2019 IRP Working Group

Meeting 10: January 30-31, 2019


welcome

Safety Moment

Building Emergency Plan

Introductions

- Name
- Organization and Role

Agenda – January 30

Highlighted sections contain confidential information

8:00 – 10:00	**Optional Individual Materials Review time** (check out Confidential booklet for review time prior to meeting) Catch up those that missed Meeting 9	**Individuals / Jane and Team**
10:00	**Welcome and Introductions and Safety Moment**	**Jo Anne Lavender**
10:10	**Meeting 9 Re-Cap – key things covered** **Overview for today's session**	**Brian Child**
10:15	**Review final results from Scenarios 1 and 2**	**Jane Elliott**
11:30	**Lunch**	
12:30	**Review final results from Scenarios 3 and 4**	**Jane Elliott**
1:30	**Review final results from Scenarios 5 and 6**	**Jane Elliott**
2:30	**What additional questions do you have?**	**Jane Elliott**
3:15	**Break**	
3:30	**Group Break out discussion and report outs**	
4:30	**Wrap Up day 1**	**Jo Anne / Brian**
6:00	**Group Dinner – McEwen's on the Square**	

Agenda – January 31

Highlighted sections contain confidential information

8:00	**Breakfast**	
8:30	**Welcome and Recap Day 1**	
9:00	**Review Construct of Metrics and Scorecards – how input was used to evolve**	**Hunter Hydas**
9:15	**Metric and Scorecard Results**	**Hunter Hydas**
10:45	**Break**	
11:00	**Metric and Scorecard Results and Q&A**	
12:00	**Lunch**	
1:00	**Group Break out discussion and report outs**	
2:30	**Wrap Up and Adjourn by 2:30**	

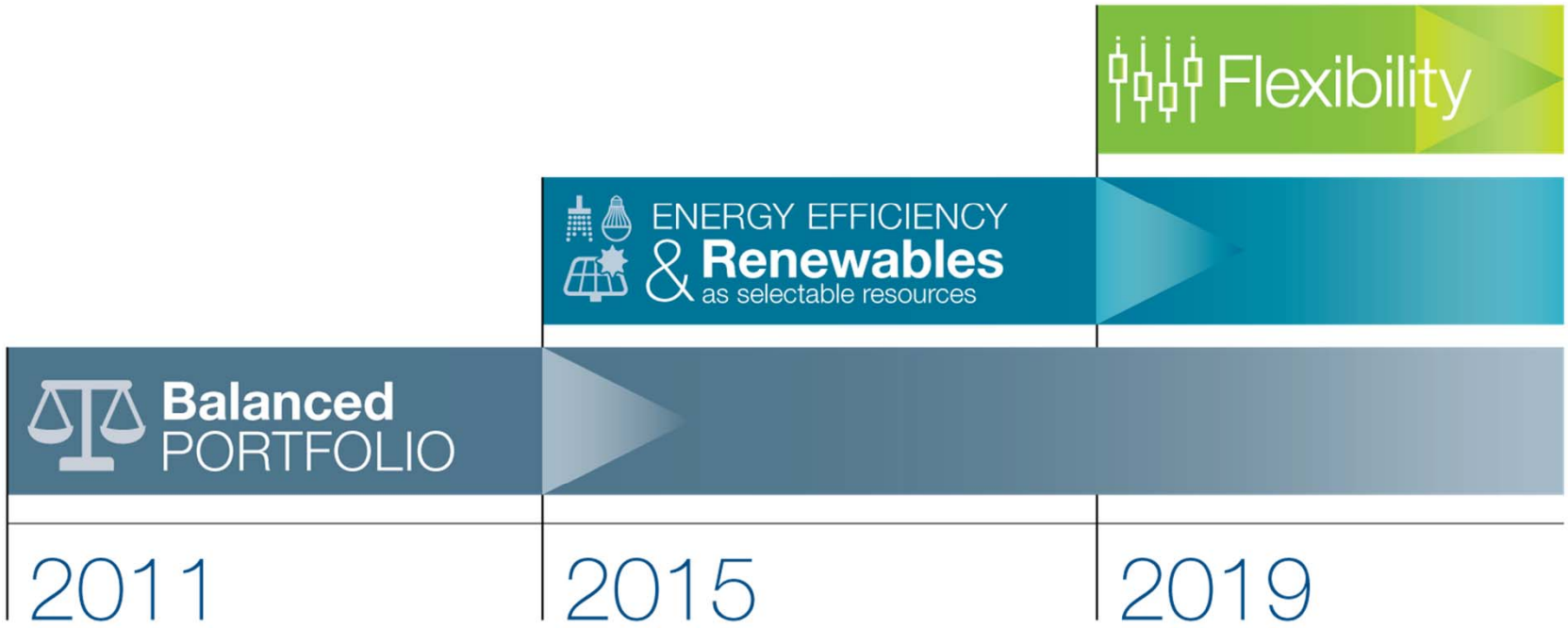
IRPWG Meeting 9 Recap

Brian Child

December Meeting Highlights

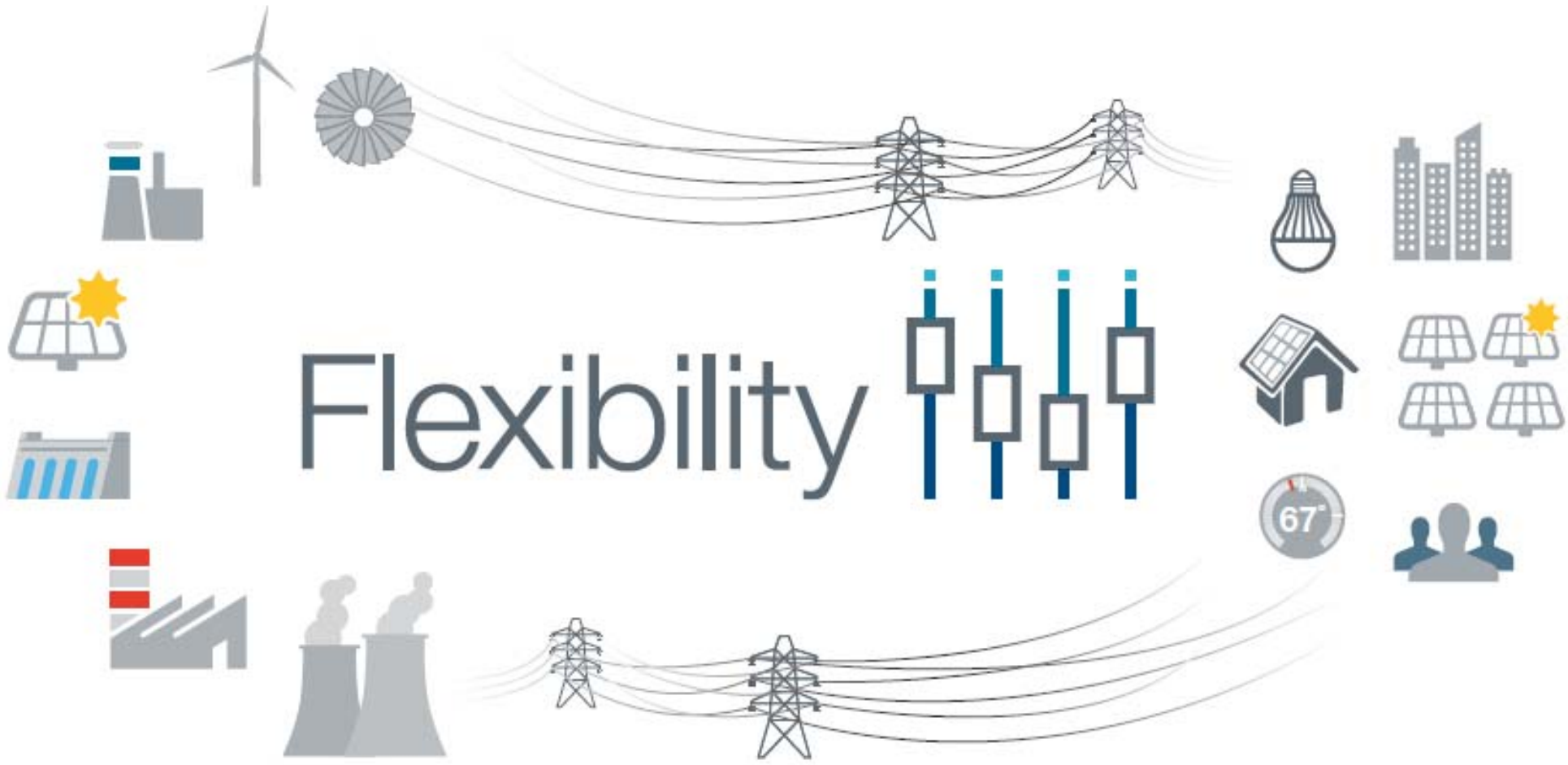
- Refresh on the Model Framework
- Reviewed Draft Results for Scenarios 1, 2, 4 and 5
- Heard group reflections and observations

INTEGRATED Resource Plan 2019



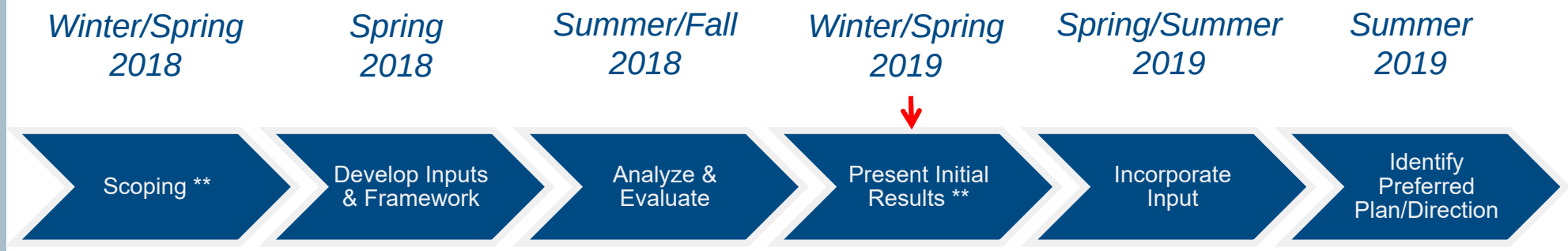
2019 IRP Focus Areas

- System flexibility
- Distributed Energy Resources
- Portfolio diversity


Flexibility
67

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

September 26th-27th	October 25th	December 19th -20th	January 30th-31st, 2019
• Strategy design (final) • Scorecard development (final) • Scorecard design • Environmental Impact Statement (EIS) outline	• Finalize Metrics • Follow up on Environmental Impact Statement • Review Reference Case	• Review Near Final Results for Draft Documents	• Review Final Results for Draft Documents

Introduce Discussion Questions

Jo Anne Lavender

Breakout Questions

1. What did you observe about Scenario 3 (Valley Load Growth) results? How did they relate to Scenario 1 results?

2. What did you observe about Scenario 6 (No Nuclear Extensions) results? How did they relate to Scenario 1 results?

3. Do you agree with the preliminary expansion observations? Would you add or change anything?

Portfolio Results

Jane Elliott
Senior Manager, Resource Strategy

2019 IRP Scenarios and Strategies

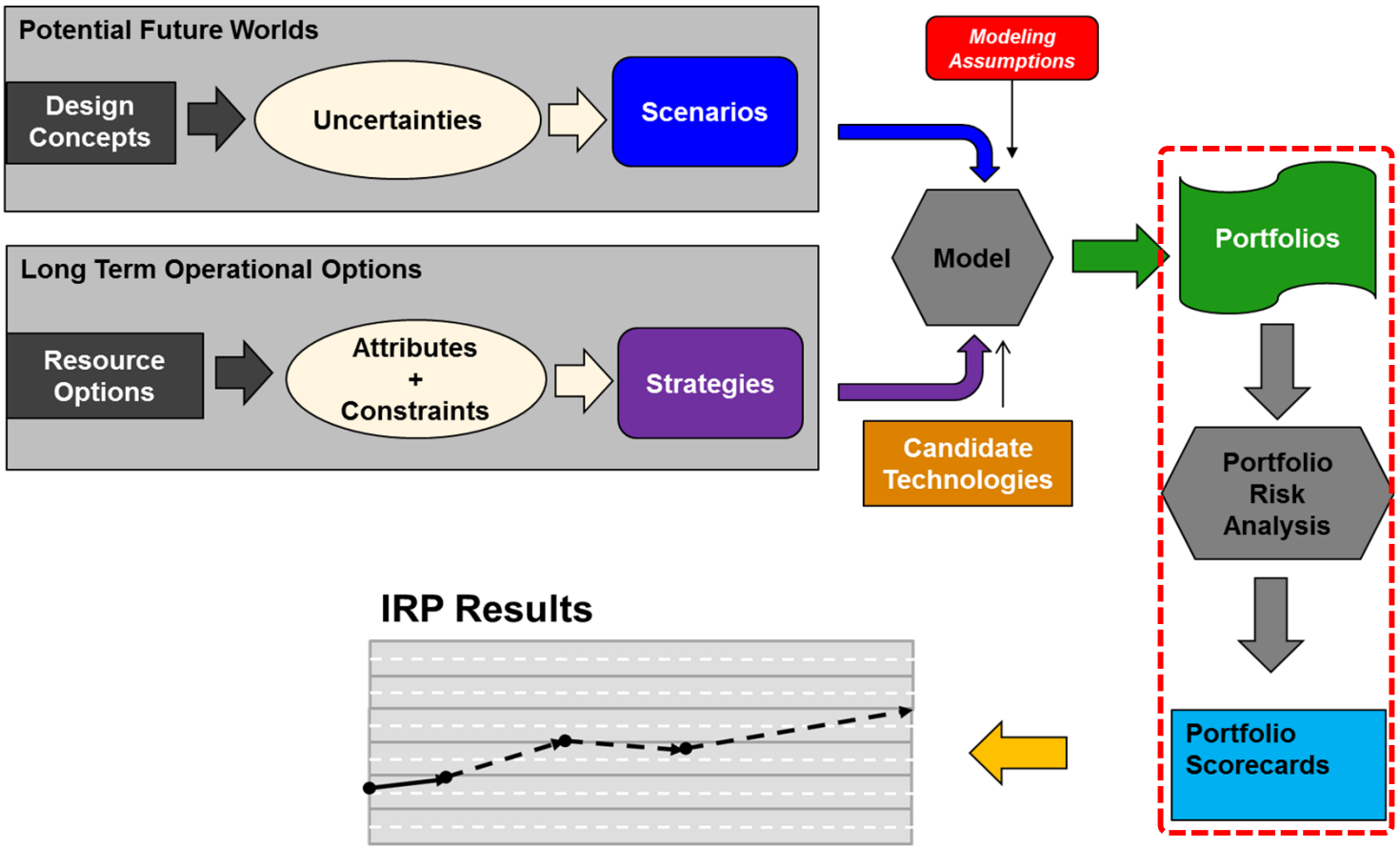
Scenarios

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*

Portfolio Results

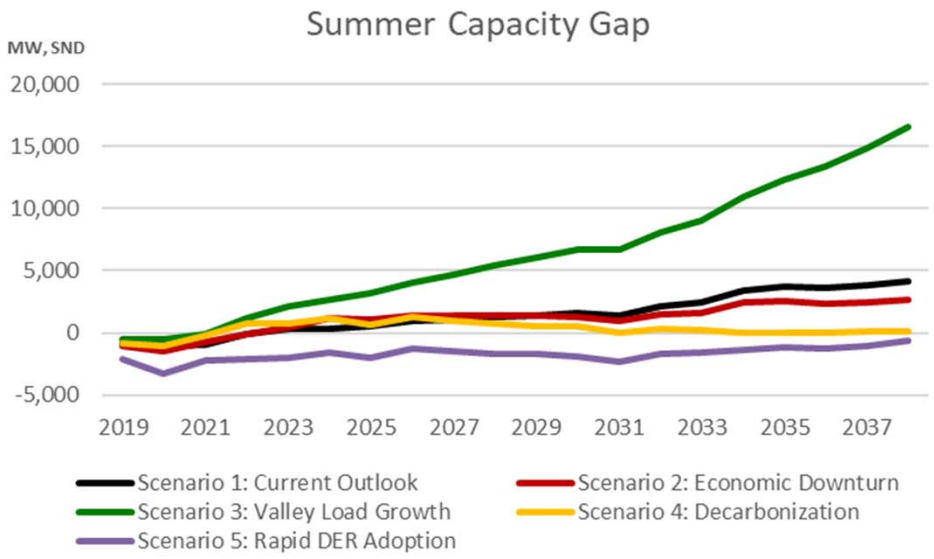


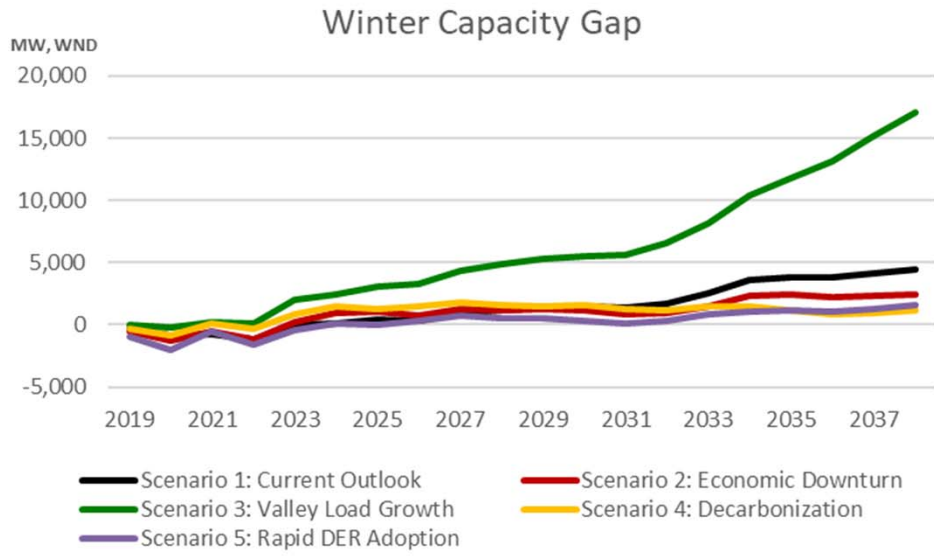
The result of a strategy evaluated in a scenario

How uncertainty impacts the portfolio results

Standard metrics to compare portfolios

Scenario Capacity Gaps

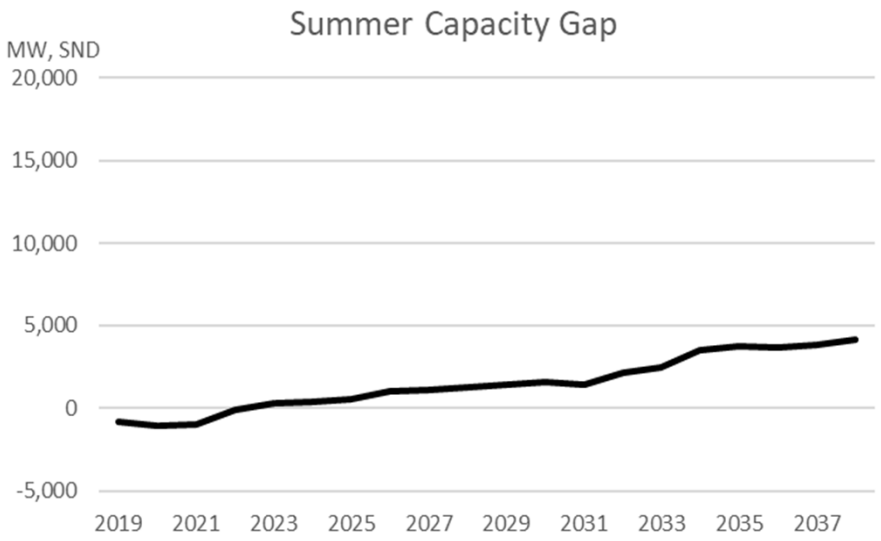


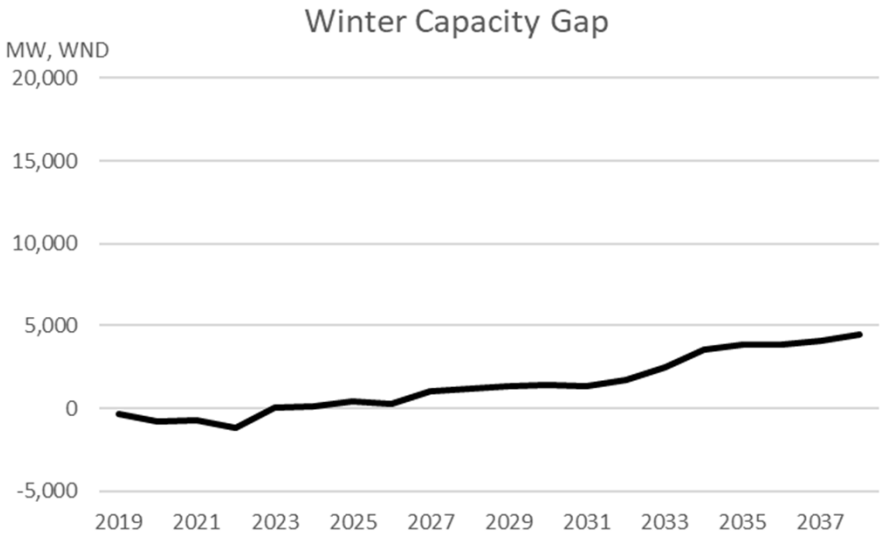


Scenario 6 is the same as the Current Outlook

Scenario 1: Current Outlook

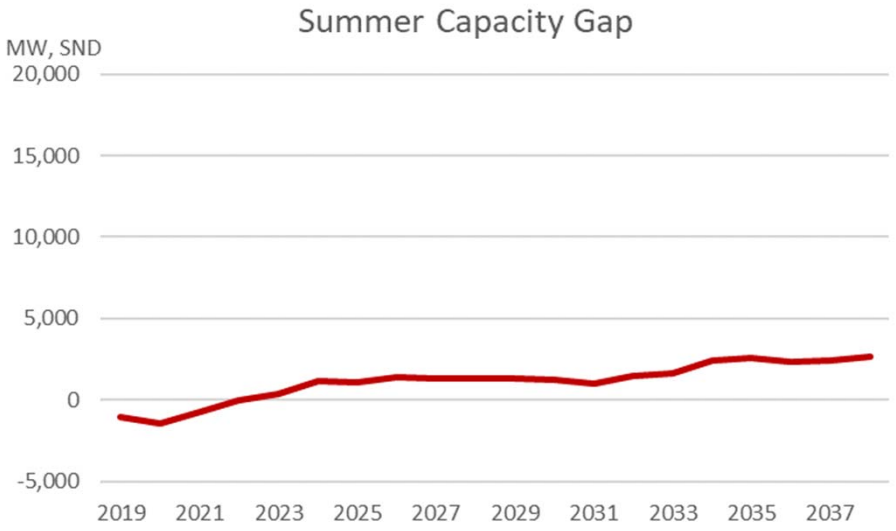
Scenario 1: Capacity Gap

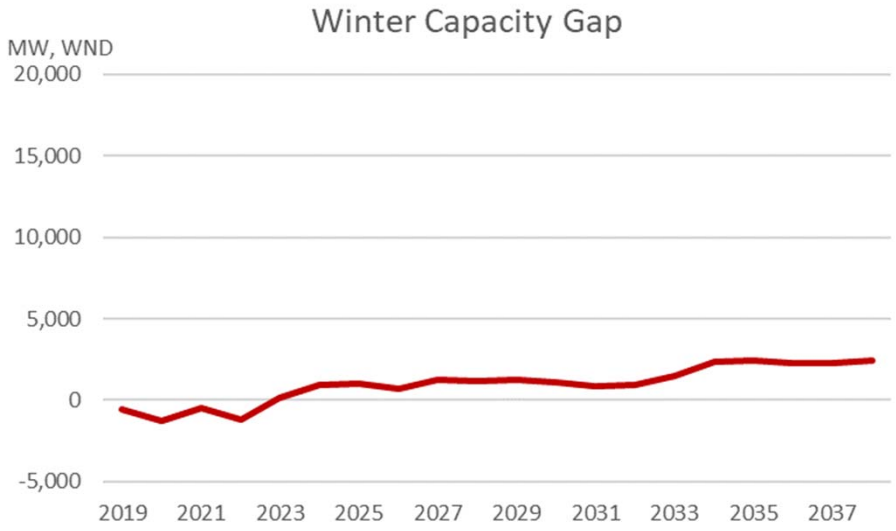




Scenario 2: Economic Downturn

Scenario 2: Capacity Gap

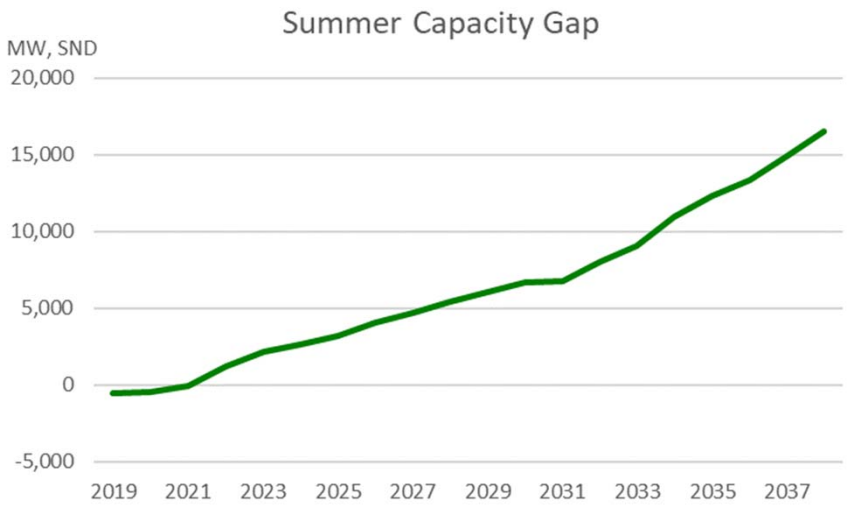


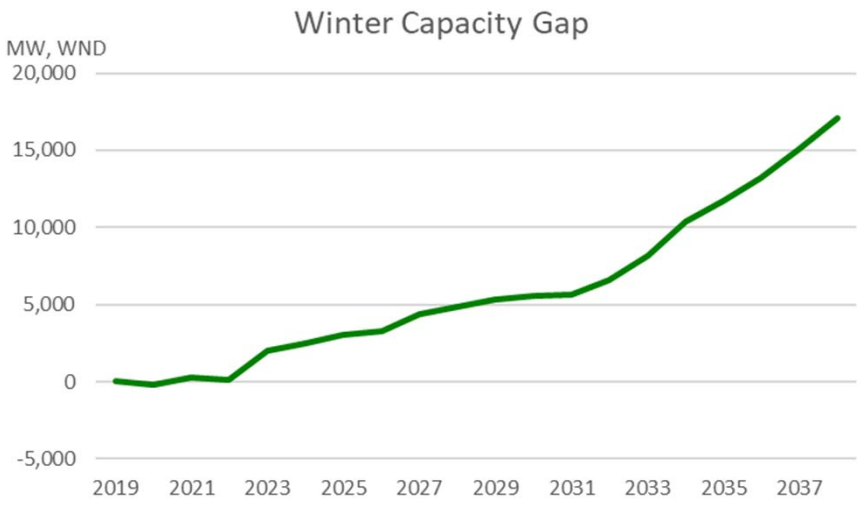



TIME FOR
LUNCH
TIME FOR

Scenario 3: Valley Load Growth

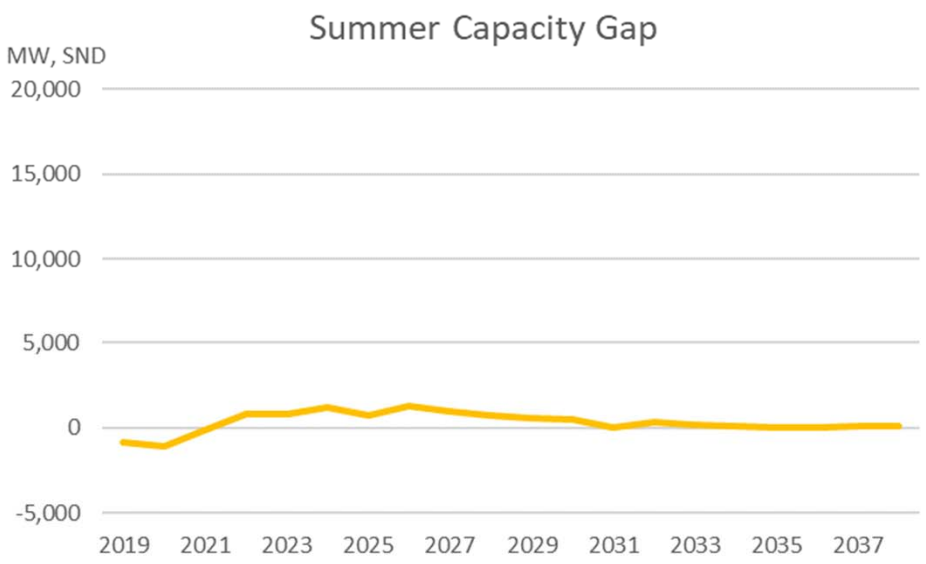
Scenario 3: Capacity Gap

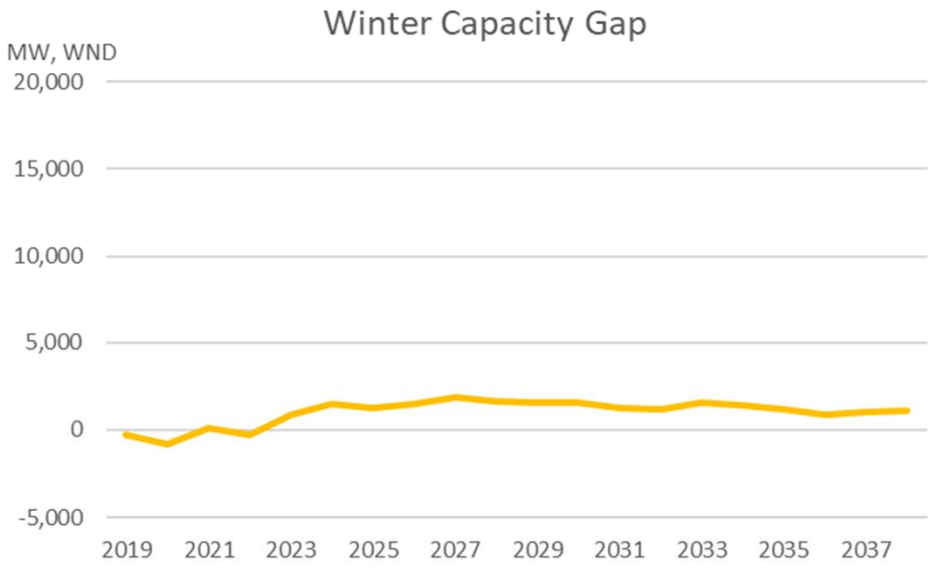




Scenario 4: De-Carbonization

Scenario 4: Capacity Gap

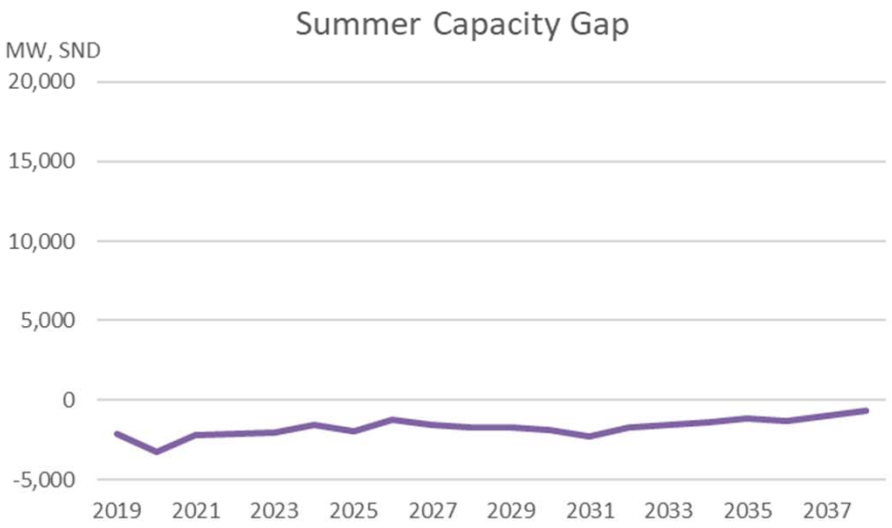


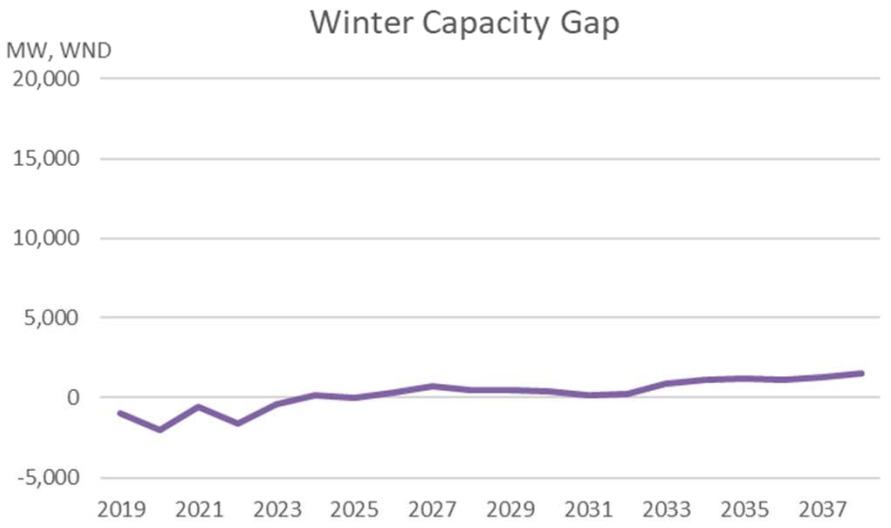


BREAK

Scenario 5: Rapid DER Adoption

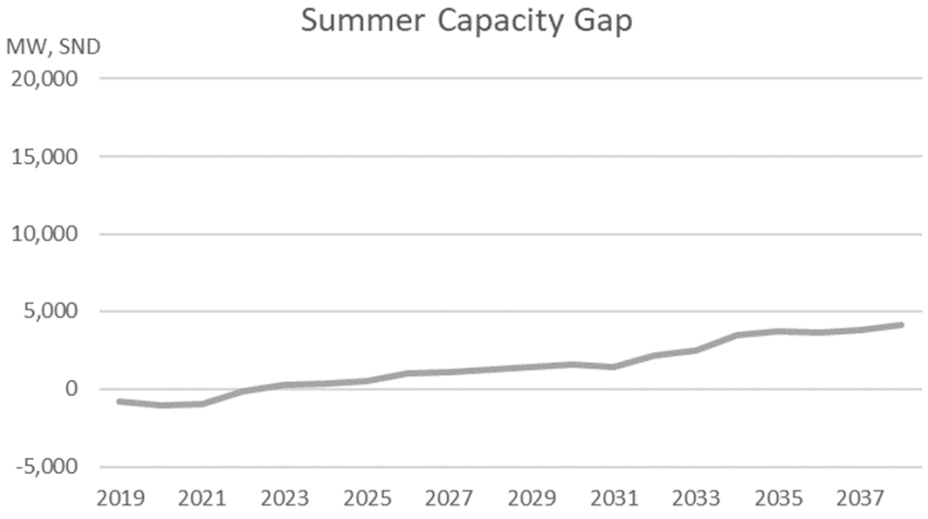
Scenario 5: Capacity Gap

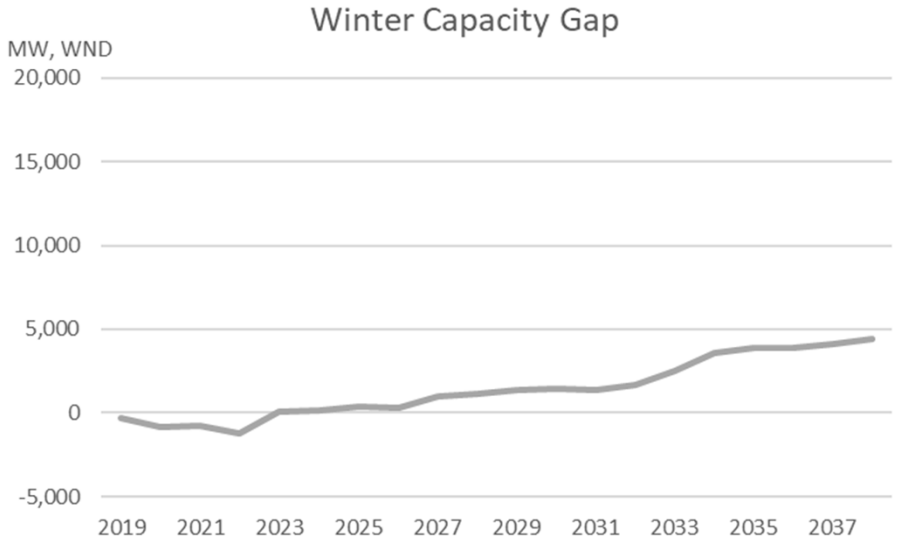




Scenario 6: No Nuclear Extensions

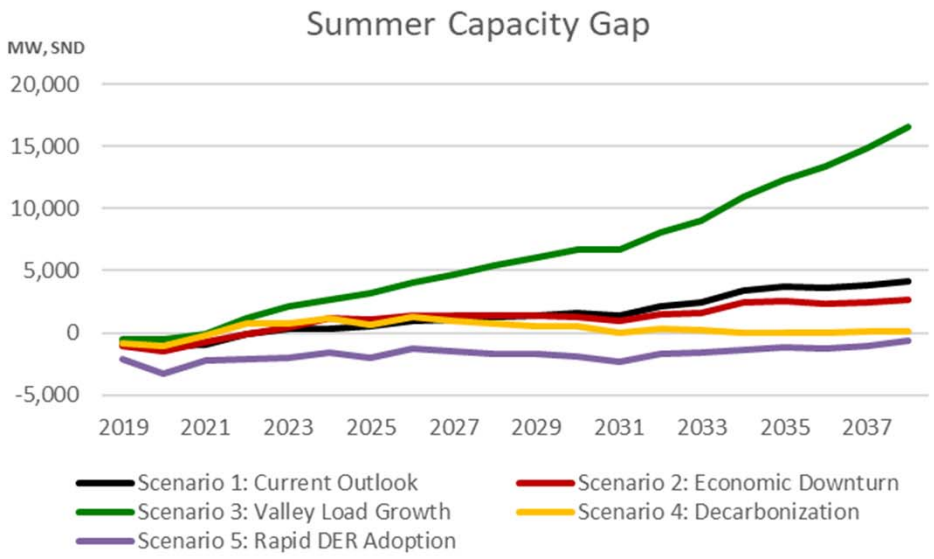
Scenario 6: Capacity Gap

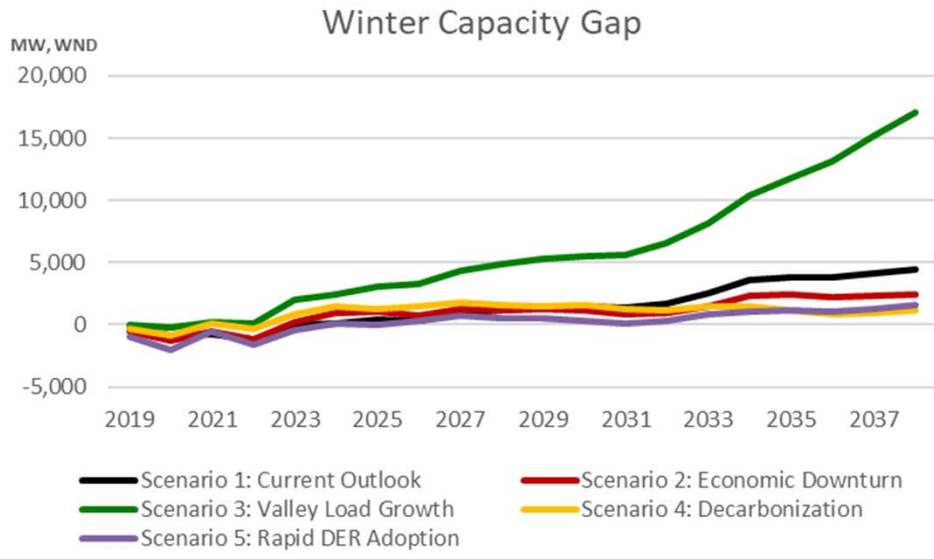




Summary of Portfolio Results

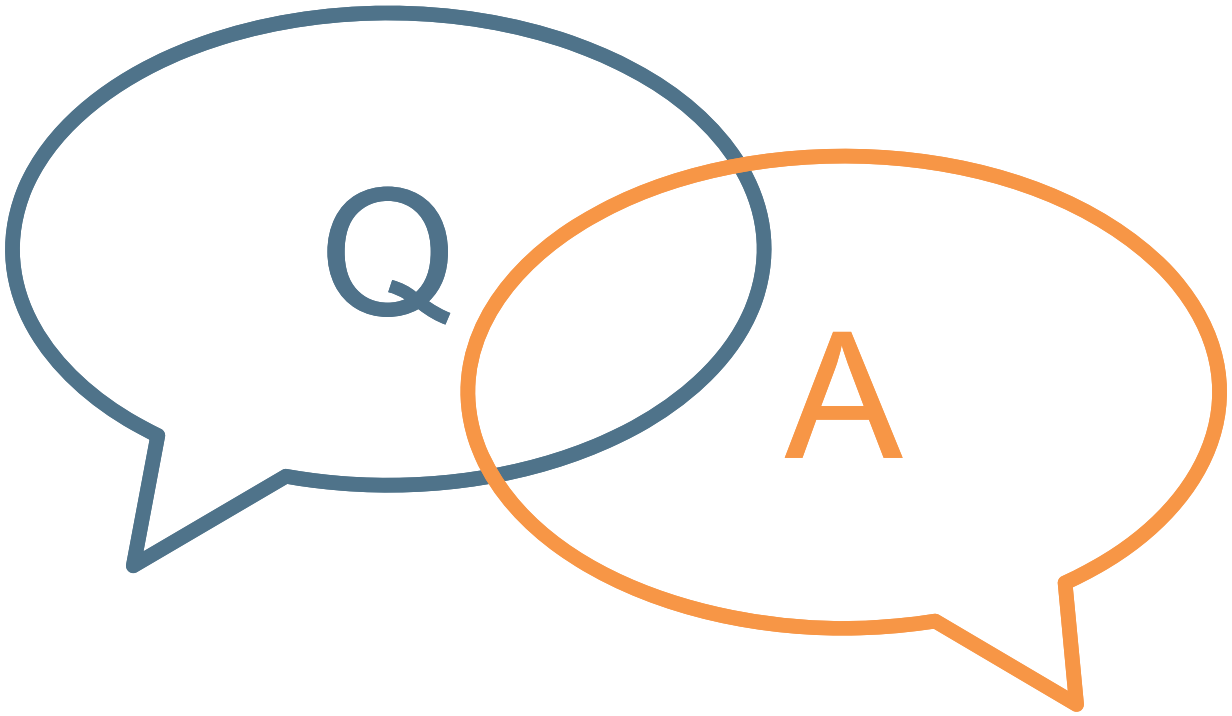
Scenario Capacity Gaps





Scenario 6 is the same as the Current Outlook

Questions about Portfolio Results?



Group Breakout: Expansion Results

Jane Elliott
Senior Manager, Resource Strategy

Breakout Questions

1. What did you observe about Scenario 3 (Valley Load Growth) results? How did they relate to Scenario 1 results?

2. What did you observe about Scenario 6 (No Nuclear Extensions) results? How did they relate to Scenario 1 results?

3. Do you agree with the preliminary expansion observations? Would you add or change anything?

BREAK

Wrap Up Day 1

Optional Dinner tonight, 6:00 PM, McEwen's.

(Hotel Shuttle Available, meet in lobby at 5:45)

2019 IRP Working Group

Meeting 10: January 30-31, 2019

Welcome and Day 1 Recap

Jo Anne Lavender / Brian Child

Agenda – January 31

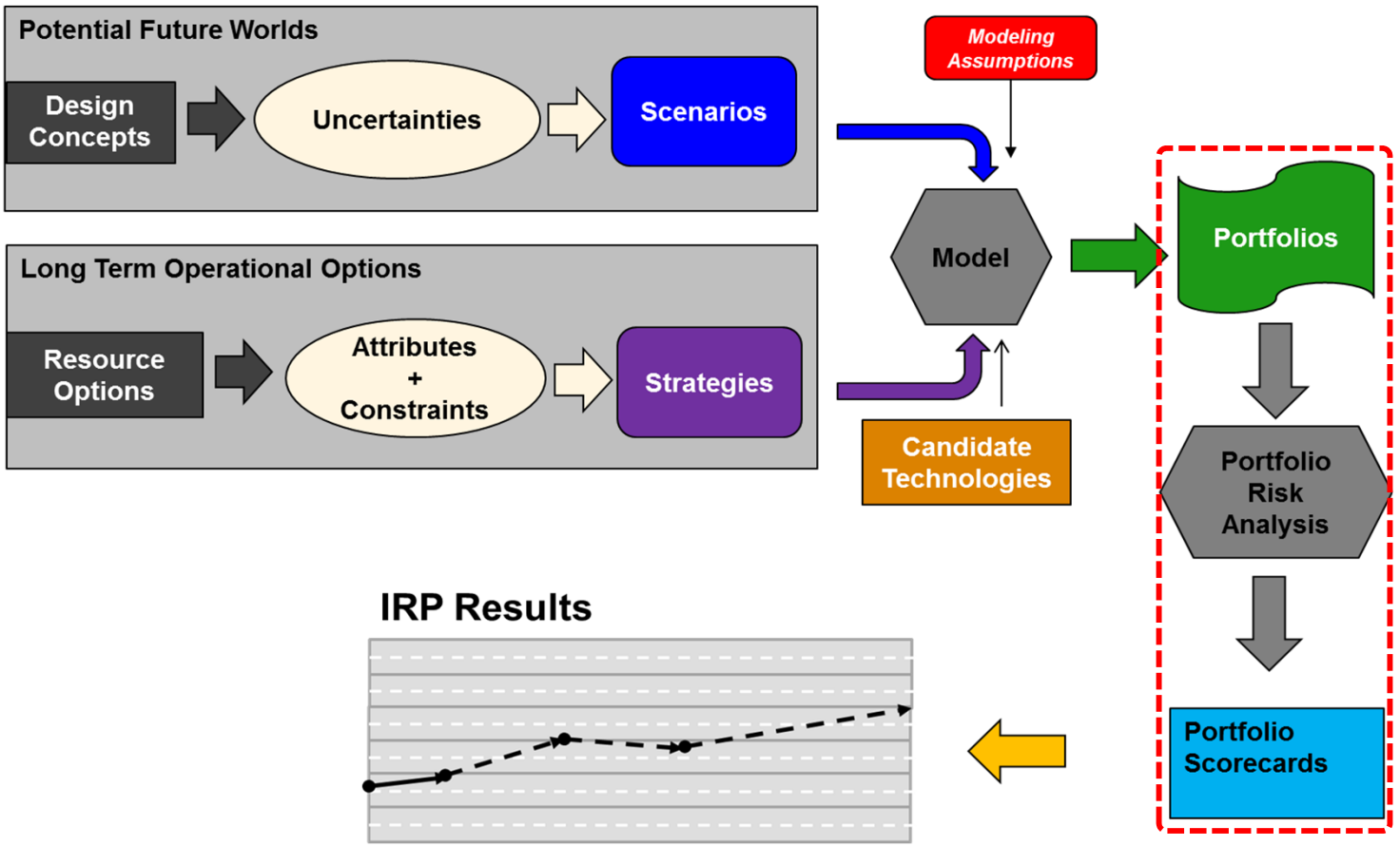
Highlighted sections contain confidential information

8:00	**Breakfast**	
8:30	**Welcome and Recap Day 1**	
9:00	**Review Construct of Metrics and Scorecards – how input was used to evolve**	**Hunter Hydas**
9:15	**Metric and Scorecard Results**	**Hunter Hydas**
10:45	**Break**	
11:00	**Metric and Scorecard Results and Q&A**	
12:00	**Lunch**	
1:00	**Group Break out discussion and report outs**	
2:30	**Wrap Up and Adjourn by 2:30**	

Scorecard Results

Hunter Hydas
Program Manager, Resource Strategy

Scorecard Results



The result of a strategy evaluated in a scenario

How uncertainty impacts the portfolio results

Standard metrics to compare portfolios

2019 IRP Metrics

Category	Metric	Definition
Cost	PVRR ($Bn)	Total plan cost (capital and operating) expressed as the expected (stochastic) present value of revenue requirements over the 20-year study period
	System Average Cost ($/MWh)	Expected average system cost for the study period, computed as the levelized annual average system cost (annual revenue requirements divided by annual sales)
	Total Resource Cost ($Bn) *	Total plan cost (capital and operating) expressed as the expected present value of revenue requirements over the study period plus participant cost net of bill savings and tax credits
Risk	Risk/Benefit Ratio	Area under the plan cost distribution curve between P(95) and expected value divided by the area between expected value and P(5) based on stochastic analysis
	Risk Exposure ($Bn)	The point on the plan cost distribution below which the likely plan costs will fall 95% of the time based on stochastic analysis
Environmental Stewardship	CO2 (MMTons)	Expected annual average tons of CO2 emitted over the study period
	CO2 Intensity (lbs/MWh)	Expected CO2 emissions expressed as an emission intensity, computed by dividing emissions by energy generated and purchased
	Water Consumption (MMGallons)	Expected annual average gallons of water consumed over the study period
	Waste (MMTons)	Expected annual average quantity of coal ash, sludge and slag projected based on energy production in each portfolio
	Land Use (Acres) *	Expected acreage needed for expansion units in each portfolio in 2038
Operational Flexibility	Flexible Resource Coverage Ratio *	The ratio of flexible capacity available to meet the maximum 3-hour ramp in demand in 2038 to the maximum 3-hour ramp demand in 2038
	Flexibility Turn Down Factor	Ability of the system to serve low load periods as measured by percent of must-run and non-dispatchable generation to sales
Valley Economics	Percent Difference in Per Capita Income	The change in per capita personal income expressed as a change from a reference portfolio in each scenario
	Percent Difference in Employment	The change in employment expressed as a change from a reference portfolio in each scenario

* New metric for 2019 IRP

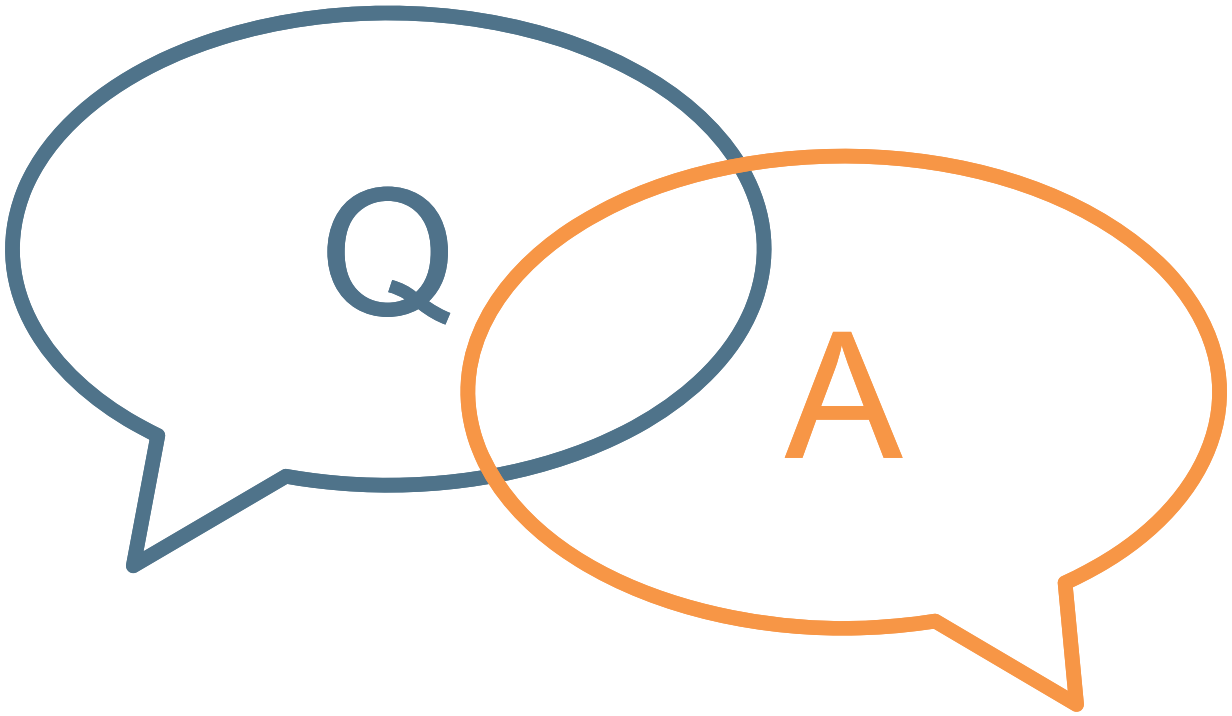
2019 IRP Metrics Alignment

IRP Scorecard Metrics		Low-Cost Reliable Power	TVA Mission Economic Development	Environmental Stewardship
Cost	PVRR ($Bn)	✓	✓	
	System Average Cost ($/MWh)	✓	✓	
	Total Resource Cost ($Bn)	✓		
Risk	Risk/Benefit Ratio	✓		
	Risk Exposure ($Bn)	✓		
Environmental Stewardship	CO2 (MMTons)		✓	✓
	CO2 Intensity (lbs/MWh)		✓	✓
	Water Consumption (MMGallons)			✓
	Waste (MMTons)			✓
	Land Use (Acres)			✓
Operational Flexibility	Flexible Resource Coverage Ratio	✓		
	Flexibility Turn Down Factor	✓		
Valley Economics	Percent Difference in Per Capita Income	✓	✓	
	Percent Difference in Employment		✓	

2019 IRP Scorecard (by Strategy)

Category	Metric	Scenarios					
		1	2	3	4	5	6
Cost	PVRR ($Bn)						
	System Average Cost ($/MWh)						
	Total Resource Cost ($Bn)						
Risk	Risk/Benefit Ratio						
	Risk Exposure ($Bn)						
Environmental Stewardship	CO2 (MMTons)						
	CO2 Intensity (lbs/MWh)						
	Water Consumption (MMGallons)						
	Waste (MMTons)						
	Land Use (Acres)						
Operational Flexibility	Flexible Resource Coverage Ratio						
	Flexibility Turn Down Factor						
Valley Economics	Percent Difference in Per Capita Income						
	Percent Difference in Employment						

Questions about Scorecard Results?




TIME FOR
LUNCH
TIME FOR

Group Breakout: Scorecard Results

Hunter Hydas
Program Manager, Resource Strategy

Breakout Questions

1. Do you agree with the preliminary scorecard observations? Would you add or change anything?

2. Are scorecard results consistent with the expansion portfolios? Are variances explained by the portfolio expansion?

3. Which metrics and metric tradeoffs do you find most interesting and why?

Next Steps

Next Steps

- Publish Draft IRP/EIS on February 15th
- Receive public comments through April 8
- Prioritize sensitivities considering IRPWG, RERC and public input
- Review sensitivities at next several IRPWG meetings
- Develop recommendation in May IRPWG meeting

Running List of Planned Sensitivities

Current Outlook & Valley Growth / Base Case

- Retire Paradise 3 (2020) and Bull Run (2023)

Current Outlook / Base Case:

- Enforce promoted resources individually at moderate and high levels *
- Enforce distributed scale solar at same penetration as utility scale solar
- Accelerate pace of utility scale solar additions *
- Remove integration cost and flexibility benefit *
- Model high and low natural gas and power prices *
- Model higher ongoing costs for aging coal units

Current Outlook / Promote DER:

- Promote utility scale storage to moderate and high levels *
- Promote distributed storage to high level *

Current Outlook / Promote Renewables:

- Promote utility scale storage to high level *

** Included based on IRPWG feedback*

Considerations for Developing Recommendation

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

Tentative Meeting Dates / Locations

#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

Future Tentative 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

NEW

Thank you and Safe Travels!!

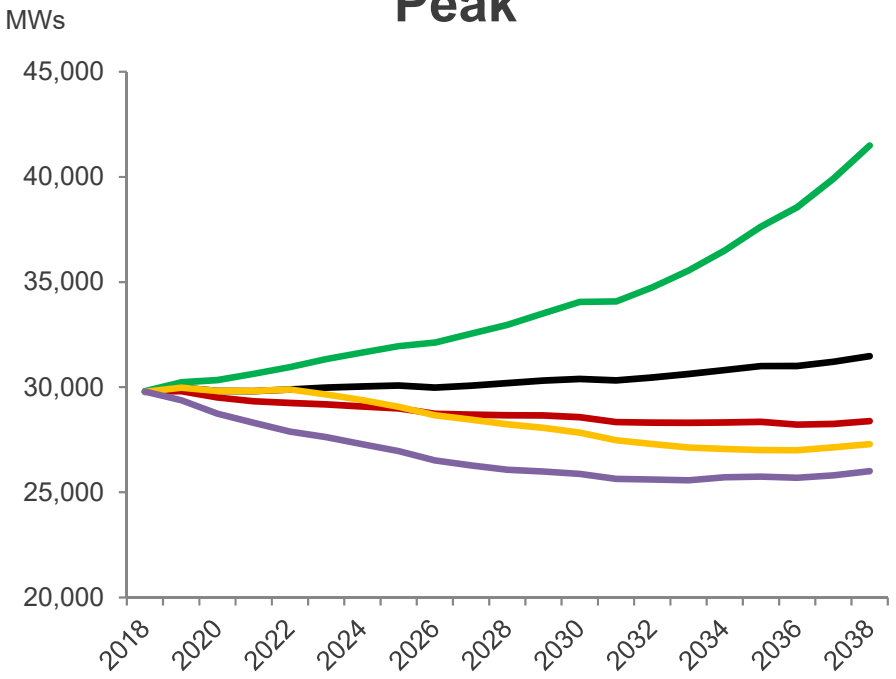
Appendix:
Portfolio Results

Appendix:
Scorecard Metrics

Appendix:
Key Planning Assumptions

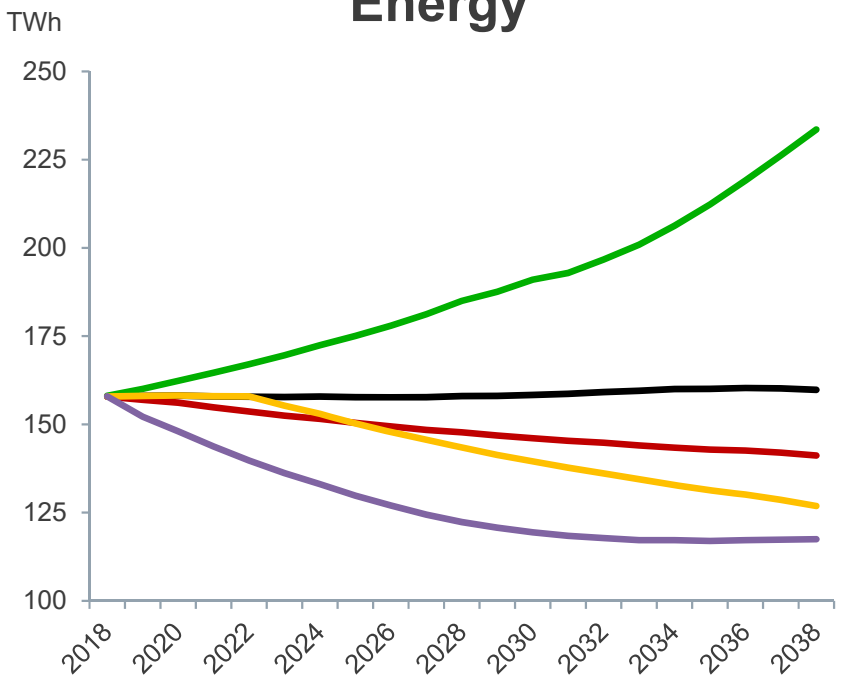
Scenario Forecasts: Load Outlook

Peak



	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	0.3%	-0.2%	1.7%	-0.4%	-0.7%	0.3%

Energy

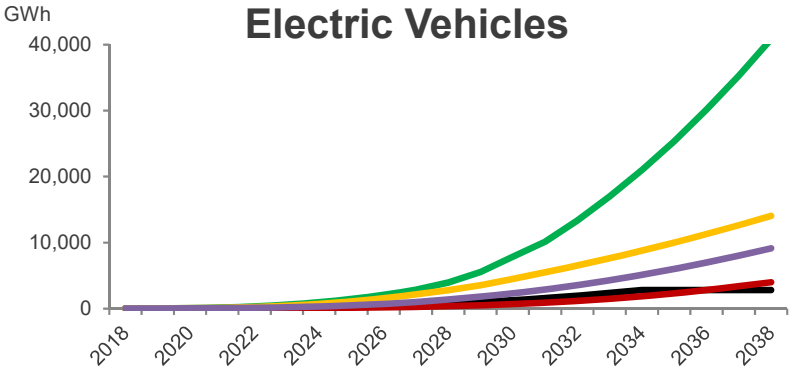


	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	0.0%	-0.5%	2.0%	-1.1%	-1.5%	0.0%

Note: Forecast for Scenario 6 Nuclear same as Scenario 1 Current Outlook

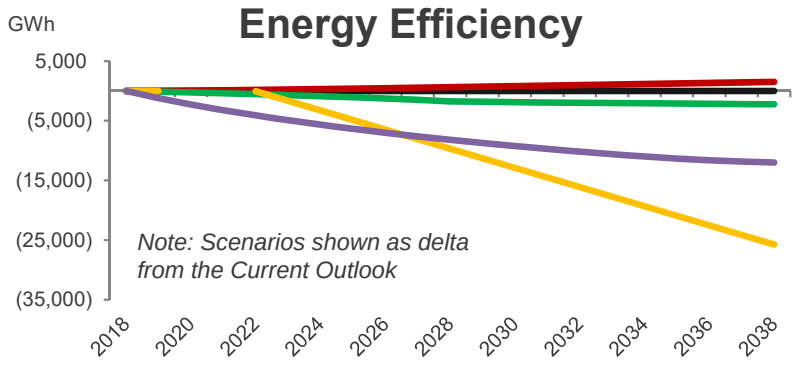
Scenario Forecasts: Behind the Meter Impacts

Electric Vehicles



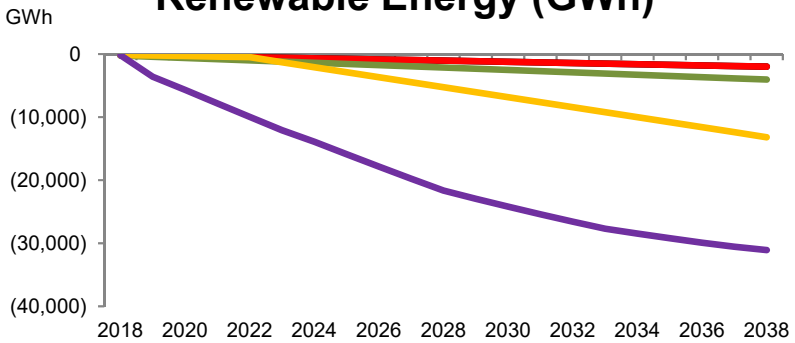
	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	27%	29%	43%	37%	34%	27%

Energy Efficiency



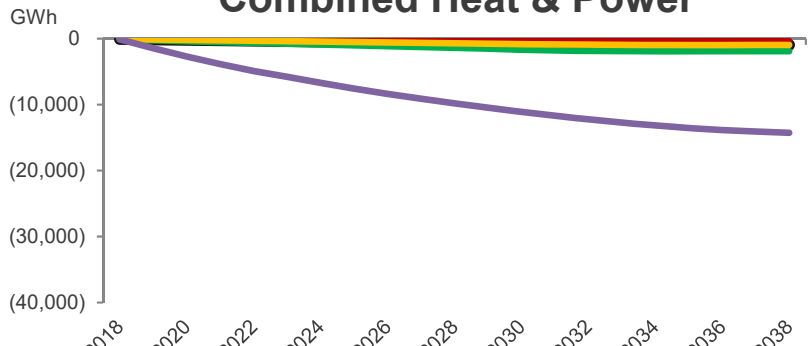
	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	N/A	44%	-47%	-66%	-60%	N/A

Renewable Energy (GWh)



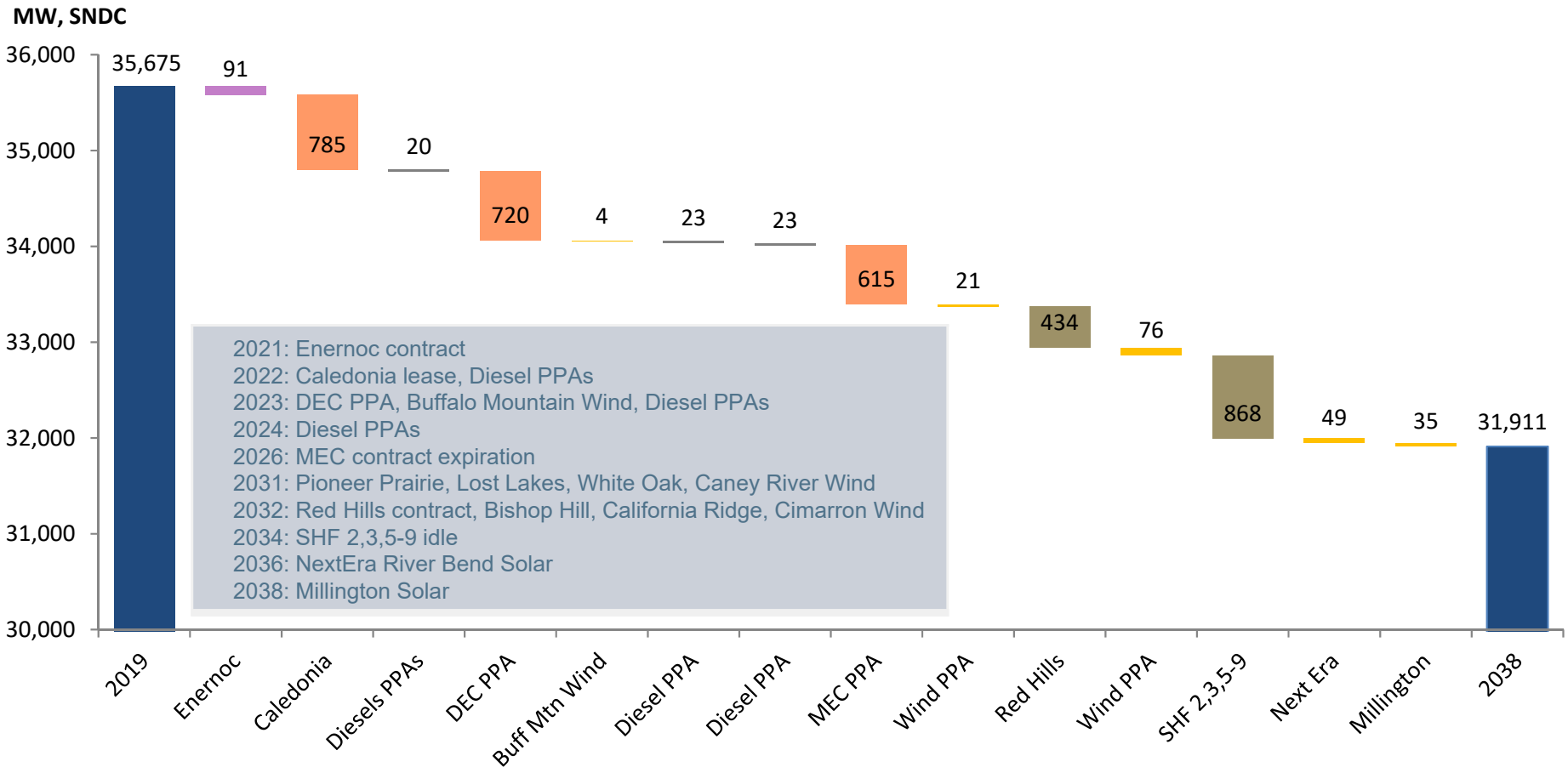
	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	-14%	-14%	-15%	-25%	-32%	-14%

Combined Heat & Power

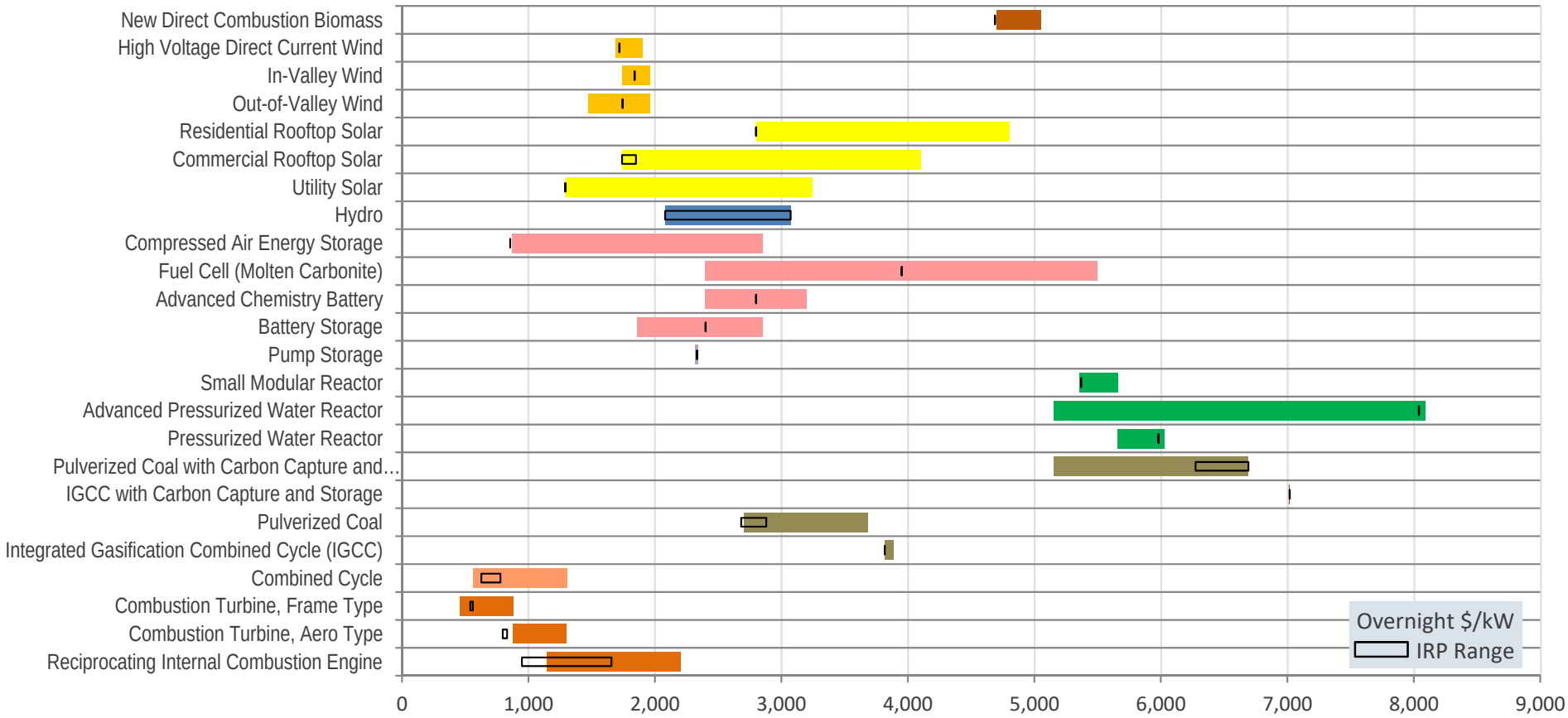


	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	-14%	-9%	-19%	-14%	-27%	-9%

Planned Reductions in Firm Capacity

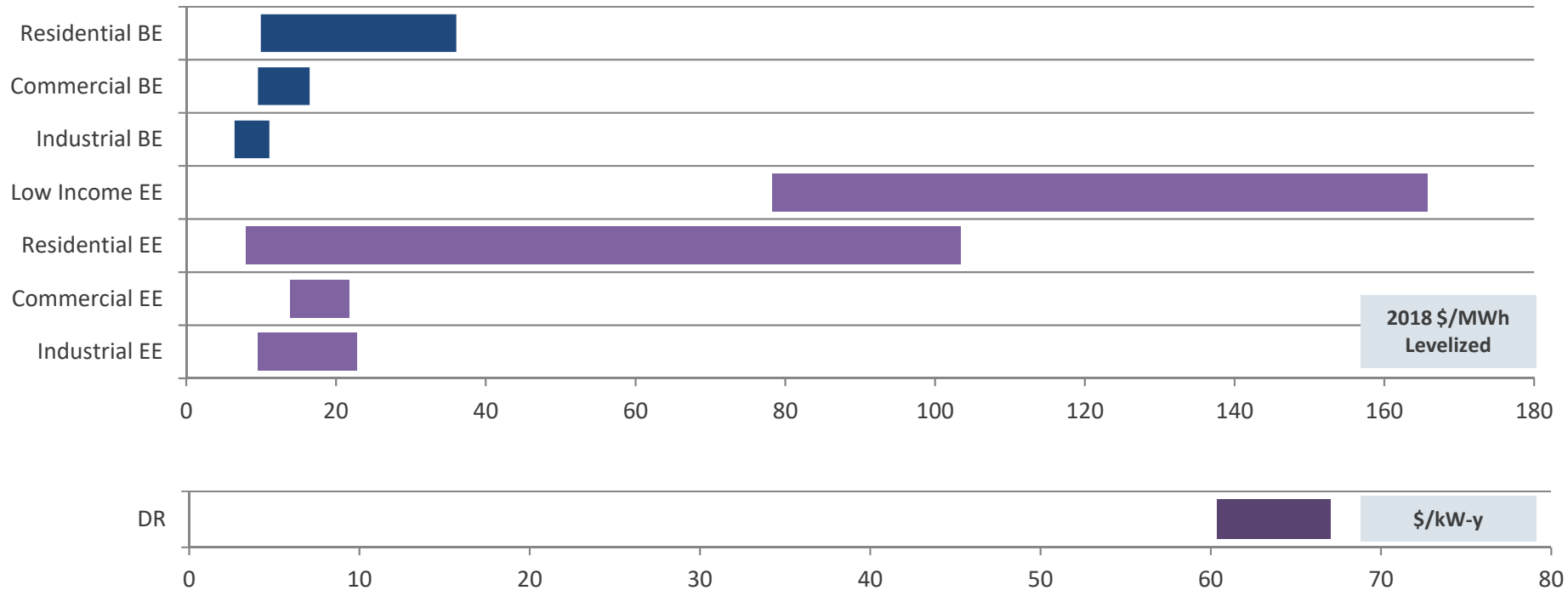


Resource Options and Cost Assumptions ($/kW)



Colored bars reflect benchmark ranges and black outlines represent TVA assumptions;
TVA assumptions outside of benchmark ranges are based on actual costs of TVA projects or vendor quotes.

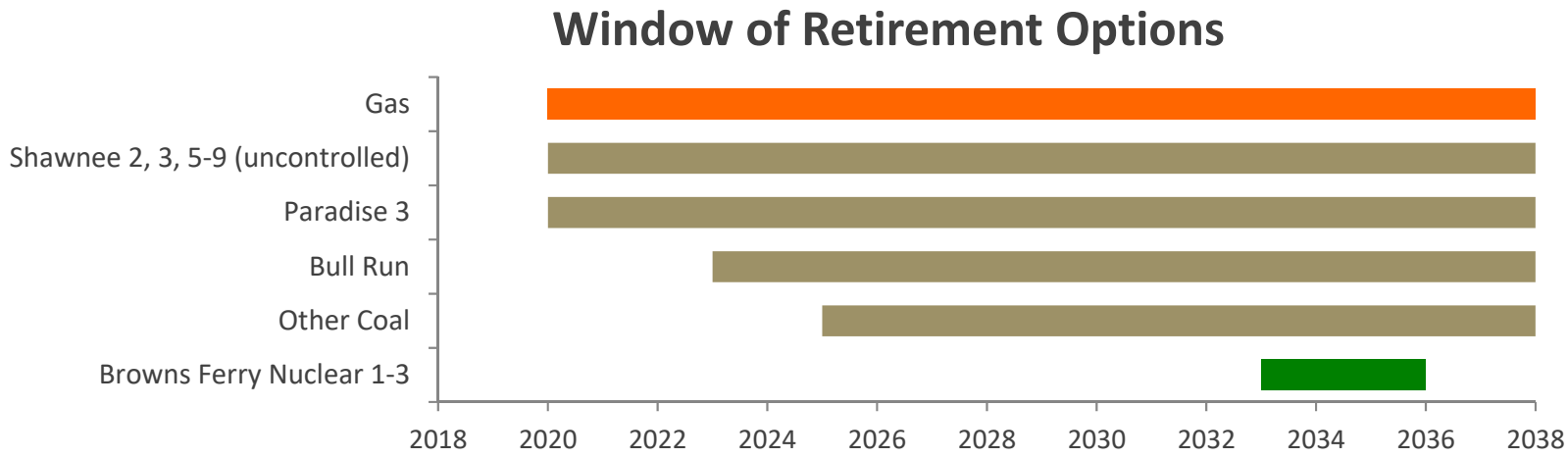
Programmatic DER Options & Cost Assumptions



BE = Beneficial Electrification
EE = Energy Efficiency
DR = Demand Response

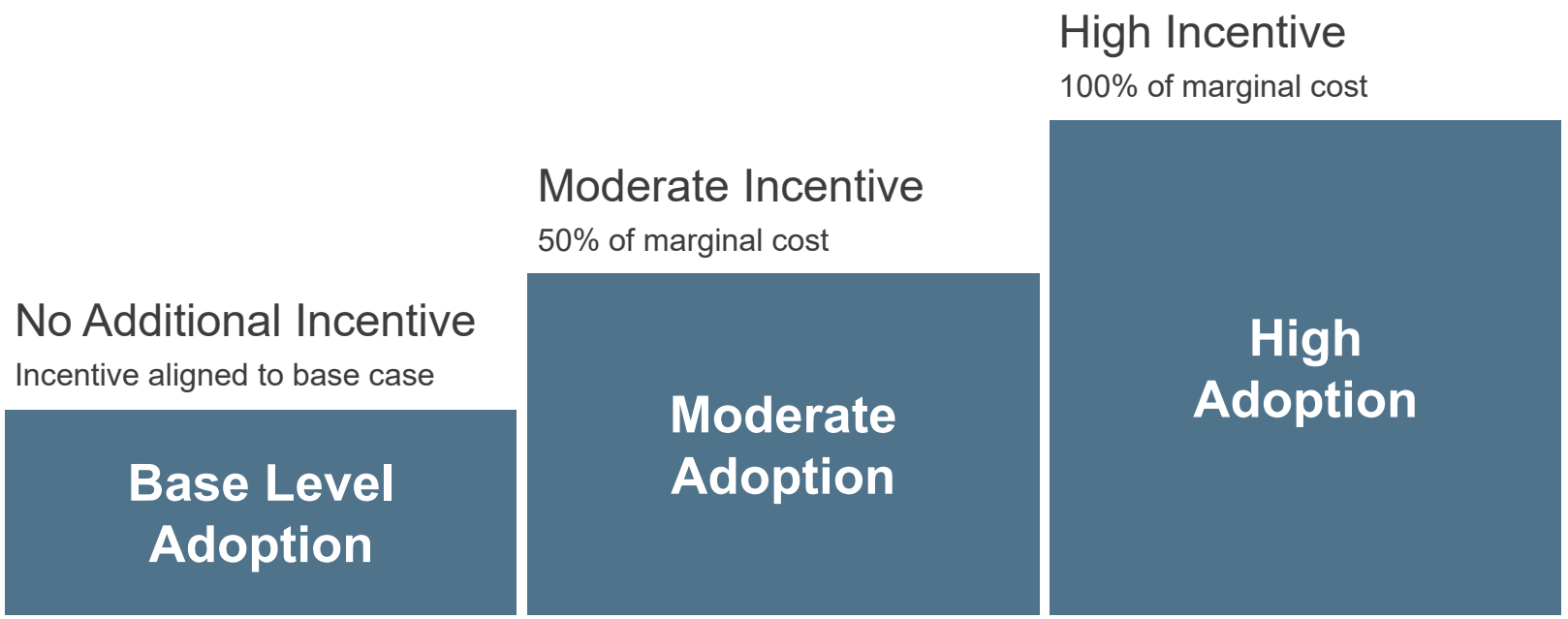
Retirement Options

Total costs can be reduced in low load scenarios or when replacement resources are more economic than the ongoing costs of existing resources. It is important that accurate ongoing costs, demolition/closure costs, and transmission upgrades required to retire resources are considered against the cost of new resources.



Strategies Promote Resources Using Incentives

Strategies provide incentives to promote adoption of certain resources, with consideration of potential, adoption curve, and reserve margin.



Strategy Design Matrix

Strategy	Distributed Resources & Electrification						Utility Scale Resources					
	Distributed Solar	Distributed Storage	Combined Heat & Power	Energy Efficiency	Demand Response	Beneficial Electrification	Solar	Wind	Biomass & Biogas	Storage	Aero CTs & Recip Engines	Small Modular Reactors
Base Case	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
Promote DER	High	Moderate	High	Moderate	Moderate	Base	Base	Base	Base	Base	Base	Base
Promote Resiliency	Moderate	High	Moderate	Base	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate
Promote Efficient Load Shape	Base	Moderate	Base	High	High	Moderate	Base	Base	Base	High	Base	Base
Promote Renewables	Moderate	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate	Moderate	Base	Base

Low Income Energy Efficiency is promoted in the following manner across the strategies:

- Pilot continuation (Base, Resiliency, Renewables)
- Pilot expanded valley-wide (DER)
- Pilot expanded valley-wide and incentives increased (Efficient Load Shape)

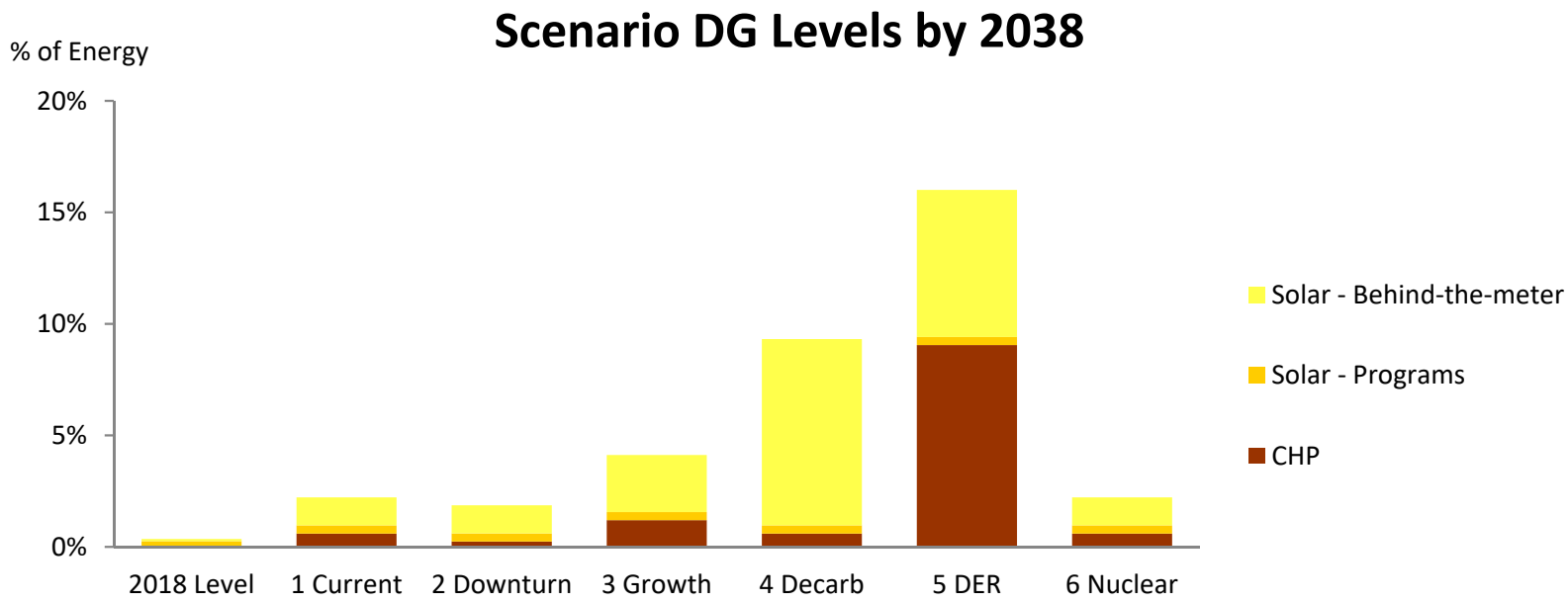
Distributed Resource Modeling Methodology

Distributed resource adoption at a base, moderate, or high level of incentives will be enforced in the model according to strategy design, prior to optimizing the balance of resources for a portfolio. The individual steps in this process are described below.

This approach for modeling distributed generation allows TVA to gain insights into the impact that distributed resources could have on the TVA system under a variety of different future states.

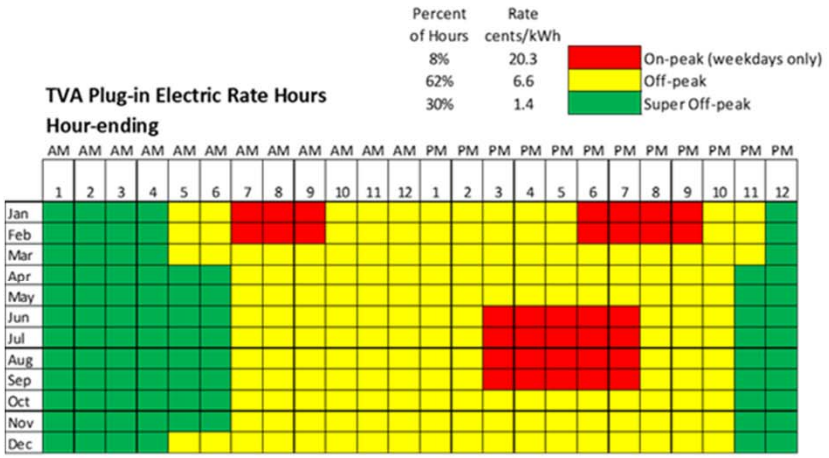
Distributed Generation Adoption Levels by Scenario

Each scenario has unique assumptions for DG penetration prior to portfolio optimization to fill the capacity gap for each strategy. In scenarios that have high DG penetration, there may be little or no opportunity to incent additional DG adoption.

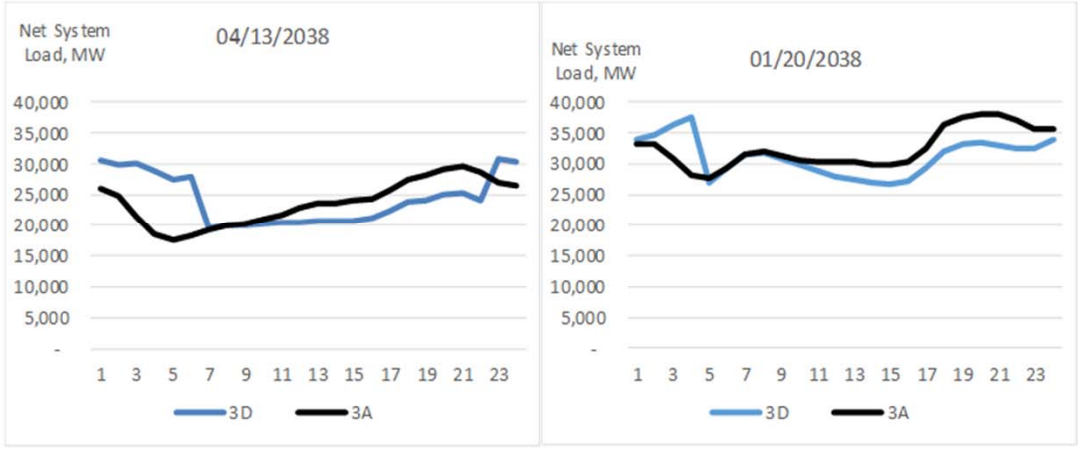


EV & Battery Charging Rate Structure (Strategy D)

Strategy D promotes an efficient load shape through a time of use rate structure applied to electric vehicle and battery usage across the scenarios. For Strategy D portfolio optimization, an alternate load shape is used applying this structure.



Note: Based upon Georgia Power's Plug-in Electric Program



Effects of rate structure are most pronounced in scenario 3

Considering Uncertainty in Resource Planning

While scenarios explore step changes in possible futures, stochastic analysis evaluates risk of uncertainty around key planning assumptions for each portfolio.

Variability occurs within each scenario and strategy combination, driven by:

- Weather
- Market conditions
- Energy usage patterns
- Unit performance
- Operating costs
- Capital costs

Monte Carlo simulation allows for a better understanding of portfolio performance by testing the variability of key assumptions and expressing portfolio results as a range around an expected case.