2019 IRP Working Group

Meeting 9: December 19-20, 2018


welcome

Safety Moment

Building Emergency Plan

Introductions

- Name
- Organization and Role

Agenda – December 19

Highlighted sections contain confidential information

9:00	Welcome and Introductions and Safety Moment	Jo Anne Lavender
9:10	Meeting 8 Re-Cap – key things covered Overview for today's session	Brian Child
9:15	Refresh of results framework as set up for showing prelim results	Jane Elliott
10:15	Break	
10:30	Introduce Discussion Questions	Jo Anne Lavender
10:35	Scenario 1 prelim results	Jane Elliott
12:00	Lunch	
1:00	Scenario 2 and 4 prelim results	Jane Elliott
2:45	Break	
3:00	Scenario 5 prelim results	Jane Elliott
4:00	Wrap Up Day 1	Lavender / Child
4:00 – 5:00	Time for individual questions / materials review	Group
6:00	Optional Group Dinner – Calhoun's on the River	

Agenda – December 20

Highlighted sections contain confidential information

8:00	Optional Breakfast – Continental at Hotel	
8:30	Welcome and Recap Day 1	Lavender / Child
9:00	Recap High Points of Prelim Results	Elliott
9:45	Q&A - What additional questions do you have?	Group
10:30	Break	
10:45	Review /Discussion	Group
12:00	Group Lunch	
1:00	Group Break out discussion and report outs	Group
2:30	Wrap Up and Adjourn by 2:30	

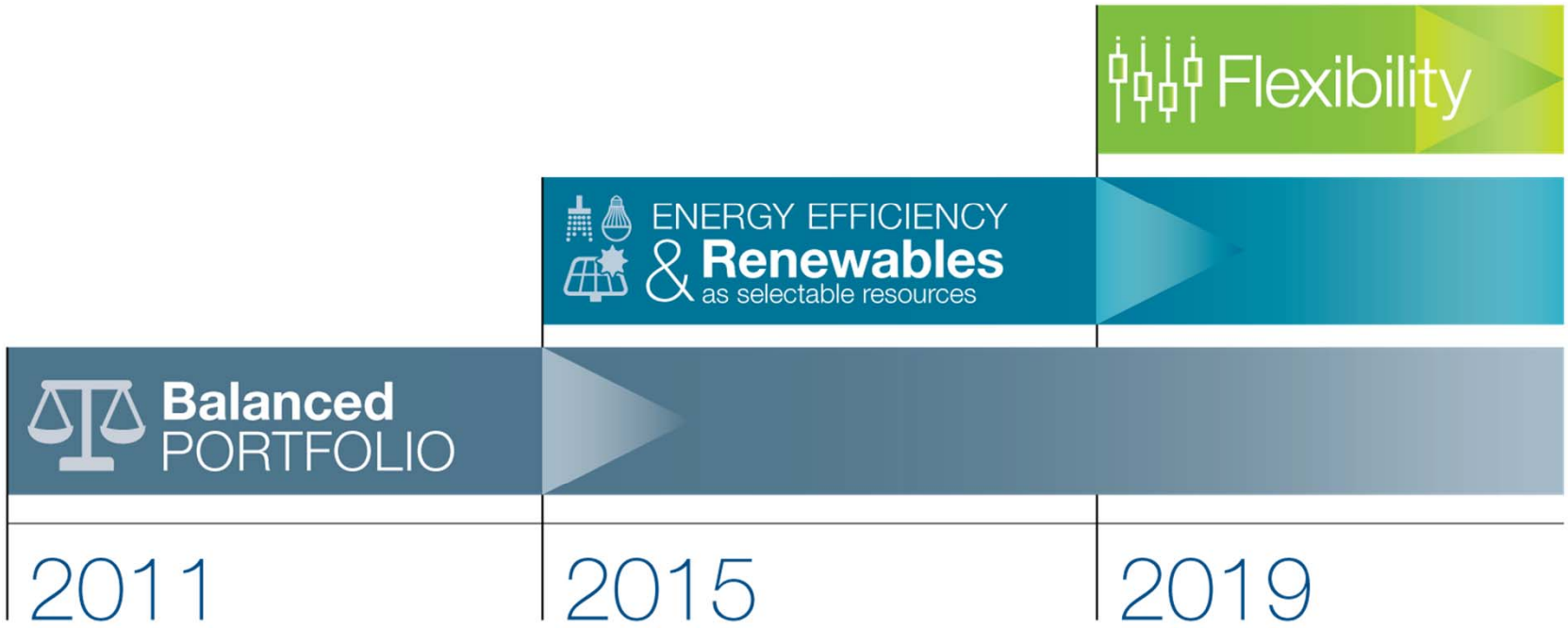
IRPWG Meeting 8 Recap

Brian Child

October Meeting Highlights

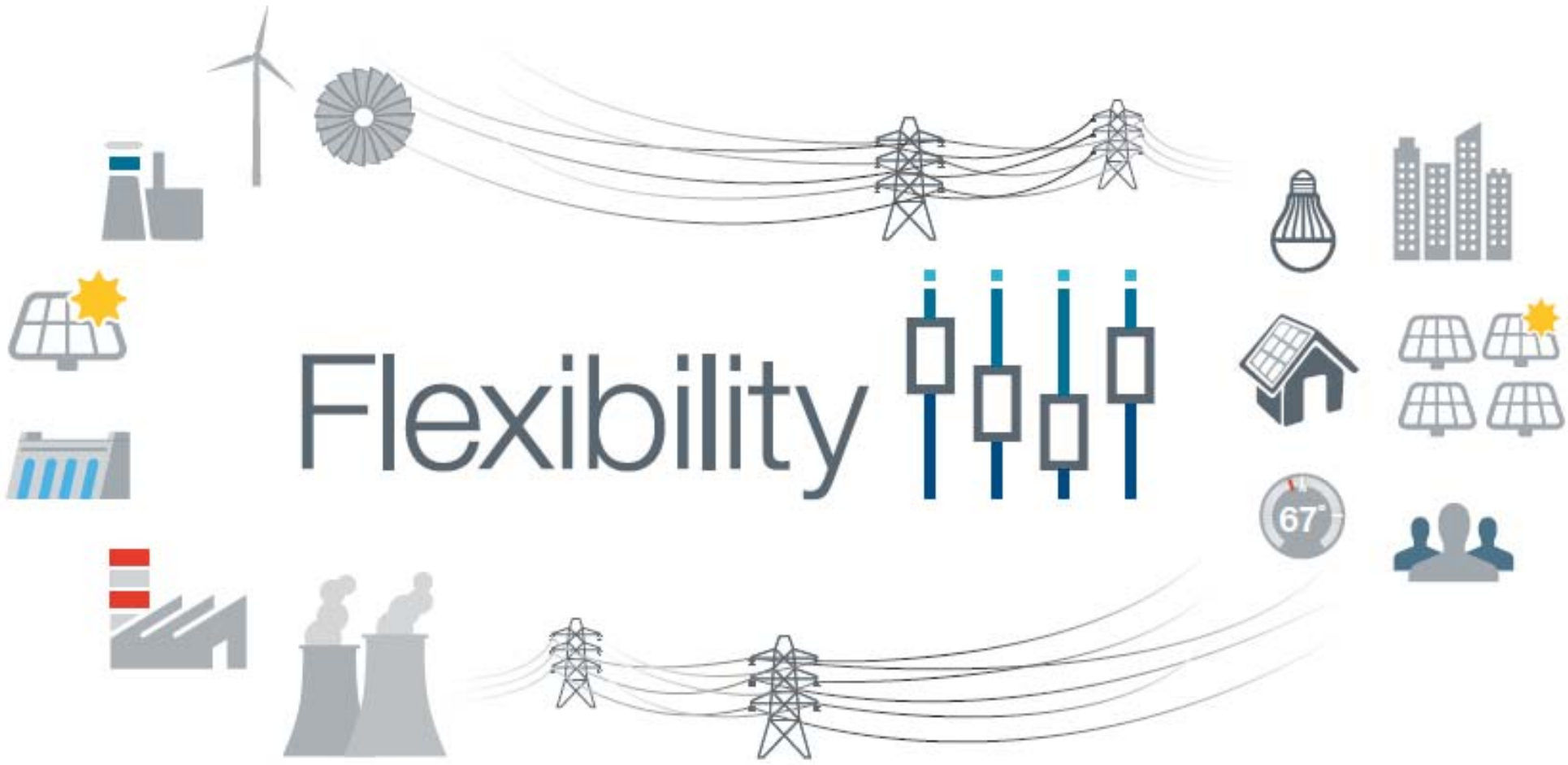
- Finalized Metrics
- Followed up on Environmental Impact Statement
- Reviewed Reference Case

INTEGRATED Resource Plan 2019



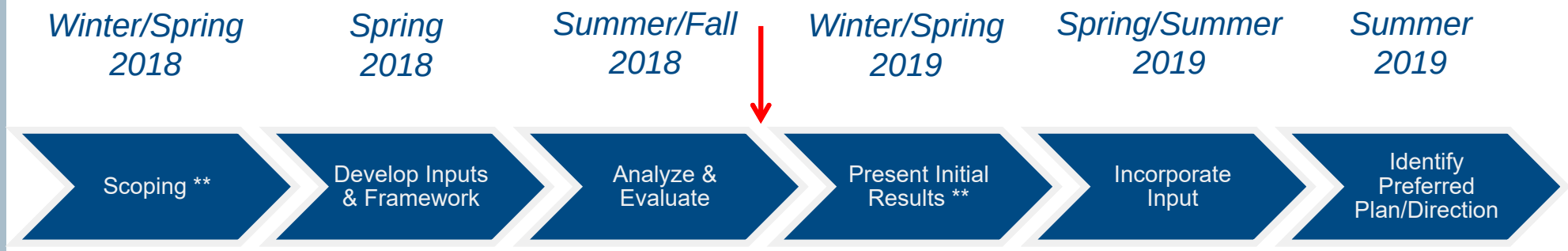
2019 IRP Focus Areas

- 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

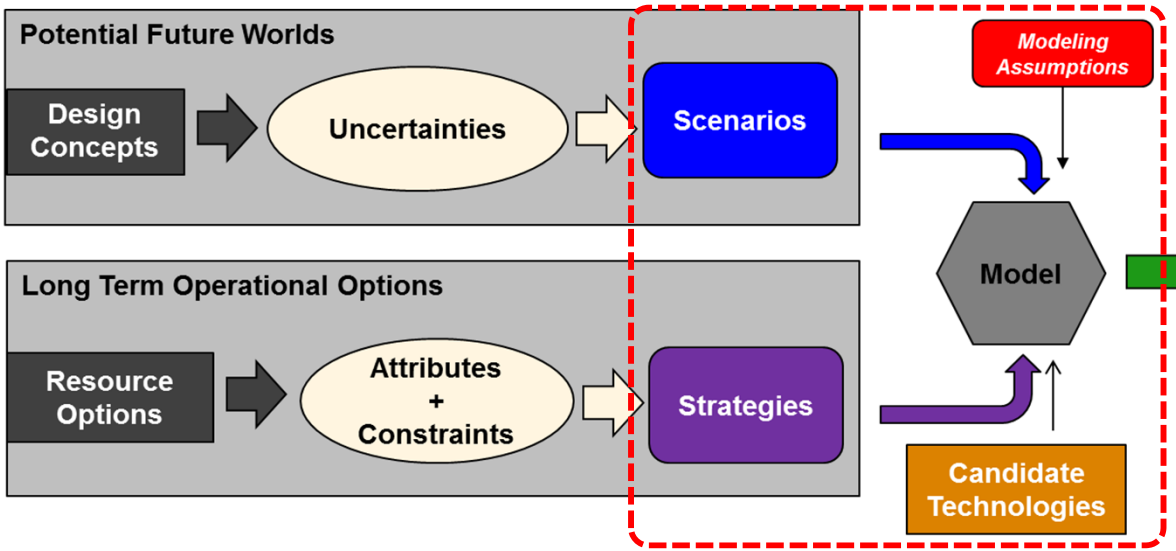
Refresher on Model Framework & Assumptions

Jane Elliott

Senior Manager, Resource Strategy

TVA

Model Framework & Assumptions Refresher



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

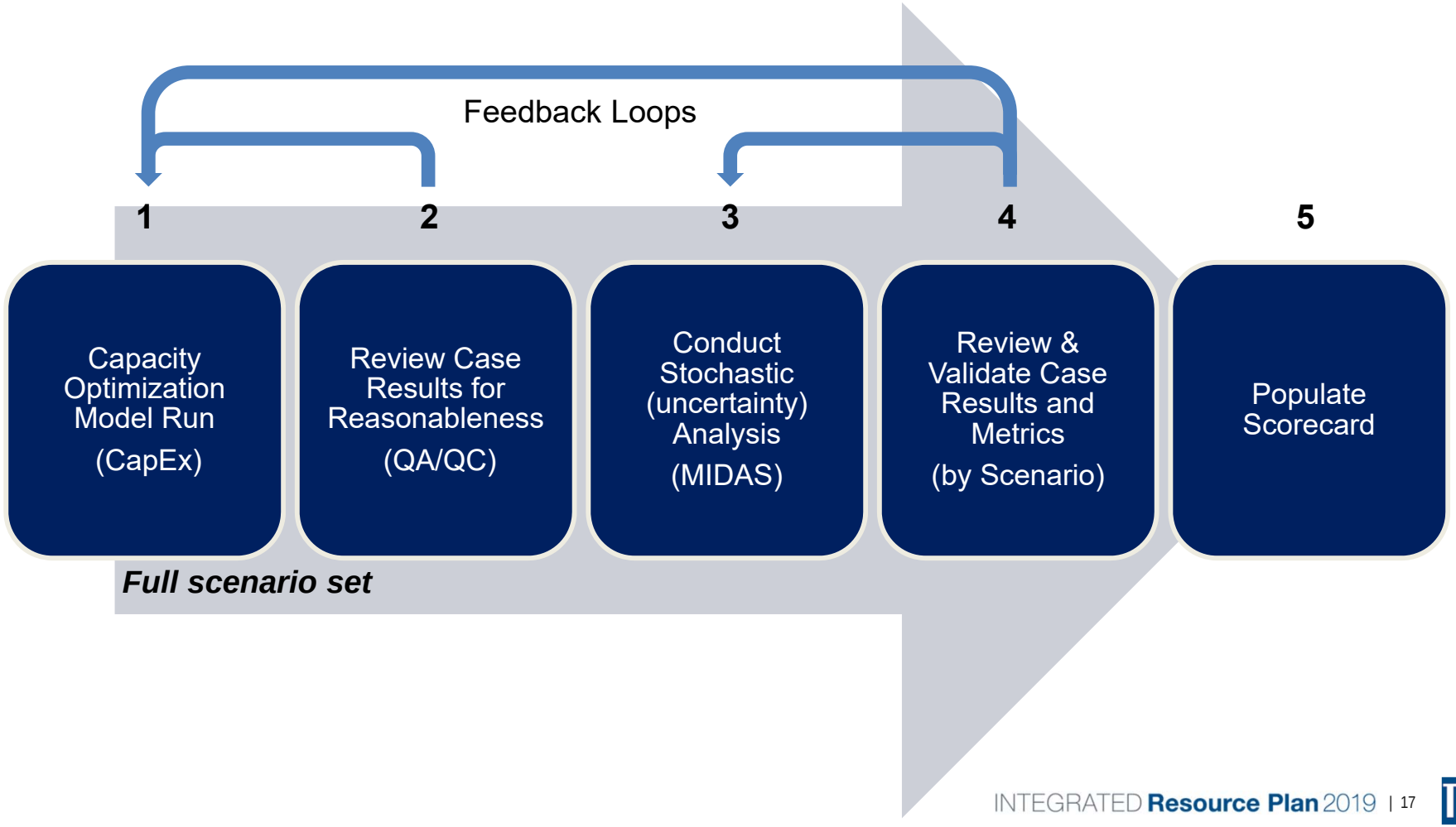
Scenarios

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

Strategies

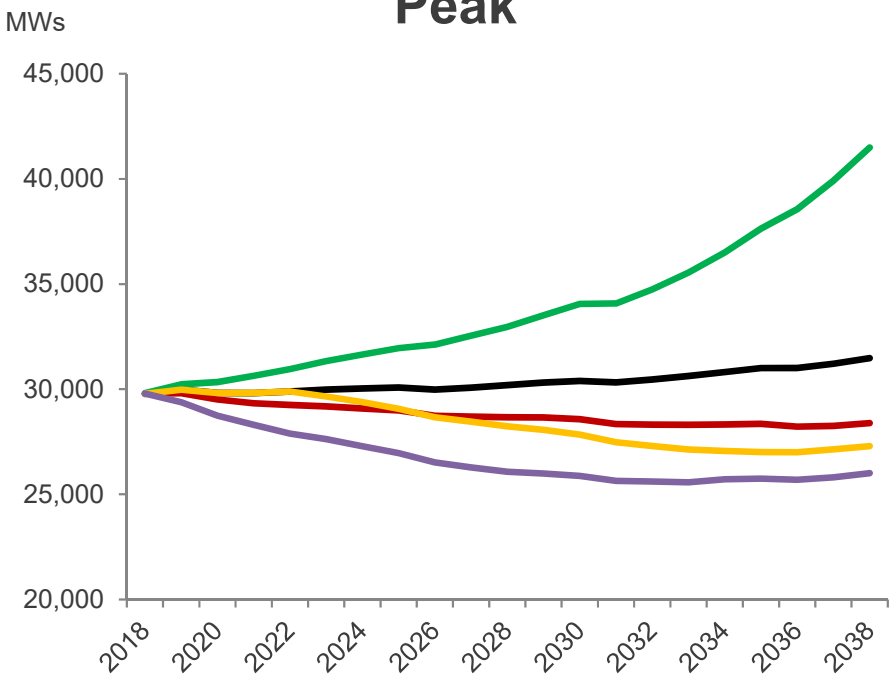
A. *Base Case*
B. *Promote DER*
C. *Promote Resiliency*
D. *Promote Efficient Load Shape*
E. *Promote Renewables*

The Modeling Process Involves Five Steps



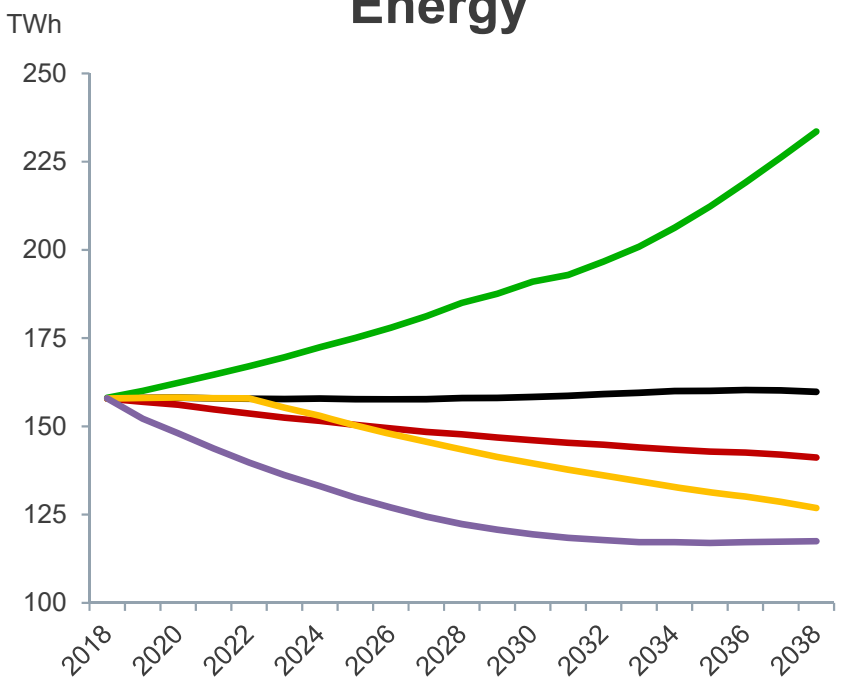
Scenario Forecasts: Load Outlook

Peak



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

Energy

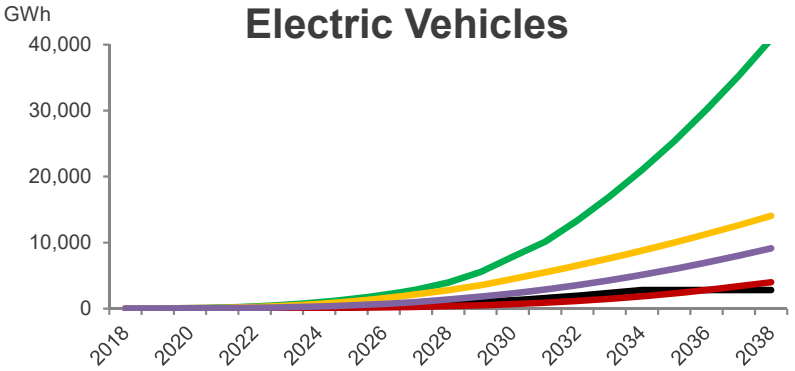


	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	0.0%	-0.5%	2.0%	-1.1%	-1.5%	0.0%

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

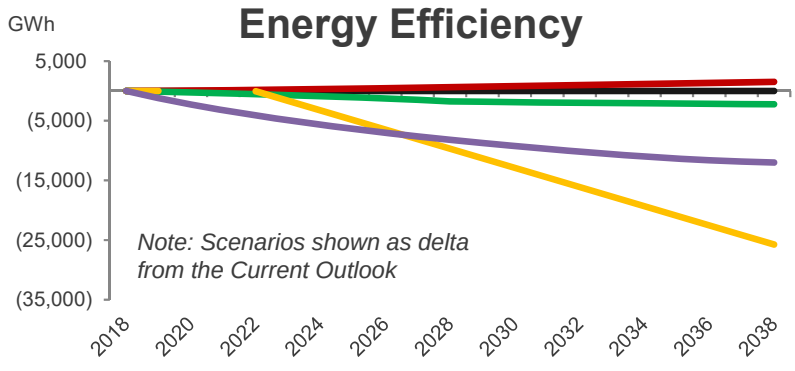
Scenario Forecasts: Behind the Meter Impacts

Electric Vehicles



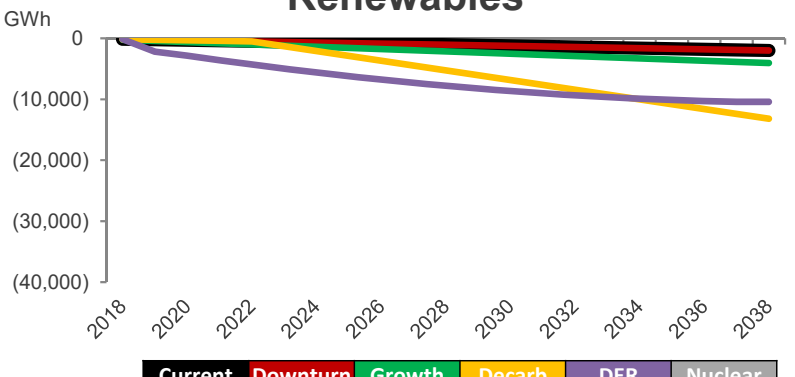
	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	27%	29%	43%	37%	34%	27%

Energy Efficiency



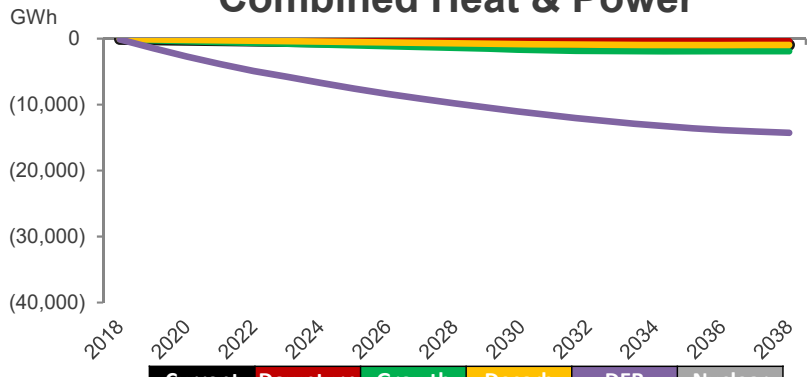
	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	N/A	44%	-47%	-66%	-60%	N/A

Renewables



	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	-14%	-14%	-15%	-25%	-23%	-14%

Combined Heat & Power



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

Planning for an Evolving System

Winter Peaking Demand

Updated reserve margins support reliability in both winter and summer and with more renewables expected on the system

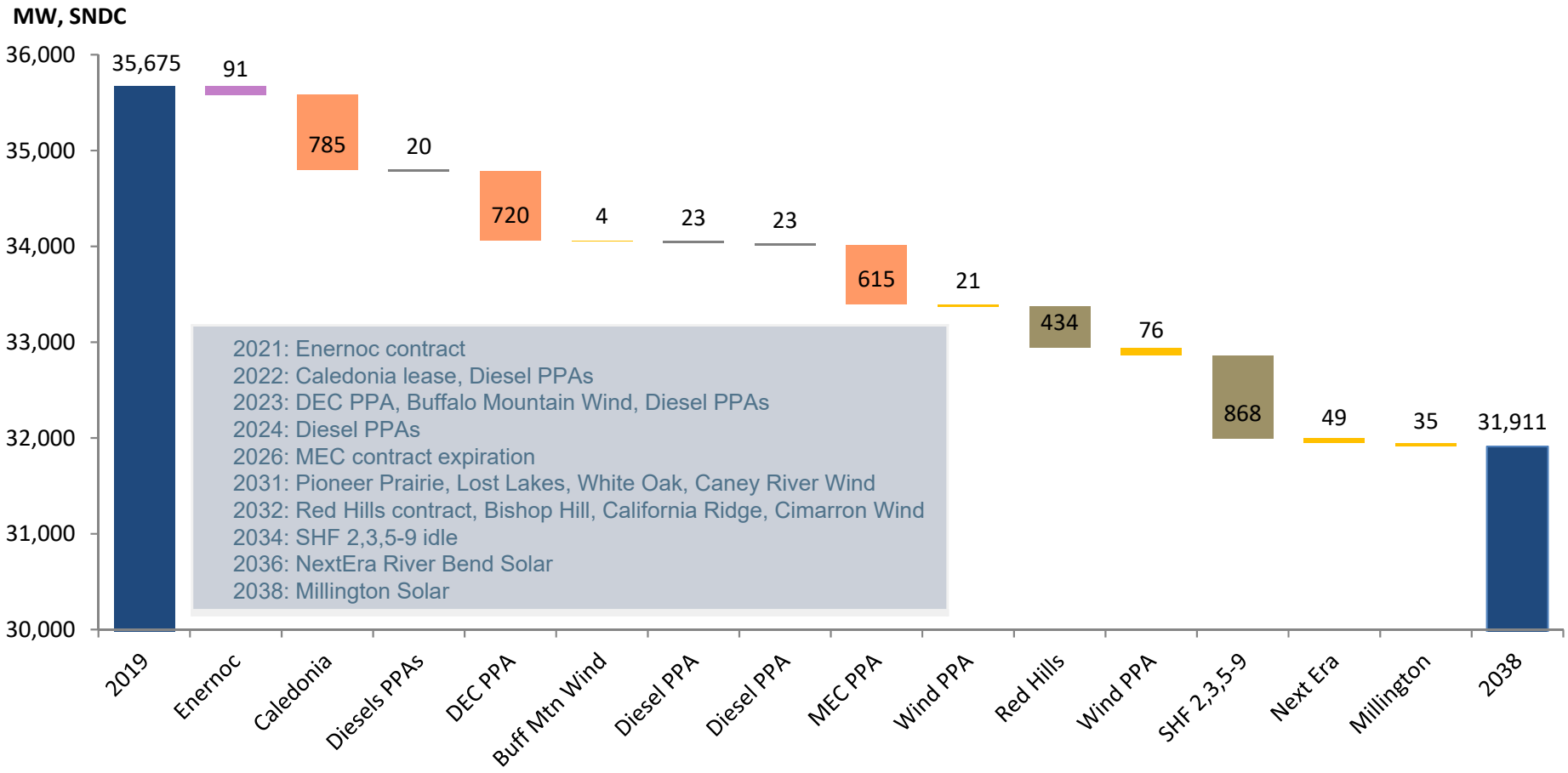
More Renewable Resources

Integration cost recognizes the sub-hourly costs driven by integrating intermittent resources onto the system

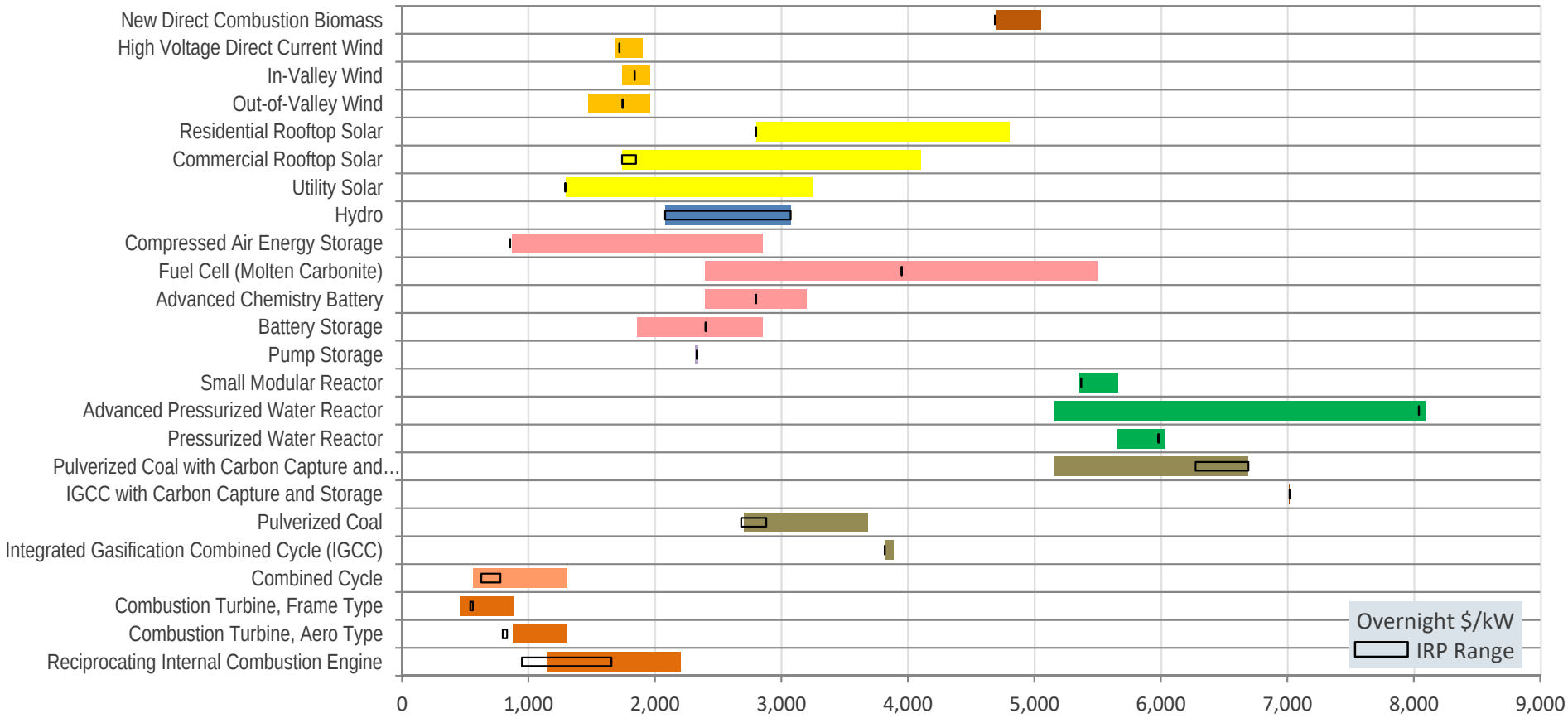
Increasing Need for Flexibility

Flexibility benefit recognizes the sub-hourly benefits driven by integrating highly flexible resources onto the system

Planned Reductions in Firm Capacity

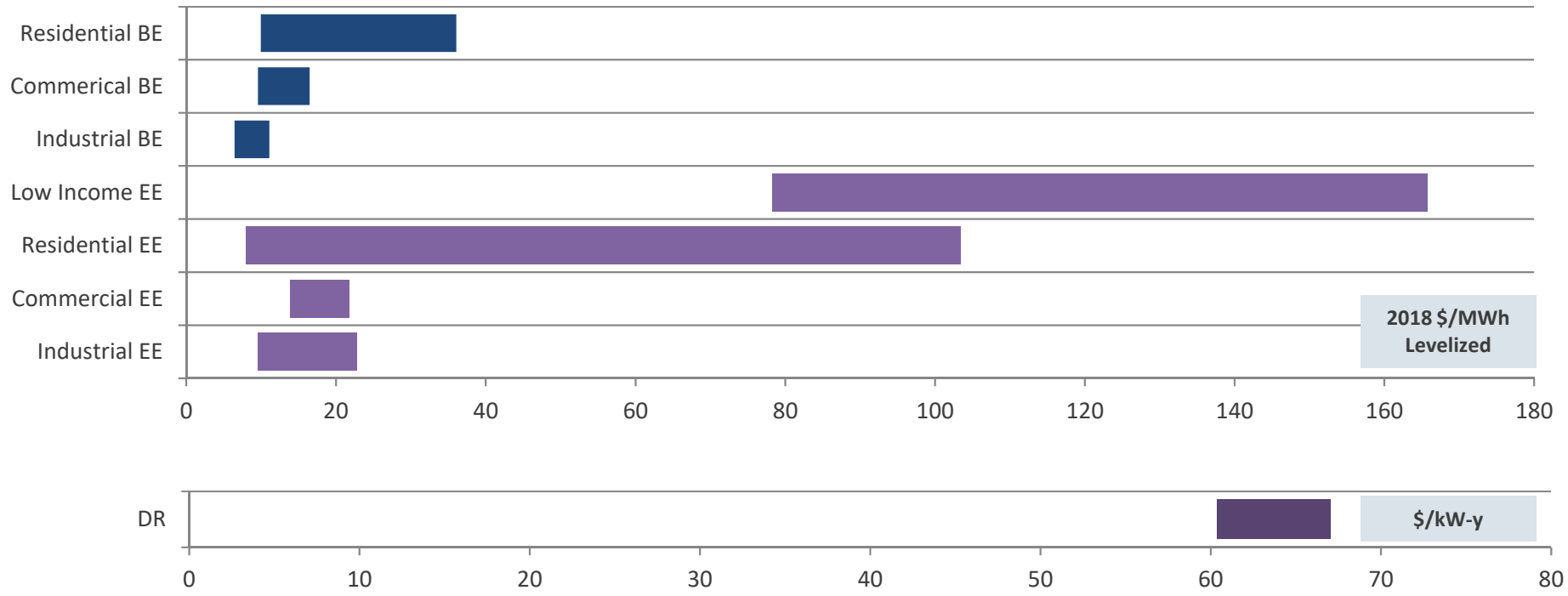


Resource Options and Cost Assumptions ($/kW)



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.

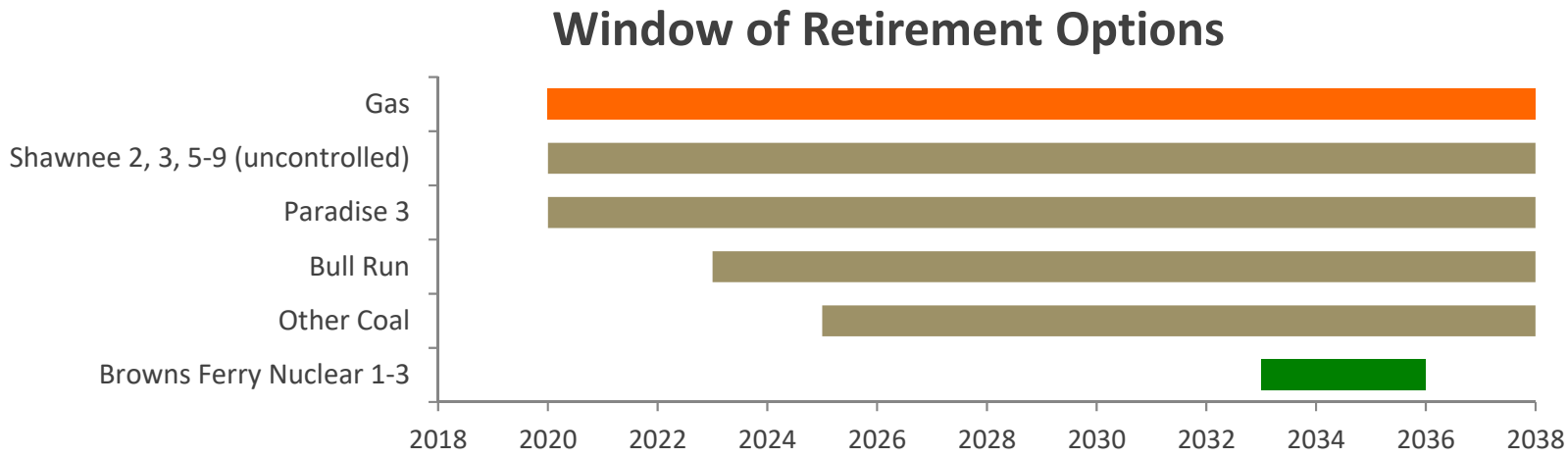
Programmatic DER Options & Cost Assumptions



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

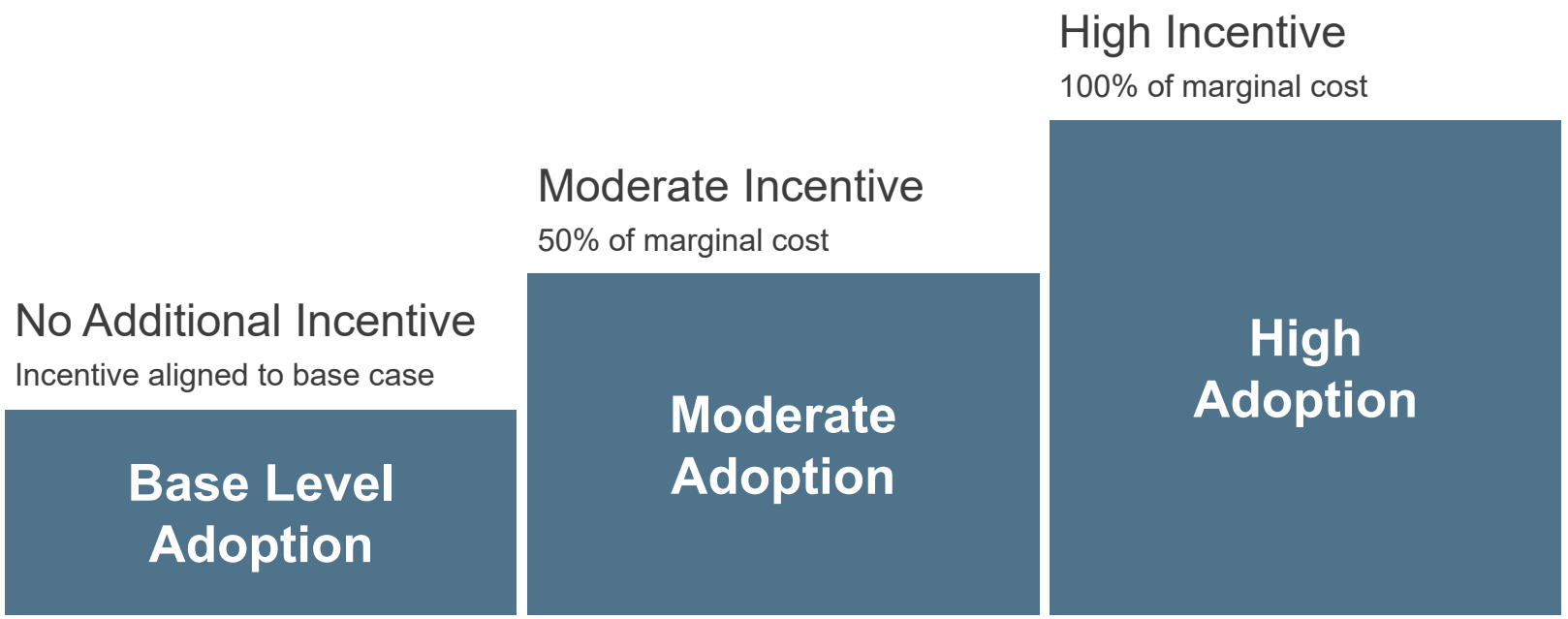
Retirement Options

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)

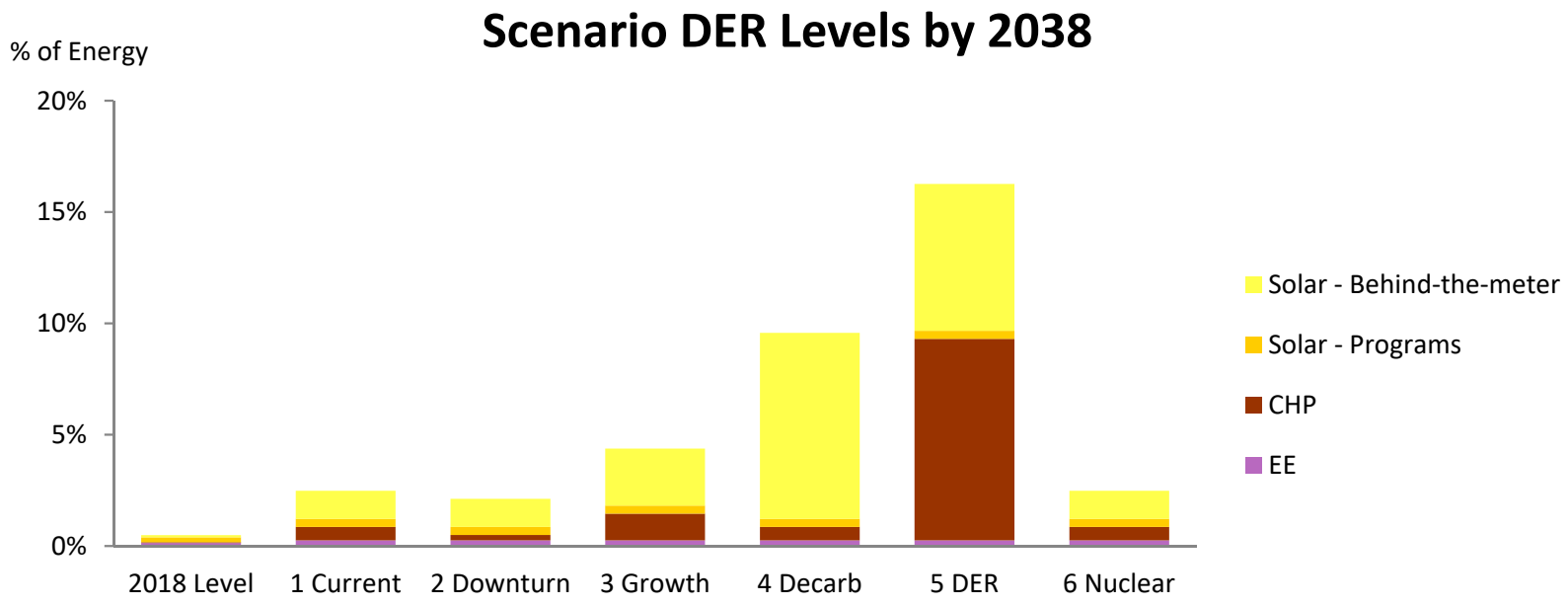
Distributed Resource Modeling Methodology

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.

DER Base Adoption Levels by Scenario

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



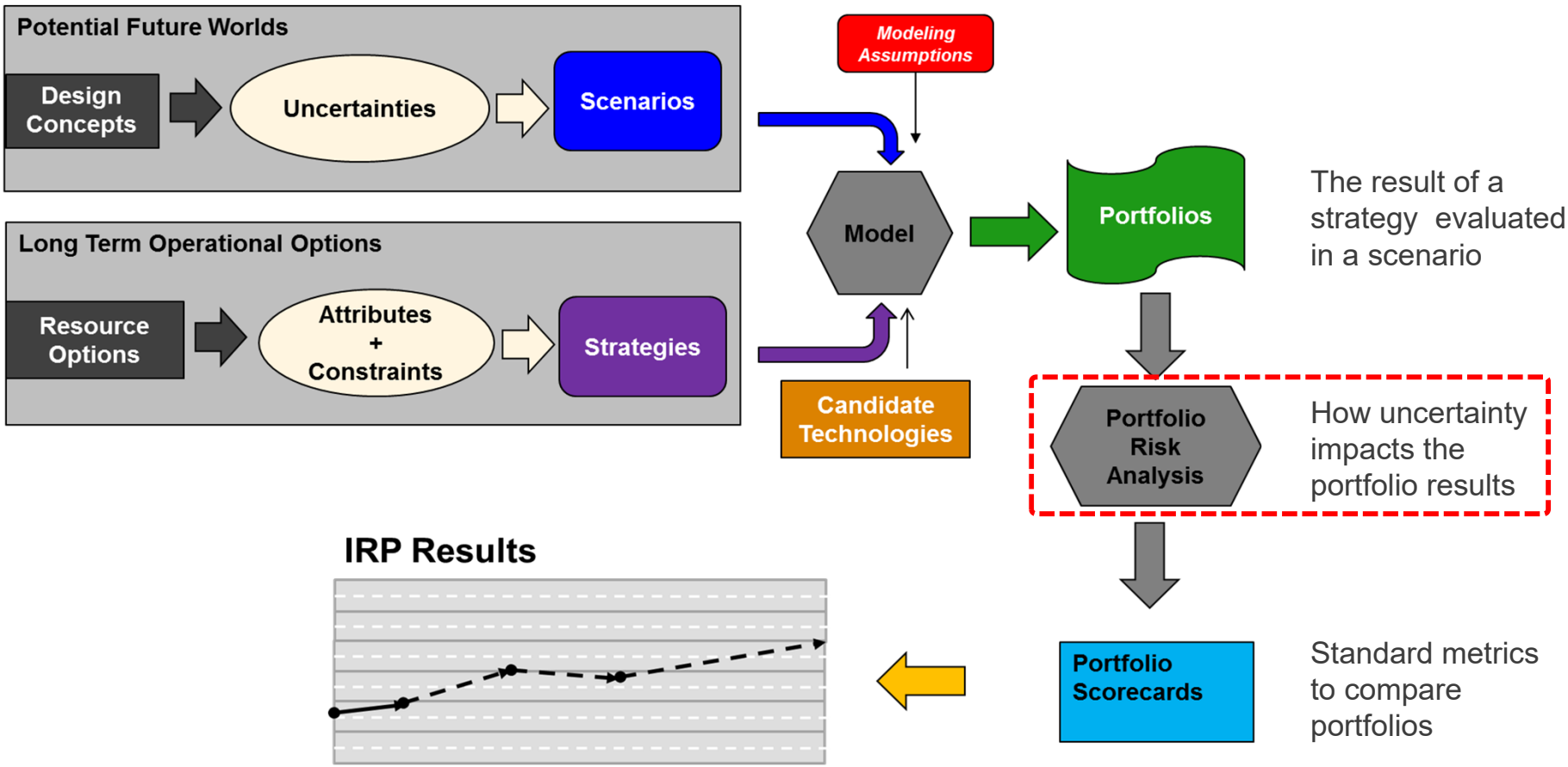
Considering Uncertainty in Resource Planning

Jane Elliott

Senior Manager, Resource Strategy

TVA

Considering Uncertainty in Resource Planning



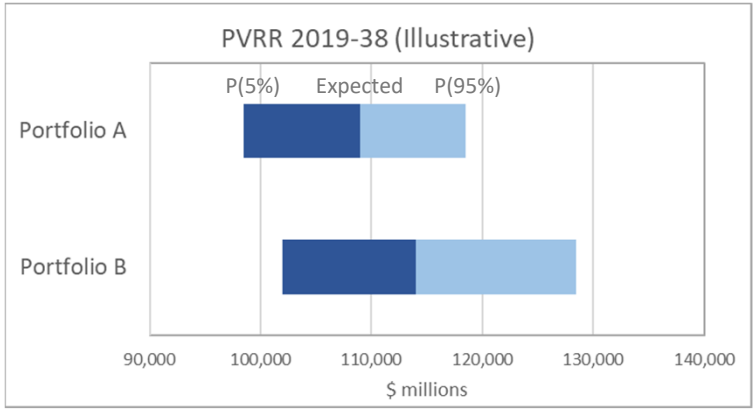
Considering Uncertainty in Resource Planning

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
- Operating costs
- Capital costs
- Unit performance

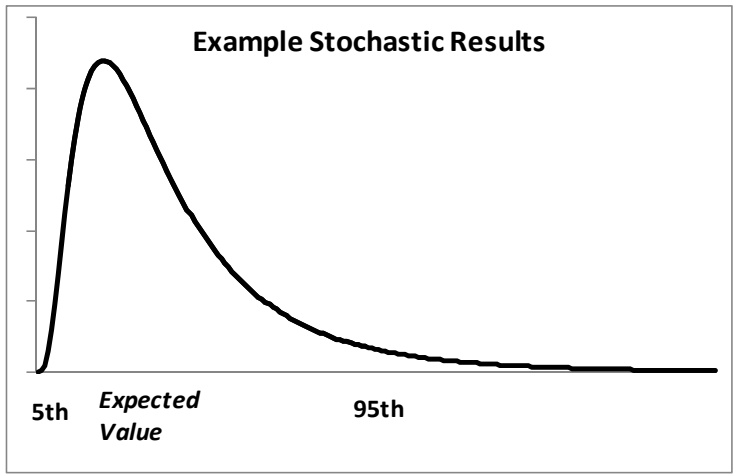
Monte Carlo simulation allows for a better understanding of portfolio performance by testing the variability of key assumptions and expressing portfolio results as a range around an expected case.



Considering Uncertainty in Resource Planning

A stochastic model estimates probability distributions of potential outcomes by allowing for simultaneous random-walking variation in many inputs over time.

Monte Carlo distributions are created using Latin Hypercube sampling of the variables that have the most impact on production cost and financial results.

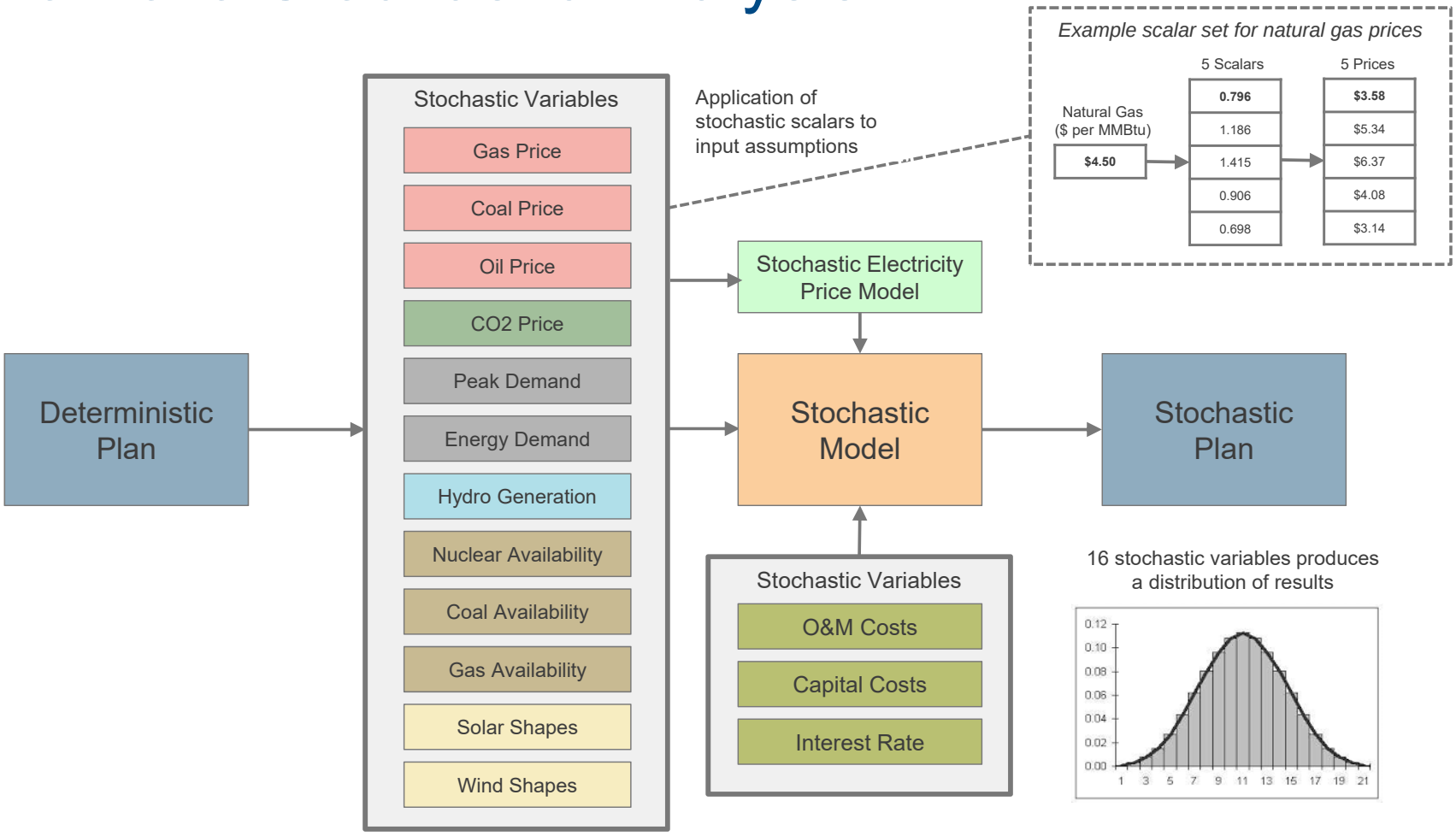


The following uncertainties vary in each iteration:

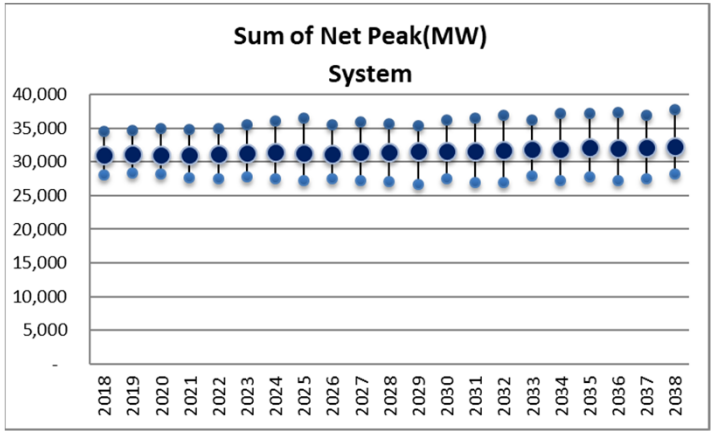
- Gas price
- Coal price
- Oil price
- CO2 price
- Peak demand
- Energy demand
- Electricity price
- Hydro generation
- Nuclear availability
- Coal availability
- Gas availability
- Solar and wind shapes
- O&M and capital costs
- Interest rates

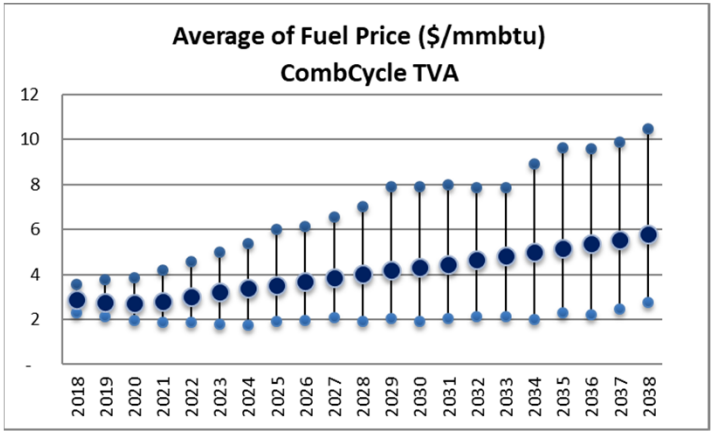
Scorecard metrics are computed on the expected values produced from stochastic runs.

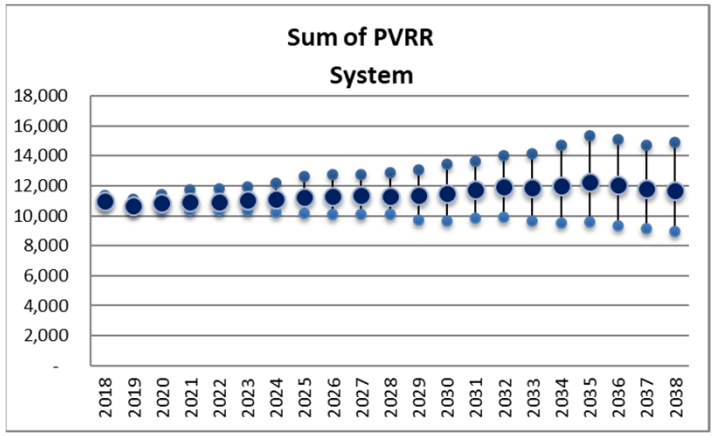
Portfolio Stochastic Analysis

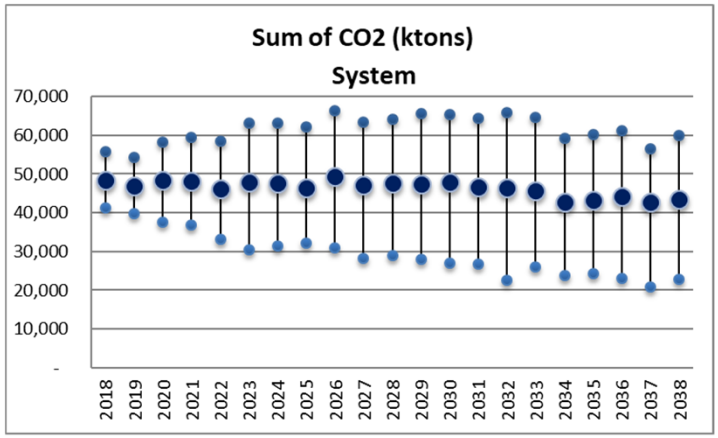


Examples of Stochastic Plan Output









BREAK

Introduce Discussion Questions

Jo Anne Lavender

Group Discussion:

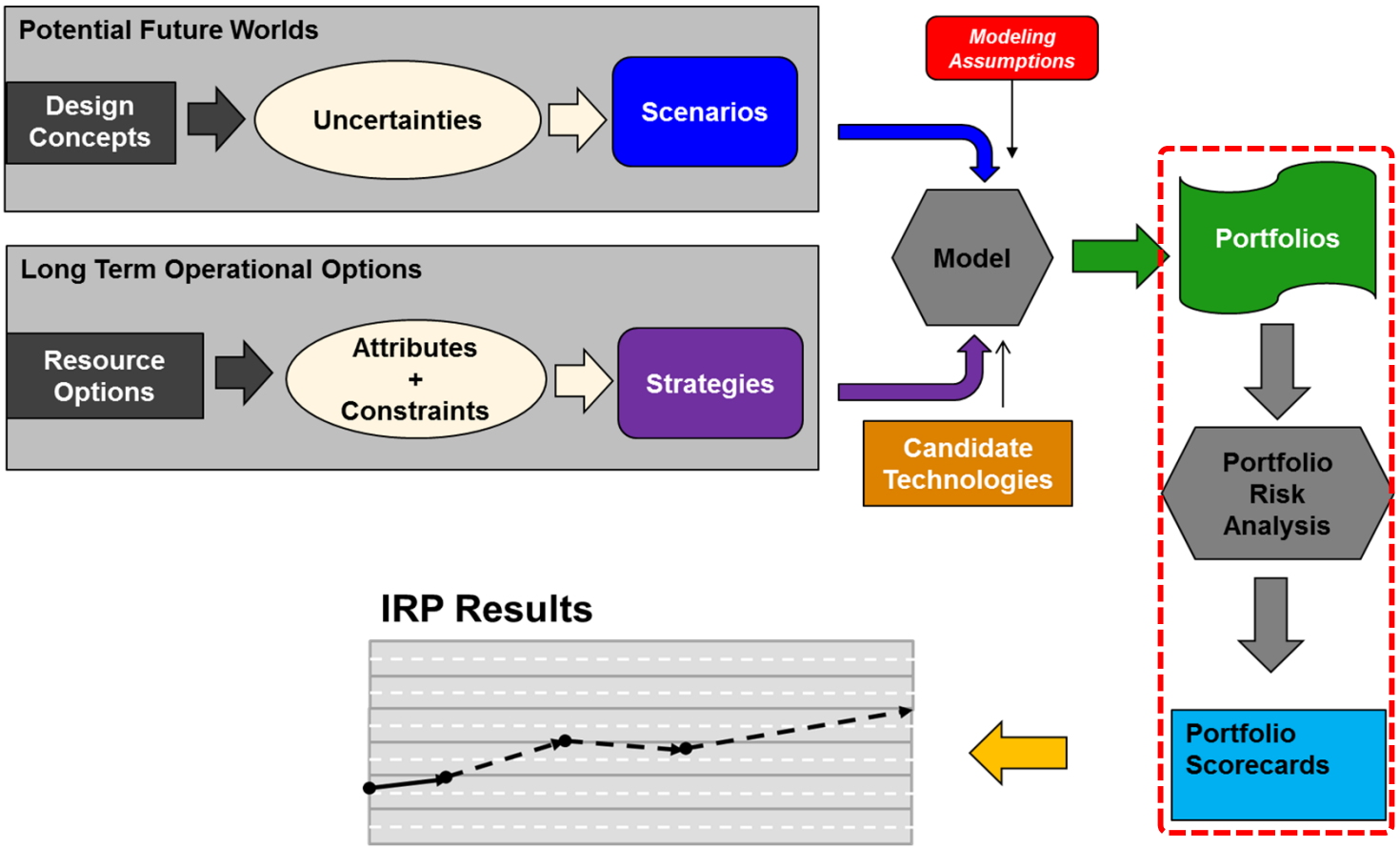
What are your observations and thoughts on the 2019 preliminary results?

Did anything surprise you?

Preliminary Modeling Results

Jane Elliott
Senior Manager, Resource Strategy

Preliminary Modeling Results



The result of a strategy evaluated in a scenario

How uncertainty impacts the portfolio results

Standard metrics to compare portfolios

2019 IRP Scenarios & Strategies

Presenting results today for Scenarios 1, 2, 4 and 5 for all 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*

Scenario 1 summaries show a 1A case (Current Outlook / Base Case without additional retirements), as well as a 1A1 case (with potential Paradise and Bull Run retirements) as a sensitivity.

Expansion Observations

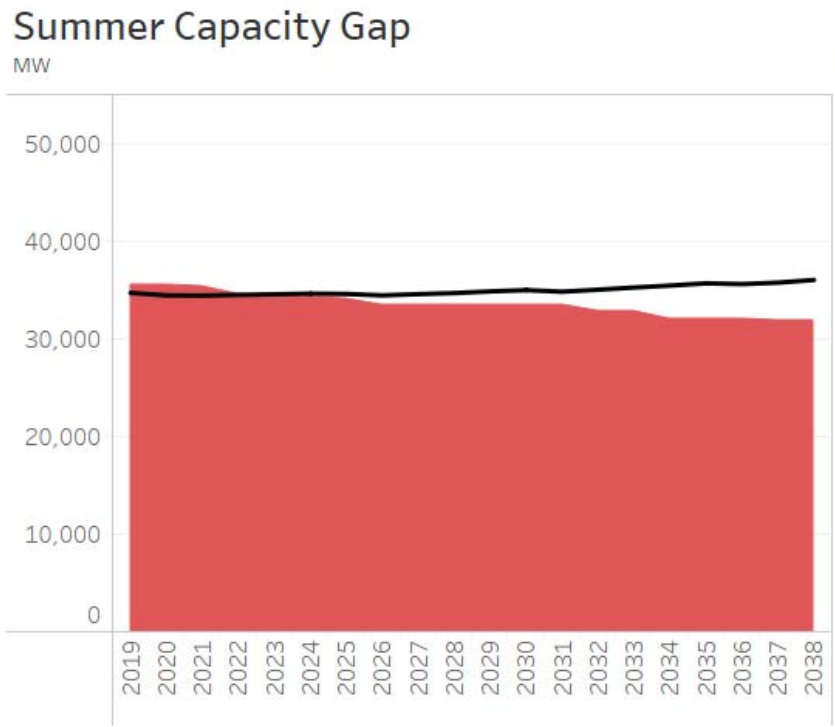
- Expansion is primarily solar, gas and storage in various combinations
- Where more coal is retired, solar and gas generally takes its place
- When distributed solar is promoted, it generally displaces utility solar
- Promoting storage has more impact than promoting solar, as the base case strategy was already selecting solar
- Aeroderivates are only selected in the strategy where incented, and no wind is selected in any strategy even where incented
- In scenarios where DER penetration is already high, no additional DER adoption is levered in any strategy
- In low load scenarios, economic solar energy is still added in the mid-2020s, and more coal and some CT units are retired

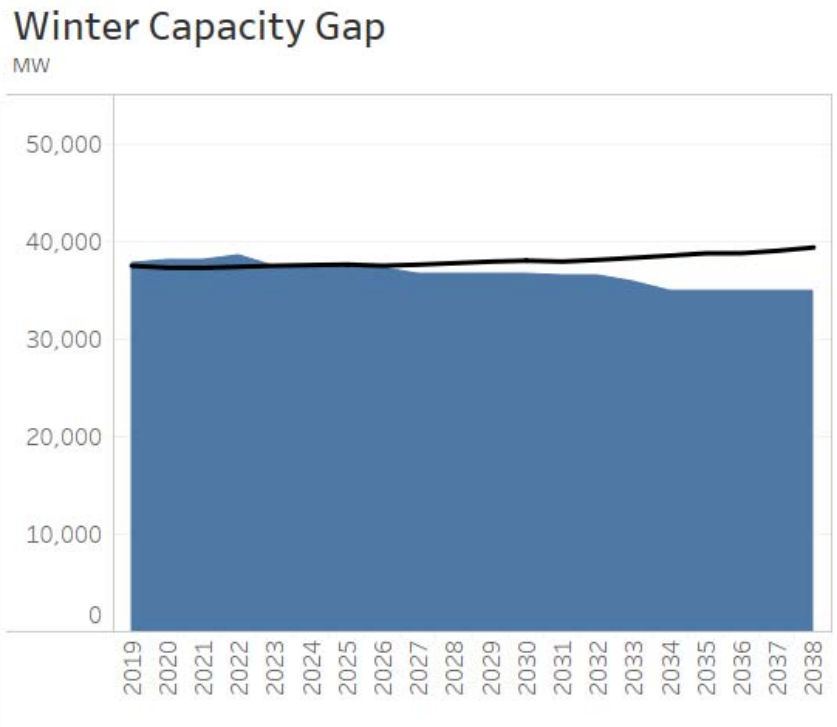
Scenario 1: Current Outlook

Scenario 1: Capacity Gap

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

The capacity gap is the difference between existing resource capacity and the required capacity needed to ensure reliability (peak load plus reserves). In the Current Outlook, an increasing peak forecast along with contract expirations and existing unit retirements contribute to the capacity gap.





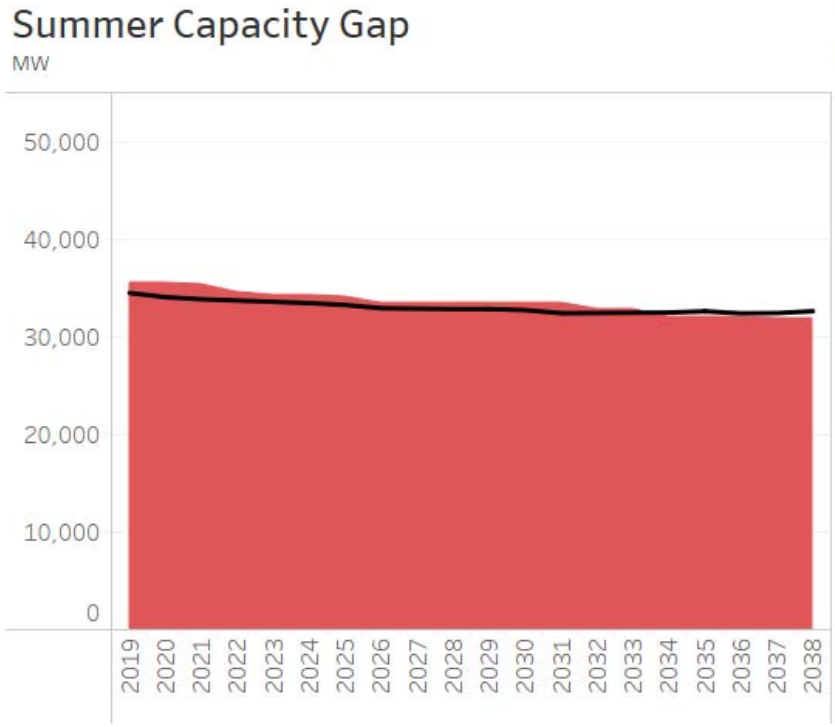

TIME FOR
LUNCH
TIME FOR

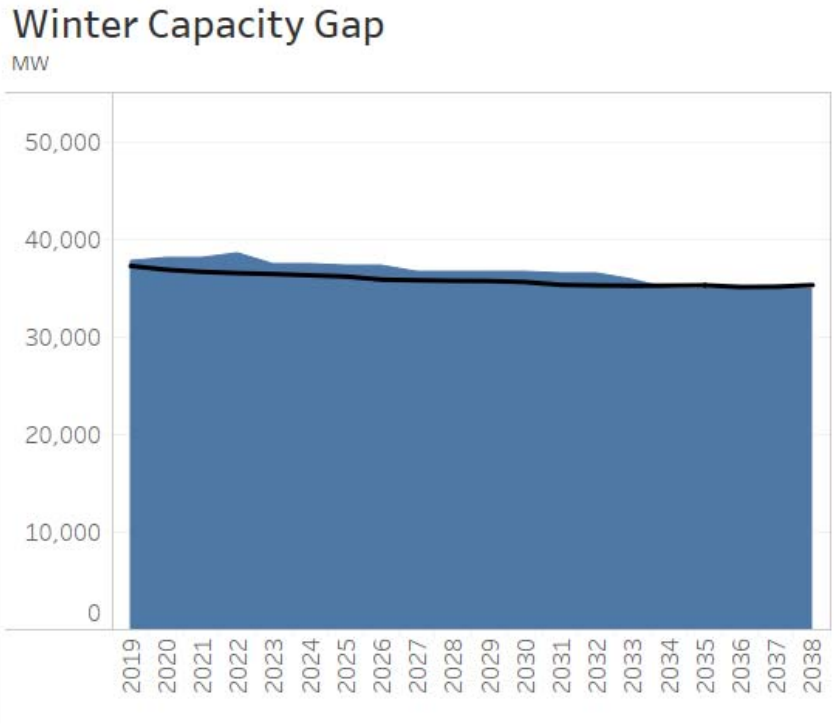
Scenario 2: Economic Downturn

Scenario 2: Capacity Gap

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

The capacity gap is the difference between existing resource capacity and the required capacity needed to ensure reliability (peak load plus reserves). In the Current Outlook, an increasing peak forecast along with contract expirations and existing unit retirements contribute to the capacity gap.



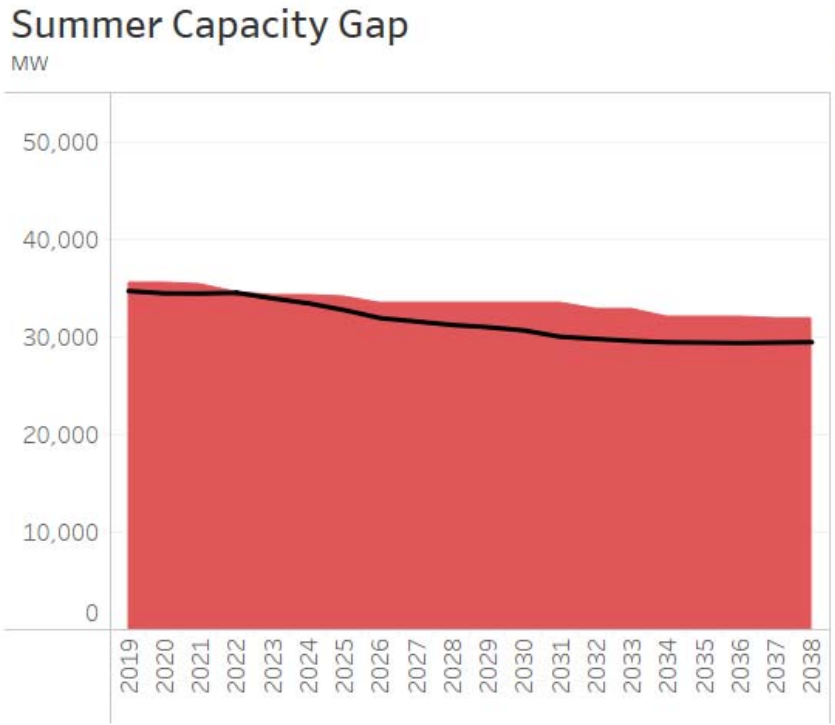


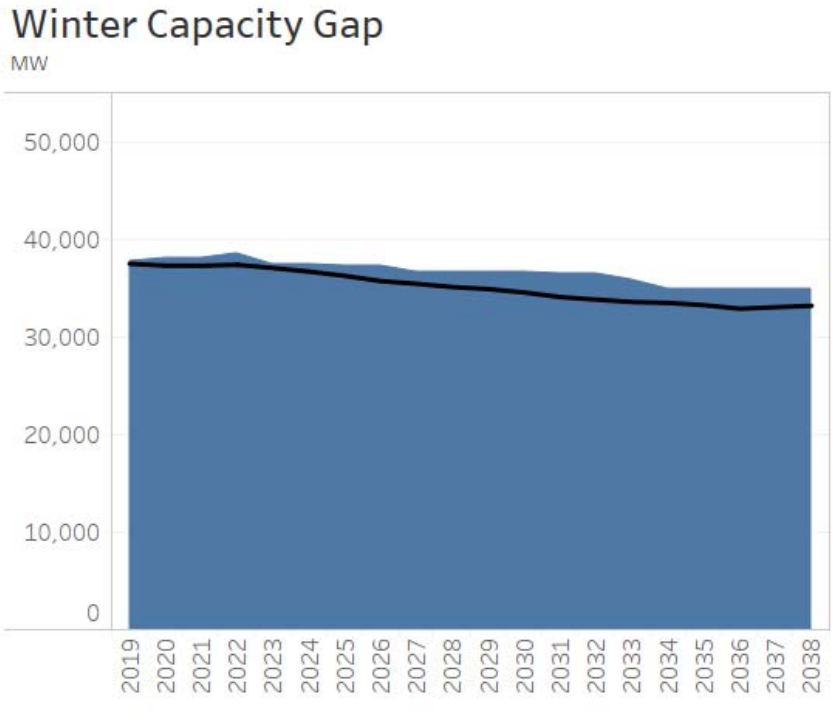
Scenario 4: Decarbonization

Scenario 4: Capacity Gap

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

The capacity gap is the difference between existing resource capacity and the required capacity needed to ensure reliability (peak load plus reserves). In the Current Outlook, an increasing peak forecast along with contract expirations and existing unit retirements contribute to the capacity gap.





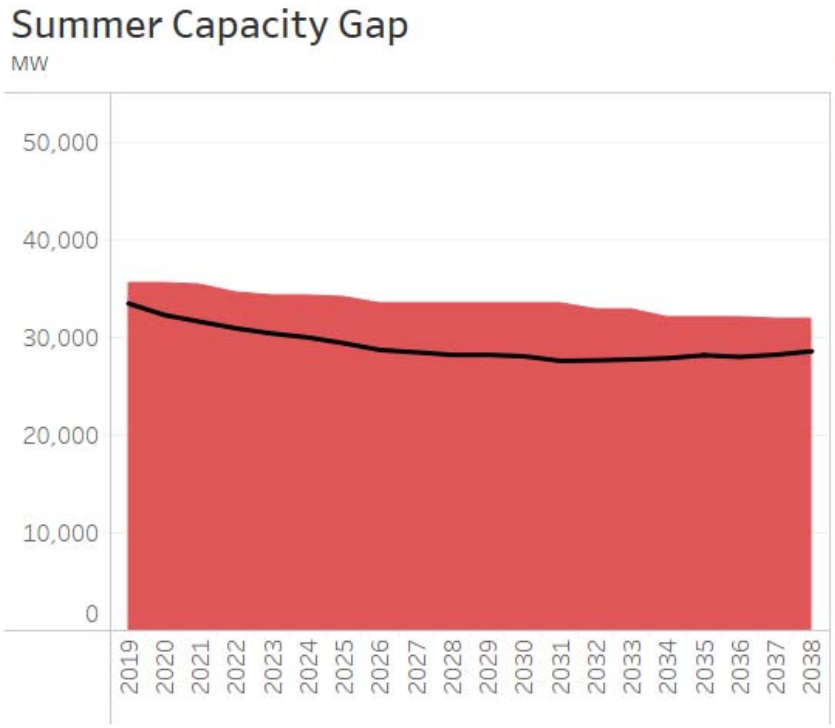
BREAK

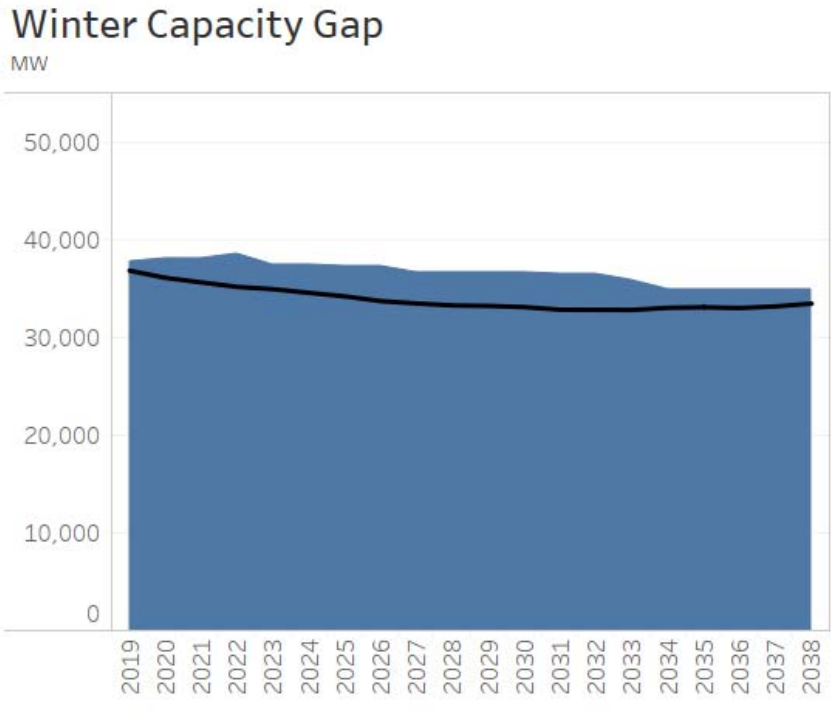
Scenario 5: Rapid DER Adoption

Scenario 5: Capacity Gap

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

The capacity gap is the difference between existing resource capacity and the required capacity needed to ensure reliability (peak load plus reserves). In the Current Outlook, an increasing peak forecast along with contract expirations and existing unit retirements contribute to the capacity gap.





Next Steps in Modeling

Next Steps

- Complete portfolio optimization for balance of scenarios
- Complete scorecards for all strategies
- Review final results at January IRPWG meeting
- Prioritize sensitivities to be run after Draft IRP/EIS is published

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*

Wrap Up Day 1

- Individual Discussion and Question time

- Optional Dinner tonight, 6:00 PM, Calhoun's On the River.

2019 IRP Working Group

Meeting 9: December 19-20, 2018

Welcome and Day 1 Recap

Jo Anne Lavender / Brian Child

Agenda – December 20

Highlighted sections contain confidential information

8:00	Optional Breakfast – Continental at Hotel	
8:30	Welcome and Recap Day 1	Lavender / Child
9:00	Recap High Points of Prelim Results	Elliott
9:45	Q&A - What additional questions do you have?	Group
10:30	Break	
10:45	Review /Discussion	Group
12:00	Group Lunch	
1:00	Group Break out discussion and report outs	Group
2:30	Wrap Up and Adjourn by 2:30	

Recap High Points

Jane Elliott
Senior Manager, Resource Strategy

Q&A

Jane Elliott
Senior Manager, Resource Strategy


TIME FOR
LUNCH
TIME FOR

Small Group Breakout

Group Discussion:

What are your observations and thoughts on the 2019 preliminary results?

Did anything surprise you?

Wrap Up

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: April 30 – May 1, 2019 Middle TN
#14: June 19-20, 2019 West TN
#15: July 24-25, 2019 Chattanooga, TN

Thank you and Safe Travels!!