2019 IRP Working Group

Meeting 6: August 29-30, 2018


welcome

Safety Moment

Building Emergency Plan

Welcome to Memphis!

Susan Hadley-Maynor, Vice-President of Economic Development, Greater Memphis Chamber

Lynn Dabney, General Manager, TVA Customer Delivery, West Tennessee

Introductions

- Name
- Organization and Role

Agenda – August 29

11:00	Lunch	
12:00	Welcome & Introductions	Jo Anne Lavender
12:10	Welcome to Memphis	Susan Hadley Maynor
12:15	Meeting 5 Recap & Overview of Meeting 6	Brian Child
12:20	IRP Communications	Amy Henry
12:25	How the IRP Fits into TVA Strategy	Laura Campbell
12:35	Final Scenarios	Tim Sorrell / Tanya Mathur
1:30	BREAK	
1:45	Final Scenarios (continued)	Tim Sorrell / Tanya Mathur
2:15	Resource Options: Third Party Review and Recommendations	Jane Elliott & Team
3:45	BREAK	
4:00	Modeling Methodology for Distributed Energy Resources	Jane Elliott & Team
5:30	Adjourn	
6:30	Optional Group Dinner	

Agenda – August 30

7:00	Breakfast (at hotel / light continental at meeting room)	
8:00	Welcome & Recap	Jo Anne Lavender & Brian Child
8:15	Preliminary Strategy Design	Jane Elliott & Team
9:15	BREAK	
9:30	Preliminary Strategy Design (continued)	Jane Elliott & Team
10:15	BREAK	
10:30	Group Breakout on Strategy Design	
11:30	LUNCH	
12:30	IRP Methodology: Metrics and Scorecards	Hunter Hydas
1:30	Group Discussion	
2:15	Closing Comments & Next Steps	Brian Child & Jo Anne Lavender
2:30	Adjourn	

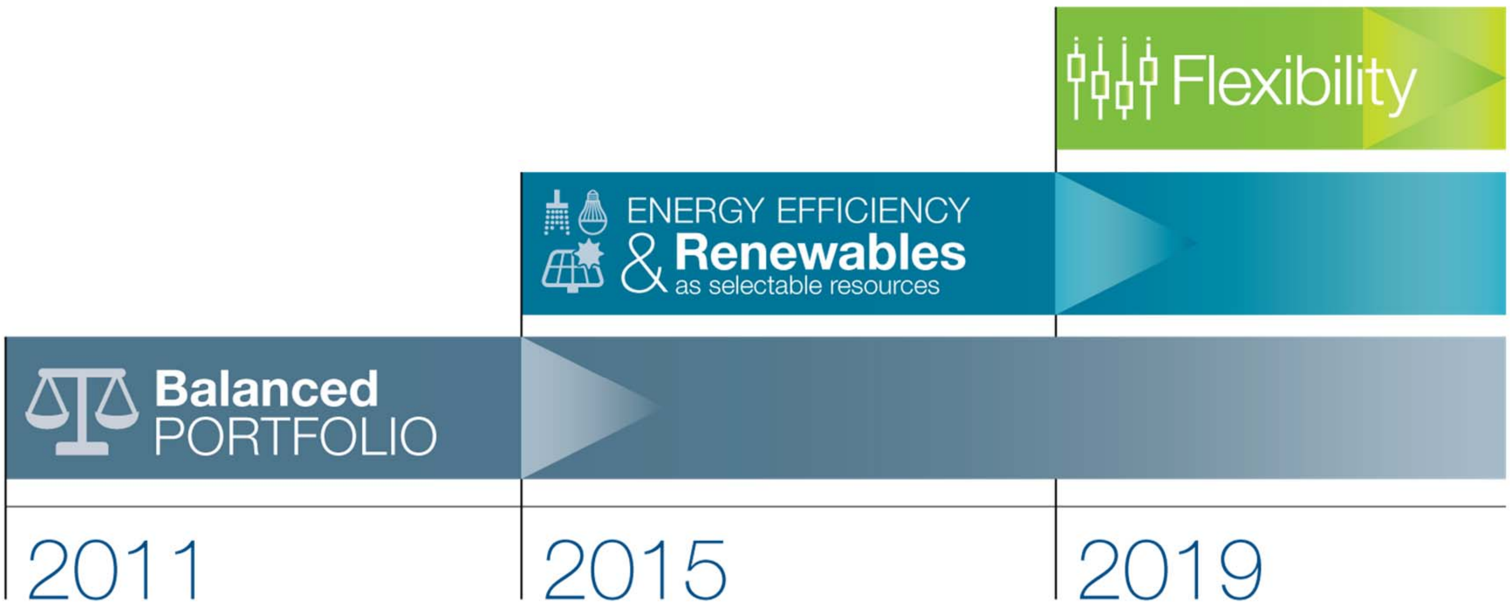
IRPWG Meeting 5 Recap

Brian Child, Director, Enterprise Forecasting & Financial Planning

July Meeting Highlights

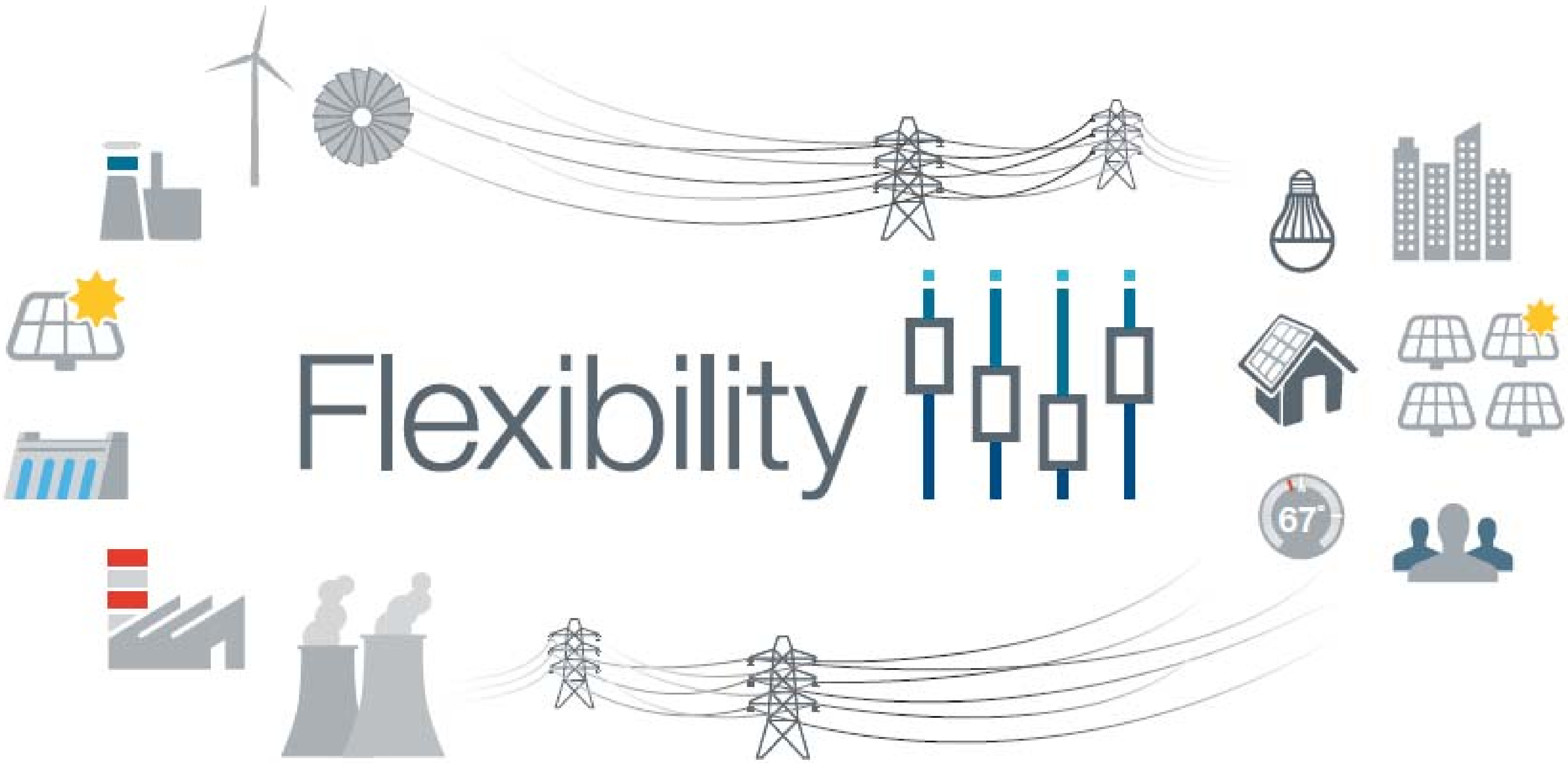
- Strategy Voting Results
- Draft Scenario Design
- IRP Model Framework
- Current Resource Portfolio
- Introduction to Resource Options

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

Winter/Spring 2018	*Spring 2018*	*Summer/Fall 2018*	*Winter/Spring 2019*	*Spring/Summer 2019*	*Summer 2019*
Scoping **	Develop Inputs & Framework	Analyze & Evaluate	Present Initial Results **	Incorporate Input	Identify Preferred Plan/Direction

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

Key Tasks/Milestones in this study timeline include:

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

IRP Working Group Meeting Objectives

June 6th-7th	July 23rd-24th	August 29th-30th	September 26th-27th
• Finalize scenarios • Review attributes and brainstorm/review strategies • Discuss proposed strategies and develop short list • Introduce resource options	• Finalize strategies • Scenario design preview • Resource options (draft) • Modeling framework	• Scenario design (final) • Strategy design preview • Resource options (final) after 3rd party review • Scorecard development	• Strategy design (final) • Scorecard design • EIS outline

Vote on scenarios

Vote on strategies

Other TVA Updates

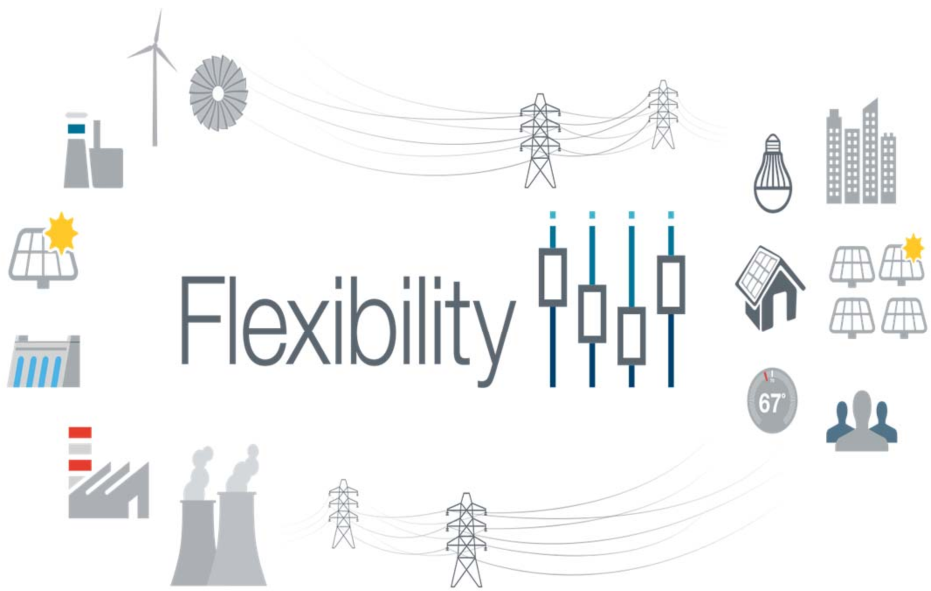
Brian Child, Director, Enterprise Forecasting & Financial Planning

Communications Strategy

Amy Henry, Senior Manager, Enterprise Relations
and Strategic Partnerships

IRP Communications Objectives

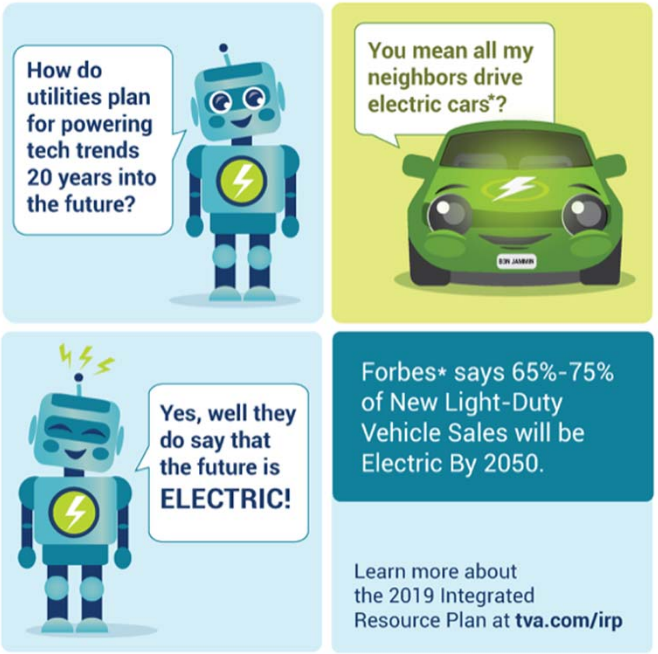
- Educate various audiences about IRP and its importance
- Keep various audiences informed throughout the IRP process
- Use simple language to explain technical concepts
- Gather input and gain buy-in from customers and stakeholders



Strategic Differences from 2015

There are differences in the communications strategies used for the 2019 IRP versus the 2015 IRP.

- Messaging tailored to different demographics to foster broader engagement
- Social media campaign
- Ongoing communication rather than communications only around milestones



Outreach to Stakeholders & Public

- Social Media Campaign
  - Facebook
  - LinkedIn
  - Twitter
  - Instagram
  - YouTube

- Other Formats
  - Videos
  - Interactive Report
  - IRP Fact Sheet
  - IRPWG Meeting Summaries
  - FAQs on Website

WHAT IS AN **INTEGRATED RESOURCE PLAN (IRP)?**

The IRP is a decision support tool that helps guide us on how to best meet future electricity demand.

WHAT IS THE IRP SCOPING REPORT?

Your feedback is a vital part of developing the IRP. The Scoping Report summarizes TVA's outreach and comments received in the 60-day public comment period following the launch of the IRP.

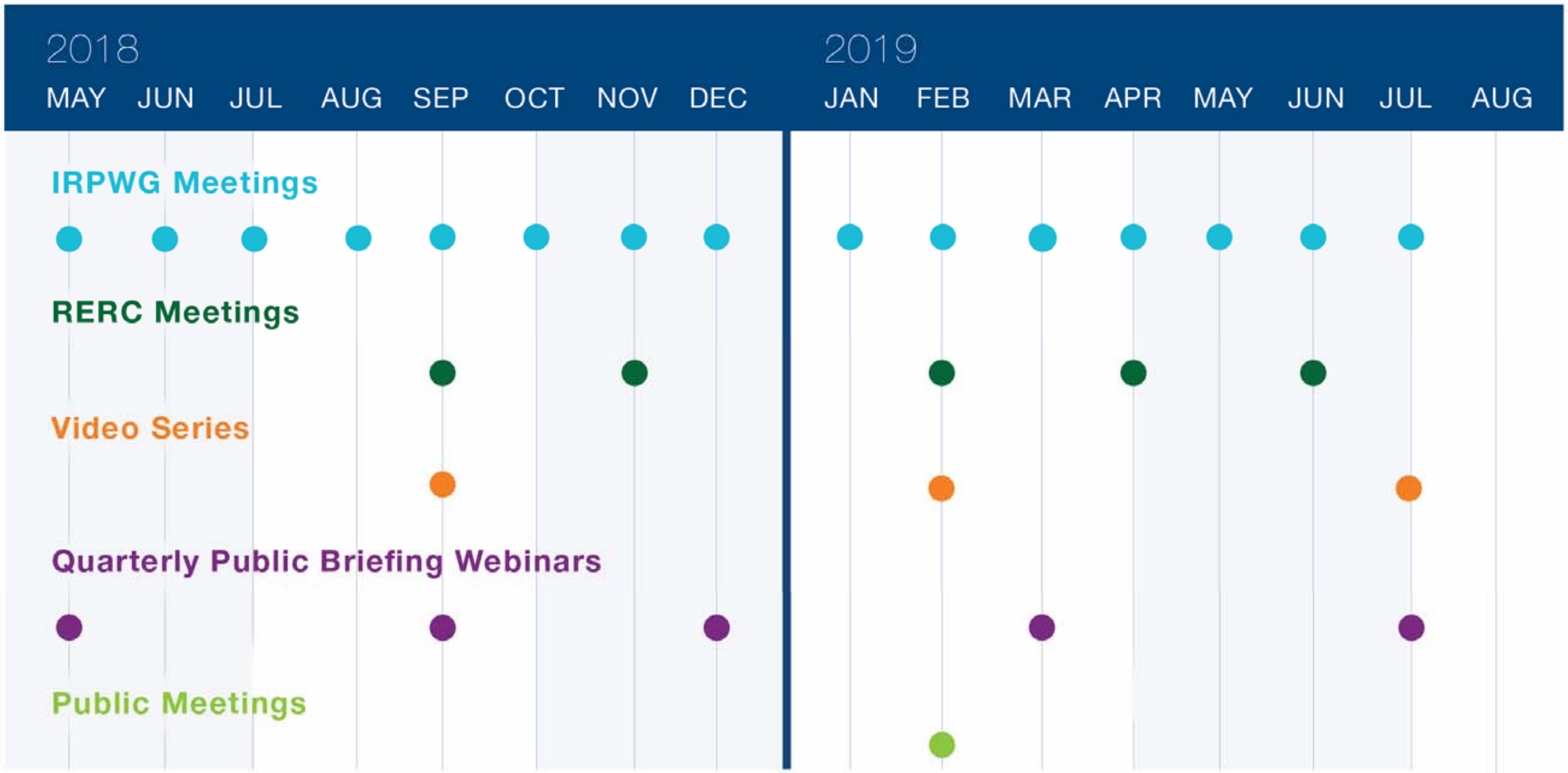
IN THE REPORT:

- **View final strategies and scenarios under consideration in the IRP**
- **See a summary of IRP topics**
- **View comments received**

Public Outreach Events

- Quarterly public webinars
- Public scoping meetings
- Public meetings
- Online meetings

Public Involvement Tools



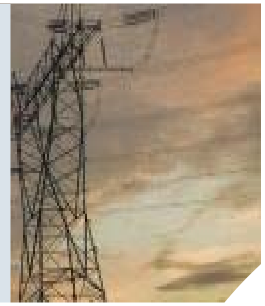
The IRP and TVA Strategy

Laura Campbell, Vice President,
Enterprise Planning

TVA's Mission and Strategic Imperatives

Energy

Delivering affordable, reliable power

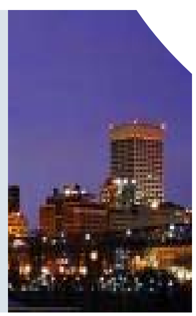


Environment

Caring for our region's natural resources

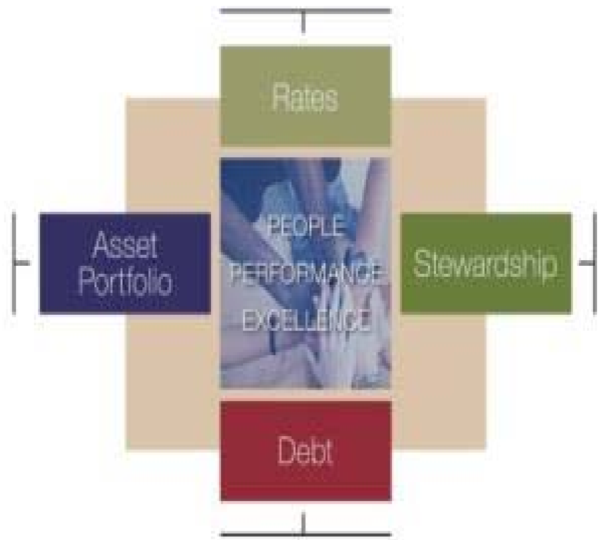
Economic Development

Creating sustainable economic growth



Maintain low rates

Meet reliability expectations & provide a balanced portfolio



Be responsible stewards

Live within our means

Drivers and Current Plan Commitments

	Rates as Low as Feasible (Rates)	Financial Health (Debt)	Reliable Energy (Load Not Served)	Cleaner Energy (CO_2)
DRIVERS	Rates as Low as Feasible (Rates)	Financial Health (Debt)	Reliable Energy (Load Not Served)	Cleaner Energy (CO_2)
STAKEHOLDERS	Local Power Companies End-Use Customers Valley States	Federal Government Bond Holders All Customers	Local Power Companies Industries End-Use Customers	Valley Residents Industries Commercial Business
GOALS	1.5% CAGR Maintain Competitiveness Economic Development Customer Loyalty	$21.8 billion Meet Federal Commitment Maintain Credit Rating Low Rates for the Long Term	Top Quartile Customer Loyalty Enable Economic Development	60% Lower Rate, 2005-2020 Provide Cleaner Air Enable Green Branding & Economic Development

STRATEGIES
- Commercial Strategy
- Asset Strategy
- Financial Strategy

Developing Plans for the Future

STRATEGIES

- Commercial Strategy
- Asset Strategy
- Financial Strategy

→

- 2020 Long-Range Financial Plan (LRFP)
- 10-Year Pricing Strategy
- 2019 Integrated Resource Plan (IRP)
- DER Strategy
- 2020 Natural Resource Plan (NRP)

FY2018				FY2019										
J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S

IRP	Public Scoping	Publish Draft Report for Public Comment	Publish Final IRP
LRFP		Align with Draft IRP	Align with IRP and Set Long-term Projections
Pricing	Develop Pricing Strategies	Evaluate Pricing Strategies against IRP Scenarios (+/-)	Finalize Long-term Pricing Strategy
DER	Partner with TVPPA on Flexibility Options by Oct 2018	Develop Plans for future Programs & Services and Processes for Customer Choice	
NRP	Public Scoping	Draft EIS	Public Comment; Final SEIS (2020)

GOALS

Future goals will be driven by these strategies

2019 IRP Scenarios

Tim Sorrell, Senior Manager, Enterprise Forecasting
Tanya Mathur, Manager, Load Forecasting

Agenda

- Overview
- Economic Impacts – All Scenarios
- Load & Generation Shapes
- Load & Commodity Prices
- Break
- Scenario Summaries
- 2015 and 2019 IRP Scenario Comparison

Economic Downturn

- Prolonged, stagnant economy results in declining loads and delayed expansion of new generation
- Labor force participation weakens; productivity stagnates due to weak investment
- Stringent environmental regulations delayed due to concerns of adding further pressure to the economy
- Weaker demand lowers cost of new plant construction, partially offset by higher inflation

Valley Load Growth

- Technology-driven investment in automation and artificial intelligence raise electricity use and boost labor productivity & economic growth while lowering inflation
- Economic growth, driven by migration into the Valley and growth in emerging markets & developing economies translates into higher energy sales
- Lower battery prices due to economies of scale drive increased electrification of transportation
- Preference for lower emissions, DER and EE reduces demand for emitting generation, translating into lower gas and coal prices

Decarbonization

- Concern over climate change creates strong federal push to curb GHG emissions, increasing CO_2 emission penalties for utilities and incentives for non-emitting technologies; gas demand impacted by CO_2 penalty
- Compliance with new rules increases energy prices and inflation; US-based industry becomes less competitive, resulting in lagging economic growth that fails to rebound to trend levels
- New expansion units necessary to replace existing CO_2-emitting fleet

Rapid DER Adoption

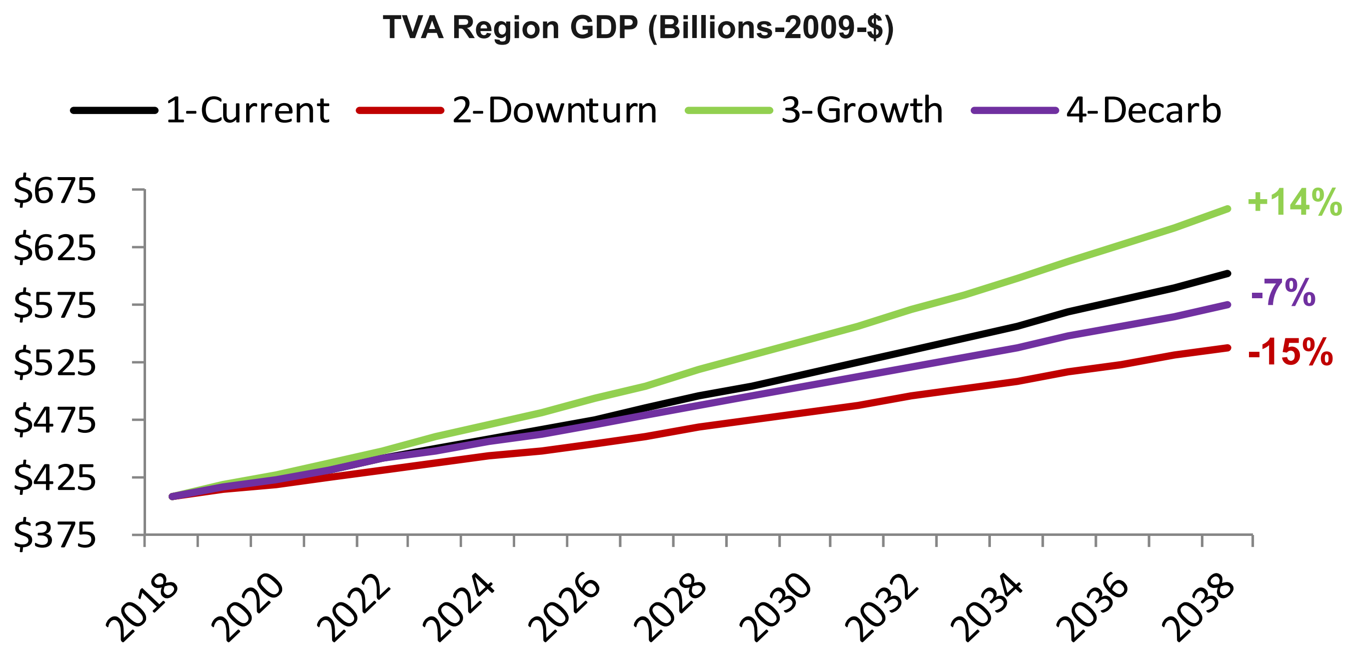
- Growing consumer awareness of and preference for energy choice, coupled with rapid advances in energy technologies, drive high penetration of distributed generation, storage, and energy management
- Utilities are no longer the sole source of generation and multiple options are available to consumers
- Market shift results in lower loads, decreased need for supply-side generation, but potential impacts to transmission and distribution planning and infrastructure

No Nuclear Extensions

- Driven by aging assets and desire for national energy security and resiliency, there is a regulatory challenge to relicensing of existing and construction of new, large scale nuclear. Both cease in favor of technologies that are more secure, modular, and flexible.
- National energy policy drives carbon regulation or legislation and promotes small modular reactor technology through subsidies to drive SMR technology breakthrough and improved economics.

Economic Impacts

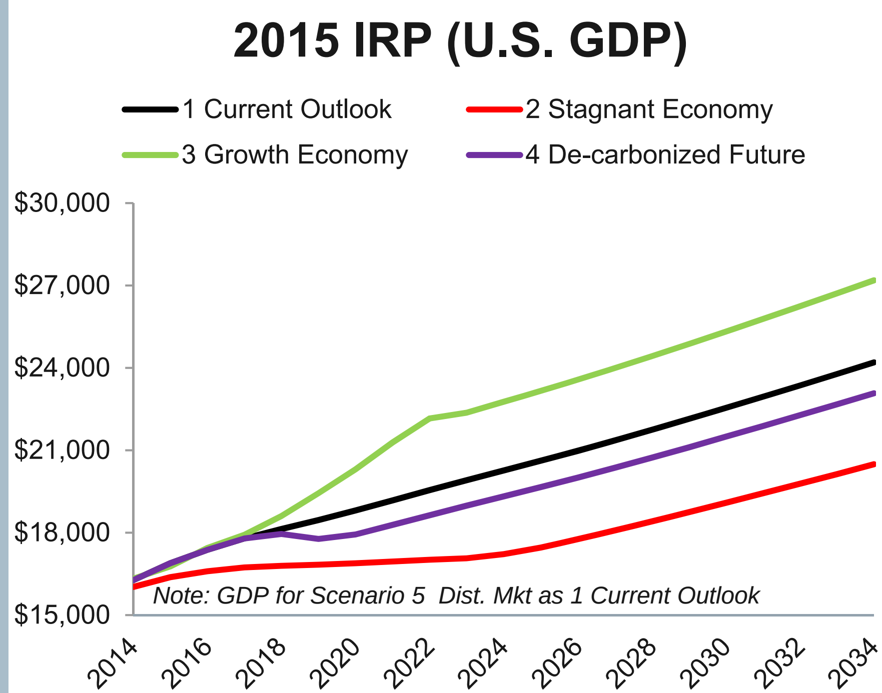
TVA Macro Forecast by Scenario*



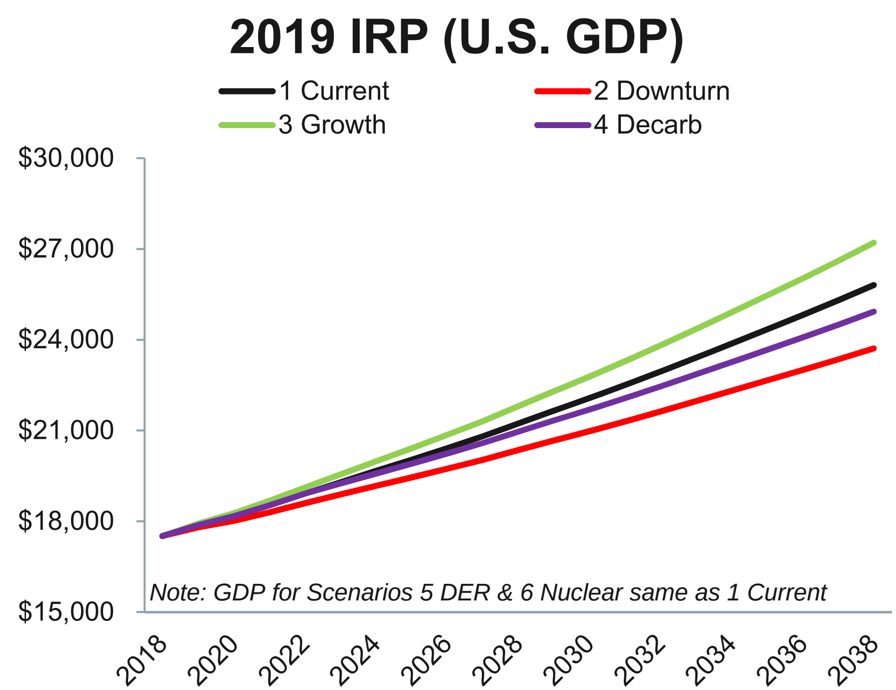
By 2038, TVA GDP ranges from $108 BB lower to $99 BB higher than Current

*Note: Economic forecast for scenarios 5 DER and 6 Nuclear are the same as for 1 Current

IRP Comparison: U.S. GDP



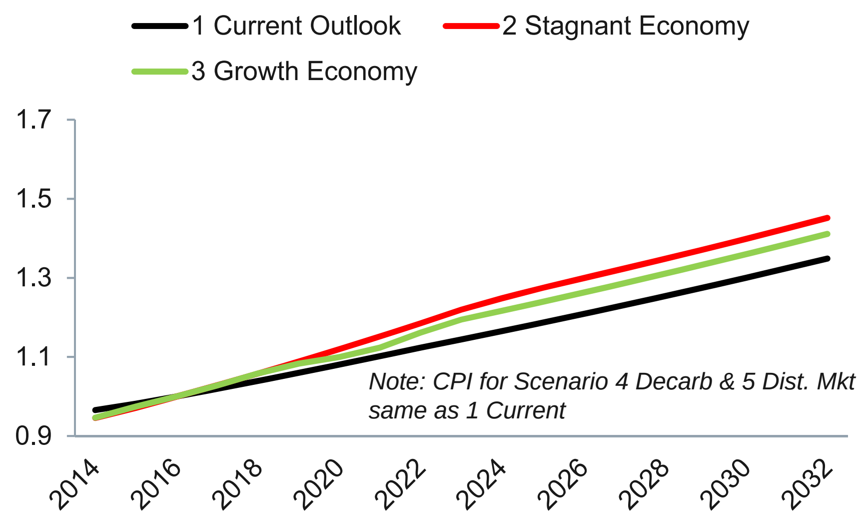
	Current	Stagnant	Growth	Decarb	Dist. Mkt
20 Year CAGR	2.0%	1.2%	2.6%	1.8%	2.0%



	Current	Downturn	Growth	Decarb	DER	Nuclear
20 Year CAGR	2.0%	1.5%	2.2%	1.8%	2.0%	2.0%

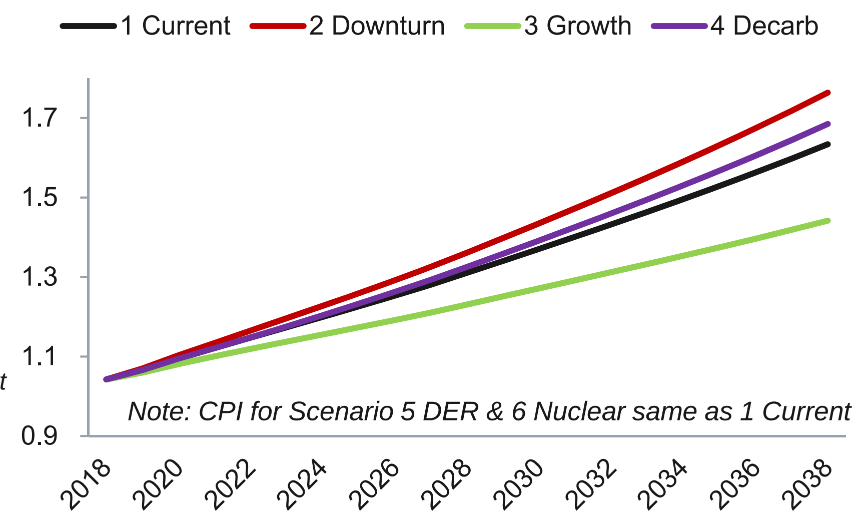
IRP Comparison: Consumer Price Index

2015 IRP (CPI)



	Current	Stagnant	Growth	Decarb	Dist. Mkt
20 Year CAGR	1.9%	2.4%	2.2%	1.9%	1.9%

2019 IRP (CPI)



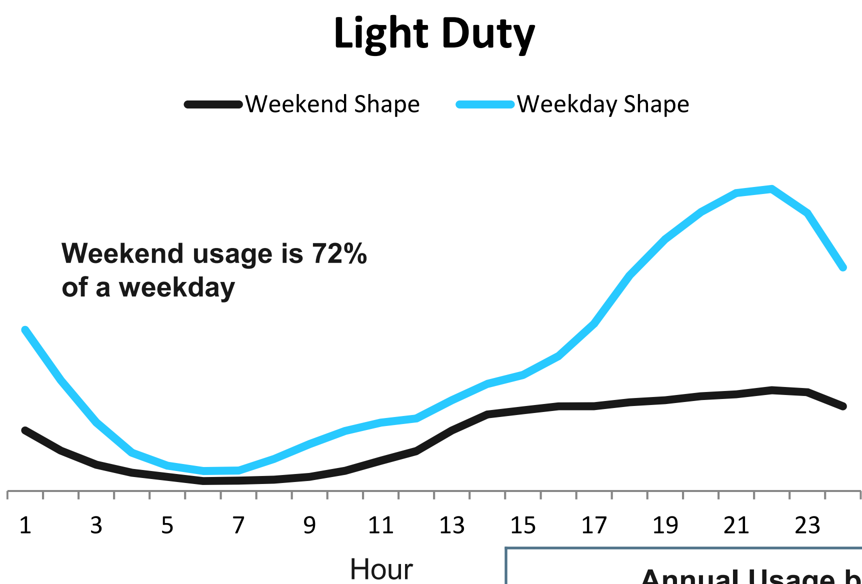
	Current	Downturn	Growth	Decarb	DER	Nuclear
20 Year CAGR	2.3%	2.7%	1.6%	2.4%	2.3%	2.3%

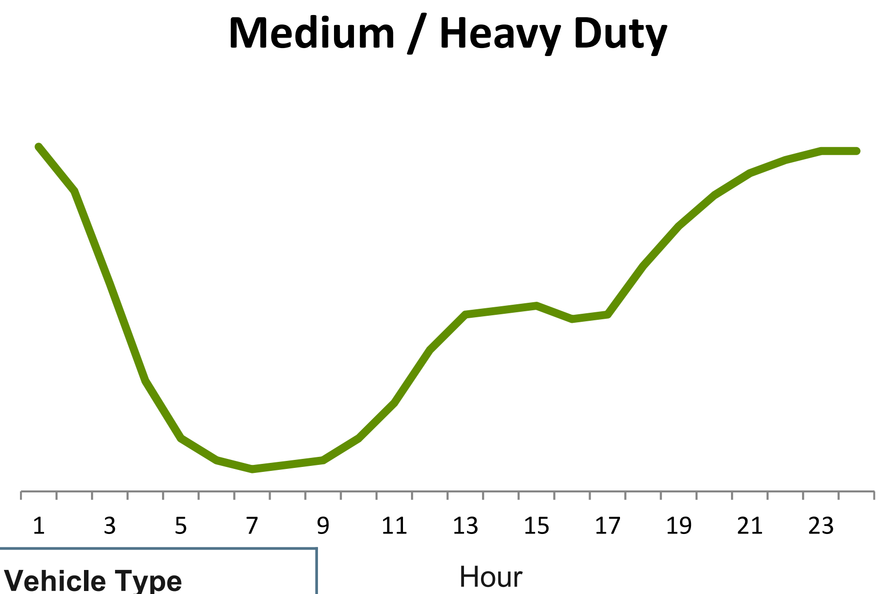
Scenario Assumptions (2018 – 2038)

20-year CAGR	Current Outlook	Economic Downturn	Valley Load Growth	Decarbonization	Rapid DER Adoption	Nuclear
U.S. GDP	2.0%	1.5%	2.2%	1.8%	2.0%	2.0%
U.S. Inflation	1.9%	2.2%	1.5%	2.0%	1.9%	1.9%
TVA Population	0.6%	0.4%	0.7%	0.5%	0.6%	0.6%
TVA Total Employment	0.6%	0.0%	0.9%	0.3%	0.6%	0.6%
TVA Manufacturing Employment	-0.6%	-2.1%	0.2%	-1.2%	-0.6%	-0.6%

Load & Generation Shapes

Electric Vehicle Shapes

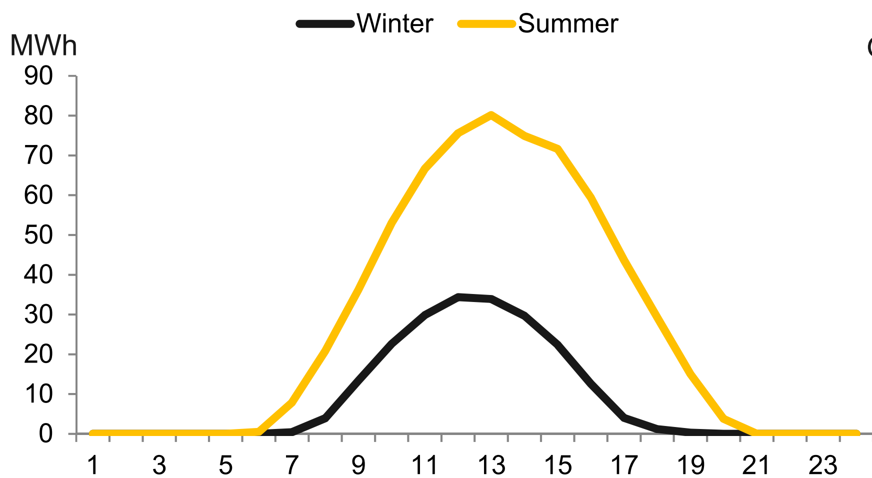


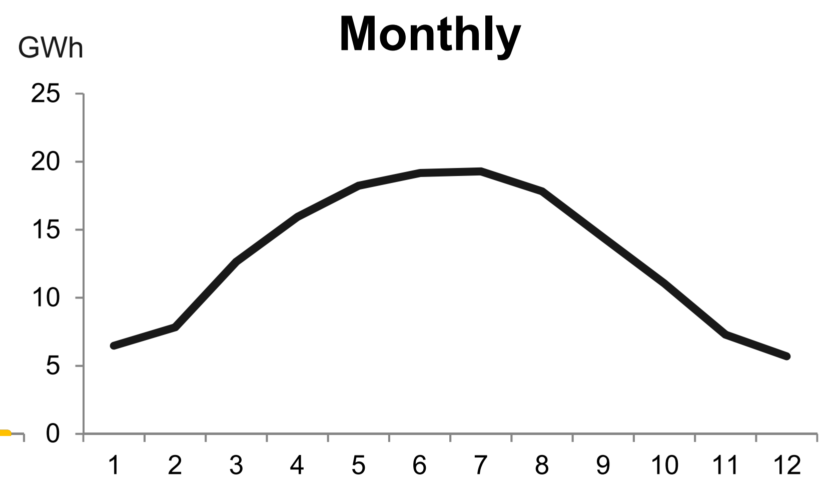


Annual Usage by Vehicle Type

EV	MWh/vehicle	Relative to LD
Light Duty	4	1
Medium Duty	60	15 times
Heavy Duty	161	40 times
Transit	82	20 times

Solar Shapes (2018)

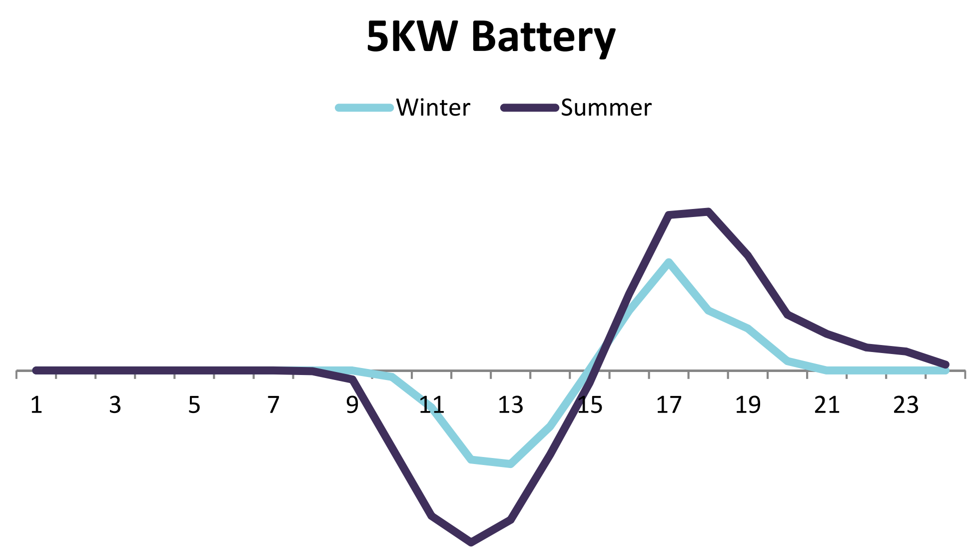




- 5KW Solar system for residential and 30KW for small commercial
- Solar shape based on Nashville irradiance
- Very little solar contribution in winter

Battery Shape

- Typical Residential Home
- 5KW Battery system
- 14KWh (Tesla Power Wall)
- 92.5% round trip efficiency
- Battery charges when solar is in excess



Residential Customer Load Shape

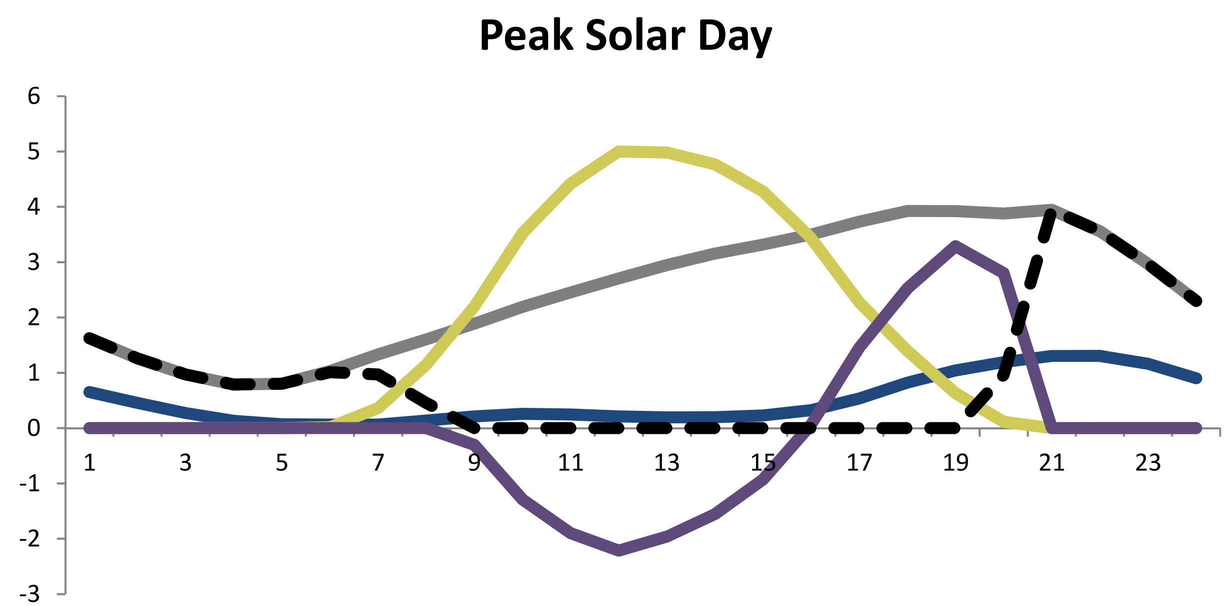
Electric Usage

EV Shape

PV Shape

Battery

Load Served



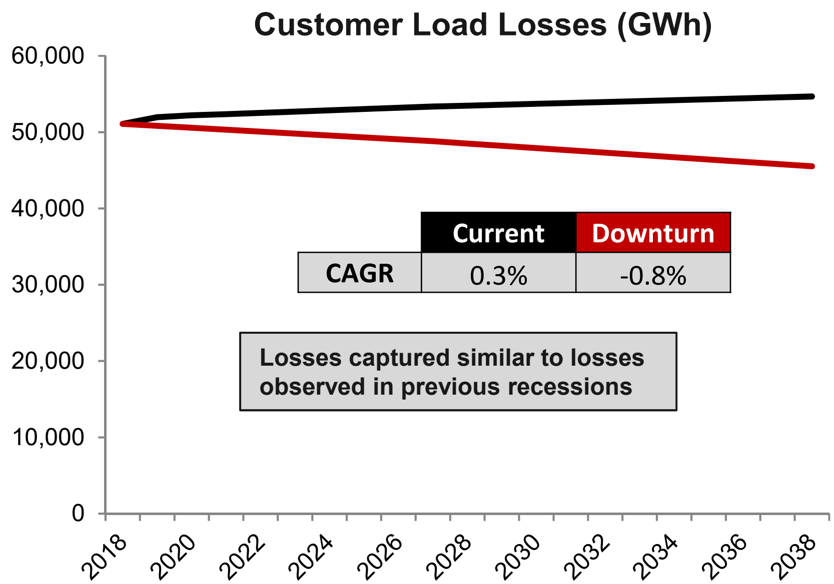
2. Economic Downturn

2. Downturn: Assumptions

Load Drivers	• C&I load: **6% reduction** due to poor economics in commercial and industrial sectors
	• Electric Vehicles: slow growth due to lower median income (4,000 GWh by 2038; 460,000 EVs)
	• Energy Conservation: behavior change to lower costs
	• Combined Heat & Power: slowed in first five years due to customer loss & depressed economy
	• Technology growth dampened

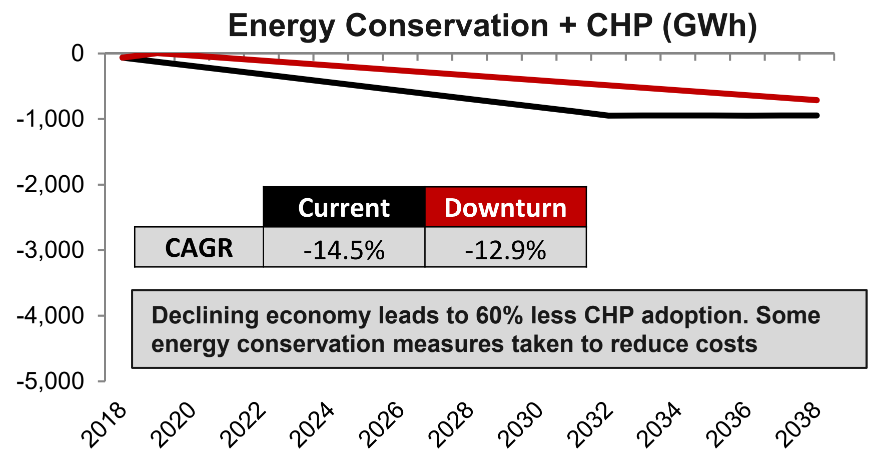
Commodity Drivers	• National electricity demand declines from 0.3% to **flat (0.1%)** reducing gas and coal demand
	• Capacity Mix: decrease in solar; coal capacity continues decline; gas capacity declines

2. Downturn: Load Drivers



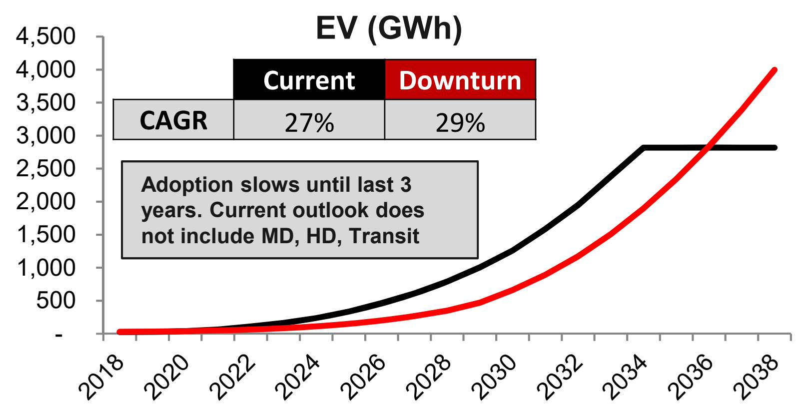
	Current	Downturn
CAGR	0.3%	-0.8%

Losses captured similar to losses observed in previous recessions



	Current	Downturn
CAGR	-14.5%	-12.9%

Declining economy leads to 60% less CHP adoption. Some energy conservation measures taken to reduce costs

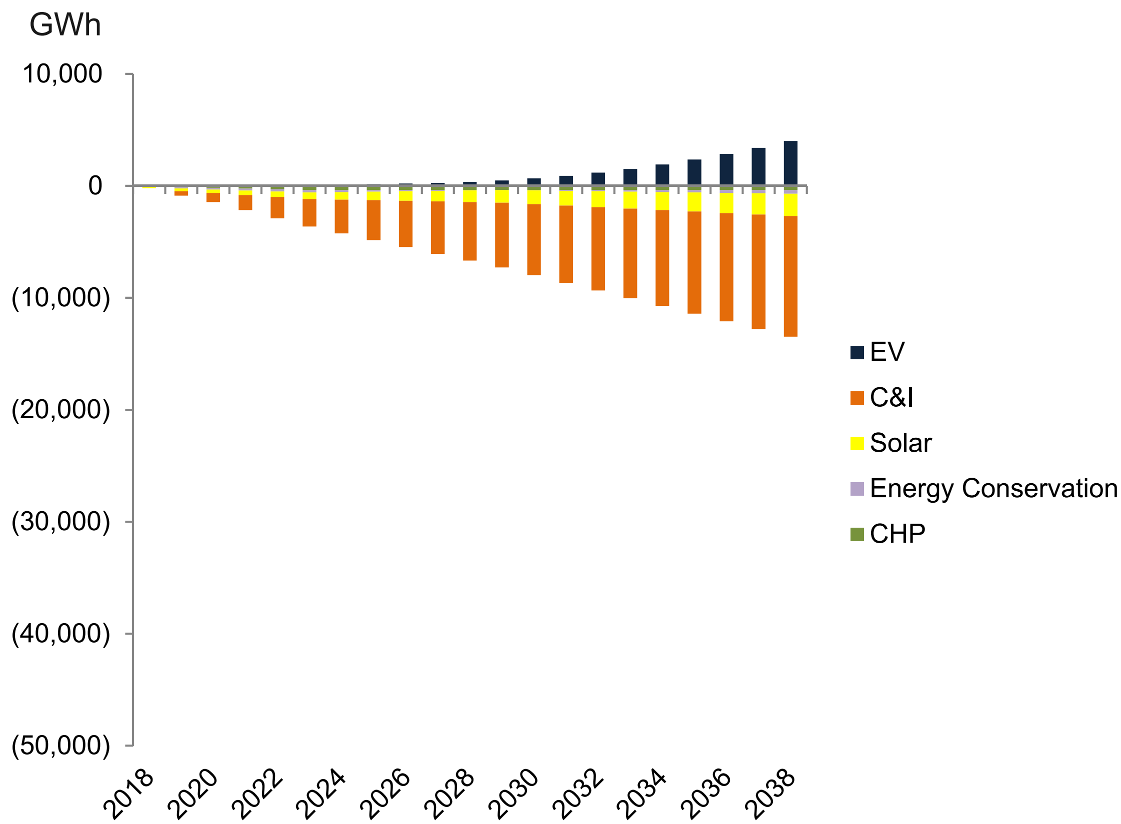


	Current	Downturn
CAGR	27%	29%

Adoption slows until last 3 years. Current outlook does not include MD, HD, Transit

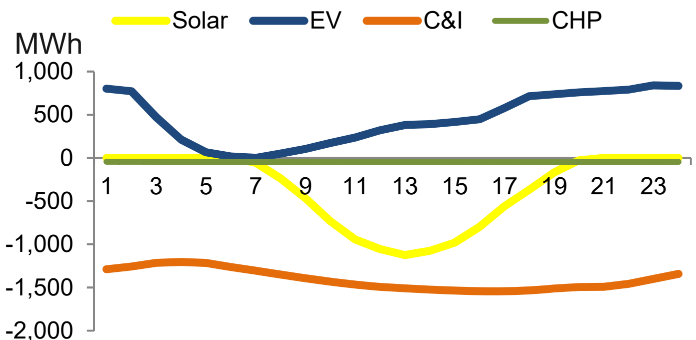
2. Downturn: Scenario Assumption Impacts

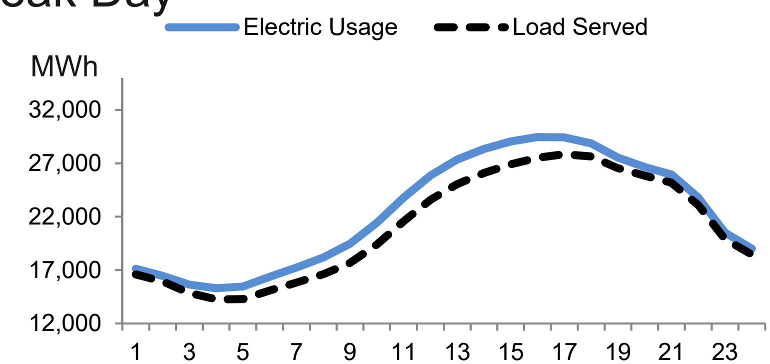
- Slower economic growth leads to a decline in C&I sector
- Lower real per capita income slows CHP, EE and EV adoption



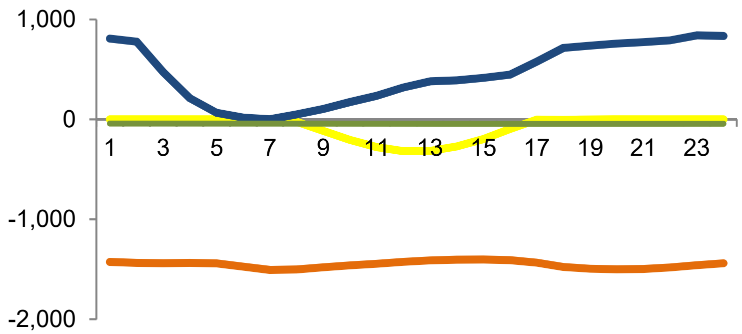
2. Downturn: Load Served 2038

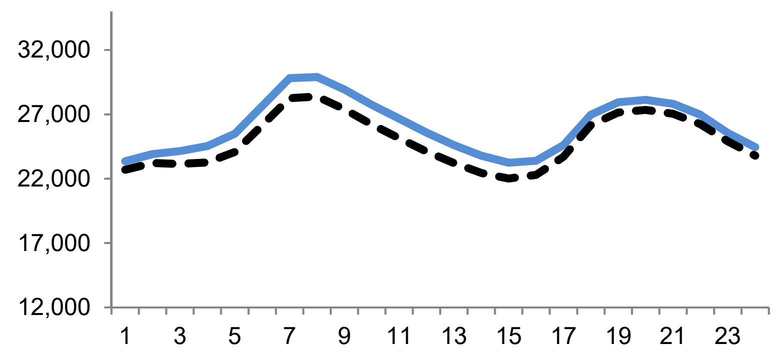
Summer Peak Day



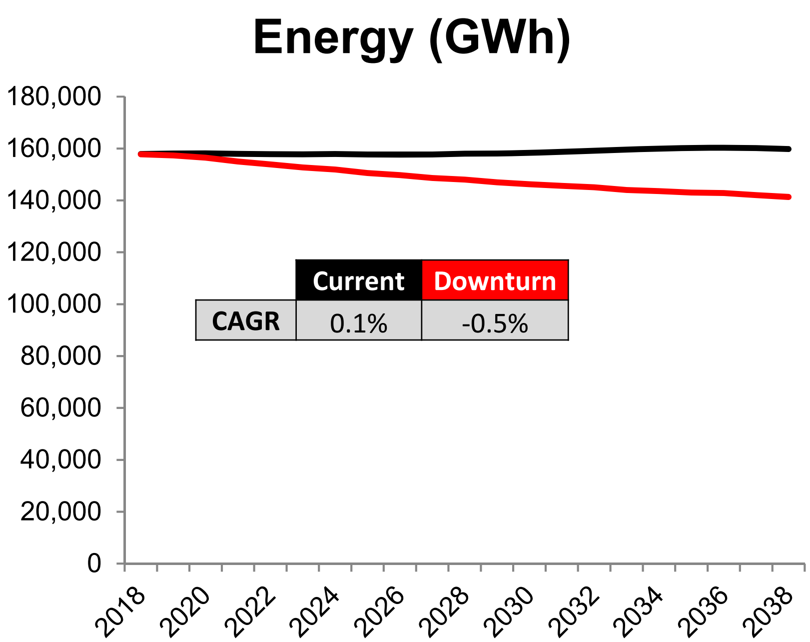


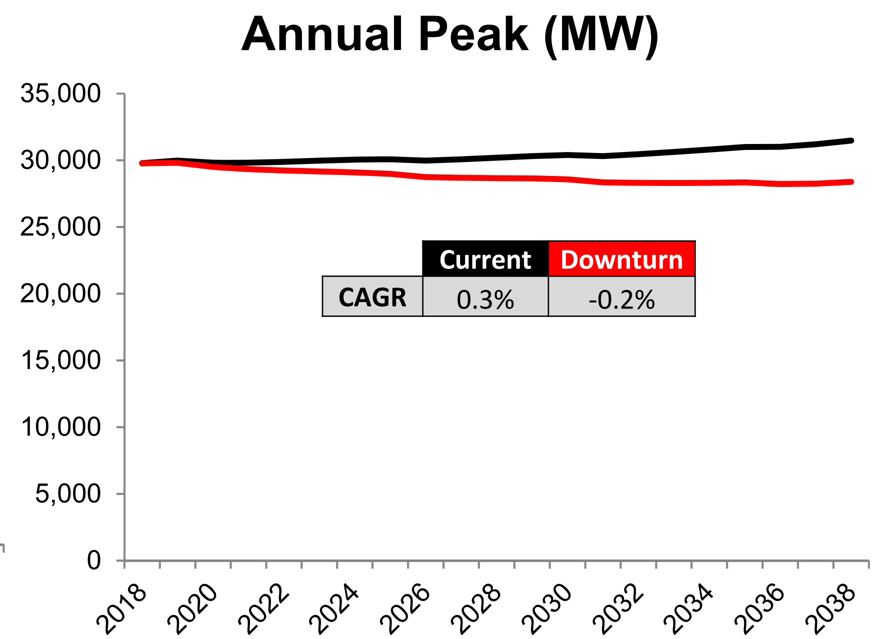
Winter Peak Day



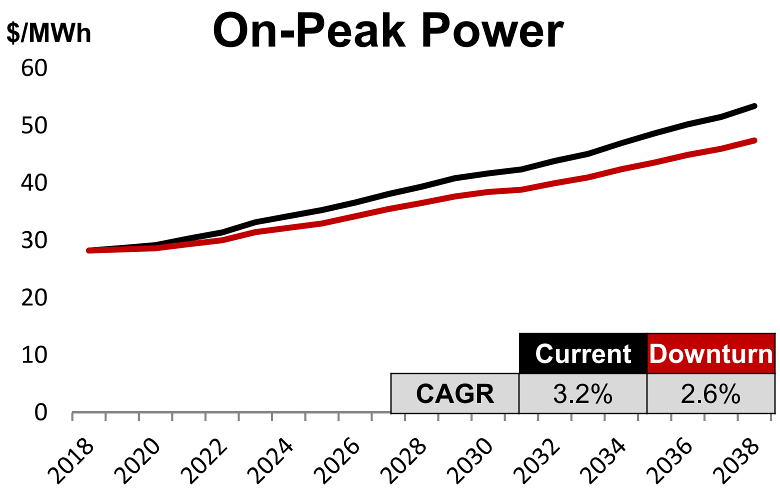


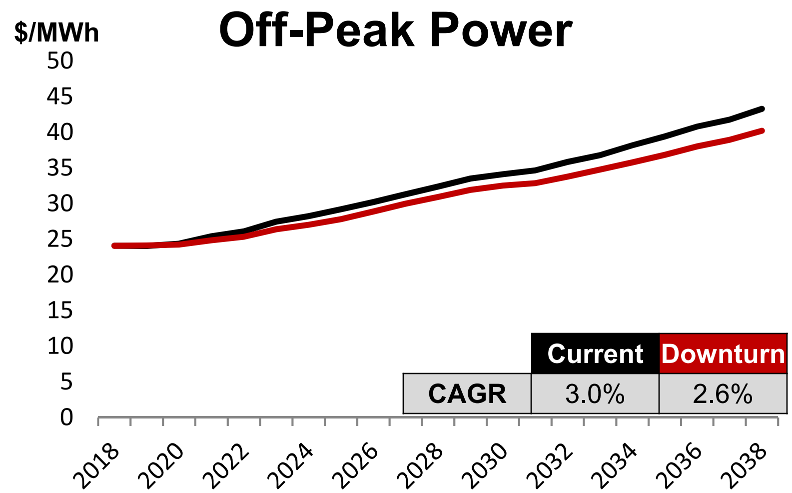
2. Downturn: Energy and Annual Peak





2. Downturn: Wholesale Power Prices





Lower natural gas and coal prices, along with lower demand depress both on and off-peak power prices.

National Capacity Mix by 2038

	Coal	NatGas	Nuclear	Hydro	Wind	FuelOil	Solar	Other
Current	20%	52%	7%	9%	7%	1%	3%	1%
Downturn	22%	46%	8%	9%	8%	1%	3%	1%

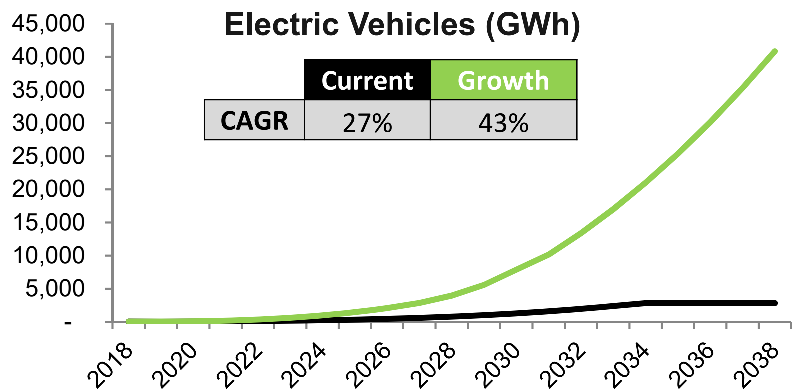
3. Valley Load Growth

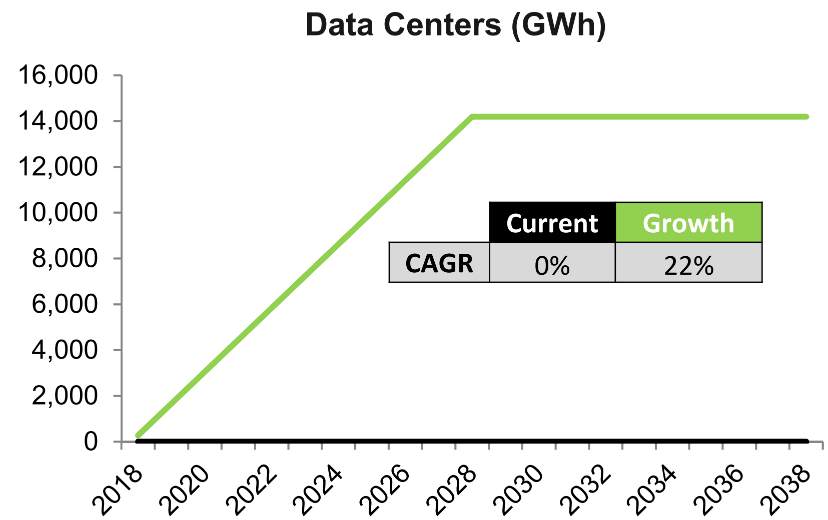
3. Growth: Assumptions

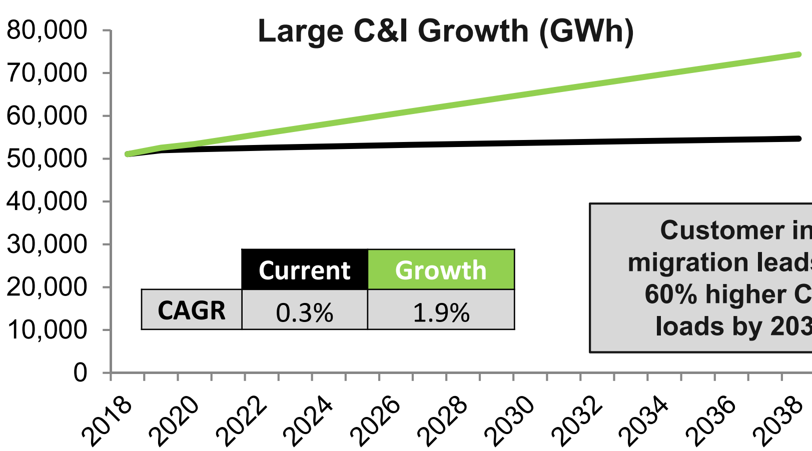
Load Drivers	• Renewables: rising incomes, declining technology costs, and social influences lead to increased residential & commercial solar despite phase out of ITC: **up to 4,000 GWh by 2038**
	• Battery Storage: rising incomes, declining technology costs, and social influences lead to **4%** of residential and commercial solar owners adopting battery storage by 2038
	• Customer Growth: migration into Valley leads to growth especially in C&I (**19,000 GWh**) and data center sectors (**14,000 GWh by 2028)**
	• Electric Vehicles: Valley electrification leads to large penetration rates; reaches **41,000 GWh by 2038 (~5M EVs)**
	• Energy Efficiency: codes and standards targets remain same as current outlook
	• Combined Heat & Power: Due to C&I growth and profits, CHP increases to **1,900 GWh by 2038**
	• Technology Adoption Growth (EV, Data Centers, CHP, DER, Renewables)

Commodity Drivers	• National demand increases from 0.3% to **1.4%** leading to higher gas demand
	• High CO2 costs starting in 2025 and **increasing with inflation**
	• National Mix: no change in solar; coal capacity declines; natural gas capacity increases

3. Growth: Load Drivers





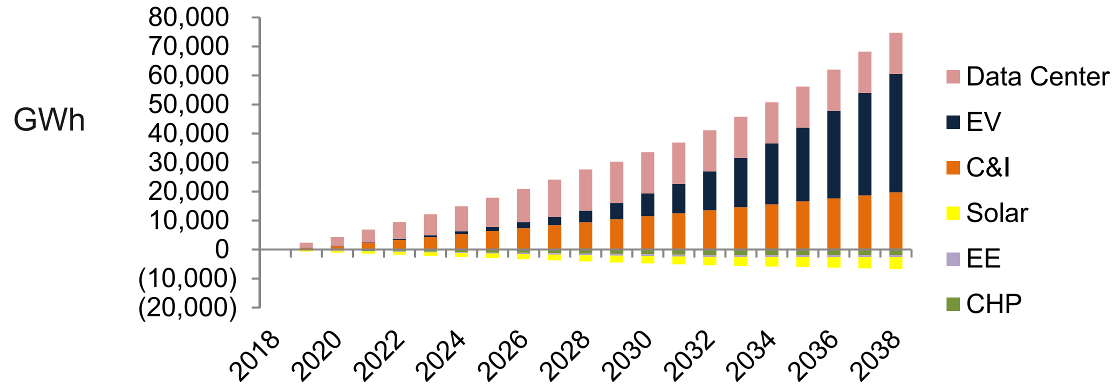


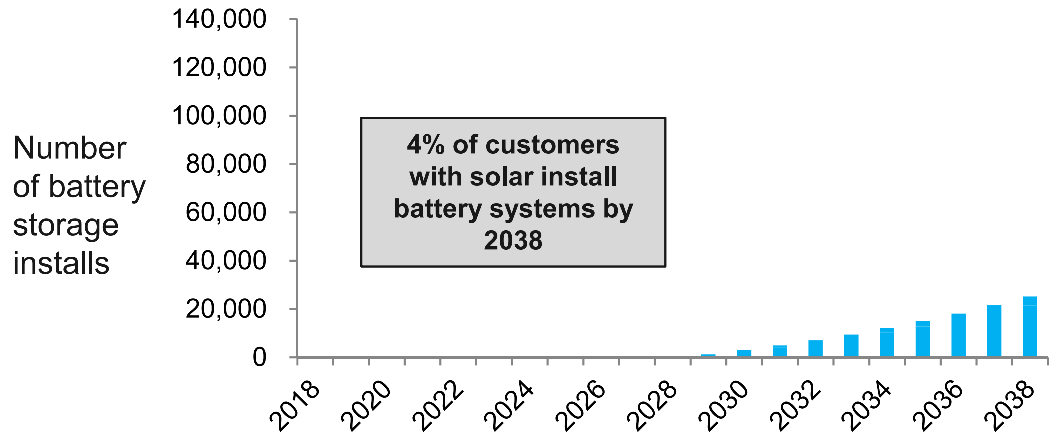
Customer in-migration leads to 60% higher C&I loads by 2038

Minor growth in Data Centers in current outlook. Recent developments indicate the potential of significant increase in penetration

3. Growth: Scenario Assumption Impacts

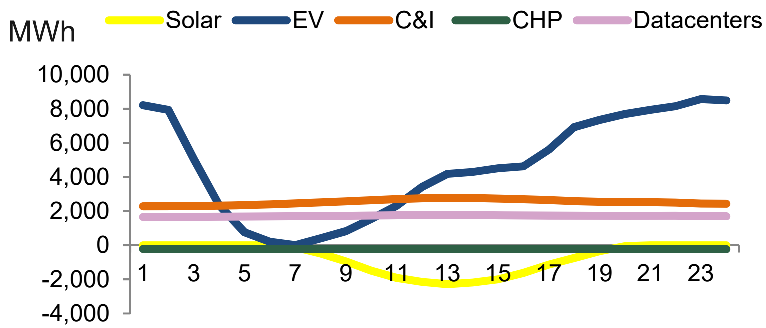
- Higher productivity yields in C&I sector lead to demand growth
- Real per capita income increases DER, Solar PV, and EV adoption
- Electrification comes from EV and Data Centers
- Battery storage post-2030 increases as costs decline and income rises

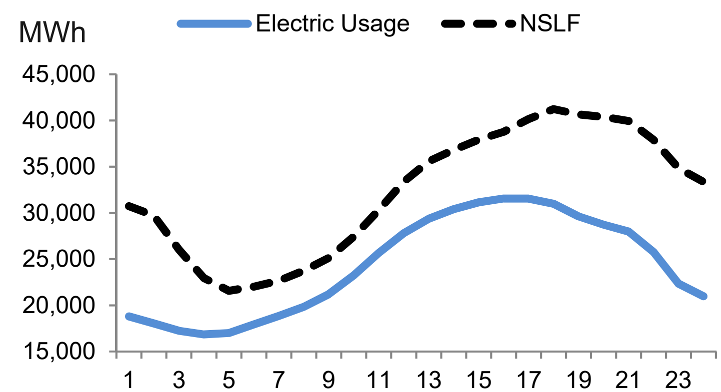




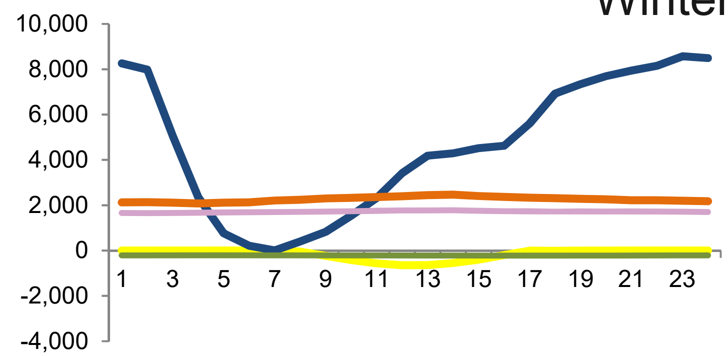
3. Growth: Load Served 2038

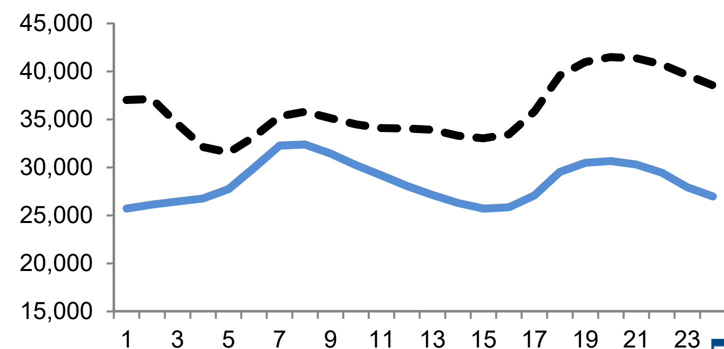
Summer Peak Day



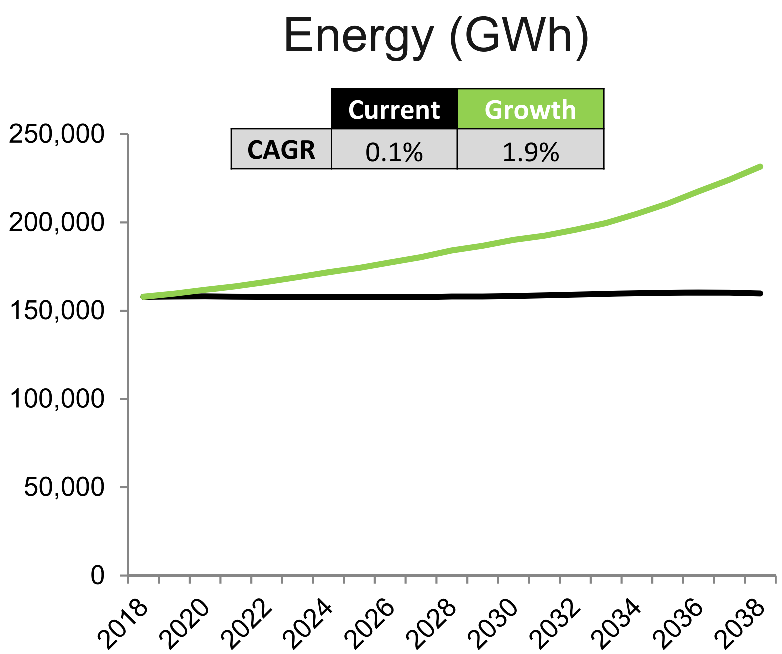


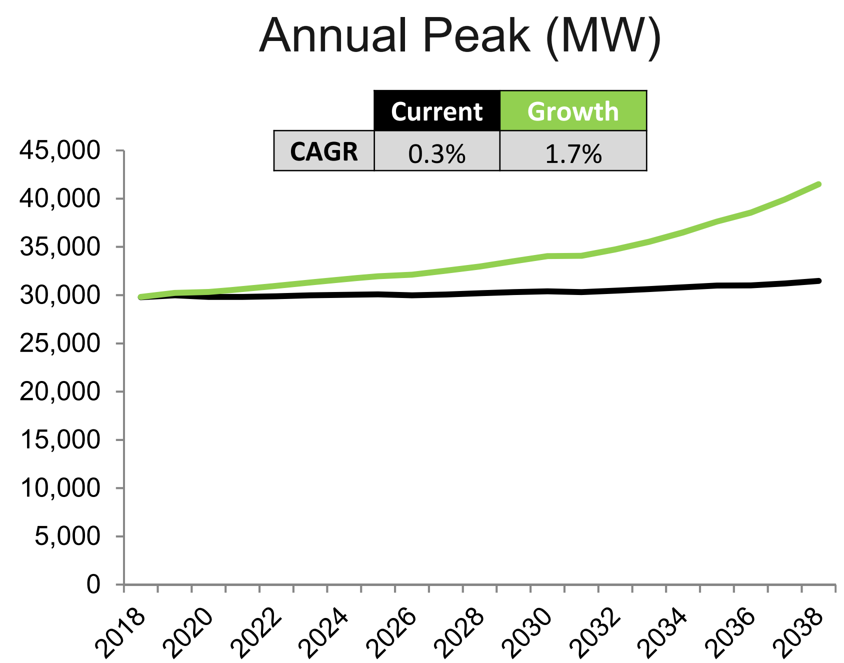
Winter Peak Day



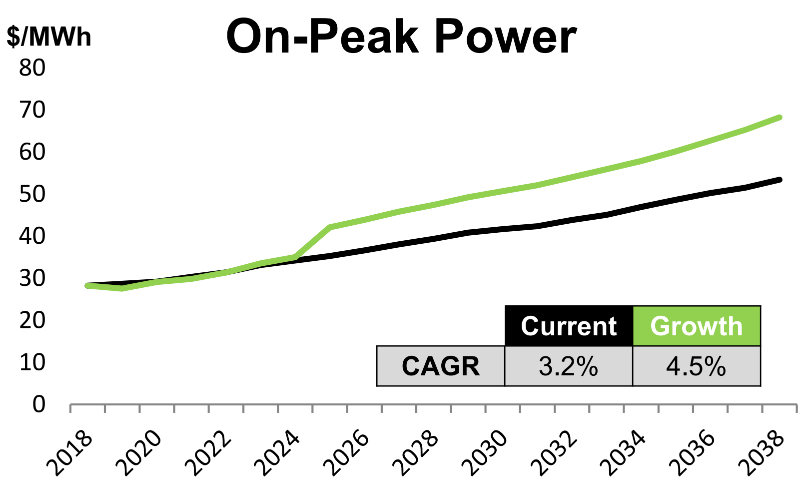


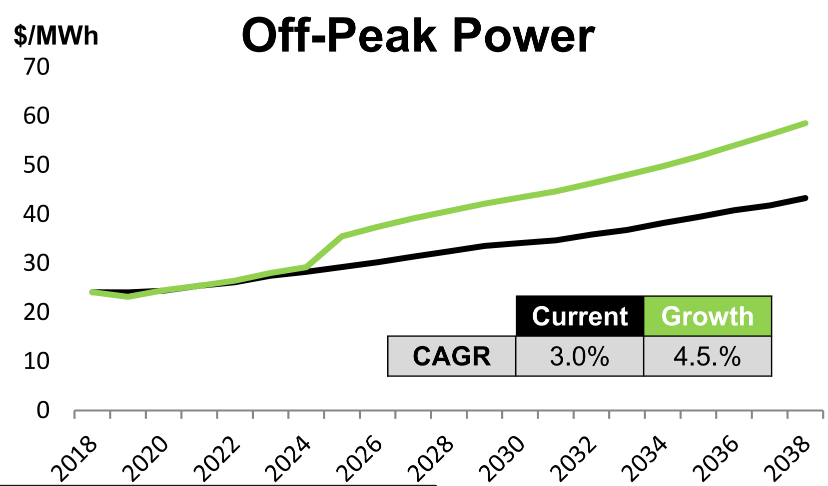
3. Growth: Energy and Annual Peak





3. Growth: Wholesale Power Prices





The combination of higher natural gas prices and CO2 costs drive power prices higher in 2025.

National Capacity Mix by 2038

	Coal	NatGas	Nuclear	Hydro	Wind	FuelOil	Solar	Other
Current	20%	52%	7%	9%	7%	1%	3%	1%
Growth	20%	53%	7%	8%	7%	1%	3%	1%

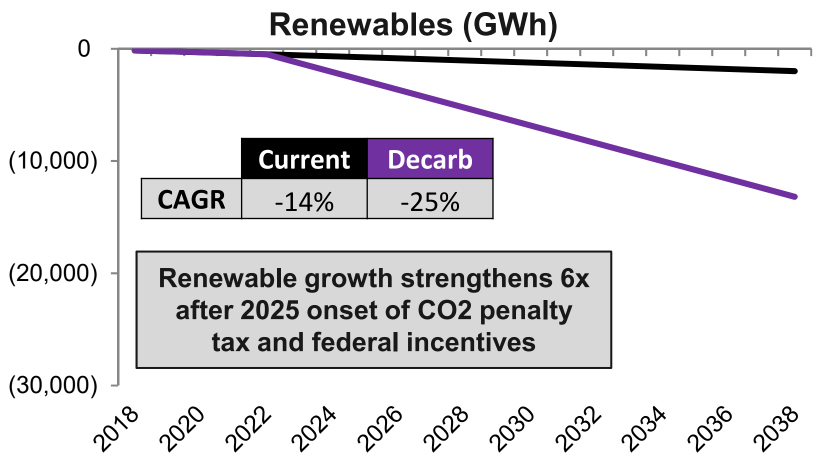
4. Decarbonization

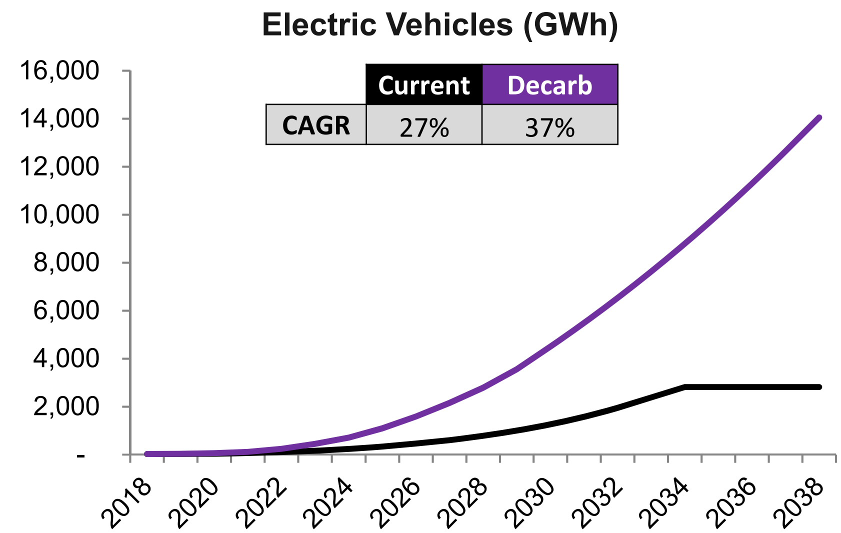
4. Decarb: Assumptions

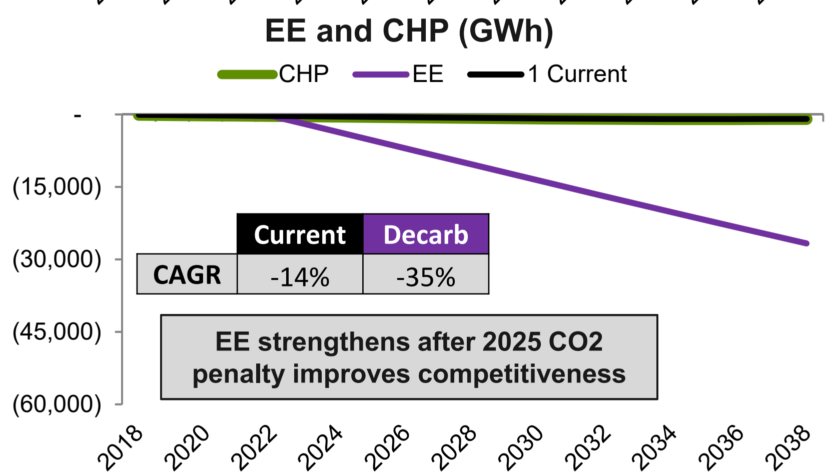
Load Drivers	• Renewables: increased behind-the-meter solar due to increased federal incentives, **up to 13,000 GWh by 2038**
	• Battery Storage: incentives, declining technology costs and desire for clean energy influences lead to 22% of residential and commercial solar owners adopting battery storage by 2038
	• Electric Vehicles: incentives to reduce CO2 leads to higher penetration, grow to **14,000 GWh by 2038 (1.8M EVs**)
	• Energy Efficiency: increases in EE penetration to reduce CO2 emissions

Commodity Drivers	• National demand **declines from 0.3% to -0.2%;** gas production drops with lower demand
	• CO2 Regulations: very high CO2 costs increase with inflation: **$22/ton in 2025** with additional **$10/ton in 2035**; drives coal prices lower
	• Solar: lower costs
	• National Mix: strong increase in solar construction; coal capacity declines; gas capacity flat

4. Decarb: Load Drivers





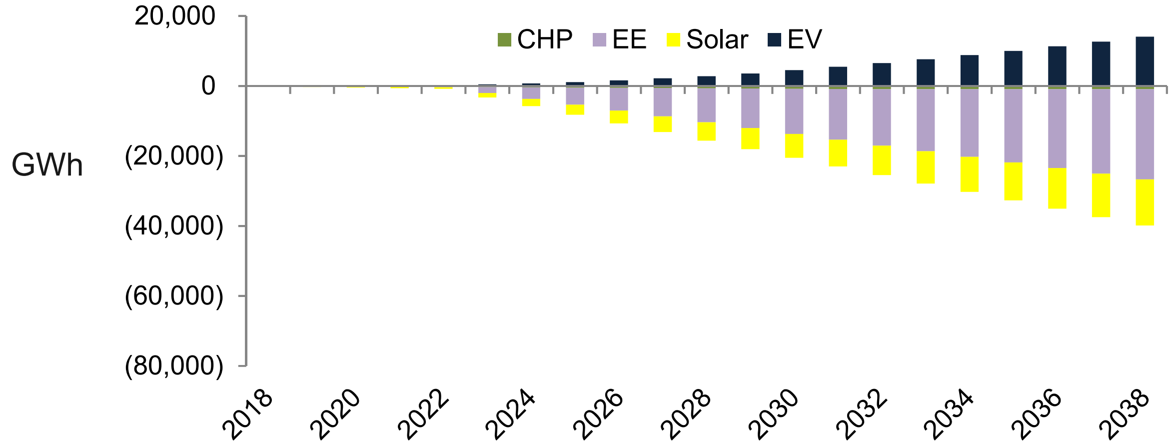


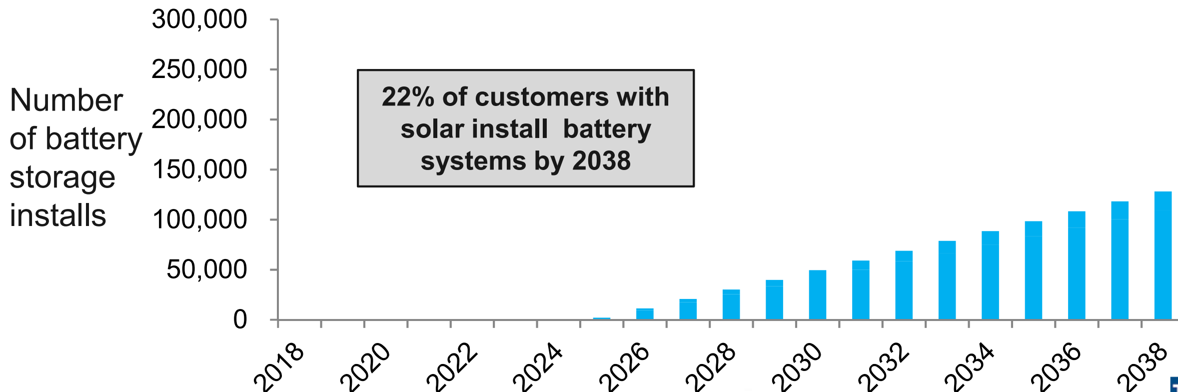
To promote CO2 reduction:

- Extension of Fed ITC (30%) until end of study
- Additional federal incentives after 2025 that reduce upfront costs of renewables
- EV incentive

4. Decarb: Scenario Assumption Impacts

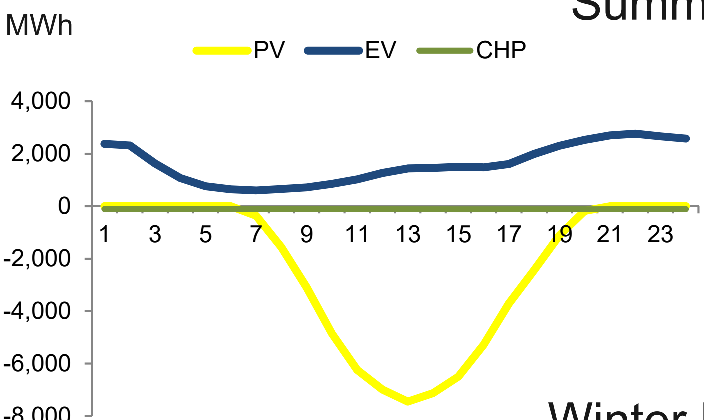
- Carbon penalty starts in 2025 leading to higher adoption of solar and energy efficiency implementation in order to reduce emissions and costs
- Federal incentives leads to more solar, battery and EV penetration

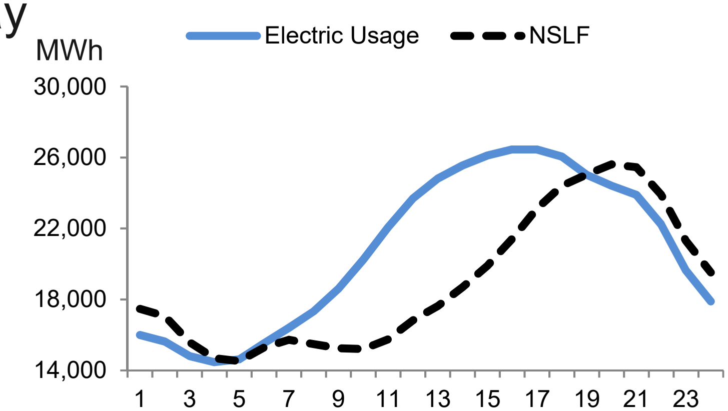




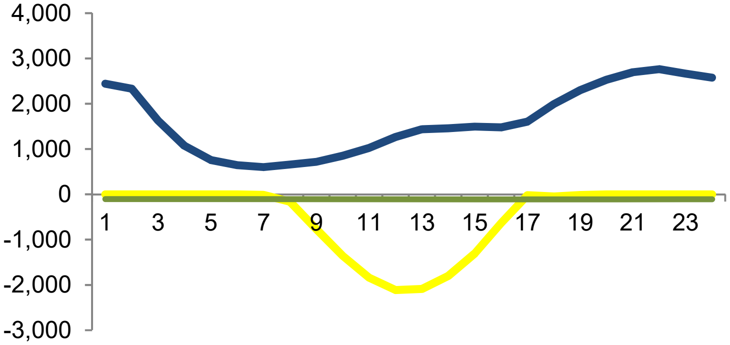
4. Decarb: Load Served 2038

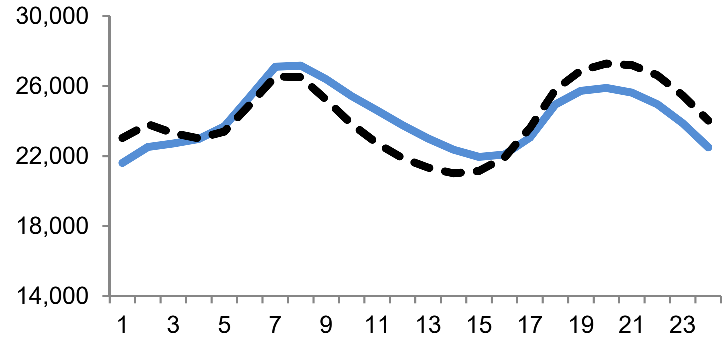
Summer Peak Day



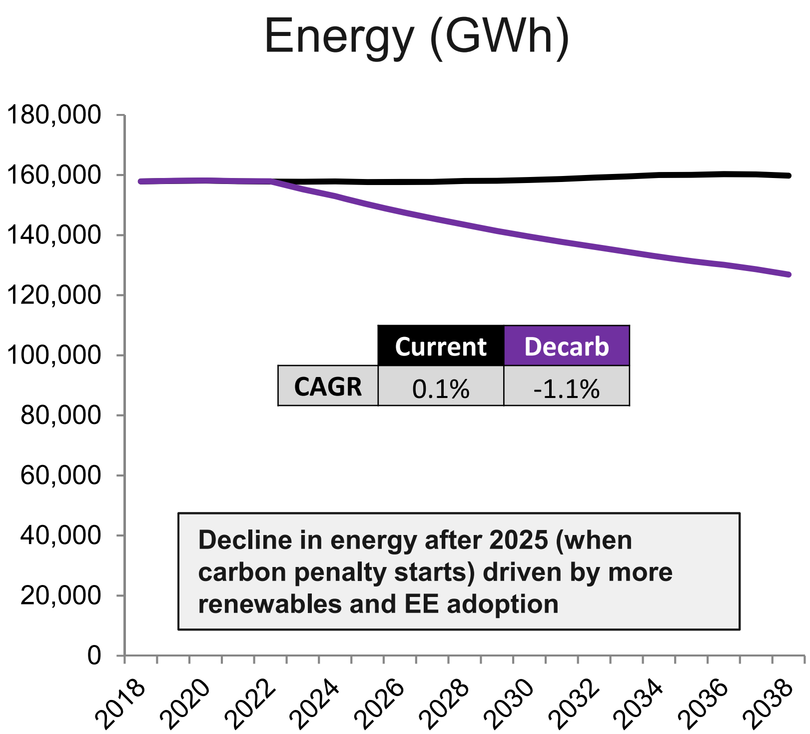


Winter Peak Day

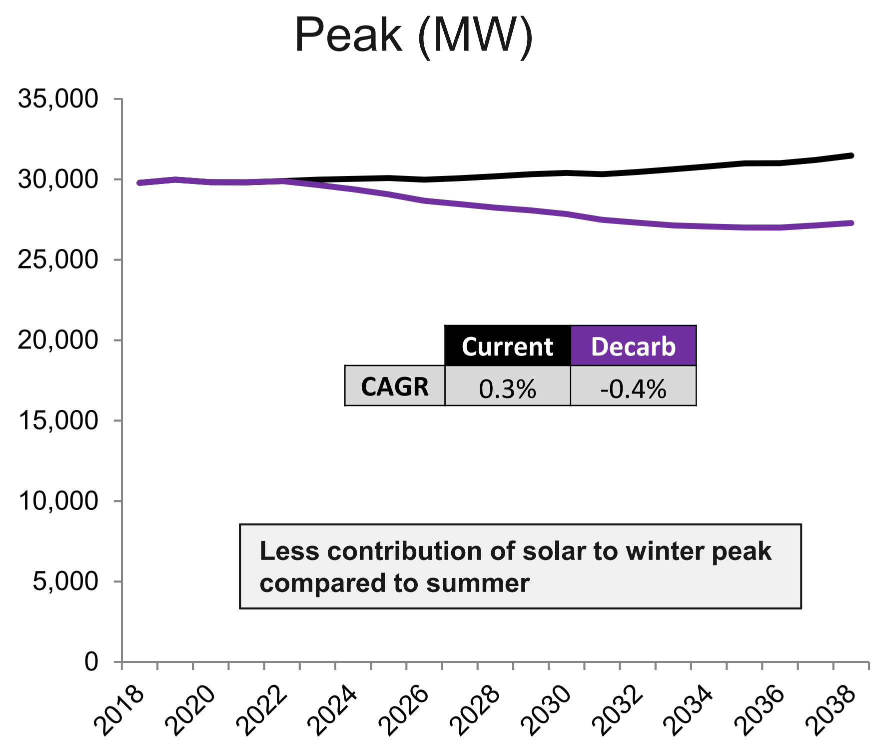




4. Decarb: Energy and Annual Peak

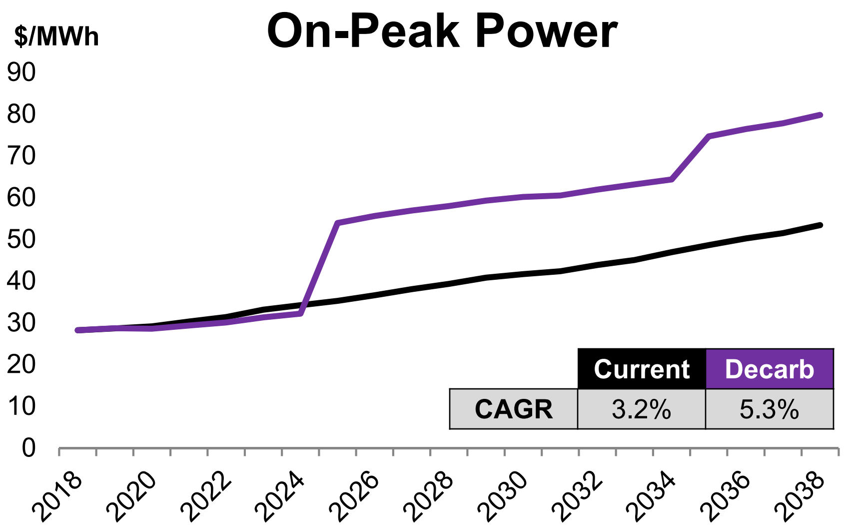


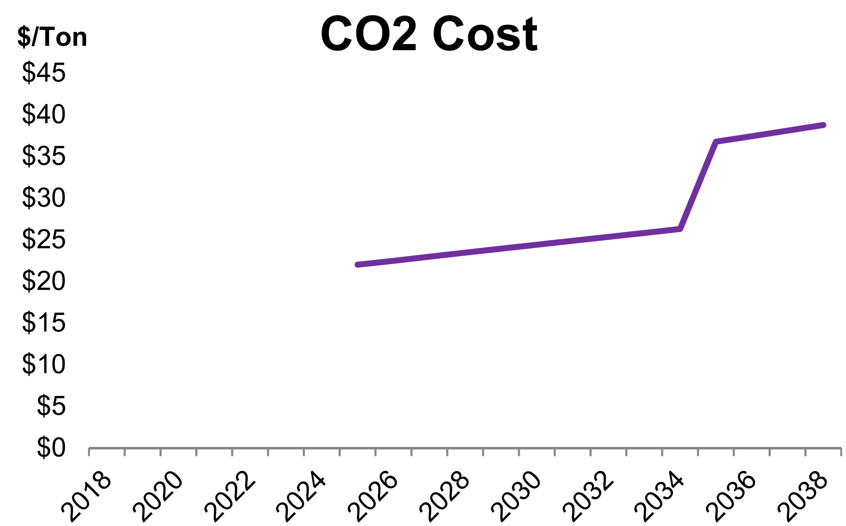
	Current	Decarb
CAGR	0.1%	-1.1%



	Current	Decarb
CAGR	0.3%	-0.4%

4. Decarb: Wholesale Power Prices





National Capacity Mix by 2038

	Coal	NatGas	Nuclear	Hydro	Wind	FuelOil	Solar	Other
Current	20%	52%	7%	9%	7%	1%	3%	1%
Decarb	21%	44%	8%	9%	9%	1%	6%	1%

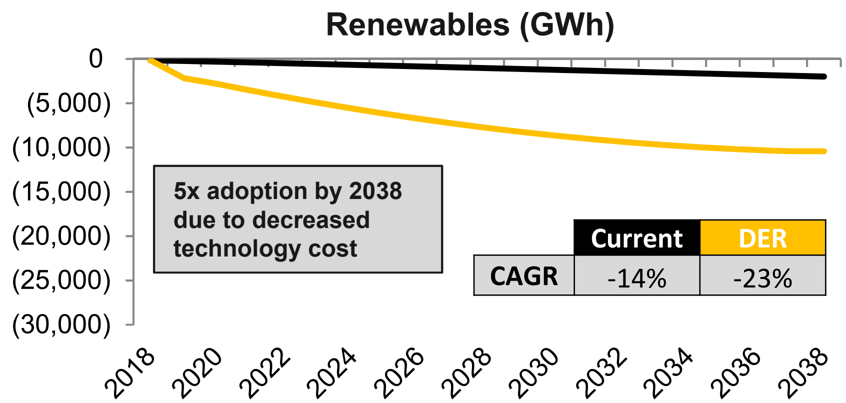
Rapid DER Adoption

5. DER: Assumptions

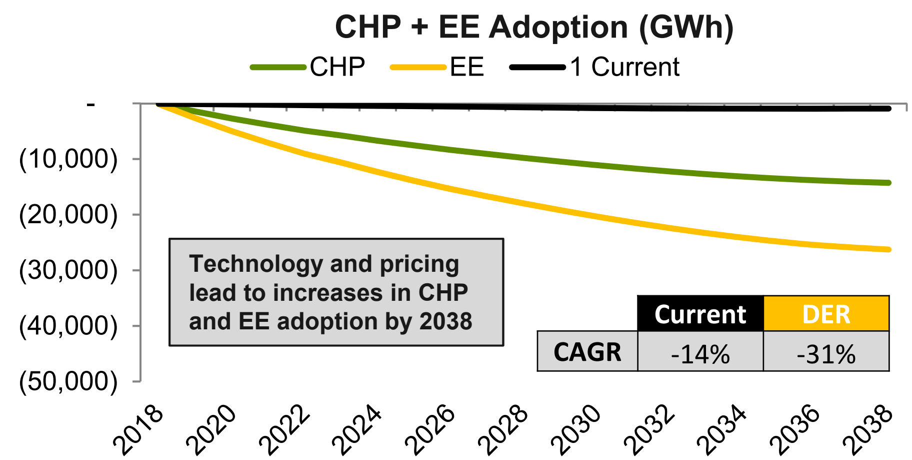
Load Drivers	• Renewables: increased behind-the-meter solar penetration due to decreasing costs for residential applications **(9,000 GWh, 8% energy reduction in 2038)**
	• Battery Storage: : declining technology costs and social influences lead to 23% of residential and commercial solar owners adopting battery storage by 2038
	• Electric Vehicles: grow to **9,000 GWh by 2038** (1.2M EVs)
	• Energy Efficiency: demand reduction increases (**12,000 GWh by 2038**)
	• Combined Heat & Power: Increase in adoption due to technology advancements and cost reduction (**10,000 GWh by 2038**)

Commodity Drivers	• National demand declines from 0.3% to -0.4% reducing gas and coal demand
	• Solar: Very low solar costs
	• National Mix: Strong increase in solar construction; coal capacity declines; gas capacity is flat

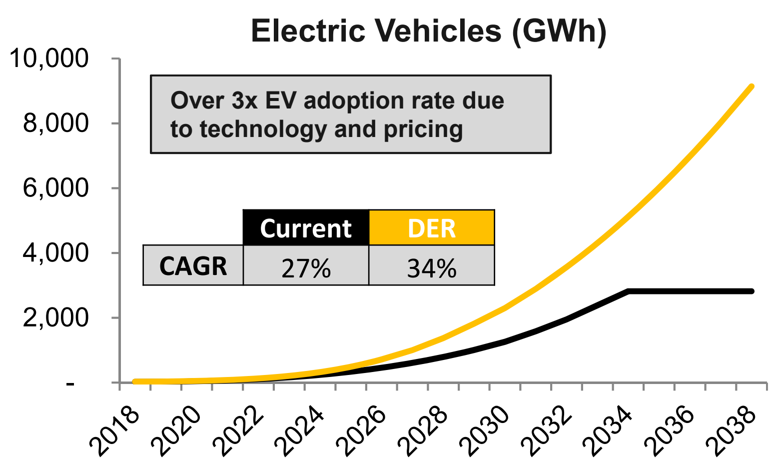
5. DER: Load Drivers



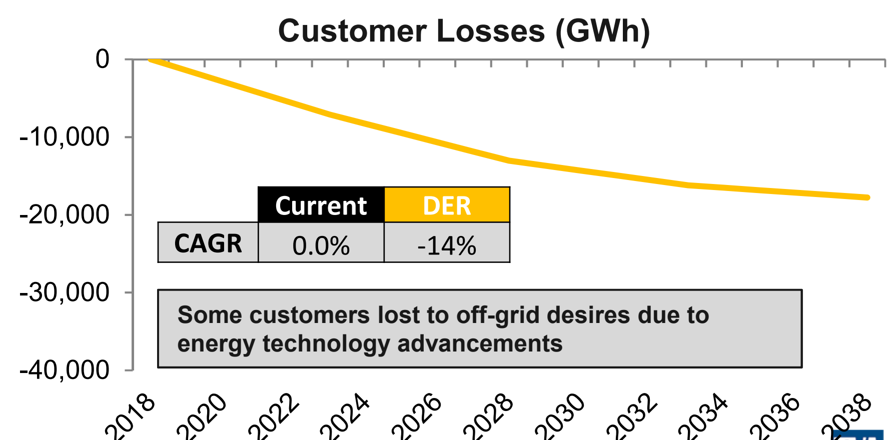
	Current	DER
CAGR	-14%	-23%



	Current	DER
CAGR	-14%	-31%



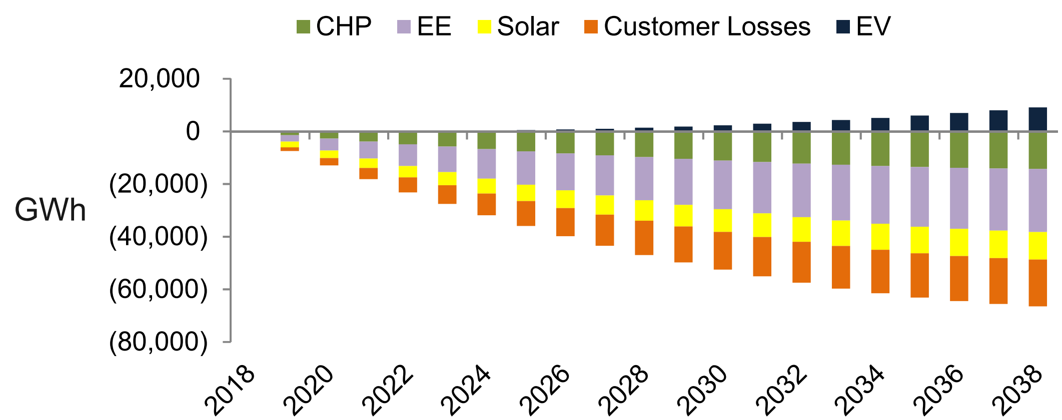
	Current	DER
CAGR	27%	34%

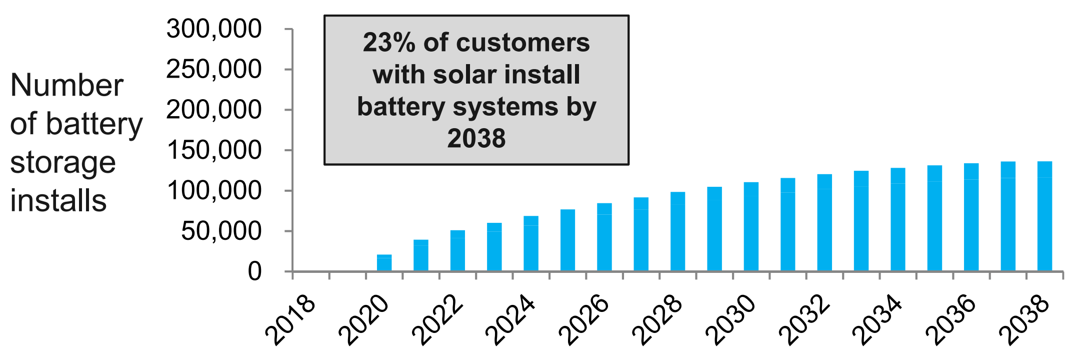


	Current	DER
CAGR	0.0%	-14%

5. DER: Scenario Assumption Impacts

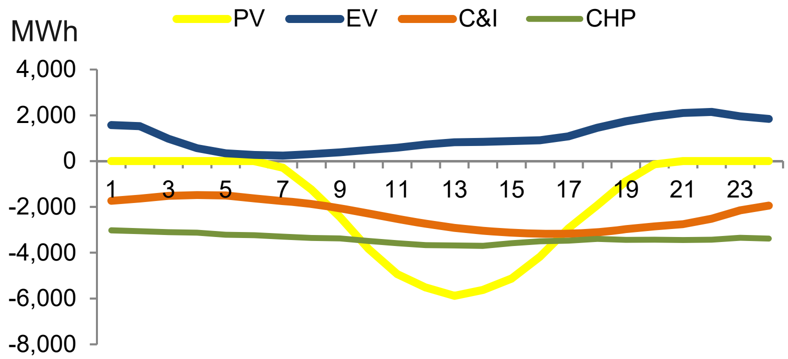
- Due to advancements in distributed energy technologies and decreasing costs, adoption happens rapidly
- EV adoption driven by increases in technology
- Customer losses due to off-grid desire and increased technological advancements resulting in off grid capability

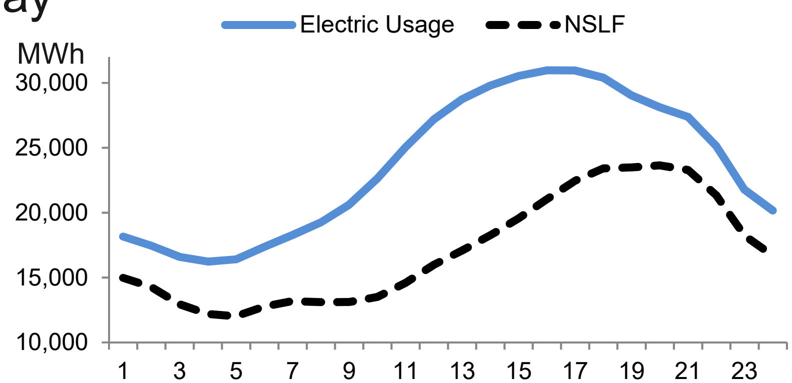




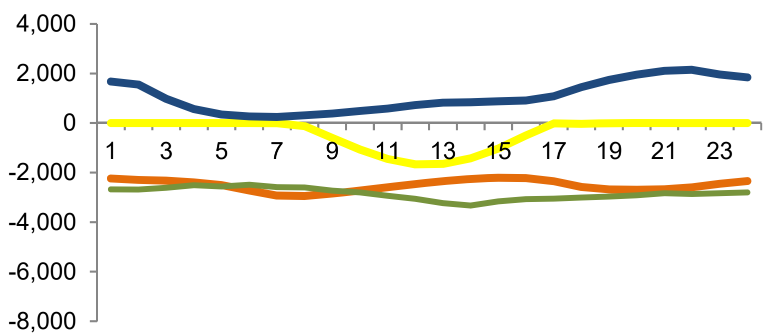
5. DER: Load Served 2038

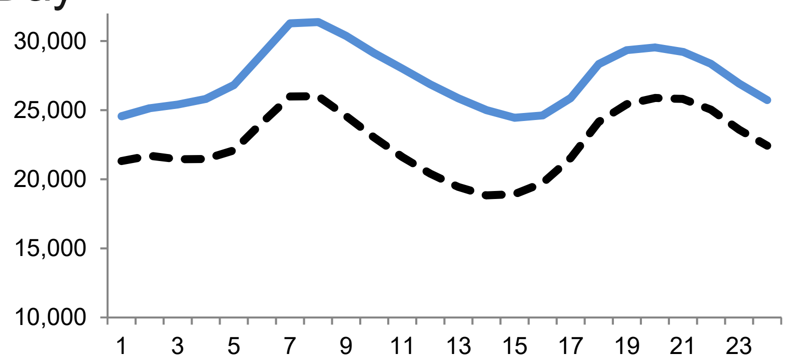
Summer Peak Day



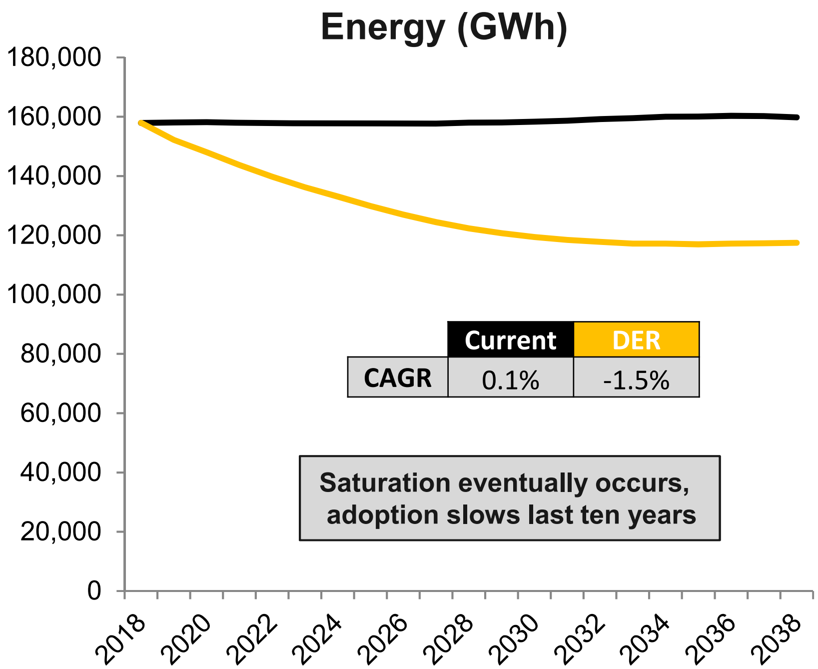


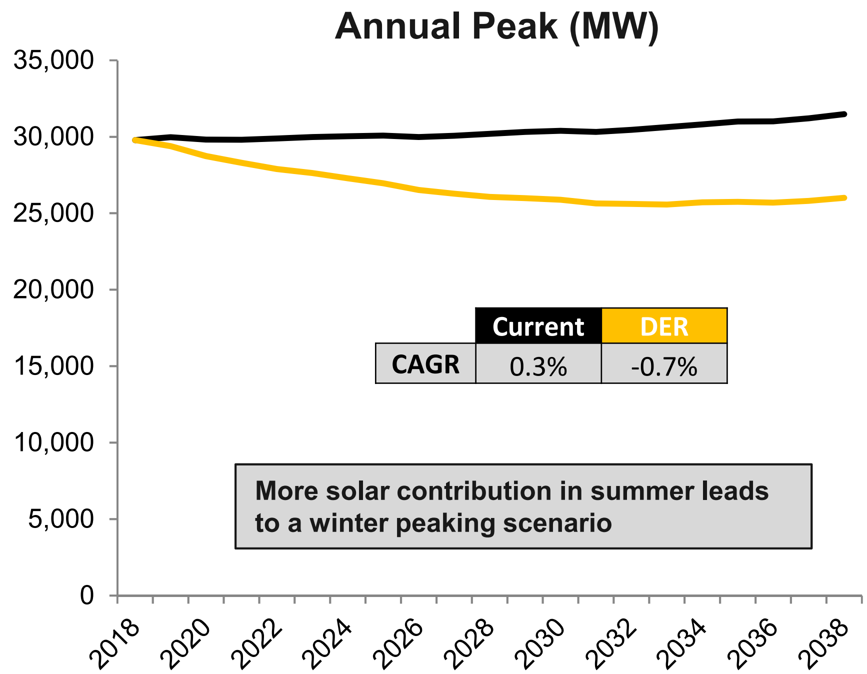
Winter Peak Day



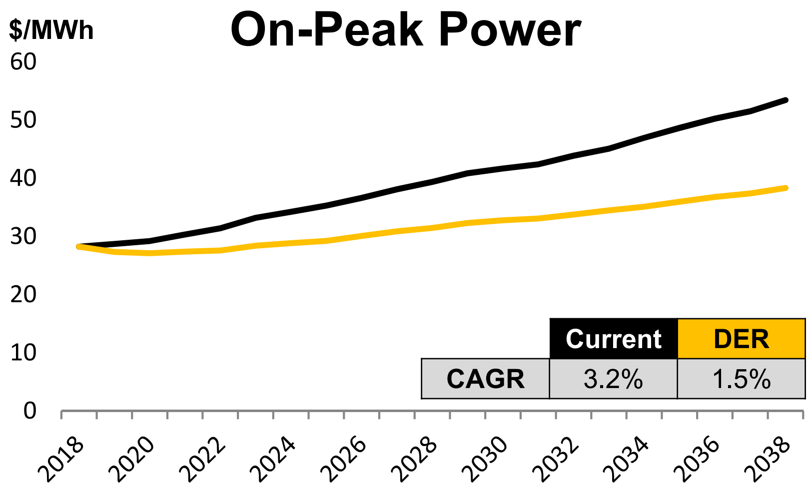


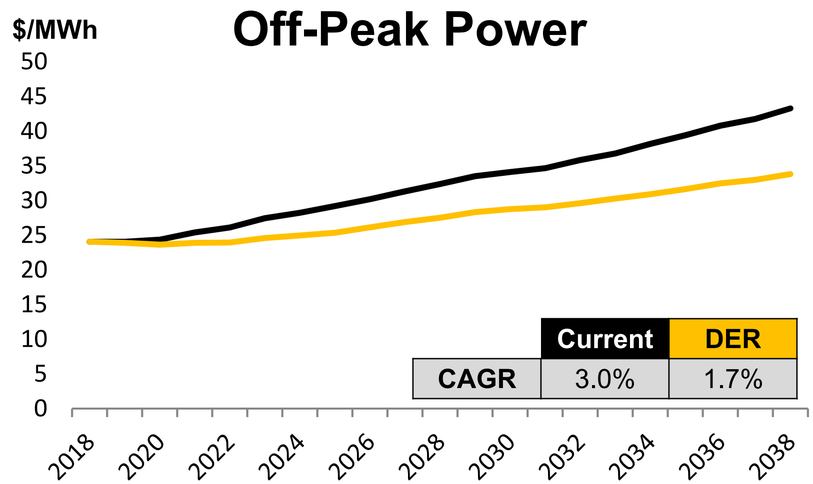
5. DER: Energy and Annual Peak





5. DER: Wholesale Power Prices





Lower coal and natural gas prices, coupled with lower demand drive the lower peak and off-peak power prices.

National Capacity Mix by 2038

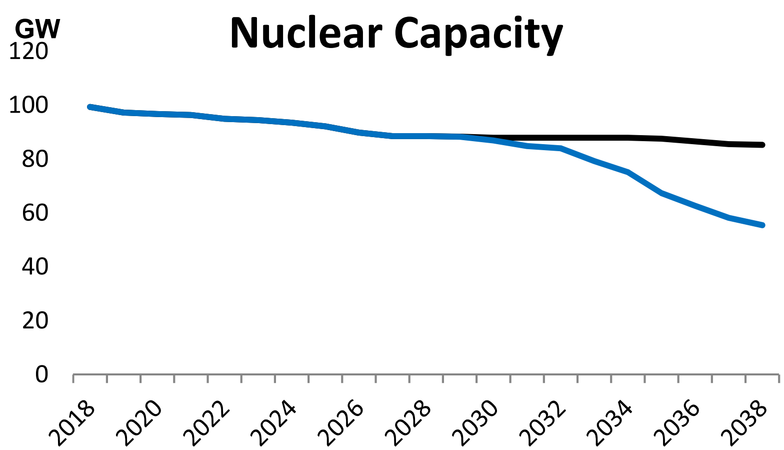
	Coal	NatGas	Nuclear	Hydro	Wind	FuelOil	Solar	Other
Current	20%	52%	7%	9%	7%	1%	3%	1%
DER	21%	45%	8%	9%	8%	1%	6%	1%

No Nuclear Extensions

6. Nuclear: Commodity Assumptions

National Capacity Mix	• Decreasing nuclear capacity after 2030; no changes in solar; coal capacity declines; natural gas capacity slightly higher replacing lost nuclear
National Demand	• No change
CO2 Regulations	• No change
Solar Prices	• No change
Gas Prices	• No change
Coal Prices	• No change

6. Nuclear: National Impacts



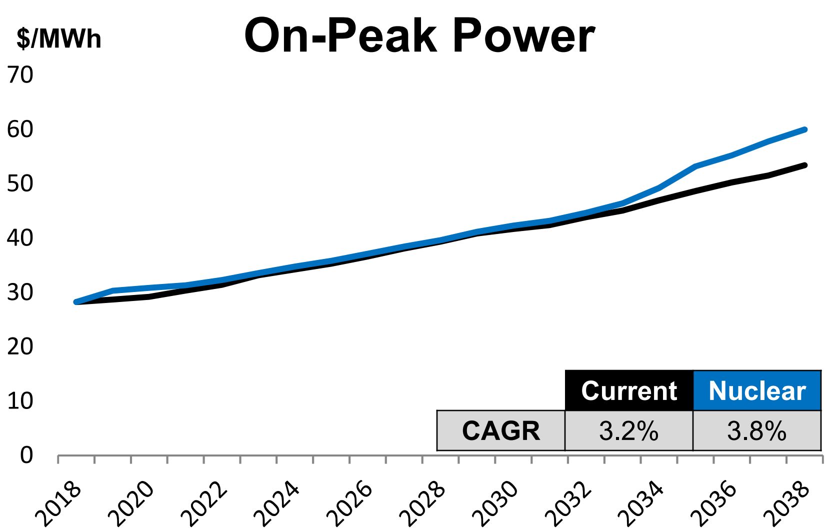
While nuclear generation and capacity is lower beyond 2030, gas and coal show a slight increase.

National Capacity Mix by 2038

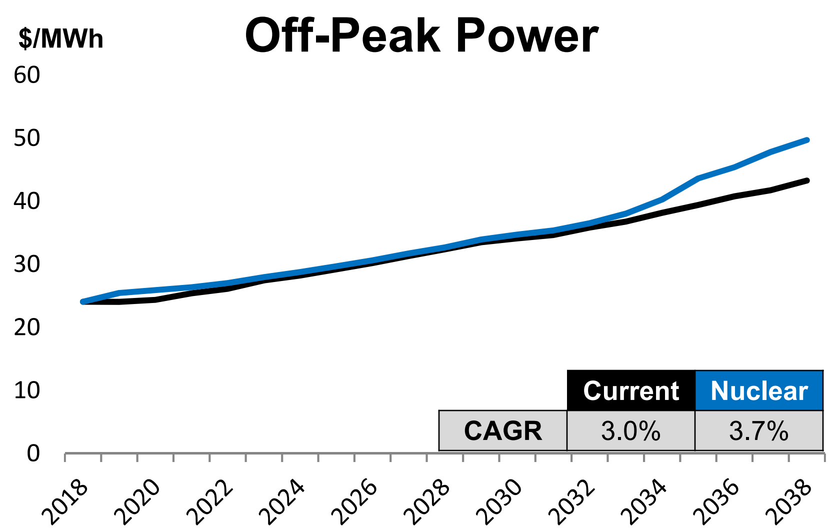
	Coal	NatGas	Nuclear	Hydro	Wind	FuelOil	Solar	Other
Current	20%	52%	7%	9%	7%	1%	3%	1%
Nuclear	20%	53%	5%	9%	8%	1%	3%	1%

Nuclear retirements, due to units reaching their 60 year operational life, lowers nuclear capacity beyond 2030.

6. Nuclear: Wholesale Power Prices



	Current	Nuclear
CAGR	3.2%	3.8%



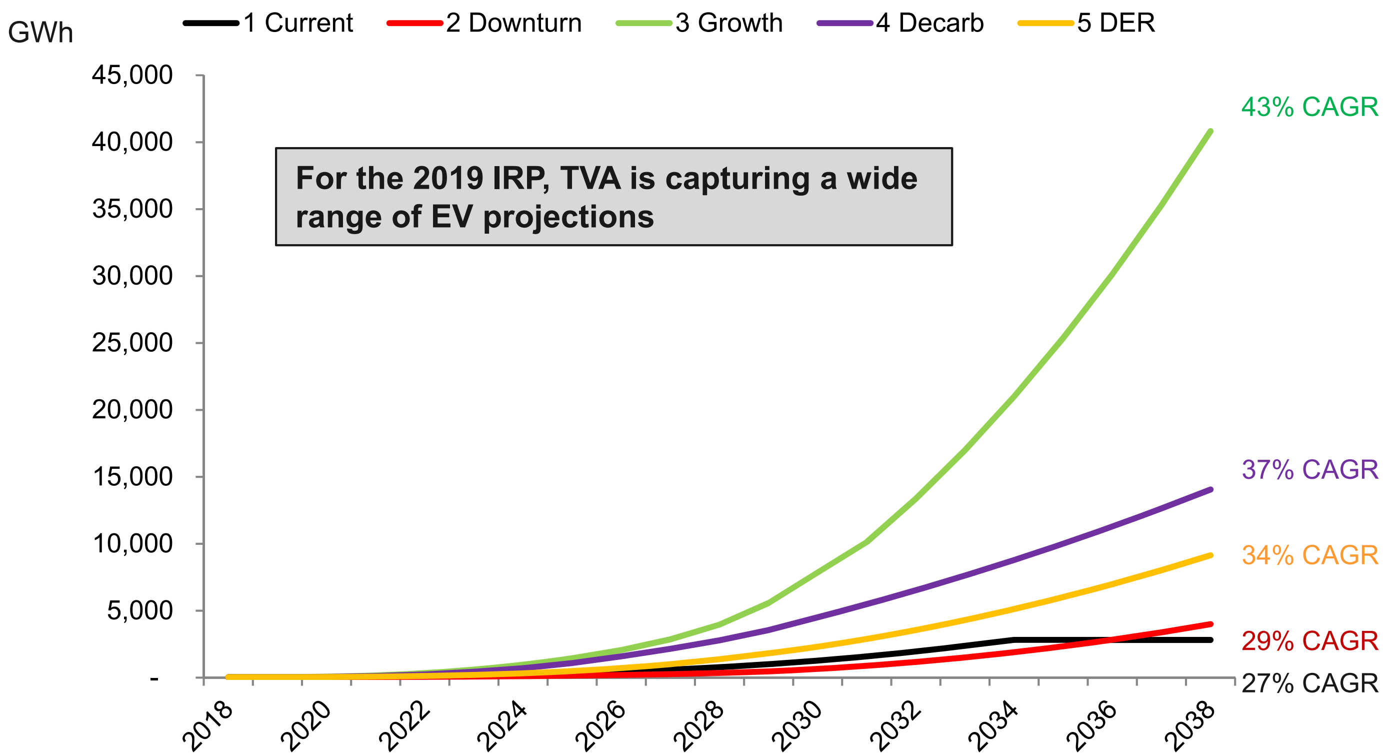
	Current	Nuclear
CAGR	3.0%	3.7%

Beyond 2030 the loss of national nuclear capacity pushes natural gas demand and prices higher and the power prices follow the upward trend.

BREAK

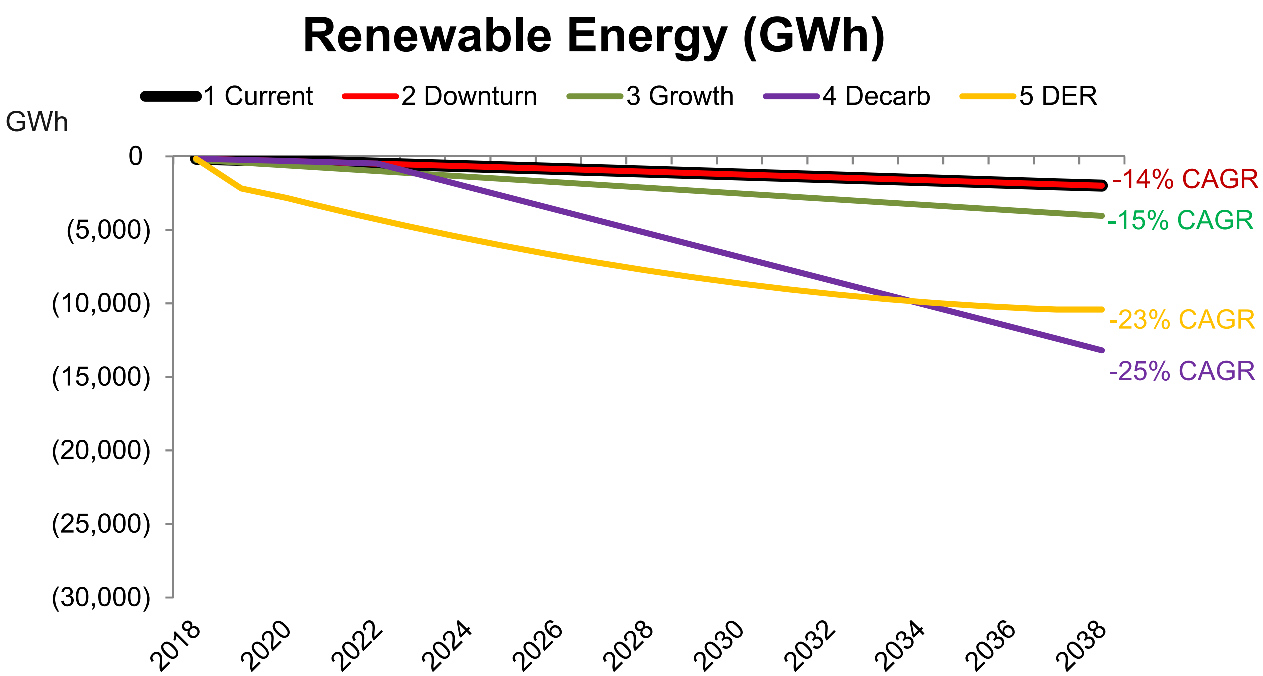
Scenario Summary

Electric Vehicle Load Projections



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

Renewables Projections



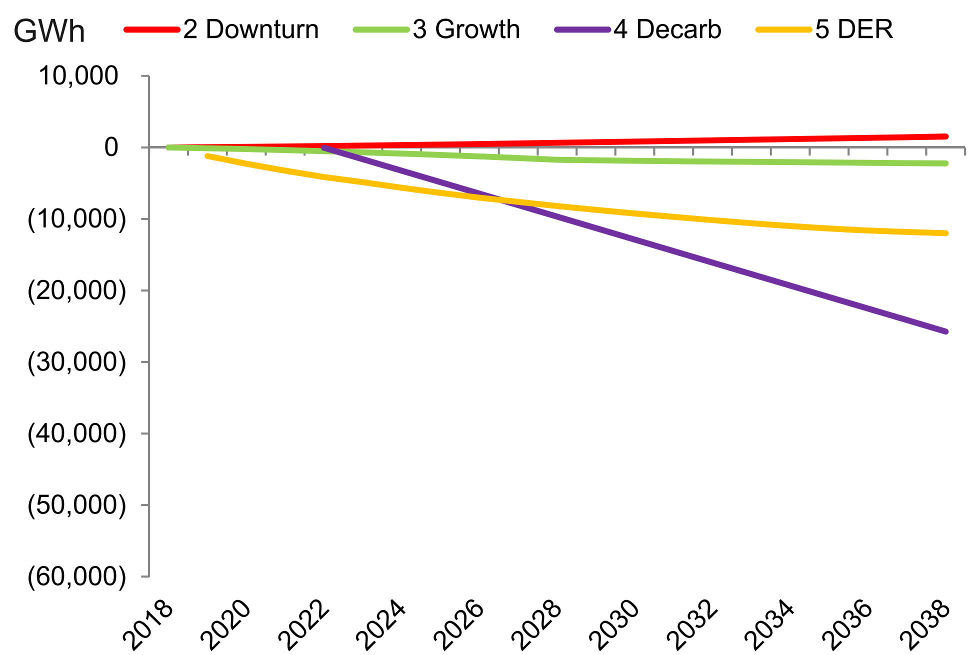
- Economic Downturn same as Current Outlook
- Decarbonization and Rapid DER see the highest renewable adoption
- In the rapid case, adoption faster in the first 10 years than in decarbonization case which sees rapid adoption after 2025

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

EE Growth Above Current Outlook

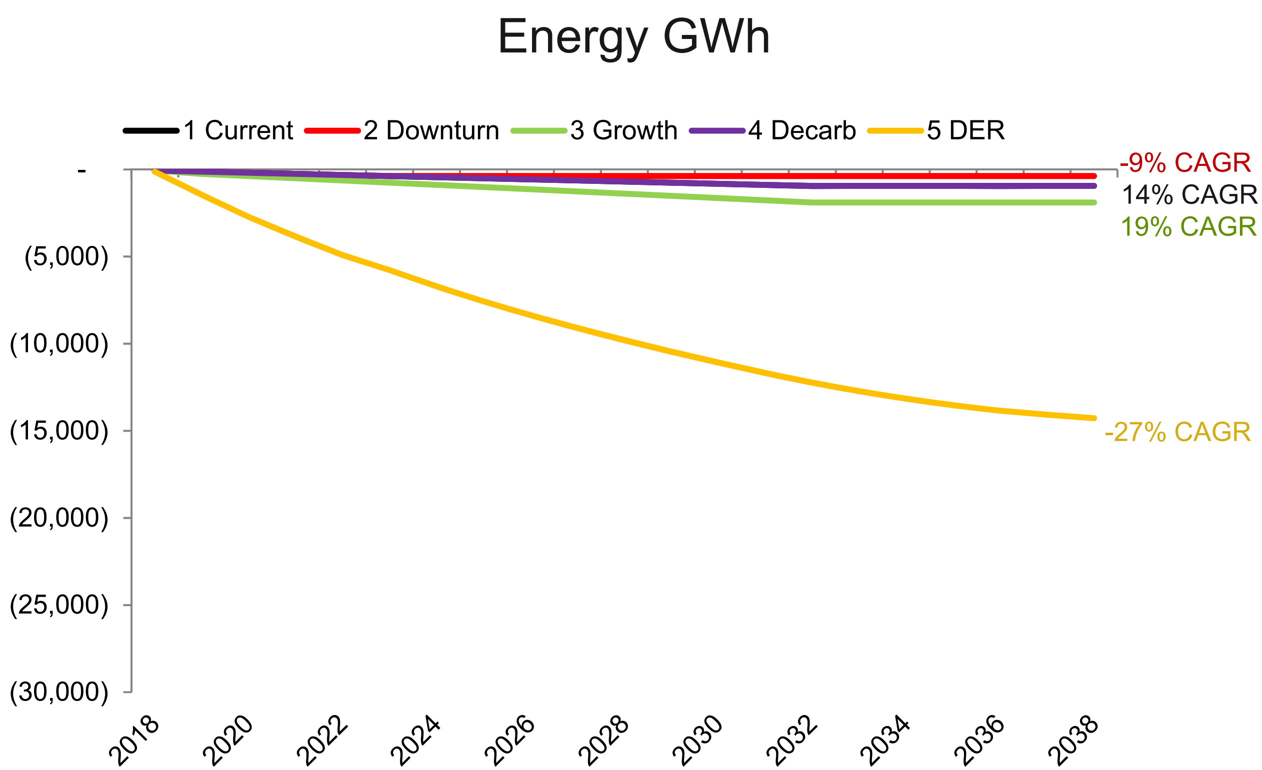
- EE impact includes energy conservation and energy efficiency adoption above current outlook DOE standards
- DOE standards remain at same stringency in Current, Downturn, and Growth scenarios
- Largest adoptions in Rapid DER scenario due to technology advancements and Decarbonization scenario due to emission reduction efforts

EE Impact Difference from Current Outlook



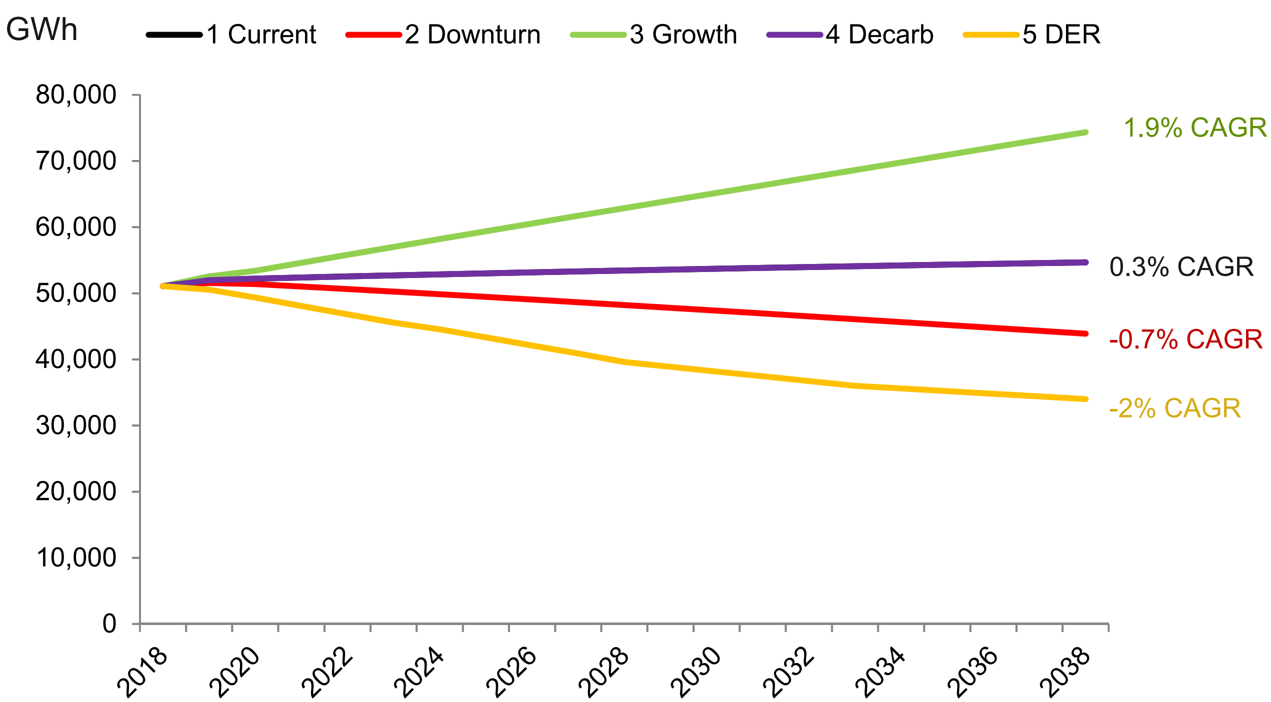
Note: Forecast for Scenario 6 Nuclear same as 1 Current Outlook

CHP Projection



- CHP growth mainly seen in the DER case due to technology advancement and decreased price
- CHP in the Growth case is 2x the Current due to increased C&I growth in the valley
- Decarb case sees no growth of CHP beyond current outlook

Customer Growth Projections

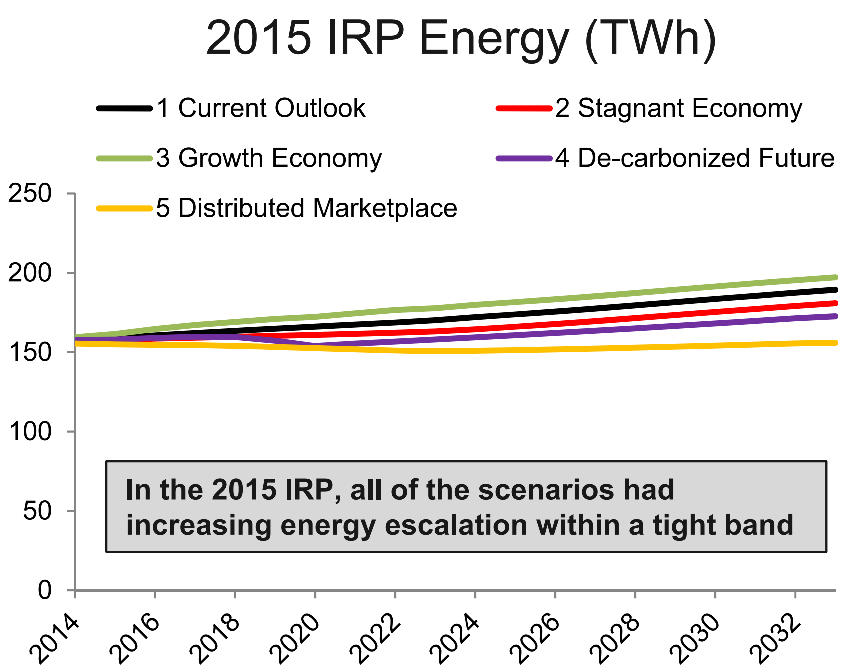


- Annual growth at 1.9% in the growth scenario due to in-migration and economic factors
- 0.7% losses occur in the downturn case due to economic factors
- Customer losses in the DER scenario due to other energy technology advancements and third party competition allowing customers to go off-grid

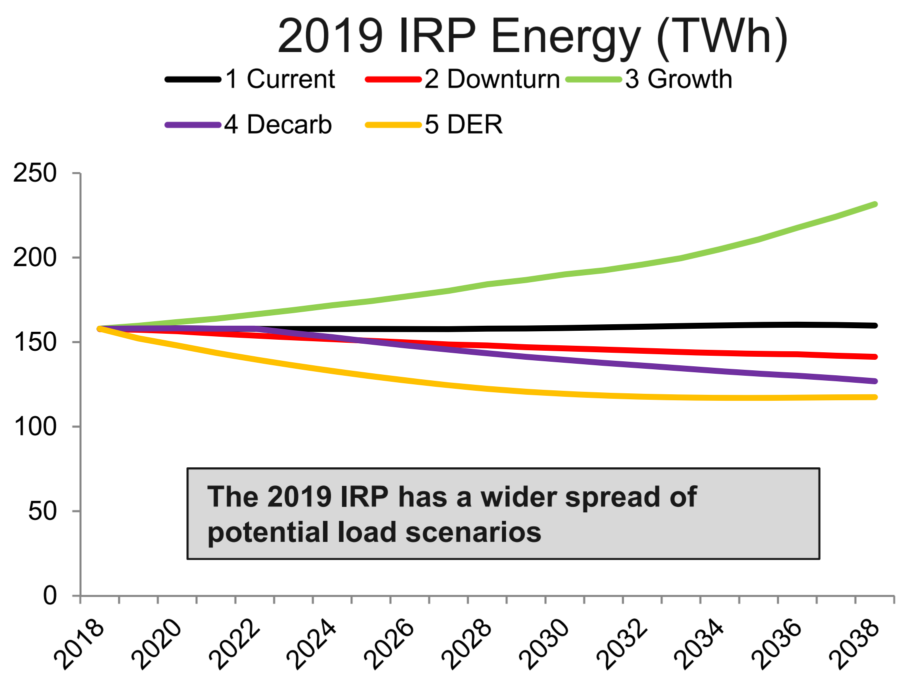
Note: Forecast for Scenarios 4 Decarb and 6 Nuclear same as 1 Current Outlook

2015 & 2019 IRP Scenario Comparison

IRP Comparison

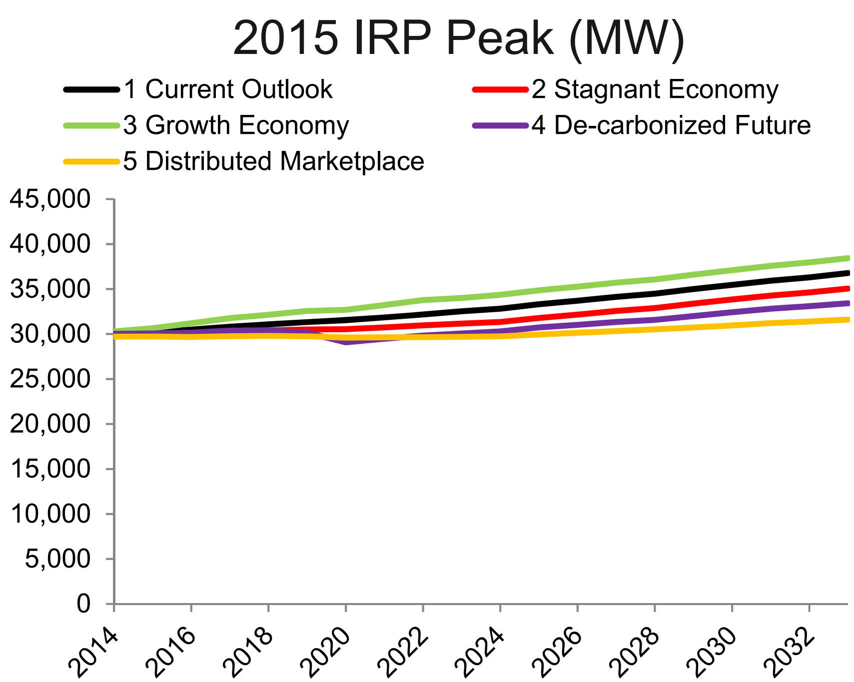


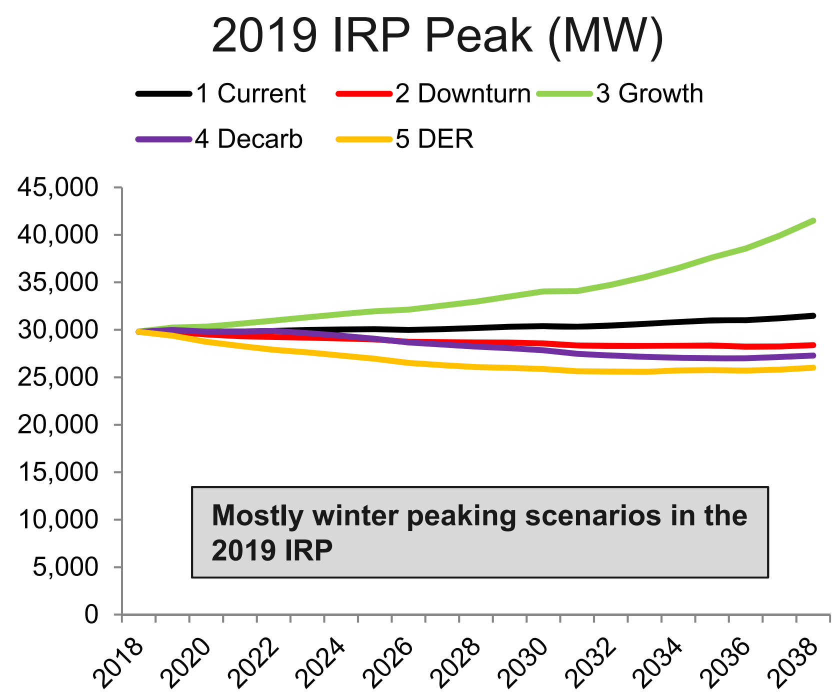
	Current	Stagnant	Growth	Decarb	Dist. Mkt
CAGR	0.9%	0.6%	1.1%	0.4%	-0.1%



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

IRP Comparison





	Current	Stagnant	Growth	Decarb	Dist Mkt
CAGR	1.1%	0.8%	1.3%	0.6%	0.3%

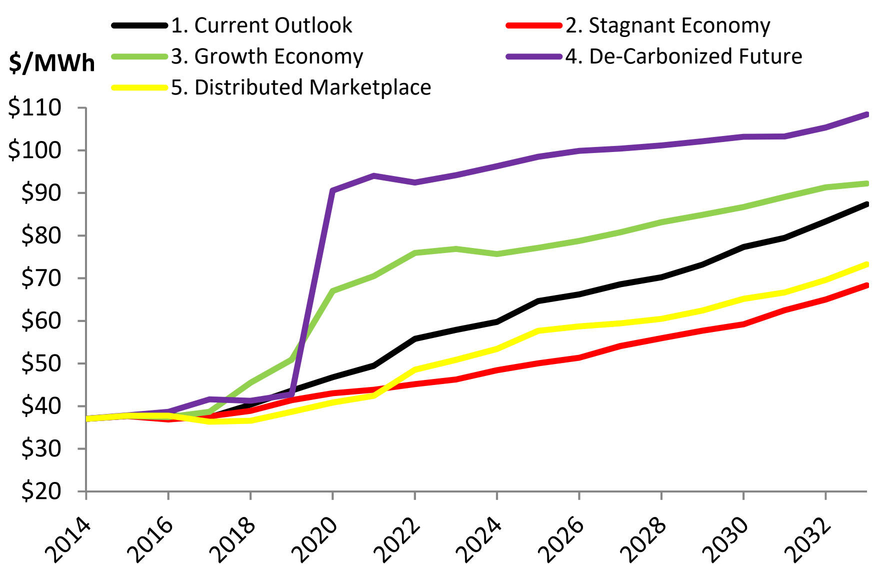
	Current	Downturn	Growth	Decarb	DER	Nuclear
CAGR	0.3%	-0.2%	1.7%	-0.4%	-0.7%	0.3%

Note: Load forecast for Scenario 6 Nuclear same as 1 Current Outlook

TVA Wholesale Power Prices

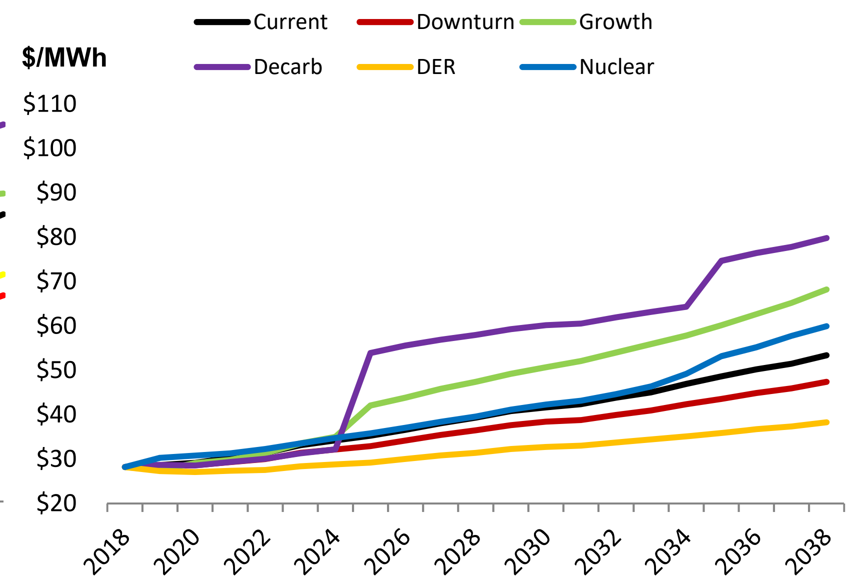
On-Peak

2015 IRP



In the 2015 IRP, all of the scenarios had increasing national demand escalation.

2019 IRP



Most significant driver of scenario differences is CO2 costs in 2025. Otherwise, national load changes influence natural gas prices & capacity additions.

Scenario Assumptions

	Current	Downturn	Growth	Decarb	DER	Nuclear
Annual Energy CAGR (2018-2038)	**Flat (0.0%)**	**Low (-0.5%)**	**High (1.9 %)**	**Low (-1.1%)**	**Very Low (-1.5%)**	**Flat (0.0%)**
Annual Peak MW CAGR (2018-2038)	0.3%	-0.2%	1.7%	-0.4%	-0.7%	0.3%
ITC Tax Credit	Follows current ITC	Follows current ITC	Follows current ITC	ITC Extension and incentives to drive decarbonization	Follows current ITC	Follows current ITC
Renewable Impact (BTM)	14% CAGR	14% CAGR	14% CAGR	25% CAGR	23% CAGR	13% CAGR
Storage (BTM)	0%	0%	37% CAGR (Last 10 years)	37% CAGR (Last 14 years)	10% CAGR (Last 18 years)	0%
CHP Impact (BTM)	14% CAGR	9% CAGR	19% CAGR	14% CAGR	27% CAGR	14% CAGR
Electrification impact - EV	27% CAGR	29% CAGR	43% CAGR	37% CAGR	34% CAGR	27% CAGR
Customer Growth Impacts	0.3% CAGR	-0.7% CAGR	1.9% CAGR	0.3% CAGR	-2% CAGR	0.3% CAGR
Electrification impact - Cryptocurrency	0%	0%	22% CAGR	0%	0%	0%

Scenario Assumptions (2018 – 2038)

20-year CAGR	Current Outlook	Economic Downturn	Valley Load Growth	Decarbonization	Rapid DER Adoption	Nuclear
National Demand	0.3%	0.1%	1.4%	-0.2%	-0.4%	0.3%
Henry Hub Gas Price	4.0%	3.4%	4.5%	4.8%	2.6%	4.4%
On-Peak Power Price	3.2%	2.6%	4.5%	5.3%	1.5%	3.8%
Coal	2.4%	2.2% *	2.4% **	2.2% *	2.0%	2.4%

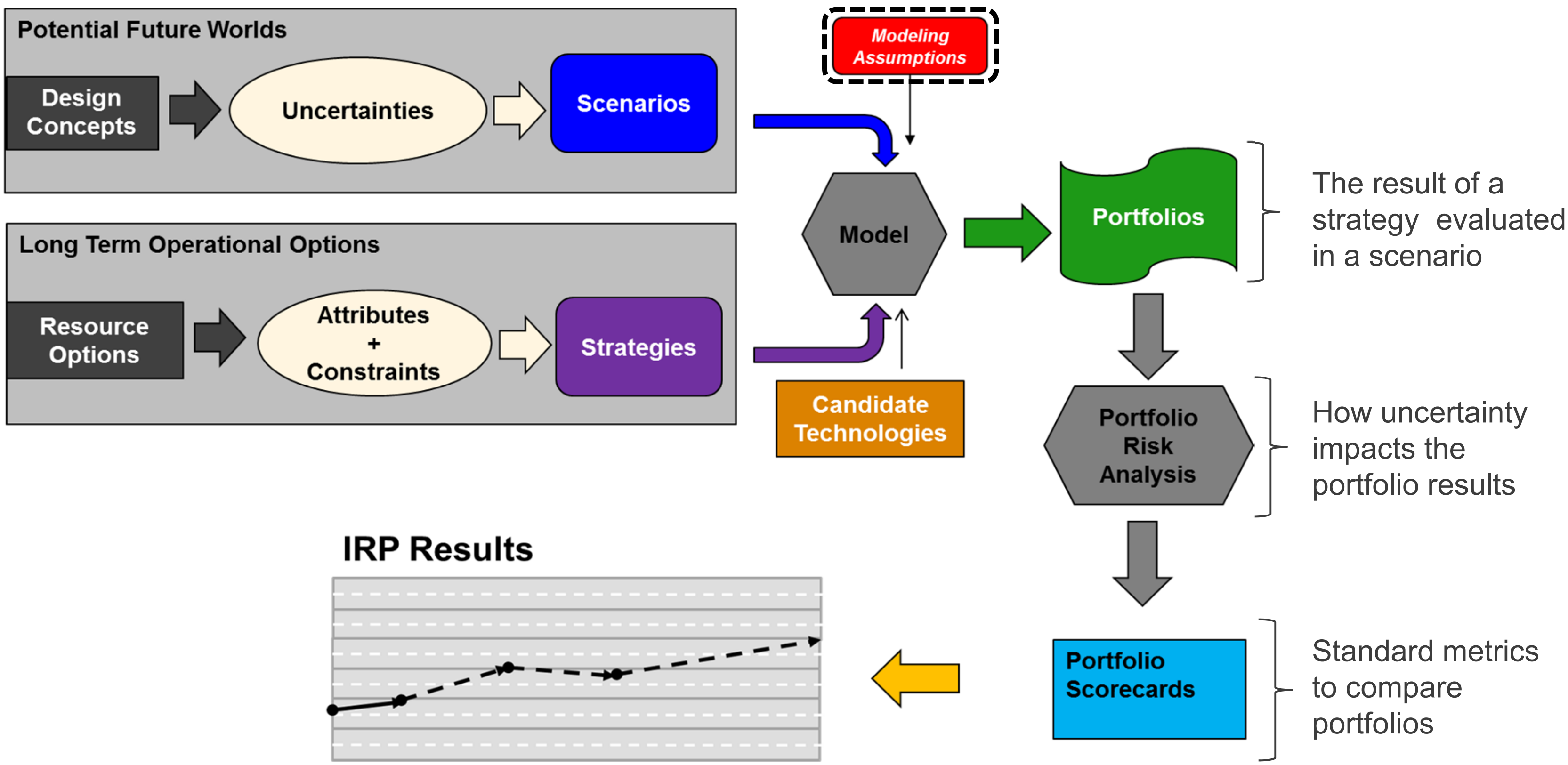
Notes:
* Real coal prices are lower than Current case, but higher inflation causes nominal prices to be slightly higher.
** Real coal prices are the same as Current case, but lower inflation causes nominal prices to be lower.

BREAK

Resource Planning Framework Review

Jane Elliott, Senior Manager
Scott Jones, Senior Program Manager
Roger Pierce, Program Manager
TVA Resource Strategy Group

Framework Informs Portfolio Optimization



Planning for an Evolving System

Winter Peaking Demand

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

More Renewable Resources

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

Increasing Need for Flexibility

Flexibility benefit recognizes the benefits driven by integrating flexible resources onto the system

Reserve Margin for Unplanned Events

Weather

Variability from normal
- Temperatures
- Thermal build up
- Hydrology

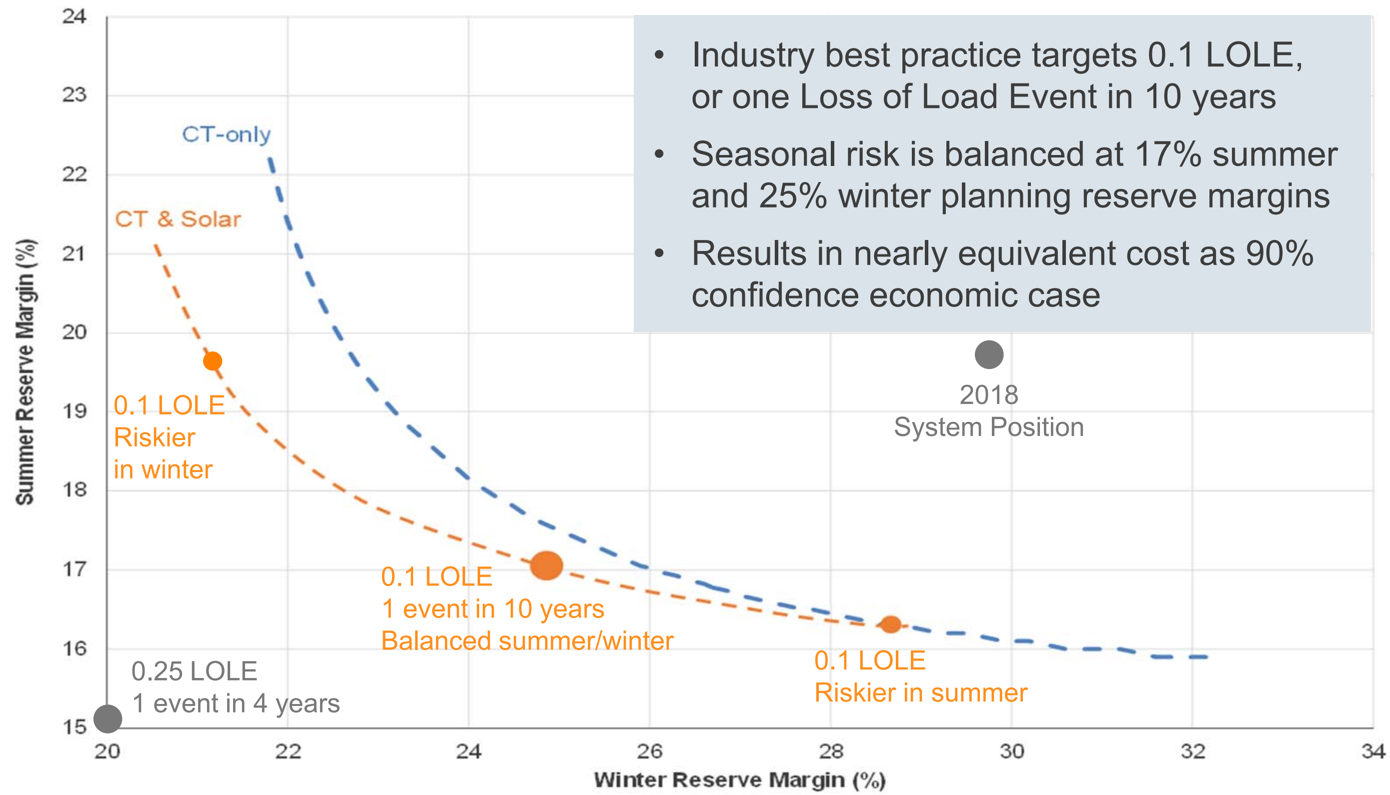
Forecast Error

Non-weather variability
- Economic cycles
- Consumer behavior

Outages

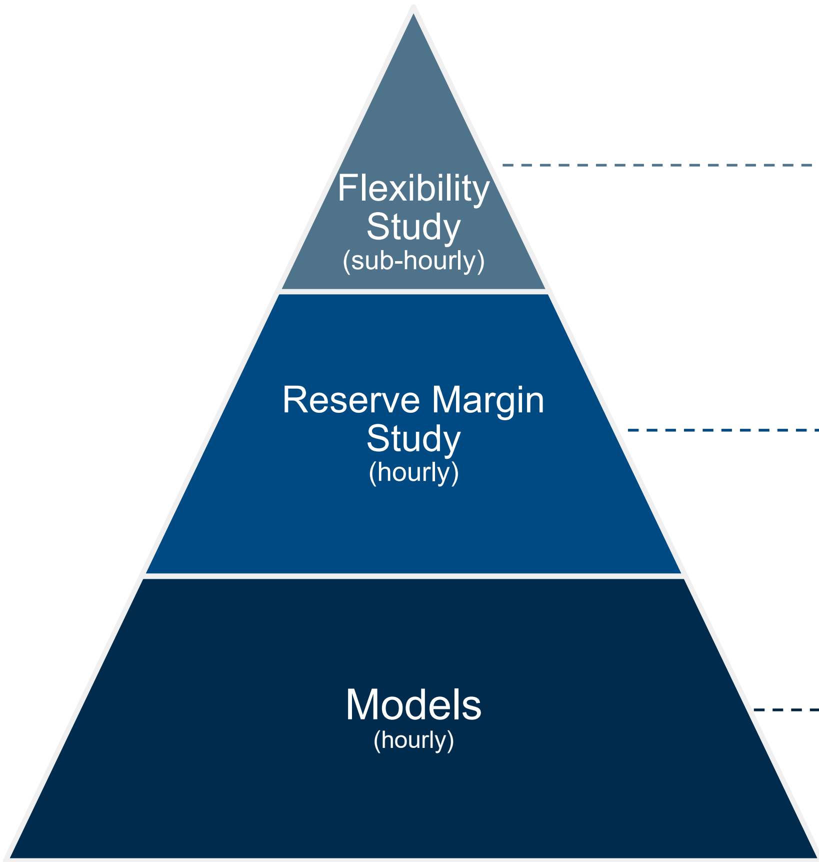
Unit performance
- Planned outages
- Forced outages
- Intermittent shapes

Balancing Seasonal Risk to Achieve 0.1 LOLE



- Industry best practice targets 0.1 LOLE, or one Loss of Load Event in 10 years
- Seasonal risk is balanced at 17% summer and 25% winter planning reserve margins
- Results in nearly equivalent cost as 90% confidence economic case

Capturing Flexibility Cost and Benefit



- Flexibility cost / benefit for:
  - o Solar and wind
  - o Aeroderivatives / reciprocating engines
  - o Batteries
- Historical solar and wind (sub-hourly)
- Island case

- Historical experience
  - o Temperature-capacity curves
  - o Load forecast error
  - o Forced outages
  - o Neighbor capabilities

- Unit characteristics
  - o Seasonal capacity
  - o Outage rates
  - o Ramping capabilities
- Solar and wind energy patterns
- Weather-normal loads

Solar & Wind Capacity and Integration Cost

- Solar and wind are non-dispatchable resources which have unique operating characteristics that are different from thermal and other more traditional resources
- Net Dependable Capacity (NDC) is represented by availability at the peaks, which can vary depending on penetration of the resource
- Intermittent resources require the balance of the system to respond to their variability, driving an integration cost

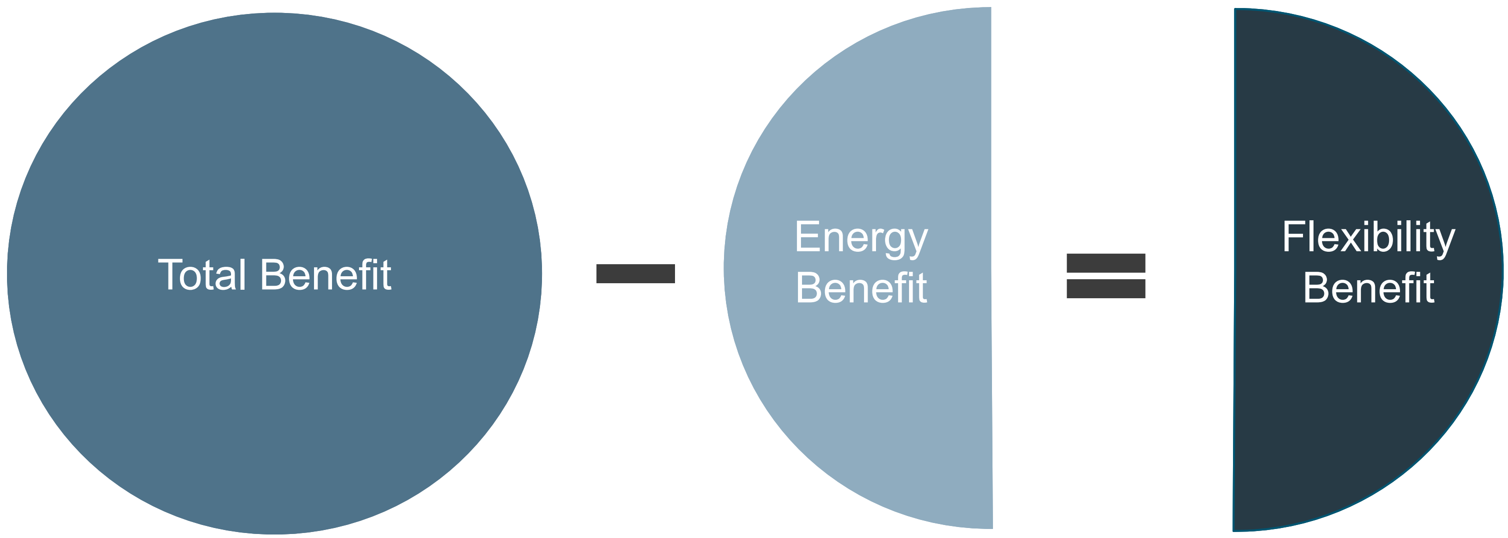
SOLAR

NDC
Integration
Cost

WIND

NDC
Integration
Cost

Integration Benefit for Flexible Resources



Calculate total benefit of aero/battery versus a CT using **sub-hourly dispatch with uncertainty and imperfect foresight**

Calculate energy benefit of aero/battery versus a CT using **hourly dispatch with uncertainty**

Cost difference results in flexibility benefit without overlap

Benefit represents favorable impact of balance of system running more efficiently when very flexible assets are available to respond to sub-hourly variations

Size & Portfolio Affect Flexibility Value

Flexibility value **increases** with solar penetration

$/kW-year	2,500 MW Additional Solar	5,500 MW Additional Solar
200 MW		
500 MW		
1,000 MW		

Flexibility value **decreases** with penetration

AERO

Flexibility Benefit
$/kW-yr

BATTERY

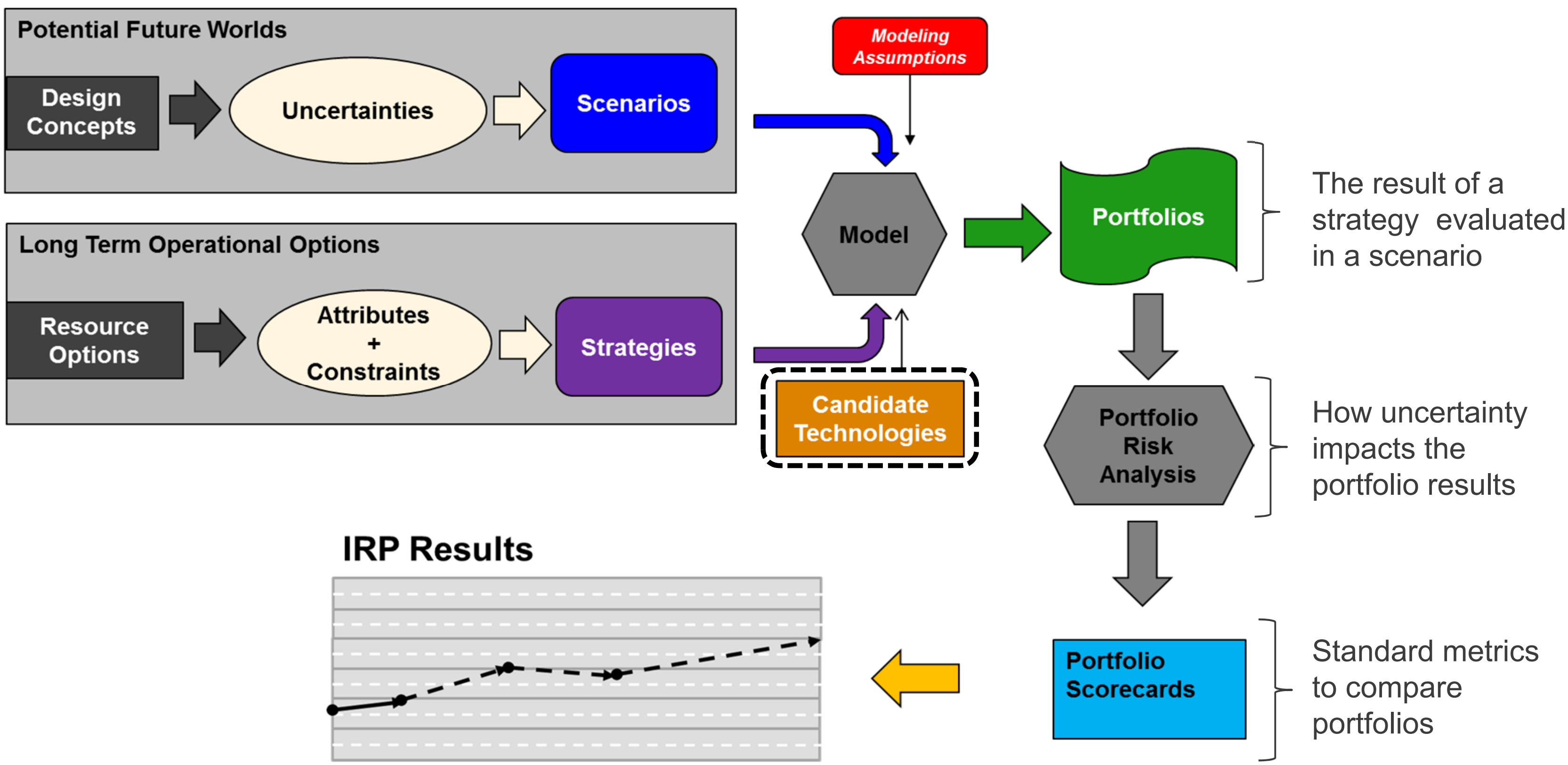
Flexibility Benefit
$/kW-yr

BREAK

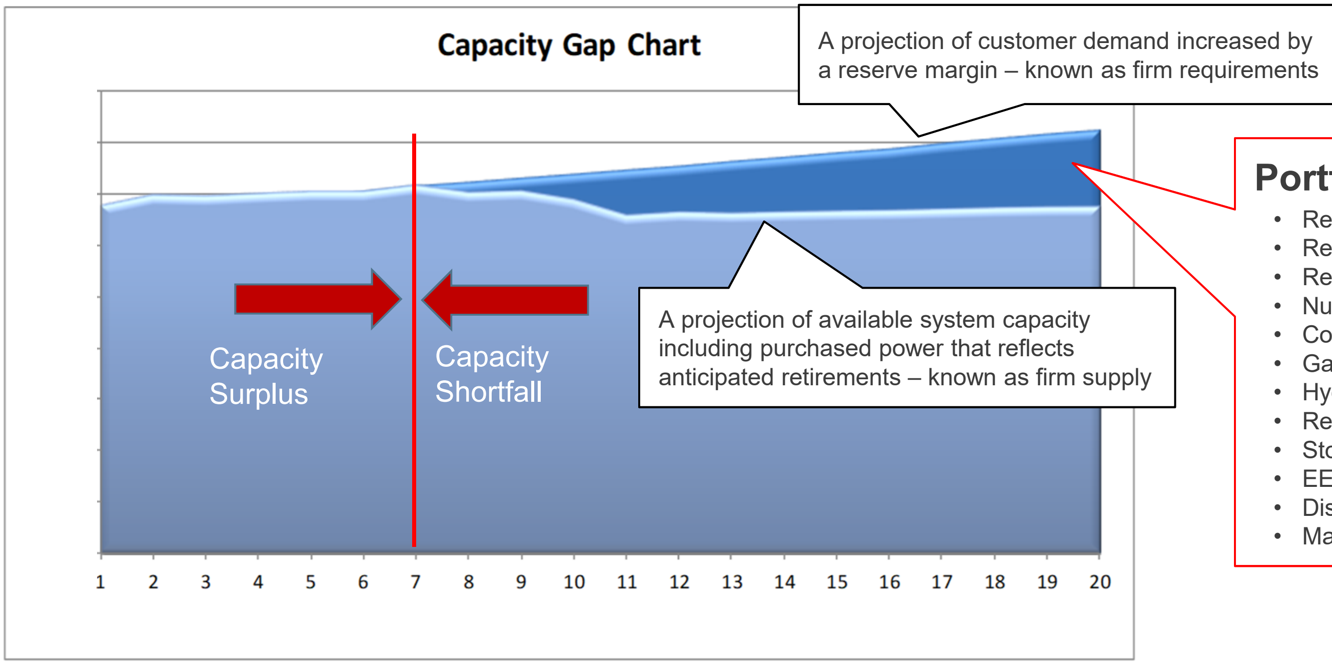
Resource Options Review and Recommendation

Jane Elliott, Senior Manager
Scott Jones, Senior Program Manager
Roger Pierce, Program Manager
TVA Resource Strategy Group

Resource Options Are Offered for Selection



Resource Planning for Future Capacity Needs



Portfolio Options

- Retired Nuclear
- Retired Coal
- Retired Gas
- Nuclear
- Coal
- Gas
- Hydro
- Renewables
- Storage
- EE/DR
- Distributed Resources
- Market Purchases

Recommended path provides a low cost, reliable, diverse and flexible system

Current Portfolio Mix to Meet Operational Needs






Hydro	Nuclear	Renewables	EEDR	Gas	Coal
4,200 MW conventional 1,600 MW pumped storage	7,800 MW	1,200 MW wind 130 MW utility scale solar 250 MW programmatic solar / biomass	1,300 MW avoided capacity	8,100 MW combined cycle 5,800 MW combustion turbine / diesels	8,400 MW

Approximately 42 percent of TVA’s capacity is emission-free

Capacity values in this table are consistent with the 2017 10-k report (rounded to nearest 100 MW)

Wide Variety of Resource Options to Consider

Conventional Power Plants

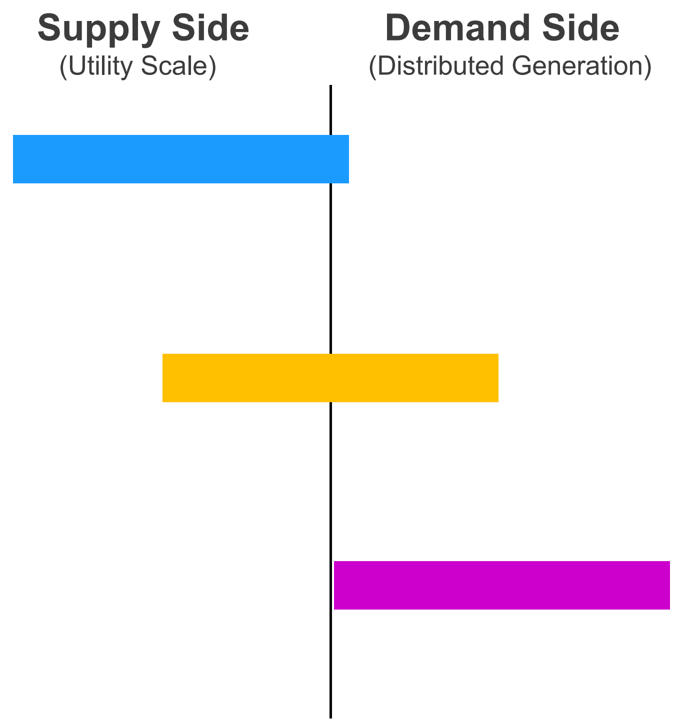
- Nuclear, coal and gas
- Screened based on feasibility, technology maturity, and levelized cost by type and duty cycle

Renewable Resources

- Hydro, wind, solar, biomass and storage resources
- Screened based on feasibility, technology, maturity, and levelized cost by type and duty cycle

Distributed Energy Resources

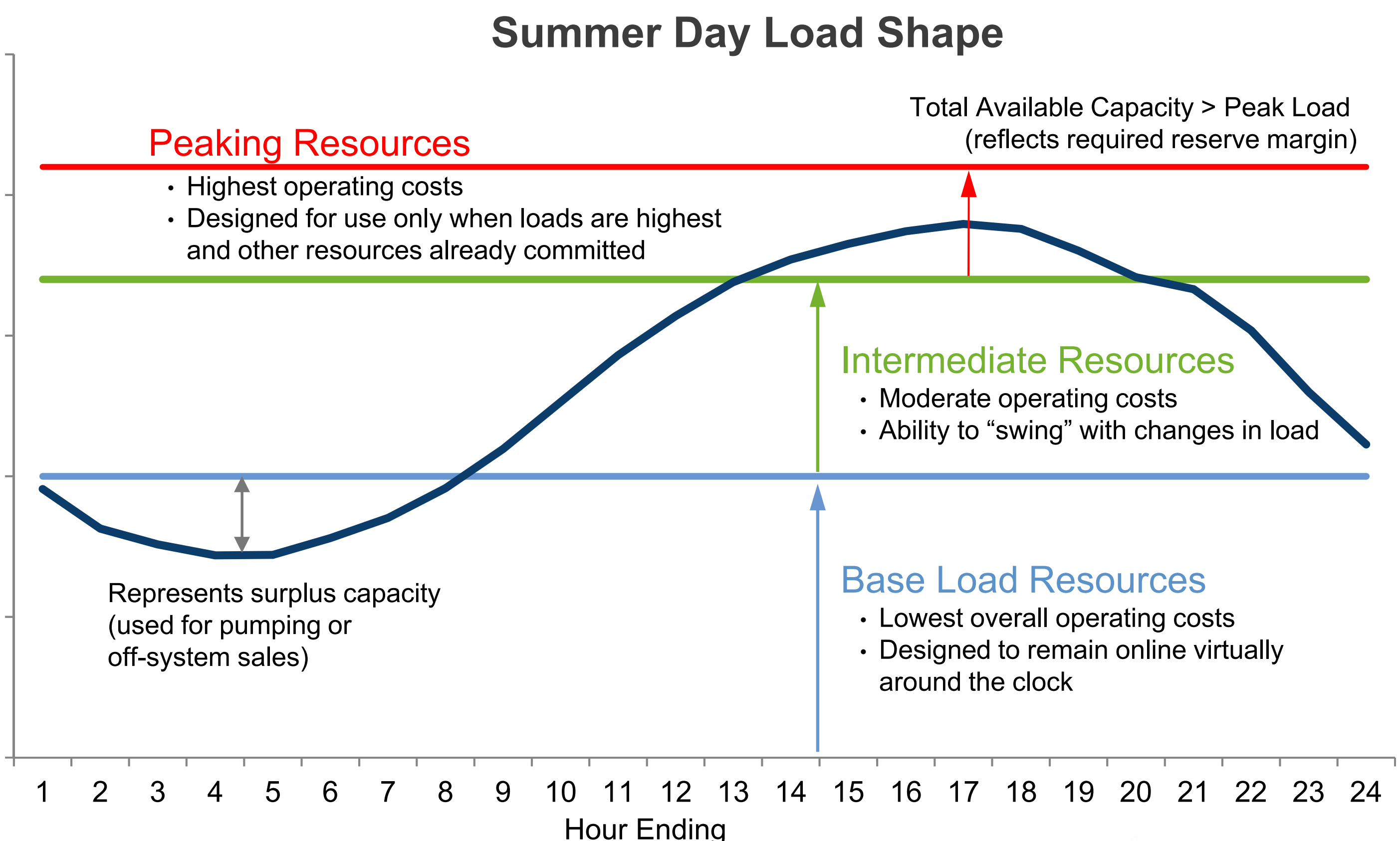
- Energy efficiency programs
- Demand response programs
- Distributed generation (e.g. solar, combined heat & power)



Resource options are screened based on multiple criteria:

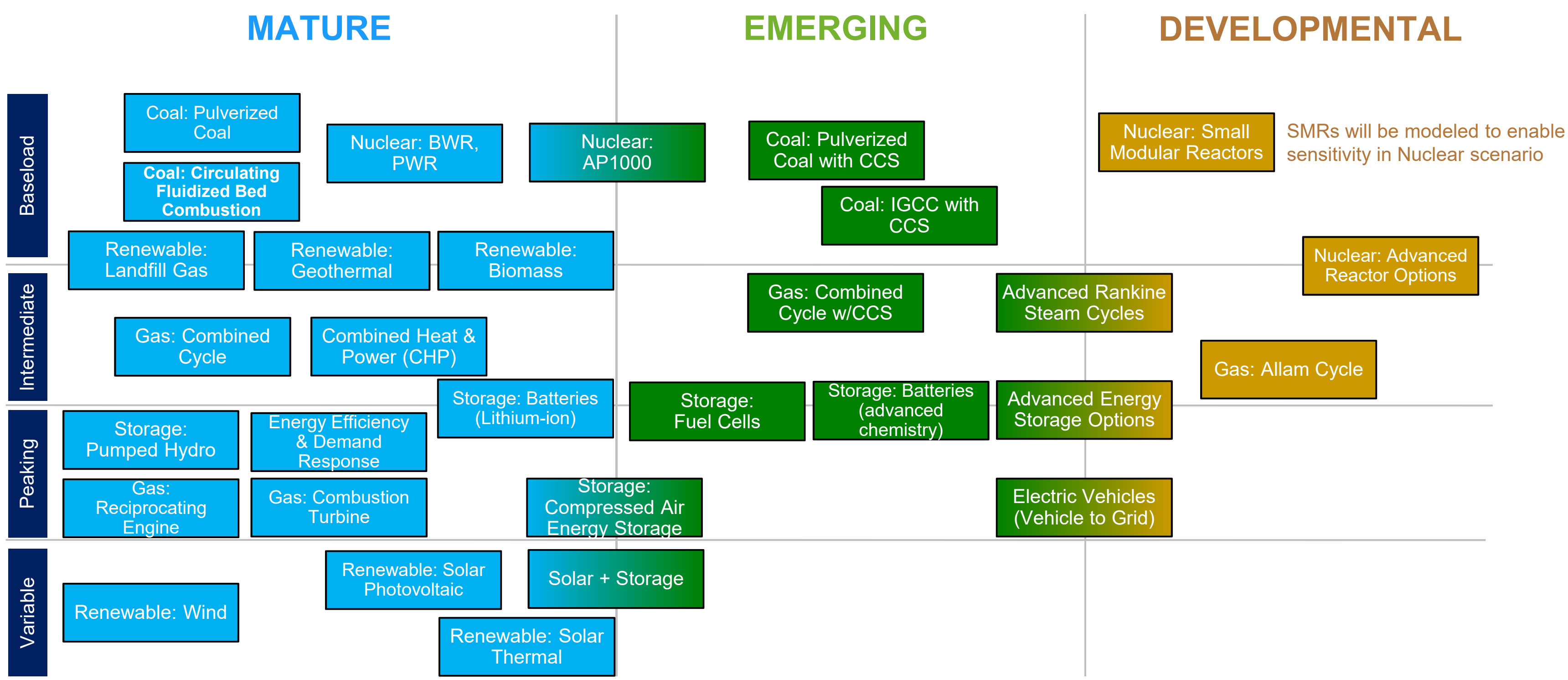
- Technological viability and maturity
- Economic (based on levelized cost)

Resources Have Different Characteristics



Mature and Emerging Options Will Be Modeled

Tabulation of resources by duty cycle and maturity



2019 IRP Resource Options

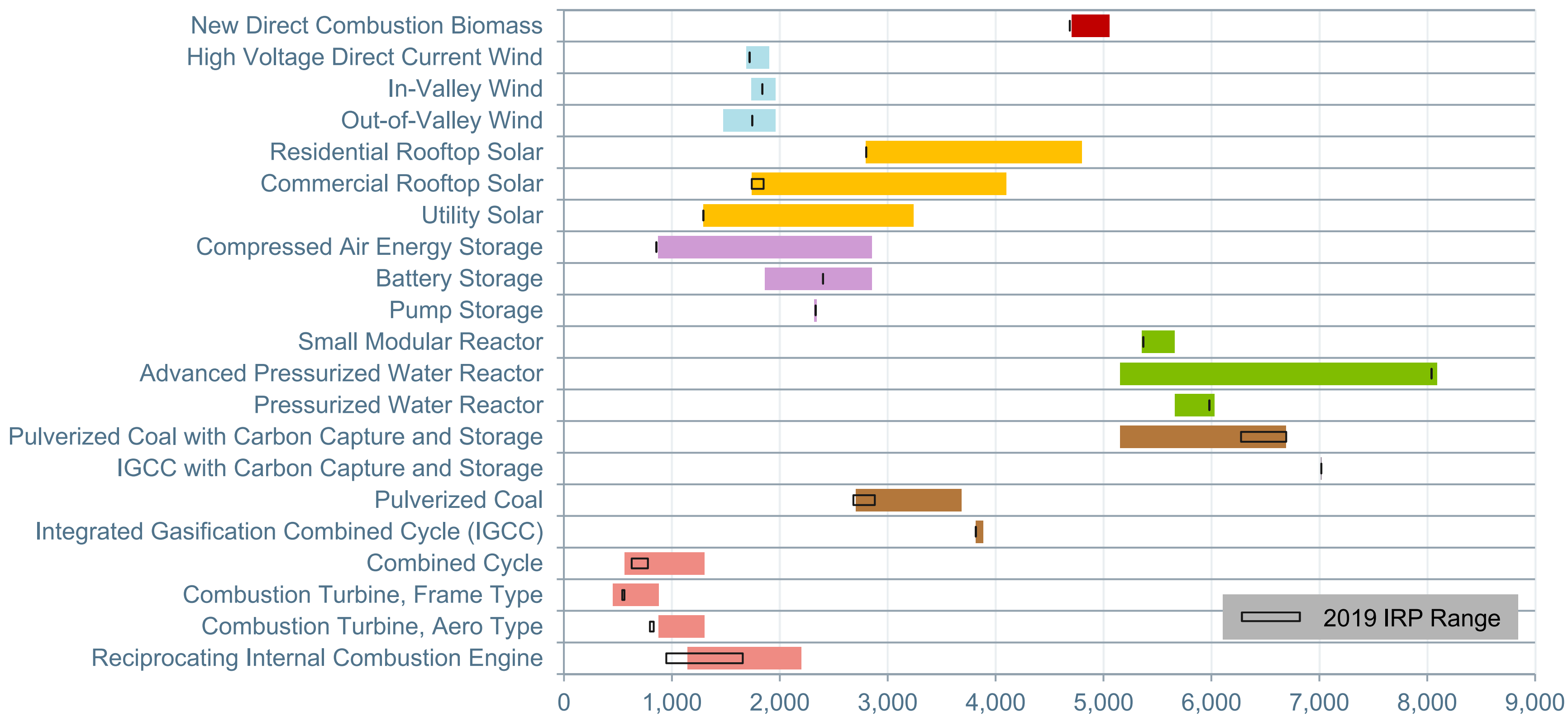
Conventional	Renewables / Storage	Distributed Resources	Purchased Power Agreements
Coal • Supercritical Pulverized Coal 800/1600 MW • Supercritical Pulverized Coal with CCS 600/1200 MW • IGCC 500 MW • IGCC with CCS 469 MW Nuclear • Nuclear AP1000 1117 MW • Small Modular Reactors 600 MW Gas • Reciprocating Engine (2x) 36MW • Reciprocating Engine (6x) 113 MW • Reciprocating Engine (12x) 226 MW • Aeroderivative CT(2x) 192 MW • Aeroderivative CT(4x) 384 MW • Aeroderivative CT(6x) 576 MW • Frame CT (3x) 703 MW • Frame CT (4x) 934 MW • Combined Cycle (1 on 1) 591 MW • Combined Cycle (2 on 1) 1182 MW • Combined Cycle (3 on 1) 1152 MW	Storage • Pumped Storage 850 MW • Battery 25 MW (lithium-ion) • Compressed Air Energy Storage 330 MW • Fuel Cells * • Battery (advanced chemistry) * Solar PV Options • Large Single-axis Tracking 25 MW • Small Fixed Tilt 25 MW • Large Commercial Rooftop 25MW Wind Options • MISO/SPP 200 MW • In-Valley 120 MW • HVDC wind 250 MW Biomass Options • Direct Combustion 115MW • Repowering 75MW Hydro Options • Split Addition 40 MW • Space Addition 30MW • Run-of-River 25MW	Energy Efficiency • Blocks by market segment; variable block size & duration Demand Response • Third-party and TVA programs Distributed Generation • Distributed Solar • Distributed Storage • Distributed Solar + Storage • Combined Heat and Power	• Options are based on proposals submitted to TVA from resources inside and outside the Valley and are usually tied to a specific project for a defined term at a negotiated price • Transmission costs and import limitations are included in the PPA characteristics, if applicable • PPAs are not screened o They are included in the database as proposed o The model treats these PPAs as a fixed transaction that can only be selected based on terms defined in the offer o PPAs cannot be rescheduled or selected in amounts that do not conform to the proposal
Fixed or Scheduled Assets			
• Existing Coal – some MWs available to retire • Existing Nuclear – some MWs available to retire • Existing Gas	• Existing Hydro • Existing Pumped Storage • Existing Renewable PPAs (Solar, Wind, Biogas, SEPA Hydro, etc.) • End-use Generation Programs • Existing Solar	• Existing EEDR Programs • Interruptible Programs • In–house Interruptible Programs	• Existing Non-renewable PPAs (Red Hills, DEC, Diesels, etc.)

* In process of obtaining planning assumptions for these emerging technologies.

Considerations for Resource Assumptions

- Benchmarks (Navigant, EIA, NREL ATB, other IRPs)
- Recent project experience
- Vendor quotes and PPA offers
- RFI / RFP responses
- TVA construction advantages
- Regional ambient weather conditions

Comparison of Resource Overnight Cost ($/kW)

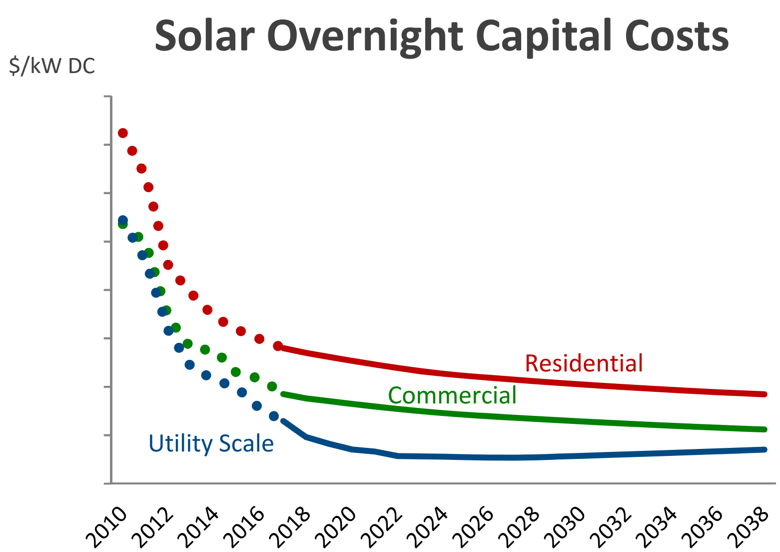


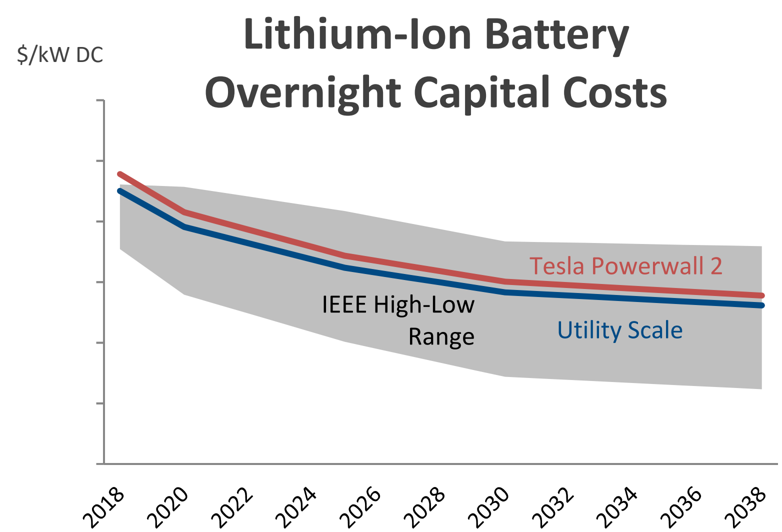
Considerations for Escalation Rates

- Overall economic conditions
- Handy-Whitman Index (utility construction cost trends)
- Tax policy implications
- Expectations for technology advances
- Scenario variations of the above

Escalation Assumptions

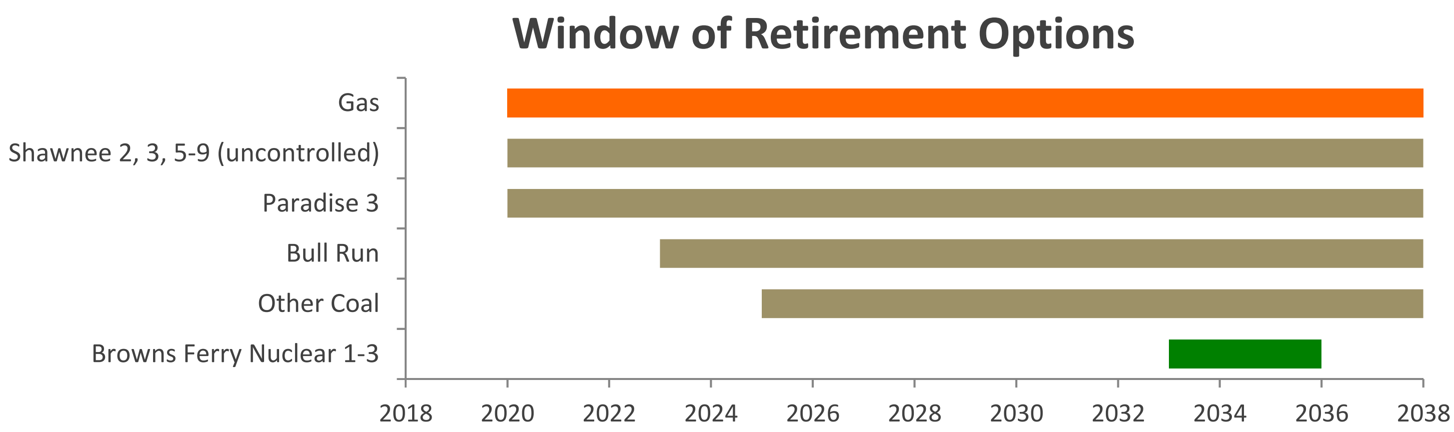
While most resource costs will escalate with inflation, costs for resources that are still rapidly evolving may escalate differently, and escalation rates can vary by scenario.





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.



BREAK

Modeling Methodology for Distributed Energy Resources (DER)

Jane Elliott, Senior Manager
Scott Jones, Senior Program Manager
Roger Pierce, Program Manager
TVA Resource Strategy Group

DER Types Modeled at Aggregated Levels

- Energy Efficiency
- Demand Response
- Combined Heat & Power
- Distributed Solar
- Distributed Storage
- Distributed Solar + Storage

DER Types Modeled in Tiers

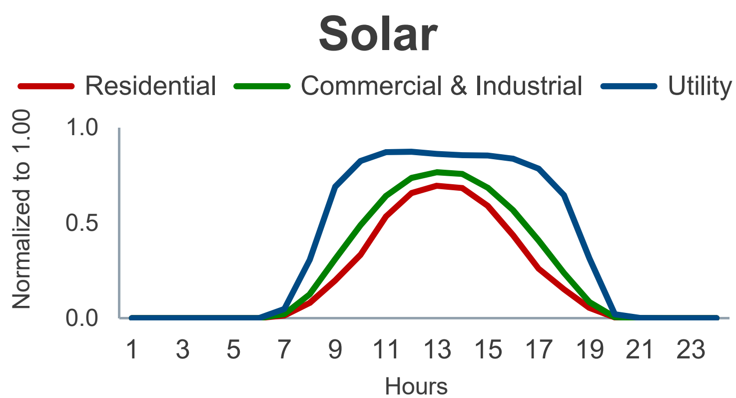
Tiers will be modeled by sector and program, as applicable (Residential, Commercial, Industrial)

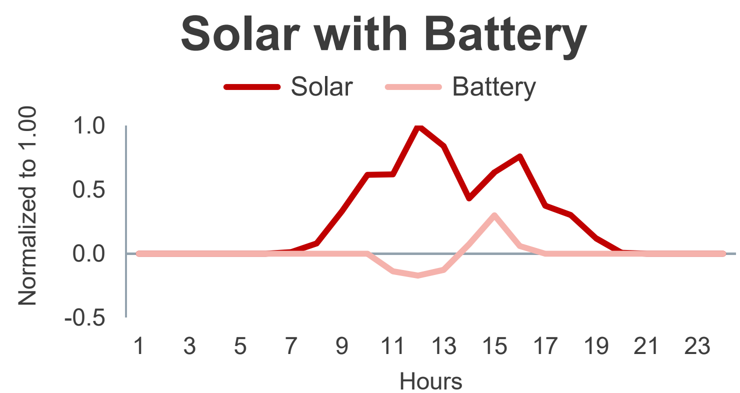
Tier 1
- Base level incentive
- Base Plan level of adoption

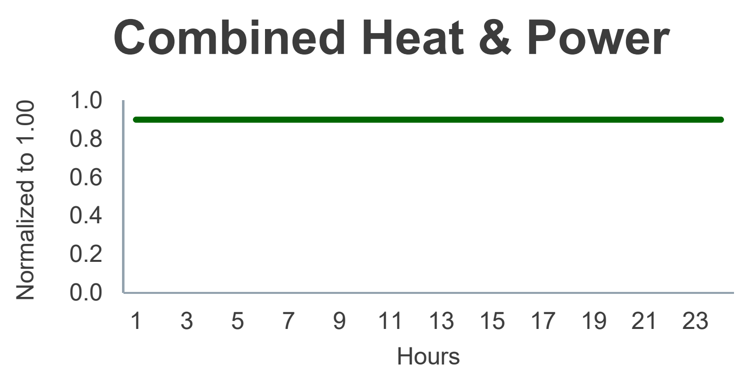
Tier 2
- Moderate incentive
- Moderately higher adoption

Tier 3
- High incentive
- Higher adoption

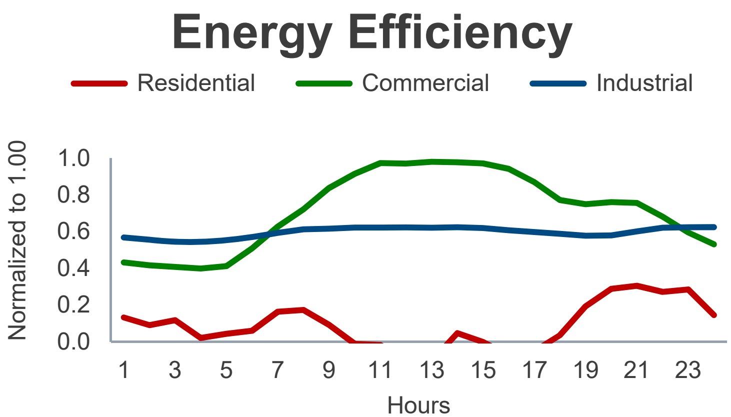
DER Types Have Unique Shapes (Illustrative)

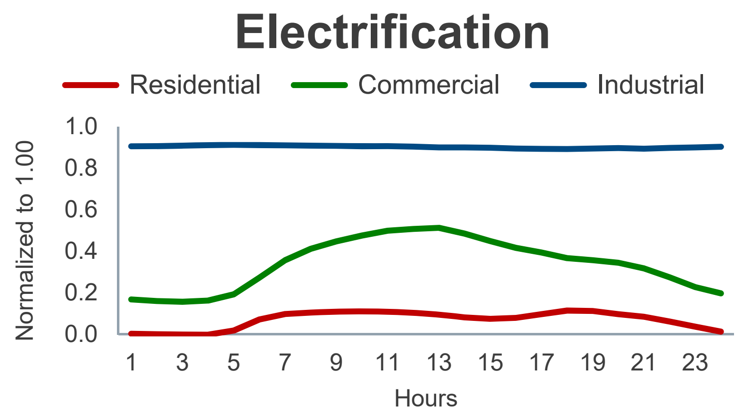






DER Types Have Unique Shapes (Illustrative)





Program Examples:

- Residential – self-audit, eScore, low income, water heater and HVAC demand response (NEST)
- Commercial & Industrial – HVAC, lighting, food service, other equipment, industrial demand response, customized

Program Examples:

- Residential – all-electric new homes, dual-fuel HVAC conversions, electric water heaters
- Commercial & Industrial – dual-fuel HVAC, food service, and fleet vehicle conversions, customized

Group Discussion

What do you think are the key drivers of adoption for the various DERs?

- Energy Efficiency and Demand Response
- Combined Heat & Power
- Distributed Solar and Distributed Storage

Wrap Up Day 1

2019 IRP Working Group

Meeting 6: August 29-30, 2018

Agenda – August 30

7:00	Breakfast	
8:00	Welcome & Recap	Jo Anne Lavender & Brian Child
8:15	Strategy Design	Jane Elliott & Team
10:15	BREAK	
10:30	Group Breakout on Strategy Design	
11:30	LUNCH	
12:30	IRP Methodology: Metrics and Scorecards	Hunter Hydas
1:30	Group Discussion	
2:15	Closing Comments & Next Steps	Brian Child & Jo Anne Lavender
2:30	Adjourn	

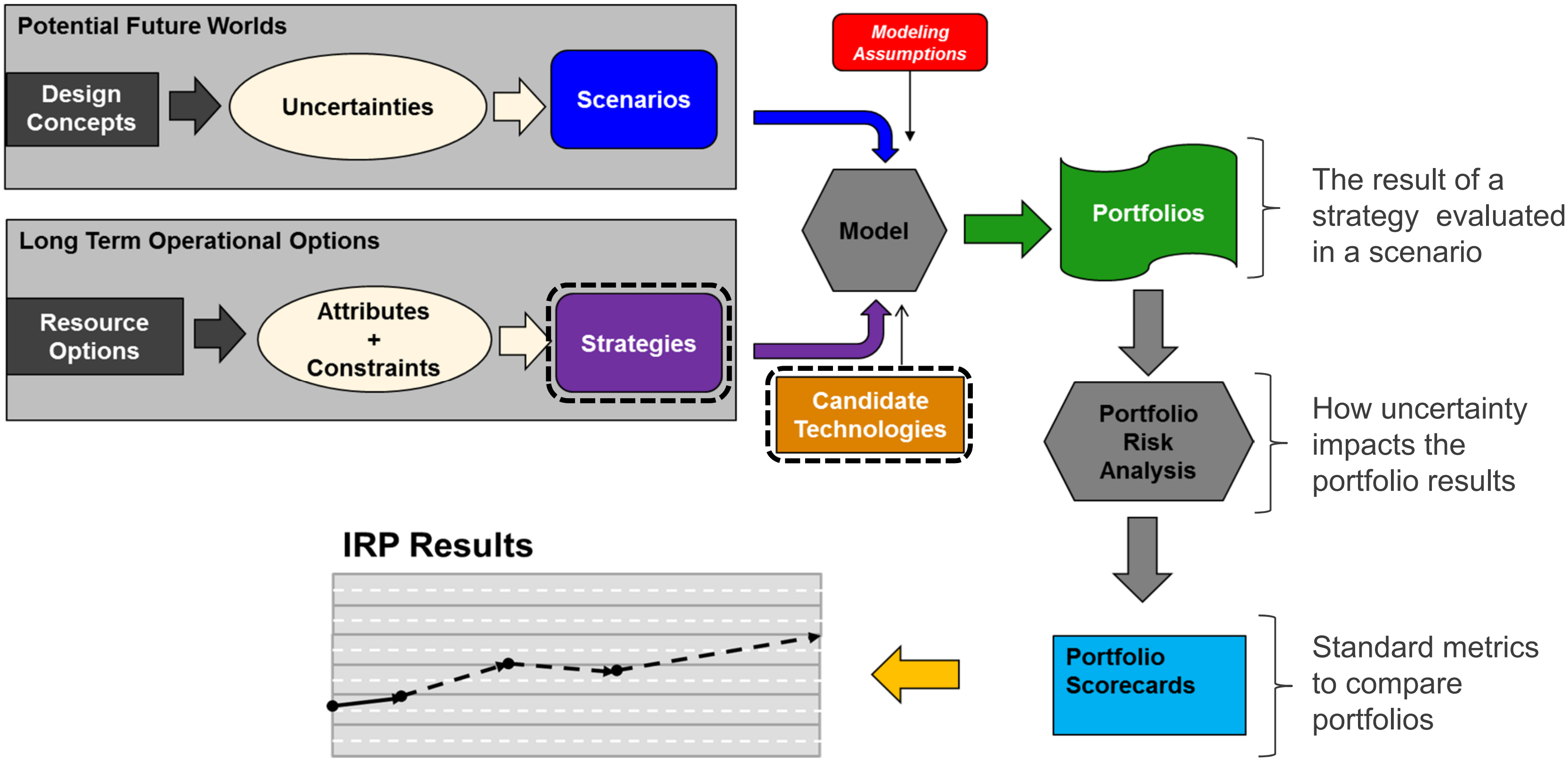
Re-Cap Day 1 and Preview Today

Brian Child, Director, Enterprise Forecasting & Financial Planning

Preliminary Strategy Design

Jane Elliott, Senior Manager
Scott Jones, Senior Program Manager
Roger Pierce, Program Manager
TVA Resource Strategy Group

Strategies Promote Certain Resource Types



Scenarios & Strategies Have DER Overlap

Strategy design must consider DER adoption holistically for each scenario and strategy pairing, along with aligned cost assumptions

Scenarios

1. *Current Outlook*
2. *Economic Turndown*
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 Energy Usage
E. Promote Renewables

B. Promote DER

- DER is incented to achieve high-end of long-term penetration levels.
- New coal is excluded. All other technologies are available while EE, DR, distributed generation and storage are promoted.

C. Promote Resiliency

- Add small, agile capacity to maximize flexibility and promote ability to respond to short-term disruptions on the power system.
- All technologies are available while nuclear additions (SMRs), gas additions (aero derivatives, reciprocating engines), DR, storage and distributed generation are promoted. Combinations of storage and distributed generation could be installed as microgrids.
- Flexible loads and DERs are aggregated to provide synthetic reserves to the grid to promote resiliency.

D. Promote Efficient Energy Usage

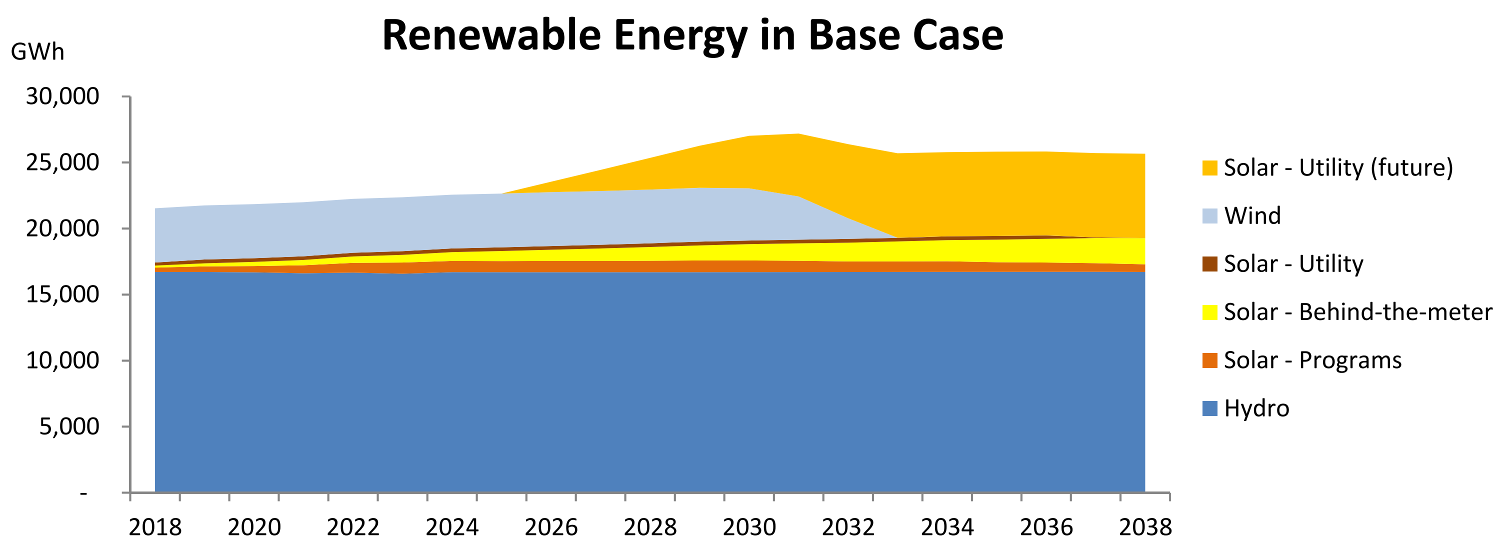
- Incent targeted electrification, demand and energy management to minimize peaks and troughs across a daily load shape and promote efficient energy usage.
- All technologies are available but those that minimize load swings are promoted (e.g., EE, DR, storage, distributed generation).
- Programs targeting low-income customers will be a part of EE promotion.

E. Promote Renewables

- Commitment to renewables at all scales to meet growing prospective or existing customer demands for renewable energy.
- New coal is excluded. All other technologies are available while renewables are promoted.

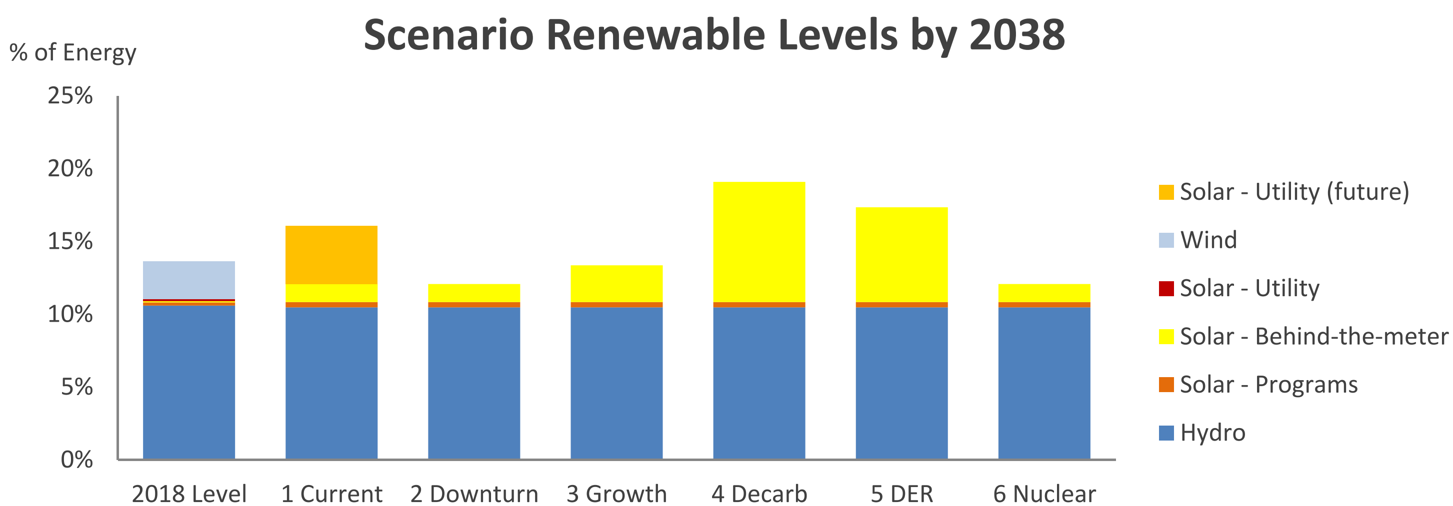
Renewables in the Preliminary Base Case

This graph illustrates renewable resources in the preliminary base case, reflecting Current Outlook behind-the-meter renewables plus renewables selected through portfolio optimization.



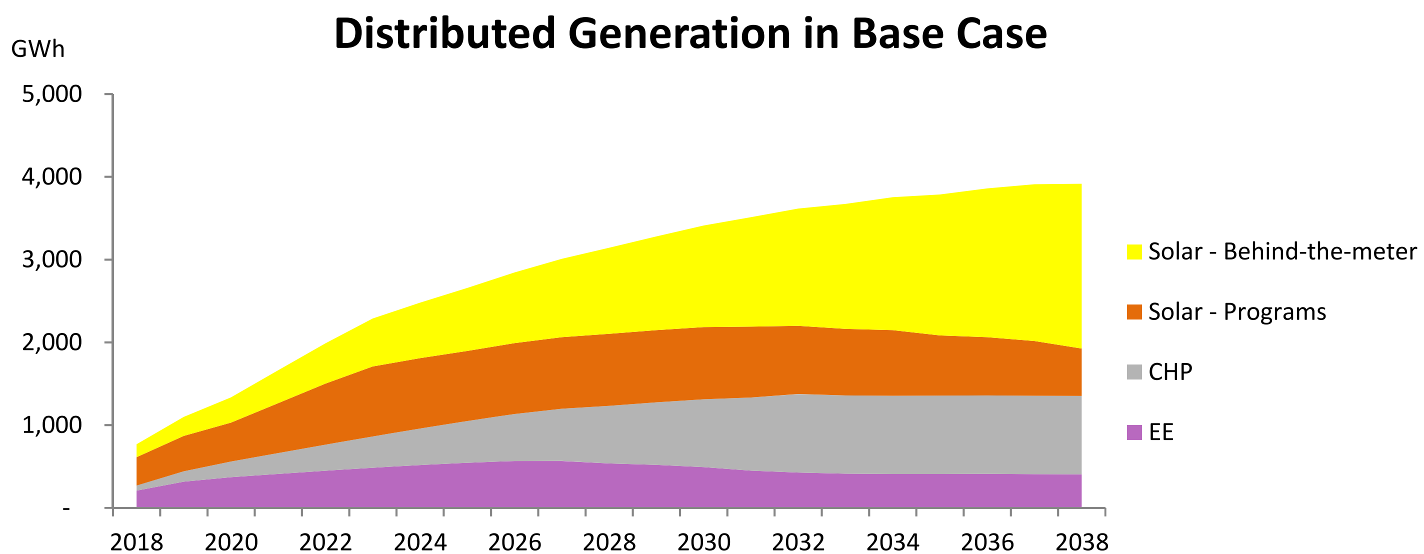
Scenario Renewable Levels

Each scenario has unique assumptions for renewable resource penetration prior to portfolio optimization to fill the capacity gap for each strategy. Utility scale solar will be determined by expansion optimization which targets a reserve margin and applies a strategy at the least cost.



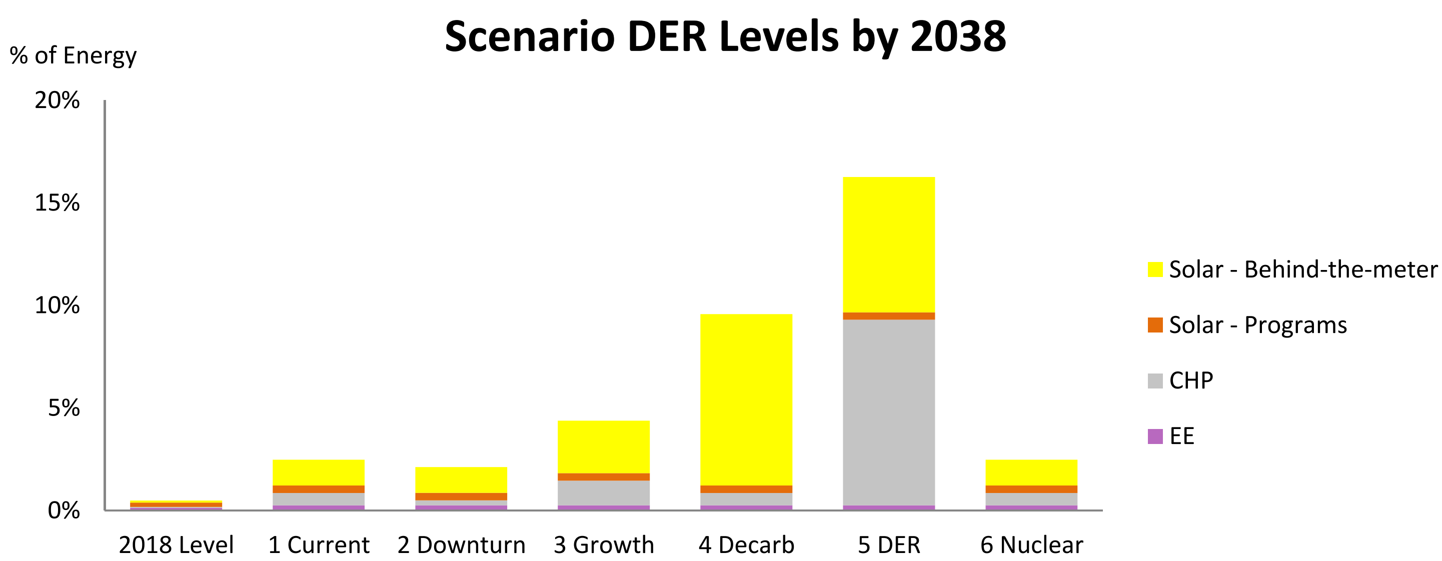
DERs in the Preliminary Base Case

This graph illustrates DERs in the preliminary base case, reflecting Current Outlook behind-the-meter resources plus DERs selected through portfolio optimization.



Scenario DER Levels

Each scenario has unique assumptions for DER penetration prior to portfolio optimization to fill the capacity gap for each strategy.



Strategies Promote Higher Adoption Levels

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

No Additional Incentive

Incentive aligned to base case

Base Level Adoption

Moderate Adoption

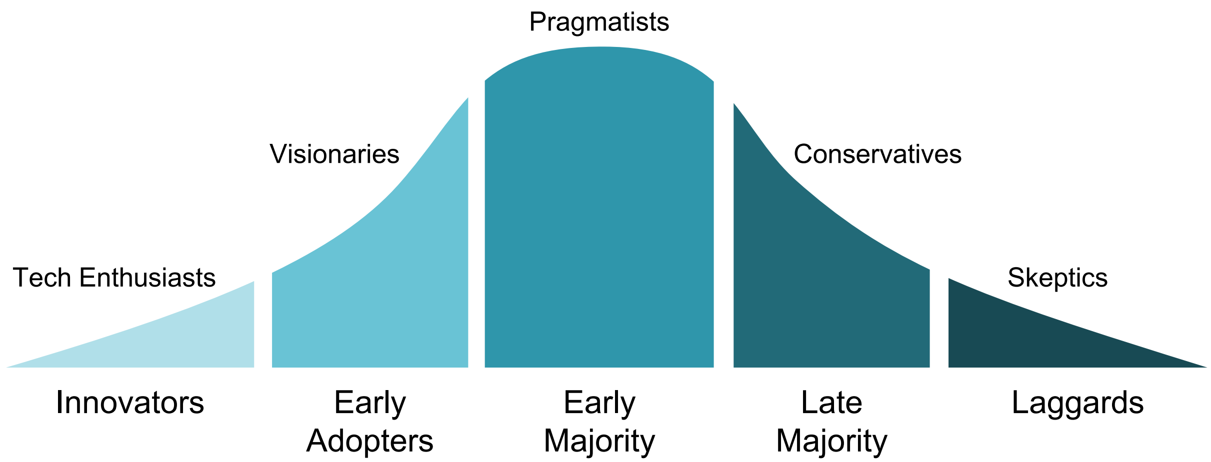
High Incentive

Up to marginal cost

High Adoption

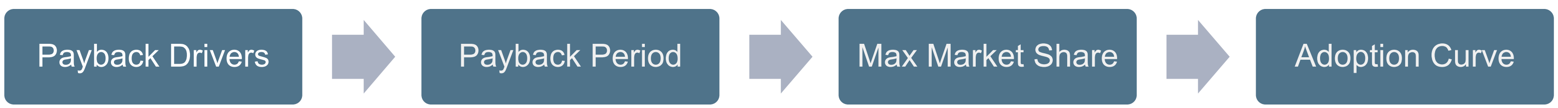
Considerations for Adoption Curves

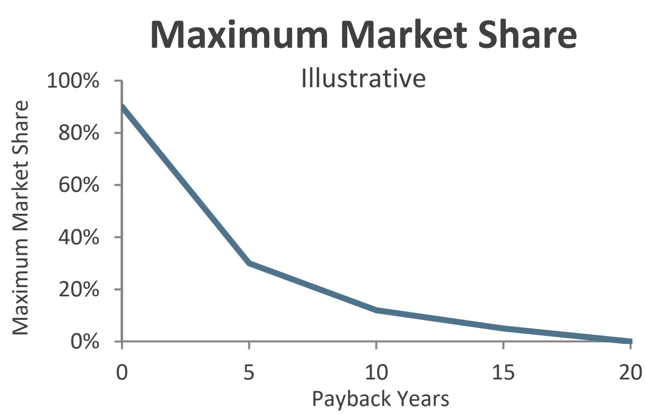
- Technical and economic potential
- Consumer tendency to adopt new energy technology
- Impact of incentives on payback
- Adoption experience of other regions with RPS and/or incentives

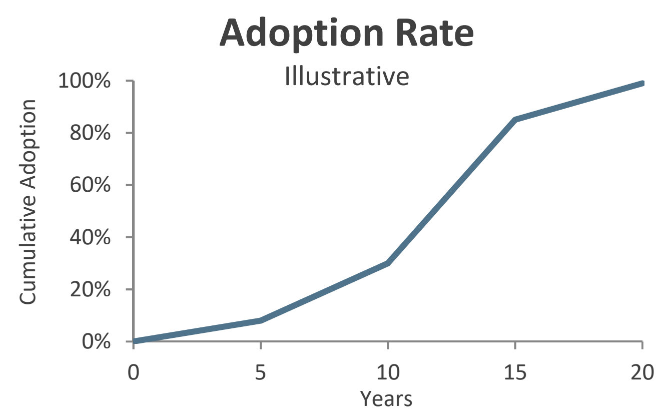


Adoption Curves under Development

Adoption curves are being developed using an approach similar to NREL's Distributed Market Demand Model, a market-penetration model that simulates the potential adoption of distributed solar







PRELIMINARY

Relative Incentive Levels by Strategy

Resources will be promoted to various levels across the strategies, with consideration of potential, adoption curve, and reserve margin.

Strategy	Distributed Resources						Utility Scale Resources				
	Distributed Solar	Distributed Storage	Combined Heat & Power	Energy Efficiency	Demand Response	Beneficial Electrification	Solar	Wind	Storage	Aeros & Recip Engines	Small Modular Reactors
Base Plan	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
Promote DER	High	High	High	Moderate	Moderate	Base	Base	Base	Base	Base	Base
Promote Resiliency	Moderate	Moderate	Moderate	Base	Moderate	Base	Base	Base	Moderate	Moderate	Moderate
Promote Efficient Energy Usage	Moderate	Moderate	Moderate	High	High	Moderate	Base	Base	High	Base	Moderate
Promote Renewables	High	Moderate	Base	Base	Base	Base	High	High	Moderate	Base	Base

Other Strategy Design Considerations

- Reserve Margin

  Resource additions of specific types may be naturally limited as the model solves to minimize capacity and energy costs, with reserve margin as the reliability constraint.

- Annual Cap

  Example: Model caps annual utility scale solar additions at 400 MW nameplate, similar to experience in other regions that have been adding renewables on their systems.

  Recommendation: Use similar approach for other resources based on adoption curve.

- Planning Horizon Cap

  Recommendation: Cap total additions at economic potential MW for each resource type.

Strategy Design – Next Steps

- Refine DER shapes and pricing
- Refine incentives and adoption curves for promoted resources
- Refine retirement option assumptions
- Implement modeling updates for the above
- Review final strategy design recommendation in September

Group Breakout – Strategy Design

Group Discussion Question:

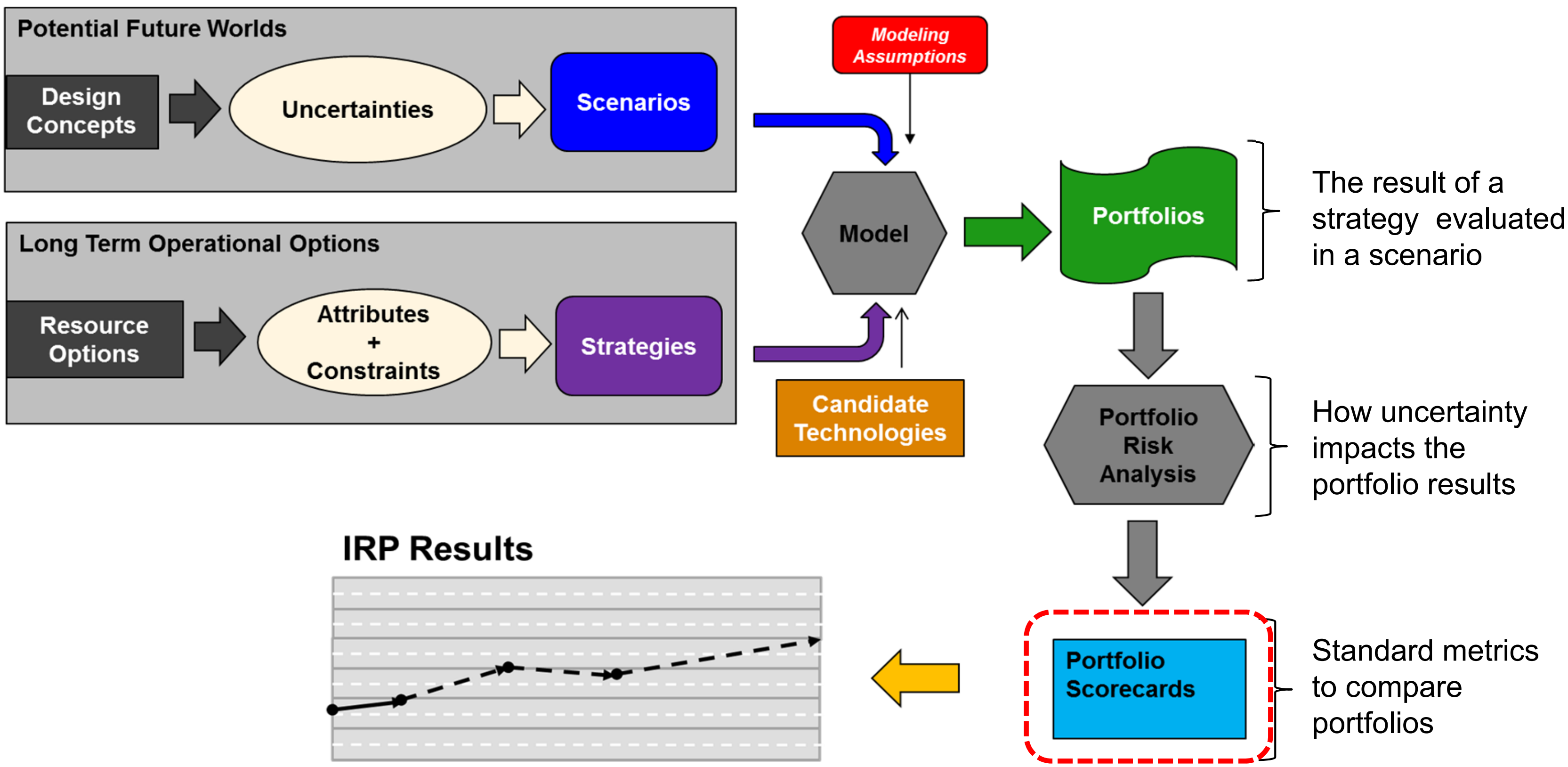
What are your comments, thoughts or inputs for Strategy design?

Lunch

IRP Methodology: Metrics and Scorecards

Hunter Hydas, Project Manager, Integrated Resource Plan

Integrated Resource Planning Process



Choosing the "Right" Resource Plan

- The challenge is not insufficient data but rather sorting through all the results to identify the preferred resource plan

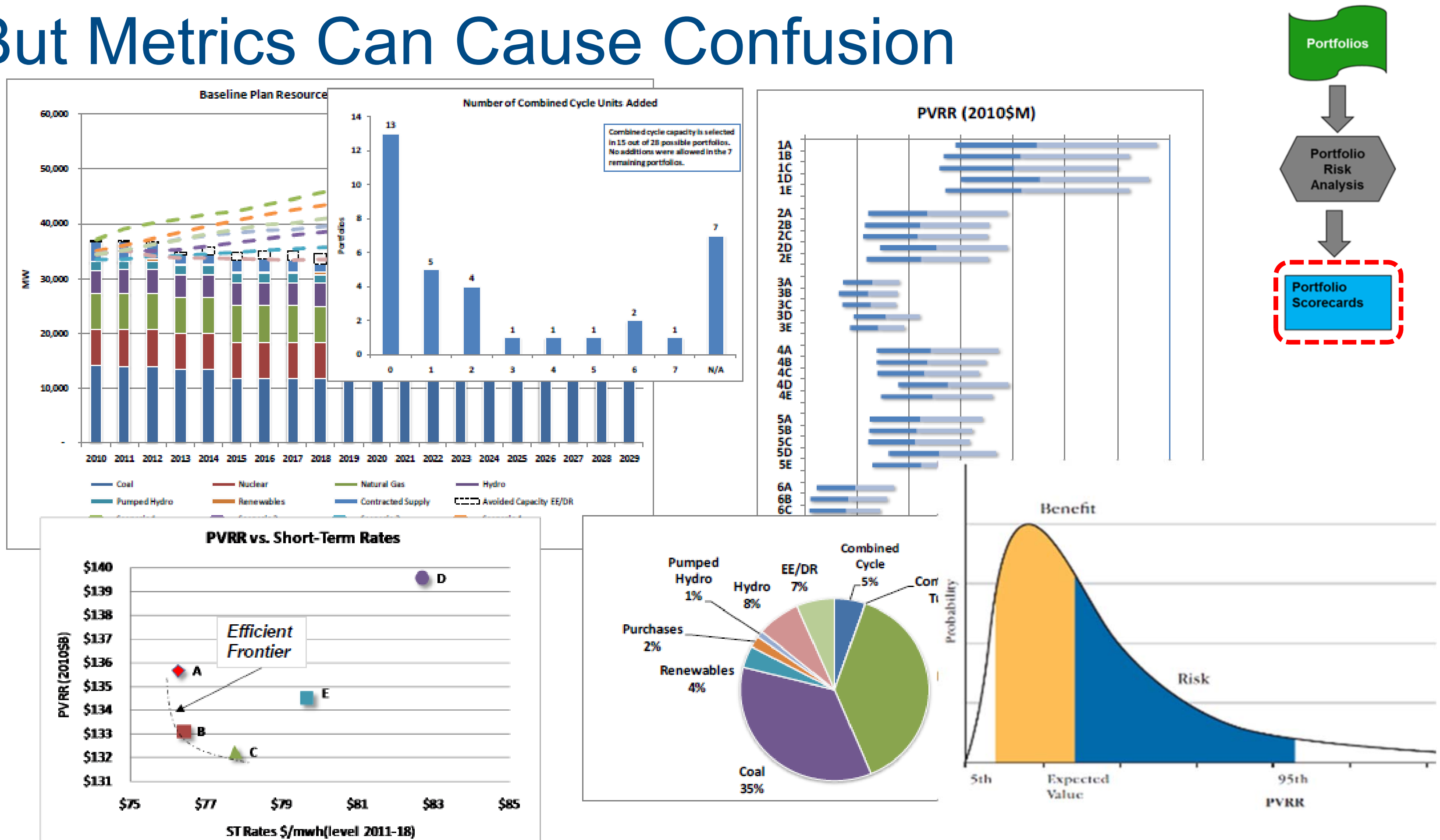
- So how do you know when the plan is "good"?

- Metrics help focus evaluation of plan results

- Metrics need to reflect the utility's (and the stakeholder's) goals and priorities

- Metrics need to be clear and easy for stakeholders and decision-makers to understand

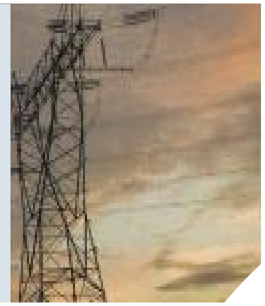
But Metrics Can Cause Confusion



TVA's Mission and Strategic Imperatives

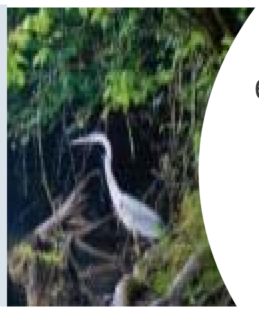
Energy

Delivering affordable, reliable power



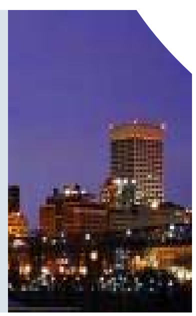
Environment

Caring for our region's natural resources



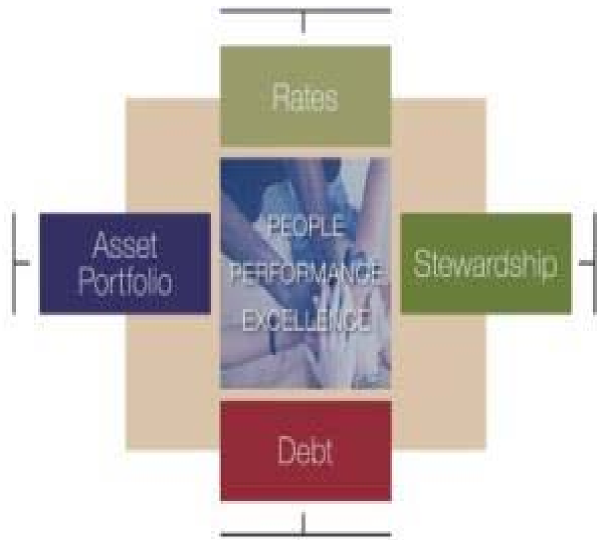
Economic Development

Creating sustainable economic growth



Maintain low rates

Meet reliability expectations & provide a balanced portfolio



Be responsible stewards

Live within our means

Types of Metrics

Metrics serve two different purposes in the IRP Process depending upon:

- Definition
- Calculation
- Insights provided

SCORING

- Well understood characteristics
- Industry standard measures
- Supports numerical comparison

REPORTING

- Optional/advanced measures
- Developmental
- Informative/Supplemental

Categories of Historical IRP Metrics

- Cost
- Financial Risk
- Environmental Stewardship
- Valley Economics
- Flexibility

Cost includes both the long-range cost of the resource plan (present value of customer costs) as well as a look at short term average system cost (an indicator of possible rate pressure)

Financial Risk measures the variation (uncertainty) around the cost of the resource plan by assessing a risk/benefit ratio and computing the likely amount of cost at risk; both of these indicators use data from probability modeling

Stewardship captures multiple measures related to the environmental "footprint" of the resource plans, like air emissions and thermal loading impacts

Valley Economics computes the macro-economic effects of the resource plans by measuring the change in per capita income compared to a reference case

Flexibility is a measure of how responsive the generation portfolio of each resource plan is by evaluating the type/quantity of resources and the extent to which this mix can easily follow load swings

2015 IRP Scorecard Alignment

IRP Scorecard Metrics	TVA Mission		
	Low-Cost Reliable Power	Economic Development	Environmental Stewardship
Present Value of Revenue Requirements	✓	✓	
System Avg. Cost	✓	✓	
Risk/Benefit Ratio	✓		
Risk Exposure	✓		
CO2 Emissions		✓	✓
Water Usage			✓
Waste			✓
Flexibility	✓		
Impact to Per Capita Income	✓	✓	

2015 IRP Scoring Metrics

Category	Scoring Metric		Formula
Cost	PVRR ($Bn)	=	Present Value of Revenue Requirements over Planning Horizon
	System Average Cost Years 1-10 ($/MWh)	=	$\frac{\text{NPV Rev Reqs}_{(2014\text{-}2023)}}{\text{NPV Sales}_{(2014\text{-}2023)}}$
Risk	Risk/Benefit Ratio	=	$\frac{95^{th}_{(PVRR)} - \text{Expected}_{(PVRR)}}{\text{Expected}_{(PVRR)} - 5^{th}_{(PVRR)}}$
	Risk Exposure ($Bn)	=	95^{th} Percentile $_{(PVRR)}$
Environmental Stewardship	CO_2 (MMTons)	=	Average Annual Tons of CO_2 Emitted During Planning Period
	Water Consumption (Million Gallons)	=	Average Annual Gallons of Water Consumed During Planning Period
	Waste (MMTons)	=	Average Annual Tons of Coal Ash and Scrubber Residue During Planning Period
Flexibility	System Regulating Capability	=	$\frac{\Sigma\,(\text{Regulating Reserve} + \text{Demand Response} + \text{Quick Start})}{\text{Peak Load}}$
Valley Economics	Per Capita Income	=	Percent Difference in Per Capita Personal Income Compared to Reference Case (for each scenario)

TVA

2015 IRP Scorecard

- Results for each IRP Strategy are presented on a scorecard developed by TVA and the IRP Working Group
- They are not intended to provide an overall ranking but are a tool for evaluating tradeoffs

Real Values	Cost		Risk		Environmental Stewardship			Flexibility	Valley Economics
Scenarios	**PVRR ($Bn)**	**System Avg Cost Years 1-10 ($/MWh)**	**Risk/Benefit Ratio**	**Risk Exposure ($Bn)**	**CO2 (MMTons)**	**Water (MMGallons)**	**Waste (MMTons)**	**System Regulating Capability (2033)[1]**	**Percent Difference in Per Capita Income[2]**
1. Current Outlook	$132.74	$76.66	0.924	$140.43	57.0	61,843	3.458	28.7%	0.00%
2. Stagnant Economy	$125.86	$75.99	0.947	$132.83	51.8	59,448	3.495	28.0%	0.00%
3. Growth Economy	$139.55	$77.67	0.907	$147.54	59.7	61,899	3.716	27.1%	0.00%
4. De-Carbonized Future	$131.71	$80.97	0.997	$140.33	44.2	55,991	3.084	18.9%	0.00%
5. Distributed Market Place	$120.38	$77.27	0.989	$127.06	44.2	56,330	3.211	22.3%	0.00%

2015 IRP Reporting Metrics

Category	Scoring Metric		Formula
Cost	System Average Cost Years 11-20 ($/MWh)	=	$\frac{\text{NPV Rev Reqs}_{(2024\text{-}2033)}}{\text{NPV Sales}_{(2024\text{-}2033)}}$
Risk	Cost Uncertainty	=	$95th_{(PVRR)} - 5th_{(PVRR)}$
	Risk Ratio	=	$\frac{95th_{(PVRR)} - \text{Expected}_{(PVRR)}}{\text{Expected}_{(PVRR)}}$
Environmental Stewardship	CO2 Intensity (Tons/GWh)	=	$\frac{\text{Tons } CO_{2\,(2014\text{-}2033)}}{\text{GWh Generated}_{(2014\text{-}2033)}}$
	Spent Nuclear Fuel Index (Tons)	=	Expected Spent Fuel Generated During Planning Period
Flexibility	Variable Energy Resource Penetration	=	$\frac{\text{(Variable Resource Capacity)}_{(2033)}}{\text{Peak Load}_{(2033)}}$
	Flexibility Turn Down Factor	=	$\frac{\text{“Must run” + “Non-Dispatachable (Wind/Solar/Nuclear)}_{(2033)}}{\text{Sales}_{(2033)}}$
Valley Economics	Employment	=	Difference in the Change in Employment Compared to Reference Strategy

Metrics & Scorecard Design for 2019 IRP

- TVA is beginning the process of revisiting the metrics and scorecard used in the 2015 IRP to determine how applicable those are to the current study
  - Do we have the right flexibility metric?
  - Do we have the right environmental metrics? How do we ensure that we are capturing the environmental impacts of electrification of other sectors?
  - How do we address environmental justice?

- A discussion of candidate metrics and basic scorecard design concepts is planned for the September IRPWG meeting.

What initial comments or suggestions do members of the IRPWG have on metrics and scorecard design for the IRP?

Individual Perspectives

What aspects of portfolio performance are most important to ensure we have metrics around?

Next Steps

Updated: 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 25-26, 2018 (updated)
Huntsville, Alabama

#9 December 5-6, 2018
West Tennessee / North Mississippi

#10 Jan 30-31, 2019
Chattanooga, Tennessee

Future Tentative Sessions :
#11: Feb 28 – March 1, 2019 **(updated)**
#12: March 27-28, 2019
#13: April 30 – May 1, 2019 **(updated)**
#14: June 19-20, 2019 **(updated)**
15: July 24-25, 2019