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April 16, 2018

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Re: Scoping Comments for TVA's 2019 Integrated Resource Plan

Dear Mr. Hydas, Ms. Henry, and Ms. Pilakowski:

On behalf of the Southern Alliance for Clean Energy (SACE), we submit the following comments in response to TVA's public comment period for the scope of the Tennessee Valley Authority's (TVA) 2019 Integrated Resource Plan (hereinafter referred to as the 2019 IRP") and accompanying Environmental Impact Statement (EIS). SACE is a regional organization that promotes responsible energy choices that create global climate change solutions and ensure clean, safe and healthy communities throughout the Southeast.

Resource planning has long played an important role in the electric generation industry, largely due to the unique physical characteristics of electricity itself: the need to meet supply with demand in real time and the historically long lead times needed to build new power generation. Resource planning in this sector is even more important in the midst of current energy and energy market transitions. The new reality for many utilities is that load growth is flat or negative, customers are demanding more choices and generation resources that cause less pollution, technologies are advancing rapidly, and low and zero carbon technology costs are continually declining. These realities represent the current and future state of the power sector. It's critical that TVA address these trends throughout TVA's upcoming 2019 IRP process. TVA has both the opportunity and the responsibility to use its 2019 IRP to be proactive in addressing the opportunities and challenges presented by the energy transition.

Input Assumptions

Renewable Costs

Initial model assumptions on renewable energy costs in TVA's 2015 IRP were excessively high compared to market offerings. TVA recently received a significant number of high quality renewable energy bids in response to Request for Information (RFI) and Request for Proposals (RFP). In its 2019 IRP modeling inputs, TVA should incorporate these realistic cost metrics, wherever and whenever possible.

National Renewable Energy Lab Annual Technology Baseline (ATB)

The National Renewable Energy Lab (NREL) publishes its Annual Technology Baseline (ATB) as a resource for "realistic and timely set of input assumptions (e.g., technology cost, fuel costs), and a diverse set of potential futures (standard scenarios) to inform electric sector analysis in the United States. The products of this work, including assessments of current and projected technology cost and performance for both renewable and conventional electricity generation technologies, as well as market projections of more than a dozen scenarios produced with NREL's Regional Energy Deployment Systems (ReEDS) model,"[1] is one of the most comprehensive and accurate resources for various energy resource inputs. NREL's ATB is used by regional transmission organizations (RTOs) including Midcontinent Independent System Operator (MISO)[2] and PJM.[3] NREL's ATB should provide a starting point for model inputs in TVA's 2019 IRP. Given that future purchases of renewable energy resources would take several years before power production, it is recommended that NREL ATB data starting in 2019, as well as incorporating future pricing and performance levels.

Wind Energy

NREL's ATB evaluates wind energy resources as "techno-resource groups" (TRGs) that effectively provides a scale of quality.[4] For example, TRG 1 resources are anticipated to be the lowest cost and highest performance wind energy resources and are mostly concentrated in the Central US. A fair amount of wind energy capacity potential in the Southeast opens up in TRG 5, with the entire

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[1] NREL (National Renewable Energy Laboratory). 2017. 2017 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data_tech_baseline.html.
[2] Midcontinent Independent System Operator (March 20, 2018). "MTEP19 Futures Development Workshop." [https://cdn.misoenergy.org/20180320%20MTEP19%20Futures%20Workshop%20Presentation150635.pdf]
[3] Muhsin K. Abdur-Rahman (April 25, 2016). "PJM's Clean Power Plan Modeling Reference Model and Sensitivities," PJM. [https://www.pjm.com/-/media/committees-groups/committees/mc/20160425-webinar/20160425-item-02-clean-power-plan-reference-model-results.ashx]
[4] National Renewable Energy Lab (November 2016). Regional Energy Deployment System (ReEDS) Model Documentation: Version 2016. [https://www.nrel.gov/docs/fy17osti/67067.pdf]

region opening up with TRG 7. Evaluating these three different wind energy resources provides an appropriate range of wind energy resources available to the Southeast. These base costs would need to include the additional cost of transmission to bring them to the TVA system, particularly TRG 1 resources from the Midwest.

Figure 1. Wind Costs from NREL ATB

	TRG1	TRG5	TRG7
Overnight $/kW (2019)	$1,422	$1,469	$1,612
Capacity Factor	49%	42%	33%
LCOE $/MWh (no PTC)	$36	$43	$58

Source: NREL ATB 2017[5]

Solar Energy

The NREL ATB evaluates utility-scale solar photovoltaic (UPV) only based on fixed-tilt projects with three different capacity factors (14%, 20% and 28%). Fixed-tilt UPV projects have a slightly lower installed and operating cost, but also have a lower capacity factor and an even more significant capacity equivalent value, when compared to single-axis tracking UPV projects. To provide a better range of pricing and performance, it is recommended that the "Low" and "Mid" overnight costs for UPV from NREL's ATB be used as inputs in the 2019 IRP, along with the 28% and 20% capacity factors, respectively. These figures should be indexed to costs for single-axis tracking projects based on RFP responses (see "Real World Examples" section below for more discussion).

Figure 2. Solar Costs from NREL ATB

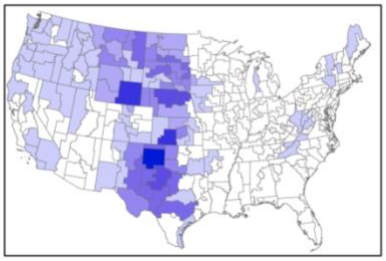
	Low	Mid
Overnight $/kW (2019)	$944	$1093
Capacity Factor	28%	20%
LCOE $/MWh (no ITC)	$34	$54

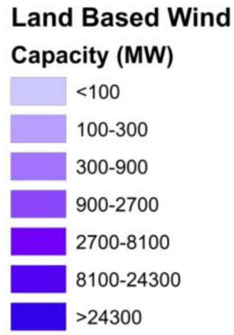
Source: NREL ATB 2017[6]

[5] NREL (National Renewable Energy Laboratory). 2017. 2017 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data_tech_baseline.html.
[6] NREL (National Renewable Energy Laboratory). 2017. 2017 Annual Technology Baseline. Golden, CO: National Renewable Energy Laboratory. http://www.nrel.gov/analysis/data_tech_baseline.html.

Figure 3. Wind Cost and Operational Information from NREL REEDS

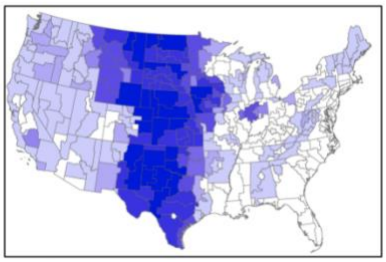
TRG1





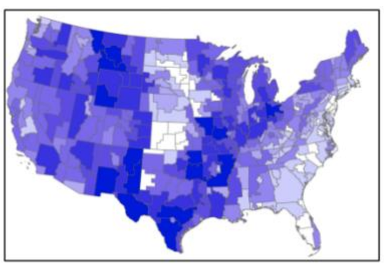
Overnight $/kW (2019)	$1,422
Capacity Factor	49%
LCOE $/MWh (no PTC)	$36

TRG5



Overnight $/kW (2019)	$1,469
Capacity Factor	42%
LCOE $/MWh (no PTC)	$43
Overnight $/kW (2019)	$1,612
Capacity Factor	33%
LCOE $/MWh (no PTC)	$58

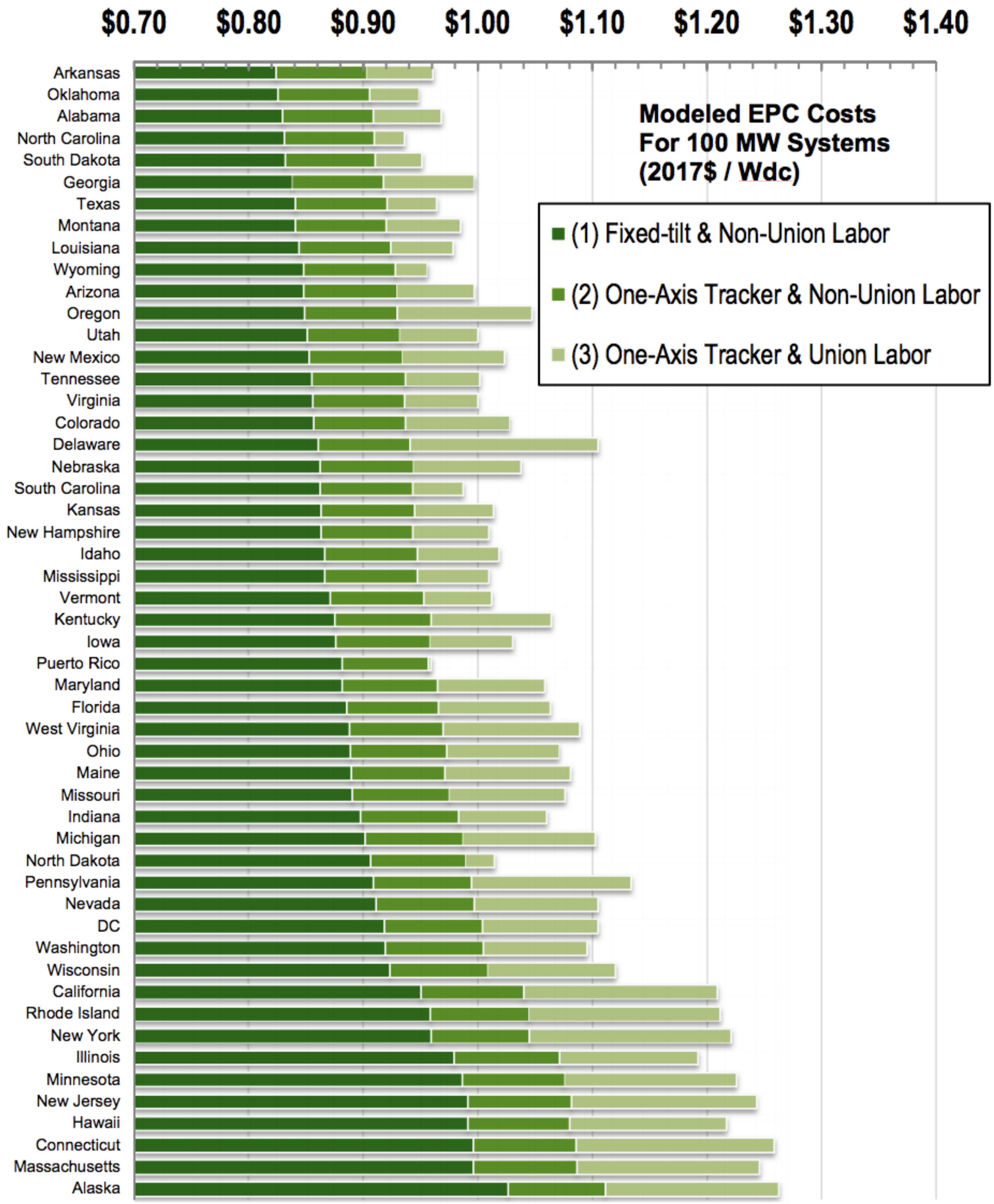
TRG7



Overnight $/kW (2019)	$1,612
Capacity Factor	33%
LCOE $/MWh (no PTC)	$58

Image Source: NREL ReEDS 2016
Data Source: NREL ATB 2017

Figure 4. Q1 2017 benchmark by location: 100-MW utility-scale PV systems, EPC only (2017 USD/Wdc)



Source: NREL 2017[7]

[7] Ran Fu (September 2017). "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017," National Renewable Energy Lab. [https://www.nrel.gov/docs/fy17osti/68925.pdf]

Lazard Associates

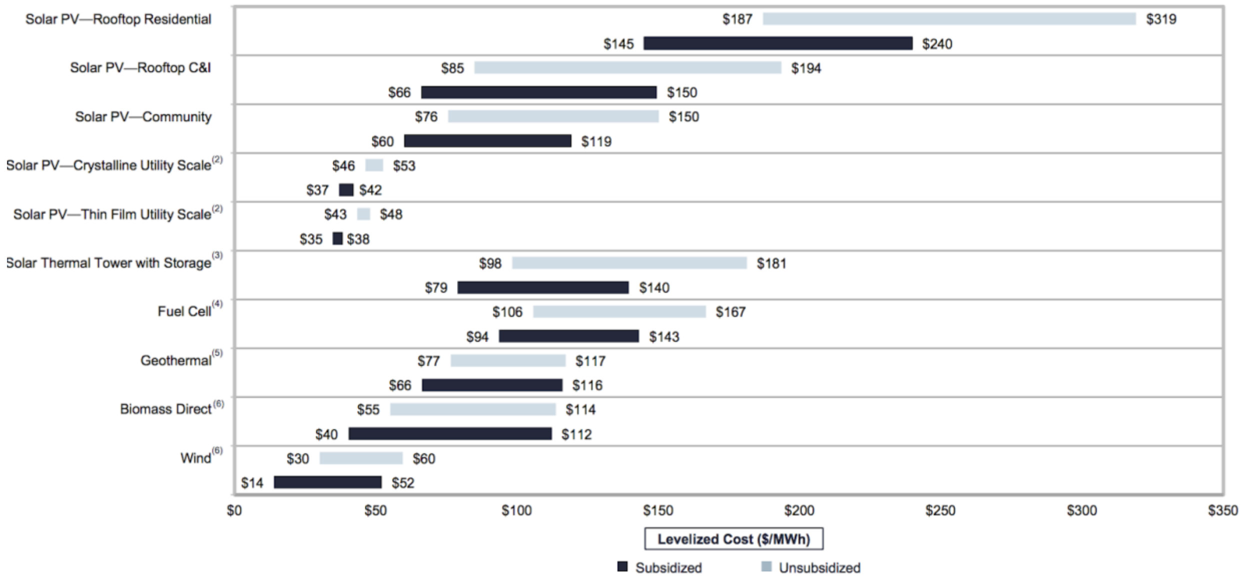
Lazard Associates develops an annual estimate of levelized cost of energy (LCOE) for a variety of generation technologies including wind energy, solar power, battery storage and others. In November 2017, Lazard Associates published its *Levelized Cost of Energy Analysis, Version 11.0*.[8] Costs are provided without subsidies or incentives, and are backwards looking, therefore the estimates used by Lazard should be evaluated and incorporated into the 2019 IRP as a current-year benchmark, with cost reductions and improvements projected for forecasts.

Current Renewable Energy Market

For wind and solar energy, Lazard's LCOE analysis is fairly straightforward. Unsubsidized utility-scale wind power prices likely range from $30-$60/MWh; adding the federal production tax credit reduces these prices to $14-$52/MWh. Unsubsidized utility-scale solar power prices likely range from $43-$53/MWh; adding the federal investment tax credit reduces these prices to $35-$42/MWh. Lazard did not include analysis of the impact of import tariffs on these prices. (See the "Tarrifs" section below for further discussion). There are technological, geographic, financial and other considerations that may slightly increase or decrease the overall LCOE for specific projects; however, Lazard's analysis should provide a clear set of bright-lines for current market benchmarks.

[8] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]

Figure 5. Subsidized and Unsubsidized Levelized Cost of Energy 2017



Source: Lazard Associates 2017[9]

Forward Projections

Over the last decade, wind energy and solar power prices have plummeted. According to Lazard Associates, wind energy prices have declined by 67% since 2009, while solar energy prices have declined by 86%.[10] The vast majority of subject matter experts agree that renewable energy resources are anticipated to continue to decline in the near-to-long terms. TVA's IRP modeling should reflect an anticipated decline in renewable energy costs over time.

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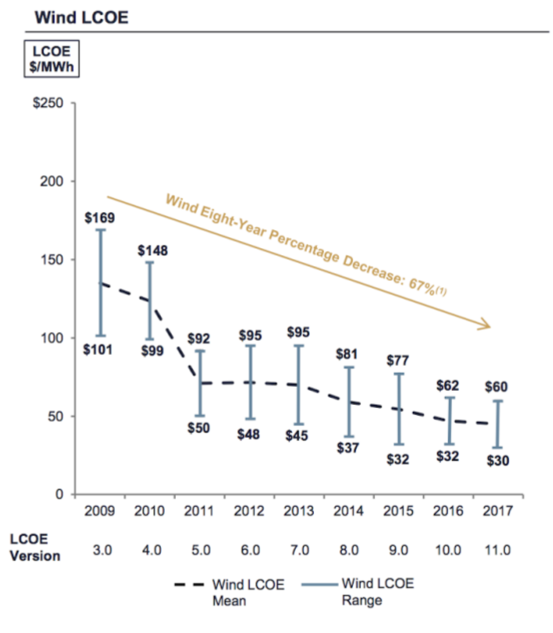
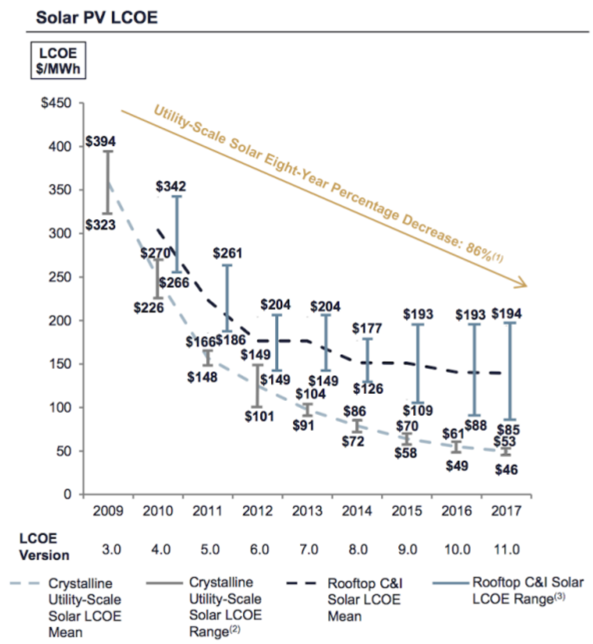
[9] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]
[10] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]

Figure 6. Unsubsidized Wind Energy and Solar Photovoltaic Levelized Cost of Energy (2009-2017)





Source: Lazard Associates 2017[11]

Federal Tax Credits

As stated in TVA's Security and Exchange Commission filings, "TVA is not subject to federal income taxation."[12] Additionally, "neither TVA nor its property, franchises, or income is subject to taxation by states or their subdivisions."[13] Other tax-exempt public power entities have structured power purchase agreements (PPAs) for wind and/or solar projects in order to enable monetization of federal tax credits. For TVA's 2019 IRP, the discussion below about tax equity is particularly relevant.

The federal Production Tax Credit (PTC) and Investment Tax Credit (ITC) are the primary incentives for the wind energy industry and solar energy industry, respectively. As a result of congressional action in 2015, the PTC and ITC are currently phasing-out. Renewable energy developers can qualify projects for specific PTC/ITC vintages by commencing construction in a particular year and bringing such project online within four calendar years. For example, a wind energy project that commences construction by the end of 2016 has until the end of 2020 to begin operation and still qualify for the full PTC. Renewable energy project developers frequently safe harbor qualified clean energy equipment, in anticipation of a future contract.

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[11] Lazard Associates (November 2017). Levelized Cost of Energy Analysis, Version 11.0. [https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf]

[12] Tennessee Valley Authority, 2017 Form 10-K

[13] *Id*; this section goes on to state that "Section 13 of the TVA Act, however, does require TVA to make tax equivalent payments to states and counties in which TVA conducts power operations or in which TVA has acquired properties previously subject to state and local taxation."

The PTC is awarded on a generation basis at a rate of $23/MWh for the first ten years of a project's operation. Because the PTC is a tax credit, it frequently exceeds a project developer's total tax liability causing developers to frequently monetize the PTC with tax equity. Tax equity erodes the full dollar value of the PTC. According to the Lawrence Berkeley National Lab (LBNL), a developer with a tax appetite can achieve a 100% PTC value reduction to $19.8/MWh.[14] For the ITC, the total credit amount is based on total expenditure, beginning with a credit for 30% of the total cost. The ITC will begin to decline in 2020. Most utility-scale solar energy projects elect to receive the ITC.

As shown by Lazard Associates, incorporating the federal PTC or ITC results in estimated LCOE's of $14-$52/MWh for wind energy and $35-$42/MWh for solar energy.

Figure 7. Schedule of PTC/ITC Project Qualification Commence Construction Dates

	2019	2020	2021	2022	2023	2024+
Wind PTC	$19.8/MWh	$19.8/MWh	$16.9/MWh	$14.2/MWh	$11.5/MWh	0
Solar ITC	30%	26%	22%	10%*	10%*	10%*
+Storage ITC	30%	26%	22%	10%*	10%*	10%*

** Residential = 0%*
Source: Adaptation from LBNL 2014[15]

Tariffs

In February 2018, tariffs were imposed on imported solar cells and modules. Modeling the impact of such tariffs in utility forecasting or resource planning, however, is exceptionally difficult. The tariffs, which expire in 2022, are set at 30%, declining 5% each year with 2.5 gigawatts of imports exempted and potential further exclusions. The tariffs also have a mid-term review, which will take place in early 2020. For impacted exporting countries, the World Trade Organization may offer a form of relief. Also, some solar cell and module companies may begin to ramp up domestic manufacturing.[16] In anticipation of the tariffs, a number of solar energy development companies began to stockpile pre-tariff cells and modules.[17] In the first year of the tariffs, industry experts estimate a negligible increase in the cost of module panels, due to the likelihood that any increase in demand resulting from this stockpiling activity would likely be equivalent to the increase in the costs of modules resulting from the tariff. Due to the complexity and ambiguity surrounding these solar tariffs,

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[14] Mark Bolinger (April 2014). "An Analysis of the Costs, Benefits, and Implications of Different Approaches to Capturing the Value of Renewable Energy Tax Incentives," Lawrence Berkeley National Lab.
[15] Mark Bolinger (April 2014). "An Analysis of the Costs, Benefits, and Implications of Different Approaches to Capturing the Value of Renewable Energy Tax Incentives," Lawrence Berkeley National Lab.
[16] Solar Energy Industries Association (January 2018). Section 201 Solar Tariffs. [https://www.seia.org/sites/default/files/2018-02/SEIA-Section201-Trade-Factsheet-Feb2018.pdf]
[17] Joe Ryan (September 12, 2017). "Solar Developers Hoard Panels as U.S. Tariff Threat Looms," Bloomberg. [https://www.bloomberg.com/news/articles/2017-09-11/solar-developers-hoarding-panels-as-threat-of-u-s-tariffs-looms]

TVA should not explicitly include these tariffs in its IRP model inputs. Any impacts may make their way into the modeling through the use of real world examples.

In March 2018, additional tariffs were announced for steel and aluminum.[18] Given the recentness of these new tariffs, significant changes to the original tariffs have already been made and will continue to be made. Given all power generators and facilities use significant quantities of steel and aluminum, these tariffs would cut across the entire power sector. Taking into consideration the uncertainty and complexity surrounding the steel and aluminum tariffs, TVA should not explicitly include these tariffs in its IRP model inputs. Just as with the solar module tariffs, potential impacts can enter the modeling assumptions via real world examples.

Real World Examples

Over the past year, several utilities have released renewable and/or storage system pricing information. TVA should include these real word examples in the benchmarking of its model input assumptions, particularly when looking at how renewable and storage costs will decline in the future.

In December 2017, Xcel Energy, a Colorado electric utility, published the results of its 2017 All-Source Solicitation request for proposals.[19] Xcel received over 400 bids representing more than 100,000 MW of capacity from a wide variety of technologies; however, most bids provided wind energy or solar power resources. The median bid price or equivalent for stand-alone wind energy resources was $18.10/MWh, suggesting a number of projects below and above that price. Adding battery storage to wind energy resulted in median bids of $21/MWh. For stand-alone solar energy resources, the median bid was $29.50/MWh. Adding battery storage to solar energy resulted in median prices of $36/MWh. While these particular prices may be specific to Xcel, that these resource prices represent real world project bids and are also aligned with projections by NREL's ATB, Lazard Associates, and these comments.

[18] United States Department of Commerce (March 18, 2018). "U.S. Department of Commerce Announces Steel and Aluminum Tariff Exclusion Process." [https://www.commerce.gov/news/press-releases/2018/03/us-department-commerce-announces-steel-and-aluminum-tariff-exclusion]

[19] Xcel Energy (December 28, 2017). 2016 Electric Resource Plan, 2017 All Source Solicitation 30-Day Report (Public Version) CPUC Proceeding No. 16A-0396E. [https://assets.documentcloud.org/documents/4340162/Xcel-Solicitation-Report.pdf]

Figure 8. Overview of Responses to Xcel 2017 All-Source RFP

RFP Responses by Technology

Generation Technology	# of Bids	Bid MW	# of Projects	Project MW	Median Bid Price or Equivalent	Pricing Units
Combustion Turbine/IC Engines	30	7,141	13	2,466	$ 4.80	$/kW-mo
Combustion Turbine with Battery Storage	7	804	3	476	6.20	$/kW-mo
Gas-Fired Combined Cycles	2	451	2	451	[redacted]	$/kW-mo
Stand-alone Battery Storage	28	2,143	21	1,614	11.30	$/kW-mo
Compressed Air Energy Storage	1	317	1	317	[redacted]	$/kW-mo
Wind	96	42,278	42	17,380	$ 18.10	$/MWh
Wind and Solar	5	2,612	4	2,162	19.90	$/MWh
Wind with Battery Storage	11	5,700	8	5,097	21.00	$/MWh
Solar (PV)	152	29,710	75	13,435	29.50	$/MWh
Wind and Solar and Battery Storage	7	4,048	7	4,048	30.60	$/MWh
Solar (PV) with Battery Storage	87	16,725	59	10,813	36.00	$/MWh
IC Engine with Solar	1	5	1	5	[redacted]	$/MWh
Waste Heat	2	21	1	11	[redacted]	$/MWh
Biomass	1	9	1	9	[redacted]	$/MWh
Total	430	111,963	238	58,283		

Source: Xcel Energy 2017[20]

Arizona's state utility regulator, the Arizona Corporation Commission (ACC), announced in March 2018 that it refused to acknowledge several electric utilities' IRPs.[21] ACC ordered that any future IRPs submitted by the offending utilities include evaluation of scenarios where:

1) no more than 20% of generation is from fossil fuels[22]
2) new natural gas power plants in excess of 150 MW are prohibited until 2019[23]
3) 1,000 MW of energy storage is developed in their next IRPs.[24]

Storage Costs

Energy storage is an increasingly important resource for consideration in power supply planning. Storage technologies have the capability to ease the integration of variable renewable resources onto the grid and provide valuable ancillary services traditionally provided by fossil fuel generators but without additional air and water pollution. There are a wide variety of storage

[20] Xcel Energy (December 28, 2017). 2016 Electric Resource Plan, 2017 All Source Solicitation 30-Day Report (Public Version) CPUC Proceeding No. 16A-0396E. [https://assets.documentcloud.org/documents/4340162/Xcel-Solicitation-Report.pdf]

[21] Arizona Corporation Commission (March 13, 2018). Commissioner Burns Proposed Amendment No. 1. [http://images.edocket.azcc.gov/docketpdf/0000186395.pdf]

[22] Arizona Corporation Commission (March 13, 2018). Commissioner Burns Proposed Amendment No. 2, Docket E-00000V-15-0094. [http://images.edocket.azcc.gov/docketpdf/0000186398.pdf]

[23] Arizona Corporation Commission (March 13, 2018). Commissioner Tobins Proposed Amendment No. 4, Docket E-00000V-15-0094. [images.edocket.azcc.gov/docketpdf/0000186484.pdf]

[24] Arizona Corporation Commission (March 13, 2018). Commissioner Tobins Proposed Amendment No. 3, Docket E-00000V-15-0094. [images.edocket.azcc.gov/docketpdf/0000186485.pdf]

technology options, from small and modular options like the many different types of batteries to large options like pumped hydro and flywheel technologies. It is critical that TVA's 2019 IRP include the latest cost figures and technology capabilities for a wide spectrum of these storage types.

Current Energy Storage Market

In November of 2017, Lazard published its *Levelized Cost of Storage Analysis, Version 3.0*.[25] Lazard Associates' estimated capital costs for various energy storage technologies as low as $1,152/kW in 2018. It is more difficult to assign a particular LCOE for energy storage solutions; not only because of the variety of technology (batteries, fly wheels, etc.) and rapidly declining prices, but because energy storage project finances are highly dependent on the type of services being provided. For example, Lazard Associates notes that, "Although energy storage developers/project owners often include Energy Arbitrage and Spinning/Non-Spinning Reserves as sources of revenue for commissioned energy storage projects, Frequency Regulation, Bill Management and Resource Adequacy are currently the predominant forms of realized sources of revenue."[26] For example, an energy storage project that predominately provides frequency regulation may appear to be exceptionally costly, on an LCOE basis, compared to a traditional power plant.; Such a facility, however, would be providing a highly valued service that may not be accurately reflected in current integrated resource planning processes, models, or specific utility markets.

The design of an energy storage project can also vary based on the specific services desired. For example, a recent presentation by GTM Research showed four-hour and eight-hour energy storage resources compared to peaking power resources. The researchers found that 82% of planned future peaking plants would be at risk of being uneconomic when compared to eight-hour storage projects (e.g., 100 MW/800 MWh).[27]

Due to limitations in resource planning practices, LCOE or even capital costs alone will not adequately assess the full benefits of energy storage. TVA should explore additional models or methodologies that better reflect the value of storage on the grid in their 2019 IRP process.

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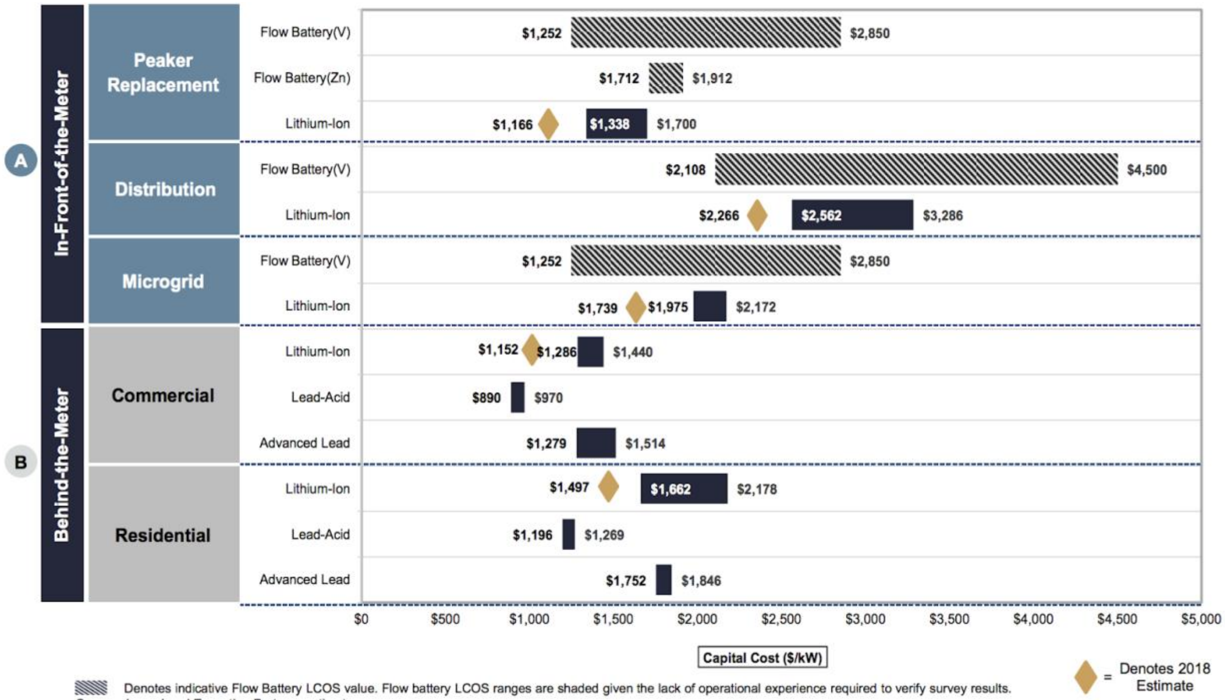
[25] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]
[26] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]
[27] Ravi Manghani (March 2018). "Will Energy Storage Replace Peaker Plants?" GTM Research. [https://d3v6gwebjc7bm7.cloudfront.net/event/15/88/96/3/rt/1/documents/resourceList1519927946005/willenergystoragereplacepeakerplantswebinarslides1519927951937.pdf]

Figure 9. Unsubsidized Energy Storage Capital Costs ($/kW)



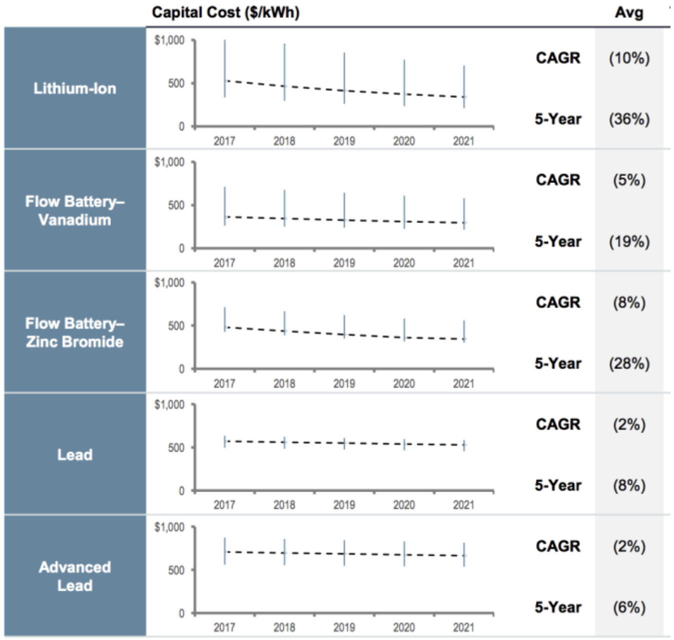
Source: Lazard Associates 2017[28]

Forward Projections

Energy storage projects, especially battery storage resources, are expected to rapidly decline in cost, with a trajectory similar to that of renewable energy technology costs. Additionally, new energy storage projects can also qualify for the ITC (discussed in detail in the "Renewable Energy" section above), provided that those projects are added to new or existing wind or solar energy projects. Currently, stand-alone energy storage projects do not qualify for the federal ITC.[29]

[28] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]
[29] Heather Cooper (November 15, 2017). "Add batteries to your wind farm and get more (ITC) juice," McDermott Will & Emery. [https://www.mwe.com/en/thought-leadership/publications/2017/11/add-batteries-to-wind-farm-get-more-juice]

Figure 10. Storage Cost Projections



Source: Lazard Associates 2017[30]

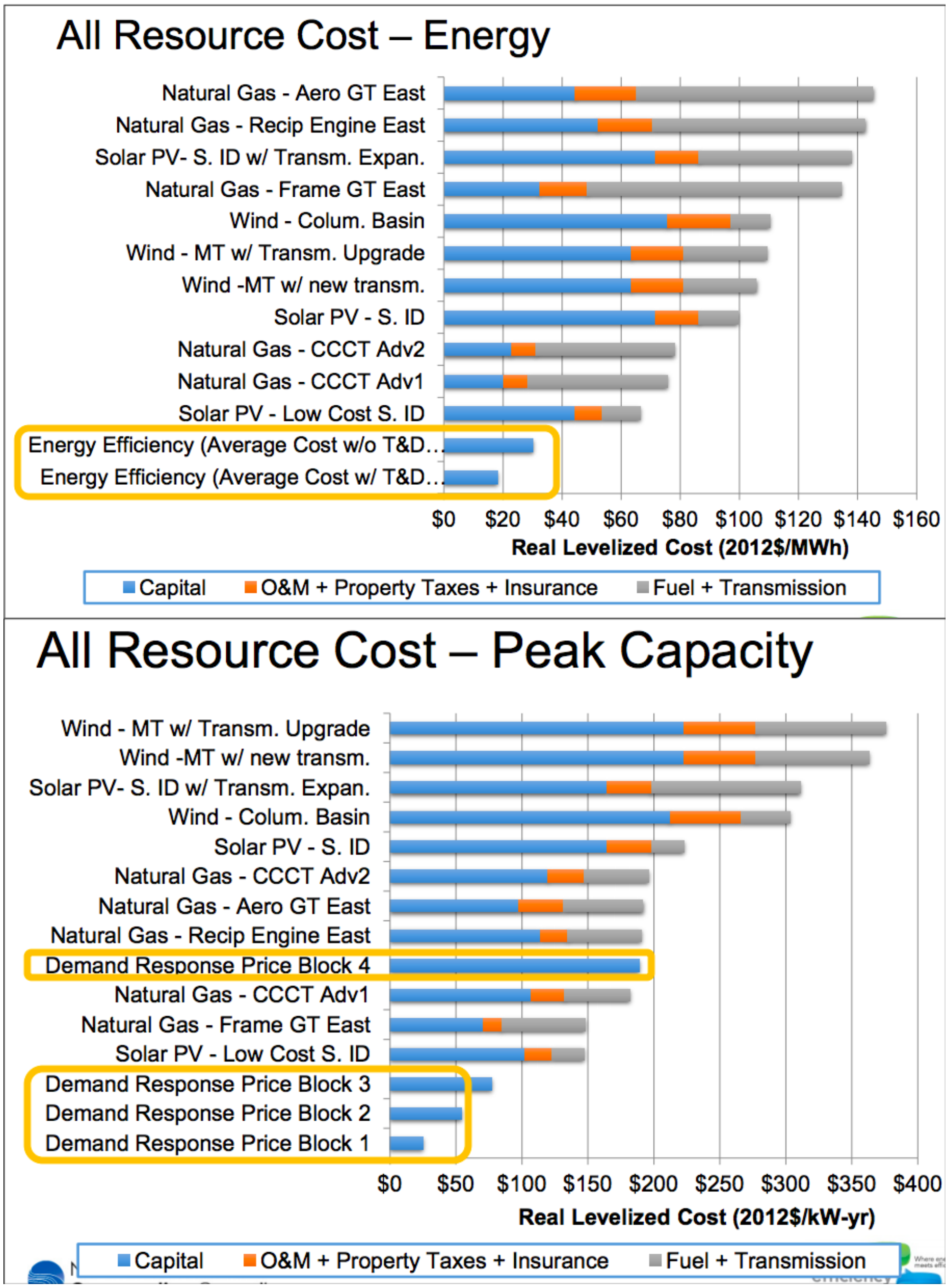
Storage provides benefits that are not captured in the traditional resource planning modeling, where the most granular resource evaluation occurs at the hourly basis. TVA's modeling for the 2015 IRP used a "representative hours" approach. Storage, besides pumped hydro, is a newer resource and power resource planning models were not designed with it in mind. Various industry players have developed "sub-hourly" modeling to evaluate the specific benefits, costs, and operations of different storage technologies, specifically for integration into resource planning. In order to meet current best practices, TVA should include sub-hourly modeling in its 2019 IRP.

Energy Efficiency Costs

Energy efficiency represents another area where TVA should look to its peer in the northwest: BPA. As discussed previously, BPA's resource plans are developed by the Northwest Power and Conservation Council (NPCC). The NPCC includes cost curves for both energy efficiency as an energy resource and demand response (DR) as a peak capacity resource. A snapshot comparing these levelized cost assumptions to those of generation resources is shown in the charts below.

[30] Lazard Associates (November 2017). Levelized Cost of Storage Analysis, Version 3.0. [https://www.lazard.com/media/450338/lazard-levelized-cost-of-storage-version-30.pdf]

Figure 11. Levelized Energy and Capacity Costs by Resource in Seventh Northwest Power Plan



Source: NPCC 2016[31]

The NPCC methodology breaks energy efficiency into a number of measure bundles across several sectors - each with its own assumptions on cost curves, potential, and load shape. These provide exponentially more detail than the "block" approach used by TVA used to model energy efficiency in its 2015 IRP, which lumps together all measures by sector.

[31] NPCC (April 2016). *Energy Efficiency in the Seventh Northwest Power Plan*, a presentation at the Efficiency Exchange conference. [https://www.nwcouncil.org/media/7150202/efficiency7thplan.pdf]

Figure 12. Energy Efficiency Measures Modeled in the Seventh Northwest Power Plan

Residential	
End-use	**Measure Bundle(s)**
Dryer	Heat pump clothes dryer
Electronics	Monitor
	Desktop
	Laptop
	Advanced power strips
HVAC	Controls, Commissioning, &
	Duct Sealing
	Ductless heat pump
	DHP with ducted system
	Ground-source heat pump
	Heat recovery ventilation
	Weatherization (Insulation +
	Air-source heat pump conversion
	ASHP upgrades
	Variable-capacity heat pump
	WiFi enabled thermostats
Lighting	LED lighting
	LED lighting – pre-2020
	Linear fluorescent lighting
Refrigeration	Refrigerator
	Freezer
Water Heating	Aerator
	Clothes washer
	Dishwasher
	Wastewater heat recovery
	Heat pump water heater
	Showerheads
	Solar water heater
Whole Bldg/ Meter Level	Behavior/Controls
	Electric vehicle supply
Food Preparation	Microwave
	Electric oven

Industrial	
End-use	**Measure Bundle(s)**
Air Compressor	Demand Reduction
	Air Compressor Equipment
	Air Compressor Management
Lighting	HighBay Lighting
	Lighting Controls
Motors	Efficient Rewind VSD Controls
	Motor Management Program
Fans	Fan Efficient Centrifugal
	Food: Fans and Blowers
	Other: Fans and Blowers
	Fan ASD Control
Pumps	Premium Pump
	Pump ASD Control
Food	Cooling and Storage
	Refrigeration Storage O&M
Metal	New Arc Furnace
Paper	Medium Consistency Pump
	Mech Pulp: Refiner Replacement
	Mech Pulp: Premium Process
	Mech Pulp: Refiner Plate Improvement
	Kraft Pulp: Effluent Treatment
	Kraft Pulp: Efficient Agitator
	Efficient Pulp Screen
	Premium Fan
	Material Handling
Wood	Replace Pneumatic Conveyor
	Hydraulic Press
Cold Storage	Retrofit
	Tuneup
	Fruit Storage Refer Retrofit
	Fruit Storage Tuneup
CS Retrofit	CO2 Scrub
	Membrane
Grocery	Dist Retrofit & Tuneup

Commercial	
End-use	**Measure Bundle(s)**
Compressed	Compressed Air
Electronics	Data Centers
	Desktop
	Laptop
	Monitor
	Smart Plug Power Strips
Food Preparation	Cooking Equipment
	Pre-rense Spray Valve
HVAC	Advanced Rooftop Controller
	Commercial Enery Management
	DCV Parking Garage
	DCV Restaurant Hood
	DCV Buildings
	Ductless Het Pumps
	Economizer
	Premium Fume Hood
	Secondary Glazing Systems
	Variable Speed Chiller
	Variable Refrigerant Flow
	Web-Enabled Programmable Thermostats
Lighting	Bi-Level Stairwell Lighting
	Exterior Building Lighting
	LEC Exit Sign
	Lighting Controls Interior
	Low Power LF Lamps
	Lighting Power Density
	Parking Garage Lighting
	Street and Roadway Lighting
Motors/Drives	ECM-Variable Air Volume
	Motors Rewind
Process Loads	Municipal Sewage Treatment
	Municipal Water Supply
Refrigeration	Grocery Refrigeration Bundle
	Water Cooler Controls
Water Heating	Water Heater Tanks
	Showerheads
	Clothes Washer

Agriculture	
End-use	**Measure Bundle(s)**
Lighting	Dairy lighting
	Outdoor barn lighting
Dairy	Vacuum pump
	Plate milk pre-cooler
	Heat recovery ventilation
Irrigation Water	Scientific Irrigation Scheduling
	Low-energy spray application
Irrigation hardware	Green motor rewind
	Replace/rebuild nozzles/gaskets/pipes
	Convert high/med pressure to low pressure

Distribution
Measure Bundle(s)
CVR
Reconductoring
VAR management
Phase load balancing
Feeder load balancing
Voltage regulators
EOL and LDC voltage control

Source: NPCC 2016[32]

In its 2015 IRP, TVA assumed energy efficiency costs would increase with increased penetration, despite the lack of adequate evidence of such a trend. An example contrary to TVA's assumption is the reduction in costs of LED lighting as the technology has become increasingly mainstream in recent years. TVA's 2019 IRP risks being inaccurate if it does not include some level of technological and cost improvements in its forecast for EE costs.

Planning Capacity Value

Stand-alone solar and wind resources are intermittent, but storage technologies currently being deployed are smoothing the dips and peaks in the output of these resources while not changing their overall capacity factor. Despite the intermittent nature of solar and wind resources, it is crucial that the ability of solar and wind to provide power during peak hours is properly quantified in the 2019 IRP. In a planning process, system planners (utilities and ISOs) account for the benefits solar and wind provide during peak hours by "derating" these resources based on a percentage of their "nameplate" capacity value – known as the planning capacity value. This derating varies regionally and depends on regional climate and system specifications. The on-peak availability of wind and solar is continuing to increase as operators gain experience with these technologies.[33] TVA should recalculate the capacity values for solar and wind used in the 2015 IRP in order to ensure they reflect the latest operational experience and technological advances. The capacity value for each generation technology should represent its availability during peak hours.

Cost Forecasts

One of the most important input metrics of any IRP are resource cost forecasts. TVA's 2019 IRP must include the latest price forecasts for coal, nuclear, hydro and natural gas, as well as for wind, solar and other renewable resources. The latest data on the cost of energy efficiency as a resource also should be used in the process. In the past, U.S. Energy Information Administration data have been unreliable as sole cost estimates. Better resources for renewable project costs in particular are discussed in a previous section.

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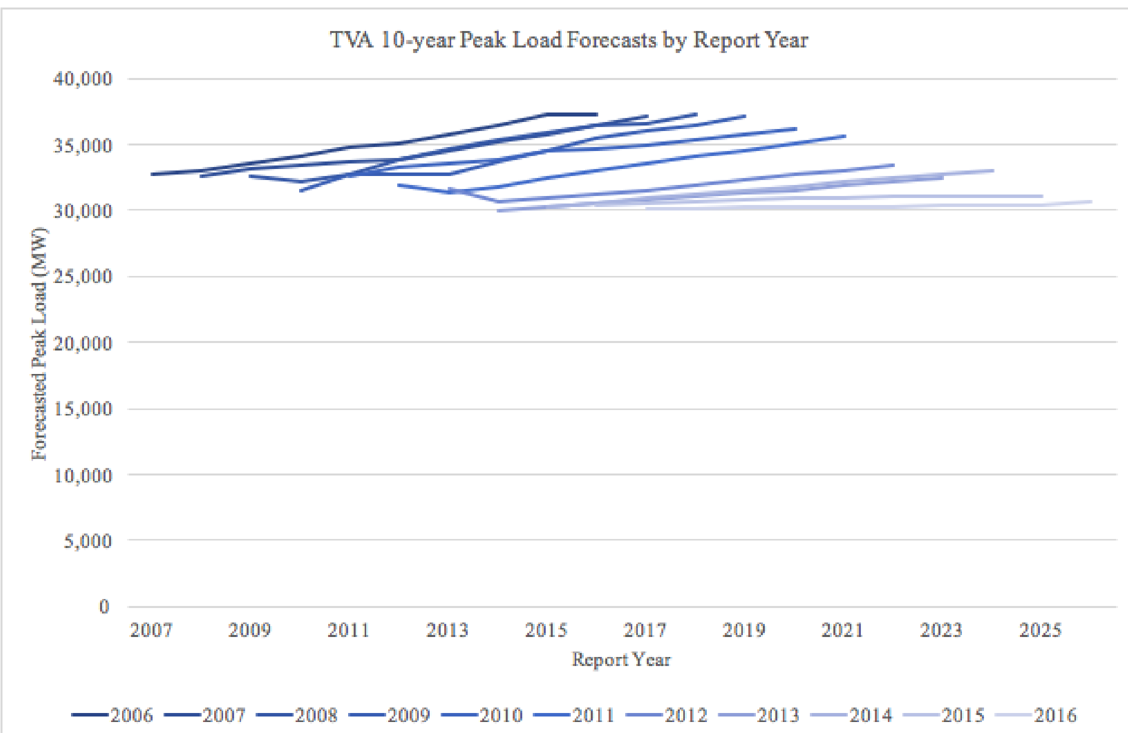
[32] NPCC (April 2016). *Energy Efficiency in the Seventh Northwest Power Plan*, a presentation at the Efficiency Exchange conference. [https://www.nwcouncil.org/media/7150202/efficiency7thplan.pdf]
[33] NERC (March 1, 2018) Long-term Reliability Assessment. [https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_12132017_Final.pdf]

Load Forecasts

Load growth trends have shifted dramatically compared to where they were 20 years ago. 2017 saw the largest drop in electricity sales since the Recession.[34] It is no longer common practice across the electricity industry to assume electricity use grows at a flat rate each year or that growth is tied directly to GDP and/or population growth. For example, PJM's 2013 Load Forecast Report included an annual growth rate of 1.3% whereas its 2017 Load Forecast Report included an annual growth rate of 0.2%, with many transmission owners reporting flat or negative load growth.[35] Factors influencing load growth include pushing load in both directions. For example, customers are reducing their load through distributed energy resources (DERs) like energy efficiency and distributed generation while also increasing their load by adopting electrification technologies like electric vehicles (EVs) (discussed further in a later section). Electric vehicle adoption is increasing and will have an impact on future load and load shapes in the region.

Figure 13. Historical TVA Load Forecast Growth Rates



Source: TVA 10-year Load Forecasts by Report Year

[34] EIA (April 3, 2018). "In 2017, U.S. electricity sales fell by the greatest amount since the recession" Today in Energy. [https://www.eia.gov/todayinenergy/detail.php?id=35612]
[35] PJM (August 3, 2017). *2017 RTEP Process Scope and Input Assumptions White Paper*. [https://www.energy.gov/sites/prod/files/2017/09/f36/2017%20RTEP%20Input%20Assumptions%20%26%20Scope%20Whitepaper_1.pdf]

Economic development activities not only influence load growth projections, but the generation resource profile, as well. And conversely, the resource profile can influence economic development activity and, hence, load growth. As further elaborated on page 6, a growing number of entities, from large corporations and manufacturers to retailers and government facilities, have stated renewable energy goals and/or have joined networks to push for renewable energy options. Access to renewable energy is a consideration for where these organizations establish or expand operations, and increase electrical load.

The NPCC holds the efficiency of appliances steady in its load forecasting in order to include energy efficiency and conservation as a resource in its resource planning model. In the latest resource plan, the Seventh Power Plan, the Council forecasts an average annual growth rate of 0.5-1.0% over the 2015-2035 timeframe *before* any energy efficiency and conservation.[36] NPCC has been a model of how to incorporate energy efficiency effectively into a resource planning framework. TVA should explore the methodologies used by the NWPP for both load forecasting and energy efficiency modeling and adapt them to the TVA framework.[37]

Coal Retirements

Coal-fired power plants are quickly becoming an antiquated means of generating electricity. They are expensive, dirty, and old. TVA has retired several coal units in recent years, following an international trend of movement away from coal as a generating fuel. Economics remains the main driver of coal retirements, though the economics are made worse for coal plants when regulations force plant owners to pay to clean up some of the damage their resources have caused for human health and the environment.

TVA still has seven active coal plants in its fleet. All analysis in the 2019 IRP should include an assumption that TVA retires at least half of its coal capacity by the end of the study period. Additional coal retirements should be included as an option in the greenhouse gas target and utility of the future strategies, discussed further below.

Nuclear

TVA's resource planning must include the latest real-world examples of nuclear project risk, including both cost overruns and delays as well as the likelihood of projects actually coming online. In addition, the 2019 IRP should consider the cost-effectiveness of continued investments in Small

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[36] Northwest Power and Conservation Council (April 4, 2016). *Seventh Power Plan, Appendix E: Load Forecast*. [https://www.nwcouncil.org/media/7149913/7thplanfinal_appdixe_dforecast.pdf]

[37] Details of the Plan and methodology are on the NPCC's website: https://www.nwcouncil.org/energy/powerplan/, and their resource planning model can be run on the website: https://www.nwcouncil.org/energy/rpm/rpmonline.

Modular Reactors (SMRs). TVA's resource plan should evaluate the benefits to customers and Valley residents of halting SMR investments and using those funds for energy efficiency, renewable energy, and storage resources in the region.

Scenarios and Strategies

TVA's previous IRPs have used scenarios and strategies to inform resource planning decisions. Generally, scenarios describe potential external forces that could impact the TVA system and strategies refer to actions TVA could take to capture opportunities or address challenges within those scenarios.

SACE is proposing that TVA include at least the following 3 scenarios and 4 strategies in its 2019 IRP.

Figure 14. SACE Proposed Scenarios and Strategies

Scenarios	Strategies
Renewable Energy	Renewable Energy
Carbon Policy	Energy Efficiency
Electrification	Greenhouse Gas Targets
	Utility of the Future

Scenarios

An IRP is only valuable if it looks at a variety of likely futures and bases its most likely future in reality. TVA's base scenario should look to the future and be driven by current industry trends, not by history. Just because electricity consumption grew from 1900 to the mid-2000's does not mean that trend will continue in the same direction or order of magnitude. It is of the utmost importance that TVA's base case represent a realistic story based in current reality and not the future that utility executives would like to have.

Utility resource plans tend to look out at least ten years. Ten years ago, distributed solar payback periods were 30 years, no one had heard of LEDs, natural gas prices were over $6/MMBtu (nominal) and predicted to rise, and the economy was in free-fall. It is always difficult to predict the future of this industry, and no one ever gets it exactly right. That is why variety is an important risk-mitigating tool in resource planning. What will change in the next 10 years that we are not even considering?

Bonneville Power Administration (BPA) is the closest TVA has to a peer. BPA tried to build 3 nuclear power plants in the 1970s based on faulty load growth forecasting, none were built but BPA customers are still paying off the debt for that major blunder. In response, in 1980 Congress put in place legislation to form the Northwest Power and Conservation Council (NPCC). One of the primary responsibilities of the NPCC is develop a long-term resource plan for the region every 5 years. In its most recent plan, the Seventh Power Plan, the Council looked at over two dozen scenarios, including:

- Existing Policy
- Social Cost of Carbon
- Retire Coal
- Retire Coal and Inefficient Gas
- Retire Coal & Impose Social Cost of Carbon
- Retire Coal & Impose Social Cost of Carbon & No New Gas
- Regional RPS @ 35%
- No Demand Response
- Increase Market Reliance
- Lower Conservation

One important takeaway from the NPCC's resource planning scenarios is the large number (over 24). Another is that they combined several scenarios to explore a variety of potential futures. For instance, they not only looked at a coal retirements scenario and a carbon cost scenario separately, but also evaluated what would happen if these two futures occurred together. This layering is important for understanding future risks in an industry as interconnected as the energy sector.

TVA Scenarios Should Focus on Generation

In its 2015 IRP, TVA evaluated five scenarios.

Figure 15. Scenarios from TVA 2015 IRP

Scenarios	Key Characteristics
1 - Current Outlook	The outlook for the future which TVA is currently using for resource planning studies
2 – Stagnant Economy	Stagnant economy results in flat to negative growth, delaying the need for new generation
3 – Growth Economy	Rapid economic growth translates into higher than forecasted energy sales and resource expansion
4 – De-Carbonized Future	Increasing climate-driven effects create strong federal push to curb greenhouse gas emissions; new legislation caps and penalizes CO_2 emissions from the utility industry and incentivizes non-emitting technologies
5 – Distributed Marketplace	Customers' awareness of growing competitive energy markets and the rapid advance in energy technologies produce unexpected high penetration rates in distributed generation and energy efficiency. TVA assumes responsibility to serve the net customer load (no backup for any customer-owned resources)

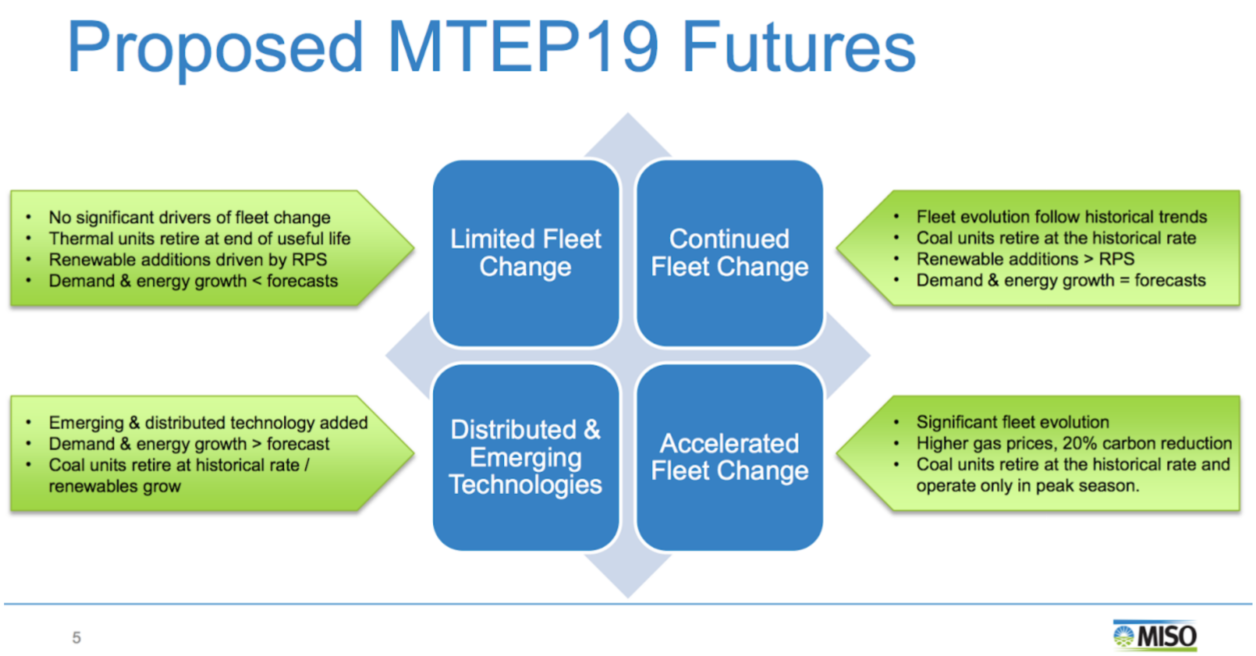
Figure 6-2: Scenario Key Characteristics

Source: TVA 2015 IRP

Generally, three scenarios evaluated were load-focused ("Current, Stagnant Economy" and "Growth Economy"), while two scenarios were generation-focused ("Decarbonized Future" and "Distributed Marketplace"). However, TVA has notified stakeholders that it anticipates relatively flat to declining load growth over the time frame covered by the 2019 IRP. Given that projections for load are anticipated to be flat to declining, evaluating multiple scenarios based on large changes in load scenarios is unrealistic and not useful. Instead, TVA should evaluate potential different load forecasts in the sensitivity analysis piece of the 2019 IRP.

MISO has abandoned evaluating futures based predominantly on load projections and instead focuses more heavily on generation projections. For example, MISO evaluates four futures in their 2019 MISO Transmission Expansion Plan (MTEP19) including scenarios for Limited Fleet Change, Continued Fleet Change, Distributed & Emerging Technologies and Accelerated Fleet Change.

Figure 16. Proposed Scenarios in MISO's 2019 MTEP



Source: MISO 2018[38]

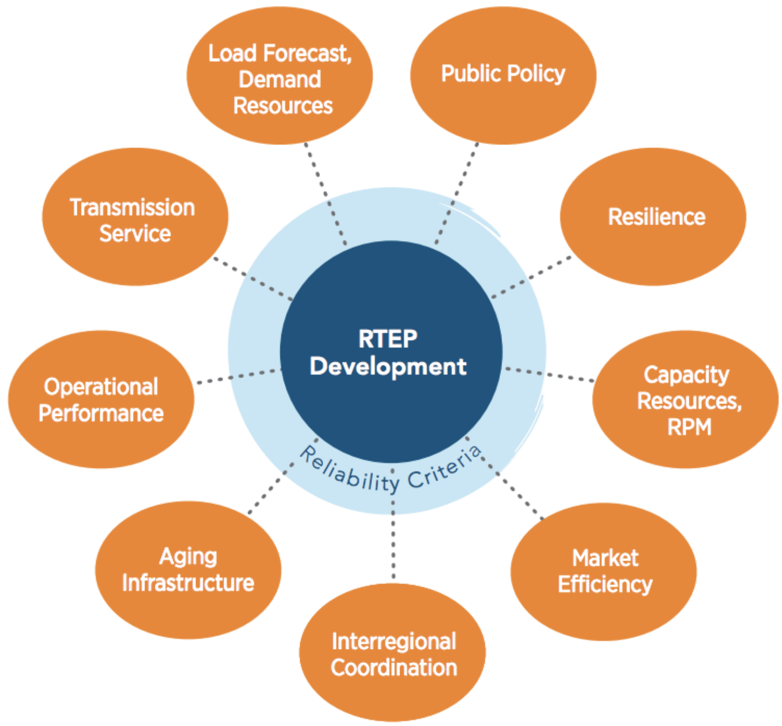
Similarly, PJM has abandoned focusing heavily on load scenarios for its planning purposes. PJM states that,

> "During the first ten years since its inception in 1997, PJM's RTEP process generally found that the magnitude of uncertainty regarding future system conditions driving transmission need was limited to fewer major variables than today. Transmission expansion plans were mainly driven by load growth and generating resource interconnection requests. RTEP process tests could reasonably determine the expected date of future reliability violations with minimal risk of fluctuation. Now, however, a single set of RTEP baseline and market assumptions is simply not sufficiently flexible to consider all possible impacts of system enhancement drivers...Today, such external factors as public policy, regulatory action, fuel economics and operational performance are examined as part of PJM scenario studies (and in a number of cases, interregional studies). They provide valuable long-term expansion planning insights beyond those obtained from conventional baseline and market efficiency analyses."[39]

[38] Midcontinent Independent System Operator (March 20, 2018). MTEP19 Futures Development Workshop. [https://cdn.misoenergy.org/20180320%20MTEP19%20Futures%20Workshop%20Presentation150635.pdf]
[39] PJM (February 28, 2018). 2017 PJM Regional Transmission Expansion Plan. [pjm.com/-/media/library/reports-notices/2017-rtep/2017-rtep-book-2.ashx?la=en]

Figure 17. PJM RTEP Drivers

Figure 8.1: System Expansion Drivers



Source: PJM 2018[40]

Because both MISO and PJM planning exercises focus heavily on factors beyond a utility's load, TVA should develop scenarios that capture broader factors that will affect its operations in the years to come. For example, TVA should develop scenarios that evaluate:

- Earlier and later retirements for existing thermal generation;
- Baseline renewable energy and energy storage cost reductions (such as provided by the NREL ATB) and more aggressive cost reductions;
- Generic cost increases for existing fleet operations, which may be represented as additional environmental regulation or increased fuel costs;
- Anticipated DER deployment and a more aggressive outlook, including energy efficiency, small scale solar, commercial and industrial solar, electric vehicles and small scale battery storage; and
- Increased LPC control over generation procurement, up to 20% of TVA's total load.

Renewable Energy Scenario

IRP modeling should examine expanded renewable energy penetration at all scales: residential, commercial/industrial, community, and utility-scale.

[40] PJM (February 28, 2018). 2017 PJM Regional Transmission Expansion Plan. [pjm.com/-/media/library/reports-notices/2017-rtep/2017-rtep-book-2.ashx?la=en]

Distributed Solar

Just as with EVs, distributed solar occurs outside of TVA's immediate control and can serve as a strategy to take advantage of opportunities or address particular challenges. Forecasting future levels of distributed solar presents challenges similar to those experienced with EV forecasting. The ability to accurately forecast distributed solar resources depends on technological and economic factors that are expected to change continually for the foreseeable future as well as on customer behaviors. For its 2019 IRP, TVA should evaluate a variety of distributed solar penetration scenarios *prior* to including any distributed solar in its strategies. As with EVs, TVA could leverage outside expertise to develop a region-specific forecast or it could look to the many expert-driven forecasts being developed on a regular basis.

GTM Research, now a part of the specialized consulting firm Wood Mackenzie, and the Solar Energy Industries Association (SEIA) put out quarterly reports on both the current state and future forecast for solar energy by segment and state.[41] Navigant Research puts out regular reports on distributed solar[42] and distributed solar-plus-storage.[43] The National Renewable Energy Laboratory (NREL) has developed a Distributed Generation Market Demand Model (dGen) - "a geospatially rich, bottom-up, market-penetration model" that simulates DER adoption in the continental US through 2050. TVA could work with NREL to apply its assumptions to the dGen model and develop a set of region-specific DER penetration forecasts for use in 2019 IRP scenarios.

Corporate and Military Renewable Procurement

A growing number of entities, from large corporations and manufacturers to retailers and government facilities, have explicit renewable energy goals and/or have joined networks to push for renewable energy options in a coordinated way. The Business Renewables Center, an initiative of the Rocky Mountain Institute, currently has 230 members, while the Ceres BICEP network has 41 members. In total, 131 companies have pledged to go 100% renewable through the RE100. Due to the current, and likely future, increase of corporate and military renewable goals, it is imperative that TVA include scenarios with different levels of achievement for existing goals as well as scenarios where additional companies and entities develop renewable goals. These metrics are separate from the distributed solar example, described above, as renewable resources used by these companies are likely

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[41] GTM Research and SEIA (2017). *U.S. Solar Market Insight*. [https://www.greentechmedia.com/research/subscription/u-s-solar-market-insight]
[42] Navigant Research (May 2017). *The Annual Installed Capacity of Global Distributed Solar PV is Expected to Exceed 429 GW by 2026*. [https://www.navigantresearch.com/newsroom/the-annual-installed-capacity-of-global-distributed-solar-pv-is-expected-to-exceed-429-gw-by-2026]
[43] Navigant Research (April 2018). *Distributed Solar PV Plus Storage Energy Systems, Q1 2017*. [https://www.navigantresearch.com/research/distributed-solar-pv-plus-energy-storage-systems]

to include medium and large-scale solar, portions of utility-scale wind and solar projects and imported solar and wind.

Figure 18. Snapshot of Corporate Renewable Energy Goals from TVA

Source: TVPPA Rates & Contracts meeting, March 21, 2017

According to the Renewable Energy Buyers Alliance (REBA), the "C&I market is now around five GW of contracted wind and solar power, with commercial customers intending to procure an additional 60 GW by 2025."[44] TVA's 2019 IRP modeling should examine expanded renewable energy penetration at all scales: residential, commercial/industrial, community and utility-scale.

Carbon Policy Scenario

Enforceable federal regulation of greenhouse gas emissions from electric generating units has been eminent twice in the last decade – once, in 2010, when cap-and-trade legislation narrowly missed passage in the Senate and again, in 2015, when the Environmental Protection Agency promulgated a regulation under the Clean Air Act known as the Clean Power Plan (CPP). The number of states that regulate carbon emissions continues to grow. It is more likely than not that greenhouse gas emissions from TVA's power plants will be regulated within the next 20 years, if not sooner.

The most common way to include the impact of a carbon policy in future utility planning is by including a cost on carbon emissions when modeling the system. Utilities across the country

[44] Retail Industry Leaders Association, RILA (January 2017). *Corporate Clean Energy Procurement Index*.

consistently include a carbon price when evaluating future planning decisions, either as the base case or as a scenario. Additionally, companies beyond the power sector are including a cost on carbon emissions in their own future planning processes. TVA risks being unprepared for the likely regulation of carbon emissions from the power sector, should it fail to develop a Carbon Policy scenario that uses transparent policy assumptions in its 2019 IRP. The projected impacts of a carbon regulated future can be based on the Paris Agreement, or other regional plans such as the California and Regional Greenhouse Gas Initiative programs.

Although the CPP represents another data set from which TVA could borrow carbon policy impact assumptions, SACE does not recommend TVA use the CPP for its 2019 IRP. The state carbon emission reduction targets outlined in the CPP too low – with market forces already driving states to meet or exceed CPP targets – and do not meet the United States' pledge under the Paris Agreement. A future carbon policy is likely to be much stricter than the CPP. The Social Cost of Carbon (SCC) is similarly inappropriate for use in the 2019 IRP. The SCC is designed to measure the magnitude of the economic externality of the economic impacts of climate change for one ton of carbon dioxide. The cost to reduce emissions is a different calculation.

Electrification Scenario

Electric vehicles adoption rates are already increasing - but what if this trend increases further and expands beyond transportation? Electric heating is already common in some parts of TVA's service territory. Electric vehicle ownership is growing in particular areas as well. Most of the push for adoption of these technologies should come from LPCs, many of which have already launched programs to encourage efficient technologies. To reflect a future with increased electrification across various sectors, TVA should explore a scenario in its 2019 IRP where LPCs quickly ramp up support for all kinds of electrification, combined with potential electrification at TVA's industrial direct-serve customers. TVA should use a recent inform the assumptions on transportation electrification, see the resources listed in the Electric Vehicles Strategy section below. For additional resources on electrification rates and impacts, TVA should use a report recently published by LBNL.[45] The report includes technical and economic potential calculations.

[45] LBNL (March 2018). *Electrification of buildings and industry in the United States: Drivers, barriers, prospects, and policy approaches*. [http://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf]

Strategies

Any IRP is not complete unless all realistic future options are considered. This is where TVA's strategies come in. It is vital that TVA's strategies include a full mix of resource options and must incorporate the true and complete costs of the resources involved.

Renewable Energy Strategy

The "Renewable Energy Strategy" in TVA's 2015 IRP was based on an insignificant renewable energy target giving it included existing large hydropower. Since the last IRP, TVA has fallen farther and farther behind other Southeastern utilities when it comes development of renewable energy. Using significant renewable targets for any 2019 IRP renewable energy strategy represents best practices. TVA should not allow these targets to be met with existing hydro (as is standard practice when implementing renewable targets across the country).

In its 2015 IRP, TVA identified a number of paths for incorporating significant quantities of both wind energy and solar power. To date, TVA has made little effort in implementing its 2015 IRP with regards to renewable energy. Specifically, TVA stated its plan would:

- Wind: "Add between 500 and 1,750 MW by 2033, depending on pricing, performance, and integration costs. Given the variability of wind selections in the scenarios, evaluate accelerating wind deliveries into the first 10 years of the plan if operational characteristics and pricing result in lower-cost options."

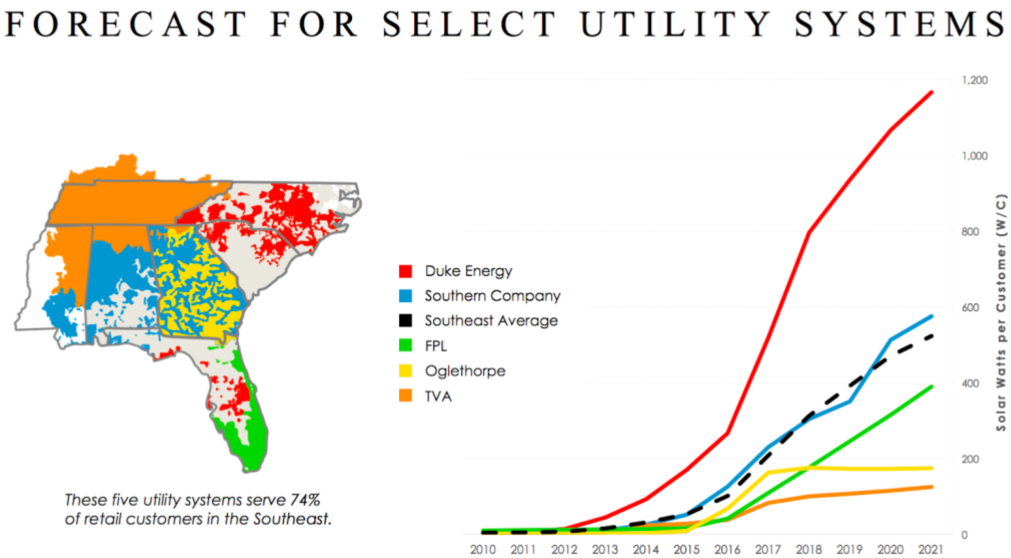
- Solar: "Add between 150 and 800 MW of large-scale solar by 2023, and between 3,150 and 3,800 MW of largescale solar by 2033. The trajectory and timing of solar additions will be highly dependent on pricing, performance and integration costs."[46]

From 2015-2017, TVA added approximately 200 MW of utility-scale solar, plus 50 MW of distributed energy solar. During that period TVA's wind portfolio actually shrank from approximately 1,540 MW to 1,240 MW (including approximately 30 MW of in-state, Tennessee, wind) when a 300 MW wind energy contract expired.

When compared on a watts per customer (W/C) basis, TVA significantly lags other utilities. The following graph compares that solar ratio for the five largest utility systems in the Southeast.

[46] Tennessee Valley Authority (March 2015). Integrated Resource Plan. [https://www.tva.com/file_source/TVA/Site%20Content/Environment/Environmental%20Stewardship/IRP/Documents/2015_irp.pdf]

Figure 19. Solar Watts per Customer for Select Southeast Utilities



Source: SACE Solar Report, December 2017

Quantity wise, TVA has more wind in its portfolio than any other utility in the Southeast: 1,240 MW (approximately 6% of TVA's capacity). As with solar, however, when compared on a watts-per-customer basis, TVA is not a Southeastern leader in wind energy. TVA's wind ratio computes as 264 W/C. In contrast, Gulf Power has more than double that ratio (600 W/C) thanks to wind contracts for 272 MW of wind (or 10% of Gulf's capacity).

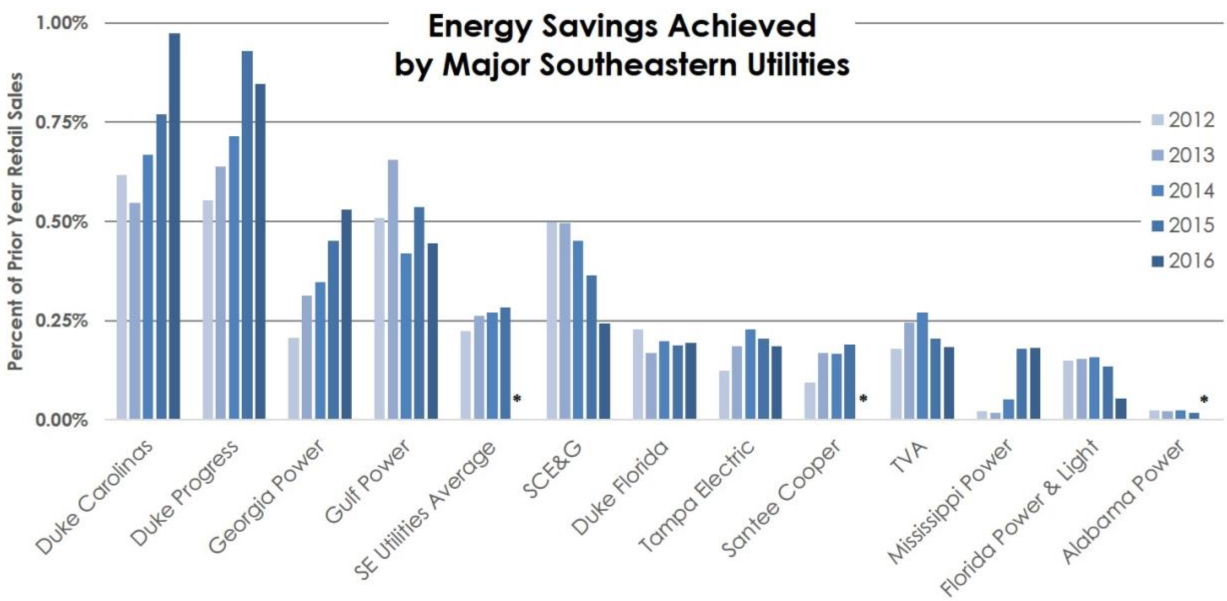
Energy Efficiency and Demand Response Strategy

Almost a decade ago, TVA's 2011 IRP promised to make the utility "a regional leader in energy efficiency." In its 2015 IRP, however, TVA drastically cut its energy efficiency targets. In its 2015 IRP, TVA purported to model energy efficiency as a resource in its resource planning methodology. While this is technically true, in reality, TVA effectively blocked energy efficiency improvements by using unrealistic assumptions for energy efficiency costs and potential by forcing in unsubstantiated constraints within the model.

In the 2019 IRP, TVA should explore a strategy to focus heavily on energy efficiency and demand response, sometimes collectively known as demand-side management (DSM). In this strategy, TVA will be able to evaluate a future where TVA and LPCs focus on maximizing energy efficiency savings across customer classes. Energy efficiency programs could be ramped up quickly by using strategies from other utilities across the Southeast and beyond.

Energy efficiency is not a new resource. Utilities in the region and across the world are meeting significant portions of load with energy efficiency. Annual savings can fall between 1-2%. TVA has some of the lowest levels of energy efficiency savings compared to other Southeastern utilities and is one of the rare utilities with a *downward* trend in annual energy savings achieved.[47] We encourage TVA to continue to model energy efficiency and demand response as resources, with the following methodology changes to reflect reality and not pick winners before modeling the system.

Figure 20. Energy Savings Achieved 2012-2016 for Select Southeast Utilities



Source: SACE, 2017[48]

Low Greenhouse Gas Strategy

There are a myriad of reasons for TVA to include a low greenhouse gas (GHG) strategy in its 2019 IRP. TVA's mission under the TVA Act is three-pronged: provide electricity, provide economic development, and protect the environment. Environmental protection in the modern era includes reducing GHG emissions. As discussed in the Carbon Policy Scenario section above, a federal carbon policy is more likely than not over the 20-year planning period TVA is looking at in their 2019 IRP. A low greenhouse gas strategy would help TVA better prepare to meet future realities, and would have the added benefit of helping to establish TVA as a leader or benefactor when that policy goes into place.

The 2015 United Nations Climate Change Conference in Paris resulted in an agreement to hold the increase in average global temperatures to "well below 2° C" and to "pursue efforts" to limit that increase to 1.5° C.[49] The latest report by the Intergovernmental Panel on Climate Change (IPCC),

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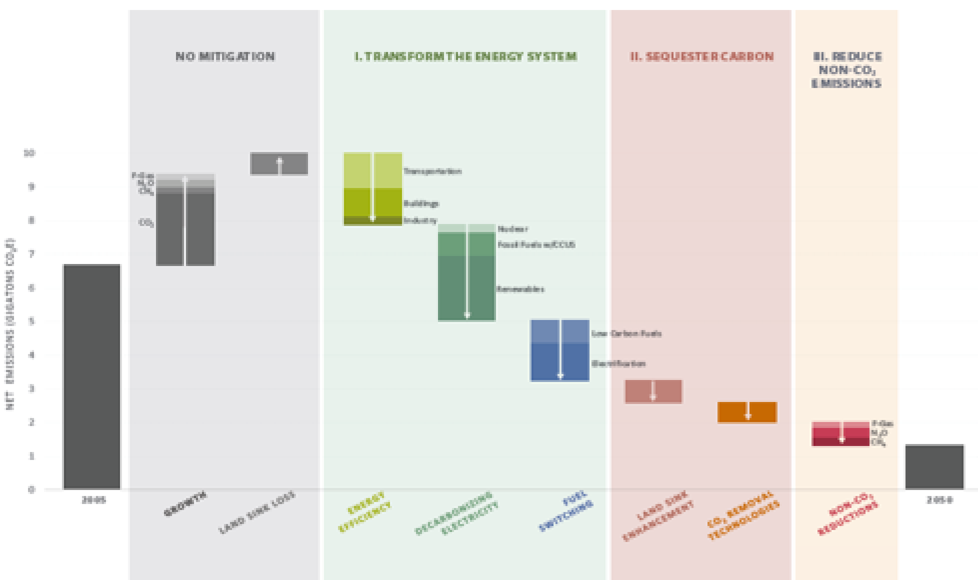
[47] SACE (October 2017). *Energy efficiency is trending up and down in the Southeast*. [http://blog.cleanenergy.org/2017/10/13/southeast-utilities-energy-efficiency-2017/]
[48] SACE (October 2017). *Energy efficiency is trending up and down in the Southeast*. [http://blog.cleanenergy.org/2017/10/13/southeast-utilities-energy-efficiency-2017/]
[49] UNFCCC (2016). *The Paris Agreement*. [https://unfccc.int/process/the-paris-agreement/what-is-the-paris-agreement]

released in 2014, stated that to limit warming to 2° C require reducing emissions to at least 90% below 2010 levels between 2040 and 2070.[50]

TVA's 2019 IRP must include a strategy where emissions are limited starting in 2020 and ramping down at a rate such that emissions in 2050 would be 90% below 2010 levels. This strategy is separate and distinct from a scenario in which a federal carbon policy is implemented. This strategy would show how a TVA-implemented carbon reduction strategy could help take advantage of future opportunities and address future challenges presented in the variety of scenarios evaluated. Conversely, the Carbon Policy Scenario is used to test the various strategies TVA would fare in a future where carbon is regulated or priced across the region.

The following graph is from the United States Mid-Century Strategy for Deep Decarbonization and illustrates a combination of interventions that can deliver 80% reduction in net GHG emissions (compared to a 2005 base year).[51] The majority of those necessary reductions are anticipated from Transforming the Energy System.

Figure 21. Measures to Achieve Deep Decarbonization



Source: United States Mid-Century Strategy for Deep Decarbonization

[50] IPCC (2014). *Fifth Assessment Report*. [https://www.ipcc.ch/report/ar5/]

[51] White House (November 2016). *United States Mid-Century Strategy for Deep Carbonization* [https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf]

TVA should note that some of its comparably-sized utility neighbors are pursuing strategies that are aligned with this basic framework:

- American Electric Power (AEP) had announced in February a clean energy strategy "that will lead to reductions in carbon dioxide emissions from its power plants of 60 percent from 2000 levels by 2030 and 80 percent from 2000 levels by 2050."[52]
- In early April, Southern Company CEO Tom Fanning announced that the generation fleet owned by Southern Co. will be "low to no-carbon" by 2050.[53]

TVA has achieved approximately 34% reduction in CO2 emissions between 2005-2016. Sustained annual reductions of almost 6% per year will be necessary for emission in 2050 to be 90% below the 2010 baseline. Examining this type of resource portfolio will be very instructive in the 2019 IRP.

Electric Vehicles Strategy

There are a number of forecasts for EV deployment that provide a wide range of estimates. For example, the EIA Annual Energy Outlook 2017 estimates that nearly 15 million plug-in vehicles will be on the road by 2030; however, EIA has historically been a rather poor predictor of new technology adoption.[54] According to Bloomberg New Energy Finance, "While EV sales to 2025 will remain relatively low, we expect an inflection point in adoption between 2025 and 2030, as EVs become economical on an unsubsidized total cost of ownership basis across mass-market vehicle classes....Electric vehicles become price competitive on an unsubsidized basis beginning in 2025. Some segments will take longer, but by 2029 most will have reached parity with comparable internal combustion engine (ICE) vehicles."[55] By 2030, BNEF projects nearly one-third of all new car sales will be fully electric. Meanwhile, the American Automobile Association (AAA) recently reported that more than 30 million Americans are likely to purchase an electric vehicle as their next vehicle.[56]

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[52] AEP (February 6, 2018). "AEP's Clean Energy Strategy Will Achieve Significant Future Carbon Dioxide Reductions." [https://www.aep.com/newsroom/newsreleases/?id=2021]

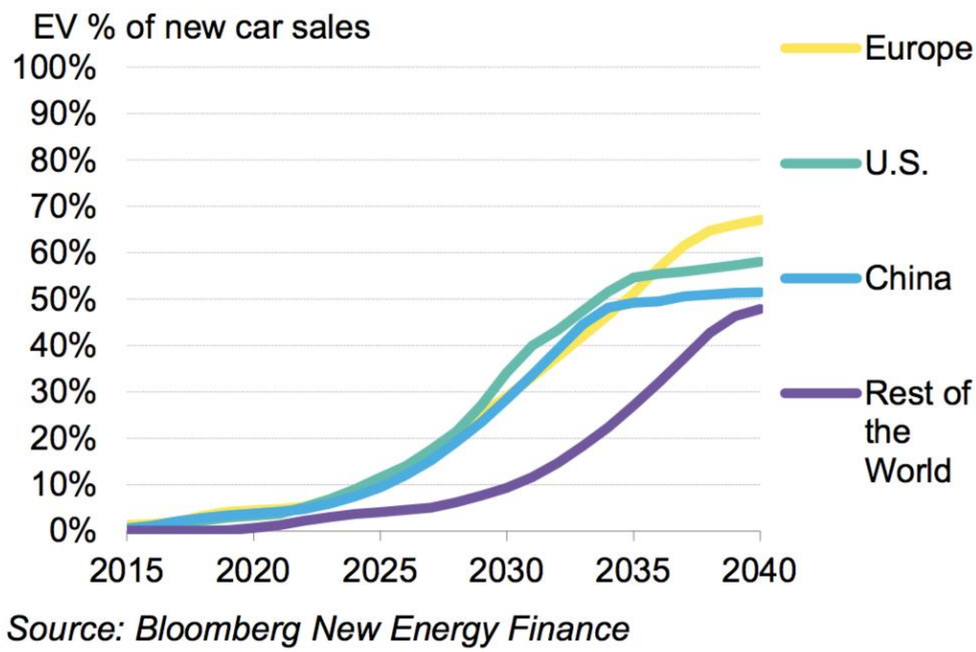
[53] UtilityDive (April 9, 2018). "Southern Co. to be 'low to no carbon' by 2050, CEO says." [https://www.utilitydive.com/news/southern-co-to-be-low-to-no-carbon-by-2050-ceo-says/520907/]

[54] Michael Coren (October 19, 2017). "The US government keeps spectacularly underestimating solar energy installation," Quartz. [https://qz.com/1103874/the-us-government-underestimated-solar-energy-installation-in-the-us-by-4813-along-with-renewable-wind-and-solar-generation/]

[55] Bloomberg New Energy Finance (2017). Electric Vehicle Outlook 2017. [https://about.bnef.com/electric-vehicle-outlook/]

[56] AAA (April 18, 2017). "Consumer Appetite for Electric Vehicles Rivals Pickups." [https://newsroom.aaa.com/2017/04/consumer-appetite-electric-vehicles-rivals-pickups/]

Figure 22. Electric Vehicles as % of New Car Sales



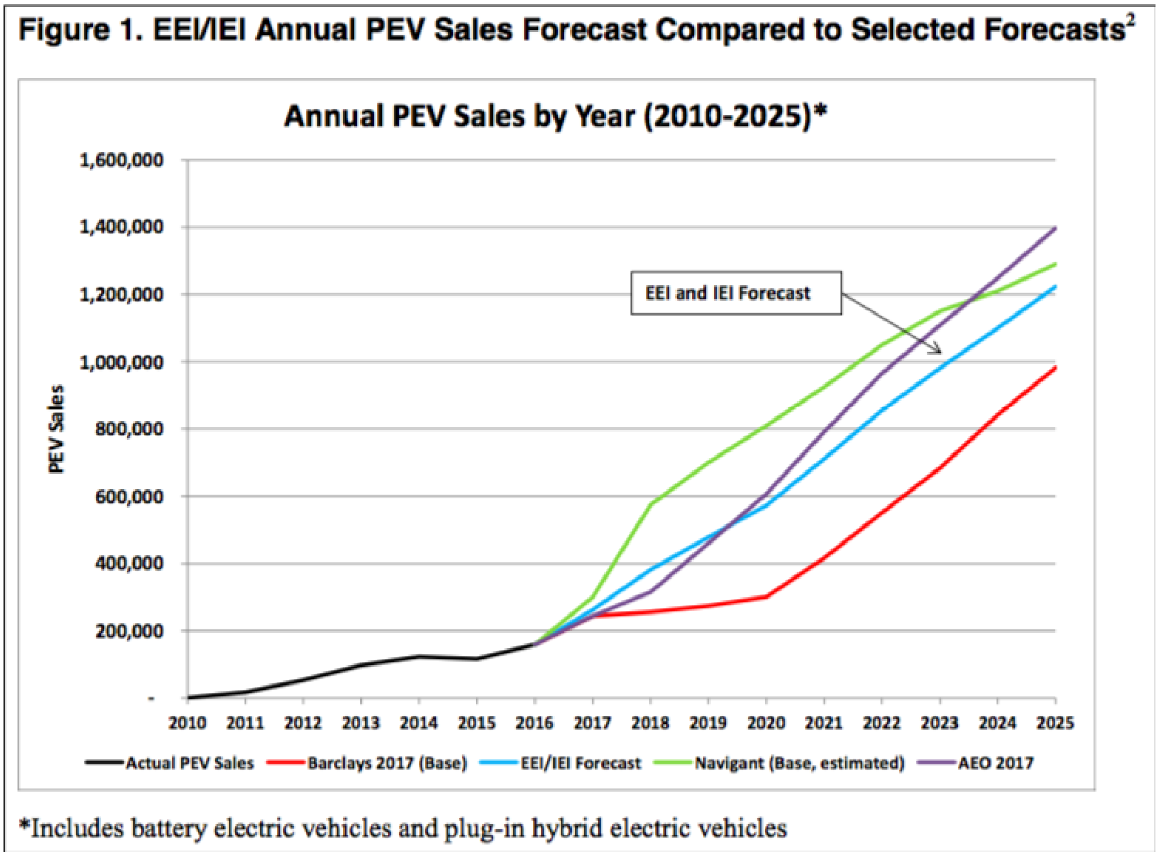
Source: BNEF 2017[57]

Electric vehicles can be both a strategy, discussed in more detail later, and also part of the variety of load scenarios TVA explores in its 2019 IRP. Forecasts of electric vehicle adoption must consider a number of drivers and barriers and the resulting forecasts can vary widely. In 2017, the IEI and EEI developed an EV forecast for the country based on three separate forecasts: one from the U.S. Energy Information Administration (EIA); one from a Barclays Equity Research Note; and one from the annual forecast from Navigant Research (see chart below).[58] Other forecasts are developed by Bloomberg New Energy Finance (BNEF),[59] the International Energy Agency (IEA)[60] and Energy Innovation.[61] TVA should include multiple EV penetration levels in their load forecast scenarios. To do so, TVA could bring in expert consultants to develop a set of forecasts specific to the region, or they could look to a variety of recent forecasts to develop a set of reasonable penetration levels (similar to what IEI and EEI did in their report). Ultimately, the TVA EV Strategy should be

[57] Bloomberg New Energy Finance (2017). Electric Vehicle Outlook 2017. [https://about.bnef.com/electric-vehicle-outlook/]
[58] IEI & EEI (June 2017). *Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required*. [http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20(2).pdf]
[59] BNEF (2017). *Electric Vehicle Outlook 2017*. [https://about.bnef.com/electric-vehicle-outlook/]
[60] IEA (2017). *Global EV Outlook 2017*. [https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf]
[61] Energy Innovation (September 2017). *The Future of Electric Vehicles in the US*. [http://energyinnovation.org/wp-content/uploads/2017/10/2017-09-13-Future-of-EVs-Research-Note_FINAL.pdf]

aggressive – similar to the Low Greenhouse Gas Strategy – in that it seeks to go well beyond what might happen in the absence of any TVA policy leadership.

Figure 23. Comparison of Plug-in Electric Vehicle Sales Forecasts



Source: IEI & EEI 2017[62]

Utility of the Future Strategy

Not only should TVA look at each of the strategies suggested above separately, it should also include a strategy that looks at these strategies in combination. This type of analysis is not duplicative, but rather serves multiple important purposes. Evaluating strategies separately is important to learn the likely outcomes of each individual strategy. Looking at these strategies in combination will allows TVA to identify additional benefits and challenges from a combination of strategies and develop appropriate planning responses. By evaluating these strategies both individually and cumulatively, the results of the 2019 IRP will better reflect reality, For example, it is extremely unrealistic to think that TVA will focus only on one strategy, renewable energy for instance, and completely halt all

[62] IEI & EEI (June 2017). *Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required*. [http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20(2).pdf]

investments in other strategies, like energy efficiency, measurement of greenhouse gases and/or implementation of electric vehicles.

Additional Considerations

Flexibility

TVA measured the flexibility of each strategy in the 2015 IRP by calculating the annual system regulating capability as a percentage of peak load. This is an extremely one-dimensional way to look at flexibility in the power sector. TVA should expand its definition of flexibility in the 2019 IRP to include additional measures that keep the grid resilient, such as fuel security and how a resource responds in an emergency, as well as measures for how quickly a resource can respond, both up and down. Solar and wind are intermittent resources in the short-term, but have substantially more secure fuel sources over the long-term compared to fossil fuels - and even hydropower in the event of a drought. Renewable resources combined with storage to create microgrids can be very effective in emergencies. For example, the state of New York is exploring ways to increase the use of these distributed technologies and microgrids in response to Hurricane Sandy.

Distributed storage, such as EVs and residential or commercial storage systems, can have levels of utility-control and be used for ramping as well as islanding in the case of emergencies. In January 2018, the Federal Energy Regulatory Commission (FERC) opened a docket to discuss reliability and resilience in the power system. In this docket. FERC defined resilience as the "ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such an event."[63] TVA should use this ongoing discussion between FERC and system operators across the country to inform its 2019 IRP.

At the least, if TVA continues to use its elementary definition of system flexibility, it should be sure to include the abilities of new technologies to provide regulation services. Natural gas plants and hydropower dams provide these services, but so do storage technologies, utility-scale renewables with controls and demand response. TVA should also be careful about how much of this kind of flexibility is needed. TVA is a well-connected utility without significant load pocket issues. With a well-thought-out combination of distributed and large-scale renewables across the grid and adequate upgrades to transmission as these resources are added to the grid, wind and solar resources can balance each other out with controls, over-paneling of solar systems, and energy storage. In TVA's 2015 IRP, all strategies, even the one with the highest level of renewable additions (Strategy E) showed system

[63] FERC Order issued January 8, 2018 under Docket RM18-1-000. [https://www.ferc.gov/CalendarFiles/20180108161614-RM18-1-000.pdf]

flexibility improving over the 20-year planning period. New technology capabilities will drive this trend to be even greater in the 2019 IRP.

Another measure of flexibility that is important to consider when planning for an uncertain future is the ability of each strategy to adapt to different policy futures. For instance, a low GHG strategy would provide the flexibility for TVA to better adapt to a future with a federal or international climate policy that limits GHG emissions when compared to a business-as-usual strategy.

Energy and Environmental Justice

Environmental Justice (EJ) is the idea that all people and communities are entitled to equal protection under environmental law.[64] This includes energy policies, since they have a major impact on the environment. Ensuring EJ issues are considered as part of the broader environmental impact analysis helps develop healthy, sustainable, equitable communities that include healthier children and a more productive workforce. Inclusive and transparent policies that build community buy-in through a collaborative process are imperative in the EJ framework. TVA must weave EJ analysis throughout its 2019 IRP, not just because it is the right thing to do, but because it is mandated under the TVA Act. TVA should include the following approaches in its 2019 IRP process:

1. Identify populations currently or potentially vulnerable;
2. Provide meaningful engagement opportunities for those populations;
3. Assess community impacts of all scenario-strategy combinations using EJ-specific metrics; and
4. Mainstream EJ in all planning and decision-making.

For more information about how to include EJ in the planning process, TVA can refer to the Environmental Toolkit developed by the Metro Washington Council of Governments as a resource for decision makers like TVA.

Recently, TVA proposed a rate structure change, outlined in its 2018 Rate Change Environmental Assessment (EA), that favors industrial customers over residential and would disproportionally harm low-income residential customers. Already, a significant amount of TVA ratepayers are suffering under high energy burdens – a metric that looks at the percent of annual income any one household spends on energy costs over the course of a calendar year. is known as energy burden. TVA should be troubled by the fact that its largest customer, Memphis, TN, is home to communities with the highest energy burdens for low-income and minority communities in the entire country.[65] Overall, low-income households in TVA's service territory have an average energy burden

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[64] MWCOG (July 2017). *Environmental Justice Toolkit*. [https://www.mwcog.org/documents/2017/07/27/environmental-justice-toolkit/]

[65] *Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low-Income and Underserved Communities*, American Council for an Energy Efficiency Economy (ACEEE), April 20, 2016.

of 12.6%, with energy burdens ranging from 7.1-28.7% by LPC.[66] Low-income households tend to use less energy than middle- and high-income households, yet TVA's Grid Access Charge included in its 2018 Rate Change EA proposal would increase the average energy burden of low-income households by as much as 2.8% of their household income. If TVA does not withdraw the proposal, as many stakeholders have recommended, it must further evaluate the socio-economic impacts of these rate changes under each 2019 IRP scenario-strategy combination.

Impacts of Climate Change

TVA has the formidable task of protecting water quality across a 41,000-square-mile watershed while also managing water resources for recreational, municipal and industrial uses. Water will be one of the natural resources most heavily impacted by climate change, particularly in the Southeast as water temperatures rise. Water resources are already in high demand, so it is crucial that TVA base its generation modeling and future planning on the best climate modeling and identify power plants or groups of power plants that may have a significant impact on water resources in the Valley.

TVA's 2019 IRP and accompanying EIS must consider both the environmental impacts and operational considerations related to current and future water resource constraints, by river basin and sub-basin, in direct relation to specific generation resources. TVA's current generation fleet is very water-intensive, including both hydroelectric dams and thermal generation plants that depend on water for cooling. The significant warming our region will experience will contribute to higher water temperatures. The 2014 National Climate Assessment warns that the Southeast will experience "decreased water availability, exacerbated by population growth and land-use change, [that] will continue to increase competition for water and affect the region's economy and unique ecosystems." [67] This will increase stress on large, inflexible generators heavily reliant on adequate water supplies at appropriate temperatures and reduce necessary flows for TVA's hydropower generators.

NREL reports that "Over the past decade, there have been more than three dozen incidents where thermal power plants have been forced to curtail generation or shut down due to water-related temperature and availability issues." This includes seven such incidents at TVA plants: four incidents at coal-fired power plants (Cumberland and Gallatin, 2 incidents each in both 2008 and 2012) as well as three water-related issues at the Browns Ferry nuclear plant (occurring in 2008, 2010, and 2011).

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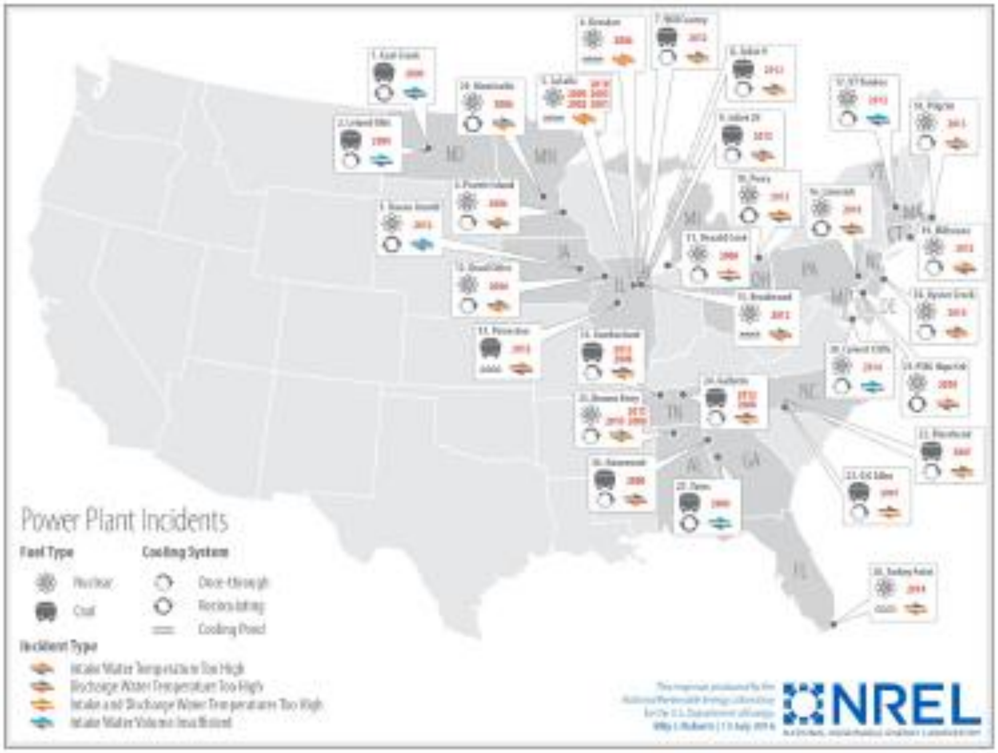
[66] SACE (April 2018). "Is TVA ignoring how a proposed new fee could put vulnerable customers at risk?" [http://blog.cleanenergy.org/2018/04/12/is-tva-ignoring-how-a-proposed-new-fee-could-put-vulnerable-customers-at-risk/]
[67] 2014 National Climate Assessment available at https://nca2014.globalchange.gov/

Figure 24. Thermal Power Plant Curtailment Incidents



Source: NREL December 2016[68]

At the least, TVA's 2019 IRP must also consider both the changes in water temperatures and changes in precipitation as part of its regional climate change impacts analysis when modeling generation resources. TVA nominally included water resource impacts in its 2015 IRP in the water component of its environmental scoring metric. Nevertheless, TVA's analysis of the relationship between thermal generation assets and resource planning were lacking and need to be improved in several key ways. TVA should augment the system-level environmental stewardship metric, along with a closer look at how specific water resources (generally, specific river basins and sub-basins) would be affected by TVA's potential strategies.

Conclusion

In order for TVA to create a sufficiently useful and informative 2019 IRP and EIS, TVA should include the various analyses approaches, strategies and scenarios outlined in the above comments. Although we recognize that TVA's IRPs are, unfortunately, unenforceable and not proscriptive, these long-range planning processes should be taken seriously and include best practices and updated cost and performance assumptions for a wide-range of electric generation resources.

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[68] NREL (December 2016). *Water and Climate Impacts on Power System Operations: The Importance of Cooling Systems and Demand Response Measures*. [https://www.nrel.gov/docs/fy17osti/66714.pdf]

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