

# Integrated Resource Plan

## TVA's Environmental & Energy Future

March 2011



## Message from the CEO

---

TVA operates one of the largest power systems in the United States. With a generating capacity of more than 34,000 megawatts, we meet the daily electricity needs for an 80,000-square-mile region where more than 9 million people live, work and go to school. That's an enormous responsibility, and one we take very seriously.

A power system large and reliable enough to handle that responsibility doesn't come about by accident. It's the culmination of work by thousands of skilled professionals, and it all starts with focused and detailed planning.

Planning a power system is complex work that involves hundreds of variables, such as consumer trends, fuel and material costs, regulations, technology advancements and the weather. It's complicated even further by the need to forecast needs and conditions decades into the future.



TVA's new integrated resource plan is a critical part of our overall planning effort. It is a comprehensive study of options and strategies and their potential economic and environmental outcomes. The plan was shaped by input from the businesses, industries and regional leaders, as well as ordinary people, whose lives and livelihoods depend on the electricity supplied by TVA. The result of this two-year exercise gives us a sound basis for making better long-term decisions.

In addition, our integrated resource plan will help us fulfill TVA's renewed vision to become one of the nation's leading providers of low-cost and cleaner energy by 2020. The options that have been identified from this process involve reducing TVA's reliance on coal, increasing our supply of nuclear and renewable energy, and working in partnership with local utilities and the people they serve to use energy more efficiently.

Like most things, the cost of electricity is not likely to stay flat in the years ahead. Our challenge will be to keep power affordable while carrying out our vital work with the least impact on the environment today and for future generations.

A handwritten signature in black ink that reads "Tom Kilgore". The signature is written in a cursive, flowing style.

Tom Kilgore

# Table of Contents

<b>Executive Summary</b>	<b>10</b>
Overview	10
Public Participation	10
Need for Power Analysis	11
Approach	13
Recommended Planning Direction	16
<b>Chapter 1 – TVA’s Environmental and Energy Future</b>	<b>18</b>
TVA Overview	22
Looking Ahead	26
Integrated Resource Planning	27
IRP Deliverables	28
IRP Outline	30
<b>Chapter 2 – IRP Process</b>	<b>32</b>
Develop Scope	35
Develop Inputs and Framework	36
Analyze and Evaluate	37
Present Initial Results	38
Incorporate Input	39
Identify Recommended Planning Direction	39
Approval of Recommended Planning Direction	39
<b>Chapter 3 – Public Participation</b>	<b>40</b>
Public Scoping Period	44
Analysis and Evaluation Period	47
Draft IRP Public Comment Period	52
Public Input Received During the IRP Process	54
Response to Public Input and Comments	57
<b>Chapter 4 – Need for Power Analysis</b>	<b>58</b>
Estimate Demand	61
Determine Reserve Capacity Needs	69
Estimate Supply	70
Estimate the Capacity Gap	76
<b>Chapter 5 – Energy Resource Options</b>	<b>78</b>
Selection Criteria	81
Options Included in IRP Evaluation	82

<b>Chapter 6 – Resource Plan Development and Analysis</b>	<b>88</b>
Development of Scenarios and Strategies	91
Resource Portfolios Optimization Modeling	100
Development of Evaluation Scorecard	102
Identification of Preferred Planning Strategies in the Draft IRP	110
Incorporation of Public Input and Performance of Additional Scenario Planning Analyses	111
Identification of Recommended Planning Direction	111
<b>Chapter 7 – Draft Study Results</b>	<b>116</b>
Analysis Results	119
Selection Process	131
Preferred Planning Strategies	142
<b>Chapter 8 – Final Study Results and Recommended Planning Direction</b>	<b>144</b>
Results Analysis	148
Component Identification	152
Recommended Planning Direction Development	155
Conclusion	165
<b>Chapter 9 – Next Steps</b>	<b>166</b>
Path Forward	169
Application	170
Areas That Require Further Work	170
Conclusion	171
<b>Appendix A – Method for Computing Environmental Impact Metrics</b>	<b>A172</b>
Purpose	A172
Process	A172
Method	A172
<b>Appendix B – Method for Computing Economic Impact Metrics</b>	<b>B182</b>
Purpose	B182
Process	B182
Methodology	B184
Analysis	B185
Findings	B185
<b>Appendix C – Energy Efficiency and Demand Response</b>	<b>C188</b>
Previous: Demand-Focused Portfolio	C188
Renewed Vision: To Become a Leader in Energy Efficiency	C189
TVA’s Long-Term Plan	C192
Next Steps	C195

<b>Appendix D – Development of Renewable Energy Portfolios</b>	<b>D196</b>
TVA's Current Renewable Energy Landscape	D196
Renewable Energy Needs	D198
IRP Renewable Additions	D198
Modeling Process	D199
<b>Appendix E – Draft IRP Phase Expansion Plan Listing</b>	<b>E204</b>
Planning Strategy A – Limited Change in Current Portfolio	E204
Planning Strategy B – Baseline Plan Resource Portfolio	E206
Planning Strategy C – Diversity Focused Resource Portfolio	E208
Planning Strategy D – Nuclear Focused Resource Portfolio	E210
Planning Strategy E – EEDR and Renewables Focused Portfolio	E212
<b>Appendix F – Stakeholder Input Considered and Incorporated</b>	<b>F214</b>
<b>Acronym Index</b>	<b>216</b>

## List of Figures

### Executive Summary

Figure 1 – Peak Load Forecast	12
Figure 2 – Capacity Gap	12
Figure 3 – Final IRP Development	15
Figure 4 – Optimization Framework for the Final IRP Analysis	15
Figure 5 – Recommended Planning Direction	17

### Chapter 3

Figure 3-1 – Public Scoping Meetings	45
Figure 3-2 – Distribution of Scoping Comments by Geographic Area	46
Figure 3-3 – Stakeholder Review Group Meetings	48
Figure 3-4 – Public Briefings	49
Figure 3-5 – Public Comment Period Meetings	52
Figure 3-6 – Type of Responses Submitted	54

### Chapter 4

Figure 4-1 – Comparison of Actual and Forecasted Summer Peak Demand (MW)	65
Figure 4-2 – Comparison of Actual and Forecasted Net System Requirements (GWh)	66
Figure 4-3 – Peak Load Forecast (MW)	68
Figure 4-4 – Energy Forecast (GWh)	69
Figure 4-5 – Illustration of Baseload, Intermediate and Peaking Resources (MW)	71
Figure 4-6 – Reference Case: Spring 2010 – Firm Capacity (MW)	73
Figure 4-7 – Reference Case: Spring 2010 – Energy (GWh)	74
Figure 4-8 – Existing Firm Supply (MW)	75
Figure 4-9 – Capacity Gap (MW)	76
Figure 4-10 – Energy Gap (GWh)	77

### Chapter 6

Figure 6-1 – Key Uncertainties	93
Figure 6-2 – Scenarios Key Characteristics	94
Figure 6-3 – Scenario Descriptions	96
Figure 6-4 – Components of Planning Strategies	97
Figure 6-5 – Planning Strategies Key Characteristics	98
Figure 6-6 – Strategy Descriptions	99
Figure 6-7 – Planning Strategy Scorecard	103
Figure 6-8 – Financial Risk Metrics	104
Figure 6-9 – Ranking Metrics Example	108
Figure 6-10 – Example of Draft IRP Scoring Process – Carbon Footprint	109
Figure 6-11 – Recommended Planning Direction Boundary Conditions	112
Figure 6-12 – Recommended Planning Direction Range of Options Tested	113

## List of Figures (continued)

### Chapter 7

Figure 7-1 – Firm Requirements by Scenario	120
Figure 7-2 – Range of Capacity Gaps by Strategy	121
Figure 7-3 – Capacity Additions by 2029	122
Figure 7-4 – Number of Nuclear Units Added	123
Figure 7-5 – Number of Coal Units Added	124
Figure 7-6 – Number of Combined Cycle Units Added	125
Figure 7-7 – Number of Combustion Turbine Units Added	126
Figure 7-8 – Range of Energy Production by Type in 2025	127
Figure 7-9 – Expected Value of PVRR by Scenario	128
Figure 7-10 – Expected Values for Short-Term Rates by Scenario	129
Figure 7-11 – PVRR Risk Ratio by Scenario	130
Figure 7-12 – PVRR Risk/Benefit by Scenario	131
Figure 7-13 – Ranking Metrics Worksheet	132
Figure 7-14 – Planning Strategy A – Limited Change in Current Resource Portfolio	133
Figure 7-15 – Planning Strategy B – Baseline Plan Resource Portfolio	134
Figure 7-16 – Planning Strategy C – Diversity Focused Resource Portfolio	134
Figure 7-17 – Planning Strategy D – Nuclear Focused Resource Portfolio	135
Figure 7-18 – Planning Strategy E – EEDR and Renewables Focused Resource Portfolio	135
Figure 7-19 – Planning Strategy Ranking Order	136
Figure 7-20 – Sensitivity Characteristics	137
Figure 7-21 – Rank Order of Strategies	138
Figure 7-22 – Strategic Metrics for Five Planning Strategies	139
Figure 7-23 – Technology Innovation Matrix	140
Figure 7-24 – Implementing Portfolios (Initial Phase)	143

### Chapter 8

Figure 8-1 – Firm Requirements by Scenario	148
Figure 8-2 – Sensitivity Runs Identified From Draft IRP	149
Figure 8-3 – The 12 Portfolios	150
Figure 8-4 – Short-Term Rate Impacts by Scenario	151
Figure 8-5 – Weighted Ranking Scores	153
Figure 8-6 – Potential 2,500 MW Renewable Portfolio	154
Figure 8-7 – Observations Developed from Preliminary Results	155
Figure 8-8 – Recommended Planning Direction	156
Figure 8-9 – Illustrative Portfolios for the Recommended Planning Direction	157
Figure 8-10 – Recommended Planning Direction	158

## List of Figures (continued)

Figure 8-11 – Planning Strategy C – Updated Scorecard	159
Figure 8-12 – Planning Strategy E – Updated Scorecard	159
Figure 8-13 – Plan Costs vs. Financial Risk	160
Figure 8-14 – Comparison of Financial Risks of Strategies	161
Figure 8-15 – PVRR (2010 \$B)	162
Figure 8-16 – Plan Costs vs. Annual CO <sub>2</sub> Emissions	163
Figure 8-17 – Other Risk Considerations	164
<b>Chapter 9</b>	
Figure 9-1 – Scope of the IRP	170
Figure 9-2 – Areas That Require Further Work	171
<b>Appendix A</b>	
Figure A-1 – Summary of 2007-2009 Average Emissions Data	A173
Figure A-2 – Tons CO <sub>2</sub> by Strategy	A174
Figure A-3 – Tons SO <sub>2</sub> by Strategy	A175
Figure A-4 – Tons NO <sub>x</sub> by Strategy	A176
Figure A-5 – Lbs Hg by Strategy	A177
Figure A-6 – Strategy Rankings for All Four Emissions	A178
Figure A-7 – Design Factors for Generation Sources	A178
Figure A-8 – Final Strategy Water Impact Ranking	A179
Figure A-9 – Weighted Ash Percentage	A180
Figure A-10 – Weighted Heat Content (BTU/lb)	A180
Figure A-11 – Final Strategy Waste Impact Ranking (Based on Total Coal and Nuclear Waste Disposal Costs)	A181
<b>Appendix B</b>	
Figure B-1 – Input and Output Impacts	B183
Figure B-2 – Final Summary Economic Impacts of IRP Cases	B185
<b>Appendix C</b>	
Figure C-1 – Existing and New EEDR Programs	C193
Figure C-2 – EEDR Program Demand Reduction (MW)	C194
Figure C-3 – EEDR Program Energy Savings (GWh)	C195
<b>Appendix D</b>	
Figure D-1 – Renewable Resource Types and Components	D201
Figure D-2 – New Renewable Capacity at 2,500 MW	D203
Figure D-3 – New Renewable Capacity at 3,500 MW	D203



## List of Figures (continued)

### Appendix E

Figure E-1 – Planning Strategy A – Limited Change in Current Portfolio	E204
Figure E-2 – Planning Strategy A – Capacity Additions by Scenario	E205
Figure E-3 – Planning Strategy B – Baseline Plan Resource Portfolio	E206
Figure E-4 – Planning Strategy B – Capacity Additions by Scenario	E207
Figure E-5 – Planning Strategy C – Diversity Focused Resource Portfolio	E208
Figure E-6 – Planning Strategy C – Capacity Additions by Scenario	E209
Figure E-7 – Planning Strategy D – Nuclear Focused Resource Portfolio	E210
Figure E-8 – Planning Strategy D – Capacity Additions by Scenario	E211
Figure E-9 – Planning Strategy E – EEDR and Renewables Focused Portfolio	E212
Figure E-10 – Planning Strategy E – Capacity Additions by Scenario	E213



## EXECUTIVE SUMMARY

### Contents

<b>Overview</b>	<b>10</b>
<b>Public Participation</b>	<b>11</b>
<b>Need for Power Analysis</b>	<b>11</b>
<b>Approach</b>	<b>13</b>
<b>Scenario Planning</b>	<b>13</b>
<b>Recommended Planning Direction Development</b>	<b>14</b>
<b>Strategic Findings</b>	<b>16</b>
<b>Recommended Planning Direction</b>	<b>16</b>

### Overview

The Tennessee Valley Authority’s (TVA) Integrated Resource Plan (IRP), entitled TVA’s Environmental and Energy Future, serves as a roadmap for identifying the resources that are acceptable and available to meet the energy needs of the Tennessee Valley region over the next 20 years. It addresses the demand for power in the region, the options available for meeting that demand and the potential environmental, economic and operating impacts of each.

This endeavor aligns with TVA’s Environmental Policy and will serve as a guide for TVA to fulfill its renewed vision—to become one of the nation’s leading providers of low-cost and cleaner energy by 2020. TVA is committed to lead the nation in improved air quality and increased nuclear production and to lead the Southeast in increased energy efficiency. This vision will be accomplished as TVA continues to carry out the mission established by Congress in 1933.

The current planning environment that confronts TVA is one of the most challenging in TVA’s history. Therefore, TVA must ensure that its strategy is robust, regardless of future conditions, and enables TVA to navigate through these challenges in a way that best supports its multiple responsibilities. This IRP establishes a strategic direction for TVA and provides it with the flexibility to make the best decisions in a dynamic, ever-changing regulatory and economic environment.

### **Public Participation**

Public participation was a significant component of the IRP process. In an effort to develop the plan in a transparent manner, TVA offered multiple opportunities for the public to contribute to and influence the development of this IRP. These opportunities included two series of public meetings, written comments, webinars, briefings, a web-based questionnaire, and a phone survey. The goal for all public participation opportunities was to encourage others to share their views on issues they believe TVA should focus on as it plans for the region's future energy needs.

In addition to public participation, TVA also formed a Stakeholder Review Group (SRG). This group consisted of 16 individuals representing a wide range of interests. Members of the group were asked to provide TVA with their viewpoints on the IRP process, assumptions, analyses and results. TVA met approximately every month with the SRG throughout the IRP process to discuss strategic findings.

### **Need for Power Analysis**

As a part of the IRP analysis, TVA developed a forecast of the need for power, referred to in the electric utility industry as “demand.” To develop this forecast, the following four basic steps were taken:

1. Demand for electricity (peak demand and energy sales) was forecasted for a 20-year planning horizon (Figure 1)
2. Firm requirements were calculated to determine generation capacity required by adding forecasted demand to a planning contingency. The planning contingency allowed for unforeseen events, inaccuracies or unplanned unit outages and other resource limitations
3. Existing generation resources available to meet the forecasted demand were identified
4. The need for power was calculated by comparing the firm requirements to the existing viable generation resources. The difference between the two defines the need for additional resources over the planning period. This is referred to as “the capacity gap” (Figure 2)

TVA expects the need for power to continue to grow due to economic recovery, population growth and other factors. However, this growth is expected to occur at a lower rate than historical average.

## EXECUTIVE SUMMARY

Figure 1 shows the Reference Case: Spring 2010 forecast of peak demand over the 20-year planning horizon. The figure also illustrates the range of load forecasts considered within this IRP, with the highest and lowest forecasts representing the upper and lower bounds.

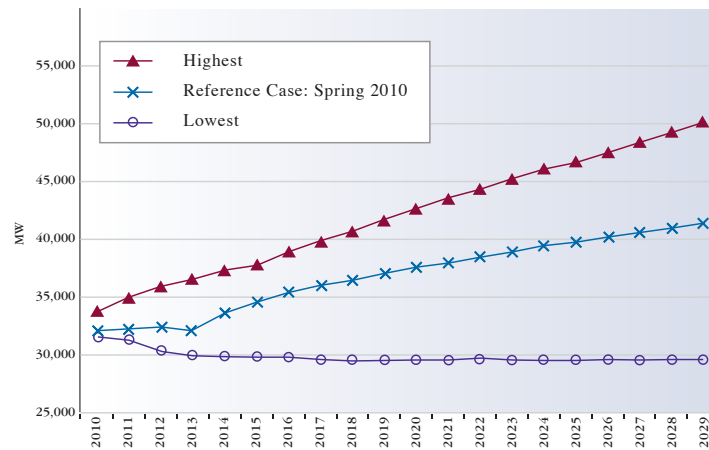


Figure 1 – Peak Load Forecast

Figure 2 shows the capacity gap for the Reference Case: Spring 2010 forecast over the 20-year planning horizon. The figure also illustrates the capacity gap based on the range of peak loads considered in this IRP. The capacity gaps were developed by adding a planning reserve margin to the peak load forecast and subtracting existing resources. Additional detail on the need for power analysis is included in Chapter 4 – Need for Power Analysis.

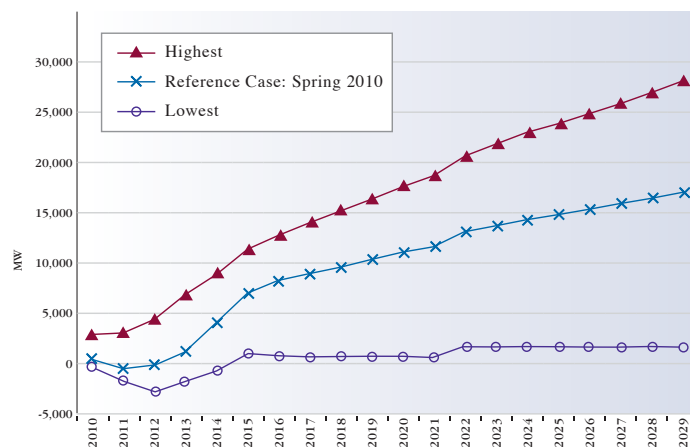


Figure 2 – Capacity Gap

## Approach

### Scenario Planning

A scenario planning approach was utilized for the development of this IRP. TVA carried out its analysis in a “no-regrets” framework. This framework defined a process in which all relevant and available information was analyzed in a careful and considered fashion, with significant attention paid to what would happen if the future unfolds in an unexpected way.

In other words, strategic options were analyzed not only from the perspective of what was expected to occur in the future, but also from the perspective of what was possible to occur in the future. Using this framework, decisions made today and in the near future are not overly dependent on the future unfolding exactly as expected. Therefore, this IRP should provide benefit and value to stakeholders even if the future turns out to be different than predicted.

Scenarios and planning strategies form the basic building blocks of the IRP analysis. Scenarios do not predict the future, but rather portray the range of possible “worlds” that TVA may encounter in the future based on a number of uncertainties outside of TVA’s control. Scenarios were also used to test resource selection and reflect key stakeholder interests.

Factors that differed between scenarios included economic growth, inflation, fuel prices, demand growth and regulatory environments. Uncertainties varied among scenarios to highlight how decisions would change under different conditions.

Six unique scenarios were developed for this IRP along with two iterations of a reference forecast. Scenario 7 – Reference Case: Spring 2010 was used in the Draft IRP analysis and was refreshed with Scenario 8 – Reference Case: Great Recession Impacts Recovery between the Draft and final IRP. The following eight scenarios were used:

- Scenario 1 – Economy Recovers Dramatically
- Scenario 2 – Environmental Focus is National Priority
- Scenario 3 – Prolonged Economic Malaise
- Scenario 4 – Game-Changing Technology
- Scenario 5 – Energy Independence
- Scenario 6 – Carbon Regulation Creates Economic Downturn

## EXECUTIVE SUMMARY

- Scenario 7 – Reference Case: Spring 2010
- Scenario 8 – Reference Case: Great Recession Impacts Recovery

Additional details on the scenarios are included in Chapter 6 – Resource Plan Development and Analysis.

### **Recommended Planning Direction Development**

The Draft IRP evaluated five specific planning strategies. These planning strategies described a broad range of business options that TVA could adopt and were built upon key decisions within TVA's control. Components such as renewable generation additions, nuclear expansion and market purchases varied among planning strategies. The following planning strategies were considered in the Draft IRP:

- Strategy A – Limited Change in Current Resource Portfolio
- Strategy B – Baseline Plan Resource Portfolio
- Strategy C – Diversity Focused Resource Portfolio
- Strategy D – Nuclear Focused Resource Portfolio
- Strategy E – EEDR and Renewables Focused Resource Portfolio

Each planning strategy was evaluated across the first seven scenarios. The results were summarized using a scorecard designed to identify financial, risk and strategic factors to consider when selecting a Recommended Planning Direction.

Based on the preliminary results, TVA focused on the top three ranked planning strategies (Strategies B, C and E) for further evaluation. Additional detail on the Draft IRP results is included in Chapter 7 – Draft Study Results.

A high-level summary of the process used for developing the final IRP is shown in Figure 3.

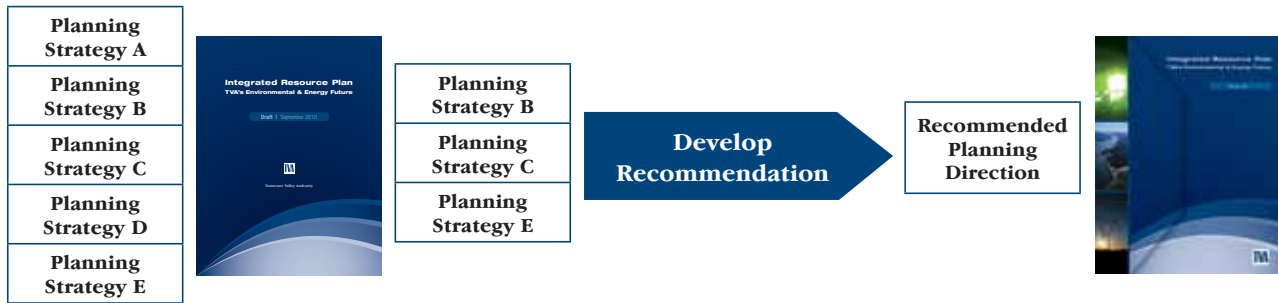


Figure 3 – Final IRP Development

A key objective in transitioning from the Draft to the final IRP was to identify a Recommended Planning Direction. The preliminary results and findings of the Draft IRP were used to establish boundaries for evaluating new combinations of planning strategy components through an optimization framework. In addition, input received during the public comment period was reviewed in detail and appropriately incorporated into the analysis. This approach produced more comprehensive results by allowing unique combinations of resources to be tested in addition to those directly considered in the Draft IRP. A summary of the options considered for the final IRP is shown in Figure 4.

Components	Range of Options Tested				
EEDR	2,100 MW & 5,900 annual GWh reductions by 2020	3,600 MW & 11,400 annual GWh reductions by 2020	5,100 MW & 14,400 annual GWh reductions by 2020		
Renewable additions	1,500 MW competitive resources or PPAs by 2020	2,500 MW competitive resources or PPAs by 2020	2,500 MW competitive resources or PPAs by 2029	3,500 MW competitive resources or PPAs by 2020	3,500 MW competitive resources or PPAs by 2029
Coal-fired capacity idled	2,400 MW total fleet reductions by 2017	3,200 MW total fleet reductions by 2017	4,000 MW total fleet reductions by 2017	4,700 MW total fleet reductions by 2017	

Figure 4 – Optimization Framework for the final IRP Analysis

The Recommended Planning Direction was evaluated in all eight scenarios. The results were used to build a fully populated scorecard with ranking and strategic metrics. The completed scorecard was compared with the Draft IRP results to evaluate improvements between previously considered planning strategies. Additional detail on the Recommended Planning Direction results is included in Chapter 8 – Final Study Results and Recommended Planning Direction.



## EXECUTIVE SUMMARY

### **Strategic Findings**

The following strategic findings emerged from the IRP analysis:

- Expanded EEDR portfolios perform well; the mid level portfolio provided the best balance of cost and implementation risk
- Renewable generation above existing wind contracts played a role in future resource portfolios, assuming certain costs
- Some increased idling of coal-fired capacity was favorable compared to adding environmental controls to the existing fleet
- Coal-fired capacity was only added in scenarios with high load growth
- Pumped-storage added needed operational flexibility
- Nuclear expansion was selected in most cases, except scenarios with no load growth
- Natural gas-fired capacity was selected in most cases after 2020, except when needed earlier to meet high load growth or to provide grid reliability

### **Recommended Planning Direction**

This IRP provides TVA with a strategic direction and the flexibility to make sound choices in a dynamic, ever-changing regulatory and economic environment. The Recommended Planning Direction is the most balanced in terms of cost, financial risk and other strategic considerations and provides direction by articulating a 20-year roadmap.

Components of the Recommended Planning Direction are based upon extensive modeling, in-depth stakeholder input and the assessment of quantified and non-quantified risks. They also allow for flexibility to adapt to future conditions by providing guideline ranges and timeframes for each component of the planning strategy. A summary of the Recommended Planning Direction is shown in Figure 5.

EXECUTIVE SUMMARY

Component	Guideline MW Range	Window of Time	Recommendations
EEDR	3,600-5,100 (11,400-14,400 GWh)	By 2020 <sup>1</sup>	Expand contribution of EEDR in the portfolio
Renewable additions	1,500-2,500 <sup>2</sup>	By 2020 <sup>1</sup>	Pursue cost effective renewable energy
Coal-fired capacity idled	2,400-4,700 <sup>3</sup>	By 2017	Consider increasing amount of coal-fired capacity idled
Energy storage	850 <sup>4</sup>	2020-2024	Add pumped-storage capacity
Nuclear additions	1,150-5,900 <sup>5</sup>	2013-2029	Increase contribution of nuclear generation
Coal additions	0-900 <sup>6</sup>	2025-2029	Preserve option of generation with carbon capture
Natural gas additions	900-9,300 <sup>7</sup>	2012-2029	Utilize natural gas as an intermediate supply source

- 1 – This range includes EEDR savings achieved through 2010. The 2020 range for EEDR and renewable energy does not preclude further investment in these resources during the following decade
- 2 – TVA’s existing wind contracts that total more than 1,600 MW are included in this range. Values are nameplate capacity. Net dependable capacity would be lower
- 3 – TVA has previously announced plans to idle 1,000 MW of coal-fired capacity, which is included in this range. MW values based on maximum net dependable capacity
- 4 – This is the expected size of a new pumped-storage hydro facility
- 5 – The completion of Watts Bar Unit 2 represents the lower end of this range
- 6 – Up to 900 MW of new coal-fired capacity is recommended between 2025 and 2029
- 7 – The completion of John Sevier combined cycle plant represents the lower end of this range

Figure 5 – The Recommended Planning Direction

*Aerial photo showing the hydroelectric Fontana Dam on the Little Tennessee River in North Carolina. The dam was constructed in the early 1940s at the height of World War II to accommodate skyrocketing energy demands.*

<b>1</b>	<b>TVA's Environmental and Energy Future</b>	<b>21</b>
1.1	TVA Overview	22
1.1.1	Yesterday – An Innovative Solution	22
1.1.2	Today – The Mission Continues	22
1.1.3	Future – A New Era	25
1.2	Looking Ahead	26
1.2.1	Bridging the Gap	26
1.2.2	Challenges Facing TVA	26
1.3	Integrated Resource Planning	27
1.3.1	Role of the Integrated Resource Plan	27
1.3.2	Integrated Resource Planning Process	28
1.4	IRP Deliverables	28
1.4.1	Draft and Final IRP Documents	28
1.4.2	Natural Resource Plan	29
1.4.3	Draft and Final Environmental Impact Statement	29
1.5	IRP Outline	30



*President Franklin D. Roosevelt (seated) signs the Tennessee Valley Authority Act, creating TVA on May 18, 1933.*



*Trout fishing in the Clinch River near Norris Dam is just one of the many recreational amenities available to the people of the Tennessee Valley.*



*Construction overlook of the Norris Dam located in Anderson and Campbell Counties in Tennessee, c. mid-1930s.*

## TVA's Environmental Policy



## 1 TVA's Environmental and Energy Future

After more than two years of development, the Tennessee Valley Authority (TVA) has completed its Integrated Resource Plan (IRP), entitled TVA's Energy and Environmental Future. This IRP is the product of extensive analysis and collaboration with many of TVA's partners and stakeholders.

Many electric utilities use the integrated resource planning process as a decision tool to help define both near- and long-term challenges. For TVA, the process was expanded to consider impacts on the environment and the economy. The IRP provides guidance in choosing the best resource options to meet future energy demand by considering future uncertainties, power reliability, financial, economic and environmental impacts associated with those options.

TVA's IRP has been developed to support TVA's mission for meeting the electric power needs of the Tennessee Valley region in a sustainable manner. The 20-year strategy recommended by the IRP provides direction for decisions that require a long lead time. It is consistent with TVA's Environmental Policy and its renewed vision – to become one of the nation's leading providers of low-cost and cleaner energy by 2020. The renewed vision and this IRP will better equip TVA to meet the substantial challenges facing the electric utility industry for the benefit of TVA stakeholders.

## 1.1 TVA Overview

### 1.1.1 Yesterday – An Innovative Solution

TVA stands as one of President Franklin D. Roosevelt’s most innovative ideas. He envisioned TVA as “a corporation clothed with the power of government but possessed with the flexibility and initiative of a private enterprise.”

TVA is a federal agency and corporation, wholly owned by the people of the United States and tasked by Congress to:

- Improve the quality of life for the residents of the Tennessee Valley region
- Foster economic development
- Promote conservation and wise use of the region’s natural resources

Since its inception, TVA has worked to improve the quality of life for the people who live in the TVA service area. For more than 75 years, TVA has succeeded in its unique mission of serving the region through energy, environment and economic development. TVA established integrated resource management as the means for solving the competing and often conflicting interests of its mission, such as managing the Tennessee River system for navigation, flood control, recreation and power production. While the challenges evolved and new ones developed, TVA has relied on its strategy of devising integrated solutions.

### 1.1.2 Today – The Mission Continues

TVA’s multi-faceted mission of providing low-cost, reliable power; serving as a catalyst for economic development; protecting the environment; stimulating technological innovation and managing an integrated river system in the Tennessee Valley region is the same today as it was 78 years ago.

TVA operates the nation’s largest public power system. It provides power to more than nine million people, through 155 distributors of TVA power and 56 directly served customers, in an area encompassing 80,000-square-miles, including most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina and Virginia.

#### Low-Cost Power

Maintaining a diverse portfolio of generation resources helps TVA keep power rates in the Tennessee Valley competitive regionally and nationally. TVA operates 56 active coal-fired units, six nuclear units, 109 conventional hydroelectric units, four pumped-storage units, 87 simple-cycle combustion turbine units, eight combined cycle units, nine diesel generator units, one digester gas site, one wind energy site and 14 solar energy sites.<sup>1</sup>

<sup>1</sup>As of Sept. 30, 2010

A portion of TVA's electrical supply is purchased from third-party operators under long-term purchased power agreements (PPAs). This diverse supply portfolio has enabled TVA to meet the region's energy demands, reliably and at competitive prices.

While keeping prices low, TVA has maintained world-class transmission reliability. TVA's transmission system is one of the largest in North America. It efficiently delivered more than 177 billion kilowatt-hours to customers in 2010. For the past 12 years, the system has achieved 99.999 percent reliability.

## **Economic Development**

A benefit of TVA's large power system is the ability to produce power at prices below the national average, thus attracting industry to the region and making TVA a national leader in economic development. During the past five years, TVA has helped attract or retain 265,000 jobs in its service territory and has secured more than \$27 billion in capital investment for the region through its Valley Investment Initiative program.

The Watts Bar Nuclear Plant's Unit 2 project created 3,200 construction jobs.

After completion in 2013, it will provide 300 permanent jobs.

In 2010, TVA worked in partnership with state and local officials in the recruitment and/or expansion of 150 companies in the TVA service area. One of TVA's most recent economic development initiatives has been the Megasites program. Through the Megasites program, five large industrial sites were sold to Dow Corning/Hemlock Semiconductor, Volkswagen, Paccar, Toyota and SeverCorr.

## **Environmental Stewardship**

TVA's environmental stewardship (non power) programs include managing the Tennessee River and approximately 293,000 acres of reservoir lands to protect natural resources, to enhance economic development, and to provide recreational opportunities, adequate water supply and improved water quality within the Tennessee Valley watershed.

TVA's Environmental Policy provides objectives for an integrated approach related to providing cleaner, reliable and affordable energy, supporting sustainable economic growth, and engaging in proactive environmental stewardship. The Environmental Policy provides additional direction in several environmental stewardship areas, including air quality improvement, climate change mitigation, water resource protection and improvements, sustainable land use and natural resource management.



Aligning with the objectives of the Environmental Policy and TVA's renewed vision, TVA is committed to continue minimizing the environmental impacts of its operations. In 1995, TVA was the first utility in the nation to participate in a voluntary greenhouse gas reduction program sponsored by the U.S. Department of Energy. As a result, TVA has reduced or avoided more than 305 million tons of carbon dioxide (CO<sub>2</sub>) from being emitted into the atmosphere.

Today, air quality across the region is the best it has been in more than 30 years. Since 1977, TVA has spent more than \$5 billion on clean air controls. The controls have reduced sulfur dioxide (SO<sub>2</sub>) emissions by 82 percent and nitrogen oxide (NO<sub>x</sub>) emissions by nearly 86 percent from 1990 levels.

### **Technological Innovation**

TVA is also committed to technological innovation. In 2000, TVA developed the first wind farm in the Southeast, and five of today's 14 solar photovoltaic sites were constructed for its green power pricing program, Green Power Switch<sup>®</sup>. In 2001, the program was expanded to include methane co-firing at Allen Fossil Plant in Memphis, Tenn.

Recently, TVA partnered with Nissan North America, the State of Tennessee, the Electric Transportation Engineering Corporation and local distributors to develop a plan to deploy electric vehicle charging stations. In January 2011, TVA and the Electric Power Research Institute unveiled an electric vehicle charging station that can make electricity from sunlight, store it and put it back in the power grid when needed.

### **Integrated River Management**

TVA has remained focused on its mission to manage the nation's seventh-largest river system. TVA works constantly to balance energy production, navigation, flood control, recreation and water supply to provide multiple benefits from its management of the river system and associated public lands. In an average year, TVA prevents about \$240 million in flood damage in the Tennessee Valley region and along the Ohio and Mississippi rivers.

### **TVA Customers**

TVA delivers electricity to three main customer groups—local utilities (distributors of TVA power), directly served customers and off-system customers. A priority for TVA is to serve customers by meeting their needs in a reliable, responsible manner. Partnership with the distributors of TVA power is crucial in the delivery of low-cost, reliable power to end-use customers.

Distributors of TVA power comprise the bulk of TVA's customer base and are the backbone of the region's power distribution system. Accounting for roughly 81 percent of total

TVA sales and 87 percent of total TVA revenue, the distributors consist of municipally-owned and consumer-owned utilities. TVA generates and delivers electricity to the local utilities, which deliver electricity to their residential, commercial and industrial end-use customers. Municipal distributors comprise the largest block of TVA customers. Many of the consumer-owned cooperative utilities were formed to bring electricity to then-sparsely populated rural, remote areas of the Tennessee Valley region.

Large industries and federal installations, such as Oak Ridge National Laboratory, that buy electricity directly from TVA, account for 19 percent of total sales and 13 percent of TVA's total revenue. The remainder of TVA's sales and revenue comes from off-system customers that buy power from TVA on the interchange market.

TVA power contracts govern the relationships between TVA and the distributors of TVA power, including the pricing structure under which power is sold. These contracts provide for distributors' total power requirements, meaning TVA agrees to generate and deliver enough electricity to meet the distributors' full electric load, including reserves, both now and in the future.

### 1.1.3 Future – A New Era

In the face of challenging economic conditions, tougher emissions standards, an aging generating fleet and emerging customer needs, TVA needed to examine its strategic direction. In August 2010, TVA President and Chief Executive Officer, Tom Kilgore, announced a renewed TVA vision. The renewed vision is the first step toward establishing a new strategic direction for TVA.

TVA's renewed vision – to become one of the nation's leading providers of low-cost and cleaner energy by 2020 – will help the region and the nation achieve a cleaner energy future. The vision has three components:

1. To be the nation's leader in improved air quality
2. To be the nation's leader in increased nuclear production
3. To be the Southeast's leader in increased energy efficiency

In support of the renewed vision, TVA plans to idle nine coal-fired units (1,000 MW) over the next five years.

TVA will work to achieve this vision while being dedicated to improving its core business of low rates, high reliability and responsibility.

## 1.2 Looking Ahead

### 1.2.1 Bridging the Gap

TVA undertook the IRP process at a critical time. Nationally, there is a consensus that energy should be produced in cleaner ways—a direction that TVA has embraced in specific goals set forth in its environmental policy and renewed vision. Achieving these goals and keeping electricity affordable is a significant challenge. Analyses of stakeholder concerns, operational constraints and the trade-offs necessary to develop an acceptable long-term solution make the challenge particularly difficult, especially when coupled with the recovering economy and regulatory uncertainty facing the utility industry.

TVA last completed an Integrated Resource Plan, entitled *Energy Vision 2020* (EV2020), in 1995. EV2020 was a comprehensive assessment of alternative strategies developed for meeting future electricity needs through 2020 based on projected future conditions in the Tennessee Valley region.

While EV2020 accurately reflected the challenges, forecasts and opportunities at the time of publication, significant changes in the industry and changing customer demand called for a fresh analysis and plan.

This IRP was built from the foundation established in EV2020, incorporates changes that have transpired and will ensure the best possible solutions are implemented for TVA and its stakeholders.

### 1.2.2 Challenges Facing TVA

The size of TVA's power system and its influence on the region's economy, environment and resources make integrated resource planning significant to the public it serves. The competitive success of businesses and industries, as well as the ability to sustain and improve the quality of life for the millions served by TVA electricity, are significantly impacted by the decisions that will be guided by the results of the IRP process.

Electricity cannot yet be stored economically in meaningful quantities, so the supply of electricity must constantly be balanced with the demand. Therefore, electricity providers such as TVA must project the future demand and take the necessary steps to meet the forecasted demand. This involves the construction of generating capacity and the procurement of purchased power. Given the long lead times required to plan, permit and build generating facilities, demand forecasts involve 10- to 20-year outlooks.

Effective transmission is usually a cost-effective means of providing power system flexibility and reliability. However, potential effects on water, vegetation, wildlife and other environmental concerns make this an option that must be carefully evaluated.

Transmission expansion also requires long lead times and is a vital component in meeting forecasted demand. It is particularly necessary to acquire renewable energy, which tends to be located outside TVA's service area and is intermittent in nature.

In addition to building generating facilities and purchasing power from independently owned facilities through long-term contracts, TVA and distributors of TVA power can meet demand by deploying programs that encourage energy efficiency and reduce demand during daily periods of peak power use. These activities entail associated uncertainty and risk that must be managed to ensure reliability.

Designing and executing an effective strategy is a major planning challenge for all electric utilities. TVA meets the challenge by working with stakeholders to design a long-term resource plan that recognizes the choices that must be made to achieve a common goal of an affordable, clean and reliable supply of electricity.

## **1.3 Integrated Resource Planning**

### **1.3.1 Role of the Integrated Resource Plan**

Integrated resource planning is a crucial element for success in a constantly changing business and regulatory environment and is based on comprehensive, holistic and risk-aware analysis. The integrated approach considers a broad spectrum of feasible supply- and demand-side options and assesses them against a common set of planning objectives and criteria, including environmental impact.

The IRP objective is to help meet future customer demand by identifying the need for generating capacity and determining the best mix of resources to fill the need. The capacity gap is the difference between the projected firm (or known) requirements and existing firm supply.

The following strategic principles guided development of this IRP:

- Mitigate risk at a reasonable cost
- Balance generation resources to reduce supply and price risk
- Balance production and load
- Minimize environmental impacts of the portfolios
- Provide incentives to customers to optimize the load factor
- Provide flexibility to adapt to changing market conditions and future uncertainty

- Improve credibility and image through a comprehensive, balanced and transparent approach
- Integrate perspectives of internal and external stakeholders throughout the process

### 1.3.2 Integrated Resource Planning Process

Instead of one correct answer, this IRP entails a robust, “no-regrets” plan that balances competing objectives while reducing costs and risks and retaining the flexibility to respond to future risks and opportunities.

This IRP was framed to assess future demand and the cost and quantity of future supply options. Therefore, forecasts of various inputs (e.g., inflation, commodity prices and environmental regulations) were simultaneously evaluated. Constraints (e.g., corporate strategic and environmental objectives) were considered as different combinations of strategies and futures were analyzed and evaluated. Afterward, additional extensive computer modeling, analyses, public input, reviews and dialogue with TVA’s leadership led to the consideration of strategic alternatives.

TVA recognizes that the future is uncertain and that forecasts and stakeholder concerns can change. To take advantage of updated information and encourage ongoing public involvement in defining the region’s future energy needs, TVA is committed to begin the next IRP effort by 2015.

“No-regrets” is a plan that best balances competing objectives while reducing costs and risk and retaining the flexibility to respond to future risk and opportunities as they unfold.

## 1.4 IRP Deliverables

### 1.4.1 Draft and Final IRP Documents

The Draft IRP was released Sept. 15, 2010, for public review and comment. It provided a broad look at all options considered by TVA and the long-term implications of various business strategies.

The final IRP recommends a robust, flexible strategy that supports TVA’s renewed vision. The Recommended Planning Direction entails an outcome that balances costs, efficiency in electricity generation, reliability, energy efficiency, environmental responsibility and competitive prices for customers.

## 1.4.2 Natural Resource Plan

Since the June 15, 2009, publication of the IRP Notice of Intent, TVA determined that planning processes for the Environmental Policy goals that are not closely tied to energy production and consumption would be better addressed in a separate study.

Therefore, a Natural Resource Plan will evaluate the implementation of TVA's reservoir lands planning, natural resource management, water resources management and recreation processes and strategies. The content of the accompanying environmental impact statement will be consistent with TVA's Environmental Policy, TVA's Land Policy, the previous Shoreline Management Initiative Environmental Impact Statement and the Reservoir Operations Study Environmental Impact Statement.

## 1.4.3 Draft and Final Environmental Impact Statement

As a federal agency, TVA must comply with the National Environmental Policy Act of 1992 (NEPA). The act requires all federal agencies to consider the impact of its proposed actions and alternatives on the environment before making decisions with potential environmental impacts. The NEPA process provides a structured means for analyzing competing options and for involving the public in TVA's decision-making process. The primary product from the NEPA process is an environmental impact statement (EIS).

Even though the IRP and the associated EIS were combined into one document for EV2020, they are published as two separate documents for this IRP. The components of the associated EIS were incorporated into the overall integrated resource planning process. This provided a preferred resource plan that focuses on reducing costs and risk while improving TVA's environmental performance.

TVA chose to develop a programmatic level EIS as opposed to a project- or site-specific document because of the broad nature of integrated resource planning.

As part of the final IRP, TVA prepared an associated EIS in accordance with the NEPA 42 USC §§ et seq., Council on Environmental Quality regulations for implementing NEPA.

## 1.5 IRP Outline

This IRP consists of nine chapters and six appendices.

Chapter 1	TVA's Environmental and Energy Future – history of TVA, TVA overview, looking ahead, the IRP's role and purpose, the goals and objectives of this IRP, the overall process, release of the Draft IRP and the associated EIS, incorporation of public input and IRP deliverables
Chapter 2	IRP Process – seven distinct steps of the IRP process and how public participation was incorporated in each step
Chapter 3	Public Participation – public participation components during this IRP process and summary of the valuable input received
Chapter 4	Need for Power Analysis – TVA's need for power analysis, TVA power supply, base-load, intermediate, peaking, storage resources and TVA's generation mix
Chapter 5	Energy Resource Options – potential supply- and demand-side options for future TVA power portfolios
Chapter 6	Resource Plan Development and Analysis – overview of scenario and strategy development, key uncertainties that defined the scenarios, planning strategies, portfolio development, planning strategy scorecard (including ranking and strategic metrics), scorecard calculation and planning strategy evaluation
Chapter 7	Draft Study Results – results from the Draft IRP analysis which includes the identification of the preferred planning strategies
Chapter 8	Final Study Results and Recommended Planning Direction – results from the final IRP study which includes the identification of the Recommended Planning Direction
Chapter 9	Next Steps – identifies next steps and recommendations
Appendix A	Method for Computing Environmental Metrics – process and results from the analysis used to determine the impact of the Recommended Planning Direction on the TVA environment
Appendix B	Method for Computing Economic Impact Metrics – process and results from the analysis used to determine the impact of the Recommended Planning Direction on the TVA economy
Appendix C	Energy Efficiency and Demand Response – process used to develop EEDR portfolio used in the Draft IRP and final analysis for the Recommended Planning Direction
Appendix D	Development of Renewable Energy Portfolios – process used to develop the renewables portfolio used in the Draft IRP and the final analysis for the Recommended Planning Direction
Appendix E	Draft IRP Phase Expansion Plan Listing – 20-year expansion plans for each strategy evaluated during the Draft IRP analysis
Appendix F	Stakeholder Input Considered and Incorporated – comments were reviewed in detail and input was incorporated





*TVA was created to be a model of benefits of integrated resource management. To fulfill its mission requires a delicate balance of energy, environmental and economic development.*

---

<b>2</b>	<b>IRP Process</b>	<b>35</b>
2.1	Develop Scope	35
2.2	Develop Inputs and Framework	36
2.3	Analyze and Evaluate	37
2.4	Present Initial Results	38
2.5	Incorporate Input	39
2.6	Identify Recommended Planning Direction	39
2.7	Approval of Recommended Planning Direction	39



*Water spills over the Fort Loudon Dam in Loudon County, Tennessee.*



*The once-endangered Snail Darter, native to rivers of the Tennessee Valley, is now thriving due in large part to the conservation efforts of TVA.*



*Enthusiasts enjoy white-water rafting down the Ocoee River in Polk County, Tennessee.*

## The IRP Process



## 2 IRP Process

The IRP process to develop the Recommended Planning Direction was extensive. More than two years were dedicated to discuss needs, wants, advantages, challenges, constraints, trade-offs and compromises required to develop a plan of this magnitude. A wide range of stakeholders were involved in this process, representing the general public, distributors of TVA power, industry groups, academia and research professionals and TVA leadership.

This IRP represents a significant investment by TVA to understand the needs of the people it serves and how to address those needs in a cost-effective, reliable manner. TVA believes in this process and has committed to begin the next IRP effort by 2015.

To fully appreciate the scope of TVA's IRP process, the road to producing the final IRP must be understood. TVA's IRP process consisted of the following seven distinct steps:

1. Develop scope
2. Develop inputs and framework
3. Analyze and evaluate
4. Present initial results
5. Incorporate input
6. Identify Recommended Planning Direction
7. Approval of Recommended Planning Direction

Public participation was included in each step of the process and is explained in more detail in Chapter 3 – Public Participation. The process for steps two through six are described in more detail in Chapter 6 – Resource Plan Development and Analysis. Step seven, approval of Recommended Planning Direction, is described in Chapter 8 – Final Study Results and Recommended Planning Direction.

### 2.1 Develop Scope

In June 2009, TVA began a public scoping period. Public scoping comments addressed a wide range of issues, including the nature of the integrated resource planning process, preferences for various types of power generation, increased energy efficiency and demand response (EEDR) and the environmental impacts of TVA's power generation. The comments received helped TVA identify issues that were important to the public.

## 2.2 Develop Inputs and Framework

When faced with a challenge like planning the power system for the next 20 years, a “no-regrets” decision-making framework is generally the best approach. A “no-regrets” framework is one in which decision makers utilize the best possible information available to them. This allows them to weigh the likelihood and consequence of the risks and challenges that could surface so that decisions have a high likelihood of being sound in many possible states of the world. In order to facilitate a “no-regrets” decision-making framework, TVA employed a scenario planning approach in the development of this IRP.

Scenario planning provides an understanding of how near-term and future decisions would change under different conditions. This allows for impacts on different courses of action to be effectively analyzed. These actions are then assessed to determine their performance in each and every scenario as well as their relative performance in all scenarios.

Future decisions that produce similar results across different conditions may imply that these decisions provide more predictable outcomes, whereas decisions that result in major differences are less predictable and therefore more “risky.”

TVA began this process in collaboration with the Stakeholder Review Group (SRG) and developed a set of resource planning strategies that would be analyzed within the framework of this IRP.

These resource strategies represent decisions that TVA has control over (e.g., asset additions, idling coal-fired capacity, integration of more flexible resource options), whereas the scenarios, which are described in more detail below, represent aspects that TVA has no control over (e.g., more stringent regulations, fuel prices, construction costs).

Different mixes of resource options (i.e., supply-side generating technologies and demand-side programs) formed the framework for distinct resource planning strategies and were designed to allow for flexible resource selection over the intended duration of the IRP planning horizon. Significant expert input was incorporated to ensure the feasibility of the elements of each planning strategy.

Strategies represent future business decisions that TVA can make and has full control over.

Scenarios represent future conditions that TVA cannot control.

A portfolio is the intersection of a strategy and a scenario and represents a multiyear resource plan detailing how TVA intends to meet future load growth.

To facilitate a “no-regrets” analysis of the strategies developed above, TVA developed a series of scenarios to analyze the various outcomes of the resource planning strategies.

These scenarios differed from each other in several key areas, such as projected customer demand, future economic conditions, fuel prices, regulatory frameworks and numerous other key drivers. Like the strategies, these scenarios were also developed in collaboration with the SRG.

The goal of defining scenarios was to identify sets of potential events, forecasts and other important drivers that TVA cannot directly control, but that would have a direct impact on TVA's ability to achieve the goals of this IRP.

One way to think of scenarios is as miniature models of the future. In one model, the economy might stagnate, prices drop and electricity demand remains flat. In another, strong economic recovery could pressure fuel prices, drive interest rates higher, lead to rapid recovery in electricity sales and long-term demand growth and put pressure on the cost of building generating assets. Both scenarios present dramatically different challenges to any one resource strategy.

Therefore, the key to sound resource planning is designing a strategy that performs reasonably well in all scenarios, regardless of which scenario best captures the actual state of the world in the future.

Seven scenarios were initially developed. Each resource planning strategy was tested within the seven scenarios for performance. The seven scenarios and five strategies are explained in detail in Chapter 6 – Resource Plan Development and Analysis.

### **2.3 Analyze and Evaluate**

After the scenarios and strategies were developed, detailed analysis was undertaken for each planning strategy within each of the scenarios. This phase of the IRP employed industry standard capacity expansion planning and production cost modeling software to develop total cost estimates of each planning strategy in each scenario. Other metrics, including near-term rate impacts, risks and environmental footprint, were also developed using model outputs.

TVA analyzed the hypothetical performance on the cost, risk and environmental footprint of each strategy based on the assumption that the future unfolds in a manner that resembles the specifics of each scenario.

A total of 35 unique capacity expansion plans or “portfolios” were developed for each of the seven scenarios specific to each of the five strategies. Each portfolio represented a long-term, least-cost plan of different asset mixes (both supply- and demand-side assets) that can be deployed to meet the power needs of the region.

Each portfolio was ranked using selected metrics within the framework of a consistent, standard scorecard. Special care was also taken to note not only those portfolios that performed best overall, but also those portfolios that performed well in most states of the future (a key requirement for a “no-regrets” portfolio development). The metrics used were chosen based on their importance and centrality to TVA’s mission and included measures for capturing financial (e.g., cost and risk), economical and environmental impacts.

The ranking was not intended to identify any single portfolio as “the best” in recognition of the fact that a portfolio with the highest overall score may not have performed as well as other portfolios across multiple scenarios. In other words, portfolios were analyzed for their robustness under stress across multiple scenarios, as opposed to overall performance in total. This was an important step since metrics alone could signify good performance in one or two future states of the “world,” but average or poor performance in all others.

The process of a consistent analytical ranking exercise provided TVA’s Board of Directors and leadership team with information that was used to help conduct evaluations of decisions pertaining to TVA’s existing generation fleet and available generation options. It also facilitates TVA’s ultimate adoption of a long-term resource planning strategy that will serve as a foundation for TVA’s near-term business and financial plans.

#### **2.4 Present Initial Results**

For this phase of the IRP process, TVA presented the results of the Draft IRP and the associated EIS to both internal TVA management and the general public. The Draft IRP outlined alternative strategies that TVA considered, but did not include an exhaustive list of all strategies that were analyzed. However, it did include a sampling of unique strategies that represent a broad spectrum of viable options for implementation.

As in the scoping period, TVA encouraged public comments on the Draft IRP and the associated EIS. The comments received enabled TVA staff to identify public concerns and recommendations concerning the future operation of the TVA power system.

The public comment period began in October 2010 with the EPA's publication of the Notice of Availability of the Draft IRP and associated EIS in the Federal Register.

During the public comment period, TVA held five public meetings to provide information about this IRP as well as the opportunity to provide input to TVA staff.

TVA addressed all substantive comments received during the public comment period in the final IRP and the associated EIS.

## **2.5 Incorporate Input**

The public comment period ended Nov. 15, 2010. TVA received approximately 500 comments. All comments were reviewed in detail and synthesized into key points that required a response. Comments were logged into a comment management database for tracking purposes and assigned to an appropriate subject-matter expert. An extensive inventory of responses is included in the associated EIS.

## **2.6 Identify Recommended Planning Direction**

After review of the public comments received and additional analysis, TVA staff identified a Recommended Planning Direction to present to TVA's Board of Directors. The Recommended Planning Direction is based on a number of key criteria, as mentioned above, and is intended to serve as a guide for implementation of TVA's planning objectives.

## **2.7 Approval of Recommended Planning Direction**

No sooner than 30 days after the Notice of Availability of the associated EIS is published in the Federal Register, the TVA Board of Directors will be asked to approve the Recommended Planning Direction. The TVA Board of Directors' decision will be described and explained in a Record of Decision.



*Public input was a vital part of developing TVA's Integrated Resource Plan.*



<b>3 Public Participation</b>	<b>43</b>
3.1 Public Scoping Period	44
3.1.1 Public Meetings	45
3.1.2 Written Comments	46
3.1.3 Scoping Questionnaire	47
3.2 Analysis and Evaluation Period	47
3.2.1 Stakeholder Review Group	48
3.2.2 Public Briefings	49
3.2.3 Phone Survey	50
3.3 Draft IRP Public Comment Period	52
3.3.1 Public Meetings	52
3.3.2 Webinars	53
3.3.3 Written Comments	53
3.4 Public Input Received During the IRP Process	54
3.5 Response to Public Input and Comments	57



*Through public meetings, webinars and various forms of gaining insight from the people we serve, TVA was able to integrate their ideas and concerns into the plan.*

## Stakeholder Review Group

**Lance Brown**, Executive Director  
Partnership for Affordable Clean Energy  
Montgomery, Alabama

**Dana Christensen**, Associate Director  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee

**Ryan Gooch**, Director, Energy Policy  
Tennessee Dept. of Economic & Community Development  
Nashville, Tennessee

**Louise Gorenflo**, TVA Committee Chair  
Sierra Club  
Crossville, Tennessee

**Richard Holland**, Vice President  
Tennessee Paper Council  
Nashville, Tennessee

**Tom King**, Director for Energy Efficiency & Electricity Technologies Program  
Oak Ridge National Laboratory  
Oak Ridge, Tennessee

**George Kitchens**, General Manager  
Joe Wheeler Electric Membership Corporation  
Trinity, Alabama

**Henry List**, Deputy Secretary  
Kentucky Energy and Environment Cabinet  
Frankfort, Kentucky

**David McKinney**, Environmental Services Division Chief  
Tennessee Wildlife Resource Agency  
Nashville, Tennessee

**Jerry Paul**, Distinguished Fellow on Energy Policy  
Howard Baker, Jr. Center for Public Policy  
Knoxville, Tennessee

**David Reister**  
Environmental Stakeholder  
Knoxville, Tennessee

**Jan Simek**, Professor of Science  
University of Tennessee  
Knoxville, Tennessee

**Jack Simmons**, President and CEO  
Tennessee Valley Public Power Association  
Chattanooga, Tennessee

**Stephen Smith**, Executive Director  
Southern Alliance for Clean Energy  
Knoxville, Tennessee

**Lloyd Webb**  
Tennessee Valley Industrial Committee  
Cleveland, Tennessee

**Deborah Woolley**, President  
Tennessee Chamber of Commerce and Industry  
Nashville, Tennessee

*TVPPA believes the overall process TVA used in conducting the IRP was sound, transparent and that it afforded opportunity for external input to TVA from the public and the other stakeholders.*

— Jack Simmons, President and CEO  
Tennessee Valley  
Public Power Association

*TVA's 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.*

— Stephen Smith, Executive Director  
Southern Alliance for Clean Energy

*TVA wanted to demonstrate transparency by including the public as much as possible during the IRP process. For example, the need for a Stakeholder Review Group was an outcome of the seven public meetings held last summer.*

— Randy Johnson, Manager  
Integrated Resource Planning  
Tennessee Valley Authority

## 3 Public Participation

TVA is the largest public power company in the nation. An objective of this IRP was to understand the needs of the people it serves and how to address those needs in a cost-effective, reliable manner. Since the needs of the people vary, some people are more concerned about the cost of power, some on reliability, while others are concerned about environmental impacts. Therefore, it is TVA's ultimate responsibility to balance these competing needs as it plans for the future.

A transparent and participatory approach was utilized in the development of this IRP. Many opportunities were available to the public that influenced the development – and ultimately the outcome – of this IRP. For example, public briefings and meetings were held across the region, and an advisory review group was created. The following key objectives of public involvement were:

- Engage numerous stakeholders with differing viewpoints and perspectives throughout the entire IRP process
- Incorporate public opinions and viewpoints into the development of the IRP, including activities and opportunities for stakeholders to review and comment on various inputs, analyses and options considered
- Encourage open and honest communication in order to facilitate a sound understanding of the process
- Provide multiple communication channels to provide several ways for members of the public to learn about the IRP process and to provide input

TVA involved the public in each critical step of the IRP process. The involvement helped TVA identify the most effective ways to serve the people of the Tennessee Valley region. Public participation was actively solicited three times during the IRP process.

1. Public scoping period
2. Analysis and evaluation period
3. Draft IRP public comment period

### 3.1 Public Scoping Period

The TVA IRP process began with a 60-day public scoping period June 15, 2009. TVA announced the start of the process in newspapers throughout the region via media releases and on TVA's website.

In addition, the EPA published the official EIS Notice of Intent in the Federal Register. This notice is required by the NEPA guidelines which require federal agencies such as TVA to prepare an EIS whenever its actions, such as the development of an IRP, have the potential to affect the environment.

During the scoping period, TVA disseminated a broad range of information to the public, including the reasons for developing an IRP, what it would focus on, the process for how an IRP is developed and how the results will be used to guide strategic decision making. Public scoping provided an early and open process to ensure:

- Stakeholder issues and concerns were identified early and properly studied
- Reasonable alternatives and environmental resources were considered
- Key uncertainties that could impact costs or performance of certain energy resources were identified
- Input received was properly considered and would lead to a thorough and balanced final IRP

TVA also reiterated the need to have a balanced approach when considering the tradeoffs of one energy resource for another. While developing this IRP, TVA sought public input on a variety of issues and asked the following questions:

- How will any changes affect system reliability and the price of electricity?
- Should the current power generation mix (e.g., coal, nuclear power, natural gas, hydro, renewable) change?

#### Public Comment Process:

##### Step 1 - Public Scoping Period

- Public Meetings
- Written Comments
- Scoping Questionnaire

##### Step 2 - Analysis and Evaluation Period

##### Step 3 - Draft IRP Public Comment Period

- Should energy efficiency and demand response be considered in planning for future energy needs?
- Should renewables be considered in planning for future energy needs?
- How can TVA directly affect electricity usage by consumers?

The scoping period helped shape the initial development and framework of this IRP. TVA used the input received to determine what resource options should be considered to meet future demand. TVA used two primary techniques, public meetings and written comments, to collect public input during the scoping period.

### 3.1.1 Public Meetings

During the scoping period, TVA held seven public meetings across the Tennessee Valley between July 20 and Aug. 6, 2009 (Figure 3-1). The meetings were conducted in an informal, open house format to give participants an opportunity to express concerns, ask questions and provide comments. Exhibits, fact sheets and other materials were available at each public meeting to provide information about the Draft IRP and the associated EIS.

Date	Location
July 20, 2009	Nashville, Tenn.
July 21, 2009	Chattanooga, Tenn.
July 23, 2009	Knoxville, Tenn.
July 28, 2009	Huntsville, Ala.
July 30, 2009	Hopkinsville, Ky.
Aug. 4, 2009	Starkville, Miss.
Aug. 6, 2009	Memphis, Tenn.

Figure 3-1 – Public Scoping Meetings

Attendees included members of the general public, representatives from state agencies and local governments, TVA’s congressional delegation representatives, distributors of TVA power, non-governmental organizations and other special interest groups.

Approximately 200 attended the public scoping meetings. TVA subject-matter experts attended each meeting to discuss issues and respond to questions about the IRP planning process and TVA’s power system and programs.

### 3.1.2 Written Comments

During the scoping period, TVA accepted comments via email, fax, letters, TVA's website, public scoping meetings and a scoping questionnaire. At the public scoping meetings, verbal comments were recorded by court reporters and attendees were able to submit written comments by logging onto TVA's website using TVA supplied computers.

Overall, TVA received approximately 1,000 comments from the following communication tools:

- Scoping questionnaire
- Email
- TVA's website
- Public meetings

Comments were received from four federal agencies and 20 state agencies representing six of the seven TVA region states. Some of these responses included specific comments, while others stated they had no comments, but asked to review the Draft IRP and the associated EIS. Figure 3-2 shows the distribution of scoping comments by geographic area.

Some agencies, organizations and individuals provided comments specific to TVA's natural and cultural resource stewardship activities. These comments were not included in the scoping report because they focused on another planning process – TVA's Natural Resource Plan (NRP) and associated EIS. The full scoping report on this IRP as well the NRP can be found on TVA's website.

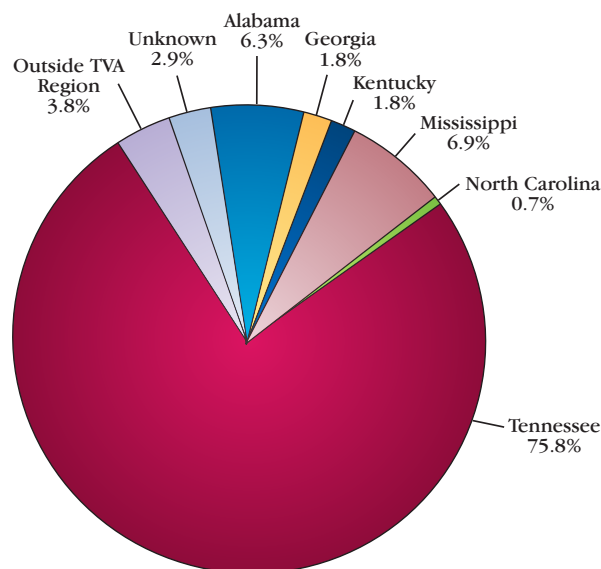


Figure 3-2 – Distribution of Scoping Comments by Geographic Area

### 3.1.3 Scoping Questionnaire

An 11-part scoping questionnaire was distributed at public meetings and made available on TVA's website. The questionnaire was developed to elicit public opinion on TVA's future generation and efficiency options. At least part of the scoping questionnaire was completed by 845 people, and 640 of the respondents answered the write-in questions as well as the multiple-choice questions.

Many of those who completed the questionnaire expressed a willingness to take various measures to reduce their energy use or pay higher rates for cleaner energy. The willingness to undertake some measures increased with the availability of financial incentives.

After further analysis, the results of the questionnaire indicated that the findings were not statistically significant and the survey population was not fully representative of the entire Tennessee Valley region. Therefore, TVA decided to conduct a phone survey of approximately 1,000 individuals across the entire region in the summer of 2010.

### 3.2 Analysis and Evaluation Period

The analysis and evaluation period took key themes and results identified from the scoping period and developed the framework for analysis and evaluation. The findings were considered when TVA developed the range of strategies for IRP analysis.

During this phase, TVA used the following three techniques to collect public input:

1. Stakeholder Review Group
2. Public briefings
3. Phone survey

#### Public Comment Process:

Step 1 - Scoping Period

Step 2 - Analysis and Evaluation Period

- Stakeholder Review Group
- Public Briefings
- Phone Survey

Step 3 - Draft IRP Public Comment Period



**3.2.1 Stakeholder Review Group**

Early in the IRP process, TVA recognized it would be difficult to get specific and continuous input from the public beyond the scoping period. To obtain more in-depth, ongoing input from the public, TVA established an advisory Stakeholder Review Group (SRG) in July 2009.

The formation of this diverse 16-member review group (listed on page 42) was the cornerstone of the public input process. It consisted of representatives from business and industry, state agencies, government, distributors of TVA power, academia, special interest groups and civic organizations. In addition to providing their individual views to TVA, SRG members represented their constituency and reported to them on the IRP process.

The SRG met approximately every month with TVA. Ten meetings were held prior to the release of the Draft IRP and the associated EIS at various locations throughout the region. Five additional meetings were held between the release of the Draft IRP and approval of the Recommended Planning Direction to facilitate ongoing feedback and guidance for this IRP. Figure 3-3 shows the dates and locations of all the SRG meetings.

Date	Location
July 29, 2009	Nashville, Tenn.
Aug. 18, 2009	Knoxville, Tenn.
Sept. 24, 2009	Chattanooga, Tenn.
Oct. 22 & 23, 2009	Chattanooga, Tenn.
Dec. 10 & 11, 2009	Nashville, Tenn.
Feb. 17, 2010	Knoxville, Tenn.
May 13, 2010	Knoxville, Tenn.
June 29, 2010	Murfreesboro, Tenn.
July 20 & 21, 2010	Chattanooga, Tenn.
Aug. 12, 2010	Chattanooga, Tenn.
Aug. 26, 2010	Chattanooga, Tenn.
Oct. 28, 2010	Knoxville, Tenn.
Nov. 18, 2010	Murfreesboro, Tenn.
Dec. 15, 2010	Chattanooga, Tenn.
Jan. 26, 2011	Knoxville, Tenn.
Feb. 24, 2011	Chattanooga, Tenn.

Figure 3-3 – Stakeholder Review Group Meetings

The meetings were designed to encourage dialogue on all facets of the IRP process, and to facilitate information sharing, collaboration and expectations for this IRP. Topics included energy efficiency best practices, TVA's power delivery structure, load and commodity forecasts and supply resource options.

The individual views of SRG members were collected on the entire range of assumptions, analytical techniques and proposed energy resource options and strategies. Given the diverse makeup of the SRG, there were a wide range of views on specific issues, such as the value of energy efficiency programs, environmental concerns and the appropriateness of some new technologies. Open discussions supported by the best available data facilitated better comprehension of the specific issues.

To increase public access and transparency to the IRP process, all non-confidential SRG meeting material (i.e., presentations, agenda and minutes) was posted on TVA's website. In addition, TVA developed an internal website specifically for SRG members to post information on and to request data from TVA staff.

### 3.2.2 Public Briefings

In addition to the public scoping and SRG meetings, TVA held four public briefings (Figure 3-4). The public briefings informed the general public of the IRP process.

Date	Location
Oct. 23, 2009	Chattanooga, Tenn.
Nov. 16, 2009	Chattanooga, Tenn.
Feb. 17, 2010	Knoxville, Tenn.
May 13, 2010	Knoxville, Tenn.

Figure 3-4 – Public Briefings

Participants had the option to attend in person or by webinar. The format of the public briefings included a brief presentation followed by a moderated Q&A session with the audience.

Topics discussed at the public briefings included an overview of the integrated resource planning process, resource options, development of scenarios and strategies and evaluation metrics.

The public briefings attendance averaged 15 to 20 in-person participants and approximately 30 to 40 participants by webinar. Videos of the briefings and presentation materials were posted on the IRP project website.

TVA also briefed the public on the IRP process through presentations given at local organizations, clubs and associations including the following:

- Association of Energy Engineers
- Tennessee Renewable Energy and Economic Development Council
- Chattanooga Engineers Club
- City of Chattanooga
- Chattanooga Green Spaces
- EPRI Environmental Aspects of Renewable Energy Interest Group Workshop
- Clean Energy Speakers Series at Georgia Tech
- Howard H. Baker, Jr. Center for Public Policy
- Technical Society of Knoxville

### 3.2.3 Phone Survey

To ensure an even wider representation of opinions on IRP choices were considered, TVA partnered with Harris Interactive to develop a statistically representative phone survey of approximately 1,000 Tennessee Valley residents. The customer phone survey was conducted during June and July 2010 for the following reasons:

- Determine primary power generation concerns among the Tennessee Valley residents (i.e., cost, reliability, use of renewables, etc.)
- Determine market potential for voluntary and financially incentivized energy efficiency programs
- Determine market potential of renewable programs, including Green Power Switch® and other existing or planned energy efficiency and demand response programs
- Estimate potential market pricing for renewable power programs, including the additional amounts Tennessee Valley residents are willing to pay each month for energy from renewable sources
- Assess Tennessee Valley residents' attitudes of and satisfaction with TVA, including analysis of the services that it provides to the Tennessee Valley

Survey results indicated that the Tennessee Valley residents have a favorable attitude of TVA, consider system reliability a critical component of utility services and want to see TVA focused on keeping prices affordable.

## Key findings included:

---

TVA quality of service	<ul style="list-style-type: none"><li>• 94 percent of respondents agreed that providing a reliable supply of electricity is very important in assessing TVA's quality of service</li><li>• 92 percent indicated that keeping electricity rates affordable is important</li></ul>
Meeting future energy needs	<ul style="list-style-type: none"><li>• 70 percent of respondents also deemed it very important for TVA to reduce air pollutants and emissions</li></ul>
Renewable energy	<ul style="list-style-type: none"><li>• 42 percent of respondents believed that adding different energy sources, such as solar and wind, into TVA resource portfolio should be emphasized the most to meet future energy needs</li><li>• 42 percent of respondents indicated they likely would pay more for renewable energy, with the following breakdown:<ul style="list-style-type: none"><li>• Those indicating they would definitely pay more would pay an average of \$12.60 per month to ensure that 10 percent of their energy comes from renewable sources</li><li>• This same group would pay an average of \$26.91 more per month to ensure that all of their energy is renewable</li><li>• Tennessee Valley residents indicating they would definitely or probably pay more were willing to pay \$11 to \$20 per month to reduce CO<sub>2</sub> emissions</li><li>• Opportunities exist for additional Green Power Switch<sup>®</sup> awareness among Tennessee Valley residents</li></ul></li></ul>
Biggest concerns related to electricity production	<ul style="list-style-type: none"><li>• Cost and billing</li><li>• Environmental impact</li><li>• Quality of power supply</li></ul>

---

**3.3 Draft IRP Public Comment Period**

After the Draft IRP was completed in the fall of 2010, TVA provided an opportunity for the public to provide comments and give input. Following the Sept. 15, 2010 publication of the Draft IRP with EPA, a 52-day comment period was provided to solicit input about the Draft IRP from the public.

Originally set to close Nov. 8, 2010, the 45-day comment period was extended an additional seven days to accommodate several external stakeholders’ requests. For this phase of the IRP process, TVA presented the results to both internal TVA stakeholders and the general public in the Draft IRP and the associated EIS.

**Public Comment Process:**

Step 1 - Scoping Period

Step 2 - Analysis and Evaluation Period

Step 3 - Draft IRP Public Comment Period

- Public Meetings
- Webinars
- Written Comments

TVA used the following three techniques to collect input during the Draft IRP:

1. Public meetings
2. Webinars
3. Written comments

**3.3.1 Public Meetings**

TVA had five meetings with the public across the Tennessee Valley region in October 2010 (Figure 3-5). These meetings gave the public an opportunity to present their views on the Draft IRP to TVA leadership and subject-matter experts.

Date	Location
Oct. 5, 2010	Bowling Green, Ky.
Oct. 6, 2010	Nashville, Tenn.
Oct. 7, 2010	Olive Branch, Miss.
Oct. 13, 2010	Knoxville, Tenn.
Oct. 14, 2010	Huntsville, Ala.

Figure 3-5 – Public Comment Period Meetings

TVA publicized the meetings and webinars by placing advertisements in major newspapers and issuing news releases prior to each meeting that many local newspapers carried. Before each of the meetings, TVA met with local reporters in each location who frequently write about TVA and the IRP process so that they, in turn, could write articles to help the public understand the IRP process and draft document.

Online advertising (i.e., announcements on TVA's Facebook page) was used to reach an even wider audience. TVA's website was also regularly updated with the latest news regarding the IRP process and logistics for each public meeting.

At each of these meetings, TVA presented an overview of the Draft IRP followed by a moderated Q&A session supported by a panel of TVA subject-matter experts. Attendees were able to address comments or questions to the panel. Attendees also had the option to submit written and verbal comments to a court reporter before or after the presentations. A transcript and video of each meeting was recorded. The presentation slides and video of the meeting in Bowling Green, Ky., and videos of each Q&A session were posted on the TVA's website.

TVA encouraged comments from the public on the Draft IRP and the associated EIS. Comments received enabled TVA staff to identify public concerns and recommendations concerning the future operation of the TVA power system. The public comments and TVA's responses are included in the associated EIS.

### **3.3.2 Webinars**

To encourage as much participation as possible, members of the public who were not able to attend public meetings were able to participate by webinar. Attendees registered in advance and were able to access the presentation and participate in the Q&A session from personal computers.

### **3.3.3 Written Comments**

During the 52-day public comment period, comments were submitted via TVA's website, email, U.S. mail and fax. Comments and questions recorded at each of the public meetings were also considered.

In all, TVA received approximately 500 responses from a multitude of individuals, organizations and agencies. These responses contained 748 comments of which 372 were unique and addressed in the associated EIS. A general summary of unique comments received during the public comment period on the Draft IRP can be seen in Figure 3-6.

Method of Comment	Number Received
Email	38
Online comment form	104
Webinar comment/question from IRP meetings	16
Oral comment/question from IRP meetings	30
Letters	16
Form Letters (pre-printed post cards)	297
Total	501

Figure 3-6 – Type of Responses Submitted

The following organizations and agencies submitted comments:

- Environmental Protection Agency
- Natural Resource Defense Council
- Southern Alliance for Clean Energy
- Sierra Club
- Earth Justice
- Distributors of TVA power
- State agencies
- Tennessee Valley Public Power Association
- Industry groups (i.e., solar energy, natural gas, etc.)

### 3.4 Public Input Received During the IRP Process

Public input received during the IRP process covered a wide spectrum of subjects. From public scoping to the comments received on the Draft IRP, the ongoing feedback assisted TVA in identifying the relevant concerns of the public with respect to resource planning. Input received during the IRP process also provided beneficial insight to common public perceptions of TVA programs and willingness to invest in certain resource options. For example, the SRG and public input encouraged TVA to consider larger renewable portfolio targets beyond current resource plans, resulting in consideration of portfolios of 2,500 and 3,500 MW.

Moreover, public input helped develop the framework for analysis and addressed a wide range of issues, including the cost of power, recommended resource options, the environmental impacts of different resource options and the integrated resource planning process. The following sections briefly summarize the issues raised with additional detail provided in the associated EIS.

## **Costs of New Capacity, Financing Requirements and Rate Implications**

Concerns about the ability of TVA to design, build and deliver major new capacity on time and within budget were expressed. Questions about the validity of construction cost estimates for new nuclear capacity were raised.

The public also expressed concerns about TVA's ability to fund future resource additions due to the \$30 billion limit on TVA's statutory borrowing authority. TVA's financing options to cover the costs of construction for major capital investments are limited to borrowing, increasing rates or other less traditional forms of financing. There were also concerns about potential impacts on short-term rates. However, some believed that higher rates may promote energy efficiency investments.

While a large number of people were opposed to any future price increases, a number of those who completed the scoping questionnaire expressed a willingness to pay \$1-\$20 more per month for TVA to increase generation from non-greenhouse gas emitting sources.

## **Recommended Energy Resource Options**

The public made recommendations about TVA's future supply- and demand-side resource options. TVA's future resource portfolio should:

- Avoid or minimize rate increases
- Minimize or reduce pollution and other environmental impacts
- Maximize reliability
- Contain a diversity of fuel sources



The following resources options were mentioned:

Nuclear expansion	<ul style="list-style-type: none"> <li>• Supported nuclear additions if implemented in a cost-effective, responsible way</li> <li>• Concerned with rising costs and nuclear waste issues related to additions to the nuclear portfolio</li> </ul>
EEDR initiatives	<ul style="list-style-type: none"> <li>• Pleased with the contribution of EEDR in the planning strategies retained in the Draft IRP</li> <li>• Comments regarding the target level of EEDR being studied and the potential for larger amounts of EE to displace new nuclear capacity</li> <li>• Uncertainty about cost, lost revenue impacts and program effectiveness; and questioned measurement and verification of benefits</li> </ul>
Renewable additions	<ul style="list-style-type: none"> <li>• Supported increased renewable generation (including wind, solar, locally-sourced biomass and low-impact hydro) as long as costs are competitive</li> <li>• Stated the need for a stronger commitment to developing renewables within the Tennessee Valley region, particularly solar, as opposed to imported wind power</li> <li>• Questioned system operational impacts caused by intermittent or off-peak resources (i.e., wind and solar)</li> </ul>
Idling coal-fired capacity	<ul style="list-style-type: none"> <li>• Commended TVA on the strategy for coal-fired capacity idling and to consider larger quantities of idled capacity</li> <li>• Concerned with the economic and environmental implications of idling certain coal-fired units</li> <li>• Concerned about TVA's risk exposure for pending carbon legislation and issues related to lead-time for positioning coal-fired assets for idling, retirement and/or return to service</li> </ul>
Energy storage	<ul style="list-style-type: none"> <li>• Recommended an increase in energy storage capability</li> </ul>
Natural gas	<ul style="list-style-type: none"> <li>• Supported additional natural gas-fired generation</li> </ul>

## **Environmental Impacts of Power System Operations**

A general concern about pollution was a frequently mentioned issue in regards to the TVA power system. Additionally, much of the public felt the issues with air pollutants, greenhouse gas emissions, climate change, spent nuclear fuel and coal combustion by-products were of high importance.

Many comments encouraged TVA to decrease its emissions of greenhouse gases while others questioned the human influence on climate change. The issue was also raised of the impacts of buying coal from surface mines, particularly mountaintop removal mines, and recommended that TVA stop this practice. The Kingston Fossil Plant ash spill in December 2008 was frequently mentioned.

## **The Integrated Resource Planning Process**

Several people addressed the IRP process. Their comments recommended that TVA continue to follow industry standard practices; enter the process without preconceptions about the adequacy of various resource options; be open and transparent throughout the planning process; treat energy efficiency and renewable energy as priority resources and address the total societal costs and benefits.

### **3.5 Response to Public Input and Comments**

Input received from the general public and stakeholders was a key part of the IRP process. Listening to different stakeholders' perspectives, viewpoints and sometimes competing objectives played a prominent role in choosing a Recommended Planning Direction for TVA. Appendix F – Stakeholder Input Considered and Incorporated provides examples on how key themes were incorporated into the IRP analysis.

*TVA is gearing up to meet the increased energy demands of growing cities throughout the Southeast, as evidenced by this photo of downtown Nashville at night.*

---



<b>4</b>	<b>Need for Power Analysis</b>	<b>61</b>
4.1	Estimate Demand	61
4.1.1	Load Forecasting Methodology	61
4.1.2	Forecast Accuracy	65
4.1.3	Forecasts of Peak Load and Energy Requirements	67
4.2	Determine Reserve Capacity Needs	69
4.3	Estimate Supply	70
4.3.1	Baseload, Intermediate, Peaking and Storage Resources	70
4.3.2	Capacity and Energy	72
4.3.3	TVA's Generation Mix	73
4.4	Estimate the Capacity Gap	76

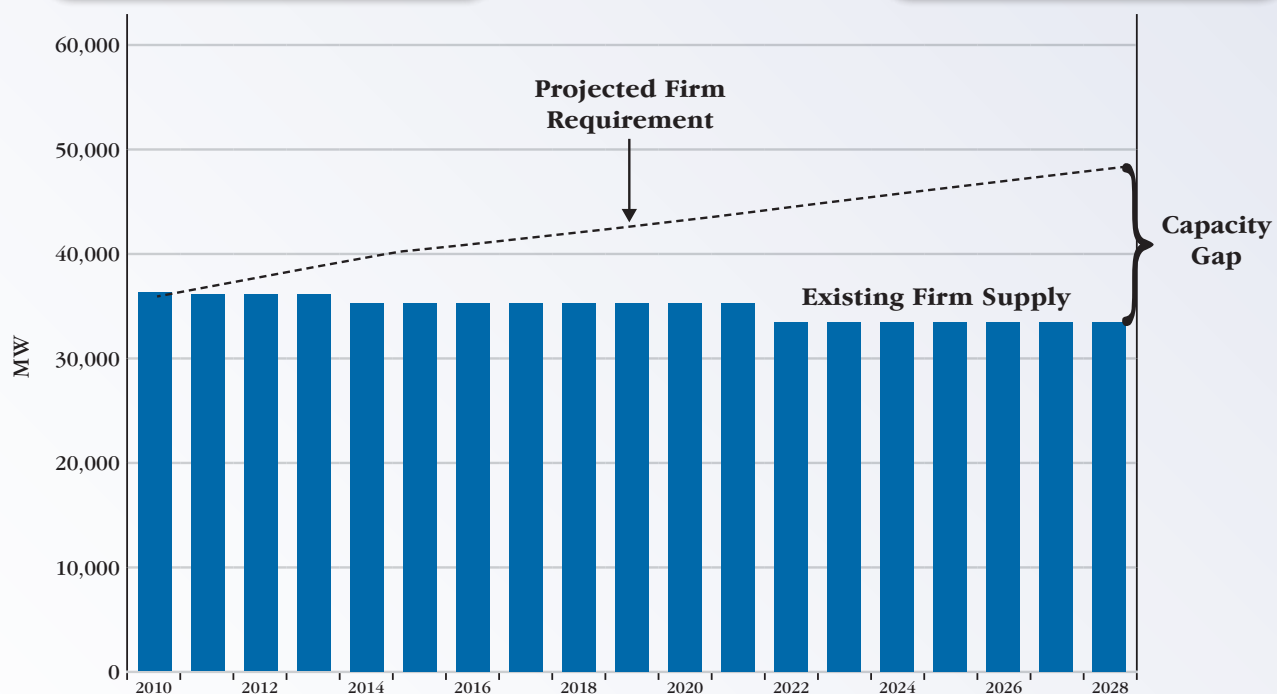


*Increasing TVA's production from cleaner energy sources like wind, solar and nuclear are at the core of the overall strategy for the future.*

## Estimating the Capacity Gap

Projected Firm Requirements are TVA's forecasted electricity requirements to meet demand over time.

Capacity Gap is the difference between total supply and total demand for electricity.



Existing Firm Supply is TVA's existing energy resources to meet projected electricity demand.

## 4 Need for Power Analysis

The need for power analysis determines the ability of TVA's existing energy resources to meet projected electricity demand. It defines the capacity gap which is the difference between supply and demand over the IRP study period. These needs will continue to vary from season to season, day to day and even minute to minute. For the purposes of this IRP, the need for power was analyzed through 2029.

The execution of this analysis included the following four steps:

1. Estimate demand
2. Determine reserve capacity needs
3. Estimate supply
4. Estimate capacity gap

$$\begin{array}{r} \text{Demand} \\ + \text{ Reserve Capacity} \\ - \text{ Supply} \\ \hline \text{Capacity Gap} \end{array}$$

### 4.1 Estimate Demand

Determination of a need for power begins with long-term forecasts of the growth in demand for electricity, both in terms of electricity sales to the end-user and the peak demands those end-users place on the TVA system. These forecasts were developed from individual, detailed forecasts of residential, commercial and industrial sales, which served as the basis for all resource and financial planning activities. Historical forecast accuracy was monitored to ensure errors in data or methodology were quickly identified and fixed. A range of forecasts (high, expected and low) were also generated to ensure that TVA's plans were not too dependent on the accuracy of a single forecast. The following sections provide more detail on the processes used to develop the forecasted demand.

#### 4.1.1 Load Forecasting Methodology

TVA's load forecasting is a complex process that starts with the best available data and is carried out using both econometric (statistical economic) and end-use models. TVA's econometric models link electricity sales to several key economic factors in the market, such as the price of electricity, the price of competing energy source options and the growth in overall economic activity. Specific values for key variables were used to develop forecasts of sales growth in the residential and commercial sectors, as well as in each industrial sector. Underlying trends within each sector, such as the use of various types of equipment or processes, played a major role in forecasting sales.

To capture these trends, along with expected changes in the stock and efficiency of equipment and appliances, TVA used a variety of end-use forecasting models. For example, in the residential sector, sales were forecasted for space heating, air conditioning, water heating and several other uses after accounting for important factors (i.e., changes in efficiency over time, appliance saturation and replacement rates and growth in the average size of the American home). In the commercial sector, a number of categories, including lighting, cooling, refrigeration and space heating, were examined with a similar attention to changes in important variables such as efficiency and saturation.

Since forecasting is inherently uncertain, TVA supplemented its modeling with industry analyses and studies of specific major issues that may have the potential to impact those forecasts. TVA also produced alternative regional forecasts based on different outcomes for key drivers (i.e., economic growth, population growth and economic behaviors) of some of TVA's largest wholesale customers. Two of these alternative forecasts, referred to as the "high-load" and "low-load" forecasts, defined a range of possible future outcomes with a high level of confidence that the true outcome will fall within this range. This ensured that TVA's resource planning took into account the variability that is the hallmark of year-to-year peak demand and energy sales.

Several key inputs were used as drivers of the long-term forecasts of residential, commercial and industrial demand. The most important of these were economic activity, the price of electricity, customer retention and the price of other sources of energy such as natural gas. These key inputs are described in the following sections.

### **Economic Activity**

Periodically, but at least annually, TVA produces a forecast of regional economic activity for budgeting, long-range planning and economic development purposes. These forecasts are based on national forecasts developed by internationally recognized economic forecasting services.

The economy of the TVA service territory has historically been more dependent on manufacturing than the United States on average. Industries such as pulp and paper, aluminum, steel and chemicals have been drawn to the region because of the wide availability of natural resources, access to a skilled workforce and the supply of reliable and affordable electricity. In recent years, regional growth has outpaced national growth as manufacturing activities have grown at a faster pace than non-manufacturing activities. However, this can also mean that in periods of recession, regional growth will contract faster and more sharply given this relatively higher degree of dependence on manufacturing. As evidenced by the ongoing recovery from the most recent recession, the regional economy tends to recover more quickly and robustly.

Future growth is expected to be lower than historical averages as a result of the impacts of the recent recession and ongoing recovery as well as the trend of declining U.S. manufacturing intensity. As markets for manufacturing industries have become global in reach, production capacity has moved overseas from the TVA region for many of the same industries. The decline in demand associated with these off-shore industries has been offset to some degree by the continued growth of the automobile industry in the Southeast over the last 20 years. The TVA region is expected to retain its comparative advantage in the automotive industry, as exemplified by the new Volkswagen auto plant under construction in Chattanooga, Tenn. However, reduced long-term prospects for the U.S. automotive industry will also have an impact on the regional industry.

Other impacts from the recent recession such as increased financial market regulation and tighter credit conditions may also work toward restraining economic growth. These impacts could continue in the long-term resulting in a slowdown in future economic growth for the TVA region and nation.

Despite the impacts of a slowed economy, population growth in the Tennessee Valley region continues to be strong. Most movement into the region is still primarily driven by economic opportunities in the contracting sectors and other expanding sectors in the region. Part of this growth is to serve the existing population (i.e., retail and other services), but, more importantly, a large part of this growth is related to export services that are sold to areas outside the region. Notable examples are corporate headquarters such as Nissan (automobile manufacturing) in Franklin, Tenn., Hospital Corporation of America (the largest private operator of hospitals in the world) in Nashville, Tenn. and FedEx, AutoZone, International Paper and Service Master in Memphis, Tenn.

In addition, the Tennessee Valley has become an attractive region for the growing ranks of America's retirees looking for a moderate climate and a more affordable region than traditional retirement locations and is increasingly fueled as Baby Boomers exit the workforce. The increase in the retiree population has a multiplier effect in the service sector, increasing the need for employees to meet growing demand.

## **Customer Retention**

In the last 20 years, the electric utility industry has undergone a fundamental change in most parts of the nation. In many states, an environment of regulated monopoly has been replaced with varying degrees of competition.

While TVA has contracts with the 155 distributors of TVA power, it is not immune to competitive pressures. The contracts allow distributors to give TVA notice of contract cancellation, after which they may procure power from other sources. Many of TVA's large



directly served customers have the option to shift production from plants in the TVA service area to plants in other utilities' service territories if TVA's rates become non-competitive.

The spring 2010 forecast expected TVA's average price of electricity to remain competitive with the rates of other utilities. As a result, the net impact of competition in the medium forecast is that TVA will retain the majority of its current customer base.

### **Price of Electricity**

Forecasts of the retail price for electricity are based on long-term estimates of TVA's total costs to operate and maintain the power system and are adjusted to include an estimate of the historical markups charged by distributors of TVA power. These costs, known in the industry as revenue requirements, are based on estimates of the key costs of generating and delivering electricity, including fuel, variable operations and maintenance costs, capital investment and interest. High and low electricity price forecasts are also derived using high and low values for these same factors after accounting for any relationships that may exist between variables.

### **Price of Substitute Fuels**

Considering electricity is a source of energy, the service derived from consuming electricity can also be obtained, where applications allow, using other sources of energy. If the price of electricity is not competitive with the price of other fuels that can provide the same energy services as electricity, such as water and space heating, customers may move away from electricity in the long-term and substitute cheaper sources of energy. The potential for this type of substitution will depend on the relative prices of other fuels, the ability of the fuel to provide a comparable service and the physical capability to make the change. For example, while consumers can take action to change out electric water heaters and replace electric heat pumps with natural gas furnaces, the ability to utilize another form of energy to power consumer electronics, lighting and many appliances is far more limited by current technology.

Changes in the price of TVA's electricity compared to the price of natural gas and other fuels will influence consumers' choices of appliances—either electric, gas or other fuels. While other substitutions are possible, natural gas prices serve as the benchmark for determining substitution impacts in the load forecasts.

## 4.1.2 Forecast Accuracy

Forecast accuracy is generally measured in part by error in the forecasts, whether day ahead, year ahead, or multiple years ahead. Figures 4-1 and 4-2 show annual forecasts from 2000 through 2010 for peak load requirements and net system requirements.

Figure 4-1 is a comparison of actual and forecasted summer peak demand in MW. Figure 4-2 is a comparison of actual and forecasted net system requirements in GWh. Note that the “Norm.Actual” line represents the normalized value of the annual energy, meaning abnormal weather impacts have been removed.

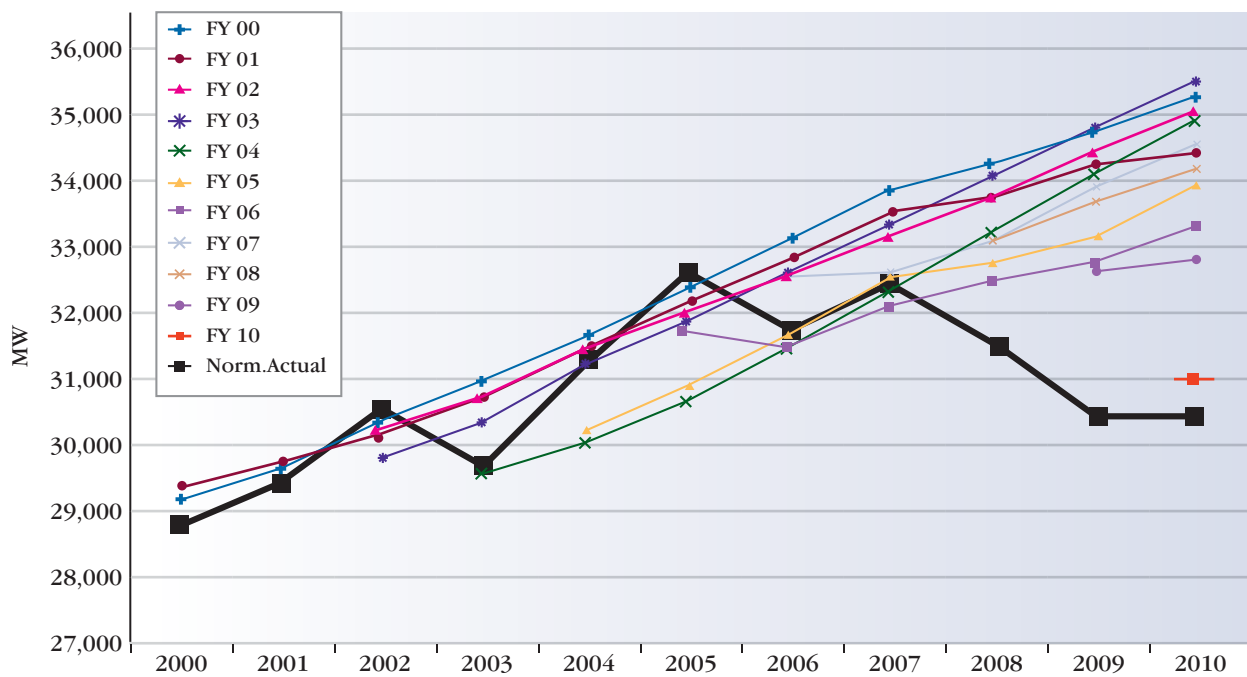


Figure 4-1 – Comparison of Actual and Forecasted Summer Peak Demand (MW)

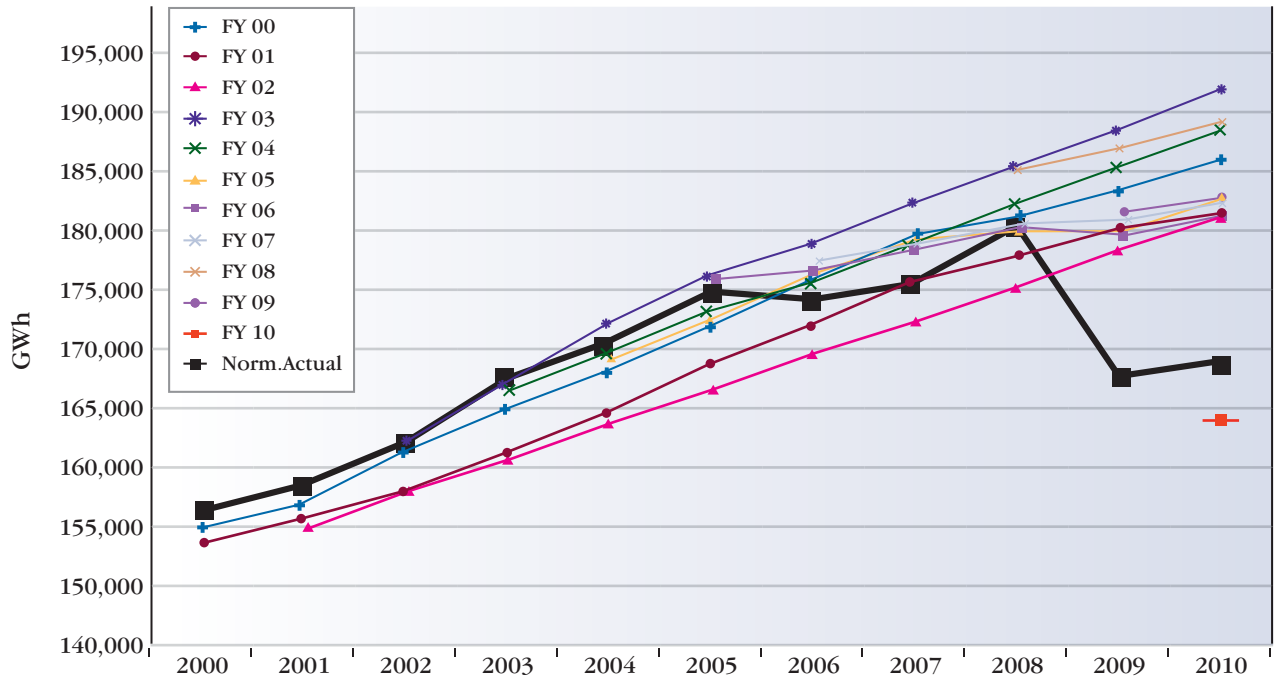


Figure 4-2 – Comparison of Actual and Forecasted Net System Requirements (GWh)

The mean annual percent error (MAPE)<sup>1</sup> of TVA's forecast of net system energy and peak load requirements for the 2000 to 2009 period was 1.9 percent and 2.8 percent, respectively. These include large errors in 2009 as the ramifications of the 2008 financial crisis and resulting economic slowdown impacted the economy. In the TVA service area, the most significant reductions were in the industrial sector, but it has already begun to show signs of recovery. The 2000 to 2008 MAPE was 1.1 percent for net system requirements and 2.2 percent for peak load, which is more representative of the accuracy of TVA year-in and year-out load forecasts. From informal conversations with peer utilities, TVA's MAPE of approximately 1 to 2 percent is in alignment with that of other utilities.

As mentioned previously in Section 4.1.1, while the economy in the Tennessee Valley region may be slightly stimulated by the creation of export services sold to areas outside the TVA region, future growth is expected to be lower than historical averages.

<sup>1</sup>MAPE is the average absolute value of the error each year; it does not allow over-predictions and under-predictions to cancel each other out.

This is a result of a number of factors, which include the impacts of the recent recession and subsequent recovery, the trend of declining U.S. manufacturing and the projected loss of some TVA customer load.

Figures 4-1 and 4-2 show the magnitude of the downturn of TVA net system requirements and summer peak loads due in part to the recession in the region. These trends are the result of a decline in energy usage by TVA customers due to a combination of factors including changes in the regional economy, improved energy efficiency and rising electricity prices.

### **4.1.3 Forecasts of Peak Load and Energy Requirements**

To deal with the inherent uncertainty in forecasting, TVA developed a range of forecasts. Each forecast corresponds to different load scenarios. Scenarios are described in more detail in Chapter 6 – Resource Plan Development and Analysis. Forecasts of net system peak load and energy requirements for the IRP reference case and the highest and lowest scenarios are respectively shown in Figures 4-3 and 4-4. Peak load grew at an average annual rate of 1.3 percent in the Reference Case: Spring 2010, varying from 0 percent in the lowest scenario to 2 percent in the highest scenario. Net system energy requirements grew at an average annual rate of 1 percent in the IRP reference case, varying from 0 percent in the lowest scenario to 1.9 percent in the highest scenario.

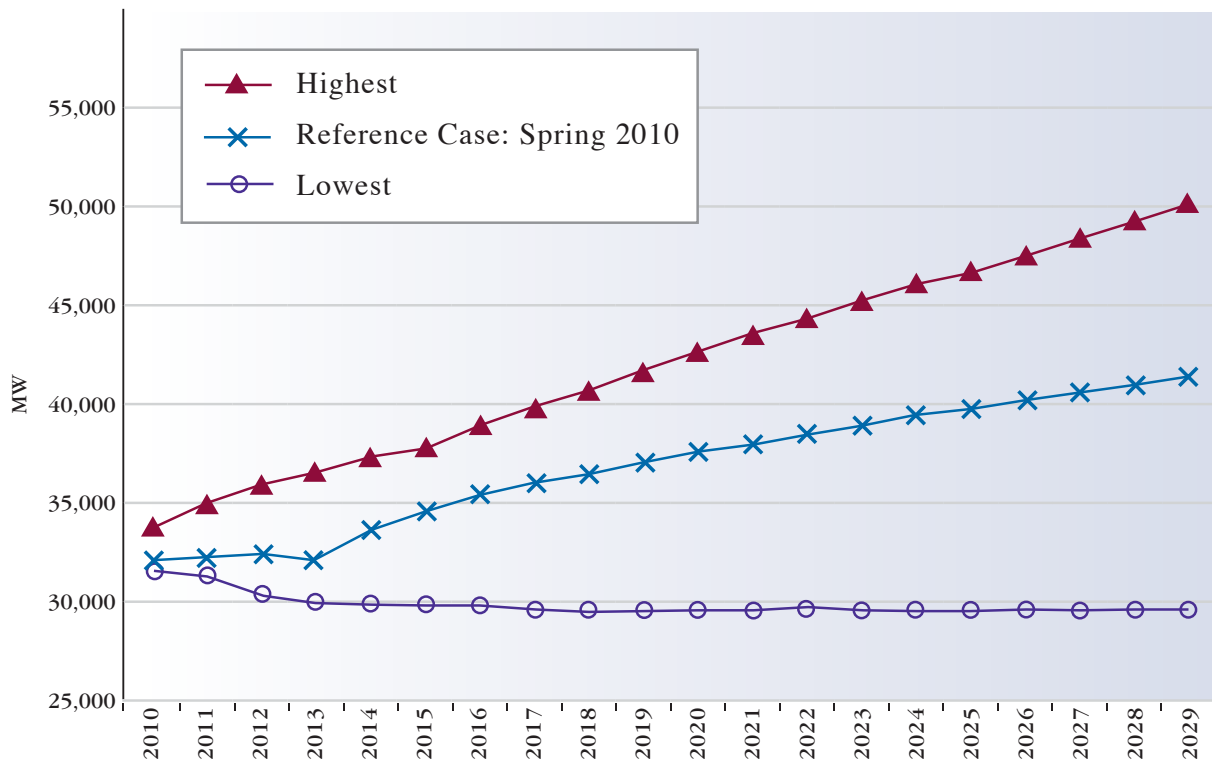


Figure 4-3 – Peak Load Forecast (MW)

The use of ranges ensured that TVA considered a wide spectrum of electricity demand in its service territory and reduced the likelihood that its plans are too dependent on the achievement of single-point estimates of demand growth that make up the midpoints of the forecasts. These ranges are used to inform planning decisions beyond pure least-cost considerations given a specific demand in each year.

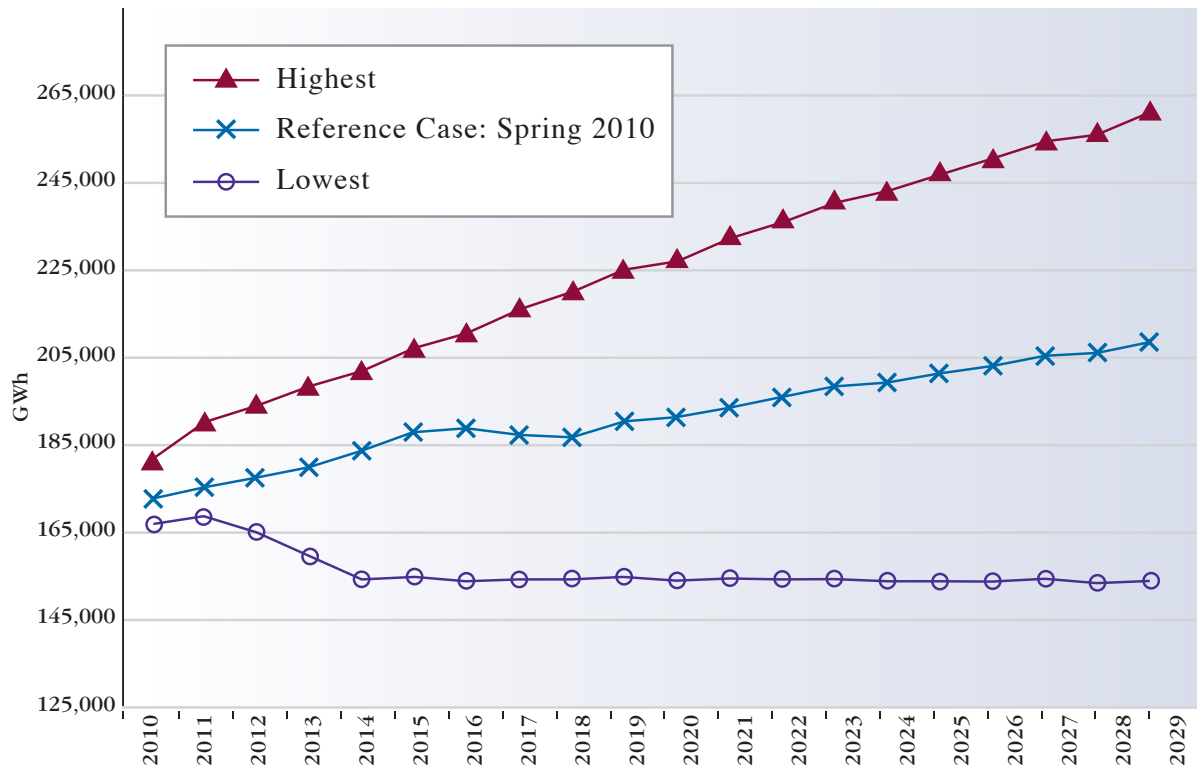


Figure 4-4 – Energy Forecast (GWh)

## 4.2 Determine Reserve Capacity Needs

To ensure that enough capacity is available to meet peak demand, including contingency for unforeseen events, additional generating capacity beyond which is needed to meet expected peak demand is maintained. This additional generating capacity (reserve capacity) must be large enough to cover the loss of the largest single operating unit (contingency reserves), be able to respond to moment-by-moment changes in system load (regulating reserves) and replace contingency resources should they fail (replacement reserves). Total reserves must also be sufficient to cover uncertainties such as unplanned unit outages, undelivered purchased capacity and load forecasting error.

TVA identified a planning reserve margin based on minimizing overall cost of reliability to the customer. This reserve margin was based on a stochastic analysis that considered the uncertainty of unit availability, transmission capability, economic growth and weather to compute expected reliability costs. From this analysis a target reserve margin was selected such that the cost of additional reserves plus the cost of reliability events to the customer

was minimized. This target or optimal reserve margin was adjusted based on TVA's risk tolerance in producing the reserve margin used for planning studies. Based on this methodology, TVA's current planning reserve margin is 15 percent and is applied during both the summer and winter seasons.

### **4.3 Estimate Supply**

Next, the current supply- and demand-side resources available to meet this demand were identified. TVA's generation supply consists of a combination of existing TVA-owned resources, budgeted and approved projects – such as new plant additions and updates to existing assets – and PPAs. Each type of generation can be categorized based on its degree of utilization in serving electricity demand. Generation can also be categorized by capacity, energy type and how it is measured.

#### **4.3.1 Baseload, Intermediate, Peaking and Storage Resources**

Figure 4-5 illustrates the uses of baseload, intermediate and peaking resources. Although these categories are useful, the distinction between them is not always clear. For example, a peaking unit, which is typically used to serve only intermittent but short-lived spikes in demand, may from time to time be called on to run continuously for an amount of time even though it may be less economical to do so. This may be due to transmission or other constraints. Similarly, many baseload units are capable of operating at different power levels, which gives them some characteristics of an intermediate or peaking unit. This IRP considered strategies that take advantage of this range of operations.

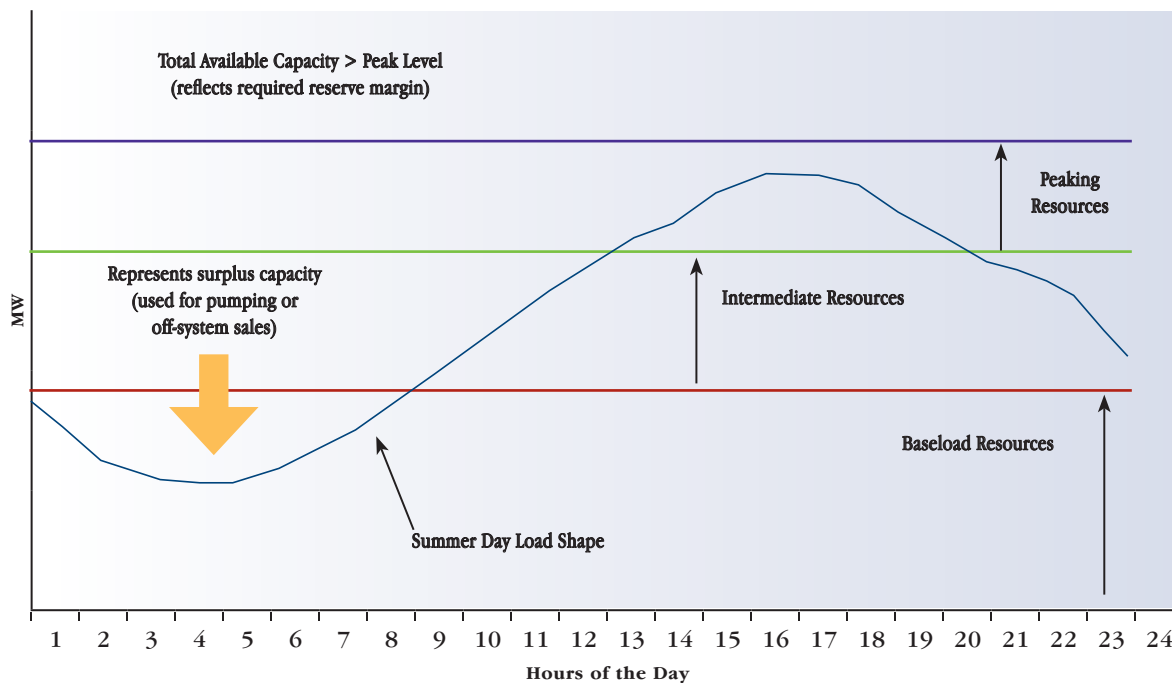


Figure 4-5 – Illustration of Baseload, Intermediate and Peaking Resources (MW)

## Baseload Resources

Baseload generators are primarily used to meet energy needs during most hours of the year due to their lower operating costs and high availability. Even though baseload resources typically have higher construction costs than other alternatives, they have much lower fuel and variable costs, especially when fixed costs are expressed on a unit basis. An example of a baseload resource that provides continuous, reliable power over long periods of uniform demand is a nuclear power plant. Some energy providers may also consider natural gas-fired combined cycle plants for use as incremental baseload generators. However, given the historical tendency for natural gas prices to be higher than coal and nuclear fuel prices when expressed on a unit basis, a combined cycle unit may be a more expensive option for larger continuous generation needs. As the fundamentals of fuel supply and demand continue to change and if access to shale gas continues to grow, this relationship may change in the future.



### **Intermediate Resources**

Intermediate resources are primarily used to fill the gap in generation between baseload and peaking needs. These units are required to produce more or less output as the energy demand increases and decreases over time, both during the course of a day and seasonally. Given current fuel prices and relative generating efficiencies, intermediate units are more costly to operate than baseload units, but cheaper than peaking units. This type of generation typically comes from natural gas-fired combined cycle plants and smaller coal-fired plants. Corresponding back-up balancing supply needed for intermittent renewable generation, such as wind or solar, also comes from intermediate resources. It is possible to use the energy generated from a solar or wind project as an intermediate resource with the use of energy storage technologies.

### **Peaking Resources**

Peaking units are expected to operate infrequently during shorter duration, high demand periods. They are essential for maintaining system reliability requirements, as they can ramp up quickly to meet sudden changes in either supply or demand. Typical peaking resources include natural gas-fired combustion turbines (CTs), conventional hydroelectric generation and pumped-storage generation.

### **Storage Resources**

Storage units usually serve the same power supply function as peaking units but use low-cost off-peak electricity to store energy for generation at peak times. An example of a storage unit is a pumped-storage plant that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of high demand. Consequently, a storage unit is both a power supply source and an electricity user.

#### **4.3.2 Capacity and Energy**

Peaks in a power system are measured in terms of capacity (e.g., MW), which is the instantaneous maximum amount of energy that can be supplied by a generating plant or system. For long-term planning purposes, capacity can be specified in many forms such as nameplate (the maximum design generation), dependable (the maximum that can typically be expected in normal operation), seasonal (the maximum that can be expected during different seasons of the year) and firm (dependable capacity less all known adjustments).

Overall power system usage is measured in terms of energy (e.g., MWh or GWh). Energy is the total amount of power that an asset delivers in a specified time frame.

For example, 1 MW of power delivered for 1 hour equals 1 MWh of energy and 1,000 MWh is equal to 1 GWh. Capacity factor is a measure of the actual energy delivered by a generator compared to the maximum amount it could have produced. Assets that are run constantly, such as nuclear or coal-fired plants, provide a significant amount of energy with capacity factors of more than 90 percent. Assets that are used infrequently, such as combustion turbines, provide relatively little energy with low capacity factors of less than five percent. However, the energy they do produce is crucial because it is often delivered at peak times.

Energy efficiency can also be measured in terms of capacity and energy. Even though energy efficiency does not input power into the system, the effect is similar as it represents power that is not required from another resource. Demand reduction is also measured in capacity and energy, but unlike energy efficiency, it is not a significant reduction in total energy used.

### 4.3.3 TVA's Generation Mix

TVA's power generation system employs a wide range of technologies to produce electricity and meet the needs of the Tennessee Valley residents, businesses and industries. Figure 4-6 shows a breakdown of firm capacity by technology for TVA's Reference Case: Spring 2010. Figure 4-7 shows a breakdown of energy by technology for TVA's Reference Case: Spring 2010.

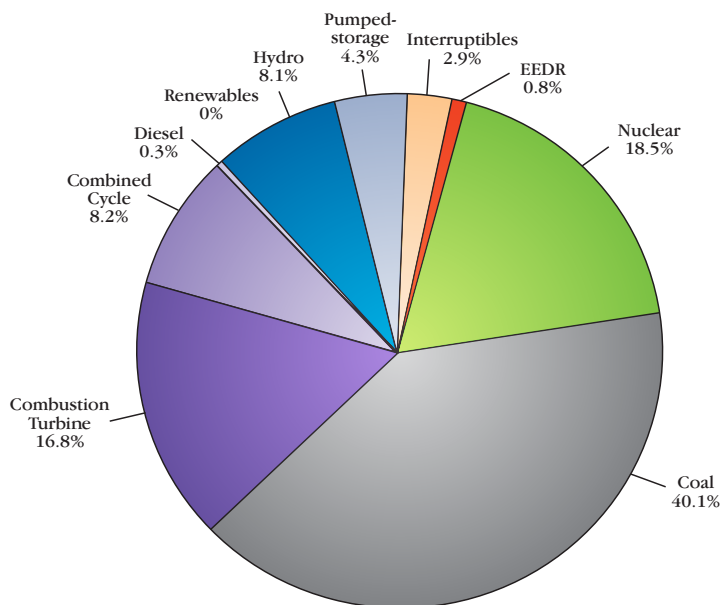


Figure 4-6 – Reference Case: Spring 2010 – Firm Capacity (MW)

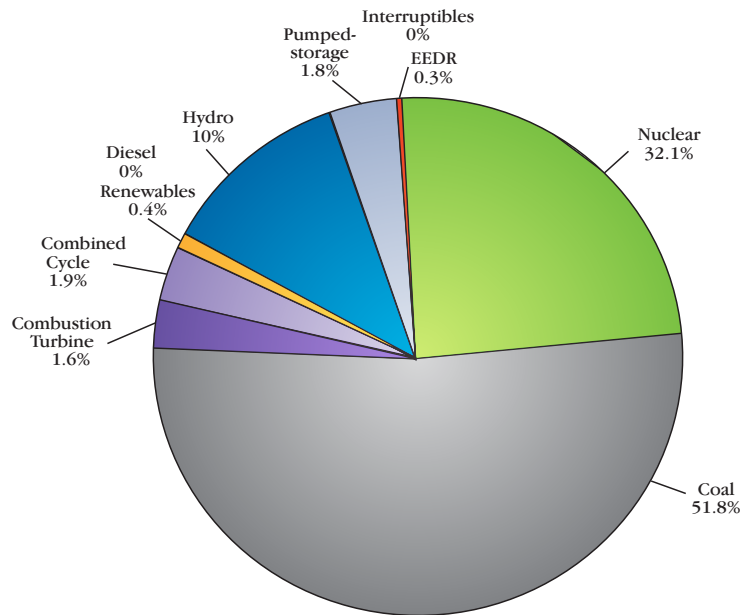


Figure 4-7 – Reference Case: Spring 2010 – Energy (GWh)

In 2010, approximately 56 percent of TVA's electricity was produced from coal-fired and natural gas-fired plants. Nuclear plants produced about 32 percent and hydroelectric plants produced approximately 12 percent. Other generation came from renewable and avoided generation sources such as EEDR.

Figure 4-8 illustrates the changing composition of existing generating resources that are assumed in planning or currently anticipated to be operated through 2029. Figure 4-8 includes only those resources that currently exist or are under contract, such as PPAs and EEDR programs, and changes to existing resources that are planned and approved, such as projects approved by TVA Board of Directors.

The total capacity of existing resources decreases through 2029 primarily because of the potential to idle coal-fired capacity. Total capacity also decreases as PPAs expire and are not extended or replaced. The renewable energy component of the existing portfolio is primarily composed of wind PPAs, which are discussed in the associated EIS. The current EEDR programs are 0.8 percent of the capacity and are also explained in further detail in associated EIS. All IRP strategies included additional renewable resources and EEDR programs beyond those depicted in Figure 4-8, as described in Chapter 7 – Draft Study Results.

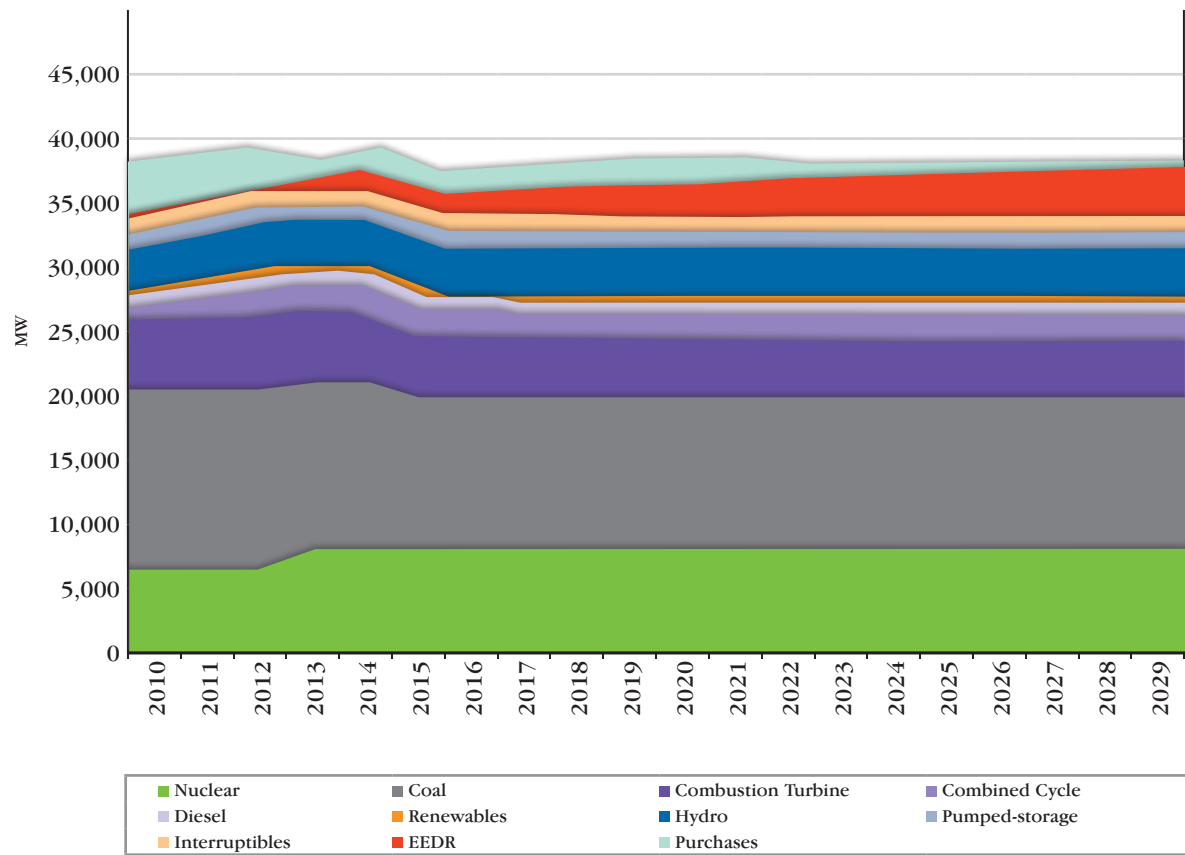


Figure 4-8 – Existing Firm Supply (MW)

The variety of resource types and the different ways they can be used provides TVA with a diverse portfolio of coal, nuclear, hydroelectric, natural gas and oil, market purchases and renewable resources. Used together, they are designed to provide reliable, low-cost power, while minimizing the risk of disproportionate reliance on any one type of resource.

#### 4.4 Estimate the Capacity Gap

The need for power can be expressed by either the capacity or energy gap. Capacity gap is the difference, specified in MW, between the existing firm supply (Figure 4-8) and the expected firm requirements, which are the load forecasts (Figure 4-3) adjusted for any interruptible customer loads plus reserve requirements. In other words, the capacity gap is the difference between total supply and total net demand. This chapter’s key reference illustrates the supply, demand and resulting capacity gap.

Energy gap is the amount of energy, specified in GWh, provided by existing resources and the new resources added in the reference case minus the energy required to meet net system requirements. Net system requirement is the required energy needed to serve the load over the entire year. It includes the energy consumed by the end-users plus distribution and transmission losses.

Figure 4-9 shows the resulting capacity gaps based on the spring 2010 peak load forecast as represented in the IRP Reference Case: Spring 2010 scenario, as well as the range corresponding to the highest and lowest capacity gap scenarios.

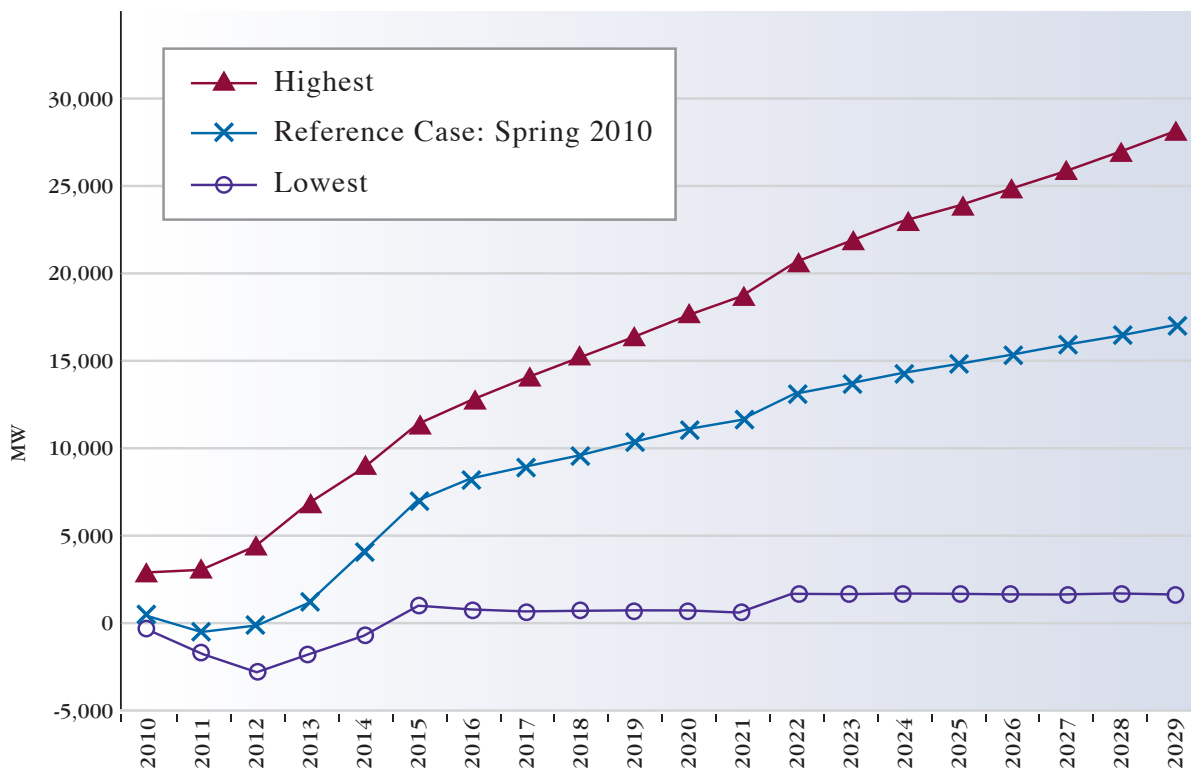


Figure 4-9 – Capacity Gap (MW)

Figure 4-10 shows the same comparison for the energy gaps.

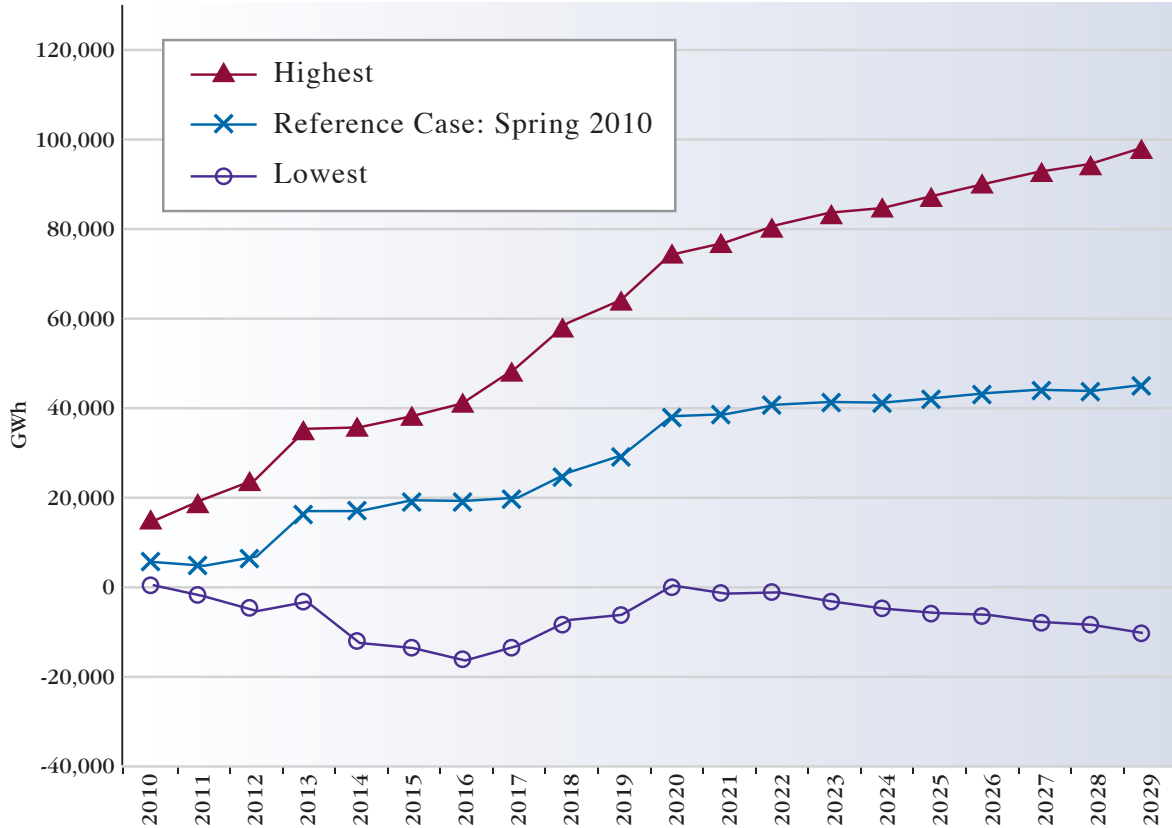
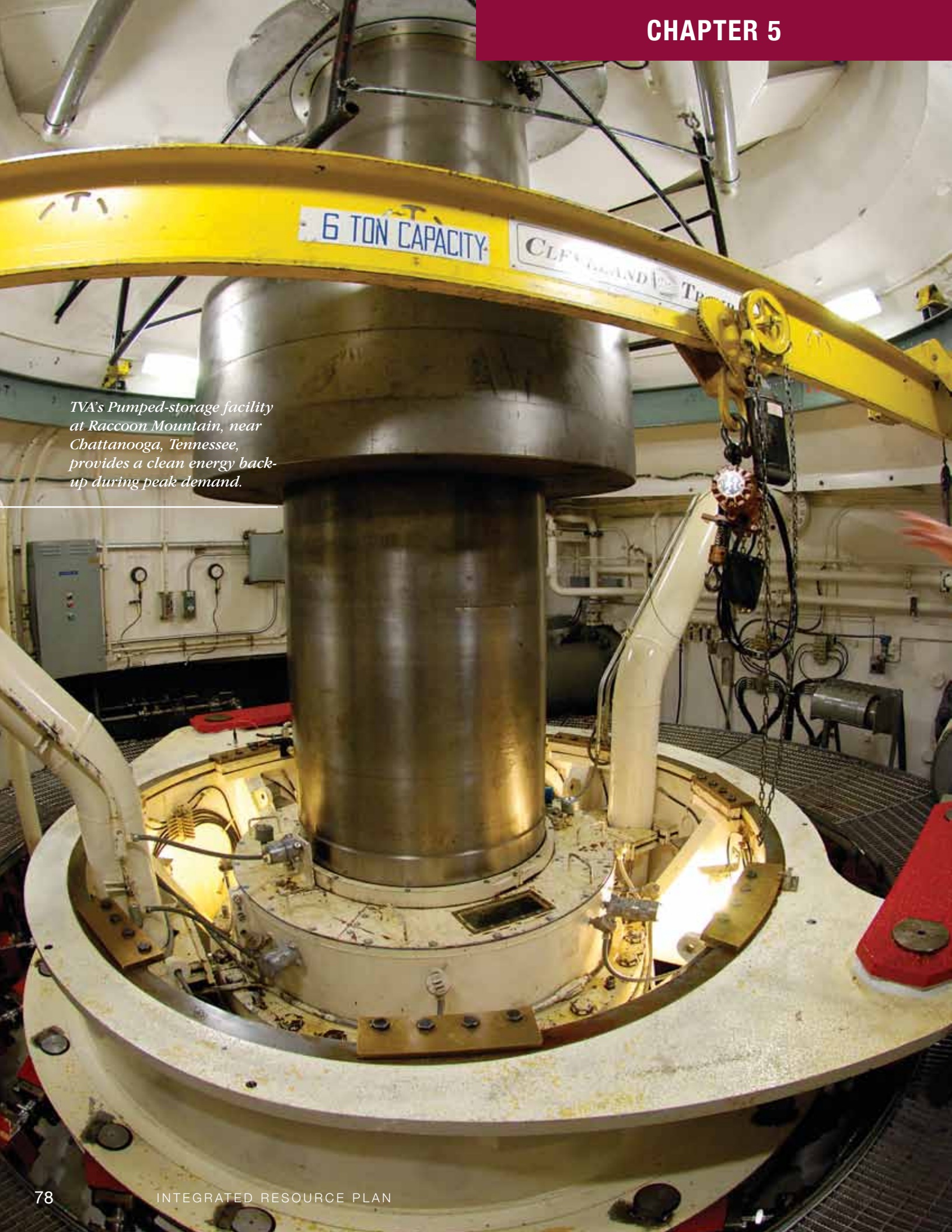


Figure 4-10 – Energy Gap (GWh)

In most scenarios and years, TVA requires additional capacity and energy of 9,600 MW and 29,000 GWh in 2019, increasing to 15,500 MW and 45,000 GWh by 2029. The alternative strategies considered by TVA to meet this gap are detailed in Chapter 7 – Draft Study Results – with the Recommended Planning Direction described in Chapter 8 – Final Study Results and Recommended Planning Direction.



*TVA's Pumped-storage facility at Raccoon Mountain, near Chattanooga, Tennessee, provides a clean energy back-up during peak demand.*

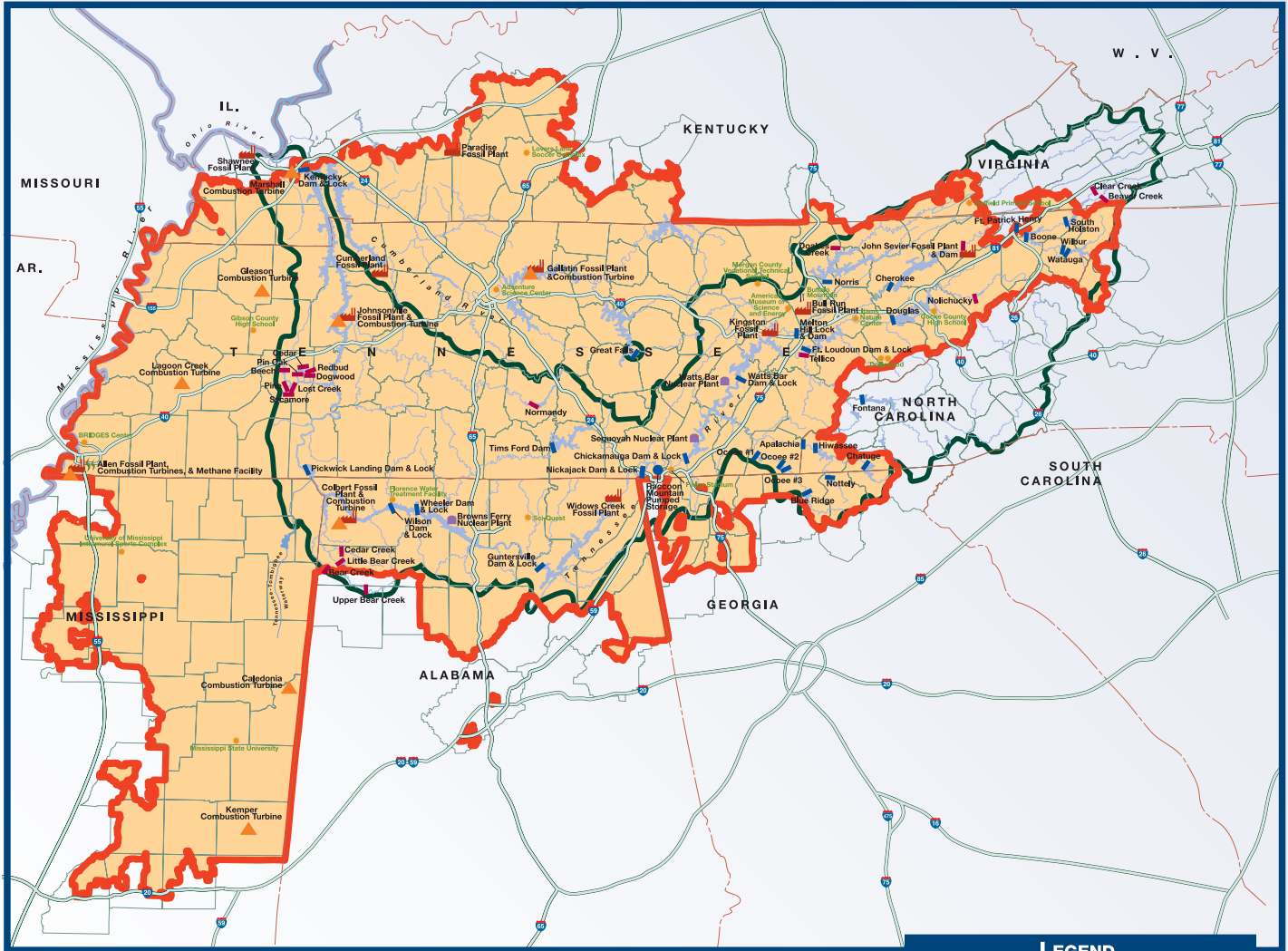
<b>5 Energy Resource Options</b>	<b>81</b>
5.1 Selection Criteria	81
5.1.1 Criteria for Considering Resource Options	81
5.1.2 Criteria for Not Considering Resource Options	82
<hr/>	
5.2 Options Included in IRP Evaluation	82
5.2.1 Nuclear Generation	82
5.2.2 Fossil-Fueled Generation	83
5.2.3 Renewable Generation	84
5.2.4 Energy Efficiency and Demand Response	87
5.2.5 Power Purchases	87
5.2.6 Repowering Resources	87



*TVA utilizes a wide variety of assets to meet the energy needs for the people living in the Tennessee Valley.*



# TVA Regional Assets Map



**LEGEND**

- State Line
- Water
- Power Service Area
- TVA Watershed
- TVA Hydroelectric Dam
- TVA Non-Power Dam
- TVA Coal-Fired Plant
- TVA Nuclear Plant
- TVA Combustion Turbine Plant
- TVA Pumped-Storage Plant
- TVA Customer Service Office
- TVA Economic Development Office
- Green Power Switch® Solar Site
- Green Power Switch® Wind Site
- Green Power Switch® Methane Site

0 20 40 60 mi.

January 2010

## 5 Energy Resource Options

Maintaining the diversity of TVA's energy resource options is fundamental to the ability of providing low-cost, reliable power. In order to fill the forecasted capacity gap defined in Chapter 4 – Need for Power Analysis, TVA considered the addition of a wide range of supply-side generating resources as well as energy efficiency and other demand-side resource options.

TVA's future portfolio of generating assets consists of various fuel sources and diverse technologies that support varying power demand and the other services required for reliable operation of the power system. TVA's resource portfolio also includes power purchases through both short- and long-term contracts, as well as increasing the use of renewable resources and demand-side options (i.e., EEDR programs).

### 5.1 Selection Criteria

During the scoping process, TVA identified a broad range of resource options. The criteria, listed in Sections 5.1.1 and 5.1.2, were applied to these options to narrow down and establish a more manageable portfolio. A complete list of resource options considered is in the associated EIS.

#### 5.1.1 Criteria for Considering Resource Options

The following criteria were applied to determine what resource options should be considered as viable for the IRP analysis:

- The resource option must utilize a developed and proven technology, or one that has reasonable prospect of becoming commercially available before 2029
- The resource option must be available to TVA, either within the TVA region or importable through market purchases
- The resource option must be economical and contribute to the reduction of air pollutants, including greenhouse gases, from the TVA power supply portfolio in alignment with overall TVA objectives

### 5.1.2 Criteria for Not Considering Resource Options

The following criteria were applied to determine what resource options should not be considered for further analysis in this IRP:

- The technology is still in very early stages in terms of maturity, in the research phase or under development and not widely available during the IRP planning period
- The resource option was previously considered by TVA and found to be uneconomic or not technically feasible
- The resource option is considered part of what private developers or individuals could elect to do as part of their participation in EEDR programs or their development of renewable resource purchase options for TVA's consideration, but is not a resource option TVA would implement on its own

## 5.2 Options Included in IRP Evaluation

Resource options that TVA considered in the IRP evaluation included existing assets in TVA's current generation portfolio from TVA-owned facilities and power purchases. Options for new generation also included TVA-owned assets and power purchases as well as repowering of current assets. The primary resource options are nuclear, fossil and renewable generation, energy storage and EEDR. A comprehensive description of all resource options, components, characteristics and technologies is included in the associated EIS.

### 5.2.1 Nuclear Generation

#### Nuclear – Existing Generation

The capacity of TVA's existing nuclear units is approximately 6,900 MW, which includes three reactors at Browns Ferry Nuclear Plant, two reactors at Sequoyah Nuclear Plant and one at Watts Bar Nuclear Plant. On Aug. 1, 2007, the TVA Board of Directors approved the completion of the 1,150 MW Unit 2 reactor at the Watts Bar Nuclear Plant. This project is included as a current resource in TVA's generating portfolio and is scheduled for completion in 2013.

#### Nuclear – New Generation

TVA included Bellefonte Units 1 and 2 at the Bellefonte brownfield site as options in this IRP. In addition to the Bellefonte units, non-site specific options based on the Advanced Passive 1000 reactor design were also considered.

## 5.2.2 Fossil-Fueled Generation

### Coal

#### Coal – Existing Generation

TVA currently operates 11 coal-fired power plants consisting of 56 active coal-fired generating units and three idled units with a total capacity of 14,500 MW. While some strategies assumed the continued operation of all the remaining coal-fired assets, others assumed placing varying amounts of coal-fired generating capacity into long-term idle status. Three of TVA's coal-fired units were idled in fall 2010. The goal of long-term idling is to preserve the asset, so that with modifications and environmental additions it could be reintroduced into TVA's generating portfolio in the future if power system conditions warrant.

In addition to its owned coal-fired assets, TVA also has access to the output from a coal-fired power plant (of approximately 430 MW) through a long-term PPA.

#### Coal – New Generation

TVA included supercritical pulverized coal (SCPC) plants with carbon capture and sequestration (CCS) technology as well as integrated gasification combined cycle (IGCC) plants with CCS technology as resource options in the IRP evaluation.

### Natural Gas

#### Natural Gas – Existing Generation

TVA has 87 combustion turbines (CT) at nine power plants, with a combined generating capacity of approximately 6,000 MW. In addition, TVA has the capacity to generate up to 890 MW from its distributor partnership with the Southaven Combined Cycle (CC) Plant and 540 MW at the Lagoon Creek CC Plant, which came online in summer 2010. TVA is also in the process of completing the construction of an 880 MW combined cycle plant at John Sevier that is expected to be operational in 2012.

Power purchases from natural gas-fired units owned by independent power producers are also part of the current resource portfolio. TVA is currently a party to a long-term lease of a 900 MW CC plant and has PPAs of more than 1,000 MW related to natural gas-fired combined cycle plants.

### **Natural Gas – New Generation**

The IRP evaluation includes both combustion turbine and combined cycle natural gas fueled options. Resource options evaluated in this IRP included procurement of power from existing merchant combined cycle plants along with self-built TVA or customer-owned combined cycle plants of up to 1,730 MW without specific site locations. The refurbishment of the natural gas-fired Gleason plant, consisting of three natural gas-fired combustion turbines, was evaluated as a resource option in this IRP, which increases the available capacity from 360 to 530 MW.

### **Petroleum Fuels**

#### **Petroleum Fuels – Existing Generation**

Currently, TVA contracts for a number of diesel fuel generated power purchases, totaling 120 MW.

#### **Petroleum Fuels – New Generation**

Petroleum power purchases are expected to be phased out by 2029. There are no diesel fuels or other petroleum based resource options as a primary fuel source under consideration in this IRP because of emissions from these facilities.

### **5.2.3 Renewable Generation**

TVA defines renewable energy as energy production that is sustainable and often naturally replenished (e.g., solar, wind, methane, biomass, geothermal and hydro). TVA presently provides renewable energy from TVA facilities and from energy acquired by PPAs. For purposes of the IRP analysis, planning strategies were developed to test a broad range of renewable additions. Therefore, renewable additions incorporated into this IRP were scheduled based on two given renewable portfolio amounts—2,500 MW and 3,500 MW. These targets are beyond TVA's current renewable resource plan (represented as the 1,500 MW portfolio), but would be in addition to TVA's existing clean energy generation sources, which include existing hydro and nuclear. As described below, renewable energy from these resources is also considered in this IRP. Additional detail can be found in Appendix D – Development of Renewable Energy Portfolios.

### **Conventional Hydroelectric**

#### **Hydroelectric – Existing Generation**

TVA operates 109 conventional hydroelectric generating facilities at 29 of its dams. These facilities have the capacity to generate 3,538 MW of electricity. TVA is also systematically updating aging turbines and other equipment in its hydro plants.

## **Hydroelectric – New Generation**

TVA included additional as-yet-unapproved modernization projects (a total of 90 MW by 2029) as a resource option for its IRP evaluation as well as up to 144 MW of small hydro by 2029. TVA also included small- and low-head hydropower as an IRP resource option.

## **Energy Storage**

### **Energy Storage – Existing Generation**

TVA operates one large energy storage facility, the 1,615 MW Raccoon Mountain Pumped-Storage Plant, which provides critical flexibility to the TVA system by storing power at off-peak times for use when demand is high.

### **Energy Storage – New Generation**

An additional pumped-storage resource option of 850 MW was included in all cases going forward. In addition, a compressed air energy storage (CAES) option is evaluated in this IRP. TVA did not evaluate any electric battery storage options because of operational limitations.

## **Wind**

### **Wind – Existing Facilities**

TVA currently purchases the output from the Southeast's largest wind farm, consisting of 15 turbines on Buffalo Mountain near Oak Ridge, Tenn. In addition, TVA owns an additional three turbines at that location.

TVA has also entered into contracts with other third-party developers for the long-term purchase of wind power. Requests for proposals were issued in December 2008 for additional wind power. By the end of 2010, TVA had contracted to receive power from approximately 1,600 MW of wind power. Iberdrola Renewables began supplying 300 MW from the Streator Cayuga Ridge Wind Farm in Livingston County, Ill. Additional wind power agreements exist with Horizon Wind Energy LLC (115 MW which started in fall 2010), CPV Renewable Energy Company (365 MW starting 2012) and Invenergy LLC (600 MW starting in 2012). All contracts are contingent on meeting applicable environmental requirements and obtaining firm transmission paths to TVA.

All wind contracts selected were competitive with forecasted market electricity prices at the time those contracts were evaluated. In December 2008, when TVA issued the request for proposals, no economically feasible in-Valley proposals were received.

### **Wind – New Generation**

TVA cannot take direct advantage of the current investment incentives offered to wind power developers. These incentives help make wind power more economically competitive with other generation resources. As such, the option of constructing its own wind power facilities in the TVA region was not included. Instead, TVA has taken the approach of procuring wind power resources through PPAs and included this as a resource option in this IRP. The procurement of wind resources, whether in or imported to the TVA region, through a request for proposal process ensures lower costs to TVA customers. This approach could change to a self-build option in the future if investment incentives and/or future federal or state renewable mandates change.

### **Solar**

#### **Solar – Existing Generation**

TVA owns 14 photovoltaic (PV) installations with a combined capacity of about 280 kW of capacity. TVA also purchases power from PV installations through TVA's Generation Partners<sup>SM</sup> program.

#### **Solar – New Generation**

For reasons similar to new wind generation, TVA cannot take advantage of the current investment incentives offered to solar power developers that help make solar power more economically competitive with other resource options. As a result, TVA has taken the approach of procuring solar power resources through PPAs and included it as a resource option in this IRP. This approach could change to a self-build option in the future if investment incentives and/or federal or state renewable mandates change.

### **Biomass**

#### **Biomass – Existing Generation**

TVA generates electricity by co-firing methane from a nearby sewage treatment plant at Allen Fossil Plant and by co-firing wood waste at Colbert Fossil Plant. In addition, TVA currently purchases about 91 MW of biomass-fueled generation. These purchases include 9.6 MW of landfill gas generation, 70 MW of wood waste generation and 11 MW of corn milling residue generation.

#### **Biomass – New Generation**

TVA included up to 490 MW of biomass generation and landfill gas generation as resource options to be evaluated in this IRP. Most of this biomass is generated through PPAs, while

some of it is not. TVA also included the conversion of existing coal-fired units to biomass-fired units and co-firing biomass with coal at existing coal-fired units as IRP resource options to be evaluated. TVA is currently performing biomass fuel availability surveys in the region, and a comprehensive study is underway to assess the feasibility of converting one or more coal-fired units to biomass fuel.

## **5.2.4 Energy Efficiency and Demand Response**

### **EEDR – Existing Program**

TVA has an existing portfolio of programs focused on EEDR. As currently implemented, TVA's EEDR portfolio focuses on reduction in peak demand and has an avoided peak capacity in excess of 300 MW, as of FY10.

### **EEDR – New Program**

This IRP reflects TVA's increased focus on EEDR. These reductions are in addition to energy savings from laws, policies and independent programs of distributors of TVA power. The IRP reference strategy includes an EEDR program that reduces required energy and capacity needs by approximately 14,000 GWh and 4,700 MW, respectively, by 2029.

A list of proposed EEDR programs for TVA implementation is listed in the associated EIS.

## **5.2.5 Power Purchases**

Power purchases refer to the procurement of energy and/or capacity from other suppliers for use on the TVA system in lieu of TVA constructing and operating its own resources. Power purchases provide additional diversity for TVA's portfolio. TVA is currently a party to numerous short- and long-term PPAs. PPA options are included in the IRP evaluation. For all PPAs, it is assumed that the supplier will either interconnect with TVA transmission or obtain a transmission path to TVA if outside the TVA region.

## **5.2.6 Repowering Resources**

Repowering electrical generating plants is the process by which utilities update and change the fuel source or technology of existing plants to realize gains in efficiency or output that was not possible at the time the plant was constructed. TVA has included approved repowering projects in its forecast for existing resources and included other as-yet-unapproved repowering options in the IRP evaluation.



*TVA is committed to becoming one of the nation's leaders in providing cleaner energy.*

---

<b>6</b>	<b>Resource Plan Development and Analysis</b>	<b>91</b>
6.1	Development of Scenarios and Strategies	91
6.1.1	Development of Scenarios	92
6.1.2	Development of Planning Strategies	97
6.2	Resource Portfolios Optimization Modeling	100
6.2.1	Development of Optimized Capacity Expansion Plan	100
6.2.2	Evaluation of Detailed Financial Analysis	101
6.2.3	Development of Portfolio	102
6.3	Development of Evaluation Scorecard	102
6.3.1	Scorecard Design	103
6.3.2	Technology Innovations Narrative	110
6.4	Identification of Preferred Planning Strategies in the Draft IRP	110
6.4.1	Scoring	110
6.4.2	Sensitivity Analyses	110
6.4.3	Identification of Preferred Planning Strategies	111
6.5	Incorporation of Public Input and Performance of Additional Scenario Planning Analyses	111
6.6	Identification of Recommended Planning Direction	111
6.6.1	Identification of Key Components	112
6.6.2	Definition of Boundary Conditions	112
6.6.3	Development of Recommended Planning Direction Candidates	113
6.6.4	Identification of Recommended Planning Direction	114



*TVA's Integrated Resource Plan is a synthesis of public input and strategic planning and professional analysis.*

## Process for Identifying the Recommended Planning Direction



## 6 Resource Plan Development and Analysis

TVA employed a scenario planning approach in the development of the Draft and the final IRP. This approach is commonly used in the utility industry. The goal of this approach was to develop a “no-regrets” strategy that was relatively insensitive to uncertainty. In other words, once strategic decisions were made, the strategy would perform well regardless of how the future unfolds. The processes used in the scenario planning approach, including evaluation methods and strategy selection, are outlined in this chapter.

This chapter describes the following six steps of the Draft IRP process:

1. Development of the scenarios and strategies used to conduct the scenario planning analysis
2. Resource portfolios optimization modeling
3. Development of scenario planning scorecards to measure the performance of the portfolios and strategies developed in the scenario planning analysis
4. Identification of preferred planning strategies for publication in the Draft IRP
5. Incorporation of public input and performance of additional scenario planning analyses
6. Identification of the Recommended Planning Direction

### 6.1 Development of Scenarios and Strategies

Scenario planning is useful for determining how various business decisions will perform in an uncertain future. Multiple strategies, which represented business decisions that TVA can control, were modeled against multiple scenarios, which represented uncertain futures that TVA cannot control. The intersection of a single strategy and a single scenario resulted in a resource portfolio.<sup>1</sup> A portfolio is a 20-year capacity expansion plan that is unique to that strategy and scenario combination.

Modeling multiple strategies within multiple scenarios resulted in a large number of portfolios. Proper analysis of these portfolios was a challenge. Accordingly, during early stages of the analysis, it was more important to observe trends or common characteristics that strategies exhibited over multiple scenarios rather than focusing on specific outcomes in individual portfolios. If a strategy behaved in a similar manner in most scenarios, the modelers could be confident of its robustness. Characteristics of robustness included increased flexibility, less risk over the long term and the ability to mitigate the impacts of

---

<sup>1</sup>Portfolios are also referred to as capacity expansion plans or resource portfolios

uncertainty. Conversely, a strategy that behaved differently or poorly in each scenario that it was modeled within was considered more risky and indicated a higher probability for disappointment and future regret.

### 6.1.1 Development of Scenarios

Most quantitative models focus on what is statistically likely based on history, market data and projected future patterns. The scenarios developed for the planning approach operated differently by utilizing assumptions that the future evolves along paths not suggested by history. They were not assigned a probability that one particular future is more likely to occur than another. Using this approach, scenarios identified and framed plausible futures that were studied in the development of the long-range resource plan.

The following three-step process was used to develop scenarios used in this IRP:

1. Identification of key uncertainties
2. Development of scenarios
3. Determination of scenario uncertainty values

Scenarios represent future conditions that TVA cannot control but must adapt to.

#### Identification of Key Uncertainties

TVA, with input from the SRG, identified uncertainties that were used as building blocks to develop scenarios for this IRP. The key uncertainties are listed in Figure 6-1.

Key Uncertainty	Description		
Greenhouse gas (GHG) requirements	<ul style="list-style-type: none"> <li>Reflects level of emission reductions (CO<sub>2</sub> and other GHG) mandated by federal legislation plus the cost of carbon allowances</li> </ul>		
Environmental outlook	Changes in regulations addressing: <ul style="list-style-type: none"> <li>Air emissions (exclusive of GHG)</li> <li>Land</li> <li>Water</li> <li>Waste</li> </ul>		
Energy efficiency and RES	<ul style="list-style-type: none"> <li>Reflects mandates for minimum generation from renewables and the viability of renewable generation sources</li> <li>It includes the percentage of the RES standard that can be met with energy efficiency</li> </ul>		
Total load	<ul style="list-style-type: none"> <li>Reflects variance of actual load to what is forecast</li> <li>Accounts for benefits of EEDR penetration</li> </ul>		
Capital expansion viability & costs	For nuclear, fossil, other generation and transmission, includes risks associated with: <ul style="list-style-type: none"> <li>Licensing</li> <li>Permitting</li> <li>Project schedule</li> </ul>		
Financing	<ul style="list-style-type: none"> <li>Financial cost (interest rate) of securing capital</li> </ul>		
Commodity prices	<ul style="list-style-type: none"> <li>Includes natural gas, coal, oil, uranium and spot price of electricity</li> </ul>		
Contract purchase power cost	<ul style="list-style-type: none"> <li>Reflects demand cost, availability of power and transmission constraints</li> </ul>		
Change in load shape	Includes effects of factors such as: <table style="width: 100%; border: none;"> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> <li>Time-of-use rates</li> <li>Plug-in Hybrid Electric Vehicles (transportation)</li> <li>Distributed generation</li> <li>Economics changing customer base</li> </ul> </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> <li>Energy storage</li> <li>Energy efficiency</li> <li>Smart grid / demand response</li> </ul> </td> </tr> </table>	<ul style="list-style-type: none"> <li>Time-of-use rates</li> <li>Plug-in Hybrid Electric Vehicles (transportation)</li> <li>Distributed generation</li> <li>Economics changing customer base</li> </ul>	<ul style="list-style-type: none"> <li>Energy storage</li> <li>Energy efficiency</li> <li>Smart grid / demand response</li> </ul>
<ul style="list-style-type: none"> <li>Time-of-use rates</li> <li>Plug-in Hybrid Electric Vehicles (transportation)</li> <li>Distributed generation</li> <li>Economics changing customer base</li> </ul>	<ul style="list-style-type: none"> <li>Energy storage</li> <li>Energy efficiency</li> <li>Smart grid / demand response</li> </ul>		
Construction cost escalation	Includes the following for nuclear, fossil and other generation: <ul style="list-style-type: none"> <li>Commodity cost escalation</li> <li>Labor and equipment cost escalation</li> </ul>		

Figure 6-1 – Key Uncertainties

## Development of Scenarios

Scenarios were constructed by utilizing various combinations of the key uncertainties in Figure 6-1. They were then further refined to ensure that the following characteristics for each scenario:

- Represented a plausible, meaningful future “world” (e.g., uncertainties related to cost, regulation and environment)
- Were unique among the scenarios being considered for study
- Reflected a future that TVA could find itself in during the timeframe studied in this IRP

- Placed sufficient stress on the resource selection process
- Provided a foundation for analyzing the robustness, flexibility and adaptability of each combination of various supply- and demand-side options
- Captured relevant key stakeholder interests

A summary of the scenarios selected for the IRP analysis is shown in Figure 6-2. During the scoping phase in summer 2009, Scenarios 1 through 6 were developed for use in the Draft IRP analysis. Scenario 7 was also developed as a reference case in the Draft IRP. It closely resembled TVA’s long-term planning outlook at the time the original scenarios were developed. Another reference case, Scenario 8 was added after the publication of the Draft IRP. It captured the impacts of the recent recession and was used in subsequent analysis.

Scenario	Key Characteristics
1 Economy Recovers Dramatically	<ul style="list-style-type: none"> <li>• Economy recovers stronger than expected and creates high demand for electricity</li> <li>• Carbon legislation and renewable electricity standards are passed</li> <li>• Demand for commodity and construction resources increases</li> <li>• Electricity prices are moderated by increased gas supply</li> </ul>
2 Environmental Focus is a National Priority	<ul style="list-style-type: none"> <li>• Mitigation of climate change effects and development of a “green economy” is a priority</li> <li>• The cost of CO<sub>2</sub> allowances, gas and electricity increase significantly</li> <li>• Industry focus turns to nuclear, renewables, conservation and gas to meet demand</li> </ul>
3 Prolonged Economic Malaise	<ul style="list-style-type: none"> <li>• Prolonged, stagnant economy results in low to negative load growth and delayed expansion of new generation</li> <li>• Federal climate change legislation is delayed due to concerns of adding further pressure to the economy</li> </ul>
4 Game-changing Technology	<ul style="list-style-type: none"> <li>• Strong economy with high demand for electricity and commodities</li> <li>• High price levels and concerns about the environment incentivize conservation</li> <li>• Game-changing technology results in an abrupt decrease in load served after strong growth</li> </ul>
5 Energy Independence	<ul style="list-style-type: none"> <li>• The U.S. focuses on reducing its dependence on non-North American fuel sources</li> <li>• Supply of natural gas is constrained and prices for gas and electricity rise</li> <li>• Energy efficiency and renewable energy move to the forefront as an objective of achieving energy independence</li> </ul>
6 Carbon Regulation Creates Economic Downturn	<ul style="list-style-type: none"> <li>• Federal climate change legislation is passed and implemented quickly</li> <li>• High prices for gas and CO<sub>2</sub> allowances increase electricity prices significantly</li> <li>• U.S. based energy-intensive industry is non-competitive in global markets and leads to an economic downturn</li> </ul>
7 Reference Case: Spring 2010	<ul style="list-style-type: none"> <li>• Economic growth lower than historical averages</li> <li>• Carbon legislation is passed and implemented by 2013</li> <li>• Natural gas and electricity prices are moderate</li> </ul>
8 Reference Case: Great Recession Impacts Recovery	<ul style="list-style-type: none"> <li>• Economic outlook includes economic recovery, but growth is at a slightly lower rate than Scenario 7 due to lingering recession impacts</li> <li>• Natural gas prices are lower to reflect recent market trends</li> </ul>

Figure 6-2 – Scenarios Key Characteristics

## Determination of Scenario Uncertainty Values

Once each of the key uncertainties were defined, specific numerical values for each aspect of the scenarios were developed utilizing the following assumptions:

- Climate change uncertainty will be based upon stringency of requirements and timeline required for compliance and cost of CO<sub>2</sub> allowances
- An aggressive EPA regulatory schedule is expected to create additional compliance requirements (e.g., Hazardous Air Pollutants Maximum Achievable Control Technology [HAPs MACT], revised ambient air standards, etc.)
- Command and control regulations for HAPs MACT will likely drive plant-by-plant compliance
- RES will help accomplish GHG reduction required at the federal level
- The spot price of electricity will be correlated with the price of natural gas and coal
- Demand, primarily driven by economic conditions, will be affected by energy efficiency, demand response and other factors
- Schedule risk will be related to demand as well as the uncertainty of permitting and licensing generation and transmission projects
- Economic conditions and associated inflationary pressures will become the primary drivers for changes in financing costs
- Construction costs will be driven by demand as well as availability of labor, equipment, design and raw materials
- Economic conditions will become the primary driver, but the legislative/regulatory environment will apply additional pressure by introducing uncertainty related to potential schedule impacts
- Cost and availability of contract power purchases will be primarily driven by economic conditions and local area demand (i.e., load growth)



A detailed description of each scenario's uncertainty values is shown in Figure 6-3.

Uncertainty	Scenario 1 Economy Recovers Dramatically	Scenario 2 Environmental Focus is a National Priority	Scenario 3 Prolonged Economic Malaise	Scenario 4 Game-changing Technology	Scenario 5 Energy Independence	Scenario 6 Carbon Legislation Creates Economic Downturn	Scenario 7 Reference Case: Spring 2010	Scenario 8 Reference Case: Great Recession Impacts Recovery
GHG requirements	CO <sub>2</sub> price \$27/ton (\$50/metric ton) in 2014 and \$82 (\$90/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO <sub>2</sub> price \$17/ton (\$19/metric ton) in 2012 and \$94 (\$104/metric ton) by 2030. 77% allowance allocation, 28% by 2030	No federal requirement (CO <sub>2</sub> price = \$0/ton)	CO <sub>2</sub> price \$18/ton (\$20/metric ton) in 2013 and \$45 (\$50/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO <sub>2</sub> price \$18/ton (\$20/metric ton) in 2013 and \$45 (\$50/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO <sub>2</sub> price \$17/ton (\$19/metric ton) in 2012 and \$94 (\$104/metric ton) by 2030. 77% allowance allocation, 28% by 2030	CO <sub>2</sub> price \$15/ton (\$17/metric ton) in 2012 and \$56 (\$62/metric ton) by 2030. 77% allowance allocation, 39% by 2030	Same as Scenario 7
Environmental outlook	Same as Scenario 7	SO <sub>2</sub> controls 2017 NO <sub>x</sub> controls Dec 2016 Hg MACT 2014 HAP MACT 2015	No additional requirements (CAIR requirements, with no MACT requirements)	Same as Scenario 7	Same as Scenario 7	Same as Scenario 7	SCR all units by 2017 FGD all units by 2018 HAPs MACT by 2015	Same as Scenario 7
Energy efficiency and RES	RES – 3% by 2012, 20% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	RES – 5% by 2012, 30% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	No federal requirement	RES – 5% by 2012, 20% by 2021 (adjusted total retail sales) EE can meet up to 40% or requirement	RES – 5% by 2012, 20% by 2021 (adjusted total retail sales) EE can meet up to 40% or requirement	RES – 5% by 2012, 30% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	RES – 3% by 2012, 15% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	Same as Scenario 7
Total load	Med grow to High by 2015; High Dist; Alcoa Returns in 2010+; USEC stays forever; Dept Dist same as Scenario 7	Medium case, then 2012 40% rate increase; Low Dist; DS customer reductions (steel/paper plants); USEC stays forever; Dept Dist same as Scenario 7	Low load case; Low Dist; Alcoa not returning, No HSC & Wacker; USEC leaves June 2013; Dept Disc same as Scenario 7	Med-High load growth through 2020, then 20% decrease 2021-2022 including USEC departure, reduced dist sales & extended TOU	Medium case, then 20% rate increase in 2014; unrestricted PHEV included; TOU	Medium load case 2010-2011; 2012 low case then flat w/no growth; USEC leaves 2013; Alcoa not returning, HSC & Wacker not in; TOU	Moderate growth	Moderate to low growth
Capital expansion viability & costs	Moderate schedule risk	High schedule risk	Low schedule risk	Moderate schedule risk	Moderate schedule risk	Low schedule risk	Moderate schedule risk	Moderate schedule risk
Financing	Higher than Scenario 7 – higher inflation due to higher economic growth	Higher than Scenario 7 – higher inflation due to looser monetary policy supporting economic growth	Lower than Scenario 7 – lower inflation due to lower economic growth	Same as Scenario 7 – increased productivity due to technology leads to stronger economic wealth and non-inflationary money growth	Higher than Scenario 7 – higher inflation due to looser monetary policy supporting economic growth	Lower than Scenario 7 – lower inflation due to lower economic growth	Based on current borrowing rate	Based on current borrowing rate
Commodity prices	Gas & coal higher than Scenario 7	Gas higher; coal lower than Scenario 7	Gas much lower & coal much higher than Scenario 7	Gas lower & coal slightly higher than Scenario 7	Gas & coal higher than Scenario 7	Gas & coal much lower than Scenario 7	Gas - \$6-8/mmBTU Coal - \$40/ton	Gas - \$5-7/mmBTU Coal - \$40/ton
Contract purchase power cost	Much higher cost & lower availability	Higher cost & lower availability	Same as Scenario 7, then much lower cost with high availability	Higher cost & lower availability, then much lower cost with high availability after load decrease	Higher cost & lower availability	Lower cost with high availability	Moderate cost & availability	Moderate cost & availability
Construction cost escalation	Much higher than Scenario 7 – high economic growth causes high demand for new plants and high escalation rate	Somewhat higher than Scenario 7 – due to “construction costs escalating at high rate due to large volume of nuclear, renewables and env controls projects”. High regulatory scrutiny adds to project costs	Lower than Scenario 7 – low load growth leads to low escalation	This scenario has two stages of escalation: 1) higher than Scenario 7 due to high load growth early, then 2) lower escalation when game-changing technology hits	Somewhat higher than Scenario 7 – moderately strong economy and load growth leads to somewhat higher than base escalation	Lower than Scenario 7 – negative load growth, very weak economy and high renewables lead to low escalation	Moderate escalation	Moderate escalation

Figure 6-3 – Scenario Descriptions

## 6.1.2 Development of Planning Strategies

After development of the scenarios, planning strategies were designed to test the various business decisions and portfolio choices that TVA has control over and might consider. Strategies are very different from the scenarios. Whereas, scenarios describe plausible futures and include factors that TVA cannot control, strategies describe business decisions over which TVA has full control. In the end, a well-designed strategy would perform well in many possible scenarios whereas a poorly designed strategy would frequently not perform well.

The following three-step process was used to design the strategies in this IRP:

1. Identification of key components
2. Development of strategies using key components
3. Definition of strategy

Planning strategies represent decisions and choices over which TVA has full control.

### Identification of Key Components

To define the planning strategies, nine distinct categories of components were identified. The choice of components was influenced by comments received during the public scoping period and input from the SRG. Comments stated that TVA should challenge its targets for EEDR and renewables beyond the current portfolios. Accordingly, the ranges for both components were significantly expanded. The components for the planning strategies are described in Figure 6-4.

Component	Description	Type
EEDR portfolio	The level of EEDR included in each strategy	Defined Model Input
Renewable additions	The amount of renewable resources added in each strategy	Defined Model Input
Coal-fired capacity idling	A proposed schedule of coal-fired unit idling that will be tested in each strategy	Defined Model Input
Energy storage	Option to include a pumped-storage unit in selected strategies	Defined Model Input
Nuclear	Constraints related to the addition of new nuclear capacity	Constraint
Coal	Limitations on technology and timing for new coal-fired plants	Constraint
Gas-fired supply (self-build)	Limitations on gas-fired unit expansion	Constraint
Market purchases	Level of market reliance allowed in each strategy	Constraint
Transmission	Type and level of transmission infrastructure required to support resource options in each strategy	Constraint

Figure 6-4 – Components of Planning Strategies

As noted in Figure 6-4, there were two types of components, used in the model.

Defined model inputs	These components were scheduled or predetermined. This applied to both the timing and the quantity of specific asset decisions
Constraints in the model optimization	These components constrained the optimization of asset choices such as minimum build times, technology limitations and other strategic constraints including limits on market purchases. The capacity optimization model selected resources that were consistent with these constraints

### Development of Strategies Using Key Components

TVA combined these nine components and created five distinct planning strategies for the Draft IRP analysis. Figure 6-5 lists the five distinct planning strategies and their key characteristics.

Planning Strategy	Key Characteristics
<b>A</b> Limited Change in Current Resource Portfolio	<ul style="list-style-type: none"> <li>Retain and maintain existing generating fleet (no additions beyond Watts Bar Unit 2)</li> <li>Rely on the market to meet future resource needs</li> </ul>
<b>B</b> Baseline Plan Resource Portfolio	<ul style="list-style-type: none"> <li>Allows for nuclear expansion after 2018 and new gas-fired capacity as needed</li> <li>Assumes idling of approximately 2,000 MW of coal-fired capacity</li> <li>Includes EEDR portfolios and wind PPAs</li> </ul>
<b>C</b> Diversity Focused Resource Portfolio	<ul style="list-style-type: none"> <li>Allows for nuclear expansion after 2018 and new gas-fired capacity as needed</li> <li>Increases the contribution from EEDR portfolio and new renewables</li> <li>Adds a pumped-storage unit</li> <li>Assumes idling of approximately 3,000 MW of coal-fired capacity</li> </ul>
<b>D</b> Nuclear Focused Resource Portfolio	<ul style="list-style-type: none"> <li>Allows for nuclear expansion after 2018 and new gas-fired capacity as needed</li> <li>Includes an increased EEDR portfolio compared to other strategies</li> <li>Assumes idling of approximately 7,000 MW of coal-fired capacity</li> <li>Includes new renewables (same as Strategy C)</li> <li>Includes a pumped-storage unit</li> </ul>
<b>E</b> EEDR and Renewables Focused Resource Portfolio	<ul style="list-style-type: none"> <li>Assumes greatest reliance on EEDR portfolio of any strategy and includes largest new renewable portfolio</li> <li>Assumes idling of approximately 5,000 MW of coal-fired capacity</li> <li>Delays nuclear expansion until 2022</li> </ul>

Figure 6-5 – Planning Strategies Key Characteristics

## Definition of Strategy

Once each strategy's key characteristics were defined, specific numerical values for each component of each strategy were defined as shown in Figure 6-6.

Components	Strategy A	Strategy B	Strategy C	Strategy D	Strategy E
	Limited Change in Current Resource Portfolio	Baseline Plan Resource Portfolio	Diversity Focused Resource Portfolio	Nuclear Focused Resource Portfolio	EEDR and Renewable Focused Resource Portfolio
EEDR	1,940 MW & 4,725 annual GWh reductions by 2020	2,100 MW & 5,900 annual GWh reductions by 2020	3,600 MW & 11,400 annual GWh reductions by 2020	4,000 MW & 8,900 annual GWh reductions by 2020	5,100 MW & 14,400 annual GWh reductions by 2020
Renewable additions	1,300 MW & 4,600 GWh competitive renewable resources or PPAs by 2020	Same as Strategy A	2,500 MW & 8,600 GWh competitive renewable resources or PPAs by 2020	Same as Strategy C	3,500 MW & 12,000 GWh competitive renewable resources or PPAs by 2020
Idled coal-fired capacity	No fossil fleet reductions	2,400 MW total fleet reductions by 2017	3,200 MW total fleet reductions by 2017	7,000 MW total fleet reductions by 2017	4,700 MW total fleet reductions by 2017
Energy storage	No new additions	Same as Strategy A	Add on pumped-storage unit	Same as Strategy C	Same as Strategy A
Nuclear	No new additions after WBN2	First unit online no earlier than 2018 Units at least 2 years apart	Same as Strategy B	First unit online no earlier than 2018 Units at least 2 years apart	First unit online no earlier than 2022 Units at least 2 years apart Additions limited to 3 units
Coal	No new additions	New coal units are outfitted with CCS First unit online no earlier than 2025	Same as Strategy B	Same as Strategy B	No new additions
Gas-fired supply (self-build)	No new additions	Meet remaining supply needs with gas-fired units	Same as Strategy B	Same as Strategy B	Same as Strategy B
Market purchases	No limit on market purchases beyond current contracts and extensions	Purchases beyond current contracts and contract extensions limited to 900 MW	Same as Strategy B	Same as Strategy B	Same as Strategy B
Transmission	Potentially higher level of transmission investment to support market purchases Transmission expansion (if needed) may have impact on resource timing and availability	Complete upgrades to support new supply resources	Increase transmission investment to support new supply resources and ensure system reliability Pursue inter-regional projects to transmit renewable energy	Same as Strategy C	Potentially higher level of transmission investment to support renewable purchases Transmission expansion (if needed) may have impact on resource timing and availability

■ Defined model inputs	□ Optimized model inputs
------------------------	--------------------------

Figure 6-6 – Strategy Descriptions

Strategy components were utilized in the modeling in several different ways. For example, Strategy A has specific defined constraints, such as including no new coal additions and 1,300 MW of renewable resource additions. Other components specified timing, such as adding nuclear resources no earlier than 2018 and no new coal additions in Strategy B. Reactive constraints were also identified, such as the need to build additional transmission capacity if imports from renewables exceed a certain limit.

## 6.2 Resource Portfolios Optimization Modeling

The generation of resource portfolios was a two-step process. First, an optimized capacity expansion plan was generated, which was then followed by a financial analysis. This process was repeated for each strategy/ scenario combination and for additional sensitivity runs.

### 6.2.1 Development of Optimized Capacity Expansion Plan

TVA utilized a capacity optimization model, System Optimizer, which is an industry standard software model developed by Ventyx. This model utilized an optimization technique where an “objective function” (i.e., total resource plan cost) was minimized and subject to a number of constraints by using mixed integer linear programming.

Resources were selected by adding or subtracting assets based on minimizing the present value of revenue requirements (PVRR). PVRR represents the cumulative present value of total revenue requirements for the study period based on an eight percent discount rate. In other words, it is the today’s value of all future costs for the study period discounted to reflect the time value of money and other factors, such as investment risk.

In addition, the following constraints were observed:

- Balance of supply and demand
- Energy balance
- Reserve margin
- Generation and transmission operating limits
- Fuel purchase and utilization limits
- Environmental stewardship

System Optimizer uses a simplified dispatch algorithm to compute production costs. The model used a “representative hours” approach in which average generation and load

values in each representative period within a week were scaled up appropriately to span all hours of the week and days of the months.

Year-to-year changes in the resource mix were then evaluated and infeasible states were eliminated. The least-cost path (based on lowest PVRR) from all possible states in the study period was retained in the Draft IRP as the optimized capacity expansion plan.

## 6.2.2 Evaluation of Detailed Financial Analysis

Next, each capacity expansion plan was evaluated using an hourly production costing algorithm, which calculated detailed production costs of each plan, including fuel and other variable operating costs. These detailed cost simulations provided total strategy costs and financial metrics that were used for evaluation of the results.

This analysis was accomplished using another Ventyx product called Strategic Planning (MIDAS). This software tool uses a chronological production costing algorithm with financial planning data used to assess plan cost, system rate impacts and financial risk. It also utilized a variant of Monte Carlo analysis<sup>1</sup>, which is a sophisticated analytical technique that varies important drivers in multiple runs, to create a distribution of total costs rather than a single point estimate, which allows for risk analysis. The Monte Carlo analysis in MIDAS utilized 13 key variables.

The following variables were selected by TVA for the analysis:

- Commodity prices – natural gas, coal, CO<sub>2</sub>, SO<sub>2</sub> and NO<sub>x</sub> allowances
- Financial parameters – interest rates and electricity market prices
- Operating costs – capital as well as operation and maintenance
- Dispatch costs – hydro generation, fossil and nuclear availability
- Load forecast uncertainty

Total PVRR for each resource plan was calculated taking into account additional considerations. These considerations included the cash flows associated with financing. The model generated multiple combinations of the key assumptions for each year of the study period and computed the costs of each combination. Capital costs for supply-side options were amortized for investment recovery using a real economic carrying cost method that accounted for unequal useful lives of generating assets.

---

<sup>1</sup>Monte Carlo analysis is also referred to as stochastic analysis

Present value calculations are widely used in business and economics to provide a means to compare cash flows at different times on a meaningful basis. It also ensures that assets with higher capital costs and longer service lives are not unduly penalized relative to assets with lower capital costs and relatively shorter economic lives.

The short-term rate metric was also calculated and provided an alternative representation of the revenue requirements for the 2011-2018 timeframe expressed per MWh. This metric was developed to focus on the near-term impacts to system cost in recognition of TVA's current debt cap of \$30 billion and the likelihood that the majority of capital expenditures in the short-term<sup>1</sup> may have to be funded primarily from rates.

### 6.2.3 Development of Portfolio

Portfolios are the output of the modeling process described in Section 6.2 – Resource Portfolios Optimization Modeling, and represent the outcome of choices made for a given view of the future. During the Draft IRP process, an optimized portfolio was developed for each of the five planning strategies within each of the six scenarios and for the Reference Case: Spring 2010. The end result was 35 distinct portfolios. Each portfolio represented a 20-year capacity expansion plan. The portfolios consisted of assets that represented various resource selections and cost characteristics optimized to meet TVA's capacity and energy needs for the IRP study period.

Due to the nature of the analysis, certain elements (i.e., emphasis on EEDR and nuclear energy) of some strategies remained relatively constant across the scenarios. However, other elements (i.e., amount of natural gas-fired capacity and market purchases) were variable and determined by the interplay between each planning strategy and the scenario within which it was analyzed.

### 6.3 Development of Evaluation Scorecard

The use of a scenario planning approach, combined with multiple strategies to be considered, resulted in a large number of distinct 20-year resource portfolios that required analysis and evaluation. Rather than looking for the best single solution contained within a large number of portfolios, the scenario planning approach looked for trends or characteristics common to multiple portfolios with a focus on outcomes considered to be successful and the strategies that guided those outcomes. Definition of what is considered successful, although difficult, was a key component in the evaluation of the planning strategies. Development of a scorecard to communicate the success or failure of the different portfolios was vital to the success of this evaluation process.

---

<sup>1</sup>prior to 2018

The following sections describe the creation of the IRP scorecard, including development of the ranking and strategic metrics. Although not part of the scorecard, the development of a technology innovation narrative is also discussed below.

### 6.3.1 Scorecard Design

Identification of preferred planning strategies in the Draft IRP and development of the Recommended Planning Direction in the final IRP involved a trade-off analysis. The analysis was focused on multiple metrics of cost, risk, environmental impacts and other aspects of TVA's overall mission.

A scorecard was designed for each strategy and was used to facilitate this trade-off analysis. The scorecard template (Figure 6-7) was comprised of two sections – ranking metrics and strategic metrics. A technology innovation narrative was included apart from the scorecard to help identify which strategies would be supported by particular technology innovations.

	Ranking Metrics			Strategic Metrics				
	Financial Impact			Environmental Stewardship			Economic Impact	
Portfolio	Cost	Risk	Ranking Metric Score	Carbon Footprint	Water Impact	Waste Impact	Total Employment	Growth in Personal Income
			Total Score:					

Figure 6-7 – Planning Strategy Scorecard

#### Ranking Metrics

Ranking metrics were used to quantify the financial impact of each given portfolio. Two metrics, cost and risk, were selected based on their ability to highlight differences between the portfolios. To further highlight differences, the ranking metric score was calculated as a blend of the two metric's scores.



**Cost Metric**

Production of the financial metrics PVRR and short-term rates was described in Section 6.2.1. The cost metric used in the strategy scorecard combined these two metrics using the following weighted formula:

$$\text{Cost} = 0.65 * \text{PVRR} + 0.35 * \text{short-term rates}$$

By considering the expected values for PVRR and short-term rates, TVA was able to better evaluate the cost and rate implications for various portfolios. The inclusion of both short-term rates and total revenue requirements helped to facilitate a trade-off analysis of alternative resource plans. This allowed TVA to explicitly evaluate funding implications, consistent with stakeholder concerns regarding increasing rate pressures.

**Risk Metric**

The PVRR risk metric was computed using both a risk ratio and a risk/benefit ratio metric for each portfolio, as shown in Figure 6-8.

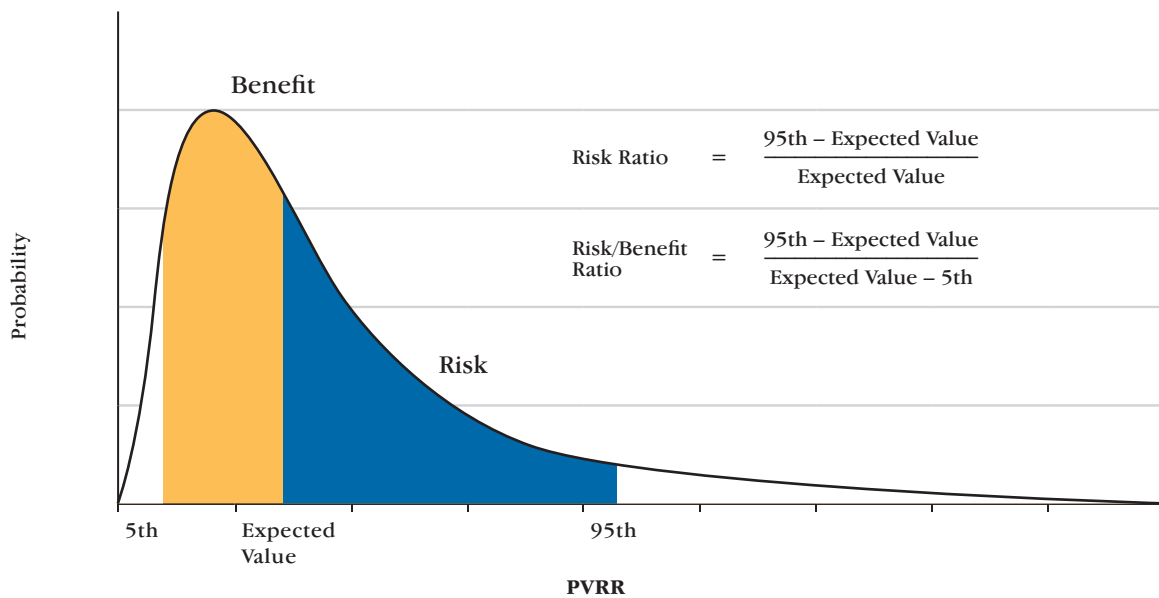


Figure 6-8 – Financial Risk Metrics

The risk metric used in the strategy scorecard combined these two metrics using the following weighted formula.

$$\text{Risk} = 0.65 * \text{risk ratio} + 0.35 * \text{risk/benefit ratio}$$

The risk ratio was expressed as the ratio of the difference between the 95th percentile of PVRR from the stochastic analysis and the expected value. It is a measure of the absolute “size” of the risk relative to the expected cost under each strategy within each scenario. A higher value signifies a portfolio with a relatively higher level of risk. The risk/benefit ratio captured the “risk” of a portfolio by examining the potential of exceeding the expected PVRR compared to the benefit of not exceeding the expected PVRR, expressed as a ratio. It compared the potential risks and the potential benefits of a strategy to determine whether or not the “risks and rewards” balance was weighted in favor of the customer.

## **Ranking Metric Score**

The ranking metrics score combined the cost and risk metrics using the following weighted formula.

$$\text{Ranking metrics score} = 0.65 * \text{cost} + 0.35 * \text{risk}$$

This metric allowed evaluation of the interaction between financial risks and overall plan cost. For example, desirable low costs may require accepting a greater risk exposure, or to achieve an acceptable level of financial risk may mean selecting a plan with costs that are slightly higher than the least-cost option. The trade-offs required to balance these competing objectives helped identify the preferred planning strategies in the Draft IRP and the Recommended Planning Direction in the final IRP.

## **Strategic Metrics**

Strategic metrics developed to consider other parts of TVA’s mission were paired with ranking metrics to complete the IRP scorecard. Two strategic metrics were developed – environmental stewardship and economic impact.

## **Environmental Stewardship Metric**

The environmental stewardship metric was developed to evaluate air, water and waste impacts. In the air metric evaluation, CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub> and Hg emissions were calculated for each portfolio. Emissions trends for SO<sub>2</sub>, NO<sub>x</sub> and Hg were steeply reduced because all cases chose large levels of coal-fired unit idling (2,000-7,000 MW) and controlled (90 percent or better emission removal rates) operating units in the future. For simplicity, the air metric was represented as a CO<sub>2</sub> impact footprint factor (annual average tons) because similar trend lines were tracked in all cases for CO<sub>2</sub>. No additional significant insight was

gained using all air emissions as opposed to using only CO<sub>2</sub>. Therefore, the air metric is represented as a CO<sub>2</sub> impact “footprint” factor (annual average tons).

The water component of the environmental stewardship metric represents the thermal load produced through the condenser cooling cycle from steam generating plants to measure thermal impacts to the environment. The water impact was estimated based on the total heat dissipated by the condenser in the generation cooling cycle.

In addition to air and water impacts, certain generation sources produce waste streams that require disposal. The waste component used in this analysis focused on coal and nuclear generation, which are the primary sources of waste streams. The volumetric and disposal costs were used to better normalize differences in mass generated (tons). Waste streams that were estimated included coal ash, flue gas desulfurization/scrubber waste and high- and low-level nuclear waste.

The final evaluation criteria for both water and waste relied on surrogate measures as a proxy for environmental impacts. Both provided a reasonable and balanced method for evaluating planning strategies when compared with other components. Additional detail on the environmental stewardship metrics is in Appendix A – Method for Computing Environmental Impact Metrics.

### **Economic Impact Metric**

Economic impact metrics were included to provide an indication of the impact of each strategy on the general economic conditions in the Tennessee Valley region. The economic metrics were represented by total employment and personal income. These metrics were compared to the impacts of Strategy B – Baseline Plan Resource Portfolio, in Scenario 7.

The IRP study defined economic impact as growth in regional economic activity. Measurement criteria included total personal income in “constant” dollars (i.e., with inflation accounted for) and total employment. These provided measures for the effects of the various planning strategies on the overall, long-term health and welfare of the economy over the next 20 years. This analysis concentrated on changes to the welfare of the general economy due to the strategies. It did not address changes to the distribution of income or employment.

In general, the greater the direct regional expenditures associated with a particular portfolio, the more positive were the effects on the regional economy. This can be offset by the fact that higher rates caused by higher costs have a negative effect on the regional economy. Thus, a resource portfolio that has high expenditures in the Tennessee Valley region may also have high costs and high rates.

The economic impact metrics for a particular planning strategy could be positive or negative depending on the net sum of the expenditure effects and the cost effects. More details about the methodology used to determine the economic impact metrics for the planning strategies is in Appendix B – Method for Computing Economic Metrics.

## **Scorecard Calculation and Color Coding**

The ranking metrics in the scorecard for this IRP were expressed in terms of a 100-point score while ensuring that the relative relationship between the actual values for each portfolio in the strategy was maintained. The following process was used to compute the scores:

- Actual values of ranking metrics (i.e., PVRR, short-term rate impacts) were converted to a relative score on a 100-point scale. This type of scoring helped to assess and prioritize risk and identify the best possible solution
- The highest ranked (“best”) value received a 100
- The rest of the scores were based on their relative position to the “best” value (e.g., a value that is 75 percent of the “best” would receive a 75)
- A color-coding method was used to assist in visual comparison of portfolio results. The coding was done within a given scenario. The “best” value for each metric was coded green, the “worst” value was coded red and the values in between were shown with a shaded color that corresponded to the relationship of the score values

An example of the translation from actual values to ranking metric scores is shown in Figure 6-9. The figure shows the conversion for the short-term rate metric.

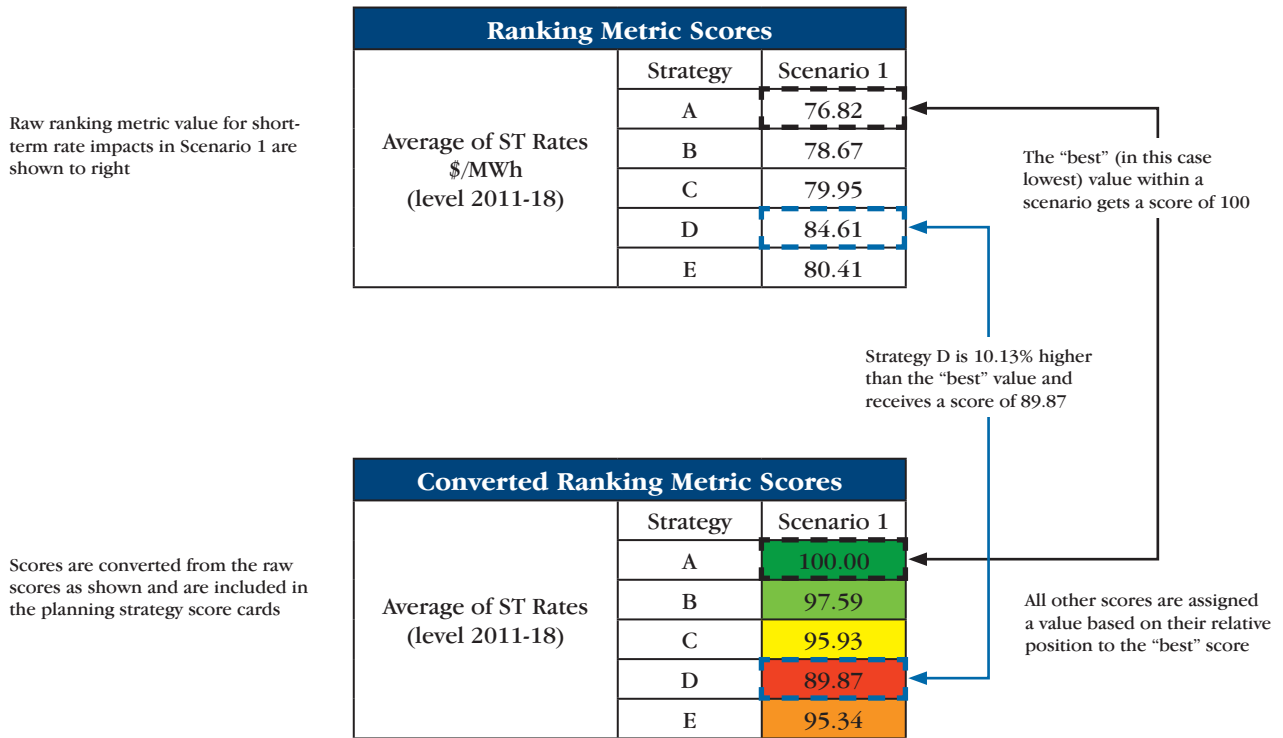


Figure 6-9 – Ranking Metrics Example

The strategic metrics were included in the scorecard in two ways. First, the environmental stewardship metrics values were translated into a relative scoring system, known as a Harvey Ball rating system. Second, the economic impact metrics were represented by a percent change from a reference case.

For the environmental stewardship metrics, the data was coded in a given scenario so that the relative relationship (rank order) among the strategies was indicated by the amount of the ball that was filled in. Figure 6-10 shows an example of how this translation was done.

- This is an example of how the Harvey Ball ratings were applied to the Carbon Footprint strategic metric
- Expected values for annual CO<sub>2</sub> emissions from stochastic analysis are shown to the right
- Planning strategies were ranked based on their performance within each scenario  
In this example, 1=highest and 5=lowest
- In this example, quantitative data was available to support the ranking, however, other strategic metrics may have required qualitative assessment for ranking
- The appropriate Harvey Ball was assigned based on the rankings

Average Annual CO<sub>2</sub> Emissions (Million Tons)

Strategy	Scenario						
	1	2	3	4	5	6	7
A	2,054	1,719	1,402	1,775	1,723	1,190	1,767
B	1,774	1,461	1,317	1,518	1,480	1,138	1,533
C	1,673	1,418	1,210	1,408	1,422	1,035	1,427
D	1,468	1,170	1,058	1,256	1,204	962	1,249
E	1,613	1,299	1,106	1,410	1,303	959	1,352

Carbon Footprint Rankings Within Scenarios

Strategy	Scenario						
	1	2	3	4	5	6	7
A	5	5	5	5	5	5	5
B	4	4	4	4	4	4	4
C	3	3	3	2	3	3	3
D	1	1	1	1	1	2	1
E	2	2	2	3	2	1	2

Populated Carbon Footprint Strategic Metric

Strategy	Scenario						
	1	2	3	4	5	6	7
A	○	○	○	○	○	○	○
B	◐	◐	◐	◐	◐	◐	◐
C	◑	◑	◑	◑	◑	◑	◑
D	●	●	●	●	●	◐	●
E	◑	◑	◑	◐	◑	●	◑

Legend	
●	Better
◐	↑
◑	
○	

Figure 6-10 – Example of Draft IRP Scoring Process – Carbon Footprint

For the economic impact metrics, data were included in the scorecard as a percent change from the reference portfolio (Strategy B in Scenario 7). Instead of computing impacts for all 35 portfolios, only the range of possible impacts was evaluated.

The range of possible impacts was evaluated by computing the values for each planning strategy in Scenarios 1 and 6. The changes in employment and personal income in these scenarios relative to the reference portfolio (Strategy B in Scenario 7) indicated the maximum impacts that could result in any of the other scenario/strategy combinations.

### 6.3.2 Technology Innovations Narrative

In addition to the ranking and strategic metrics, a brief narrative of technology innovations associated with each planning strategy was prepared for the TVA Board of Directors. The narrative gave insight into the technology utilization implicit in each strategy for the Draft IRP.

This narrative was not a metric, but included as a supplement to the fully populated scorecard as background information to consider for selection of a Recommended Planning Direction. The technology innovation narrative discussed which technologies would justify investment to enable the resource mix identified in each strategy (e.g., a planning strategy with extensive EEDR may need smart grid investments for energy savings to be fully realized). A full description of the technology innovation matrix is in Chapter 7 – Draft Study Results.

## 6.4 Identification of Preferred Planning Strategies in the Draft IRP

Identification of preferred planning strategies was the key deliverable of the Draft IRP. The preferred planning strategies were identified by using the following three steps:

1. Scoring
2. Sensitivity analysis
3. Identification of preferred planning strategies

### 6.4.1 Scoring

For the Draft IRP, the identification of preferred planning strategies began by computing a score for each of the 35 portfolios evaluated in the study. Scores were based on the expected value for the cost and risk metrics. A total planning score was then calculated by summing the scores (ranking metrics) for each portfolio produced. Strategic metrics were combined with the ranking metrics for each of the selected reference resource portfolios to complete the scorecard. The technology innovation narrative was also utilized to help inform the scorecard. The initial scorecard was publicly shared during the Draft IRP and associated EIS public comment period and helped to facilitate discussion of trade-offs, constraints and compromises by considering the scorecard values of cost, risk and the strategic metrics.

### 6.4.2 Sensitivity Analyses

Sensitivity analyses were conducted to refine the preliminary results. The results focused on key assumptions in the strategies based on review of the scorecard results. For the

Draft IRP, sensitivity analyses consisted of selected cases intended to assess the robustness of the top performing strategies prior to selecting which strategies would be retained for further analysis for the final IRP.

### **6.4.3 Identification of Preferred Planning Strategies**

By utilizing the ranking metrics, strategic metrics and technology innovation narrative, the preferred planning strategies were identified. Three strategies were retained in the Draft IRP – Strategies C, E and B. Resource portfolios were then identified from the preferred planning strategies. These resource portfolios represented the planning strategies for the purpose of comparative analysis and impact assessment and were used to define the broad range of options considered in the Draft IRP.

### **6.5 Incorporation of Public Input and Performance of Additional Scenario Planning Analyses**

Following publication of the Draft IRP, the data used for analysis was re-evaluated and refreshed for key assumptions like load forecasts and commodity prices. Also during this time, the Scenario 8 reference case was created to better capture the impacts of the recent economic recession. Figure 6-3 has more details on that scenario. In other cases, suggestions received from the SRG and general public were incorporated into the analysis. The modeling and evaluation processes were also carefully examined and changes were made to further improve the quality of the analysis.

### **6.6 Identification of Recommended Planning Direction**

After the Draft IRP public comment period, efforts continued to prepare the final IRP. The primary deliverable for this phase was the identification of the Recommended Planning Direction. This strategy will help define TVA's short- and long-term strategic direction and identify short-term actions that need to be accomplished. The preparation of the final IRP consisted of the following steps:

1. Identification of key components
2. Definition of boundary conditions
3. Development of Recommended Planning Direction candidates
4. Identification of the Recommended Planning Direction



**6.6.1 Identification of Key Components**

Components of the preferred planning strategies from the Draft IRP were evaluated for characteristics that would likely comprise the Recommended Planning Direction.

The revised approach reduced the number of inputs that were included in model optimization to produce a more focused result while allowing other unique combinations of resources to be tested that were not directly considered in the Draft IRP.

A key variable that was retained as a defined input was the level of idled coal-fired capacity. Idled capacity was not optimally selected within the model runs and required model iterations to test the different levels. This constraint meant that the optimum renewable and EEDR portfolio amounts were then selected for each assumed level of idled coal-fired capacity.

Portfolios for renewable additions and EEDR levels were optimized in the final analysis, along with the components identified in the Draft IRP. The model selected the best renewable and EEDR portfolio from the iterations provided as a part of optimizing all other resource alternatives.

**6.6.2 Definition of Boundary Conditions**

As described above, the Recommended Planning Direction was identified based on a blended optimization analysis using certain components from Strategies B, C and E. Figure 6-11 outlines the boundary conditions used in this stage of the analysis.

Components	Boundaries
EEDR	The EEDR portfolio will be no less than 2,100 MW & 5,900 annual GWh reduction by 2020
Renewable additions	Renewable additions will be no less than the existing wind contracts
Coal-fired capacity idled	Coal-fired capacity idled will be between 2,400 MW and 4,700 MW
Energy storage	The pumped-storage hydro unit (850 MW) will be included in all cases
Nuclear	Nuclear units cannot be added any earlier than 2018 and large units must be a minimum of two years apart – B&W technology at BLN cannot be added any later than 2020
Coal	New units cannot be added prior to 2025 and must be equipped with carbon capture and sequestration
Market purchases and transmission	If more than 900 MW/year are purchased beyond current contracts and extensions, potential transmission costs should be considered
Transmission	Transmission upgrades will be made to support new supply resources and maintain system readability

Figure 6-11 – Recommended Planning Direction Boundary Conditions

Within these boundaries, the capacity optimization model selected a resource plan that met the study constraints for reliability and least cost. To identify the optimum resource plan, multiple iterations were run within the model using the ranges of EEDR, renewable additions and idled coal-fired capacity as shown in Figure 6-12.

Components	Range of Options Tested				
EEDR	2,100 MW & 5,900 annual GWh reductions by 2020	3,600 MW & 11,400 annual GWh reductions by 2020	5,100 MW & 14,400 annual GWh reductions by 2020		
Renewable additions	1,500 MW competitive resources or PPAs by 2020	2,500 MW competitive resources or PPAs by 2020	2,500 MW competitive resources or PPAs by 2029	3,500 MW competitive resources or PPAs by 2020	3,500 MW competitive resources or PPAs by 2029
Coal-fired capacity idled	2,400 MW total fleet reductions by 2017	3,200 MW total fleet reductions by 2017	4,000 MW total fleet reductions by 2017	4,700 MW total fleet reductions by 2017	

Figure 6-12 – Recommended Planning Direction Range of Options Tested

Figure 6-12 also indicates the coal-fired capacity idling levels that were studied. As previously stated, these levels were not selected by the optimization model based on the full incremental costs of retaining these assets as part of the portfolios, but functioned as defined model inputs. As a result, the options shown for renewables and EEDR, along with any other resource options, were available for selection during optimization for each of the four assumed coal-fired idling levels.

### 6.6.3 Development of Recommended Planning Direction Candidates

Optimization results were produced by testing the four coal-fired idling levels across a subset of the scenarios originally developed for the Draft IRP.

The following scenarios were used to efficiently test the full range of possible futures for a total of 12 optimized cases:

- Scenario 1 – represented the upper bound
- Scenario 8 – represented a mid range of possible futures
- Scenario 3 – represented the lower bound and did not include climate change regulation

The following iterative six-step approach was used to produce the case results for the final IRP:

1. Incremental changes were made to strategy components in an attempt to improve upon the preferred planning strategies identified in the Draft IRP
2. The new strategy was tested in Scenarios 1 – 8 to evaluate new component combinations
3. The results were rescored to build a fully populated scorecard with ranking and strategic metrics
4. The completed scorecard was compared with results in the Draft IRP and previously considered alternatives to identify improvement, if any
5. Components common to strategies that exhibited improvement were selected to describe the proposed Recommended Planning Direction
6. Steps 1-5 were repeated until no further improvements were identified

#### **6.6.4 Identification of Recommended Planning Direction**

A Recommended Planning Direction was identified and is fully described in Chapter 8 – Final Study Results and Recommended Planning Direction. The identification of the Recommended Planning Direction was an iterative process that utilized the results of more than 3,000 modeling runs and evaluation of the results. The scorecard, along with stakeholder input and other considerations, was used to identify changes from the preferred planning strategies identified in the Draft IRP.



*The scenic beauty of the Tennessee Valley is an asset TVA works hard to preserve for future generations.*

---

<b>7 Draft Study Results</b>	<b>119</b>
7.1 Analysis Results	119
7.1.1 Firm Requirements and Capacity Gap	119
7.1.2 Expansion Plans	121
7.1.3 System Energy Mix	127
7.1.4 Plan Cost and Risk	128
<hr/>	
7.2 Selection Process	131
7.2.1 Scorecard Results	132
7.2.2 Ranking of Strategies	136
7.2.3 Sensitivity Cases	137
7.2.4 Other Strategic Considerations	138
<hr/>	
7.3 Preferred Planning Strategies	142



*The Guntersville Dam in Marshall County, Ala., has a generating capacity of 140,400 kilowatts of electricity.*

## Draft Planning Scenarios and Strategies

### Scenario

- 1 Economy Recovers Dramatically
- 2 Environmental Focus is a National Priority
- 3 Prolonged Economic Malaise
- 4 Game-Changing Technology
- 5 Energy Independence
- 6 Carbon Regulation Creates Economic Downturn
- 7 Reference Case: Spring 2010

### Planning Strategy

- A Limited Change in Current Resource Portfolio
- B Baseline Plan Resource Portfolio
- C Diversity Focused Resource Portfolio
- D Nuclear Focused Resource Portfolio
- E EEDR and Renewables Focused Resource Portfolio

## 7 Draft Study Results

This chapter describes the results and findings from the Draft IRP, published in September 2010. The Draft IRP studied five strategies in a total of six scenarios and one reference case scenario. As a result, 35 distinct 20-year portfolios or capacity expansion plans were created. These portfolios were scored and the results were evaluated as described in Chapter 6 – Resource Plan Development and Analysis. Results of this IRP are fully described in Chapter 8 – Final Study Results and Recommended Planning Direction

### 7.1 Analysis Results

#### 7.1.1 Firm Requirements and Capacity Gap

Forecasted capacity needs for the range of scenarios considered were presented in Section 4.3 – Estimate Supply. Consistent with TVA's scenario planning approach, variations from the expected forecast were studied as well. These variations were grouped into scenarios that represented different plausible futures in which TVA may have to operate. The key components of each scenario were translated into a forecast of firm requirements (demand plus reserves), which was used to identify the resulting capacity gap and need for power, driving the selection of resources in the capacity planning model.

Figure 7-1 illustrates the firm requirements forecasts for the seven scenarios that were studied in the Draft IRP. Six of the seven scenarios were specifically designed for the IRP study and are discussed in Section 6.1 – Development of Scenarios and Strategies. The seventh scenario represented the spring 2010 market view and was considered the reference case for analysis in the Draft IRP.



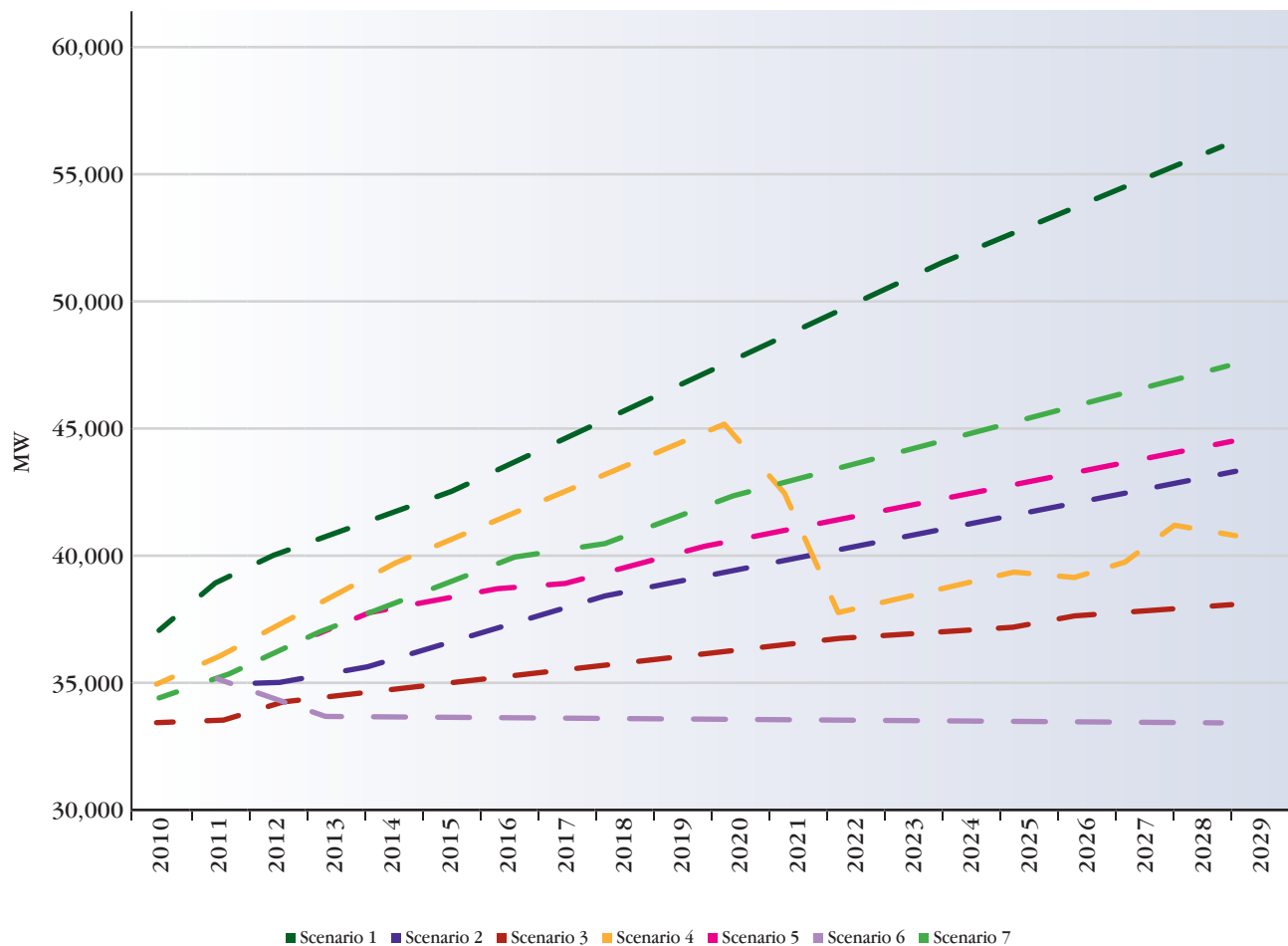


Figure 7-1 – Firm Requirements by Scenario

Firm requirements were greatest in Scenario 1 (highest load growth scenario) and lowest in Scenario 6 (flat to slightly negative load growth). The remaining scenarios fell within this range and generally displayed smooth but unique growth trends, with the exception of Scenario 4 (game-changing technology scenario). Firm requirements for Scenario 4 experienced a dramatic drop in load in 2021, reflecting that scenario’s assumptions of rapid commercialization of alternative technologies displacing the need for traditional resources.

The shape of the firm requirements curves influenced the type and timing of resource additions in the strategies, especially in Scenario 4 where resource additions were reduced or eliminated in the latter years. The timing of additional resources was a function of the existing system capacity and the impact of the defined model inputs for each strategy.

Figure 7-2 summarizes the range of the capacity gaps at the end of the study period for the cases studied in the Draft IRP. The range of the capacity gaps in this figure is based on the minimum and maximum gaps found in the five planning strategies developed for the Draft IRP. The maximum gap represents the largest capacity gap and is based on Scenario 1. The minimum gap represents the smallest capacity gap or potentially a surplus of generation and is based on Scenario 6.

Strategy	Max Capacity Gap (MW)	Min Capacity Gap (MW)
A	18,000	(4,800)
B	20,000	(3,000)
C	17,000	(6,000)
D	19,000	(4,000)
E	18,000	(5,000)

Figure 7-2 – Range of Capacity Gaps by Strategy

This broad range of capacity gaps resulted in a wide range of expansion plans across the 35 portfolios developed in the Draft IRP.

### 7.1.2 Expansion Plans

The amount and type of resource additions for the five planning strategies that were evaluated in the Draft IRP are consistent with the following assumptions that define each of the scenarios:

- The largest amount of resource additions occurred in Scenario 1
- Scenario 7, representing the Reference Case: Spring 2010, required an average amount of new resources over the study period
- Scenarios 3 and 6 had the least amount of resource additions
- Small amounts of new resources were added in Scenarios 2 and 5
- In Scenario 4, no resources were added after 2020, consistent with the dramatic drop in load beginning in 2021

The individual capacity expansion plans for each of the five planning strategies are presented in Appendix E – Draft IRP Phase Expansion Plan Listing, and are grouped by scenario. These plans reflect the contributions from the TVA Board of Directors’ approved projects. In addition, the impacts of the defined model inputs, particularly the capacity associated with the renewable resource portfolios and the avoided capacity value from EEDR, are also included. Figure 7-3 illustrates the range of capacity additions by resource type across all the strategies.

Type	Minimum (MW) <sup>1,2</sup>	Maximum (MW) <sup>1,3</sup>
Nuclear	0	4,754 (4)
Combustion turbine	0	8,092 (11)
Combined cycle	0	6,700 (7)
IGCC	0	934 (2)
SCPC	0	800 (1)
Avoided capacity (EEDR) <sup>4</sup>	1,905	6,361
Renewables <sup>4</sup>	160	1,157
Pumped-storage <sup>4</sup>	0	850
Coal-fired capacity idled <sup>4</sup>	0	7,000

Notes:

1 – Values shown are for dependable capacity at the summer peak. Nameplate capacity of renewables range from 1,300 to 3,500 MW

2 – Minimums exclude Board-approved projects (WBN 2, JSFCC, and Lagoon Creek)

3 – Number of units shown in ( )

4 – Defined model input

Figure 7-3 – Capacity Additions by 2029

To provide a different view of the expansion plan results for the strategies evaluated in the Draft IRP, a set of histograms was developed that presents data on the frequency of selection of key resource types across the 35 portfolios. Figures 7-4 through 7-7 are plots that illustrate the number of portfolios and the specific number of nuclear, coal, combined cycle and combustion turbine units that may be added.

Nuclear capacity beyond Watts Bar Unit 2 was prominent in the analysis results, as illustrated in Figure 7-4. At least two nuclear units, and up to four, were added in 19 of the 28 possible portfolios, and the first nuclear unit was added between 2018 and 2022. Nuclear capacity was not added to portfolios in scenarios with nearly flat load growth. In one strategy, nuclear was not a permitted resource expansion option.

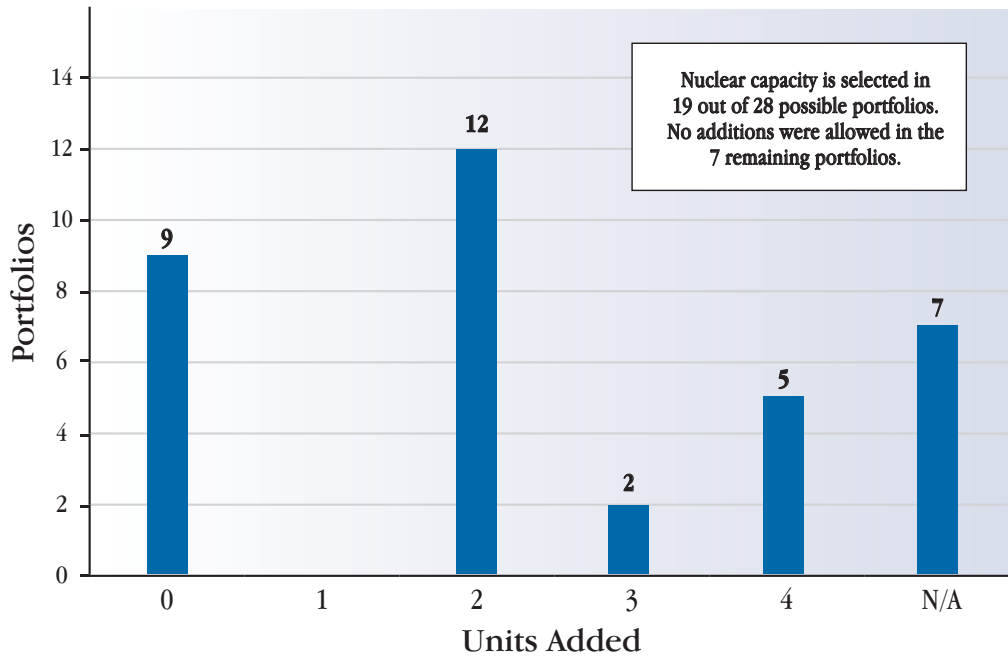


Figure 7-4 – Number of Nuclear Units Added

Coal capacity additions were very infrequent (Figure 7-5). Integrated gasification combined cycle (IGCC) units with carbon capture were selected only after 2025 and in just three of the 21 possible portfolios. Supercritical pulverized coal (SCPC) with carbon capture was added after 2035 and in only one of the 21 possible portfolios. Two strategies do not permit additional coal-fired units.

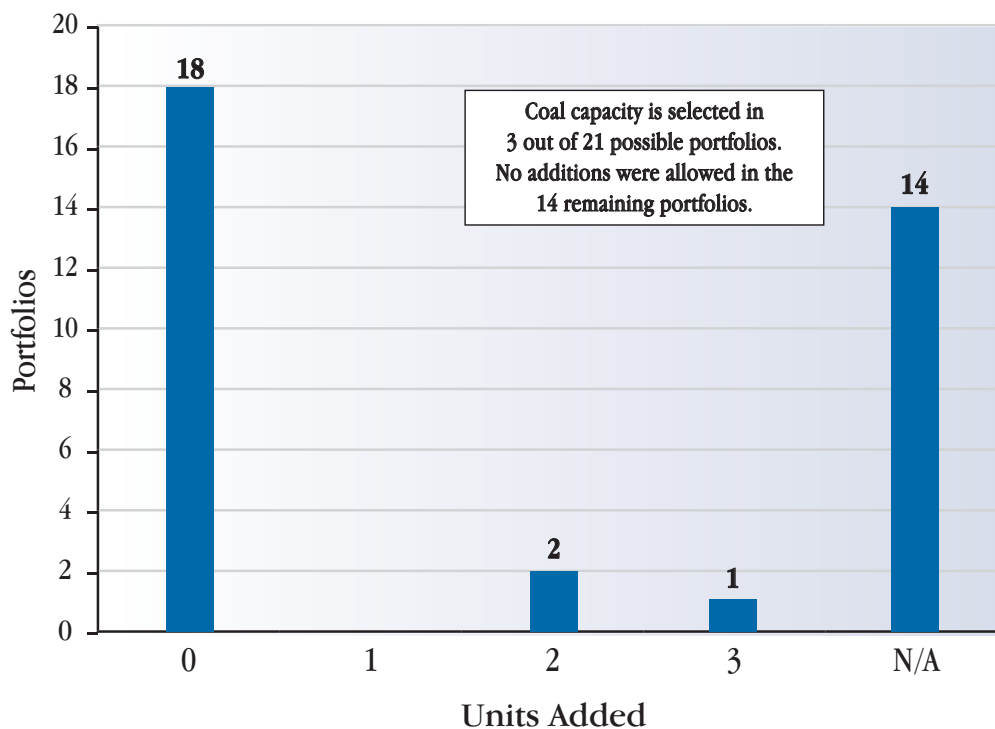


Figure 7-5 – Number of Coal Units Added

Additions of combined cycle capacity (including potential acquisitions of IPP projects) ranged from 0–7 units (0-6,700MW) as shown in Figure 7-6. Combined cycle capacity was selected in 15 of 28 possible portfolios.

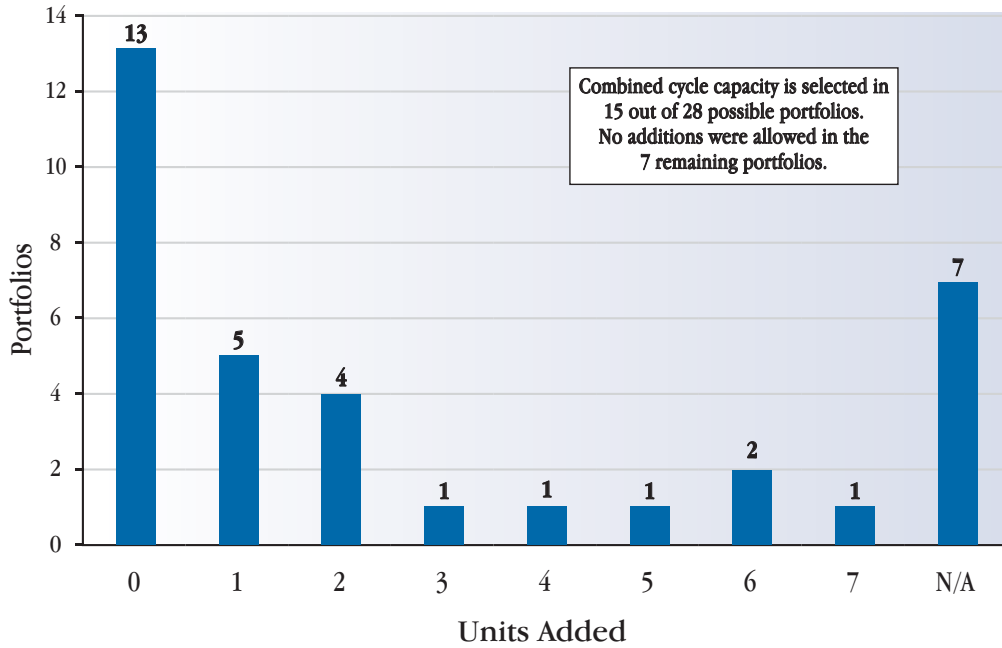


Figure 7-6 – Number of Combined Cycle Units Added

As illustrated in Figure 7-7, combustion turbine capacity additions ranged from 0–11 units (0-8,000 MW) and the majority of portfolios that selected combustion turbine capacity added just a single unit. Natural gas capacity (CT/CC) was not selected for portfolios in scenarios with nearly flat load growth or scenarios with the largest avoided capacity from EEDR.

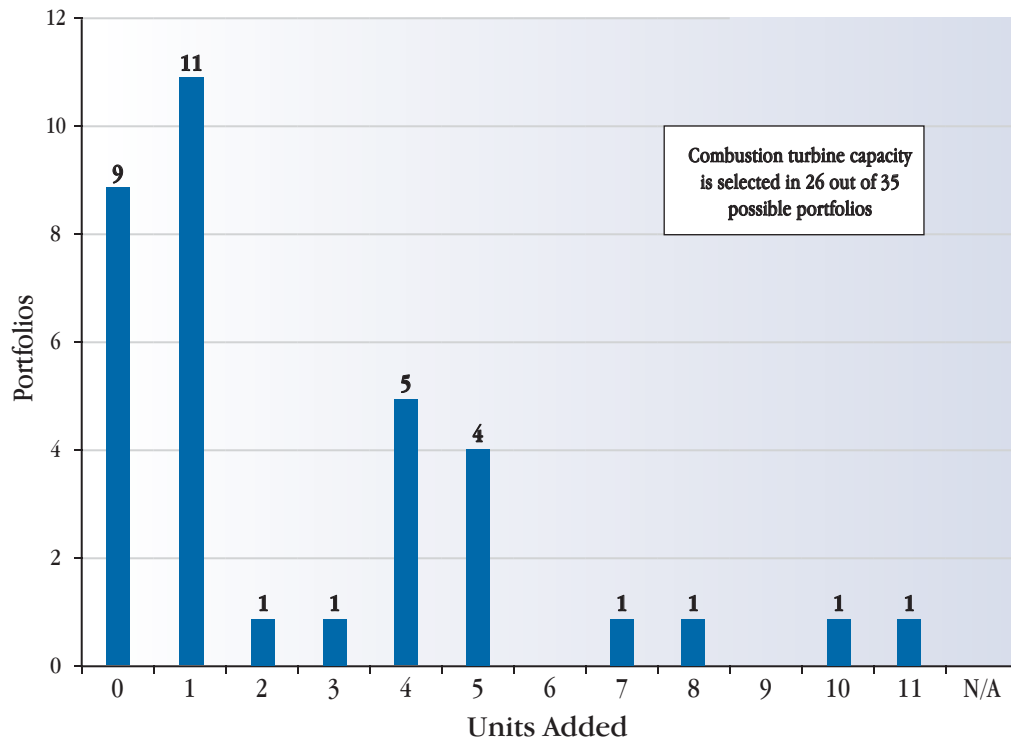


Figure 7-7 – Number of Combustion Turbine Units Added

### 7.1.3 System Energy Mix

Figure 7-8 lists the minimum and maximum percentage contributions to total energy production by type in 2029 from the 35 portfolios produced in the Draft IRP. Values represent the highest and lowest percentages for each type and are not from a single portfolio; therefore, they do not add to 100 percent.

Type	Minimum	Maximum
Combined Cycle	0%	13%
Combustion Turbine	0%	3%
Nuclear	27%	47%
Coal	24%	47%
Renewables	2%	8%
EEDR (savings)	2%	11%

Figure 7-8 – Range of Energy Production by Type in 2025

Nuclear and coal had the greatest swings in percentage contribution to total energy. In the majority of scenario and strategy planning combinations, nuclear overtook coal to produce the greatest percentage of total energy. Strategy A is the exception with coal remaining the largest energy producer in that strategy.



7.1.4 Plan Cost and Risk

A comparison of the expected value of PVRR by scenario for the strategies evaluated in the Draft IRP is illustrated in Figure 7-9. Scenario 1 resulted in the highest value for PVRR, while the lowest PVRR values were found in Scenario 6. Within each scenario, Strategy D generally produced the highest cost portfolios due to the larger amount of coal-fired capacity idled that must be replaced by new resources. Strategy A resulted in the set of portfolios with the next highest cost, caused by retaining a higher level of coal-fired capacity compared to other strategies, exposing it to more significant CO<sub>2</sub> compliance costs. Strategy C produced the lowest PVRR values in six of the seven scenarios. However, Strategy C was near the middle of the pack on short-term rate impacts which are discussed in the next section.

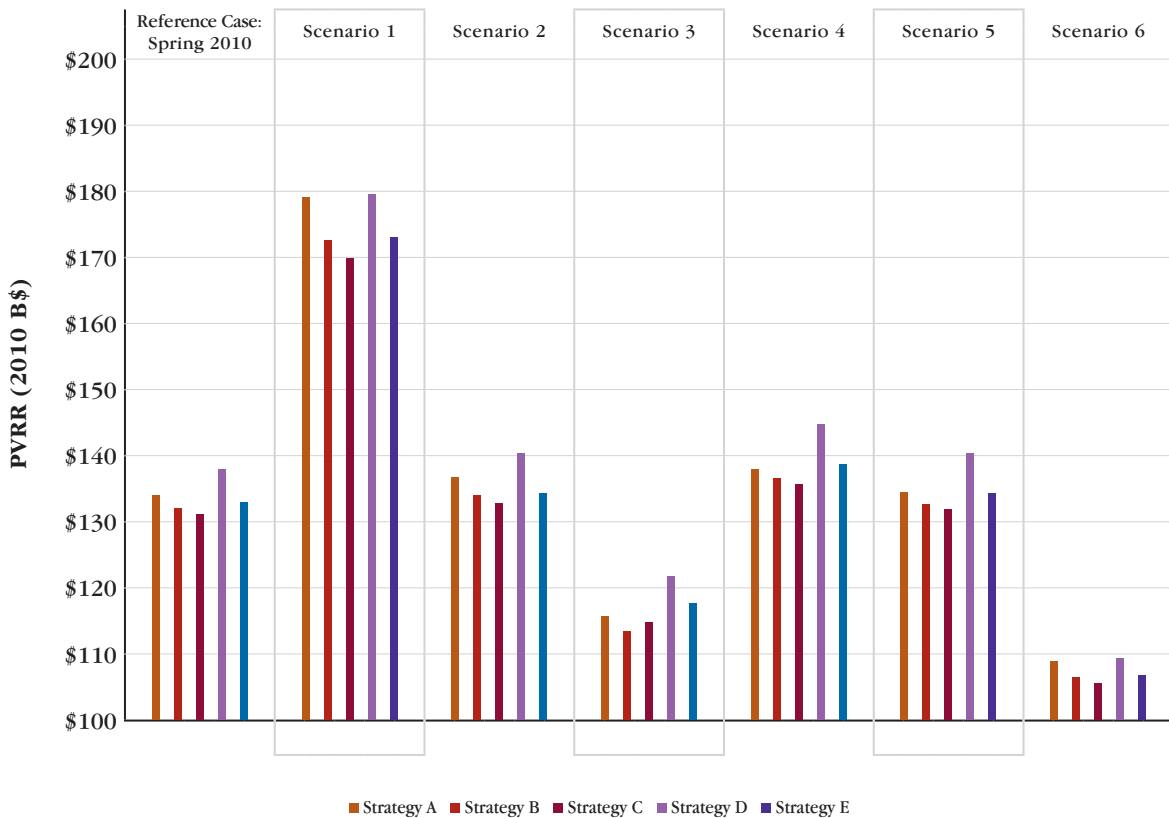


Figure 7-9 – Expected Value of PVRR by Scenario

Figure 7-10 presents the short-term rate impacts (average system costs) by scenario. The strategy with the highest expected value of short-term rates was Strategy D because this strategy had the most new capacity additions in the 2011–2018 timeframe. Strategy A produced the lowest short-term rate values in five of the seven scenarios because no new capacity was added to any portfolios within that strategy. However, Scenarios 3 and 6 included higher CO<sub>2</sub> compliance costs, which drove up the cost of the coal-heavy portfolios in Strategy A (in those scenarios). Strategy A's exclusive reliance on the market to serve load growth also has greater risk as shown in the discussion of risk metrics in the next section.

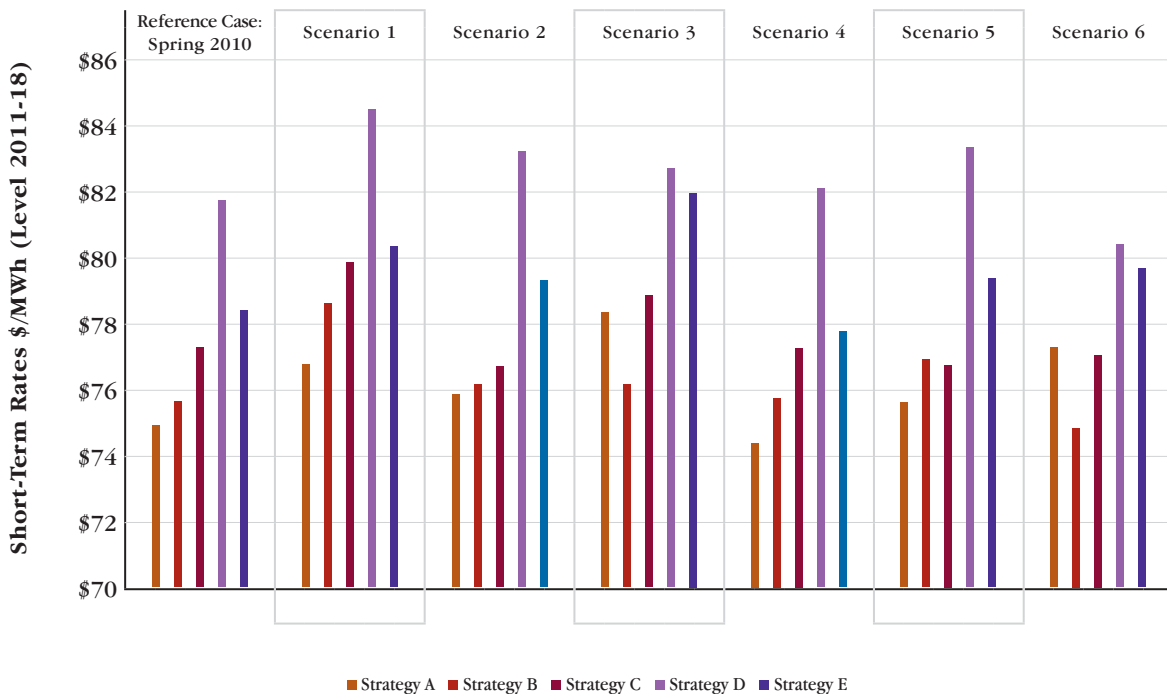


Figure 7-10 – Expected Values for Short-Term Rates by Scenario

Figures 7-11 and 7-12 compare the two risk metrics for the planning strategies. Lower ratios indicated less risky portfolios based on the probability distributions of the portfolio PVRR values. The relative relationship across the scenarios for both the risk ratio and the risk/benefit ratio were consistent. The highest values occurred in Scenario 1, the risk ratio was lowest in Scenario 3 and the risk/benefit ratio was lowest in Scenario 6.

In both cases, these low values were caused by much lower load forecasts in those scenarios, which resulted in lower PVRR values with more narrow probability distributions. Strategy A had the highest risk profile in five of the seven scenarios, which was caused by the retention of coal-fired capacity. Strategy C was the least risky strategy in six of the seven scenarios due to its generally balanced resource mix.

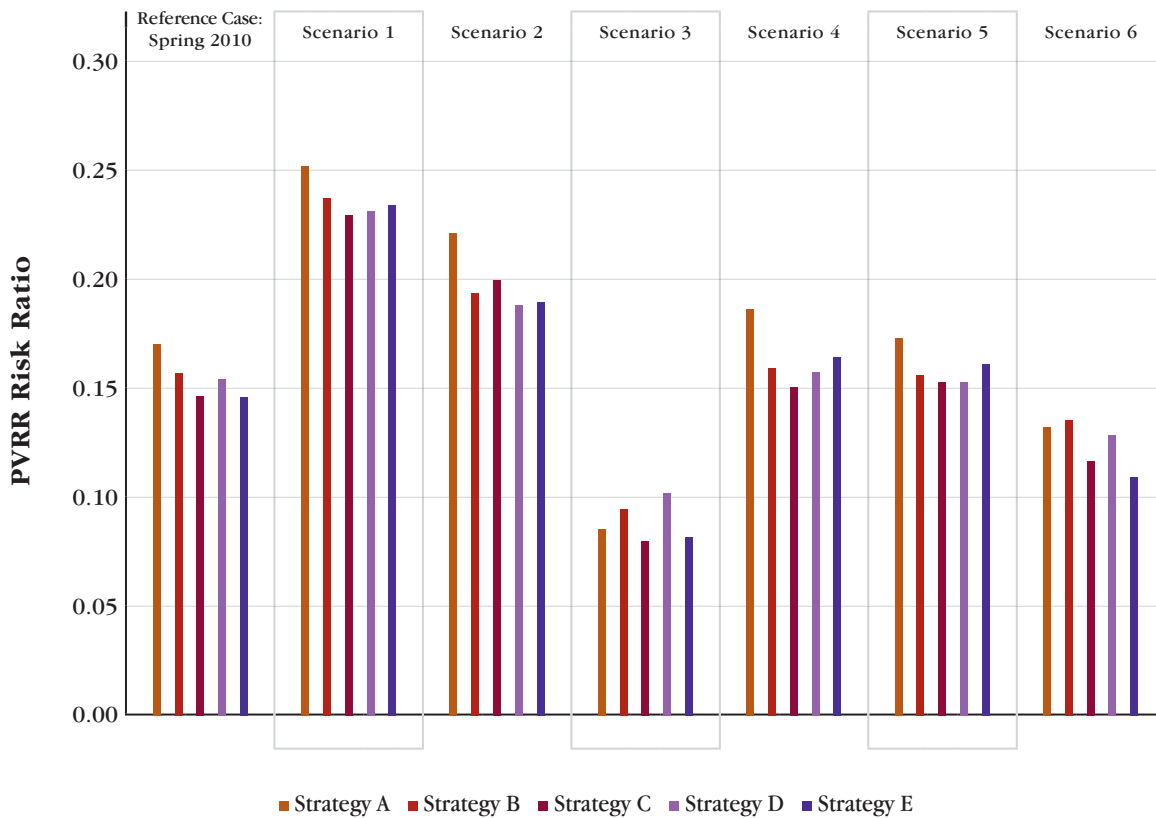


Figure 7-11 – PVRR Risk Ratio by Scenario

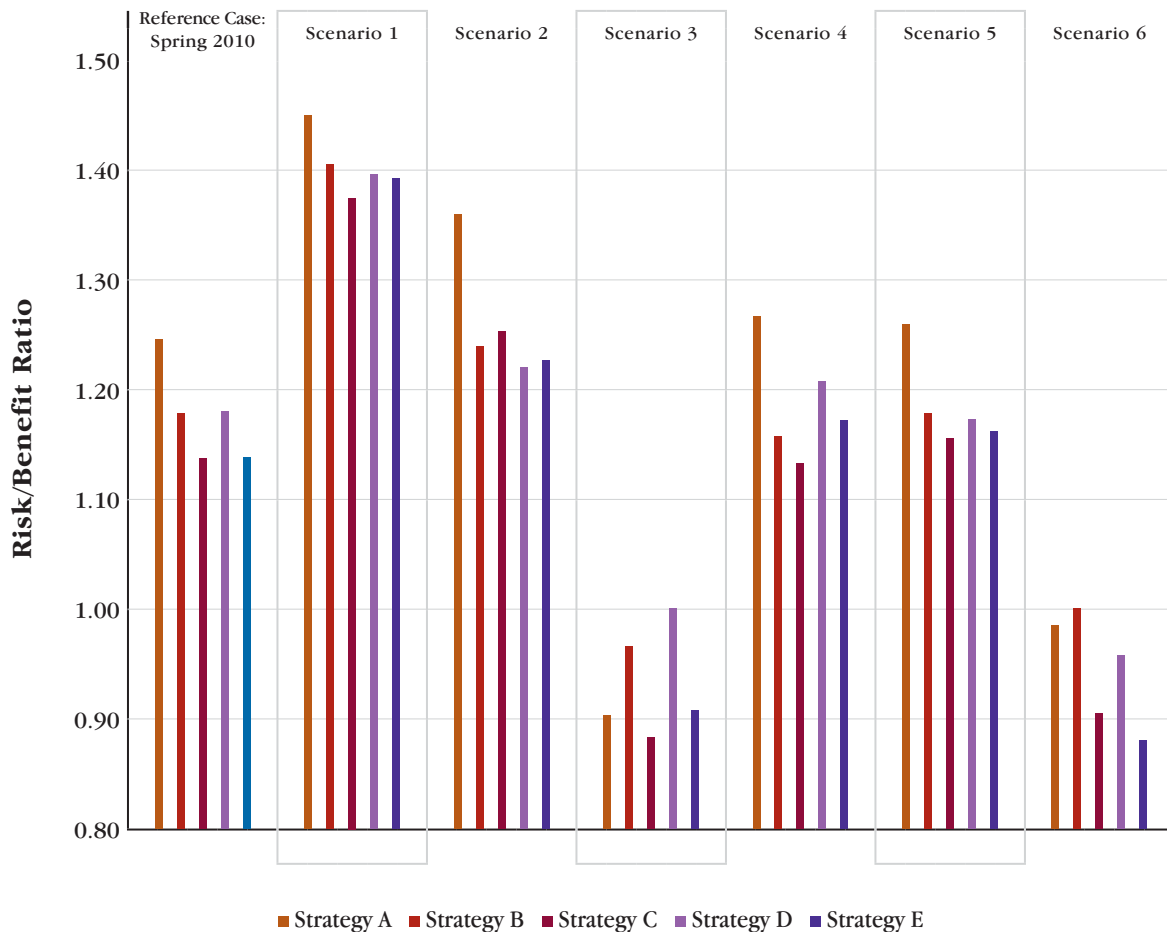


Figure 7-12 – PVRR Risk/Benefit by Scenario

## 7.2 Selection Process

The process that was used to rank and identify the preferred planning strategies was discussed in Chapter 6 – Resource Plan Development and Analysis. That process involved the following four steps:

1. Planning strategies were scored (based on cost and risk metrics) and ranked
2. Strategic metrics were added to the ranking metrics to complete the scorecard for the top ranked strategies
3. Selected strategies were released for public comment in the Draft IRP and the associated EIS
4. Sensitivity analyses were done as a result of public comments

The ranking of each strategy was based on the expected values of the cost and risk metrics generated by the stochastic analysis, which is described in Chapter 6 – Resource Plan Development and Analysis. The expected values were translated into a score, and the scores across all seven scenarios were combined to produce a total strategy score. Strategies were ranked based on total score from highest to lowest. A subset of strategies was selected for further consideration based on scores and other strategic considerations such as potential environmental impacts.

### 7.2.1 Scorecard Results

Scorecards were generated by translating the expected values from the modeling results into a standardized score that was summed across the scenarios for each planning strategy. Figure 7-13 summarizes the average expected values of PVRR, short-term rates, risk/benefit and risk computed for the five planning strategies in each of the seven scenarios.

		Scenarios							
Strategy		1	2	3	4	5	6	7	Average
Average of PVRR (2010 B \$)	A	180	137	116	138	135	109	134	<b>136</b>
	B	179	136	114	137	133	107	133	<b>134</b>
	C	175	133	114	135	131	105	130	<b>132</b>
	D	181	137	115	138	134	103	132	<b>134</b>
	E	174	131	115	136	131	104	130	<b>132</b>
Average of ST Rates (level 2011-18)	A	76.82	75.92	78.42	74.47	75.75	77.31	74.97	<b>76.24</b>
	B	82.49	77.49	76.22	75.88	77.04	74.91	75.72	<b>77.11</b>
	C	83.57	74.60	77.40	76.00	75.64	75.55	75.94	<b>76.96</b>
	D	84.83	79.54	75.24	75.98	76.80	72.70	75.13	<b>77.17</b>
	E	78.91	75.94	78.23	74.78	76.01	75.90	75.14	<b>76.42</b>
Average of Risk/Benefit	A	1.45	1.36	0.91	1.27	1.26	0.99	1.25	<b>1.21</b>
	B	1.43	1.24	0.97	1.16	1.18	1.00	1.18	<b>1.17</b>
	C	1.41	1.29	0.89	1.14	1.16	0.91	1.14	<b>1.14</b>
	D	1.45	1.26	1.06	1.25	1.20	1.00	1.23	<b>1.21</b>
	E	1.42	1.24	0.93	1.19	1.18	0.90	1.15	<b>1.15</b>
Average of Risk	A	0.25	0.22	0.09	0.19	0.19	0.13	0.17	<b>0.18</b>
	B	0.23	0.19	0.10	0.16	0.17	0.14	0.16	<b>0.16</b>
	C	0.23	0.20	0.08	0.15	0.17	0.12	0.15	<b>0.16</b>
	D	0.23	0.19	0.11	0.17	0.18	0.14	0.16	<b>0.17</b>
	E	0.24	0.20	0.08	0.17	0.17	0.11	0.15	<b>0.16</b>

Figure 7-13 – Ranking Metrics Worksheet

After applying the methodology for translating actual values into color-coded scores, which is described in Chapter 6 – Resource Plan Development and Analysis, a scorecard was produced for each of the five planning strategies. In Figure 7-14, planning Strategy A was used to demonstrate how scores were computed and then summed to produce the total ranking score.

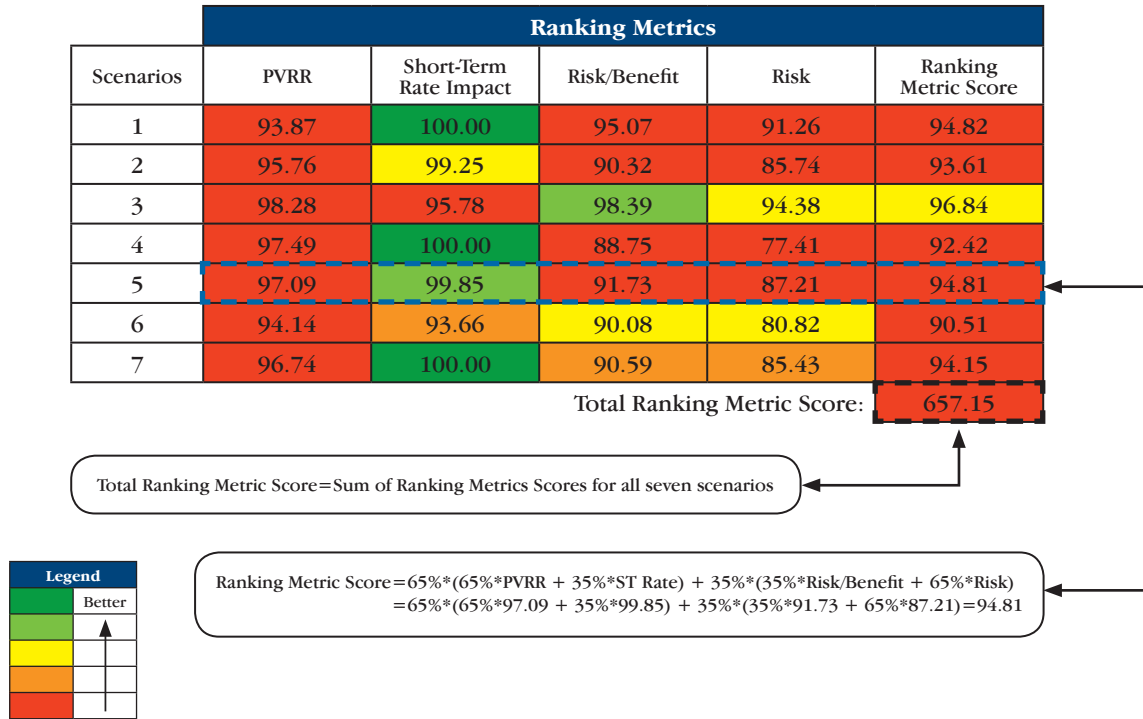


Figure 7-14 – Planning Strategy A – Limited Change in Current Resource Portfolio

Scorecards for the remaining four strategies are shown in Figures 7-15, 7-16, 7-17 and 7-18.

Ranking Metrics					
Scenarios	PVRR	Short-Term Rate Impact	Risk/Benefit	Risk	Total Plan Score
1	97.71	97.59	98.40	97.34	97.68
2	97.76	98.85	100.00	99.98	98.79
3	99.61	98.70	91.37	83.79	94.79
4	98.38	98.11	98.25	93.79	97.26
5	98.44	98.14	98.61	98.94	98.51
6	96.55	96.96	88.56	78.46	91.55
7	98.01	99.01	96.50	94.26	97.20
Total Ranking Metric Score:					<b>675.78</b>

Legend	
	Better
	↑

Figure 7-15 – Planning Strategy B – Baseline Plan Resource Portfolio

Ranking Metrics					
Scenarios	PVRR	Short-Term Rate Impact	Risk/Benefit	Risk	Total Plan Score
1	100.00	97.48	100.00	100.00	99.43
2	99.58	100.00	96.20	96.17	98.49
3	100.00	97.13	100.00	100.00	99.35
4	100.00	97.94	100.00	100.00	99.53
5	100.00	100.00	100.00	100.00	100.00
6	98.59	96.09	98.19	93.22	96.75
7	100.00	98.71	100.00	100.00	99.71
Total Ranking Metric Score:					<b>693.25</b>

Legend	
	Better
	↑

Figure 7-16 – Planning Strategy C – Diversity Focused Resource Portfolio

Ranking Metrics					
Scenarios	PVRR	Short-Term Rate Impact	Risk/Benefit	Risk	Total Plan Score
1	97.40	97.54	96.41	96.81	97.18
2	97.90	98.51	99.04	98.90	98.40
3	99.41	100.00	81.31	69.12	90.43
4	97.40	97.97	90.14	92.05	95.42
5	97.86	98.47	96.57	92.60	96.64
6	100.00	100.00	89.16	78.46	93.77
7	98.56	99.79	92.15	91.33	96.41
Total Ranking Metric Score:					<b>668.26</b>

Legend	
	Better
	↑

Figure 7-17 – Planning Strategy D – Nuclear Focused Resource Portfolio

Ranking Metrics					
Scenarios	PVRR	Short-Term Rate Impact	Risk/Benefit	Risk	Total Plan Score
1	99.43	99.21	97.82	96.78	98.58
2	100.00	99.22	99.79	100.00	99.80
3	99.15	96.03	95.91	97.73	97.72
4	99.45	99.58	95.32	89.57	96.73
5	99.83	99.50	98.87	99.47	99.56
6	99.16	95.61	100.00	100.00	98.64
7	99.68	99.77	98.98	98.96	99.45
Total Ranking Metric Score:					<b>690.47</b>

Legend	
	Better
	↑

Figure 7-18 – Planning Strategy E – EEDR and Renewables Focused Resource Portfolio

The scores assigned to each strategy and the associated color coding was done within a given scenario. To properly interpret the scoring for each strategy, the values for each individual ranking metric in all five strategies were compared within a particular scenario.



### 7.2.2 Ranking of Strategies

Detailed descriptions of strategies were introduced in Chapter 6 – Resource Plan Development and Analysis. Figure 7-19 shows the rank order of the five planning strategies evaluated in the Draft IRP based on the total ranking metrics scores. The total strategy scores range from 657 to 693 out of a possible 700 points.

Rank	Planning Strategy	Preliminary Observations
1	C	<ul style="list-style-type: none"> <li>• Performs the best against PVRR and risk metrics</li> <li>• Near the median for short-term rates</li> </ul>
2	E	<ul style="list-style-type: none"> <li>• Near the median for short-term rates</li> <li>• Performs near the best for PVRR</li> </ul>
3	B	• Ranks near the median for PVRR, short-term rates and risk
4	D	• Ranks below the median for PVRR, rates and risk
5	A	<ul style="list-style-type: none"> <li>• Performs the worst on PVRR and risk</li> <li>• Ranks the best for short-term rates in some scenarios</li> </ul>

Figure 7-19 – Planning Strategy Ranking Order

A key element of a “no-regrets” strategy is that a portfolio performs relatively well in most scenarios, not just the reference case scenario. Using the initial planning results, Strategy C was the top-ranked planning strategy on the basis of the total ranking metric score. However, the separation between the scores of Strategies C and E was not statistically significant. Strategy C represented an attempt to define a balanced approach to the resource mix and performed best in five of the seven scenarios based on total plan score, performed second best in another and third in just one scenario. The ranking metrics implied that Strategy C was the most robust in many possible futures. Strategy C was the top performer for PVRR and for both risk metrics. It performed reasonably well on short-term rates, but it was not the best strategy in that category.

The second best planning strategy, based on total ranking metric score, was Strategy E. As with Strategy C, this strategy represented an expanded commitment to cleaner resource options, especially pertaining to EEDR and renewable energy options. The strategy performed well in all four of the ranking metrics and performed best in two of the seven scenarios based on total plan score, resulting in a total strategy score that was very close to Strategy C.

The third best planning strategy was Strategy B. This strategy represented a “business-as-usual” approach that did not significantly deviate from existing portfolio mixes over the long term. This strategy performed reasonably well with scores in the four ranking metrics that were in the mid range for each metric, but did not rank first in any of the scenarios.

Strategy B was retained for further analysis in this IRP as a baseline strategy for impact analysis.

Strategies A and D were in the lower tier of the total strategy scores and did not represent options that offer preferable planning approaches. These two strategies represented approaches that tended to define the boundary conditions within which the other strategy results could be placed. Strategy A was an approach that included retention of all existing coal-fired capacity, with a high level of clean air capital and maintenance spending and heavy reliance on the market. The scorecard for this strategy showed it to be the worst performer in most metrics for most of the scenarios, except for the short-term rate metric where it performed quite well. Strategy D was characterized by the largest level of coal-fired capacity idled which called for the most new capacity additions. This resulted in poor strategy scores across the scenarios, although this strategy outperformed Strategy A.

### 7.2.3 Sensitivity Cases

In addition to the initial 35 portfolios developed from the five planning strategies, TVA also performed certain sensitivity analyses. These analyses focused on key assumptions within those strategies based on review of the scorecard results. In the Draft IRP, the sensitivity analyses consisted of four cases involving Strategies C and E (the top-ranked strategies based on the results to date). The characteristics of these sensitivity cases are described in Figure 7-20.

Sensitivity Description	Basis for Selection
C1 – Strategy C with pumped-storage hydro removed	Test for improvement in short-term rate impacts by removing defined model input for pumped-storage hydro unit
C2 – Same as Sensitivity C1 with no capacity additions prior to 2018	Test for improvements in short-term rate impacts by defining near-term capacity additions. Modeled after Strategy A, which performs the best on rates
E1 – Strategy E with greater (7,000 MW) coal-fired idling (same as Strategy D)	Test to see if largest values for EEDR, renewables, and coal unit idling significantly improve the PVRR and short-term rate impacts of Strategy E
E2 – Strategy E with lower (2,500 MW) renewable portfolio (same as Strategy C)	Improve PVRR and short-term rates by using the lower renewable portfolio applied in Strategy C

Figure 7-20 – Sensitivity Characteristics

When these sensitivity cases were evaluated using the same ranking metrics applied to the original five planning strategies, a new rank order of strategies was established, as shown in Figure 7-21. The scores now range from 655 to 689.

Rank	Planning Strategy
1	C1 – Strategy C without pumped-storage hydro
2	C – Diversity Focused Resource Portfolio
3	C2 – same as C1 with no capacity additions prior to 2018
4	E – EEDR and Renewables Focused Resource Portfolio
5	E2 – Strategy E with greater coal unit idling
6	E1 – Strategy E with lower renewable portfolio
7	B – Baseline Plan Resource Portfolio
8	D – Nuclear Focused Resource Portfolio
9	A – Limited Change in Current Resource Portfolio

Figure 7-21 – Rank Order of Strategies

Sensitivity C1 was a slight improvement over planning Strategy C and now has the highest-ranking metric score among the options considered in the Draft IRP. Sensitivity C2 was slightly lower than Strategy C. As components changed, the stability of Strategy C represented a noteworthy quality. Sensitivities E1 and E2 did not improve the results as compared to Strategy E and were removed from further consideration for the final IRP.

#### 7.2.4 Other Strategic Considerations

In addition to the metrics used to establish the rank order of the planning strategies, TVA included strategic metrics in the fully populated scorecard. These strategic metrics included environmental and regional economic impact measures that recognize other aspects of TVA's mission. These strategic metrics are fully discussed in Chapter 6 – Resource Plan Development and Analysis. Note that for the economic impact measures, all of the IRP strategies were analyzed only for Scenarios 1 and 6 – the scenarios that defined the upper and lower range of strategy impacts within the scenario range.

Figure 7-22 shows the strategic metrics for each of the five planning strategies.

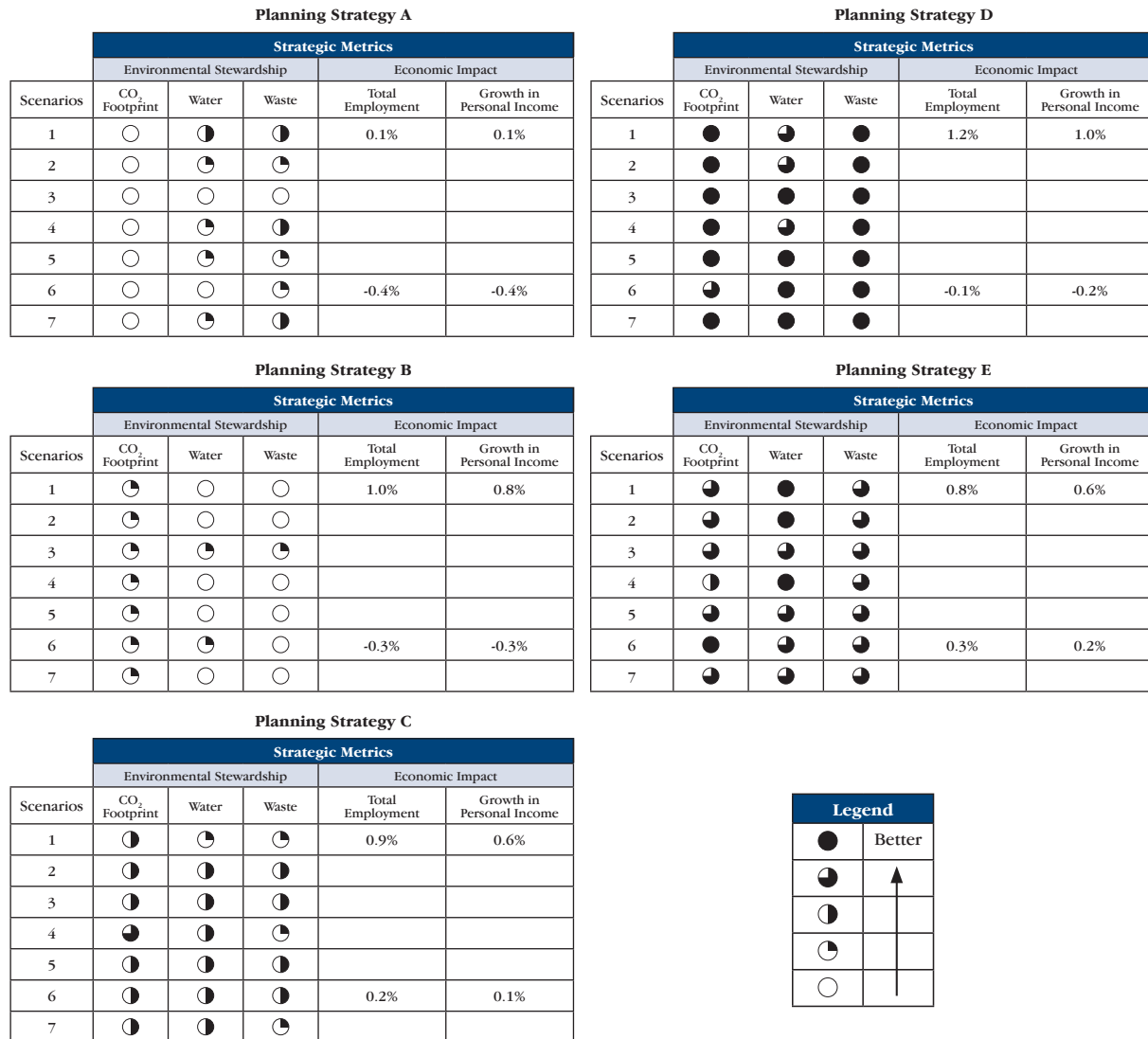


Figure 7-22 – Strategic Metrics for Five Planning Strategies

Results of the CO<sub>2</sub> metric showed that Strategy D had the best performance (lowest emissions), followed by Strategies E, C, B and A. Each strategy showed a declining rate of emissions and the variance between each strategy was quite low since all coal-fired units that will remain in service are assumed to receive environmental controls. With that being said, all five strategies will be fully compliant with applicable air emissions regulations.

Results of the water metric indicated that Strategy D had the best performance, followed by Strategies E, C, A and B. Results of the waste metric show Strategy D had the best performance, followed by Strategies E, C, A and B. Additional information on all environmental metrics calculations can be found in Appendix A – Method for Computing Environmental Impact Metrics.

Based on the Draft IRP results, planning Strategies D and E had the best relative performance across the environmental metrics. Strategy C was average to slightly above average, and Strategies A and B had the lowest relative performance.

For the economic impact metrics, Strategy A was the worst performer. Strategies B, C, D and E had comparable results, within a few tenths of a percentage difference from the impacts computed for the reference portfolio (Strategy B in Scenario 7). Strategies C and E had very similar impacts, performing above the reference portfolio in the long term under both Scenarios 1 and 6.

Along with the strategic metrics, innovations that enable the utilization of key technologies in the planning strategies have been identified and summarized in Figure 7-23. The figure shows which of the five planning strategies would be impacted by each of the innovations in the future.

Technology Innovation	Description	A	B	C	D	E
Smart Grid Technologies	Advancements in this area are necessary to fully realize the EEDR benefits included in certain planning strategies		X	X	X	X
Transmission Design & Infrastructure	Improvements in transmission system devices to manage power flows and advancement in dc line technologies will be needed to facilitate power transfers and the import of additional wind-sourced power			X	X	X
Advanced Energy Storage	More research is needed to improve the design of pumped-storage hydro (PSH) and identify new storage technologies that might offer advantages similar PSH			X	X	X
Small Modular Nuclear Reactors	This technology may offer some flexibility for siting and operating nuclear capacity in those strategies that include a reliance on new nuclear capacity later in the planning period		X	X	X	X
Advanced Emission Controls for Coal-Fired Units	To enable full use of coal-fired resources, advances in emission controls (especially carbon capture and sequestration) are needed to achieve a more balanced long-term generation portfolio	X	X	X		

Figure 7-23 – Technology Innovation Matrix

TVA will closely monitor and possibly invest in these and other technology innovations during the planning period. The particular technology innovations that are necessary to implement the Recommended Planning Direction will likely shift as more information becomes available about each technology area and as power supply needs change.

In addition to the PVRR risk metrics discussed in Chapter 6 – Resource Plan Development and Analysis, there are other risks that were considered when evaluating the merits of

alternative strategies. The financial risk measures included in the ranking metrics portion of the planning strategy scorecard may have indirectly accounted for some of these risks, but only in part. Examples of these broader, more difficult to quantify, risk considerations include:

- The ability of EEDR programs to stimulate distributor and customer participation and the programs' ability to deliver forecasted energy savings and demand reductions. The planning strategies with higher EEDR targets have a greater exposure to these risks
- The availability and deliverability of natural gas. There is finite capacity in the existing natural gas infrastructure. Risks of being limited by deliverability and availability will likely increase as natural gas generation capacity is increased
- The ability to achieve schedule targets for licensing/permitting, developing and constructing new generation capacity. Risks of meeting schedule targets will likely increase as the number and complexity of construction projects increase. In addition, projects with more extensive licensing/permitting requirements will likely have greater exposure to schedule risk
- The timely build-out of transmission infrastructure to support future resources. This is a particular concern with projects that may require transmission expansion outside of the TVA system, such as power purchase agreements for wind energy. Risks will likely increase as the amount of construction required increases and if that construction is undertaken by entities other than TVA
- Legislative and regulatory risks that could strand certain investments in coal-fired assets by, for example, applying a more stringent regulatory framework around coal-fired assets, or by mandating certain other types of generation, including renewables, that could crowd out existing sources of generation
- Game-changing technologies, either on the supply or demand side, that could either dramatically increase (i.e., new sources of demand) the need for electricity or dramatically decrease (i.e., distributed generation) the need for electricity in the long term

The list above is not intended to be exhaustive. It provides examples of other strategic components that TVA considered when it identified the preferred planning strategies in the Draft IRP as well as the Recommended Planning Direction in the final IRP. In addition, the analysis results and public input were considered. TVA encouraged those commenting on the Draft IRP to provide information about and share their views on these other risks.

### 7.3 Preferred Planning Strategies

Based on the Draft IRP results, TVA retained the top three ranked planning strategies for further analysis for the final IRP (Chapter 8 – Final Study Results and Recommended Planning Direction). Strategies C, E and B were retained from the Draft IRP to be subjected to additional analysis and sensitivity testing in an effort to determine improved combinations of planning components.

Illustrative portfolios (20-year resource plans) were identified as part of the evaluation. In the Draft IRP, a broad set of portfolios were identified that corresponded to the three planning strategies that were retained in the Draft IRP.

Four representative resource portfolios were selected from planning Strategies C, E and B. The 12 implementing portfolios for the Draft IRP are shown in Figure 7-24. These portfolios described a relatively broad set of resource plan options that were subjected to additional analysis before completing the final IRP. Portfolios produced in Scenario 1 represented the largest amount of new resource additions, while those produced in Scenario 3 represented the least amount of new resources that could be added over the planning period.

Year	Planning Strategy C				Planning Strategy E				Planning Strategy B			
	SC 1	SC 2	SC 3	SC 7	SC 1	SC 2	SC 3	SC 7	SC 1	SC 2	SC 3	SC 7
2010	PPAs & Acq				PPAs & Acq				PPAs & Acq			
2011												
2012	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	CTa								CTa CT GL CT Ref			
2015	CT GL CT Ref CC			GL CT Ref CC	GL CT Ref CTa CC (2)			GL CT Ref CC	CT CC	GL CT Ref		GL CT Ref CTa MKT
2016	CT			MKT	CT			MKT	CT			CT MKT
2017	MKT			MKT				MKT	CT			CTa MKT
2018	BLN1			BLN1	CT			CC	BLN1			BLN1
2019	MKT				CC				CT	BLN1		
2020	BLN2 PSH	PSH	PSH	BLN2 PSH	CC			MKT	BLN2			BLN2
2021	CT				CTa			MKT	CC	BLN2		
2022	CC MKT	BLN1			BLN1 MKT	BLN1		BLN1 MKT	CT CC			CC
2023	CC MKT				CT MKT			MKT	CT			CT
2024	NUC	BLN2		MKT	BLN2	BLN2		BLN2	NUC MKT			
2025	IGCC			CT	CT				IGCC	NUC		CT
2026	NUC			MKT	CT			CT	NUC		MKT	MKT
2027	CT			CC	CT				CT	NUC	MKT	CT
2028	CT				NUC			CTa	CC		MKT	MKT
2029	IGCC CTa	NUC		CTa	CT			CTa	IGCC CTa	CTa	CTa MKT	CC

Defined Model Inputs		Defined Model Inputs		Defined Model Inputs	
Coal-fired capacity idled	3,252 MW by 2015	Coal-fired capacity idled	4,730 MW by 2015	Coal-fired capacity idled	2,415 MW by 2015
Renewable firm capacity	953 MW by 2029	Renewable firm capacity	1,157 MW by 2029	Renewable firm capacity	160 MW by 2029
	8,791 GWh by 2029		12,251 GWh by 2029		4,231 GWh by 2029
EEDR	4,638 MW by 2029	EEDR	6,043 MW by 2029	EEDR	2,520 MW by 2029
	14,032 GWh by 2029		16,455 GWh by 2029		7,276 GWh by 2029

**Key:**

PPAs & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)

JSF CC = the combined cycle unit to be sited at the John Sevier plant (TVA Board of Directors' approved project, currently under development)

WBN2 = Watts Bar Unit 2 (TVA Board of Directors' approved project, currently under development)

GL CT Ref = the proposed refurbishment of the existing Gleason CT units

CC = combined cycle

CT/CTa = combustion turbines

PSH = pumped-storage hydro

BLN1/BLN2 = Bellefonte Units 1 & 2

NUC = nuclear unit

IGCC = integrated gasification combined cycle (coal technology)

MKT = Purchased Power

**Figure 7-24 – Implementing Portfolios (Initial Phase)**



*Consumer energy efficiency and conservation will play a vital part of TVA's overall strategy for a greener future.*

---



<b>8</b>	<b>Final Study Results and Recommended Planning Direction</b>	<b>147</b>
8.1	Results Analysis	148
8.1.1	Firm Requirements and Capacity Gap	148
8.1.2	Previously Identified Sensitivities	149
8.1.3	Final Study Results	149
8.2	Component Identification	152
8.2.1	Idled Coal-Fired Capacity	153
8.2.2	Renewable Portfolio	153
8.2.3	EEDR Portfolio	154
8.3	Recommended Planning Direction Development	155
8.3.1	Key Characteristics	155
8.3.2	Recommended Planning Direction Illustrative Portfolios	156
8.3.3	Recommended Planning Direction Validation	158
8.3.4	Other Considerations	164
8.4	Conclusion	165



*TVA's resource portfolio will continue to diversify in the future with the pursuit of new ways to harness renewable energy sources that are environmentally conscious and sustainable.*

## Scenarios and Strategies

### Scenario

- 1 Economy Recovers Dramatically

---

- 2 Environmental Focus is a National Priority

---

- 3 Prolonged Economic Malaise

---

- 4 Game-Changing Technology

---

- 5 Energy Independence

---

- 6 Carbon Regulation Creates Economic Downturn

---

- 7 Reference Case: Spring 2010

---

- 8 Reference Case: Great Recession Impacts Recovery

### Planning Strategy

- A Limited Change in Current Resource Portfolio

---

- B Baseline Plan Resource Portfolio

---

- C Diversity Focused Resource Portfolio

---

- D Nuclear Focused Resource Portfolio

---

- E EEDR and Renewables Focused Resource Portfolio

---

- R Recommended Planning Direction

## **8 Final Study Results and Recommended Planning Direction**

TVA's IRP was developed in two major phases – the draft and final. The Draft IRP recommended retaining three of the five original planning strategies. This provided the starting point for the development of the final IRP in fall 2010. Considering updated forecast information and public comments, additional analyses were conducted with the goal of developing a “no-regrets” strategy. This was accomplished by fine-tuning and improving the strategies selected in the Draft IRP. The analyses included rescoring the ranking and strategic metrics in order to evaluate new component combinations identified in the analyses. This chapter describes the final analysis results and the Recommended Planning Direction that was produced by evaluating the analysis results, stakeholder input and other considerations.

8.1 Results Analysis

8.1.1 Firm Requirements and Capacity Gap

The final IRP used the same firm requirements and capacity gaps as discussed in Chapter 7 – Draft Study Results. In addition to the scenarios used in the Draft IRP, an additional reference case was created to reflect the lingering economic recession as shown in Figure 8-1.

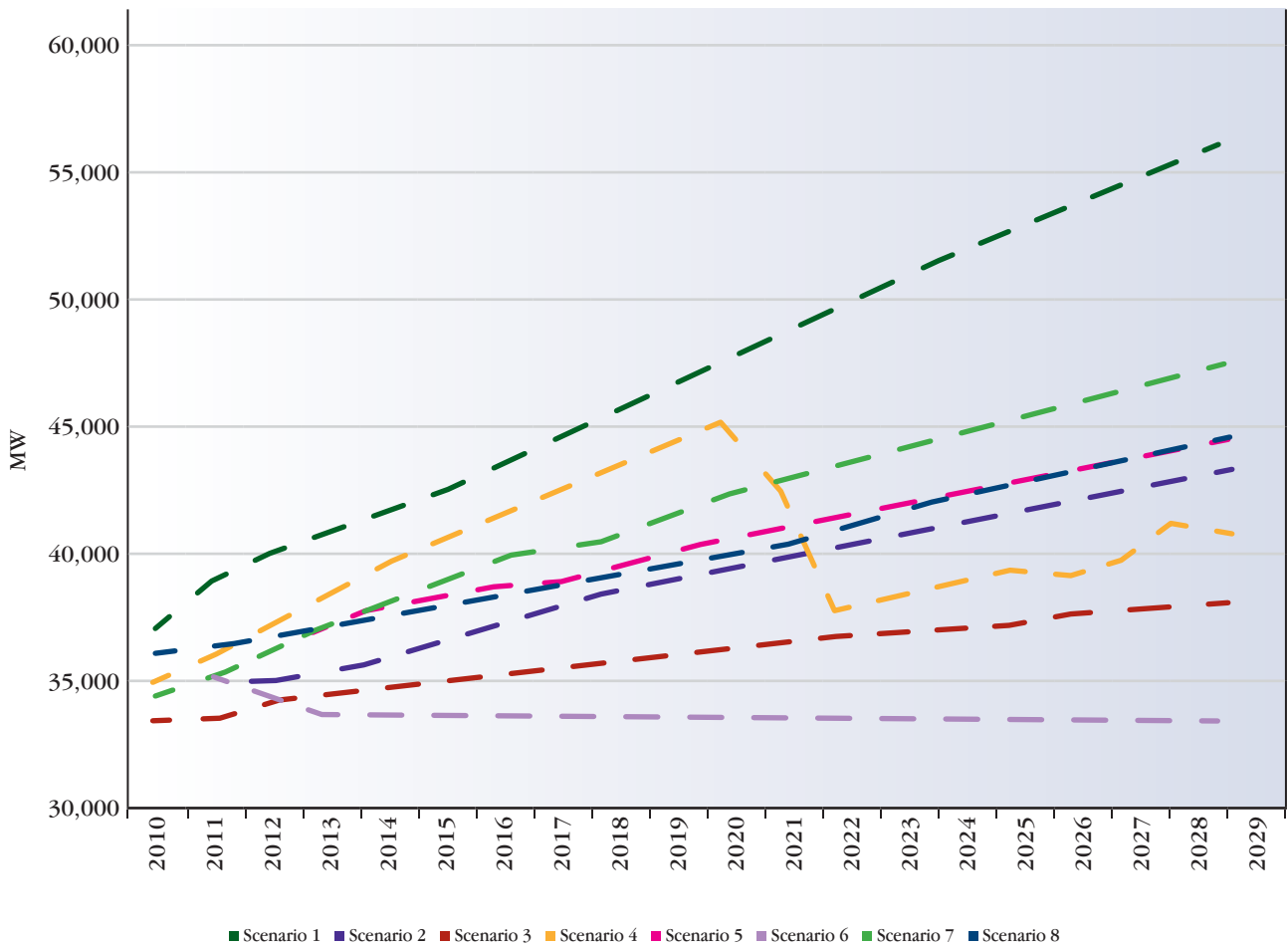


Figure 8-1 – Firm Requirements by Scenario

## 8.1.2 Previously Identified Sensitivities

Additional sensitivity cases were identified from work done for the Draft IRP and feedback received from stakeholders. The type of sensitivity, the purpose for analysis and the method that was incorporated into the final IRP analysis are listed in Figure 8-2.

Sensitivity Description	Basis for Selection	Method for Addressing
Evaluate increment/decrement of renewable additions for Strategy C	To identify the optimum level of renewable additions given the other assumptions already set in this strategy	<ul style="list-style-type: none"> <li>The range of renewable additions retained in the Draft IRP (along with additional increments) will be a selectable resource in the blended optimization</li> </ul>
Evaluate alternate idled capacity values for Strategy C	To test the impact of varying idled capacity values	<ul style="list-style-type: none"> <li>The range of idled capacity retained in the Draft IRP will be evaluated with all other resources in the blended optimization</li> </ul>
Evaluate increment/decrement of EEDR impacts for Strategy C	To identify the optimum level of EEDR given the other assumptions already set in this strategy	<ul style="list-style-type: none"> <li>The range of EEDR portfolios retained in the Draft IRP will be a selectable resource in the blended optimization</li> </ul>
Test “gas-only” expansion in Strategy C	To evaluate the impact of gas capacity expansion on the short-term rate metric score	<ul style="list-style-type: none"> <li>“Gas-only” expansion will not allow nuclear additions</li> <li>To be tested with 3,200 MW of idled capacity</li> <li>All other factors will be optimized</li> </ul>
Evaluate an aggressive EEDR portfolio that targets 50% of the capacity gap beginning in 2015	To evaluate the impact on plan cost and risk for a more aggressive portfolio of EEDR programs	<ul style="list-style-type: none"> <li>The 50% target will be based upon the capacity gap in the latest reference case (Scenario 8) with 3,200 MW of idled capacity</li> <li>All other factors will be optimized</li> </ul>
Test deferral of nuclear expansion in Strategy C until 2020	To identify the capacity additions that would be required if nuclear was not available	<ul style="list-style-type: none"> <li>Schedule of nuclear additions will be optimally selected based on the options and constraints described previously</li> </ul>

Figure 8-2 – Sensitivity Runs Identified From Draft IRP

## 8.1.3 Final Study Results

The study approach in the final IRP produced 12 portfolios that resulted from a blended optimization. The boundaries (resource constraints) were defined by the planning strategies (Strategies B, C and E) retained in the Draft IRP. The 12 cases were produced by testing four possible levels of idled coal-fired capacity in each of the three representative scenarios (Scenarios 1, 3 and 8) which represent the high, medium and low load forecasts described in Section 6.1 – Development of Scenarios and Strategies. Multiple iterations were used to test all levels of idled coal-fired capacity. Optimum renewable and EEDR portfolios were selected for each assumed level of idled coal-fired capacity. Figure 8-3 summarizes the results of those cases.

Scenario 1 Capacity Additions					Scenario 8 Capacity Additions				Scenario 3 Capacity Additions			
Idled Capacity <sup>1</sup>	2,400	3,200	4,000	4,700	2,400	3,200	4,000	4,700	2,400	3,200	4,000	4,700
Renewable Portfolio	2,500	2,500	2,500	2,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
EEDR Portfolio	5,074	5,074	5,074	5,074	3,627	3,627	5,074	5,074	3,627	3,627	3,627	3,627

Year	PPAs	PPAs	PPAs	PPAs									
2010													
2011													
2012	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2
2014													
2015	CTb PPAs	CTb PPAs MKT	CC CTb PPAs	CC (2) CTb PPAs	CTb	CTb	CTb	CC CTb					CC
2016	MKT	CC	CTa	CTa									
2017	CC	CTa	CT	CTa									
2018	BLN 1	BLN 1	BLN 1	BLN 1									
2019						MKT							
2020	BLN 2 PSH	BLN 2 PSH	BLN 2 PSH	BLN 2 PSH	BLN 1 PSH	BLN 1 PSH	BLN 1 PSH	BLN 1 PSH	PSH	PSH	PSH	PSH	PSH
2021													
2022	CT CTa	CC CT	CC CT	CC CT	BLN 2	BLN 2	BLN 2	BLN 2					
2023	CT	CT	CTa	CT									
2024	NUC	NUC	NUC	NUC									
2025	IGCC	MKT	IGCC	IGCC									
2026	NUC	NUC	NUC	NUC		CTa							
2027	CT	CT	IGCC	IGCC		MKT							
2028	CT	CT	CT	CTa IGCC	CTa	CT	CTa	CTa					
2029	CC	CT IGCC	CT IGCC	CTa IGCC	CT	CT	CTa	CTa					

1 – MW values based on maximum net dependable capacity

Abbreviation	Name
BLN 1	Bellefonte Nuclear Unit
CC	Combined Cycle Combustion Turbine (Natural Gas)
CT	Combustion Turbine (Natural Gas) ~800 MW
CTa	Combustion Turbine (Natural Gas) ~600 MW
CTb	Combustion Turbine Refurbishment (Natural Gas)
IGCC	Integrated Gasification Combined Cycle (Coal)
JSF CC	John Sevier Combined Cycle (Natural Gas)
MKT	Annual market purchases greater than 400 MW
NUC	AP 1000 Nuclear Unit
PPAs	Purchased Power Agreements and Acquisitions
PSH	Pumped-storage Hydro
WBN 2	Watts Bar Nuclear Unit 2

Figure 8-3 – The 12 Portfolios

Referring to the blended optimization results, the following general observations were made:

- Nuclear expansion is present in the majority of portfolios with the first unit on line between 2018 and 2020
- Expanded energy efficiency and demand response (EEDR) portfolios performed well in the optimization cases. The mid level portfolio (3,600 MW and 11,400 annual GWh reductions by 2020) was chosen in half of the cases
- Renewable generation above existing wind contracts plays a key role in future resource portfolios
- Expansion of natural gas capacity is needed, but typically occurs after 2024. Gas may serve as the most advantageous way to address any emerging supply shortage
- Preliminary financial results show that component ranges considered produced relatively robust plans with little variation in total plan costs (PVRR) within scenarios

The cost and risk metrics for the portfolios produced in the blended optimization were relatively constant across the coal-fired capacity levels, especially in Scenarios 3 and 8. This is illustrated in Figure 8-4 which compares the short-term rates ranking metrics for the portfolios organized by idled coal-fired capacity level (2,400/3,200/4,000/4,700 MW).

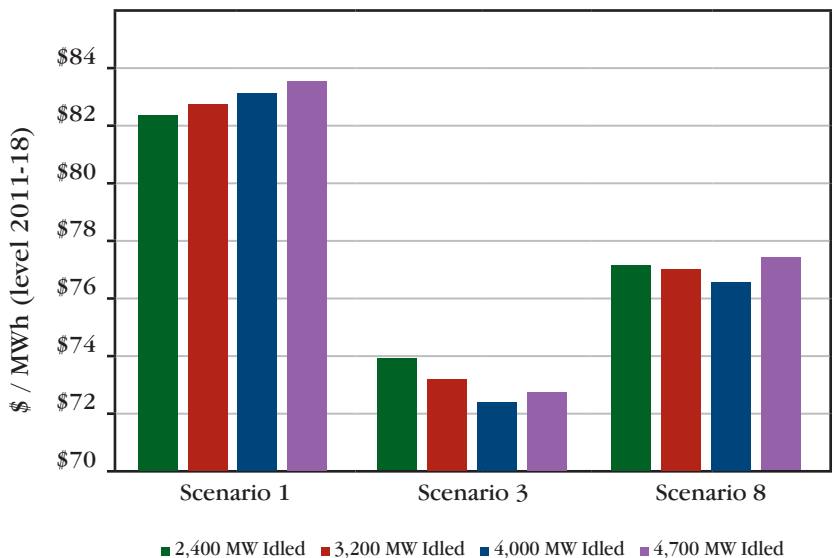


Figure 8-4 – Short-Term Rate Impacts by Scenario



This outcome was primarily driven by two characteristics. First, new unit additions are very similar in these two scenarios for all four coal-fired idling levels. Second, as the amount of idled coal-fired capacity increased from 3,200 to 4,700 MW, a larger EEDR portfolio was selected in Scenario 8. This larger portfolio had similar costs in comparison to the smaller EEDR portfolio chosen at the 2,400 MW and 3,200 MW levels. In addition, no expansion resources were selected in Scenario 3. As a result, overall PVRR for the plans was essentially unchanged.

The two metrics that measure financial risk for these resource plans were also essentially unchanged across the levels of idled coal-fired capacity except for Scenario 3. The variation seen in Scenario 3 was the result of increasing idling levels, which had an impact on the dispatch of resources in the existing system since there were no expansion resources added in that scenario.

In general, the ranking metrics show that the 12 cases produced in the blended optimization represented robust expansion solutions. The overall results were clustered closely together despite the changes in idled coal-fired capacity assumed and the variation of the key assumptions tested in the stochastic analysis. This set of portfolios represents a more focused set of possible expansion alternatives and was used to define the characteristics of the Recommended Planning Direction.

**8.2 Component Identification**

The Recommended Planning Direction was designed by utilizing the findings from the blended optimization to select the components that became part of the strategy. The strategy design considered the following major factors:

Stakeholder input	<ul style="list-style-type: none"> <li>• Continuous dialogue with the Stakeholder Review Group</li> <li>• Input received from the fall 2010 Draft IRP public comment period</li> <li>• Quarterly public briefings conducted by TVA staff and responses to surveys</li> </ul>
Analysis results	<ul style="list-style-type: none"> <li>• Output from the resource optimization cases and associated financial modeling translated into ranking and strategic metrics</li> </ul>
Recognition of non-quantified risks	<ul style="list-style-type: none"> <li>• “No-regrets” approach</li> <li>• Broader considerations not fully captured in the quantitative analysis, but have some impact on the selection process</li> </ul>

## 8.2.1 Idled Coal-Fired Capacity

Selection of the preferred level of idled coal-fired capacity was the next step in producing the case results in the final IRP. Cost and risk ranking metrics used in the Draft IRP were applied to select a level of idled coal-fired capacity from the options considered. Each idled capacity level was given an ordinal rank for each metric within a scenario.

The ordinal rankings for each scenario were weighted using the same formula as applied in the Draft IRP. Scores were summed for each idled coal-fired capacity level to create total ranking scores. Results are shown in Figure 8-5.

	Idled Capacity	Scenarios			Total
		Sc 1	Sc 3	Sc 8	
Weighted Ranking	2,400	1.7	3.0	2.4	7.1
	3,200	2.7	2.2	2.7	7.7
	4,000	2.5	1.7	1.7	5.9
	4,700	3.1	3.1	3.2	9.4

Figure 8-5 – Weighted Ranking Scores

Based on the ranking results, the 4,000 MW level performed the best across the three scenarios and was used as the scorecard value. This level of idled coal-fired capacity was used as a fixed assumption for further refinement of the remaining components of the Recommended Planning Direction. Model results were then reviewed to identify optimal values for the renewable resources portfolio and the level of EEDR.

## 8.2.2 Renewable Portfolio

In the least-cost optimized plans, results tended to favor the 1,500 MW portfolio, which represented the current wind contracts as the preferred level. However, based on stakeholder comments and feedback on the Draft IRP desiring an increased emphasis on renewable development, the Recommended Planning Direction was increased to incorporate the 2,500 MW portfolio which was used as the scorecard value. This reflects projected growth of 1,000 MW of additional renewables above existing and contracted amounts. Figure 8-6 shows a potential mix of components in this renewable portfolio.

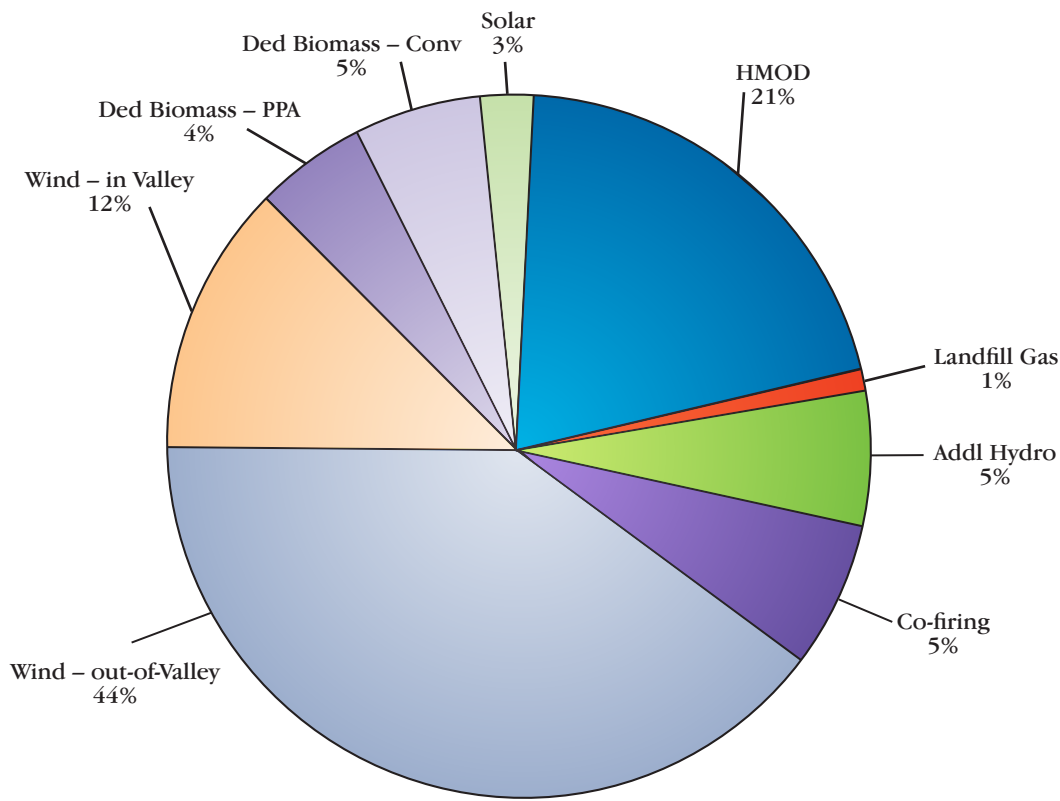


Figure 8-6 – Potential 2,500 MW Renewable Portfolio

Prior to making this decision, the cost premium to increase to the 2,500 MW portfolio was calculated. It was determined to be relatively small (typically less than 1 percent of total plan cost). Not all of this cost change was directly attributable to the renewable portfolio itself because of other changes in the resource plan. This premium was deemed acceptable given TVA's objectives to increase reliance on cleaner and more environmentally responsible energy sources.

### 8.2.3 EEDR Portfolio

The modeling results were evenly split in selecting either the mid level EEDR portfolio (3,600 MW by 2020) or the larger portfolio (5,100 MW by 2020). For reference, the mid level portfolio was part of Strategy C, and the larger portfolio was included in Strategy E in the Draft IRP.

Given the uncertainty about the pace of customer participation and the implementation challenge for TVA associated with the larger portfolio, the mid level EEDR portfolio was used as the scorecard value. This selection also recognized there are similar non-quantified risks

associated with implementation of this mid level portfolio. Those risks were deemed to be sufficiently manageable to include the portfolio in the Recommended Planning Direction.

For a more complete discussion of the non-quantified risks that were part of TVA's assessment of the planning strategies, see Chapter 6 – Resource Plan Development and Analysis.

## 8.3 Recommended Planning Direction Development

### 8.3.1 Key Characteristics

After the key components of idled coal-fired capacity, EEDR and renewables were determined, the key characteristics of the strategies following the blended optimization were observed. These observations are shown in Figure 8-7.

Component	Observations
Nuclear additions	Nuclear expansion is present in the majority of portfolios. Up to three <sup>1</sup> units are added between 2013 and 2029
Coal additions	New coal capacity is only selected after 2025 in scenarios with dramatic load growth
Natural gas additions	Expansion of natural gas is needed, but typically occurs after 2024 with simple-cycle combustion turbines. The dramatic load growth scenario is an exception as combined cycles and combustion turbines are chosen as early as 2015. Additional units may be required for reliability and/or grid stability
Renewable additions	Model results tend to favor the current wind contracts (1,500 MW) as the least cost plan. The renewable portfolio that delivers 2,500 MW by 2029 is selected in the dramatic load growth scenario
EEDR	Results evenly split in selecting either the 3,600 MW by 2020 portfolio and the 5,000 MW by 2020 portfolio

1 – Included in number of nuclear units is TVA Board of Directors' approved project Watts Bar Unit 2

Figure 8-7 – Observations Developed from Preliminary Results

The remaining components of the Recommended Planning Direction were selected with consideration of these outcomes. Figure 8-8 is a tabular summary of the Recommended Planning Direction.

Component	Guideline MW Range	Window of Time	Recommendations
EEDR	3,600-5,100 (11,400-14,400 GWh)	By 2020 <sup>1</sup>	Expand contribution of EEDR in the portfolio
Renewable additions	1,500-2,500 <sup>2</sup>	By 2020 <sup>1</sup>	Pursue cost-effective renewable energy
Coal-fired capacity idled	2,400-4,700 <sup>3</sup>	By 2017	Consider increasing amount of coal capacity idled
Energy storage	850 <sup>4</sup>	2020-2024	Add pumped-storage capacity
Nuclear additions	1,150-5,900 <sup>5</sup>	2013-2029	Increase contribution of nuclear generation
Coal additions	0-900 <sup>6</sup>	2025-2029	Preserve option of generation with carbon capture
Natural gas additions	900-9,300 <sup>7</sup>	2012-2029	Utilize natural gas as an intermediate supply source

1 – This range includes EEDR savings achieved through 2020. The 2020 range for EEDR and renewable energy does not preclude further investment in these resources during the following decade

2 – TVA's existing wind contracts that total more than 1,600 MW are included in this range. Values are nameplate capacity. Net dependable capacity would be lower

3 – TVA has previously announced plans to idle 1,000 MW of coal-fired capacity, which is included in this range. MW values based on maximum net dependable capacity

4 – This is the expected size of a new pumped-storage hydro facility

5 – The completion of Watts Bar Unit 2 represents the lower end of this range

6 – Up to 900 MW of new coal-fired capacity is recommended between 2025 and 2029

7 – The completion of John Sevier combined cycle plant represents the lower end of this range

Figure 8-8 – Recommended Planning Direction

The above figure contains seven components that comprise the strategy and shows a range of the amount for each component as well as the timing of when these components would be added to the system.

### 8.3.2 Recommended Planning Direction Illustrative Portfolios

After the Recommended Planning Direction was defined, it was evaluated to determine if it represented an improvement over the strategies evaluated in the Draft IRP. A group of portfolios was developed and scored.

To produce the portfolios, the Recommended Planning Direction was tested in each of the eight scenarios. These portfolios were based on scorecard values for the key components of the Recommended Planning Direction (idled coal-fired capacity, EEDR and renewables) with optimized additions of the other resources that made up the capacity plans.

# Final Study Results and Recommended Planning Direction

The resultant portfolios are illustrative in nature and based on the particular set of assumptions contained in each of the scenarios. Figure 8-9 is a tabular summary of the illustrative portfolios for the Recommended Planning Direction and shows the resource plans that result in each of the eight scenarios.

Year	Capacity Additions by Scenario									
	EEDR	Renewables	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
2010	300 MW	300 MW	PPAs							
2011										
2012			JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013			WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2	WBN 2
			PPAs							
2014			CT			CTb				
				PPAs						
2015			CC			CC	CTb		CTb	CTb
			CTb							
			CT							
			PPAs			PPAs	PPAs		PPAs	PPAs
2016			CT			CT	MKT		MKT	MKT
2017			MKT			MKT			MKT	
2018			BLN 1	BLN 1		BLN 1			BLN 1	
2019			MKT			MKT	MKT		MKT	MKT
2020	3,600 MW	2,500 MW	BLN 2	BLN 2	PSH	BLN 2	BLN 1	PSH	BLN 2	BLN 1
			PSH	PSH		PSH	PSH		PSH	PSH
2021			CC							
2022			CC				BLN 2			BLN 2
			MKT							
2023			CT						CTa	
			MKT							
2024			NUC							
2025			IGCC						CT	
			MKT							
2026			NUC						MKT	CT
2027			CT				MKT		CT	MKT
2028			CT				CT		MKT	CT
2029	4,600 MW	2,600 MW	CT	CT			CT		CT	CT
			IGCC							

\*Illustrative portfolios assume 4,000 MW of idled coal-fired capacity by 2015

Additions			
Natural Gas		Pumped Hydro	
Coal		Renewables	
Nuclear		EEDR	
Purchased Power			

Figure 8-9 – Illustrative Portfolios for the Recommended Planning Direction

After reviewing the resource plans in Figure 8-9, the following observations can be made about near-term and long-term additions:

- Near-term additions (0-5 years) were generally consistent across the scenarios, reflecting the addition of approved projects by the TVA Board of Directors, which include additions at John Sevier and Watts Bar. Resource additions in this time frame also included new natural gas plants and purchased power arrangements, depending on load growth
- Long-term additions (5-20 years) were somewhat more flexible. Nuclear capacity was a major component of the capacity plans in this period, with the first nuclear unit typically added between 2018 and 2020. Expansion of natural gas capacity often occurred after 2024

### 8.3.3 Recommended Planning Direction Validation

The Recommended Planning Direction was scored using the same ranking and strategic metrics utilized in the Draft IRP. The scorecard results of the Recommended Planning Direction were compared to the scorecard results of the strategies retained from the Draft IRP. Figure 8-10 is a fully populated scorecard for the Recommended Planning Direction, and Figures 8-11 and 8-12, respectively, show scorecards from the Draft IRP for Strategy C and Strategy E.

Scenarios	Ranking Metrics					Strategic Metrics				
	Financial Impact					Environmental Stewardship			Economic Impact	
	PVRR	Short-Term Rate Impact	PVRR Risk/Benefit	PVRR Risk	Total Plan Score	CO <sub>2</sub> Foot-print	Water	Waste	Total Employment	Growth in Personal Income
1	99.00	95.13	100.00	99.53	98.36	●	●	●	0.9%	0.7%
2	100.00	95.58	99.40	95.30	97.85	●	●	●		
3	100.00	100.00	99.81	89.37	97.56	●	●	●		
4	100.00	97.40	100.00	95.37	98.36	●	●	●		
5	100.00	96.43	100.00	100.00	99.19	●	●	●		
6	100.00	100.00	100.00	86.69	96.97	●	●	●	0.2%	0.1%
7	100.00	97.24	100.00	97.03	98.70	●	●	●		
8	99.84	96.66	98.35	97.93	98.50	●	●	●		
Total Ranking Metric Score					785.49					

**Legend**

●	Better
●	↑
●	
●	
○	

Figure 8-10 – Recommended Planning Direction

Scenarios	Ranking Metrics					Strategic Metrics				
	Financial Impact					Environmental Stewardship			Economic Impact	
	PVRR	Short-Term Rate Impact	PVRR Risk/Benefit	PVRR Risk	Total Plan Score	CO <sub>2</sub> Foot-print	Water	Waste	Total Em-ploy-ment	Growth in Per-sonal Income
1	99.22	94.09	97.68	100.00	98.04	☐	☐	☐	0.9%	0.6%
2	96.35	100.00	96.46	95.85	97.08	☐	☐	☐		
3	95.56	94.68	100.00	100.00	96.91	☐	☐	☐		
4	97.39	98.37	98.19	100.00	98.30	☐	☐	☐		
5	98.90	100.00	97.49	99.17	99.04	☐	☐	☐		
6	95.08	94.41	97.83	93.22	94.82	☐	☐	☐	0.2%	0.1%
7	98.88	98.94	99.45	100.00	99.22	☐	☐	☐		
8	99.56	99.63	99.03	99.31	99.45	☐	☐	☐		
Total Ranking Metric Score					782.86					

**Legend**

☐ Better

↑

**Legend**

● Better

↑

Figure 8-11 – Planning Strategy C – Updated Scorecard

Scenarios	Ranking Metrics					Strategic Metrics				
	Financial Impact					Environmental Stewardship			Economic Impact	
	PVRR	Short-Term Rate Impact	PVRR Risk/Benefit	PVRR Risk	Total Plan Score	CO <sub>2</sub> Foot-print	Water	Waste	Total Em-ploy-ment	Growth in Per-sonal Income
1	100.00	100.00	96.78	95.46	98.57	●	●	●	0.8%	0.6%
2	97.74	98.20	99.96	98.54	98.30	●	●	●		
3	94.67	93.55	95.91	97.73	95.26	●	●	●		
4	96.83	100.00	93.42	89.57	95.48	☐	●	●		
5	98.72	99.50	96.33	98.64	98.59	●	●	●		
6	95.62	93.91	99.65	100.00	96.72	●	●	●	0.3%	0.2%
7	98.56	100.00	98.42	98.96	98.96	●	●	●		
8	100.00	100.00	100.00	100.00	100.00	●	●	●		
Total Ranking Metric Score					781.88					

**Legend**

☐ Better

↑

**Legend**

● Better

↑

Figure 8-12 – Planning Strategy E – Updated Scorecard



Comparing the Recommended Planning Direction to the top two strategies from the Draft IRP (Strategy C and Strategy E) shows that the Recommended Planning Direction represents the most favorable blending of portfolio components. The performance of the Recommended Planning Direction across all scenarios implies that it is a more robust approach with a lower likelihood of regret. The following are additional observations based on the scorecard results:

- The Recommended Planning Direction was the top performer on total plan cost (PVRR) in six of the eight scenarios tested
- The Recommended Planning Direction was the top performer on the risk/benefit ratio metric in five of the eight scenarios
- The strategic metrics for the Recommended Planning Direction were improved from metrics for Strategy C (the top-ranked strategy from the Draft IRP), but were not as good as the strategic metrics for Strategy E
- The economic impact metrics for the Recommended Planning Direction were similar to the metrics for the strategies retained from the Draft IRP, indicating there was no significant difference among the strategies in terms of macroeconomic impacts

The Recommended Planning Direction provided a more effective balance between plan cost and financial risk, as shown in Figure 8-13. The graph presents a cost versus risk curve, and the Recommended Planning Direction provided the lowest combination of plan cost (PVRR) and financial risk of any of the strategies that were considered in this IRP.

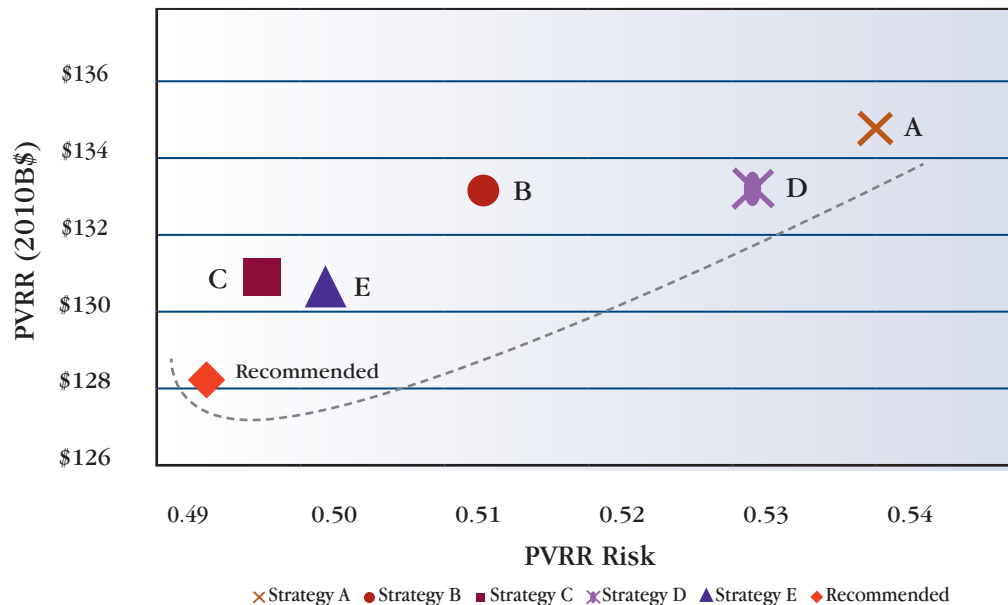


Figure 8-13 – Plan Costs vs. Financial Risk

Figure 8-14, a risk trade-off graph that compares financial risk versus the risk/benefit ratio, reinforces the conclusion drawn from Figure 8-13. This shows that improved risk performance comes at a higher overall plan cost.

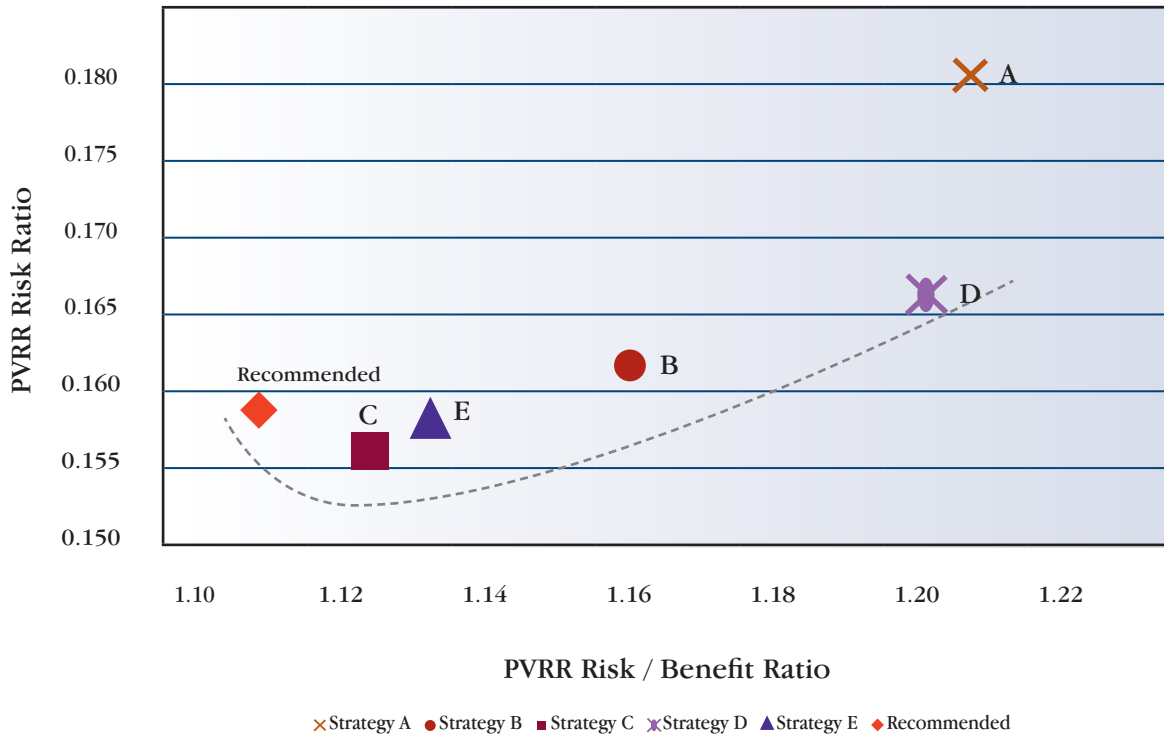


Figure 8-14 – Comparison of Financial Risks of Strategies

The uncertainty range in PVRR across the scenarios was another measure of performance used to assess the Recommended Planning Direction. Figure 8-15 is a tornado diagram of the variation in total plan cost (PVRR) from the stochastic analysis of the strategies in each of the eight scenarios. The width of the bars indicates the variation and uncertainty in plan cost. This figure shows that in most scenarios the Recommended Planning Direction (R) had the smallest range of cost uncertainty and that the expected value of the total plan cost was lower compared to the other strategies (C or E).

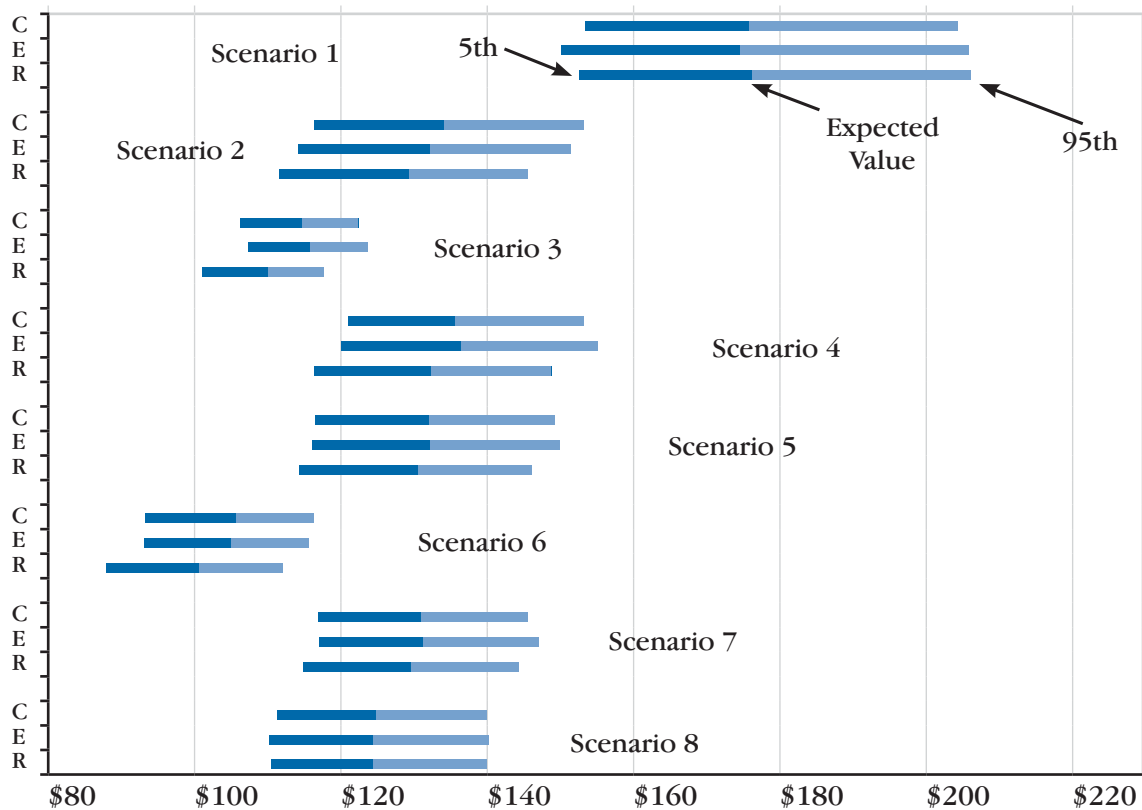


Figure 8-15 – PVRR (2010 \$B)

In addition to financial trade-offs, the Recommended Planning Direction also provided the best balance of plan cost and environmental footprint, represented by the graph of plan cost versus CO<sub>2</sub> tons shown in Figure 8-16.

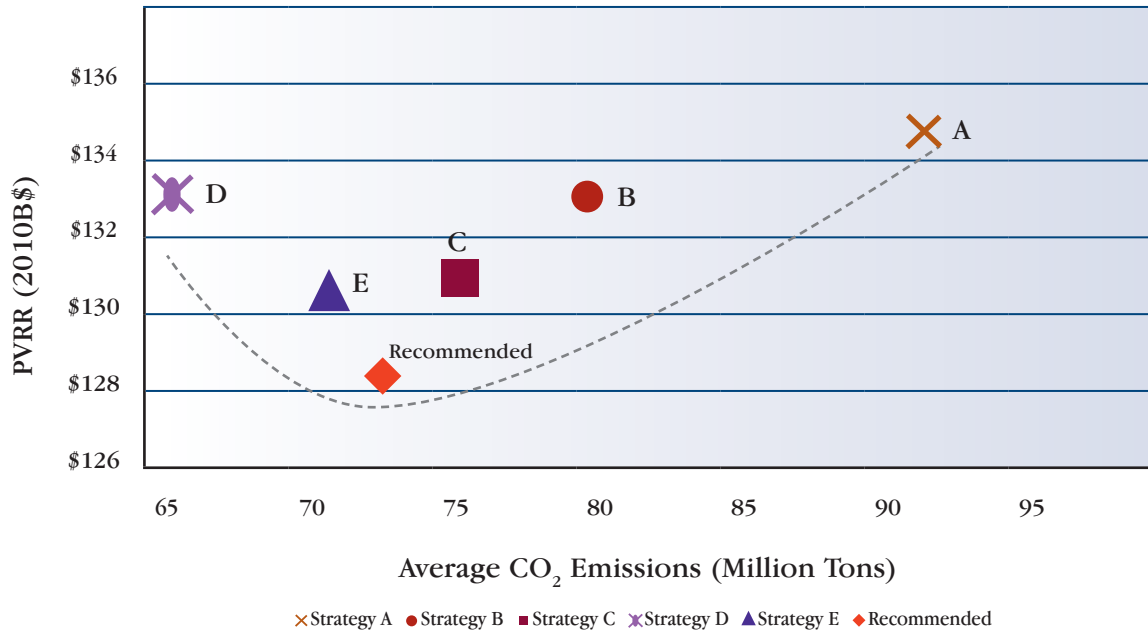


Figure 8-16 – Plan Costs vs. Annual CO<sub>2</sub> Emissions

8.3.4 Other Considerations

The modeling results represented by the ranking and strategic metrics, along with other financial and risk assessments discussed in the preceding section, provided strong support for the Recommended Planning Direction. However, as indicated in Section 7.2.4 – Other Strategic Considerations, the analytics are not the only considerations that were factored into the selection of TVA’s Recommended Planning Direction. Certain non-quantified risk concerns, also known as “no-regrets considerations,” were included, either directly or indirectly, when making the selection. Figure 8-17 shows the key items of the “no-regrets considerations.”

Other Risk Considerations	Potential Implications	Potential Early Warning Signs
Establishing a successful partnership with distributor group to administer EEDR programs and deliver forecasted reductions	<ul style="list-style-type: none"> <li>• Planning strategies with higher EEDR targets will have a greater exposure to this risk</li> </ul>	<ul style="list-style-type: none"> <li>• Delays in establishing formal agreement with distributors by end of FY 2012</li> </ul>
The ability of EEDR programs to stimulate customer participation and deliver forecasted reductions	<ul style="list-style-type: none"> <li>• Planning strategies with higher EEDR targets will have a greater exposure to this risk</li> </ul>	<ul style="list-style-type: none"> <li>• Measurement and verification data of actual reductions is significantly below forecast</li> </ul>
The ability to achieve schedule targets for licensing/permitting, developing and constructing large baseload generation	<ul style="list-style-type: none"> <li>• Risks of meeting schedule targets will likely increase as the number and complexity of construction projects increase</li> <li>• Projects with more extensive permitting requirements may have greater exposure to schedule risk</li> </ul>	<ul style="list-style-type: none"> <li>• Critical internal resources for permitting, design, and construction are not maintained for upcoming projects</li> <li>• Dramatic changes in licensing/permitting requirements</li> </ul>
The timely build-out of transmission and distribution (smart grid) infrastructure to support future resources	<ul style="list-style-type: none"> <li>• Risks will likely increase as the amount of construction required increases; particularly if that construction is undertaken by entities other than TVA</li> </ul>	<ul style="list-style-type: none"> <li>• Diminished availability of transmission design and construction resources</li> <li>• Limited smart grid capability added to distribution system by 2015</li> </ul>
The ability to maintain appropriate operational flexibility after significant changes in resource mix	<ul style="list-style-type: none"> <li>• Risks of limiting operational flexibility increase as the quantity of baseload, dispatchable, and non-dispatchable resources change</li> </ul>	<ul style="list-style-type: none"> <li>• Prolonged increases in system load factor</li> <li>• Emergence of barriers that delay addition of energy storage</li> </ul>

Figure 8-17 – Other Risk Considerations

The Recommended Planning Direction provides the most balanced approach to mitigating the risk associated with these non-quantified factors while providing the best performance in key metrics.

## **8.4 Conclusion**

Based on the results of the analysis conducted in the Draft and final IRP, as well as the consideration of non-quantified risk factors, the Recommended Planning Direction positions TVA with the best balance of flexibility and “no-regrets” risk mitigation. A discussion of next steps and recommendations for implementation of this strategy is discussed in Chapter 9 – Next Steps.



*Renewable, sustainable, environmentally-friendly initiatives, as well as consumer education regarding energy efficiency in the home and at work are all key components of TVA's future strategy for the Tennessee Valley.*



<b>9 Next Steps</b>	<b>169</b>
9.1 Path Forward	169
9.2 Application	170
9.3 Areas That Require Further Work	170
9.4 Conclusion	171



*Implementing this strategy will help TVA meet its renewed vision—to be one of the nation's leading providers of low-cost and cleaner energy by 2020.*



## Elements of Vision 2020



Low Rates



High Reliability



Responsibility



Cleaner Air



More Nuclear Generation



Greater Energy Efficiency

## 9 Next Steps

After two years of extensive analysis and the issuance of the Draft IRP, the final IRP has been completed. Another key piece of the puzzle is defining the next steps that follow this IRP's completion. For that reason, it is important to remember that this IRP is meant to serve as a roadmap for making future asset decisions and not meant to define specific decisions.

Approval of this IRP provides an updated strategic direction that will help TVA fulfill its renewed vision and set the direction for many decisions that will be proposed in the future. This chapter defines some of the key areas that need additional work or investigation to help determine TVA's "next steps" in these specific areas.

### 9.1 Path Forward

TVA formulated this IRP to help prepare for a wide range of future conditions and ensure a sustainable future for the Tennessee Valley region. This IRP will serve as a guide to achieve TVA's renewed vision – to become one of the nation's leading providers of low-cost and cleaner energy by 2020. TVA takes great pride in the reliable service it provides to its customers. Transmission reliability will remain a key focus of all future operations. TVA will also strive to maintain the proper generation mix in order to ensure reliable and flexible power system operation.

Furthermore, TVA remains committed to reducing air emissions from its power generation facilities. Emissions reduction will help TVA plan for and promote a sustainable future. Coal-fired plant idling and the addition of scrubbers and other emissions control equipment are essential for TVA to provide cleaner energy.

The reputation of delivering reliable, competitively priced power makes the Tennessee Valley region an attractive place to start or expand a business. Therefore, TVA will continue to support and encourage economic development in the region. TVA offers an array of services that include capital investment loans for new or growing businesses, site-selection assistance and other business support services. These services help attract companies to the region and provide more jobs to aid in economic stability of the region, which is especially important with the current sluggish economy.

TVA President and CEO Tom Kilgore stated, "TVA's basic missions have not changed, but the times have changed and requirements are changing for the energy industry." The analysis performed within this IRP will help TVA prepare for future uncertainties and properly position itself to effectively continue its mission to serve the people of the Tennessee Valley.

**9.2 Application**

While this strategy will help guide TVA in making important decisions in the years to come, this IRP does not dictate a specific series of actions. It is important to understand what analysis was considered to be within the scope of this IRP and what areas may require more analysis. Figure 9-1 lists what was considered in-scope versus outside-of-scope in this IRP.

This IRP Does	This IRP Does Not
Articulate a 20-year planning direction	<ul style="list-style-type: none"> <li>• Finalize specific asset decisions</li> <li>• Serve as a substitute for the “fine-tuning” of the annual planning and budgeting processes</li> </ul>
Present recommended strategy alternatives	<ul style="list-style-type: none"> <li>• Narrow the breadth of NEPA coverage established in the Draft IRP and the associated EIS</li> <li>• Does not discard analyses done for alternative strategies</li> </ul>
Describe guideline ranges for key components of the Recommended Planning Direction (i.e., EEDR, idling of coal-fired units, etc.)	<ul style="list-style-type: none"> <li>• Make specific commitments for key components of the Recommended Planning Direction</li> </ul>
Present illustrative portfolio(s) that show potential asset additions by year	<ul style="list-style-type: none"> <li>• Commit to a specific 20-year capacity addition schedule</li> </ul>
Highlight key asset additions by showing a specific value within the guideline range in the illustrative portfolio	<ul style="list-style-type: none"> <li>• Imply that any asset addition or in-service date shown in the illustrative portfolio represents a formal decision or is not subject to change</li> </ul>
Discuss other strategic considerations and non-quantified risk considerations	<ul style="list-style-type: none"> <li>• Quantify all risks in the analysis or imply all decision criteria are within the IRP scope</li> </ul>
Commit to beginning the next IRP by 2015	<ul style="list-style-type: none"> <li>• Expect to provide NEPA coverage for the same duration as EV2020</li> <li>• Limit TVA’s ability to continue to do analysis and amend this IRP in the future</li> </ul>

Figure 9-1 – Scope of the IRP

**9.3 Areas That Require Further Work**

By closely evaluating the areas that require more analysis, a number of recommendations have been identified and summarized on the next page. This list is not designed to be exhaustive but does provide insight into additional work that TVA will consider undertaking.

Issue	Recommendation
Idling coal-fired units	<ul style="list-style-type: none"> <li>• Perform detailed optimization analyses to determine both the optimum level of idling and the best units for idling after accounting for risks, uncertainty and all known costs</li> </ul>
Renewables	<ul style="list-style-type: none"> <li>• Analyze renewable technologies and business models and monitor market trends for strategic options to develop cost-effective renewable resources</li> </ul>
Nuclear power	<ul style="list-style-type: none"> <li>• Complete project specific evaluation of B&amp;W technology at Bellefonte site and refine timing</li> <li>• Continue to study development of small modular reactors as part of the continuing effort to advance carbon-free, baseload power generation alternatives</li> </ul>
EEDR	<ul style="list-style-type: none"> <li>• Proactively pursue the Southeast leadership goal, monitor results and evaluate programs</li> </ul>
Gas-fired supply	<ul style="list-style-type: none"> <li>• Analyze gas-fired supply opportunities to cost effectively fill short lead time capacity gaps</li> </ul>
Pumped-storage	<ul style="list-style-type: none"> <li>• Study more detailed project economics of and justification for additional pumped-storage with a goal of making a recommendation on how to proceed</li> </ul>
Stakeholder involvement	<ul style="list-style-type: none"> <li>• Continue to solicit input from external stakeholders and incorporate that input into future IRP planning and decision making processes</li> </ul>
Next IRP	<ul style="list-style-type: none"> <li>• TVA has committed to begin the next IRP effort by 2015</li> </ul>

Figure 9-2 – Areas That Require Further Work

## 9.4 Conclusion

Fifteen years separated the completion of this IRP and the 1995 IRP, EV2020. Comments TVA received from SRG members and the public recommend that TVA needs to regularly update its IRP. Frequently updating this IRP would enhance TVA’s ability to effectively respond to future developments. For that reason, TVA is committed to begin the next IRP effort by 2015.

TVA’s IRP has produced an energy resource strategy that will help TVA meet the Tennessee Valley region’s energy demands in the future in a sustainable manner. Implementing this strategy will also help TVA meet its renewed vision – to be one of the nation’s leading providers of low-cost and cleaner energy by 2020. More specifically, this IRP will help TVA lead the nation in improved air quality and increased nuclear production, and lead the Southeast in increased energy efficiency.

---

**This concludes the 2011 TVA Integrated Resource Plan,  
TVA’s Environmental and Energy Future.**

## Appendix A – Method for Computing Environmental Impact Metrics

<b>Purpose</b>	<b>A172</b>
<b>Process</b>	<b>A172</b>
<b>Method</b>	<b>A172</b>
<b>Air Impact Metric and Ranking</b>	<b>A173</b>
<b>Water Impact Metric and Ranking</b>	<b>A178</b>
<b>Waste Calculations</b>	<b>A179</b>

### **Purpose**

The IRP used a multi-component scorecard analysis of ranking and strategic metrics for evaluating the impacts of the planning strategies. In addition to the metrics used to establish the rank order of the planning strategies (cost and risk) with emissions costs imbedded, TVA developed strategic metrics, such as the environmental impact metric, to more clearly depict environmental stewardship attributes.

### **Process**

In developing the criteria for the environmental impact metric, TVA staff wanted to create a metric representative of the trade-offs between energy resources rather than identifying a single resource with the “best” environmental performance. The final evaluation criteria relied on some surrogate measures as a proxy for environmental impacts, but when used comparatively with the other attributes, they provided a reasonable and balanced method for evaluating planning strategies. By considering air, water and waste in the IRP scorecard, coupled with the broader qualitative discussion of anticipated environmental impacts in the EIS, a robust comparison of the environmental footprint of the planning strategies better informed the selection of the Recommended Planning Direction.

### **Method**

Outlined below is the methodology that was used for the environmental impact metric, by attribute, including a revised scoring of the strategies that were considered in the Draft IRP, excluding Strategies A and D, and inclusion of Strategy R – Recommended Planning Direction.

## Air Impact Metric and Ranking

Model results provided data on the production of four emissions: CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub> and Hg by generation source (e.g., coal and lignite). The suite of emissions selected to evaluate the air impacts of the IRP strategies were meant to represent a range of emissions primarily associated with fossil-fueled power generation. It was suspected that evaluating the strategies on the basis of all four emissions would give the same results (i.e., declining emissions trends) as just using CO<sub>2</sub> alone, but emission trend plots were developed to confirm this assumption. Emission trends were plotted against averaged, historic TVA generation data from 2007 to 2009 for coal and combustion turbines. The most recent three years were used to provide a better representation of average air emissions, as 2009 was a historically low year for air emissions due partly to the economic recession and decreased electricity demands. Historic mercury emissions for lignite sources were unavailable, so projected data for 2010 was used and added to the other totals. Figure A-1 provides a summary of the baseline emissions that data emissions trends were plotted against.

	<b>SO<sub>2</sub> (tons)</b>	<b>NO<sub>x</sub> (tons)</b>	<b>CO<sub>2</sub> (tons)</b>	<b>Hg (lbs)</b>
TVA Coal	302,818	140,528	94,879,125	2,597
TVA CTs	27	359	1,954,211	N/A
Lignite	817	1,235	2,092,848	55
<b>Totals</b>	<b>303,622</b>	<b>142,122</b>	<b>98,926,184</b>	<b>2,652</b>

Figure A-1 – Summary of 2007-2009 Average Emissions Data

Again using model results by generation sources for each of the cases, excluding cases associated with Strategies A and D, CO<sub>2</sub> emissions data from all emission sources were summed for selected spot years (five-year increments) 2010, 2015, 2020, 2025 and 2028. Then for each of these years, the CO<sub>2</sub> emissions for each strategy, excluding Strategies A and D, were summed across all eight scenarios, which gives a value for the total CO<sub>2</sub> emissions associated with each strategy. These totals were divided by eight to provide a representative average value for each spot year that could be compared to the 2007–2009 averaged historical baseline data. These data were plotted to demonstrate how CO<sub>2</sub> emissions vary over time (Figure A-2).

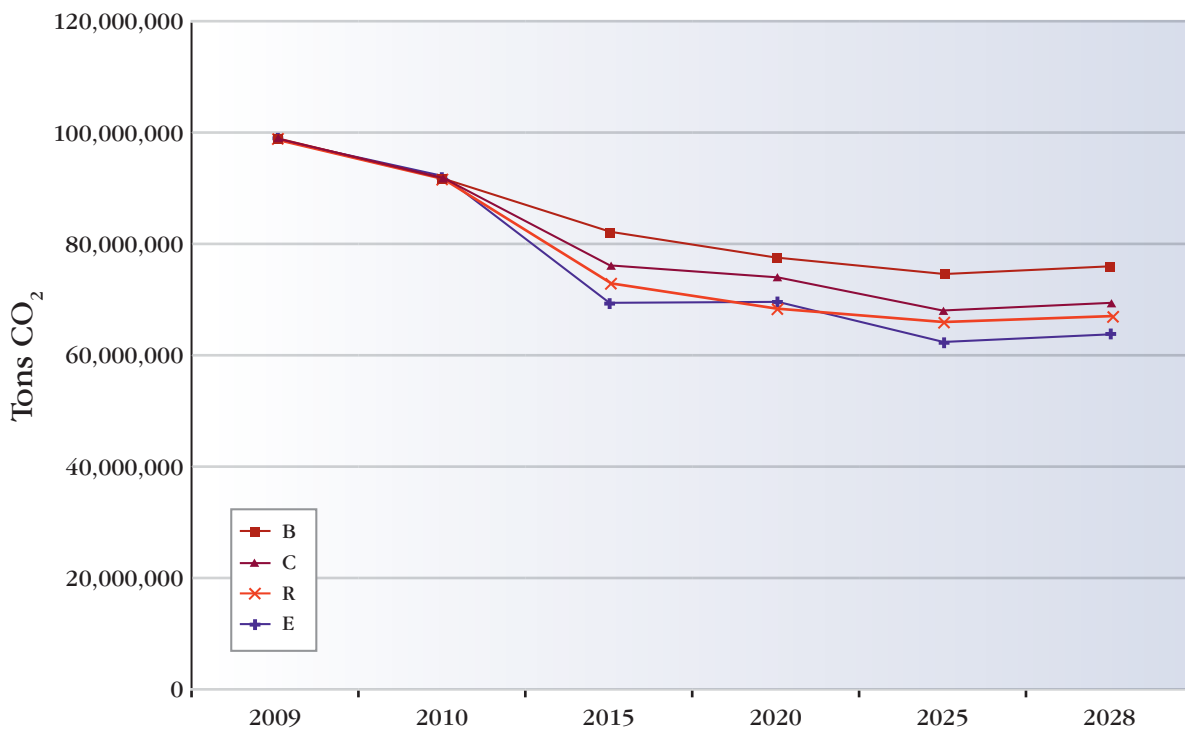


Figure A-2 – Tons CO<sub>2</sub> by Strategy

Similar calculations were also done for SO<sub>2</sub>, NO<sub>x</sub> and Hg as shown in Figures A-3, A-4 and A-5.

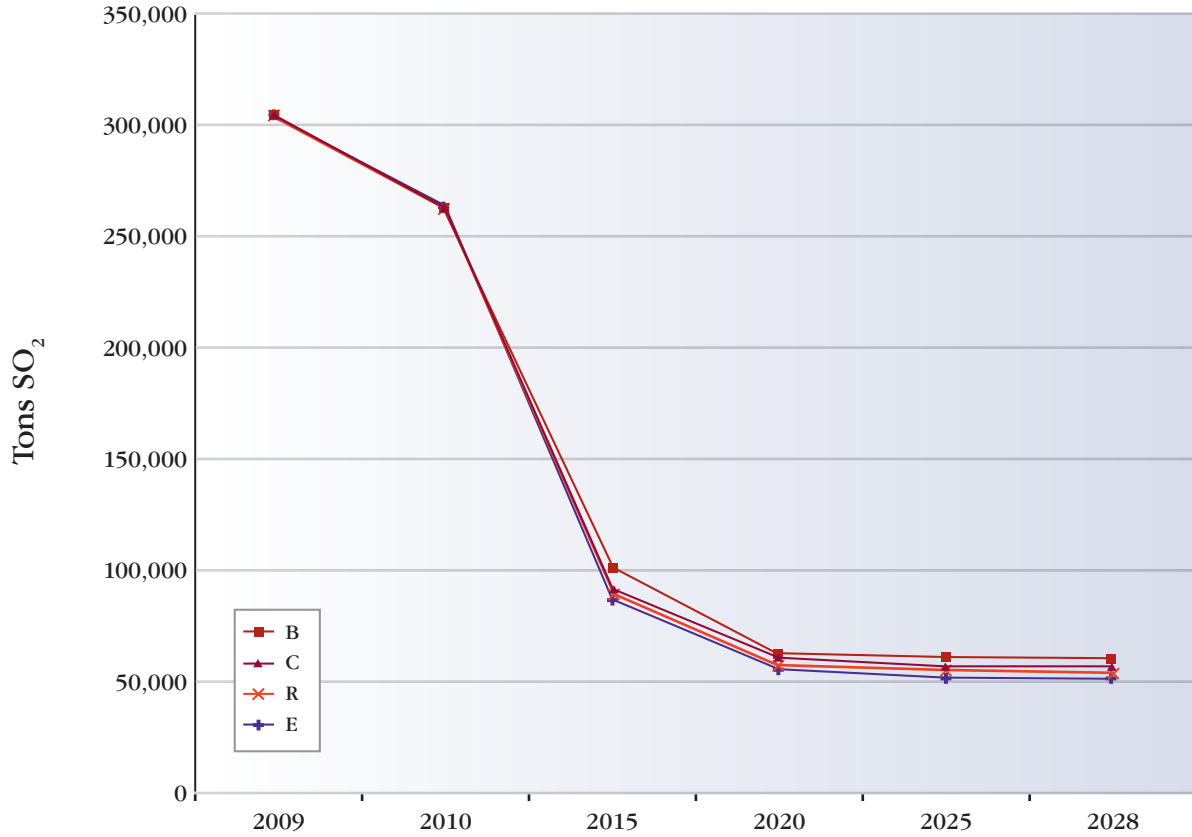


Figure A-3 – Tons SO<sub>2</sub> by Strategy



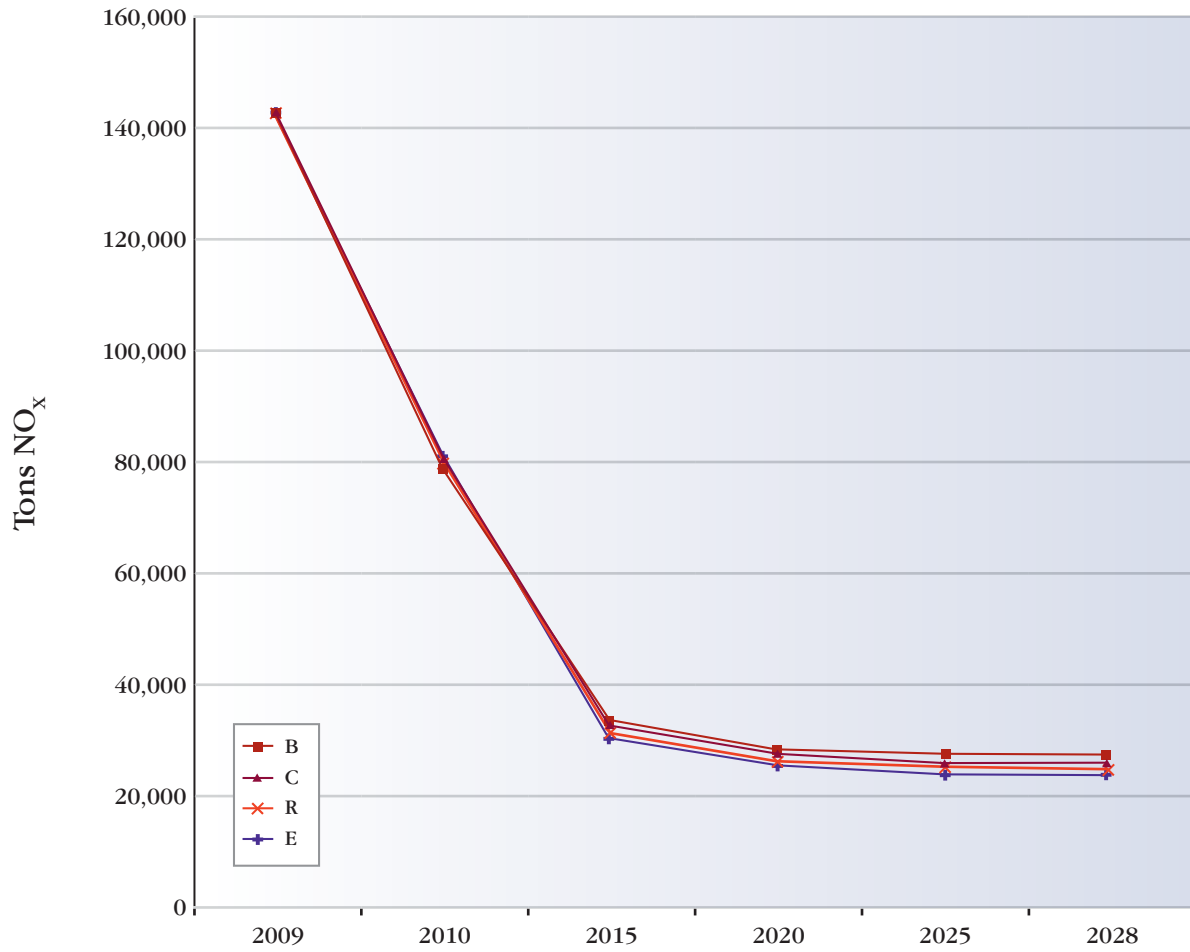


Figure A-4 – Tons NO<sub>x</sub> by Strategy

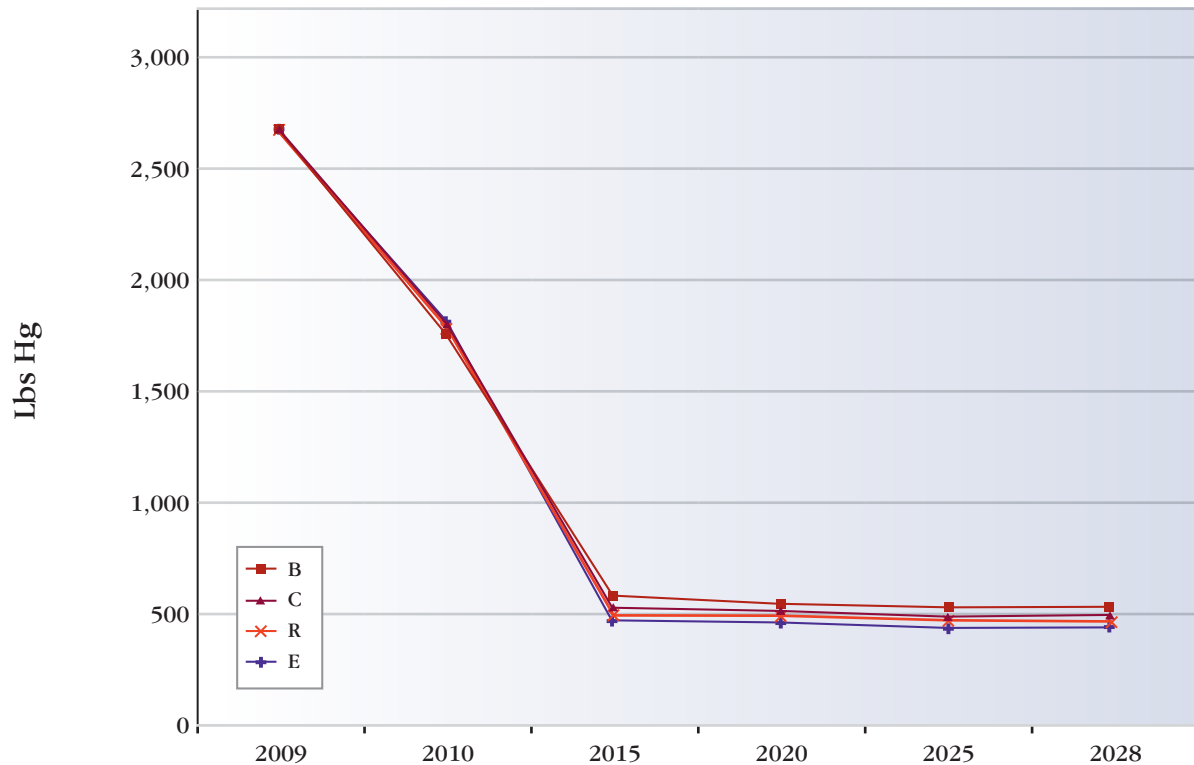


Figure A-5 – Lbs Hg by Strategy

These plots confirm that all emissions decrease over the planning horizon, and thus selecting CO<sub>2</sub> as a surrogate measure was an appropriate proxy for the trend in all air emissions.

To further verify that all evaluated strategies' performance on all four emissions give the same rankings, the total yearly emissions from all sources for each strategy, across all eight scenarios, were summed for five spot years and used to rank the strategies for each emission. Figure A-6 shows the results of these rankings, again confirming that the CO<sub>2</sub> ranking alone gives the same information as using information on all four emissions.

Strategy	SO <sub>2</sub>	NO <sub>x</sub>	Hg	CO <sub>2</sub>
B	4	4	4	4
C	3	3	3	3
E	1	1	1	1
R	2	2	2	2

Figure A-6 – Strategy Rankings for All Four Emissions

**Water Impact Metric and Ranking**

The major way thermal generating plants impact water is by the amount of heat they reject to the environment. IRP strategies were evaluated on the basis of the BTUs delivered to the plants’ condensers, which is where rejected heat is transferred. The calculation involved taking the generation sources shown in Figure A-7 and multiplying their generation (GWh) by heat rate (BTU/kWh) (with unit conversions) by a design factor for the specific generation technology.

Generation Source	Design Factor
Coal	51%
Combined cycle (CC)	11%
Future integrated gasification CC	27%
Future super critical pulverized coal (SCPC)	46%
Lignite	51%
Uranium	66%

Figure A-7 – Design Factors for Generation Sources

The heat rejected to the environment (BTUs) is summed for all five spot years (2010, 2015, 2020, 2025, 2028) and all generation sources for each case, excluding cases associated with Strategies A and D. For each scenario (1–8), the strategies, excluding Strategies A and D, were compared to each other and ranked. A preferred strategy (R) is described by being the most robust, meaning it performs the best across all eight scenarios. Therefore, the rankings of each strategy in each scenario were summed and re-ranked on the basis of their total score. A strategy that performed the best in each of the eight scenarios would have a total score of 8 (1 x 8), and a strategy that performed the worst in all eight scenarios would have a score of 32 (4 x 8). The total scores and associated final ranking is shown in Figure A-8.

Scenarios	Strategies			
	B	C	E	R
1	4	3	1	2
2	4	2	1	3
3	4	3	1	2
4	4	3	1	2
5	4	3	1	2
6	4	3	1	2
7	4	3	1	2
8	4	3	1	2
Sum of Rankings	32	23	8	17
Final Ranking	4	3	1	2

Figure A-8 – Final Strategy Water Impact Ranking

## Waste Calculations

The metric used to rank strategies in terms of their waste impact (coal and nuclear) was the cost of handling the waste generated—the assumption is that the costs of disposal, in accordance with all applicable regulations, is a proxy for the wastes’ impacts on the environment. Handling costs are based on actual, historical TVA averages, and expected future handling costs are based on operations and transportation estimates.

Coal waste comes from two sources: coal burning and scrubber sludge. Coal waste for TVA plants was calculated using weighted coal ash<sup>1</sup> and heat content (BTU/lb) values from 2009 historical data. The weighted averages are shown in Figures A-9 and A-10.

Year	Strategy			
	B	C	E	R
2010	8.19%	8.19%	8.19%	8.19%
2015	8.04%	7.91%	8.15%	7.85%
2020	8.04%	7.91%	8.15%	7.85%
2025	8.04%	7.91%	8.15%	7.85%
2028	8.04%	7.91%	8.15%	7.85%

Figure A-9 – Weighted Ash Percentage

Year	Strategy			
	B	C	E	R
2010	11,033	11,033	11,033	11,033
2015	11,004	10,948	11,134	10,941
2020	11,004	10,948	11,134	10,941
2025	11,004	10,948	11,134	10,941
2028	11,004	10,948	11,134	10,941

Figure A-10 – Weighted Heat Content (BTU/lb)

For each evaluated strategy, from the model results, the fuel consumed (mmBTU) for TVA coal was multiplied by one million to get the units into BTUs, then multiplied by the coal fuel conversion values (from the weighted BTU/lb figure), and then multiplied by the percentage ash value (from the weighted ash figure). The product was then divided by 2000 to get an answer in tons. A handling cost (\$/ton) was then applied to the calculation.

Coal waste from the lignite plant under contract to TVA was calculated based on fuel consumed (mmBTU), divided by 5,234 BTU/lb, multiplied by 14.64 percent ash content (based on Mississippi lignite source information) and divided by 2000 to get an answer in tons. A handling cost (\$/ton) was then applied to the calculation.

Coal waste from future Integrated Gasification Combined Cycle (IGCC) was calculated by multiplying generation times 62lb/MWh (slag production) and divided by 2000 to get an answer in tons. For 2010 scrubber waste, waste was calculated by taking fuel consumed (mmBTU), multiplied by 0.5 (about 50 percent of TVA generation is now scrubbed), then

<sup>1</sup>Coal ash consists of both fly and bottom ash

# Method for Computing Environmental Impact Metrics

multiplied by 11 lbs/mmBTU (average of TVA existing fleet). For future year calculations, it was assumed that all remaining TVA coal generation (based on coal-fired idling assumptions) are scrubbed. Waste was calculated by multiplying fuel consumed by 11 lbs/mmBTU. A handling cost (\$/ton) was then applied to the calculation.

The combined coal and nuclear waste handling costs were used to rank all strategies, excluding Strategies A and D. All coal waste costs, including lignite and future base generation, and nuclear waste costs were summed for all five spot years (2010, 2015, 2020, 2025, 2028) and all generation sources for each case, excluding cases associated with Strategies A and D. For each scenario (1–8), the evaluated strategies were compared to each other and ranked with the strategy having the lowest waste handling cost (ranked #1) and the strategy with the highest costs (ranked #4).

A preferred strategy is the most robust, meaning it performs the best across all eight scenarios. Therefore, we summed the rankings of each strategy in each scenario, and re-ranked them on the basis of their total score. A strategy that performed the best in each of the eight scenarios would have a total score of 8 (1 x 8), and a strategy that performed the worst in all eight scenarios would have a score of 32 (4 x 8). The total scores and associated final ranking is shown in Figure A-11.

Scenario	Strategy B	Strategy C	Strategy E	Strategy R
1	4	3	1	2
2	4	2	1	3
3	4	3	1	2
4	4	3	1	2
5	4	2	1	3
6	4	3	1	2
7	4	3	1	2
8	4	2	1	3
Sum of Rankings	32	21	8	19
Final Ranking	4	3	1	2

Figure A-11 – Final Strategy Waste Impact Ranking (Based on Total Coal and Nuclear Waste Disposal Costs)

**Appendix B – Method for Computing Economic Impact Metrics**

<b>Purpose</b>	<b>B182</b>
<b>Process</b>	<b>B182</b>
<b>Methodology</b>	<b>B184</b>
<b>Analysis</b>	<b>B185</b>
<b>Findings</b>	<b>B185</b>

**Purpose**

Economic metrics are included in the IRP scoring to provide a general indication of the impact of each strategy on the economic conditions in the TVA service area. The impacts are represented by the change in total employment and personal income indicators as compared to the impacts under Strategy B – Baseline Plan Resource Portfolio, in Scenario 7 – Reference Case: Spring 2010.

**Process**

The process used is the same as has been used by TVA for programmatic region-wide EIS studies dating back to the 1979-1980 PURPA study and is also used by other models and studies. As shown in Figure B-1, direct expenses by TVA in the region for labor, equipment and materials stimulate economic activity. At the same time, the costs of electricity for customers (the bills customers pay, including savings from energy efficiency) reduces customers' income, which could be used to buy goods and services in the region.

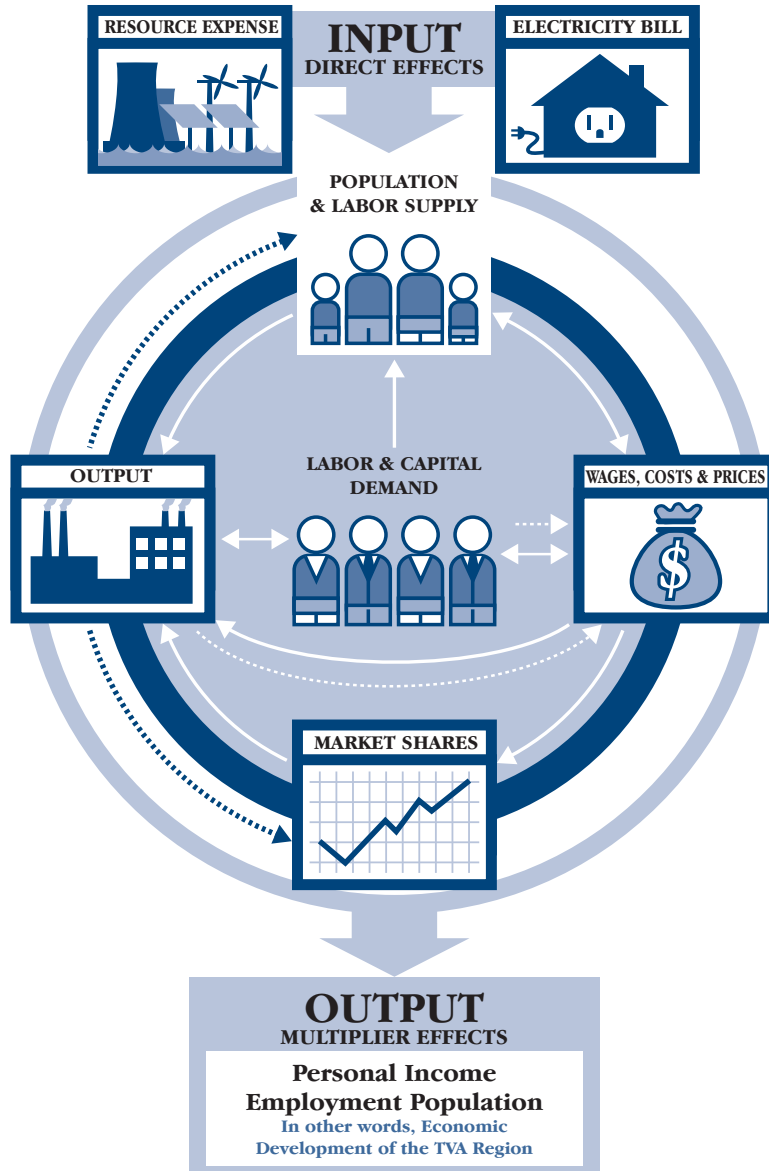


Figure B-1–Input and Output Impacts

These “direct effects” are input into a regional economic model, which captures the interactions within the regional economy—the so-called multiplier effect. TVA uses a Regional Economic Models Inc. (REMI) model of the economies of the TVA region and surrounding areas.



This model maps the TVA region's economic structure, its inter-industry linkages and responses to TVA rate and customer cost changes, including changes from energy efficiency. The model also captures interactions with areas outside the region, such as coal purchases.

The analysis includes data on direct TVA expenditures, including applicable payrolls, material and supply purchases and fuel costs for all energy resource options that comprise a particular strategy for both construction and operations. It also includes data on TVA rates and total resource costs resulting from each strategy, as well as savings to customer bills from energy efficiency and demand reduction programs.

### **Methodology**

Annual construction expenses were entered into the regional economic model for each strategy and scenario analyzed. The model then calculated two types of indirect effects from these construction expenses:

1. Increases in goods manufactured in the TVA region resulting from purchasing materials and supplies associated with a project
2. Additional income generated in the regional economy resulting from the spending of workers hired for construction

The analysis of operations was similar to the construction analysis. Annual operations expense data for the strategy portfolio was entered into the economic model. Since most fuel purchases came from outside the region, they were entered into the analysis as expenses in areas outside the region.

The analysis also estimated the effects of cost differences among strategies. Differences in customer costs or electric bills either add to or subtract from the spending capacity of customers. Therefore, the differences affect the amount of income and revenue available for other uses.

When the income is returned to the economy, it generates additional economic growth. Estimates of annual total resource costs for each strategy, as well as net savings from energy efficiency and demand reduction programs, were used to estimate net cost differences among strategies. The net cost differences were used with the TVA regional economic model to compute the impacts.

## Analysis

All IRP strategies were analyzed for Scenario 1 and Scenario 6. These scenarios were used to define the upper and lower range of the impacts on the various strategies. The factors discussed above were incorporated into the regional economic model for each strategy and scenario to measure the overall economic development effects.

Overall, economic impacts are the net effect of both resource expenses and customer electricity bills. Both factors are measured in terms of employment and income changes from the base case, represented in Strategy B – Baseline Plan Resource Portfolio, in Scenario 7 – Reference Case: Spring 2010.

## Findings

The major finding is that there was no significant change in both the short- and long-term for the range of strategies and scenarios.

Even though none of the strategies had significant differences from the base case, there were minimal differences of 1 percent or less for each strategy. The differences are outlined in Figure B-2.

Strategy	Scenario	Percent Difference from IRP Reference Portfolio			
		Total Employment		Total Personal Income	
		Average 2011-2028	Average 2011-2015	Average 2011-2028	Average 2011-2015
A	1	0.1%	-0.4%	0.1%	-0.2%
	6	-0.4%	-0.4%	-0.4%	-0.3%
B	1	1.0%	0.3%	0.8%	0.3%
	6	-0.3%	-0.4%	-0.3%	-0.3%
C	1	0.9%	0.2%	0.6%	0.2%
	6	0.2%	-0.2%	0.1%	-0.1%
D	1	1.2%	0.4%	1.0%	0.3%
	6	-0.1%	-0.4%	-0.2%	-0.4%
E	1	0.8%	0.0%	0.6%	0.0%
	6	0.3%	-0.1%	0.2%	-0.1%
R	1	0.9%	0.2%	0.7%	0.2%
	6	0.2%	-0.2%	0.1%	-0.1%

**Scenario**

- 1 Economy Recovers Dramatically
- 2 Environmental Focus is a National Priority
- 3 Prolonged Economic Malaise
- 4 Game-Changing Technology
- 5 Energy Independence
- 6 Carbon Legislation Creates Economic Downturn
- 7 Reference Case: Spring 2010
- 8 Reference Case: Great Recession Impacts Recovery

**Planning Strategy**

- A Limited Change in Current Resource Portfolio
- B Baseline Plan Resource Portfolio
- C Diversity Focused Resource Portfolio
- D Nuclear Focused Resource Portfolio
- E EEDR and Renewables Focused Resource Portfolio
- R Recommended Planning Direction

**Reference Portfolio: Spring 2010 is Scenario 7, Strategy B**

Figure B-2- Final Summary Economic Impacts of IRP Cases

Listed below is an outline of the strategies and analysis results:

- Strategy A performed worse than any of the other strategies for the scenario range
- Strategies B, C, D and E had more comparable results, with only a few tenths of a percent difference
- The impacts of Strategies B and D were very similar
- Both strategies performed better in the high growth Scenario 1 than Strategies C or E
- However, both strategies performed worse in the low growth Scenario 6 than Strategies C or E or the reference portfolio
- These results are consistent with strategies that lean toward building to meet load
- On the other hand, Strategies C and E lean toward conservation
- Strategy C and Strategy E's impacts were very similar
- Both performed above the reference portfolio in the long-term for both Scenarios 1 and 6
- The Recommended Planning Direction results are similar to the results for Strategy C



## Appendix C – Energy Efficiency and Demand Response

<b>Previous: Demand-Focused Portfolio</b>	<b>C188</b>
<b>Renewed Vision: To Become a Leader in Energy Efficiency</b>	<b>C189</b>
<b>Program Infrastructure to Support Renewed Vision</b>	<b>C190</b>
<b>Portfolio Design</b>	<b>C190</b>
<b>About TVA and Power Delivery Structure</b>	<b>C190</b>
<b>TVA Program Development</b>	<b>C191</b>
<b>TVA’s Long-Term Plan</b>	<b>C192</b>
<b>Program Offerings and Initiatives</b>	<b>C193</b>
<b>Next Steps</b>	<b>C195</b>

### Previous: Demand-Focused Portfolio

In May 2007, the TVA Board of Directors adopted a strategic plan that recognized the need for a comprehensive approach to meet the Tennessee Valley region’s future electrical power needs, including increased energy efficiency and demand response (EEDR) initiatives. On May 19, 2008, the TVA Board of Directors approved the guiding principles of an EEDR plan, which included recommendations for reducing the growth in peak demand by up to 1,400 MW by the end of 2012.

The plan recognized that improving peak demand reduction can help slow demand growth in a cost-effective manner while addressing air pollution and global climate change. TVA recognized this goal could only be achieved through a broad cooperative effort with strong support from TVA’s customers and stakeholders.

At this time, TVA did not have an energy reduction goal. Therefore, TVA’s EEDR program efforts were targeted to achieve the maximum power demand reductions during the periods of highest demand on the TVA system. TVA’s existing energy efficiency programs would reduce energy consumption over all hours of the day, but were designed to achieve maximum effect on the peak periods in the early years of the plan. Under this goal, achievements for EEDR programs were measured in MW.

## **Renewed Vision: To Become a Leader in Energy Efficiency**

Since 2007, changes in economic, environmental and power supply market conditions, along with the initiation of TVA's IRP process, provided additional opportunities to assess the potential of energy efficiency program contributions to TVA's resource mix. From the additional work of this IRP and benchmarking research of other utilities in the Southeast, in August 2010, the TVA Board of Directors adopted a renewed vision – to become one of the nation's leading providers of low-cost, cleaner energy by 2020.

To help achieve this renewed vision, TVA set a goal to lead the Southeast in increased energy efficiency by achieving 3.5 percent of sales in energy efficiency savings by 2015. Therefore, EEDR will track both energy and demand savings, and achievements for energy efficiency programs will be measured in GWh.

The actual measure of this effort is the sum of total program results that have the net effect of reducing future load requirements by 3.5 percent. This percentage would result in an energy savings of about 6,000 GWh by the end of 2015. Meeting this goal would:

- Save residential and commercial power customers more than \$350 million in FY15
- Provide 1,900 MW of extra power capacity on the TVA system
- Prevent TVA from having to build at least two new power plants

Achievements in FY10 toward the new goal resulted in 211 GWh of energy savings – enough to power about 13,000 homes and avoid carbon emissions equal to 22,700 vehicles. For FY11, TVA has increased its energy efficiency goal to 550 GWh and its associated budget by 50 percent to \$135 million. Additional steps in the process to achieve this goal include:

- Refocusing of existing energy efficiency program incentives from demand to energy
- Third-party potential study with renewed energy goal focus amidst today's economic climate
- Development of a five-year EEDR action plan for achieving greater energy savings and to begin implementing new programs by the start of FY12

### **Program Infrastructure to Support Renewed Vision**

TVA's energy efficiency strategy includes incentive programs, price structure changes and education efforts to raise awareness and encourage smart consumer choices. Currently, TVA offers eight energy efficiency programs through participating power distributors under the TVA EnergyRight® Solutions brand.

In May 2009, TVA added the three following programs for residential, business and large industrial markets: In-Home Energy Evaluation, EnergyRight® Solutions for Business and the Major Industrial Program.

### **Portfolio Design**

Energy efficiency and demand-side management programs have been a part of TVA's energy supply resource mix since the late 1970s. The programs were initiated in response to the rising cost of energy and construction of new electric generating units. These programs promoted energy conservation and the efficient use of electricity.

From 1975 to 1988, TVA's efforts resulted in a 1,200 MW reduction in peak demand and more than 3,200 GWh of annual energy savings. These efforts positioned TVA as a national leader in energy efficiency improvements. TVA's achievement was a result of programs such as home energy audits, energy-efficient equipment and weatherization installations. During this period, TVA had a direct impact on the energy efficiency of more than one million homes in the Tennessee Valley region.

In the 1990s, TVA's focus shifted toward the promotion of energy-efficient electro-technologies. The aim was for end users to adopt these technologies when it was economically sensible, in terms of their total energy cost. These programs also delivered demand reduction benefits.

Subsequently, from 1996 to 2008, TVA programs offered in conjunction with distributors of TVA power resulted in a cumulative demand reduction of more than 545 MW. Nearly 90 percent of this total was derived from TVA's EnergyRight® residential program. The program provides items such as low-interest heat pump loans and incentives for energy efficient new home construction. The remaining percentage of the reduction was attributed to residential direct load control programs for air conditioning and water heating and large commercial and industrial programs.

### **About TVA and Power Delivery Structure**

As a wholesale provider of electricity, TVA's operational structure has unique distinctions. TVA differs from prevalent, vertically-integrated utilities because it does not have direct interaction with the majority of end-use consumers.

TVA sells the power it produces to 155 municipal and cooperative power distributors who in turn sell that power to end-use consumers, both residential and commercial. The distributor community is made up of independently operated companies. TVA also directly serves 56 large industries and federal agencies across its service territory.

## **TVA Program Development**

In 2007, TVA retained the services of PA Consulting (PA) to identify potential demand reduction-focused programs that could be implemented to reduce summer peak demand by 1,400 MW in 2012. The recommendations PA provided were derived from a review of industry programs and selected based on economic capability. TVA reviewed PA's designs for applicability to the TVA market, and the programs were prioritized for customization to the demographic and climatic parameters of the region. The programs were prioritized based on qualitative factors to select candidates for design that were highly likely to succeed.

Once preliminary program designs were constructed, the estimated costs and system impacts were documented in a format to permit financial analysis. These inputs were reviewed for consistency and used to create a load shape for each program effort. The load shapes and financial inputs were subjected to a basic financial review to determine their scores on the typical evaluation tests of Total Resource Cost (TRC), Utility Cost Test (UCT) and Rate Impact Measure (RIM).

Performance against these tests was used to fine-tune the program designs to achieve positive impacts. Once the program designs were solidified, more detailed analysis was performed when the load shapes and costs were compared to other resource options in the IRP modeling process.

Because TVA does not serve the majority of end users directly, its program design process includes not only consumer research, but also close involvement by the power distributor community. TVA and distributors coordinate these design activities through the Tennessee Valley Public Power Association's (TVPPA) Energy Services Committee.

TVA's development process was driven by customer insight gained through primary market research conducted with distributors and their customers. Initial program hypotheses were derived from regional market segment data and secondary research on successful programs from across the country. The hypotheses were tested and refined through qualitative and quantitative market research to craft program concepts that best fit TVA's unique relationship with distributors and their customers.



Once program concepts had been refined, TVA worked with distributors and TVPPA to develop program delivery mechanics needed to successfully offer new programs for residential, commercial and industrial customers, as well as education and outreach initiatives. The programs were further refined through market testing prior to system-wide expansion. This process considerably enhances TVA's potential for success and to help keep electricity rates low.

Currently, TVA is engaged in evaluating these new programs and their delivery process following test markets in FY10 and expansion for FY11. These programs will continue to evolve in response to new assumptions, influences and research and market test results. TVA is also establishing measurement and verification protocols to evaluate programs, validate assumptions in program design, document verifiable program impacts and influence new program development.

By using energy more efficiently, the amount of electricity TVA needs to generate to meet the power demand of more than nine million consumers in the Tennessee Valley region will reduce. When fully implemented, these programs will help:

- Reduce reliance on power purchased from other suppliers
- Reduce the impact of power production on the environment
- Mitigate rate pressures by providing direct benefits to the TVA system and consumers

### **TVA's Long-Term Plan**

TVA's view is that EEDR improvement over the long term ultimately must be accomplished through a transformation in the marketplace. The transformation would increase consumer demand for energy-efficient products and services and provides the delivery channels to meet their needs.

The transformation will not be made through TVA purchasing the marketplace, but rather by accomplishing the following important supporting mechanisms:

- Educating the public to make informed choices about their energy use and energy-related purchases
- Electricity rates that send appropriate price signals to encourage consumers to reduce usage during periods of high demand
- Advanced electric metering and other technologies that allow communication between end users and their power provider

- A strong, vibrant infrastructure for end-use generation technologies
- A robust network of commercial providers offering a wide array of energy-efficient products and services
- Exploration and development research of end-use efficiency technology

## Program Offerings and Initiatives

TVA continues to offer programs under the EnergyRight® Solutions brand that include residential, commercial, industrial, renewable, education/outreach and demand response initiatives. Figure C-1 outlines existing and new EEDR programs.

Type of Program	Program Name
Energy efficiency	New Homes Plan Heat Pump Plan Water Heater Plan Manufactured Homes Plan Do-It-Yourself Home Energy Evaluation In-Home Energy Evaluation Program EnergyRight® Solutions for Business Major Industrial Program
End-use generation	Generation Partners <sup>SM</sup> Green Power Switch <sup>®</sup>
Demand response	Commercial and Industrial Demand Response Pilot Direct Load Control Program Conservation Voltage Reduction Program (new)
Education and outreach	National Theatre for Children Alliance to Save Energy Green Schools Program Trade Ally Network Internal Energy Management Program (IEMP)

Figure C-1 – Existing and New EEDR Programs

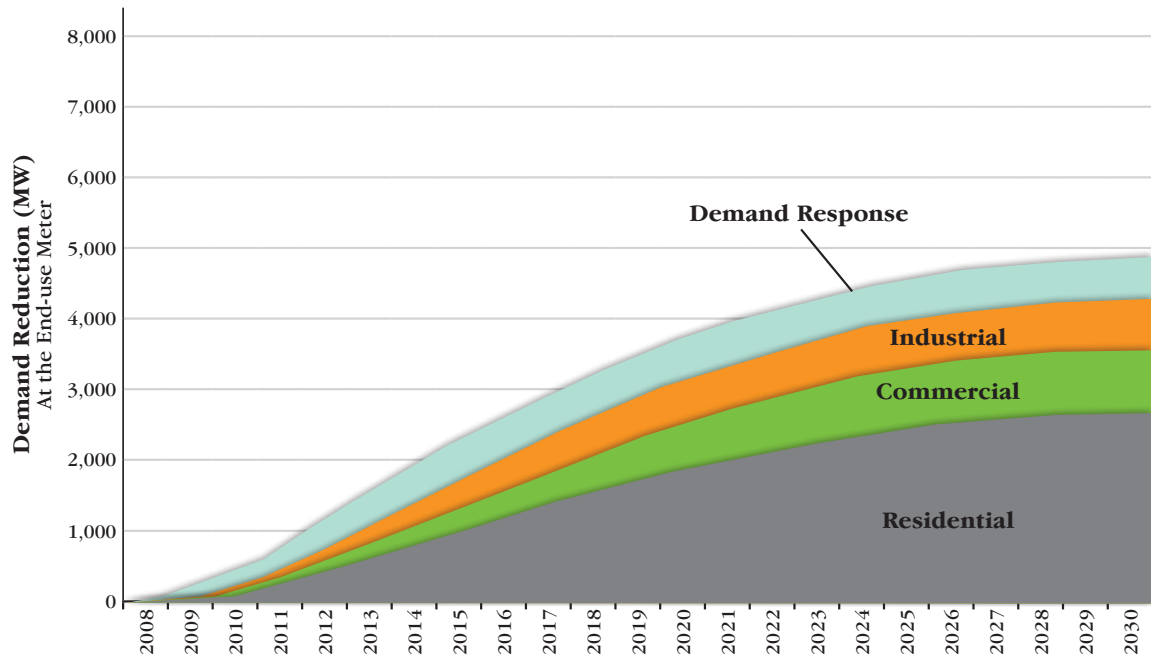


Figure C-2 – EEDR Program Demand Reduction (MW)

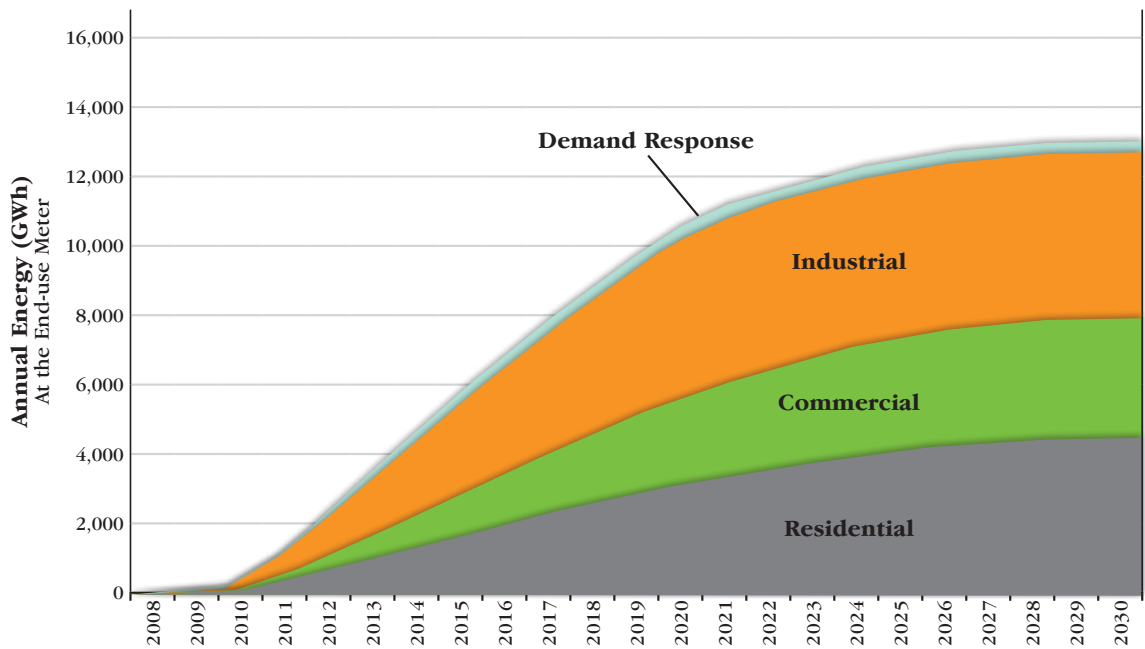


Figure C-3 – EEDR Program Energy Savings (GWh)

## Next Steps

The EEDR portfolios used by the IRP process are shown in Figures C-2 and C-3. TVA is building on the results of the analyses performed in the process and refining the EEDR portfolio contained in the Recommended Planning Direction into a more expansive, fully defined five-year plan to accomplish the energy and demand savings identified. As such, the modest post 2020 range for EEDR growth does not preclude further investments in these resources during the decade. Development of the five-year plan will involve improvement of existing efforts as well as implementation of new program designs.

## Appendix D – Development of Renewable Energy Portfolios

<b>TVA’s Current Renewable Energy Landscape</b>	<b>D196</b>
<b>Renewable Energy Needs</b>	<b>D198</b>
<b>IRP Renewable Additions</b>	<b>D198</b>
<b>Modeling Process</b>	<b>D199</b>
<b>Model Inputs</b>	<b>D199</b>
<b>Assumptions for Developing Renewable Portfolios</b>	<b>D200</b>
<b>Renewable Resource Types and Components</b>	<b>D201</b>
<b>Additional Sensitivities</b>	<b>D202</b>

### TVA’s Current Renewable Energy Landscape

In addition to nuclear energy and energy efficiency, expansion of TVA’s long history as a renewable energy provider can help achieve TVA’s renewed vision for a cleaner and more secure energy future, with less reliance on carbon intensive sources of generation. In addition, a federal renewable energy standard (RES) or, alternatively, a clean energy standard, is expected to be adopted within the next few years, prior to enactment of any additional state-level Renewable Portfolio Standards (RPS) requirements in the Tennessee Valley region.

TVA defines renewable energy as energy production that is sustainable and often naturally replenished (e.g., solar, wind, methane, biomass, geothermal and hydro). There is currently no federal statutory definition of renewable energy resources, but recent federal renewable energy legislative proposals would exclude most of TVA’s extensive 3,300 MW conventional hydropower installations. Therefore, TVA has been taking significant strides to increase the non-conventional hydro renewable energy portfolio.

These actions are being taken in part to reduce the risk associated with potential renewable energy requirements, and more importantly, to align with the approved TVA Board of Directors renewed vision, policies and other strategic aspirations (e.g., Strategic Plan, Environmental Policy, Renewable and Clean Energy Guiding Principles, Federal Renewable Portfolio Standard Compliance for Customers, State RPS Compliance for Customers). Actions to date that support these policies are described below:

- Since 1992, TVA has increased generating capacity at its conventional hydropower plants by 565 MW through the Hydro Modernization Program (HMOD). Generation associated with these HMOD improvements could be eligible to meet federal RPS
- Green Power Switch<sup>®</sup> (GPS) was launched in 2000 to offer Tennessee Valley residents the choice to support renewable energy. 100 percent of the renewable energy produced from GPS is from Tennessee Valley resources, including 14 solar sites, 18 wind turbines, two methane gas sites and nearly 400 Generation Partners solar and wind installations. The GPS program was the first green power pricing program in the Southeast and currently has approximately 12,000 participants. GPS is sold to residential and business consumers in 150 KWh blocks. Each block is \$4, which is added to the consumers' power bill each month
- Generation Partners<sup>SM</sup> (GP) was launched as a pilot program in 2003 and provides technical support, incentives and premium rates to purchase energy from small-scale (<200 kW) renewable generation systems from eligible resources such as solar photovoltaics, wind, biomass and small hydro. The renewable power generated from GP currently goes towards GPS supply. In the winter of 2009, GP capacity was close to 9 MW, made up of approximately 1 MW of biomass, 7 MW of solar and a little less than 1 MW in wind
- The TVA Board of Directors authorized the purchase of up to 2,000 MW of renewable and clean energy. By February 2011, more than 1,600 MW of solar, wind and methane contracts had been signed. Other proposals are being evaluated
- TVA developed a renewable power purchase plan, known as the Renewable Standard Offer, to further encourage small renewable energy projects in the service territory. This initiative offers a set price for renewable energy projects from 201 kW to 20 MW. The first agreement was signed under this program in January 2011 with Waste Management Renewable Energy LLC for a 4.8 MW landfill gas (i.e., methane) facility

Considering all of these efforts, TVA's current 2012 estimated non-conventional hydro renewable energy portfolio, including commitments for renewable resources not yet online, is approximately 1,800 MW.

Further, TVA is taking initiatives that will advance development of renewable energy efforts, including:

- Completing a biomass conversion feasibility, fuel supply and cost assessment study
- Collaborating with the Tennessee Valley and Eastern Kentucky Wind Working Group to update Tennessee Valley wind energy resource assessments and transmission capabilities using newer wind turbine technology and taller towers
- Partnering with the State of Kentucky to evaluate Kentucky renewable energy resources
- Reviewing waste heat recovery capabilities
- Collaborating with Tennessee Solar Institute to host a solar forum in late 2011
- Partnering to explore a variety of smart grid technologies designed to increase energy efficiency
- Involvement in a multi-partner initiative, called the Electric Vehicle Project, which is the largest deployment of electric vehicles and charging infrastructure in history

### **Renewable Energy Needs**

In 2007, North Carolina became the first state in the Southeast to adopt a RES and energy efficiency standard. Investor-owned utilities operating in North Carolina will be required to meet up to 12.5 percent of their retail sales through renewable energy resources or energy efficiency measures by 2021.

The combination of TVA's renewed vision, the growth in customer demand for renewable energy, the increasing regulatory stringency related to coal burning sources of generation and the anticipation of future federal and state mandates is prompting TVA to move towards generation that reduces or eliminates emissions altogether. Renewable energy is a generation resource that meets many of these challenges. Renewables aid in the reduction of air emissions from electric generation activities and use readily available "fuel" sources that are easily replenished.

### **IRP Renewable Additions**

Two renewable energy portfolios were developed for use in the IRP modeling process in summer and fall 2010. This appendix provides background on information needed by modelers, development of estimates and assumptions common to all portfolios, preparation of 2,500 MW and 3,500 MW portfolios and recent/ongoing events.

## Modeling Process

IRP scenarios were developed using two different fixed and given schedules for the introduction of new renewable capacity at TVA, including both self-builds and long-term PPAs. One renewables portfolio was developed to achieve a target of 2,500 MW of new renewable generating capacity (busbar) by 2020. The other portfolio was developed to achieve a target of 3,500 MW of new renewable capacity by that same year.

These portfolio development schedules were designed to be feasible and reasonable in terms of achievability, current and future cost, resource availability and diversity, and federal renewable energy and tax policies. They were intended to be treated in expansion planning models as “must-take” capacity for the Draft IRP (i.e., the capacity additions specified in a schedule were incorporated into the system irrespective of any other alternatives or their costs). This ensures that the scheduled quantities are included in a modeling output no matter the other features of the scenario. The approach was initially applied so the schedule also represented the maximum limit of renewable capacity additions. Subsequent tests were run allowing the model to choose between four different portfolios for the final IRP.

## Model Inputs

Inputs provided to model renewable capacity included:

- New renewable capacity at the busbar, by type, by year, in MW (either self-build or PPA)
- Equipment lifetime or PPA term (years)
- Annual capacity factor by year, for intermittent resources (wind and solar) and an assumed hourly profile
- Energy delivered to busbar by year in MWh
- Real “all-in” cost per kilowatt for constructing and operating (including fuel, where applicable) generating equipment over the lifetime and for self-builds (constant 2010 dollars per kW)
- Real “all-in” cost per kW for energy delivery under a PPA over its term (constant 2010 dollars per kW)
- Nominal annual expenditures for use in estimating budget impacts (\$ million as spent)



### Assumptions for Developing Renewable Portfolios

A number of common assumptions were applied in the development of both the 2,500 MW and 3,500 MW renewable energy portfolios, either across the board or specific to a given resource type. These include:

- Real discount rate (5.5 percent) applied for discounting purposes to all resource types
- Equipment lifetimes or PPA terms by resource type
- Federal investment tax credits, grants and production incentives (except if TVA-owned)
- Capacity factors by resource type
- Per kW all-in cost or cost range by resource type
- A wind generation profile and a solar generation profile representative of Tennessee Valley resources
- Existing or planned capacity already included in power planning models in summer 2010
- Existing or planned capacity not included in power planning models in summer 2010
- Capacity excluded (e.g., existing hydro)

## Renewable Resource Types and Components

Figure D-1 shows the resource types, assumed lifetimes, capacity factors, all-in costs and resulting levelized cost.

Resource	Lifetime	Capacity Factor	All-in Cost <sup>1</sup> 2010\$/KW	LCOE 2010\$/ MWh <sup>2</sup>	Simplifying Assumptions
Hydro modernization	30 years	12%-17%	\$454	\$30	All cost loaded into first year, including lifetime fuel & O&M
Landfill gas	20 years	85%	\$3,851	\$38	All cost loaded into first year, including lifetime fuel & O&M. LCOE net of Production Tax Credit
Additional hydro	30 years	33%-45%	\$1,688	\$40	All cost loaded into first year, including lifetime fuel & O&M
Co-firing (Biomass)	25 years	78%	\$3,977-\$4,048	\$45-\$47	All cost loaded into first year, including lifetime fuel & O&M. Revised nominal expenditures
Wind – out-of-Valley (market)	20 years	35%	\$4,500	\$82	Cost spread over lifetime, one payment per year (revised)
Wind – in Valley	25 years	20%	\$4,618	\$207	All cost loaded into first year, including lifetime fuel & O&M. Revised nominal expenditures
Dedicated biomass (market)	25 years	89%	\$7,038	\$40	Cost spread over lifetime, one payment per year (revised)
Dedicated biomass (conversion)	25 years	70%	\$4,634	\$59	All cost loaded into first year, including lifetime fuel & O&M. Revised nominal expenditures
Solar PV	25 years	15%	\$5,217	\$219	All cost loaded into first year, including lifetime fuel & O&M. LCOE net of tax credits/grants

1 – All-in cost estimates in real 2010\$ (including all capital and expense), but excluding any tax incentives.

2 – Levelized Cost of Electricity, real 2010\$. Includes relevant tax incentives.

Figure D-1 – Renewable Resource Types and Components

The cost estimates were developed or adapted from a variety of sources, including consultant and industry estimates, internal TVA project estimates and existing PPA price quotes.

Existing and planned renewable capacity already incorporated into power planning by summer 2010 included 580-618 MW of hydro unit modernization and 2 MW of wind in the Tennessee Valley region at Buffalo Mountain (TVA-owned). Existing or planned capacity not already incorporated into power planning in the summer of 2010 included approximately 5 MW of landfill gas (Chestnut Ridge and Middle Point), approximately 3 MW of biomass co-firing at Colbert and Allen coal plants, 27 MW of in-valley wind at Buffalo Mountain (lease agreement with Invenergy) and approximately 2 MW of solar through Generation Partners<sup>SM</sup> or other resources.

“New” capacity was set for renewables over and above the amounts listed in Figure D-1. A reasonable deployment schedule was developed for each of the two requested portfolios (2,500 MW and 3,500 MW), with consideration given to the following:

- Cost
- Technology maturity and future advances
- Regional renewable resource availability
- A diversified renewable portfolio strategy
- Anticipated federal legislation/regulation and tax policy

In the Draft IRP, the new renewables were scheduled into the model to meet anticipated renewable energy mandates by 2020. Because of the generally higher cost of renewables and given the use of a model whose objective is minimizing cost of service, the more costly alternatives would not have been picked over more traditional capacity. The modeled portfolio growth in renewables capacity mostly tapers off after 2020 due to higher cost and/or regulatory uncertainty.

The modest post 2020 growth range for renewable energy modeled in the portfolios does not preclude further investments in these resources during the decade. TVA has committed to begin the next IRP effort by 2015. With the development of new data and knowledge the renewable portfolios will be developed further.

An effective improvement of 0.5 percent per year in solar photovoltaic energy output per unit cost was incorporated into the IRP portfolios associated with anticipated technology advancements and declining module cost over time. No other performance or real cost improvements were assumed through 2029 for any of the other resource types. Future market demand and innovation for these resources was dependent on unknown technology-by-technology treatment under future energy and environmental regulation or legislation, as well as future tax policy.

### **Additional Sensitivities**

Sensitivities were explored with targets at 2,000 MW (at a variant of the 2,500 MW portfolio) and at 3,000 MW (at a variant of the 3,500 MW portfolio). These capacity values were targeted for the year 2020. TVA evaluated a model-portfolio selection approach that employed the two core renewable portfolios and the two sensitivities, where the selection of a single portfolio in a model run was driven by a cost criterion that includes costs for emissions and carbon, in addition to traditional cost elements.

# Development of Renewable Energy Portfolios

Figures D-2 and D-3 contain the capacity values for the 2,500 MW and 3,500 MW renewables portfolios, respectively, prepared for this IRP in summer and fall 2010. These reflect target MW values for the year 2020.

Net Capacity (MW Cumulative)																		
FY:	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
HMOD						9.6	20.2	31.6	42.9	53.9	64.5	74.7	82.8	88.8	88.8	88.8	88.8	88.8
Landfill gas	1.8	3.7	12.0	15.6	18.4	21.4	25.2	27.9	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3
Addl hydro		24.3	24.3	48.6	48.6	75.6	75.6	107.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6
Co-firing		60.0	118.0	118.0	118.0	118.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0	146.0
Wind – out-of-Valley (PPA)	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0	1,380.0
Wind – in Valley			50.0	100.0	150.0	200.0	250.0	300.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0
Ded Biomass – PPA		35.0	35.0	67.0	67.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0
Ded Biomass – Conv			80.0	80.0	80.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0
Solar	20.0	25.0	40.0	45.0	60.0	65.0	80.0	85.0	100.0	105.0	120.0	125.0	140.0	145.0	160.0	165.0	180.0	185.0
<b>Total</b>	<b>1,401.8</b>	<b>1,528.0</b>	<b>1,739.3</b>	<b>1,854.2</b>	<b>1,922.0</b>	<b>2,156.6</b>	<b>2,264.0</b>	<b>2,365.1</b>	<b>2,489.8</b>	<b>2,505.8</b>	<b>2,531.4</b>	<b>2,546.6</b>	<b>2,569.7</b>	<b>2,580.7</b>	<b>2,595.7</b>	<b>2,600.7</b>	<b>2,615.7</b>	<b>2,620.7</b>

Figure D-2 – New Renewable Capacity at 2,500 MW

Net Capacity (MW Cumulative)																		
FY:	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
HMOD						9.6	20.2	31.6	42.9	53.9	64.5	74.7	82.8	88.8	88.8	88.8	88.8	88.8
Landfill gas	1.8	3.7	12.0	15.6	18.4	21.4	25.2	27.9	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3	30.3
Addl hydro	0.0	24.3	24.3	48.6	48.6	75.6	75.6	107.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6	143.6
Co-firing	0.0	60.0	118.0	118.0	118.0	118.0	141.0	169.0	169.0	169.0	169.0	169.0	169.0	169.0	169.0	169.0	169.0	169.0
Wind – out-of-Valley (PPA)	1,380.0	1,480.0	1,630.0	1,780.0	1,930.0	2,080.0	2,230.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0	2,380.0
Wind – in Valley			50.0	100.0	150.0	200.0	250.0	300.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0	360.0
Ded Biomass – PPA	0.0	35.0	35.0	67.0	67.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0	117.0
Ded Biomass – Conv	0.0	0.0	80.0	80.0	80.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0	170.0
Solar	35.0	45.0	75.0	85.0	115.0	125.0	155.0	165.0	195.0	205.0	235.0	245.0	275.0	285.0	315.0	325.0	355.0	365.0
<b>Total</b>	<b>1,416.8</b>	<b>1,648.0</b>	<b>2,024.3</b>	<b>2,294.2</b>	<b>2,527.0</b>	<b>2,939.6</b>	<b>3,212.0</b>	<b>3,468.1</b>	<b>3,607.8</b>	<b>3,628.8</b>	<b>3,669.4</b>	<b>3,689.6</b>	<b>3,727.7</b>	<b>3,747.7</b>	<b>3,773.7</b>	<b>3,783.7</b>	<b>3,813.7</b>	<b>3,823.7</b>

Figure D-3 – New Renewable Capacity at 3,500 MW

**Appendix E – Draft IRP Phase Expansion Plan Listing**

<b>Planning Strategy A – Limited Change in Current Portfolio</b>	<b>E204</b>
<b>Capacity Additions by Scenario</b>	<b>E205</b>
<b>Planning Strategy B – Baseline Plan Resource Portfolio</b>	<b>E206</b>
<b>Capacity Additions by Scenario</b>	<b>E207</b>
<b>Planning Strategy C – Diversity Focused Resource Portfolio</b>	<b>E208</b>
<b>Capacity Additions by Scenario</b>	<b>E209</b>
<b>Planning Strategy D – Nuclear Focused Resource Portfolio</b>	<b>E210</b>
<b>Capacity Additions by Scenario</b>	<b>E211</b>
<b>Planning Strategy E – EEDR and Renewables Focused Portfolio</b>	<b>E212</b>
<b>Capacity Additions by Scenario</b>	<b>E213</b>

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Idled Capacity	1	2	3	4	5	6	7
2010	246	35	-							
2011	408	48	-							
2012	421	137	-	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	666	155	-	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	1733	155	-							
2015	1434	160	-	GL CT Ref	GL CT Ref		GL CT Ref	GL CT Ref		GL CT Ref
2016	1557	160	-							
2017	1684	160	-							
2018	1812	160	-							
2019	1940	160	-							
2020	2051	160	-							
2021	2069	160	-							
2022	2014	160	-							
2023	2061	160	-							
2024	2131	160	-							
2025	2085	160	-							
2026	2226	160	-							
2027	2076	160	-							
2028	1980	160	-							
2029	1905	160	-							

Figure E-1 – Planning Strategy A – Limited Change in Current Portfolio

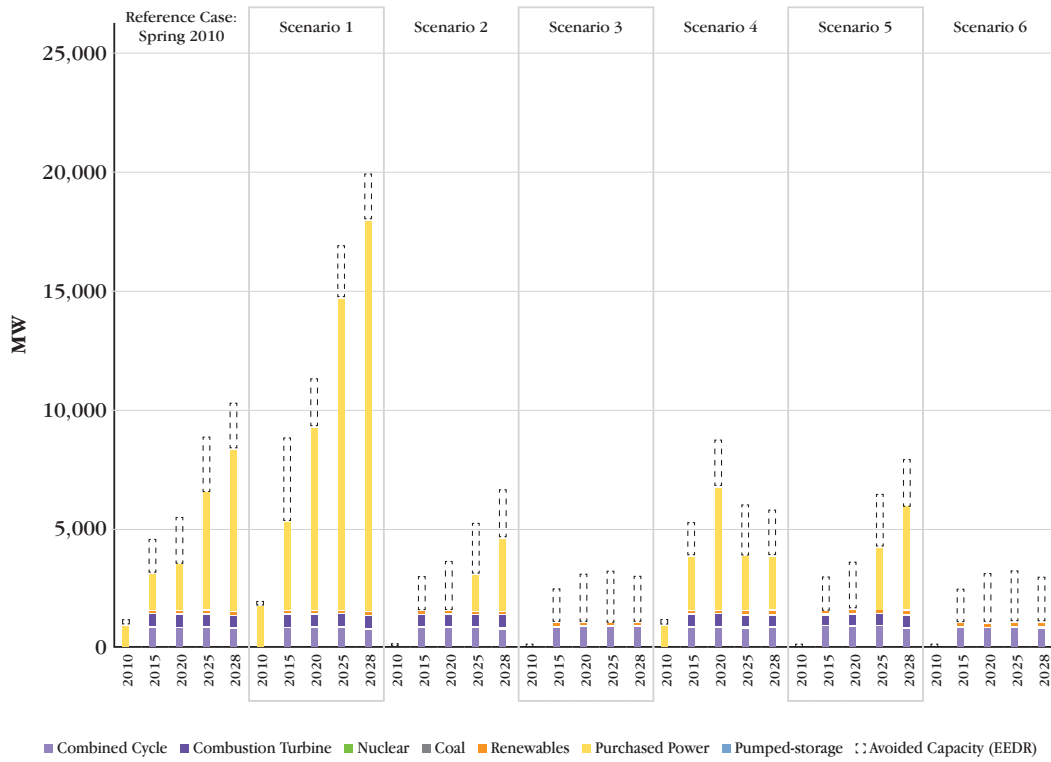


Figure E-2 – Planning Strategy A – Capacity Additions by Scenario

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Idled Capacity	1	2	3	4	5	6	7
2010	229	35	-	PPAs & Acq			PPAs & Acq			
2011	385	48	(226)							
2012	384	137	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	610	155	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	1363	155	(935)	CTa CT GL CT Ref			CTa		GL CT Ref	
2015	1496	160	(2,415)	CT CC	GL CT Ref		GL CT Ref CT CC	GL CT Ref		GL CT Ref CTa
2016	1622	160	(2,415)	CT			CT			CT
2017	1751	160	(2,415)	CT			CT			CTa
2018	1881	160	(2,415)	BLN1			BLN1	BLN1		BLN1
2019	2012	160	(2,415)	CT	BLN1					
2020	2124	160	(2,415)	BLN2			BLN2	BLN2		BLN2
2021	2216	160	(2,415)	CC	BLN2					
2022	2294	160	(2,415)	CT CC				CTa		CC
2023	2362	160	(2,415)	CT				CTa		CT
2024	2429	160	(2,415)	NUC						
2025	2470	160	(2,415)	IGCC	NUC			CC		CT
2026	2495	160	(2,415)	NUC						
2027	2509	160	(2,415)	CT	NUC			CT		CT
2028	2516	160	(2,415)	CC						
2029	2520	160	(2,415)	IGCC, Cta	Cta	Cta		CT		CC

Key:

PPAs & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)

JSF CC = the combined cycle unit to be sited at the John Sevier plant (TVA Board of Directors' approved project, currently under development)

WBN2 = Watts Bar Unit 2 (TVA Board of Directors' approved project, currently under development)

GL CT Ref = the proposed refurbishment of the existing Gleason CT units

CC = combined cycle

CT/CTa = combustion turbines

PSH = pumped-storage hydro

BLN1/BLN2 = Bellefonte Units 1 & 2

NUC = nuclear unit

IGCC = integrated gasification combined cycle (coal technology)

Figure E-3 – Planning Strategy B – Baseline Plan Resource Portfolio

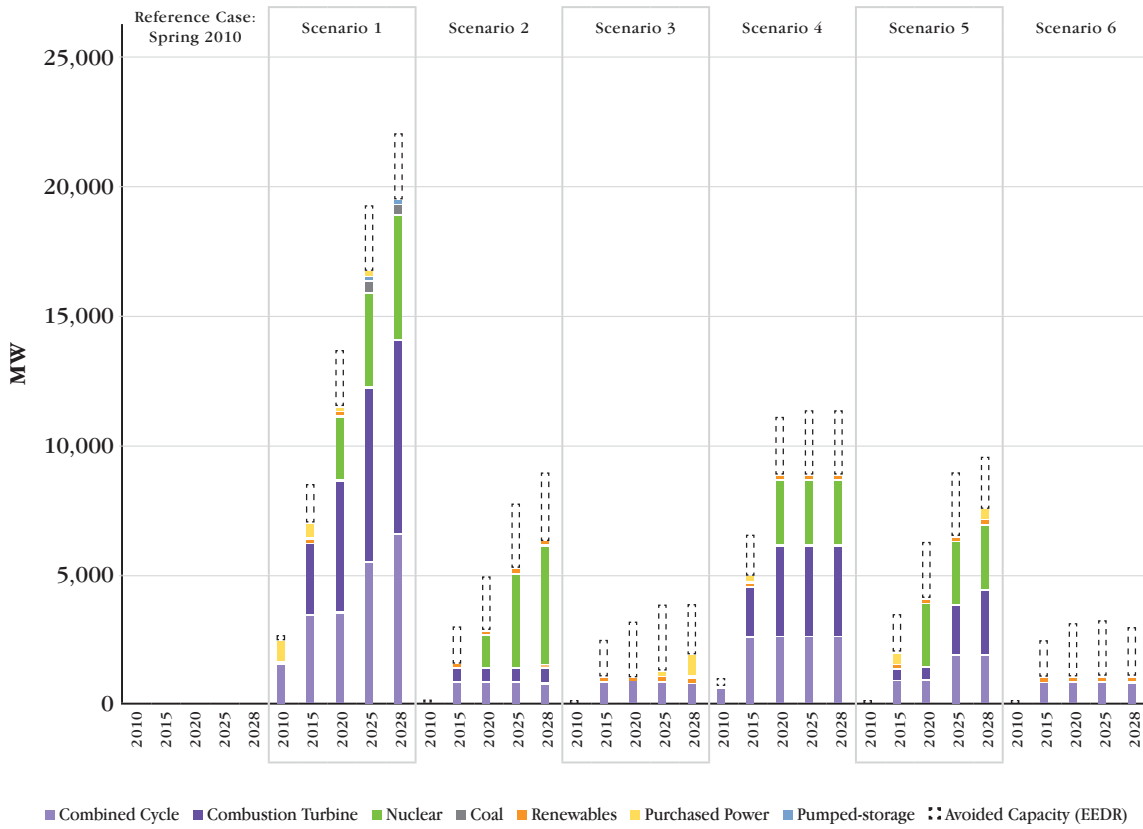


Figure E-4 – Planning Strategy B – Capacity Additions by Scenario



Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Idled Capacity	1	2	3	4	5	6	7
2010	298	35	-	PPAs & Acq						
2011	389	48	(226)							
2012	770	145	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	1334	286	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	1596	44	(935)	CTa			CTa			
2015	2069	515	(3,252)	GL CT Ref CT CC			GL CT Ref CT CC	GL CT Ref		GL CT Ref CTa
2016	2537	528	(3,252)	CT			CT			
2017	2828	715	(3,252)							
2018	3116	768	(3,252)	BLN1			BLN1			BLN1
2019	3395	822	(3,252)							
2020	3627	883	(3,252)	BLN2 PSH	PSH	PSH	BLN2 PSH	PSH	PSH	BLN2 PSH
2021	3817	896	(3,252)	CT						
2022	3985	911	(3,252)	CC	BLN1			BLN1		
2023	4143	922	(3,252)	CC						
2024	4295	935	(3,252)	NUC	BLN2			BLN2		
2025	4412	942	(3,252)	IGCC						CT
2026	4502	947	(3,252)	NUC						
2027	4561	948	(3,252)	CT						CC
2028	4602	953	(3,252)	CT						
2029	4638	954	(3,252)	IGCC, Cta	NUC			CTa		CTa

Figure E-5 – Planning Strategy C – Diversity Focused Resource Portfolio

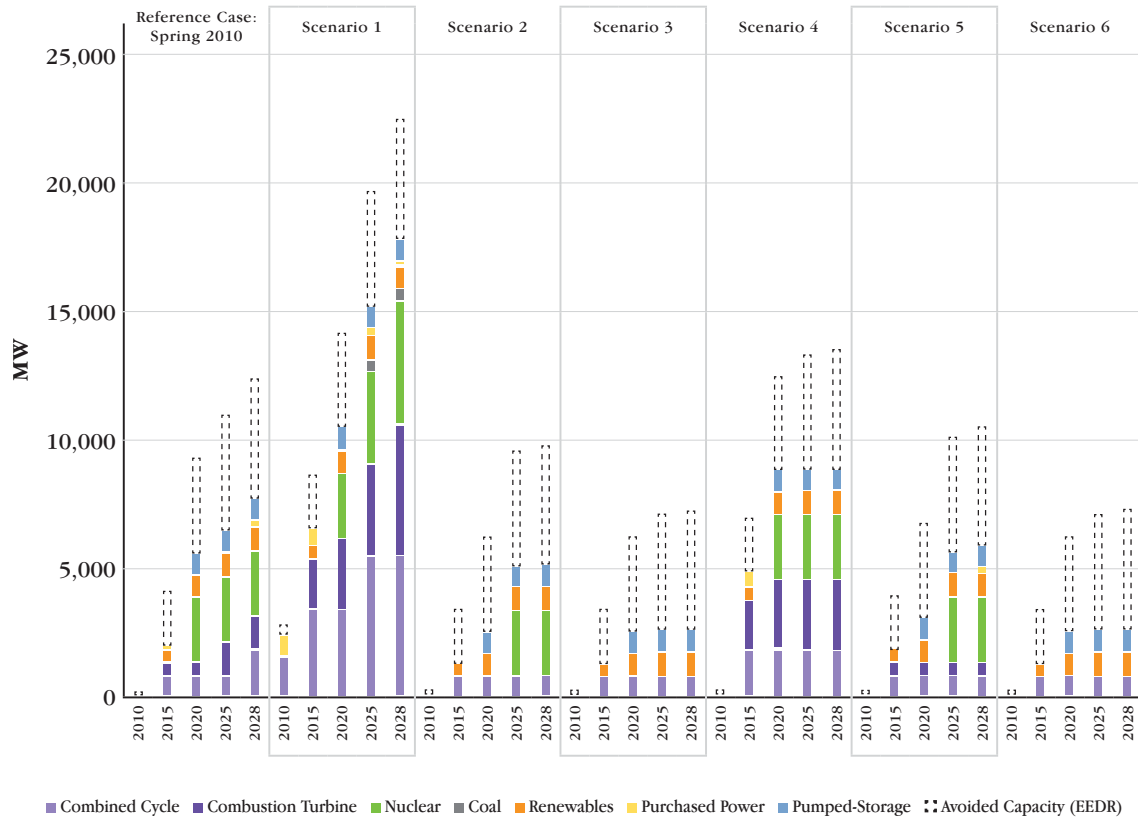


Figure E-6 – Planning Strategy C – Capacity Additions by Scenario

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Idled Capacity	1	2	3	4	5	6	7
2010	1300	35	-	PPAs & Acq						
2011	1126	48	(226)							
2012	1394	145	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	1795	286	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	2228	442	(935)	CTa		GL CT Ref	GL CT Ref CT CTa			
2015	2612	515	(5,718)	GL CT Ref CT(2) CC(2)	GL CT Ref		CT(2) CC(2)	GL CT Ref CC		GL CT Ref CTa(2) CC
2016	2846	528	(5,718)	CT			CC	CC		CC
2017	3104	715	(6,972)	CC	CC		CC			CTa
2018	3389	768	(6,972)	BLN1	BLN1		BLN1	BLN1		BLN1
2019	3704	822	(6,972)							
2020	3993	883	(6,972)	BLN2 PSH	BLN2 PSH	PSH	BLN2 PSH	BLN2 PSH	PSH	BLN2 PSH
2021	4092	896	(6,972)							
2022	4040	911	(6,972)	CC (2)						
2023	4042	922	(6,972)							CTa
2024	4303	935	(6,972)	NUC						
2025	4991	942	(6,972)	IGCC	NUC					
2026	5201	947	(6,972)	NUC						
2027	5711	948	(6,972)		NUC					
2028	6198	953	(6,972)	IGCC						
2029	6316	954	(6,972)	SCPC						

**Key:**

PPAs & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)

JSF CC = the combined cycle unit to be sited at the John Sevier plant (TVA Board of Directors' approved project, currently under development)

WBN2 = Watts Bar Unit 2 (TVA Board of Directors' approved project, currently under development)

GL CT Ref = the proposed refurbishment of the existing Gleason CT units

CC = combined cycle

CT/CTa = combustion turbines

PSH = pumped-storage hydro

BLN1/BLN2 = Bellefonte Units 1 & 2

NUC = nuclear unit

IGCC = integrated gasification combined cycle (coal technology)

**Figure E-7 – Planning Strategy D – Nuclear Focused Resource Portfolio**

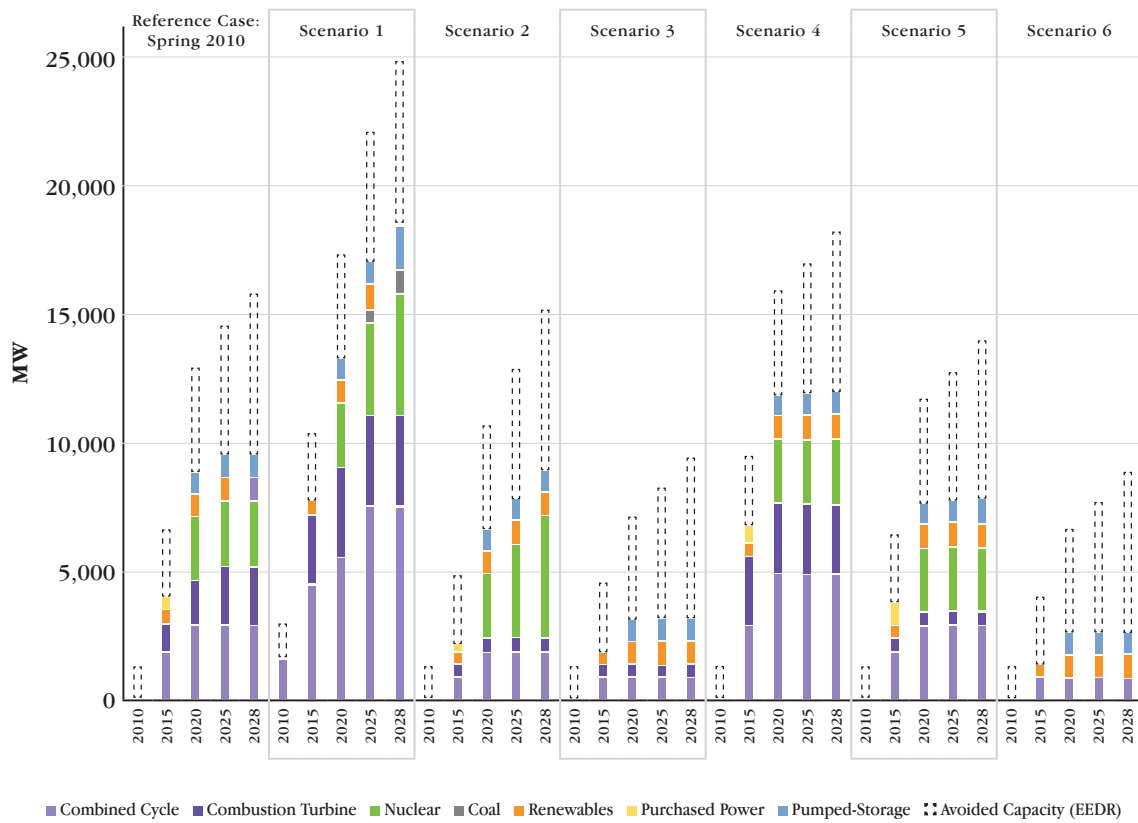


Figure E-8 – Planning Strategy D – Capacity Additions by Scenario

Year	Defined Model Inputs			Capacity Additions by Scenario						
	EEDR	Renewables	Idled Capacity	1	2	3	4	5	6	7
2010	34	35	-	PPAs & Acq						
2011	181	48	(226)							
2012	1136	178	(226)	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC	JSF CC
2013	1664	314	(935)	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2	WBN2
2014	2431	493	(935)							
2015	3479	580	(4,730)	GL CT Ref CTa CC(2)			GL CT Ref CTa CC(2)	GL CT Ref		GL CT Ref CTa
2016	3843	616	(4,730)	CT			CT			
2017	4183	846	(4,730)							
2018	4504	921	(4,730)	CT			CT			CC
2019	4811	994	(4,730)	CC (2)						
2020	5074	1060	(4,730)	CC (2)			CC			
2021	5353	1074	(4,730)	CTa						
2022	5460	1094	(4,730)	BLN1	BLN1			BLN1		BLN1
2023	5599	1107	(4,730)	CT						
2024	5739	1124	(4,730)	BLN2	BLN2			BLN2		BLN2
2025	5815	1133	(4,730)	CT						
2026	5893	1142	(4,730)	CT						CT
2027	5961	1145	(4,730)	CT						
2028	6009	1154	(4,730)	NUC				CTa		CTa
2029	6043	1157	(4,730)	CT				CTa		CTa

Key:

PPAs & Acq = purchased power agreements, including potential acquisition of third-party-owned projects (primarily combined cycle technology)

JSF CC = the combined cycle unit to be sited at the John Sevier plant (TVA Board of Directors' approved project, currently under development)

WBN2 = Watts Bar Unit 2 (TVA Board of Directors' approved project, currently under development)

GL CT Ref = the proposed refurbishment of the existing Gleason CT units

CC = combined cycle

CT/CTa = combustion turbines

PSH = pumped-storage hydro

BLN1/BLN2 = Bellefonte Units 1 & 2

NUC = nuclear unit

Figure E-9 – Planning Strategy E – EEDR and Renewables Focused Portfolio

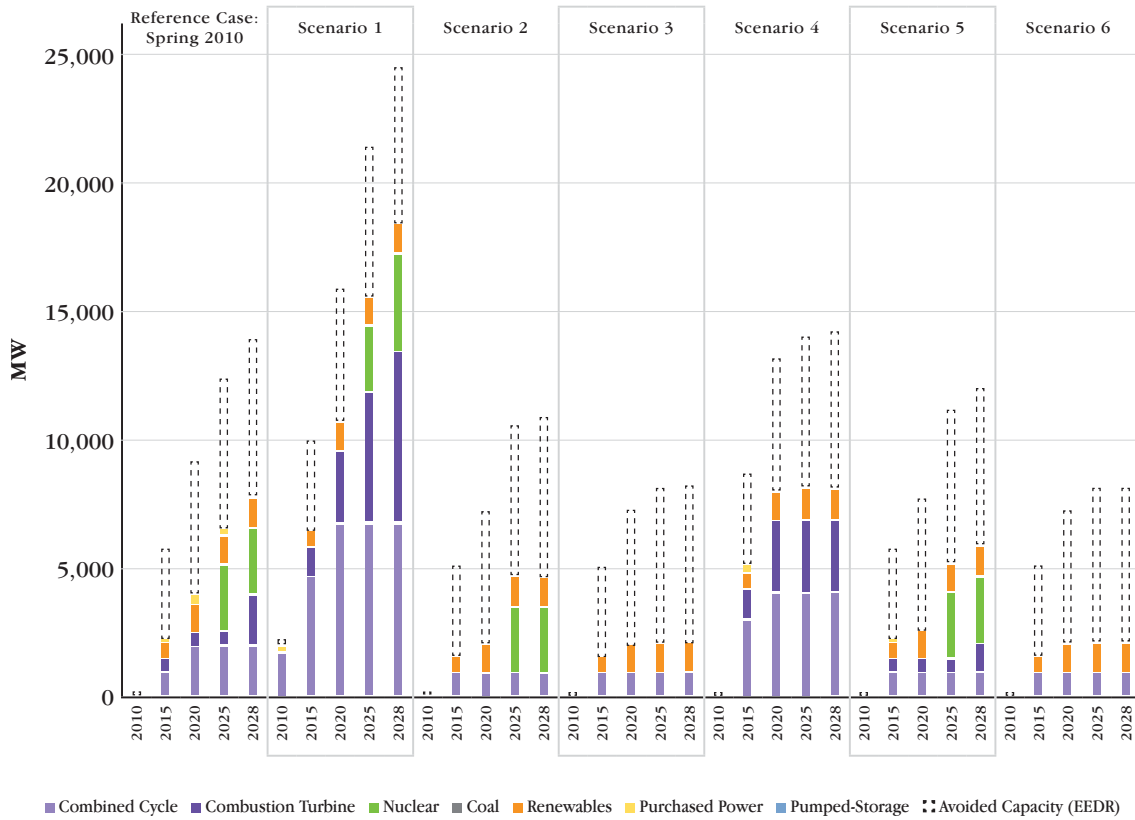


Figure E-10 – Planning Strategy E – Capacity Additions by Scenario

Input from Stakeholders	How Input was Incorporated
<ul style="list-style-type: none"> <li>Contribution of EEDR should be increased</li> </ul>	<ul style="list-style-type: none"> <li>The range of EEDR considered in the planning strategies was broadened in this IRP</li> </ul>
<ul style="list-style-type: none"> <li>Renewable investment (particularly within the Valley) should be increased</li> </ul>	<ul style="list-style-type: none"> <li>Renewable portfolios were expanded beyond existing contracts and include in-Valley resources</li> <li>Additional renewable power can be selected as part of the market supply identified by this IRP</li> </ul>
<ul style="list-style-type: none"> <li>EEDR and renewable portfolios with significant growth beyond 2020 should be evaluated</li> </ul>	<ul style="list-style-type: none"> <li>An additional sensitivity with EEDR and renewable portfolios that grew dramatically after 2020 was tested</li> </ul>
<ul style="list-style-type: none"> <li>Biomass is the most viable renewable resource within the Valley and should be expanded where sustainable</li> </ul>	<ul style="list-style-type: none"> <li>Biomass was included in the renewable portfolios evaluated in this IRP</li> </ul>
<ul style="list-style-type: none"> <li>Combined Heat and Power (CHP) should be included as a resource option</li> </ul>	<ul style="list-style-type: none"> <li>CHP was able to be selected as part of the market supplied power identified in this IRP</li> </ul>
<ul style="list-style-type: none"> <li>A large amount of the aging coal fleet should be idled</li> <li>TVA should consider the impacts of more stringent environmental requirements</li> </ul>	<ul style="list-style-type: none"> <li>Range of idled coal capacity considered was expanded in the development of the planning strategies</li> </ul>
<ul style="list-style-type: none"> <li>Capability for energy storage should be increased</li> </ul>	<ul style="list-style-type: none"> <li>A pumped-storage unit was included in the development of the Recommended Planning Direction</li> </ul>
<ul style="list-style-type: none"> <li>A strategy that does not include nuclear after WBN2 should be considered</li> </ul>	<ul style="list-style-type: none"> <li>Strategy A did not allow any capital expansion beyond WBN2</li> <li>An additional sensitivity was completed to test a “no nuclear” case</li> </ul>
<ul style="list-style-type: none"> <li>The use of natural gas should be significantly expanded</li> </ul>	<ul style="list-style-type: none"> <li>The Recommended Planning Direction supported a broad range of potential natural gas capacity expansion</li> </ul>
<ul style="list-style-type: none"> <li>Price forecast for natural gas should be lower based on emergence of shale gas</li> <li>Forecast should not change because shale gas has yet to be demonstrated as a reliable source of supply</li> </ul>	<ul style="list-style-type: none"> <li>Forecast was based upon recent market conditions as well as long-term economic views of the market that include shale gas</li> </ul>
<ul style="list-style-type: none"> <li>Engagement with distributors is the key to successfully implementing EEDR programs</li> </ul>	<ul style="list-style-type: none"> <li>TVA is committed to maintaining a strong partnership with the distributors of TVA power</li> </ul>
<ul style="list-style-type: none"> <li>Distributor-owned generation should be increased</li> </ul>	<ul style="list-style-type: none"> <li>TVA is engaged in dialogue to identify opportunities for distributor-owned generation outside this IRP</li> </ul>
<ul style="list-style-type: none"> <li>The public should have more opportunities to interact with the IRP process</li> </ul>	<ul style="list-style-type: none"> <li>TVA initiated quarterly briefings with the public in November 2009</li> </ul>
<ul style="list-style-type: none"> <li>TVA should explore alternatives that allow for greater participation in public events</li> </ul>	<ul style="list-style-type: none"> <li>TVA began broadcasting quarterly briefings via webinar in February 2010</li> <li>All meetings during the public comment period (October 2010) were also available via webinar</li> </ul>

# Stakeholder Input Considered and Incorporated

Input from Stakeholders	How Input was Incorporated
<ul style="list-style-type: none"> <li>The debt ceiling should be raised in order to minimize rate impacts from capital expansion</li> </ul>	<ul style="list-style-type: none"> <li>The IRP scorecard included a short-term rate impact measure</li> <li>Stakeholder desire for an increased debt ceiling was shared with appropriate groups within TVA</li> </ul>
<ul style="list-style-type: none"> <li>Potential economic impacts of carbon legislation being implemented were not represented in scenarios</li> </ul>	<ul style="list-style-type: none"> <li>Scenario 6 – Carbon Legislation Creates Economic Downturn was created to address this concern</li> </ul>
<ul style="list-style-type: none"> <li>Scenarios should reflect forecasts for demand that are flat and possibly negative</li> </ul>	<ul style="list-style-type: none"> <li>Scenario 3 – Prolonged Economic Malaise had nearly-flat load growth and Scenario 6 had a load forecast that is slightly negative</li> </ul>
<ul style="list-style-type: none"> <li>TVA should use “true cost accounting” to monetize all external impacts related to operations</li> </ul>	<ul style="list-style-type: none"> <li>TVA used industry standard methods for accounting for project and operations cost</li> <li>Environmental impact measures were included in the IRP scorecard</li> </ul>
<ul style="list-style-type: none"> <li>A technology innovation metric is out of context for this IRP and should not be included in the IRP scorecard</li> </ul>	<ul style="list-style-type: none"> <li>Technology innovation metric was dropped, but was included as a separate discussion from the IRP scorecard</li> </ul>
<ul style="list-style-type: none"> <li>Graphical indicators for economic impact in the IRP scorecard may imply greater differences than actually exist</li> </ul>	<ul style="list-style-type: none"> <li>The IRP scorecard was modified to show the percentage difference from the baseline for economic impacts</li> </ul>
<ul style="list-style-type: none"> <li>Strategic metrics should be populated for all planning strategies considered in the Draft IRP</li> </ul>	<ul style="list-style-type: none"> <li>Process was modified to create fully populated scorecards for all planning strategies</li> </ul>
<ul style="list-style-type: none"> <li>Other emissions (e.g., SO<sub>2</sub> and NO<sub>x</sub>) should be added as a separate environmental measure from CO<sub>2</sub> emissions</li> </ul>	<ul style="list-style-type: none"> <li>TVA determined that CO<sub>2</sub> emissions were a suitable proxy for other emissions and documented the supporting facts in Appendix A – Method for Computing Environmental Impact Metrics</li> </ul>
<ul style="list-style-type: none"> <li>New approaches that combine components of different planning strategies should be tested</li> </ul>	<ul style="list-style-type: none"> <li>Analysis to identify the Recommended Planning Direction optimally selected strategy components</li> </ul>
<ul style="list-style-type: none"> <li>Requests were received to extend the 45-day public comment period on the Draft IRP</li> </ul>	<ul style="list-style-type: none"> <li>The public comment period was extended seven days to allow additional time to submit comments</li> </ul>
<ul style="list-style-type: none"> <li>The IRP should be a recurring process for TVA</li> </ul>	<ul style="list-style-type: none"> <li>TVA has committed to begin the next IRP effort by 2015</li> </ul>



### Acronym Index

<b>BLN1/ BLN2</b> – Bellefonte Nuclear Plants Units 1&2	<b>MACT</b> – Maximum Achievable Control Technology
<b>B&amp;W</b> – Babcock and Wilcox	<b>MAPE</b> – Mean annual percent error
<b>CAES</b> – Compressed air energy storage	<b>MSW</b> – Municipal solid waste
<b>CEQ</b> – Council on Environmental Quality	<b>MW</b> – Megawatt
<b>CC</b> – Combined cycle	<b>MWh</b> – Megawatt hour
<b>CCS</b> – Carbon capture and sequestration	<b>NEPA</b> – National Environmental Policy Act
<b>CO<sub>2</sub></b> – Carbon dioxide	<b>NO<sub>x</sub></b> – Nitrogen oxide or Nitrous oxide
<b>CRP</b> – Conservation Reserve Program	<b>NRC</b> – Nuclear Regulatory Commission
<b>CSP</b> – Concentrating solar power	<b>NREL</b> – National Renewable Energy Laboratory
<b>CT</b> – Combustion turbine	<b>NUC</b> – Nuclear unit
<b>DOE</b> – Department of Energy	<b>PC</b> – Pulverized coal
<b>EEDR</b> – Energy efficiency and demand response	<b>PPAs</b> – Power purchase agreements
<b>EERE</b> – Energy efficiency and renewable energy	<b>PSH</b> – Pumped-storage hydro
<b>EIS</b> – Environmental Impact Statement	<b>PV</b> – Photovoltaic
<b>EPRI</b> – Electric Power Research Institute	<b>PVRR</b> – Present Value of Revenue Requirements
<b>EV2020</b> – Energy Vision 2020	<b>SCPC</b> – Supercritical pulverized coal
<b>FBC</b> – Fluidized bed combustion	<b>SEER</b> – Seasonal energy efficiency ratio
<b>FERC</b> – Federal Energy Regulatory Commission	<b>SEIS</b> – Supplemental environmental impact statement
<b>GWh</b> – Gigawatt hour	<b>SO<sub>2</sub></b> – Sulfur dioxide
<b>HAP</b> – Hazardous Air Pollutant	<b>SRG</b> – Stakeholder Review Group
<b>Hg</b> – Mercury	<b>TVA</b> – Tennessee Valley Authority
<b>IGCC</b> – Integrated gasification combined cycle	<b>TVPPA</b> – Tennessee Valley Public Power Association
<b>IRP</b> – Integrated Resource Plan	<b>WBN2</b> – Watts Bar Unit 2