2019 IRP Working Group

Meeting 7: September 26-27, 2018


welcome

Safety Moment

Building Emergency Plan

Introductions

- Name
- Organization and Role

Agenda – September 26

11:00	Lunch	Salon 4
12:00	Welcome & Introductions	Jo Anne Lavender
12:10	Meeting 6 Recap & Overview of Meeting 7	Brian Child
12:25	Recap of Stakeholder Engagement Activities	Amy Henry
12:45	BREAK	
1:00	Metrics & Scorecard Design	Hunter Hydas
2:30	BREAK	
2:45	EIS Overview & Environmental Justice Overview	Ashley Pilakowski & Chuck Nicholson
3:30	Small Group Breakout on Environmental Justice	
4:30	Wrap Up & Adjourn	Jo Anne Lavender
6:00	Optional Group Dinner	

Agenda – September 27

7:00	Breakfast	Salon 7
8:00	Welcome & Recap	Jo Anne Lavender & Brian Child
8:15	Review of Modeling and Strategy Design	Jane Elliott
9:00	BREAK	
9:15	Energy Efficiency, Demand Response, and Beneficial Electrification Program Design	Cindy Herron & Kyle Lawson
10:15	BREAK	
10:30	Distributed Generation Overview and Strategy Design	Lucy Wansley, Laura Duncan, Scott Jones
11:30	LUNCH	Salon 7
12:30	Small Group Breakout on Strategy Design	Jane Elliott
1:30	Final Strategy Design Recap	Jane Elliott
1:45	Closing Comments & Next Steps	Brian Child
2:30	Adjourn	

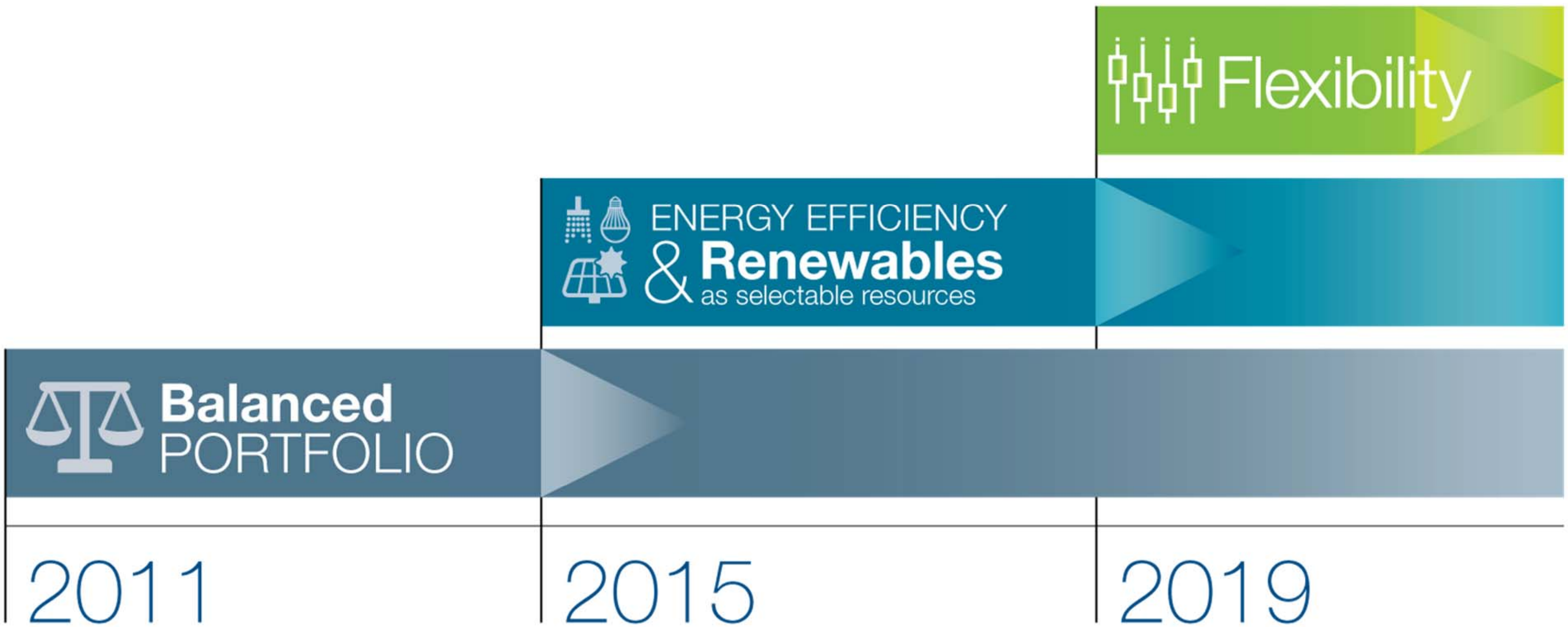
IRPWG Meeting 6 Recap

Brian Child

August Meeting Highlights

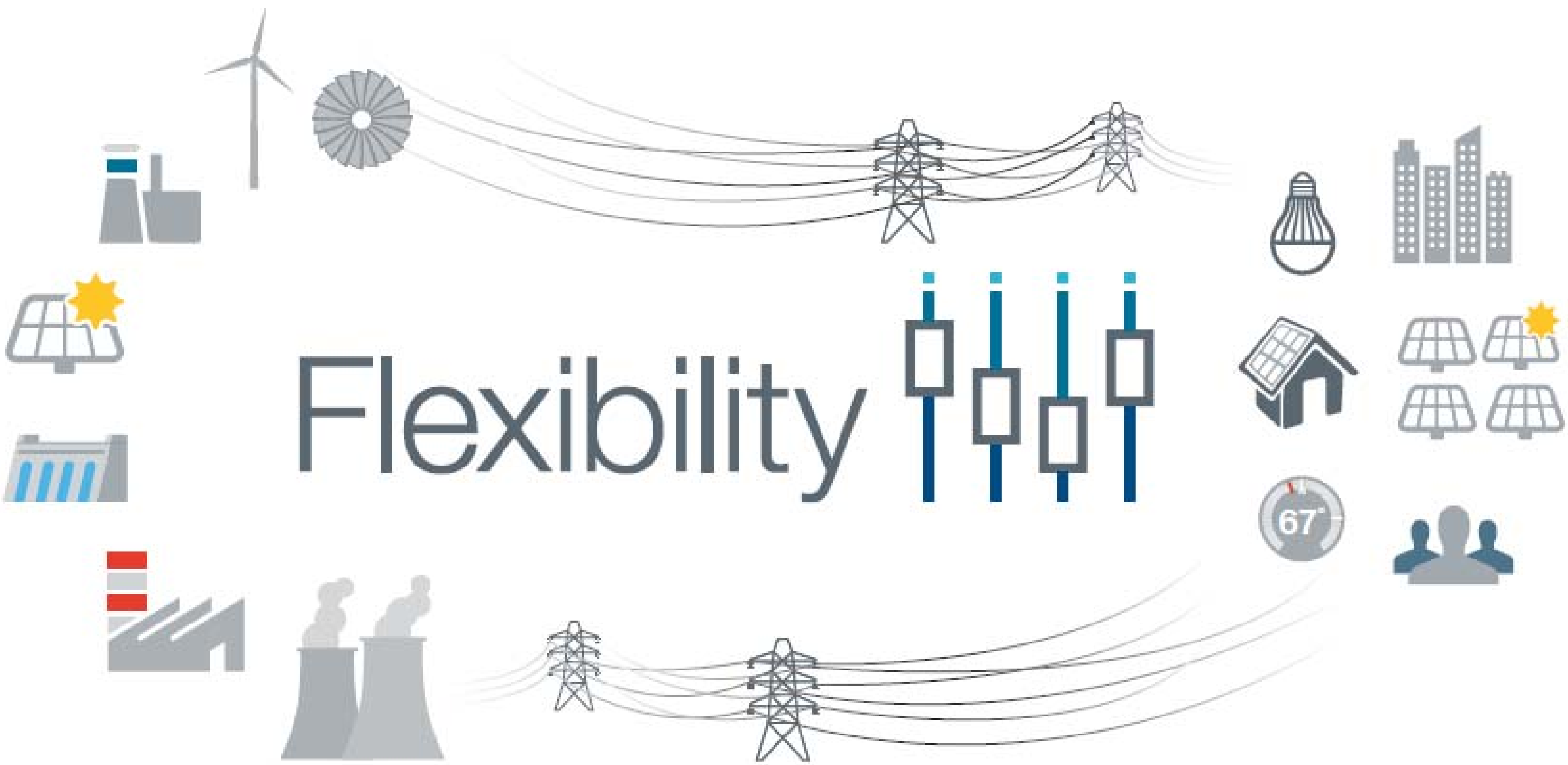
- Resource Options
- Modeling for Distributed Energy Resources
- Strategy Design
- IRP Metrics & Scorecards

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

August 29th-30th	September 26th-27th	October 25th-26th	December, 2018
• Scenario design (final) • Strategy design preview • Resource options (final) after 3rd party review • Scorecard development	• Strategy design (final) • Scorecard development (final) • Scorecard design • Environmental Impact Statement (EIS) outline	• Review Base Case • Review Current Outlook across all Strategies • Follow up on Environmental Impact Statement	• Review Near Final Results for Draft Documents

Recap of RERC Meeting, IRP Public Webinar & Social Media Activities

Amy Henry

Regional Energy Resource Council (RERC) Meeting

September 5, 2018

Knoxville, TN

RERC Meeting Agenda

- 2019 IRP Update
  - 2019 IRP focus areas
  - IRP process and schedule
  - Scoping results and development of Draft IRP and Draft EIS
  - IRP Communications
- Future Scenarios
- Planning Strategies
- Council Discussion
- RERC Advice Statement

Incentive Level Matrix*

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

* Slide 90 Referenced in Sentiment Statement from September 5, 2018 Meeting

PRELIMINARY

Council Sentiment Statement*

*(*Not formal advice statement due to a lack of an RERC Quorum to formally approve)*

The RERC has reviewed the 2019 IRP Scenarios and their characteristics. In terms of the breadth of coverage of plausible future conditions, the RERC feels that the Scenarios generally do push the boundaries of future plausible conditions based on what we know today. We suggest that you pay attention to the lower end of growth to ensure this IRP considers the lower end of the scale fully. We appreciate that these future scenarios consider more aggressive adoption of varying technologies including renewables and other distributed energy resources. Recognizing that gas prices are subject to fluctuation, it is important to understand the sensitivity of gas prices being much higher or lower as we predict future conditions.

TVA should be guided by the matrix (slide 90 in RERC deck**), after input is incorporated, on the relative level of incentives to be applied to resources in each Strategy. Related to the business decisions, or Strategies, the RERC believes that TVA should consider adding clarification for how the Strategies both differ from each other and how they also purposefully overlap in terms of the promotion level of various technologies underneath each Strategy.

*** see appendix for copy of slide indicated.*

IRP Public Webinar

September 10, 2018

Webinar Agenda

- Overview of the 2019 Integrated Resource Plan and current status
  - Scenarios and Strategies being considered in the IRP
  - About Resource Technologies
  - Model Framework Elements
- Update on the NEPA process
- How to stay up-to-date on the 2019 IRP

Public Webinar Questions by Topic

- Mature, emerging, and development tech – how to define?
- Differences in 2015 vs 2019 IRP
- Projections – how does TVA benchmark compared to other utilities?
- Resiliency – how to define? As related to fuel security?
- Renewable energy – solar/ wind integration costs; basis & need for standard energy resources; future of EV
- What modeling programs does TVA use?
- Suggestions for additional considerations – joining an RTO? Capacity shortfall? Pump storage? Early retiring units?

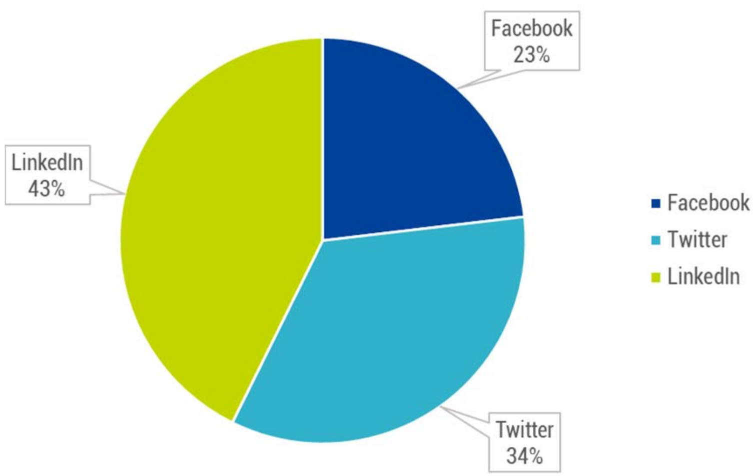
Social Media Activities

Analytics Summary

- **LinkedIn** has shown as performing best on all KPIs
- Posts **advertising specific events** have generally performed better versus general education posts on the IRP
- Number of **impressions** *(# of times content has been displayed in follower's feeds)* continues to **trend high** across Facebook, LinkedIn and Twitter
- Overall **sentiment** on posts is **positive** (measured by # of likes, positive/negative reactions and comments)

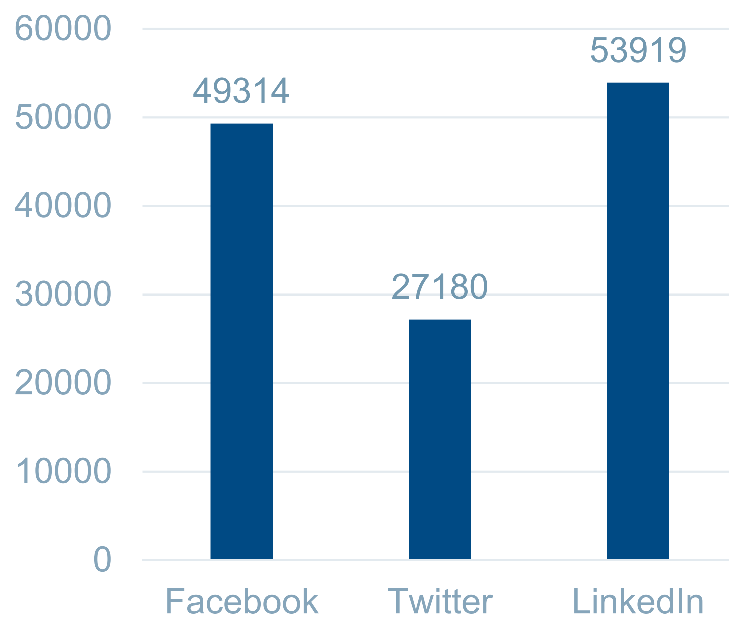
Key Performance Indicators

Total Engagements



* “Engagements” refers to any type of interaction with a post (i.e., “like”, “share”, “comment”)

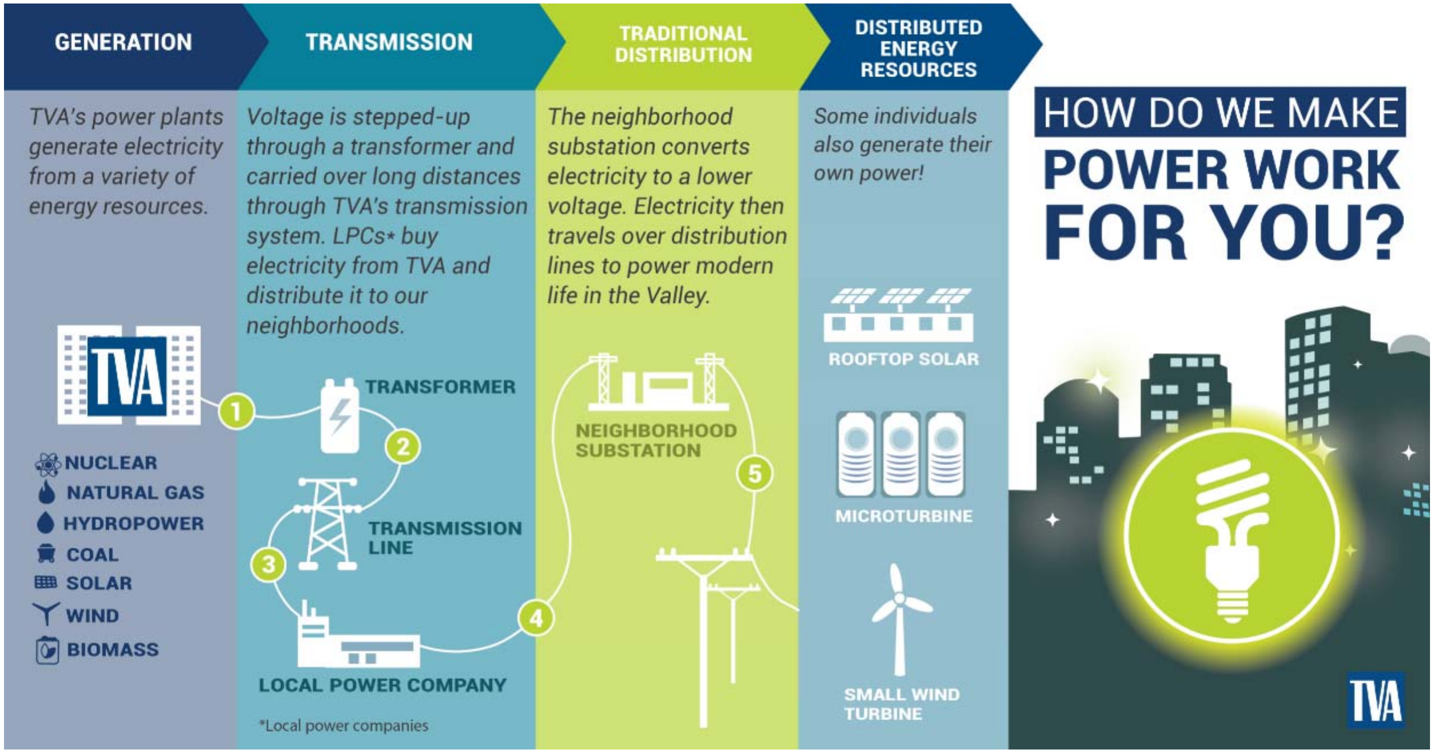
Total Impressions



* “Impressions” is total number of times content is displayed

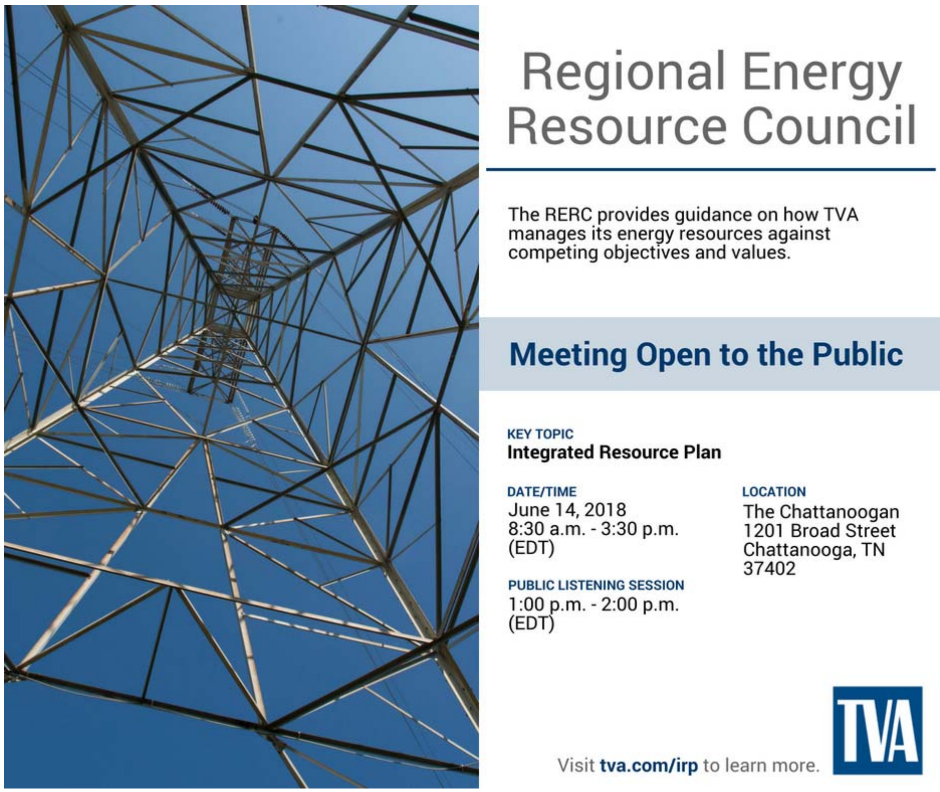
Highest Performing Post - LinkedIn

Total Engagements: 100



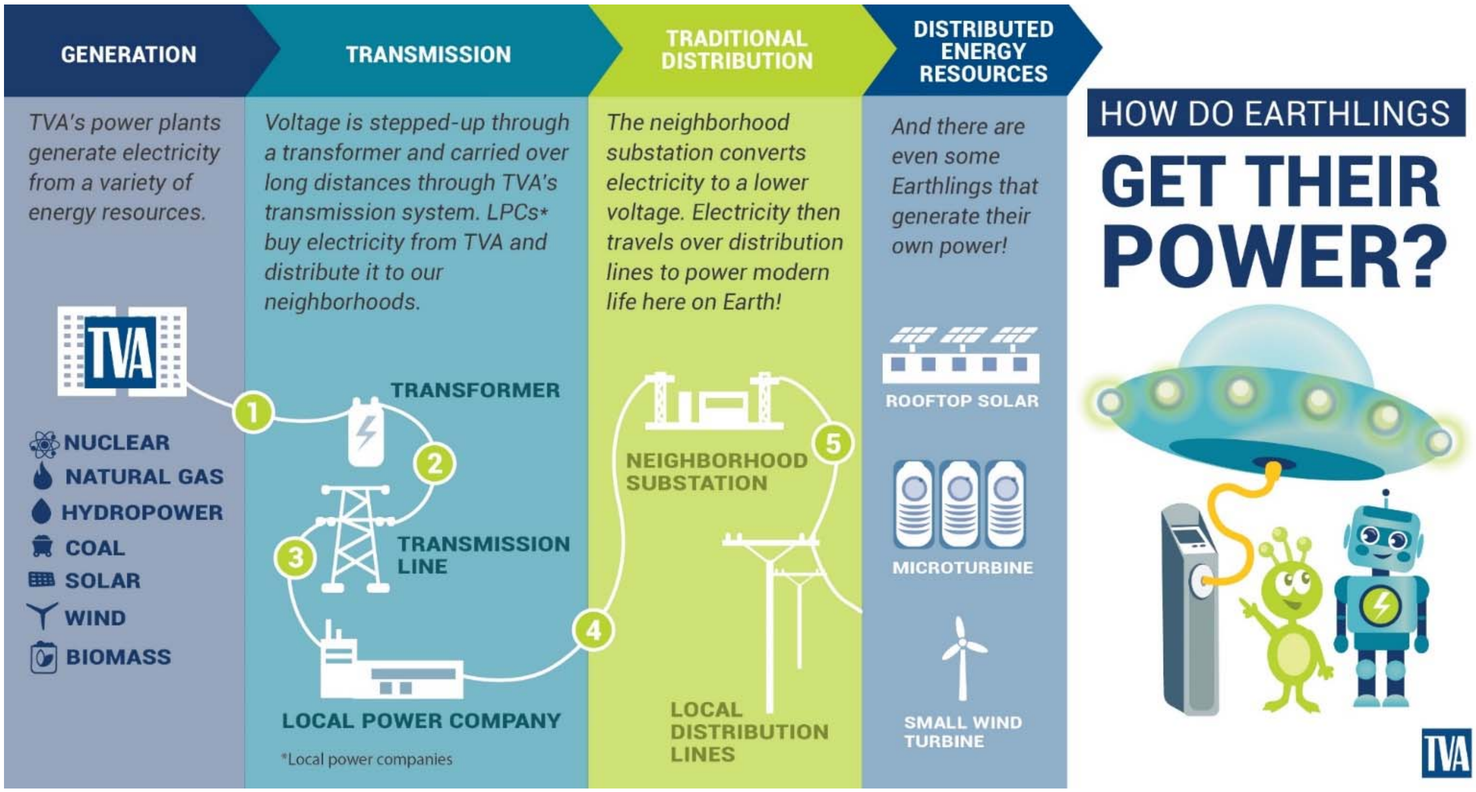
Highest Performing Post - Facebook

Total Engagements: 41



Highest Performing Post - Twitter

Total Engagements: 56



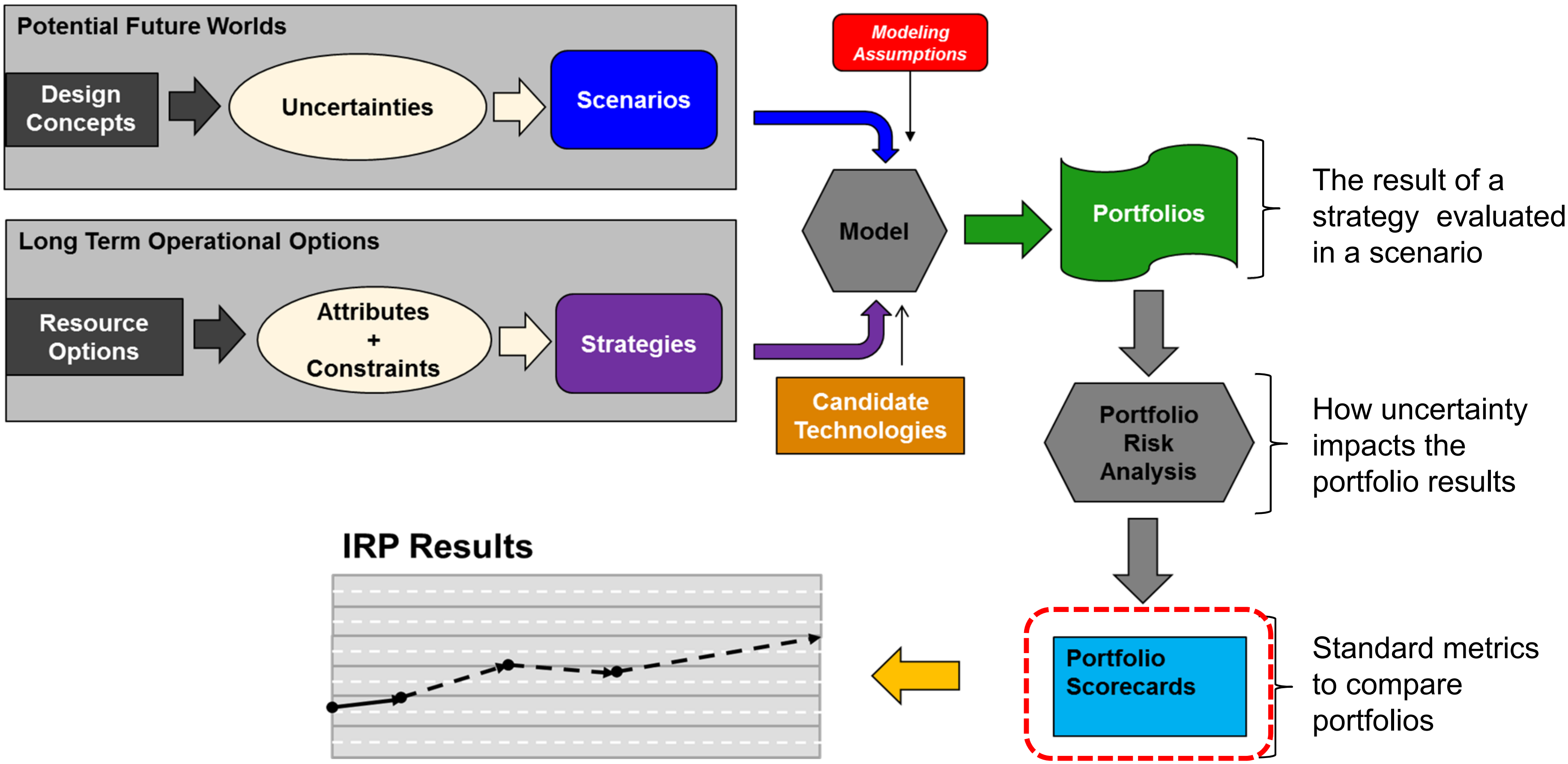
Upcoming Videos

October 2018	November 2019	February 2019	August 2019
"A Better Future for IRP-Y"	IRP Modeling	Draft IRP/ EIS Video	Overview of Final IRP & preferred alternative
• General education on IRP • Targeted for Gen Z/ Millennial for early education on value of TVA as this demographic comes into being rate payers	• Basic education on IRP modeling – strategies, scenarios, constraints	• Increase direct engagement w/ members of public • Encourage attendance at public meetings	• Overview of final IRP & public input • Present preferred alternative

Metrics & Scorecard Design

Hunter Hydas

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

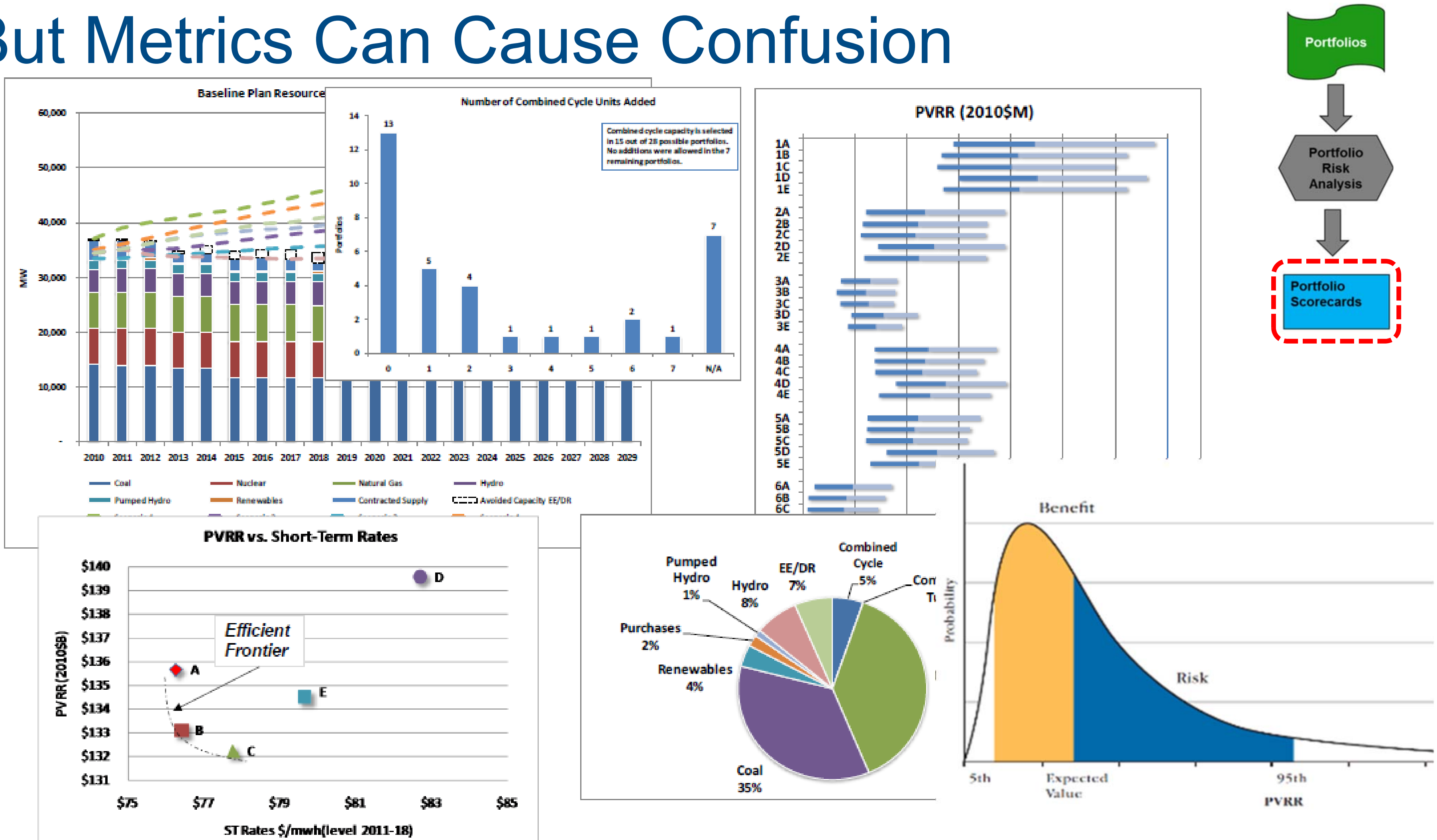
- So how do you know when the plan is “good”?

- 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

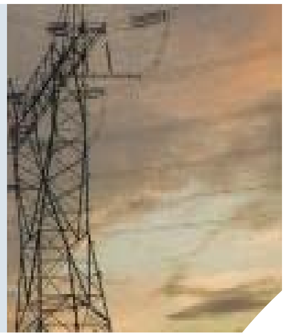
But Metrics Can Cause Confusion



TVA's Mission and Strategic Imperatives

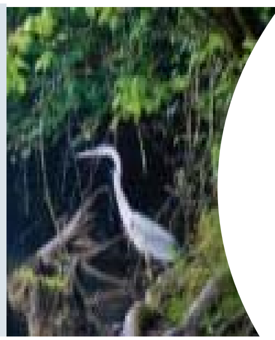
Energy

Delivering affordable, reliable power



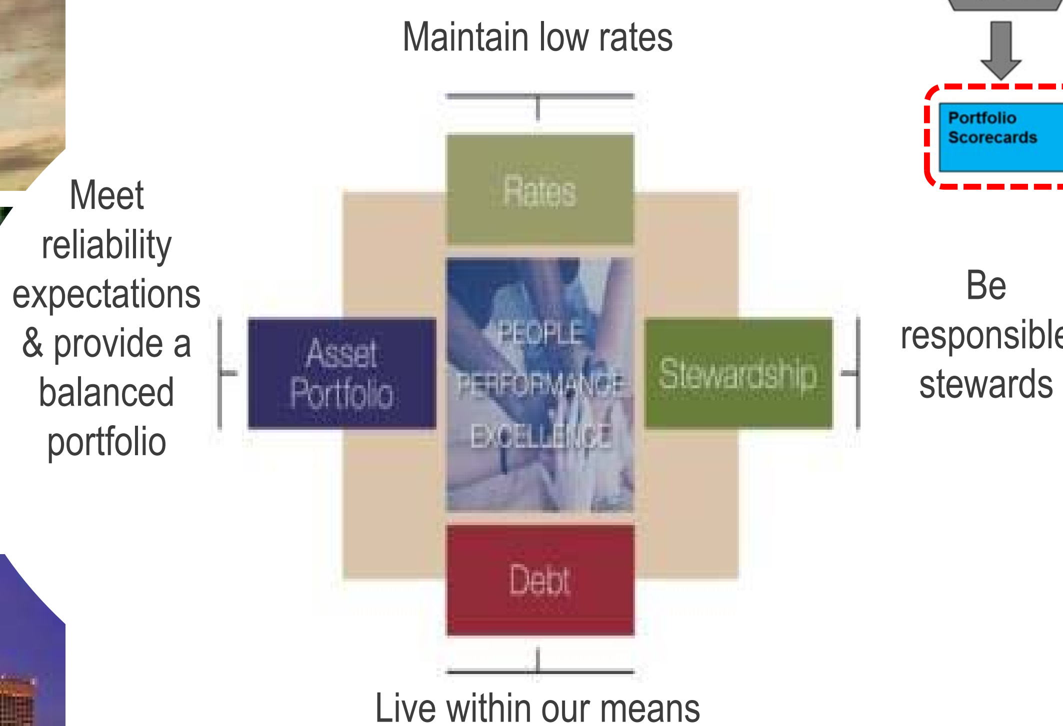
Environment

Caring for our region's natural resources



Economic Development

Creating sustainable economic growth



Types of Metrics

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

- Definition
- Calculation
- Insights provided

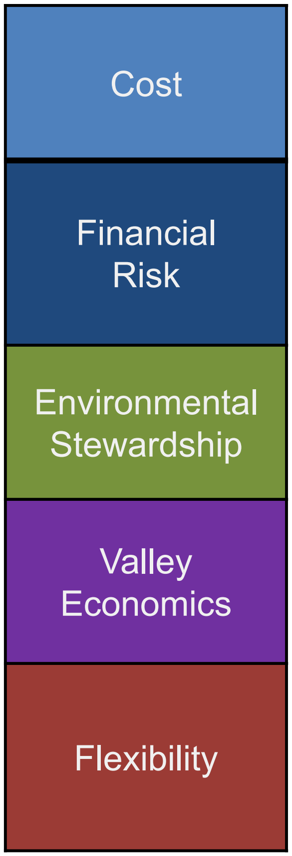
<u>SCORING</u>

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

<u>REPORTING</u>

- Optional/advanced measures
- Developmental
- Informative/Supplemental

Categories of Historical IRP Metrics



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

	TVA Mission		
IRP Scorecard Metrics	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**	=	$\frac{\Sigma\,(\text{Regulating Reserve + Demand Response + Quick Start})}{\text{Peak Load}}$
Valley Economics	**Per Capita Income**	=	Percent Difference in Per Capita Personal Income Compared to Reference Case (for each scenario)

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	=	$95\text{th}_{(PVRR)} - 5\text{th}_{(PVRR)}$
	Risk Ratio	=	$\frac{95\text{th}_{(PVRR)} - \text{Expected}_{(PVRR)}}{\text{Expected}_{(PVRR)}}$
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

Proposed 2019 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)	$\frac{\text{NPV Rev Reqs (2019–2028)}}{\text{NPV Sales (2019–2028)}}$
	Total Resource Cost ($Bn)**	PVRR + Participant cost net of savings (bill savings, tax credits)
Risk	Risk/Benefit Ratio	$\frac{\text{95th}_{(PVRR)} - \text{Expected}_{(PVRR)}}{\text{Expected}_{(PVRR)} - \text{5th}_{(PVRR)}}$
	Risk Exposure ($/Bn)	95th Percentile $_{(PVRR)}$
Environmental Stewardship	CO2 (MMTons)	Average Annual Tons of CO2 Emitted During Planning Period
	Water Consumption (MMGallons)	Average Annual Gallons of Water Consumed During Planning Period
	Waste (MMTons)	Average Annual Tons of Coal Ash and Scrubber Residue During Planning Period
	Land Use (Acres)**	Acreage Needed for Each Portfolio (2038)
Flexibility	Flexible Resource Requirement (MW)**	Capacity (MW) Required to Meet Maximum 3-Hour Ramp in 2038
Valley Economics	Percent Difference in Per Capita Income	Percent Difference in Per Capita Personal Income Compared to the Base Case (for each scenario)

** New metric for 2019

New Scoring Metrics

- Total Resource Cost

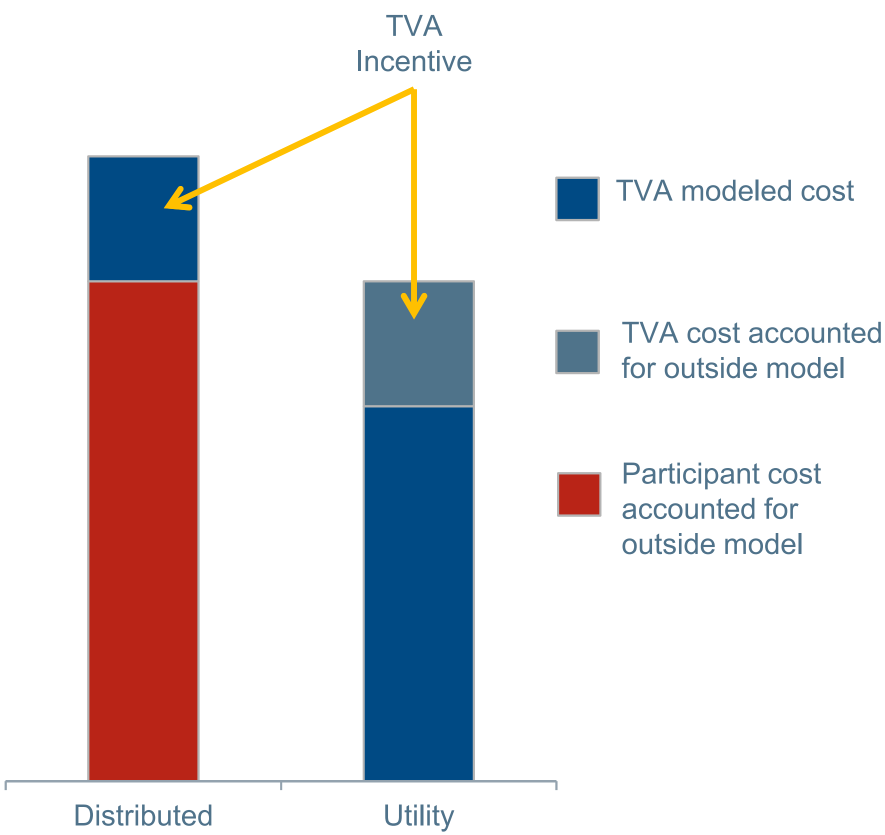
- Land Use

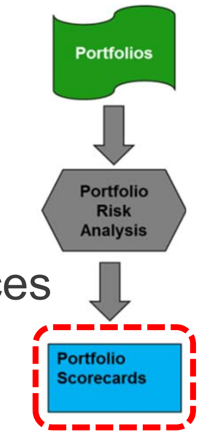
- Flexible Resource Requirement

New Scoring Metrics

- Total Resource Cost
- Land Use
- Flexible Resource Requirement

Total Resource Cost





- Utility and distributed resources receive the same incentives
- The TVA modeled cost for a distributed resource is the incentive, with the balance of the cost carried by the participant
- Utility scale resources are modeled at the lower cost for resource selection

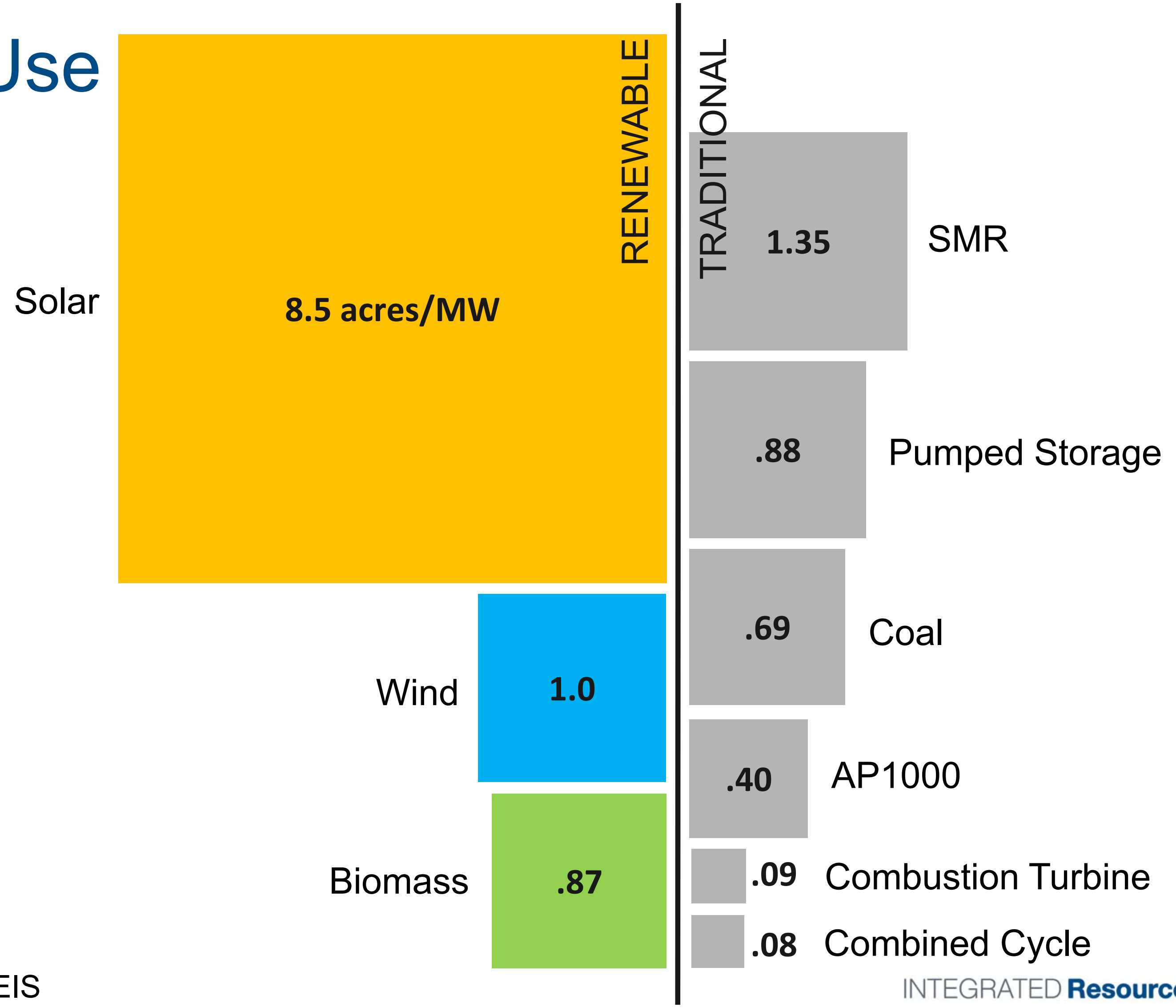
New Scoring Metrics

- Total Resource Cost

- Land Use

- Flexible Resource Requirement

Land Use



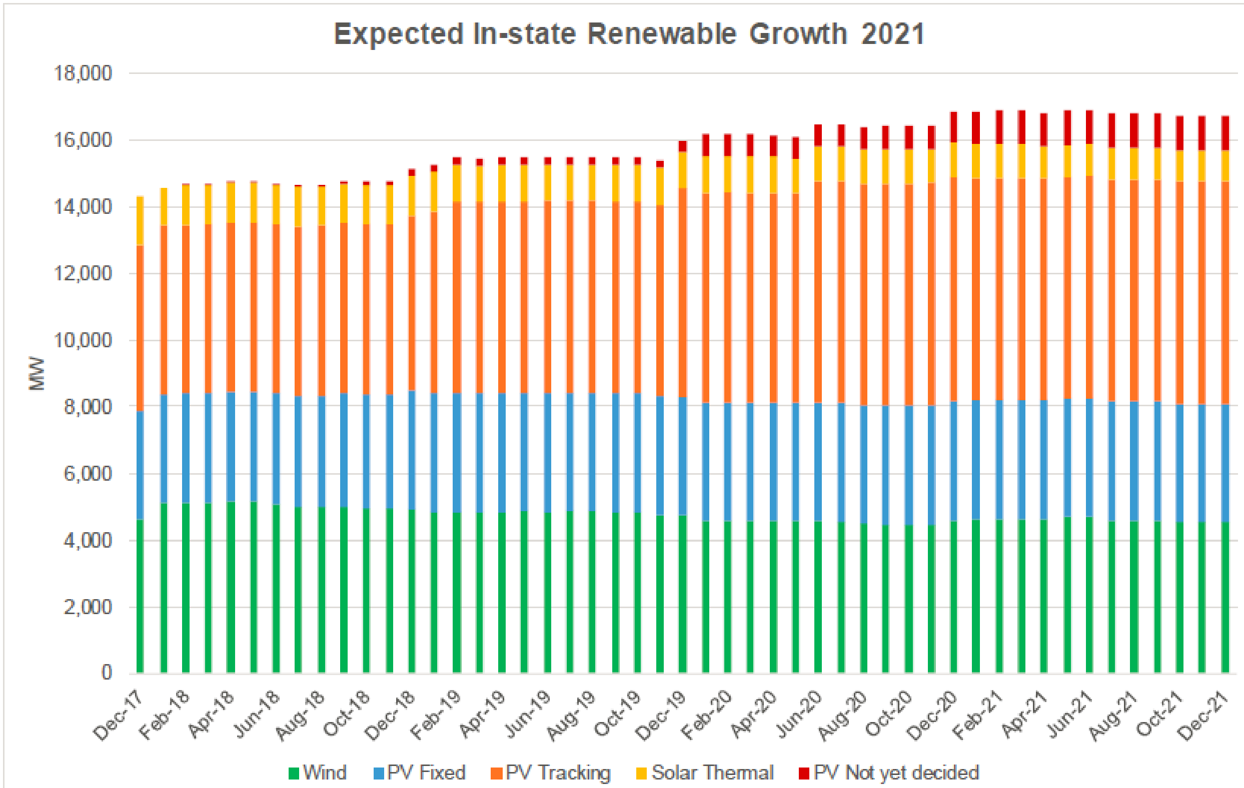
Source: 2015 IRP EIS

New Scoring Metrics

- Total Resource Cost
- Land Use
- Flexible Resource Requirement

CAISO Flexible Capacity Needs Assessment

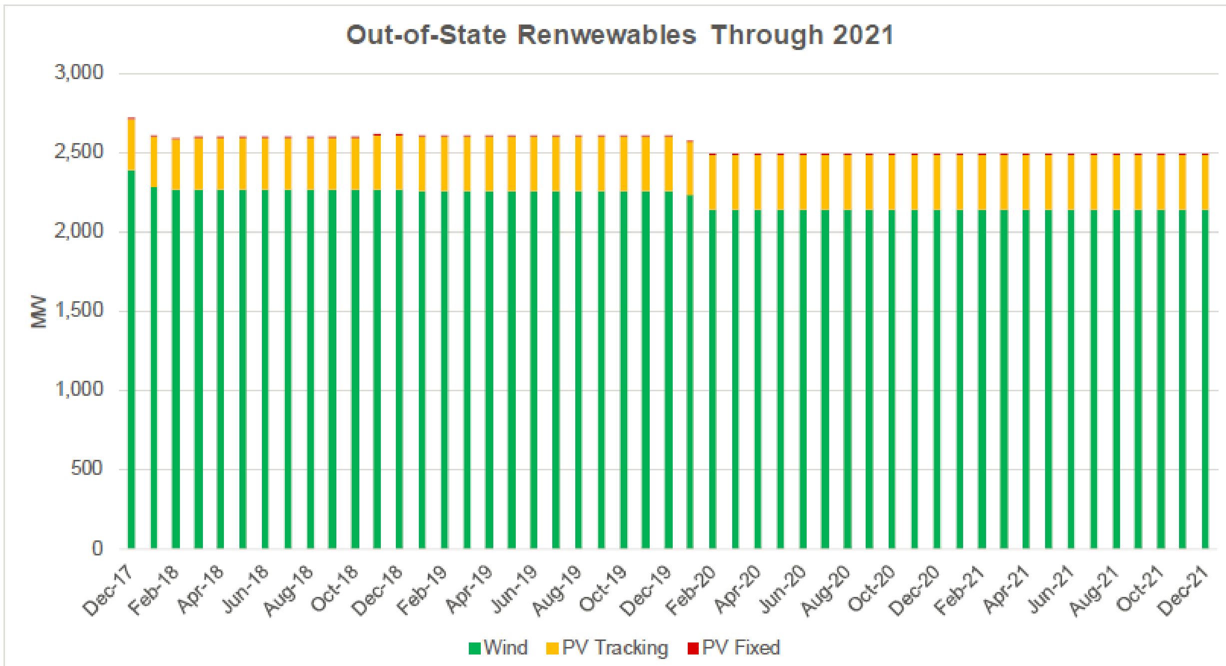
Renewable build-out through December 2021



California ISO   2018 CAISO - Public   Page 6

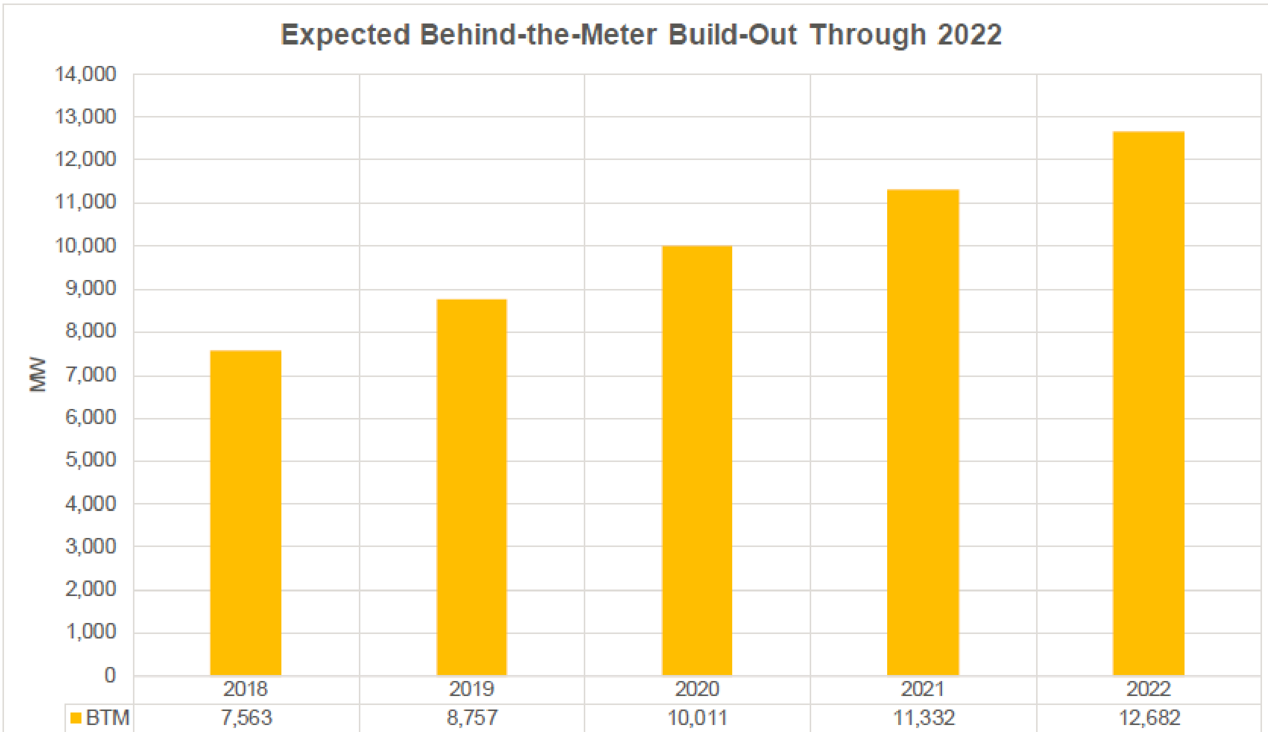
CAISO Flexible Capacity Needs Assessment

Out of state contracted renewable through December 2021



CAISO Flexible Capacity Needs Assessment

LSEs estimate of behind the meter solar PV capacity build-out through 2022



California ISO

2018 CAISO - Public

Page 9

CAISO Flexible Capacity Needs Assessment

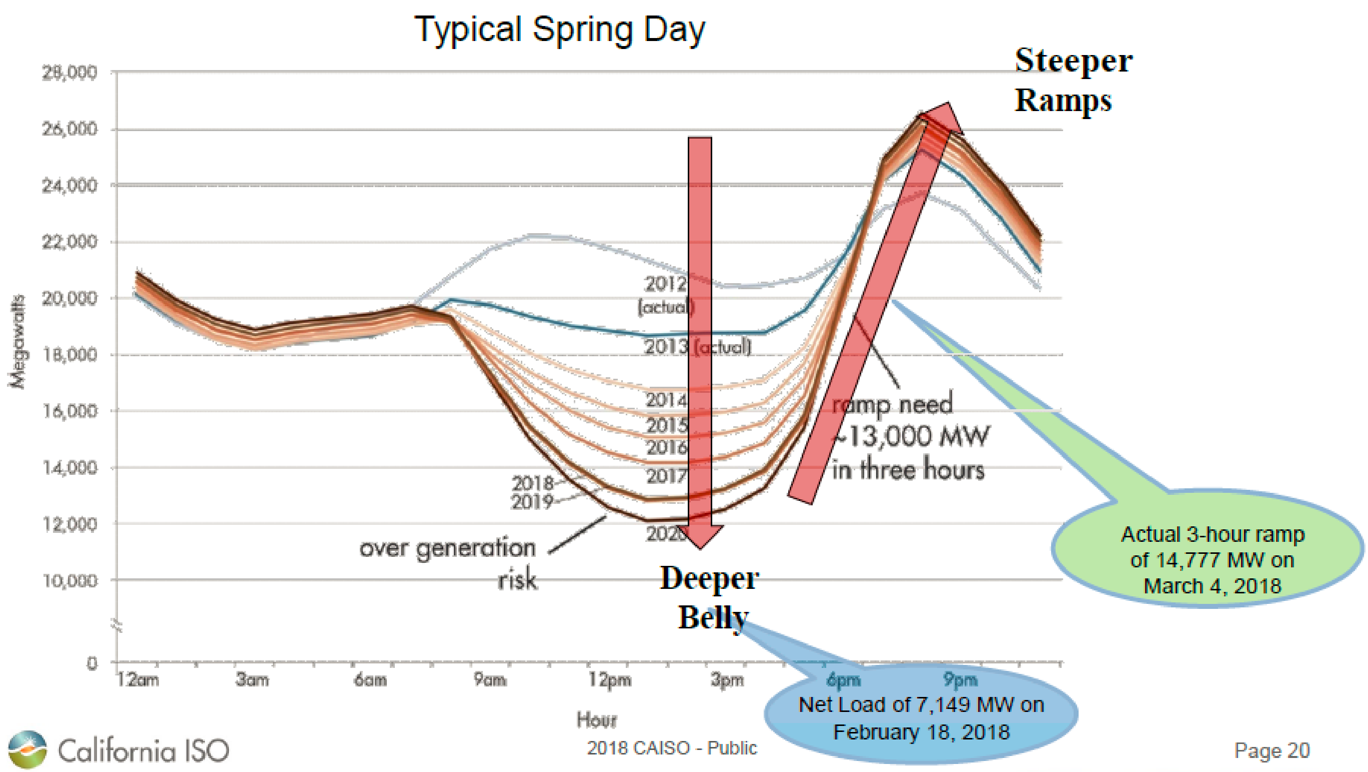
Net-load is a NERC accepted metric[1] for evaluating additional flexibility needs to accommodate VERs

- Net load is the aggregate of customer demand reduced by variable generation power output
- Net-load is more variable than load itself and it increases as VER production increases
- The monthly three-hour flexible capacity need equates to the largest up-ward change in net-load when looking across a rolling three-hour evaluation window
- The ISO dispatches flexible resources to meet net-load

1 NERC Special Report
Flexibility Report Requirements and metrics for Variable Generation: Implications for System Planning Studies, August 2010 . http://www.nerc.com/files/IVGTF_Task_1_4_Final.pdf

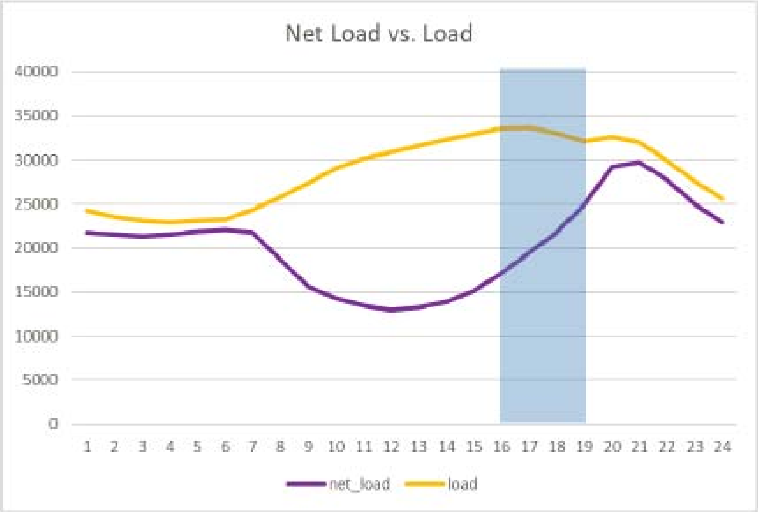
CAISO Flexible Capacity Needs Assessment

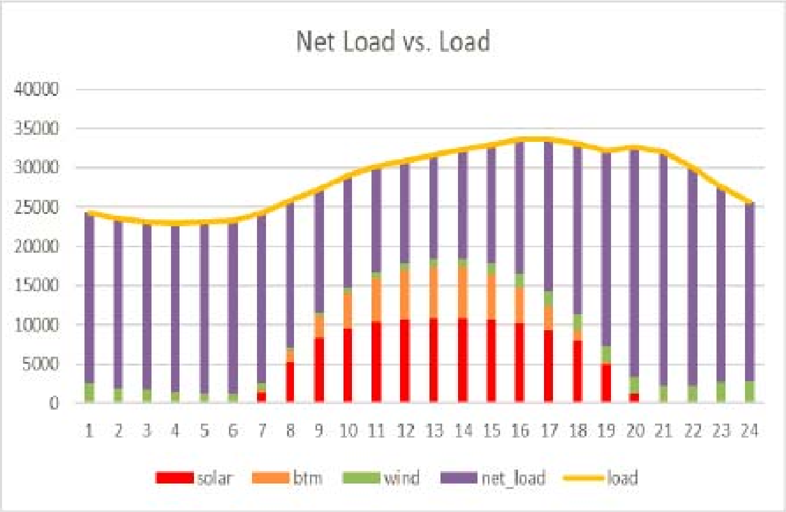
Actual net-load and 3-hour ramps are about four years ahead of the CAISO's original estimate primarily due to under forecasting roof-top solar PV installation



CAISO Flexible Capacity Needs Assessment

Understanding Negative Contributions of Load to the three hour net load ramp

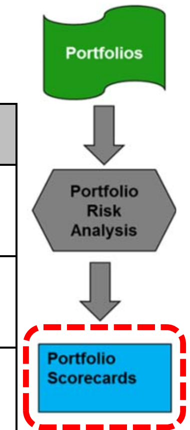




TVA Operating Reserve Requirements

Operating Reserves	Response Time	MW
Regulating Reserve	5 minutes	200
Contingency Reserve	15 minutes	1350
Replacement Reserve	90 minute	1500
		3050

Proposed 2019 IRP Reporting Metrics



Category	Reporting Metric	Formula
Cost	System Average Cost Years 11-20 ($/MWh)	$\frac{\text{NPV Rev Reqs (2029–2038)}}{\text{NPV Sales (2029–2038)}}$
Risk	Cost Uncertainty	95th Percentile $_{(PVRR)}$ - 5th Percentile $_{(PVRR)}$
	Risk Ratio	$\frac{\text{95th}_{(PVRR)} - \text{Expected}_{(PVRR)}}{\text{Expected}_{(PVRR)}}$
Environmental Stewardship	CO2 Intensity (Tons/GWh)	$\frac{\text{Tons } CO_2 \text{ (2019–2038)}}{\text{GWh Generated (2019–2038)}}$
	Net CO2 Emissions**	Change in CO2 Emissions Compared to the Base Case in each Scenario
	Water Consumption by Basin**	Average Annual Gallons of Water Consumed During Planning Period by Basin
	Spent Nuclear Fuel Index (Tons)	Expected Spent Fuel Generated During Planning Period
	Land Use Intensity**	$\frac{\text{Acreage Needed for Each Portfolio (2038)}}{\text{GWh Generated (2038)}}$
Flexibility	Flexibility Turn Down Factor	$\frac{\text{"Must Run" + "Non–Dispatchable" (2038)}}{\text{Sales (2038)}}$
Valley Economics	Employment	Difference in the Change in Employment Compared to the Base Case

** New metric for 2019

New Reporting Metrics

- Net CO_2 Emissions

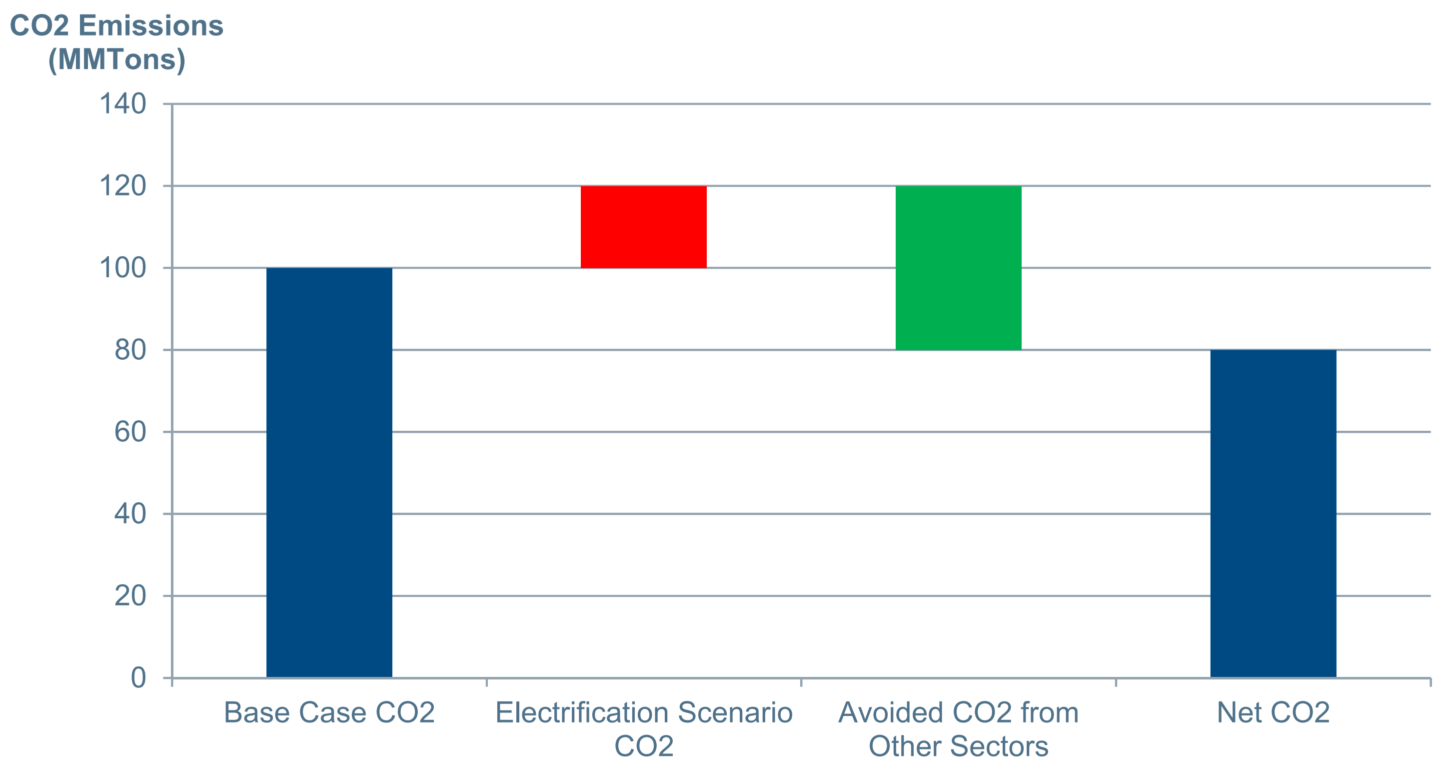
- Water Consumption by Basin

New Reporting Metrics

- Net CO_2 Emissions

- Water Consumption by Basin

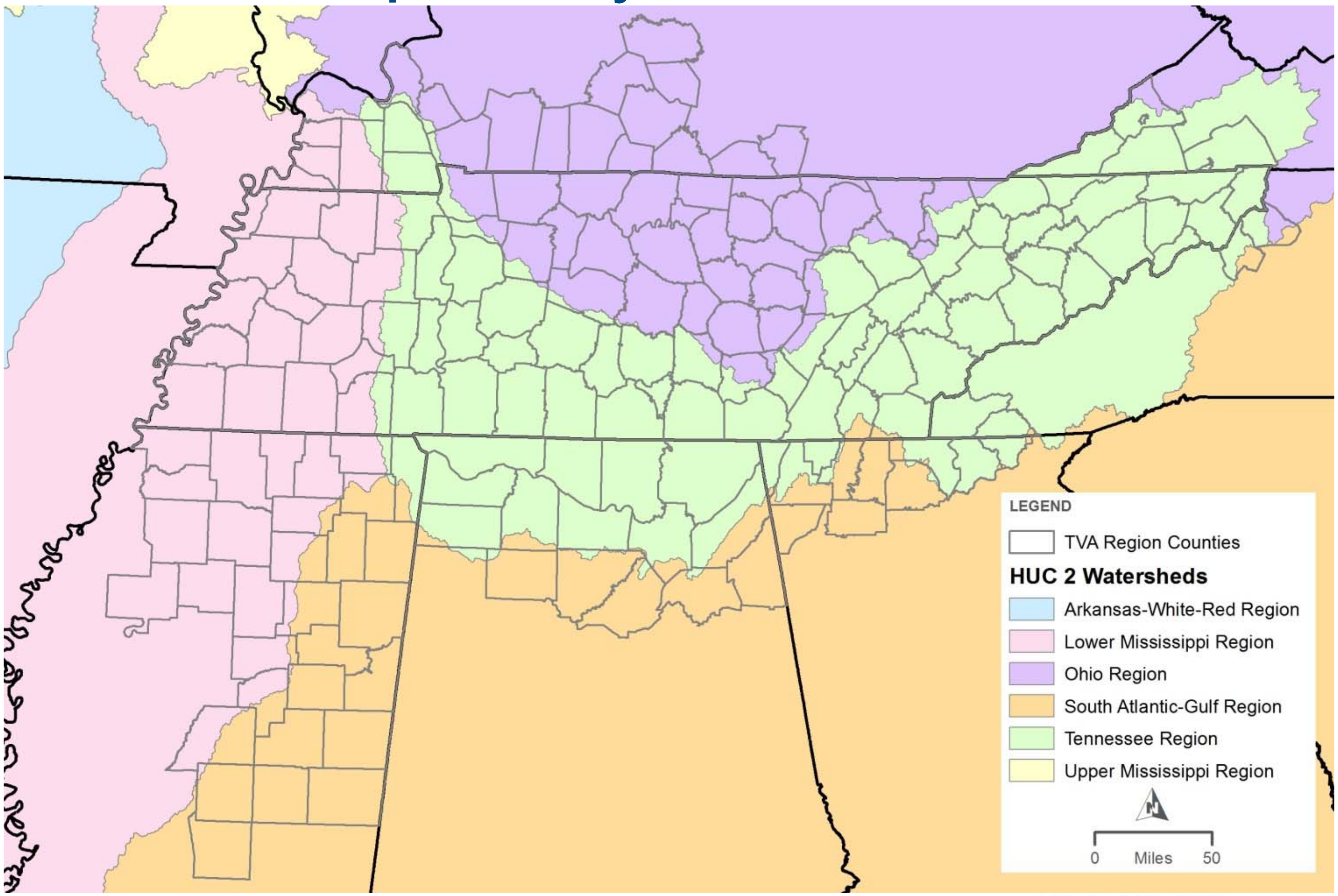
Net CO2 Emissions



New Reporting Metrics

- Net CO2 Emissions
- Water Consumption by Basin

Water Consumption by Basin



2019 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

	Cost			Risk		Environmental Stewardship				Flexibility	Valley Economics
Scenarios	PVRR ($Bn)	System Avg Cost Years 1-10 ($/MWh)	Total Resource Cost ($Bn)	Risk/Benefit Ratio	Risk Exposure ($/Bn)	CO2 (MMTons)	Water (MM Gallons)	Waste (MMTons)	Land Use (Acres)	Flexible Resource Requirement (MW)	Percent Difference in Per Capita Income
1. Current Outlook											
2. Economic Downturn											
3. Valley Load Growth											
4. Decarbonization											
5. Rapid DER Adoption											
6. No Nuclear Extensions											

Group Discussion Question:

What are your final comments or questions regarding metrics and scorecard design?

Environmental Impact Statement Overview

Ashley Pilakowski

Contents of Draft EIS

1 Introduction

2 TVA Power System

3 Alternatives

4 Affected Environment

5 Anticipated Environmental Impacts

6 Literature Cited

7 List of Preparers

8 EIS Recipients

9 Index

FOUR MAIN CHAPTERS

TVA Power System

- Provides an overview of TVA's existing power system and its characteristics
  - power sales and purchases,
  - generating facilities,
  - energy efficiency and demand response programs,
  - and the existing transmission system.

Alternatives

- Describes the capacity expansion plans or resource portfolios associated with each alternative strategy.
- Presents the metrics used to evaluate the strategies.
- Summarizes the environmental impacts of the alternatives.

- The 2019 IRP EIS will include five Alternatives including the Base Case.
- The Base Case is a resource plan that was developed using the current methodology of resource optimization, consistent with the direction established by the 2015 IRP and will serve as the No-Action Alternative.

Affected Environment

- Existing natural and socioeconomic resources of the Tennessee Valley
  - Regulatory framework
  - Regional as opposed to site-specific.
  - Existing conditions and forecasted trends
- Includes Air, Land, Water, Socioeconomics and Environmental Justice

Anticipated Environmental Impacts

- Facility Siting and Review Processes
- Environmental Impacts of Supply-Side Resource Options
- Environmental Impacts of Energy Efficiency and Demand Response Programs
- Environmental Impacts of Transmission Facility Construction and Operation
- Environmental Impacts of Alternative Strategies and Portfolios
- Potential Mitigation Measures
- Unavoidable Adverse Environmental Impacts

Environmental Justice Overview

Chuck Nicholson

Executive Order 12898 - Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations

- Issued February 11, 1994
- "…each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations…"

What Is Environmental Justice?

The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies.

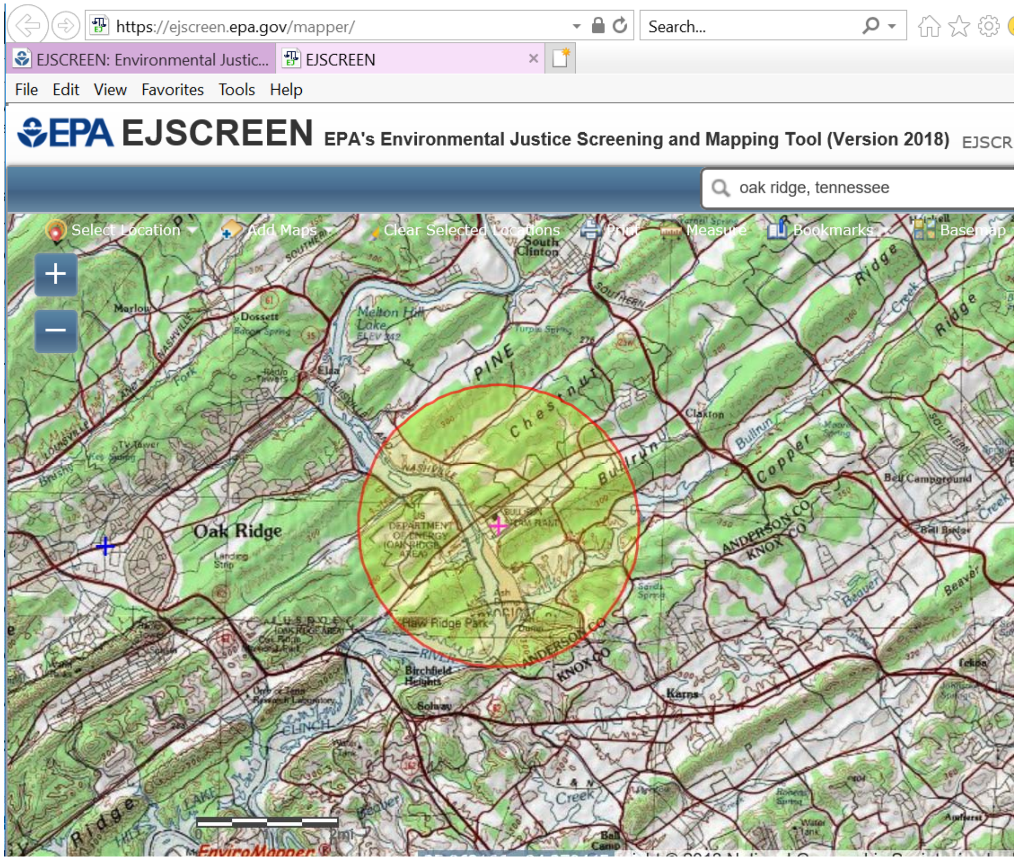
More Definitions

- Fair Treatment: no group of people should bear a disproportionate share of the negative environmental consequences resulting from industrial, governmental and commercial operations or policies.
- Meaningful Involvement:
  - People have opportunity to participate in decisions affecting their environment and/or health
  - Community concerns are considered in the decision-making process
  - Decision makers seek out and facilitate the involvement of those potentially affected

The Typical Environmental Justice Analysis

- Determine potential impact area
- Quantify minority and low income populations in impact area
- If proportions of minority and low income populations are lower than regional proportions, there may not be impacts
- But a closer look is often necessary
- If concentration of minority and/or low income residents occurs, assess potential impacts and consider mitigation
- Throughout process, engage local residents; targeted outreach may be necessary for minority and low income residents

Define Potential Impact Area

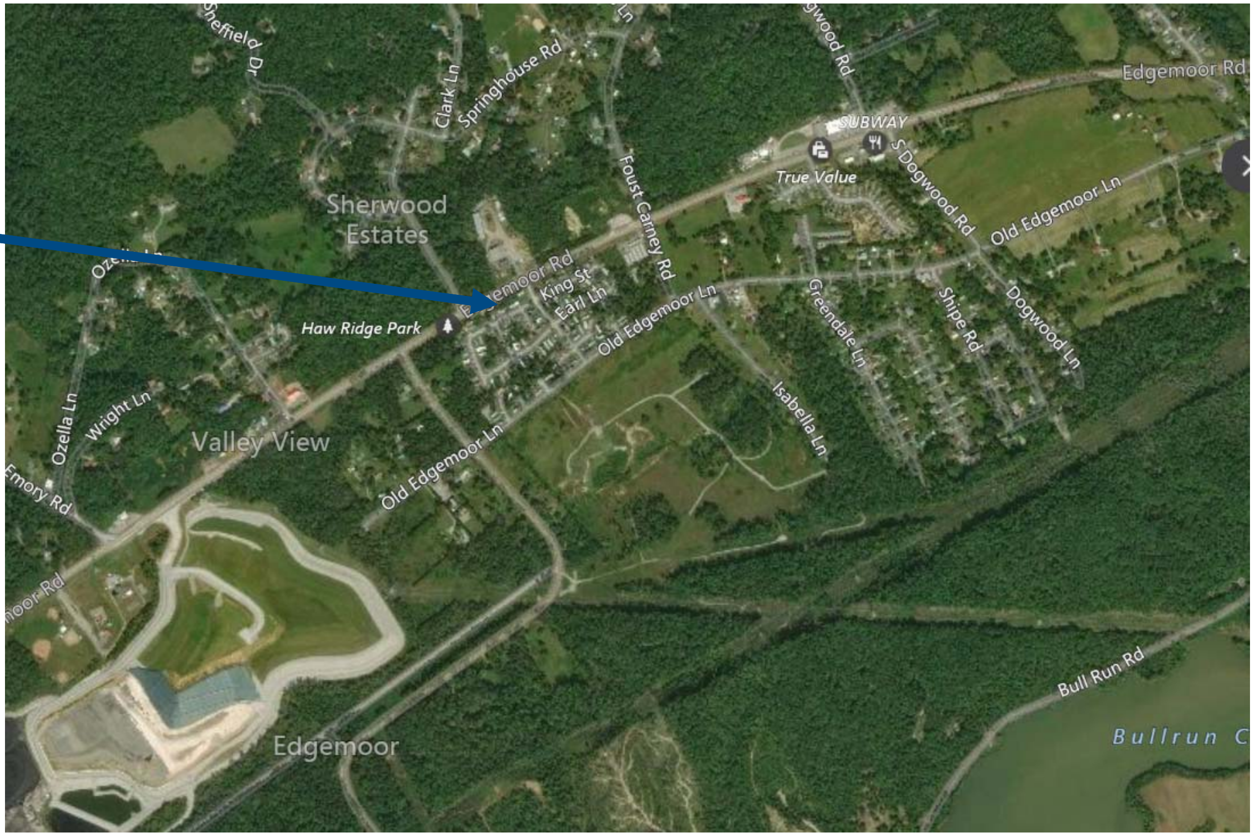


Quantify Minority and Low Income Populations

Selected Variables	Value	State Average	Percentile in State	EPA Region Average	Percentile in EPA Region	USA Average	Percentile in USA
Demographic Indicators							
Demographic Index	18%	32%	27	38%	18	36%	26
Minority Population	7%	25%	31	38%	14	38%	16
Low Income Population	30%	38%	38	38%	38	34%	49
Linguistically Isolated Population	0%	1%	66	3%	51	4%	44
Population with Less Than High School Education	15%	14%	58	14%	61	13%	67
Population under Age 5	6%	6%	52	6%	54	6%	51
Population over Age 64	17%	15%	61	16%	63	14%	67

A Closer Look May Be Necessary

Trailer Park



Environmental Justice And The IRP

Scoping Comments:

- Conduct a detailed evaluation of the impacts of the scenario/strategy combinations on minority and low income populations, including communities of color, with consideration of their high energy burden and the effects of any rate changes on their household income.
- Analysis techniques suggested, included Metropolitan Washington Council of Governments Environmental Toolkit

Environmental Justice And The IRP

In Scope	Outside of Scope
- Economic & Social Justice - Impacts of the scenario/strategy combinations on minority and low income populations	- Typical analysis of site-specific disproportionate environmental impacts - Rate trajectories

Environmental Justice And The IRP

- Expanded outreach efforts to low income populations under development
- Promote Efficient Load Shape strategy promotes EE programs targeting low-income customers

Group Discussion Question

What are we missing in the Environmental Justice analysis?

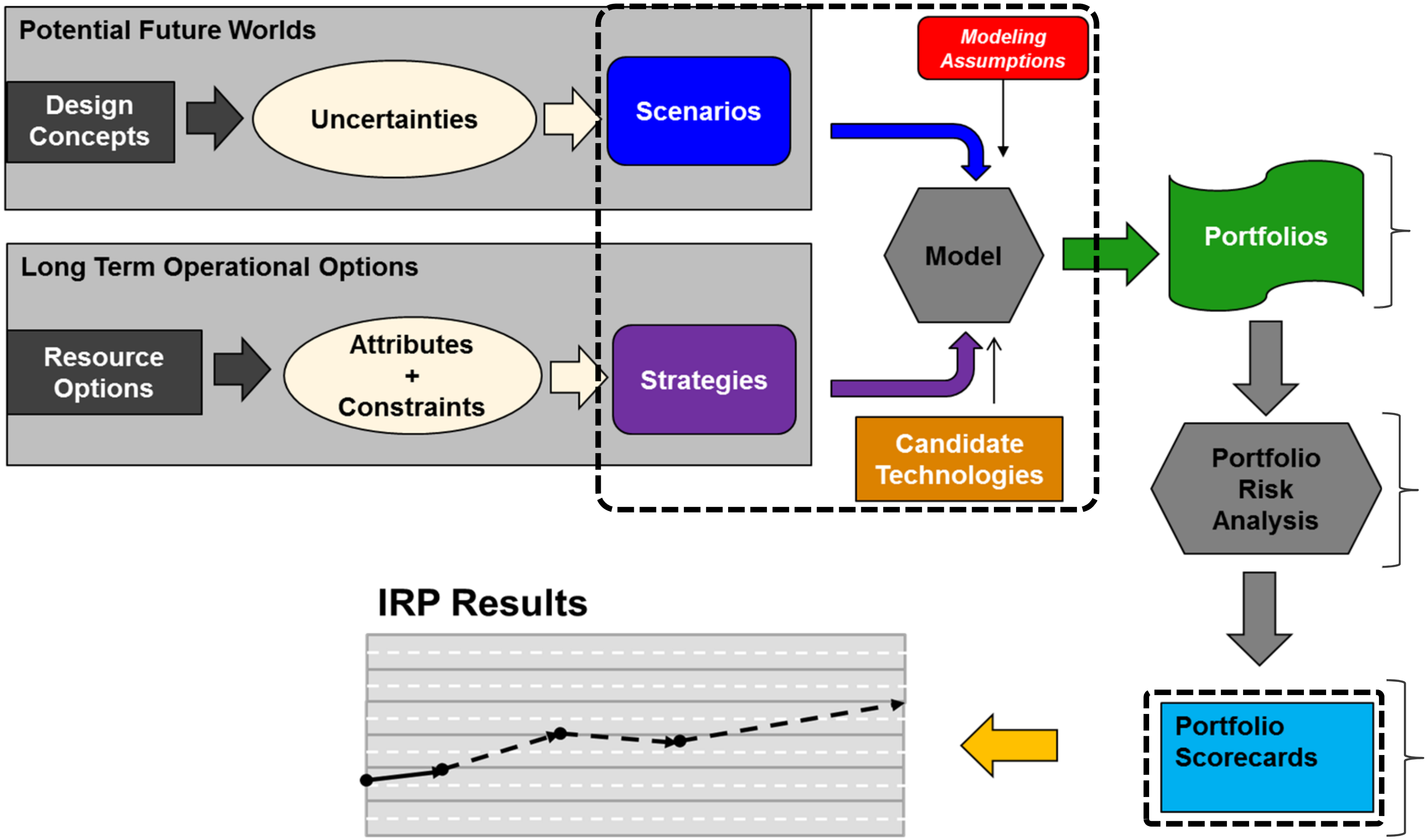
Overview of Modeling and Strategy Design

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

Strategy Design – Today's Discussion

- Review of strategies and adoption curve considerations
- Final strategy design recommendation
- Approach for promoting resources
- EE, DR and BE background and program offerings
- DG & Storage background and adoption levels
- IRPWG final comments and questions

Keys to Effective Modeling: Inputs & Framework

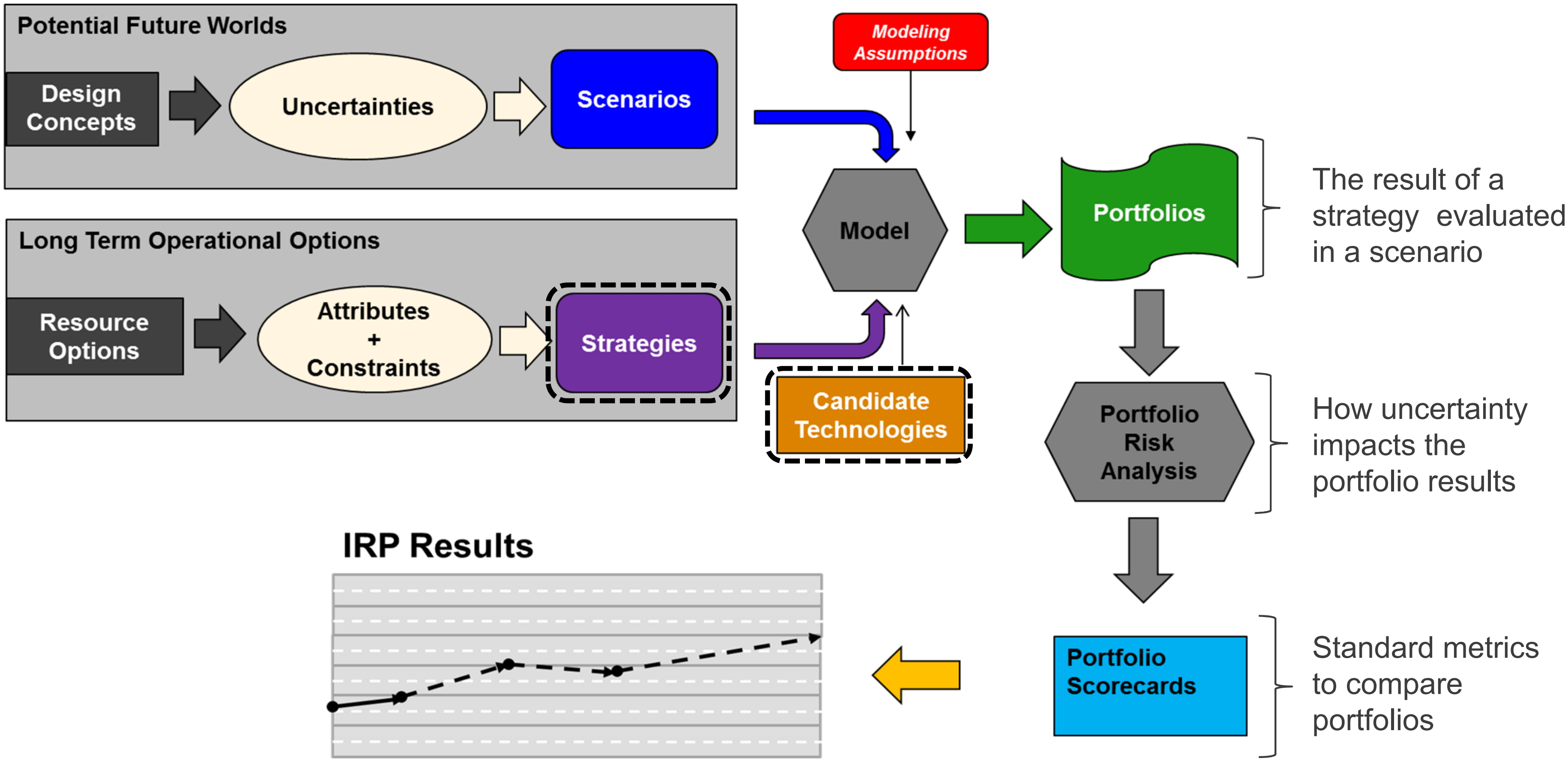


The result of a strategy evaluated in a scenario

How uncertainty impacts the portfolio results

Standard metrics to compare portfolios

Strategies Promote Certain Resource Types



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 Energy Usage*
E. *Promote Renewables*

A. Base Case

- Planning Reserve margins for summer and winter peak seasons are applied, targeting an industry best-practice level of reliability.
- No specific resource types are promoted beyond business as usual.
- Portfolios are then optimized based on least cost.

All Other Strategies

- Planning Reserve margins for summer and winter peak seasons are applied, targeting an industry best-practice level of reliability.
- Specific resources are promoted according to the strategy design matrix.
- Portfolios are then optimized based on least cost.

B. Promote DER

- DER is incented to achieve higher 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

- Small, agile capacity is incented to maximize flexibility and promote ability to respond to short-term disruptions on the power system.
- All technologies are available while small nuclear (SMRs) and 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

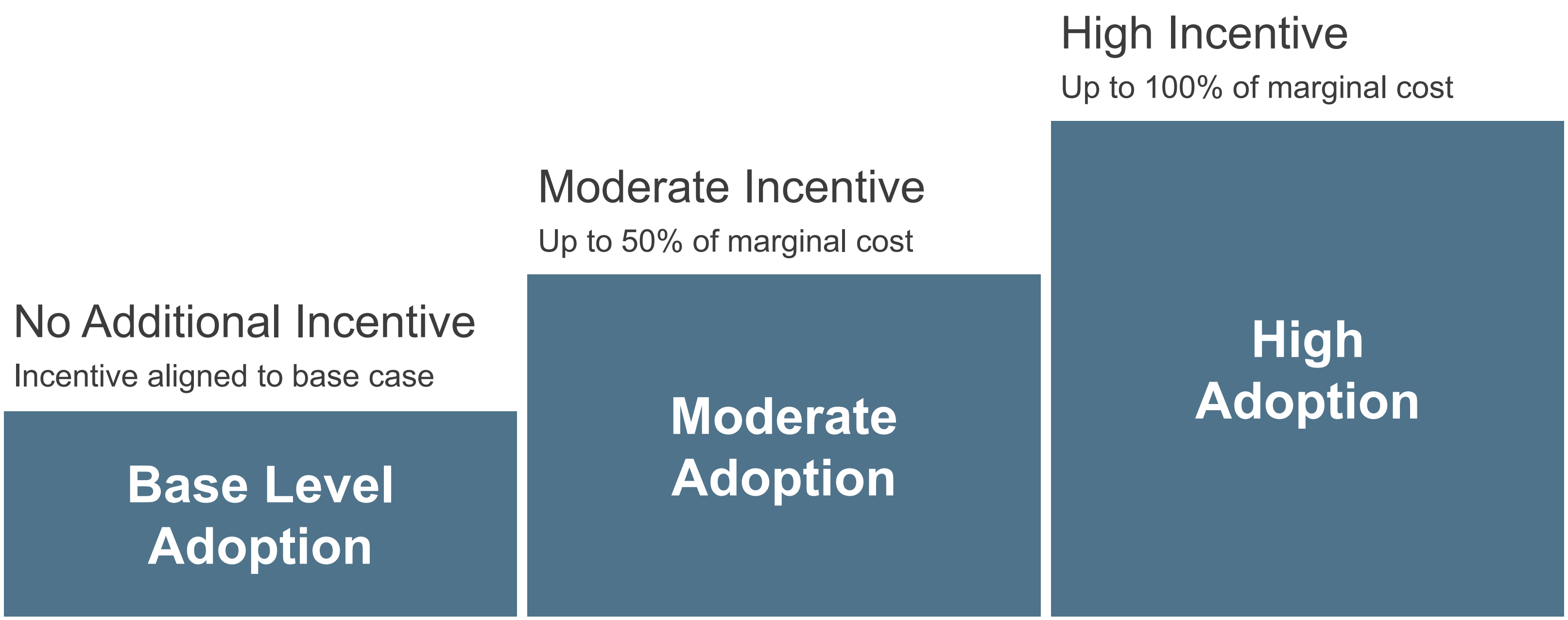
- Targeted electrification and demand and energy management, are incented to minimize peaks and troughs and promote an efficient load shape.
- All technologies are available but those that minimize load swings, including EE, DR and storage, are promoted.
- Programs targeting low-income customers will be a part of EE promotion.

E. Promote Renewables

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

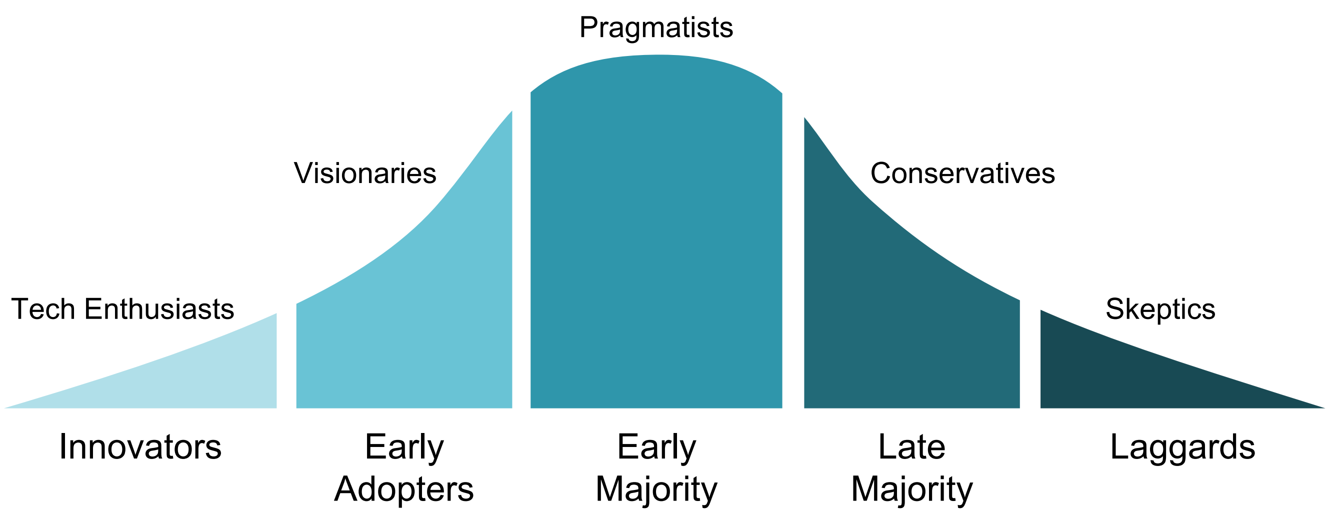
Strategies Promote Higher Adoption Levels

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



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

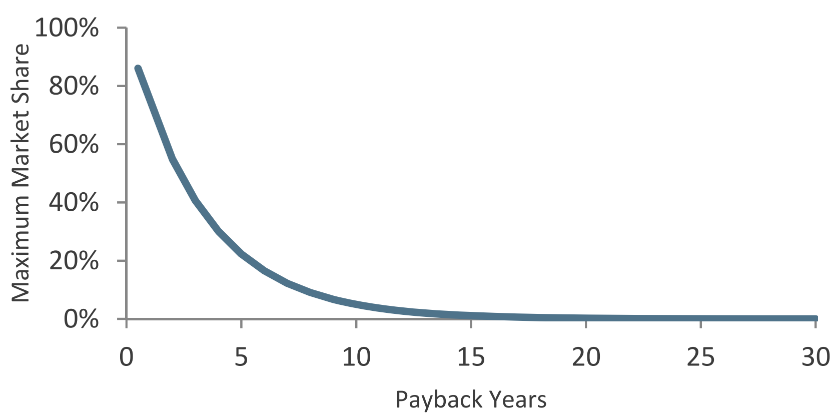


Adoption Curve Approach

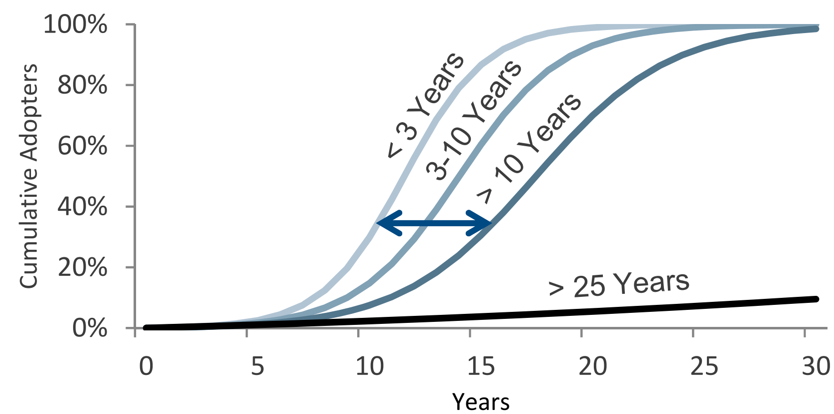
Adoption curves were developed using an approach similar to NREL's Distributed Market Demand Model, a market-penetration model that simulates the potential adoption of distributed solar, which changes with payback period.

Payback Drivers → Payback Period → Max Market Share → Adoption Curve

Maximum Market Share



Adoption Curve



Relative Incentive Levels by Strategy – Prelim

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

Strategy	Distributed Resources & Electrification						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

Considerations for Final Strategy Design

- IRP Working Group feedback
- Insights from adoption curve development
- Relative economics of promoted resources
- Alignment within a strategy
- Differentiation across strategies

Relative Incentive Levels by Strategy – Changes

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

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 Plan	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
Promote DER	High	High to Moderate	High	Moderate	Moderate	Base	Base	Base	Base	Base	Base	Base
Promote Resiliency	Moderate	Moderate to High	Moderate	Base	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate
Promote Efficient Load Shape	Moderate to Base	Moderate	Moderate to Base	High	High	Moderate	Base	Base	Base	High	Base	Moderate to Base
Promote Renewables	High to Moderate	Moderate	Base	Base	Base	Base	High to Moderate	High to Moderate	Moderate	Moderate	Base	Base

Relative Incentive Levels by Strategy – Final

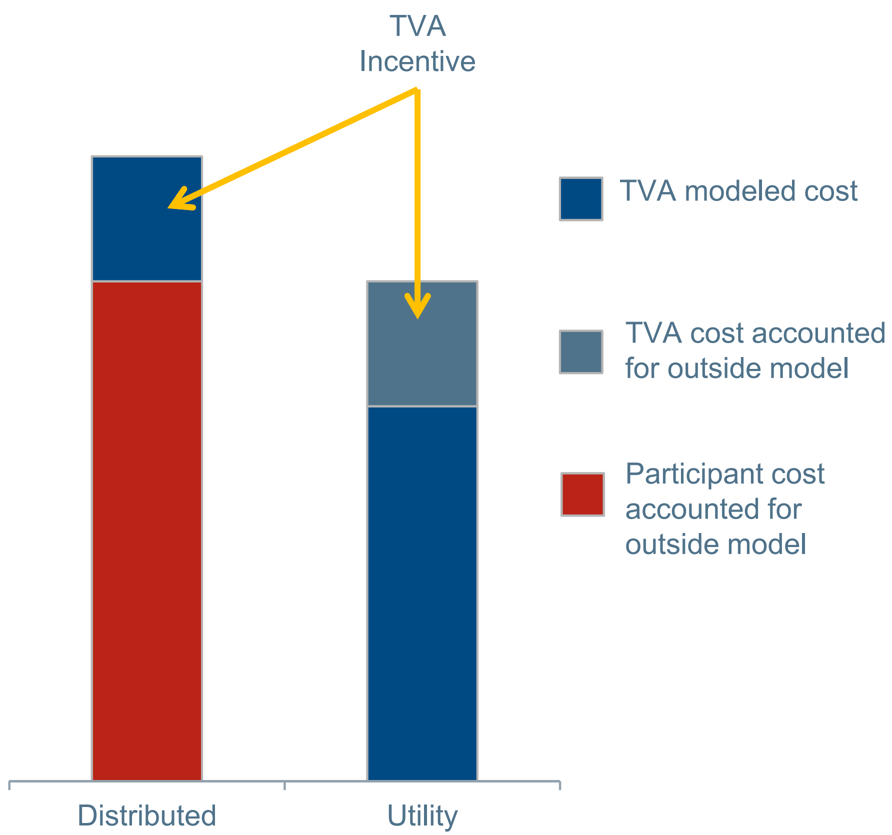
Resources will be promoted to various levels across the strategies, with consideration of potential, adoption curve, and reserve margin.

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 Plan	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

Approach for Promoting Resources

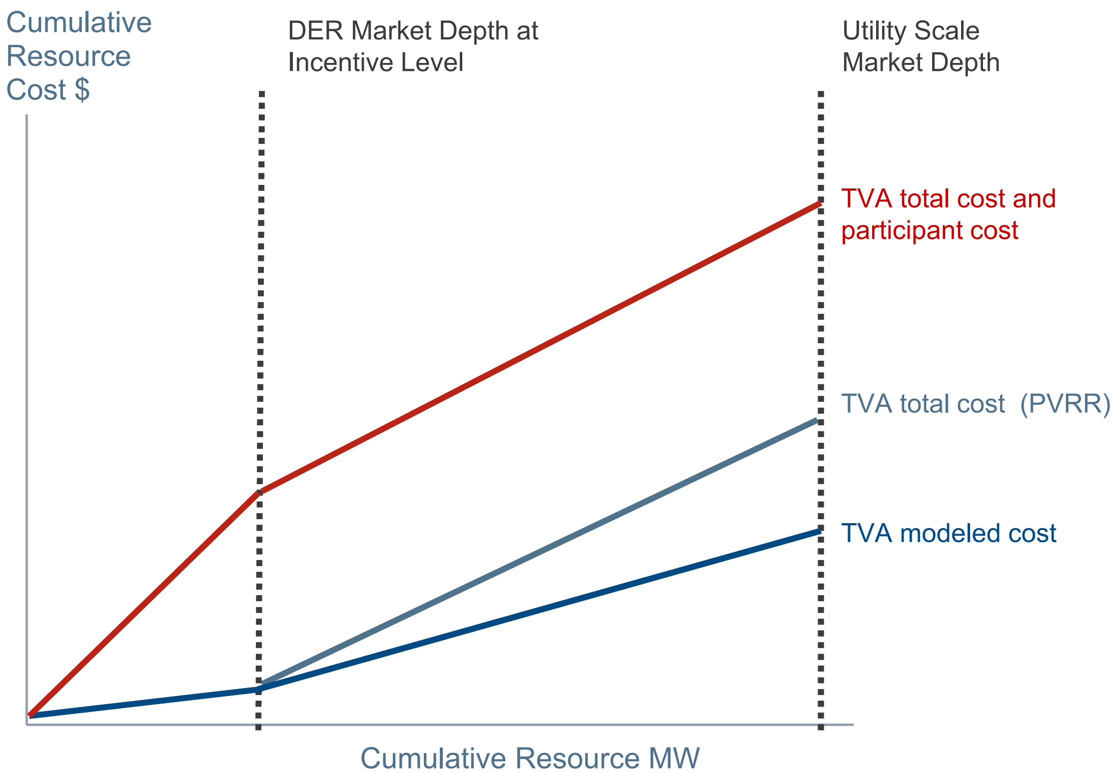
- Promoted utility scale and distributed resources will receive the same incentives
- Distributed generation and storage adoption based on participant economics at various incentive levels has been developed and will be enforced in the model
- Energy efficiency, demand response, and electrification programs are selectable options in the model, promoted with incentives as applicable in each strategy
- Utility scale resources are modeled with an incentive for resource selection, but the incentive is added back into revenue requirements
- For DER, some costs are paid by TVA (programmatic and incentive), and some costs are paid by the DER participant (installation cost and maintenance)
- DER net participant costs (after tax incentives and energy savings) will be captured for use in metrics

Approach for Promoting Resources – Illustration



- Utility and distributed resources will receive the same incentives
- The TVA modeled cost for a distributed resource is the incentive, with the balance of the cost carried by the participant
- Utility scale resources are modeled at the lower cost for resource selection

Approach for Promoting Resources – Illustration



- Market depth for DERs is limited by participant economics
- Utility scale depth is larger and limited by construction constraints
- Net participant cost for distributed resources will be captured in metrics

Strategies Consider DER Adoption in Scenarios

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

Scenarios

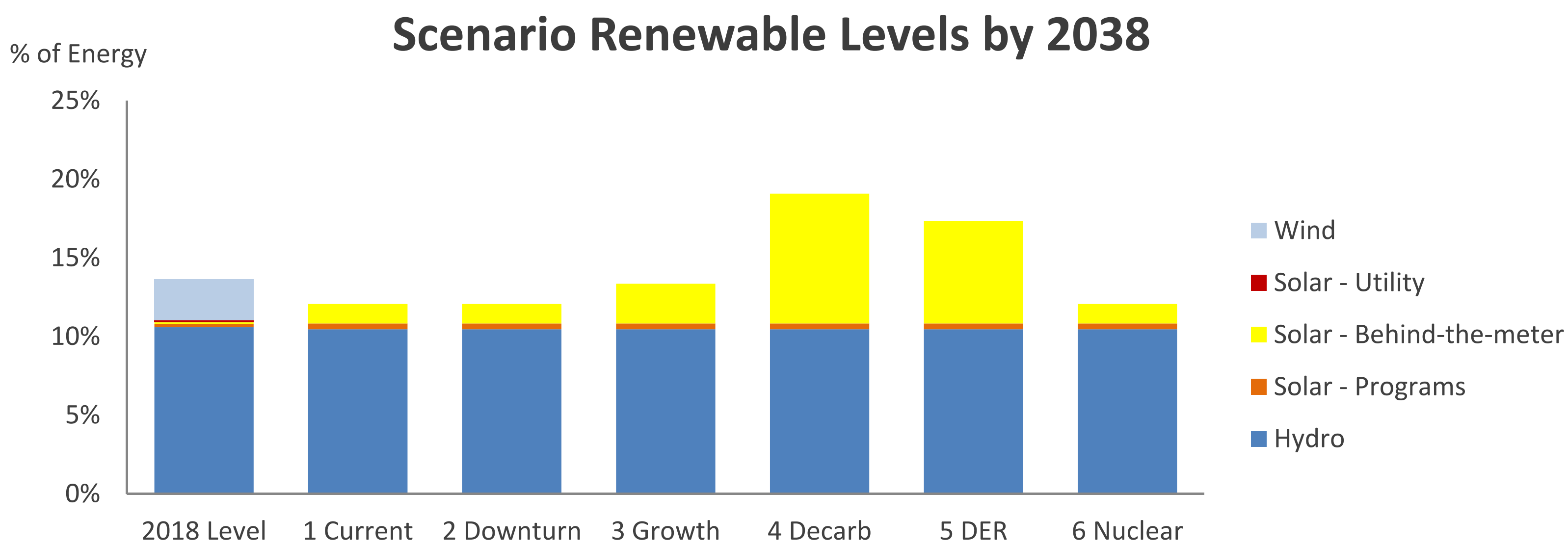
1. *Current Outlook*
2. *Economic Turndown*
3. *Valley Load Growth*
4. *Decarbonization*
5. *Rapid DER Adoption*
6. *No Nuclear Extensions*

Strategies

A. *Base Case*
B. *Promote DER*
C. *Promote Resiliency*
D. *Promote Efficient Energy Usage*
E. *Promote Renewables*

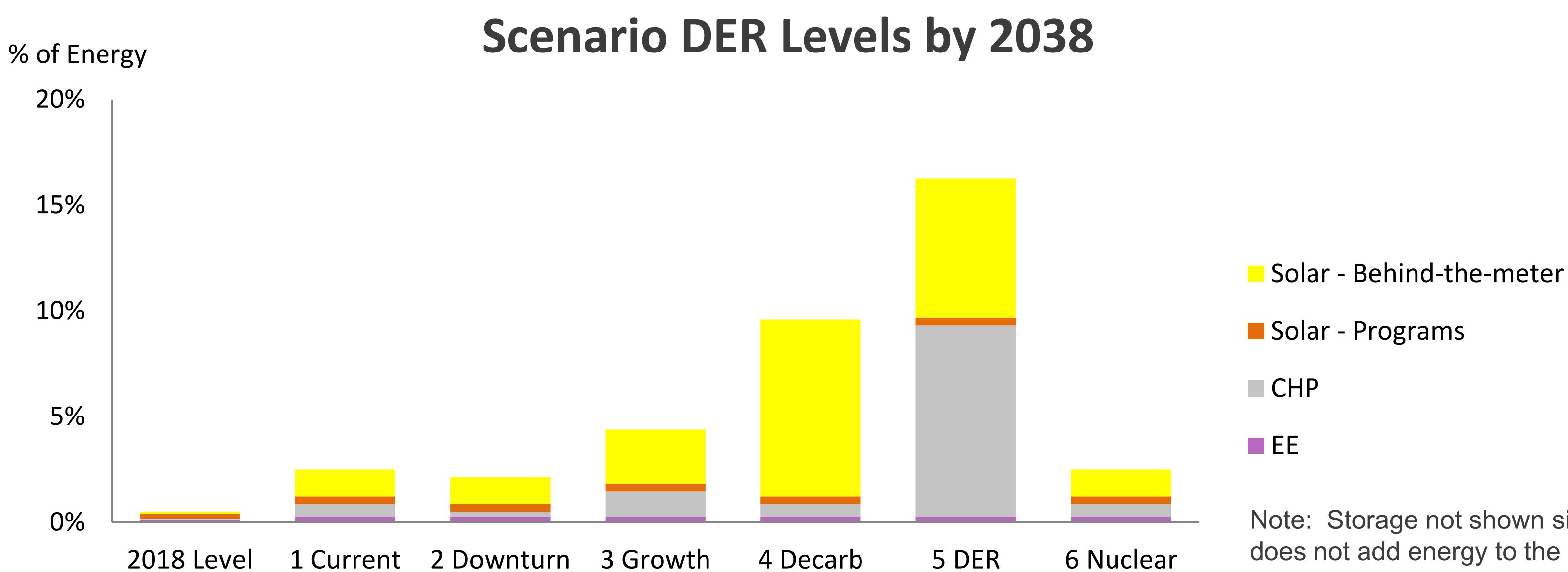
Scenario Renewable Levels

Each scenario has unique assumptions for renewable penetration prior to portfolio optimization for each strategy, which targets reserve margins and applies a strategy at the least cost.



Scenario DER Levels

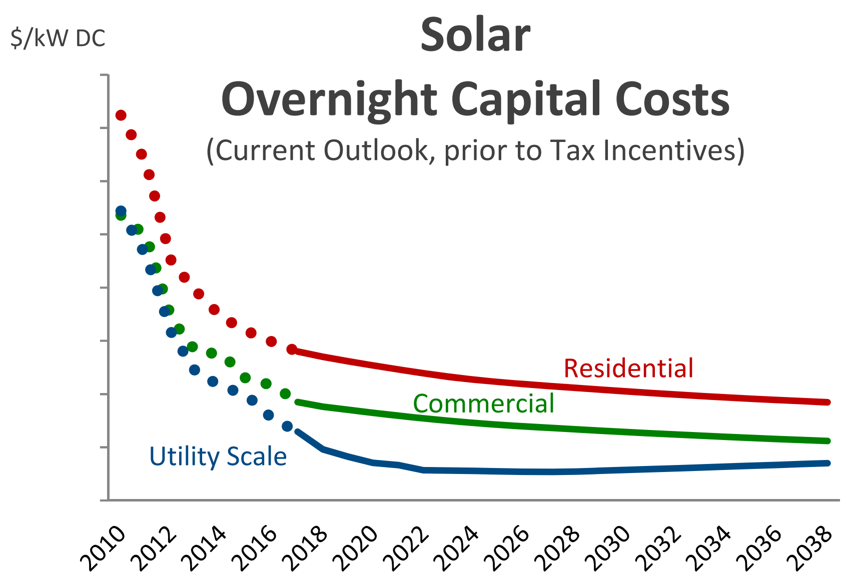
Each scenario has unique assumptions for DER penetration prior to portfolio optimization for each strategy, which targets reserve margins and applies a strategy at the least cost.

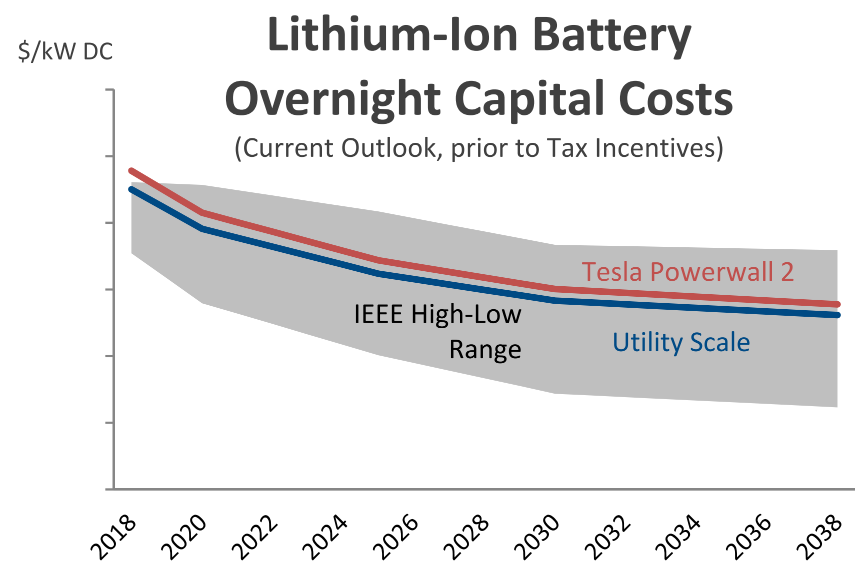


Note: Storage not shown since it does not add energy to the system.

Escalation Assumptions Can Vary by Scenario

While most resource costs escalate with inflation, costs for resources still rapidly evolving may escalate differently. Escalation rates can vary by scenario, driven by assumptions around tax policy and pace of technology advancement. Resulting impacts on payback can shift the adoption curve.





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

  Annual caps for resource additions and retirements are used in planning to reflect practical considerations of managing major projects and changing resource mix.

- Planning Horizon Cap

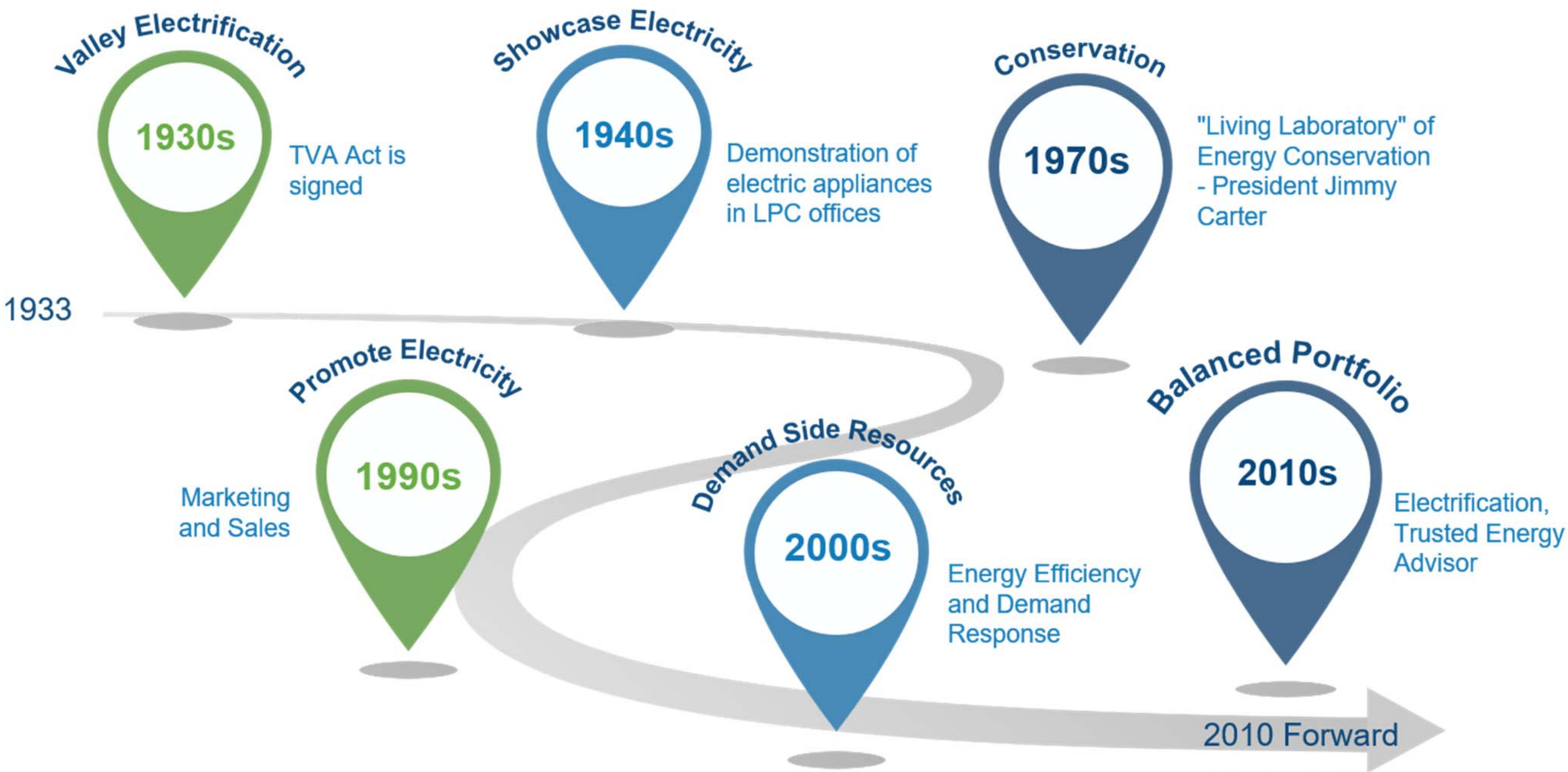
  Planning horizon additions for each type of distributed generation will be capped at incremental economic potential over the base case, which may vary by scenario.

EE, DR & BE Overview and Program Design

Cindy Herron
Kyle Lawson
TVA Energy Right Solutions Group

History & Current State

TVA Energy Program History – A Long View



EE Programs – Recent History

Our Approach

From 2013 -2017, due to projected load growth, we sought to utilize energy efficiency as a system resource to position Local Power Companies (LPCs) and TVA as trusted energy advisors through support to consumers to install energy efficient upgrades that increase comfort and reduce costs.

- Energy audits and advice
- Incentives below system cost
- Access to financing

EE Programs – Current State

Context

- Flat to declining load
- Naturally occurring energy efficiency (i.e., DOE standards)
- LPC and TVA efforts helped spur market transformation
- Changing consumer expectations

This Year

- Discontinued incentives
- Launched six residential limited-income pilots
- Repositioned and streamlined programs to better support LPCs as the Trusted Energy Advisor

Going Forward

- Maximize economies of scale, platform capabilities and other funding sources to engage customers and provide better products at lower costs
- Support Energy Efficiency via education, advice and focus on limited-income consumers

DR Programs – Recent History

Our Approach

Utilize demand response as a zero emissions resource that shapes the load, lowers system costs, increases reliability and improves power quality. These programs facilitate low rates and help Valley businesses and industries.

DR Programs – Current State

Interruptible Power	Peak Power Partners	EPA Voltage Optimization
TVA contracts with participating LPC customers and directly served customers to suspend a portion of their load, upon 5 or 30 minutes notice, during time of power system need	TVA-managed program to provide economic load reduction through aggregators	Enables LPCs to operate distribution feeder voltages in the lower half of the ANSI standard voltage range to lower peak demand

BE Programs – Current State

Our Approach

Promote adoption of smart energy technologies with a favorable load shape, which decrease CO_2 emissions and increase profitability for Valley businesses. Results in lower rates for all consumers and a positive return for LPCs and TVA.

Program Options in the IRP

EE, DR and BE IRP Programs Modeled in Tiers

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

Tier 1

- DR and BE incentives aligned to base case
- EE primarily education focused

Tier 2

- EE incentivized
- BE incentives increased
- Moderately higher adoption

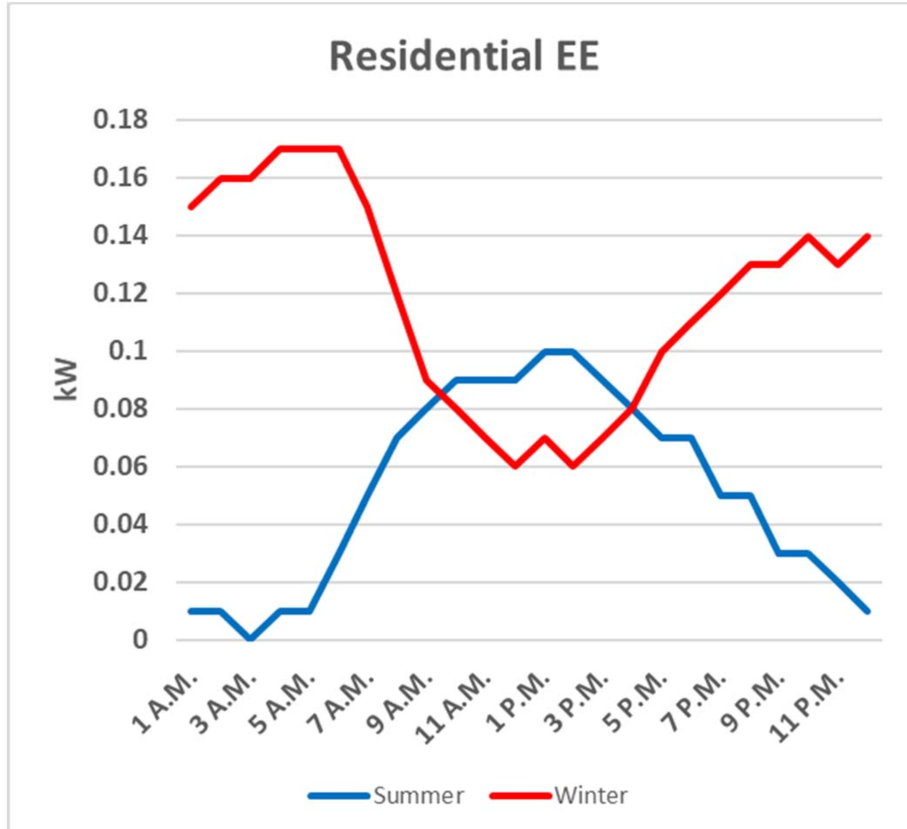
Tier 3

- High incentives
- Higher adoption

2019 IRP Programs – Residential EE

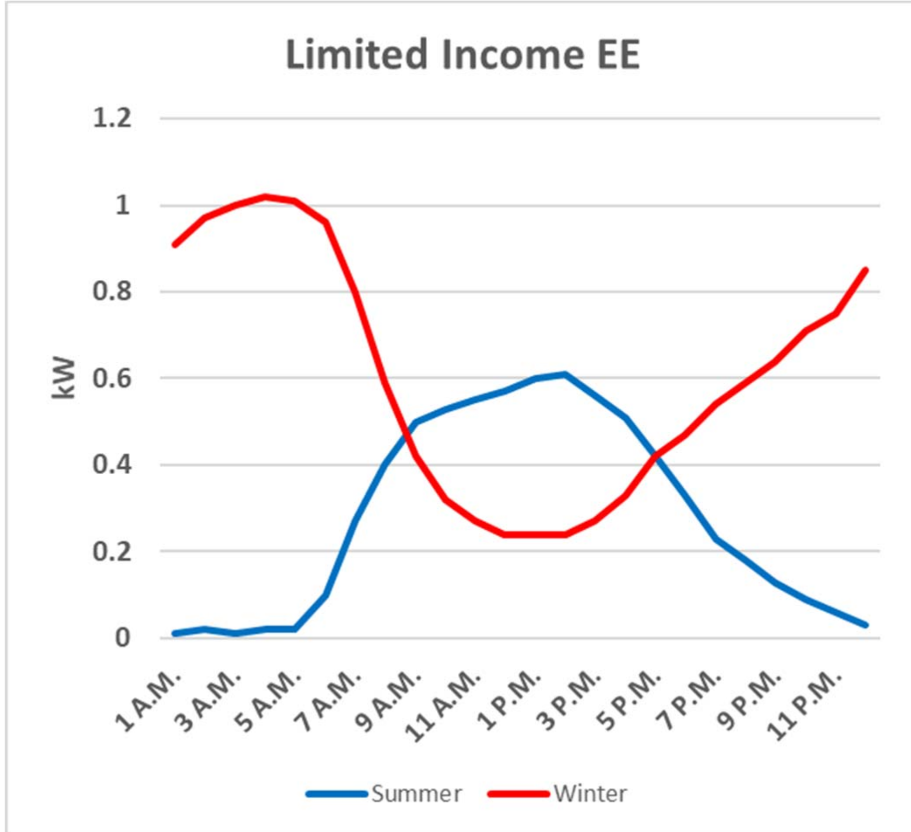
- Tier 1 focuses on consumer education
- Tiers 2 and 3 include incentives
- Tier 2 volume and cost mirrors past program offerings
- Tier 3 includes more aggressive offerings

Residential EE			
	Tier 1	Tier 2	Tier 3
Max Incremental Installs/Yr	22,600	65,000	105,000
Avg/Unit Cost	$381	$318	$564
Total Cost	$8,600,000	$20,700,000	$59,200,000



2019 IRP Programs – Limited Income EE

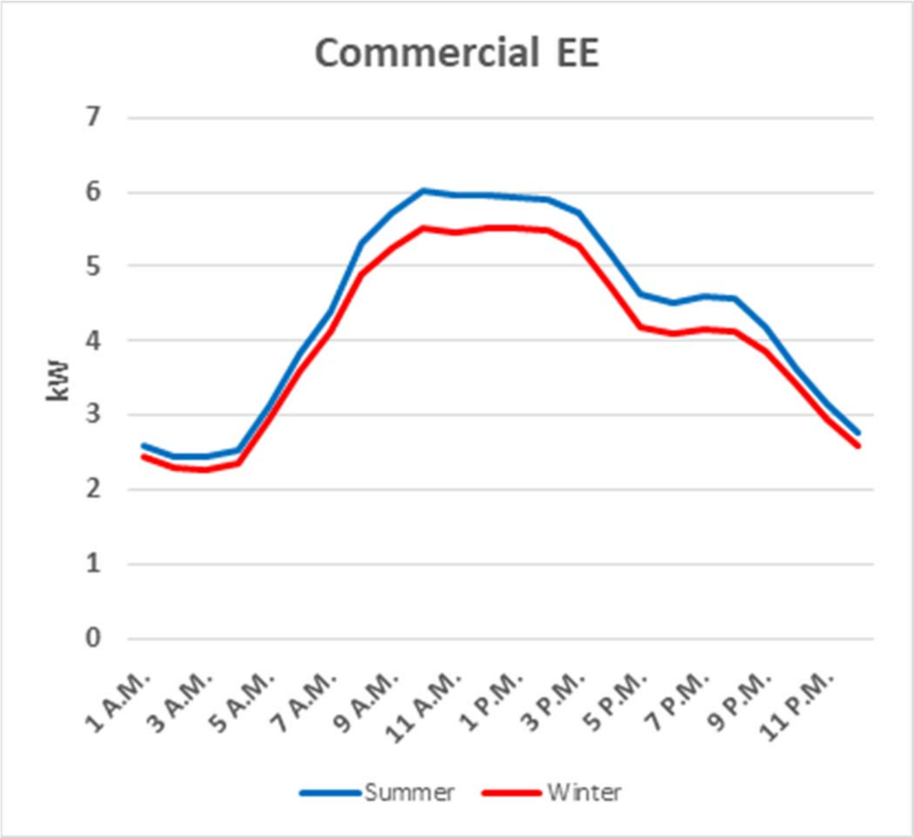
- Tier 1 includes infrastructure support for partner agencies
- Tiers 2 and 3 include TVA matching funds from partners



Limited Income EE			
	Tier 1	Tier 2	Tier 3
Max Incremental Installs/Yr	600	3,000	5,600
Avg/Unit Cost	$2,333	$3,800	$5,054
Total Cost	$1,400,000	$11,400,000	$28,300,000

2019 IRP Programs – Commercial EE

- Tier 1 focuses on Strategic Energy Management (SEM)
- Tiers 2 and 3 include incentives

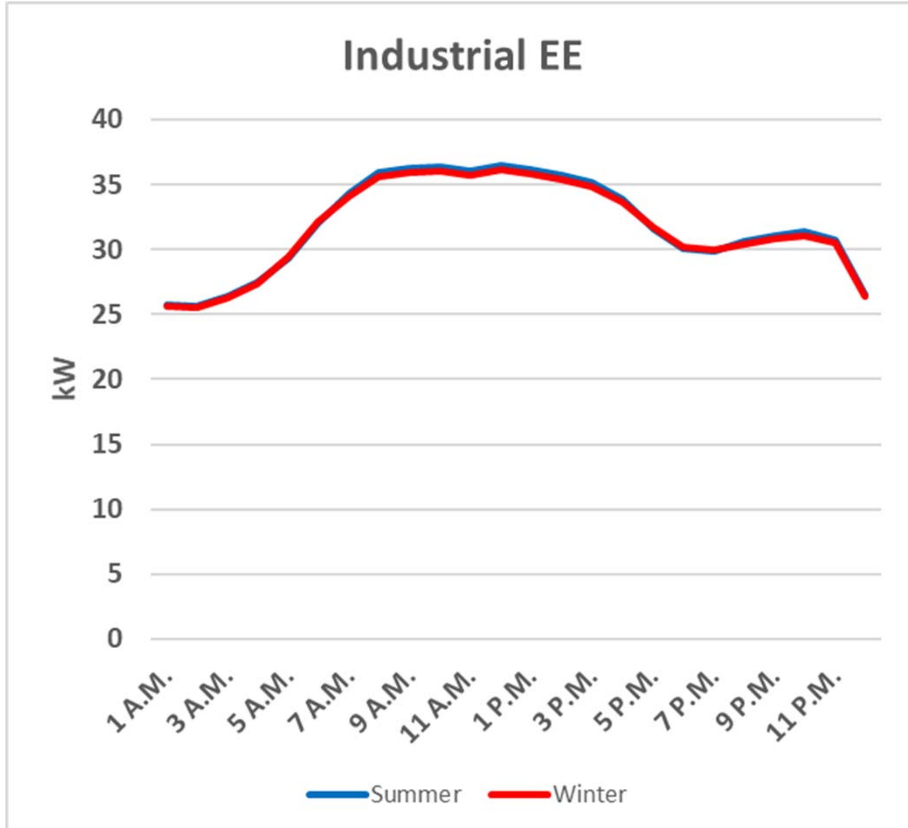


Commercial EE			
	Tier 1	Tier 2	Tier 3
Max Incremental GWh/Yr	3	150	350
Avg/Unit Cost	$140,000	$114,667	$152,000
Total Cost	$350,000	$17,200,000	$53,200,000

2019 IRP Programs – Industrial EE

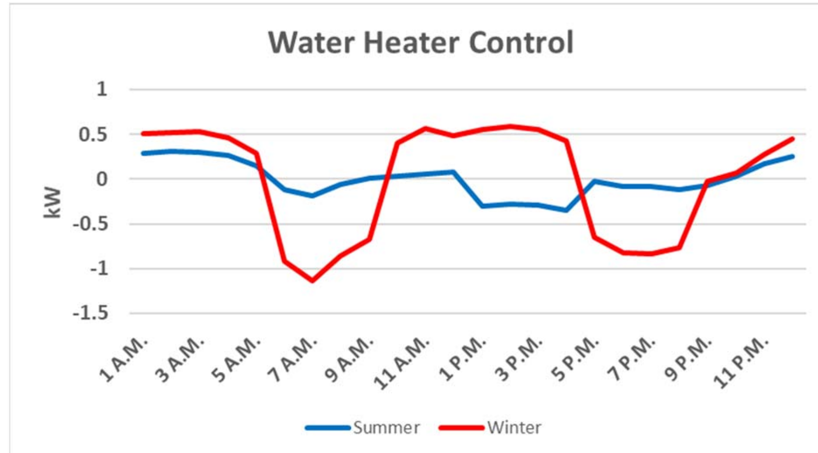
- Tier 1 focuses on SEM
- Tiers 2 and 3 include incentives

Industrial EE			
	Tier 1	Tier 2	Tier 3
Max Incremental GWh/Yr	5	125	370
Avg/Unit Cost	$70,000	$84,800	$140,541
Total Cost	$350,000	$10,600,000	$52,000,000

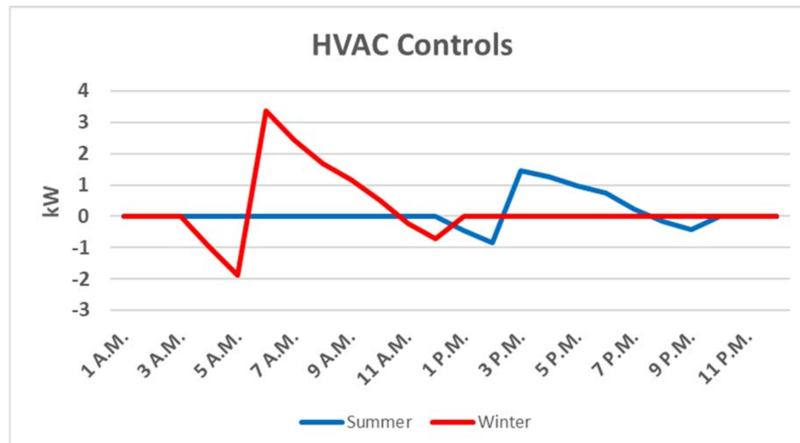


2019 IRP Programs – Residential DR

- Hypothetical water heater control program modeled (top graph)
- Hypothetical HVAC control program included as a selectable option (lower graph)



Residential DR		
	Water Heater	HVAC Controls
Max Cumulative Installations	100,000	400,000
Annual Incentive Cost/Unit	$50	$60
Upfront Equipment Cost/Unit	$120	$45
Annual Incentive Cost	$5,000,000	$24,000,000

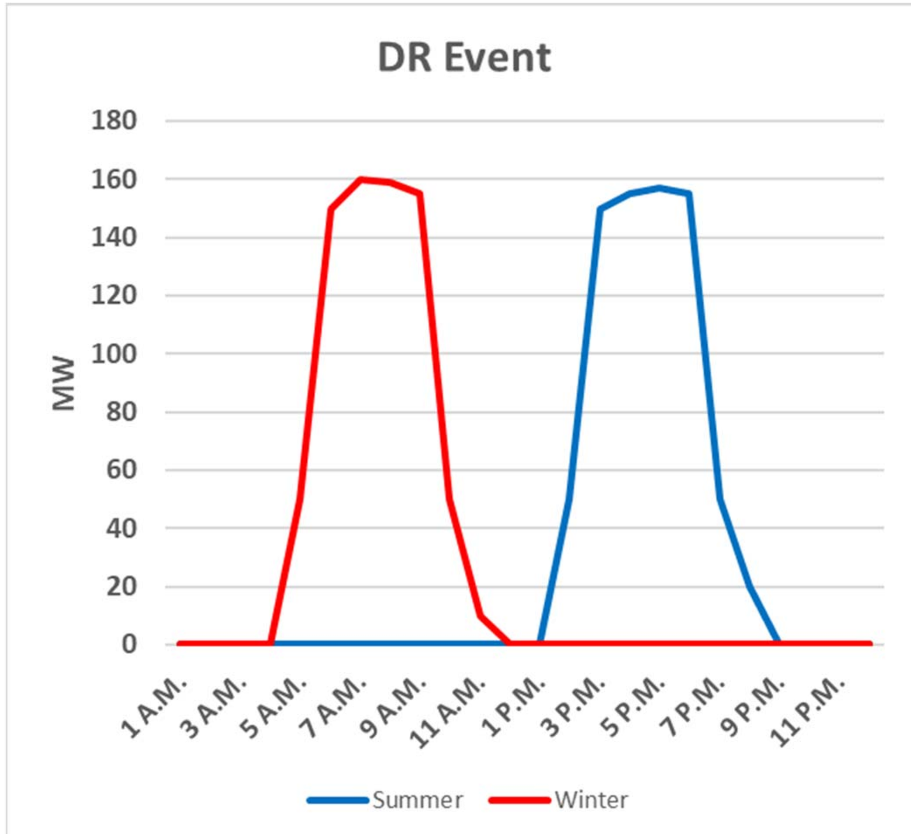


2019 IRP Programs – C&I DR

- Aggregated commercial DR offering via Peak Power Partners
- Shape illustrates generic C&I DR event performance

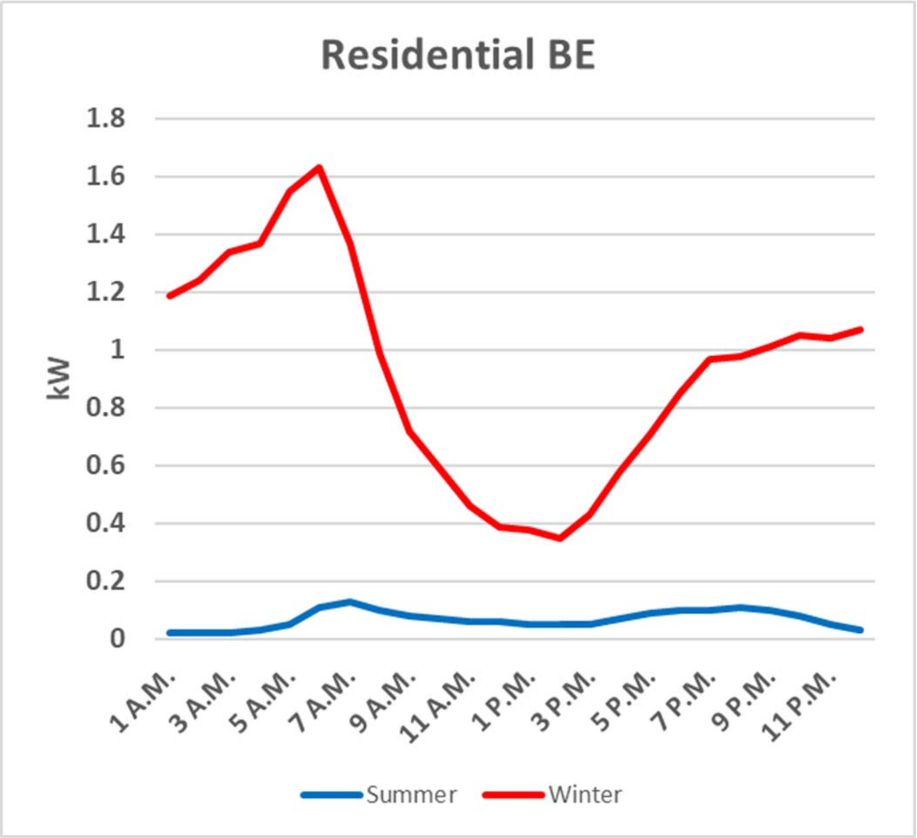
Peak Power Partners			
	Tier 1	Tier 2	Tier 3
MW	96	215	325
Hours	58	58	58
Incentive ($kW/Month)	$4.35	$5.22	$6.26
Budget	$9,700,000	$25,700,000	$46,300,000

Interruptible Power			
	Tier 1	Tier 2	Tier 3
MW	1000	1295	1700
Hours (Economic Only)	12	12	12
Incentive ($kW/Month)	$4.33	$5.70	$6.84
Budget	$52,000,000	$88,600,000	$139,600,000



2019 IRP Programs – Residential BE

- Similar approach to EE and DR in that tiered approach employed
- Focus on retrofit and new construction markets

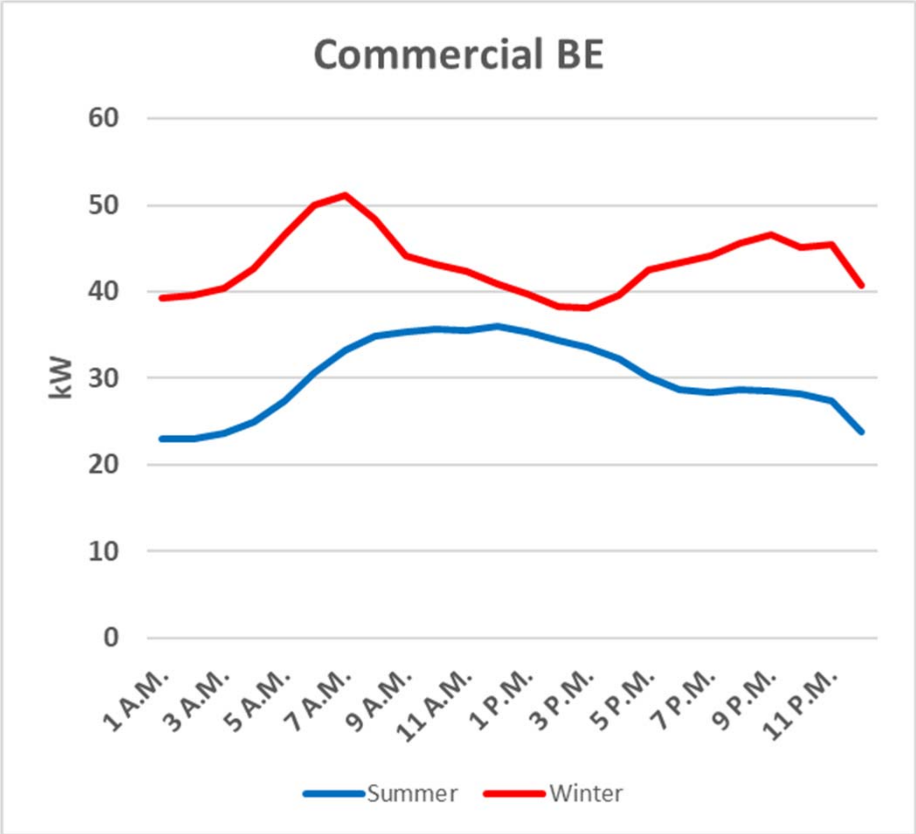


Residential BE			
	Tier 1	Tier 2	Tier 3
Max Incremental Installs/Yr	6,400	11,550	17,4000
Avg/Unit Cost	$1,001	$1,033	$1,139
Total Cost	$6,408,000	$11,928,928	$19,826,000

2019 IRP Programs – Commercial BE

- Programs focus on diverse technology offerings to help shape load
- Tier 1 incentives mirror current programs
- Tiers 2 and 3 increase incentives

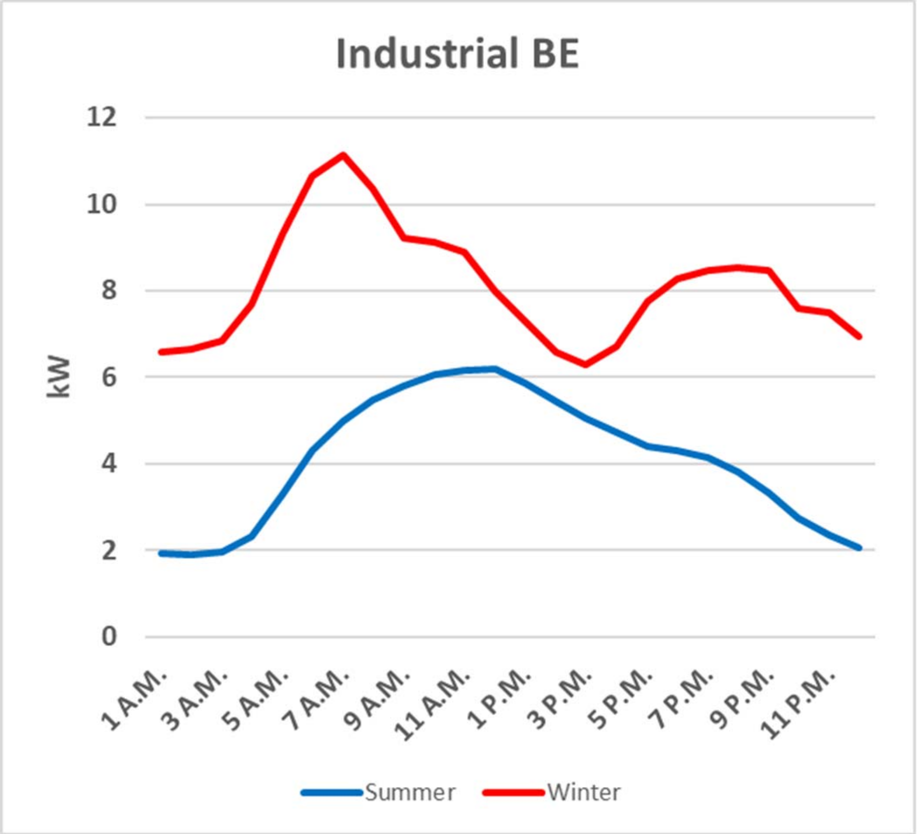
Commercial BE			
	Tier 1	Tier 2	Tier 3
Max Incremental GWh/Yr	80	150	200
Avg/Unit Cost	$142,500	$162,000	$183,000
Total Cost	$11,400,000	$24,300,000	$36,600,000



2019 IRP Programs – Industrial BE

- Programs focus on diverse technology offerings to help shape load
- Tier 1 incentives mirror current programs
- Tiers 2 and 3 increase incentives

Industrial BE			
	Tier 1	Tier 2	Tier 3
Max Incremental GWh/Yr	80	150	200
Avg/Unit Cost	$142,500	$162,000	$183,000
Total Cost	$11,400,000	$24,300,000	$36,600,000



Distributed Generation Overview and Strategy Design

Lucy Wansley and Laura Duncan
TVA Business Development & Renewables Group
Scott Jones
TVA Resource Strategy Group

History & Current State

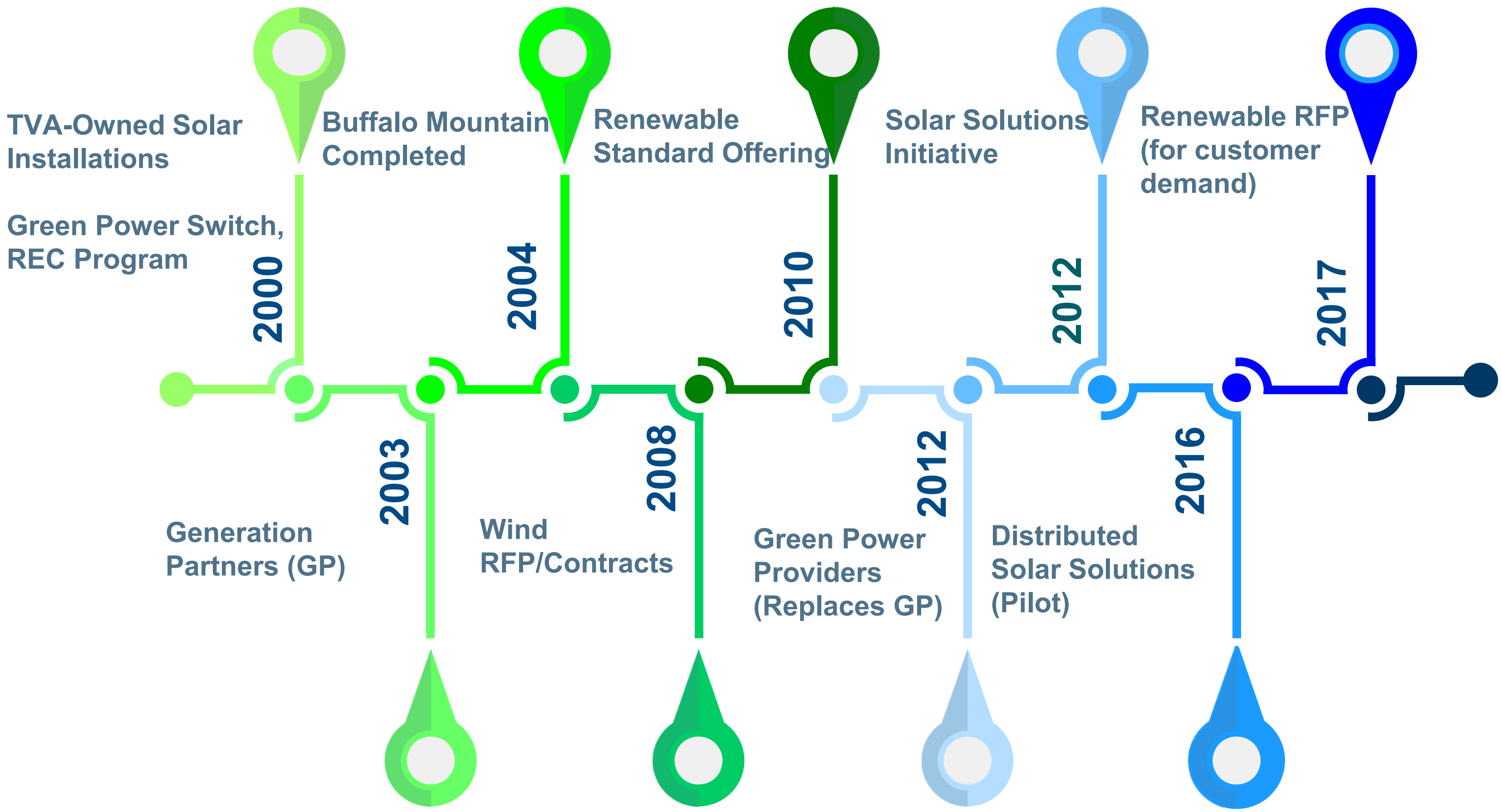
Built on Renewables

1933 – Hydropower (conventional hydro)

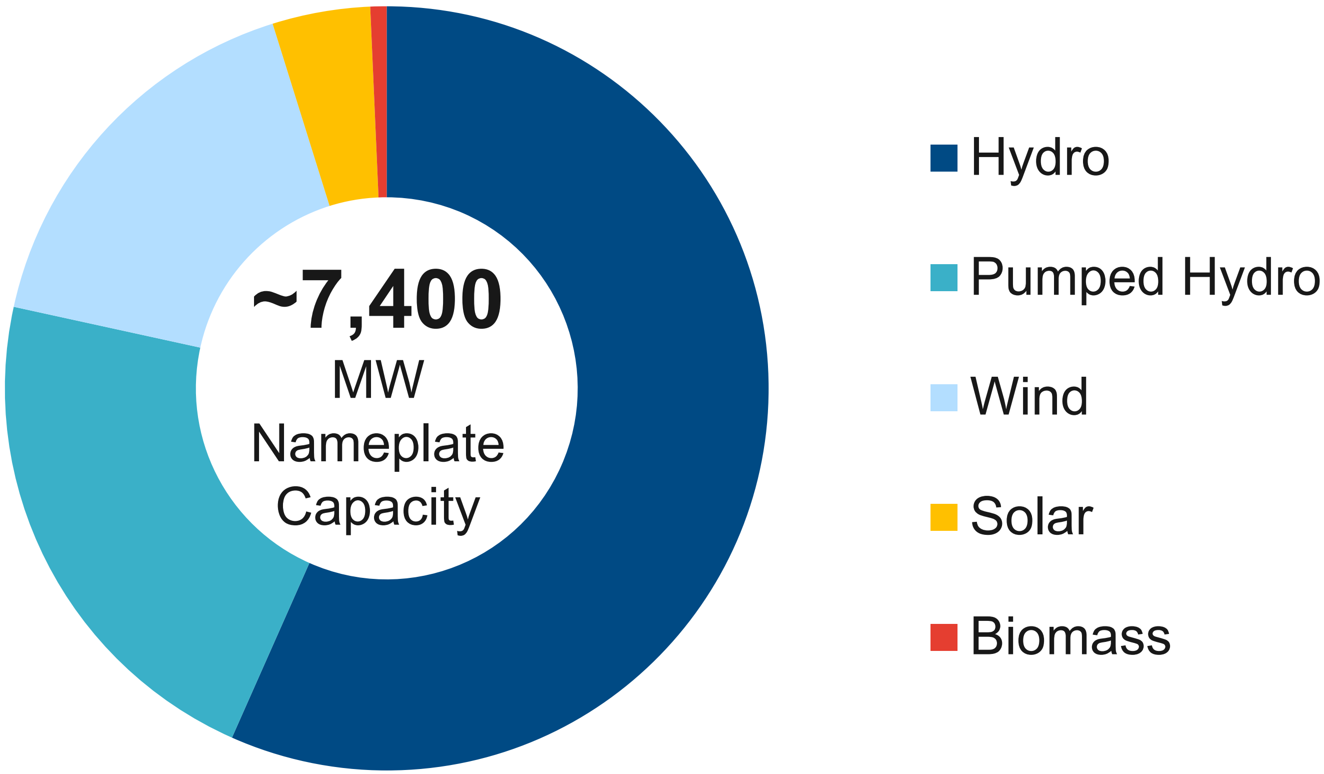
1978 – Raccoon Mountain Pumped Storage

1981- Dispersed Power Program (DPP)

Valley Renewable Energy History



TVA's Renewable Portfolio



Over the next 20 years, TVA has committed to
invest about $8 billion to support our renewable energy portfolio.

Market Drivers and Options

National Market Demand for Renewables

Commercial & Industrial Renewable Energy Goals

RE 100

- Committed to 100% renewable electricity
- 145 companies to date

Stated Renewable Energy Goals

- Publicly stated renewable energy goals, but not RE100 commitment

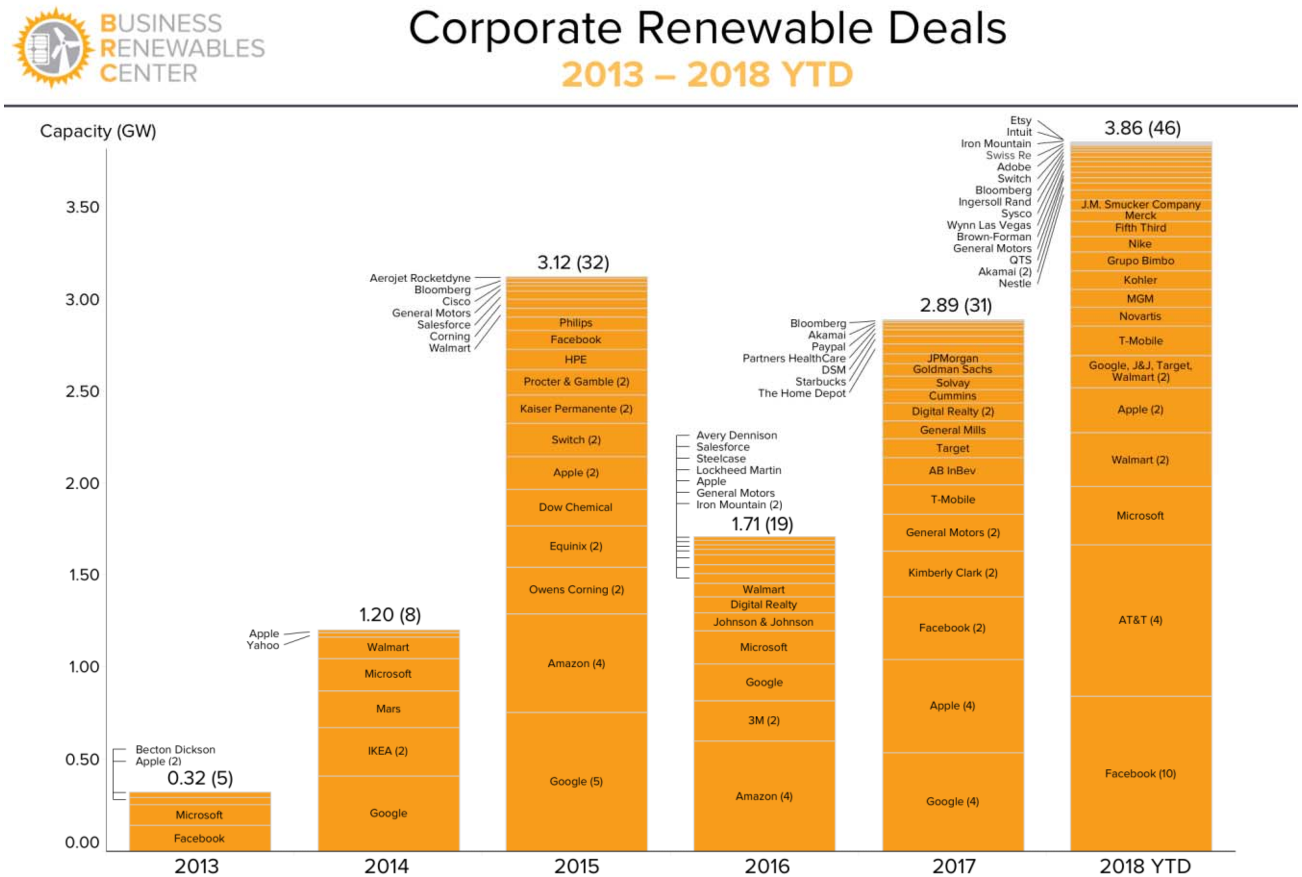
Business Renewables Center

- Committed to accelerating procurement of wind and utility-scale solar energy
- 260 members

REBA

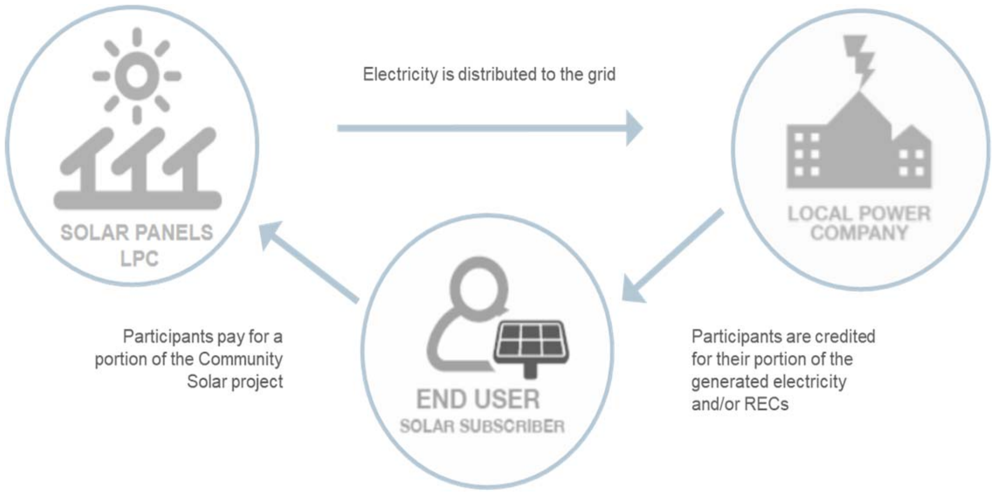
- Goal of growing corporate demand for renewables
- 58 signatures to date

Commercial and Industrial Demand



As of August 6, 2018. Publicly announced contracted capacity of corporate Power Purchase Agreements, Green Power Purchases, Green Tariffs, and Outright Project Ownership in the US, 2013 – 2018 YTD. Excludes on-site generation (e.g., rooftop solar PV) and deals with operating plants. (#) indicates number of deals each year by individual companies.

Community Solar



Participants voluntarily pay for a portion of the Community Solar Pojrect and receive a **credit** on the electricity bill and/or the **RECs** for their portion(s) of the array

Why Community Solar?

- Satisfy customer demand and build relationships with customers
- Provide community alternative to rooftop solar
- Opportunity to build and support local projects
- Environmental benefits and sustainability goals

Residential and Small Business Market

- Rebates and incentives are being phased out as installed costs continue to decrease significantly
- Majority of those who are interested have already installed systems
- Valley Payback averages 17 years due to low cost energy in the Valley
- Shift to community solar as a quicker, easier, more affordable option, especially for those who are unable to put solar on their home or business

Adoption Curves in the IRP

DG and Storage Adoption Curves Developed

Base level of resource adoption aligns to the Base Case, reflecting business as usual. Moderate and high levels of adoption are based on impact of incentives on economic potential and payback.

No Additional Incentive
Incentive aligned to base case

Base Level Adoption

Moderate Incentive
Up to 50% of marginal cost

Moderate Adoption

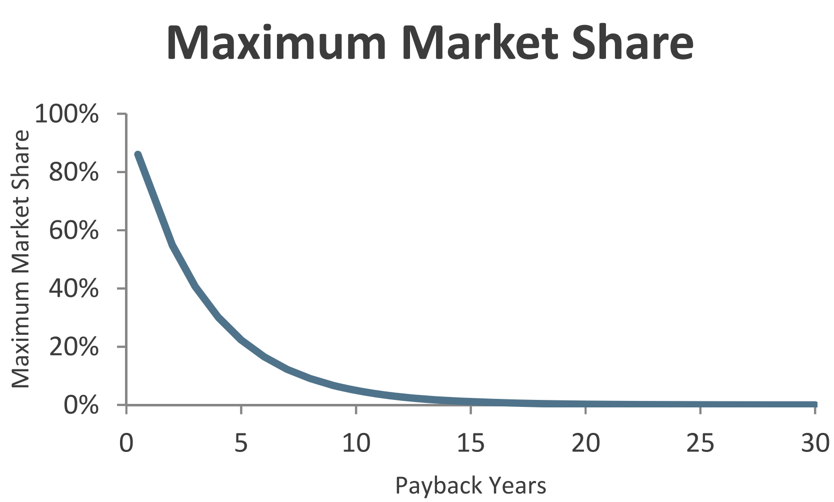
High Incentive
Up to 100% of marginal cost

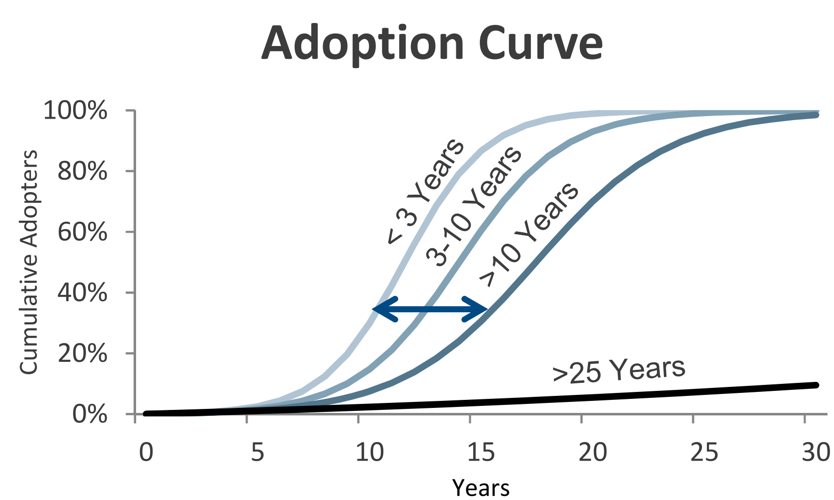
High Adoption

Adoption Curve Approach

Adoption curves were developed using an approach similar to NREL's Distributed Market Demand Model, a market-penetration model that simulates the potential adoption of distributed solar, which changes with payback period.

Payback Drivers → Payback Period → Max Market Share → Adoption Curve

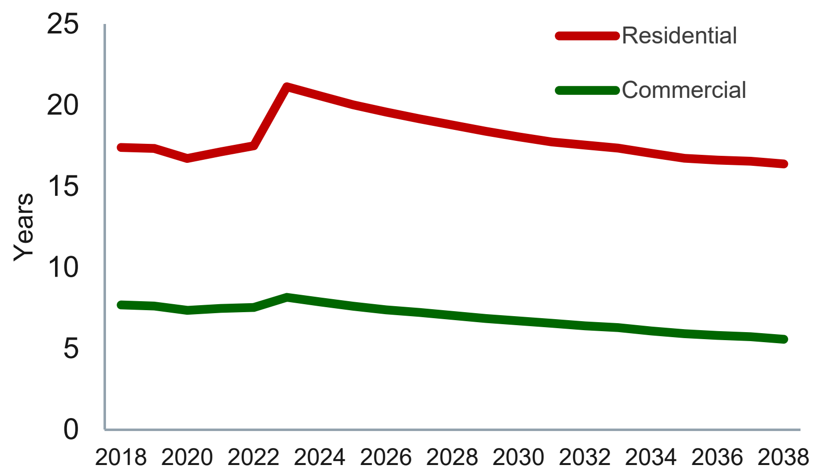




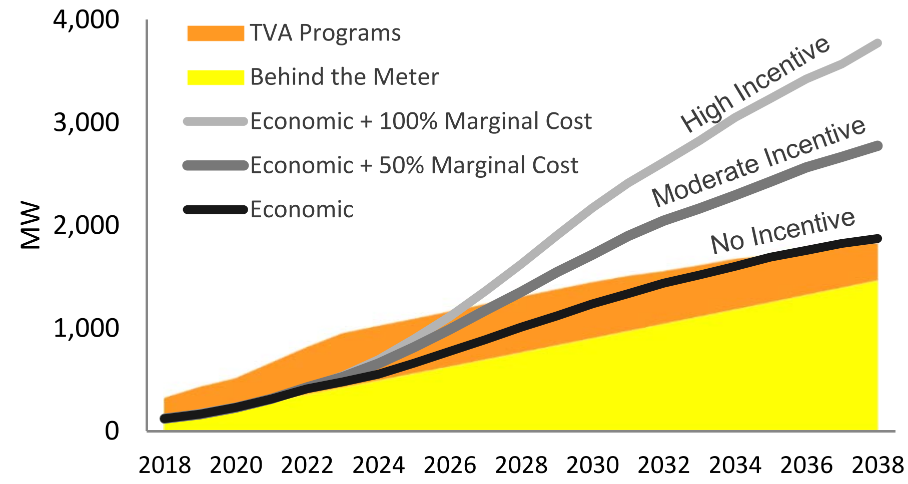
Adoption Levels – Distributed Solar

Base, moderate and high levels of adoption for Distributed Solar have been modeled for the Current Outlook. Levels can vary based on scenario assumptions around tax policy and technology advancement.

Payback Years

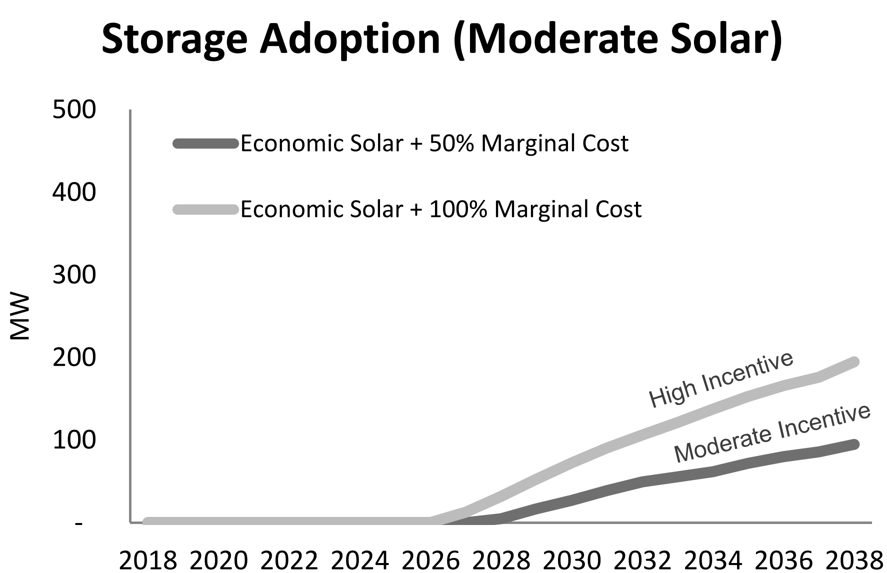


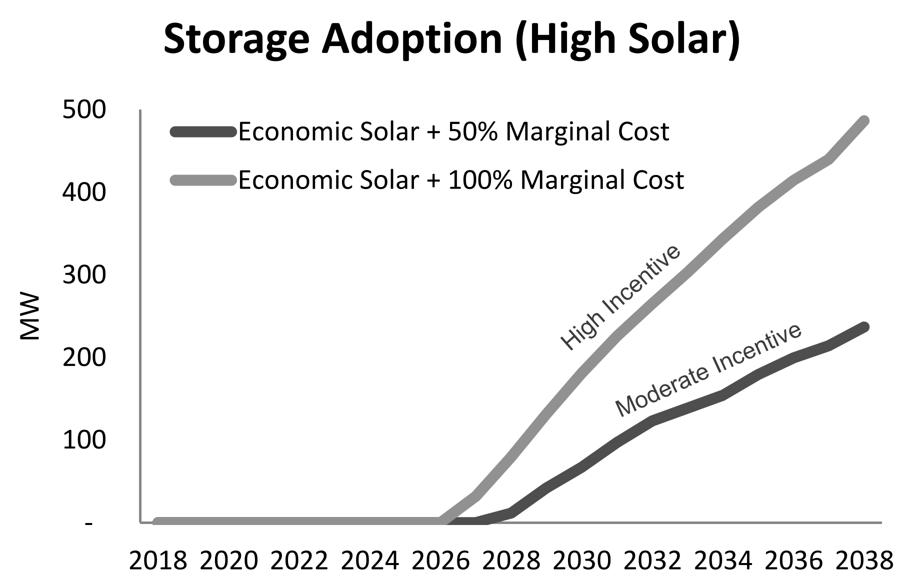
Distributed Solar Adoption



Adoption Levels – Storage (Utility & Distributed)

Incremental adoption levels for Storage have been modeled as a function of Solar, with moderate at 10% and high at 25% of Solar. Levels can vary based on scenario assumptions around tax policy and technology advancement.

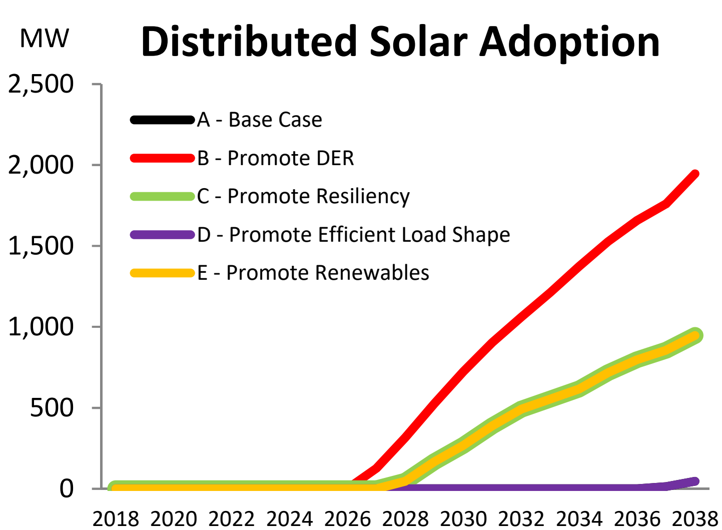


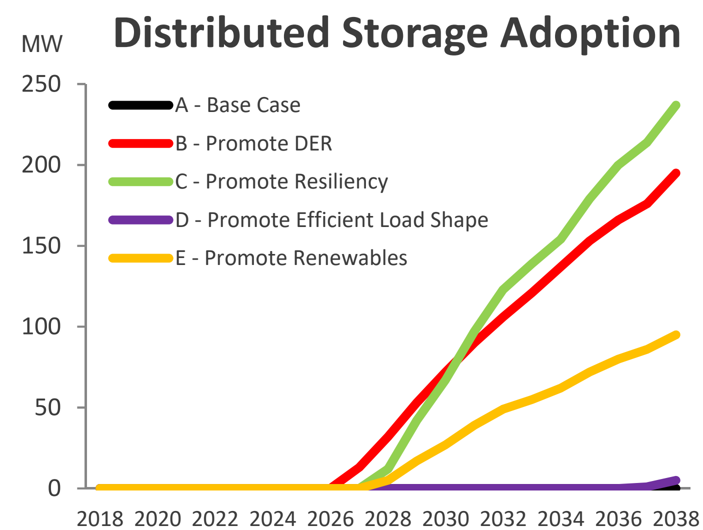


Adoption Levels – Distributed Solar & Storage by Strategy in the Current Outlook

Distributed Solar & Storage incremental adoption by strategy for the Current Outlook is shown, with Storage at 10% (moderate) or 25% (high) of Solar. Levels can vary based on scenario assumptions around tax policy and technology advancement.

Strategy	Distributed Solar	Distributed Storage
Base Plan	Base	Base
Promote DER	High	Moderate
Promote Resiliency	Moderate	High
Promote Efficient Load Shape	Base	Moderate
Promote Renewables	Moderate	Moderate

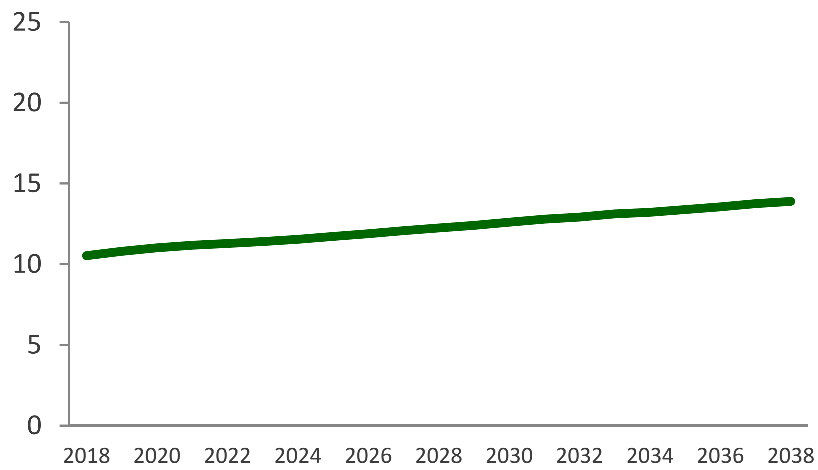




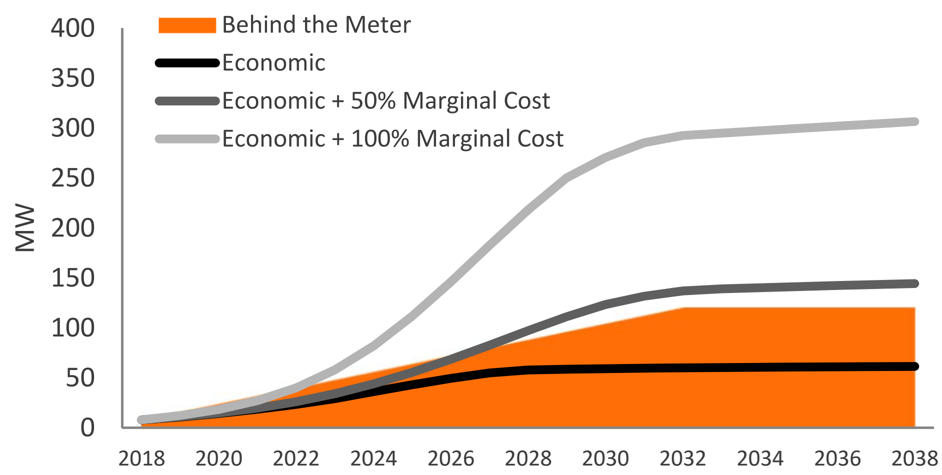
Adoption Levels – Combined Heat & Power

Base, moderate and high levels of adoption for Combined Heat & Power have been modeled for the Current Outlook. Levels can vary based on scenario assumptions around tax policy and natural gas prices.

Payback Years



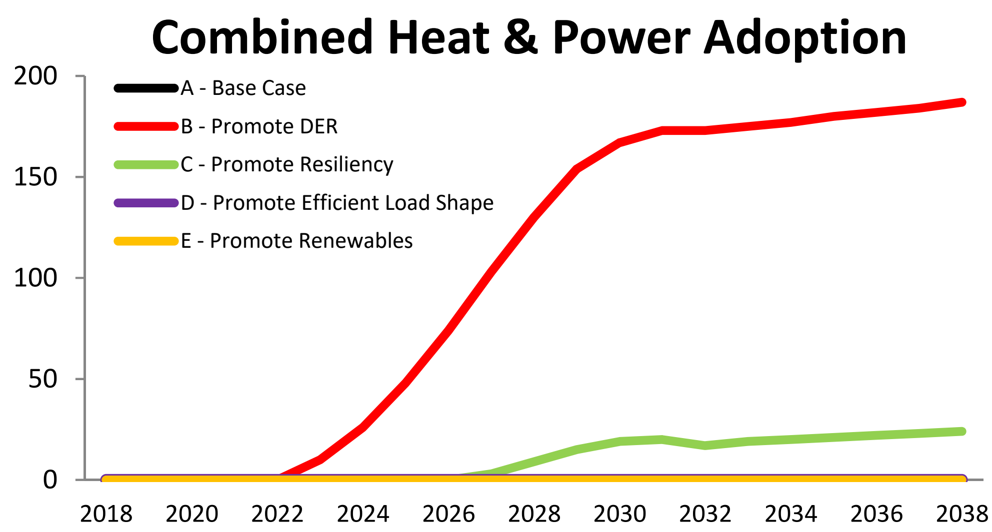
Combined Heat & Power Adoption



Adoption Levels – Combined Heat & Power by Strategy in the Current Outlook

Combined Heat & Power incremental adoption by strategy for the Current Outlook is shown below. Levels can vary based on scenario assumptions around tax policy and natural gas prices.

Strategy	Combined Heat & Power
Base Plan	Base
Promote DER	High
Promote Resiliency	Moderate
Promote Efficient Load Shape	Base
Promote Renewables	Base



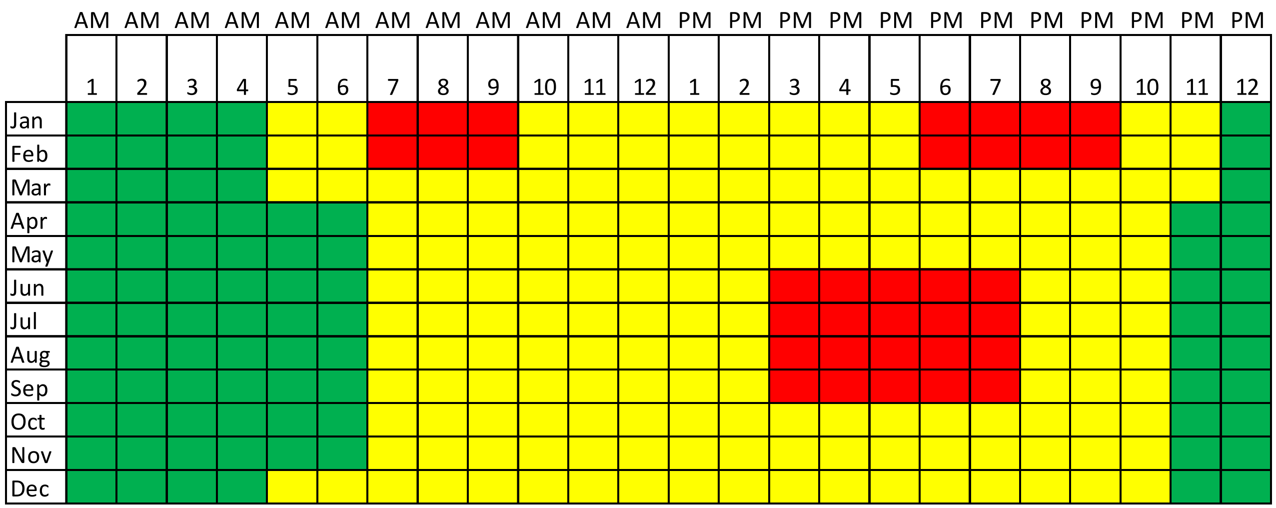
Promoting Efficient EV & Battery Charging

We will model a time-of-use rate structure that would incent owners of electric vehicles and batteries to economically optimize the hours of use and provide TVA with a load shape with a lower cost to serve.

Percent of Hours	Rate cents/kWh	
8%	20.3	On-peak (weekdays only)
62%	6.6	Off-peak
30%	1.4	Super Off-peak

TVA Plug-in Electric Rate Hours

Hour-ending



Note: Modeled approach is similar to Georgia Power Plug-in Electric program.

Group Breakout – Strategy Design

Group Discussion Question:

What are your final comments or questions regarding Strategy design?

Final Strategy Design Recap

Jane Elliott, Senior Manager
TVA Resource Strategy Group

Strategy Design – Recap of Today's Discussion

- Review of strategies and adoption curve considerations
- Final strategy design recommendation
- Approach for promoting resources
- EE, DR and BE background and program offerings
- DG & Storage background and adoption levels
- IRPWG final comments and questions

Modeling Next Steps

- Finalize Base Case for review at October IRPWG meeting
- Run optimization for all other portfolio combinations
- Complete scorecards for all strategies
- Review overall results and preliminary recommendation at December IRPWG meeting

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
Huntsville, Alabama

#9 December 12/13 or 19/20, 2018 (updated)
Chattanooga or Knoxville, Tennessee (updated location)

#10 Jan 30-31, 2019
West Tennessee / North Mississippi (updated location)

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