Comments in response to Tennessee Valley Authority's November 16, 2010 release of its Draft Integrated Resource Plan and accompanying Environmental Impact Statement (No. 20100379) for public review and comment

Submitted by the Southern Alliance for Clean Energy

November 15, 2010

The Southern Alliance for Clean Energy (SACE) respectfully submits these comments in response to TVA's request for review and comment on its Draft Integrated Resource Plan (IRP) and accompanying Draft Environmental Impact Statement (EIS).

The IRP process is necessary to ensure TVA's ability to meet the Tennessee Valley's future energy demand while fulfilling its statutory mandates to steward the environment, support economic development and be a leader in technological innovation. The current planning process, including the formation of the Stakeholder Review Group, is a significant step forward not only for TVA's planning processes, but also for TVA's relationship with the nine million people it serves.

SACE strongly encourages TVA to establish a policy of updating its resource plan on a biannual basis, with major updates (including a programmatic EIS) occurring every four years. Prevailing practice among major utilities is to update resource plans every 1-3 years, which provides transparency and consistency in responding to changing economic and policy circumstances. Furthermore, regular review and amendment of TVA's IRP will ensure continued dialogue between TVA and its constituents. In short, an iterative planning process ensures TVA the best plan for meeting future energy demand.

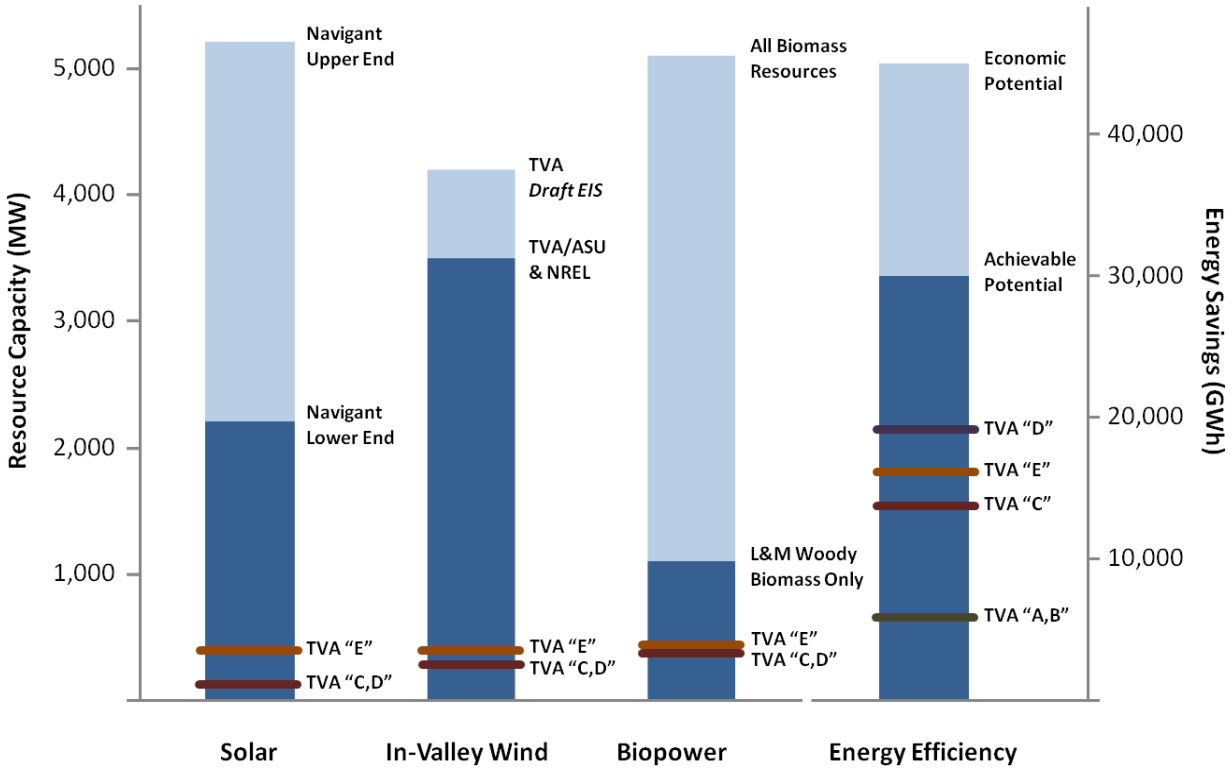
TVA's general framework for analysis is consistent with national best practices and provides a structured format to stress-test various resource portfolios. We also acknowledge that TVA leadership and staff have been candid and responsive to stakeholder input and requests for additional information (after occasional delays and disagreement), making our involvement with TVA's Stakeholder Review Group (SRG) worthwhile. We commend TVA for these accomplishments.

However, SACE has identified several shortcomings of the Draft IRP and EIS, most of which can be addressed within TVA's existing planning framework. Several of these shortcomings, however, are symptoms of broader concerns that we have regarding TVA operations. These issues may limit the effectiveness of the IRP process.

TVA maintains a general lack of interest in renewable energy resources, and has not committed to relying on energy-efficiency as a long-term resource.

TVA has yet to make any meaningful commitment to developing the Valley's renewable energy resources at a utility scale. TVA's failure to conduct the necessary analysis to fully define the Valley's renewable energy resources, discussed in detail below, is a symptom of TVA's overall lack of commitment to developing these resources. While TVA's various strategies were designed with the intent of studying a wide range of resource options, renewable energy potential is barely varied among the strategies, and the full range of energy efficiency potential is not explored (Figure 1).

Figure 1: TVA Strategies Do Not Fully Explore Potential Renewable and Energy Efficiency Resource Opportunities



Renewable energy resources in strategies "A" and "B" rely primarily on out-of-Valley wind resources and a small amount of capacity from TVA's Generation Partners program. Resource capacity details are described below (Figures 3, 4, 5, 21 and 23).

Unlike TVA's recent progress in developing energy efficiency programs, TVA has yet to commit any significant budget or staff to developing the Valley's renewable energy resources. Further, TVA's August 20th announcement of its new vision made no mention of renewable energy resources, leaving many stakeholders wondering when, if ever, TVA will recognize the potential of these resources to meet a significant portion of the Valley's

future electrical demand. Irrespective of whether TVA develops utility scale renewable generation internally or via power purchase agreements (PPAs), it will require dedicated staff and budget to assess renewable resource costs and benefits and to manage TVA's resource development efforts. Without these commitments, the role of in-Valley renewables in meeting TVA's future energy demand will continue to be undervalued regardless of the IRP process.

TVA is over-enthusiastic about increasing its nuclear generating capacity.

TVA has accelerated its nuclear program prematurely, relying on analysis that is unsound for reasons that are similar to many of the detailed concerns described in our comments on the Draft IRP and EIS. At the August 20th TVA Board meeting, TVA stated the goal of being the national leader in nuclear power production and committed nearly $250 million towards completing Bellefonte Unit One. TVA's rationale for these commitments, in spite of the ongoing IRP process, was that preliminary IRP results indicate a strong likelihood that Bellefonte Unit One would be necessary to meet demand in 2018[1] and would facilitate higher levels of coal plant retirements.[2] However, with proper levels of efficiency and renewable energy[3], TVA could achieve aggressive levels of coal-plant retirements and meet energy demand beyond 2018 while delaying, or possibly avoiding altogether, the need to construct additional nuclear reactors. .

The Draft IRP lays out several portfolios that include large-scale coal-plant retirements without additional nuclear reactors before 2022 if ever. Figure 2 compares the timing of Bellefonte Unit One under the Draft IRP's Strategy B, TVA's Baseline, and Strategy C, the diversity-focused strategy.

Figure 2: Timing of Bellefonte Unite One Under Strategies B and C

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Draft IRP Baseline
Strategy B	2018	2020	N/A	2018	2018	N/A	N/A
Strategy C	2018	2022	N/A	2018	2022	N/A	2018

TVA, *Stakeholder Review Group Working Session*, presented to the Stakeholder Review Group, July 20, 2010.
Note: Constraints on the Draft IRP's other strategies, i.e. Strategy A's prohibition on new supply-side generation and Strategy E's prohibition on nuclear units before 2022, did not allow for a proper comparison.

Strategy C only adds Bellefonte Unit One in 2018 under the Baseline Scenario and Scenarios 1 and 4, the three highest load growth strategies.[4] Under the moderate (and more realistic)

[1] TVA, *Draft IRP,* p. 110 – 111.
[2] See, for example: TVA, *Draft Supplemental Environmental Impact Statement: Single Nuclear Unit at the Bellefonte Plant Site,* November, 2009, p. 12 – 14.
[3] The Draft IRP's flawed treatment of efficiency and renewables is discussed at length later in these comments.
[4] TVA, *Scenarios for IRP Project*, slide 8. Presented to the Stakeholder Review Group, December 9, 2010.

load growth conditions of Scenarios 2 and 5, Bellefonte Unit One is delayed until 2022. Strategy C includes 1,000 MW *more* coal plant retirements and nearly twice as much energy efficiency, demand response and renewable energy than Strategy B.[5]

It is also worth noting that Strategy E: EE/DR and Renewables Focused Strategy, while not directly comparable due to its set prohibition on new nuclear units before 2022, is almost identical in generation additions to Strategy B other than Bellefonte Unit One.[6] However, Strategy E includes 3,000 MW more coal plant retirements and almost three times as much efficiency, demand response and renewables as Strategy B.

These results indicate that reduced load growth due to energy efficiency and demand response, coupled with modest levels of renewable energy resources, can allow for significant levels of coal plant retirement without additional nuclear units.[7] The Draft IRP simply does not adequately consider whether an even higher, yet feasible, level of energy efficiency and renewable energy would be a better path forward than nuclear energy (even from TVA's current perspective). While there are several additional factors at play in this analysis, we question TVA's decision to continue pursuing this high cost, high risk resource in spite of several indications that it is not necessary.

TVA's Board of Directors is not compelled to act in accordance with the IRP.

While SACE supports this IRP process, we continue to be concerned because the TVA Act does not require the TVA Board of Directors to act in accordance with IRP results. Unlike the Bonneville Power Administration where the Administrator is statutorily compelled to act in accordance with the Northwest Power Council's IRP, the TVA Board of Directors has sole discretion in its decision-making, potentially impacting the current IRP's effectiveness.

This is not meant to be a criticism of current TVA Board members. However, Board members change over time, and inconsistent strategic direction has hampered TVA's past ability to meet electricity demand while fulfilling its statutory environmental and economic directives. Given the significant investments of time and effort by TVA staff, the Stakeholder Review Group and others who have engaged in this process to draft a sound strategy, the TVA Board of Directors should be compelled to act in accordance with the final IRP in the absence of compelling justification for diverting from the IRP's recommendations.

[5] TVA, *Draft IRP,* p. 103.
[6] TVA, *Draft IRP*, p. 145 – 148.
[7] The additional sensitivity runs that TVA plan to conduct between now and the release of the final IRP may shed further light on how efficiency and renewables can delay, or even obviate the need for additional nuclear generation.

The Draft IRP has a number of shortcomings, particularly with respect to renewable energy, energy efficiency, and load forecasts that should be addressed.

In support of the general concerns described above, SACE has identified several shortcomings in the Draft IRP and EIS that should be addressed. In the interest of brevity, SACE is not commenting on areas of the IRP where we are in general agreement with TVA. Furthermore, in cases where we have a different interpretation of data or methods, but we have not identified any path in which these differences would likely affect the IRP's results in a meaningful manner, we are also refraining from comment. However, these differences may be important in the context of specific programmatic or policy decisions.

The shortcomings SACE has identified are discussed below. In most cases, this discussion reflects a refinement of comments and input provided by SACE during the Stakeholder Review Process. To some extent, our comments also reflect new reactions that were only possible after receiving the results of the analysis and consulting with outside experts to validate assumptions or methods used by TVA.[8] SACE urges TVA to revise its Draft IRP and EIS in response to our concerns to ensure a sound strategy for meeting the Valley's future electricity needs.

1. TVA has not accurately assessed the Valley's potential for renewable energy resources. As a result, these resources are undervalued in the Draft IRP and EIS.

Even though TVA's "Strategy E" is characterized as "EE/DR and Renewables Focused," TVA has not evaluated any resource strategy that includes truly aggressive level of renewable energy resources. For some resources, TVA does not appear to have completed the appropriate analysis to fully quantify these resources. For other resources, TVA has inexplicitly restricted use of the identified resources. SACE estimates of feasible potential, confirmed by independent analyses, demonstrate how TVA could develop significantly higher levels of renewable energy resources over the course of the planning period.

[8] SACE gratefully acknowledges the input of experts from Crossborder Energy, Larson & McGowin, Navigant Consulting, and Optimal Energy who provided analysis or advised us on aspects of our participation in the Stakeholder Review Group process and the review of the Draft IRP and EIS.

a. The Draft IRP's assessment of in-Valley renewable energy resources is incomplete and inaccurate.

TVA's Draft IRP and EIS lack the necessary analysis to reasonably assess the potential for developing the Valley's renewable energy resources. One reason TVA offers for its weak analysis of in-Valley renewables is that it does not have the in-house expertise to develop these resources.[9] TVA's analysis of in-Valley renewable energy resources is incomplete because:

- A comprehensive resource potential study was not completed to determine the feasible potential of the Valley's wind, solar and biomass resources;
- No integration study was completed to determine how the Valley's renewable resources could be integrated into TVA's transmission and distribution system;
- TVA has not completed an analysis of the potential ancillary benefits or costs of integrating significant levels of in-Valley renewable energy resources, including:
    - The potential benefits regarding grid stability;
    - The potential efficiency gains in transmission and distribution associated with higher levels of distributed generation;
    - The economic benefits of higher levels of in-Valley investments; and
    - The reduced costs associated with greenhouse gas and air pollutant mitigation.

We recommend that TVA re-consider its limitations on renewable energy resources, including a full assessment and characterization of the cost-effectiveness of renewable energy resources in the context of its IRP.

Without comprehensive resource potential and implementation assessments encompassing the entire 20-year planning period, TVA has arbitrarily limited in-Valley renewable resources to model inputs that reflect only a small fraction of their potential. These defined incorrectly imply a very limited potential for in-Valley renewable energy resources.

The Draft IRP considers a maximum of about 1,120 MW by 2029 of in-Valley renewable energy from solar, wind and biomass resources.[10] This maximum development path is "Strategy E" in the Draft IRP, the EE/DR and Renewables Focused Strategy (Figure 3), including:

- In-Valley solar: approximately 350 MW
- In-Valley wind: approximately 360 MW
- In-Valley biomass (including co-firing, conversions and power-purchase agreements): approximately 410 MW

In contrast, this strategy anticipates approximately 2,450 MW of out-of-Valley wind.

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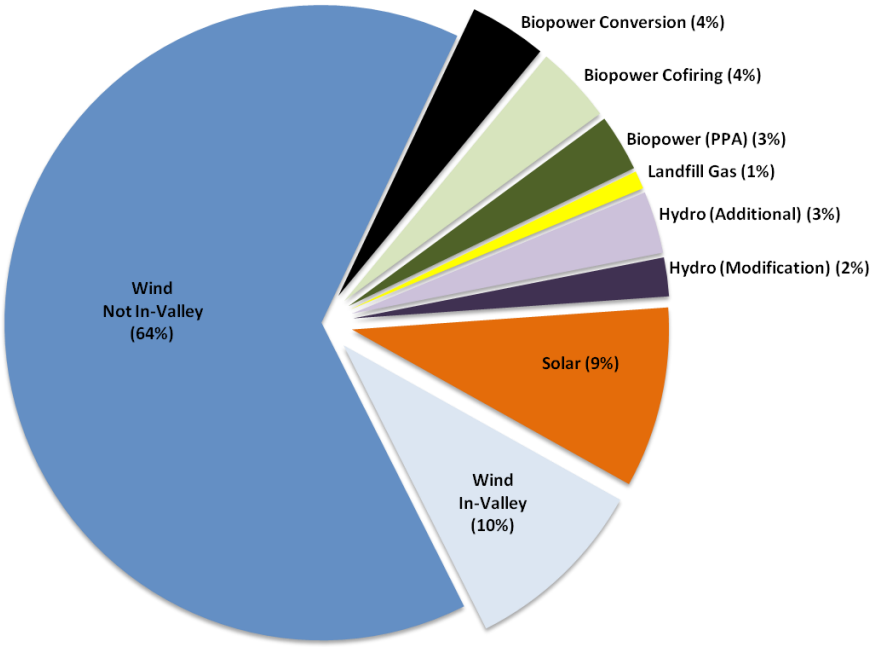
[9] *Draft IRP*, p. 70 and 71.

[10] The entire maximum renewable energy package, including out-of-Valley resources, consists of approximately 3,800 MW.

Figure 3: TVA's IRP Strategy E Renewable Energy Portfolio (by 2029)



TVA, *IRP Renewable Energy Additions*; provided to IRP Stakeholder Review Group, June 2010.
Note: Total capacity of this renewable energy package is approximately 3,800 MW by 2029. All values are approximate as estimated from charts provided by TVA.

It is clearly appropriate for TVA to aggressively develop out-of-Valley wind resources (providing that appropriate transmission development is feasible). Nevertheless, available independent analysis, summarized in Figure 4 below, confirms that the realistic achievable potential for in-Valley wind, solar and bioenergy resources is significantly higher than what is represented by the Draft IRP's most aggressive proposed portfolio.

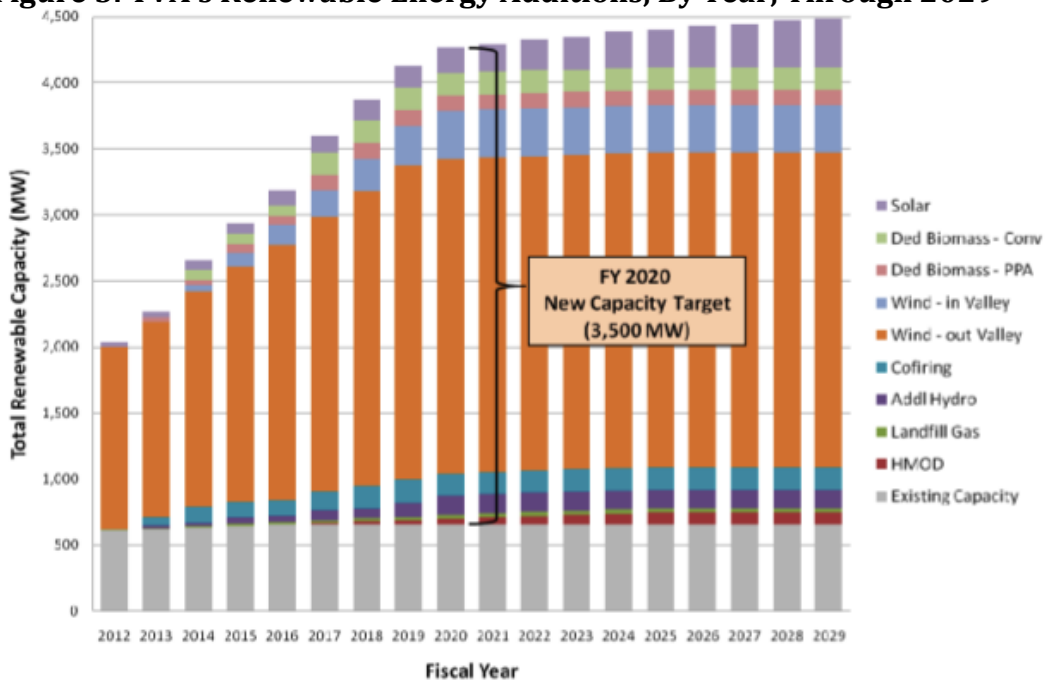
Figure 4: The Draft IRP's Maximum Development of in-Valley Renewable Energy Compared with SACE Estimates of Feasible Potential by 2029

Resource	**TVA Maximum Capacity** (MW)	**SACE Feasible Potential** (MW)
Solar Photovoltaic	350	2,200 – 5,200
In-Valley Wind	360	3,500 +
Biopower	410	1,100 – 4,000
Total	**1,120**	**6,800 – 12,700**

TVA considered hydroelectric, out-of-Valley wind, and other renewable energy resources in its Draft IRP. This table highlights areas where SACE feels TVA should improve its analysis. The details of SACE's feasible potential estimates are discussed below.

Furthermore, TVA effectively limits renewable energy development to the first half of the planning period. None of TVA's strategies consider substantial renewable energy development after 2020. For example, TVA's most aggressive renewable energy portfolio adds 3,500 MW of renewable energy by 2020, but only about 300 MW between 2020 and 2029 (Figure 5). As a result, TVA's resource options are unreasonably constrained in the 2020-2029 timeframe. These constraints potentially leave significant amounts of cost-effective renewable energy undeveloped and artificially skew the model towards other resource options such as natural gas and nuclear.

Figure 5: TVA's Renewable Energy Additions, By Year, Through 2029



TVA, *IRP Renewable Energy Additions*, provided to IRP Stakeholder Review Group, June 2010.

In all, TVA has failed to conduct a proper analysis of in-Valley renewable energy resources, leading to improper assumptions about the potential for these resources to contribute to meeting TVA's energy demand over the planning period. As a result, the Draft IRP and EIS are skewed against in-Valley renewable energy resources and in favor of more traditional and potentially more costly generation resources. Independent analysis of the Valley's potential for solar, wind and biomass resources clearly indicates significantly higher potential than what is represented in the Draft IRP.

b. Solar Photovoltaic Resources

The Draft IRP's defined model inputs for in-Valley solar PV represent only a fraction of this resource's potential over the course of the planning period.

Independent analysis clearly indicates a much larger in-Valley solar PV resource than what is represented in TVA's Draft IRP and EIS. TVA could reasonably achieve 10 to 15 times more solar PV than the levels identified by the Draft IRP and EIS.

The Draft IRP and EIS provide only a superficial analysis of TVA's available solar PV resource. The Draft IRP provides only a brief description of this technology, with no discussion of solar PV's achievable potential over the course of the planning period. The Draft EIS provides a bit more substantive analysis, but still fails to address the key questions necessary for a proper evaluation, namely how much solar PV could be developed within the planning period and what are the costs and benefits of developing this resource.

Even the Draft EIS's limited discussion, however, suggests that TVA is significantly undervaluing this resource. Using 2009 data collected by the National Renewable Energy Laboratory (NREL), the Draft EIS briefly explores the land area requirements necessary to meet TVA's entire 2005 electrical load with solar PV and reviews the available rooftop area in the TVA region to develop solar PV resources. The conclusions drawn by this brief analysis are that:

- The solar resource in the TVA region is plentiful[11], and
- The TVA power service area PV rooftop potential in 2010 is approximately 23,000 MW, expected to grow to approximately 30,000 MW of capacity in 2015.[12]

This "technical potential" analysis reaches findings similar to a 2009 report published by SACE (see Attachment 1). Utilizing the best available data from independent and governmental sources, SACE estimated 45,851 MW of solar capacity in Tennessee, considering rooftop and ground-mounted resource opportunities.[13]

In order to address the lack of current solar energy data in the draft IRP and EIS, SACE commissioned a study by Navigant Energy Consulting to analyze the solar PV resource in TVA's service territory (see Attachment 2).[14] Navigant's study estimates the level of penetration that TVA could reasonably achieve by 2030, considering:

- A 2008 Navigant study completed for NREL,
- TVA data provided in the Draft IRP and EIS,
- TVA's baseline forecast for 1.1% load growth and 1.4% peak demand growth,

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[11] *Draft EIS*, p. 128 – 129.
[12] *Draft EIS*, p. 129.
[13] Southern Alliance for Clean Energy, *Yes We Can: Southern Solutions for a National Renewable Energy Standard*, February 2009, p. 12
[14] Navigant Consulting, *Independent Solar Assessment*, completed for the Southern Alliance for Clean Energy, November 2010.

- Available public research, particularly regarding the uncertainties surrounding the upper limit on PV penetration that could impact grid operation and the location of PV interconnection,
- Navigant's own in-house expertise.

Navigant analyzed nine different combinations of maximum penetration levels and allocations of investment between rooftop-mounted and ground-mounted technologies. Based on this analysis, Navigant Consulting estimated that TVA could add as much as 5,200 MW of solar energy resources to its system by 2030 without impacting grid operations (see Figure 6).[15]

Figure 6: Solar Energy Installation Scenarios for 2030, Navigant Consulting

Penetration Levels	Capacity Scenario		Estimated Energy Output*	
	MW	% of Baseline Forecast	GWh	% of Baseline Forecast
Lower End	2,200 – 3,200	5 – 8 %	3,900 – 5,600	2 – 3 %
Mid Range	3,200 – 4,200	8 – 10 %	5,600 – 7,400	3 – 4 %
Upper End	4,200 – 5,200	10 – 13 %	7,400 – 9,100	4 – 5 %

* Energy output specific to the TVA service area was beyond the scope of the project conducted by Navigant Consulting. SACE estimated energy output based on a 20% capacity factor for illustration purposes only. The actual output would depend on characteristics such as technology, site and interconnection opportunities.

In comparison, TVA's most aggressive renewable energy package includes only about 350 MW of solar PV capacity by 2030. This represents only 7 to 16% of the reasonable solar PV potential identified by Navigant.

TVA's cost estimates for solar PV are excessively high.

The Draft IRP also uses excessively high cost estimates for solar PV resources in the TVA service territory. The Draft IRP assumes a levelized cost of energy (LCOE) of approximately $296 per MWh for solar PV resources.[16] This is clearly too high, and as a result solar PV resources are artificially disadvantaged compared with other resource options.

A primary resource in determining the levelized costs of solar PV is the June 2010 presentation from Black & Veatch (B&V), a consultant to the California Public Utilities

[15] Note that Navigant Consulting recommends that TVA conduct load flow and solar integration studies to better understand the impacts of aggressive levels of solar energy development on the TVA system. Navigant consulting found that the levels of solar PV installation it considered in this study "will not likely significantly impact TVA's grid operation." (Navigant, p. 7)

[16] TVA, *Stakeholder Review Group Working Session*, presentation to the Stakeholder Review Group, February 17, 2010, slide 28.

Commission (CPUC), in its docket on planning the state's Renewables Portfolio Standard.[17] B&V has extensive experience both with large-scale PV projects and with public databases on PV costs. We adjusted for the difference between the cost and performance of the California-based systems studied by B&V (Figure 7).

Figure 7: Tennessee vs. California Solar PV Index

PV Characteristic	TN/CA
PV output	0.86
Local Construction Costs	0.76
Local cost %	50%
System cost	0.88
LCOE	1.020

Our adjustment for PV output is based on the National Renewable Energy Lab's industry-standard PVWATTS calculator, comparing the outputs of reference PV arrays in Fresno, San Francisco, Knoxville and Nashville.[18] Using this calculator, we estimate that the output of the California arrays is, on average, 14% higher than solar PV arrays in Tennessee.

Discrepancies in construction costs can be accounted for using the U.S. Army Corps of Engineers' Civil Works Construction Index System.[19] In 2009, such costs were 24% less expensive in Tennessee than in California. We assume that the costs of PV panels and inverters is the same in both states, and that the cost difference applies only to the balance of the plant that consists of standard structural materials, typical construction techniques, or involves straightforward utility equipment (approximately 50% of the total project costs altogether). Considering these factors, the levelized cost of energy for a solar PV project in Tennessee should be approximately 2% higher than one in California on a per MWh basis, taking into account the greater output of solar PV projects in California.

Because cost advantages almost exactly balance out performance disadvantages, a $296 per MWh cost in Tennessee is equivalent to a $290 per MWh cost in California. This is equivalent to the highest cost for the least cost-effective technology identified by B&V (Figure 8). A far more reasonable comparison for use in the Draft IRP would be to the larger and utility-scale systems identified by B&V, which is less than 60% of the cost estimate used by TVA.

[17] Ryan Pletka, *LTPP Solar PV Performance and Cost Estimates*, Black & Veatch presentation to the California Public Utilities Commission, June 18, 2010.
[18] NREL's PVWATTS calculator is available at: http://www.nrel.gov/rredc/pvwatts/version1.html
[19] USACE Civil Works Construction Index System in available at: http://140.194.76.129/publications/eng-manuals/em1110-2-1304/entire.pdf

Figure 8: Black and Veatch Cost Estimates for Solar PV ($ per MWh)

Cost	Rooftop	Ground			Utility-Scale	
	0.5 – 2 MW Fixed	0.5 – 2 MW Tracking	2 – 5 MW Fixed	5 – 20 MW Fixed	150 MW Tracking	150 MW Fixed
Low	$248	$185	$175	$168	$148	$137
High	$290	$229	$213	$205	$161	$155

Ryan Pletka, *LTPP Solar PV Performance and Cost Estimates*, Black & Veatch presentation to the California Public Utilities Commission, June 18, 2010.

Recent utility experience with procuring solar PV resources in the U.S. also indicates that the actual costs of solar PV resources are lower than the Draft IRP's estimate of $296/MWh. Some recent examples of solar PV development include:

- The CPUC has established a cap of $260 per MWh for Southern California Edison (SCE) 0.5 to 10 MW rooftop and ground-mounted PV projects in its service territory. SCE recently announced that it had awarded over 50 MW of 20-year contracts under this cap.[20]
- Sacramento Municipal Utility District (SMUD) contracted for 100 MW of solar PV capacity, consisting of 3-to-5 MW projects, under a feed-in tariff with a levelized, 20-year price of $148 per MWh[21] for projects commencing operations in 2012.[22]
- Pacific Gas and Electric (PG&E) has 13.5 MW, consisting of nine small (1.5 MW) solar PV projects, under contract at a 20-year price of approximately $140-$150 per MWh.[23]

Taken together, the B&V cost estimates, these contracts, and the evidence that levelized costs in California are coincidentally similar to those in the TVA region clearly indicate that TVA has overestimated solar PV costs. TVA should revisit its cost estimate for solar PV resources based on a reasonable expectation of significantly lower average price per MWh for solar PV projects in the TVA service territory than the $296/MWh estimated in the Draft IRP.

The Draft IRP and EIS unreasonably assume that the installed cost of solar PV will remain constant throughout the planning period.

Projected future cost trends should also be incorporated into the Draft IRP's analysis of solar PV resources to reflect the rapid development of the region's solar markets and supply chains. TVA provided its assumed cost of installed solar energy to its Stakeholder Review Group on a confidential basis. For this reason, we cannot directly discuss it in these

[20] SCE advice Letters 2513-E and 2514-E, available at: www/sce/com/AboutSCE/Regulatory/adviceletters/pending.htm

[21] This price includes a $20/kW development security cost that developers must pay to SMUD.

[22] SCE Advice Letters 2513-E and 2514-E, available at www.sce.com/AboutSCE/Regulatory/adviceletters/pending.htm.

[23] PG&E's under 1.5 MW solar PV contracts are summarized at: www.pge.com/b2b/energysupply/wholesaleelectricsupplierssolicitation/standardconstractsforpurchase/.

public comments. However, based on our review of this information, the Draft IRP and EIS assume that the costs associated with solar energy installation remain constant throughout the planning period, which is inconsistent with its forecast methods for other resources.[24]

The industry standard for assessing future cost trends in solar PV is to look at the cost of installed solar on a $/kW basis. Navigant Energy Consulting analyzed current and future installed cost trends for solar PV technologies on a $/installed kW basis in the TVA service territory (Attachment 2). Based on this analysis, supported by industry and DOE projections, it would be more reasonable for TVA to assume a declining cost trend for solar PV technologies over the course of the planning horizon.

Navigant's analysis "is based upon Navigant's internal cost models that account for regional variations in system costs, publicly available data on system costs in TVA's territory, and interviews with installers active in TVA's territory." [25] Notably, Navigant *did not assume* "technological breakthroughs or significant business changes" that have led the US Department of Energy to set even lower installed cost goals. Therefore, Navigant's cost estimates are likely conservative.

Navigant estimates various solar PV technologies to have an installed cost of $4,800 – $7,100 per kW, and projects the costs of solar PV technologies to decline between 17 and 22% by 2020 and between 35 and 45% by 2030.

In contrast, TVA's Draft IRP and EIS provide no discussion of forecasted cost trends of solar PV. Given the rapid growth of solar supply chains in the TVA service territory in recent years, TVA's Draft IRP and EIS should include an analysis of solar PV's potential to become a more cost-effective resource option over the course of the planning horizon.

[24] TVA, *Solar Wind and Biomass Co-firing*, provided to the Stakeholder Review Group, September 24, 2009.
[25] Navigant, p. 18.

Figure 9: Projected Installed Cost Trends of Solar PV Technologies

Technology	Installed Cost Estimate ($/kW$_{DC}$)		
	2010 (Current)	2020	2030
Ground-mounted Polycrystalline PV: with tracking (10 – 50 MW)	5,900	4,900	3,750
Ground-mounted Polycrystalline PV: w/o Tracking (10 – 50 MW)	5,500	4,300	3,100
Ground-mounted polycrystalline PV: w/o tracking (100 – 300 MW)	4,800	3,800	3,100
Ground-mounted Thin-film PV: w/o tracking (10 – 50 MW)	4,800	3,800	3,100
Ground-mounted Thin-film PV: w/o tracking (100 – 300 MW)	4,700	3,700	3,000
Roof-mounted Polycrystalline PV: commercial (10 kW – 2 MW)	5,600	4,350	3,100
Roof-mounted Polycrystalline PV: residential (1 kW – 10 kW)	7,100	5,700	4,400

Navigant, p. 21 to 25.
Note: Costs include permitting and interest during construction, but do not include any necessary interconnection, transmission or substation upgrade costs. Costs are given in $2010.

TVA could achieve Navigant's "Lower End" penetration level at a cost that would be approximately 3% of its forecast revenue requirement.

In order to place the costs of investing in solar PV resources in context, we compared the cost forecast developed by Navigant to the Draft IRP's revenue requirement forecast. TVA forecasts a revenue requirement of about $14.8 billion for 2018 (Figure 10). In Navigant's Lower End, Minimal Central Station scenario, Navigant projects a revenue requirement of about $520 million for 2018 (Figure 11).[26] Therefore, solar energy investment in this scenario would represent about 3% of total system costs in 2018.

Figure 10: TVA Revenue Requirement Estimate, 2018

Energy forecast	185,000 GWh	Draft IRP, p. 52
Rate	$ 80 per MWh	Draft IRP, p. 118
Revenue Requirement	$ 14.8 billion	

[26] These costs are based on a scenario with a "lower end" penetration, a linear adoption rate, and a minimal level of central station located systems. Specific costs for 2018 were confirmed by Navigant staff.

Figure 11: Solar Capital Costs, Operating Costs, and Fuel Savings, 2018

Capital expenditures	$ 475 million	Navigant, p. 35
Operating expenditures	$ 45 million	Navigant, p. 35
Solar revenue requirement	$ 520 million	

The point of this analysis is not to specifically define how TVA should develop the solar PV resources of the Tennessee Valley, but rather to highlight that an aggressive pursuit of the Valley's solar PV resource would not require an outlandish investment by TVA. In contrast, an orderly, sustained approach to developing the solar PV resource would result in economic and environmental benefits to Tennessee Valley residents while supplying a significant portion of TVA's future electricity demand.

c. Wind Resources

Even the Draft IRP's most aggressive renewable energy strategy represents less than one-tenth of the potential wind resource that could be developed by TVA within the Valley.

The Draft IRP and EIS limit the development of in-Valley wind resources to a fraction of the Valley's potential to develop this resource. The problem is not with TVA's assessment of the resource, as our potential estimate is similar to TVA's potential estimate. Rather, the Draft IRP's strategic options for resource development limit the contribution of in-Valley wind resources to a maximum of approximately 360 MW by 2030 (Figures 3 and 4 above).[27] Similar to TVA's treatment of solar PV resources, these defined model inputs seem both arbitrary and unreasonably low.

Unfortunately, the Draft IRP and EIS do not provide an explanation for why wind resource development is limited to less than one-tenth of the in-Valley resource opportunity. TVA does discuss the relatively greater "potential and economics" for wind energy development outside the TVA region, but considering TVA's mission to support economic development in the Valley, more attention to the feasibility of in-Valley wind energy development is warranted.

Specific concerns regarding TVA's opportunity to pursue in-Valley wind development are discussed in the Draft IRP, but these are not clearly substantiated. For example, TVA claims a net capacity factor for the TVA service area of 20-22%, and that "taller turbine hub heights do not increase the net capacity factor significantly."[28] Yet both of these claims are contradicted by the NREL resource cited in TVA's previous paragraph.[29]

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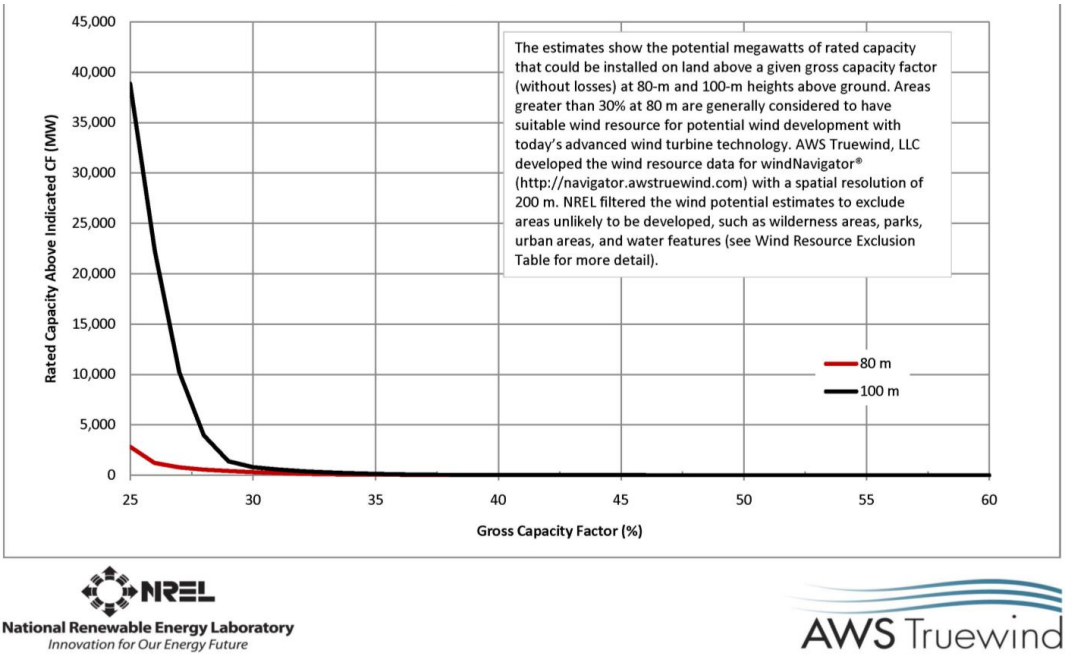
[27] *Draft EIS,* p. 144.
[28] *Draft IRP,* p. 71.
[29] National Renewable Energy Laboratory, *Tennessee Wind Map and Resource Potential*, Wind and Water Power Program website, content dated October 6, 2010.

As illustrated in Figure 12, NREL suggests that development of more than 2,000 MW in Tennessee could occur at a gross capacity factor of greater than 25% for 80 m turbines. For the same 2,000 MW level of development at 100 m, the gross capacity factor increases to about 29%. NREL does not provide a net-to-gross calculation estimate; if TVA has alternative data resources, these have not been disclosed.

Figure 12: Tennessee Wind Resource Potential, Cumulative Rated Capacity vs. Gross Capacity Factor (CF)



National Renewable Energy Laboratory, *Tennessee Wind Map and Resource Potential*, Wind and Water Power Program website, content dated October 6, 2010.

Other concerns, such as the brief description of possible siting resistance and competition for "choice" sites are also inadequately developed to explain why TVA considered extremely limited wind resource potential in the Draft IRP.[30] The Draft IRP does not explain why siting is more difficult or costly than similar challenges associated with the IRP's non-constrained fossil fuel and nuclear resource options. The Draft IRP also fails to reconcile concerns about competition for "choice" sites with the TVA's negative characterization of in-Valley wind potential.

While the Draft IRP and EIS clearly acknowledge the presence of significant in-Valley wind resources, the ability of the planning model to choose these resources is constrained by defining the in-Valley wind resource as a set model input. Because little substantive explanation is given in either the Draft IRP or Draft EIS as to why this resource should be

[30] *Draft IRP,* p. 71.

limited, it is difficult to comment on TVA's rationale. However, we feel strongly that TVA should reevaluate the potential for this resource and re-define the wind resource on more equal footing with TVA's other, more traditional resources options.

TVA's wind potential estimate is somewhat higher than the estimate developed by SACE.

The Draft IRP, relying on a Tennessee Wind Map and Resource Potential estimates from the DOE's Office of Energy Efficiency and Renewable Energy, acknowledges the availability of approximately 4,200 MW of wind power at an 80-meter turbine hub height.[31] The Draft EIS also notes the estimated 1,247 MW of wind resources discussed in the NREL Eastern Wind Integration and Transmission Study.[32]

In comparison, SACE estimates that about 3,500 MW of wind power is available in the TVA region. We developed our estimate using two resources, a 2005 study by Carson and Raichle (Figure 13) and a 2010 resource assessment by NREL (Figure 14).[33]

Figure 13: Carson and Raichle Study of Appalachian Wind Potential in the TVA Region

Site	State	Feasible Wind Development				report source
		Wind Class	Size (Mi)	Capacity (MW)	Energy (GWh)	
Bryson Mountain	KY TN	3	8.1 12.2	122 183	266 402	Table 5.2-3
Black Mountain	KY	3	38.8	582	1,275	Table 5.1-3
Cross Mountain	TN	3	103.6	1,554	3,404	Tables 5.3-3, 4
English Mountain	TN	3	1.1	17	37	Page 5-21
Forge Mountain	TN	4	10.8	162	426	Table 5.5-3
Subtotal	KY TN		46.9 127.8	704 1,917	1,541 4,268	
Total			**174.7**	**2,620**	**5,809**	

Note: These data were developed by SACE based on the discussion and data provided in TVA's wind prospecting report by Carson and Raichle[34] and a memo describing wind potential estimating methods.[35]

[31] *Draft IRP*, p. 70 – 71. The Draft IRP also discusses an estimate of 57,000 MW available at 100 m at a 25% capacity factor. It is unclear why the 57,000 MW estimate is discussed, since NREL's discussion of industry practice indicates a minimum 30% capacity factor at 100 m.
[32] *Draft EIS,* p. 127. Note that an expected annual energy generation of 3,500 – 4,000 GWh from 1,247 MW suggests a net capacity factor of 32-37%, which is significantly higher than the 20-22% claimed by TVA (*Draft IRP,* p. 71).
[33] Carson, R. and B. Raichle, *Wind Monitoring Around the Tennessee Valley Region*, Tennessee Valley Authority - Appalachian State University Wind Assessment Collaboration, December 2005.
[34] Carson, R. and B. Raichle, *Wind Monitoring Around the Tennessee Valley Region*, Tennessee Valley Authority - Appalachian State University Wind Assessment Collaboration, December 2005.
[35] Raichle, B., *Method for Estimating Potential Wind Generation in the Appalachians*, Appalachian State University, 2007.

Figure 14: NREL Wind Potential Data for TVA States (100 meter height, >30% capacity factor)

State	**Feasible Wind Development** 80 meter height, >30% capacity factor			**Feasible Wind Development** 100 meter height, >30% capacity factor		
	Area (km^2)	**Capacity** (MW)	**Energy** (GWh)	**Area** (km^2)	**Capacity** (MW)	**Energy** (GWh)
Alabama	23.6	118	333	113.6	568	1,588
Georgia	26.0	130	380	58.7	294	863
Kentucky	12.1	61	173	139.7	699	1,899
Tennessee	61.9	309	900	163.3	817	2,355
Total	**123.6**	**618**	**1,786**	**475.3**	**2,378**	**6,705**

National Renewable Energy Laboratory (NREL) and AWS Truewind, *Estimates of Windy Land Area and Wind Energy Potential by State*, spreadsheet dated February 4, 2010.

Although it is authoritative for most developable wind resource areas, we do not recommend the more recent NREL resource assessment for ridgetop wind in the TVA service territory. As TVA notes, "Due to the spatial resolution of this data, the ridgetop potential in the TVA region appears to have been devalued from previous National Renewable Energy Laboratory (NREL) estimates."[36] While spatial resolution is an issue, we have reviewed this issue, discussed it with NREL staff, and identified three additional problems that suggest the most recent NREL assessment is not ideally suited to estimating ridgetop potential.

- When ridge crests are aligned perpendicular to prevailing winds, wind strength is substantially increased along the ridge crest. For example, Carson and Raichle concluded that, "Wind maps developed by computer modeling should only be used as an indication of the wind resource. Many of the sites where monitoring data was available were estimated incorrectly by one wind class."[37] This issue is a refinement of the "spatial resolution" issue, as NREL's national models lack the spatial resolution to model this effect and thus tend to underestimate the capacity factor in the ridge crest locations where wind turbines are most ideally located.
- The NREL resource assessment may have improperly applied forest-related exclusions in non-protected areas on ridge crests in the Appalachians.
- The NREL studies relied on a 5 MW per km^2 turbine area density estimate, which is appropriate for most sites other than ridgetops. A 15 MW per mile linear density estimate is appropriate for development along the crests of ridgetops.[38]

Until NREL addresses these issues, we recommend the use of other data sources where available.

[36] *Draft EIS,* p. 127.
[37] Carson, R. and B. Raichle, *Wind Monitoring Around the Tennessee Valley Region*, Tennessee Valley Authority - Appalachian State University Wind Assessment Collaboration, December 2005.
[38] Raichle, B., *Method for Estimating Potential Wind Generation in the Appalachians*, Appalachian State University, 2007.

For Alabama and Georgia, however, we do recommend use of the 100 meter NREL data as the best representation of wind resource potential (Figure 14). We recommend this data set due to a lack of alternative data sources and because many or most of the mapped locations with substantial wind potential appear to be appropriately analyzed using the NREL data (i.e., while they are elevated areas, they may not be ridge crests). Better studies would be worthwhile but the NREL data are likely to provide a reasonable "order of magnitude" estimate.

For Tennessee and Kentucky, the 2005 Carson and Raichle study is the best available resource (Figure 13). This study provides site-specific data for several promising wind resource development sites in the TVA region. We analyzed these data in 2008 and estimated the wind development potential for sites in Tennessee and Kentucky. While this data resource is highly credible and likely to provide a useful foundation estimate, a number of sites mapped by NREL with additional capacity up to 2,00 MW are not included in the Carson and Raichle study.

Based on these resources, we estimate that TVA could feasibly develop about 3,500 MW of wind resource within the TVA service territory, resulting in about 8,300 GWh of annual generation, which is equivalent to an average 27% capacity factor (Figure 15).

An alternative (in our opinion, highly conservative) estimate of wind development potential would be NREL's estimate of 618 MW for 80 meter turbine heights at greater than 30% capacity factor (Figure 14). This would offer nearly twice the capacity and nearly three times the annual energy generation as the largest resource considered among the Draft IRP's strategic options.

Figure 15: TVA Wind Potential

State	Feasible Wind Development		
	Capacity (MW)	**Energy (GWh)**	**Notes**
Alabama	568	1,588	- NREL 100 m data used - NREL maps indicate wind potential is in or near TVA service area
Georgia	294	863	
Kentucky	704	1,541	- TVA/ASU study data used - NREL maps indicate additional areas with wind potential, but the data were insufficiently detailed to assess those areas
Tennessee	1,917	4,268	
Total	3,483	8,260	

SACE synthesis of data in Figures 13 and 14, as discussed.

TVA should also consider forthcoming findings from NREL in establishing near-term wind resource potential. TVA partnered with Tennessee's Energy Office and the Southern Alliance for Clean Energy in the summer of 2010 to apply to the US Department of Energy Technical Assistance Program. In response to this request, NREL will identify specific locations, especially non-ridgetop, which may be suitable for a utility-scale wind development in the TVA service territory. The report from NREL will be completed by the end of 2010 and should be integrated into the IRP process before the final IRP is produced.

TVA should consider between two and ten times more in-Valley wind capacity in its Draft IRP.

Given the wealth of data indicating a significant in-Valley wind resource, TVA should reevaluate the Draft IRP's treatment of in-Valley wind and consider analyzing the development of between 720 and 3,500 MW of this resource. Because the Draft IRP and EIS treat in-Valley wind as a fixed model input, the model's ability to choose in-Valley wind to fill TVA's potential future capacity gaps in improperly constrained. However, even as a fixed model input, the evaluation of significantly higher levels of in-Valley wind resources would be more appropriate.

d. Biopower Resources

The Draft IRP and EIS also significantly undervalue the potential biopower resources available in the Valley. Even the most aggressive strategy (Strategy E: EE/DR and Renewables Focused Strategy) represents less than one-tenth of the potential biopower that could be developed by TVA using in-Valley biomass resources as fuel.

The Draft IRP's shortcoming is not with TVA's assessment of the resource, as our potential estimate is similar to TVA's estimate of potential biomass resources of 36 million potential tons per year. Rather, TVA unreasonably concludes that its own potential assessment may be "too optimistic" and therefore restricts the biopower potential in its plan to 456 MW (Figure 16).[39] Notably, TVA estimates that it could increase biopower generation by only about 3,400 GWh,[40] in contrast to the resource potential estimate cited by TVA of 47,000 GWh of annual generation using in-Valley biomass resources.[41]

Figure 16: TVA Biomass-fueled Generation Options in Draft EIS

Biomass co-firing	169 MW	Draft EIS, p. 147
Conversion (coal to biomass)	170 MW	Draft EIS, p. 147
New biomass-fueled facilities (via PPAs)	117 MW	Draft EIS, p. 147
Total Capacity	**456 MW**	
Total Annual Generation	**3,400 GWh**	Assumes 85% capacity factor.

TVA has not provided a clear rationale as to why the Draft EIS indicates a biopower potential that is restricted to 7% of the total resource potential. TVA describes some operating requirements that suggest a methodical development strategy is required. We agree, but a methodical development strategy could be much more aggressive than the one considered by TVA. TVA also provides one statement that suggests that its concern relates to "current ownership and competing markets." However, TVA has not made a persuasive case that "current ownership and competing markets" constrain TVA to such a limited use of biopower resources.[42]

Furthermore, the most aggressive strategy considered in the Draft IRP further limits biopower utilization to 410 MW (Figure 4). This additional 10% reduction below the amount identified in the Draft EIS is unexplained.

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[39] *Draft EIS*, p. 147.
[40] Information on assumed capacity factors and anticipated generation from TVA's proposed renewable energy portfolios was provided to the Stakeholder Review Group in June 2010.
[41] *Draft EIS,* p. 130.
[42] We are unaware of any analysis by TVA that explores this issue.

Independent analysis confirms that TVA could develop much higher levels of bioenergy resource using existing resources in the TVA service territory.

In order to explore the issue of resource competition, SACE commissioned a study of the woody biomass inventory and supply in the TVA region (included as Attachment 3).[43] The consultant that conducted the study for SACE, Larson & McGowin, is a forestry firm that provides a full range of land management and on-demand decision support and consulting services, with a focus on forests in the South. Among its services, Larson & McGowin provides financial analysis for timberland appraisals and acquisitions, in addition to its core business of owning and managing timberland. In short, we consulted experts in the very markets that TVA suggests are a constraint on biopower development opportunities.

The Larson & McGowin analysis includes both US Forest Service estimates of forest resources and urban wood waste resources. In addition to an assessment for the TVA region, the assessment provides estimates for the vicinity of TVA's existing coal plants. The assessment of forest resources includes the full range of forest resources, as follows:

- Inventory of woody biomass based on USFS Forest Inventory and Analysis data which reflects an average age of 2005;
- Annual growth and removal projections (supply and demand) for pulpwood and sawtimber are based on the 2010 Southern Forest Resource Assessment Consortium (SOFAC) Subregional Timber Supply Model Southwide V23 Demand Run;
- Annual supply is based on the difference between growth and removal projections representing historical timber removals and growth including land use changes;
- Resource stocks and supply are reported in dry tons, based on individual tree components using the component ratio method as described in the FIA database description and users manual;
- Urban wood waste assessment is restricted to large diameter wood generated by tree services companies;
- Resources are sorted into "supply buckets" based on current timber market specifications;
- Excludes mill residues because markets generally exist for these resources;
- Excludes public lands and stands over 80 years in age;
- Restricted for utilization constraints and possible environmental considerations;
- No consideration of management options for increasing future supply; and
- No consideration of cost feasibility.

Even though Larson & McGowin did not consider cost feasibility, SACE took cost considerations into account by evaluating only the three lowest value supply buckets included in the analysis. Since the assessment makes several conservative assumptions (e.g., no consideration of options for increasing supply), the overall assessment represents a reasonable effort to assess available supply.

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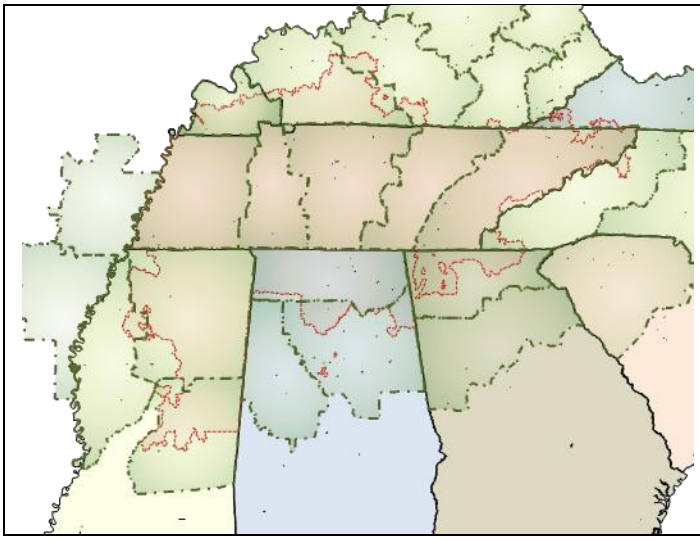
[43] Seawell, R. C., *Woody Biomass Supply and Forest Resource Issues*, Larson & McGowin, Inc., prepared for Southern Alliance for Clean Energy, November 1, 2010.

According to Larson & McGowin's analysis (see Attachment 3), an annual supply of about 14 million dry tons of woody biomass is available in the TVA region. This matches the estimate of 14 million dry tons discussed by TVA in the Draft EIS.[44] Of these 14 million dry tons, over 7 million dry tons are included in low value "supply buckets."

Figure 17: TVA Woody Biomass Resource Potential, based on Larson & McGowin analysis

Woody Biomass Resource "Supply Buckets"	**Resource Total** (Dry Tons)
Urban Wood Waste	646,720
Salvage from Damaged Stands	510,776
Slash & Brush	856,572
Logging Residuals (merchantable)	5,312,049
Subtotal – Low Value "Supply Buckets"	**7,326,117**
Logging Residuals (pre-merchantable)	288,202
Pulpwood from Pre-merchantable Stands	233,099
Pulpwood Inventory from Merchantable Stands	2,983,376
Small Sawtimber Inventory	3,315,406
Total – Annual Woody Biomass Resource Supply	**14,146,200**

Figure 18: Larson & McGowin Analysis is Based on GIS Interpretation of FIA Unit-Level Data



Larson & McGowin used FIA unit-level data to develop area-specific resource supply estimates. Thirty-five FIA units were included in the analysis for the TVA region. Only 5% of the potential biomass supply region for TVA coal plants was outside the FIA units used for the analysis.

FIA units outlined in green.
TVA service area outlined in red.

[44] *Draft EIS, p. 132.*

TVA could reasonably develop about twice as much biopower capacity as it considers in its Draft IRP with woody biomass fuels for which there is little or no competing market.

We developed a scenario in which TVA develops 1,100 MW of biomass-fueled power generation using "low value" woody biomass resources (Figure 19). This scenario has the following constraints:

- Woody biomass is restricted to four "low value" biomass "supply buckets":
  - Salvage from damaged stands
  - Slash and brush
  - Logging residuals (merchantable)
  - Urban wood waste
- Co-fire modifications (20 MW) or biopower conversions (50 MW) are applied to each of TVA's existing coal plant sites to take advantage of existing infrastructure. (In the event that the suggested technology is infeasible, a similar capacity new unit could be sited nearby.) A maximum scale of 100 MW is assumed at any single site.
- The required annual fuel supply for the plants sited at existing TVA facilities is determined based on typical operating data.
- It is assumed that independent developers build remaining capacity, utilizing most of the remaining "low value" biomass resources as fuel.

A total of approximately 25-40 biopower plants, co-fire modifications, or conversions would be built in this scenario.

Figure 19: TVA Woody Biomass-fueled Generation Options, based on Larson & McGowin analysis

Potential Biomass Plants	**Capacity** (MW)	**Annual Fuel Required** (thousand tons)	**Woody Biomass** 50 mile supply region (Fig 19a) (thousand tons)		**Notes**
			Low Value	Total	
Allen	20	112	245	1,019	1 co-fire unit
Bull Run	20	112	141	487	1 co-fire unit
Colbert	20	112	172	996	1 co-fire unit
Cumberland	50	280	378	1,469	1 conversion unit
Gallatin	100	561	1,446	4,904	2 conversion units
John Seveir	50	280	379	1,826	1 conversion unit
Johnsonville	40	224	290	1,458	2 co-fire units
Kingston	20	112	150	523	1 co-fire unit
Paradise	100	561	821	2,720	2 conversion units
Shawnee	50	280	307	1,258	1 conversion unit
Widows Creek	50	280	362	1,350	1 conversion unit
Total Coal Plant Sites	**520**	**2,914**			
Independent Plants (PPAs)	580	3,253			11-26 units
Total TVA	**1,100**	**6,167**	**7,326**	**14,146**	**25 – 40 units**

Figure 20: Biomass Supply Areas for Existing TVA Coal Plants (50 mile region)

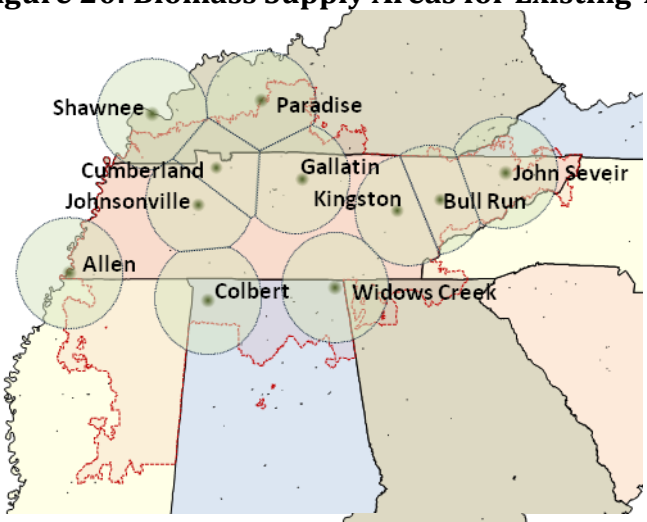


Figure 20a: Non-overlapping supply regions are used for data presented in Figure 19. This supply scenario assumes eventual development of biopower generation at all coal plants, if feasible.

TVA service area outlined in red.

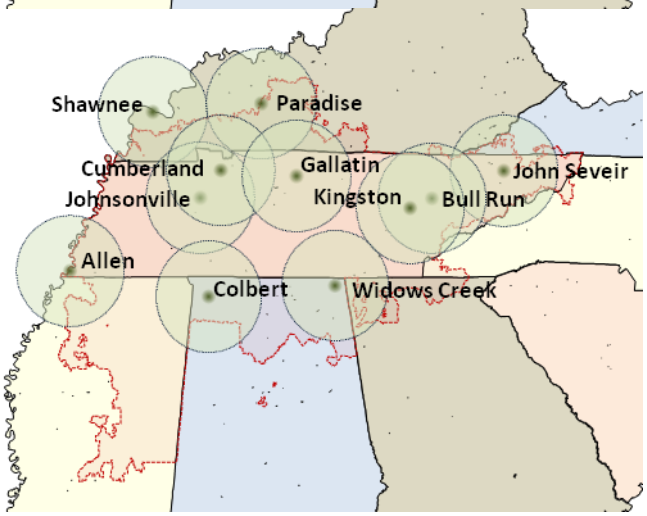


Figure 20b: Larson & McGowin also calculated available supplies at each coal plant within a 50-mile radius. These data will be useful in assessing the feasibility of individual biomass-fueled power plants at these locations. In the aggregate, however, these data would over-represent total biomass potential within these regions due to (intentional) double-counting.

TVA service area outlined in red.

Based on our analysis, it is apparent that TVA has the available resources to develop as much as 1,100 MW of bioenergy utilizing in-Valley resources of limited current markets. Therefore, doubling the in-Valley bioenergy resources considered by the Draft IRP would be reasonable given the apparent resource potential.

In addition to woody biomass resources, TVA also recognizes a potential annual supply of about 22 million tons of energy crops, crop residues and methane sources.[45] If such potential were fully accessed, about 4,000 MW of additional biopower capacity could be fueled.

[45] *Draft EIS*, p. 132.

TVA has a strong interest in successful biopower development.

In-Valley biopower development has the potential to support every aspect of TVA's mission by providing power, supporting economic development and enhancing the environment. Yet by understating the resource opportunity, TVA is failing to make a clear commitment to developing biopower resources. Rather, TVA is signaling that it won't commit to the resource's development until the markets are developed. The result of this catch-22 is a failure to reasonably consider how biopower resources should be a meaningful part of TVA's future generation portfolio.

While it should be obvious that biopower can provide power and support economic development,[46] the case for environmental enhancement is less well established. A wide variety of stakeholders feel that environmental safeguards are insufficient to provide for the economic and environmental sustainability of forests that will come under additional pressure from bioenergy development. Nevertheless, these same stakeholders also see a potential "connection" between "biomass harvesting" and "ecosystem restoration."[47]

In sum, the Draft IRP and EIS, while recognizing the abundance of biopower resources, do not properly value these resources as potentially significant contributors to TVA's future generation requirements. Based on TVA's own estimates of this resource, and reinforced by the analysis conducted by Larson and McGowin, TVA should substantially increase both TVA-owned and independently developed biomass generation resource options in the Draft IRP and EIS.

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[46] A 40 MW plant supports $21 million in annual economic impact and 370 jobs. Hodges, A. W. and M. Rahmani, *Economic Impacts of Generating Electricity*, University of Florida, Institute of Food and Agricultural Sciences, Publication FOR-136, September 2007.

[47] The Heinz Center and the Pinchot Institute for Conservation, *Forest Sustainability in the Development of Wood Bioenergy in the U.S.*, June 2010.

2. TVA does not properly value the energy efficiency resource, leaving significant amounts of cost-effective efficiency undeveloped over the planning horizon.

TVA's increased emphasis on energy efficiency is a welcome development and appears likely to position TVA as one of the leading energy efficiency utilities in the Southeast. Nevertheless, the Draft IRP uses methods and makes assumptions that constrain the opportunity for energy efficiency to meet future energy demand. As a result, the final preferred strategy will likely include higher costs and risks than would be the case if efficiency were treated as a resource on equal footing with other resource options.

a. TVA's choice to analyze energy efficiency as an adjustment to the load forecast does not allow the model to optimize cost-effective energy efficiency in portfolio outputs.

TVA should not be judging efficiency as a limited, defined resource input when the preferred treatment of energy efficiency, evidenced by national trends, is to treat it as equal or even preferred to supply-side resources for planning purposes.

TVA's Draft IRP and EIS integrate energy efficiency as a fixed model input, best characterized as a load adjustment.[48] As a result, the IRP's model basically "works around" the efficiency input, selecting resources to meet TVA's "adjusted load."

In contrast to TVA's method, utilities that seek to identify the "best" level of energy efficiency investment generally model energy efficiency and other DSM on an equivalent basis to supply-side resources. In the California Public Utilities Commission's "Best Practices" report, eight of thirteen non-California utilities were identified as using this approach.[49] Only three[50] of the thirteen utilities surveyed used an approach similar to that of TVA.

If TVA uses its resource planning process to establish the level of energy efficiency investment, it should use an approach that models energy efficiency and other DSM on an equivalent basis to supply-side resources. Ideally, it would adopt the advanced approach used in the Pacific Northwest, where the Northwest Power and Conservation Council has pioneered the use of *two* supply curves for energy efficiency in the model that develops least-cost portfolios.[51]

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[48] See *Draft IRP*, discussion of EE resource, p. 75 to 82, and Figure 5-4: Attributes of Planning Strategies, p. 89.
[49] Aspen Environmental Group and Energy and Environmental Economics, Inc. (Aspen/E3), *Survey of Utility Resource Planning and Procurement Practices for Application to Long-Term Procurement Planning in California: Final Report and Appendices*, prepared for California Public Utilities Commission, April 2009. Utilities identified as modeling energy efficiency on an equivalent basis to supply-side resources include Avista Energy, British Columbia Hydro, Georgia Power Company, Idaho Power, PacifiCorp, Puget Sound Energy, Northwest Planning and Conservation Council, and Seattle City Light (p. 71-73).
[50] Public Service Colorado, Arizona Public Service, and Public Service New Mexico are the three utilities that follow a similar approach to TVA (Aspen/E3, p. 69).
[51] Apsen/E3, p. 71.

The use of two supply curves allows for different treatment of discretionary and lost-opportunity energy efficiency resources.

- Discretionary energy efficiency resources are investments that can be advanced or deferred based on near-term market decisions. An example of a discretionary energy efficiency resource would be a CFL market promotion.
- Lost-opportunity energy efficiency resources are programs that take advantage of opportunities due to market or customer circumstances. New construction and replace-on-burnout programs are the major categories of lost-opportunity programs.

Just as utilities use short-term market power purchases for different purposes than investments in new power plants, the most sophisticated energy efficiency planning process includes appropriate distinction between discretionary and lost-opportunity resources. TVA's load-adjustment approach does not allow for this distinction to be incorporated into its IRP process.

We would recommend that TVA adopt a similar, two-supply-curve approach to evaluate the energy efficiency resource in its IRP process. At a minimum, TVA should model energy efficiency and other DSM on an equivalent basis to supply-side resources within the IRP planning process. This would be preferable to TVA's "adjusted load" method that does not account for all cost-effective energy efficiency and therefore leads to resource portfolios with unnecessarily high levels of both cost and risk.

b. The failure to allow incremental increases in energy efficiency beyond 2020 skews the Draft IRP towards unnecessary additions of supply-side resources.

In four of the Draft IRP's five strategies,[52] energy efficiency program impacts grow during the first decade, but level off to a nearly flat trend in the second decade of the planning horizon. As a result, while aggressive levels of energy efficiency may be sufficient to eliminate load growth through about 2020, the Draft IRP is skewed towards unnecessary supply-side additions in the second decade of the planning period.

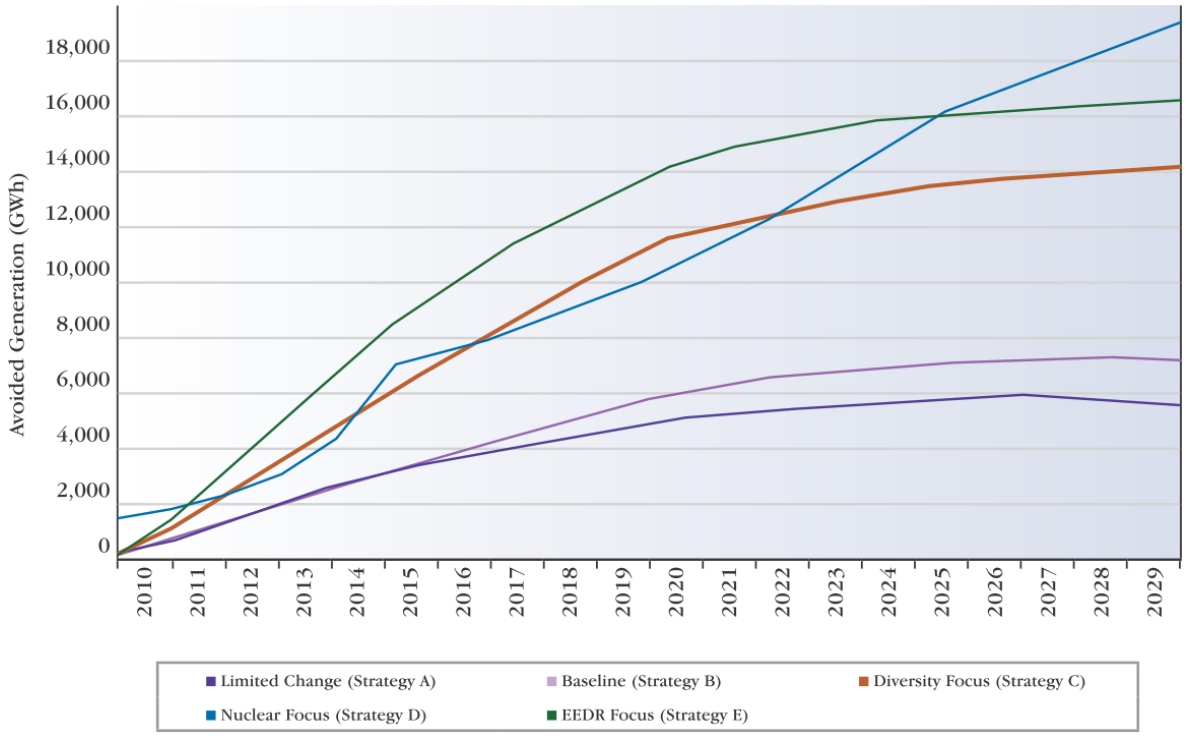
Because of the Draft IRP's failure to include incremental increases in energy efficiency beyond 2020, the capacity gap from 2020 to 2029 is artificially increased. As a result, the Draft IRP recommends excessive levels of supply-side generation that carry increased cost and risk compared with the efficiency resource. Given the long lead-time required to construct supply-side resources, the artificially increased capacity gap leads to unnecessary near-term investments in supply-side resources.

This phenomenon has already begun to occur as TVA committed nearly $250 million in FY 2011 towards completing a proposed nuclear unit at the Bellefonte Nuclear Site in anticipation of needing this resource in 2018. This is approximately the time that the

[52] The only exception is Strategy D, which is not being recommended by staff for further evaluation. For reasons that were never clearly explained, the energy efficiency resource inputs in that strategy were developed in a unique manner.

efficiency resource begins to level off in the Draft IRP. A more realistic representation of the potential for efficiency to continue contributing to TVA's resource portfolio beyond 2020 would likely allow deferral of this expense, if not obviate it altogether.

Figure 21: Avoided Generation of Energy Efficiency Options



TVA, *Draft IRP*, p. 79.

The Draft IRP and EIS provide no explanation for the leveling off illustrated in Figure 21. However, in conversations with TVA staff, it was indicated to us that TVA did not feel confident relying on potential, but as yet uncertain, investment opportunities for energy efficiency beyond 2020. We do not find this explanation adequate to explain the leveling off of EE/DR portfolios after 2020.

In our review of numerous energy efficiency and IRP documents, we are unaware of any utility with a serious commitment to energy efficiency[53] that assumes energy efficiency opportunities will effectively cease to exist after a decade. One perspective on TVA's "confidence" is that the Northwest Power and Conversation Council concluded in a retrospective review that at least 85% of the projected 20 year energy savings in its first regional plan were realized.[54]

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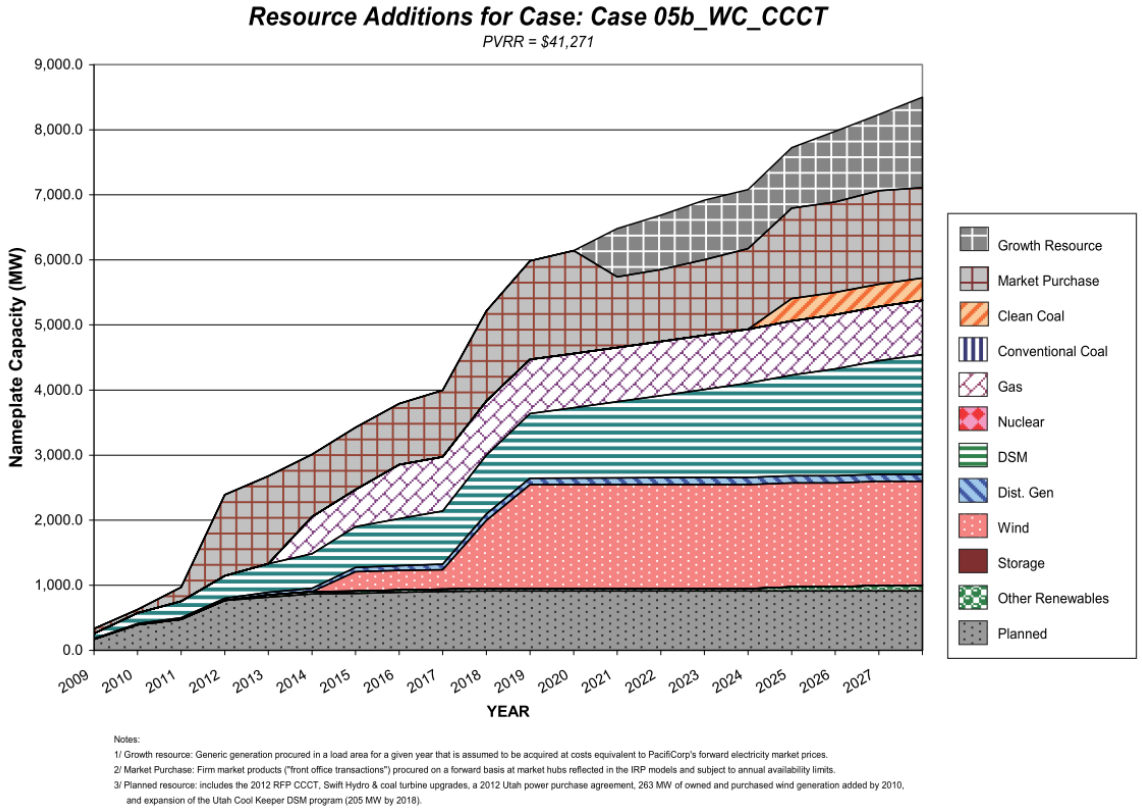
[53] By "serious commitment," we mean a plan to achieve more than 3% energy savings over 10 years – a relatively low threshold.

[54] Northwest Power and Conservation Council, *Achievable Savings: A Retrospective Look at the Northwest Power and Conservation Council's Conservation Planning Assumptions*, Council document 2007-13, August 2007.

Another example is illustrated in PacifiCorp's 2008 preferred resource portfolio (Figure 22), where the contribution of DSM resources continued to grow throughout the second decade of the plan.

Figure 22: PacifiCorp Preferred Resource Portfolio, 2008 IRP



PacifiCorp, *2008 Integrated Resource* Plan, May 2009, Volume I, p. 239 and Appendix A, p. 31.

The durability of energy efficiency programs is also suggested by a study for Rhode Island, a state that has been aggressively pursuing the efficiency resource for several years. According to KEMA, Rhode Island could continue to achieve increasing levels of efficiency, saving as much as 29% of projected energy demand over the next decade at a savings of $1.85 billion for ratepayers.[55] As a result, the latest energy efficiency plan filed with the state's Public Utilities Commission aims to double annual energy savings over the next three years, from approximately 1.2% currently to 2.5% by 2014.[56]

Apparent from these cases is that TVA can and should rely on new technologies to be brought to market and additional cost-effective opportunities for efficiency in the outer years of the IRP planning horizon. This should be reflected in the Draft IRP and EIS by the inclusion of incremental energy efficiency gains beyond 2020.

[55] KEMA, Inc., *The Opportunity for Energy Efficiency that is Chepare than Supply in Rhode Island*, prepared for Rhode Island Energy Efficiency and Resource Management Council, August 26, 2010.
[56] Association of Energy Services Professionals newsletter October, 2010; available at: http://aesp.org/

c. TVA's reliance on the EPRI study to estimate TVA's achievable efficiency potential is misguided, resulting in undervaluation of this resource.

TVA has unreasonably adopted a 7% cumulative energy reduction as its maximum energy efficiency potential. While the Draft IRP and EIS do not discuss it, TVA has indicated to the SRG that it relies on the conclusions of a March, 2010 report by the Electric Power Research Institute (EPRI) to constrain its inputs of energy efficiency into the IRP model.[57] This report claims a realistic achievable potential of 5% of baseload demand by 2020 and 7% by 2030.

The EPRI report's claim of an achievable potential of 5% by 2020 and 7% by 2030 cumulative energy reduction over TVA's draft baseline demand forecast is simply not credible. The credibility of this figure is challenged by actual impacts in many states across the country, by energy efficiency potential studies in the Southeast, and by identified flaws in EPRI's methods.

Current efforts by dozens of utilities across the country are likely to exceed 7% energy savings within one decade, suggesting EPRI's potential estimate is excessively conservative. According to ACEEE, 2008 energy efficiency programs reduced energy use by more than 1% in five states.[58] Further, the Consortium for Energy Efficiency reports that dozens of utilities are investing in energy efficiency at a pace that will easily exceed 7% within a decade or less.[59] Given the fact that the TVA service territory currently ranks as one of the least energy efficient regions in the nation, it is difficult to find the EPRI study's estimates of achievable efficiency reliable.

Recent analysis of the South's energy efficiency potential confirms that this resource is larger than the EPRI estimate for the TVA region.[60] A meta-analysis of energy efficiency potential studies conducted by Georgia Tech indicated that the South has the economic potential to reduce its energy consumption by 1.5% per year and the achievable potential, with vigorous policies, to reduce energy consumption by one percent per year.[61] While the meta-analysis targeted the next decade, the state level studies that accompanied Georgia Tech's 2010 report, *Energy Efficiency in the South*[62] examined energy efficiency potential over a 15-20 year time horizon suggested an economic potential of 20-35%, consistent with the study's 1.5 percent per year finding, and a maximum achievable potential of 15-30% in all but one study, well in excess of the study's 1% per year finding.

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[57] Electric Power Research Institute, *Assessment of Achievable Potential for Energy Efficiency and Demand Response Programs for the Tennessee Valley Authority*, March 2010.
[58] American Council for an Energy-Efficient Economy, *The 2010 State Energy Efficiency Scorecard*, Report E107, October 2010.
[59] Consortium for Energy Efficiency, *The State of the Efficiency Program Industry: Budgets, Expenditures, and Impacts 2009*, March 2010.
[60] Discussed estimates of achievable efficiency potential include the development of recycled energy opportunities such as combined heat and power and waste-heat recovery projects.
[61] Chandler, S. and M. Brown, *Meta-Review of Efficiency Potential Studies and Their Implications for the South*, Georgia Tech, Working Paper #51, August 2009.
[62] Brown, M. et al, *Energy Efficiency in the South,* Georgia Tech, April 13, 2010; See specifically *Appendix G: State Profiles of Energy Efficiency Opportunities in the South.*

The various energy efficiency potential studies reviewed by Georgia Tech researchers strongly suggest that TVA can achieve significantly more energy efficiency than 7% by 2030 and the Draft IRP should reflect this greater potential. Based on this analysis, we suggest that TVA could achieve energy savings of 30 - 45,000 GWh by 2030 (Figure 23).

Figure 23: Energy Efficiency Potential in TVA Region, Based on Conclusions in Georgia Tech Meta-Analysis

	2030 Energy Savings (GWh)
Economic Potential	45,000
Maximum Achievable Potential	30,000
Maximum in Draft IRP, Scenario D	19,500
Maximum in Draft IRP, Scenario E	16,500

Based on Chandler, S. and M. Brown, *Meta-Review of Efficiency Potential Studies and Their Implications for the South*, Georgia Tech, Working Paper #51, August 2009; assuming 200,000 GWh in 2030.

Several issues with the EPRI study have also been identified that call into questions its accuracy. EPRI's analysis of efficiency potential in the TVA service territory involved applying the methodology and technology data developed for the EPRI National Study on the same subject.[63] Both McKinsey and Company and ACEEE challenged this methodology as over conservative. The fundamental problem with EPRI's analysis is, as explained by McKinsey & Company, "EPRI focuses on understanding existing programs and best practices to capture energy efficiency and analyzing likely achievability based on current experience."[64] Similarly, ACEEE notes:

> The EPRI/EEI estimates include only existing efficiency technologies and nothing that is not already commercialized and cost-effective. This is illustrated by the fact that the EPRI/EEI savings estimates are virtually the same in 2020 and 2030. Essentially, EPRI/EEI estimated 2020 potential and not 2030 potential, and did not take into account technology change or innovation that would create new efficiency opportunities in the 2020-2030 period.[65]

Both the McKinsey and ACEEE critiques of EPRI's approach are critical of the fact that EPRI does not take into account additional cost-effective efficiency opportunities for energy efficiency arising in the future. As a result of the EPRI study's failure to account for technological advances and innovation, McKinsey and ACEEE both conclude that EPRI's estimate is overly conservative.

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[63] Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S.: (2010- 2030). EPRI, Palo Alto, CA: 2009. 1016987

[64] McKinsey & Company, *EPRI and McKinsey Reports on Energy Efficiency: A Comparison*, October 2009.

[65] American Council for an Energy-Efficient Economy, *ACEEE Review of the Preliminary EPRI/EEI Estimates of Energy Efficiency Potential*, April 2008.

Further, the EPRI study conducted for TVA does not make effective use of advanced energy efficiency program methods to foster adoption of efficiency products and opportunities. For example, under EPRI's models, three incentive scenarios are considered: no incentives, 10% of incremental costs and 20% of incremental costs, amounting to 1.5 and 3.0 cents/kWh respectively. In contrast, national best practices consider incentives ranging as high as 100% of incremental costs because even these incentives levels are often less costly than developing supply-side resources. The EPRI study provides no discussion of a similar analysis for the TVA service territory.

Larger incentive levels are not the only program strategy overlooked by EPRI. A relatively new concept in residential energy auditing and education is the home energy comparison report. Based on the experience of utilities elsewhere in the country, deployment of this program across TVA's distribution utilities could save about 0.7% of annual energy use, or *one-tenth* of the total potential that EPRI claims is available in the TVA region over two decades. Recent measurement and verification studies of similar programs indicate an opportunity for almost immediate 2% residential energy savings.[66] Furthermore, Arizona Public Service (APS) notes that, "It is anticipated that in addition to achieving conservation related savings of approximately 2% usage reductions per household, this program can help increase participation in other efficiency programs by up to 25%."

In all, TVA's reliance on the EPRI study of achievable efficiency potential is misguided. We have raised these same issues with TVA staff through our position on the Stakeholder Review Group and, to TVA's credit, TVA staff have responded to our concerns by adding additional sensitivity runs that will be conducted before the IRP is finalized. The pending sensitivity runs[67] should help to reduce some of the impacts of the shortcoming identified in these comments. However, we would strongly recommend that TVA include energy efficiency contributions of at least 1% after a brief ramp-up period in the IRP model, and, in the longer term, undertake renewed analysis of the potential for energy efficiency to contribute significantly to meeting future electricity demand.

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[66] Allcott, H., *Social Norms and Energy Conservation*, MIT Center for Energy and Environmental Policy Research Report 09-014, October 2009; and Summit Blue Consulting, LLC, *Impact Evaluation of OPOWER SMUD Pilot Study*, September 24, 2009.
[67] *Draft IRP, p. 125.*

3. TVA's "high" scenario demand forecast is implausible. Portfolios developed with this scenario result in levels of resources that TVA is unlikely to utilize as scheduled.

The Draft IRP's scenarios represent a range of potential demand growth, the high end of which is not realistic and should, therefore, not be included in the IRP model. While considering a range of growth scenarios is certainly reasonable, consideration of a 2% average annual growth rate across the entire 20-year planning period, as is represented in TVA's Scenario 1: Economy Recovers Dramatically, is implausible (Figures 24 and 25). TVA should either remove Scenario 1 from the analysis or substantially reduce the annual growth rate in that scenario.

Portfolios based on the inflated demand growth projections of Scenario 1 include excessive resource additions that influence the Draft IRP's conclusions. For example, TVA highlights that "Nuclear capacity is selected in 19 out of 28 possible portfolios."[68] However, based on Appendix C data, if Scenario 1 were removed, then nuclear capacity would be selected in only 15 of 24 possible portfolios. More dramatically, if Scenario 1 were removed, *the TVA plan would not contain a single portfolio with new coal generation*.

Figure 24: TVA Projected Generation Growth (GWh per year)

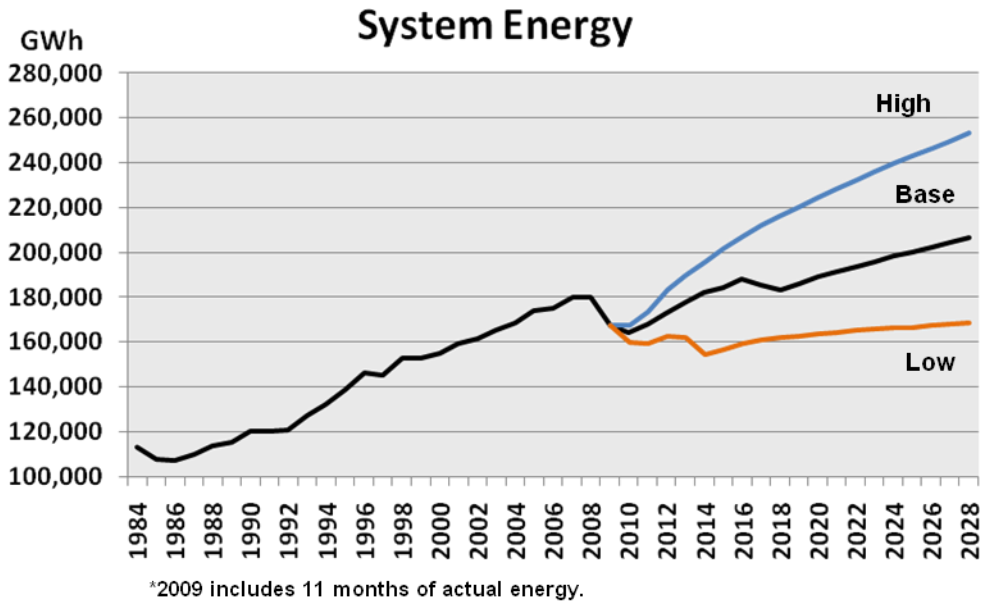
Scenario	2010	2028	Annual Growth
High (#1)	175,000	250,000	2.0%
Low (#3)	155,000	155,000	0.0%
Medium (#7)	165,000	200,000	1.1%

Scenario 1 does not represent either long-term historical trends or the historical link between population growth and growth in electrical demand.

Figure 25, shows TVA's load forecasts compared with historical trends. While TVA sales did increase rapidly in the early 1990s (i.e. by over 4% per year from 1992 to 1996), the trend in sales from 1998 through 2009 increased at an average of just 0.7% per year. In fact, when analyzed over the past 12 years, even the 1.1% annual load growth in the medium forecast (Scenario #7) is higher than the trend in historical load growth from the prior twelve years (0.7% per year). While growth is certainly likely to exceed 2% per year over a short period sometime in the future, current conditions do not indicate that 2% per year growth per year for 20 years is plausible absent some dramatic technology shift (e.g., widespread adoption of electric vehicles).

[68] *Draft IRP,* p. 111.

Figure 25: TVA Load Forecasts and Historical Trends

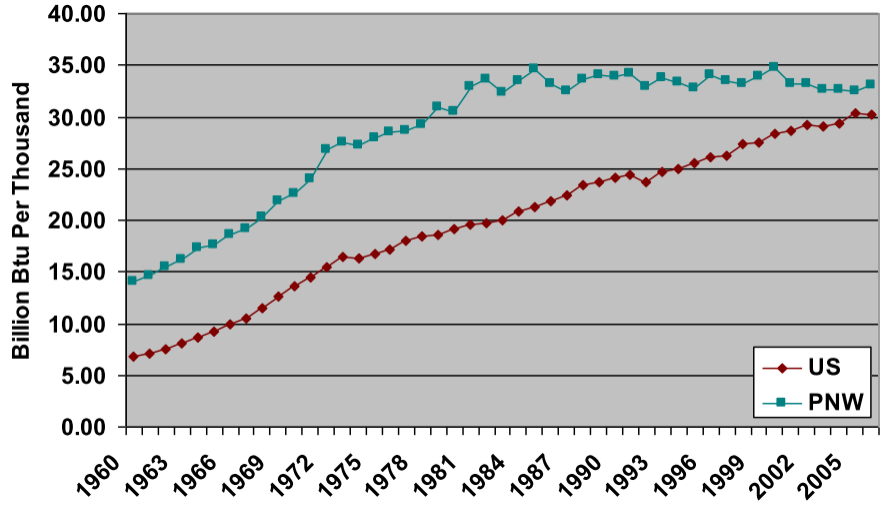


TVA, *Planning Inputs*, External Stakeholder Review Presentation, October 23, 2009.

We also challenge TVA's underlying assumption, apparent from the Draft IRP's scenarios, that growth in electricity demand is directly related to economic growth. California provides the classic long-term example that calls this link into question. Since the mid-1970s, per capita electric demand in California has been constant, at about 7,000 kWh per year per capita. At the same time, electric demand in the rest of the U.S. has grown by about 50%, to 12,000 kWh per capita in 2005. Even though California has experienced a wide variety of economic conditions over the past thirty years, none has had a major impact on the state's per capita electricity use.

Similarly, the Pacific Northwest region has held per capita residential and commercial electricity use essentially flat for three decades (Figure 26).

Figure 26: Residential and Commercial Electricity Use Per Capita, US Compared to the Pacific Northwest Region



Northwest Power and Conservation Council, Sixth Northwest Conservation and Electric Power Plan, Council Document 2010-09, February 2010, p. 1-9.

California and the Pacific Northwest have distinguished themselves by keeping per capita electric use constant over such a long period due in large part to energy efficiency programs. These regions have used comprehensive, consistently applied, continuously improved programs over several decades. Their success provides authoritative evidence that electricity demand is not necessarily linked to economic growth.

With the artificial link between economic growth and growth in electricity demand removed, it is more appropriate for the Draft IRP to model possible load growth based on potential population growth. According to US Census data, Tennessee's population grew by 0.9% per year from 2000 to 2010. Similarly, TVA's electric sales increased at a rate of 0.8% per year over the decade from 1998 to 2009. It would therefore seem that an assumption that load growth should be consistent with constant per capita electric use is more reasonable than the assumption that load growth is directly related to economic growth.

The implausibility of the high load growth numbers are suggested by a comparison to California forecasts. Coincidentally, California and Tennessee are forecast by the US Census Bureau to have similar population growth rates through 2030.[69] Nevertheless, TVA and the California Energy Commission have very different ideas regarding maximum growth rates for electricity use.

- TVA's stochastic analysis takes load growth well beyond the 2% per year assumed in Scenario 1. While the exact values used by TVA are considered confidential, for illustrative purposes we can assume that TVA analyzed a range of ± 1/3, or 1.3% to 2.7%, for Scenario 1.

[69] U.S. Census Bureau, Population Division, *Interim State Population Projections*, 2005.

- The highest recent load growth scenario by the California Energy Commission is 1.2% per year, which did not take into consideration many of the state's energy efficiency programs and goals.[70] Using the same ± 1/3 range of analysis, we could consider an upper bound of 1.6% per year.

Applying these population and load forecasts to each state through 2030 would suggest that California's per capita electricity use would be about 7,600 kWh per year and Tennessee's per capita electricity use would be about 21,000 kWh per year. It is clearly absurd to anticipate that TVA's customers will be using nearly three times as much electricity as California energy users within two decades. While we understand the purpose of the scenario, TVA notes several times that scenarios are meant to be "plausible."

We recommend that TVA revise the range of demand growth in its scenarios to reflect a range of 0% (low) to 1.2% (high), with a medium case at 0.7% per year based on the recent historical trend in TVA loads from 1998 to 2009.[71] In particular, the high Scenario 1 forecast, which assumes rapid economic recovery, should assume median (50th percentile) load growth that is not above 1.2% per year over 2008 loads, which is the rate of load growth over the last 18 years, including the high-growth years of the 1990s.

[70] California Energy Commission, *California Energy Demand 2010-2020, Adopted Forecast*, CEC-200-2009-012-CMF, December 2009.

[71] We are aware that TVA is either considering, or has decided to, revise its baseline forecast to indicate lower long-term growth rates for the Valley. If TVA makes this revision, it provides further support for substantially decreasing projected growth in the high growth scenario.

4. TVA has not properly estimated natural gas and nuclear resource costs such that it may impair the Draft IRP's ability to choose the best resource portfolio.

The Draft IRP's cost estimates for natural gas and nuclear generation appear flawed. As a result, the Draft IRP's selection of future generation resources may be skewed.

While the draft documents do not provide a discussion of the resource cost estimates used in the Draft IRP, TVA shared its cost estimates for various resource options in presentations to the Stakeholder Review Group.[72] TVA also provided the Stakeholder Review Group with confidential material providing further details on its resource cost estimates.[73] Based on an analysis of these estimates, we recommend TVA review and revise its projections of natural gas prices, nuclear resource costs, and solar PV costs (discussed earlier in these comments).

a. Natural gas fuel cost projections

The Draft IRP relies on projections of natural gas prices that appear too high when compared with reference market forecasts. According to TVA, it considers five "key drivers" when developing its long-range price forecasts for natural gas.[74]

- Production cost
- Domestic and global supply
- Storage conditions and accessibility
- Regulatory developments (e.g., emission limits)
- Competing fuel sources

TVA uses the NYMEX Henry Hub natural gas market price forecast for its commodity forecasts. To a large extent, this market price forecast will take into account these same "key drivers" to the extent that market traders are able to form an opinion regarding potential impacts on market prices.

For comparison, SACE obtained the assistance of Crossborder Energy in analyzing forward market prices at the Henry Hub. Crossborder Energy used an approach that is similar to the method that the California Public Utilities Commission uses to forecast long-term gas market prices for its benchmark "market price referent."[75] Rather than using a single day's forward market prices, the CPUC reduces volatility by sampling Henry Hub forward market prices over a 22-day period.

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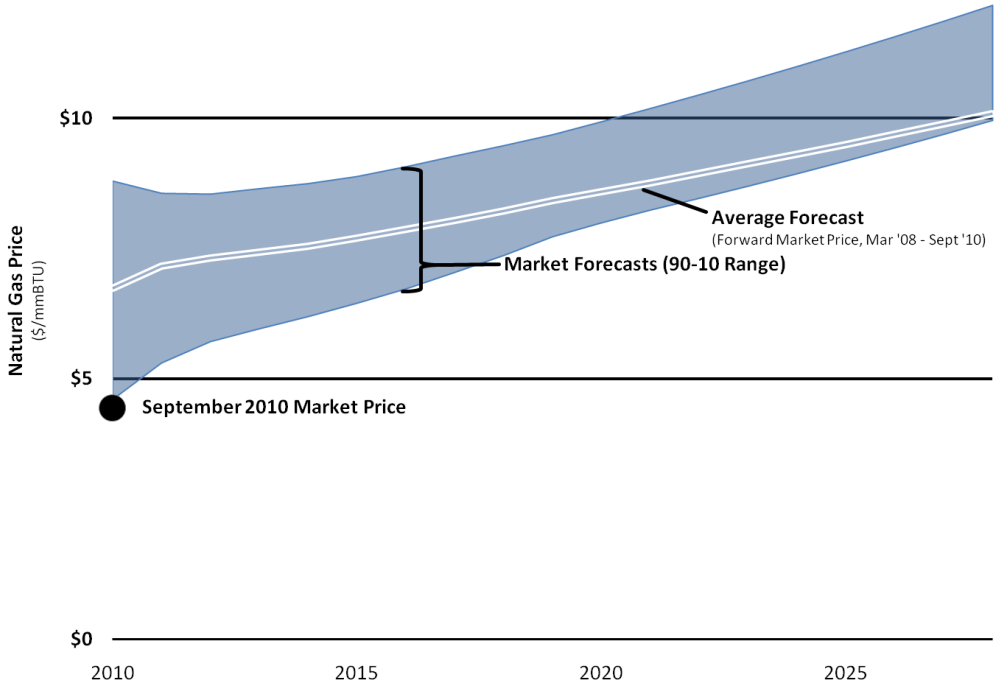
[72] TVA, *Supply Resource Options,* presentation to the Stakeholder Review Group, October 22, 2009; and TVA, *Stakeholder Review Group Working Session*, presentation to the Stakeholder Review Group, February 17, 2010.
[73] TVA, *Range of Stochastic Variables*, September 20, 2010 informational report to the Stakeholder Review Group.
[74] TVA, *Planning Inputs*, presentation to the Stakeholder Review Group, October 23, 2009.
[75] The MPR is the key pricing benchmark in the California renewable energy program, and is similar to an avoided cost estimate in some respects.

Crossborder Energy sampled over a longer period of time to consider a broad range of gas market conditions,[76]selecting one set of forward market prices for each of the past 31 months, generally sampling on the first day of the month. The three highest and lowest values were excluded, providing a "90-10" range of values. The period sampled includes periods with very high and very low prices, reflecting a wide range of price environments, as illustrated in Figure 27.

Figure 27: Natural Gas Price Projections, Henry Hub Forward Market Prices



Crossborder Energy, analysis provided to Southern Alliance for Clean Energy, October 2010.

In general, the natural gas price projections used by TVA for many of the scenarios in the Draft IRP are significantly higher than market forecasts for the second decade of the planning period. This is surprising, since we understood that TVA based its natural gas price forecasts on the same data that Crossborder Energy analyzed for SACE. The divergence is particularly large for the "Economic Recovery" scenario which appears to consider a range of natural gas prices in the 2025-2030 time period that are inconsistent with market price projections.

Natural gas price forecasts are a particularly important component of the models used to develop the Draft IRP because natural gas fuel prices often serve as the marginal cost, or basis for the marginal price, against which other energy resources are measured.

[76] Crossborder Energy noted that current forward gas prices are at the lowest level over the past several years, so its analysis provided us with references from periods with higher forward market prices as well as current, lower forward market prices.

Therefore an artificially high natural gas price forecast would likely result in model results skewed in favor of decreased coal retirements and the quicker build out of nuclear capacity. This is even more pronounced under the current IRP because TVA's model does not allow renewable energy or energy efficiency capacity to be increased in portfolio outputs. If TVA were to adopt a lower natural gas price forecast that is more in line with market forecasts, the IRP model would likely correct itself in favor of increased coal retirements and delays in adding nuclear capacity.

It is reasonable for TVA to consider a wide range of natural gas price projections in the development of its plan. Nevertheless, TVA's projections should be grounded in market fundamentals, and be adjusted in a manner that is systematic. Since we lack full information regarding TVA's methods for developing its natural gas price scenarios, we cannot reach a clear conclusion regarding these projections. However, we recommend that TVA re-evaluate its natural gas price scenarios for the Final IRP.

b. Nuclear resource cost estimates

TVA appears to have estimated inappropriately low costs for its AP1000 nuclear reactor cost estimate. While TVA provided members of the Stakeholder Review Group with information regarding its capital cost estimate for nuclear units, the only data provided regarding other nuclear costs was in the form of a levelized cost component comparison, with the levelized cost indicated as $71 per MWh.[77] We compared the figures presented by TVA with the output of the *California Energy Commission's Cost of Generation Model*.[78]

SACE operated the model using default assumptions with input selections that appeared to most closely match TVA circumstances.[79] Using the CEC model, we found significant discrepancies between the levelized cost components used by TVA and those suggested by the CEC model (Figure 28).

[77] TVA, *Stakeholder Review Group Working Session*, presentation to the Stakeholder Review Group, February 17, 2010, slide 29.
[78] California Energy Commission, *Cost of Generation Model User's Guide: Version 2*, Publication CEC-200-2010-002, April 2010. Model version 2.02 was applied.
[79] For example, the "Default POU" ownership type was selected.

Figure 28: Comparison of AP1000 Nuclear Unit Levelized Cost Components From TVA With CEC Model Outputs ($/MWh – 2009 dollars)

Components	CEC Model Outputs	TVA Data
Capital & Financing Costs, Taxes, and Insurance	54	42
Fixed O&M	28	15
Nuclear Decommissioning	0	0
Fuel	11	13
Variable O&M	7	1
Total Levelized Cost ($ / MWh)	**$ 100**	**$ 71**

CEC Cost of Generation Model, version 2.02; and TVA, *Stakeholder Review Group Working Session*, presentation to the Stakeholder Review Group, February 17, 2010, slide 29.

TVA's estimates are substantially lower than the CEC model with respect to capital costs, fixed O&M and variable O&M costs.

- With respect to capital costs, we verified that the "instant" cost estimated in the CEC model ($3,900 per kW) is comparable with the TVA estimate ($3,700 to $4,300 per kW[80]). We also varied certain financial parameters (e.g., interest rates, financing periods, and inflation rates); these adjustments affected the CEC model output by no more than $5, which fails to reconcile the results. We also considered whether TVA may be assuming use of existing land and other infrastructure, but presumably this would be reflected in the "instant" cost estimate and would not be a factor in the levelized cost discrepancy.
- With respect to Fixed O&M and Variable O&M, we were unable to identify any assumptions that might explain the discrepancies. While labor costs and other factors affecting O&M costs may be lower in the TVA region compared to California, this is unlikely to explain the substantial differences.

The CEC model's review of nuclear resource development costs is highly transparent and conducted by credible consulting firms.[81] While SACE provided this review to TVA during the SRG process, there is no indication that TVA considered these data in its analysis.

Our review of TVA model results left us somewhat uncertain what the impact of higher nuclear costs might be on model results. It appears that the primary alternatives to nuclear power would be natural gas capacity and delays in coal retirements because TVA's model does not allow renewable energy or energy efficiency capacity to be increased in portfolio outputs. However, based on our analysis, we recommend that TVA re-evaluate its nuclear power costs for the Final IRP for both the AP1000 and the BLN BW2005[82] nuclear technologies.

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[80] TVA, *Stakeholder Review Group Working Session*, presentation to the Stakeholder Review Group, February 17, 2010, slide 29.

[81] KEMA, Inc., *Renewable Energy Cost of Generation Update*, prepared for California Energy Commission, PIER Interim Project Report CEC-500-2009-084, August 2009.

[82] Because no other utilities are planning BLN BW2005 technology, there are no external benchmarks to compare with TVA data.

5. TVA's inclusion of a $0 cost estimate for GHG requirements artificially skews the model towards higher levels of fossil-fuel generation.

Even excluding the possibility of federal regulation of greenhouse gas (GHG) emissions, the inclusion of a zero-cost estimate for greenhouse gas requirements is not reasonable. U.S. utilities, including TVA, will continue to face mounting public, regulatory and international pressure to reduce GHG emissions. Because of this mounting pressure, U.S. utilities will almost certainly face future costs to reduce GHG emissions. Therefore, it would seem more reasonable for the Draft IRP to place the lower bound of potential GHG reduction costs at a level higher than $0, the figure utilized in Scenario 3 of the Draft IRP.[83]

To calculate a minimum bound of the GHG cost uncertainty, it would be more reasonable for TVA to look to the European Union (EU) market – the most comprehensive carbon emission allowance market in the world. The EU carbon market for 2010 allowances is currently trading at about $19 per short ton (as reported by Evolution Markets). While TVA does not interact with this market, current prices on the EU carbon market give a good indication of the current costs of reducing greenhouse gas emissions.

In the longer-run, TVA should look at "meta-studies" that have sought to synthesize available projections of the costs of mitigating GHG emissions. In 2007, Synapse Energy Economics prepared a meta-study of the available models of long-term GHG mitigation costs, including models run by EIA, EPA, MIT, and the Tellus Institute.[84] Synapse used this work to prepare low, medium, and high projections for GHG mitigation costs in 2020 and 2030 (Figure 29).

Figure 29: Synapse GHG Mitigation Cost Forecasts (nominal $ per ton CO_2)

Year / Case	Low	Medium	High
2015	$7	$21	$26
2020	$14	$36	$58
2025	$26	$51	$75
2030	$37	$65	$93

Adjusted to 2010 dollars, assuming a 2.5% annual inflation rate.
Synapse Energy Economics, *Climate Change and Power: Carbon Dioxide Emissions Costs and Electricity Resource Planning*, p. 50-55.

[83] See *Draft EIS,* p. 28.
[84] Synapse Energy Economics, *Climate Change and Power: Carbon Dioxide Emissions Costs and Electricity Resource Planning*, p. 50-55.

While the IRP's Medium and High GHG prices are similar to the Low-to-High range of the Synapse projections, TVA's low price of $0.00 for the long-term essentially assumes that there will be no future need to reduce GHG emissions. This assumption is not reasonable in light of EPA's recent Endangerment Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act.[85] This finding, in response to a Supreme Court order[86], formally declared carbon dioxide and five other heat-trapping gases to be pollutants that endanger public health and welfare. The finding is also the first step towards the implementation of regulations that will govern the emissions of greenhouse gases. Given these regulatory happenings, it would be more appropriate for TVA to assume that some level of greenhouse gas regulation will be implemented over the course of the planning period.

The impact of TVA's $0 GHG price assumption is that the potential cost and risk of either developing additional carbon-intensive resources or declining to reduce TVA's carbon footprint is artificially reduced. TVA should revise IRP Scenario 3 to include a non-zero, lower end, albeit modest, price on carbon.

[85] Environmental Protection Agency, *Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act.* December 7, 2009.
[86] *Massachusetts v. EPA*, 549 U.S. 497 (2007).

6. The Draft IRP's economic impact indicator may not provide meaningful distinctions among the different resource portfolios.

While TVA reasonably selected the REMI Policy Insight model to conduct its economic impact indicator analysis, it is not clear that the analysis was conducted in a manner to provide meaningful distinctions between the various resource options. The analysis was rushed, did not clearly adopt best practices from similar projects that also used the REMI Policy Insight model, and was incomplete in several ways that may have adversely affected TVA's observations about the model results.

The Stakeholder Review Group did not have an adequate opportunity to provide feedback and impact the development of the economic impact indicator.

TVA did not develop the economic impact indicator until late in the process; the evaluation method was presented to the Stakeholder Review Group on July 21, 2010. The presentation offered a general overview of the REMI Policy Insight model.

During the presentation, a number of questions were raised relating to aspects of the model application that TVA staff had not considered due to resource constraints that affected the schedule. Some of the questions and topics of discussion were noted in the minutes:[87]

- Does the model you are running account for investment inside or outside the valley [for renewables]? – the model spits out jobs, economic development and investment
- Can the model reflect the reality of the Tennessee valley region being in position to be a clean energy producer?
- Make sure the economic development indicators are appropriate assessments
- Look into using the JEDI model
- Can the model assess the impact of Energy Efficiency consumer savings in economic development?

As participants in this meeting, we were not confident that TVA had developed this metric in a manner that is well adapted to its purpose.

[87] TVA Integrated Resource Plan Stakeholder Review Group, Working Session Meeting Minutes, July 20-21, 2010.

SRG members continued to express concerns at the August 26, 2010 meeting. The meeting notes reflect concern about the economic and technology innovation metrics as lacking a "level of rigor" equal to the financial indicators. Relevant comments or questions noted in the minutes include:[88]

- Still have concerns on the economic development strategic metric in terms of the rigor and inputs – hard to sort through how conclusions were reached. Can lead to skewed interpretation of results
    - (It was stated that the IRP is not supposed to predict an economic development strategy for TVA but is meant to set a pathway for TVA. From the analysis, it is evident that the impact is pretty small).
- May be more appropriate to change economic development to economic impact because economic development implies that the economy is "developing" as a result of what TVA is doing; but, if it is a result of what happens in a strategy, might be considered economic development.

To date, we have not been presented with additional information that addresses the concerns raised at the SRG meeting and have not had an opportunity to fully understand, much less evaluate and provide feedback on, the Draft IRP's economic indicator metric.

REMI Policy Insight is a highly regarded tool for analysis of economic impacts and has been successfully applied to provide useful information for similar projects.

There are a number of tools that may be used to assess the economic benefits of energy plans or projects. According to a US Environmental Protection Agency report, the REMI Policy Insight model is the "most sophisticated" approach for conducting economic analysis of energy policy or projects.[89]

However, the EPA report's praise for the REMI Policy Insight model is accompanied by some cautions.

- The REMI model can "require a fair amount of massaging inputs, especially with energy sector inputs." EPA notes that, "Many states have found that detailed energy-related analyses require energy modeling to be done separately and used as inputs to a hybrid model."
- It is "important to examine how [the] energy sector is treated."
- Default data provided in the REMI model may need to be updated "to account for most recent energy assumptions."

Other applications of the REMI model to energy policy issues illustrate how these cautions may be addressed.

The need for customized inputs is illustrated in a 2004 study of energy efficiency activities for Massachusetts.[90] In order to model expenditures on energy efficiency products and services, a firm developed "Bill of Goods" data which desegregated energy efficiency

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[88] TVA Integrated Resource Plan Stakeholder Review Group, Working Session Meeting Minutes, August 26, 2010.

[89] US Environmental Protection Agency, *Assessing the Multiple Benefits of Clean Energy: A Resource for States*, Climate Protection Partnerships Division,

[90] Massachusetts Division of Energy Resources, *2002 Energy Efficiency Activities*, Office of Consumer Affairs and Business Regulation, Summer 2004.

expenditures across specific industry sectors. Examples of sectors with energy efficiency related demand are manufacturing, including spending on windows, insulation, HVAC controls, and motors; plastics and rubber industry products; and professional and business services. Changes in these and other industries' demand were input as policy variables to the REMI model.

A similar approach was used by NYSERDA to analyze the economic impact of its programs. Product sales data were obtained directly from NYSERDA financial records generated as a result of "recoupment agreements" with funding recipients. These data were mapped to economic sectors for entry into the REMI policy insight model.[91]

A particularly detailed discussion of the process of analyzing economic impacts of energy programs is provided in an Economic Development Research Group report on Wisconsin's energy efficiency and renewable energy programs.[92] Some of the key steps considered necessary to use of the REMI model in the Wisconsin study include:

- Use program evaluation report data to estimate program spending, program participant spending, induced spending by non-participants, direct financial benefits (particularly energy cost savings), and shifts in retail energy sales and development business.
- Reduction in power plant emissions, resulting in reduced energy generation costs.

These data were then mapped to the relevant industries; program evaluators assisted with determining to what extent these products and services are provided by in-state firms.

Effective use of the REMI model should provide a clear understanding of four types of economic development impacts, as described in the Wisconsin study:

- "Increased efficiency, conservation, and lower emission compliance costs" can decrease energy costs, which in turn enhances "business competitiveness."
- These decreased energy costs also lower the cost of living for current residents and make the state a more attractive place to live and work.
- The programs "stimulate sales" for in-state manufacturers and other firms involved in developing in-state "solar, wind and biomass energy production." This "import substitution" effect stimulates job creation, increases personal income, and makes the economy more competitive.
- Spending changes induced by energy programs are "both positive and negative." Some businesses see "less growth (or actual reductions) in business sales and jobs," while other firms can "realize increased orders."

The Wisconsin study provides a good example of how the REMI Policy Insight model can be used to cover "all aspects of changes in the economy," including changes in business sales, gross regional product, real after-tax income, and jobs (Figure 30).

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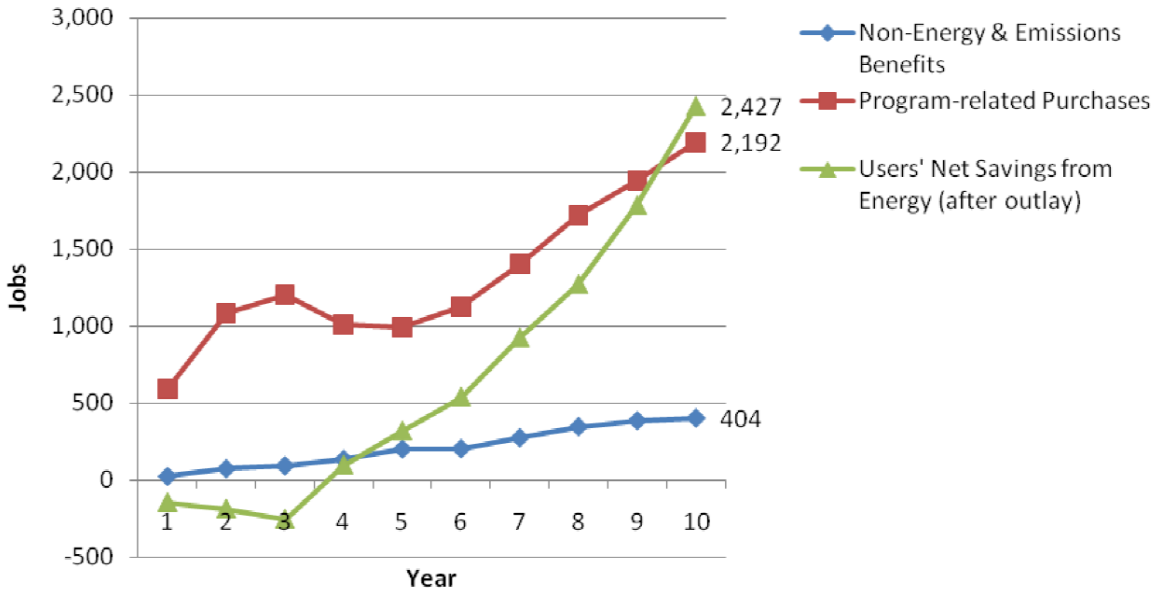
[91] New York State Energy Research and Development Authority (NYSERDA), *New York Energy $mart℠ Program Evaluation and Status Report, Year Ending December 31, 2008,* report to the Public Service Commission, March 2009.

[92] Economic Development Research Group (EDRG), *Focus on Energy Evaluation, Economic Development Benefits: CY09 Economic Impacts*, report to Public Service Commission of Washington, March 2, 2010.

Figure 30: REMI Model Estimates of Employment Impacts for Focus on Wisconsin Programs



Economic Development Research Group (EDRG), *Focus on Energy Evaluation, Economic Development Benefits: CY09 Economic Impacts*, report to Public Service Commission of Washington, March 2, 2010.

In sum, the REMI model has been used in a variety of ways to analyze the economic impacts of resource development strategies. However, the experiences of the stakeholder Review Group, coupled with modest discussion of this tool's use in the Draft IRP and EIS, does not give us confidence that this tool was used successfully by TVA in its assessment of the Draft IRP's model outputs.

The Draft IRP does not indicate that the types of data necessary to assess energy efficiency and renewable energy were developed and used in the REMI model. If this step was not completed, the model results may be misleading.

While TVA has used the REMI Policy Insight model in the past to assess its energy projects, these projects have likely been "conventional" energy projects such as natural gas, coal and nuclear development projects. TVA's investment in energy efficiency and renewable energy has increased recently, but it is not clear that TVA has yet invested in developing the necessary model inputs to ensure that these new clean energy resources are adequately modeled.

The Draft IRP discusses the methodology used to run TVA's regional economic model, and specifically mentions the entry of "annual construction expenses" and "annual operations expense data." Some detail is offered, such as an explanation of the application of fuel purchase expenses to areas outside the Valley, and methods for estimating customer energy costs and savings attributable to the various portfolio resource mixes.

However, the Draft IRP gives no indication that resource expenditures associated with energy efficiency and renewable energy programs were estimated and mapped to specific industries. Nor is there any discussion given to how any such expenditure was allocated geographically. In contrast to the accurate allocation of fuel purchase expenses outside the Valley, there is no indication that TVA has allocated energy efficiency or renewable energy product and service expenditures appropriately.

Limiting the data to the most extreme cases may bias TVA's calculation of the economic impact indicator.

TVA limited its analysis of economic impacts for each strategy to Scenario 1 and Scenario 6, due to time or resource constraints. TVA considered this reasonable because the two Scenarios would define the "upper and lower range of the impacts of the strategies within the scenario range."[93]

Even though TVA states that its use of scenarios does not "assign probabilities or likelihoods to certain futures arising," by selecting only two scenarios for analysis in this measure, there is a certain implication that each of these two scenarios represents a plausible boundary on impacts. This implication is not clearly supported because:

- TVA did not develop the scenarios to explore a linear relationship with two boundaries,
- Scenario 1 is problematic due to an unreasonably high average annual load growth rate and unreasonably high natural gas price projections, and
- The REMI Policy Insight model was not clearly configured in a manner that estimated benefits in an accurate and consistent manner.

We are not certain that providing model output for all six scenarios will result in a credible economic impact indicator, but it should not be assumed that output for two scenarios provides adequate information without conducting further analysis across at least one strategy.

Ideally, TVA would revisit the economic impact indicator prior to finalizing the IRP. Due to time constraints, however, this may not be practical. At a minimum, TVA should address these shortcomings in the final IRP and EIS and acknowledge the need to expand its analysis to include the proper valuation of efficiency and renewable energy resources. Considering the importance of economic development to the mission of the TVA and to the people who live and work in the Valley, this aspect of the resource plan should be better developed.

[93] TVA, *Draft IRP*, p. 141. The Stakeholder Review Group had limited opportunity to comment on this decision; it was only mentioned once, during open discussion late in the August 26, 2010 SRG meeting.

7. The Draft IRP and EIS do not include certain pieces of information that would inform a more comprehensive review of TVA's options:

In addition to the issues identified above, the Draft IRP and IES are silent on certain key pieces of information that would allow for more meaningful input by the public in this commenting process.

a. A discussion of purchased power as an energy resource option

In order to fully evaluate all of TVA's resource options for meeting future energy demand, the Draft IRP and accompanying EIS should include a discussion of purchased power, including recycled energy installations, as an energy resource option.

It is clear from the draft documents that TVA considers purchase power to be a viable resource option for meeting future energy demand. The discussion regarding renewable energy options, particularly wind and solar, indicate that TVA considers power purchase agreements to be the primary method for adding these resources to TVA's generation portfolio. Also, nearly all of the model's portfolio outputs contain some level of power purchases to meet future energy demand. However, the draft documents provide almost no discussion of purchase power as a resource option to meet future energy demand.

While a brief discussion of current power purchase agreements is provided in the Draft EIS[94], the Draft IRP and Draft EIS are silent on purchased power as a potential future resource. Cost estimates, a discussion of the resource's potential contributions, or a discussion of the relative costs and benefits of pursuing this as a resource option are not provided in the draft documents. At a minimum, the Draft IRP and EIS should provide a description of how this resource was modeled and how it was modeled as a proxy for a number of technologies that were not modeled. Once this information is provided, a more informed review of TVA's resource options for meeting future energy demand is possible.

Of particular interest would be a discussion of the potential for recycled energy technologies to contribute to TVA power needs through the use of PPAs. SACE has engaged in discussions with leading developers of recycled energy technologies that indicate hundreds, possibly thousands of MW of potential are available for development across the TVA service territory[95], yet the Draft IRP and EIS provide no discussion of these technologies.[96]

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[94] *Draft EIS,* p. 44

[95] For example, a high-level potential study conducted by a developer of recycled energy technologies estimates as much as 4,300 MW of potential for recycled energy in Tennessee alone.

[96] In conversations with TVA staff, it is apparent that TVA has no current initiative in place to identify and develop recycled energy technologies. However, this does not obviate the need to analyze this resource in the context of this IRP process.

b. Model outputs in terms of energy use per resource type:

While the Draft IRP and EIS provide a generally complete description of the model outputs in terms of capacity, they do not provide an adequate description of the model outputs in terms of energy generated or saved by resource type.

Providing levels of generation by resource type for the models portfolio outputs is critical to a thorough review of the Draft IRP's results. Levels of generation are directly correlated to several of the Draft IRP's uncertainties, including GHG and environmental compliance costs, and the Draft IRP's evaluation metrics, including cost, risk and environmental performance.

In order to truly evaluate the various resource portfolio options and provide meaningful comment on their potential impact on the Valley's environmental and economic future, it is critical that Valley stakeholders be able to understand how the various resource portfolios differ in terms of generation output by resource type. Without this level of understanding, it is difficult to truly evaluate the various options and determine whether the Draft IRP is, in fact, presenting the best path forward towards meeting the Valley's future energy demand.

SACE respectfully submits these comments in response to TVA's Draft Integrated Resource plan and Programmatic Environmental Impact Statement. We look forward to working with TVA to address these concerns.

Attachments

1. Southern Alliance for Clean Energy, *Yes We Can: Southern Solutions for a National Renewable Energy Standard*, February 2009.

2. Navigant Consulting, *Independent Solar Assessment*, completed for the Southern Alliance for Clean Energy, November 2010.

3. Seawell, R. C., *Woody Biomass Supply and Forest Resource Issues*, Larson & McGowin, Inc., prepared for Southern Alliance for Clean Energy, November 1, 2010.

Yes We Can:
Southern Solutions for a National Renewable Energy Standard

Prepared by: Southern Alliance for Clean Energy

February 12, 2009
Revised February 23, 2009 (See Appendix A)

Southern Alliance for Clean Energy
P.O. Box 1842
Knoxville, TN 37901

1.866.522.SACE
www.cleanenergy.org

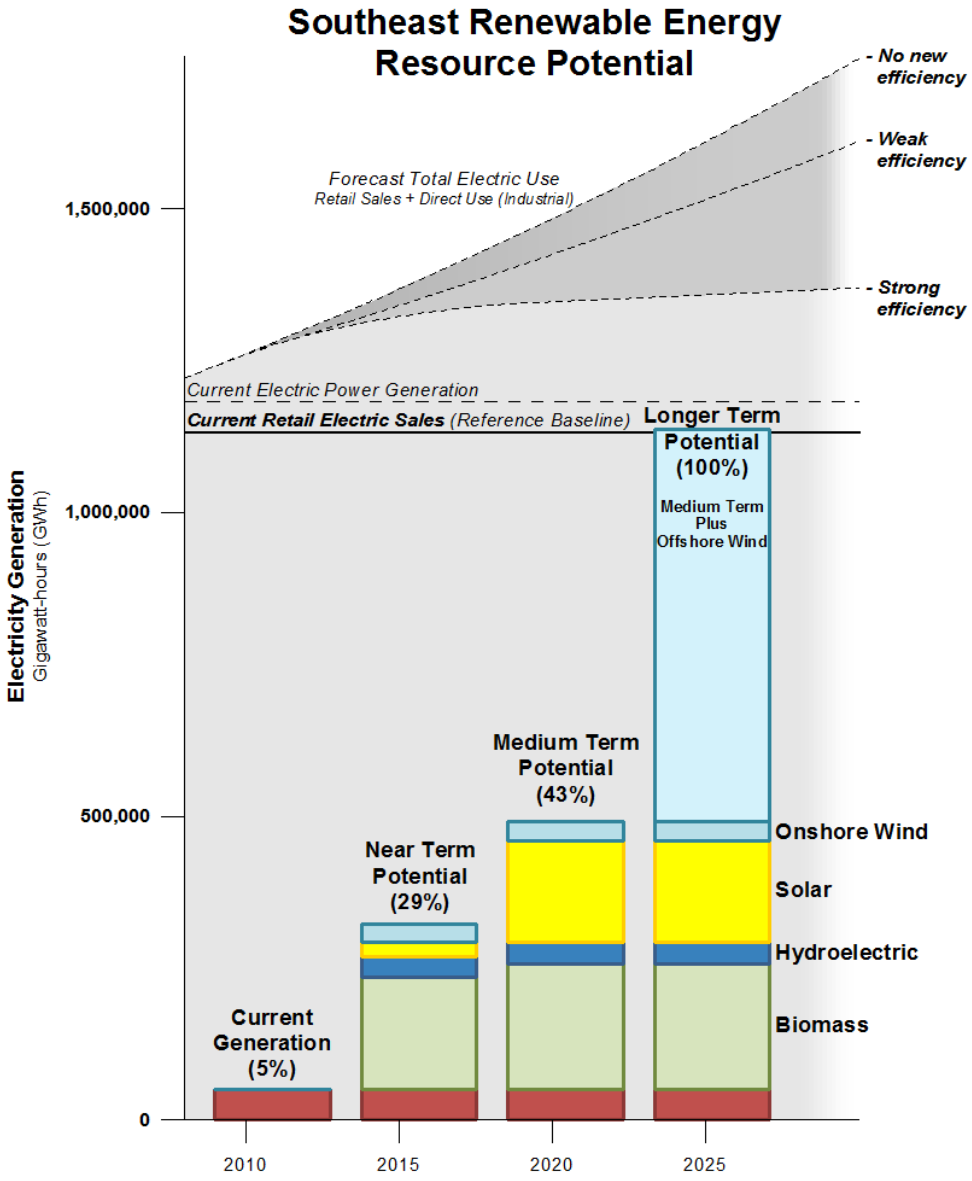
For technical inquiries, please contact:
John D. Wilson, Research Director
wilson@cleanenergy.org

Executive Summary

The Southeast has the ingenuity and renewable energy resources to become more prosperous and energy independent. Utilities across eleven Southeastern states can tap homegrown clean energy resources to meet a significant percentage of electric power demands. Our analysis of renewable energy estimates in the region show sufficient resources to fulfill an aggressive national mandate for renewable energy.

- Today, renewable energy resources generate enough power to serve approximately 5% of retail electric sales in the Southeast.
- Near-term renewable energy resources can generate more than 15% of forecast electricity demand by 2015. If utilized today, these resources would represent about 29% of today's retail sales.
- The Southeast's resources are ample, diverse and widely distributed. Utilities and state regulators will have flexibility in choosing the solutions that are in the public interest.
- With energy efficiency improvements, renewable energy could meet 30% or more of the Southeast's need for electric power.
- One day, renewable energy and energy efficiency may be able to meet nearly all electricity demand.

In summary, the Southeast can meet a national renewable energy standard of at least 15% by 2015, 20% by 2020, and 25% by 2025 with today's technology and tomorrow's jobs.



A National Renewable Energy Standard

A national Renewable Energy Standard (RES) requires that a designated percentage of utilities' electricity production comes from renewable energy sources. The Southern Alliance for Clean Energy assembled data from a large number of regional and national studies to determine whether the Southeast has the resources needed to meet a national RES. Our analysis includes the following assumptions:

- The standard would escalate gradually from today's 5% generation level to:
  - A near-term goal of 15% generation by 2015,
  - A medium-term goal of 20% generation by 2020, and
  - A longer-term goal of 25% generation by 2025.
- Supplemental federal and state policies will support an RES.
- All utilities will be required to comply.

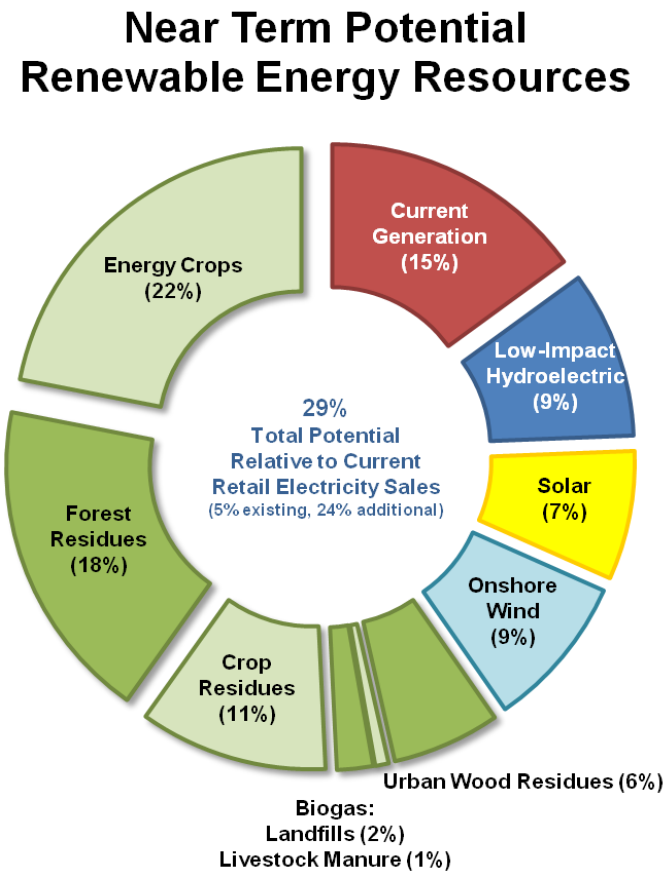
The Southeast has been portrayed as a region that will face significant cost and difficulty meeting a national RES due to scarce access to renewable energy resources. *This assertion is simply inaccurate*. The Southeast has sufficient renewable energy resources to comply with a strong RES. Developing our region's renewable energy potential and meeting an RES will actually benefit the region.

Renewable Resources Ready in the Near-Term

The Southeast possesses a variety of renewable energy resources, but biomass is the region's most important near-term option. Today, biomass and hydroelectric power are equally responsible for nearly all of the Southeast's renewable energy generation. Biomass represents about two-thirds of the Southeast's near-term potential for expanding renewable energy. Realizing the Southeast's vast potential for homegrown renewable energy starts with the thoughtful use of our biomass resources.

Today, biomass generation is mainly associated with the use of mill and agricultural processing wastes. Tomorrow's opportunities for using biomass to generate electricity in the Southeast include a diverse assortment of options, particularly energy crops and wood resources.

Energy crops are typically thought of as agricultural crops planted and harvested explicitly for energy generation. However, certain fast-growing trees that can be planted on marginal forest acreage not currently under good stewardship also fit into this category. Energy crops, which can be grown on disused land in poor condition, can provide auxiliary benefits as wildlife habitat. Our analysis builds on



regional stakeholder research as well as scientific expertise at federal laboratories to set out an ambitious goal for energy crops. Nevertheless, developing our resources to this extent would make a major contribution to energy production using only four percent of today's farmland.

The Southeast's wood resources include forest residues – underutilized portions of felled trees – and urban wood waste from landscaping and other such activities. Some industrial users of forest products express understandable concern about new competitors for critical resources. However, the resources cataloged in this analysis are not currently utilized for high-value purposes. Furthermore, the use of wood residues would not directly add to the considerable ecological problems affecting southeastern forests, as only about 0.2% of forest stocks are included in the biopower component of the medium-term feasible resource potential.

The potential for biogas energy generation in this region remains modest. As biogas projects capture methane that would otherwise contribute to global warming, they should not be neglected.

Biomass is a widely available resource in the Southeast, but it is not the only resource that is ready to rely upon. Southeastern utilities are also beginning to develop the region's solar and wind resources. In response to new state renewable energy policies in Florida and North Carolina, as well as improved cost-effectiveness, several new solar, biomass and wind projects are underway.

- Duke Energy contracted with SunEdison for a 16 MW solar generation facility in Davidson County, North Carolina.
- North Carolina issued Duke Energy regulatory approval to install 10 MW of solar panels on residential and business rooftops.
- Progress Energy has announced three 1 MW solar PV projects in North Carolina.
- Vanir Energy announced a 1.5 MW solar heating and cooling project to serve a Henderson County, North Carolina business park without utility involvement.
- Georgia Power is seeking regulatory approval to convert its coal-fired Plant Mitchell to a 96 MW wood waste biomass plant with reduced fuel and operating costs. The utility has contracted for half the output of a similar privately-built 110 MW plant.
- Oglethorpe Power is planning two to three 100 MW biomass power plants in Georgia.
- Florida Power and Light (FPL) is planning a 14 MW wind farm on Hutchinson Island.
- FPL is planning the world's first hybrid solar / natural gas power plant with a 75 MW solar thermal facility.

Also of note, Gainesville Regional Utilities has developed a solar photovoltaic "feed in tariff" (GRU 2008). The analysis supporting this approach is particularly relevant to questions regarding appropriate rates to pay for solar power.

Of the different types of near-term potential resources, only low-impact hydroelectric power has failed to attract much attention from Southeastern utilities. However, this proven technology is getting a fresh look around the world as low-impact projects that do not require dams or other major structures are proving to be a useful addition to the power system.

Renewable Energy Opportunities Across the Southeast

State	Electric Power Generation (avg GWh, 2005-07)	Renewable Share of Generation	Feasible Renewable Resource Potential (Relative to 2006 retail sales)				Breakthrough Technologies
			Current	Near-Term	Medium-Term	Longer-Term	
Alabama	137,694	8 %	12 %	41 %	61 %	61 %	Geothermal
Arkansas	51,113	8 %	9 %	75 %	112 %	112 %	Geothermal
Florida[i]	220,931	2 %	2 %	11 %	20 %	21 %	Ocean current
Georgia	139,597	4 %	4 %	25 %	39 %	78 %	Ocean current
Kentucky	97,094	3 %	3 %	26 %	39 %	39 %	
Louisiana	91,475	4 %	5 %	32 %	51 %	51 %	Geothermal
Mississippi	47,098	3 %	3 %	77 %	113 %	113 %	Geothermal
North Carolina	126,974	4 %	4 %	29 %	42 %	250 %	Ocean current
South Carolina	101,129	3 %	3 %	21 %	33 %	242 %	Ocean current
Tennessee	93,669	8 %	7 %	31 %	44 %	44 %	
Virginia	76,087	3 %	2 %	20 %	31 %	179 %	Ocean current
Southeastern States	**1,182,861**	**4 %**	**5 %**	**29 %**	**43 %**	**100 %**	

Crafting State-Specific Solutions

Near-term renewable energy resources in the Southeast are *ample, widely distributed and diverse.* Because of the wide availability of resources, initial investments in renewable energy will not require special changes to the Southeast's transmission system. As most major Southeastern utilities operate across state lines, the specific resources available in each state are only a useful indication of regional resource distribution.

Mississippi and Arkansas have a special opportunity to develop and *export* biomass resources or the electricity they generate. Other Southeastern states have enough homegrown resources to meet 10-25% of electricity demand in the near-term without crossing state lines. With these resources, the Southeast can meet a near-term national RES target of 15% by 2015.

Even without considering untapped resources like offshore wind, ocean energy or geothermal resources, the medium-term outlook for the Southeast is also promising. Every Southeastern state has the potential to meet a goal of 20% by 2020.

Because the Southeast's renewable energy resources are ample, widely distributed, and diverse, the Southeast has many paths to meeting a renewable energy standard. Because most proposals for a

renewable energy standard incorporate market-based flexibility, utilities can reach across state lines if that is in the interests of their customers and consistent with state policy. Furthermore, efforts to accelerate use of offshore wind and "breakthrough" technologies could bring forward additional opportunities not accounted for in our estimates.

The Southeast will need to look to offshore wind and ocean energy to meet a goal of 25% by 2025, and a variety of coastal energy projects are already underway. For example:

- University of North Carolina is studying the feasibility of wind energy in the state's sounds.
- South Carolina is studying the feasibility of offshore wind energy in state waters.
- Georgia is studying regional transmission infrastructure for ocean-based renewable energy.
- Southern Company has received a federal government lease to collect site-specific wind data in waters off of Georgia's coast.
- Florida Atlantic University's Center for Ocean Energy Technology receives state funds to explore ocean energy by placing a turbine in the Gulf Stream and studying the generation of energy from extreme temperature differences that naturally occur in the ocean.

While the Southeast has not demonstrated widespread national leadership on renewable energy, utilities and state governments throughout the region are exploring the renewable energy potential with creative and dynamic projects. Effective policies like a national RES can help accelerate renewable energy development across the Southeast.

21st Century Challenges, 21st Century Solutions

In less than a century, the United States succeeded in building a network of electric utilities that provide reliable, universal electric service to America. Sustained policy action supported that remarkable achievement and addressed the challenges of that period. Today a new set of laws, regulations and practices are needed to deploy renewable energy and energy efficiency while rebuilding our economy in the rural South.

Twenty-first century policies must prioritize actions that will achieve energy independence *and* minimize global warming pollution. In addition to a national Renewable Energy Standard (RES), the following policies are needed (and assumed in this analysis) to help achieve these goals:

- National carbon dioxide "cap-and-trade" or equivalent policy.
- Third party suppliers of electricity paid at market-based cost of service, reflecting off-peak and peak system value.
- A solar "carve-out," feed-in tariff, or other policy that provides a premium value for investment in solar energy (to the extent that this value is not already reflected in payments at a market-based cost of service).
- Complementary government biofuel policies.

- Responsible and predictable permitting for low-impact hydro, onshore wind, offshore wind and biomass power plants.
- Extension and expansion of state and federal tax credits for renewable energy and efficiency through 2020.

These assumptions are implicit in the primary references used to inform this analysis (see Navigant 2008 for example). In addition, the following conditions (assumed in this analysis) will contribute to or provide an incentive for achieving energy independence while minimizing global warming pollution:

- Moderately high fossil fuel costs.[ii]
- Relatively low capital costs for renewable energy projects that are sustained from recent experience.
- Biomass resources proven to be available at the higher end of resource potential range.
- Relatively rapid rate of technology adoption.

Notably, high electricity rates are not among the conditions needed to support renewable energy development. Renewable energy can be developed at a moderate cost of electricity (relative to future expectations). High electricity rates are more likely to occur if utilities continue to build high-cost baseload generation (expensive coal and nuclear) power plants and neglect inexpensive energy efficiency opportunities.

Tomorrow's Energy, Tomorrow's Jobs

A national Renewable Energy Standard (RES) that reaches a target of 25% by 2025 can play an important role in strengthening our region's economy. Developing the Southeast's renewable energy potential will create new economic opportunities and spur demand for a variety of skilled trades and professional careers.

For example, in 2007 the University of Florida partnered with the USDA Forest Service and other organizations to study the economic impact of a 20 or 40 MW wood-fueled power plant. The study looked at the impact in counties and states throughout the South, including 15 counties in Tennessee, Georgia, Florida and the Carolinas, and found that one 20 MW plant could create an average of 177 full-time, part-time and seasonal jobs while a 40 MW plant could create an average of 393 jobs. Furthermore, the analysis revealed that a 20 MW facility would generate average additional economic activity of $11.07 million and a 40 MW facility would produce nearly $23 million in economic activity (University of Florida 2007).

A 2008 analysis of North Carolina's state-level RES also shows economic benefits. Accounting for job loss and the economic consequences of potential rate increases, the analysis indicated that the RES would result in a net job gain of nearly 2,050 jobs per year over 20 years by the year 2021 (La Capra 2008).

The Bureau of Labor Statistics reports that the Southeast lost more than 612,000 jobs in 2008. Currently, the average unemployment in Southeastern states is 8.5% compared to a national unemployment rate of 7.2%. While we cannot expect a national RES to reverse the unemployment trends completely, the resulting increase in economic and employment opportunities prove beneficial.

Appendix A: Summary of Southeast Renewable Energy Resource Potential

Total Potential Capacity (MW)	**SE 11**	**SE 8**	**AL**	**AR**	**FL**	**GA**	**KY**	**LA**	**MS**	**NC**	**SC**	**TN**	**VA**
Onshore Wind	70,911	60,950	-	9,655	186	4,728	306	-	-	15,777	924	4,395	34,940
Offshore Wind	494,047	494,047	-	-	40,300	71,472	-	-	-	140,097	149,768	-	92,410
Biomass	92,906	70,825	10,861	8,634	6,727	12,175	5,674	7,773	13,137	9,111	6,502	6,651	5,660
Hydroelectric	63,274	36,785	4,877	12,714	1,075	4,066	6,497	7,279	6,709	4,231	2,242	8,797	4,789
Geothermal	1,058,703	589,848	102,865	214,522	39,114	39,018	60,051	194,281	200,743	49,716	69,226	50,733	38,433
Solar	545,476	423,787	48,567	42,136	90,516	65,187	38,282	41,271	39,768	55,628	32,022	45,851	46,249
Total	**2,325,317**	**1,676,243**	**167,170**	**287,660**	**177,918**	**196,645**	**110,810**	**250,604**	**260,357**	**274,561**	**260,684**	**116,427**	**222,481**
Maximum Feasible Capacity (MW)	**SE 11**	**SE 8**	**AL**	**AR**	**FL**	**GA**	**KY**	**LA**	**MS**	**NC**	**SC**	**TN**	**VA**
Onshore Wind	14,106	10,819	-	3,186	49	1,560	101	-	-	4,857	305	2,089	1,959
Offshore Wind	179,390	179,390	-	-	612	17,180	-	-	-	73,789	43,360	-	44,450
Biomass	27,515	20,346	3,028	2,559	2,380	3,049	2,120	2,490	4,512	2,332	1,561	2,091	1,393
Hydroelectric	9,031	5,926	1,053	1,402	181	525	976	727	708	766	453	1,296	944
Geothermal	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar	79,298	58,951	8,256	7,747	9,826	8,790	5,843	6,758	7,397	7,691	4,664	6,438	5,888
Total	**309,341**	**275,432**	**12,337**	**14,894**	**13,047**	**31,104**	**9,040**	**9,975**	**12,618**	**89,435**	**50,344**	**11,914**	**54,634**
Maximum Feasible Generation (GWh)	**SE 11**	**SE 8**	**AL**	**AR**	**FL**	**GA**	**KY**	**LA**	**MS**	**NC**	**SC**	**TN**	**VA**
Onshore Wind	33,166	25,682	-	7,256	86	3,635	228	-	-	11,882	679	4,645	4,753
Offshore Wind	644,902	644,902	-	-	2,069	52,788	-	-	-	262,557	169,252	-	158,236
Biomass	204,878	151,496	22,548	19,053	17,721	22,703	15,785	18,544	33,597	17,364	11,624	15,569	10,371
Hydroelectric	36,046	23,660	4,038	5,168	683	2,015	4,538	2,681	2,610	3,057	1,856	5,738	3,662
Geothermal	-	-	-	-	-	-	-	-	-	-	-	-	-
Solar	166,799	124,071	17,821	16,550	21,532	18,668	11,546	14,632	15,609	15,798	9,895	12,824	11,924
Total	**1,085,792**	**969,810**	**44,407**	**48,027**	**42,091**	**99,809**	**32,098**	**35,856**	**51,817**	**310,659**	**193,306**	**38,777**	**188,945**
Total excluding offshore wind	***440,889***	***324,908***	***44,407***	***48,027***	***40,022***	***47,021***	***32,098***	***35,856***	***51,817***	***48,101***	***24,054***	***38,777***	***30,709***
Current Renewable Generation (2005-2007 avg)	51,333	40,748	10,468	4,041	5,169	5,824	2,853	3,692	1,415	5,599	2,585	7,242	2,446
Total Generation (2005-2007 avg)	1,182,861	943,179	137,694	51,113	220,931	139,597	97,094	91,475	47,098	126,974	101,129	93,669	76,087

Data are summarized as "SE 11" (referring to all states studied) and "SE 8" (referring to all states except Arkansas, Louisiana, and Kentucky.) The details for each of these resource estimates are provided in the following appendices.

This report was revised on February 23, 2009 to address requests for clarification. The major change is to include retail sales in addition to in-state generation as a baseline for comparing renewable energy generation. In-state generation resources are used to meet retail sales demand and direct use (by industrial facilities, for example), as well as covering losses during transmission and (for some states) net power exports to other states. Because renewable resources are used to generate a substantial percentage of electricity classified as "direct use" in some states, there can be substantial differences at the state level when comparing various renewable energy generation rates to various estimates of electricity generation or use. All of these data are available in the accompanying workbook available on our website.

Additional revisions include revisions to the discussion of forest resources to clarify potential impacts to forest ecosystems, and the following explanation of resource potential classifications that was inadvertently omitted from the original publication.

Characterization of Resource Potential
Resources are presented in the appendix using three classifications.

Total potential capacity indicates the potential maximum peak output (in megawatts) if all resources identified in this study were used to generate power. For each resource, the number presented reflects the maximum power output prior to the application of any constraints. In some studies, this figure was not provided. If a similar study provided this figure for similar resource characteristics (say, for a nearby state), then the total potential capacity was calculated assuming that a similar share of the resource base is feasible. Because the total potential capacity includes resources that cannot be developed under any likely scenario, this figure is useful only as an indication of how the feasibility criteria affected the resource. Furthermore, because there is no potential generation from many of these resources due to unsuitability for generation, it is not meaningful to calculate a "total potential generation" estimate and none is attempted.

Total feasible capacity indicates the potential maximum peak output (in megawatts) of resources that may feasibly be developed. Because the data in this analysis are drawn from a variety of studies, the feasibility criteria used vary somewhat from resource to resource, and state to state. In general, a feasible resource is one that can be developed without compromising an obvious restriction or and under a reasonable (but perhaps aggressive) policy scenario. Examples of obvious restrictions include no wind development in national parks or offshore in shipping lanes. Examples of policy scenario restrictions include the exclusion of geothermal resources due to high cost even under aggressive policy scenarios and the exclusion of unsustainable forest resource extraction. Examples of policy scenario incentives that result in including resources are the state and federal policy scenarios from Navigant (2008).

Total feasible generation indicates the potential annual energy output (in megawatt-hours) of the development of the resources identified as within the total feasible capacity. In other words, capacity (MW) and generation (MWh) are two ways of measuring the utilization of the same energy resources. For purposes of load planning, capacity is the critical measure. However, for purposes of studying the implications of a national renewable energy standard (RES), the important quantity is the generation potential of the resources.

Energy Demand Scenarios
Unless a scenario is clearly specified, all calculations of renewable energy potential as a percentage of electricity sales are relative to average state retail sales for in 2006. These sales figures are obtained from the Energy Information Administration.

Where noted in the report, renewable energy potential is compared to future demand. For this purpose, three scenarios of electricity demand are considered. Because most Southeastern states have minimal energy efficiency programs (Florida achieves annual savings of 0.2% and other states achieve far less), the analysis considers the various levels of effort made to reduce electricity demand.

- *No energy efficiency* – All states experience 1.7% retail sales growth per year. This assumption is based on our informal review of recent planning assumptions (see, for example, Navigant 2008).
- *Weak energy efficiency* – Annual retail sales growth is reduced by 25% (approximately 1.3%) beginning in 2011. Relative to the *no energy efficiency* scenario, the cumulative impact of these annual results is about 4% overall energy savings by 2020 and 6% in 2025.
- *Strong energy efficiency* – Energy efficiency programs are assumed to be phased in gradually, reaching a performance target of 1% annual energy savings in 2015 and 1.5% annual energy savings in 2020. Relative to the *no energy efficiency* scenario, these annual results create a cumulative impact of nearly 11% overall energy savings in 2020 and 19% in 2025.

In all scenarios, direct use is assumed to remain flat. This assumption is based on the approximation that growth in the efficiency of direct use is balanced by overall economic growth in these sectors. Because direct use is a relatively small share of total electrical end use, the overall trends are not particularly sensitive to this assumption.

For the generation forecast in each scenario, the state's overall end use growth rate is applied to the generation baseline (average of 2005-2007 generation) to provide an estimate of total in-state generation.

Timeframes for Renewable Energy Development Potential

Not all renewable energy resources can be developed quickly. In addition to considerations of cost and the availability of technology, some projects take longer to design and construct. Furthermore, suppliers' ability to hire skilled managers and laborers, then manufacture and distribute key components at substantially higher volumes might require time to develop. For these reasons, renewable energy resources are categorized into three categories.

Near-term resources are resources that could be developed in significantly less than a decade, potentially within six years. Near-term resources include current generation and partial implementation of other resources as follows:

- Current generation data are from the Energy Information Administration, except for Florida (Navigant 2008).
- Biomass resources, assuming 90% implementation of feasible renewable energy resources (Appendix B)
    - Achieving this rate of implementation would require significant development of the supply chain for forest, crop and urban wood residues. However, since the amount of forest residues required (0.2% of total forest stock) and crop residues (1% of total crop production) is relatively small, the impact on the scale of forest and agricultural operations will be modest.
    - Approximately 4 million acres of energy crops would be needed. This represents conversion or addition of farmland representing about 4% of 2007 farmland (Perlack 2005, USDA-NASS 2008). This figure varies from 1% of farmland in Florida and Virginia to 11% of farmland in Mississippi due to varying soil suitability and existing land uses in those states.
    - Co-firing at existing coal plants could provide a substantial amount of the generation (reducing the use of coal), but some new power plants would be needed (Southern Alliance for Clean Energy 2008).
    - Since biogas from livestock manure and landfills represents less than 5% of total biomass energy potential, there is flexibility in how quickly these resources are developed. However, since these resources currently represent ongoing sources of methane emissions to the atmosphere, addressing these concerns quickly is a necessary and effective strategy to reduce global warming pollution.
- Solar resources, assuming 15% implementation (Appendix C)
    - Utility and private sector commitments have already been announced. This implementation rate reflects the region's current cautious attitude towards the cost of solar energy as well as its suitability to provide electricity in the current utility management paradigm for reliability. However, the total potential for solar energy resources does reflect the impact of a broad range of supportive state and federal policies (see Appendix C).
- Onshore wind resources, assuming 90% implementation (Appendix D)
    - Our organization is aware of private energy developers pursuing an interest in wind development projects. This aggressive implementation rate reflects the maturity of this technology and the availability of data to target developments to the suitable locations. Although projects can be developed in under

two years, onshore wind projects typically require three to five years to accomplish all phases of development. Given the challenges of development on ridgelines, immediate policy signals would be needed to achieve 90% implementation in five to six years.

- Hydroelectric resources, assuming 90% implementation (Appendix E)
  - Achieving this rate of implementation would require significant development by an industry that does not currently exist at scale in the Southeast. However, the technology and its means of production are relatively simple and could be expanded rapidly. The major obstacle to this technology is the current lack of interest in small-scale distributed renewable energy resources.

For purposes of comparison to electricity sales scenarios (above), near-term resources are benchmarked to 2015.

Medium-term resources are those resources that could be developed in approximately one decade. Medium-term resources are 100% implementation of near-term resources.

Longer-term resources are medium-term resources, plus offshore wind resources. While pilot projects for offshore wind could feasibly be developed in much less than a decade, planning for large scale projects is unlikely to begin for several years. As a consequence, development is unlikely to reach levels much beyond pilot project levels until at least 2020. Although there are substantial engineering challenges to offshore wind development in addition to unresolved policy questions, these obstacles could be resolved to enable major development by 2025.

In addition to offshore wind, longer-term resources could conceivably include breakthrough technologies, particularly geothermal and ocean current power generation. Current technology projections for geothermal electricity generation (Appendix F) do not indicate cost-effectiveness without cost improvements. Ocean current generation remains a conceptual energy resource and is currently undergoing active research and development. If engineering research and development are successful, manufacturing and deployment of these technologies is likely to be feasible on a reasonable timescale; potentially by 2025 but perhaps much sooner.

Appendix B: Southeast Biomass Energy Resource Potential

Biomass	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Capacity (MW)	92,906	70,825	10,861	8,634	6,727	12,175	5,674	7,773	13,137	9,111	6,502	6,651	5,660
Projected Feasible Capacity (MW)	27,515	20,346	3,028	2,559	2,380	3,049	2,120	2,490	4,512	2,332	1,561	2,091	1,393
Projected Feasible Generation (GWh)	204,878	151,496	22,548	19,053	17,721	22,703	15,785	18,544	33,597	17,364	11,624	15,569	10,371
Current Generation (GWh)	23,925	18,925	3,489	1,634	4,128	3,394	458	2,908	1,415	1,759	1,881	404	2,455
Total Potential Generation (GWh)	228,803	170,421	26,036	20,687	21,849	26,097	16,243	21,452	35,012	19,123	13,504	15,973	12,826
Total Potential Capacity (MW)													
Forest Production	56,694	45,691	7,142	4,853	3,471	9,102	2,218	3,932	5,889	6,887	4,898	3,783	4,518
Crop Residues	10,866	5,374	197	2,416	1,643	502	893	2,183	1,104	752	167	756	253
Urban Wood Residues	3,510	2,884	243	158	845	465	229	239	155	420	38	309	409
Livestock Manure	435	350	43	66	9	63	16	3	33	169	14	9	11
Landfills	1,174	979	108	5	209	92	114	76	42	195	83	125	126
Energy Crops	20,227	15,546	3,128	1,135	550	1,950	2,205	1,341	5,914	688	1,303	1,668	344
Total	**92,906**	**70,825**	**10,861**	**8,634**	**6,727**	**12,175**	**5,674**	**7,773**	**13,137**	**9,111**	**6,502**	**6,651**	**5,660**
Projected Feasible Capacity (MW)													
Forest Production	8,417	6,783	1,060	721	515	1,351	329	584	874	1,023	727	562	671
Crop Residues	4,890	2,418	89	1,087	740	226	402	983	497	339	75	340	114
Urban Wood Residues	2,808	2,308	195	127	676	372	183	191	124	336	30	247	328
Livestock Manure	348	280	34	53	7	51	12	2	26	135	11	7	8
Landfills	939	783	86	4	167	73	91	61	34	156	66	100	100
Energy Crops	10,113	7,773	1,564	568	275	975	1,102	670	2,957	344	652	834	172
Total	**27,515**	**20,346**	**3,028**	**2,559**	**2,380**	**3,049**	**2,120**	**2,490**	**4,512**	**2,332**	**1,561**	**2,091**	**1,393**
Projected Feasible Generation (GWh)													
Forest Production	62,673	50,509	7,895	5,365	3,837	10,062	2,452	4,347	6,510	7,614	5,415	4,182	4,994
Crop Residues	36,408	18,008	660	8,094	5,507	1,683	2,991	7,316	3,698	2,521	559	2,533	847
Urban Wood Residues	20,909	17,182	1,449	942	5,034	2,772	1,362	1,422	921	2,499	225	1,842	2,439
Livestock Manure	2,590	2,086	256	394	52	378	93	16	196	1,007	82	54	63
Landfills	6,994	5,832	642	30	1,243	547	680	451	253	1,161	492	745	748
Energy Crops	75,304	57,878	11,646	4,227	2,048	7,261	8,207	4,991	22,019	2,562	4,851	6,212	1,279
Total	**204,878**	**151,496**	**22,548**	**19,053**	**17,721**	**22,703**	**15,785**	**18,544**	**33,597**	**17,364**	**11,624**	**15,569**	**10,371**

The major source for biomass data is the *Bioenergy Roadmap for Southern United States* (Alavalapati 2009). However, this report provides the technical potential in terms of resource volume and potential energy value for forest biomass (USDA-FS), crop residues (USDA-NASS 2007), urban wood residues (Milbrandt 2005), livestock manure (Barker 2001) and methane from landfills (Milbrandt 2005). Since energy crops were not included, an alternate source was selected (Milbrandt 2005).

Additional analysis was necessary to convert these data into potential electric capacity and develop feasible capacity and generation estimates. The conversion to electricity resources assumes an 85% capacity and uses conversion factors from government or national laboratories. To determine feasible resource use, factors from a Florida study (Mulkey 2008) were adapted to the resource categories used in this analysis.

Appendix C: Southeast Solar Energy Resource Potential

Solar	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Capacity (MW)	545,476	423,787	48,567	42,136	90,516	65,187	38,282	41,271	39,768	55,628	32,022	45,851	46,249
Projected Feasible Capacity (MW)	79,298	58,951	8,256	7,747	9,826	8,790	5,843	6,758	7,397	7,691	4,664	6,438	5,888
Projected Feasible Generation (GWh)	166,799	124,071	17,821	16,550	21,532	18,668	11,546	14,632	15,609	15,798	9,895	12,824	11,924
Current Generation (GWh)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Potential Generation (GWh)	166,799	124,071	17,821	16,550	21,532	18,668	11,546	14,632	15,609	15,798	9,895	12,824	11,924
Rooftop PV													
Total Potential Capacity (MW)	190,757	163,595	12,500	6,128	52,000	24,921	10,079	10,955	6,846	21,545	11,042	16,053	18,689
Projected Feasible Capacity (MW)	3,057	2,834	276	3	1,047	130	111	108	292	489	136	267	197
Projected Feasible Generation (GWh)	4,819	4,480	442	5	1,730	202	163	171	455	746	213	398	293
Ground Mounted PV													
Total Potential Capacity (MW)	346,127	253,256	34,816	35,725	37,000	39,730	27,258	29,888	32,184	33,421	20,659	28,280	27,166
Projected Feasible Capacity (MW)	74,391	54,624	7,709	7,683	8,458	8,544	5,528	6,557	6,946	7,059	4,458	5,843	5,606
Projected Feasible Generation (GWh)	159,481	117,517	17,010	16,462	19,263	18,307	11,169	14,334	14,936	14,856	9,587	12,030	11,527
Large Scale Solar Water Heating													
Total Potential Capacity (MW)	8,212	6,556	1,251	283	1,136	535	945	428	738	662	321	1,518	394
Projected Feasible Capacity (MW)	1,775	1,417	270	61	246	116	204	93	160	143	69	328	85
Projected Feasible Generation (GWh)	2,348	1,923	369	84	387	158	215	127	218	195	95	397	103
CSP - feasibility limited to Florida due to need for direct incidence of sunlight													
Total Potential Capacity (MW)	380	380			380								
Projected Feasible Capacity (MW)	75	75			75								
Projected Feasible Generation (GWh)	151	151			151								

The most authoritative analysis of solar energy potential in the Southeast is the *Florida Renewable Energy Potential Assessment* (Navigant Consulting 2008). All Florida data for the solar energy resource are derived from this study, which used three policy and forecast scenarios that resulted in different levels of renewable energy potential. In response to this study in January 2009, the Florida Public Service Commission recommended a renewable energy standard of 20% by 2020. Using a weighted average of two scenarios, the solar resource potential for Florida was estimated for an overall 20% renewable energy potential as recommended by the commission; these data are used in this report.

Since there is no comparable data for any other Southeastern state, the Florida study findings were extended to other states using technology-specific adjustment factors.

- *Rooftop PV* – The total potential capacity for all Southeastern states (using somewhat less robust methods) has been estimated as 223 thousand GWh on a state by state basis (Paidipati 2008). The newer Florida estimate is approximately 15% less than the prior estimate; accordingly, the total potential for each state is reduced by the same factor. The feasible potential capacity for states other than Florida is extended from the same study (2015 cumulative best case, SAI pricing scenario). The newer Florida estimate is roughly three times larger than the prior estimate, which is reasonable considering that the newer estimate includes five additional years of opportunity to install solar resources as well as different policy and forecast assumptions. The feasible potential generation was determined using the same approach except that the energy output per unit of capacity is reduced relative to Florida based on the relative energy density of each state (Denholm and Margolis 2007).

- *Ground Mounted PV* - The Florida study determined the total potential capacity based primarily on an in-depth land use analysis using GIS technology; less than 1% of Florida land area was identified as suitable. Because other Southeastern states appear generally less intensively developed, and have fewer acres in wetlands or other restricted land uses, it is likely that a larger percentage of land in those states might fit the same criteria developed for Florida. For that reason, adjusting the total potential capacity across the Southeast based on the land area of each state relative to Florida provides a fairly conservative assumption. The feasible potential capacity was reduced based on the energy density of each state relative to Florida, using this factor as a proxy for the slightly less attractive economic opportunity to develop solar in those states. The feasible potential generation was reduced in the same way to account for the economic opportunity, and the energy density factor was reapplied to also account for the difference in energy output per unit of capacity.
- *Large Scale Solar Water Heating* – Although solar water heating does not generate electricity per se, it does tend to displace electricity used to generate hot water. The Florida study considered opportunities to generate the equivalent of greater than 2 MW of water heating capacity. The total and feasible potential capacity for each state was determined by adjusting the Florida estimate based on the state's large commercial roof area relative to Florida (Chaudhari 2004) because most large solar water heating opportunities would be at major commercial sites (e.g., hospitals, hotels). The feasible potential generation for each state was derived from the Florida data adjusted for both the roof area data and the state's solar fraction relative to Florida (Denholm 2007).
- *Concentrated Solar Power* – A literature review indicates that this technology depends on a high incidence of direct sunlight to be successful. These conditions do not occur in the Southeast anywhere north of approximately Gainesville, Florida. Accordingly, we assume no potential for other Southeastern states.

In addition to these resources, smaller scale solar water heating is also a widely available resource in the Southeast. Although these resources could be considered eligible for a renewable energy standard, they are often omitted due to difficulties in incorporating them into a market-based trading framework. Accordingly, we have not included these smaller resources in our inventory of renewable energy potential. This approach follows the Florida study.

Appendix D: Southeast Wind Energy Resource Potential

Wind (Total)	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Capacity (MW)	564,959	554,998	-	9,655	40,486	76,200	306	-	-	155,874	150,693	4,395	127,350
Projected Feasible Capacity (MW)	193,496	190,209	-	3,186	661	18,740	101	-	-	78,646	43,665	2,089	46,409
Projected Feasible Generation (GWh)	678,068	670,584	-	7,256	2,155	56,423	228	-	-	274,440	169,931	4,645	162,989
Current Generation (GWh)	36	36	-	-	-	-	-	-	-	-	-	36	-
Total Potential Generation (GWh)	678,104	670,620	-	7,256	2,155	56,423	228	-	-	274,440	169,931	4,681	162,989

Onshore Wind Resources

Onshore	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Capacity (MW)	70,911	60,950	-	9,655	186	4,728	306	-	-	15,777	924	4,395	34,940
Projected Feasible Capacity (MW)	14,106	10,819	-	3,186	49	1,560	101	-	-	4,857	305	2,089	1,959
Projected Feasible Generation (GWh)	33,166	25,682	-	7,256	86	3,635	228	-	-	11,882	679	4,645	4,753

A variety of resources were used to estimate onshore wind energy resource potential. (Note that the totals above include offshore wind energy resource potential, presented in Appendix E.)

- *Appalachian State University* (North Carolina, Tennessee) – Using data from NREL and AWS Truewind, along with their own field and GIS analysis, wind resource experts maintain an ongoing assessment of potential wind energy development sites in western North Carolina (Raichle 2007). For eastern North Carolina, data were obtained from a study of North Carolina's renewable energy resources (La Capra Associates 2006). For Tennessee, extensive data were provided to the Tennessee Valley Authority (Carson and Raichle 2005); these data required some analysis for purposes of summarization following methods used for North Carolina (Raichle 2007).
- *AWS Truewind* (Georgia) – AWS Truewind assessed the wind resource potential for Georgia (Bailey 2006). The total potential capacity was obtained from this report. Based on North Carolina results, feasible potential capacity is assumed to be 33% of total potential capacity; generation is derived from that figure using a capacity factor appropriate to the wind class (Raichle 2007).
- *AWS Truewind* (South Carolina) – Using data from AWS Truewind, a research team at University of South Carolina assessed the wind resource potential for South Carolina (Beacham 2008). The feasible potential capacity and generation were obtained from this report. The total potential capacity is derived from these data assuming that the feasible potential is 33% of total potential capacity based on North Carolina results (Raichle 2007).
- *WindDS* (Arkansas, Kentucky) – The National Renewable Energy Laboratory maintains a national model of wind energy potential (Denholm and Short 2006). The total potential capacity was obtained from these data. Feasible potential capacity is assumed to be 33% of total potential capacity; generation is derived from that figure using a capacity factor appropriate to the wind class (Raichle 2007).
- *Virginia Center for Coal and Energy Research* (Virginia) – All necessary data were available in a study of Virginia renewable energy resources and via personal communication with the study author, although some calculations were required to present the data in a consistent framework for this analysis (Virginia Center 2005, Hagerman 2007).
- *Navigant Consulting* (Florida) - The most authoritative analysis of wind energy potential in Florida is the *Florida Renewable Energy Potential Assessment* (Navigant Consulting 2008), which relied on unpublished data from NREL. The Florida study used three policy and forecast scenarios that resulted in different levels of renewable energy potential. Acting on findings in this study in January 2009, the Florida Public Service Commission recommended a

renewable energy standard of 20% by 2020. Using a weighted average of two scenarios, the onshore wind resource potential for Florida was estimated for an overall 20% renewable energy potential as recommended by the commission; these data are used in this report.

No studies have identified significant onshore wind resources for Alabama, Louisiana or Mississippi. Small, specialized wind generation opportunities might exist in these states, and there might be limited opportunity for utility-scale generation on ridgelines in northeast Alabama.

Offshore Wind Resources

Offshore	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Capacity (MW)	494,047	494,047	-		40,300	71,472		-	-	140,097	149,768		92,410
Projected Feasible Capacity (MW)	179,390	179,390	-		612	17,180		-	-	73,789	43,360		44,450
Projected Feasible Generation (GWh)	644,902	644,902	-		2,069	52,788		-	-	262,557	169,252		158,236

A variety of resources were used to estimate offshore wind energy resource potential. (Note that the totals above include onshore wind energy resource potential, presented in Appendix D.)

- *AWS Truewind* (Georgia) – AWS Truewind assessed the wind resource potential for Georgia (Bailey 2006). The total potential capacity was obtained from this report. Feasible potential capacity is assumed to be 25% for Class 4-5 and 60% for Class 6 (based on Virginia findings, see below). Capacity factors are from the WinDS documentation.
- *AWS Truewind* (South Carolina) – Using data from AWS Truewind, a research team at University of South Carolina assessed the wind resource potential for South Carolina (Beacham 2008). The feasible potential capacity and generation were obtained from this report. The total potential capacity is derived from these data assuming that the feasible potential capacity is 25% for Class 4-5 and 60% for Class 6 (based on Virginia findings, see below).
- *WindDS* (North Carolina) – The National Renewable Energy Laboratory maintains a national model of wind energy potential (Denholm and Short 2006). The total potential capacity was obtained from these data. Feasible potential capacity is assumed to be 25% for Class 4-5 and 60% for Class 6 (based on Virginia findings, see below). Capacity factors are from the WinDS documentation. (Note that offshore wind has been excluded from North Carolina specific resource studies for policy or program reasons.)
- *Virginia Center for Coal and Energy Research* (Virginia) – All necessary data were available in a study of Virginia renewable energy resources and via personal communication with the study author, although some calculations were required to present the data in a consistent framework for this analysis (Virginia Center 2005, Hagerman 2007).
- *Navigant Consulting* (Florida) – The most authoritative analysis of wind energy potential in Florida is the *Florida Renewable Energy Potential Assessment* (Navigant Consulting 2008), which relied on unpublished data from NREL. The Florida study used three policy and forecast scenarios that resulted in different levels of renewable energy potential. In response to this study in January 2009, the Florida Public Service Commission recommended a renewable energy standard of 20% by 2020. Using a weighted average of two scenarios, the offshore wind resource potential for Florida was estimated for an overall 20% renewable energy potential as recommended by the commission; these data are used in this report.

These studies use generally consistent methods and data sources, except that North Carolina and Florida data are derived from NREL data that represent potential at 50 meters above the surface. AWS Truewind data represent conditions at 90-100 meters–a height more representative of the wind conditions that a modern offshore wind turbine might experience. No studies have identified significant offshore wind resources for Alabama, Louisiana or Mississippi. Data from Florida and Texas suggest that it is highly unlikely that those states have significant offshore wind resource potential.

Appendix E: Southeast Hydroelectric Energy Resource Potential

Hydroelectric	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Additional Capacity (MW)	63,274	36,785	4,877	12,714	1,075	4,066	6,497	7,279	6,709	4,231	2,242	8,797	4,789
Projected Feasible Additional Capacity (MW)	9,031	5,926	1,053	1,402	181	525	976	727	708	766	453	1,296	944
Projected Feasible Additional Generation (GWh)	36,046	23,660	4,038	5,168	683	2,015	4,538	2,681	2,610	3,057	1,856	5,738	3,662
Current Generation (GWh)	26,567	20,982	6,980	2,407	235	2,430	2,395	784	-	3,840	704	6,802	(9)
Total Potential Generation (GWh)	62,613	44,641	11,018	7,575	918	4,445	6,932	3,464	2,610	6,897	2,560	12,540	3,653
Low Power and Small Hydro Class Plants													
Total Potential Hydro (MWa)	32,334	19,795	3,171	5,697	464	2,061	3,754	3,088	2,823	2,329	1,378	5,295	2,274
Total Developed Hydro (MWa)	3,725	3,048	1,036	347	-	281	305	25	-	402	328	848	153
Total Potential (MWa) (Total minus developed)	28,609	16,747	2,135	5,350	464	1,780	3,449	3,063	2,823	1,927	1,050	4,447	2,121
Annual capacity factor			0.4378	0.4208	0.4316	0.4378	0.5309	0.4208	0.4208	0.4555	0.4691	0.5055	0.4429
Convert MWa to MW (Total Potential Capacity)	63,271	36,781	4,877	12,714	1,075	4,066	6,497	7,279	6,709	4,231	2,238	8,797	4,789
Available High Power (MWa)	2,808	1,714	311	405	51	101	441	248	194	199	153	481	224
Available Low Power (MWa)	1,306	986	150	185	27	129	77	58	104	150	58	174	194
Feasible Capacity (MW)	9,028	5,923	1,053	1,402	181	525	976	727	708	766	450	1,296	944
Feasible Generation (GWh)	36,039	23,652	4,038	5,168	683	2,015	4,538	2,681	2,610	3,057	1,848	5,738	3,662

The potential hydroelectric generation is from an Idaho National Laboratory study (INL 2006). The total potential generation (in average megawatts or MWa) is estimated as the difference between total potential hydroelectric energy and the total developed hydroelectric resource in the state. Using a state-specific capacity factor (INL 2003), the total potential capacity is derived from this figure. The potential feasible resource is derived from the available high and low power generation using the same state-specific capacity factor. Converting available power from MWa to GWh is a straightforward conversion by definition.

The INL report is specifically limited to technologies with low or no environmental impact. In South Carolina, a small additional increment of conventional generation is included (3.5 MW, 7.7 GWh, La Capra and GDS 2007).

Appendix F: Southeast Geothermal Energy Resource Potential

Geothermal	SE 11	SE 8	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Total Potential Capacity (MW)	1,058,703	589,848	102,865	214,522	39,114	39,018	60,051	194,281	200,743	49,716	69,226	50,733	38,433
Projected Feasible Capacity (MW)	-	-	-	-	-	-	-	-	-	-	-	-	-
Projected Feasible Generation (GWh)	-	-	-	-	-	-	-	-	-	-	-	-	-
Current Generation (GWh)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Potential Generation (GWh)	-	-	-	-	-	-	-	-	-	-	-	-	-
Total recoverable energy (MW)			102,865	214,522	39,114	39,018	60,051	194,281	200,743	49,716	69,226	50,733	38,433
Developable - lowest cost resource (MW)			135	418	39	126	3,588	58,202	211	205	3,594	436	1,636
Cost (cents / kWh)			29	22	39	58	67	28	22	38	57	48	48
Developable w/cost improvements < 13 c/kWh (MW)			212	37,029				30,800	7,247				
Developable w/cost improvements < 13 c/kWh (GWh)			1,671	291,940	-	-	-	242,824	57,136	-	-	-	-

There is currently no report that identifies significant geothermal electric generation potential in the Southeast. Although isolated locations may have the potential for relatively small utility-scale generation projects, no such opportunities were catalogued in the most recent study (MIT 2006). However, with cost improvements, sites in Arkansas, Louisiana, Mississippi and Alabama could become potential sites for geothermal electric generation at costs that are similar to those being proposed for nuclear and coal generation facilities. (Note that this technology is different from a geothermal heat pump, which is considered an energy efficiency technology, not a renewable energy technology.)

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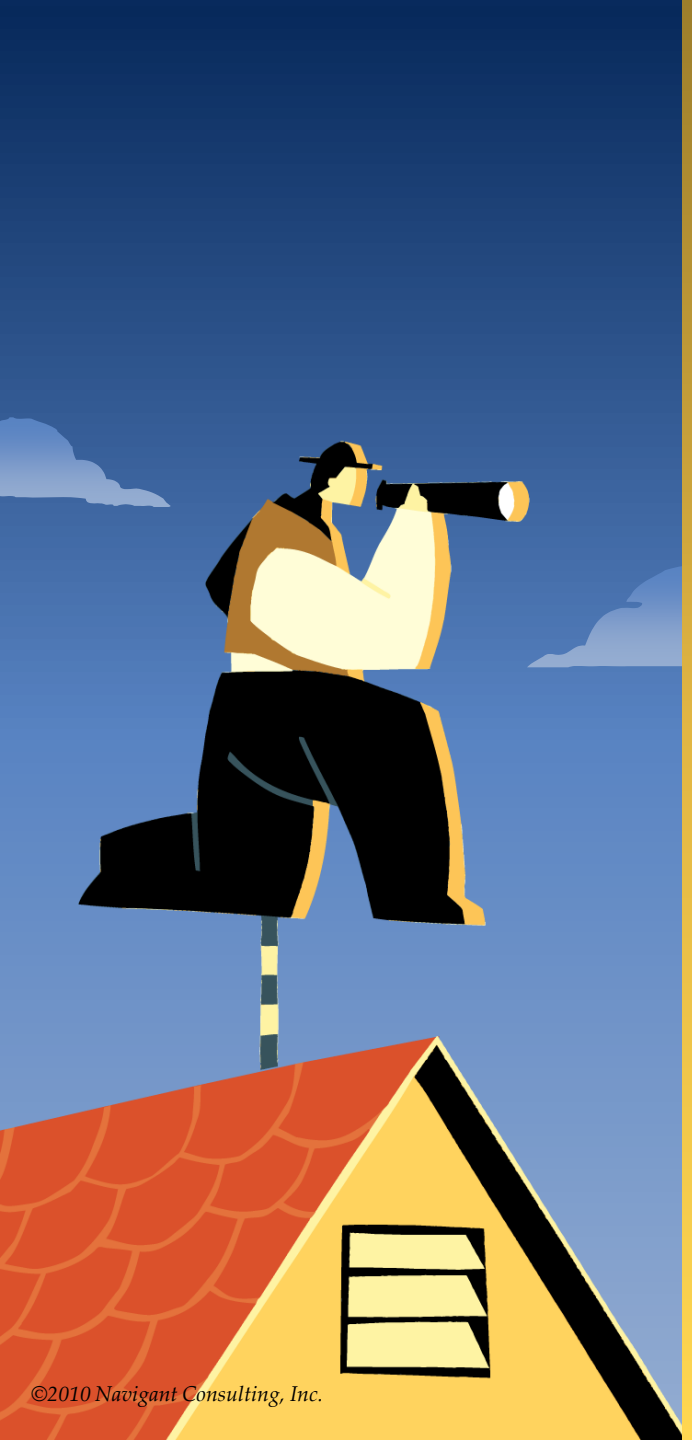
Endnotes

[i] The 2% figure cited for Florida's current generation differs from the approximately 5% figure reported in a recent Florida study (Navigant 2008). The difference can be accounted for by differences in the baselines. The Florida study considered renewable energy relative to a sales baseline of the four largest investor-owned utilities, rather than a statewide total sales baseline. Another distinction in the Florida study is the addition of sulfuric acid waste heat recovery, which is defined by statute in Florida as a renewable energy resource.

[ii] Typical assumptions would be natural gas at $11-14 per MMBtu, coal $2.5-3.5 per MMBtu, biomass $60 per dry ton, electricity rates increase from 9¢ to 17¢ per kWh, MSW tipping fee $70 per ton (Navigant 2008).



Independent Solar Assessment

Phase 1 – Penetration Levels and Costs

FINAL

Celebrating 25 Years

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Working towards a clean energy future

Southern Alliance for Clean Energy

November 5, 2010

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NCI Reference: 142962

Content of Report

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November 5, 2010

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SACE retained Navigant to investigate potential PV penetration levels in the Tennessee Valley Authority's territory.

Scope of Work
SACE has retained Navigant to investigate photovoltaic (PV) in the Tennessee Valley Authority's (TVA) territory. This portion of the work consisted of the following tasks: 1. Develop reasonable penetration levels of PV in TVA's territory, by market segment, through 2030. 2. Analyze and project current and future costs of PV • Both up-front and on-going in TVA's territory. 3. Calculate the total costs of each penetration scenario. The following slides present a summary of the work conducted by Navigant.

Navigant used data from public sources to select 3 levels of PV penetration in TVA's territory.

Methodology

- Select three levels of PV penetration for further study.
- To date, no solar integration studies have been done for TVA or the eastern interconnect.
  - The National Renewable Energy Laboratory (NREL) has done an initial study for the western interconnect[1], but the study is not applicable to TVA given regional differences in generators available, weather, and load.
- As a result, Navigant undertook the process shown on the right.

1. Characterize TVA's current and future load, and generation assets
2. Collect data on state and utility solar programs and targets
3. Assess technical limits for PV penetration
4. Select 3 levels of penetration that are in line with other state and utility programs, but that will not likely significantly impact TVA's grid operation

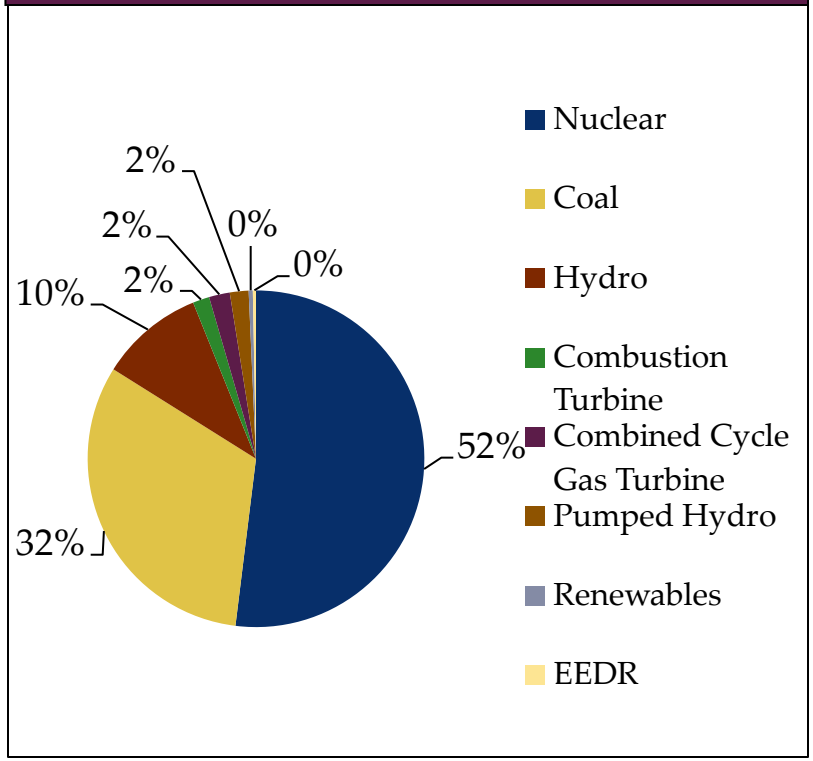
Source:
1. Available at http://www.nrel.gov/wind/systemsintegration/wwsis.html.

TVA serves 56 customers and 155 power distributors directly. These customers provide electricity to ~9 million people. [1]

TVA Overview

	2008	2009
Peak Load[2]	31,750 MW	30,500 MW
Annual Load[2,3]	180,500 GWh	194,300 GWh
Expected Load Growth to 2030[2]	1.1% average annual increase	
Expected Peak Demand Growth to 2030_2	1.4% average annual increase	

TVA Generation Mix[4]



Sources:
1. http://www.tva.gov/foia/foia_guide.htm
2. http://www.tva.gov/irp/pdf/irp_complete.pdf, Used IRP Baseline
3. Southern Alliance for Clean Energy
4. U.S. Department of Energy's Energy Information Administration (EIA)

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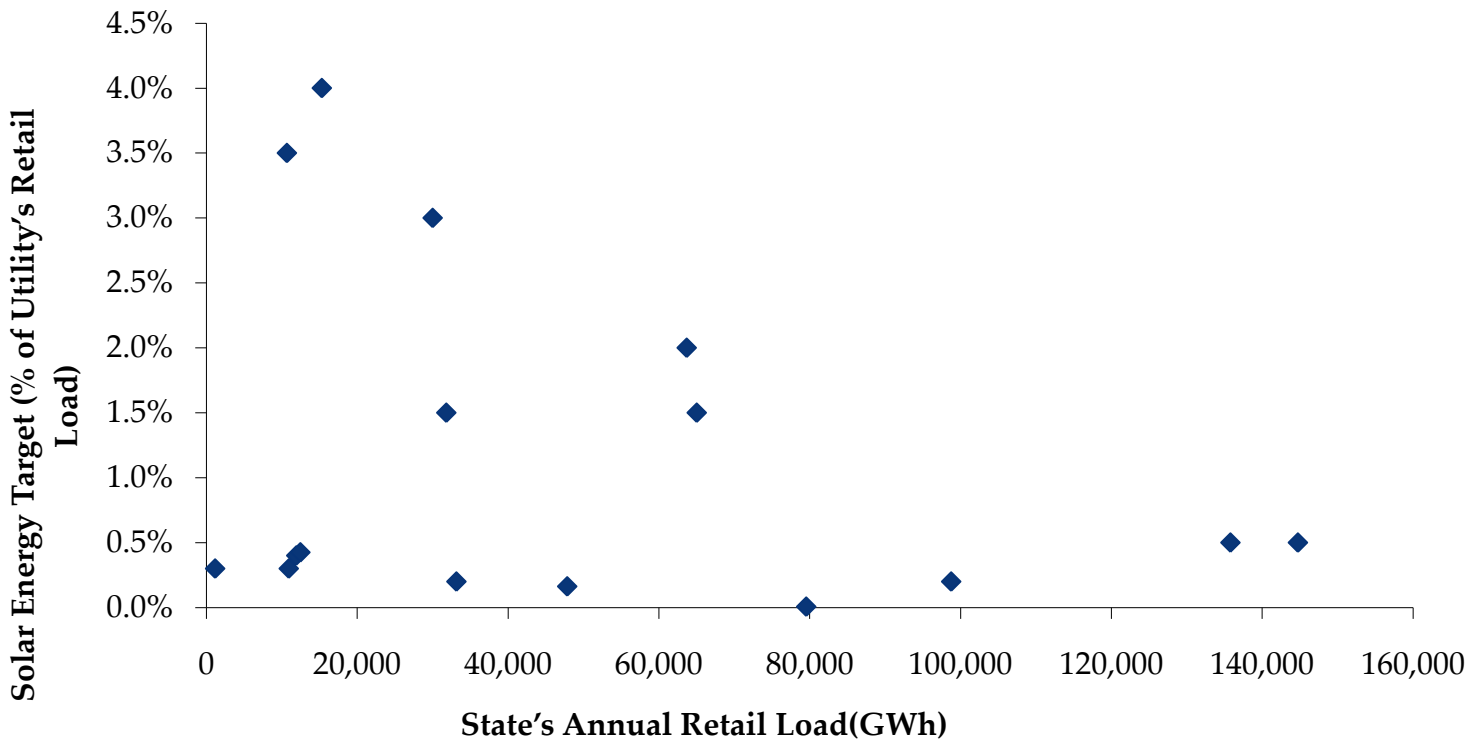
Many states have established solar specific targets as part of their Renewable Portfolio Standards (RPS). Targets range from 0.1% to 4%.

Mapping of State RPS Solar Set Aside Targets[1]



Notes:

1. Sources: EIA and www.dsireusa.org

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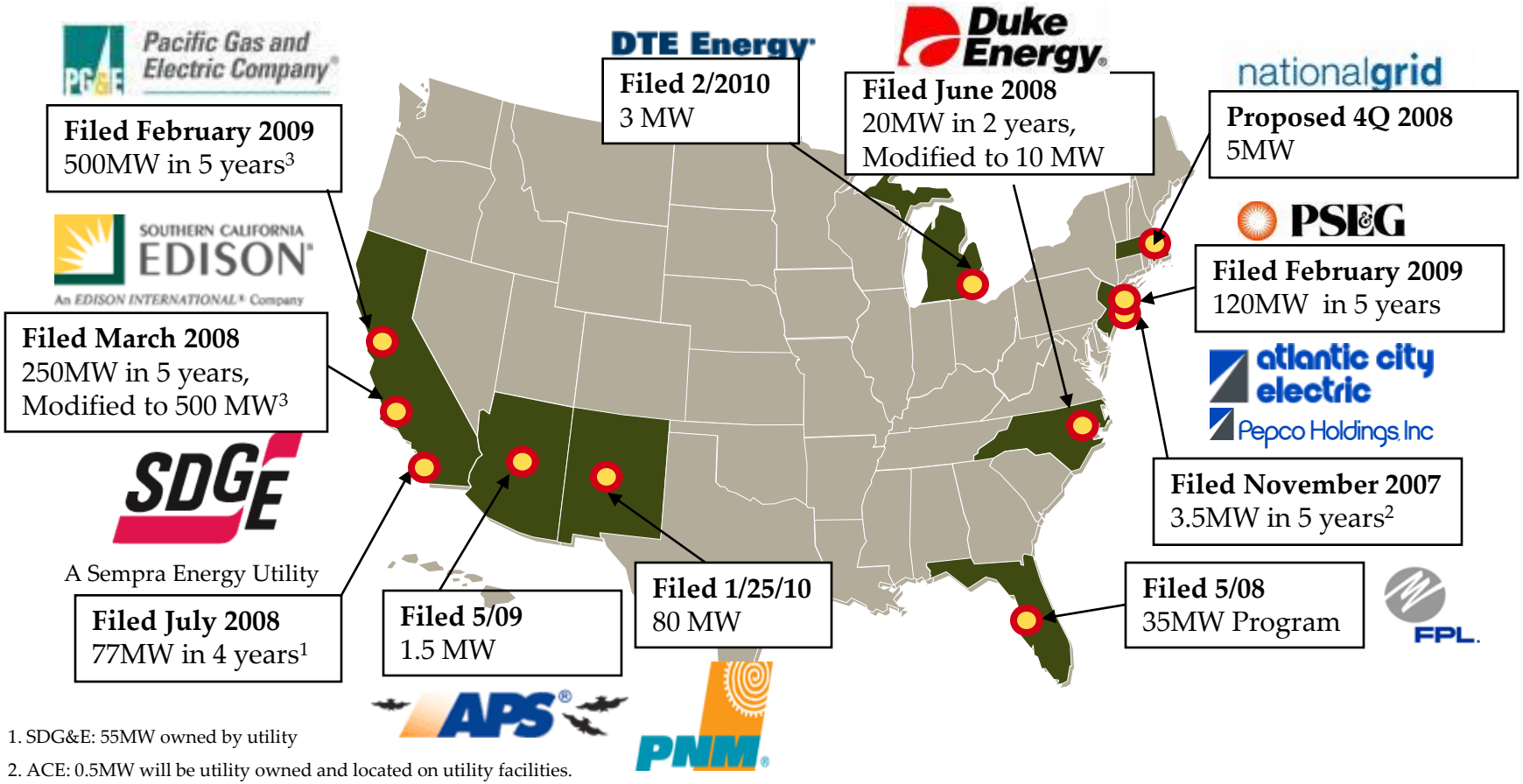
In addition to state driven programs, many utilities are filing to own solar assets.

Utility Programs for Distributed PV: Examples of Filings for Rate Basing



1. SDG&E: 55MW owned by utility
2. ACE: 0.5MW will be utility owned and located on utility facilities.
3. PG&E and SCE 50% ownership

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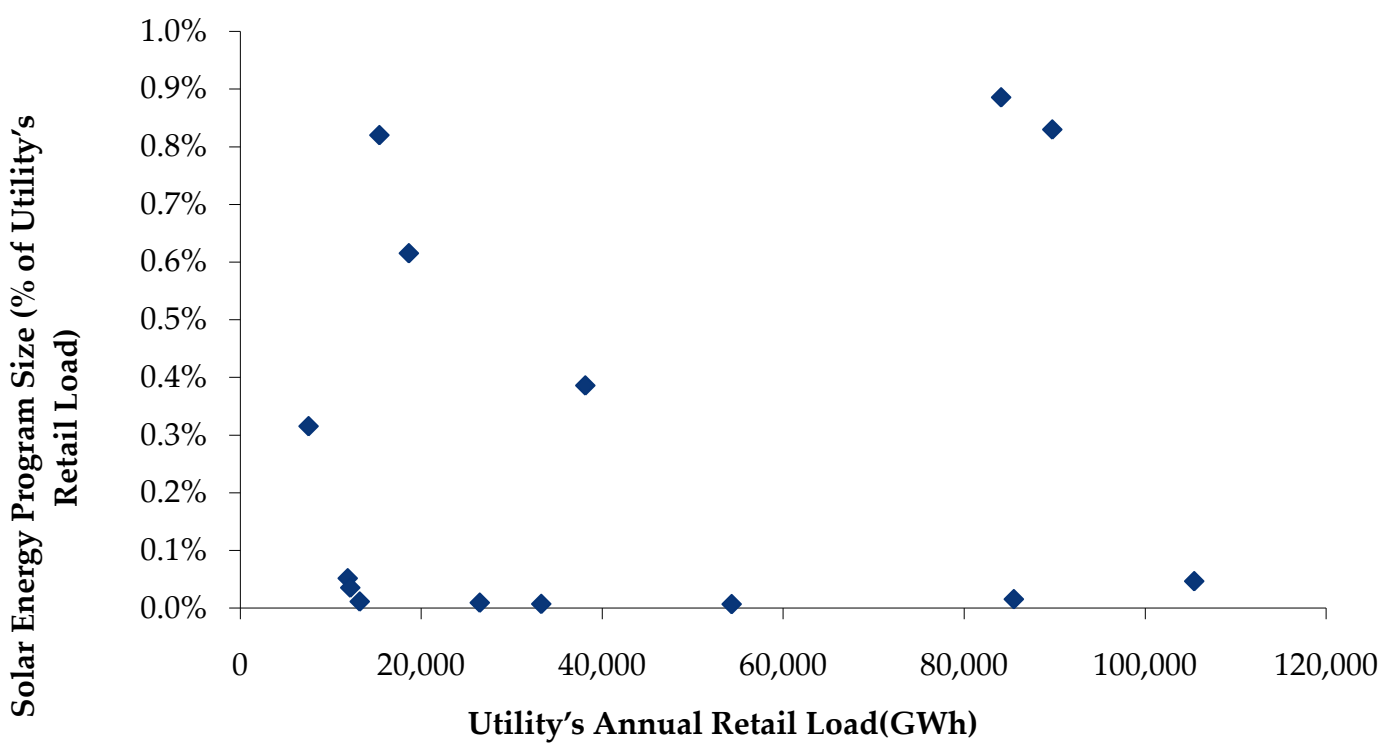
Utility solar ownership programs will amount to between 0.05% and 1% of their retail load.

Mapping of Utility Solar Ownership Programs[1]



Notes:

1. Sources: EIA, NREL's System Advisory Model available at https://www.nrel.gov/analysis/sam/

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The amount of roofspace and land available for PV development provides one upper bound on the penetration of PV in TVA's territory.

Roof-Mounted PV

- Not every square foot of rooftop is suitable for PV because of shading, orientation (e.g. north facing slope), and structural adequacy.
- In 2008, Navigant published a study for NREL investigating the actual amount of roofspace available for PV[1] on a state-by-state basis.
- Using the results of this study, Navigant estimates the technical potential (defined as the physical ability to install PV, independent of economics) at between 12 and 18 GW for residential and commercial rooftop in TVA's territory.

Ground-Mounted PV

- For ground-mounted PV, Navigant only considers certain land use types as viable for PV development:
  - Open, un-forested land not in a park, nature reserve, wetlands, etc.
  - Agricultural land not being used
  - Barren land (e.g. reclaimed mining lands)
- It was beyond the scope of this study to identify constraints on suitable locations for installation of ground-mounted PV, but high level reviews of land use patterns (from satellite photos) suggest that most of the available land in TVA's territory is forested or used for agriculture.
- There may be locations suitable for ground-mounted PV, but Navigant was not able to quantify the amount.

1. Refer to the full report (J. Paidipati, L. Frantzis, H. Sawyer, A. Kurrasch *Rooftop Photovoltaic Market Penetration Scenarios* NREL/SR-581-42306 February 2008) for more detail on the methodology used.

The variability of PV output requires dispatchable resources to firm output.

Dispatchable Resources

- Given that PV is a non-dispatchable resource and output can vary during the course of a day, dispatchable resources are needed for back-up.
- However, the required back up capacity is typically not one to one[1] for variable resources such as wind and solar power, but a full solar integration study[2] is required to appropriately assess the amount needed for TVA to integrate solar.
- Given that a full integration study is outside the scope of this project, Navigant quantified the amount of dispatchable resources available in TVA's territory from the data on slide 8:
  - Combustion Turbines: 11,641 MW
  - Storage: 1,712 MW
  - Hydro: 5,074 MW (Note: Hydro is not always dispatchable, it depends on how a utility operates its resources)
  - In addition, TVA is exploring 580 MW of new pumped storage by 2029[3].

Notes:

1. For example, the *Eastern Wind Integration and Transmission Study* conducted by Enernex Corporation for the National Renewable Energy Laboratory (available at http://www.nrel.gov/wind/systemsintegration/ewits.html) showed that 1,247 MW of wind in TVA's territory only needed between 365 and 420 MW of spinning reserves.
2. An example study was conducted by Xcel Energy for Colorado for penetration levels <10% and is available at http://www.xcelenergy.com/SiteCollectionDocuments/docs/PSCo_SolarIntegration_020909.pdf
3. http://www.tva.gov/irp/pdf/irp_complete.pdf

Upper limits of penetration depend on where PV is interconnected.

Distributed PV

- For PV installed as distributed generation, Navigant has found that penetrations, on a peak basis, of higher than 5% to 10% can impact grid operations.
- Above this level, impacts could include:
  - Adequate voltage regulation may be difficult due to changes in feeder load and power flow while PV is producing.
  - Changes in PV output can cause the power flow on distribution feeders to vary, and in some high generation/low load cases, the flow could reverse.

Central Station PV

- For PV installed on the transmission system, Navigant has found that penetrations, on a peak basis, of higher than 10% to 15% can impact grid operations.
- Above this level, impacts could include:
  - Changes to operation of base load resources if PV is high and load is low.
  - The variability of PV output due to cloud transients has been shown to create power fluctuations, and may be incompatible with the ramp rates of some central station generation.

Scenarios

- Given the uncertainty as to what level of penetration (as a % of system peak) will impact grid operation, Navigant examined three scenarios of penetration level (as a % of system peak) that impact grid operation:
  - **Lower End** – 5% for DG and 10% for Central Station
  - **Mid Range** – 7.5% for DG and 12.5% for Central Station
  - **Upper End** – 10% for DG and 15% for Central Station

Sources include: Distributed Photovoltaic Systems Design and Technology Requirements, C. Whitaker, J. Newmiller, M. Ropp, and B. Norris, February 2008; Navigant experience from similar studies; interconnection rules in other states outside TVA's territory, and U.S Department of Energy, *Solar Visions Study – Draft*, May, 2010 available at http://www1.eere.energy.gov/solar/vision_study.html

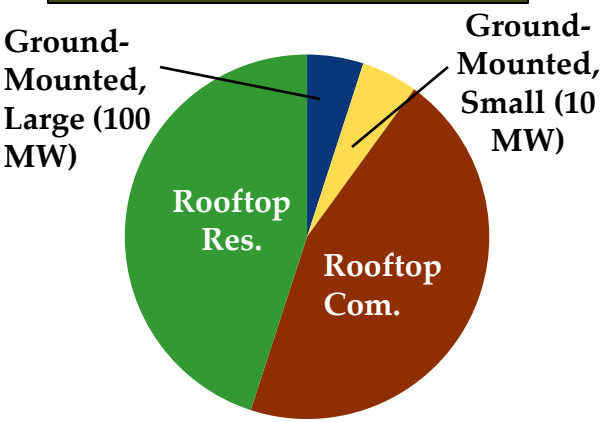
Given that system location will likely impact penetration levels, Navigant looked at different scenarios of system locations.

System Location

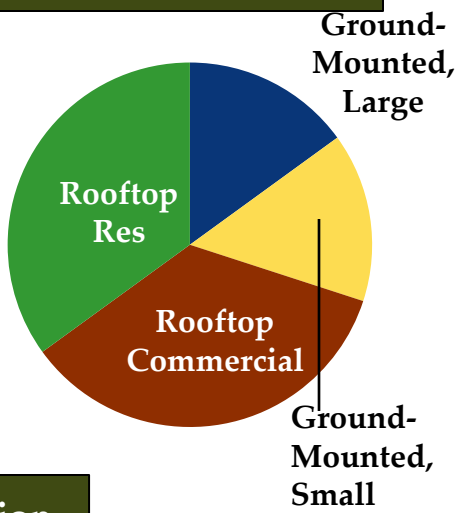
- As discussed on the proceeding slide, the point of PV interconnection would likely influence the level of penetration at which PV impacts grid operation.
- Given that an exact assessment of the technical potential of ground mounted (assumed to be primarily central station PV) has not been done for TVA's territory, Navigant analyzed 3 different levels of central station PV.

Scenarios Analyzed

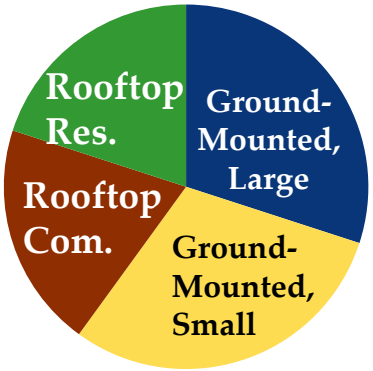
Minimal Central Station



1/3 Central Station



Majority Central Station



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Chosen penetration levels result in between ~2.2 and 5.2 GW of PV installed by 2030.

Selected Penetration Level[1,2]

- Given that two uncertainties exist in Navigant's analysis – upper limit on PV penetration that could impact grid operation and location of PV interconnection – Navigant analyzed nine different combinations of maximum penetration and system location:

Total Installations by 2030 (MW_{pDC})	Interconnection Point		
Maximum Penetration Level	Minimal Central Station	1/3 Central Station	Majority Central Station
Lower End	2,200	2,600	3,200
Mid Range	3,200	3,600	4,200
Upper End	4,200	4,600	5,200

- Navigant's rationale to support these assumptions is as follows:
  - The precedent exists – from state programs – for potential PV penetration up to 4% on an energy basis. This analysis stays below that amount with 3% penetration in the highest case.
  - The precedent also exists from utilities that currently have short term (e.g. in the next 5 years) plans to procure up to 1% solar. Given that announced plans are only in the short term, many utilities might have higher PV Penetration levels by 2030.
  - The corresponding capacities do not exceed the technical potential for rooftop PV in TVA's territory shown on slide 12.
- The cost of these penetration levels will be analyzed in the final section of this study.

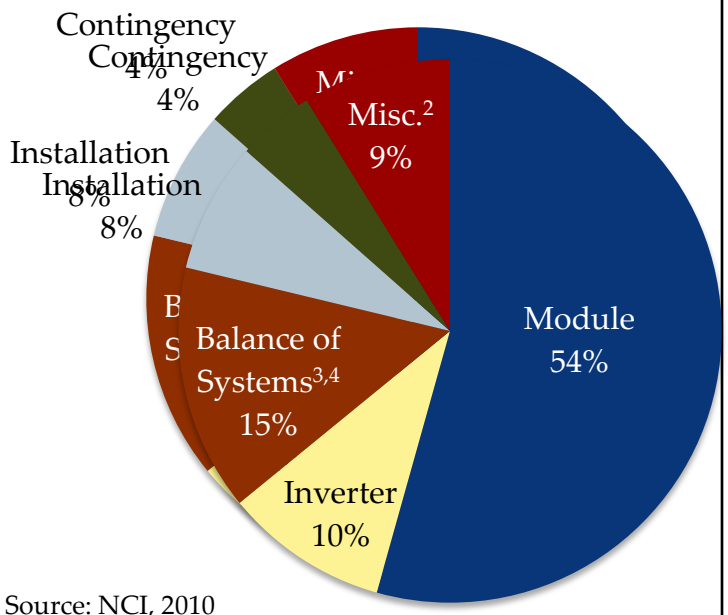
Notes:
1. This assumes a 1.4%/Year peak demand growth in load taken from TVA's Baseline Forecast in its IRP.
2. This analysis assumes a DC to AC de-rate of ~85%. The actual penetration is based upon the AC ratings of the system, which will be ~15% lower than what is shown here.

System Cost Overview

- This section reviews Navigant's calculations and analysis on current and future installed costs for PV in TVA's territory.
- The analysis is based upon Navigant's internal cost models that account for regional variations in system costs, publicly available data on system costs in TVA's territory, and interviews with installers active in TVA's territory.
- The projections to 2030 represent Navigant's best estimate for how system costs will change over time.
  - Organizations, such as the U.S. Department of Energy, have set installed cost goals that are lower than Navigant's assessments.
  - These goals assume several technological breakthroughs or significant business changes that have not occurred yet, so Navigant assumed it would be premature to take them into account.
- The following slides review Navigant's analysis for ground mounted and roof mounted PV systems.
  - Note that every PV system is different and variations in design can impact cost.
  - The estimates here are for typical systems.
  - Some actual systems might be higher or lower than the estimates shown here.

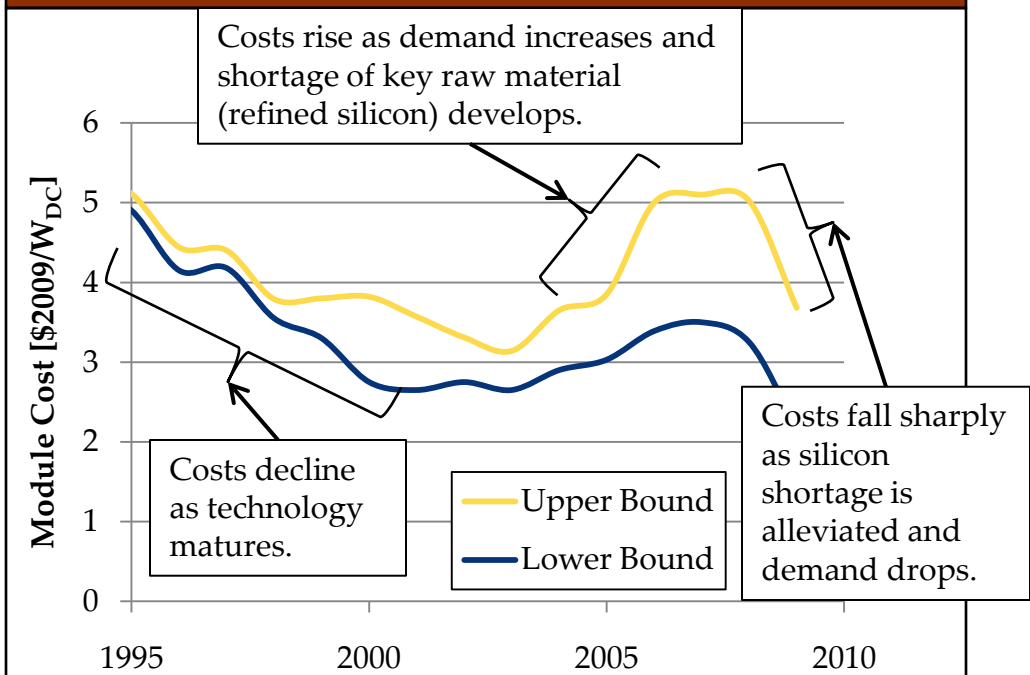
Module costs dominate installed system costs, but have historically seen the most variability in pricing.

2010 Typical Cost Breakout[1,2]



Source: NCI, 2010

Historical Module Costs ($2010/$W_{DC}$)



Source: NCI PV Services Program, 2010

Notes:

1. The data shown is for a typical ground mounted system. The relative proportions will change whether or not tracking is used and with what efficiency modules are used.
2. This pie chart does not includes costs for transmission, interconnection, or substation upgrades.
3. Miscellaneous includes permitting costs, engineering, land, application costs, etc.
4. The Balance of System component can vary depending on whether or not trackers are used
5. Balance of Systems includes: the mounting system, trackers and all electrical components (wires, combiner boxes, conduits, disconnects,…)

Ground-mounted systems can vary in design, cost, and performance.

Ground-Mounted Photovoltaics - Overview

- To capture variability in system design and pricing, Navigant picked three system designs to analyze:
  - A high efficiency system using advanced silicon cells and a single axis tracking system.
  - A high efficiency system using advanced silicon cells without use of a tracking system
  - A lower efficiency system using thin-film cells and a fixed axis tracking system.
- For each system design, two different classes of system size were analyzed:
  - Given the land use patterns in TVA's territory, Navigant assumes most systems will be smaller (~10 MW).
  - However, there might be some locations suitable for larger systems, so Navigant calculated the costs of larger systems (~100 MW). For larger systems, the per unit costs (on a $/kW basis) will likely be lower because of economies of scale (relative to a 10 MW plant) in purchasing and fixed costs being spread over a larger plant.
- Navigant also researched potential regional variations within TVA's service territory.
  - Land: Navigant found land prices can vary from $3,000/Acre to over $5,000/Acre in areas away from population centers[1].
  - Labor: Hourly wages (for plant construction) in TVA's service territory are approximately 30% lower than national U.S. average[2].
  - However, these costs are minor compared to other components, so they do not have a large impact on the overall price.
- The analysis accounted for TVA territory specific wind speed rating (90 mph) and soil conditions.
- Finally, the team benchmarked internal cost data against information from local programs like the TVA Generation Partners Program and the Solar Opportunity Fund.
- Key findings:
  - As shown on the previous slide, module prices have declined significantly in recent years.
  - Navigant expects further system cost reductions as the local and global PV industry matures and as module efficiencies increase.

Notes:
1. Navigant did not investigate areas very close to population centers because of the likely difficulty of permitting, but land costs could be significantly higher. Data taken from public land auction and realty websites.
2. Data from the R.S. Means Cost Databases.

Navigant projects that while prices may rise in the near term, prices will fall over the long term.

	Polycrystalline PV with Single Axis Tracking - Economic Assumptions for Given Year of Installation (2010$)				
	2010	2015	2020	2025	2030
Plant Nameplate Capacity (MW_{DC})[1]	10	10	10	10	10
Project Life (yrs)	25 - 30	25 - 30	25 - 30	25 - 30	25 - 30
Construction Time (yrs)[2]	1	1	1	1	1
Installed Cost ($/$kW_{DC}$)[3]	5,900	5,500	4,900	4,300	3,750
Fixed O&M ($/$kW_{DC}$-yr)	35	30	26	23	21
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0
Land Requirements (Acres/MW)	6 to 9				

Notes:
1. PV is a modular technology and ground mounted plants can range in size from 1 MW to 500 MW. Some costs scale with size and others do not. The costs presented here are valid for systems between 10 MW and 50 MW in size. Larger systems will have a lower $/kW cost.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an average.
3. This includes permitting and interest during construction, but does not include interconnection, transmission or substation upgrade costs.

Not having tracking reduces system costs.

	Polycrystalline Silicon PV w/o Tracking – Economic Assumptions for Given Year of Installation (2010$)				
	2010	**2015**	**2020**	**2025**	**2030**
Plant Nameplate Capacity (MW_{DC})[1]	10	10	10	10	10
Project Life (yrs)	25 - 30	25 - 30	25 - 30	25 - 30	25 - 30
Construction Time (yrs)[2]	1	1	1	1	1
Installed Cost ($/$kW_{DC}$)[3]	5,500	4,900	4,300	3,700	3,100
Fixed O&M ($/$kW_{DC}$-yr)	28	24	21	19	17
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0
Land Requirements (Acres/MW)	5 to 8				

Notes:
1. PV is a modular technology and ground mounted plants can range in size from 1 MW to 500 MW. Some costs scale with size and others do not. The costs presented here are valid for systems between 10 MW and 50 MW in size. Larger systems will have a lower $/kW cost.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an average.
3. This includes permitting and interest during construction, but does not include interconnection, transmission or substation upgrade costs.

As PV systems increase in size price is reduced. However, beyond a certain size, economies of scale do not allow further price reductions.

	Polycrystalline PV w/o Tracking - Economic Assumptions for Given Year of Installation (2010$)				
	2010	2015	2020	2025	2030
Plant Nameplate Capacity (MW_{DC})[1]	100	100	100	100	100
Project Life (yrs)	25 - 30	25 - 30	25 - 30	25 - 30	25 - 30
Construction Time (yrs)[2]	2-3	2-3	2-3	2-3	2-3
Installed Cost ($/$kW_{DC}$)[3]	4,800	4,400	3,800	3,400	3,100
Fixed O&M ($/$kW_{DC}$-yr)	28	24	21	19	17
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0
Land Requirements (Acres/MW)	5 to 8				

Notes:
1. PV is a modular technology and ground mounted plants can range in size from 1 MW to 500 MW. Some costs scale with size and others do not. The costs presented here are valid for systems between 100 MW and 300 MW in size.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an estimate as installers have not installed a single 100MW PV field in the US.
3. This includes permitting and interest during construction, but does not include interconnection, transmission or substation upgrade costs.

The thin film costs are lower for a 10 MW systems because of lower module costs.

	Thin-Film PV w/o Tracking - Economic Assumptions for Given Year of Installation (2010$)				
	2010	**2015**	**2020**	**2025**	**2030**
Plant Nameplate Capacity (MW_{DC})[1]	10	10	10	10	10
Project Life (yrs)	25 - 30	25 - 30	25 - 30	25 - 30	25 - 30
Construction Time (yrs)[2]	1	1	1	1	1
Installed Cost ($/$kW_{DC}$)[3]	4,800	4,400	3,800	3,400	3,100
Fixed O&M ($/$kW_{DC}$-yr)	40	34	30	27	25
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0
Land Requirements (Acres/MW)	7 to 10				

Notes:
1. PV is a modular technology and ground mounted plants can range in size from 1 MW to 500 MW. Some costs scale with size and others do not. The costs presented here are valid for systems between 10 MW and 50 MW in size. Larger systems will have a lower $/kW cost.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an average.
3. This includes permitting and interest during construction, but does not include interconnection, transmission or substation upgrade costs.

Thin film systems will likely see a slight reduction in costs with larger system sizes.

	Thin-Film PV w/o Tracking - Economic Assumptions for Given Year of Installation (2010$)				
	2010	**2015**	**2020**	**2025**	**2030**
Plant Nameplate Capacity (MW_{DC})[1]	100	100	100	100	100
Project Life (yrs)	25 - 30	25 - 30	25 - 30	25 - 30	25 - 30
Construction Time (yrs)[2]	2-3	2-3	2-3	2-3	2-3
Installed Cost ($/$kW_{DC}$)[3]	4,700	4,300	3,700	3,300	3,000
Fixed O&M ($/$kW_{DC}$-yr)	40	34	30	27	25
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0
Land Requirements (Acres/MW)	7 to 10				

Notes:
1. PV is a modular technology and ground mounted plants can range in size from 1 MW to 500 MW. Some costs scale with size and others do not. The costs presented here are valid for systems between 100 MW and 300 MW in size.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an estimate as installers have not installed a single 100MW PV field.
3. This includes permitting and interest during construction, but does not include interconnection, transmission or substation upgrade costs.

Rooftop system prices have declined in recent years.

Rooftop Photovoltaics - Methodology

- A variety of module technologies may be used in Tennessee for rooftop systems, but Navigant used polycrystalline silicon for this analysis to provide average cost and performance data.
- Methodology:
  - Navigant started with internal market data and internal PV system cost model.
  - Navigant benchmarked internal cost data against information form local programs like the TVA Generation Partners Program and the Solar Opportunity Fund.
  - Next, Navigant updated module prices with the data shown in the ground mounted section.
  - Navigant also researched potential labor costs[1].
  - Labor costs are also effected by the maturity of local market and the experience of local installers.
- Navigant accounted for Tennessee-specific requirements for wind speed rating (90 mph).
- Key findings:
  - As discussed in the ground mounted section, module prices have declined significantly since 2008, leading to overall lower system costs.
  - Labor maturity impacts system prices. Due to the relatively small size of the market, installation prices are still higher than more mature markets. However, local incentive programs are over subscribed and even had to turn applications down and revise incentive criteria. This high growth will drive the market and reduce installation price.

Notes:
1. Data from the R.S. Means Cost Databases.

Commercial rooftop system prices will likely fall as the PV industry matures and efficiency increases.

	Polycrystalline PV - Economic Assumptions for Given Year of Installation (2010$)				
	2010	**2015**	**2020**	**2025**	**2030**
Plant Nameplate Capacity (MW_{DC})[1]	0.200	0.200	0.200	0.200	0.200
Project Life (yrs)	25	25	25	25	25
Construction Time (yrs)[2]	0.2-0.3	0.2-0.3	0.2-0.3	0.2-0.3	0.2-0.3
Installed Cost ($/$kW_{DC}$)[3]	5,600	5,000	4,350	3,700	3,100
Fixed O&M ($/$kW_{DC}$-yr)	28	24	21	19	18
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0

Notes:
1. PV is a modular technology, typical commercial rooftop systems can range in size from 10 kW to 2 MW. Navigant picked an average system size.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an average.
3. This does not include potential increases in property taxes.

Residential systems required more overhead per system than commercial systems and have higher per unit costs.

	Polycrystalline PV - Economic Assumptions for Given Year of Installation (2010$)				
	2010	**2015**	**2020**	**2025**	**2030**
Plant Nameplate Capacity (MW_{DC})[1]	0.005	0.005	0.005	0.005	0.005
Project Life (yrs)	25	25	25	25	25
Construction Time (yrs)[2]	0.02 – 0.03	0.02 – 0.03	0.02 – 0.03	0.02 – 0.03	0.02 – 0.03
Installed Cost ($/$kW_{DC}$)[3]	7,100	6,400	5,700	5,100	4,400
Fixed O&M ($/$kW_{DC}$-yr)[4]	28	24	21	19	18
Non-Fuel Variable O&M ($/MWh)	0	0	0	0	0
Fuel/Energy Cost ($/MWh)	0	0	0	0	0

Notes:
1. PV is a modular technology, typical residential rooftop systems can range in size from 1 kW to 10 kw. Navigant picked an average system size.
2. Installing companies have some level in flexibility in installation time because they can just use more people to install faster. This estimate represents an average.
3. This does not include potential increases in property taxes.

Installing PV requires other costs – some are up front and others are on-going.

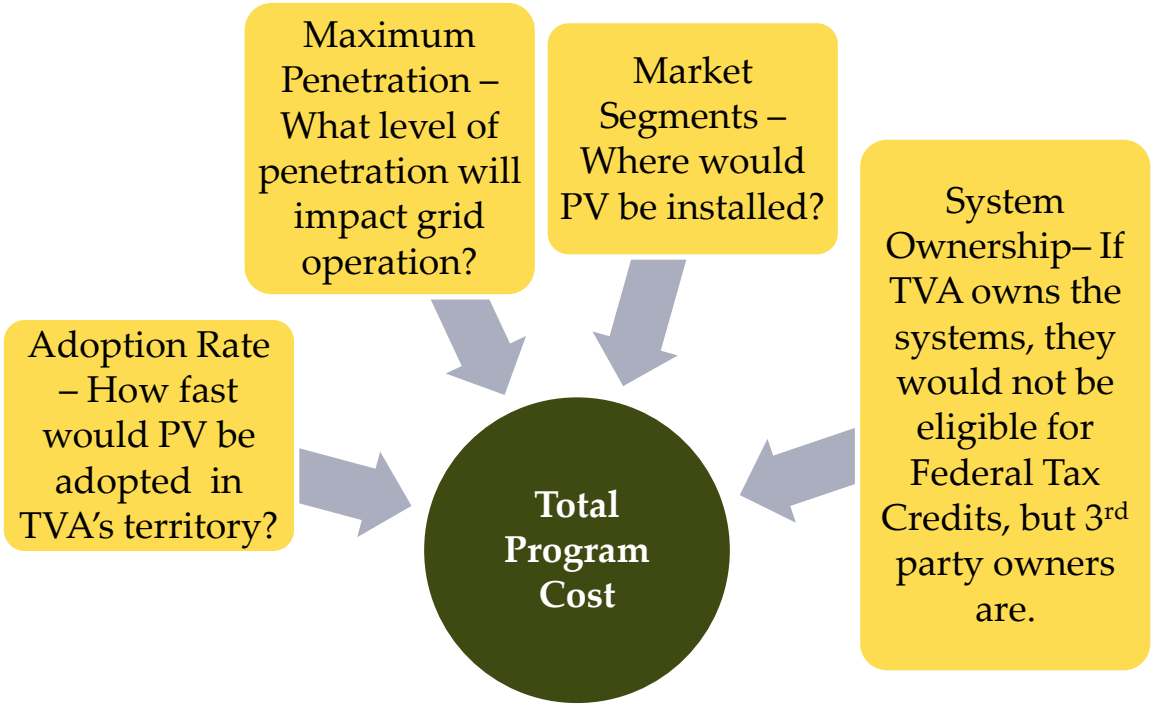
Cost	Definition	Typical Values	Discussion
Insurance	Property Insurance	0.5% to 2% of system value	This will vary by state and system type.
Property Tax	Increase in property tax for rooftop systems or annual property tax paid for ground mounted systems	1% to 2%	Property tax amount will vary significantly throughout TVA's territory
Transmission	New transmission that might need to be build to support ground mounted systems	$500,000/Mile to $2,000,000/Mile	The amount of transmission required will vary depending on where and how many ground mounted systems are installed.
Substation Upgrades	Potentially required to connect ground mounted systems at substations	Highly Variable	If a substation has access capacity, upgrades will not be required. However, if upgrades are required, the cost will depend on age of the substation, amount of upgrade required, etc.
Integration Costs	Additional ancillary service costs to manage variable PV resources	Unknown for TVA	The only public solar integration study[1] showed costs ranging from $1.96 to 5.15/MWh as solar penetration increased to 10%.

Notes:
1. Available at http://www.xcelenergy.com/SiteCollectionDocuments/docs/PSCo_SolarIntegration_020909.pdf

The total program costs will depend on several variables.

Overview

- The objective of this section is to calculate the total costs over 20 years of achieving the three chosen levels of PV penetration.
- Several variables, such as ramp rate, market segmentation, maximum penetration and system ownership will influence the eventual overall cost of the program.
- Given the number and possible level of variables, Navigant ran all possible scenarios to calculate the range of possible costs.

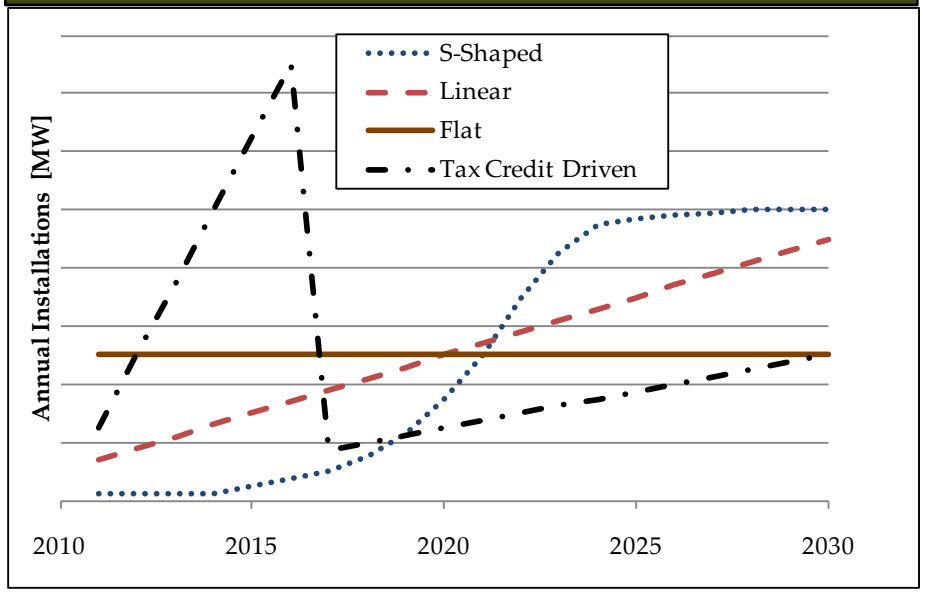


How fast systems are adopted will impact overall program costs.

Adoption Rates

- Given the dynamic situation with the costs of adopting PV– costs are expected to fall going forward, but the Federal Investment Tax Credit is expiring at the end of 2016 – when systems are installed will impact the total program cost out to 2030.
- Navigant analyzed four adoption rate scenarios:
  - S-Shaped: This is a typical trend experienced when a new product is introduced into the residential and commercial markets.
  - Linear: This would be experienced if TVA started a program that linearly increased over time or if consumers gradually adopted PV
  - Flat: This could be experienced if TVA started a regular annual procurement of new PV systems.
  - Tax Credit Driven: This scenario could occur if residential and commercial customers purposely install systems in the near-term specifically take advantage of the expiring Tax Credit.

Possible Adoption Rates



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TVA is not eligible for the Federal 30% Investment Tax Credit and TVA ownership would result in higher program costs.

System Ownership
• TVA has no Federal tax liability, so it cannot claim the Federal Investment Tax Credit (ITC)[1]. • Residential or commercial customers that would own a system or 3rd party Independent Power Producers that would own a system and sell power to TVA can take the ITC. • To look at the impact of the ITC impact, Navigant analyzed three system ownership scenarios, taking into account TVA's total debt limit of $30 Billion: — TVA owns 10% of the systems — TVA owns 20% of the systems — TVA owns 30% of the systems

Notes:
1. Note that TVA ownership has other advantages, such as lower cost of capital, but looking at cost of capital is outside the scope of this project.

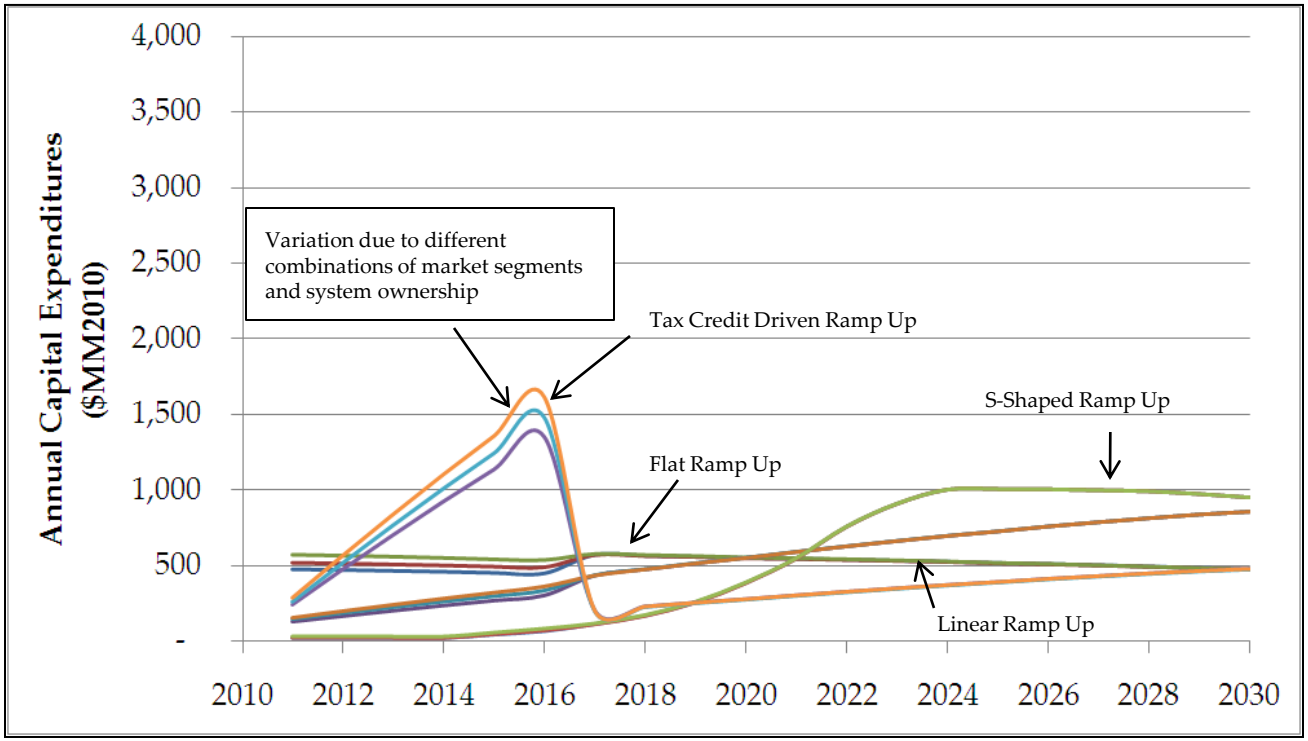
Navigant calculated the up-front and on-going costs of each combination of variables.

Calculation of Total Costs

- Navigant calculated the up-front and on-going costs of each combination of variables.
- This resulted in 108 different cost scenarios.
- For brevity, this report will show the range of costs for three different combinations of maximum penetration and interconnection point, highlighted below.

Maximum Penetration Level	Minimal Central Station	1/3 Central Station	Majority Central Station
Lower End	2,200	2,600	3,200
Mid Range	3,200	3,600	4,200
Upper End	4,200	4,600	5,200
	Case A	Case B	Case C

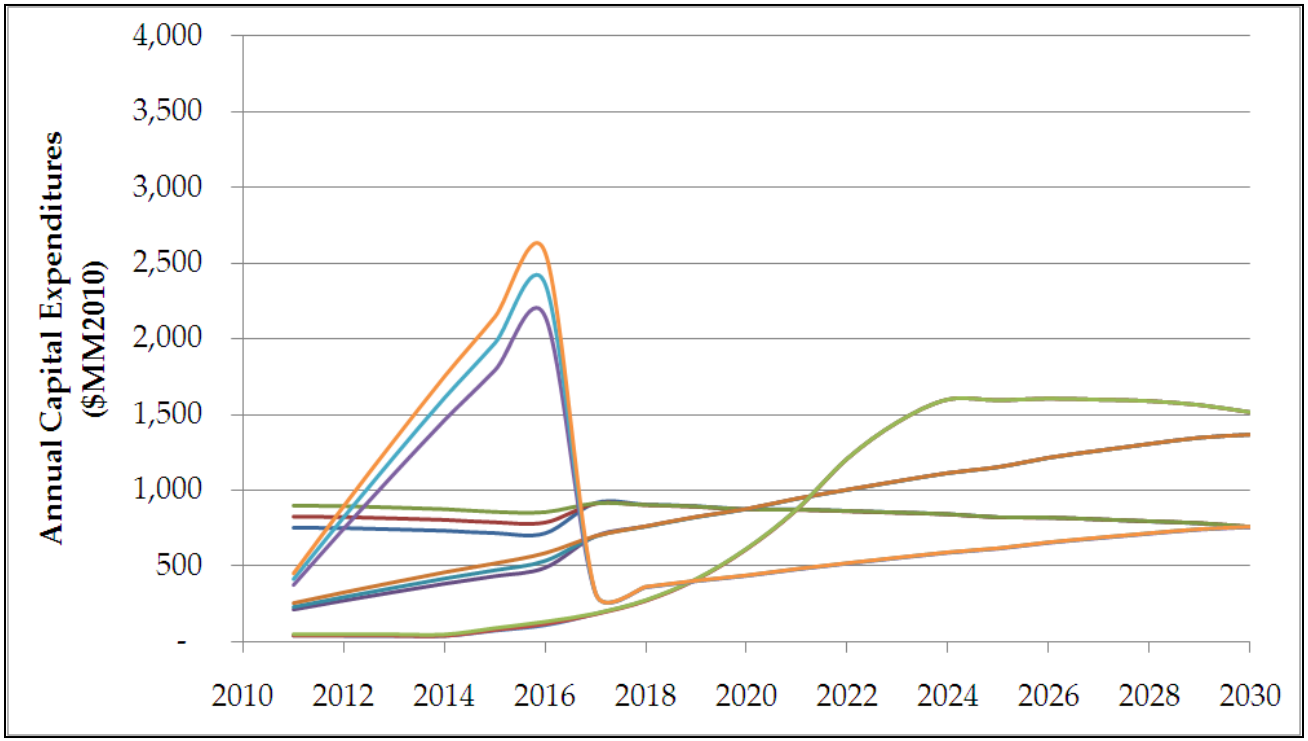
Case A would require between $9,700 and $12,300 Million in capital expenditures.



Summary Data – Case A[1]	
Item	**Value**
Total MW Installed (MW_{pDC})	2,200
Total Capital Expenditures[2] ($MM2010)	9,700 to 12,300
Total Operating Expenditures[3] ($MM2010)	1,200 to 2,500
Operating Expenditures in 2018 ($MM2010)	10 to 120

Notes:
1. This includes capital costs (including equipment, installation, permitting, and development fees), It does not include transmission, or substation costs.
2. This includes operation & maintenance costs, insurance costs, and property taxes. It does not include potential integration costs.
3. Note that this is in 2010 dollars and does not account for inflation or the time value of money.

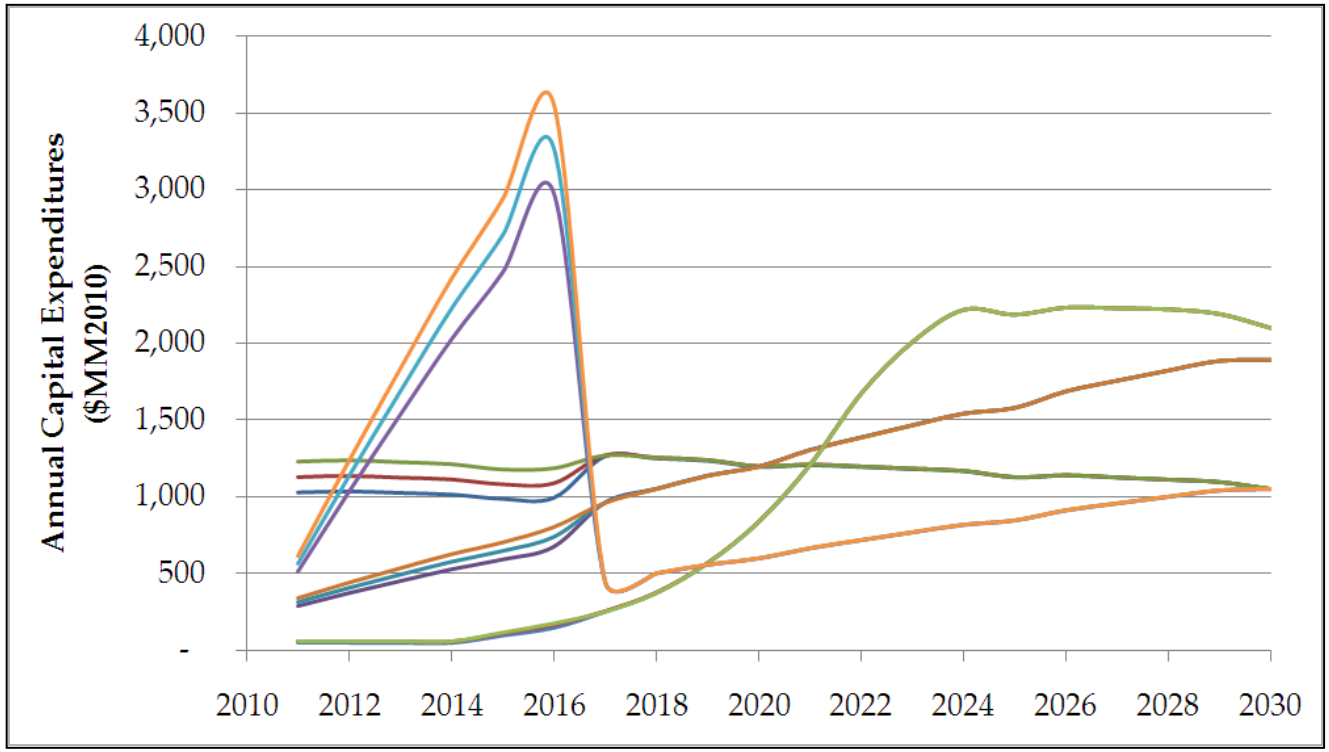
Case B would require between $15,500 and $17,400 Million in capital expenditures.



Summary Data – Case B[1]	
Item	**Value**
Total MW Installed (MW_{pDC})	3,600
Total Capital Expenditures[2] ($MM2010)	15,500 to 17,400
Total Operating Expenditures[3] ($MM2010)	1,900 to 4,000
Operating Expenditures in 2018 ($MM2010)	16 to 195

Notes:
1. This includes capital costs (including equipment, installation, permitting, and development fees), It does not include transmission, or substation costs.
2. This includes operation & maintenance costs, insurance costs, and property taxes. It does not include potential integration costs.
3. Note that this is in 2010 dollars and does not account for inflation or the time value of money.

Case C would require between $21,400 and $24,100 Million in capital expenditures.



Summary Data – Case C[1]	
Item	**Value**
Total MW Installed (MW_{pDC})	5,200
Total Capital Expenditures[2] ($MM2010)	21,400 to 24,100
Total Operating Expenditures[3] ($MM2010)	2,700 to 5,600
Operating Expenditures in 2018 ($MM2010)	22 to 272

Notes:
1. This includes capital costs (including equipment, installation, permitting, and development fees), It does not include transmission, or substation costs.
2. This includes operation & maintenance costs, insurance costs, and property taxes. It does not include potential integration costs.
3. Note that this is in 2010 dollars and does not account for inflation or the time value of money.

Navigant's analysis found that delaying installations would likely result in overall lower capital costs.

Impact of Each Variable
• Increasing the PV penetration level increases costs. • The higher the proportion of ground mounted systems, the lower overall program costs (on a real basis) are. — Using Case A (Lower End of Penetration) as an example, getting to 2,200 MW with a majority of ground mounted systems (~60%) would cost between $8,700 and $11,000 Million, or ~10% lower than getting to 2,200 MW with mostly rooftop systems. • The adoption rate had up to a 6% impact in overall program costs (on a real basis) — The S-Shaped and Tax Credit Driven adoption rates resulted in ~6% lower capital costs than the Linear rate. — The Flat adoption rate was 4% lower the Linear rate. • Because TVA can not take the ITC, their capital costs will likely be higher. As a result, the lower TVA's ownership, the lower overall capital costs were. • In summary, a program that was predominantly ground mounted and had mostly 3rd party ownership would likely result in the lowest capital costs. Adoption rate would impacts costs, but to a lesser degree.

Conclusions

- Navigant's has found that between 5% and 15% penetration of PV (on a peak basis) will not likely impact grid operation significantly and is feasible given the technical potential in TVA's territory, but the point of PV interconnection (DG vs. central station) will influence the level, with central station likely being able to handle higher penetration.
- The capital costs will range from $9,700 Million to 24,100 Million (in 2010 dollars) depending on penetration level.
- Given the various dynamics in the PV industry (e.g. federal tax credits, different costs by market segment, etc.), Navigant's analysis found that a program that was predominantly ground mounted and had mostly 3rd party ownership would likely result in the lowest capital costs.

Next Steps

- Navigant's recommended next steps in analyzing PV in TVA's territory would be:
  - Assess the benefits (e.g. avoided costs, potential capacity contribution, employment impacts, etc.) of installing PV in TVA's territory.
  - Conduct a GIS analysis to identify candidate sites for ground mounted systems. Such an analysis was outside of Navigant's scope of work, so Navigant could not develop definitive assumptions on installations by market segment.
  - After this, conduct load flow studies to understand if new or upgraded transmission would be required. Navigant was not able to estimate these costs.
  - Conduct a solar integration study to calculate expected integration costs.

Key Contacts

Lisa Frantzis, Managing Director-in-Charge
Managing Director
Burlington, MA
(781) 270-8314
lfrantzis@navigantconsulting.com

Jay Paidipati, Project Manger
Associate Director
San Francisco, CA
(415) 399-2191
jpaidipati@navigantconsulting.com

Shalom Goffri
Managing Consultant
Burlington, MA
(781) 270-8374
Shalom.Goffri@navigantconsulting.com

Maria Duaime
Consultant
Burlington, MA
(781) 270-8355
Maria.Duaime@navigantconsulting.com

Tucker Moffat
Consultant
Burlington, MA
(781) 270-8367
Tucker.Moffat@navigantconsulting.com

NAVIGANT CONSULTING

Woody Biomass Supply and Forest Resource Issues

Prepared by
Ruth Cardinal Seawell RF/ACF
Vice-President
Larson and McGowin Forestry Consultants, Inc.

Southern Alliance for Clean Energy
TVA Integrated Resource Plan – Stakeholder Review
Woody Biomass Supply

Overview of Project

- Contracted by Southern Alliance for Clean Energy (SACE) to review TVA IRP in regard to woody biomass supply and provide additional supply data.
- **Documents Reviewed**
  - Integrated Resource Plan – TVA's Environmental & Energy Future Draft 1 September 2010 (TVA-IRP)
  - Integrated Resource Plan TVA's Environmental & Energy Future Environmental Impact Statement Draft 1 September 2010 (TVA-EIS)
- **L&M Estimated Woody Biomass Inventory and Supply for Micro Supply Regions for Selected TVA co-fire plants**
  - Mill locations provided by SACE
  - 50 mile procurement radius established using ESRI ArcInfo
  - Data Source – USFS FIA Database Version 4.0 and Various FIA Annual Surveys
    - USFS dry weight of individual tree components using component ratio method
    - Excludes all public lands and stands older than 80 years
    - Derived from FIA Survey Unit Level Inventories
- **L&M Estimated Urban Waste Wood Supply**
  - Geospatial analysis cities in TVA supply area for potential supply

November 1, 2010

L&M Estimated Woody Biomass Inventory
Data Source

- Excludes mill residues because markets already exist for this resource.
- Includes Logging Residues and Small Size Roundwood Inventory
  - Derived from USFS FIA NIMS data which reflects average age of 2005
  - Reported in Dry Tons based USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB-Database Description and Users Manual
  - Biomass Supply Buckets based on current timber market specifications
  - Excludes public lands and stands over 80 years

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Woody Biomass Supply

L&M Estimated Woody Biomass Supply
Biomass Database Fields/Calculations

Database Fields - Acres and Dry Tons
- Management Type – Planted Pine, Natural Pine, Pine/Hardwood, Upland Hardwood, Bottomland Hardwood
- Age Class – Five Year
- Damaged Class – 1 – Significant 25% trees affected 0 – No Significance
- Diameter class – Tons only

Database Volume Calculations
- **Mervolsum**-sum of net merchantable volume in cubic feet (1 foot stump to 4 inch top bole diameter). This is the traditional FIA volume variable.
- **Sawcfsum**-sum of net volume of saw-log section in cubic feet. This is a subset of Mervolsum. Only populated for growing stock trees of sawtimber size.
- **Bolewtsum**-sum of dry weight of the merchantable bole in tons.
- **Sawwtsum-**sum of dry weight of the saw-log section in tons.
- **Upstemwtsum**-sum of dry weight (tons) in the upper stem (saw-log top to 4.0 inch bole diameter) of sawtimber trees.
- **Stumpwtsum**-sum of dry weight (tons) in the stump (ground level to 1.0 foot above ground) of trees 5.0 inches d.b.h. and larger.
- **Topwtsum**--sum of dry weight (tons) in the top of trees 5.0 inches d.b.h. and larger. Includes bole from 4.0 inch top diameter to tip and all branches. Does not include foliage.
- **Sapwtsum**--sum of dry weight (tons) of trees 1.0--4.9 inches d.b.h.
- **Understory**- dry weight (tons) of understory components (seedlings, shrubs, brush) above ground. Derived from Carbon_understory_AG variable

L&M Estimated Woody Biomass Supply

Biomass Supply Buckets

Tree and Stand Components

- **Slash & Brush -** Under utilized and Non-Commercial species
- **Logging Residue** - Tops, Branches, Stumps and Unused bole of merchantable trees, Saplings – total tree weight
- **Pulpwood Tree Volume** – The portion of live trees 5.0 inches DBH and above not allocated to sawlog section of the tree
- **Small Sawtimber Tree Volume** – The sawlog section of live trees 10-12 DBH only
- **Salvage from Fire, Insect & Disease** - All tree volume associated with damaged stands
- **Pre-Merchantable** – Stands 0-10 Years
- **Merchantable** – Stands >10 Years

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Woody Biomass Supply

L&M Estimated Urban Wood Waste

Assumptions

- 2007 Census Population
- Urban Wood Waste = Large Diameter Wood Generated by Tree Servicing Companies
- Availability Factor – 60% Source Carter etal. 2007
- Yield - .203 Green Tons/Capita/Year – Source Wiltsee 1998
- Dry Tons = .5*Green Tons
- All Cities within Procurement Radius

Results for Total Supply for TVA Coal Plants

- Large Cities >90,000 population – 118,150 Dry Tons
- Medium Cities 25,000<>90,000 population – 40,192 Dry Tons
- Small Cities <25,000 population – 127,011 Dry Tons

L&M Estimation of Annual Biomass Supply

- Biomass inventory restricted for utilization constraints and possible environmental considerations
- Annual growth and removal projections for pulpwood and sawtimber derived from 2010 SOFAC SRTS (Subregional Timber Supply Model) Southwide V23 Demand Run
- Projections represent historical timber removals and growth including land use changes
- Derived annual % growth of inventory and % removal inventory for pulpwood and sawtimber
- % Growth minus % Removal = Estimated available annual supply %

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TVA Integrated Resource Plan – Stakeholder Review
Woody Biomass Supply

L&M Analysis of Annual Biomass Supply by TVA Coal Plant 50 Mile Procurement

- Compared estimated annual demand for 50 MW Co-Fire plant to each 50 mile procurement radius
- Considering only the traditional biomass supply buckets (damage volume, slash & brush and logging residuals), six procurement areas have greater Annual Biomass Supply than Annual Biomass Demand
  - Shawnee
  - John Sevier
  - Paradise
  - Willows Creek
  - Cumberland
  - Gallatin
- Note Annual Biomass Supply estimates do not reflect cost feasibility, only supply
- Also, Annual Biomass Supply estimates do not reflect any management options for increasing future supply in roundwood supply buckets

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TVA Integrated Resource Plan- Stakeholder Review

Estimated Total Woody Biomass Inventory (Dry Tons) Within 50 Mile Procurement Radius - Overlapping

Total Dry Tons - Detail and Summary (1) (2)

Supply Bucket	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (7) (8 & 9)	80,930,487	7,771,246	1,527,029	9,720,445	5,778,625	6,035,583	6,114,511	3,369,551	10,686,068	6,987,238	3,302,632	11,421,617
Slash & Brush (3) (8) (9)	67,860,213	1,742,658	2,273,513	4,640,864	6,167,437	4,165,627	5,455,270	5,933,360	4,944,144	5,719,087	4,798,378	5,293,555
Tops, Limbs, Stumps Merchantable (4) (9)	350,697,072	9,818,348	11,244,859	29,655,000	35,592,881	24,923,669	29,567,209	27,874,112	30,419,373	33,572,110	29,368,206	32,377,821
Tops, Limbs, Stumps Pre-merchantable (4) (8)	19,026,890	88,256	648,007	872,464	1,274,101	136,914	1,678,051	2,067,357	1,121,524	832,344	248,069	1,178,761
Pulpwood from Premerchantable Stands (5) (8)	12,311,200	59,391	478,538	618,401	724,541	105,963	1,074,656	1,346,037	741,042	479,005	167,674	748,995
Pulpwood Inventory from Merchantable Stands (5) (9)	393,919,992	11,339,830	12,221,083	33,054,480	41,196,770	28,186,171	33,456,609	30,889,301	34,226,898	39,045,179	35,177,350	36,785,236
Small Sawtimber Inventory (6) (8 & 9)	461,228,907	13,236,472	15,620,241	43,774,818	46,118,007	33,590,200	39,365,109	35,209,537	44,308,278	43,162,312	36,607,305	46,746,925
Total	1,385,974,762	44,056,201	44,013,270	122,336,471	136,852,362	97,144,127	116,711,415	106,689,256	126,447,328	129,797,275	109,669,615	134,552,910

Larson&McGowin INC
FOREST MANAGERS & CONSULTANTS

Prepared November 1, 2010

Southern Alliance for Clean Energy (SACE)
TVA Integrated Resource Plan- Stakeholder Review

Estimated Woody Biomass Dry Tons Inventory Within 50 Mile Procurement Radius - Not Overlapping

Total Dry Tons - Detail and Summary (1) (2)

Supply Bucket	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (7) (8 & 9)	80,930,487	8,393,720	1,527,029	8,705,063	2,869,004	5,865,452	6,114,511	3,086,398	5,801,274	3,640,922	2,173,366	7,838,735
Slash & Brush (3) (8) (9)	67,860,213	1,633,414	2,273,513	4,042,377	4,476,328	4,049,009	5,455,270	5,649,354	2,656,574	2,504,219	4,093,532	3,697,175
Tops, Limbs, Stumps Merchantable (4) (9)	350,697,072	9,273,434	11,244,859	25,754,988	25,425,244	24,152,894	29,567,209	26,637,782	16,301,178	14,975,307	25,172,120	22,408,265
Tops, Limbs, Stumps Pre-merchantable (4) (8)	19,026,890	24,139	648,007	807,049	1,146,035	130,264	1,678,051	1,960,881	604,670	248,628	197,258	826,102
Pulpwood from Premerchantable Stands (5) (8)	12,311,200	18,496	478,538	569,285	651,745	105,469	1,074,656	1,309,819	402,747	141,515	135,398	508,962
Pulpwood Inventory from Merchantable Stands (5) (9)	393,919,992	10,692,118	12,221,083	28,793,032	29,133,634	27,195,017	33,456,609	29,477,397	18,285,310	17,637,673	30,427,811	25,620,779
Small Sawtimber Inventory (6) (8 & 9)	461,228,907	12,395,731	15,620,241	38,121,359	33,528,600	32,882,521	39,365,109	33,625,835	23,747,170	18,754,698	30,857,308	32,021,553
Total	1,385,974,762	42,431,053	44,013,270	106,793,153	97,230,592	94,380,627	116,711,415	101,747,468	67,798,923	57,902,961	93,056,793	92,921,571

Based on the following customized query of FIA Database March 2010

(1) USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB - FIA Database description and Users Manual for Phase 2, Version 4.0, revision 2, December 2009, Utilizes a compiled set of specie and bark specific gravities to adjust green weight volumes. For smaller trees (saplings and woodland species), only a total biomass value representing wood and bark from ground to tip excluding foliage is available.

(2) Exclude all public lands and timber acres older than 80 years

(3) Understory_bio_sum--estimated biomass (in Tons) of understory components (seedlings, shrubs, brush) aboveground. Derived from Carbon_understory_AG variable, which is in tons/acre in Condition table of FIADB 4.0. This variable is estimated from models based on region, forest type and live tree carbon density (Smith and Health 2008). Understory biomass values at the population level were computed as follows:
Understory_bio = Carbon_understory_AG * 2 * Condition Acres

(4) Logging Residue - Tops, Branches and Unused bole of merchantable trees based on following formulas
Upstemwtsum-sum of dry weight (tons) in the upper stem (saw-log top to 4.0 inch bole diameter) of sawtimber trees.
Stumpwtsum-sum of dry weight (tons) in the stump (ground level to 1.0 foot above ground) of trees 5.0 inches d.b.h. and larger.
Topwtsum--sum of dry weight (tons) in the top of trees 5.0 inches d.b.h. and larger. Includes bole from 4.0 inch top diameter to tip and all branches. Does not include foliage.

(5) Pulpwood Tree Volume - The portion of live trees 5.0 inches DBH and above not allocated to saw-log section of the tree based on following formula
Bolewtsum-sum of dry weight of the merchantable bole in tons.

(6) Small Sawtimber Tree Volume - The saw-log section of live trees < 13 DBH based on following formula
Sawwtsum-sum of dry weight of the saw-log section in tons.

(7) Salvage from Fire, Insect & Disease - All tree volume associated with damaged stands based on FIA Formulas Upstemwtsum, Stumpwtsum, Topwtsum, Bolewtsum

(8) Pre-Merchantable - Stands 0-10 Years

(9) Merchantable -Stands >10 Years and <80 years

Larson&McGowin Inc
FOREST MANAGERS & CONSULTANTS

Prepared November 1, 2010

Southern Alliance for Clean Energy (SACE)
TVA Integrated Resource Plan- Stakeholder Review

Estimated Total Woody Biomass Inventory (Dry Tons) Within 50 Mile Procurement Radius - Overlapping
Restricted for Utilization Limits and Possible Environmental Considerations

Total Dry Tons - Detail and Summary (1) (2) - Restricted for Utilization Assumptions (10)

Supply Bucket	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (7) (8 & 9)	20,232,622	1,942,811	381,757	2,430,111	1,444,656	1,508,896	1,528,628	842,388	2,671,517	1,746,809	825,658	2,855,404
Slash & Brush (3) (8) (9)	33,930,107	871,329	1,136,756	2,320,432	3,083,719	2,082,813	2,727,635	2,966,680	2,472,072	2,859,544	2,399,189	2,646,778
Tops, Limbs, Stumps Merchantable (4) (9)	210,418,243	5,891,009	6,746,915	17,793,000	21,355,729	14,954,202	17,740,325	16,724,467	18,251,624	20,143,266	17,620,923	19,426,692
Tops, Limbs, Stumps Pre-merchantable (4) (8)	11,416,134	52,954	388,804	523,478	764,461	82,148	1,006,831	1,240,414	672,915	499,406	148,841	707,256
Pulpwood from Premerchantable Stands (5) (8)	9,233,400	44,543	358,904	463,801	543,406	79,473	805,992	1,009,528	555,782	359,254	125,756	561,747
Pulpwood Inventory from Merchantable Stands (5) (9)	118,175,998	3,401,949	3,666,325	9,916,344	12,359,031	8,455,851	10,036,983	9,266,790	10,268,069	11,713,554	10,553,205	11,035,571
Small Sawtimber Inventory (6) (8 & 9)	138,368,672	3,970,942	4,686,072	13,132,445	13,835,402	10,077,060	11,809,533	10,562,861	13,292,483	12,948,694	10,982,192	14,024,077
Total	541,775,175	16,175,537	17,365,534	46,579,611	53,386,403	37,240,443	45,655,926	42,613,129	48,184,462	50,270,527	42,655,764	51,257,526

Based on the following customized query of FIA Database March 2010

(1) USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB - FIA Database description and Users Manual for Phase 2, Version 4.0, revision 2, December 2009, Utilizes a compiled set of specie and bark specific gravities to adjust green weight volumes. For smaller trees (saplings and woodland species), only a total biomass value representing wood and bark from ground to tip excluding foliage is available.

(2) Exclude all public lands and timber acres older than 80 years

(3) Understory_bio_sum--estimated biomass (in Tons) of understory components (seedlings, shrubs, brush) aboveground. Derived from Carbon_understory_AG variable, which is in tons/acre in Condition table of FIADB 4.0. This variable is estimated from models based on region, forest type and live tree carbon density (Smith and Health 2008). Understory biomass values at the population level were computed as follows: Understory_bio = Carbon_understory_AG * 2 * Condition Acres

(4) Logging Residue - Tops, Branches and Unused bole of merchantable trees based on following formulas
Upstemwtsum-sum of dry weight (tons) in the upper stem (saw-log top to 4.0 inch bole diameter) of sawtimber trees.
Stumpwtsum-sum of dry weight (tons) in the stump (ground level to 1.0 foot above ground) of trees 5.0 inches d.b.h. and larger.
Topwtsum--sum of dry weight (tons) in the top of trees 5.0 inches d.b.h. and larger. Includes bole from 4.0 inch top diameter to tip and all branches. Does not include foliage.

(5) Pulpwood Tree Volume - The portion of live trees 5.0 inches DBH and above not allocated to saw-log section of the tree based on following formula
Bolewtsum-sum of dry weight of the merchantable bole in tons.

(6) Small Sawtimber Tree Volume - The saw-log section of live trees < 13 DBH based on following formula
Sawwtsum-sum of dry weight of the saw-log section in tons.

(7) Salvage from Fire, Insect & Disease - All tree volume associated with damaged stands based on FIA Formulas Upstemwtsum, Stumpwtsum, Topwtsum, Bolewtsum

(8) Pre-Merchantable - Stands 0-10 Years

(9) Merchantable -Stands >10 Years and <80 years

(10) Utilization Rates - share of each supply bucket that might be captured or utilized based on technical constraints, source Abt/Seawell 2010 and Mulkey 2010

Larson&McGowin INC
FOREST MANAGERS & CONSULTANTS

Prepared November 1, 2010

Southern Alliance for Clean Energy (SACE)
TVA Integrated Resource Plan- Stakeholder Review

Estimated Woody Biomass Dry Tons Within 50 Mile Procurement Radius WITHOUT Overlapping Supply
Restricted for Utilization Limits and Possible Environmental Considerations

Total Dry Tons - Detail and Summary (1) (2) - Restricted for Utilization Assumptions (10)

Supply Bucket	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (7) (8 & 9)	20,232,622	2,098,430	381,757	2,176,266	717,251	1,466,363	1,528,628	771,600	1,450,318	910,231	543,342	1,959,684
Slash & Brush (3) (8) (9)	33,930,107	816,707	1,136,756	2,021,188	2,238,164	2,024,505	2,727,635	2,824,677	1,328,287	1,252,109	2,046,766	1,848,588
Tops, Limbs, Stumps Merchantable (4) (9)	210,418,243	5,564,061	6,746,915	15,452,993	15,255,147	14,491,737	17,740,325	15,982,669	9,780,707	8,985,184	15,103,272	13,444,959
Tops, Limbs, Stumps Pre-merchantable (4) (8)	11,416,134	14,484	388,804	484,230	687,621	78,159	1,006,831	1,176,529	362,802	149,177	118,355	495,661
Pulpwood from Premerchantable Stands (5) (8)	9,233,400	13,872	358,904	426,964	488,809	79,101	805,992	982,364	302,060	106,136	101,548	381,721
Pulpwood Inventory from Merchantable Stands (5) (9)	118,175,998	3,207,636	3,666,325	8,637,910	8,740,090	8,158,505	10,036,983	8,843,219	5,485,593	5,291,302	9,128,343	7,686,234
Small Sawtimber Inventory (6) (8 & 9)	138,368,672	3,718,719	4,686,072	11,436,408	10,058,580	9,864,756	11,809,533	10,087,750	7,124,151	5,626,409	9,257,193	9,606,466
Total	541,775,175	15,433,908	17,365,534	40,635,957	38,185,662	36,163,126	45,655,926	40,668,809	25,833,919	22,320,548	36,298,818	35,423,312

Based on the following customized query of FIA Database March 2010

(1) USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB - FIA Database description and Users Manual for Phase 2, Version 4.0, revision 2, December 2009, Utilizes a compiled set of specie and bark specific gravities to adjust green weight volumes. For smaller trees (saplings and woodland species), only a total biomass value representing wood and bark from ground to tip excluding foliage is available.

(2) Exclude all public lands and timber acres older than 80 years

(3) Understory_bio_sum--estimated biomass (in Tons) of understory components (seedlings, shrubs, brush) aboveground. Derived from Carbon_understory_AG variable, which is in tons/acre in Condition table of FIADB 4.0. This variable is estimated from models based on region, forest type and live tree carbon density (Smith and Health 2008). Understory biomass values at the population level were computed as follows: Understory_bio = Carbon_understory_AG * 2 * Condition Acres

(4) Logging Residue - Tops, Branches and Unused bole of merchantable trees based on following formulas
Upstemwtsum-sum of dry weight (tons) in the upper stem (saw-log top to 4.0 inch bole diameter) of sawtimber trees.
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(5) Pulpwood Tree Volume - The portion of live trees 5.0 inches DBH and above not allocated to saw-log section of the tree based on following formula
Bolewtsum-sum of dry weight of the merchantable bole in tons.

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Sawwtsum-sum of dry weight of the saw-log section in tons.

(7) Salvage from Fire, Insect & Disease - All tree volume associated with damaged stands based on FIA Formulas Upstemwtsum, Stumpwtsum, Topwtsum, Bolewtsum

(8) Pre-Merchantable - Stands 0-10 Years

(9) Merchantable -Stands >10 Years and <80 years

(10) Utilization Rates - share of each supply bucket that might be captured or utilized based on technical constraints, source Abt/Seawell 2010 and Mulkey 2010

Larson&McGowin INC
FOREST MANAGERS & CONSULTANTS

Prepared November 1, 2010

Southern Alliance for Clean Energy (SACE)
TVA Integrated Resource Plan- Stakeholder Review

Estimated Annual Woody Biomass Dry Tons Within 50 Mile Procurement Radius WITH Overlapping Supply
Based on Subregional Timber Supply Model Projections (SRTS) Surplus Growth (Growth minus Removals) by FIA Unit

Total Dry Tons - Detail and Summary (1) (2) - Restricted for Utilization Assumptions (10)

Supply Bucket	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (7) (8 & 9)	510,776	75,338	8,769	47,556	(1,957)	65,896	21,242	6,038	30,548	88,425	70,734	23,978
Slash & Brush (3) (8) (9)	856,572	33,788	26,112	45,410	(4,176)	90,960	37,904	21,265	28,267	144,753	205,538	22,226
Logging Residuals Merchantable (4) (9)	5,312,049	228,440	154,982	348,200	(28,922)	653,074	246,522	119,881	208,702	1,019,674	1,509,581	163,135
Logging Residuals Pre-merchantable (4) (8)	288,202	2,053	8,931	10,244	(1,035)	3,588	13,991	8,891	7,695	25,280	12,751	5,939
Pulpwood from Premerchantable Stands (5) (8)	233,099	1,727	8,244	9,076	(736)	3,471	11,200	7,236	6,355	18,186	10,773	4,717
Pulpwood Inventory from Merchantable Stands (5) (9)	2,983,376	131,920	84,218	194,058	(16,738)	369,281	139,475	66,425	117,412	592,953	904,091	92,671
Small Sawtimber Inventory (6) (8 & 9)	3,315,406	253,511	206,655	432,705	286,833	136,736	151,187	244,466	82,744	514,014	415,958	8,177
Est Annual Supply	13,499,481	726,777	497,911	1,087,249	233,269	1,323,005	621,520	474,203	481,724	2,403,286	3,129,426	320,843
Est Annual Demand (11)	2,557,424	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419
Demand/Supply	18.94%	38.58%	56.32%	25.79%	120.21%	21.20%	45.12%	59.13%	58.21%	11.67%	8.96%	87.40%

Based on the following customized query of FIA Database March 2010

(1) USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB - FIA Database description and Users Manual for Phase 2, Version 4.0, revision 2, December 2009, Utilizes a compiled set of specie and bark specific gravities to adjust green weight volumes. For smaller trees (saplings and woodland species), only a total biomass value representing wood and bark from ground to tip excluding foliage is available.

(2) Exclude all public lands and timber acres older than 80 years

(3) Understory_bio_sum--estimated biomass (in Tons) of understory components (seedlings, shrubs, brush) aboveground. Derived from Carbon_understory_AG variable, which is in tons/acre in Condition table of FIADB 4.0. This variable is estimated from models based on region, forest type and live tree carbon density (Smith and Health 2008). Understory biomass values at the population level were computed as follows: Understory_bio = Carbon_understory_AG * 2 * Condition Acres

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Stumpwtsum-sum of dry weight (tons) in the stump (ground level to 1.0 foot above ground) of trees 5.0 inches d.b.h. and larger.
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(5) Pulpwood Tree Volume - The portion of live trees 5.0 inches DBH and above not allocated to saw-log section of the tree based on following formula
Bolewtsum-sum of dry weight of the merchantable bole in tons.

(6) Small Sawtimber Tree Volume - The saw-log section of live trees < 13 DBH based on following formula
Sawwtsum-sum of dry weight of the saw-log section in tons.

(7) Salvage from Fire, Insect & Disease - All tree volume associated with damaged stands based on FIA Formulas Upstemwtsum, Stumpwtsum, Topwtsum, Bolewtsum

(8) Pre-Merchantable - Stands 0-10 Years

(9) Merchantable -Stands >10 Years and <80 years

(10) Utilization Rates - share of each supply bucket that can might captured or utilized based on technical constraints, source Abt/Seawell 2010 and Mulkey 2010

(11) TVA Total Future Production Projections- page 147 TVA-EIS
Single Plant - Co-Fire conversion, 50 MW, 8,600 BTU/LB Green and 13,002 BTU/Kwh
Total TVA -456 MW Total Biomass Demand, 8,600 BTU/LB and 13,002 BTU/Kwh

Larson&McGowin Inc
FOREST MANAGERS & CONSULTANTS

Southern Alliance for Clean Energy (SACE)
TVA Integrated Resource Plan- Stakeholder Review

Estimated Woody Biomass Dry Tons Within 50 Mile Procurement Radius WITHOUT Overlapping Supply
Based on Subregional Timber Supply Model Projections of Surplus Growth (Growth minus Removals) by FIA Unit

Total Dry Tons - Detail and Summary (1) (2) - Restricted for Utilization Assumptions (10)

Supply Bucket	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (7) (8 & 9)	510,776	71,801	8,275	39,461	11,214	65,894	22,153	6,333	13,771	29,722	42,387	16,349
Slash & Brush (3) (8) (9)	856,572	27,945	24,641	36,649	34,994	90,975	39,529	23,185	12,612	40,886	159,671	15,422
Logging Residuals Merchantable (4) (9)	5,312,049	190,383	146,250	280,200	238,519	651,212	257,092	131,188	92,867	293,400	1,178,228	112,167
Logging Residuals Pre-merchantable (4) (8)	288,202	496	8,428	8,780	10,751	3,512	14,591	9,657	3,445	4,871	9,233	4,135
Pulpwood from Premerchantable Stands (5) (8)	233,099	475	7,780	7,742	7,643	3,555	11,680	8,063	2,868	3,466	7,922	3,185
Pulpwood Inventory from Merchantable Stands (5) (9)	2,983,376	109,754	79,473	156,626	136,654	366,617	145,456	72,586	52,085	172,781	712,115	64,124
Small Sawtimber Inventory (6) (8 & 9)	3,315,406	219,741	201,826	372,285	286,650	171,762	162,838	241,409	54,919	182,336	309,582	43,037
Est Annual Supply	13,499,481	620,596	476,673	901,743	726,427	1,353,527	653,339	492,422	232,567	727,462	2,419,138	258,419
Est Annual Demand (11)	2,557,424	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419	280,419
Demand/Supply	18.94%	45.19%	58.83%	31.10%	38.60%	20.72%	42.92%	56.95%	120.58%	38.55%	11.59%	108.51%

Based on the following customized query of FIA Database March 2010

(1) USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB - FIA Database description and Users Manual for Phase 2, Version 4.0, revision 2, December 2009, Utilizes a compiled set of specie and bark specific gravities to adjust green weight volumes. For smaller trees (saplings and woodland species), only a total biomass value representing wood and bark from ground to tip excluding foliage is available.

(2) Exclude all public lands and timber acres older than 80 years

(3) Understory_bio_sum--estimated biomass (in Tons) of understory components (seedlings, shrubs, brush) aboveground. Derived from Carbon_understory_AG variable, which is in tons/acre in Condition table of FIADB 4.0. This variable is estimated from models based on region, forest type and live tree carbon density (Smith and Health 2008). Understory biomass values at the population level were computed as follows: Understory_bio = Carbon_understory_AG * 2 * Condition Acres

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Upstemwtsum-sum of dry weight (tons) in the upper stem (saw-log top to 4.0 inch bole diameter) of sawtimber trees.
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Topwtsum--sum of dry weight (tons) in the top of trees 5.0 inches d.b.h. and larger. Includes bole from 4.0 inch top diameter to tip and all branches. Does not include foliage.

(5) Pulpwood Tree Volume - The portion of live trees 5.0 inches DBH and above not allocated to saw-log section of the tree based on following formula
Bolewtsum-sum of dry weight of the merchantable bole in tons.

(6) Small Sawtimber Tree Volume - The saw-log section of live trees < 13 DBH based on following formula
Sawwtsum-sum of dry weight of the saw-log section in tons.

(7) Salvage from Fire, Insect & Disease - All tree volume associated with damaged stands based on FIA Formulas Upstemwtsum, Stumpwtsum, Topwtsum, Bolewtsum

(8) Pre-Merchantable - Stands 0-10 Years

(9) Merchantable -Stands >10 Years and <80 years

(10) Utilization Rates - share of each supply bucket that can might captured or utilized based on technical constraints, source Abt/Seawell 2010 and Mulkey 2010

(11) TVA Total Future Production Projections- page 147 TVA-EIS
Single Plant - Co-Fire conversion, 50 MW, 8,600 BTU/LB Green and 13,002 BTU/Kwh
Total TVA -456 MW Total Biomass Demand, 8,600 BTU/LB and 13,002 BTU/Kwh

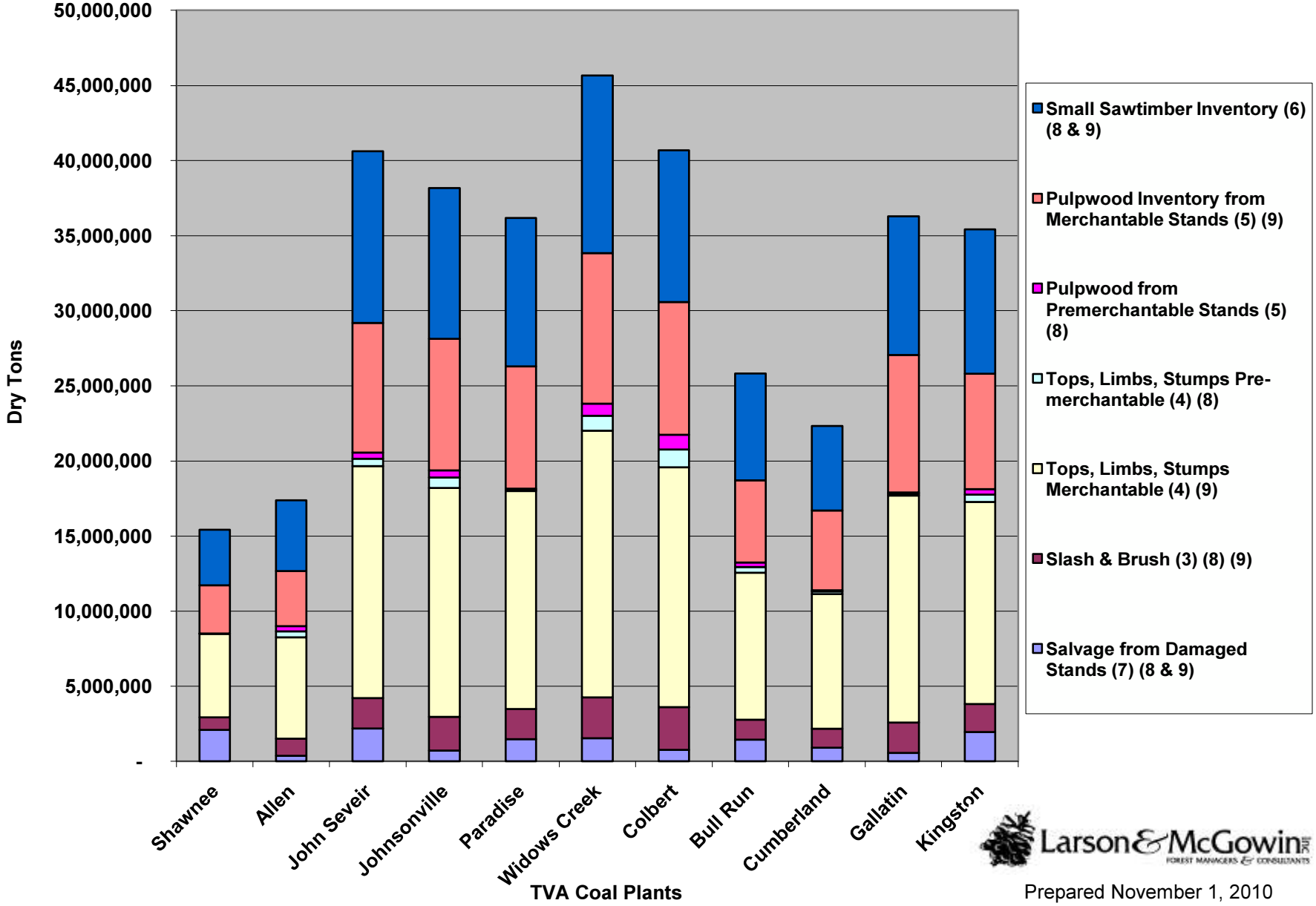
Larson&McGowin INC
FOREST MANAGERS & CONSULTANTS

Prepared November 1, 2010

Southern Alliance for Clean Energy (SACE)
TVA Integrated Resource Plan - Stakeholder Review

Estimated Total Woody Biomass Inventory for Non-Overlapping 50 mile Procurement Radius

Source - USFS FIADB Woody Biomass Database including utilization restrictions



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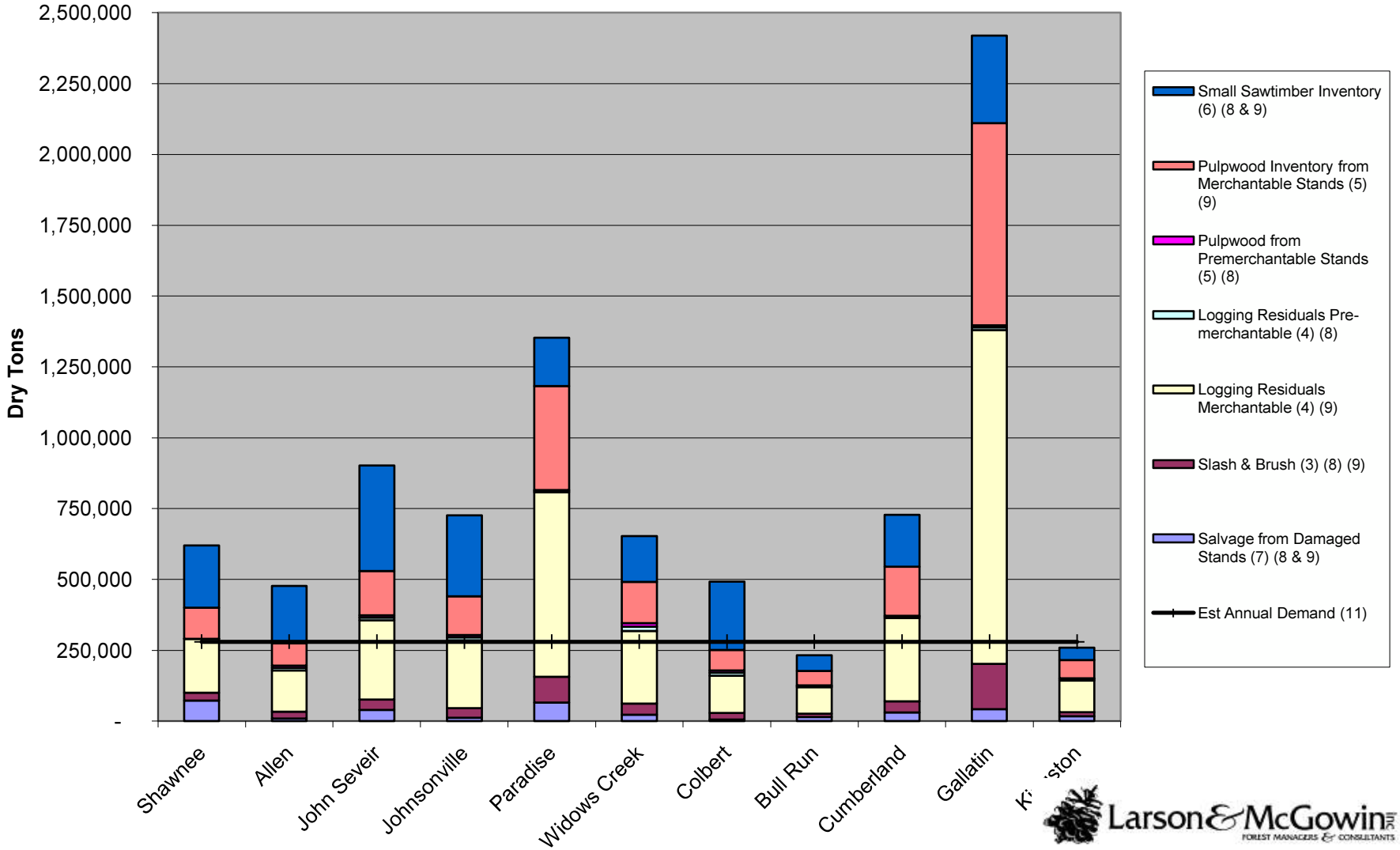
Prepared November 1, 2010

Estimated Annual Woody Biomass Supply for Non-Overlapping 50 mile Procurement Radius
Source - USFS FIADB including utilization restrictions
Based on Subregional Timber Supply Model (SRTS) Projections of Weighted Average Surplus Growth by FIA Unit



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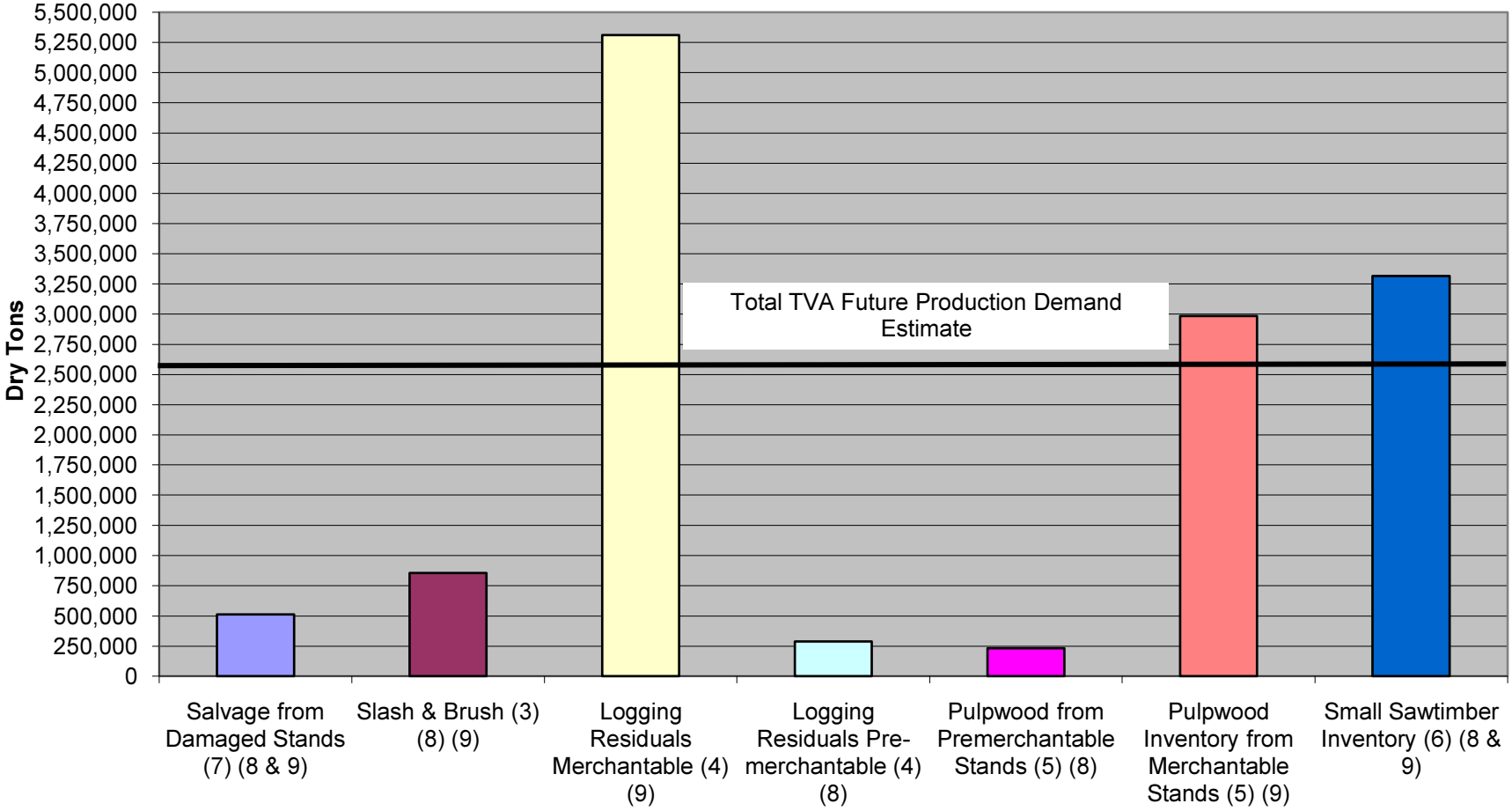
Estimated Annual Woody Biomass Supply for TVA Service Area

Source - USFS FIADB Woody Biomass Database including utilization restrictions
Based on Subregional Timber Supply Model (SRTS) Projections of Surplus Growth by FIA Unit



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Biomass Estimate of Urban Wood Waste in TVA Supply Area

Assumptions
2007 Census Population
Urban Wood Waste = Large Diameter Wood Generated by Tree Servicing Companies
Availability Factor - 60% - Carter et al. 2007
Yield = .203 Green Tons/Capita/Year Wiltsee 1998
Dry Tons=.5*Green Tons
Large City > 100,000 Population included 8 Cities
Medium City 25,000 <>99,000 population included 62 cities
Small City <25,000 population included over 1,695 cities

Total Annual Biomass Supply - Dry Tons

	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Large Cities	181,449	-	39,342	-	-	-	19,657	-	11,131	7,576	35,021	-
Medium Cities	155,833	2,174	11,332	6,330	-	6,652	1,963	2,196	-	1,789	13,179	-
Small Cities	309,438	14,880	14,895	16,145	4,915	6,316	21,869	8,949	10,995	4,505	17,907	6,292
Total	646,720	17,054	65,568	22,475	4,915	12,968	43,490	11,145	22,126	13,870	66,107	6,292

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Scenarios for Supply/Demand Analysis

Scenario 1 - TVA Suggested Co-Fire Plant Conversion	
Megawatts (MW)	20
Equivalent dry tons of wood	112,168
Green tons of wood	224,335
Million BTUs/year	1,890,699
Assumptions	
Moisture content (green weight basis)*	50%
Ash content*	2%
Btu/pound wood**	8,600
Facility capacity factor*	0.83
Heat rate (Btu/kWhr)**	13,002

Scenario 2 - TVA Suggested Dedicated Boiler Conversion	
Megawatts (MW)	50
Equivalent dry tons of wood	280,419
Green tons of wood	560,839
Million BTUs/year	4,726,747
Assumptions	
Moisture content (green weight basis)*	50%
Ash content*	2%
Btu/pound wood**	8,600
Facility capacity factor*	0.83
Heat rate (Btu/kWhr)**	13,002

Scenario 3 - TVA Total Annual Production Projections	
Megawatts (MW)	456
Equivalent dry tons of wood	2,557,424
Green tons of wood	5,114,847
Million BTUs/year	43,107,933
Assumptions	
Moisture content (green weight basis)*	50%
Ash content*	2%
Btu/pound wood**	8,600
Facility capacity factor*	0.83
Heat rate (Btu/kWhr)**	13,002

Scenario 4 - TVA Quoted Annual Biomass Supply Estimate	
Megawatts (MW)	6,419
Equivalent dry tons of wood	36,000,225
Green tons of wood	72,000,450
Million BTUs/year	606,819,790
Assumptions	
Moisture content (green weight basis)*	50%
Ash content*	2%
Btu/pound wood**	8,600
Facility capacity factor*	0.83
Heat rate (Btu/kWhr)**	13,002

Current Production Levels - Page 145 TVA-EIS

Colbert Fossil Plant
Co-Fire Wood Waste
29,000 MWh in 2009

PPA
70 MW Wood Waste

Future Production Levels - page 147 TVA-EIS

Co-Fire Conversion
Pulverized Coal Boilers
Suggested Size 20 MW Annually

Dedicated Boiler Conversion
Stoker/Cyclone/Circulating Boilers
Suggested Size 50 MW Annually

TVA Total Future Production Projections- page 147 TVA-EIS

Co-Fire Conversion
Annual Capacity 169 MW

Dedicated Boiler Conversion
Annual Capacity - 170 MW

New Facilities
Stoker/Circulating Boilers
Annual Capacity - 117 MW

TVA Quoted Annual Biomass Supply Estimate - page 130 TVA-EIS

All Biomass Resources*
36,000,000 Tons Annually

Biomass Energy Generation
47 GWh Annually

***No distinction between biomass type

*http://forestencyclopedia.net/Encyclopedia/bioenergy/Encyclopedia_Page.2005-07-19.0020/Encyclopedia_Page.2006-04-12.2315
**NIST - US National Institute of Standards and Technology - 8,600 Bone Dry HHV, 13,002 - 26.25 Efficiency

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Allocation of acres within 50 mile radius of power plant - excluding public lands

Power Plant	% *Outside* FIA Unit	% *Outside* FIA Unit AND Forested	% *Inside* FIA Unit AND Forested
Allen	0%	0%	20%
Bull Run	0%	0%	45%
Colbert	0%	0%	49%
Cumberland	0%	0%	52%
Gallatin	0%	0%	43%
John Seveir	0%	0%	52%
Johnsonville	0%	0%	56%
Kingston	0%	0%	48%
Paradise	6%	2%	40%
Shawnee	41%	9%	25%
Widows Creek	0%	0%	48%
Grand Total	4%	1%	44%

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Current Utilization Rates*

Detail Supply Bucket	TVA Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Salvage from Damaged Stands (Fire, Insect, Disease) (7)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Slash & Brush From Non-Damaged Stands (3)	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Logging Residues (4)	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
Pulpwood - Premerchantable (6) (8)	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Pulpwood - Merchantable (6) (9)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Small Sawtimber (6) (9)	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%

*Source
Abt and Seawell - SAFER September 2010, Mulkey 2008

Based on the following customized query of FIA Database March 2010

(1) USFS FIA dry weight of individual tree components (stemwood, top, branches, bark, stump and coarse roots) using component ratio method (CRM) as described in Appendix J Biomass Estimation in the FIADB - FIA Database description and Users Manual for Phase 2, Version 4.0, revision 2, December 2009, Utilizes a compiled set of specie and bark specific gravities to adjust green weight volumes. For smaller trees (saplings and woodland species), only a total biomass value representing wood and bark from ground to tip excluding foliage is available.
(2) Exclude all public lands and timber acres older than 80 years
(3) Understory_bio_sum--estimated biomass (in Tons) of understory components (seedlings, shrubs, brush) aboveground. Derived from Carbon_understory_AG variable, which is in tons/acre in Condition table of FIADB 4.0. This variable is estimated from models based on region, forest type and live tree carbon density (Smith and Health 2008). Understory biomass values at the population level were computed as follows:
Understory_bio = Carbon_understory_AG * 2 * Condition Acres
(4) Logging Residue - Tops, Branches and Unused bole of merchantable trees based on following formulas
Upstemwtsum-sum of dry weight (tons) in the upper stem (saw-log top to 4.0 inch bole diameter) of sawtimber trees.
Stumpwtsum-sum of dry weight (tons) in the stump (ground level to 1.0 foot above ground) of trees 5.0 inches d.b.h. and larger.
Topwtsum--sum of dry weight (tons) in the top of trees 5.0 inches d.b.h. and larger. Includes bole from 4.0 inch top diameter to tip and all branches. Does not include foliage.
(5) Pulpwood Tree Volume - The portion of live trees 5.0 inches DBH and above not allocated to saw-log section of the tree based on following formula
Bolewtsum-sum of dry weight of the merchantable bole in tons.
(6) Small Sawtimber Tree Volume - The saw-log section of live trees < 13 DBH based on following formula
Sawwtsum-sum of dry weight of the saw-log section in tons.
(7) Salvage from Fire, Insect & Disease - All tree volume associated with damaged stands based on FIA Formulas Upstemwtsum, Stumpwtsum, Topwtsum, Bolewtsum
(8) Pre-Merchantable - Stands 0-10 Years
(9) Merchantable -Stands >10 Years and <80 years

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Weighted Average Annual Removal and Growth and Percentage of Inventory

2010 SRTS Model Projections*

With Overlapping Procurement Radius

% of Inventory	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Pulpwood Removals	2.66%	2.31%	2.73%	2.00%	2.90%	1.51%	3.37%	3.00%	2.91%	2.36%	1.75%	4.19%
Pulpwood Growth	5.19%	6.18%	5.03%	3.96%	2.77%	5.88%	4.76%	3.71%	4.05%	7.42%	10.31%	5.03%
Sawtimber Removals	2.66%	2.32%	2.94%	2.22%	3.19%	1.61%	2.86%	3.47%	2.67%	2.49%	1.73%	3.47%
Sawtimber Growth	5.06%	8.70%	7.35%	5.51%	5.27%	2.97%	4.14%	5.78%	3.29%	6.46%	5.52%	3.53%

Without Overlapping Procurement Radius

% of Inventory	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Pulpwood Removals	2.66%	2.26%	2.73%	1.99%	2.73%	1.53%	3.36%	3.03%	2.98%	2.48%	1.86%	3.55%
Pulpwood Growth	5.19%	5.68%	4.89%	3.80%	4.29%	6.02%	4.81%	3.85%	3.93%	5.75%	9.67%	4.39%
Sawtimber Removals	2.66%	2.28%	2.92%	2.23%	2.97%	1.62%	2.81%	3.46%	2.76%	2.66%	1.82%	3.10%
Sawtimber Growth	5.06%	8.19%	7.23%	5.49%	5.82%	3.36%	4.19%	5.86%	3.53%	5.90%	5.17%	3.55%

With Overlapping Procurement Radius

Growth-Removals	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Surplus Growth PW	2.52%	3.88%	2.30%	1.96%	-0.14%	4.37%	1.39%	0.72%	1.14%	5.06%	8.57%	0.84%
Surplus Growth Saw	2.40%	6.38%	4.41%	3.29%	2.07%	1.36%	1.28%	2.31%	0.62%	3.97%	3.79%	0.06%

Without Overlapping Procurement Radius

Growth-Removals	Total TVA Supply Area	Shawnee	Allen	John Seveir	Johnsonville	Paradise	Widows Creek	Colbert	Bull Run	Cumberland	Gallatin	Kingston
Surplus Growth PW	2.52%	3.42%	2.17%	1.81%	1.56%	4.49%	1.45%	0.82%	0.95%	3.27%	7.80%	0.83%
Surplus Growth Saw	2.40%	5.91%	4.31%	3.26%	2.85%	1.74%	1.38%	2.39%	0.77%	3.24%	3.34%	0.45%

*Source - ABT - Subregional Timber Supply Model (SRTS) - 2010 SOFAC V23 Southwide Demand Runs

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