2019 IRP Working Group

Meeting 3: April 26, 2018


welcome

Safety Moment

Building Emergency Plan

Agenda

8:30	Welcome	Jo Anne Lavender
8:35	Recap of Meeting 2	Brian Child
8:50	2019 IRP Scoping Summary	Ashley Pilakowski
9:20	Examination of Peer Utilities' IRPs – Uncertainties and Scenarios	Randy McAdams
9:50	BREAK	
10:05	Uncertainties & Scenarios: Feedback and Additional Group Discussion	Hunter Hydas / Jo Anne Lavender and Group
12:00	Lunch	
1:00	Discuss Comments	Hunter Hydas and Group
1:30	Finalize List of Scenarios	Jo Anne Lavender & Brian Child
2:45	BREAK	
3:00	Overview of Attributes & Strategies	Brian Child
3:30	Next Steps	Jo Anne Lavender
3:45	River Forecasting Center Tour	James Everett
4:30	Adjourn	

IRPWG Meeting 2 Recap

Brian Child

March 29, 2018 Meeting Highlights

- Distributed Energy Resources Overview
- Current Forecasts – Load, Economics & Commodities
- Uncertainties & Scenarios
  - Introduction
  - Working Group brainstorm & feedback
  - Possible 2019 IRP scenarios
- Tour of System Operations Center and Commercial Operations Center (trading floor)

2019 IRP Focus Areas

- Distributed Energy Resources
- System flexibility
- Portfolio diversity

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

February 28th	March 29th	April 26th	June 7th	July 12th
• IRPWG orientation • General overview of process	• Overview of scenario design process • Review uncertainties, current forecasts, and brainstorm/review scenarios • IRPWG feedback	• Discuss IRPWG feedback • Discuss proposed scenarios • Develop short list of scenarios for voting • Overview of strategy design process	• Finalize scenarios • Review attributes and brainstorm/review strategies • Discuss proposed strategies and develop short list • Introduce resource options	• Finalize strategies • Planning assumptions • Modeling constraints

Vote on scenarios

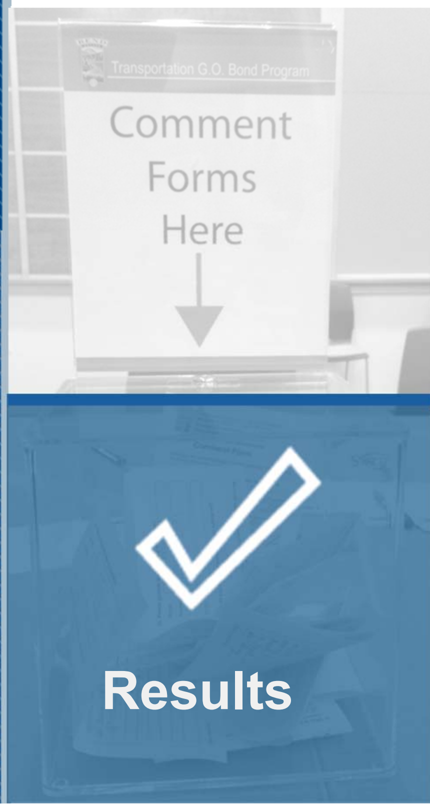
Vote on strategies

2019 Integrated Resource Plan Scoping Summary

Ashley Pilakowski

The Purpose of Public Scoping

Scoping is process to define how the IRP study will be done with help from the general public, TVA customers, organizations and agencies.



Topics included:

- An overview of the IRP Process
    - TVA's methodology for resource planning
    - Why resource planning is important
    - Rationale for 2019 IRP
    - How IRP results will be used
- Schedule for 2019 IRP study
- Overview of the environmental impact assessment method

Results are used to define:

- The sources TVA will use to generate power
- How TVA will manage the demand for power
- How conditions in the TVA territory could change during the planning period
- The important environmental topics to be evaluated

Scoping Questions

How do you think **energy usage** will **change** in the next 20 years in the Tennessee Valley Region?

Should the **diversity** of the current power **generation mix** (e.g., coal, nuclear, power, natural gas, hydro, renewable resources) **change**? If so, how?

How should **Distributed Energy Resources** (DER) be considered in TVA planning?

How should **energy efficiency and demand response** be considered in planning for **future energy needs?**

And how can TVA **directly affect electricity usage** by consumers?

How will the resource decisions discussed above affect the **reliability, dispatchability** (ability to turn on or off energy resources) and **cost of electricity**?

2019 IRP Public Scoping: Effort and Responses

Efforts

Scoping period: 2/15/2018 to 04/16/2018

7 media outlets received news releases throughout TVA region

2,500 scoping notices sent to people, agencies and organizations on 2019 IRP mailing list

Webinar held:	**Scoping meeting:**	**Scoping meeting:**
2/21/2018 Link	2/27/2018 Chattanooga, TN	3/5/2018 Memphis, TN

Responses

Comments from

- 7 Valley states (40% from TN)
- 9 other states
- Several undisclosed

Commenters self-ID:

- 28 business,
- 30 self/ individual,
- 4 government agencies
- 2 educational institution,
- 23 civic or other organizations

120
attendees

87
Scoping comment received

Major themes

Encouragement of clean energy initiatives, renewable energy, R&D on DERs

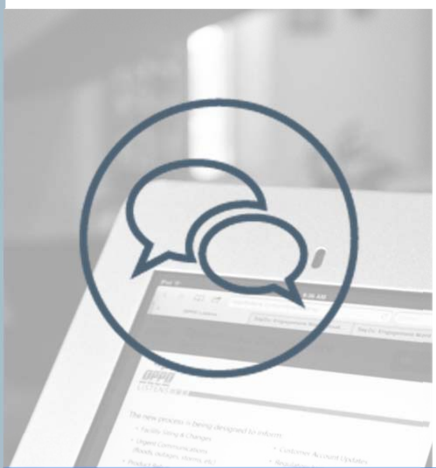
Call for special attention to environmental justice/ affected environment analyses on impacts to limited income households

General interest in energy efficiency measures and energy storage alternatives

General input on modeling, metrics/ calculations and evaluation criteria

General comments on fuel diversification options

Scoping Comments: IRP Assumptions & Method



Comments on the IRP analysis itself addressed the following themes:

- Climate change impacts & risks
- General scenario design goals
- Adequate evaluation of environmental costs for technologies and fuel types
- Treatment of rate impacts
- Inclusion of robust research on innovative renewable energy technologies & fuel options
- Recognition of macroeconomic and socioeconomic aspects of the strategies

Commenters raised questions considered outside the scope of the IRP, e.g.

- Operational and business planning topics such as beneficial reuse of fly ash from fossil plants
- Concerns and opposition related to the recent rate restructure.

IRP Planning

Allocations of funding	Renewable Energy	Scenarios	Strategies/ Alternatives

Energy Resources

Coal	Natural Gas	Nuclear	Renewable Energy

Energy Resources

Solar	Wind	Biomass
Energy Efficiency/ Demand Response	Distributed Energy Resources	Energy Storage

Environmental Impact Statement (EIS)

Wildlife/T&E Species	Land Use	Socioeconomics/ Environmental Justice	Water

Upcoming IRP Public Outreach

Spring 2018

FAQs posted on website

Monthly:
Social media updates

Quarterly webinar:
May 15, 2018

Summer 2018

Video about IRP process

Monthly:
Social media updates

Quarterly webinar:
Late Summer 2018

Fall/ Winter 2018

Monthly:
Social media updates

Quarterly webinar:
Winter 2018

Interactive Report of
Draft IRP

Draft EIS public comment period begins
Feb 2019

Spring 2019

Videos about portfolio options

Public meeting series

Launch of **online public meeting**

IRP fact sheet

Monthly:
Social media updates

Quarterly webinar:
Spring 2019

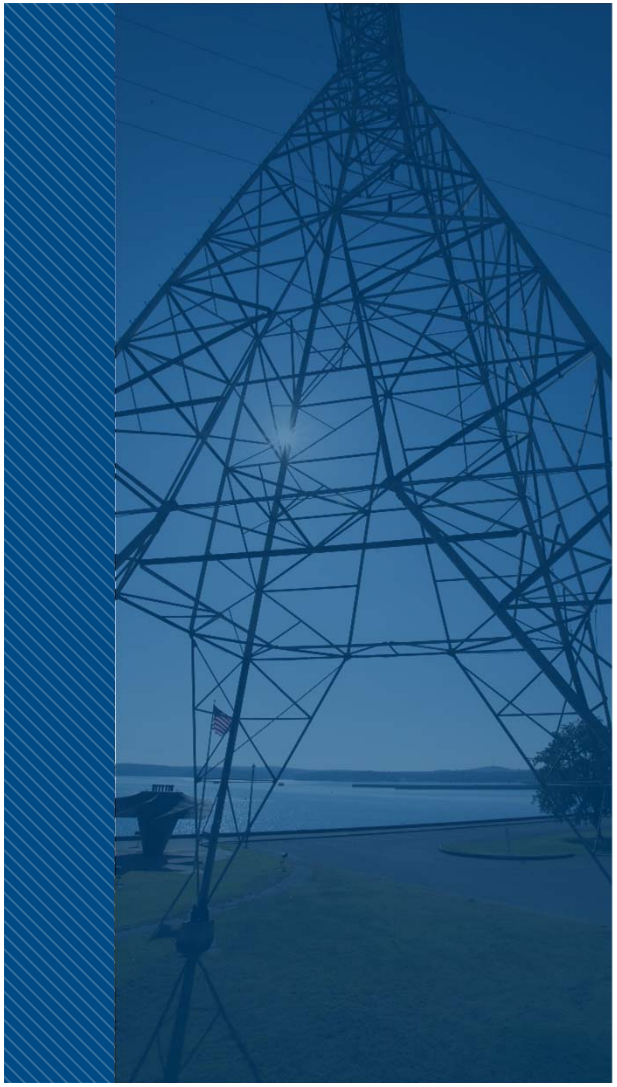
Summer 2019

Video of preferred portfolio

Interactive report of
Final IRP

Monthly:
Social media updates

Quarterly webinar:
Summer 2019



Next Steps

- TVA is compiling a report summarizing the scoping input.
- The scoping report will describe how TVA is responding to scoping input during the development of the IRP and the EIS.
- The scoping report will also describe scenarios, strategies, and energy resources being carried forward in the IRP and IRP EIS analysis.
- The scoping report is scheduled for posting to the IRP website in early July 2018.

Examination of Peer Utilities' Integrated Resource Plans

Use of Scenario Planning in IRP Development

April 2018

Overview of Peer Utility IRP Benchmarking

- Approach and Peer Utilities Examined
- IRP Development Process
- Summary of Scenario Planning Observations
- Comparison of Peer Uncertainties to TVA
- Comparison of Peer Scenarios to TVA
- Appendix – Scenario Approaches Employed by Peer Utilities




Overview of Peer Utility IRP Benchmarking

- ScottMadden examined IRPs most recently released by 10 peer utilities
- IRPs were examined for approaches, results, and themes
- Industry developments, including the evolving IRP process in California, were reviewed along with recent planning documents from SMUD and PG&E
- Today's Objectives: Share observations on use of scenario planning by peer IRPs

Peer Panel Company Profiles

	aps	Dominion Energy	DUKE ENERGY CAROLINAS	DUKE ENERGY FLORIDA	DUKE ENERGY PROGRESS
Description	Using a balanced energy mix that is nearly 50% carbon-free, APS has one of the country's cleanest energy portfolios	One of the nation's largest producers and transporters of energy, with one of the nation's largest natural gas storage systems	Regulated public utility primarily engaged in the generation, transmission, distribution, and sale of electricity in portions of NC and SC	Regulated public utility primarily engaged in the generation, transmission, distribution, and sale of electricity in portions of Florida	DEP owns nuclear, coal-fired, natural gas, renewables, and hydroelectric generation, providing service within portions of NC and SC
Total Revenue ($000,000,000)	$3.6B	$12.9B	$7.4B	$4.7B	$5.2B
IRP Filing Date/ Filing Frequency	April 2017 / Annually	May 2017 / Biennially	Sept. 2017 / Annually	April 2017 / Annually	Sept. 2017 / Annually
IRP Planning Horizon	15 Years	25 Years	15 Years	10 Years	15 Years
Customers	1,221,485	2,588,084	2,571,820	1,800,000	1,556,402
Capacity	6,450 MW	26,268 MW	20,475 MW	9,869 MW	14,197 MW

Peer Panel Company Profiles (Cont'd)

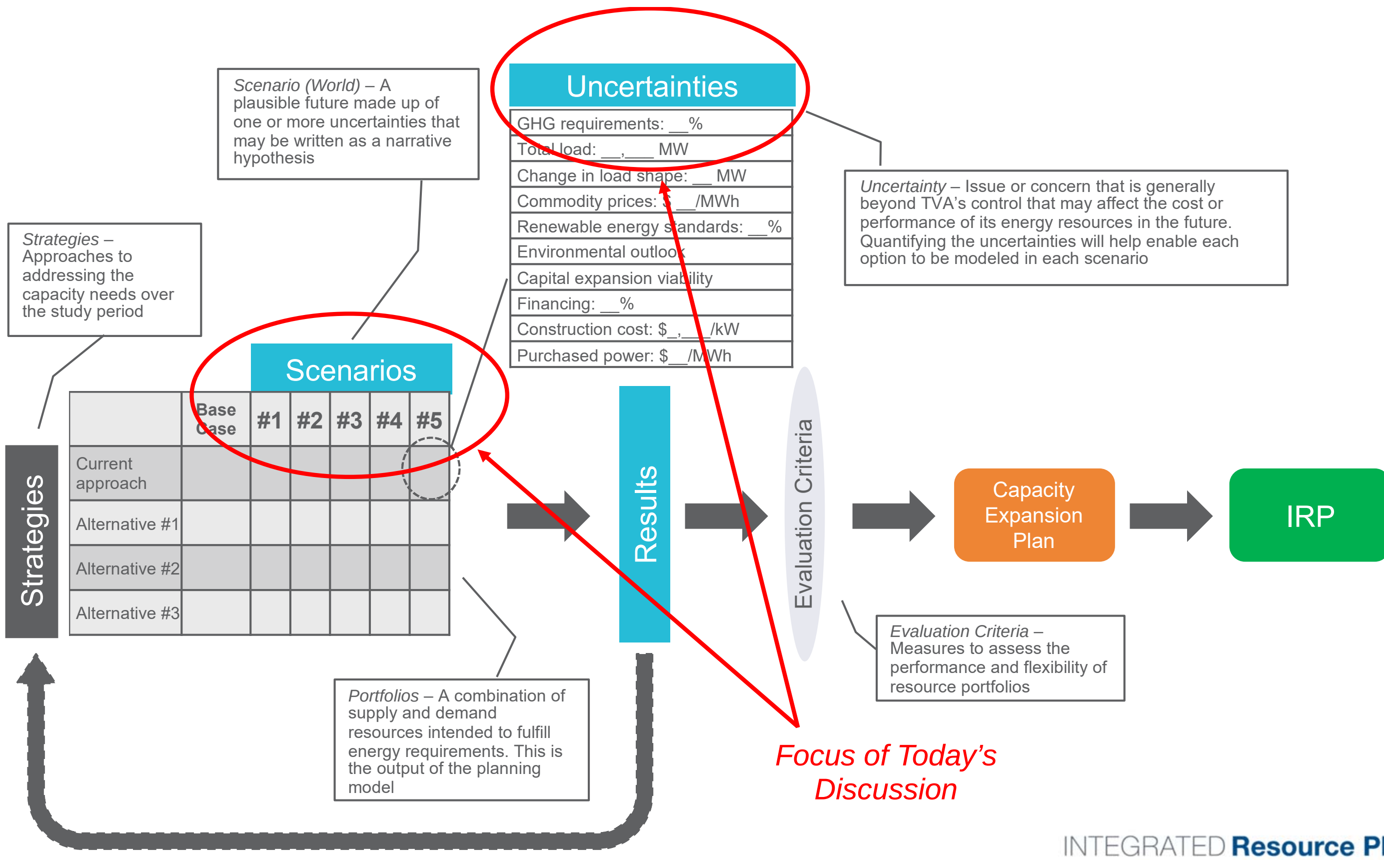
	Entergy	FPL	Georgia Power	PacifiCorp	PGE
Description	Integrated energy company engaged primarily in electric power production and retail distribution operations	A subsidiary of Juno Beach, Florida-based NextEra Energy, Inc., FLP is the third-largest electric utility in the U.S.	The largest electric subsidiary of Southern Company, with a diverse and innovative generation mix	A subsidiary of Berkshire Hathaway Energy, the electric utility serves customers across six states	Vertically integrated electric utility that serves customers in the Portland / Salem metropolitan area of Oregon
Total Revenue ($000,000,000)	$11.4B	$12.0B	$8.3B	$2.3B	$2.0B
IRP Filing Date/ Filing Frequency	Aug. 2015 / Every Three Years	April 2017 / Annually	Jan. 2016 / Every Three Years	April 2017 / Biennially	Nov. 2016 / Every Three Years
IRP Planning Horizon	20 Years	10 Years	20 Years	20 Years	25 Years
Customers	2,884,881	4,922,000	2,515,131	1,867,000	875,000
Capacity	24,168 MW	27,122 MW	16,422 MW	1,132 MW	4,005 MW

Peer Panel Company Profiles (Cont'd)

	PG&E	SMUD	TVA
Description	A subsidiary of PG&E Corp., PG&E serves Californians across a 70,000 square mile service area in Northern California	Sixth-largest community-owned electric service provider, with a power mix that is 50% non-carbon emitting	Federally owned agency providing electricity, flood control, navigation, land management, and economic development in seven states
Total Revenue ($000,000,000)	$17.2B	$1.6B	$10.7B
IRP Filing Date/ Filing Frequency	N/A	N/A	Aug 2015 / Every Four Years
IRP Planning Horizon			20 Years
Customers	5,384,525	628,953	>9,000,000[1]
Capacity	7,715 MW	1,043 MW	36,153 MW

[1]TVA customer counts reflect retail customers serviced by independent power distributors

A Typical IRP Development Process



Summary of Scenario Planning Observations

Uncertainties Contained in Scenarios

- Whether included as part of a named scenario or tested as independent variables, all peer IRPs include uncertainties of CO_2 compliance costs, natural gas prices, and load growth rate; Peer Benchmarking conducted in 2009 and 2014 identified the same three as common to all peer IRPs
- The majority of peer IRPs include uncertainties of capital cost and availability, technology cost and performance, and non-CPP regulations and policies
- Only four peers (APS, ETR, PCQ, and PGE) identified distributed generation penetration as an uncertainty
- For all peers, capacity expansion tools (e.g., System Optimizer, Strategist) are essential to model and analyze increasing numbers of uncertainties, scenarios, technologies, and portfolios

Summary of Scenario Planning Observations

Development and Use of Scenarios

- Terminology and approaches to modeling future scenarios differ widely between the peers
- Four peers developed alternative portfolios without creating scenarios; single and multivariable sensitivity tests determined the preferred portfolio (APS, DOM, DEF, and FPL)
- Peers that created scenarios modeled as few as four (DEC, DEP, and ETR) to as many as 23 (PGE)
- Four of the six peers who created scenarios modeled a base case that reflected current trends for key uncertainties
- PGE documented the most comprehensive creation and modeling of varying possible scenarios

Six of the 10 peers created scenarios to test strategies or portfolios

Summary of Scenario Planning Observations

Scenario Selection

- Peers did not document the process for selection of scenarios, but load growth, fuel prices and regulations (related to both CPP and RPS) are included in the construction of most scenarios
- Despite increasing focus on DER, only ETR created a scenario to identify heavy penetration of DG as a possible future; others (e.g., APS, PCQ) created uncertainty cases to test the impact of DG penetration on portfolios
- DEC and DEP share a single modeling work group, and identified four common scenarios
- Most peers that were included in the 2014 benchmarking exercise maintained a similar approach to the use and number of scenarios
- DOM modeled four scenarios in the 2013 IRP but bypassed scenario creation for 2017, utilizing sensitivity case testing on eight portfolios

Summary of Scenario Planning Observations

PUC and Stakeholder Engagement

- For eight of the peers, state PUCs require periodic filing of IRPs, ranging from annually to every four years
- Two of the peers, DEF and FPL, are required to file an annual Ten Year Site Plan, which includes a limited section for integrated resource plan
- The PUC requirements for IRP content differ significantly between peers (e.g., PGE's IRP is over 850 pages, while ETR a utility more than five times larger, filed an IRP with less than 100 pages)
- The level of stakeholder engagement varied widely, with most peers not describing details of stakeholder involvement in the development process
- PGE and PCQ describe well-developed stakeholder engagement processes, including at least eight public meetings held throughout the development process

Possible TVA IRP Uncertainties

Uncertainty	Description
Electricity Demand	The customer energy requirements (GWh) for the TVA service territory including losses; it represents the load to be served by TVA
Market Power Price	The hourly price of energy ($/MWh) at the TVA boundary; used as a proxy for market price of power
Natural Gas Prices	The price ($/MMBtu) of the commodity including transportation
Coal Prices	The price ($/MMBtu) of the commodity including transportation
Solar Prices	The price ($/MWh) of solar power purchase agreements delivered to TVA
Storage Prices	The price ($/kW) of storage new builds
Regulations	All regulatory and legislative actions, including applicable codes and standards, that impact the operation of electric utilities excluding CO2 regulations
CO2 Regulation/Price	The cost of compliance with possible CO2 related regulation and/or the price of cap-and-trade legislation, represented as a $/Ton value
Distributed Generation Penetration	National trending of distributed generation resources and potential regional activity by customers or third party developers (not TVA)
Energy Efficiency Adoption	An estimate of the adoption of energy efficiency measures by customers nationally; a measure of interest/commitment of customers in general to adopt EE initiatives, recognizing the impacts of both technology affordability and electricity price on willingness to adopt efficiency measures
Economic Outlook (National/Regional)	All aspects of the regional and national economy, including general inflation, financing considerations, population growth, GDP and other factors that drive the overall economy

Shaded uncertainties reflect potential additions to the 2015 IRP uncertainties

Comparison of Peer Uncertainties to TVA

Uncertainty	TVA	APS	DOM	DEC	DEF	DEP	ETR	FPL	GPC	PCQ	PGE
Load Growth Forecasts	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Natural Gas Prices	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO_2 Regulations / Costs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Capital Availability, Costs, & Escalation[1]	✓	✓		✓		✓			✓	✓	✓
Technology Costs & Performance[2]	✓	✓	✓	✓	✓	✓	✓	✓			✓
Policies and Regulations (excl. CO_2)	✓	✓	✓	✓		✓	✓	✓			✓
Nat'l EE Adoption and EE Costs	✓			✓		✓					
Coal Price	✓		✓						✓		✓
Distributed Generation Penetration	✓	✓					✓			✓	✓
Economic Outlook[1]	✓	✓									✓
Market Power Price	✓										
Demand Side Management Achievement		✓	✓	✓		✓		✓	✓		
Renewables Energy Requirements			✓	✓		✓		✓			✓
Generation In-Service Delays/Retirement			✓				✓		✓		
Resource Selection Constraints					✓						✓
PPA Availability / Costs									✓	✓	
Regional Gen and Load Imbalance								✓			

[1]TVA intends to capture *Capital Cost and Escalation* as part of the *Economic Uncertainty* scenario
[2]TVA identified individual uncertainties for Storage and Solar Costs

Comparison of Peer Uncertainties to TVA (Cont'd)

Uncertainty	TVA	APS	DOM	DEC	DEF	DEP	ETR	FPL	GPC	PCQ	PGE
Nuclear Challenges				✓		✓					✓
Externalities (monetizing SO_2, NOX, etc.)		✓							✓		
Renewable Tax Credits							✓				
Construction Capacity Additions									✓		
Future Reserve Margins		✓					✓				
Generator Forced Outage Rates							✓		✓		

Comparison of Peer Uncertainties to TVA – Key Takeaways

- On balance, TVA's uncertainties are comprehensive and align with industry peers
- Seven of TVA's 11 uncertainties are modeled by a majority of peers; Only one uncertainty, *Market Power Price,* is unique to TVA
- Ten uncertainties are included by at least one, but less than five, of the peers and are not among TVA's uncertainties. Basis for inclusion of these uncertainties appears to be driven by environmental, regulatory or operational priorities that may differ from those of TVA

Peer Scenario Comparisons

Company	Current Environment	Economic Boom	Economic Slowdown	Gas Prices	Carbon Tax/ Mass Cap	Renewables Portfolio	Capital Cost	Load Growth	Water Constraints	Distributed Generation
Duke Energy Carolinas (DEC)	✓	✓	✓	C	✓					
Duke Energy Progress (DEP)	✓	✓	✓	C	✓					
Entergy (ETR)	✓	✓			✓					✓
Georgia Power Company (GPC)				✓	✓					
Portland General Electric (PGE)	✓			✓	✓	✓	✓	✓	✓	
PacifiCorp (PCQ)				✓	✓					
Arizona Public Service (APS)	APS tested individual uncertainties (e.g., load, gas price carbon tax, cost of capital) against seven portfolios									
Dominion (DOM)	DOM tested individual uncertainties (e.g., load, gas price carbon tax, construction costs) against eight portfolios									
Duke Energy Florida (DEF)	DEF did not describe scenarios but used a “highest probability of outcome” to inform portfolio design									
Florida Power & Light (FPL)	FPL did not create scenarios but built portfolios based on costs, environmental constraints, and regulatory requirements									

C – Included as a component within one or more of the named scenarios
PCQ created six scenarios based on variations of gas prices and carbon emission limits
GPC created nine scenarios based on variations of gas prices and carbon tax

Possible Alternative TVA IRP Scenarios

Declining Economy
- *Weak Economy*

Economic Growth
- *Strong Economy*

Stringent Environmental
- *CO2 Regulation/Legislation*
- *Limited Natural Gas Extraction*
- *Water Scarcity*

Changing Paradigm
- *Advanced Manufacturing*
- *Decarbonized Society*
- *No Nuclear Extensions*

Emerging Technology
- *High DER*
- *Technology Breakthrough*

Observations

- Similar to four of the peers, TVA modeled a Current Outlook scenario (not shown) that reflects current trends in addition to the ten alternative scenarios
- Four of the six peers who utilized scenarios modeled six scenarios or less
- For the 2015 IRP, TVA evaluated ten scenarios and selected five to be modeled

Comparison of Peer Scenarios to TVA

Company	Current Outlook	Economic Slowdown	Economic Boom	CO2 Regulation / Legislation	Limited Natrual Gas Extractions	Water Scarcity	Advanced Manufacturing	Decarbonized Society	No Nuclear Extensions	High DER	Technology Breakthrough
Duke Energy Carolinas (DEC)	✓	✓	✓	✓							
Duke Energy Progress (DEP)	✓	✓	✓	✓							
Entergy (ETR)	✓		✓	✓						✓	
Georgia Power Company (GPC)				✓							
Portland General Electric (PGE)	✓			✓		✓					
PacifiCorp (PCQ)			✓	✓						✓	
Arizona Public Service (APS)	APS tested individual uncertainties (e.g., load, gas price carbon tax, cost of capital) against seven portfolios										
Dominion (DOM)	DOM tested individual uncertainties (e.g., load, gas price carbon tax, construction costs) against eight portfolios										
Duke Energy Florida (DEF)	DEF used a "highest probability of outcome" to inform portfolio design, and performed sensitivity analysis										
Florida Power & Light (FPL)	FPL did not create scenarios but built portfolios based on costs, environmental constraints, and regulatory requirements										

- Four of the six peers who created scenarios included a Base Case / Current Outlook model
- PCQ created six scenarios based on variations of gas prices and carbon emission limits, and 18 others based on variations on uncertainties

Comparison of Peer Scenarios to TVA – Key Takeaways

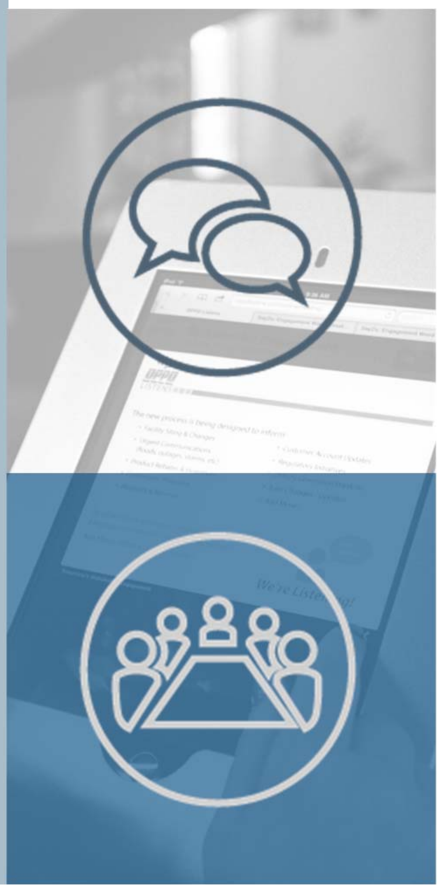
- TVA's eleven possible scenarios provide a comprehensive set of futures that match or exceed peer IRP scenarios
- Three of TVA's possible scenarios were modeled by most peers who created scenarios (i.e., *Current Trends, Economic Boom, CO2 Regulation / Legislation*)
- Three of TVA's scenarios were modeled by one or two peers (i.e., *Economic Slowdown, Water Scarcity, High DER*)
- Five scenarios were not included by any of the peers (i.e., *Limited Natural Gas Extraction, Advanced Manufacturing, Decarbonized Society, No Nuclear Expansion, Technology Breakthrough*)
- Opportunities exist to combine / reduce scenarios to five to seven, and to address any additional future variables through sensitivity testing

Break

Feedback on Uncertainties & Scenarios

Hunter Hydas

Scoping Comments: IRP Scenarios



<u>Themes from Public Scoping Comments on Scenarios</u>:

- **Renewable Energy**
  - Expanded renewables at all scales
  - DER (specifically distributed solar plus storage)
- **Utility-Scale Storage**
- **Carbon Policy**
  - Follow examples of Paris Agreement, CA, or RGGI
- **Electrification**
  - Higher EV penetration
  - C&I, Direct-served electrification

2019 IRP Proposed Uncertainties

Uncertainty	Description
Electricity Demand	The customer energy requirements (GWh) for the TVA service territory including losses; it represents the load to be served by TVA
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Economic Outlook (National/Regional)	All aspects of the regional and national economy, including general inflation, financing considerations, population growth, GDP and other factors that drive the overall economy

Current Outlook

Uncertainty	Outlook
Electricity Demand	Growth in customer count and large commercial & industrial offset by increased energy efficiency and distributed generation, leading to slightly declining energy sales and slightly increasing peaks
Market Power Prices	Average prices determined by marginal natural gas generators
Natural Gas Prices	Near term natural gas prices below $3.00/MMBtu and longer term average around $3.25/MMBtu
Coal Prices	Low gas prices drive lower growth in coal prices, and coal becomes more competitive in the long term as nuclear units begin to retire
Solar Prices	Solar prices becoming competitive with traditional resources
Storage Prices	Storage prices declining but still more expensive than traditional resources
Regulations	Little to no change in stringency of environmental regulations, and assume current projection of tariffs and tax credits
CO2 Regulation/Price	Given TVA's diverse portfolio and current state of regulations, carbon price of $0/ton assumed
Distributed Generation Penetration	Limited DG penetration in the Valley compared to other areas of the country, with 4% of residential and commercial customers projected to have distributed solar by 2038
Energy Efficiency Adoption	Energy efficiency gains from EIA projected saturation of codes and standards currently on the books
Economic Outlook (National/Regional)	Gross Domestic Product growth of 2% per year

General Correlations for Uncertainties

Electricity Demand	↑	Economic Outlook	↑
Natural Gas Prices	↑	Market Power Prices	↑
Solar Prices	↑	Storage Prices	↑
DG Penetration	↑	EE Adoption	↑
Regulation	↑	Electricity Demand Economic Outlook Coal Prices	↓

Uncertainties (Relative to Current Forecasts)		CO_2 Reg/Leg
	Electricity Demand	Low
	Market Power Price	High
	Natural Gas Prices	High
	Coal Prices	Low
	Solar Prices	Low
	Storage Prices	Low
	Regulations	High
	CO_2 Regulation/Price	Very High
	Distributed Generation Penetration	High
	National Energy Efficiency Adoption	High
	Economic Outlook (National/Regional)	Low

Potential Plausible Futures Brainstorming Session March 2018

IRPWG members were asked to consider:

- How **technology** is changing
- How **electricity demand** is likely to change in the future
- How **customer preferences** are evolving and impacting the demand for electricity
- How the **regulatory environment** may affect the future (regulation overall, not TVA specific regulation)
- How the **economy** will change

Summary of Brainstorming Ideas

Technology:
-Costs of solar decline
- IOT / Fiber
- EV's and EE
- CHP
- Grid Technologies / System Controls
- Microgrids
- DR
- SMRs

Electricity Demand:
-Lots of positive and negative influences
- EV raises demand – can we control it?
- Younger people will have different practices
- High Tech telecom demand
- Rural to Urban shift
- Rate Structure
- Water system efficiency
- Off grid defection

Customer Preferences
- Low cost / cost predictability
- Raise flexibility / menu of options
- wants: Instant service / controls / privacy / rate options / green/perception of green / do it themselves / keep up with the Jones/
- Corporate mandates
- LPC controls
- Reliability
- Greater Customer Diversity
- Equity concerns

Regulatory Environment
-Environmental Regulations
-Codes/Standards
-Transmission Access
-Cyber Security Policy
-Reliability / Cyber / Physical

Economy
-Global Conflict
-Regional disparities / Urban/Rural / Rationality / Growth areas more granule
- Impact of regulations
- Tax structure
- Recession modeling
- Interplay of economy and customer demographics

Possible 2019 IRP Scenarios

Declining Economy
- *Weak Economy*

Economic Growth
- *Strong Economy*

Stringent Environmental
- *CO2 Regulation/Legislation*
- *Limited Natural Gas Extraction*
- *Water Scarcity*

Changing Paradigm
- *Advanced Manufacturing*
- *Decarbonized Society*
- *No Nuclear Extensions*

Emerging Technology
- *High DER*
- *Technology Breakthrough*
- *High EV Penetration *New from IRPWG**

Scenario Group 1: Declining Economy

Weak Economy

Scenario Narrative

- Prolonged, stagnant economy results in negative growth and delayed expansion of new generation
- Ballooning budget deficits and rising public debt hits record levels
- More tariffs on imports are followed by retaliatory tariff on exports
- Stringent environmental regulations are delayed due to concerns of adding further pressure to the economy
- Weaker demand drives lower cost of new construction, lower productivity and lower real prices
- Comment: Reduced disposable income and earnings increases adoption of energy efficiency as a means of reducing cost

Scenario Group 2: Economic Growth

Economic Boom

Scenario Narrative

- Rapid economic growth translates into higher than forecasted energy sales and energy expansion
- Rebound in commodity exports (gas and other material)
- Strong growth in emerging markets and developing economies, driving productivity growth and lower inflation
- Increasingly positive public attitude toward adoption of energy efficiency programs and distributed generation
  - Comment: Disagree. Historically, energy efficiency has been less of a priority during economic booms (e.g., when people have more disposable income they drive more, turn the AC/Heat up, buy bigger SUVs and homes, etc.)
- Advances in electric vehicles make it cheaper to buy electric than gas cars
  - Comment: Advances in EVs should be grouped somewhere else, as EV development isn't necessarily linked with the strength of the economy (e.g., the Nissan Leaf and Tesla Model S were introduced at the height of the recession in 2008-2009.)

Scenario Group 3: Stringent Environmental

CO2 Regulation/Legislation

Scenario Narrative

- Increasing climate-driven effects create strong federal push to curb GHG emissions, driving CO_2 emission penalties for the utility industry and incentives for non-emitting technologies
- Compliance with new rules increases energy prices and US-based industry becomes less competitive, resulting in lagging U.S. economic growth that fails to rebound to trend levels
  - Comment: Regulation of CO2 does not necessarily mean a hit on the economy long-term (e.g. CAA 1970s)
- Fracking regulations never materialize, but gas demand is impacted by the CO_2 penalty
- New expansion units are necessary to replace existing CO_2 -emitting fleet
  - Question: With what type of expansion?

Scenario Group 3: Stringent Environmental

Limited Natural Gas Extraction

Scenario Narrative

- Increasing concern with fossil fuel production and use drive regulations to limit natural gas extraction along with more stringent water regulations
- New legislation moderately penalizes CO_2 emissions from the utility industry and incentivizes non-emitting technologies
- Compliance with new rules increases energy prices and US-based industry becomes less competitive, resulting in lagging U.S. economic growth that fails to rebound to trend levels
- New expansion units are necessary to replace existing CO_2 -emitting fleet
  - ➢ Question: With what type of expansion?

Scenario Group 3: Stringent Environmental

Water Scarcity

<u>Scenario Narrative</u>

- Climate variability leads to prolonged drought and reduced hydro generation as well as hydrothermal limitations for plants that depend on water for cooling
  - Comment: Future water availability is location specific and varies significantly through the year. Therefore, impact across the Tennessee Valley will vary significantly.
- Population and demographic changes lead to increasing demand for water in urban areas, contributing to localized water scarcity
  - Comment: Drought and drought conditions are likely to impact rural and non-urban communities more than urban cities. The vast majority, if not all, of the major urban centers are located on major river systems which provide water supply.
  - Comment: Heavy precipitation events could contribute to flooding
- Public and political sensitivity to large water users and natural ecosystem impacts drives penalty on water use.

Scenario Group 4: Changing Paradigm

Advanced Manufacturing

<u>Scenario Narrative</u>

- Automation and artificial intelligence drive increased labor productivity, boosting economic growth and lowering inflation
- Increased penetration of artificial intelligence and advanced manufacturing leads to higher energy use in the manufacturing sector and increased need for improved reliability, power quality and reactive capability
  - Comment: Could also result in no net change to energy consumption due to reduced transportation of workers and manufacturing space heating/cooling. Also, AI could be cloud-based with servers located outside the Valley.
- New facilities proactively incorporate energy efficiency and renewable technology

Feedback to consider removing scenario if impacts immaterial <u>or</u> moving scenario to Emerging Technology category

Scenario Group 4: Changing Paradigm

Decarbonized Society

Scenario Narrative

- Driven by customer preference, transportation and other sectors are electrified, resulting in increased sales
- Preference for lower emissions, DER and energy efficiency drives lower demand for emitting generation, resulting in lower gas and coal prices
  - Comment: Demand for natural gas could increase in the near term as it acts as a “bridge fuel” until solar, SMRs, etc. are cheaper
- ~~U.S. economy in slight decline due to higher electricity prices~~
  - Comment: What is the basis for the link between higher electricity prices and economic decline?
- U.S. economy performs similarly with higher electricity prices offset by reduced spending on gasoline

Scenario Group 4: Changing Paradigm

No Nuclear Extensions

<u>Scenario Narrative</u>

- Driven by desire for national energy security and resiliency, relicensing of existing and construction of new large scale nuclear both cease in favor of technologies that are more secure, modular, and flexible
  - Comment: Not necessarily. A "desire for energy security and resiliency" would demand that baseload nuclear generation is relicensed and possibly increased, not retired.
- National energy policy drives carbon regulation and legislation and promotes small modular reactor technology through subsidies to drive SMR technology breakthrough and improved economics
  - Question: Why would no new large nukes result in lower economic growth given growth of SMRs?

Scenario Group 5: Emerging Technology

High DER

Scenario Narrative

- Consumer growing awareness of and preference for energy choice, coupled with rapid advances in energy technologies, drive high penetration of distributed generation, storage and energy efficiency
- Utilities are no longer the only 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

Scenario Group 5: Emerging Technology

Technology Breakthrough

<u>Scenario Narrative</u>

- Technology breakthrough in the cost and capability of storage technology, small modular reactors, carbon capture, and energy management
- Technology enables clean fossil generation with a reduced emission profile along with emission-free technologies for a lower-emitting diverse portfolio

Scenario Group 5: Emerging Technology

High EV Penetration

Scenario Narrative

- High penetration of electric vehicles (including light duty, medium duty, and heavy duty – passenger vehicles to buses to class 4-8 trucks)
- High penetration of EV shifts vehicle fuel source from petroleum to electricity, which results in increase in electricity demand
- Higher number of battery EVs results in lower battery prices due to economies of scale
- With multiple auto manufacturers located within the TVA region, EVs present an economic growth opportunity

Summary of Scenarios & Uncertainties

Uncertainties (Relative to Current Forecasts)	Potential Scenarios										
	Declining Economy	Economic Growth	Stringent Environmental			Changing Paradigm			Emerging Technology		
	Weak Economy	Strong Economy	CO2 Reg/Leg	Limited NG Extraction	Water Scarcity	Advanced Manufacturing	Decarbonized Society	No Nuclear Extensions	High DER	Technology Breakthrough	High EV Penetration
Electricity Demand	Very Low	Very High	Low	Low	Low	High	High	Same	Same	Same	Very High
Market Power Price	Low	High	High	Very High	Very High	High	High	High	Very Low	High	Low
Natural Gas Prices	Low	High	High	Very High	Very High	High	Low	High	Very Low	Same	Same
Coal Prices	Low	Same	Low	High	Very High	Same	Low	Same	Very Low	Same	Same
Solar Prices	High	Same	Low	Low	Low	Same	Low	Same	Low	Very Low	Same
Storage Prices	High	Same	Low	Low	Low	Same	Low	Same	Low	Very Low	Low
Regulations	Low	Same	High	Very High	Very High	Same	Same	High	Same	Same	Same
CO2 Regulation/Price	Same	Same	Very High	High	Very High	Same	Very High	High	Same	High	Same
Distributed Generation Penetration	Low	High	High	High	High	High	High	High	Very High	Very High	Same
National Energy Efficiency Adoption	Low	High	High	High	High	High	High	High	Very High	Very High	Same
Economic Outlook (National/Regional)	Very Low	Very High	Low	Low	Low	High	Same	Low	Same	Same	High

Would electricity demand be lower in these scenarios?

Would coal prices be very low?

Would solar and storage prices remain unchanged in a weak economy?

Would EE move opposite of economy?

Would economy remain unchanged? Duration?

Proposed Scenario: Emerging Technology

			Scenario Narrative
		High EV Penetration	High penetration of Electric Vehicles (including light duty, medium duty, and heavy duty -- passenger vehicles to buses to class-4-8 trucks)
		Level of Impact relative to the Current Outlook	**Rationale**
Uncertainties (Relative to Current Forecasts)	Electricity Demand	Very High	High penetration of EV shifts vehicle fuel source from petroleum to electricity, which results in significant increase in electricity demand.
	Market Power Prices	Low	Load growth allows TVA/LPCs to allocate fixed costs over higher number of kWh, therefore reducing unit costs.
	Natural Gas Prices	Same	Load growth met by baseload nuclear, hydro, and natural gas.
	Coal Prices	Same	
	Solar Prices	Same	
	Storage Prices	Low	Higher number of battery EVs results in lower battery prices due to economies of scale.
	Regulations	Same	
	CO2 Regulation/Price	Same	
	Distributed Generation Penetration	Same	
	National Energy Efficiency Adoption	Same	
	Economic Outlook (National/Regional)	High	With mulitple auto manufacturers located within TVA region, EVs present an economic growth opportunity.

Individual Feedback on Scenarios

Jo Anne Lavender

Individual Feedback on Scenarios

1. If you have a question or concern, please write it on a sticky note and place it on the appropriate Scenario.

2. After lunch, we will work through all the questions and concerns together as a group.

Lunch

Discussion of Comments

Hunter Hydas

Group Discussion

Jo Anne Lavender

Small Group Discussion Questions

1. Are Scenarios distinct from each other? Should any be combined?

2. Do the proposed scenarios capture the probable futures?

3. What, if anything, is missing?

Check In – Scenario List

Jo Anne Lavender

Next Steps - Scenarios

Hunter Hydas

Next Steps on Scenarios

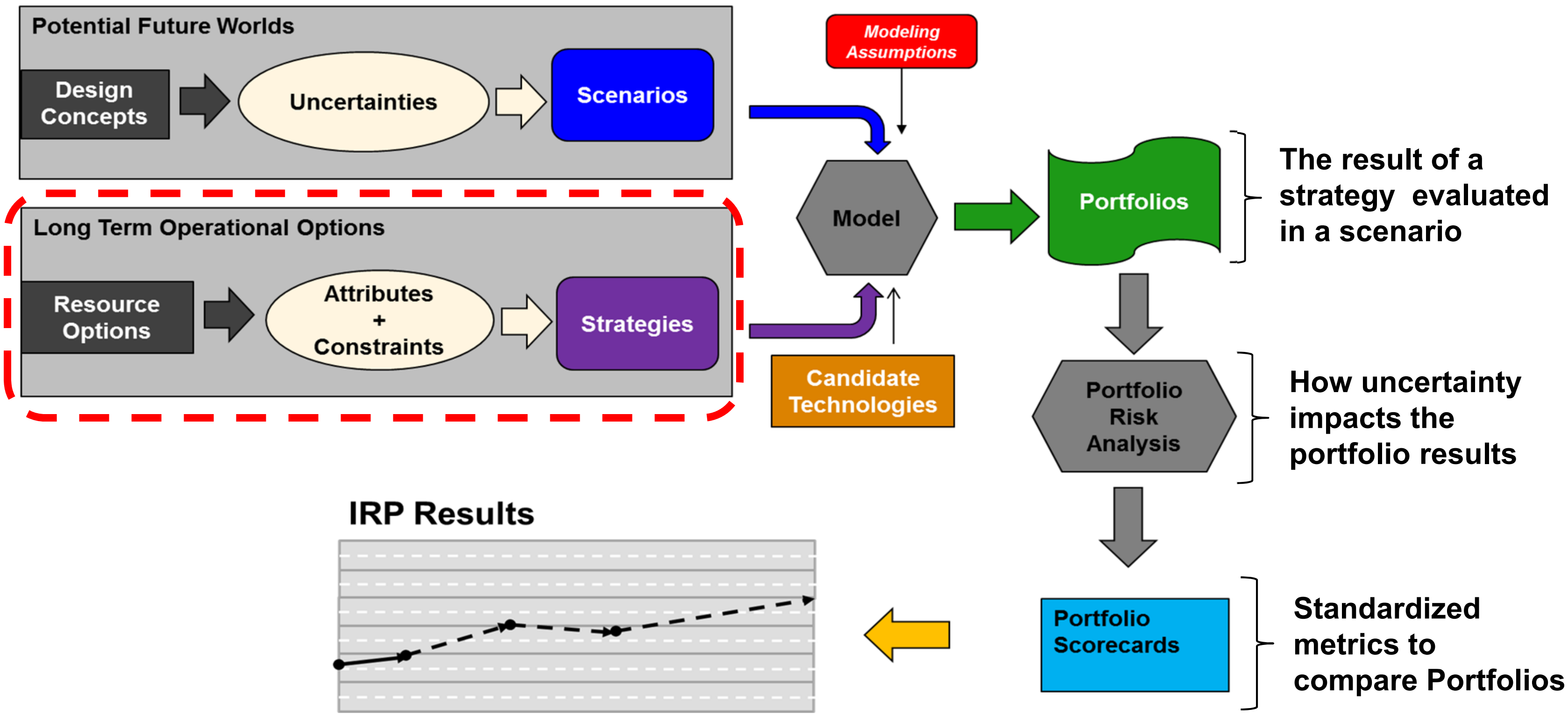
- Are there any final questions about scenarios?
- Our goal is to get the final list down to ~5 scenarios in addition to the Current Outlook.
- Voting process:
  - By April 30, the final scenario list, narratives, and uncertainty matrix will be provided to the IRPWG along with a ranking template.
  - You will rank scenarios in order of preference for inclusion in the IRP and email ranking back to us by May 11.
  - Scenarios will be finalized based on IRPWG ranking and TVA ranking and results will be presented at the June meeting.

Break

Overview of Attributes & Strategies

Brian Child

How Integrated Resource Planning Works



Scenarios and Strategies Establish Framework

Scenarios
Outside TVA's Control

- Describe potential outcomes of factors (uncertainties) outside of TVA's control
- Represent possible conditions and are not predictions of the future
- Include uncertainties that could significantly impact operations, such as:
  - Load forecasts
  - Commodity prices
  - Environmental regulations
- Lends insight to riskiness of portfolio choices

Strategies
Within TVA's Control

- Test various business options within TVA's control
- Defined by a combination of resource assumptions, such as:
  - DER portfolio
  - Nuclear expansion
  - Energy storage
- Consider multiple viewpoints
  - Public scoping period comments
  - Assumptions that would have the greatest impact on TVA long-term

A well-designed strategy will perform well in many possible scenarios

Process for Building Strategies

Brainstorming – resource mix goals & objectives

1. Identification of key attributes
2. Development of strategies using the attributes
3. Review candidate strategies for robustness & feasibility
4. Determine list of proposed planning strategies

- The key questions in developing our list of potential strategy attributes are
  - Is this attribute something we want to evaluate in this IRP?
  - Is this attribute something we need to define? Or can this aspect of the resource portfolio be an outcome of the modeling?
  - Does this attribute capture an existing policy of TVA?
  - Does this attribute capture work done outside the IRP to meet goals or objectives of TVA?
- Describe the intent of each candidate strategy by defining the "value" of each attribute for that strategy
- Review attributes within the strategy for correlation; also compare attribute variability across all candidate strategies to ensure robust resource portfolios will be possible
- TVA & IRPWG select a short list of strategies to be modeled
  - Define each of the proposed planning strategies including objectives and key characteristics

10 Attributes used in 2015 IRP

Attributes	Description
Existing Nuclear	Constraints related to the existing nuclear fleet; EPU's are considered part of existing nuclear
Nuclear Additions	Limitations on technologies and timing related to the addition of new nuclear capacity; Watts Bar 2, SMRs, A/P 1000s and BLN are considered in this category
Existing Coal	Constraints related to the existing coal fleet; the current schedule plan of coal unit idling is considered as an input
New Coal	Limitations on technology and timing on new coal-fired plants; includes CCS on conventional coal plus IGCC technology
Gas Additions	Limitations on technologies and timing related to the expansion options fueled by natural gas (CT, CC)
EEDR	Considers energy efficiency and demand response programs that are incentivized by TVA and/or LPC's (excludes impacts from naturally occurring efficiency/ conservation)
Renewables (Utility Scale)	Limitations on technologies and timing of renewable resources; considers options that would be pursued by TVA or in collaboration with LPC's
Purchased Power Agreements (PPA)	Level of market reliance allowed in each strategy; no limitation on the type of energy source (conventional or renewable)
DG/DER	Includes customer-driven resource options or third party projects that are distributed in nature
Transmission	Type and level of transmission infrastructure required to support resource options in each strategy

2015 IRP Selected Strategies

STRATEGY	DESCRIPTION
"Traditional" Least Cost Planning	• All resource options available for selection; traditional utility "least cost optimization" case
Meet an Emission Target	• Resources selected to create lower emitting portfolio instead of focusing only on a traditional least cost approach • This lower emissions plan will be based on an emission rate target or level using CO2 as the emissions metric (the target will be set as a reduction from current emissions forecast) • Additional existing unit retirements may be included in the plan.
Lean on the Market	• Most new capacity needs are met using market resources and/or third-party assets acquired through PPA or other bilateral arrangements • TVA makes a minimal investment in owned assets (deployment of EEDR to meet resource needs will continue)
Doing More EEDR	• In order to establish TVA as a regional energy efficiency leader, a majority of capacity needs are met by setting an annual energy target for EEDR (e.g., minimum contribution of 1% of sales) • Renewable energy and gas are secondary options with no coal or nuclear additions permitted
Embracing Renewables	• In order to establish TVA as a regional renewable leader, a majority of new capacity needs are met by setting immediate and long-term renewable energy targets (e.g., 20% by 2020 and 35% by 2040), including hydroelectric energy • A utility-scale approach is targeted initially with growing transition to distributed generation as the dominant renewable resource type by 2024 • EEDR and gas are secondary options with no coal or nuclear additions permitted

Next Steps on Strategies

- Review strategies from 2015 IRP
- Consider whether these attributes and strategies are still relevant or if they should be modified.
- Next meeting will focus on brainstorming and selecting a short list for voting between the June and July meeting

Wrap Up and Tour

Thank you!