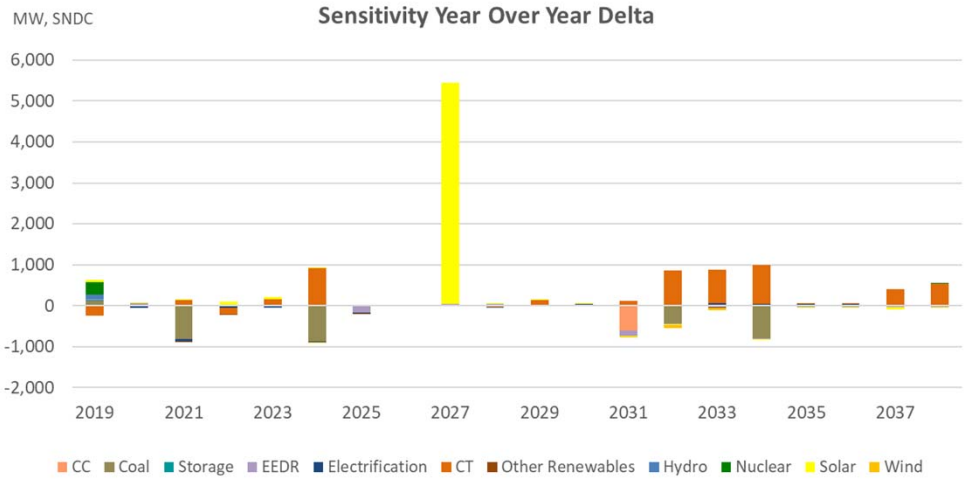
Objective: Perform a sensitivity case to evaluate the potential impact of removing annual solar limits.

Approach: Remove the annual and cumulative cap on solar additions, then rerun models to derive impact on capacity expansion plan and metric results.

No Annual Solar Cap



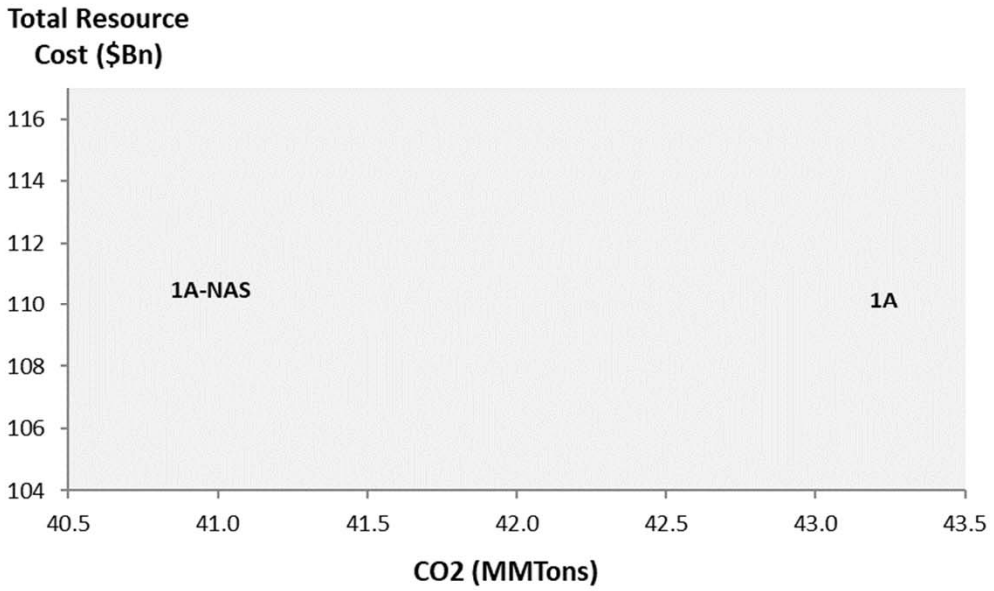


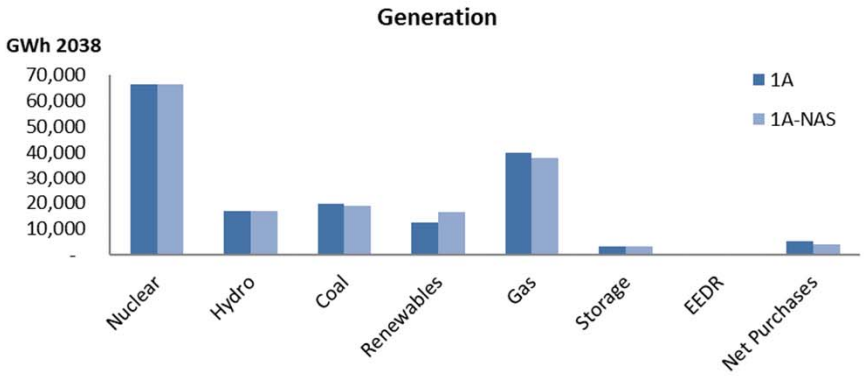


- By 2038, ~1,300 MW of additional solar capacity is added
- In practicality, it is unrealistic to have perfect foresight of the “optimal year” and to manage additions of this magnitude in a single year

No Annual Solar Cap

No annual solar cap results in additional solar capacity that further displaces some fossil generation and results in lower carbon emissions.





No Annual Solar Cap

Sensitivity Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income*	Percent Difference in Employment*
No Annual Solar Cap	110	70	111	1.03	119	41	513	53,237	2,181	245,696	1.77	52%	0.00%	0.00%
Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
Delta from Base Case	0.32	0.25	0.33	-0.03	-0.01	-2	-28	-816	-88	202,331	-0.21	3%	0.00%	0.00%

**Economic analysis was not re-run for sensitivities*

Breakeven Analysis:
Wind, Storage, CHP & SMR Capital Costs

Breakeven Analysis

Objective: Perform a breakeven analysis for resources that were promoted but not selected based on economics. These resources include:

- Wind
- Battery Storage
- Combined Heat & Power
- Small Modular Reactors

Approach: Force each resource into the expansion plan at zero cost in the first year available to determine PVRR impacts from displaced energy and capacity, then derive the levelized breakeven cost or value of that resource.

Breakeven Analysis

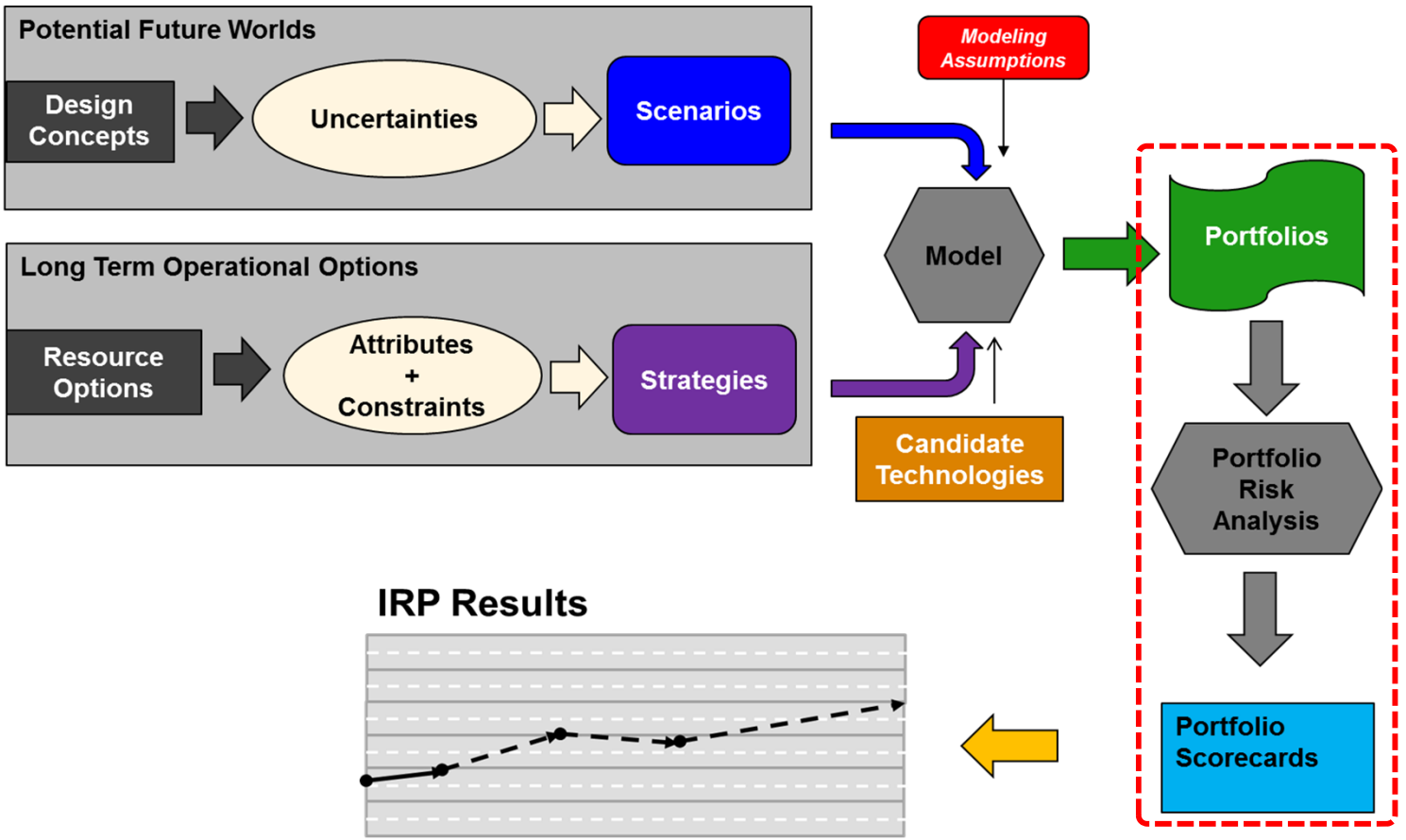
Resource	COD Year	Length	MW/y	Levelized Breakeven	IRP Assumption
Wind	2023	20	200	$27/MWh	$80/MWh
Utility Battery	2023	20	200	$122/kW-y	$299/kW-y
CHP	2023	20	200	$43/MWh	$80/MWh
SMR	2028	40	600	$46/MWh	$111/MWh

- Wind costs for the IRP reflect an expectation that the PTC will end, there is not a decreasing technology curve as with solar and battery storage, and the cost of wheeling from neighboring regions over existing transmission
- Resource breakeven given in $/MWh beginning in that COD year except in the case of battery where lower capacity factors would distort $/MWh
- SMR breakeven only considered through the last year of the simulation, and if additional years were considered the breakeven would be higher

IRP Sensitivity Analysis

Jane Elliott, Roger Pierce, Scott Jones
Resource Strategy

Sensitivity Analysis Informs Recommendation



The result of a strategy evaluated in a scenario

How uncertainty impacts the portfolio results

Standard metrics to compare portfolios

2019 IRP Scenarios and Strategies

Scenarios

1. *Current Outlook*
2. *Economic Downturn*
3. *Valley Load Growth*
4. *Decarbonization*
5. *Rapid DER Adoption*
6. *No Nuclear Extensions*

Strategies

A. *Base Case*
B. *Promote DER*
C. *Promote Resiliency*
D. *Promote Efficient Load Shape*
E. *Promote Renewables*

What is the Purpose of Sensitivity Analysis?

- Sensitivity analyses are performed to help answer questions meriting further evaluation
- Sensitivity analyses are typically run as variations from Case 1A, the Base Case strategy applied in the Current Outlook scenario, to isolate the impact of a change in one key assumption
- All sensitivities will be run off the updated Base Case reflecting recent plant retirement decisions made by the TVA Board
- Sensitivities will be considered, along with the balance of portfolio results, when developing the 2019 IRP recommendation

2019 IRP Sensitivities

Last Meeting

- ✓ Older Gas CT retirements
- ✓ Integration cost and flexibility benefit

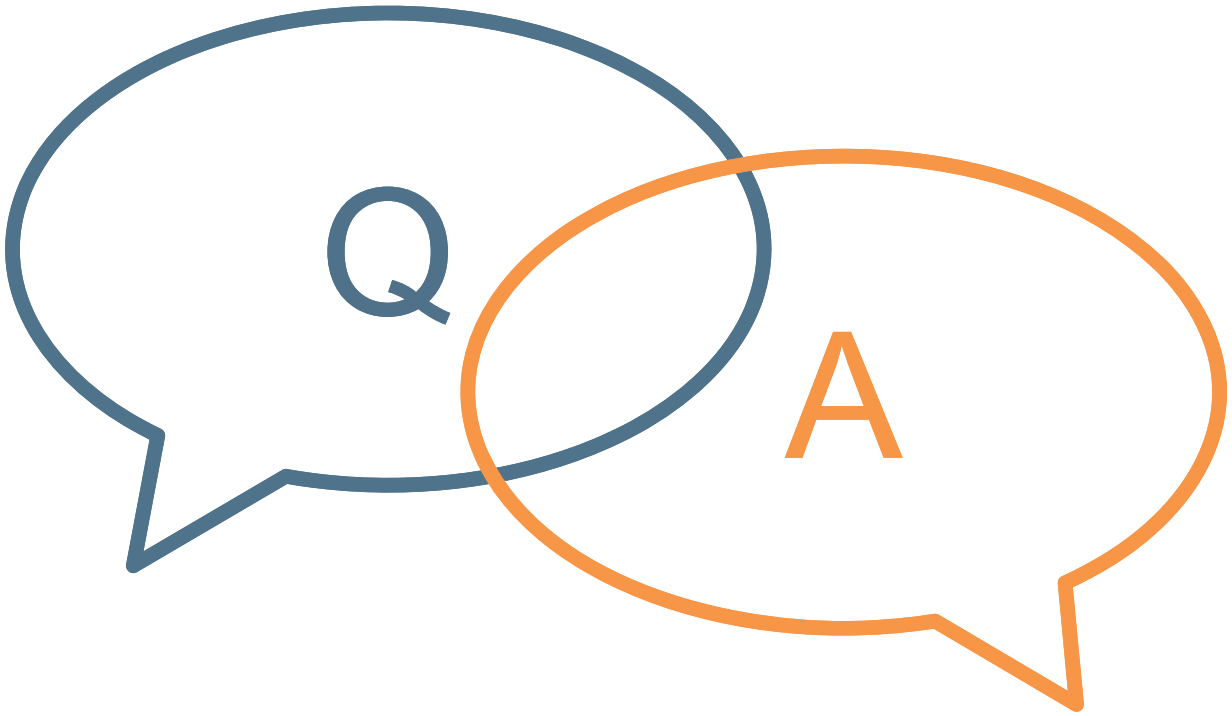
Today

- ✓ High and low gas prices (two standard deviations)
- ✓ Solar acceleration and caps
- ✓ Breakeven analysis for storage, wind, CHP and SMR capital costs

Next Meeting

- More stringent carbon penalty (Double decarbonization scenario)
- Increasing ongoing operating costs for coal plants
- Extreme weather case (acute and chronic)
- Increased EE and DR market depth

Questions about Sensitivity Results?



Group Breakout

2019 IRP Sensitivities

Last Meeting

- ✓ Older Gas CT retirements
- ✓ Integration cost and flexibility benefit

Today

- ✓ High and low gas prices (two standard deviations)
- ✓ Solar acceleration and annual caps
- ✓ Breakeven analysis for storage, wind, CHP and SMR capital costs

Next Meeting

- More stringent carbon penalty (Double decarbonization scenario)
- Increasing ongoing operating costs for coal plants
- Extreme weather case (acute and chronic)
- Increased EE and DR market depth

Breakout Questions

1. What are your observations / insights on the sensitivity results?

2. What should TVA consider when running the additional planned sensitivities?

Wrap Up Day 1

2019 IRP Working Group

Meeting 12: March 27– 28, 2019


welcome

Agenda – March 28

RED text indicates confidential

7:15	***Breakfast – at hotel for guests - use voucher.*** ***Coffee / light refreshments in meeting room***	
8:30	**Welcome and Recap Day 1**	**Jo Anne / Brian**
9:00	**Recap Sensitivities**	**Jane Elliott**
9:30	**IRPWG Activity: Developing your recommendation**	**Jo Anne and Group**
10:00	**TVA Approach for Developing a Recommendation**	**Hunter Hydas**
10:30	**Group Break Out - Input on Developing a Recommendation**	**Jo Anne and group**
11:30	**Recap Meeting** **Review next steps and adjourn.**	
12:00	**Lunch**	**Meeting Room 5**

Recap: Sensitivities

Jane Elliott, Roger Pierce, Scott Jones
Resource Strategy

Individual Activity: Developing Your Recommendation

Jane Elliott, Roger Pierce, Scott Jones
Resource Strategy

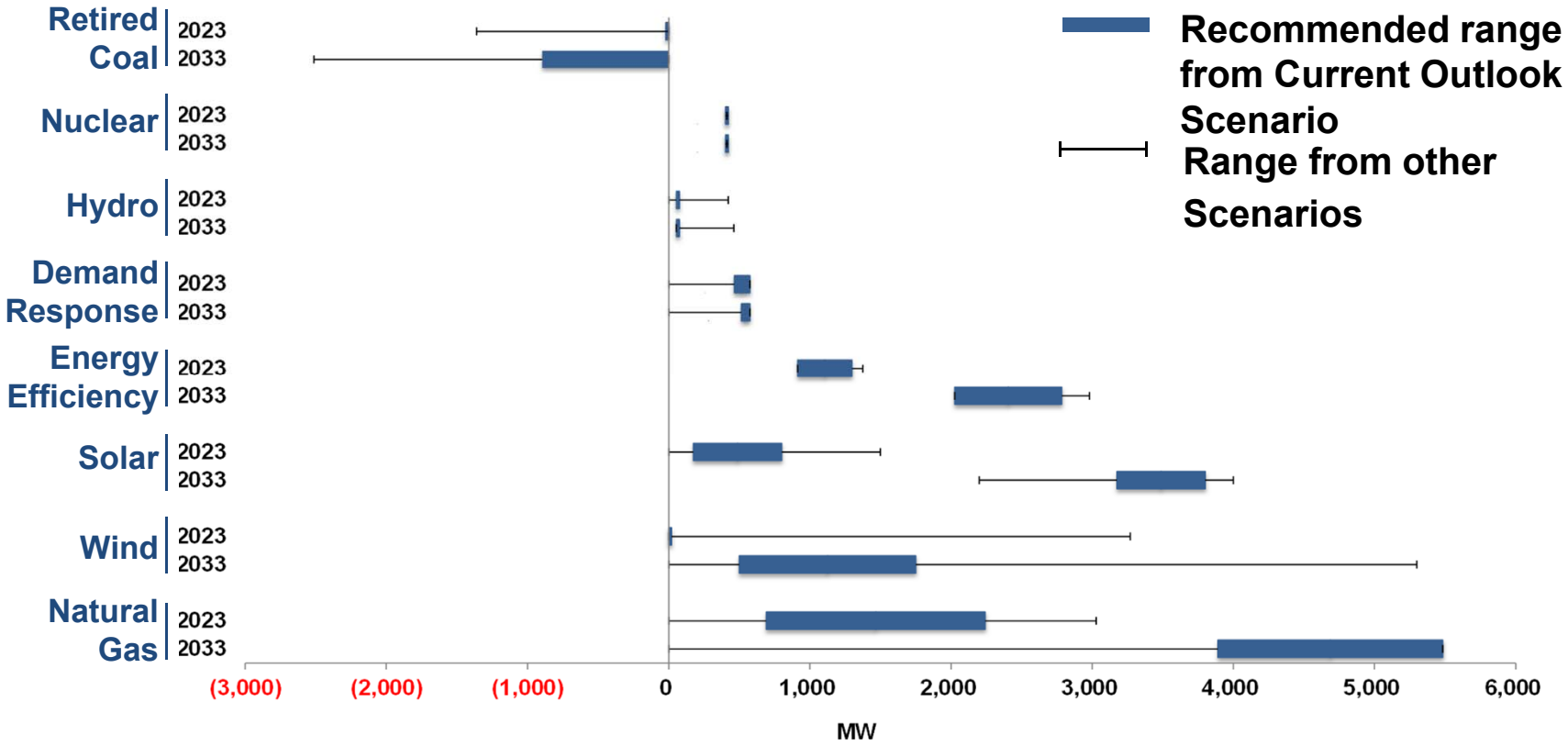
Developing Your Recommendation

- Individually, spend about 30 minutes reviewing the materials and determine:
  - What strategy or combination of strategies you think are the best for TVA.
  - Also determine the range of portfolio additions and retirements you think are the best mix for the future of the Valley.
- What considerations and metrics were most important to you in your determination?

Developing the Recommendation

Hunter Hydas

2015 IRP Recommendation



MWs are incremental additions from 2014 forward. Board-approved coal retirements and natural gas additions as of August 2015 are excluded.

Considerations for Developing Recommendation

- Draft IRP portfolio results and scorecards
- Tradeoff considerations
- Public comments
- Sensitivity results

Group Breakout

Group Discussion and Report Out

Recap Meeting 12

Next Steps

Next Steps

- Receive public comments through April 8 and consider additional sensitivities
- Continue work to run prioritized sensitivities and review at upcoming meetings
- Develop recommendation in May IRPWG meeting

Tentative Meeting Dates / Locations

Future Sessions:

- #11: Feb 28 – March 1, 2019 Knoxville, TN
- #12: March 27-28, 2019 Bowling Green, KY
- #13: May 13 - 14, 2019 Middle TN
- #14: June 25, 2019 Chattanooga, TN

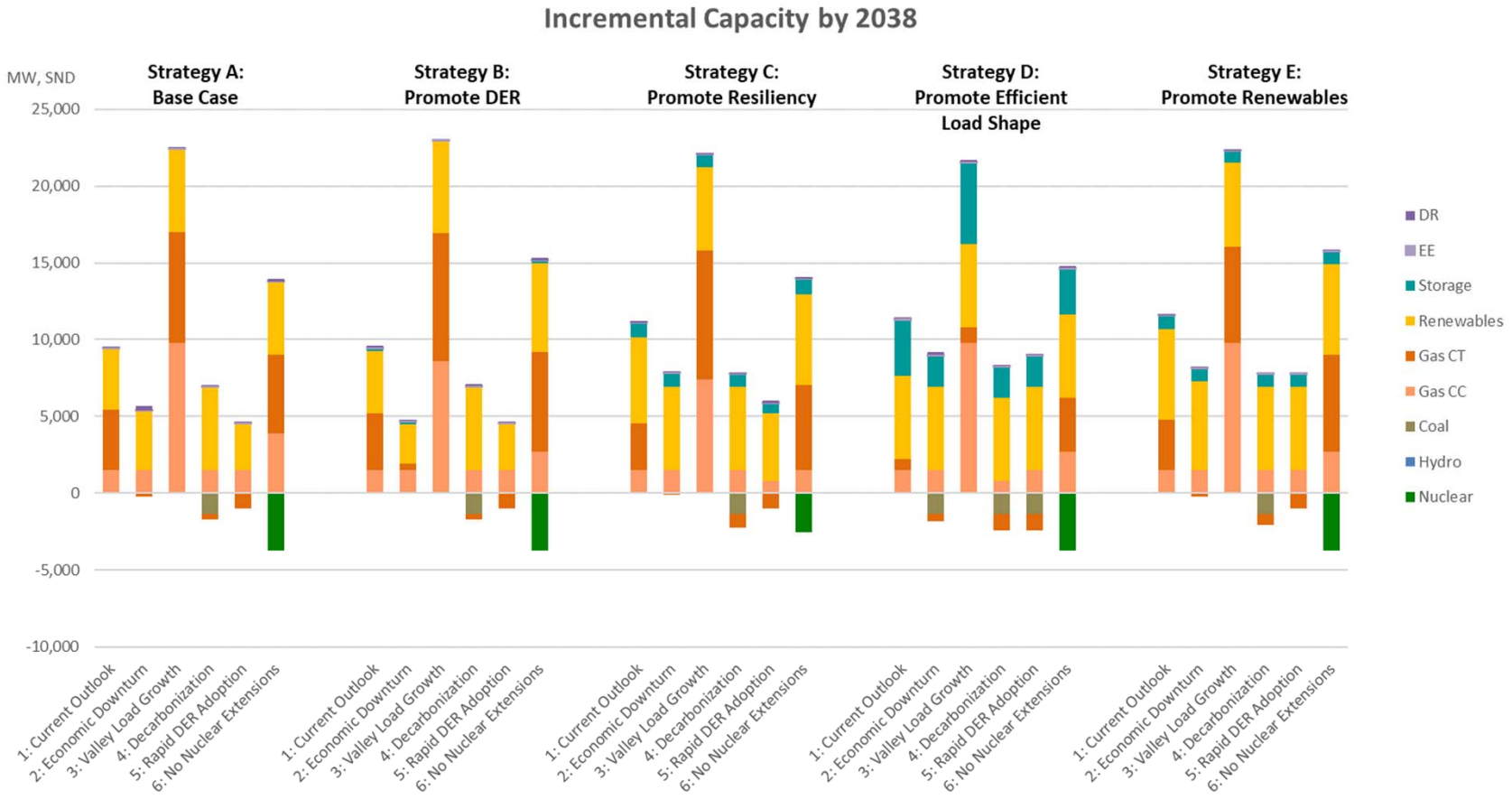
Completed Sessions:

- #4 June 6 and 7, 2018
  Nashville, TN Music City Sheraton
- #5 July 23-24, 2018
  Middle Tennessee
- #6 August 29 – 30, 2018
  Memphis, TN / Memphis Chamber of Commerce
- #7 September 26-27, 2018
  Franklin, TN, Marriott
- #8 October 25, 2018
  Huntsville, Alabama
- #9 December 19-20, 2018
  Knoxville, Tennessee
- #10 Jan 30-31, 2018
  Oxford, Mississippi

Thank you and Safe Travels!!

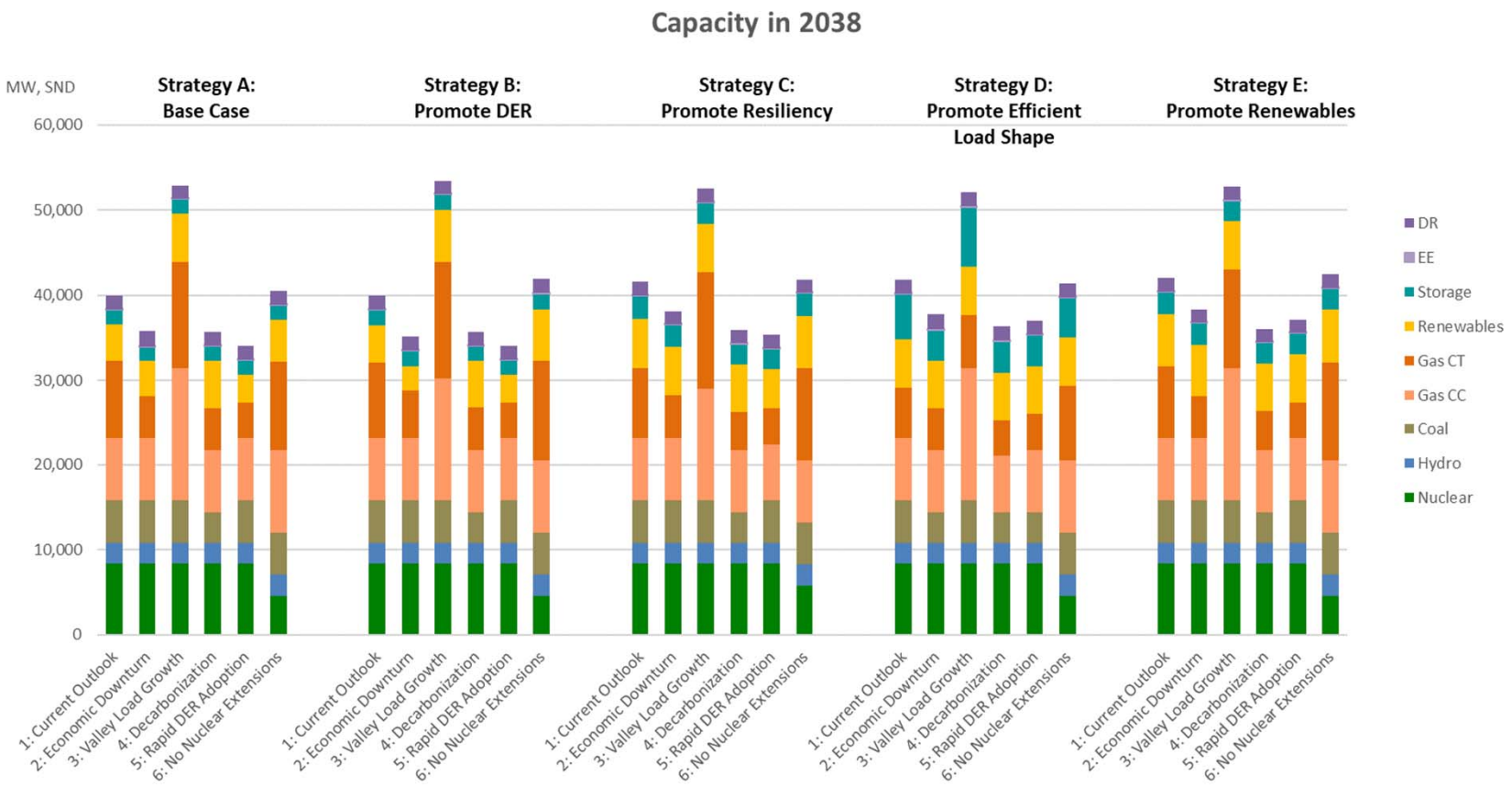
Appendix:
Base Case Portfolio Results

Incremental Capacity by 2038



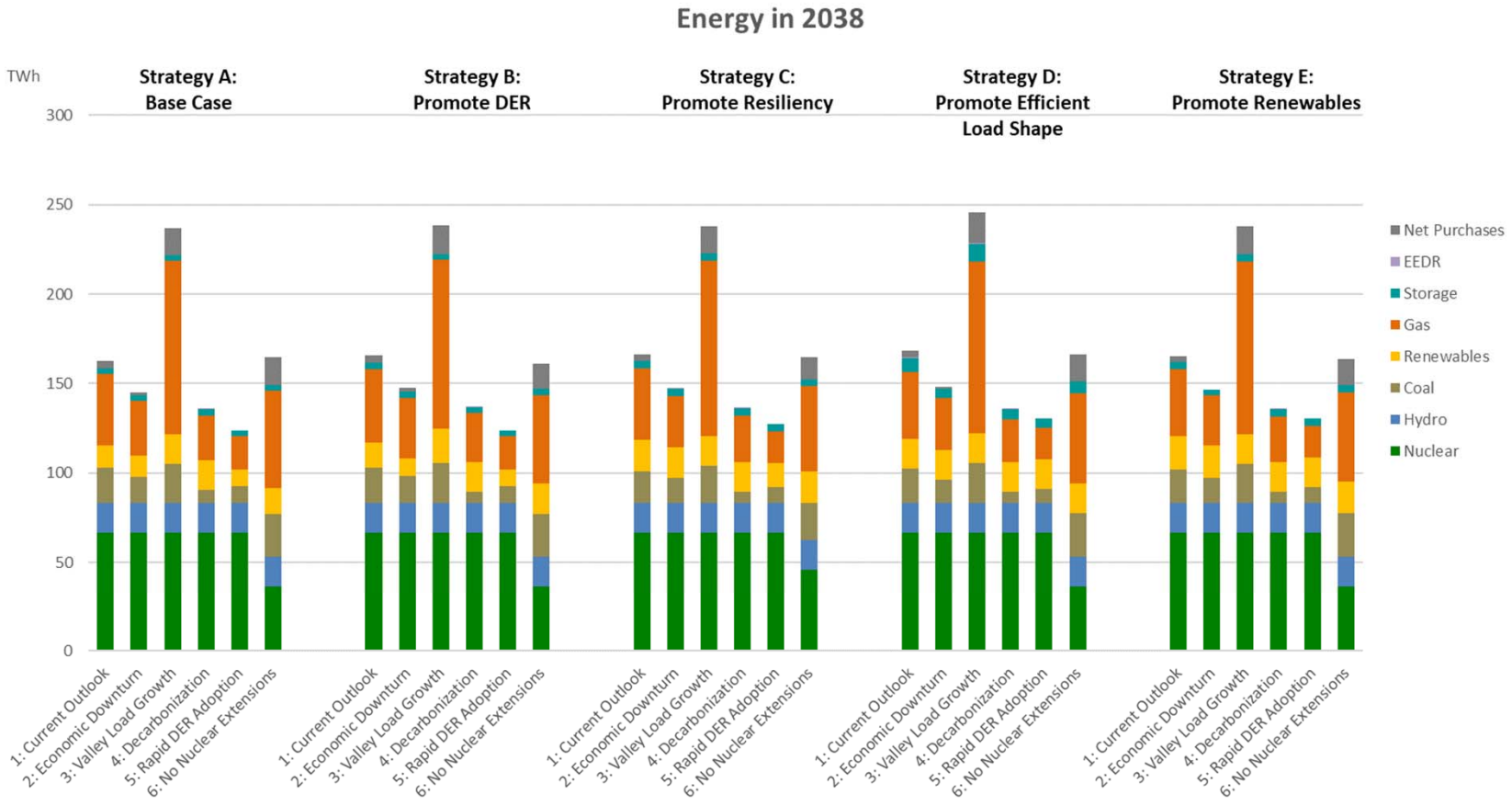
Results updated based on 2/14/2019 TVA Board decision to retire Bull Run and Paradise 3 fossil plants.

Capacity in 2038



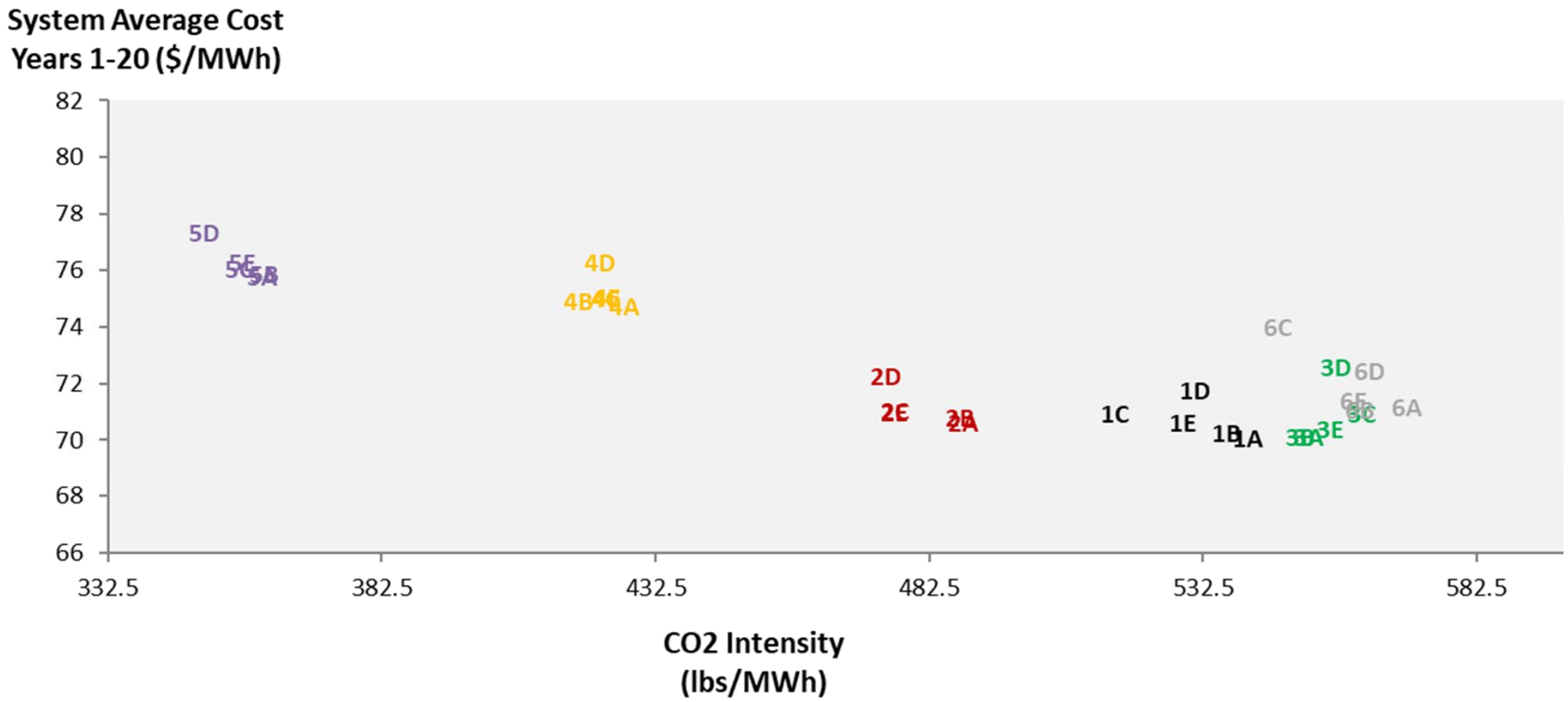
Results updated based on 2/14/2019 TVA Board decision to retire Bull Run and Paradise 3 fossil plants.

Energy in 2038



Results updated based on 2/14/2019 TVA Board decision to retire Bull Run and Paradise 3 fossil plants.

Portfolio Cost and CO2 Tradeoff



Results updated based on 2/14/2019 TVA Board decision to retire Bull Run and Paradise 3 fossil plants.

Appendix:
Draft vs. Updated Base Case

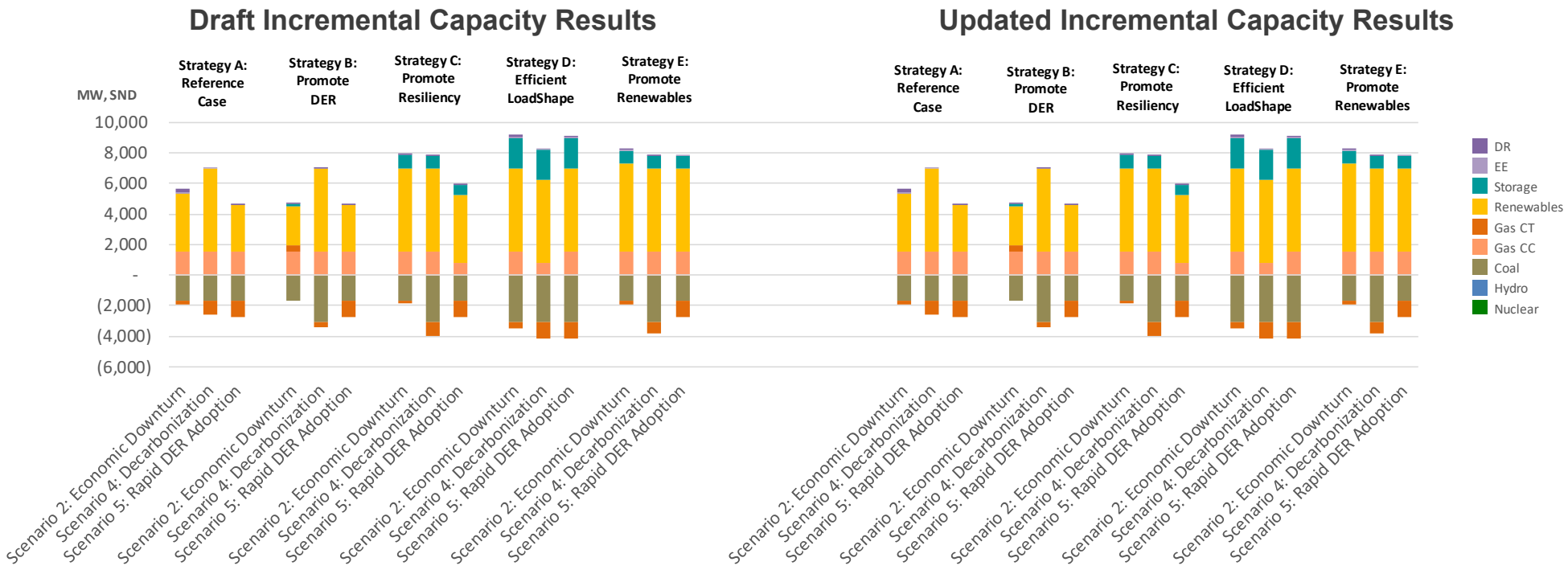
Updated Base Case

Objective: Reflect the impact of TVA Board decision to retire Paradise 3 (PAF3) and Bull Run (BRF) fossil plants on IRP results.

Approach: Include PAF3 (2020) and BRF (2023) retirements as reductions in baseline firm supply, along with aligned cost estimates, in the full set of portfolio and scorecard results.

Updated Base Case: Lower Loads (Scenarios 2,4,5)

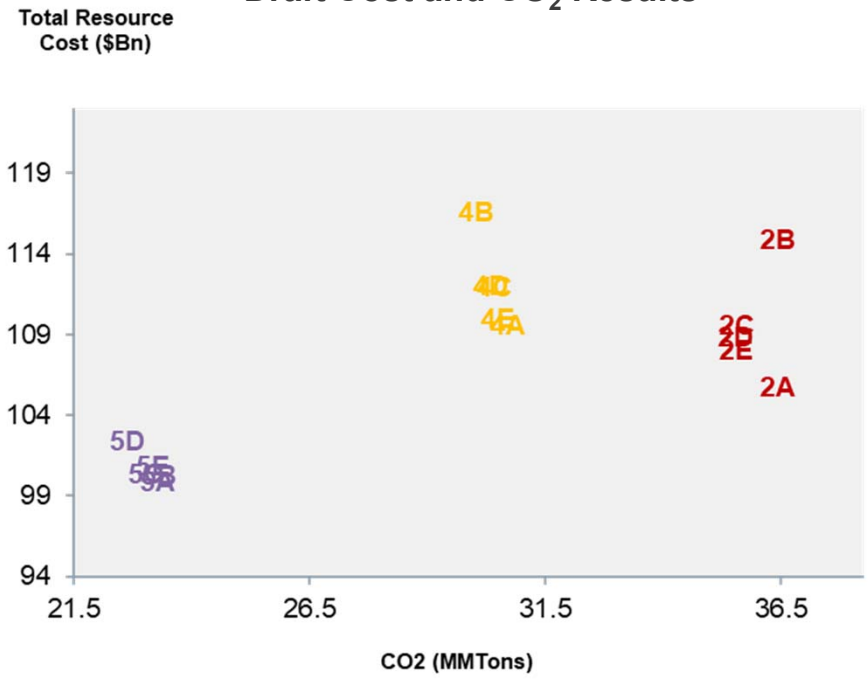
As both plants were selected for retirement in all lower load cases, reflecting the retirement decisions drives no change in capacity expansion plans for these cases.



Updated Base Case: Lower Loads (Scenarios 2,4,5)

Cost estimates for PAF3 & BRF ongoing operation were updated after the Draft IRP base case was finalized. Aligning cost estimates drives a negligible change to results.

Draft Cost and CO_2 Results



Updated Cost and CO_2 Results

Updated Base Case: Economic Downturn (Scenario 2)

Updated Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	105	71	106	1.00	113	36	489	51,136	1,865	41,245	1.37	56%	0.00%	0.00%
B: Promote DER	105	71	115	1.00	113	36	488	51,133	1,861	18,324	1.71	53%	0.00%	0.00%
C: Promote Resiliency	106	71	109	0.98	113	36	476	50,681	1,840	54,810	1.29	59%	0.00%	0.00%
D: Promote Efficient Load Shape	108	72	109	0.98	116	36	475	50,658	1,849	58,560	1.39	59%	-0.02%	-0.02%
E: Promote Renewables	106	71	108	0.98	113	36	476	50,694	1,840	58,464	1.18	59%	0.00%	0.00%

Delta from Draft Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	-0.21	-0.14	-0.21	0.00	-0.24	0	0	0	0	0	0.00	0%	0.00%	0.00%
B: Promote DER	-0.21	-0.14	-0.21	0.00	-0.24	0	0	0	0	0	0.00	0%	0.00%	0.00%
C: Promote Resiliency	-0.21	-0.14	-0.21	0.00	-0.24	0	0	0	0	0	0.00	0%	0.00%	0.00%
D: Promote Efficient Load Shape	-0.21	-0.14	-0.21	0.00	-0.24	0	0	0	0	0	0.00	0%	0.00%	0.00%
E: Promote Renewables	-0.21	-0.14	-0.21	0.00	-0.24	0	0	0	0	0	0.00	0%	0.00%	0.00%

Updated Base Case: Decarbonization (Scenario 4)

Updated Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	109	75	109	1.04	118	31	427	50,276	1,272	58,400	0.98	66%	0.00%	0.00%
B: Promote DER	109	75	116	1.03	118	30	418	48,706	1,271	58,400	0.98	66%	0.00%	0.00%
C: Promote Resiliency	109	75	112	1.04	118	30	423	48,765	1,264	58,464	1.04	66%	0.00%	0.00%
D: Promote Efficient Load Shape	111	76	112	1.02	120	30	422	48,627	1,235	58,560	1.15	66%	-0.02%	-0.02%
E: Promote Renewables	109	75	110	1.03	118	31	424	50,173	1,246	58,464	1.04	66%	0.00%	0.00%

Delta from Draft Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	-0.21	-0.14	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%
B: Promote DER	-0.21	-0.14	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%
C: Promote Resiliency	-0.21	-0.14	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%
D: Promote Efficient Load Shape	-0.21	-0.14	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%
E: Promote Renewables	-0.21	-0.14	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%

Updated Base Case: Rapid DER Adoption (Scenario 5)

Updated Metric Results

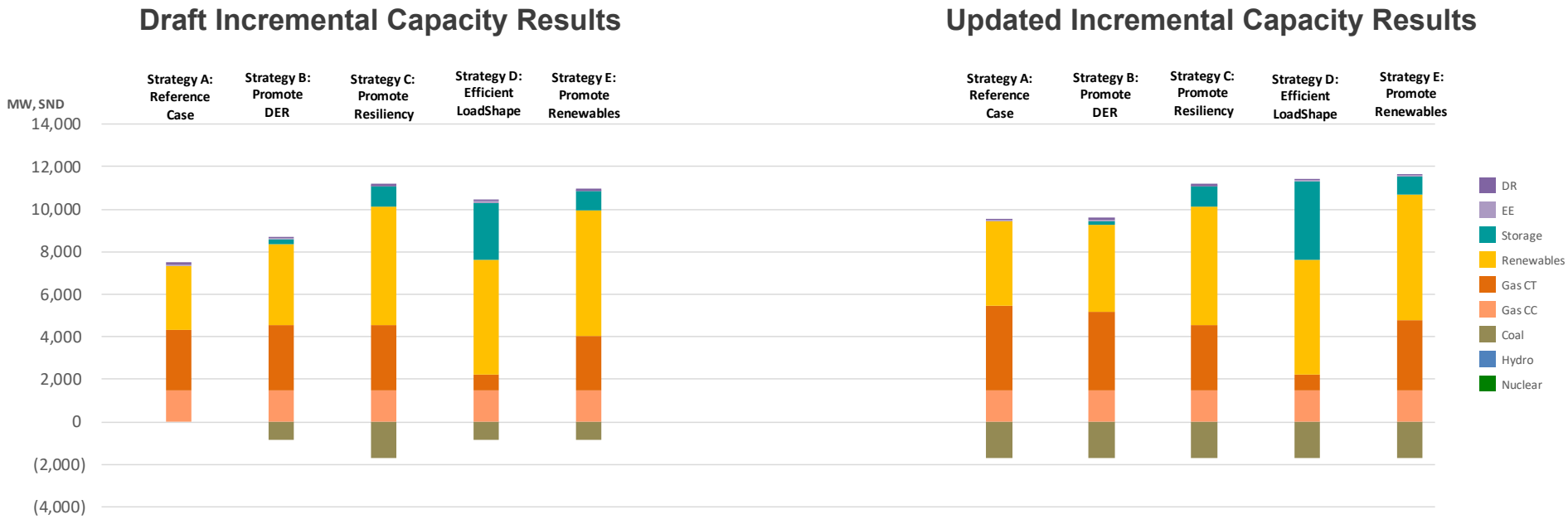
	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	99	76	100	0.94	106	23	361	45,678	1,177	32,850	1.14	63%	0.00%	0.00%
B: Promote DER	99	76	100	0.94	106	23	361	45,697	1,176	32,850	1.14	63%	0.00%	0.00%
C: Promote Resiliency	100	76	100	0.94	106	23	356	45,563	1,162	47,502	1.02	66%	0.00%	0.00%
D: Promote Efficient Load Shape	101	77	102	0.93	108	23	350	45,383	1,137	58,560	1.13	69%	-0.02%	-0.02%
E: Promote Renewables	100	76	101	0.93	107	23	357	45,621	1,167	58,464	1.02	67%	-0.01%	-0.01%

Delta from Draft Metric Results

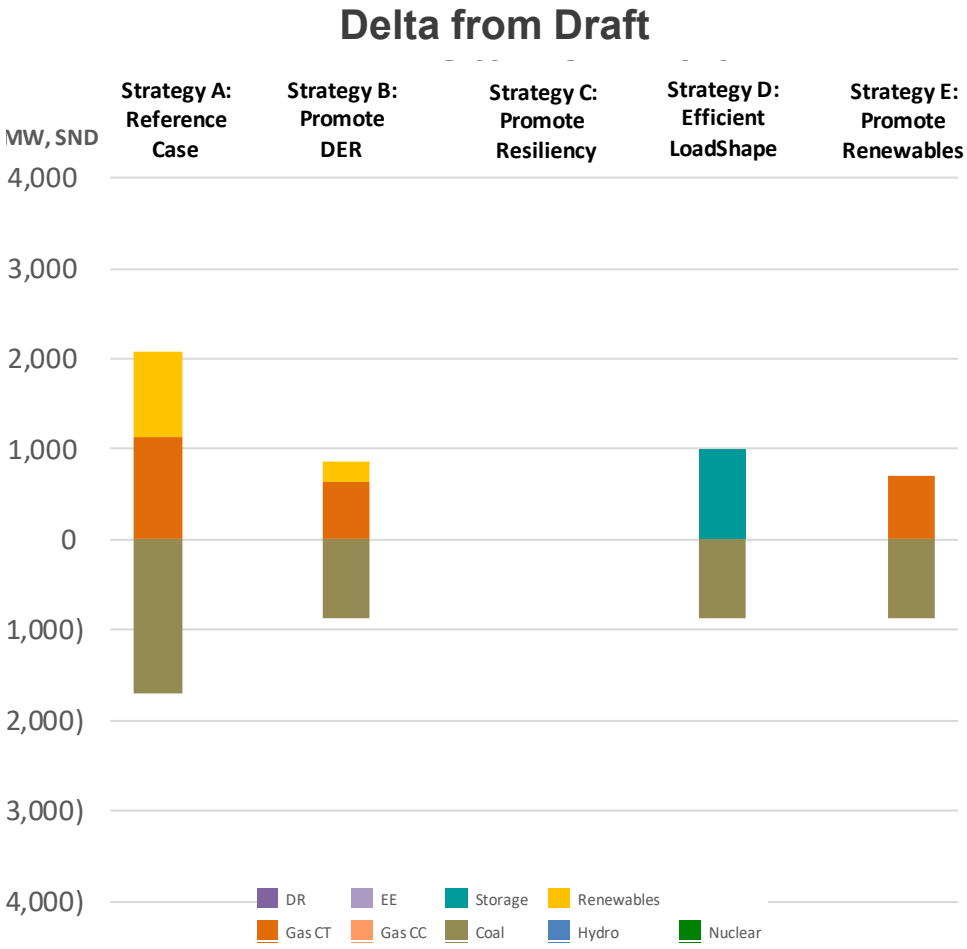
	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	-0.21	-0.16	-0.21	0.00	-0.25	0	0	0	0	0	0.00	0%	0.00%	0.00%
B: Promote DER	-0.21	-0.16	-0.21	0.00	-0.25	0	0	0	0	0	0.00	0%	0.00%	0.00%
C: Promote Resiliency	-0.21	-0.16	-0.21	0.00	-0.25	0	0	0	0	0	0.00	0%	0.00%	0.00%
D: Promote Efficient Load Shape	-0.21	-0.16	-0.21	0.00	-0.25	0	0	0	0	0	0.00	0%	0.00%	0.00%
E: Promote Renewables	-0.21	-0.16	-0.21	0.00	-0.25	0	0	0	0	0	0.00	0%	0.00%	0.00%

Updated Base Case: Current Outlook (Scenario 1)

One or both plants were selected for retirement in the initial Current Outlook cases, aside from the draft Base Case where continued operation was assumed. In cases where both plants were not initially selected for retirement, reflecting retirement decisions drives additional solar and gas expansion later in the plan. Strategy D adds additional storage capacity due to promotion.



Updated Base Case: Current Outlook (Scenario 1)



Strategy A

- BRF and PAF capacity replaced by solar and CT

Strategy B

- BRF capacity replaced by CT and solar

Strategy C

- No change

Strategy D

- BRF capacity replaced by incented storage

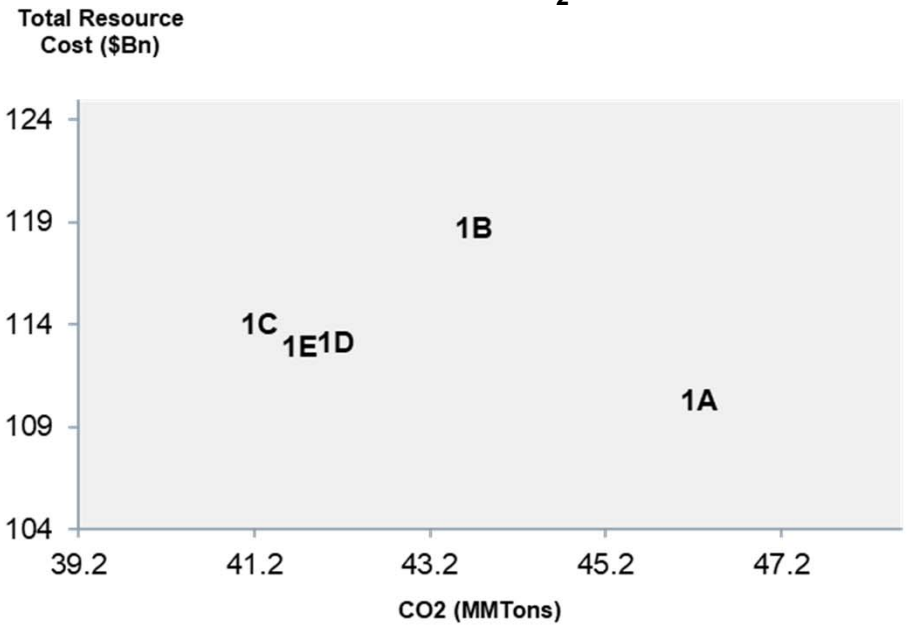
Strategy E

- BRF capacity replaced by CT

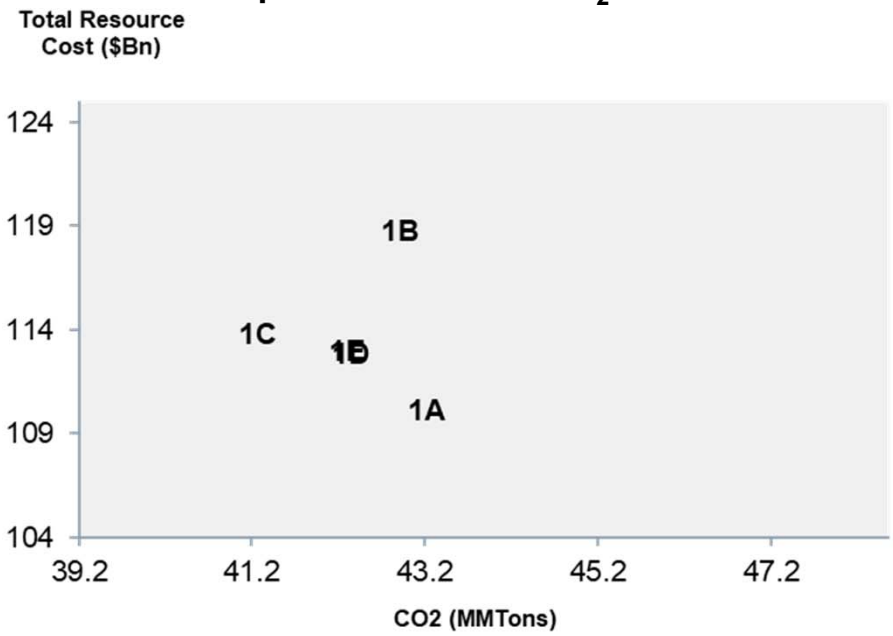
Updated Base Case: Current Outlook (Scenario 1)

Retiring both plants in all Current Outlook cases results in similar costs and lower carbon emissions, due to the nature of replacement resources selected later in the plan.

Draft Cost and CO_2 Results



Updated Cost and CO_2 Results



Updated Base Case: Current Outlook (Scenario 1)

Updated Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	110	70	110	1.06	119	43	541	54,053	2,269	43,365	1.98	50%	0.00%	0.00%
B: Promote DER	110	70	119	1.05	119	43	537	53,958	2,256	33,145	1.97	50%	0.00%	0.00%
C: Promote Resiliency	111	71	114	1.06	120	41	516	53,101	2,197	55,058	1.56	53%	-0.01%	-0.01%
D: Promote Efficient Load Shape	112	72	113	1.02	121	42	531	53,746	2,229	59,034	1.60	53%	-0.01%	-0.01%
E: Promote Renewables	111	71	113	1.04	120	42	529	53,720	2,227	58,759	1.65	53%	0.00%	0.00%

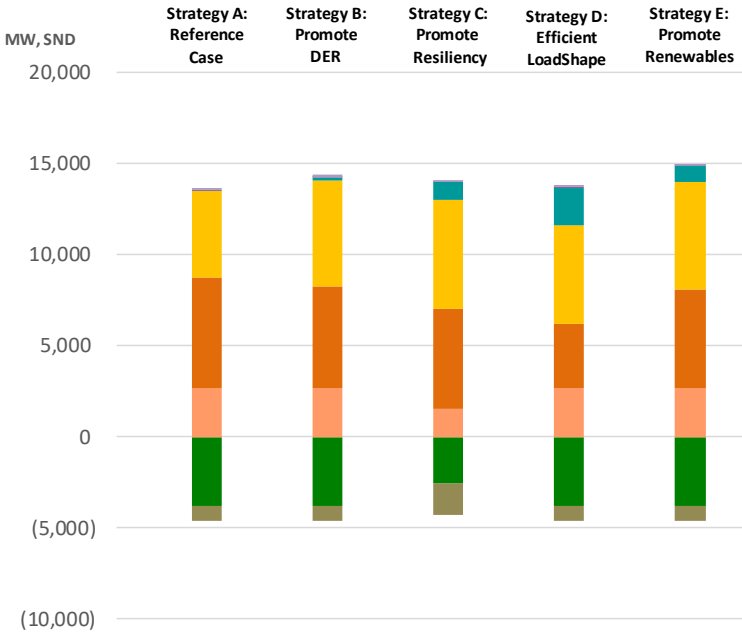
Delta from Draft Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	-0.24	-0.08	-0.19	0.01	-0.17	-3	-38	-2,501	-358	10,294	-0.08	2%	0.00%	0.00%
B: Promote DER	0.09	0.05	0.09	0.00	0.10	-1	-10	-278	-22	2,629	0.03	0%	0.00%	0.00%
C: Promote Resiliency	-0.21	-0.13	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%
D: Promote Efficient Load Shape	-0.26	0.05	-0.26	0.00	-0.38	0	5	20	-23	240	0.17	0%	0.00%	0.00%
E: Promote Renewables	0.05	-0.06	0.05	0.00	-0.05	1	6	81	-5	74	0.16	0%	0.00%	0.00%

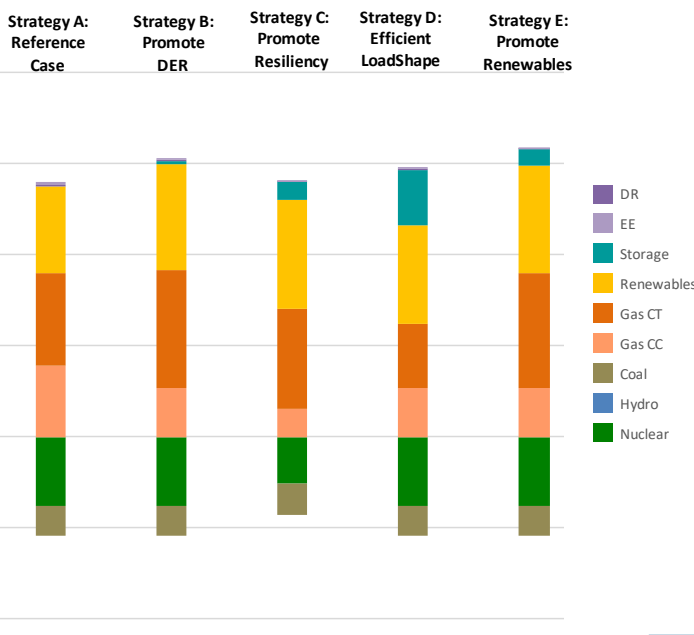
Updated Base Case: No Nuclear Extensions (Scenario 6)

PAF3 was selected for retirement in all No Nuclear Extensions cases, and BRF was selected in Strategy C. Reflecting retirement decisions in all cases drives additional gas expansion later in the plan, except for in Strategy D where additional storage capacity is added due to promotion.

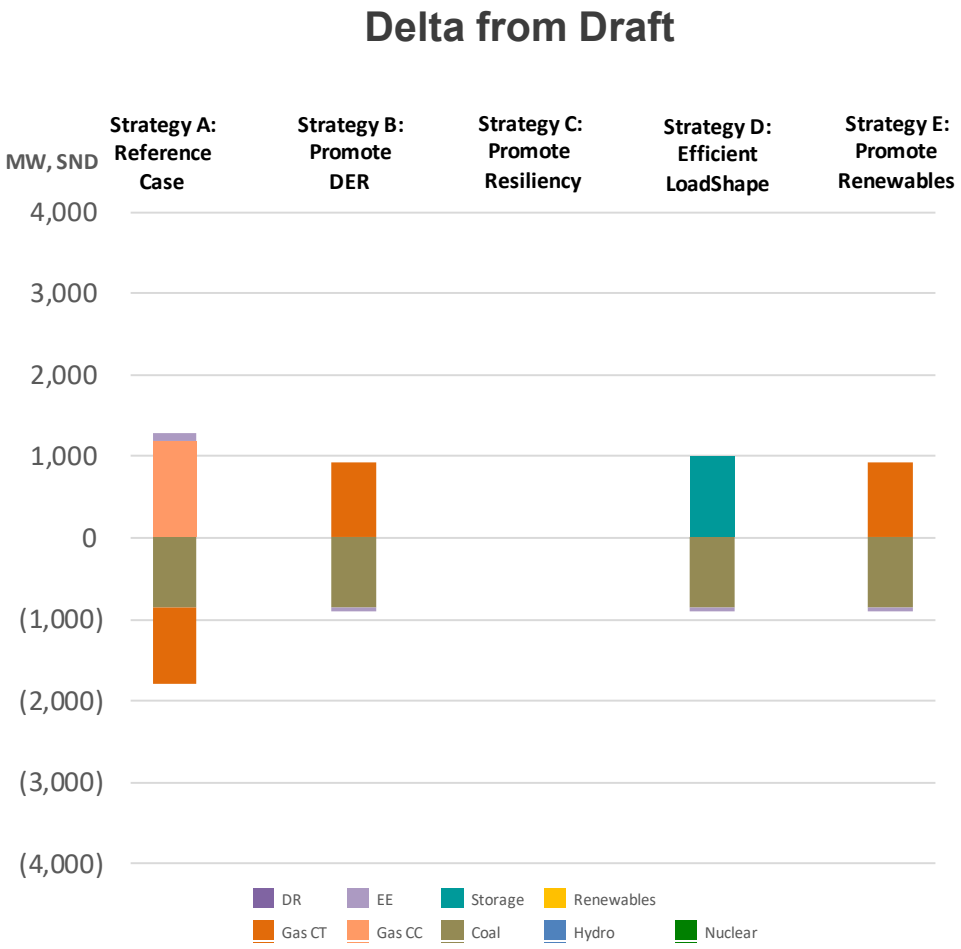
Draft Incremental Capacity Results



Updated Incremental Capacity Results



Updated Base Case: No Nuclear Extensions (Scenario 6)



Strategy A

- BRF capacity and previously selected CT capacity replaced by CC

Strategy B

- BRF capacity replaced by CT

Strategy C

- No change

Strategy D

- BRF capacity replaced by incented storage

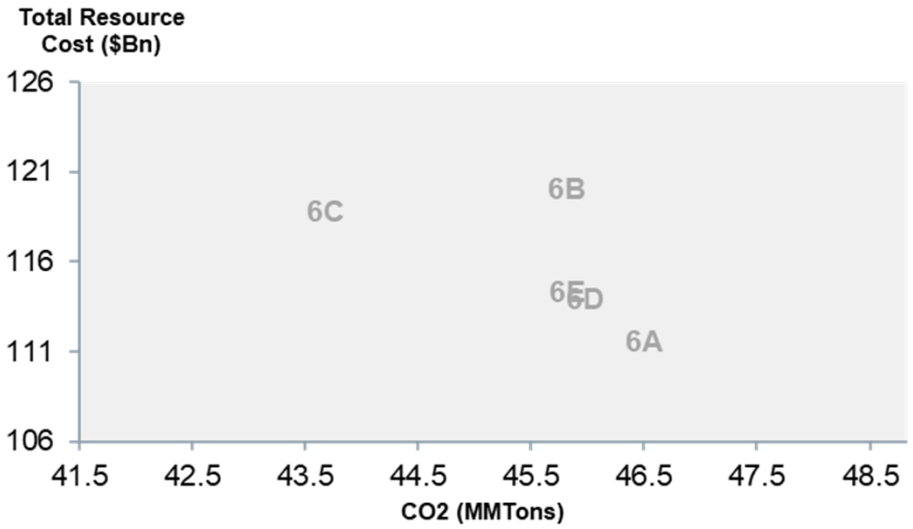
Strategy E

- BRF capacity replaced by CT

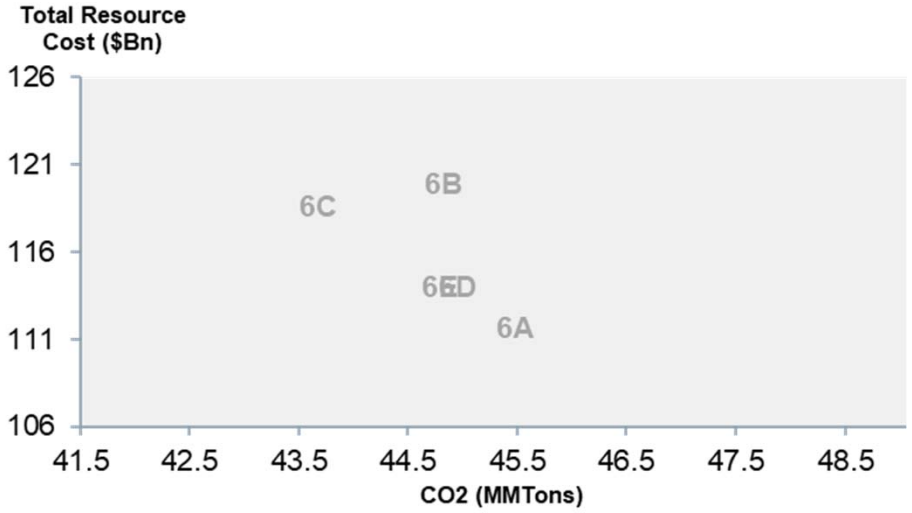
Updated Base Case: No Nuclear Extensions (Scenario 6)

Retiring both plants in all No Nuclear Extensions cases results in similar costs and lower carbon emissions, due to the nature of replacement resources selected later in the plan.

Draft Cost and CO_2 Results



Updated Cost and CO_2 Results



Updated Base Case: No Nuclear Extensions (Scenario 6)

Updated Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	111	71	112	1.08	121	46	570	51,895	2,371	51,730	2.22	32%	0.00%	0.00%
B: Promote DER	111	71	120	1.07	121	45	561	51,637	2,354	51,710	2.03	34%	0.00%	0.00%
C: Promote Resiliency	116	74	119	1.07	125	44	546	52,183	2,302	59,711	1.83	40%	-0.03%	-0.03%
D: Promote Efficient Load Shape	113	72	114	1.06	123	45	563	51,684	2,367	59,189	1.92	34%	-0.01%	-0.01%
E: Promote Renewables	112	71	114	1.07	121	45	560	51,624	2,352	59,074	2.07	34%	0.00%	0.00%

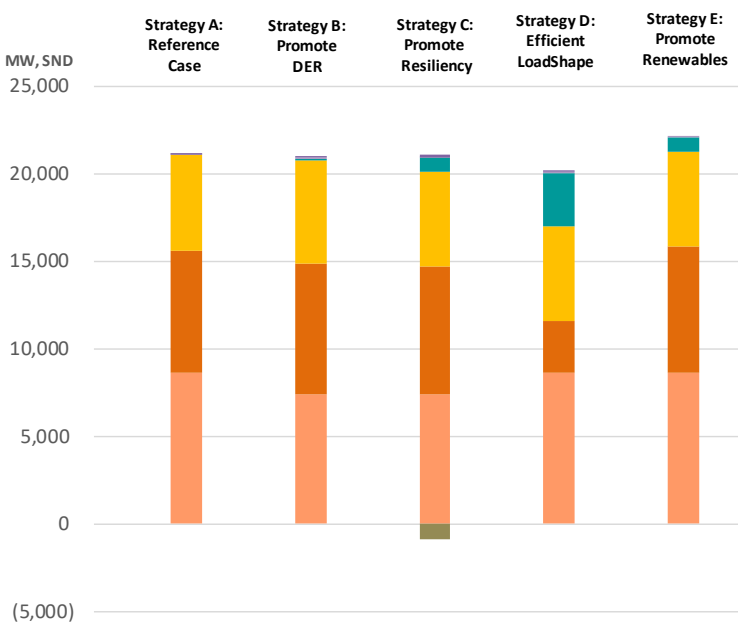
Delta from Draft Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	0.05	0.03	0.05	0.00	0.06	-1	-13	-347	-68	20	0.02	0%	0.00%	0.00%
B: Promote DER	-0.14	-0.09	-0.14	0.00	-0.12	-1	-12	-319	-66	74	0.10	0%	0.00%	0.00%
C: Promote Resiliency	-0.21	-0.13	-0.21	0.00	-0.23	0	0	0	0	0	0.00	0%	0.00%	0.00%
D: Promote Efficient Load Shape	0.11	0.16	0.11	0.00	0.16	-1	-12	-227	-46	240	0.09	0%	0.00%	0.00%
E: Promote Renewables	-0.25	-0.09	-0.24	0.00	-0.25	-1	-12	-355	-57	74	0.10	0%	0.00%	0.00%

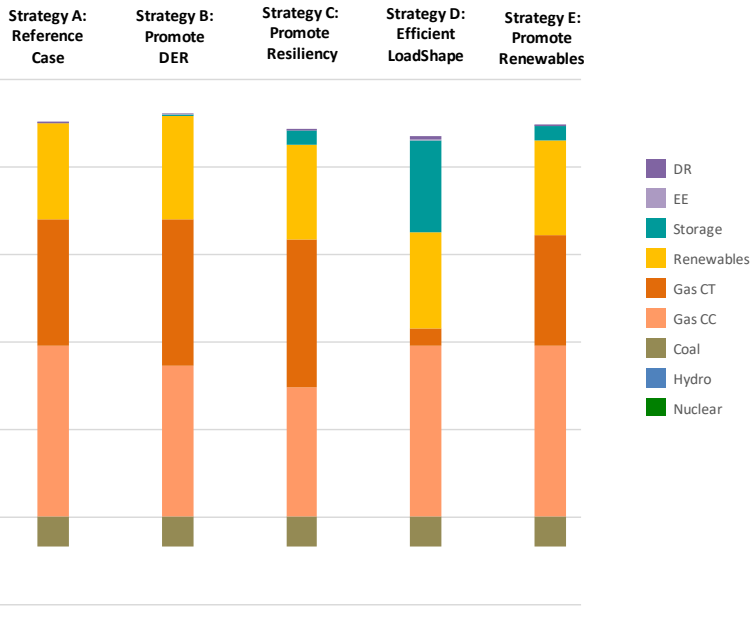
Updated Base Case: Valley Load Growth (Scenario 3)

BRF was selected for retirement in one of the Valley Load Growth cases. Reflecting the retirement decisions in all cases drives additional solar, gas, and storage later in the plan.

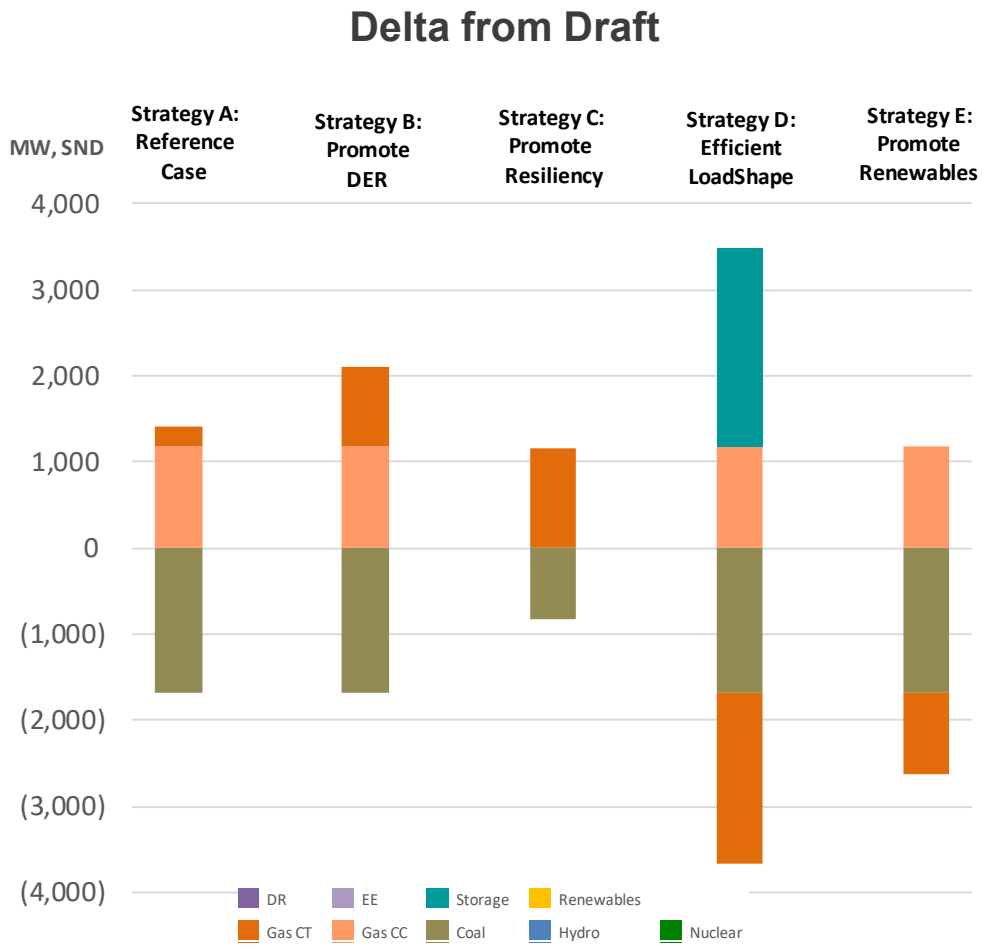
Draft Incremental Capacity Results



Updated Incremental Capacity Results



Updated Base Case: Valley Load Growth (Scenario 3)



Strategy A

- PAF and BRF capacity replaced by CC

Strategy B

- PAF and BRF capacity replaced CC and CT

Strategy C

- BRF capacity replaced by CT

Strategy D

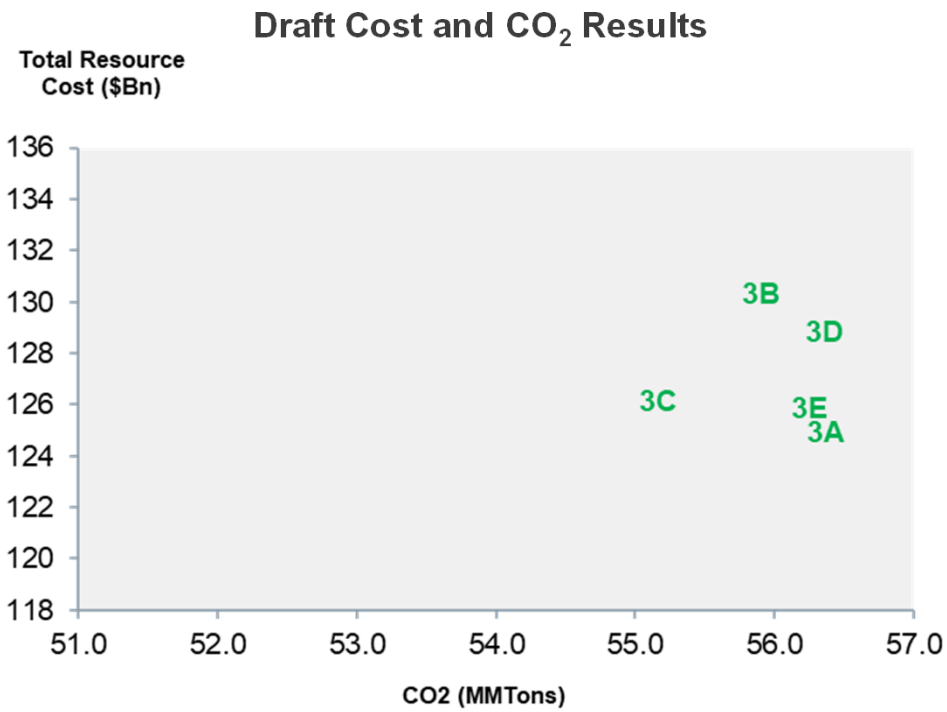
- PAF, BRF, and previously selected CT capacity replaced by incented storage and CC

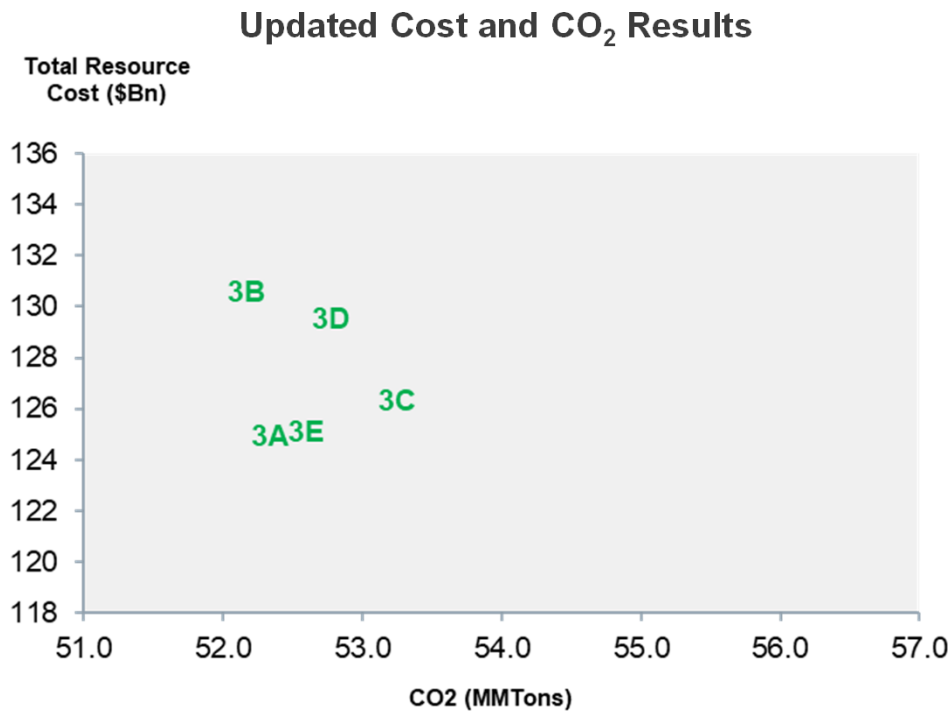
Strategy E

- PAF, BRF, and previously selected CT capacity replaced CC

Updated Base Case: Valley Load Growth (Scenario 3)

Retiring both plants in all Valley Load Growth cases results in similar costs and lower carbon emissions, due to the nature of replacement resources selected later in the plan.





Updated Base Case: Valley Load Growth (Scenario 3)

Updated Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	125	70	125	1.06	137	52	552	58,823	2,283	59,647	2.17	36%	0.00%	0.00%
B: Promote DER	124	70	131	1.06	137	52	550	58,675	2,318	59,627	2.11	36%	0.01%	0.01%
C: Promote Resiliency	126	71	126	1.06	138	53	561	57,456	2,363	59,679	2.09	36%	-0.01%	-0.01%
D: Promote Efficient Load Shape	129	73	130	1.04	142	53	557	58,999	2,386	60,091	1.79	36%	-0.04%	-0.04%
E: Promote Renewables	125	70	125	1.06	137	53	556	58,843	2,350	59,637	2.15	36%	-0.01%	-0.01%

Delta from Draft Metric Results

	PVRR ($Bn)	System Average Cost Years 1-20 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($Bn)	CO2 (MMTons)	CO2 Intensity (lbs/MWh)	Water Consumption (MMGallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Coverage Ratio	Flexibility Turn Down Factor (2038)	Percent Difference in Per Capita Income	Percent Difference in Employment
A: Base Case	-0.03	-0.01	-0.03	0.00	0.15	-4	-43	-2,891	-527	94	0.11	0%	0.00%	0.00%
B: Promote DER	0.24	0.10	0.26	0.00	0.44	-4	-40	-2,871	-491	168	0.16	0%	0.00%	0.00%
C: Promote Resiliency	0.19	0.05	0.19	0.00	0.42	-2	-21	-2,937	-328	99	0.09	0%	0.00%	0.00%
D: Promote Efficient Load Shape	0.70	0.29	0.70	0.00	1.10	-4	-39	-2,563	-476	506	0.07	0%	0.00%	0.00%
E: Promote Renewables	-0.72	-0.23	-0.73	0.00	-0.57	-4	-37	-2,842	-444	20	0.01	0%	0.00%	0.00%