Review of TVA's Draft 2015 Integrated Resource Plan

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1. INTRODUCTION AND SUMMARY

TVA issued the first draft of its 2015 Integrated Resource Plan (IRP) in March 2015, and has requested public comments on the draft. Sierra Club retained Synapse Energy Economics, Inc. (Synapse) to review the draft IRP and the draft environmental impact statement (EIS) report attached to the draft IRP. This report presents a comprehensive summary of Synapse's assessment of TVA's 2015 IRP materials, with a focus on the draft IRP and the draft EIS.

This assessment of the draft IRP is limited by the availability of key IRP information. Unfortunately, the public IRP documents lack a substantial amount of critical information that would illuminate TVA's modeling process. While Synapse appreciates that TVA presented additional materials upon request, these materials still lack information that is key to fully evaluating TVA's IRP modeling results. A summary of modeling results is, in many cases, insufficient to assess TVA's methodology and assumptions, in particular for modeling related to resource dispatch results.

Nevertheless, Synapse was able to draw some meaningful conclusions from the available information and to provide recommendations for TVA. Synapse also identifies and discusses areas where TVA has not provided key data. Specifically, this report provides an assessment of key assumptions, methods, and results in the draft IRP regarding (a) energy efficiency, (b) renewable energy, (c) coal retirements, (d) commodity price forecasts, and (e) scorecard. Findings and recommendations in these areas are summarized below.

Energy efficiency

In its 2015 Draft IRP, TVA substantially overestimates the cost of energy efficiency resources, assumes overly conservative annual savings ramp-up rates, and underestimates the amount of energy efficiency available each year. For example, TVA's IRP model requires programs to take about 14 years to reach the maximum annual savings level of about 2,484 MW (or about 1.6 percent of sales). This slow ramp-rate equates to about 0.1 percent per year. In addition, it appears that TVA significantly undervalues a few additional benefits of energy efficiency, such as avoided generation capacity and avoided transmission and distribution, as well as avoided environmental compliance costs. If TVA used more realistic assumptions, it could develop substantially more efficiency in its IRP scenarios and reduce the overall scenario costs, while also further reducing carbon emissions and minimizing other environmental impacts. For example, Synapse's own analysis of Strategy D found that TVA could actually save almost 3 billion dollars (in net present value) if it used more realistic, but still conservative cost assumptions. These adjustments would make Strategy D the least-cost option among all strategies.

Synapse's recommendations in the area of energy efficiency are as follows:

1. TVA should remove its artificial constraints on annual unit availability schedules (e.g., Tier 3's residential block is not available until 2026) and annual maximum growth rate (e.g., 25 percent growth rate from Years 1 to 5).

2. TVA should set the annual ramp rate at 0.2 percent per year, based on best practices as used by U.S. EPA for its proposed Clean Power Plan.

3. TVA should allow the model to reach a maximum annual savings level equal to 2 percent of annual energy sales. While this aggressive level of energy efficiency programs may place some upward pressure on rates, they are likely to be in customers' best interest nonetheless. With aggressive efficiency programs, a much greater number of customers will be able to participate in TVA's energy efficiency programs and will thereby enjoy reduced energy bills.[1]

4. TVA should use much lower program costs in the range of 1.5 cents to 4 cents per kWh (in terms of real dollars) throughout the study period.

5. TVA should use a 20 percent marginal transmission and distribution (T&D) loss factor to calculate avoidable generation capacity from energy efficiency programs.

6. If TVA's IRP model cannot model avoided T&D costs, TVA should investigate the value of avoided T&D and consider incorporating it in its IRP modeling as cost savings (or negative costs) to its energy efficiency program costs.

Renewable energy

The draft IRP employs a number of overly conservative assumptions on wind power cost, performance, and operation, which together force the model to select a suboptimal level of wind resources. The most critical, flawed cost assumptions by TVA are escalated wind power costs over time, [redacted] wheeling charges on wind from the Southwest Power Pool (SPP) region, and no production tax credits (PTC). In terms of wind performance and operation, TVA assumes a very low capacity credit and does not provide any option for wind power to be coupled with hydro resources, because TVA does not consider its dams dispatchable/controllable resources. As a result of these overly restrictive or flawed assumptions, TVA's modeling results are more expensive and produce more emissions than necessary.

Synapse's recommendations in the area of renewable energy are as follows:

1. TVA should assume a reasonable decreasing cost trend in capital costs for wind over time, and should at least perform additional wind cost sensitivity analysis where the PTC is extended, and the wheeling cost issue [redacted] is resolved. These adjustments would make wind more competitive, and result in more wind in model results, which in turn would reduce overall costs and emissions in each scenario.

2. TVA should model hydro as a dispatchable resource and not preschedule its output *a priori*.

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[1] When seeking to mitigate rate impact concerns, the State and Local Energy Efficiency Action Network (SEE Action) recommends that "regulators should consider increasing program budgets—rather than decreasing them—as a way of increasing participation and increasing the portion of customers that experience net benefits from the energy efficiency programs." (The State and Local Energy Efficiency Action Network. July 2011. Analyzing and Managing Bill Impacts of Energy Efficiency Programs; Principles and Recommendations – Driving Ratepayer-Funded Energy Efficiency through Regulatory policies Working Group.)

3. Further, recognizing that it will include more intermittent resources in the future, TVA should work to loosen the restrictive operating parameters within which it must operate its dams.

Coal retirements

In the 2015 IRP, TVA models existing coal plant idling endogenously, allowing the System Optimizer model to make decisions about if it is economic to operate or retire existing coal units. While the decision to move to endogenous retirements is commendable, the process used by TVA may overly restrict the ability of the model to make least-cost decisions. TVA released little information about what parameters are used in modeling existing coal units, or which costs could be avoided by retiring existing coal units. The decisions that are apparent based on the information that TVA has made available raise significant questions about whether TVA has executed endogenous coal retirement appropriately. For instance, TVA's model makes it impossible to review any compliance alternatives for environmental regulations prior to 2020, and aggregates units into retiring plants rather than models individual units. Decisions about existing unit retirement could raise the barrier to retirement (in the model) excessively, causing the model to fail to remove non-economic units and incur costs that should otherwise not be borne by TVA or ratepayers. Improved methodology in this area could result in outcomes that save hundreds of millions of dollars.

Synapse's recommendations in this area are as follows:

1. TVA should make sure it models the additional environmental costs of complying with the finalized coal combustion residuals (CCR) and proposed effluent limitation guidelines (ELG), as well as a revised version of the upheld Cross-State Air Pollution Rule (CSAPR) and National Ambient Air Quality Standards (NAAQS) for ozone (O_3) and sulfur dioxide (SO_2).

2. TVA should model the economics of each individual coal unit and allow individual units, rather than whole plants, to retire or idle when uneconomic.

3. TVA should ensure that noneconomic units are fully retired, not just idled.

4. TVA's modeling should seek to avoid capital investments in the last five years or so of a unit's life when reviewing coal retirements endogenously, as avoiding these costs can be critical in choosing to make economic decisions about existing assets.

5. To the extent that TVA expects to sign long-term contracts for coal in the future, these contracts should be modeled as variable costs, rather than fixed costs.

6. TVA should make sure it distinguishes between fixed and variable operation and maintenance (O&M) costs of coal units, as the operational characteristics of coal units become increasingly important when considering coal retirement.

7. [redacted] TVA should reconsider its decision to retrofit Shawnee 1 & 4 and conduct a rigorous retrofit/retire analysis instead of consider the units "committed" *a priori*.

Commodity price forecasts

TVA's commodity price forecasts on coal and CO_2 used in the draft IRP are inconsistent with historical evidence and recent studies on these prices. Despite recent coal price volatility and a wide price margin recently forecasted by EIA, TVA uses an extremely tight forecast for coal prices over a period of nearly two decades. None of the scenarios vary by more than about [redacted] The latest forecast in EIA's Annual Energy Outlook (AEO) 2015 show that prices may stay near TVA's forecast for the East South Central region (covering Kentucky, Tennessee, Alabama, and Mississippi), but could go much higher by [redacted] TVA's coal price forecast in the first year of its IRP analysis is also lower than the historical coal price in 2014.

Further, TVA forecasts CO_2 prices much lower than prices found by a recent study by SNL Energy, which modeled the CO_2 price impacts of EPA's Clean Power Plan. A higher CO_2 price, akin to the SNL estimate, reduces the gap between the reference case and cases with lower CO_2 emissions by $200 million to $1.5 billion. Clearly, a higher CO_2 price could have a significant impact on the choice of the least-cost scenario.

Synapse recommendations in the area of commodity price forecasts are as follows:

- TVA should run scenarios with a wider bound of coal prices, exploring scenarios with significantly higher costs as well.
- TVA should assess a series of CO_2 prices at price points higher (and earlier, beginning in 2020) than the "Current Outlook" or "Growth Economy" options.

Scorecard

Most electric companies are expected to develop a plan that minimizes the long-term cost of providing safe, reliable power; TVA's mission, on the other hand, is broader. TVA is expected to provide safe, reliable power, but it must balance low rates with other priorities, including economic development in the Valley and environmental stewardship. Because TVA must co-optimize, a scorecard can be a useful tool. However, for the scorecard to help decision makers, it must be designed correctly and it must report correctly calculated information. TVA's scorecard can be helpful, but only with some essential improvements.

Synapse's recommendations in this area include:

1. TVA should recognize the primacy of PVRR—only plans within a few percent of the lowest PVRR should be considered.

2. Including the system average cost from 2014 to 2023, a risk-benefit ratio, and system regulating capacity metrics in the scorecard is distracting and misleading; these metrics should be removed from the scorecard entirely.

3. Because the relative weights of the metrics and the scoring system within each metric wasn't determined before TVA's analysis was performed, it is inappropriate to explicitly weight the metrics and sum the relative scores, as TVA did in 2011. Instead, TVA should

use PVRR to remove poorly performing plans and then use the set of helpful metrics to shape short- and longer-term resource plans on a more qualitative basis.

4. For its next IRP, TVA should develop the scorecard metrics, scoring mechanics, and weights *before* any resource plan analysis, to ensure that the final selection metrics, mechanics, and weights aren't subject to bias or pressure from groups within or outside TVA.

2. ENERGY EFFICIENCY

In its 2015 Draft IRP, TVA substantially overestimates the cost of energy efficiency resources, assumes overly conservative annual savings ramp-up rates, and underestimates the amount of energy efficiency available each year. In addition, TVA undervalues the benefits of energy efficiency to defer or avoid investment in generation capacity, and distribution and transmission systems. Further, it appears that TVA also substantially underestimates future environmental compliance costs for supply-side resources that could be avoided by efficiency. Together, these assumptions significantly undervalue the benefits of energy efficiency, limit the availability of energy efficiency in TVA's IRP scenarios, and make the modeled overall cost of energy efficiency unrealistically high. If TVA used more realistic assumptions, it could develop substantially more efficiency in its IRP scenarios and reduce the overall scenario costs, while also further reducing carbon emissions and minimizing other environmental impacts.

2.1. Cost of energy efficiency

TVA breaks down its efficiency resources into three tiers. The draft IRP claims that Tier 1 resembles and is priced according to TVA's current energy efficiency program portfolio. Tiers 2 and 3 represent yet-to-be developed programs and are priced much higher than Tier 1. TVA substantially overestimates the costs of energy efficiency in two ways. First, Tier 1 efficiency measures—those that are supposed to represent TVA's current program portfolio—are priced too high relative to what TVA has achieved recently for all sectors and also relative to what many other regions have achieved for residential programs. Second, the cost increases assumed for Tiers 2 and 3 are unrealistically high, and not supported by historical evidence.

Cost of Tier 1 – TVA's current program portfolio

For Tier 1 resources, TVA assumes that residential measures cost about [redacted] per kilowatt hours (kWh) saved lifetime and both commercial and industrial measures cost about [redacted] per kWh saved lifetime.[2] However, as shown in Table 1, the costs of saved energy for TVA's most recent historical program data for 2013 from the Energy Information Administration (EIA) are just over 1 cent per kWh for commercial

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[2] TVA. (n.d.). "IRP Sensitivity Summary" slide deck, page 6.

and industrial programs, and 2.4 cents per kWh for residential programs. This is about [redacted] lower than the TVA cost estimates in the draft IRP.

Table 1. Costs of Saved Energy for TVA's 2013 Programs

	Residential	Commercial	Industrial	Total
First Year Cost (cents/kWh, first year)	34	16	12	17
Weighted average measure life (years)	15	15	12	14
Levelized Cost of Saved Energy[3] (cents/kWh, lifetime)	2.4	1.2	1.1	1.4

Sources: EIA 861 for first-year cost and weighted average measure life.

In addition, the residential cost estimate for Tier 1 is more expensive than many typical residential program portfolios in other jurisdictions. For example, a 2014 comprehensive study by the Lawrence Berkeley National Laboratory (LBNL) assessed recent costs of saved energy and reviewed program results for more than 100 program administrators in 31 states across the country. They found that the cost of saved energy was 1.6 cents per kWh on average for the residential sector (at a 3 percent discount rate).[4] Given TVA's short history of implementing efficiency programs and lack of a comprehensive residential program portfolio, Synapse expects the residential cost of efficiency for TVA for the near-term future will be more in line with LBNL's numbers than with the increased costs estimated in the IRP.

Cost of Tier 2 and 3 – TVA's future program portfolio

Costs of Tier 2 and 3 resources are 10 to 200 percent greater than Tier 1 costs, depending on the type (e.g., incentives, operating costs) (See Table 2 below). The majority of Tier 3 program costs—including incentives for the commercial and industrial (C&I) sectors—are 200 percent greater. These levels of cost increases are unreasonably high and inconsistent with historical evidence regarding costs.

[3] The levelized cost of saved energy was estimated by amortizing the first-year costs over the weighted average measure life, using a nominal discount rate of 3.36% and the inflation rate assumed by TVA in the draft IRP. The nominal discount rate is based on the current rate of TVA 1999 Series A (NYSE: TVE) PARRS bonds, available at: http://www.snl.com/IRWebLinkX/GenPage.aspx?IID=4063363&GKP=1073746878.

[4] LBNL. (2014). The Program Administrator Cost of Saved Energy for Utility Customer-Funded Energy Efficiency Programs, Table 3-4, Page 28.

Table 2. Energy Efficiency Cost Increase for Tier 2 and Tier 3 relative to Tier 1

	Residential	Commercial & Industrial
Tier 2		
Incentives	50%	70%
Variable Costs	26%	70%
Fixed and Low Variable	15%	10%
Other	19%	70%
Tier 3		
Incentives	100%	200%
Variable Costs	51%	200%
Fixed and Low Variable	25%	20%
Other	29%	200%

While many states have expanded their electric energy efficiency programs over the past decade, and total spending on programs has quadrupled from $1.4 billion to about $5.9 billion (Figure 1),[5] the cost of saved energy has remained constant during this period. The American Council for an Energy-Efficient Economy (ACEEE) examined trends in the cost of saved energy for many states in 2004, 2009, and 2014 and found that the average costs across all states have remained consistently at $0.25-$0.30 per kWh.[6] Further, a closer look at several leading states and a few utilities in Florida and North Carolina reveals that states and utilities that have aggressively increased their energy savings in recent years have not increased their costs significantly. As shown in Figure 2, the majority of such states have actually maintained their costs around the same level over 2009-2013, even when their annual savings levels increased dramatically.[7] These pieces of historical evidence strongly suggest that TVA's assumption regarding costs of saved energy for its future energy efficiency programs in the draft IRP is critically flawed. Accordingly, Synapse strongly recommends that TVA use much lower program costs in the range of 1.5 cents to 4 cents per kWh (in real dollars) throughout the study period.

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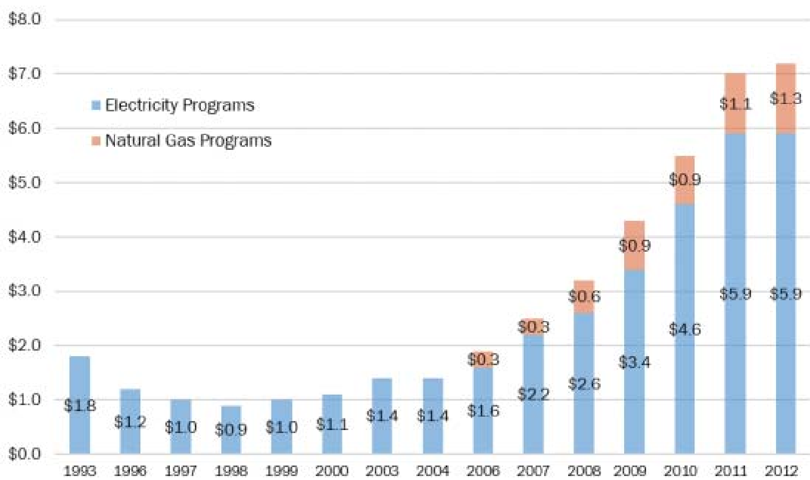
[5] Downs et al. (2013). The 2013 State Energy Efficiency Scorecard. Washington, DC: American Council for an Energy-Efficient Economy. Available at: http://aceee.org/research-report/e13k.

[6] Molina. (2014). The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs. ACEEE. Available at: http://www.cectoxic.org/AEEE_Best_Value_is_Energy_Efficiency.pdf.

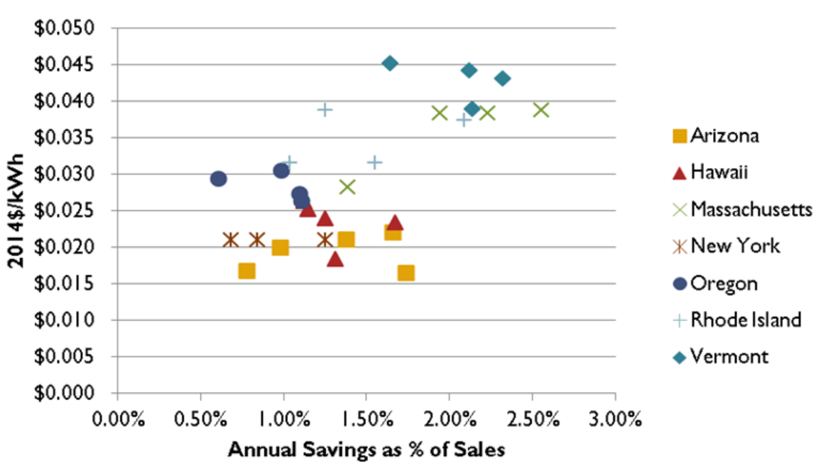
[7] Some regions such as the Northeast have had traditionally higher program costs than other states. Possible factors affecting such high costs include those that program administrators can influence (e.g., comprehensive electric program offerings that promote oil and other fuel savings, higher incentives), and those largely outside of program administrator control (e.g., high labor costs, climate, and higher baseline).

Figure 1. History of Annual Electric and Natural Gas Energy Efficiency Program Spending or Budgets ($ billion)



Sources: Downs et al. (2013). The 2013 State Energy Efficiency Scorecard.

Figure 2. Energy Efficiency Cost of Saved Energy ($/kWh) and Annual Savings (% of Sales) from 2009 to 2013[8]



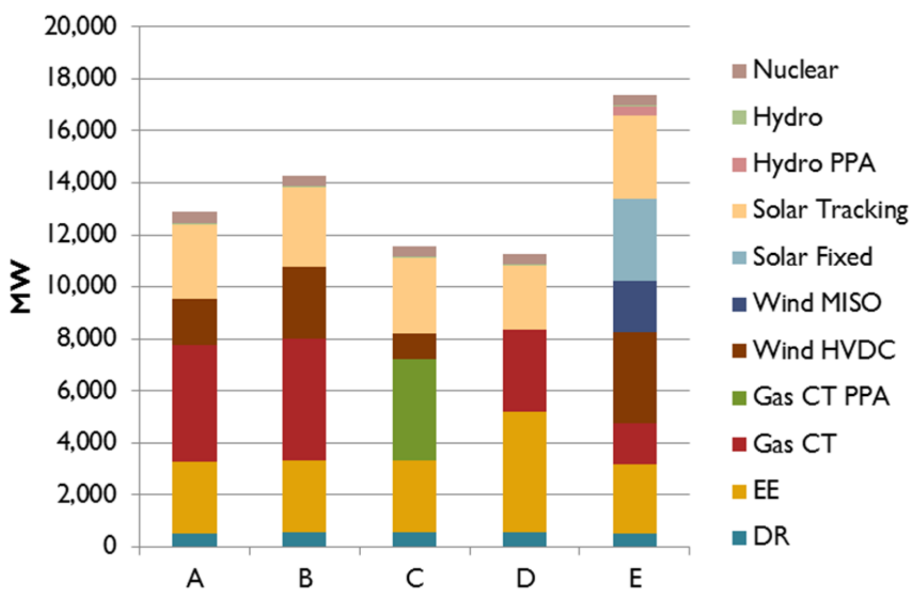
Sources: (1) Molina (2014). (2) ACEEE State Energy Efficiency Scorecard reports in 2011, 2012, and 2013. (3) Duke Energy Progress. (2014). Application for DSM/EE Rider and Filing Requirements, SC PSC Docket 2014-89-E. (4) Gulf Power DSM program progress reports in 2011, 2012, and 2013. (5) Geller, et al. (2014). Maintaining High Levels of Energy Savings from Utility Energy Efficiency Programs: Strategies from the Southwest. (6) Hawaii Energy Annual Reports in 2012 to 2014 National Grid Electric and Gas Energy Efficiency Programs Year-End reports in 2010 to 2013. (7) Massachusetts program administrators' data obtained from Jeff Loiter, a member of the Massachusetts Energy Efficiency Advisory Council consultant team on April 2, 2015.

[8] Annual program costs are levelized (e.g., amortized) over average measure life values at state-specific discount rates. Where state-specific discount rates are not known, a 5% discount rate was used.

Impact of high program costs on IRP modeling results

As a result of the overly expensive program cost assumptions, the TVA IRP modeling runs that are constrained by cost-effectiveness tests found significantly lower energy efficiency resource capacity additions than TVA's "Strategy D – Maximize Energy Efficiency (EE)" run. Strategy D dictates that efficiency be used to meet all future energy needs before other sources, to the extent that TVA's own constraints other than costs permit (See the following subsection for details). Figure 3 presents this result for the reference case across all five strategies (from A to E) in 2033 in megawatts (MW). Strategy D selected a total of 4,624 MW from efficiency, while the rest of the scenarios selected only around 2,700 MW, over 40 percent lower than Strategy D.

Figure 3. TVA DRAFT IRP Capacity Expansion Results under the Reference Scenario by Strategy



Sources: TVA (2015b) Integrated Resource Plan - 2015 Draft Supplemental Environmental Impact Statement, Chapter 6.

2.2. Energy savings assumptions

The 2015 Draft IRP further handicaps energy efficiency potential by assuming overly restrictive constraints on annual energy efficiency availability and setting an artificially low limit on the maximum achievable annual savings amount. The experiences of other utilities and states, as well as TVA's own energy efficiency potential study, demonstrate that TVA would be able to ramp up efforts much more rapidly and reach a higher maximum annual savings level—at a much lower cost—than the draft IRP currently assumes.

Annual savings ramp rates

While the draft IRP does not provide detailed year-by-year projected energy savings outputs, key assumptions and constraints outlined in the IRP make it clear that the modeling outputs will show low savings for many years.[9] Three major areas of such assumptions are the following:

1. **Annual maximum efficiency growth rate**: The 2015 Draft IRP restricts energy efficiency to 25 percent annual growth from Years 1 to 5, 20 percent growth from Years 6 to 15, and to 15 percent growth thereafter.[10] These constraints alone limit the maximum annual availability to less than what many leading states and utilities have demonstrated in the past decade (discussed below).

2. **Annual maximum incremental energy and capacity savings**: The 2015 Draft IRP limits the total annual incremental savings per year for each energy efficiency Tier. When all efficiency Tiers are available, the maximum annual energy savings from the residential, commercial, and industrial sectors are 1,200 GWh, 708 GWh, and 576 GWh, respectively, with a total of 2,484 GWh (equivalent to about 1.6 percent of projected sales). The maximum annual capacity savings from the residential, commercial, and industrial sectors are 240 MW, 120 MW, and 80 MW, respectively, with a total of 440 MW.[11]

3. **Annual unit availability schedules**: TVA further restricts the availability of energy efficiency with their annual efficiency unit availability schedules, under which TVA assumes that Tier 2 and 3 resources are not available until certain future years. Tier 2 resources are not available until 2022 for residential measures, 2019 for commercial measures, and 2018 for industrial measures. Tier 3 resources are not available until 2026 for residential measures, and 2022 for commercial and industrial measures.

TVA provides only snapshots of annual energy savings for selected years. Thus, Synapse has developed a model to replicate TVA's annual energy and capacity savings from energy efficiency measures, based on the overly restrictive assumptions discussed above and assuming that TVA's model selects all available efficiency resources regardless of their assumed costs.[12] The model used the most recent historical energy savings data for TVA in order to develop a starting point in 2015. The historical program data are for TVA's 2013 programs across seven different states, obtained from EIA's 861 data. To develop the energy savings data in 2015, Synapse adjusted the 2013 historical energy savings data while keeping the same capacity reduction as the original 2013 data and using the TVA capacity factor assumption

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[9] Maximum incremental block assumptions for each Tier and sector provided in Table D-5 on page 131 in the Draft IRP. TVA assumes that growth of the total energy savings cannot exceed 25% of the savings in the previous year during the first five years; the annual ramp rate decreases to 20% from years 6-15, and to 15% from Year 16 on, to the extent that total annual savings do not exceed the annual maximum limit of 2,484 GWh (~1.6% of projected sales).

[10] TVA. (2015a). Integrated Resource Plan – 2015 Draft Report, Table D-5, page 131. Available at: http://tva.gov/environment/reports/irp/pdf/TVA-Draft-Integrated-Resource-Plan.pdf.

[11] Ibid.

[12] As discussed in Section 2.1, TVA did select all available resources in the majority of the strategies because it assumes unrealistically high efficiency costs for Tier 3.

provided in the draft IRP.[13] The resulting annual cumulative savings for the snapshot years for Strategy D are very similar to the actual results (See Figure 4 below).

Figure 4. Comparison of Energy Savings Estimates for Strategy D between Synapse and TVA Draft IRP

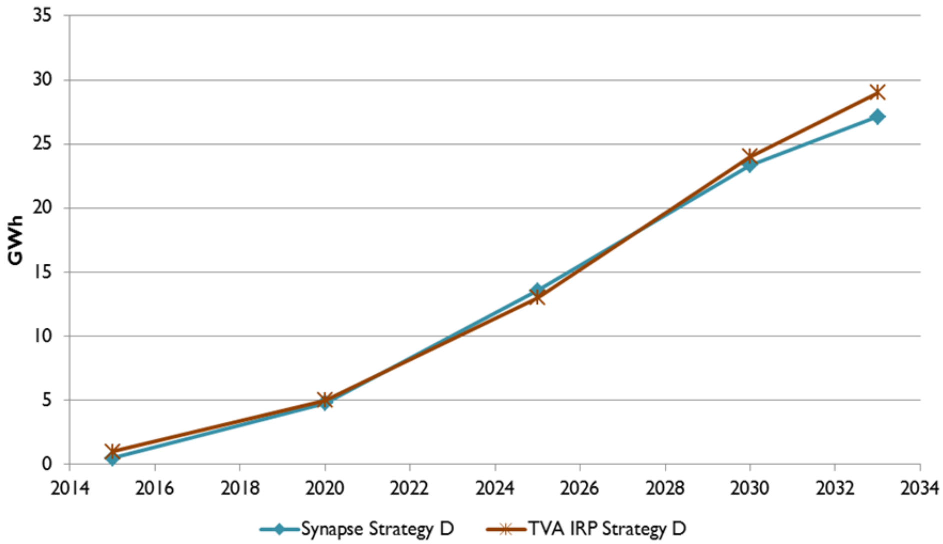
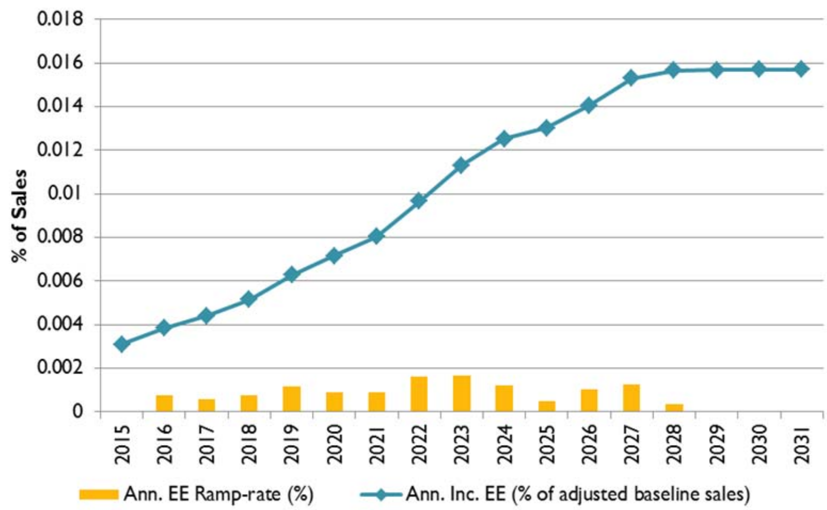


Figure 5 provides our translation of TVA's annual incremental savings over time and annual ramp-up rates using Synapse' model described above. Annual ramp rates result in only about 120 GWh savings increase (or 0.07 percent of sales) in the second year. Ramp rates go up and down over time, ranging from 0.03 percent to 0.17 percent with an average of 0.1 percent per year over the first 14 years, and then drop to zero in the 15th year when the model reaches its maximum annual incremental savings of 2,484 GWh (or about 1.57 percent of sales).[14]

[13] Table D-5 on page 131 in the draft IRP provides MW and GWh savings amounts available for each block by sector.

[14] Assuming the first-year savings are equal to TVA's actual savings in 2013—about 480 GWh or 0.3% of sales according to EIA 861 data. Available at: http://www.eia.gov/electricity/data/eia861. Projected sales by TVA are adjusted downward for additional energy savings.

Figure 5. Implied, Maximum Annual Incremental Savings in the Draft TVA IRP (% of Sales)



Current state policies and historical data suggest that TVA could assume a much faster ramp rate and reach a higher annual maximum savings level than what it assumes in the draft IRP. For example, EPA examined state Energy Efficiency Resource Standards (EERS) and found that the 10 states with annual ramp-up schedules mandated in their EERS expect annual savings at a pace ranging from 0.11 percent (Colorado and Oregon) to 0.40 percent (Rhode Island), with an average of 0.21 percent per year. Further, EPA reviewed numerous efficiency program data from 2003 to 2012 as part of its filing for the proposed Clean Power Plan, and found that about 75 entities across the nation took just about 3 years to increase annual incremental energy savings by 1 percent, which equates to annual average ramp rates of 0.33 percent. For comparison, recall that TVA's ramp rate is 0.1 percent on average. Table 3 presents these findings broken out into two groups: *Top Saver 1%*, which achieved maximum first-year savings of 0.8 to 1.5 percent, and *Top Saver 2%*, which achieved maximum first-year savings of above 1.5 to 3 percent. Based on these results, EPA has chosen 0.2 percent per year as an annual savings ramp rate for each state to adopt for the purpose of complying with the proposed Clean Power Plan.[15] Synapse recommends TVA set the annual ramp rate at 0.2 percent per year at minimum, based on best practices as used in the proposed Clean Power Plan.

[15] U.S. EPA. (2014). GHG Abatement Measures, Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants.

Table 3. Energy Savings Ramp-up Trends in 2003 through 2012

	Top Saver 1%		Top Saver 2%	
	Average Annual Savings Increase	Estimated Years to Gain Incremental 1%	Average Annual Savings Increase	Estimated Years to Gain Incremental 1%
Average	**0.30%**	**3.4**	**0.38%**	**2.6**
Median	**0.29%**	**3.4**	**0.34%**	**3.0**
Max	0.63%	1.6	1.28%	0.8
Min	0.10%	10	0.14%	7.3
# of sample entities	47		26	

Source: U.S. EPA. (2014). GHG Abatement Measures, Technical Support Document (TSD) for Carbon Pollution Guidelines for Existing Power Plants. Appendix 5-2.

Maximum achievable annual savings and total cumulative savings

TVA's maximum annual incremental savings (about 1.6 percent of sales) is lower than what leading utilities and states have achieved to date. As presented in Figure 2 above, a few leading states, such as Massachusetts, Vermont, and Rhode Island, have achieved around 2 percent per year, despite the fact that they have run comprehensive programs for many years.[16] Emerging leading states such as Arizona and Hawaii have also achieved savings beyond 1.6 percent. Further, as presented in Table 3, 26 utilities have achieved maximum first-year savings of 1.5 to 3 percent between 2003 and 2012.

TVA's achievable savings are also out of sync with its own findings on energy efficiency potential: The total cumulative energy efficiency resources selected in TVA's IRP modeling runs are significantly lower than what the 2012 energy efficiency potential study found for TVA.[17] This study found 4,460 MW of energy efficiency in 2030 under the *Low Achievable* potential scenario, and about 8,300 MW under the *High Achievable* potential (Figure 6 below). In contrast, the draft IRP modeling runs by TVA under the reference case scenario found only about 4,600 MW in 2033 under Strategy D, which is not constrained by TVA's cost-effectiveness screening. When subject to TVA's cost-effectiveness screening under other strategies, in addition to the other constraints described above, that number dropped to about 2,700 MW in 2033. This means that the highest capacity savings from energy efficiency in the TVA Draft IRP modeling runs is only about half of the upper bound of the achievable potential estimates found in the 2012 potential study for TVA.[18]

Given this ample room for additional energy savings and the aggressive savings performance by leading entities discussed above, we strongly recommend that TVA allow the model to reach a maximum annual

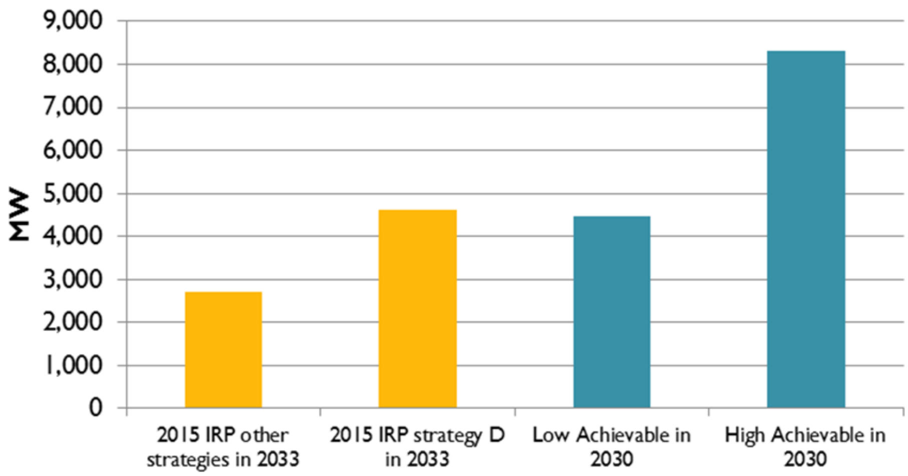
[16] The fact that leading states such as Massachusetts, Rhode Island, and Vermont are still finding a lot of savings contradicts the belief that energy efficiency becomes more difficult to achieve when programs are running for many years because they have exhausted the easiest and low-cost savings opportunities.

[17] EnerNOC. (2012). *Tennessee Valley Authority Potential Study - 2012 Update*. Available at: http://www.tva.com/news/releases/energy_efficiency/TVA_EE_potential_update_REPORT_2012-10-12.pdf.

[18] Synapse also found this TVA 2012 potential study contains various overly conservative assumptions, in particular its cost of saved energy assumptions. See Fisher, J. et al. (2012). *TVA Coal in Crisis – Using Energy Efficiency to Replace TVA's Highly Non-Economic Coal Units*. Synapse Energy Economics. August 14, 2012, available at: http://www.synapse-energy.com/sites/default/files/SynapseReport.2012-08.SC_.TVA-Coal-in-Crisis.12-041.pdf.

savings level equal to 2 percent of annual sales. TVA claims in the draft IRP that "a commitment to significant levels of energy efficiency as part of the resource portfolio will likely put upward pressure on rates, and that could have negative consequences for low/fixed income customers as well as renters."[19] While aggressive energy efficiency programs may place some upward pressure on rates, they are likely to be in customers' best interest nonetheless. Increases in rates tend to be very small, especially in light of the reduced system costs from efficiency programs. With aggressive efficiency programs, a much greater number of customers will be able to participate in TVA's energy efficiency programs and will thereby enjoy reduced energy bills.

Figure 6. Comparison of TVA Draft IRP Modeling Results on Efficiency



Magnitude of overestimation of TVA energy efficiency program costs

Using the energy efficiency program model described above that Synapse developed to replicate TVA's energy efficiency program scenario, we also attempted to estimate the magnitude of efficiency program cost overestimation by TVA for Strategy D under the reference case. Synapse compared two scenarios for Strategy D: In the first scenario (called "TVA IRP EE cost"), we simulated TVA's model using the confidential efficiency program data (described above); in the second scenario (called "Synapse EE cost"), we used more reasonable costs (3 cents per kWh for residential measures, and 2 cents per kWh for C&I measures). Note these costs are still significantly higher than the current TVA program costs, as shown in Table 4. While the C&I cost of 2 cents per kWh is only slightly higher than the national average costs estimated by LBNL, the residential cost is significantly higher than the national average estimated by LBNL as shown in Table 4.

[19] TVA. (2015a). page 104.

Table 4. Cost of Saved Energy Comparison (cents per kWh)

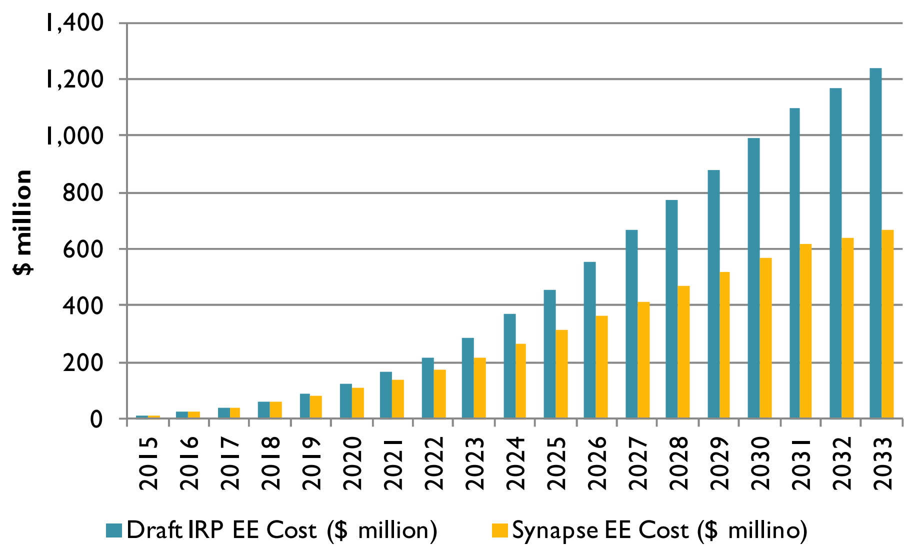
	Synapse	Current TVA	LBNL
Residential	3.0	2.4	1.6
Commercial	2.0	1.2	1.8
Industrial	2.0	1.1	1.8

Source: EIA861; LBNL (2014). The Program Administrator Cost of Saved Energy for Utility Customer-Funded Energy Efficiency Programs

The resulting cost gap between the two scenarios is substantial. It starts at about $1 million in 2015, grows gradually over time, and reaches $570 million in 2033 (as shown in

Figure 7 below). The sum of annual cost gaps through 2033 is almost $3 billion in net present value—a magnitude that could make Strategy D the lowest-cost choice among all strategies, if it were modeled with more reasonable program costs.

Figure 7. Estimated Annualized Energy Efficiency Investment for Strategy D - Draft IRP Cost Assumption vs. Synapse Cost Assumption



2.3. Additional limitations in energy efficiency selection

For the draft IRP, TVA incorporated energy efficiency in its IRP model as an endogenous resource, along with power generating resources. TVA let its IRP model select energy efficiency (subject to the many constraints discussed above) when it is more economical to provide energy and capacity with efficiency than with other resources. This approach has an inherent limitation when selecting an optimal level of energy efficiency, because it cannot appropriately value the benefits of energy efficiency to defer or avoid transmission investment and does not value at all avoided distribution investment. In addition, there is a possibility that TVA's model undervalues capacity contribution, as TVA may be using an incorrect transmission and distribution loss factor. Further, future environmental compliance costs that could be avoided by efficiency are likely to be underestimated for supply-side resources. We discuss these limitations in further detail below.

Avoided transmission and distribution

Energy efficiency has the potential to defer forecasted transmission and distribution (T&D) investments. While not all forecasted T&D investments will be deferrable (some investments must be made to repair time-related deterioration of equipment, for example), a significant portion of T&D investment is likely to be associated with load growth. The potential benefits of deferring even a modest portion of such investments could be substantial.[20] For example, when the Bonneville Power Administrator (BAP), another federal power agency in the country, identified a need to build additional high voltage transmission lines over the Cascade mountain range into the Puget Sound area back in the early 1990s, BPA and the local utilities chose to pursue an alternative path that included adding voltage support to the transmission system and more intensive energy efficiency programs targeted at the transmission-constrained area. This project ended up delaying the construction of a new transmission line for a decade.[21]

While the IRP model may be capable of incorporating transmission, the draft IRP includes no indication that TVA modeled any additional transmission investment needed to meet growing customer load. If transmission is not modeled, the effects of efficiency on transmission investments cannot be evaluated. It is likely that lower load due to energy efficiency does not result in lower transmission investment in the model.

Further, it is important to note that System Optimizer, the model TVA uses for its IRP modeling, is not capable of modeling distribution system investments. Synapse has collected avoided distribution cost data for 26 different jurisdictions across the country that indicate that the avoided cost of distribution system investments can be substantial. The average avoided cost is about $60 per kW-year, with a 25th percentile value of $25 per kW-year and a 75th percentile value of $83 per kW-year (as shown in Figure 8). The average avoided cost of distribution can be translated into 1 cent per kWh for TVA.[22] Given the cost of efficiency for TVA is currently about 2 cents per kWh, adding the avoided cost of distribution would represent a substantial increase in the benefits of efficiency. Based on these data, we recommend TVA investigate the value of avoided T&D and consider incorporating it in its IRP modeling in the form of a credit (i.e., a negative cost) to efficiency program costs to the extent that TVA's IRP model cannot model T&D avoided costs.

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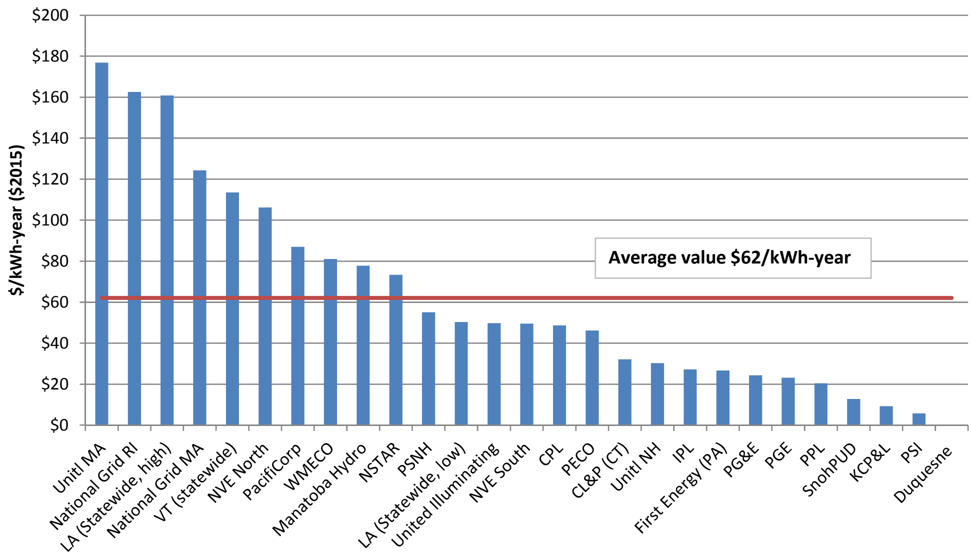
[20] Kushler, M., et al. (2012). *A National Survey of State Policies and Practices for the Evaluation of Ratepayer-Funded Energy Efficiency Programs*. American Council for an Energy-Efficient Economy.

[21] Neme, K. et al. (2015). *Energy Efficiency as a T&D Resource: Lessons from Recent U.S. Efforts to Use Geographically Targeted Efficiency Programs to Defer T&D Investments*. Energy Futures Group, Prepared for the Northeast Energy Efficiency Partnership

[22] Based on a 70 percent load factor, which was derived from TVA's efficiency program performance in 2013 from the EIA 861 data.

Figure 8. Estimates of Avoided Distribution Costs across 26 Jurisdictions



Source: Synapse Energy Economics (2013). Avoided Energy Supply Costs in New England: 2013 Report, Appendix G-1; Northwest Power and Conservation Council (2010). Sixth Northwest Power Plan, Appendix E; GDS Associates et al. (2015). Demand Response Potential Pennsylvania, February 25, 2015; Interstate Power and Light Company (2012). 2014-2018 Energy Efficiency Plan, Docket No. EEP-2012-0001; Energy and Environmental Economics (2014). Nevada Net Energy Metering Impacts Evaluation, July 2014; Dismukes D. (2015). Estimating the Impact of Net Metering on LPSC Jurisdictional Ratepayers (draft), February 27, 2015; Manitoba Hydro (2004). Report on Marginal Transmission & Distribution Cost Estimates.

Avoided generation capacity

The draft IRP states that TVA's model "grossed up" the amount of energy efficiency for T&D losses to create a "supply side equivalent" when modeled with other resource options.[23] This means that energy and capacity savings at the end-use site are adjusted upward to account for T&D losses, because efficiency can avoid such losses.

Utilities often use the average loss factor when converting energy savings to the generation level. This is appropriate for estimating avoided energy. However, it is inappropriate to use an average loss factor for estimating avoided capacity, as TVA has done, because the T&D loss factor is significantly high during the highest peak hours, which matter the most for estimating avoiding generation (and T&D). Thus, using an average loss factor does not appropriately capture the benefit that energy efficiency provides when most needed: during peak hours. Thus, the most appropriate metric to calculate avoided generation capacity is the marginal (or incremental) T&D losses that occur at the system peak time. Such a marginal T&D loss factor could reach as high as 20 percent, while a system average loss factor is

[23] TVA. (2015a). Integrated Resource Plan – 2015 Draft Report, page 129.

usually around 6 to 10 percent.[24] We recommend TVA use a 20 percent marginal T&D loss factor to calculate avoided capacity from energy efficiency programs.

Environmental compliance costs

As will be discussed in detail in Sections 4 and 5 below, Synapse found that TVA potentially underestimates the cost of future environmental compliance costs. First, the draft IRP does not discuss any future costs for existing coal plants to meet the finalized coal combustion residuals (CCR) rule and proposed effluent limitation guidelines (ELG), nor costs associated with future revised versions of the upheld Cross-State Air Pollution Rule (CSAPR) or National Ambient Air Quality Standards (NAAQS) for ozone (O_3) and sulfur dioxide (SO_2). Second, we found that TVA's CO_2 price forecast is significantly lower than a recent CO_2 market price forecast by SNL Energy.[25] It is likely that comprehensively incorporating future environmental compliance costs would increase the cost of operating traditional power generation in TVA's current IRP modeling, which would in turn increase the value of energy efficiency resources.

3. Renewable Energy

The draft IRP employed a number of overly conservative assumptions on wind power cost, performance, and operation, which together force the model to select a suboptimal level of wind resources. The most critical, flawed cost assumptions by TVA are escalated wind power costs over time, [redacted] wheeling charges on wind from the SPP region, and no production tax credits (PTC). In terms of wind performance and operation, TVA assumes a very low capacity credit and does not provide any option for wind power to be coupled with hydro resources, because TVA does not consider its dams as dispatchable/controllable resources. As a result of these overly restrictive or flawed assumptions, TVA's modeling results are more expensive and produce more emissions than necessary.

3.1. Wind power cost assumptions

Wind power technology costs and development potential in the Tennessee Valley

Wind power potential is currently underutilized in Tennessee. On a capacity basis, the wind potential of Tennessee has been estimated at over 80 times higher when using 140-meter tall turbines than with

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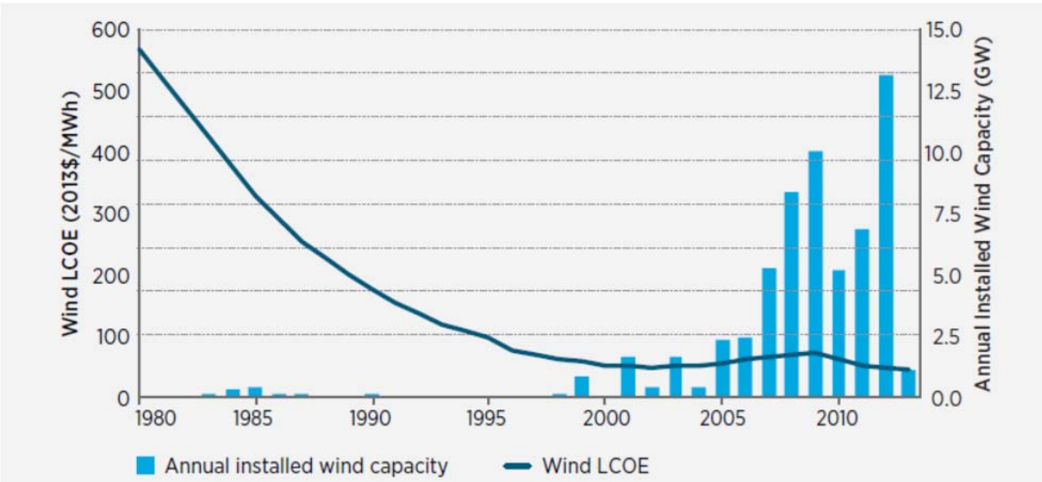
[24] Lazar, J. et al. (2011). *Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements. Regulatory Assistance Project*. Available at: http://www.raponline.org/document/download/id/4537.

[25] SNL Energy. (2015). *Critical Mass: An SNL Energy Evaluation of Mass-based Compliance Under the EPA Clean Power Plan*.

standard (80m) turbines (25,000 MW of potential versus 300 MW, respectively).[26] Figure 9 below shows the historical levelized cost of energy (LCOE) trajectory for wind in the United States, by annual installed capacity.

Figure 9. U.S. Wind LCOE and Annual Installed Capacity from 1980 – 2013



Source: US Department of Energy (DOE). (2013). 2013 Wind Technologies Market Report.

Further, studies are finding that wind technology costs are still projected to continue to decrease into the future. Figure 10 shows a summary of LCOEs through 2030 from 13 major expert elicitation, engineering, and market studies that have forecasted a range of wind costs. As depicted, the 20-80 percentiles of the range show a decrease in LCOE of about 20-30 percent. While several different technological and market factors will affect the cost decreases wind power will actually see in the future, the vast majority of studies Synapse reviewed found costs to decrease over time (only 1 out of 18 scenarios used a flat cost over time).

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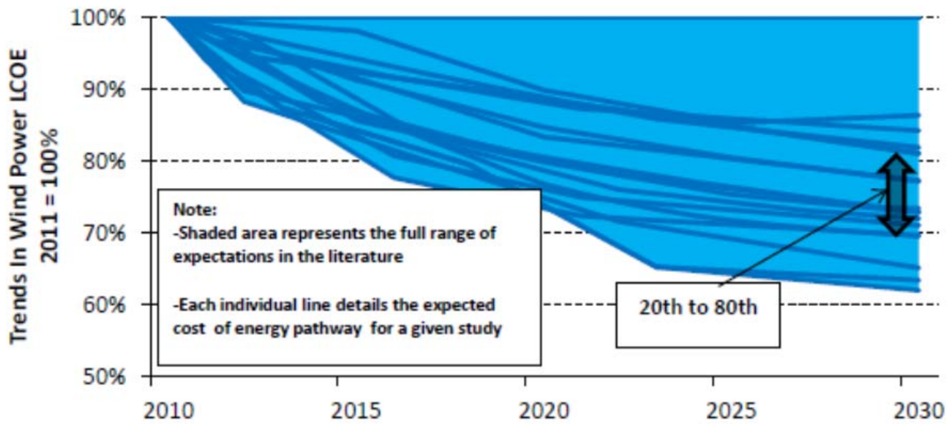
[26] National Renewable Energy Laboratory (NREL). (2013). *Land-Based Wind Potential Changes in the Southeastern United States*. Available at: http://www.nrel.gov/docs/fy14osti/60381.pdf; NREL. (2010). *Estimates of Windy Land Area and Wind Energy Potential*. By State, for areas >=30% Capacity Factor at 80m. Available at: http://apps2.eere.energy.gov/wind/windexchange/docs/wind_potential.xls.

Figure 10. Estimated range of LCOEs for wind power through 2030



Source: Lantz, E., Wiser, R., and M. Hand. (2012). The Past and Future Cost of Wind Energy. IEA Wind Task 26 Report/National Renewable Energy Laboratory Technical Report TP-6A20-53510.

TVA's draft IRP reference case assumes that wind costs actually escalate at between [redacted] and a sensitivity case assumes that wind capital costs escalate at the rate of inflation over time.[27] Given the cost decline expected by many studies into the future, TVA should assume a reasonable decreasing trend in capital costs for wind over time. This adjustment would make wind more competitive, and result in more wind resources built in model results, which in turn will reduce overall costs and emissions in each scenario.

Wheeling charge

The IRP model did not select any wind power from the Southwest Power Pool (SPP) region under the reference case, as shown in Figure 11 below. This is largely caused by TVA's modeling assumption that SPP wind must pay [redacted]

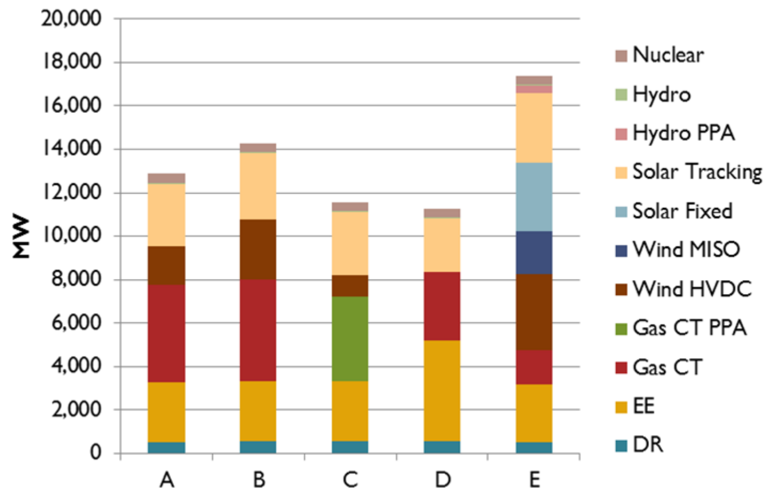
27 [redacted]

28

29

[redacted] This would allow the IRP model to select more wind resources from the SPP region.

Figure 11. TVA Draft IRP Capacity Expansion Results under the Reference Scenario by Strategy



Sources: TVA. (2015b). Integrated Resource Plan - 2015 Draft Supplemental Environmental Impact Statement, Chapter 6.

Treatment of production tax credit

TVA states that it "cannot take direct advantage of the tax credits and other investment incentives offered by the federal government to encourage wind power development," and therefore, it is "more financially advantageous to acquire wind power resources through PPAs [power purchase agreements]." However, it does not appear that TVA considered a future in which the production tax credit (PTC) was available. Currently expired, the PTC has expired five other times over the past twenty years, and in each of those instances, the expired PTC was extended within a year.[30] TVA's election to use as a base input to its model an assumption that the PTC is never renewed during the entire 20-year planning period is thus an unsupported and improper decision that biases the analysis against wind resources.

TVA should model a sensitivity in which the PTC is renewed in order to test whether or not an extended PTC would result in a least-cost plan procuring a wind PPA in the very near future. TVA should analyze a PTC extension effective as of a near-term date such as January 1, 2016, as well as PTC availability after the completion of the Clean Line HVDC, such as January 1, 2021. If the planning model chooses to build more wind in a PTC scenario, or build the wind sooner, it is important for TVA to understand the ramifications of that possibility now. TVA would then be in a position to procure PTC-enabled lower cost

[30] NREL (2014). Implications of a PTC Extension on U.S. Wind Deployment.

PPAs should they become available, be it from MISO or SPP in the near term or via the HVDC line in the early 2020s.

3.2. Integration of intermittent resources

It appears that TVA is not fully utilizing its unique and valuable resource portfolio to integrate intermittent resources at low cost. Unlike many utilities, TVA has vast hydro resources, which come with a variety of operational constraints. The total potential energy at any given time is limited to the amount of water above the dam. However, TVA states specifically that "hydropower cannot be dispatched based on price alone because water releases in the Tennessee River system also are required for navigation and flood damage reduction and take into account recreation, water quality, and other purposes."[31]

While TVA cannot operate hydro resources in the same way it operates gas-fired combustion turbines (CTs), TVA can adjust the output of the hydroelectric generators both to help the TVA system operate at lower cost and to help the TVA system balance supply and demand on a minute to minute basis. Within the TVA system, "hydro generating asset . . . flexibility allows them to operate in the full range from baseload to peaking,"[32] and "typical peaking resources are natural gas fired combustion turbines, conventional hydroelectric generation and pumped storage generation."[33] TVA clearly recognizes the ability for hydro facilities to integrate intermittent resources. However, TVA explicitly prevents its models from using the flexibility provided by hydro: "an hourly hydro generation schedule, totaling 8,760 hours, is pre-loaded into the capacity expansion model."[34]

Pre-loading the hydro generation schedule negates the flexibility provided by hydro, making the integration of intermittent, non-dispatchable resources more costly and challenging than necessary. For scenarios in which substantial solar PV capacity is installed, dispatching the hydro during morning and evening hours allows the PV-hydro combination to follow load, providing a far smoother generation profile in aggregate. Wind output is more erratic over a 24-hour period; ramping hydro up and down in concert with wind ramping down and up would allow TVA to effectively shape the wind output to blocks that more closely matched the shape of load. Yet TVA does not model dispatch this way, and instead assumes a very low capacity credit of 14 percent for wind resources regardless of capacity factor, even for HVDC wind that has a high capacity factor of 55 percent.[35] As a result, TVA's IRP modeling results for wind are suboptimal, making it likely that the model chooses insufficient quantities of wind, and later on the planning horizon than appropriate. Further, it is likely that TVA's PVRR overestimates the cost of scenarios with more renewables because it overestimates the need for dispatchable capacity and overestimates the actual dispatch of CT generation.

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[31] TVA (2015a), page 46.

[32] Ibid., page 28.

[33] Ibid., page 28.

[34] Ibid., page 46.

[35] TVA (2014). IRPWG Meeting Session 8 slide deck, June 19-20, page 49.

It is not clear if TVA pre-loaded Raccoon Mountain, its pumped hydro station. Pumped hydro is doubly effective at integrating intermittent resources. Not only can the unit's generating capacity be dispatched to fill the valleys left when intermittent generation operates at less than full capacity, but the pumped hydro station can switch to pump mode when intermittent resources are generating at high capacities during times of low system load. This reduces the need for relatively inflexible resources like coal or combined cycle generators to ramp downward.

TVA can and should make a number of alterations to better utilize its valuable hydro resources. It should model dispatchable hydro as dispatchable within the constraints associated with hydro use, and not pre-schedule its output *a priori*. Similarly, it should utilize its pumped storage to full efficiency, allowing it to generate or pump whenever economic to do so, as a direct function of hourly load, steam generation, and the output of intermittent, non-dispatchable generation. Finally, recognizing that TVA will include more intermittent resources in the future, TVA should work to loosen the restrictive operating parameters within which it must operate its dams. The resulting increased hydro flexibility would allow low-cost integration of even more low-cost intermittent resources.

4. COAL RETIREMENTS

In the 2015 IRP, TVA models existing coal plant idling endogenously, allowing the System Optimizer model to make decisions about if it is economic to operate or retire existing coal units. While the decision to move to endogenous retirements is commendable, the process used by TVA may overly restrict the ability of the model to make least-cost decisions. TVA released little information about what parameters are used in modeling existing coal units, or which costs can be avoided by retiring existing coal units. The decisions that are apparent based on the information that TVA has made available raise significant questions about whether TVA has executed endogenous coal retirement appropriately. For instance, TVA's model makes it impossible to review any compliance alternatives for environmental regulations prior to 2020, and aggregates units into retiring plants rather than models individual units. Decisions about existing unit retirement could raise the barrier to retirement (in the model) excessively, causing the model to fail to remove non-economic units and incur costs that should otherwise not be borne by TVA or ratepayers. Improved methodology in this area could result in outcomes that save hundreds of millions of dollars.

4.1. An overview of TVA's unit retirement decision

In a coal-heavy fleet such as that of TVA, the fate of the utility's existing resource base is one of the primary determinants of future emissions. The continued operation and investment in TVA's aging coal fleet poses one of the largest barriers to the adoption of a cleaner energy profile. As other coal owners and operators have found, the existing coal fleet is becoming markedly more expensive to operate relative to other options. This is a result of falling market energy costs, the increasing availability of high-performance renewable energy options, the greater adoption of energy efficiency, a sustained low-cost long-term outlook for natural gas, and increasingly stringent environmental control requirements.

In 2013, Sierra Club commented extensively on TVA's planning mechanism, and noted in particular that TVA's 2013 IRP lacked the ability to retire non-economic coal units endogenously—that is, the model could not choose to cease using coal-fired units that were no longer economic, and was forced to utilize high-cost resources. It was particularly notable that the optimization software used by TVA, System Optimizer, was capable of endogenous coal unit retirements in 2013, but this capacity was not harnessed by TVA. Nonetheless, it was clear at the time that TVA was exploring coal unit retirements, but not from an integrated planning perspective. This shortcoming markedly decreased the value of the 2013 IRP, and likely impacted coal unit decisions made in 2013 and 2014.

In the 2015 Draft IRP, TVA allowed System Optimizer to choose coal unit idling or retirements, an apparent significant improvement to the modeling process previously employed. While Synapse appreciates the strides taken by TVA to consider best practices in resource planning, the extent to which existing unit retirements were considered optimally is unclear. TVA released very little information on this process either publicly or in confidence. As elsewhere in the draft IRP, one must read in between the lines to interpret how TVA has considered critical issues.

4.2. Potential issues with TVA's unit retirement decision

In general, when a unit is considered for retirement in a system planning model, several key modeling decisions can significantly impact the outcome of the model. This report breaks these into the following categories, and describes each in detail below, particularly with regards to TVA's planning:

- Avoided environmental costs
- Unit aggregation
- Idling vs. retirement
- Avoided life extension costs
- Long-term contract exist fees
- Future long-term contracts
- Distinguishing variable and fixed operational costs
- Retirement or closure costs

Note that TVA has revealed very little about its existing asset modeling; however, because TVA appears to be new to endogenous retirements in system planning, it would not be surprising if TVA had not fully considered these issues.

Avoided environmental costs

One of the key reasons to consider retiring an existing coal asset is to avoid imminent or expected capital costs. At TVA, the slated retirements of a number of units are driven by the desire to avoid high expense capital retrofit costs to settle an environmental suit and reach compliance with mercury rules. However, the limited retrofits discussed by the draft IRP in various locations (including the flue gas desulfurization [FGD] and selective catalytic reduction [SCR]) are not the end of the story for existing coal units. Compliance with the finalized coal combustion residuals (CCR) and proposed effluent limitation guidelines (ELG) could certainly entail additional costs not discussed or even implied in the draft IRP. A revised version of the upheld Cross-State Air Pollution Rule (CSAPR), and National Ambient Air Quality Standards (NAAQS) for ozone (O_3) and sulfur dioxide (SO_2) could readily require additional or improved controls at some units. To the extent that the risk of future environmental retrofits have been ignored or sidelined, the benefits of retirement will not have been fully realized. It is unclear to what extent TVA believes these risks to be imminent, or if they have been modeled as part of the resource plan. Finally, TVA explicitly allows coal units to be retired economically only after 2020,[36] which means that currently planned but uncommitted retrofits are unassessed in this draft IRP. This would include FGD and SCRs at Shawnee 1 & 4, and impending retrofits at Gallatin. Appropriately accounting for these costs can be worth tens to hundreds of millions of dollars.

Unit aggregation

The 2015 Draft IRP's discussion of coal unit idling implies that individual units can be selected by the model for idling which, if true, could allow the model substantial flexibility in choosing the amount of relatively non-economic coal to remove from the system in any given year. However, a closer look at results from the modeling suggests that TVA may aggregate whole coal plants for the purposes of evaluating retirement and retrofit decisions. The discussion of unit retirements in the accompanying EIS consistently discuss the idling of whole plants (comprised of multiple units) rather than one or more units at a plant. This implies that plants are idled as a whole, or not at all, which substantially decreases the flexibility afforded to the model and obscures lower cost outcomes.

Idling vs. retirement

In the public IRP, TVA terms almost all of the future coal unit decisions as "idling" rather than "retirement" decisions, explaining that idling provides the opportunity for TVA to re-activate units should economic decisions change in the future. Idling, or mothballing, is not a cost-free enterprise. Units must be prepared for long-term idling, and idled units incur fixed security and basic maintenance costs to ensure that infrastructure is readily available at a future date. In other words, the choice to idle a unit may incur costs well above and beyond a cost to retire a unit. Therefore, while some units might otherwise be chosen for economic retirement, TVA's modeling may preclude those units from shuttering

[36] "Unit retirements occur as already scheduled through 2020, other units assumed to generate through end of planning period unless selected in portfolio for retirement; approved air emissions controls on Gallatin and Shawnee units completed as scheduled." Draft EIS, page 29.

simply because the only option available is a more expensive idling. TVA should ensure that noneconomic units are fully retired, not just idled.

Avoided life extension costs

To maintain large, long-lived generating units, generation owners regularly invest in large maintenance capital projects designed to extend the unit's life and reduce maintenance costs. Such projects include replacement turbines, boilers and boiler tubes, superheaters, and loading facilities, amongst other large maintenance expenses. These projects, designed to break even over many years, if not decades, can generally be avoided as a unit reaches the end of its life. Rather than investing in high-cost maintenance, plant owners can and should plan to ramp down investment towards the end of an existing unit's life. From a planning perspective, this is a difficult and often skipped step: System Optimizer does not readily accommodate avoided maintenance capital in the last years of a plant's life. Nonetheless, avoiding these costs can be critical in choosing to make economic decisions about existing assets. TVA's modeling should seek to avoid capital investments in the last five years or so of a unit's life when reviewing endogenous retirements. At mid to large coal units (several hundred MW), large maintenance projects may represent tens of millions of dollars.

Long-term contract exist fees

Accounting for long-term contracts in system planning models is difficult. In particular, it is not uncommon for coal units to hold long-term coal supply contracts with steep exit fees. Existing contracts may have early termination fees or liquidated damages. Some forward plans seek to simply avoid these fees altogether by restricting retirements; others model withdrawal fees explicitly. Examining TVA's coal contract structures from public EIA 923 data, it is not clear that TVA remains bound to any contracts extending beyond 2020 (a Paradise contract extending to 2028 appears to have terminated; Shawnee appears to hold contracts through the early 2020s). TVA should model withdrawal fees explicitly, to the extent that they exist.

Future long-term contracts

To the extent that TVA expects to sign long-term contracts for coal in the future, these contracts should be modeled as variable costs, rather than fixed costs. These costs are not yet incurred, and TVA can avoid incurring those costs (they are avoidable) and can, in fact, avoid each ton of coal purchased in the future by ramping down production (they are variable). It is not clear if TVA expects to sign additional long-term contracts, but these should be modeled on a variable basis.

Distinguishing variable and fixed operational costs

Utilities familiar with modeling coal as a long-term baseload resource may not traditionally distinguish the fixed and variable components of operations and maintenance (O&M) costs for these units. However, when considering coal retirement, the operational characteristics of coal units become increasingly important, and thus distinguishing fixed and variable O&M costs can be a key point. The decision to continue operating or retire a unit hinges on when fixed costs exceed marginal revenues. In

TVA, coal units compete against other new and existing options; if O&M costs are all fixed, units will dispatch at a high capacity factor and simply incur a large fixed annual cost. If O&M costs are broken into fixed and variable categories, units will dispatch at lower capacity factors, and if the variable cost of operation exceeds alternatives, may not dispatch at all, only incurring fixed costs. It is important to understand the cost thresholds at which units do, or do not, dispatch and are economic.

Retirement or closure costs

Utilities exploring the closure of existing facilities will often include a cost of retirement or closure, incurred at the time of retirement. This cost sometimes includes improvements to transmission required to facilitate the closure, or costs associated with site remediation, less salvage costs. It is not clear if TVA has assumed such costs, which costs were assumed, and if those costs are reasonable.

4.3. IRP modeling results on coal retirements

The outcome of the IRP modeling with respect to coal idling/retirement is ambiguous and poorly characterized within the draft IRP and EIS. The use of generic timeframes (i.e. “mid-2020s”) and broadly framed statements makes it particularly unclear what drives units into idling, and what resources are built to replace idling resources. The most informative graphic is available only in a confidential document from December 2014 called “Preliminary IRP Results,” and even this graphic is short of useful information.

[redacted]

The “coal selections” graphic [redacted], presented in confidential session in December 2014, shows the cumulative incremental coal retirements chosen by System Optimizer, as well as “additional controlled coal” relative to an unknown baseline. The graphic does not show the years in which coal units are selected for retirement.

The graphic tells several stories:

[redacted] TVA should reconsider its decision to retrofit Shawnee 1 & 4 and conduct a rigorous retrofit/retire analysis instead of consider the units "committed" *a priori*.

[redacted]

Through the remainder of the same December 2014 document, retirement dates are listed occasionally. In almost all circumstances, the results indicate that whenever retirements occur at Shawnee, they occur in [redacted] Similarly, whenever coal retirements occur at Kingston, they occur in [redacted] Moreover, [redacted] indicates that [redacted] While this statement leaves many ambiguities, it implies that Shawnee may be locked into a [redacted] retirement date, if at all—that is, System Optimizer can only choose to retire Shawnee in [redacted] and no other date. If this is the case, then TVA may be leaving significant opportunities for economic retirement on the table by locking in the date of retirement. This would also be an inappropriate assumption.

Sierra Club commends TVA on examining coal unit retirements endogenously within the construct of the draft IRP, representing a significant improvement over the 2013 IRP mechanism. However, without significant attention to the issues raised here, the coal unit retirement construct may result in plans that are not least cost, and maintain coal capacity well in excess of what is economically valuable to TVA and its ratepayers.

[37] Draft EIS, page 42.

5. COMMODITY PRICE FORECAST

TVA's commodity price forecasts on coal and CO_2 used in the draft IRP are inconsistent with historical evidence and recent studies. Despite recent coal price volatility and a wide price margin recently forecasted by EIA, TVA uses an extremely tight forecast for coal prices over a period of nearly two decades. TVA's coal price forecast in the first year of its IRP analysis is also lower than the historical coal price in 2014. Further TVA forecasts CO_2 prices much lower than a recent study by SNL Energy, which modeled CO_2 price impacts of EPA's proposed Clean Power Plan. A higher CO_2 price, akin to the SNL estimate, reduces the gap between the reference case and the cases with lower CO_2 emissions by $200 million to $1.5 billion. Clearly, a higher CO_2 price could have a significant impact on the choice of the least-cost scenario.

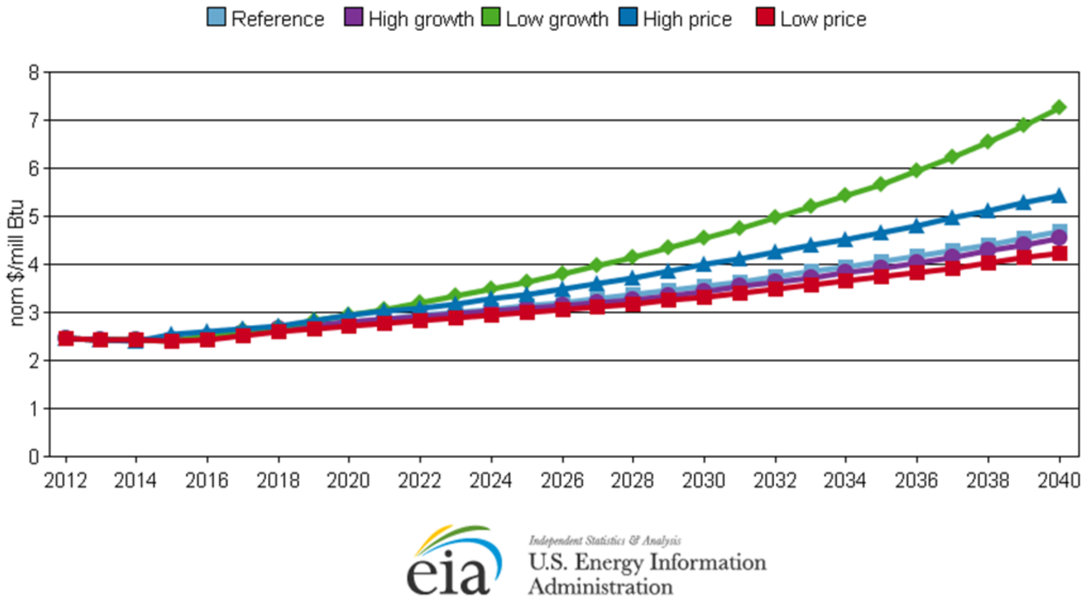
5.1. Coal price forecast

Over the last decade, numerous utilities have found that their assessment of long-term resource plans hinges on assumptions of natural gas prices and future carbon dioxide (CO_2) pricing. These forecasts impact the balance of gas, coal, and energy efficiency /renewable energy (EERE) chosen by optimization models. Over time, coal price forecasts, once considered to be stable, predictable, and low, have shifted with the changing face of the coal industry. In the 2015 Draft IRP, TVA considers a fairly stable and tight coal price on a forward-looking basis. It is not clear if the single price shown in [redacted] represents an average compiled for presentation purposes, or a global average price used for all of TVA's coal plants in the Draft IRP. The forecasts between all of the scenarios do not vary by more than about [redacted] an extremely tight forecast for a forecast extending nearly two decades.

[redacted]

While the overall trend of the forecast is similar to the reference case of the recently released 2015 Annual Energy Outlook (AEO 2015), the lack of variation seems overly optimistic considering both historic prices delivered to TVA and the range of coal price forecasts made available in AEO 2015. The forecasts provided in AEO 2015 for the East South Central region (covering Kentucky, Tennessee, Alabama, and Mississippi) show that prices may stay near TVA's forecast (near the AEO 2015 Reference Case), but could go much higher (as in the "Low Growth" and "High Price" cases), but are unlikely to go much lower (Figure 14). TVA should run scenarios with a wider bound of coal prices, exploring scenarios with significantly higher costs as well.

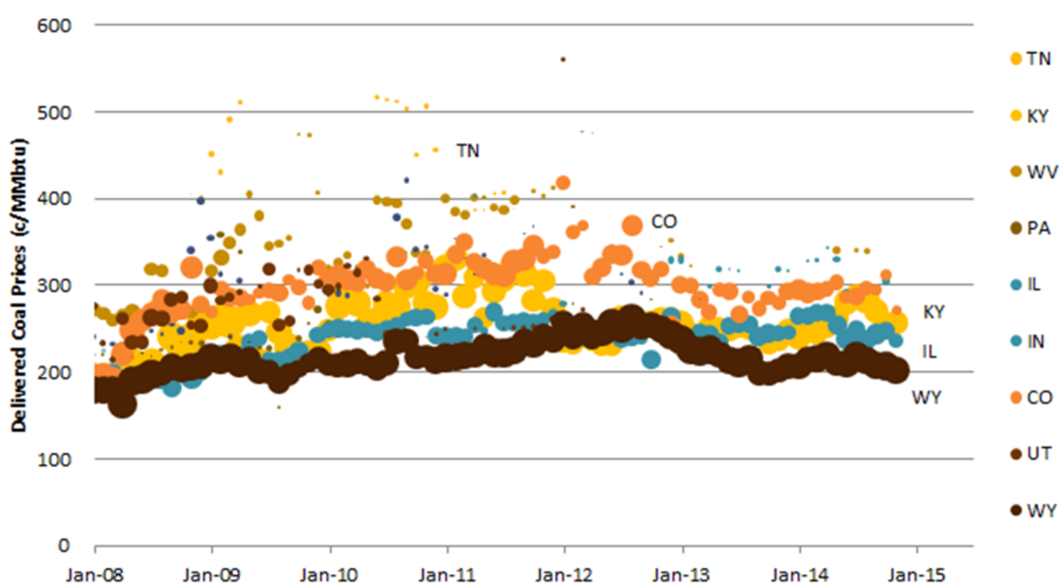
Figure 14. Energy Prices for delivered Steam Coal in the East South Central AEO 2015 Region (nominal)



Source: Energy Information Administration, 2015.

TVA's coal plants do not receive the same coal across the board, and there is considerable variation in the prices of coal delivered to the individual coal units. In addition, the price of coal delivered to TVA's coal plants from its various sources in the Illinois Basin, Powder River Basin, and Colorado have disparate price trends and different price forecasts as well.

Figure 15. Coal prices delivered to TVA plants (EIA Form 923)



Source: EIA Form 923

Coal prices received in the last few years at TVA have covered a spread of about $1-$2/MMbtu (see Figure 15, above). Even over the last seven years, TVA has dropped coal contracts with suppliers in Utah and ramped down reliance on Colorado supplies. In addition, TVA holds few very long-run contracts for coal supplies, with most expiring by 2020, if not earlier. Neither TVA nor any other utility or provider has perfect foresight into pricing, and thus the particularly tight coal forecast does not represent a reasonable planning assumption.

TVA's near-term prices may also be on the low side in the forecast. For example, in 2014, the first year of the 2015 Draft IRP analysis, the average delivered coal price at TVA was about $2.40/MMBtu—about [redacted] higher than the forecast used in the 2015 Draft IRP. While this would seem to be a small differential, it can have a significant impact on the dispatch margin.

Overall, TVA should (a) ensure that their coal plants each have delivered coal prices that are representative of the individual coal plants, (b) explore a wider high range of coal price forecasts, and (c) consider adjusting near-term prices to reflect actual delivered and likely delivery prices.

5.2. CO_2 price forecast

TVA uses a carbon price forecast in all of the scenarios explored, seemingly reflecting a move towards a lower carbon economy, current rulemaking activities at the EPA, and potential long-term moves towards a politically acceptable solution for obtaining carbon emissions reductions. The "Current Outlook" (Scenario 1) starts at around [redacted] (nominal), and rises to [redacted] by 2033 [redacted]), a nominal growth rate of just under [redacted] or a real growth rate of about [redacted] per year.

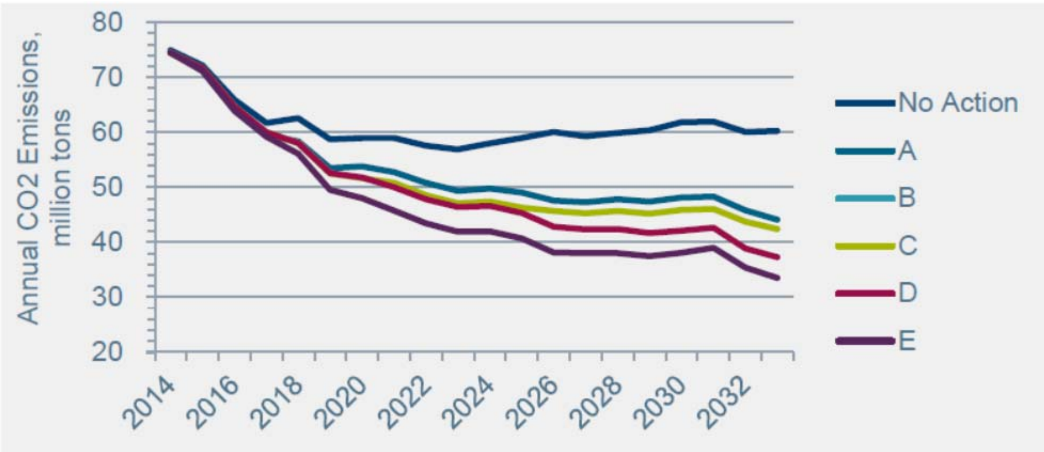
[redacted]

The EPA is moving quickly to finalize the Clean Power Plan, a mechanism of obtaining carbon reductions and/or encouraging new EERE programs to effectively displace CO_2 emitting sources. The current version of the Clean Power Plan has significant "flexibility" built into it, either calling for mass-based reductions, or a series of activities that result in a lower carbon intensity, such as coal/gas switching and energy efficiency programs.

In the proposed rule, Tennessee has a CO_2 emissions reduction target that declines from 2015 lbs CO_2/MWh in 2012 to 1163 lbs CO_2/MWh in 2030 for existing sources, approximately a 42 percent reduction. In late 2014, the EPA released a technical support document (TSD) which walked through an illustrative rate-to-mass translation, implying that states would be bound to a similar reduction in mass terms as in rate terms (if the states chose a mass-based reduction mechanism). For Tennessee in particular, the illustrative mass-based target in 2030 is 39 percent lower than 2012 for existing sources only. Taking into account new sources and load growth, the 2030 target is about 12 percent lower than 2012.[38]

Figure 7-4 in the 2015 Draft IRP EIS shows trends of CO_2 emissions in TVA's 2015 Draft IRP. In the Reference Case (A), emissions drop from about 75 million tons in 2014 to about 55 million tons in 2020, and about 49 million tons in 2030. Overall, TVA estimates that in the reference case, emissions will fall by about 35 percent. If TVA's reported emissions account for new sources as well as existing sources, TVA would meet their presumptive target (assuming a pro-rata share of emissions in surrounding states); if these emissions do not account for new sources, then TVA's reference case does not meet the EPA presumptive targets.

Figure 17. CO_2 emissions trends for scenarios explored in the 2015 TVA IRP



Sources: TVA (2015b) Integrated Resource Plan - 2015 Draft Supplemental Environmental Impact Statement, Figure 7-4, page 198.

[38] EPA estimate of 2012 emissions: 37.4 million tons. 2030 goal for existing sources: 22.8 million tons. 2030 goal for new and existing sources: 33.0 million tons.

Regardless of whether or not TVA meets its emissions target under the Clean Power Plan, TVA can expect to see the impact of a carbon price on their fleet at the start of the Clean Power Plan implementation. To the extent that TVA can trade with surrounding utilities and can either offer emissions reductions credits to surrounding utilities and states, or can buy emissions credits to offset its own emissions, TVA will realize an opportunity cost for their emissions. For each ton of CO_2 emitted by a TVA plant, TVA could have opted not to emit that ton, selling a credit or avoiding the purchase of a credit. If TVA chooses not to participate in a credit trading market, it will likely realize higher costs for its compliance. Even if TVA can meet their emissions targets without trading, trading affords the opportunity to sell excess emissions reductions at a market cost. If TVA cannot meet emissions targets without trading, then it will have to buy emissions reductions at market cost. Whichever scenario is true of TVA, it is likely to realize a market price for its emissions, and should therefore model this market price.

In December of 2014, SNL Energy published a report estimating the market cost of CO_2 emissions in various regions of the United States.[39] In the U.S. south, the report found that shadow prices for CO_2 ranged between $29 - $33/ton (base case). According to the report, "this level of pricing places the South as the region with the highest marginal cost of compliance with the CPP targets." Again, while the SNL report may not precisely capture TVA's schedule idling and retirement, nor Tennessee's exact compliance path, it strongly indicates that there will be a market price for CO_2 in the south in excess of that estimated by TVA in the reference case.

It is notable that in TVA's estimate, in the "Current Outlook" scenario, where the cost of CO_2 is very low, Strategy A (the Reference Case) is $1.7 and $3.5 billion less expensive than Strategies D and E, respectively. Keeping all other factors the same, and retaining the same buildout and operations, a higher CO_2 price, akin to the SNL estimate, reduces the gap between these scenarios by $200 million to $1.5 billion (respectively). Clearly, a higher CO_2 price could have a significant impact on the choice of the least-cost scenario.

6. SCORECARD

TVA developed a scorecard in an effort to help TVA decision makers determine which of several proposed alternative strategies is in the best interest of the utility. The industry commonly uses such scorecards in an attempt to find a co-optimal strategy that balances a variety of objectives.[40] Most electric companies are expected to develop a plan that minimizes the long-term cost of providing safe, reliable power; TVA's mission, on the other hand, is broader. TVA is expected to provide safe, reliable

[39] SNL Energy. (2015). Critical Mass: An SNL Energy Evaluation of Mass-based Compliance Under the EPA Clean Power Plan.

[40] KCP&L, Dominion. (2014). Available at: https://www.dom.com/library/domcom/pdfs/corporate/integrated-resource-planning/nc-irp-2014.pdf.

power, but it must balance low rates with other priorities, including economic development in the Valley and environmental stewardship. Because TVA must co-optimize, a scorecard can be a useful tool. However, for the scorecard to help decision makers, it must be designed correctly and it must report correctly calculated information. TVA's scorecard can be helpful, but only with some essential improvements.

6.1. General scorecard problems

Typically, scorecards employ multiple metrics, and score each strategy using the aggregation of the metrics. The scorecard algorithm combines the values of each metric for a given strategy to generate a single score for that strategy, often times weighting some metrics more heavily than others. The implication is that the strategy scoring the highest in the aggregation of metrics is objectively the best strategy.

Which metrics should be included?

Clearly, present value of revenue requirement (PVRR) must be included. Minimizing total cost is a fundamental principle, and comparing present value dollars is straightforward and well understood. The inclusion of other metrics, however, is less obvious. Reducing risk seems intuitive, but the best way of capturing the complexities of risk in a single scalar is not generally agreed upon. For example, a strategy with a high risk of being far more expensive than its expected value (downside risk) is clearly not desirable, so how should a metric value a strategy with a high risk of being far less expensive than its expected value? Further, how much PVRR is the utility (and its ratepayers) willing to forgo to reduce downside risk? Co-optimizing PVRR with a risk metric requires the explicit choice of how to measure risk, and necessarily requires allowing a lower risk scenario with higher PVRR to be chosen over a lower cost, higher risk plan.

Including environmental metrics is important to the evaluation process for TVA, but they suffer from a similar problem of which metrics to choose. How does one compare tons of CO_2 emitted per year with water consumption? Defining a co-optimization requires assigning value to each by assigning weight to each metric: exactly how much water saved is necessary to overcome an additional ton of CO_2 emissions? Metrics that don't measure an explicit goal of the utility often *inappropriately* appear in scorecards. System flexibility is an example of this—all strategies considered should be safe and reliable, and to the extent that more or less system flexibility implies a cost, that cost should already (and accurately) be reflected in PVRR. Metrics such as these ought not to be included in a scorecard under any circumstance. The only metrics that should be co-optimized are the ones that directly relate to the utility's objective.

How should metrics be weighted?

When there are multiple metrics included in a scorecard, the metrics must have a relative weight. A default could be that each metric has equal weight, although utilities tend to give more weight to some metrics than others. Should PVRR be 60 percent of the final score or 42.25 percent? There is no natural or universally agreed upon weighting when performing a co-optimization, nor is there any mathematical formula that produces the right balance among metrics. Therefore, weighting factors are always subject to the judgment of the analysts who develop scores.

By eventually blending the values in a formula to produce a single result, the scorecard does implicitly put a shadow price dollar value on non-monetized metrics. Changing the relative weights can result in different strategies performing better or worse on a relative basis, and has the effect of changing the shadow price of each non-monetized metric. For example, two different, seemingly reasonable but arbitrary decisions numerically comparing long-term costs to tons per year to a ratio of risk can produce dramatically different rankings of strategies (and different implied prices). The outcome could range from unstable decision-making at best to outright manipulation of results at worst. For these reasons, the metrics and the weights should be determined before any resource planning analysis takes place, to ensure that there is no temptation or pressure to adjust the metrics to support a plan that is preferred by the utility or a stakeholder irrespective of its performance.

Because neither the metrics nor the weights were established before this TVA IRP process, PVRR is the only metric that should be used quantitatively. The remaining metrics should only provide qualitative, “directional” guidance.

How are metrics with different units aggregated?

When the various metrics have differing units (such as dollars, gallons, or percent), each metric must be converted to a consistent scale, so that all metrics can be directly compared. In many scorecard schemes, each outcome within a same metric is converted to an absolute unit-less scale, for example from 0 to 100. If the best outcome is scored 100, the other scores will get a smaller value. The question then becomes: What score should the worst outcome have? If the worst outcome is assigned a score of 0, then a strategy that performs terribly in that metric will result in all the other strategies being assigned very high scores. This reduces the differences between the non-terrible strategies within that metric and, as a result, reduces the relative importance in the category because all non-terrible strategies within that metric have similar scores.

If, on the other hand, the worst outcome is simply expressed as a fraction of 100, there are problems when comparing very large numbers that are close in a relative but not absolute scale. If the lowest PVRR is $130 billion and the highest is $132.5 billion,[41] their relative scores would be 100 and 98.1. Another category could have a much wider range, such as waste varying from 3.10 million tons of waste per year to 3.39 million tons of waste per year, resulting in relative scores of 100 and 91.4.[42] In this case, the broader spectrum of metric values from the waste metric could easily have less impact on the scoring difference between two strategies than some other less important metric with much larger differences.

[41] These values are the average PVRRs for strategies A – E described on TVA 2015 IRP, page 89.

[42] These values are the average million tons of waste per year for strategies A – E described on TVA 2015 IRP, page 90.

Whether the scoring within a metric is mapped to a 0-100 scale or a relative scale, the breadth of the spectrum of strategy values within the metric determines the relative value of the category on the scorecard. That is, when the performance of two strategies in a given metric is mapped to a score, it is the gap between those scores that dictates how heavily the difference between those two strategies in that metric will weigh in their aggregate scoring. As a result, the inclusion of a third strategy that performs particularly well (or especially poorly) in a specific metric and doesn't score well overall can change the rankings of the two other strategies being considered. This instable behavior is another reason why the scoring system should be established before the resource planning analysis takes place. As that didn't happen for the 2015 TVA IRP process, the appropriate approach is to not use the quantitative results for non-PVRR metrics in a formulaic aggregation, but rather to use the non-PVRR metric results qualitatively.

6.2. TVA scorecard

There are a number of ways in which the TVA scorecard, as presented, can and likely does lead to inappropriate results.

It appears that TVA is weighting each of the five scenarios equally—that is, for a given metric and a given strategy, the reported average is the simple arithmetic average.[43] This implicitly suggests that TVA believes that each of the five scenarios (current outlook, stagnant economy, growth economy, de-carbonized future, and distributed marketplace) are distinct and equally likely. However, they are neither distinct nor equally likely; for example, a de-carbonized future could occur during a time of stagnant economy or growth economy, and a carbon-constrained future is particularly likely, given pending federal regulation in the form of the Clean Power Plan currently being finalized by EPA.

Further, the way TVA weights different metrics is also problematic. TVA includes nine scoring metrics in its scorecard: PVRR ($ billion), System Average Cost 2014-2023 ($/MWh), Risk/Benefit Ratio, Risk Exposure ($ billion), CO_2 Emissions (million tons/year), Water Consumption (million gallons/year), Waste (million tons/year), System Regulating Capability (2033), and Percent Difference in Per Capita Income (Relative to Strategy A). It is unclear how TVA weighted the nine metrics. Perhaps TVA weighted them the same—the PVRR metric scores given the same final scoring weight as the risk exposure metric, and so forth. The 2011 TVA IRP used an uneven weighting system; PVRR was worth 42.25 percent of the final score, short-term rate impacts worth 22.75 percent, risk ratio worth 22.75 percent, and risk/benefit worth 12.25 percent of the final score.[44]

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[43] TVA (2015a), page 89, Table 7.3.

[44] TVA 2015 Integrated Resource Plan IRPWG Meeting, Session 6, April 29-30 2014, page 70. Note that 42.25 percent is calculated as the product of 65 percent and 65 percent, short-term rate impacts are the product of 65 percent and 35 percent, etc.

Because TVA did not establish the scoring system before generating results, and because TVA's mission includes environmental stewardship and economic well-being, Synapse recommends that TVA employ a two-step process to select a strategy.

First, TVA should use PVRR as an initial step to screen out strategies that are particularly expensive relative to the strategy with the smallest expected value. Because the PVRR calculations contain a margin of error, only strategies that are within a few percent of the lowest PVRR should be retained, and those strategies should be considered equivalent from a PVRR perspective. However, given margins of error inherent in the numerous assumptions factored into cost projections over a 20-year planning period (such as the erroneous assumptions made by TVA concerning energy efficiency and renewables pricing, discussed above), PVRR may not be a useful tool in distinguishing among plans that differ by only a few percentage points in overall cost. These plans should be evaluated in a second step through use of other metrics.

In the second phase, TVA should review the remaining strategies' performance in the remaining metrics, but in a more qualitative way, whittling down the list of strategies by eliminating the ones that perform worse in the non-PVRR metrics. In this way, TVA ensures that it's choosing a low-cost strategy, and one that helps TVA accomplish its missions related to economic development and environmental stewardship.

Detailed comments regarding the seven proposed metrics can be found below.

PVRR

The inclusion of a complete PVRR, including the expected cost of future regulatory and market price changes, is appropriate for every scorecard. Because minimizing cost is fundamental to the IRP process, PVRR is the metric that should be used to screen all strategies and should be given primacy above all other metrics. The PVRR metric produces a single value, representing a complex spectrum of forecasts and futures, and therefore has a margin of error. TVA should compare all strategies to the strategy with the lowest PVRR, and eliminate any strategies that produce costs outside the margin of error of the least-cost strategy.

The 2015 Draft IRP considers five strategies with average PVRRs ranging from a low of 130.0 to a high of 132.5.[45] Even the apparent most expensive strategy (Strategy E) is less than 2.0% more costly than the apparent least expensive strategy (Strategy A). Strategy E's estimated PVRR is clearly within the margin of error of Strategy A's estimated PVRR. Therefore, all five strategies should pass the PVRR screening test and be considered on equal footing when applying subsequent metrics in the scorecard.

[45] TVA (2015a), page 89, Figure 7-24.

System Average Cost 2014-2023 ($/MWh)

The inclusion of a nearer-term cost has a clear implication: it is reasonable to have a higher total system cost over the length of the study if the nearer-term costs are lower. Put another way, by including the metric system average cost 2014-2023, TVA is indicating that it is reasonable to saddle future ratepayers with unnecessarily high costs to save current ratepayers a bit of money now. The inclusion of this metric explicitly incentivizes a wealth transfer from future generations to the current generation. It also disincentives long-term investments that require higher upfront costs, such as wind and solar PV generation and energy efficiency, even though these resources result in lower overall costs. For these reasons, it is inappropriate to include system average cost 2014-2023 as a metric—TVA's mission does not include the directive to provide slightly lower-cost power now at the cost of substantially more expensive power later. This metric does not help decision makers chose a strategy that aligns with TVA's mission, and therefore it should be eliminated from the scorecard altogether.

Risk/Benefit Ratio

A risk/benefit ratio is the ratio of a strategy's upside to its downside, and measuring the relative risk of different strategies can be useful. This risk/benefit ratio metric has problems not incurred by other risk metrics. By definition, the ratio's numerator is the value of a strategy's 95^{th} percentile PVRR minus the expected value of its PVRR, and its denominator is its PVRR expected value minus its 5^{th} percentile PVRR.

This metric has a troubling characteristic: It does nothing to distinguish between two strategies with different risk. If one strategy has a particularly large P(95) value and an equally small P(5) value, it could have the identical risk/benefit ratio of another strategy with a smaller P(95) and larger P(5) value. For example, if Strategy I has an expected PVRR of 100, a P(5) value of 80, and a P(95) value of 125, its risk/benefit ratio is (125 – 100)/(100 – 80) = 1.25. Strategy II also has a PVRR of 100, but a P(5) value of 60 and a P(95) value of 150. It is far riskier—the highs are higher, the lows lower. Its risk/benefit ratio, however, is identical: (150 – 100)/(100 – 60) = 1.25. The metric scores both strategies equally, despite the first strategy being far less risky than the second. Ratepayers do not value risk and uncertainty, and this metric cannot reliably distinguish between strategies with very different risk profiles. Because this metric allows high levels of upside risk to obscure high levels of downside risk, it cannot be used effectively by decision makers to avoid downside risk and therefore should be eliminated from the scorecard.

Risk Exposure

While the inclusion of risk metrics is problematic for the reasons described above, to the extent that a risk metric is included, the risk exposure metric is a better choice for an IRP scorecard because it discourages risk-taking strategies. While the draft IRP finds that more aggressive energy efficiency (Strategy D) and renewable energy (Strategy E) carry higher financial risks than the other three strategies based on PVRR using the risk exposure metric,[46] it is highly likely that risk exposure values for these strategies will actually be lower than those for the other three strategies if TVA uses more realistic, lower unit cost estimates for both efficiency and wind power as described in Section 2 and 3 above, given a greater price uncertainty of natural gas (as shown on page 140 of the draft IRP) versus the more stable cost of energy efficiency and renewable energy (as discussed in Section 2 and 3 above).

CO_2 Emissions

Because it is likely that the Clean Power Plan will result in an explicit or shadow price of CO_2 emissions, TVA should model that emissions cost within PVRR. In addition to CO_2 costs reflected in PVRR, the CO_2 emissions should also be included as a metric in the qualitative stage of the scorecard review. The reason is straightforward: the range of CO_2 prices (explicit or shadow) TVA will face under the Clean Power Plan are less than the social cost of carbon. Because TVA is obligated by its mission to consider CO_2 emissions from the perspective of environmental stewardship in addition to least-cost planning, CO_2 emissions should be included as a metric used in the qualitative phase of scorecard analysis.

Water Consumption

To the extent that current or reasonably expected future regulations require TVA to bear a cost related to water consumption, those costs should be included in its PVRR calculation. Additionally, just like the CO_2 emissions metric, it is reasonable to include the water consumption metric in the qualitative phase of the scorecard method.

Waste

To the extent that current or reasonably expected future regulations require TVA to bear a cost related to coal ash, sludge, or slag, those costs should be included in its PVRR calculation. Additionally, just like the CO_2 emissions metric, it is reasonable to include the water consumption metric in the qualitative phase of the scorecard method.

System Regulating Capability

TVA includes this metric in an effort to assign value to system flexibility, arguing that it is "a key consideration for long-range resource planning."[47] This is rather misguided. It goes without question that TVA should not propose implementing a strategy with reliability performance below a minimum threshold. The lowest-cost reliable plan might be very flexible according to a flexibility metric or not particularly flexible. Flexibility is not, in itself, a property of value, and the value of incremental system flexibility to operation is non-linear. To the extent that a flexible strategy provides actual savings, those

[46] Ibid, page 97.

[47] Ibid, page 98.

savings will be reflected in a lower PVRR. Therefore, all strategies that meet TVA's reliability performance threshold should be considered on equal footing.

The specific flexibility metric TVA proposes is the sum of regulating reserves, demand response, and quick start capacity divided by peak load, but only "to respond to rapid increases in demand."[48] No flexibility scorecard is appropriate because flexibility isn't in itself core to TVA's missions of low-cost power, environmental stewardship, and economic development, but this particular metric—one that values the ability to ramp upward but not downward—is particularly puzzling. Grid operators are charged with ensuring that supply matches load; putting too much power on the grid is just as problematic as putting too little power on the grid. The distinction is important because while steam units (coal, nuclear, and gas steam) cannot ramp quickly up or down, operating wind units and PV with single- or dual-axis tracking can ramp down extremely quickly by rotating wind turbine blades and tilting PV panels away from the sun. Wind and PV units that have been ramped down can subsequently be ramped up by re-optimizing the angles of the turbine blades or PV panels to capture more energy. In addition to the fact that the system regulating capability metric provides no added benefit, it is not clear how TVA is incorporating the different ramping capabilities of different units.

All proposed strategies result in substantially more flexible capabilities than TVA has now, both regarding upward and downward ramping capabilities. This metric should not be included in the scorecard because flexibility isn't one of TVA's mandates and because all five proposed strategies are sufficiently reliable, despite different degrees of upward flexibility.

Percent Difference in Per Capita Income

For most utilities, considering the economic impact on the region in resource decision-making is prohibited by law, decision, or tradition. TVA is different: The economic development of the Valley is explicitly part of TVA's mission. For this reason, including economic impact in the scorecard may be appropriate.

6.3. Conclusion

TVA can use a scorecard to provide useful information to decision makers, but the scorecard approach proposed in the IRP needs several modifications to ensure the scorecard helps sound decision making, rather than hinders it.

The scorecard should reflect the primacy of PVRR. Any strategy with a PVRR that is clearly greater than the least-cost PVRR should be excluded. Conversely, all strategies with a PVRR within the margin of error of the least-cost PVRR should be considered on equal footing from a cost perspective.

[48] TVA Draft IRP EIS, page 33.

Once the PVRR screening is complete, the remaining *useful* metrics should be employed in a qualitative manner, whereby the results of each strategy are compared within each metric. The metrics that should remain within the scorecard are risk exposure, CO_2 emissions, water consumption, waste, and percent difference in per capita income. The proposed metrics that should be eliminated from the scorecard include system average cost 2014-2023, risk/benefit ratio, and system regulating capacity.

TVA should take great pains to ensure that the results of the scorecard are transparent. It should be possible to trace each value back to original sources, and all calculations should be made explicit.

For future IRPs that employ a scorecard, the scorecard metrics and formulas should be defined completely before the rest of the IRP process proceeds. This ensures that TVA explicitly enumerates the outcomes it value and prevents TVA from being accused of designing a scorecard that favors a specific proposed strategy.