Integrated Resource Plan

T V A ' S   E N V I R O N M E N T A L   A N D   E N E R G Y   F U T U R E

Preliminary Scenarios for IRP Project

External Stakeholder Review

August 18, 2009

Discussion Topics

- Provide background of scenario planning effort
  - Review/discuss uncertainties chosen for scenarios (worlds)
  - Identify other uncertainties that should be considered
  - Details of uncertainties chosen to be discussed at a future meeting/workshop

- Review preliminary scenarios at a high level
  - Discuss relative relationship between scenarios (attributes)
  - Detailed modeling assumptions for the scenarios to be discussed at a future meeting/workshop

- Identify questions/concerns for follow up

Background

IRP Project Scope and the Role of Scenarios

Where We Want to Go

The 2008 Environmental Policy sets objectives in six key areas:

- Climate change mitigation
- Water resource protection and improvement
- Air quality improvement
- Waste minimization
- Sustainable land use
- Natural resource management

How We Will Get There

Plans and programs are/will be developed to meet the objectives

- New Integrated Resource Plan
  - Includes both supply side and demand side alternatives
    - Will identify a diverse portfolio of resources
    - Flexibility for future decisions
  - Closely integrated with the Power Supply Planning process

Developing scenarios will help achieve these objectives

Environmental Impact of Our Actions

An environmental review of the plans and programs will be performed

Role of Scenarios:

Develop scenarios to be used in the Integrated Resource Plan. Scenarios will provide a foundation to consider various supply and demand options for future decision making

Scenario Development

- Scenarios allow us to bound, within reasonable ranges, key uncertainties to create a wide range of possible outcomes
- Scenario analysis looks at a set of "plausible futures," most of which can be described in a few words
  - While these futures are plausible, they do not cover the universe of unpredictable possibilities and are not intended to predict the future
- Plans developed in these futures ("worlds") show how near-term and future decisions would differ under these different conditions
  - If these futures occur as envisioned, then these plans would hold up over time
  - Commonality across these scenarios concerning near-term decisions give some comfort that these decisions are less "risky" (i.e., don't depend much on the scenario we find ourselves on)
  - Conversely, major differences in near-term decisions across scenarios may imply some risk of future regret

- Scenario analysis does not model the annual planning process as it would play out over time, especially in how the process would react to sudden path changes
- Optimization models process as if they have perfect foreknowledge of all demands, costs, and conditions, even if path changes are forecasted
- Scenario analysis can show what resources planners might wish were in place when the path changes mid-stream

TVA

Background

Scenario Development Approach

The approach combines prior TVA work, input and direction from TVA, and external research

Active participation from TVA executives and representatives is achieved through weekly committee working sessions and individual meetings

TVA Input
- Scenario Steering Committee
- TVA executives
- Technical experts

Leveraging of prior TVA work and strategic documents helps ensure a more efficient process and alignment with strategic direction

Prior and Ongoing Work
- TVA Strategic Plan
- TVA Environmental Policy
- Energy Vision 2020
- Other internal analyses

Understanding of best practices and lessons learned is gained through industry research

External Research
- Utility IRPs
- Public power company IRPs
- Public testimony to utility commissions
- Other company scenarios
- Industry reports and analysis

→ **Scenarios**

Background

Process and Work Accomplished

Scenario Development Process

1. Document the specific issue or decision
- Document how the scenarios will align with the overall IRP development process

2. Identify key uncertainties to be evaluated
- Consider regulatory, economic/financial, social, technological, and other factors

3. Identify the critical uncertainties
- For each uncertainty, consider the range of variation and the relative impact

4. Determine scenario framework
- Identify the scenarios that logically result from various combinations of the critical uncertainties

5. Develop scenarios around key uncertainties
- For each scenario, create a narrative that can be used for planning

6. Assess implications of scenarios
- Ensure scenarios will be useful in evaluating different business options

Summary of Work Accomplished

- Conducted relevant industry research to guide scenario development (e.g., utility IRPs, public testimony, example scenarios)
- Identified key uncertainties and driving factors that provide the framework for the scenarios
- Developed preliminary scenarios

Application of Industry Benchmarking to TVA's IRP Approach

Topic	Implications	How it is being Used
Summary of other utility IRPs	◆ New generation capacity is predominantly gas and nuclear ◆ Very few coal additions with many more facilities adding emission control equipment or being retired ◆ Renewable energy is being pursued through many channels, including PPAs ◆ Some utilities have established aggressive energy efficiency (EE) and demand side management (DSM) goals	◆ Establish context and capacity strategies of utilities used in comparison
Uncertainties in other utility IRPs	◆ Most common uncertainties are load forecast, greenhouse gas (GHG) regulation, and gas prices ◆ "Emerging" uncertainties include coal plant retirement, plug-in hybrid electric vehicles (PHEVs), and DSM/EE	◆ Utilize uncertainties identified by peers in defining TVA's list of key uncertainties
Scenarios used by other utilities	◆ Definition of "scenario" varies by company – some utilities use "scenario" to describe sensitivity analysis while others use them to bound possible outcomes of uncertainties ◆ Many example scenarios are narrowly defined ◆ Typical considerations: high/low carbon, high/low load growth, and fuel price variability	◆ Integrate with prior TVA approaches and incorporate comparisons into the development of scenario planning process
Common issues in public testimony to utility commissions	◆ Energy efficiency and DSM programs should be an integral part of the discussion around meeting future electricity needs ◆ The public will likely be unreceptive to new coal generation and will expect plants to manage emissions ◆ There will be a demand for renewable energy ◆ The economic downturn will likely result in significant questioning of load forecasts	◆ Discuss recurring themes in public testimony to identify other areas that may require consideration

Background

Key Uncertainties Used in Scenario Development

Initial List of Uncertainties
Total load
Change in load shape
Demand side management penetration
Energy efficiency penetration
Technology improvement (e.g., PHEV)
Greenhouse gas regulation
Cost of emissions allowances
Coal ash regulation
Hydrothermal effects (weather)
Judicial mandates
Environmental legislation
Public sentiment for "go green"
Renewable requirements
Cost of capital
Construction cost
Natural gas price
Coal price
Wholesale electricity price
Natural gas infrastructure (pipeline)
Oil price
Cost of purchased power
Availability of purchased power
Price hedging program
Nuclear build out viability
Nuclear legislation
Transmission capability / limitations
Cost/time of transmission expansion
Generating unit availability
Hydro unit availability
Catastrophic event
Retirement of existing assets

- Uncertainties are factors that may impact the cost or performance of TVA's energy resources. They are used to describe the scenarios
- The Steering Committee identified a list of key (i.e., most important) uncertainties, which were pared down from an initial list
- This list of key uncertainties is aligned with those identified in other utility IRPs

Key Uncertainty	Description
Greenhouse gas (GHG) requirements	• Reflects level of emission reductions (CO_2 and other GHG) mandated by federal legislation plus the cost of carbon allowances
Total load	• Reflects variance of actual load to what is forecast • Accounts for impacts of DSM/EE penetration
Change in load shape	Includes effects of factors such as: • Time-of-use rates • PHEV (transportation) • Distributed generation • Economics changing customer base • Energy storage • Energy efficiency • Smart grid / demand response
Commodity prices	Includes natural gas, coal, oil, uranium, and spot price of electricity
Renewable electricity standards (RES)	• Reflects mandates for minimum generation from renewables and the viability of renewable generation sources
Environmental outlook	Includes: • Air emissions (exclusive of GHG) • Water • Land • Waste
Capital expansion viability	For nuclear, fossil, other generation, and transmission, includes risks associated with: • Licensing • Permitting • Project schedule
Financing	Financial cost (interest rate) of securing capital
Construction cost escalation	Includes the following for nuclear, fossil, and other generation: • Commodity cost escalation • Labor and equipment cost escalation
Contract purchase power cost	• Reflects demand cost, availability of power and transmission constraints

Key Uncertainties Used in Scenario Development (Cont'd)

- Questions on key uncertainties?

Overall Assumptions

Assumptions Applied in Scenario Development

- Climate change uncertainty is based upon stringency of requirements, timeline required for compliance, and cost of CO_2 allowances
- Momentum behind the Clean Air Act will likely lead to additional requirements (e.g., Hazardous Air Pollutants Maximum Achievable Compliance Technology – HAPs MACT)
- Command and control requirements for HAPs MACT will drive unit by unit compliance and reduce the value of any cap and trade programs (for SO_2 and NOx)
- Renewable Electricity Standards (RES) will follow greenhouse gas requirements at the federal level
- The spot price of electricity will follow the price of natural gas
- Total load is primarily driven by economic conditions but will also affected by energy efficiency, demand response, and other factors
- Schedule risk is related to demand and uncertainty of permitting and licensing of generation and transmission projects
- Economic conditions and associated inflationary pressures are the primary drivers for financing costs
- Construction costs are driven by demand and availability of labor, equipment, design, and raw materials. Economic conditions are the primary driver, but the legislative / regulatory environment can apply additional pressure by introducing uncertainty related to potential schedule impacts
- Cost and availability of contract power purchases are primarily driven by economic conditions (i.e., load growth)
- No fundamental changes to TVA's business structure occur

Preliminary Scenarios

Considerations for Scenario Development

- Include key uncertainties (e.g., greenhouse gas emission requirements, changes in load) that reflect TVA business requirements and industry context
- Assess how these uncertainties may be affected by:
  - Economic conditions
  - Legislative and regulatory mandates
  - Significant technology advancements
  - Societal and customer concerns
- Refine scenarios so that they:
  - Are distinct and reflect plausible, meaningful risks (e.g., uncertainties related to cost, regulation, environment) to TVA
  - "Stress" resource selection to provide a foundation for analyzing the combination of various supply and demand options (capacity plans)
  - Reflect key stakeholder interests, to the extent possible

Results: Developed five preliminary scenarios that reflect the considerations outlined above

- 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 Narratives

Scenario #1 – Economy Recovers Dramatically

- This scenario is characterized by a robust economy that recovers at a rate stronger than expected. Public and government focus turns to maintaining low unemployment and the strength of global financial markets
- A strong economy drives very high demand for electricity. Industrial sectors increase production of manufactured goods, and residential growth resumes as the housing market recovers. In addition, the high load growth creates more opportunities for customer generating asset ownership or enables the emergence of qualified facilities for power production
- A federal climate change policy for CO_2 is established. Beginning in 2014, a cap and trade program is implemented that includes the allocation of 75% of CO_2 allowances, with full auction by 2040. CO_2 allowance prices are about $25 per ton in 2014 and rise to about $60 per ton by 2030. New coal generation must be carbon capture-ready and retrofitted with CCS by 2025. A federal Renewable Electricity Standard (RES) of 3% by 2012 and 15% by 2020 is established
- Environmental mandates related to the Clean Air Interstate Rule (CAIR) and Clean Air Mercury Rule (CAMR) include Selective Catalytic Reduction (SCR) systems required on all operating units by 2020 (to control nitrogen oxide emissions), Flue Gas Desulfurization (FGD) systems required on all operating units by 2018 (to control sulfur dioxide emissions), and Hazardous Air Pollutants Maximum Achievable Control Technology (HAPs MACT) compliance required by 2015 (to control mercury emissions)
- Economic and load growth drive demand and higher prices for conventional fuels and electricity, which are offset some by productivity gains. Production levels of unconventional gas wells enable supply to be more responsive to demand increases, limiting any sustained price run-ups. The increased supply of domestic natural gas moderates prices for gas and electricity, despite high demand
- Moderate electricity prices without significant legislative or regulatory mandates related to conservation provide little incentive for customers to reduce demand during peak times. Penetration of energy efficiency and demand-side management programs is modest
- Demand for new generation is high due to economic and load growth. Construction costs escalate at a high rate because of demand (and higher prices) for raw materials, equipment, and labor. The regulatory environment is favorable to new generation and transmission, but schedule risk arises from slower processing times for licensing and permitting with the increased demand (e.g., for transmission interconnection queuing). The economic growth applies inflationary pressures on interest rates

Scenario Narratives (Cont'd)

Scenario #2 – Environmental Focus is a National Priority

- This scenario is centered on a significant increase in the cost of CO_2 allowances ($90-100 per ton by 2030). Mitigating climate change effects becomes a national priority. Environmentally-focused legislative and regulatory activity is supported by society's desire for clean air and water. Carbon emissions from existing and new coal generation are severely limited
- The economy is strong enough to absorb the impact of increased energy costs and enables speedy enactment of climate change legislation. The economy drives moderate load growth, but load is dampened by customer response to higher energy prices and a federal mandate to reduce energy demand growth 15% from projected levels by 2020
- A federal climate change policy for CO_2 is established. Beginning in 2012, a cap and trade program is implemented that includes the allocation of 75% of CO_2 allowances, with full auction by 2040. CO_2 allowance prices are about $30 per ton in 2012 and rise to about $90-100 per ton by 2030. No safety valve or terms exist under which caps would be suspended or loosened. Carbon reductions are accomplished by the electric utility sector with few offsets from other sources. Additional price pressure is applied as carbon capture technology does become not viable on a sufficient scale
- Environmental mandates related to the CAIR and CAMR include SCR systems required on all operating units by 2020 (to control nitrogen oxide emissions), FGD systems required on all operating units by 2018 (to control sulfur dioxide emissions), and HAPs MACT compliance required by 2015. There is some consideration for accelerating the timelines for these requirements. Additional controls for water and waste are required
- The price of natural gas climbs as a result of economic growth and increased demand as generators move away from coal. High gas prices also drive up the price of electricity, while decreasing its availability
- Congress establishes a federal RES of 5% by 2012 and 30% by 2020. Energy sources counted as renewable include wind, solar, biomass, landfill gas, and incremental hydro (developed after 2001)
- Industry focus turns to nuclear, renewables, conservation, and gas to meet energy needs. A high-degree of regulatory scrutiny and a long queue for approval create significant schedule risk for non-renewable projects. The potential for schedule delays for nuclear projects is high due to the many construction and operating licenses submittals to the Nuclear Regulatory Commission (NRC). The Federal Regulatory Energy Commission (FERC) implements a streamlined national planning and siting process for renewable energy and related transmission projects that mitigates some of the schedule risk. Construction costs escalate at a high rate as demand for raw materials, equipment, and labor climbs. Escalation is compounded by the high volume of projects related to renewable, nuclear, and environmental controls

Scenario Narratives (Cont'd)

Scenario #3 – Prolonged Economic Malaise

- This scenario is characterized by a prolonged, stagnant economy. Economic recovery is a national priority and is integral to policy-making for legislators and regulators
- The weak economy continues to erode demand for electricity. Load growth is flat or very slight. The industrial sector reduces production, and manufacturing facility closures are common as demand for goods remains low. Residential load growth is also flat as new construction is limited in a languishing home market
- Due to concerns of adding further pressure to the economy, Congress does not enact legislation for a cap and trade program for CO_2 or a federal renewable electricity standard
- There are no additional requirements related to the CAIR or CAMR
- A stagnant economy and low demand create downward pressure on commodity prices. Low demand for energy in the U.S. keeps natural gas prices low, and low global demand results in a significant increase in U.S. imports of liquefied natural gas (LNG)
- With load growth that continues to be flat or very slight, the industry sees little economic incentive to invest in technologies or programs that promote energy efficiency. Low electricity prices without significant legislative or regulatory mandates related to conservation provide little incentive for customers to invest in efforts to reduce demand during peak times. Penetration of energy efficiency and demand-side programs is modest
- Demand for new generation is low in this scenario. The lack of load growth leads stakeholders to question the need for additional generation. As a result, some utilities and power providers defer construction of larger generation projects. Construction cost escalation is low because of decreased demand for raw materials, equipment, and labor

Scenario Narratives (Cont'd)

Scenario #4 – Game-Changing Technology

- This scenario is characterized by a legislative / regulatory environment and economic growth that provide a strong incentive for the industry to reduce energy consumption, develop distributed generation, or improve generation/transmission efficiency. This incentive leads to one or more significant technology advancements. These game-changing technologies make it easier to produce and transmit power. Such advancements enable higher availability, make compliance easier, and result in less cost pressure on the system
- The strong economy drives high demand for electricity. As a result, energy companies experience high load growth, which is expected to continue. To meet this future growth, utilities and power providers begin developing generation units
- Industry concerns over climate change have led to a federal policy that limits carbon emissions. A federal climate change policy for CO_2 is established. Beginning in 2014, a cap and trade program is implemented that includes the allocation of 75% of CO_2 allowances, with full auction by 2040. CO_2 allowance prices are about $20 per ton in 2014 and rise to about $50 per ton by 2030. A federal Renewable Electricity Standard (RES) of 3% by 2012 and 15% by 2020 is established
- Environmental mandates related to the CAIR and CAMR include SCR systems required on all operating units by 2020 (to control nitrogen oxide emissions), FGD systems required on all operating units by 2018 (to control sulfur dioxide emissions), and HAPs MACT compliance required by 2015
- The high demand for energy drives high prices for natural gas and for carbon allowances. Electricity prices are high
- High price levels and concerns about the environment result in efforts to reduce energy consumption. In a strong economy, there is sufficient funding to develop technologies that increase energy efficiency and enable more distributed generation. A major (game-changing) advancement in one or more of these technologies eventually leads to one or more of the following:
  - Substantial and sustained decrease of total load (e.g., energy efficient buildings, lighting, and appliances, Smart grid)
  - Substantial and sustained decrease of load served by large centralized baseload generation (e.g., distributed generation, Smart grid, low cost photovoltaic, small nuclear generating units)
  - Decrease in peak demand (e.g., energy storage, demand response)
  - Development of commercially viable CCS
  - Improvement of transmission capabilities (e.g., superconductivity)

  The decrease in total load and/or load served, after a period of strong growth, leads the industry to question the need for baseload generation assets, even those that are in an advanced development or construction phase
- Demand response programs (e.g., time-of-use rates, load control) have high penetration due to initially higher electricity prices and drive a shift of energy consumption from peak to off-peak hours

Scenario Narratives (Cont'd)

Scenario #5 – Energy Independence

- In this scenario, there is political and public consensus that the U.S. must reduce its dependence on non-North American fuel sources
- Federal and state government entities establish explicit policies to limit imports of fuel from non-North American countries. A federal climate change policy for CO_2 is established. Beginning in 2014, a cap and trade program is implemented that includes the allocation of 75% of CO_2 allowances, with full auction by 2040. CO_2 allowance prices are about $20 per ton in 2014 and rise to about $50 per ton by 2030. The cap and trade program incorporates a safety valve to suspend or loosen caps in the event of economic hardship. Domestic coal is viewed as an enabler to support energy independence. As a result, new coal generation is viewed more favorably in the utility industry, provided new generating units are CCS capable
- Environmental mandates related to the CAIR and CAMR include SCR systems required on all operating units by 2020 (to control nitrogen oxide emissions), FGD systems required on all operating units by 2018 (to control sulfur dioxide emissions), and HAPs MACT compliance required by 2015
- In a moderately strong economy, utilities/local distribution companies are experiencing moderate load growths. The demand for energy is high enough to support relatively high energy prices and also create interest in renewable sources
- The energy independence movement constrains the supply of natural gas. Sources are primarily limited to Alaska, Canada, and the Gulf of Mexico, as LNG imports are severely restricted. Demand for natural gas grows. The transportation sector shifts much of its energy use from oil to natural gas. To help reduce the nation's dependence on foreign oil, the federal government establishes policies and incentives to promote the use of natural gas vehicles (NGVs). There is continued demand for natural gas by power generators and by direct users in residential, commercial, and industrial markets. This combination of decreased supply and increased demand drives up gas prices
- An additional shift in the transportation sector is the emergence of plug-in electric vehicles (PHEVs), which are viewed as another way to reduce U.S. dependence on foreign oil
- Restrictions on non-North American fuel imports also include coal. The decreased coal supply, along with continued demand, result in moderate increases in coal prices. Electricity prices increase in correlation with natural gas and coal
- Higher energy costs, public support, and a legislative push for independence increase interest in renewable energy sources. An RES of 3% by 2012 and 20% by 2020 is established. FERC implements a streamlined national planning and siting process to facilitate development of transmission from renewable generating sources
- Energy efficiency moves to the forefront. Business and individual consumers look for ways to reduce their energy use and support the nation's objective of achieving energy independence. Regulating authorities and energy companies establish programs and ratemaking mechanisms designed to reduce energy consumption, such as time of use rates and efficiency standards

Scenario Narratives (Cont'd)

- Questions on scenario narratives?

Preliminary Scenarios
Scenario Framework

Scenarios are outlined in the table below, along with the relative responses of key uncertainties.

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	TVA's Reference Case[1]
Greenhouse gas requirements	CO_2 price \$25/ton in 2014 and ~\$60/ton by 2030. 75% allowance allocation, 0% by 2040	CO_2 price \$30/ton in 2012 and ~\$90+/ton by 2030. 75% allowance allocation, 0% by 2040	No cap and trade for CO_2	CO_2 price \$20/ton in 2014 and ~\$50/ton by 2030. 75% allowance allocation, 0% by 2040	CO_2 price \$20/ton in 2014 and ~\$50/ton by 2030. 75% allowance allocation, 0% by 2040	CO_2 price \$10/ton in 2015 and \$60/ton by 2030. 80% allowance allocation
Environmental outlook	SCR all units by 2020 FGD all units by 2018 HAPs MACT by 2015	SCR all units by 2020 FGD all units by 2018 HAPs MACT by 2015 Additional controls for water/waste	No additional requirements	SCR all units by 2020 FGD all units by 2018 HAPs MACT by 2015	SCR all units by 2020 FGD all units by 2018 HAPs MACT by 2015	SO_2 – CAIR Cap & Trade NO_X – CAIR & 20% reduction by 2015 Hg MACT by 2015
Renewable Electricity Standards (RES)	3% by 2012 15% by 2020 (adjusted total retail sales)	5% by 2012 30% by 2020 (adjusted total retail sales)	No federal RES	3% by 2012 15% by 2020 (adjusted total retail sales)	3% by 2012 20% by 2020 (adjusted total retail sales)	2% by 2013 11% by 2022
Commodity prices	Same as Reference Case	Gas higher than Reference Case; coal same as Refer. Case	Gas and coal lower than Reference Case	Gas, coal higher than Reference Case; lower after load decrease	Gas and coal higher than Reference Case	Gas - \$6-8 / MMBTU Coal \$40 / ton [2]
Total load	Highest growth	Moderate growth	Low or no growth	High growth and sudden decrease	Moderate growth	Moderate growth
Change in load shape	Current shape	Shift from peak	Current shape	Shift from peak	Shift from peak	Current shape
Capital expansion viability	Moderate schedule risk	High schedule risk	Low schedule risk	Moderate schedule risk	Moderate schedule risk	Moderate schedule risk
Financing	Much higher than Reference Case	Higher than Reference Case	In line with Reference Case	Much higher than Reference Case	Higher than Reference Case	Based on current borrowing rate
Construction cost escalation	Higher than Reference Case	Much higher than Reference Case	Lower than Reference Case	Higher than Reference Case	Same as Reference Case	Moderate escalation
Contract Purchase Power Cost	Higher cost and lower availability than Reference Case	Cost much higher and availability much lower than Reference Case	Cost and availability in line with Reference Case	High cost / low avail. then moderate after load decrease	Cost much higher and availability much lower than Reference Case	Moderate cost and availability

1. Reflects the July 2009 plan – Base Case will be created to reflect new Regulatory Outlook, updated commodity prices, and updated capital costs
2. Reflects average prices through 2030, not inflation adjusted. Coal price does not include delivery

Wrap-Up Discussion

- Address questions about scenario development
- Identify detailed topics/concerns for follow-up