# 2015 Integrated Resource Plan

IRPWG Meeting

Session 7

May 29-30, 2014

REDACTED VERSION

# IRPWG Meeting – May 29th Agenda

| | **Day 1** | |
|---|---|---|
| 8:30 | **Welcome** | Randy McAdams |
| 8:45 | **Description of Selected Scenarios**<br>**Orientation About Today's Session** | Gary Brinkworth |
| | **Assumptions and Projections of Critical Uncertainties:** | |
| 9:15 | Economic and Financial Assumptions | Nathan Donahoe |
| 9:45 | Environmental Regulations and CO2 Prices | John Myers |
| 10:15 | *Break* | |
| 10:30 | EE Adoption | James Linder |
| 11:00 | DG Penetration | Neil Placer |
| 11:30 | *Lunch* | |
| 12:15 | Demand and Energy Forecasts | Nathan Donahoe |
| 12:45 | Coal and Gas Price Forecasts | Connie Trecazzi |
| 1:15 | Electricity Price Forecasts | Patrick Obrien |
| 1:45 | *Break* | |
| 2:00 | Additional Variables Stochastic Ranges | Scott Jones |
| 2:45 | Integrated View of Uncertainties by Scenario Ranges | Gary Brinkworth |
| 3:15 | **Group Feedback on Scenario Forecasts** | Randy McAdams |
| 3:45 | **Overview of Day 2** | Randy McAdams |
| 4:00 | *Adjourn* | |

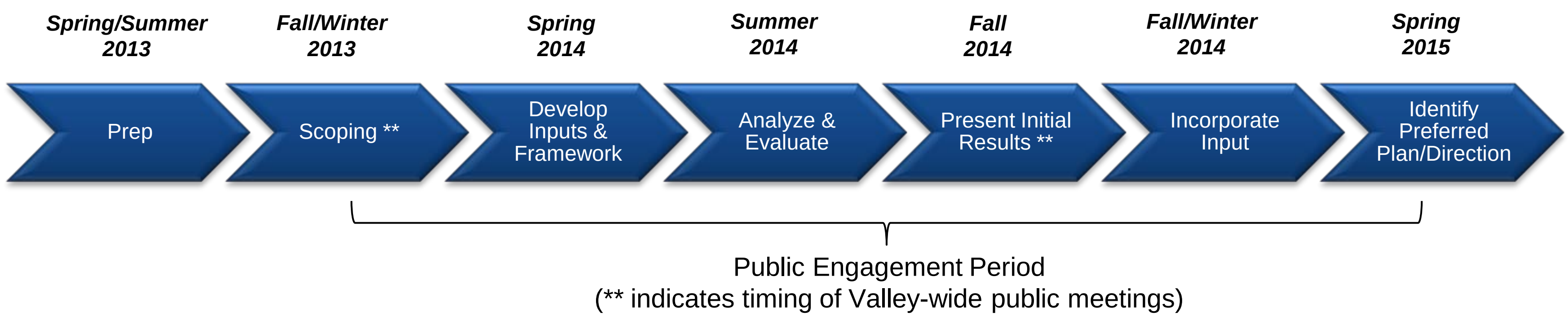
# IRPWG Meeting – May 30th Agenda

| | Day 2 | |
|---|---|---|
| 8:30 | **Recap from Previous Day/Overview of Day 2** | Randy McAdams |
| 8:45 | **Overview of Assumptions on the Planning Strategies** | Gary Brinkworth |
| | **Resources and Planning Assumptions** | |
| 9:15 | Overview of Capacity Planning | Tom Rice |
| 9:45 | Generation Resource Characteristics & Costs | Candy Cooper |
| 10:30 | *Break* | |
| 10:45 | Generation Resources (con't) | |
| 11:30 | Wind / Solar Resource Characteristics & Modeling | Scott Jones or Tom Rice |
| 12:15 | *Lunch* | |
| 1:00 | EE Modeling Update | Ed Colston / Tom Rice |
| 1:30 | Group Feedback – Resources and Planning Assumptions | Randy McAdams |
| 2:00 | **Wrap-up and Next Steps** | Gary Brinkworth |
| | *Adjourn* | |

*Welcome*

# 2015 IRP Schedule: Major Project Phases and Milestones

***The 2015 IRP  is intended to ensure transparency and enable stakeholder involvement.***




**Key tasks/milestones in this study timeline include:**

- Establish stakeholder group and hold first meeting (Nov 2013)
- Complete first modeling runs (June 2014)
- Publish draft Supplemental Environmental Impact Statement (SEIS) and IRP (Nov 2014)
- Complete public meetings (Jan 2015)
- Final publication of SEIS and IRP and Board approval (exp. Spring 2015)

# May 29th-30th IRPWG Meeting Objectives

**March 2014**
- Short list of strategies
- Review Resource options
- Study methods
- Modeling constraints

TVA Board Members Briefing

**April 2014**
- Review modeling approach
- Explain analysis methodology
- Discuss scorecard metrics
- Review current Gen. plan and proposed strategies

RERC Briefing

TVA Board Members Briefing

**May 2014**
- Short list technology options
- Review of model assumptions and forecasts

**June 2014**
- Follow-up if needed from May assumptions review
- Final design of scorecard
- Modeling runs begin later this month

During this two day meeting we aim to accomplish the following objectives:

- Explain the main drivers for critical uncertainties
- Present the assumptions and projections for critical uncertainties for the selected scenarios
- Justify the robustness provided to the IRP analysis by the range of values in the critical uncertainties
- Review with the group the assumptions behind the planning strategies
- Present the technology options used in the model
- Gather the group’s comments and feedback on the items above

*Description of Selected Scenarios*

# Uncertainties and Scenarios selected for the 2015 IRP

**TVA has selected 9 uncertainties and 5 scenarios grouped around 5 themes**

## ***Selected Uncertainties***

| Uncertainty | Description |
|---|---|
| **TVA Sales** | ◆ The customer energy requirements (GWh) for the TVA service territory including losses; it represents the load to be served by TVA |
| **Natural Gas Prices** | ◆ The price ($/MMBtu) of the commodity including transportation |
| **Wholesale Electricity Prices for TVA** | ◆ The hourly price of energy ($/MWh) at the TVA boundary; used as a proxy for market price of power |
| **Coal Prices** | ◆ The price ($/MMBtu) of the commodity including transportation |
| **Regulations** | ◆ All regulatory and legislative actions, including applicable codes and standards, that impact the operation of electric utilities excluding CO2 regulations |
| **CO2 Regulation/Price** | ◆ The cost of compliance with possible CO2 related regulation and/or the price of cap-and-trade legislation, represented as a $/Ton value |
| **Distributed Generation Penetration** | ◆ National trending of distributed generation resources and potential regional activity by customers or third party developers (not TVA) |
| **Nat'l Energy Efficiency Adoption** | ◆ An estimate of the adoption of energy efficiency measures by customers nationally; a measure of interest/commitment of customers in general to adopt EE initiatives, recognizing the impacts of both technology affordability and electricity price on willingness to adopt efficiency measures |
| **Economic Outlook (National/Regional)** | ◆ All aspects of the regional and national economy including general inflation, financing considerations, population growth, GDP and other factors that drive the overall economy |

## ***Selected Scenarios***

- Current Outlook
- Stagnant Economy
- Growth Economy
- De-Carbonized Future
- Distributed marketplace

*Description of Selected Scenarios*

# The Scenarios Selected Provide a Diversity of Futures

***Scenarios Selected for the 2015 IRP***

| | Scenarios | | | | |
|---|---|---|---|---|---|
| | **Current Outlook** | **Stagnant Economy** | **Growth Economy** | **De-carbonized Future** | **Distributed Marketplace** |
| TVA Sales | | Very Low | High | Low | Low |
| Natural Gas Prices | Same | Low | High | High | Low |
| Wholesale Electricity Prices to TVA | Same | Low | High | High | Low |
| Coal Prices | Same | Low | High | Same | Low |
| Regulations | Same | Low | High | Same | Same |
| CO2 Regulation/Price | Same | Very Low | High | Very High | Same |
| Distributed Generation Penetration | Same | Low | High | High | Very High |
| Nat'l Energy Efficiency Adoption | Same | Low | High | High | Very High |
| Economic Outlook (National/Regional) | Same | Very Low | High | Low | Same |

# *Description of Selected Scenarios*
# Stagnant Economy

***Scenario Narrative***

- Prolonged, stagnant economy results in low to negative growth and delayed expansion of new generation
- Stringent environmental regulations are delayed due to concerns of adding further pressure to the economy
- Cost of capital is decreased, inflation increases

| Uncertainty | Level Of Impact (*) | Rationale |
|---|---|---|
| TVA Sales | Very Low | Very low sales due to stagnant economy |
| Natural Gas Prices | Low | Low natural gas prices due to low demand and less stringent environmental legislation |
| Whole Sale Electricity Prices for TVA | Low | Lower demand creates lower commodity prices |
| Coal Prices | Low | Low coal prices due to low demand and less stringent environmental legislation |
| Regulations | Low | Economic downturn and decreased energy demand lead to less stringent environmental regulations |
| CO2 Regulation/Price | Very Low | Economic downturn and decreased energy demand lead to delay of CO2 legislation beyond the forecast horizon |
| Distributed Generation Penetration | Low | Traditional generation over-capacity decreases the interest of investing in these technologies |
| Nat'l Energy Efficiency Adoption | Low | Energy efficiency is not a priority due to sluggish economy and energy sales |
| Economic Outlook (National/Regional) | Very Low | Stagnant national and regional economy |

(*) Note: Compared to current view of the future

# *Description of Selected Scenarios*
# Growth Economy

***Scenario Narrative***

- Rapid economic growth translates into higher than forecasted energy sales and energy expansion
- Increasingly positive public attitude toward adoption of energy efficiency programs and new technology
- Advances in electric vehicles make it cheaper to buy electric than gas cars
- Tightened environmental legislation with increased focus on cost-efficient energy efficiency choices and pressure for retirement of existing coal assets
- Ambient and water temperatures remain normal. Gas, oil, and coal are more costly due to regulations

| Uncertainty | Level Of Impact (*) | Rationale |
|---|---|---|
| TVA Sales | High | Higher due to overall economic growth; similar to TVA experience in the 1990s |
| Natural Gas Prices | High | Higher due to increased demand and regulations |
| Whole Sale Electricity Prices for TVA | High | Electricity driven by NG prices and higher demand |
| Coal Prices | High | Higher regulations, but they do not overcome coal utilization in coal / gas tradeoff |
| Regulations | High | Prosperity as a regulatory driver… |
| $CO_2$ Regulation/Price | High | Prosperity drives more stringent and earlier $CO_2$ goals |
| Distributed Generation Penetration | High | This scenario focuses in the economic impact and the feedback of higher prices more than adoption of DG |
| Nat'l Energy Efficiency Adoption | High | Higher prices mitigated by greater energy efficiency (prices drive response) |
| Economic Outlook (National/Regional) | High | Overall economic growth is higher on both a TVA level and a National level similar to 1990s |

(*) Note: Compared to current view of the future

# De-carbonized Future

***Scenario Narrative***

- Increasing climate-driven effects create strong federal push to curb GHG emissions: new legislation caps and penalizes $CO_2$ emissions from the utility industry and incentivizes non-emitting technologies
- Compliance with new rules increases energy prices and US based industry becomes less competitive; later in the decade, the US economy begins another downward turn and loads begin to decline
- Fracking regulations never materialize but gas contends with the $CO_2$-adder
- New expansion units are necessary to replace existing $CO_2$-emitting fleet and not to meet load growth

| Uncertainty | Level Of Impact (*) | Rationale |
|---|---|---|
| TVA Sales | Low | CO2 penalties drive industry to non-emitting technologies; raising prices and leading to economic decline later in the decade |
| Natural Gas Prices | High | Demand for gas increases spiking prices |
| Whole Sale Electricity Prices for TVA | High | Rush to switch to lower-emitting/non-emitting technologies results in increase in energy prices |
| Coal Prices | Same | Demand decreases and keeps prices in current forecasted range |
| Regulations | Same | No additional coal requirements/controls |
| CO2 Regulation/Price | Very High | Stringent federal CO2 penalties |
| Distributed Generation Penetration | High | DG resources increase due to higher energy prices and CO2 penalties |
| Nat'l Energy Efficiency Adoption | High | Higher energy prices drive EE |
| Economic Outlook (National/Regional) | Low | Higher energy prices make US less competitive and economy downturns |

(*) Note: Compared to current view of the future

*Description of Selected Scenarios*

# Distributed Marketplace

***Scenario Narrative***

- Customers' awareness of growing competitive energy markets and the rapid advance in energy technologies produce unexpected high penetration rates in distributed generation (DG) and energy efficiency (EE)
- Utilities are no longer the only source of generation and multiple options are available to customers (solar, wind, hydro, Wal-Mart, Distributed Generation, First Solar, Solar City, Google…etc.), causing the load to diminish
- Growing implementation of DG and EE resources by customers lead to a continual decrease in supply-side generation sources and an increased need for transmission infrastructure and utilization planning.

| Uncertainty | Level Of Impact (*) | Rationale |
|---|---|---|
| TVA Sales | Low | End use customers continue to find ways to control their energy demands and look to the utility to fill in the gaps |
| Natural Gas Prices | Low | Reduced energy demand lessens the dependency on CT/CC's |
| Whole Sale Electricity Prices for TVA | Low | Utilities are long on capacity |
| Coal Prices | Low | Nuclear and DG has coal only filling in the gaps when needed |
| Regulations | Same | Codes and standards for EE and renewables drive emissions lower, diminishing the impetus for more regulation |
| CO2 Regulation/Price | Same | CO2 goals are being met with the increased EE and DG |
| Distributed Generation Penetration | Very High | DG becomes an integral part of customers' energy supply |
| Nat'l Energy Efficiency Adoption | Very High | Codes and standards increases the adoption of EE |
| Economic Outlook (National/Regional) | Same | The economy continues to grow but, businesses will continue to work on process efficiencies to gain more market share |

(*) Note: Compared to current view of the future

*Orientation About Today's Session*

# Presentation of the Assumptions for the Scenarios

- Following, during today's session we are going to be presenting the assumptions for the values of the critical uncertainties for each of the selected scenarios
- The flow and purpose of the agenda for the rest of the day is the following:

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These fundamental assumptions (drivers) will impact all the uncertainty forecasts for the scenarios, so we will explore these first

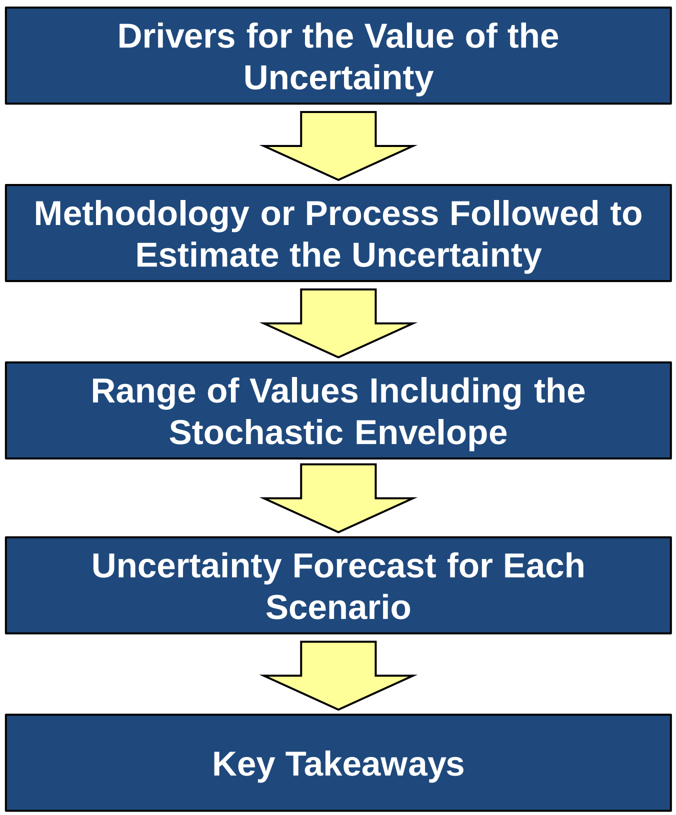
Then the key uncertainties can be presented & compared across all 5 scenarios selected for use in the study

To complete the review, we look at the uncertainty forecasts by scenario for internal consistency and reasonableness

# *Orientation About Today's Session*

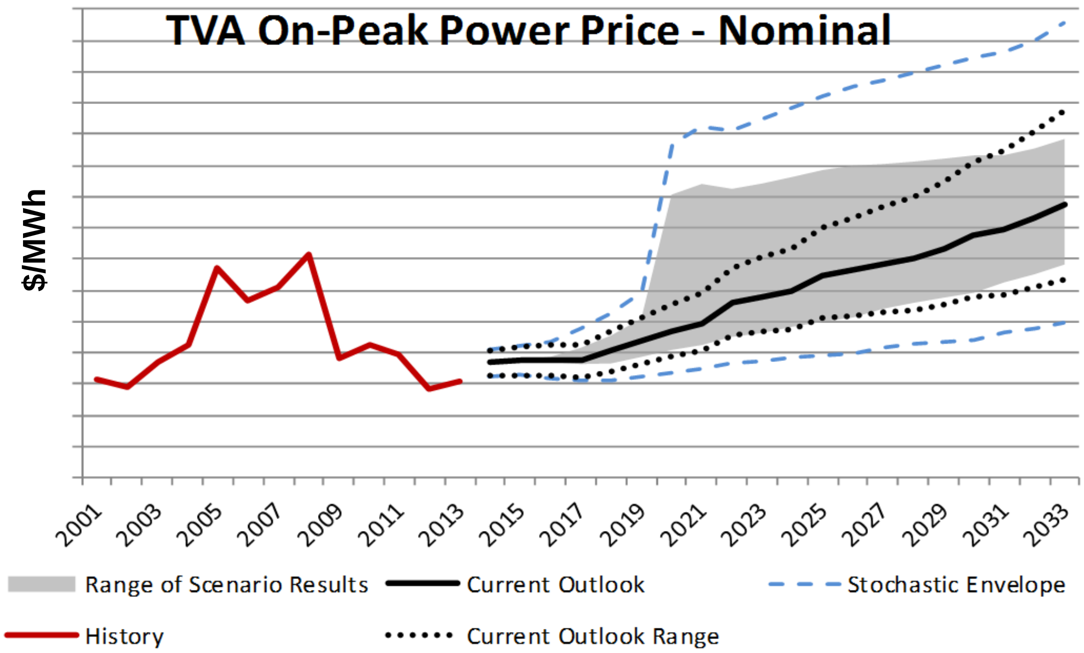
# Presentation of the Assumptions for Uncertainties' Values

- Also during today's session we are going to be presenting the assumptions for the values of the critical uncertainties for each of the selected scenarios
- The flow of the presentation for each of the uncertainties is the following:



# Graphs and Terminology During Today's Session

**Example:**

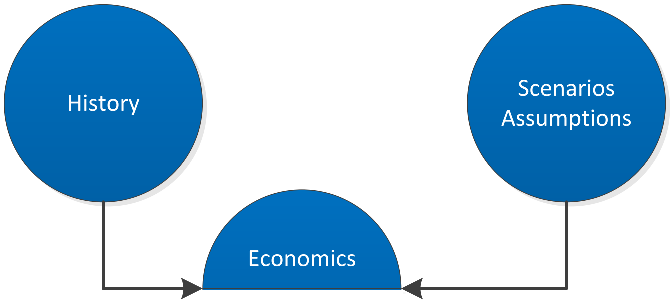



- Cone or Range of Scenario Results: Range in the forecasted values of an uncertainty among the selected scenarios
- Stochastic Envelope: Range of values of an uncertainty in particular scenario during the stochastic analysis
  - Each scenario has an stochastic envelope
  - The graph above shows the envelope around the current outlook (dotted black line) and the upper and lower limits of the envelopes for the most extreme scenarios (dotted blue line)

# Economics Variables: Drivers and Process

- Economic Outlook was defined as a critical uncertainty for the scenario planning
- The Economic Outlook will help quantify the world as defined by the Scenario Assumptions
- This Economic Outlook, both at a national and regional level, can be described by the following variables:
  - **Gross Domestic Product (GDP):** Measures the change in total economic output
  - **Regional NonFarm Employment:** Drives the local economy and customer count growth
  - **Consumer Price Index (CPI):** A measure of how inflation is impacting the consumer
- The Economic Variables impact other critical uncertainties, for example commodity or electricity prices
- For TVA's current outlook, these economic variables were derived from various external sources
- The two primary drivers considered to create the forecasts for the economic variables within each planning scenario are:
  - The underlying scenario assumptions
  - Historical values

***Drivers of the Economic Variables' Forecasts***



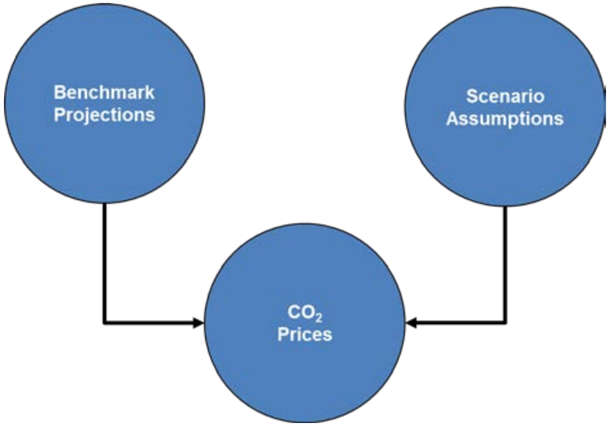
# Economic Variables: Key Takeaways

- Focusing on the real price levels helps draw out the true changes in the underlying item
- Economic assumptions will have varying impacts on the different scenarios depending on how leveraged they are to the macro economic environment
- The Growth Economy and Stagnant Economy create the bounding scenarios for the macro economic environment
- De-carbonized Future is differentiated by a retooling period late in the decade as the economy adapts to the new normal
- The Distributed Marketplace scenario is not assumed to be any different from the Current Outlook

## *Environmental and CO2 Prices Assumptions*

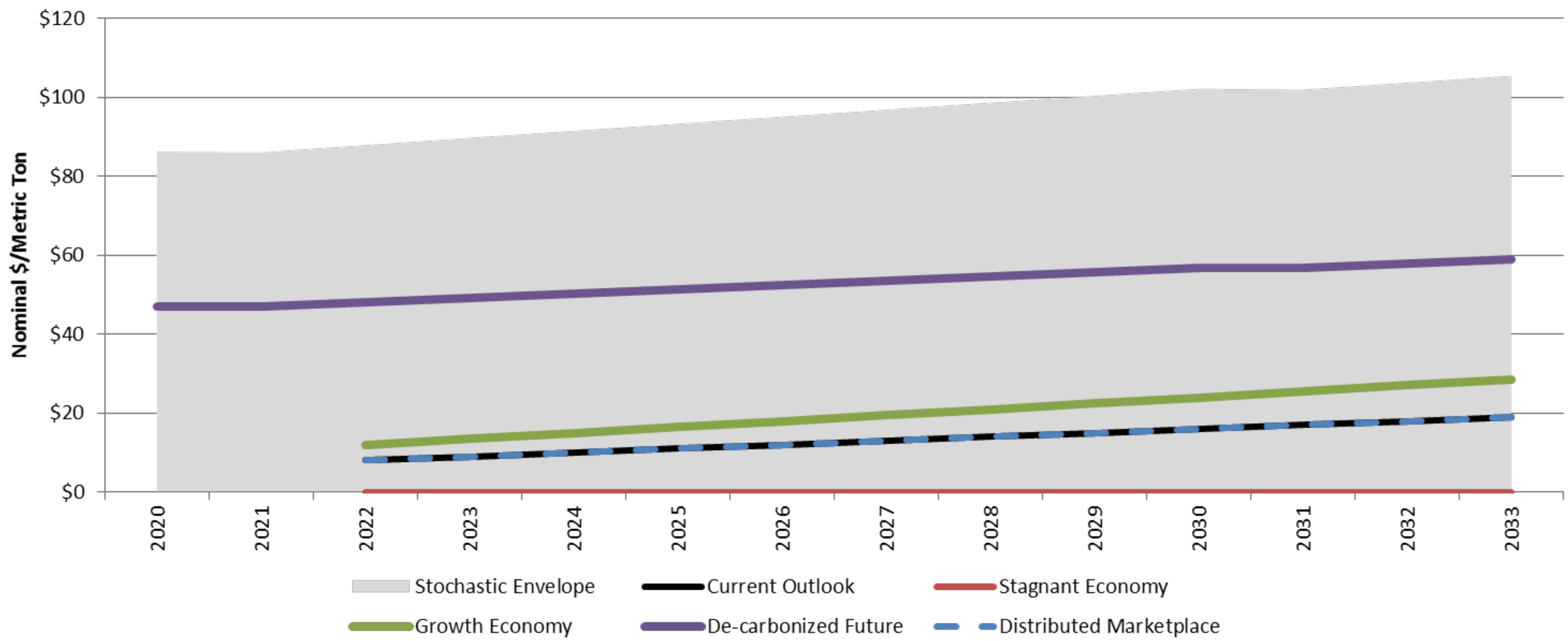
# $CO_2$ Pricing : Drivers and Method

- The main driver behind $CO_2$ prices are environmental regulations
- CO2 prices is a critical uncertainty that will have a significant impact on other critical uncertainties like Electricity Price or DG penetration and it will affect the cost of generation from fossil sources.
- All scenarios call for a more stringent regulatory future with no relaxation of current requirements
- Timing and severity will vary by scenario and therefore $CO_2$ pricing varies greatly
- The two main elements being considered to create the forecasts for the economic variables within each planning scenario are:
  - The underlying scenario assumptions
  - Benchmark projections



# $CO_2$ Pricing Scenarios

***CO2 Pricing Scenarios and Stochastic Envelope***




- The De-carbonized Future $CO_2$ price is set at the United States Government's Social Cost of Carbon (SCC)
- The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO2) emissions, conventionally one metric ton, in a given year
- The SCC is meant to be a comprehensive estimate of climate change damages and includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk

# *Environmental and CO2 Prices Assumptions*

# Upcoming Regulatory Requirements

| Less Stringent | Expected | More Stringent |
|---|---|---|
| **Stagnant Economy** | **Current Outlook**<br>**De-Carbonized Future**<br>**Distributed Marketplace** | **Growth Economy** |
| **Slower implementation and somewhat less restrictive requirements** | **Continued progression of more stringent environmental rules and regulations** | **More stringent and earlier implementation of environmental rules and regulations** |

**Coal Ash**: Closure for existing coal ash impoundments

**Effluent Limitation Guidelines**: Wastewater treatment system upgrades and dry fly ash handling

**316(b)** : Regulation of cooling water intakes
* applies to nuclear as well as coal and combined cycle gas

**Ozone NAAQS**

**PM2.5 NAAQS**

**Fracking Regulations & Taxes**

| Color | Category |
|---|---|
| Red | Air |
| Yellow | Waste |
| Green | Fracking |
| Blue | Water |
| Purple | Renewables |

# $CO_2$ Pricing: Key Takeaways

- The scenarios cover a wide range of CO2 prices.
- All scenarios forecast a more stringent regulatory future.

## *EE Adoption Assumptions*

# EE Adoption: Drivers and Method

- Data available on national and regional EE adoption rates are scarce and hard to benchmark due to the regulatory and policy differences
- EEIX members help bridge the gap in data by drawing on personal and professional experience
- The data available point to two main drivers behind EE adoption rate:
  - Electricity Rates
  - Codes and standards
- Studies reviewed by TVA and the input received EEIX members help form EE adoption rates

***EEIX Members***

*Local Power Companies*

*State Energy Offices*

*Non-government Organizations*

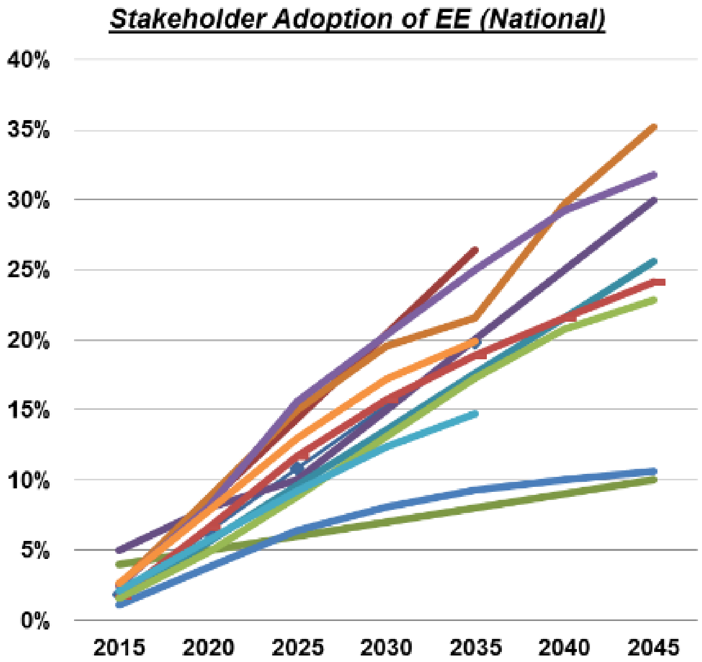
***EEIX Member Questions:***

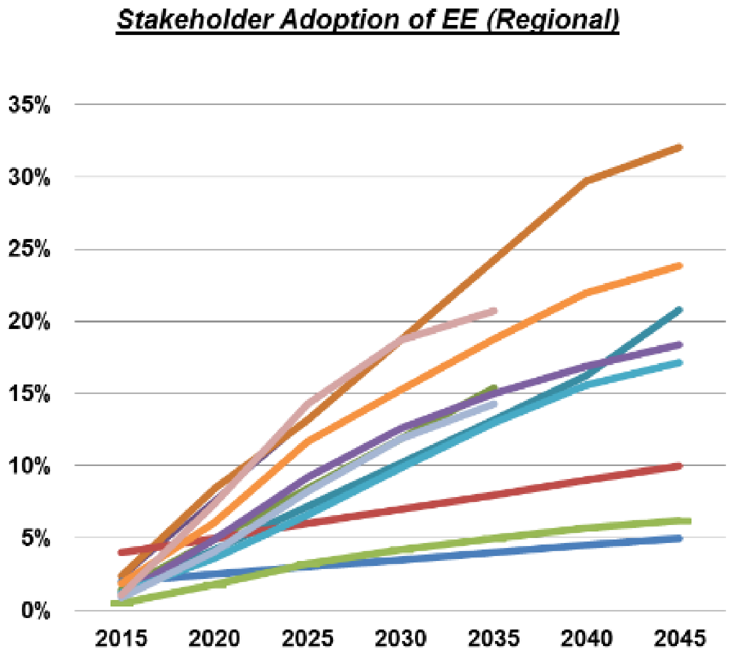
- **What are the National and Regional Drivers for EE adoption?**
- **Using 2013 as a base year: What is the cumulative percentage of increased energy efficiency, excluding changes to mandated codes and standards, (i.e., naturally occurring, technology improvements, and etc.), you estimate from 2015 to 2045 for National and Regional EE Adoption?**

# Input Received From EEIX Members

## ***Key Drivers for EE Adoption***

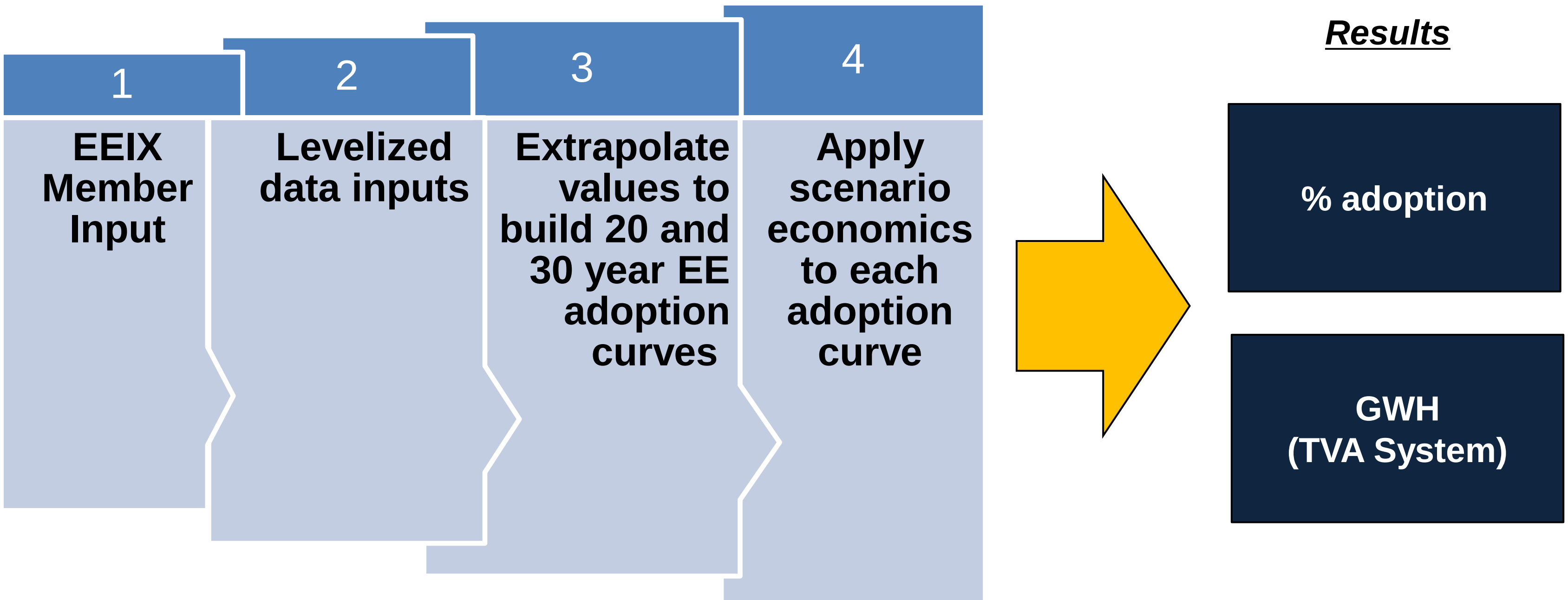
- Rising energy cost and volatility in NG prices
- Increased environmental regulations
- States adopting energy efficiency standards
- Average income increases vs. inflation
- Local government standards
- Demand for energy efficient equipment
- Robust trade ally infrastructure
- Changing public perception



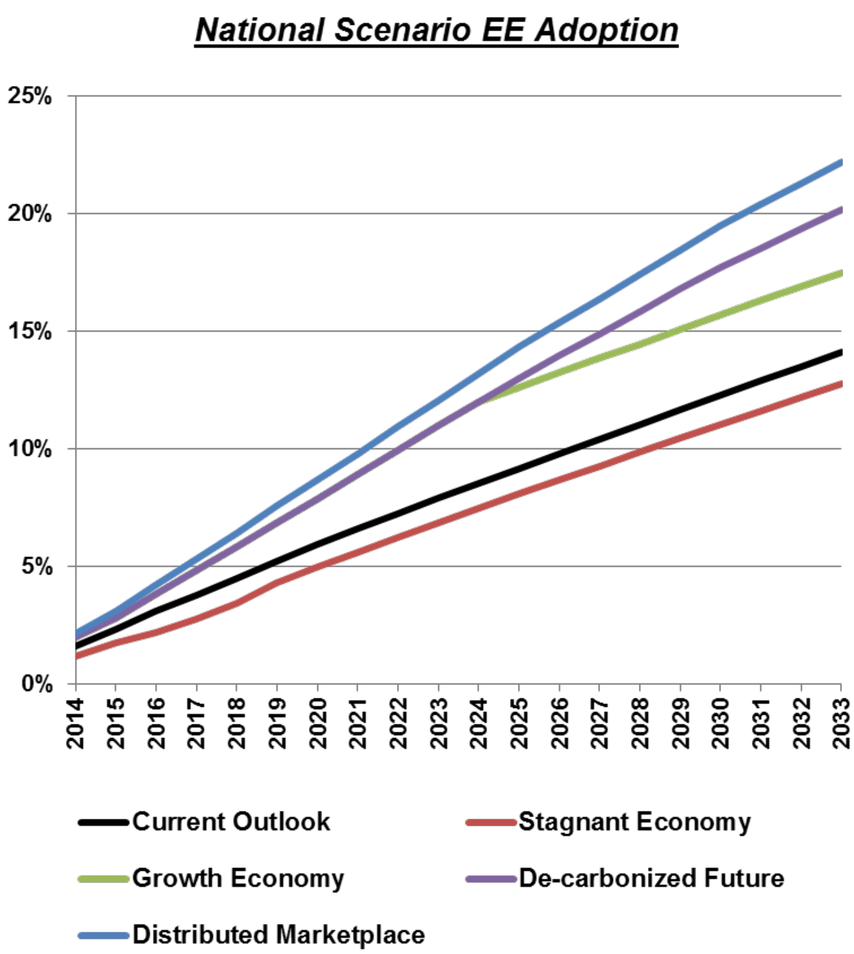

**The range of inputs are consistent for national and regional**

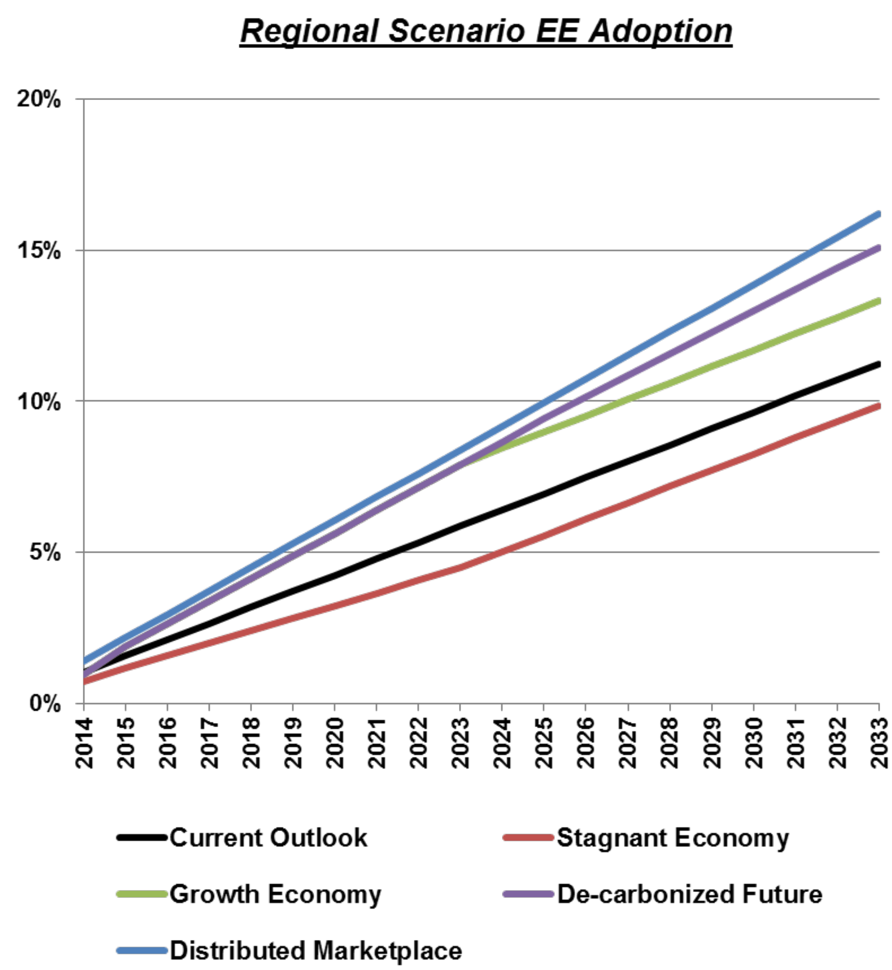
# Studies Reviewed by TVA and the Input Received EEIX Members Helped Define EE Adoption Rates




- Current Outlook – Baseline
- Stagnant Economy – Low
- Growth Economy – High
- De-carbonized Future – High
- Distributed Market Place – Very High

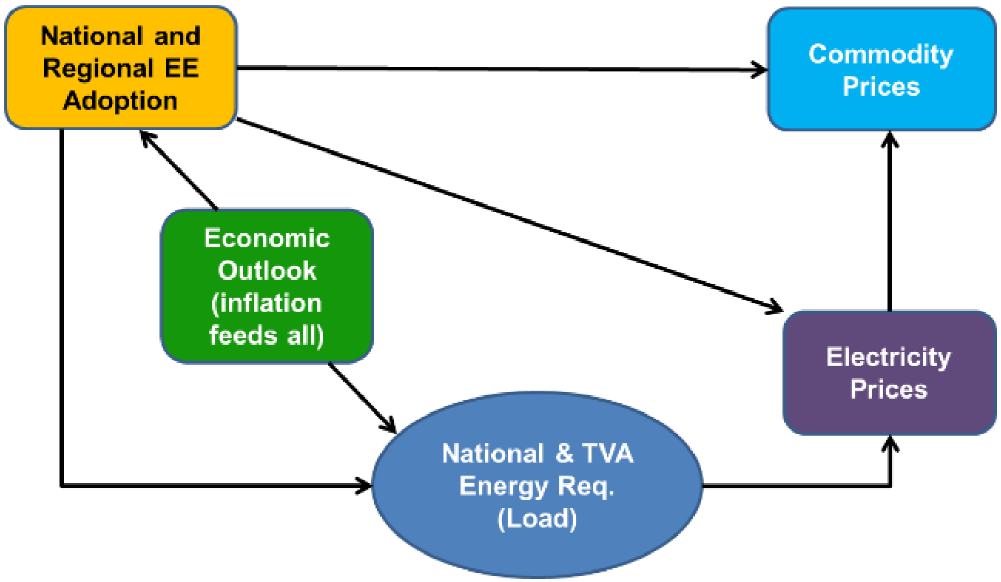
# Scenario EE Adoption Level



# EE Adoption: Key Takeaways

- In resource planning, key variables have dependencies:




- Economic Outlook changes by scenario
- In addition to implications for energy efficiency adoption within the Tennessee Valley, national energy efficiency adoption can have significant impact on commodity (i.e., coal, gas, electricity) prices
- As shown above, the uncertainties EE Adoption level, both national and regional, is used to estimate de loads fro the different scenarios
- This is different than the EE that result from TVA programs which are modeled in the strategies

# *Distributed Generation Penetration Assumptions*

# *Distributed Generation Penetration Assumptions*
# Segments in Distributed Generation

- **Distributed Generation (DG):** In the context of IRP scenarios (i.e., futures that are outside of TVA's control), DG is defined as demand-side generation that is customer-driven (outside of utility involvement) and results in a reduction to utility loads
- The drivers behind the growth of Distributed Generation for the Industrial and Residential/Commercial customers segments are different, therefore we have used different assumptions and methodologies to forecast their penetration across the various scenarios

| | Scenarios | | | | |
|---|---|---|---|---|---|
| | **Current Outlook** | **Stagnant Economy** | **Growth Economy** | **De-carbonized Future** | **Distributed Marketplace** |
| TVA Sales | | Very Low | High | Low | Low |
| Natural Gas Prices | Same | Low | High | High | Low |
| Wholesale Electricity Prices to TVA | Same | Low | High | High | Low |
| Coal Prices | Same | Low | High | Same | Low |
| Regulations | Same | Low | High | Same | Same |
| CO2 Regulation/Price | Same | Very Low | High | Very High | Same |
| Distributed Generation Penetration | Same | Low | High | High | Very High |
| Nat'l Energy Efficiency Adoption | Same | Low | High | High | Very High |
| Economic Outlook (National/Regional) | Same | Very Low | High | Low | Same |

| | Current Outlook | Stagnant Economy | Growth Economy | De-carbonized Future | Distributed Marketplace |
|---|---|---|---|---|---|
| **Industrial** | | | ✓ | | ✓ |
| **Residential / Commercial** | | ✓ | ✓ | ✓ | ✓ |

*Distributed Generation Penetration Assumptions*

# Industrial DG Penetration: Drivers and Method

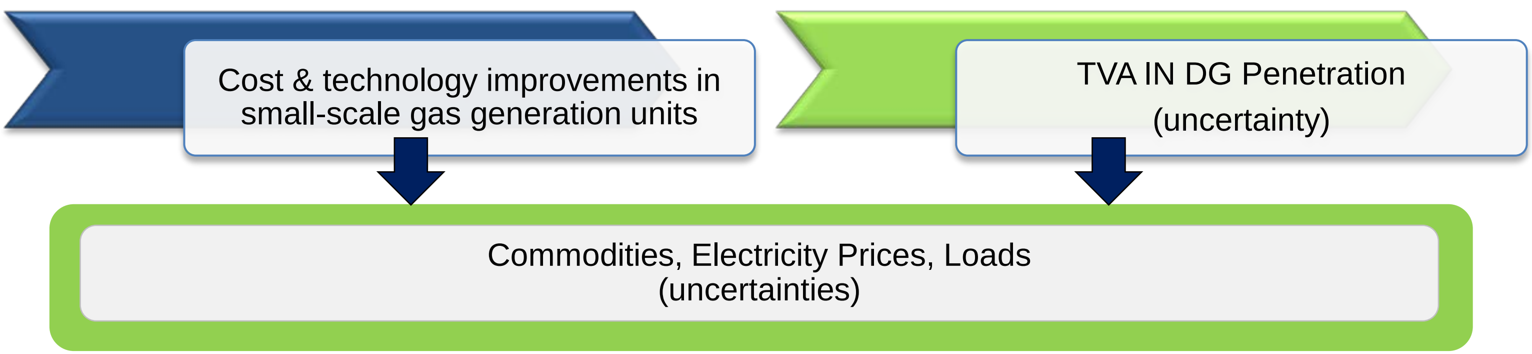
**Definitions:**

- **Industrial Distributed Generation (IN DG) Penetration:** % of TVA's industrial consumption load that will be self-generated by the customer; the drivers and assumptions are:

**Industrial**

**Drivers and Assumptions for Determining IN DG Penetration:**

- All industrial self-generation is assumed to be gas based
- Two Scenarios Impacted:
  - **Distributed Marketplace**: 50% of industrial customer's load lost to self-generation over study period representing 10% of total TVA load)
  - **Growth Economy**: 10% of the load of industrial customers with high steam needs lost to self-generation over study period (0.6% of total TVA load)
- The graphic below shoes the sequential flow of drivers followed to determine the Industrial DG penetration levels *(uncertainties – green, supporting data – blue)*:



*Distributed Generation Penetration Assumptions*

# Residential/Commercial DG Penetration: Drivers and Method

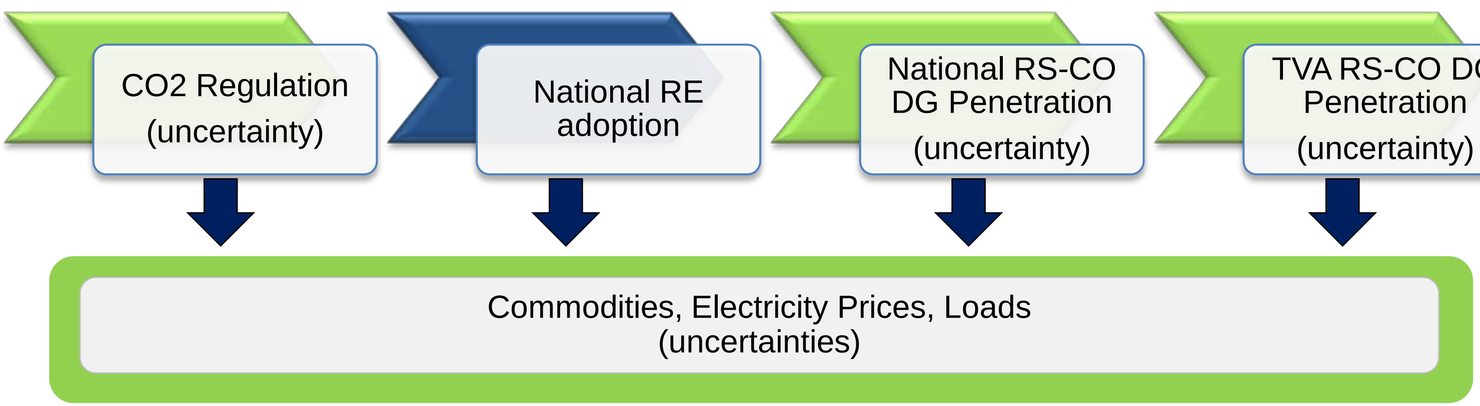
**Definitions:**

- **Renewable Energy (RE) :** Renewable energy encompasses all traditional renewable resource types (solar, wind, hydro, biomass, geothermal)
- **Residential and Commercial Distributed Generation (RS-CO DG) Penetration:** % of TVA's residential and commercial customer's energy consumption that is self-generated

**Residential / Commercial**

**Drivers and Assumptions for Determining RS-CO DG Penetration:**

- All Residential and Commercial DG is assumed to be solar PV
- The main driver behind renewable growth, and therefore solar PV, is $CO_2$ regulation
- The graphic below shoes the sequential flow of drivers followed to determine both the national and the regional Residential DG penetration levels *(uncertainties – green, supporting data – blue)*:



*Distributed Generation Penetration Assumptions*

# National Renewable Energy (RE) Adoption

CO2 Regulation (uncertainty) → National RE adoption → National RS-CO DG Penetration (uncertainty) → TVA RS-CO DG Penetration (uncertainty)

- Source Data:
  - U.S. Energy Information Administration (EIA) - 2013 Annual Energy Outlook
  - Cases Utilized: Reference, GHG 10, GHG 15, GHG 25

- EIA and TVA CO2 price assumptions were correlated to interpolate reasonable renewable adoption levels by 2040 (end of EIA's analysis period).

| Analysis Basis | TVA IRP Scenarios | TVA CO2 Uncertainty Level | National RE Adoption (% of generation by 2040) |
|---|---|---|---|
| EIA – Reference | Stagnant Economy | Very Low CO2 | 16.5% |
| | Current Outlook | Same | 18% |
| | Distributed Marketplace | Low CO2 | 20% |
| EIA - GHG 10 | | | 23.5% |
| | Growth Economy | High CO2 | 25% |
| EIA - GHG 15 | | | 28.4% |
| EIA - GHG 25 | | | 31.4% |
| | De-carbonized Future | Very High CO2 | 35% |

*Distributed Generation Penetration Assumptions*

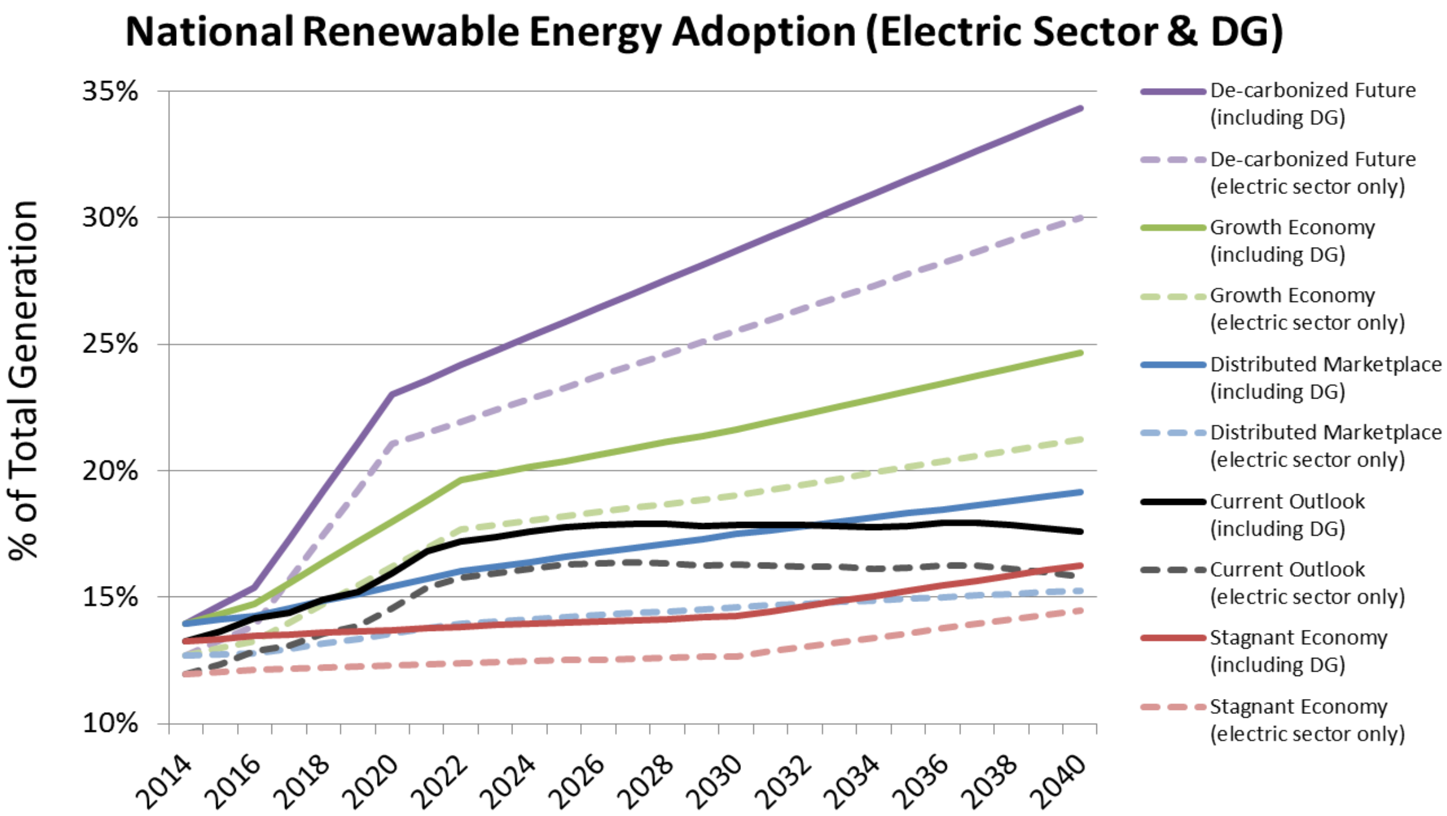
# National RE DG Penetration


- EIA data was adjusted to TVA scenarios to derive national RS-CO DG adoption

| **TVA IRP Scenarios** | **National RE Adoption by 2040** | | **National RS-CO DG Penetration by 2040** | |
|---|---|---|---|---|
| | % of total generation | Growth Curve Basis | % of RE growth | Basis/Justification |
| Stagnant Economy | 16.5% | EIA Reference | 16% | Same as EIA reference case |
| Current Outlook | 18% | Ventyx | 11% | Applied EIA reference case growth rate |
| Distributed Marketplace | 20% | EIA GHG 15 adjusted to match TVA scenarios (original EIA value was 28.4% of total generation) | 50% | Set high; primary objective of this scenario is customer driven DG |
| Growth Economy | 25% | | 20% | Set twice as high as EIA GHG 15 (~10%); greater customer-driven DG anticipated in favorable economic growth conditions |
| De-carbonized Future | 35% | | 15% | Set 50% higher than EIA GHG 15; assumes regulation drives more utility activity rather than customer-driven DG |

*Distributed Generation Penetration Assumptions*

# National RE DG Penetration (Cont.)

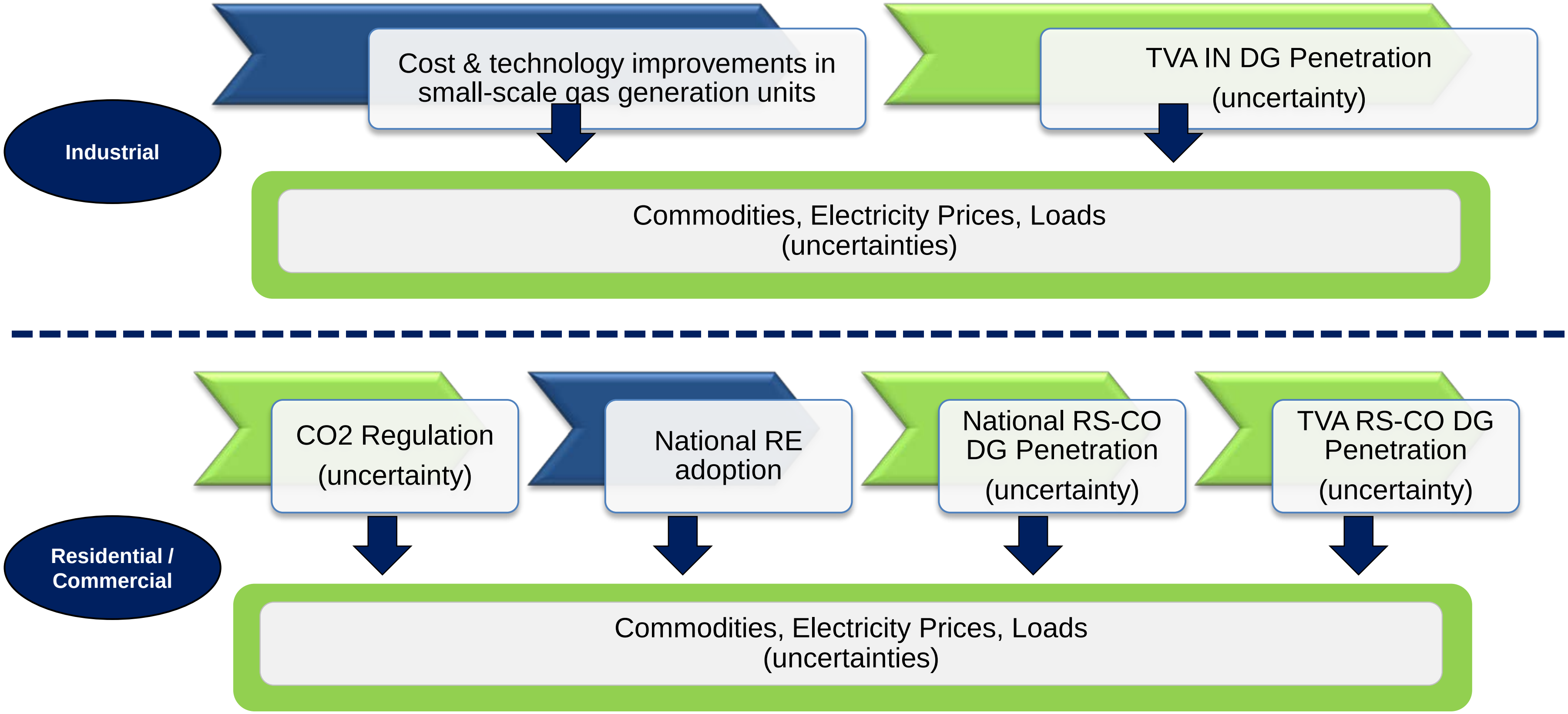



*Distributed Generation Penetration Assumptions*

# DG Penetration: Key Takeaways

- DG, both nationally an at the TVA level, is defined as demand-side renewable generation that is customer-driven (outside of utility involvement) and results in a reduction to utility loads.

- Industrial DG is considered primarily from natural gas and will be discussed as part of the IRP load uncertainty analysis; all Residential and Commercial DG is considered mainly solar PV and the main driver is CO2 regulation



# Demand and Energy Forecast: Drivers of Loads

- The product of the load forecast is:
  - Net System Requirements (in GWh's) – How much energy TVA will plan to serve
  - TVA System Peak (in MW's) – How much capacity TVA needs
- The variables that we have found have the best explanatory power are:
  - Gross Domestic Product (GDP) – Measures the change in total economic output
  - Regional NonFarm Employment – Drives the local economy and customer count growth
  - Electricity and Natural Gas Prices:
    - Electricity price accounts for the elasticity effects of the price of power
    - Natural Gas prices pick up on customer substitution situation
- Accounts for the impacts of Economics, National Energy Efficiency, Renewable Distributed Generation and Industrial Distributed Generation
- TVA and LPC administered EE is modeled as a supply side resource and is not modeled in these loads

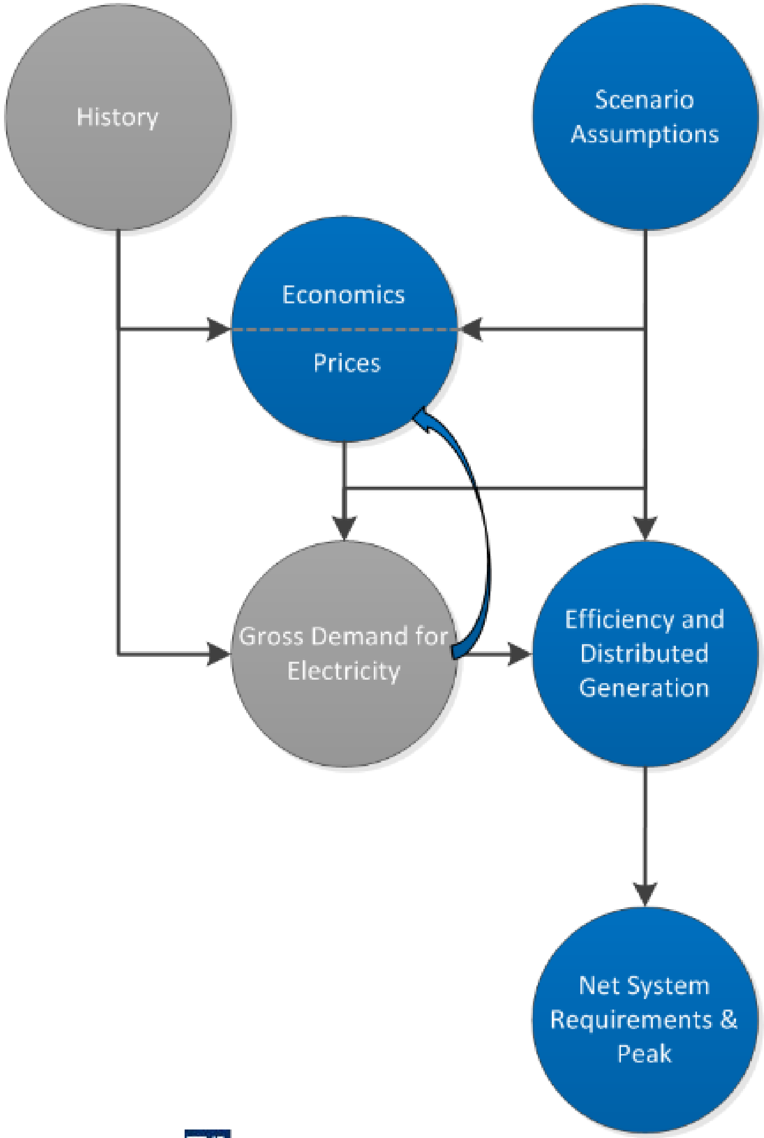
# Methodology

- The load forecast is developed using a regression model to study how the demand for electricity response to historic movements in economic and price variables

- Data that is feed into the load forecast is:
  - Economics and Prices
  - Energy Efficiency
  - Historical Data
  - Fundamental Scenario Assumptions

- Historical data is used to estimate the proportional changes in demand relative to the other model drivers based on elasticity

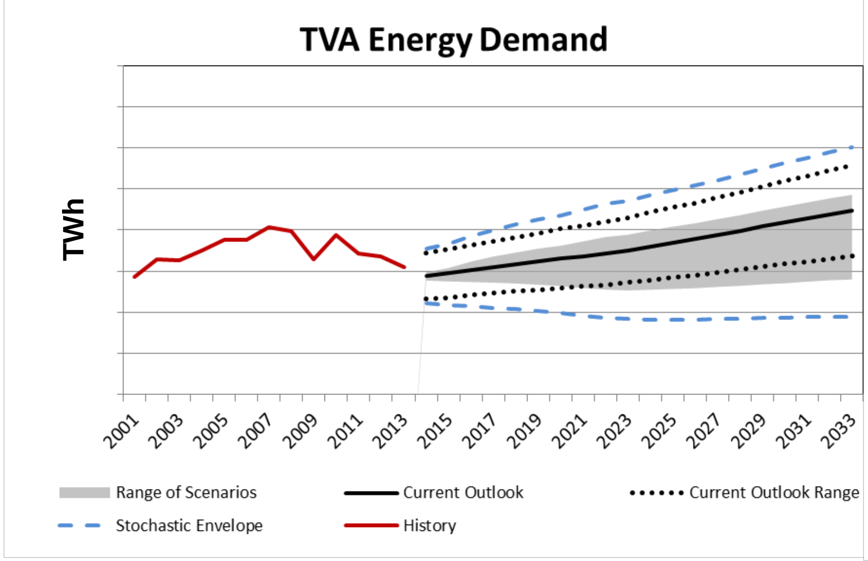
- The gross demand forecasts are used to inform other scenario variables in an attempt to model real world interdependencies

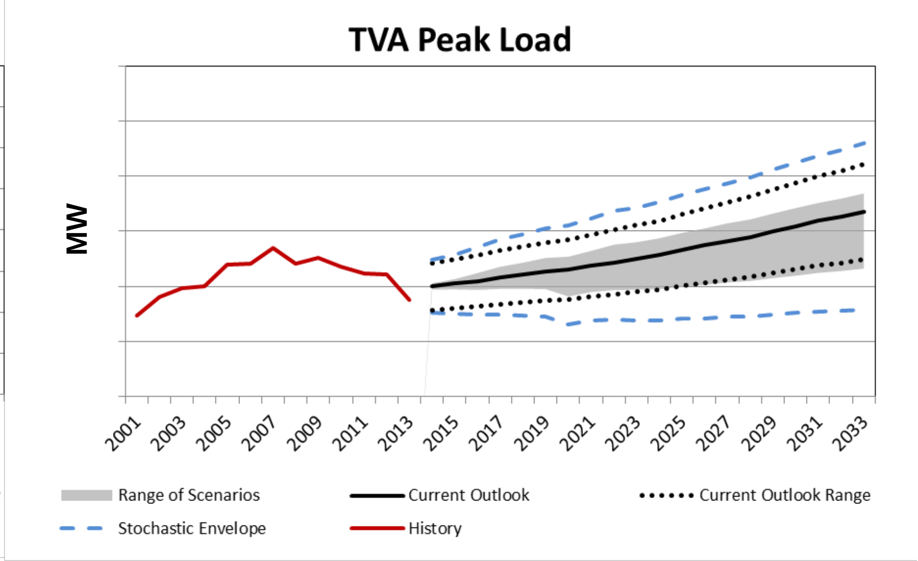


# *Demand and Energy Forecast*
# Range of Outcomes for Loads

- The range of possible Net System Requirements:
  - Range of compound annual growth rates is 1.1% to 0.0%
  - Range of forecasted values in 2033 is between 4% and -18% around the Current Outlook
  - The stochastic envelope widens the range by ~12%

- The range of possible System Peak:
  - Range of compound annual growth rates is 1.3% to 0.3%
  - Range of forecasted values in 2033 is between 4% and -14% around the Current Outlook
  - The stochastic envelope widens the range by ~12%



# Demand and Energy Forecasts: Key Takeaways

- The Load forecast defines the energy and peak demand TVA must satisfy for the customers
- The Growth Economy and Stagnant Economy scenarios primarily are driven by economic assumptions
- The Growth Economy scenario is the high side bounding scenario for the load forecast
- $CO_2$ prices in the De-carbonized Future scenario create an step change in the loads
- The Distributed Marketplace scenario is the low side bounding scenario and is driven by residential customers turning to distributed solar and industrial customers self generating with natural gas

# *Coal and Gas Price Forecasts*

# Natural Gas Forecast Drivers

## Supply

**Gas Plays:**
- Shale Gas
- Tight Gas
- Conventional Offshore

**Gas Type:**
- Dry Gas
- Wet Gas
- Oil Associated Gas

**Production Costs:**
- Local infrastructure
- Labor
- Drilling technique
- Regulations
  - Emissions
  - Zoning
  - Water use

## Transportation

**Pipeline Transport Costs:**
- Interstate Transmission
- Intrastate Transmission
- Local Distribution Companies

**Pipeline Constraints:**
- Interconnects
- Receipt/Delivery Points
- Compression
- NIMBY

## Demand

**Demand Factors:**
- Economic Outlook
- Regulation
- Storage

**Traditional Demand:**
- Residential
- Commercial
- Industrial
- Electric Power

**Emerging Demand:**
- LNG Exports
- NGV Demand
  - Oil & Gas Equipment
  - Locomotives
  - Bunker Fuel
  - Fleet Vehicles
  - OTR Trucks

# Coal Forecast Drivers

## Supply

**Coal Reserves:**
- Bituminous
- Sub-bituminous
- Lignite

**Production Type:**
- Underground
  - Longwall
  - Continuous Miner
- Surface

**Production Costs:**
- Local infrastructure
- Labor
- Regulations
  - Reclamation
  - Emissions
  - Zoning
  - Water use

## Transportation

**Transport Costs:**
- Rail
- Barge
- Truck
- Fuel

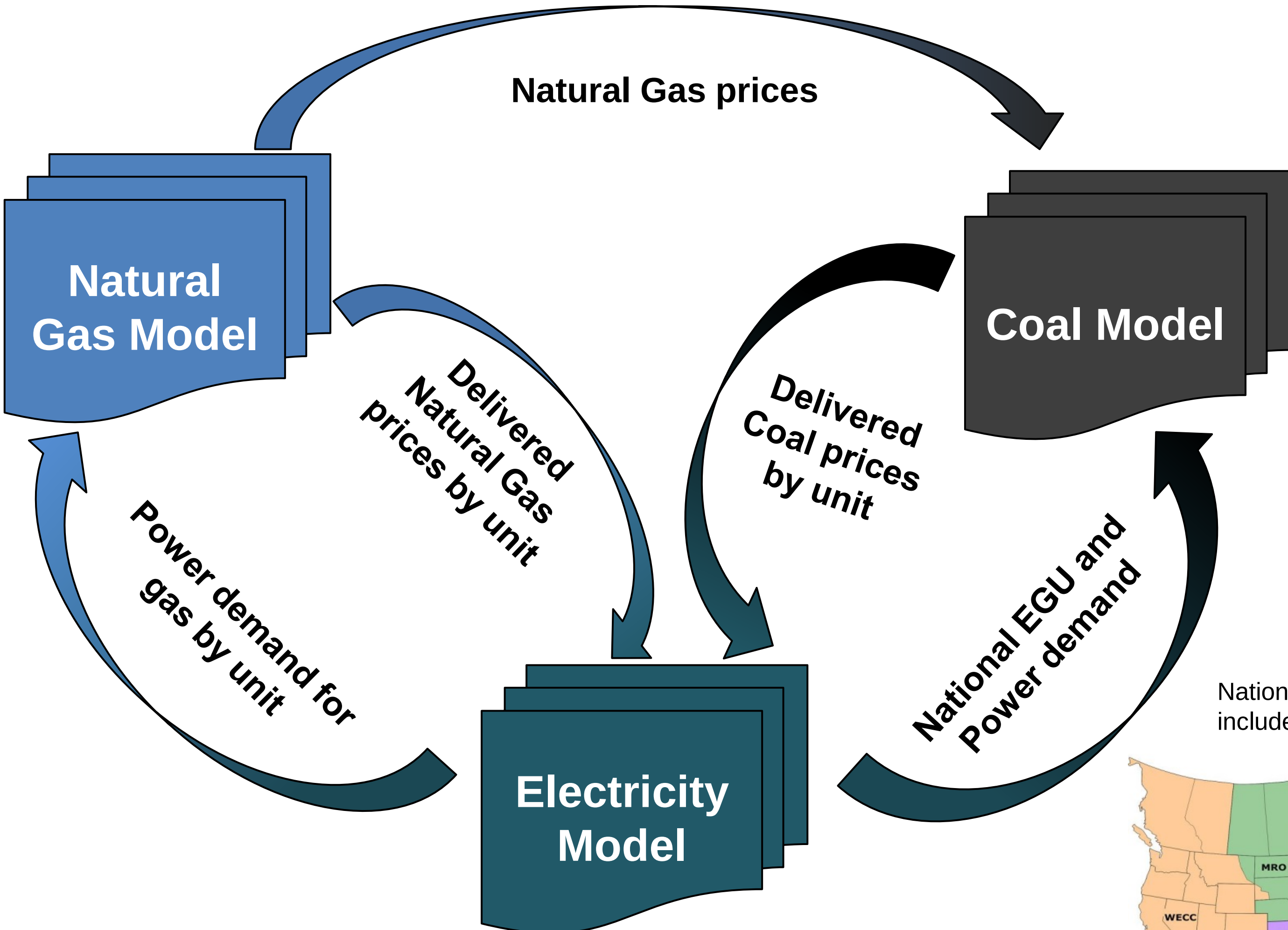
**Transport Constraints:**
- Congestion
- Infrastructure

## Demand

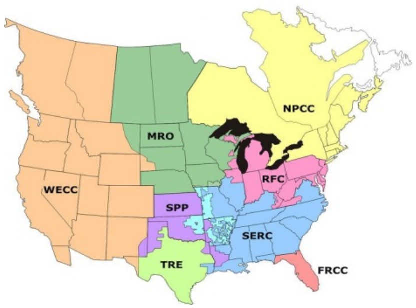
**Demand Factors:**
- Economic Outlook
- Regulation
- Stocks

**Traditional Demand:**
- Commercial
- Industrial
- Electric Power
- Exports

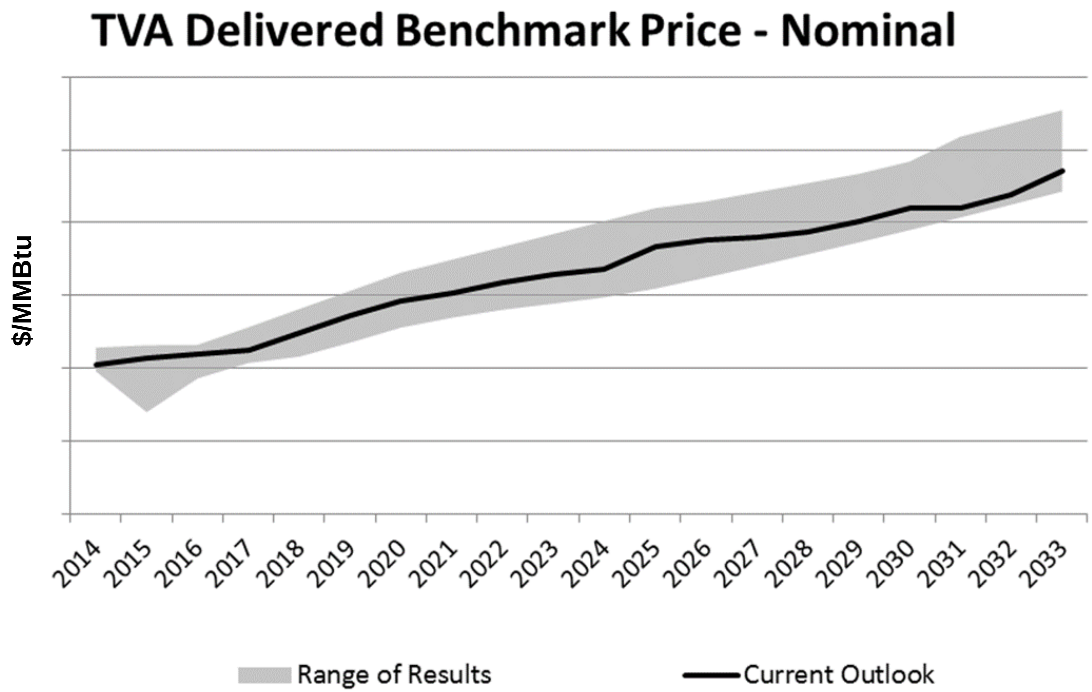
# Model Integration




National models include all EGUs

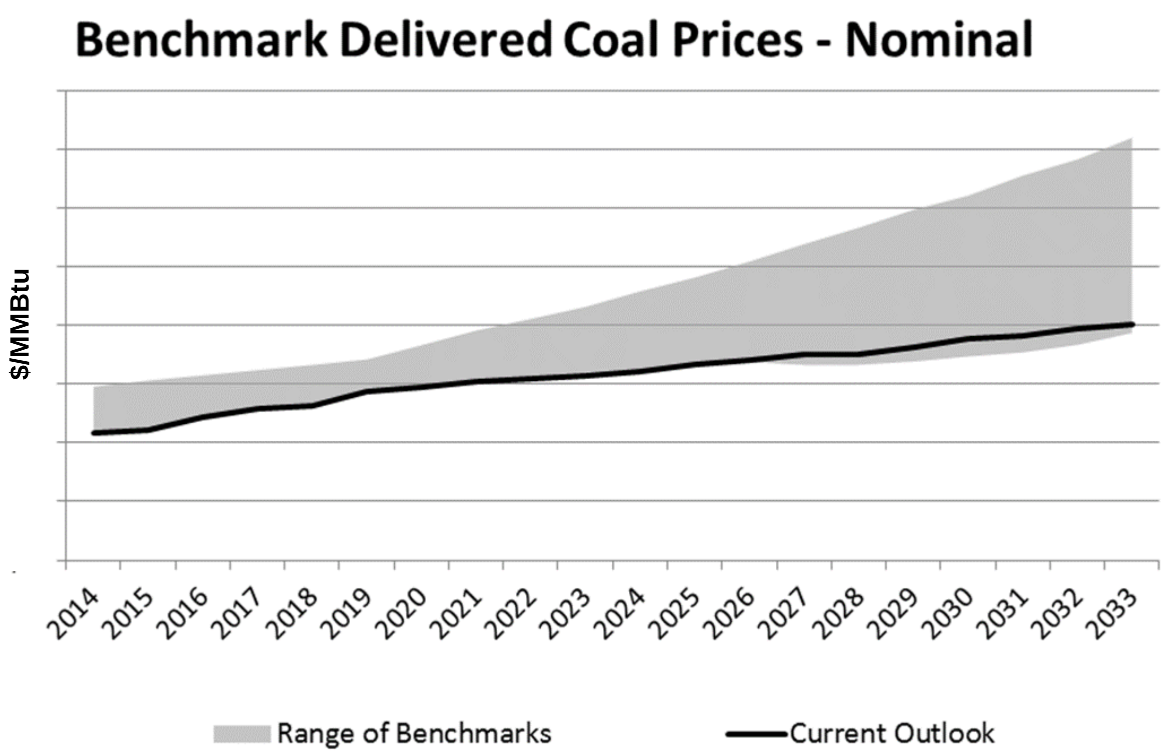


# TVA's Gas Outlook is Within the Range of Benchmarks




- One vendor is consistently lower in its view of natural gas price escalation, skewing the range to the downside
- TVA's outlook is closely aligned with the other benchmark forecasts

*Coal and Gas Prices Forecasts*
# Coal Benchmarks




- The number of benchmarks providing delivered costs into TVA area is limited
- TVA's Coal Outlook is within the range of comparable benchmarks
- One vendor is consistently higher in its view of coal price escalation, skewing the range to the upside

# Coal and Gas Prices: Key Takeaways

- The Growth Economy and Decarbonized Future Scenarios result in the greatest increase in gas demand, driving high gas prices
- The Stagnant Economy Scenario resulted in the lowest gas price with no CO2 price in place to support switching from coal
- While the De-carbonized Future Scenario produces the lowest coal prices, high emission costs keep demand low
- In the Distributed Marketplace Scenario, increased industrial gas demand offsets the impact of reduced power demand
- TVA's Fuels Outlook is within the range of comparable benchmarks

# Electricity Forecast Drivers

**_Supply_**

**Electricity Generation / Plant Characteristics:**

- Unit type: Coal, Natural Gas, Nuclear, Hydro, Pumped Storage, Wind, Solar, Fuel Oil, Other – biomass, refuse
- **Fuel Prices** – monthly, annual
- Long term capacity expansion
- Unit retirements (esp. coal)
- Wind and Solar hourly availability by zone
- **Emission rates & prices**
- Capacity, Heat Rate
- **Location (zone dispatch stack)**
- **VOM**, FOM, Start Up Costs
- Forced Outage Rates, Must Run
- Start & Retire Dates
- Minimum up and down time

**_Transportation_**

- Transmission Lines
- Transmission constraints between zones
- Wheeling charges

**_Demand_**

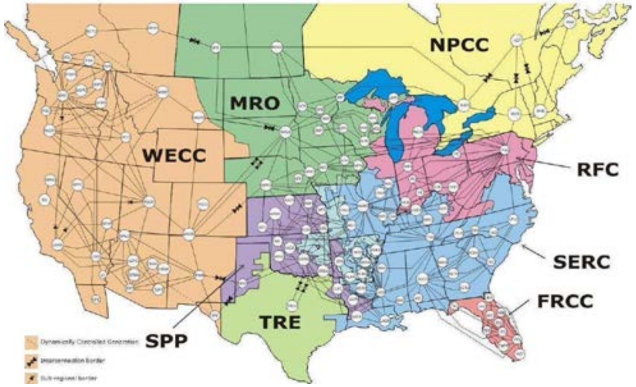
- National Demand Escalation
- Zonal Demand
- **Hourly Demand Shapes**
- Weather Normalized
- Inflation assumptions

Note: Main drivers in blue

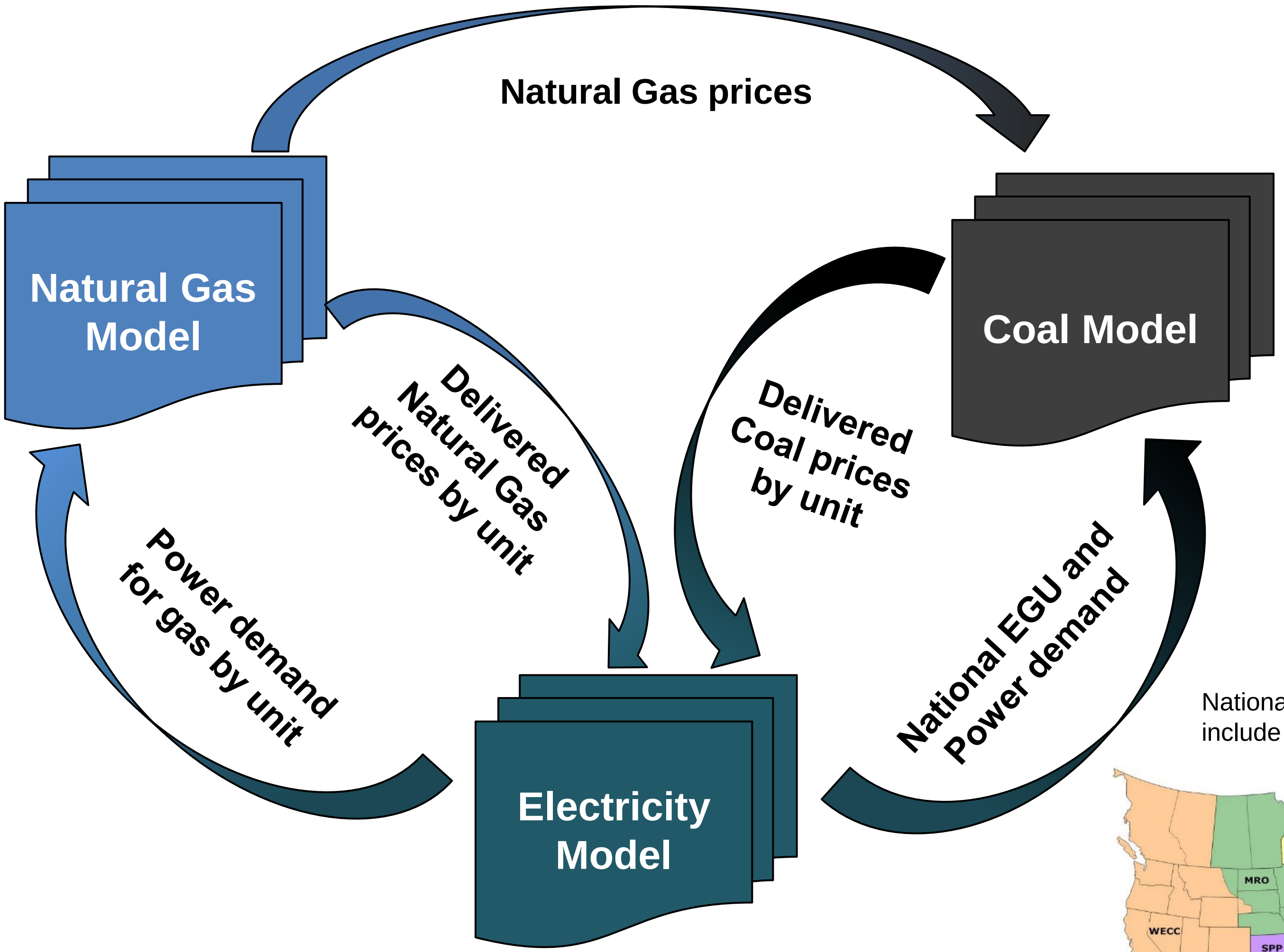
# Electricity Price Drivers

***Deterministic Forecast – Fundamental Hourly Dispatch***

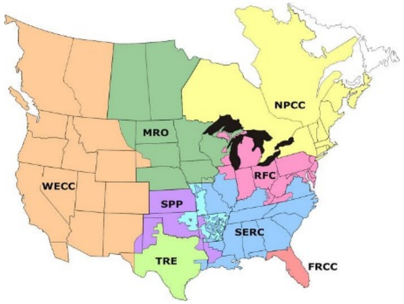
- A national model calculates a wholesale clearing price for all regional zones in the Eastern Interconnect, ERCOT and WECC
- All electricity generating units included in zone dispatch stack
  - Coal Unit retirements
  - Gas and Renewable profile expansion
- Major contributors to dispatch cost
  - Fuel Prices – Coal, Natural Gas, Oil, etc.
  - Unit Characteristics – Capacity, Heat Rate, Emission Rates
  - Emission Costs – CO2 allowance price
  - Other Variable Operating and Maintenance costs
- National and regional hourly demand
  - Native Load / Reserve Margin
  - Zonal dispatch stack
  - Neighboring zone prices – purchases / sales
  - Effects of EE and DG on load



# Model Integration

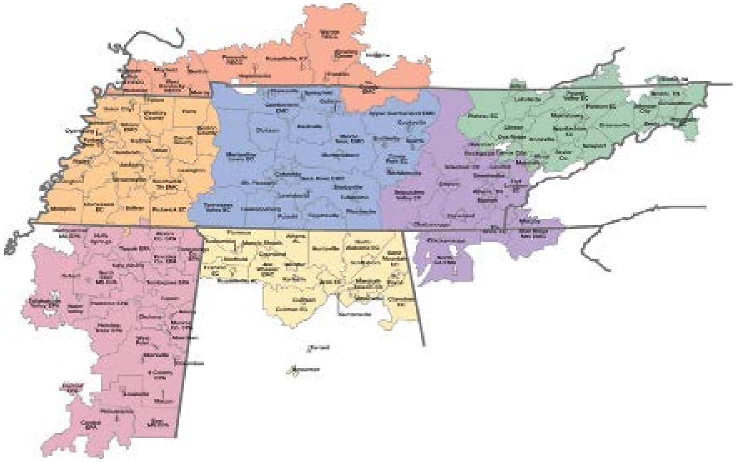



National models include all EGUs



# Wholesale Electricity Prices: Key Takeaways

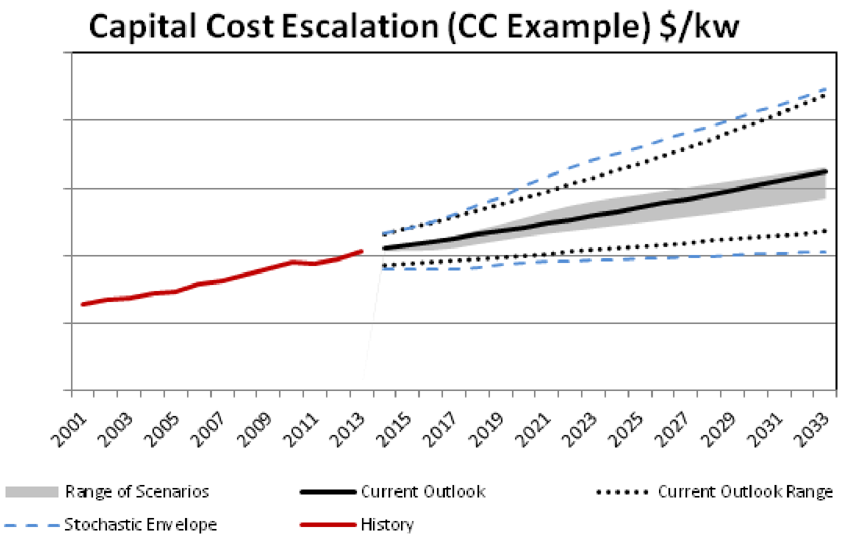
- **Wholesale power prices in TVA region**
  - Primary drivers:
    - Fuel prices – especially natural gas
    - Environmental regulations – especially $CO_2$ costs
    - Demand escalation – driven by national and regional economic outlook
- **Scenario variations**
  - Underlying fundamentals (especially the primary drivers) affect the hourly dispatch power prices both locally and nationally
  - TVA Strategy portfolio changes will affect final price results
  - Power Prices vs. Electricity Demand – supply and demand economics and social forces can mitigate upside risks

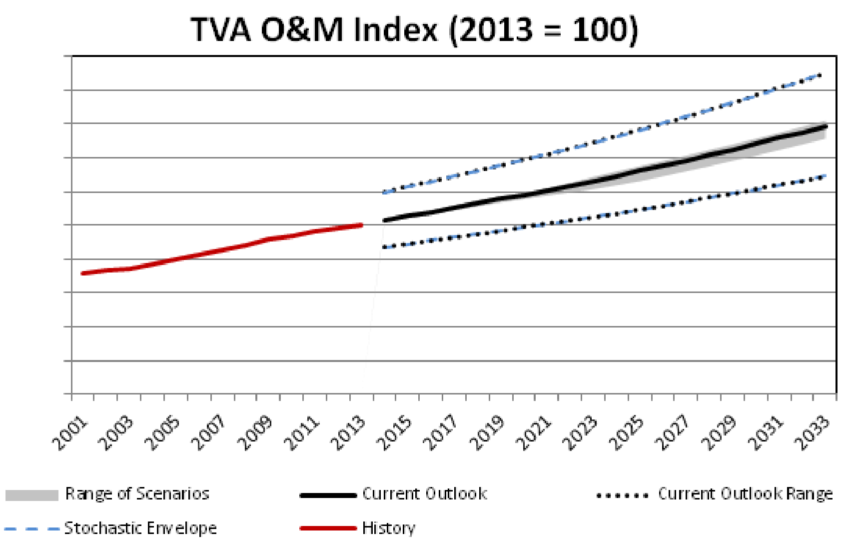


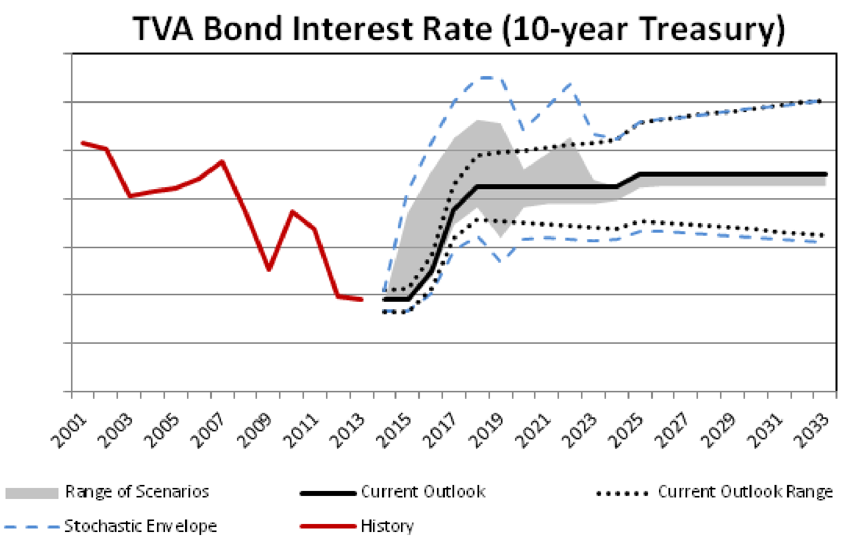
*Additional Variables Stochastic Ranges*

# *Additional Variables Stochastic Ranges*
# Capital Cost Escalation and Bond Interest Rate

- Capital Cost escalation is based on the Handy Whitman index of South Atlantic Construction & Equipment costs of Steam Production Plants.
- TVA's O&M rate is specific to the TVA region.
- The 10-year Treasury bond interest rate is used as a proxy in the IRP for TVA bond interest rates.

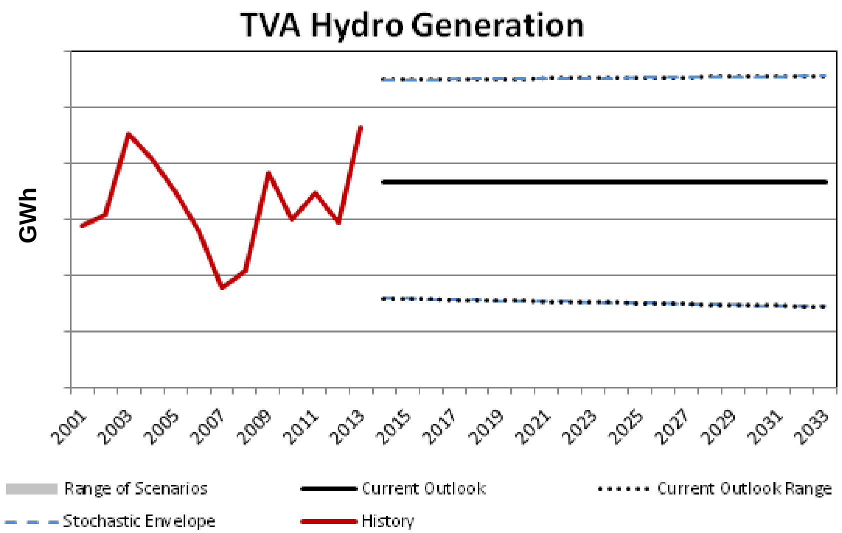


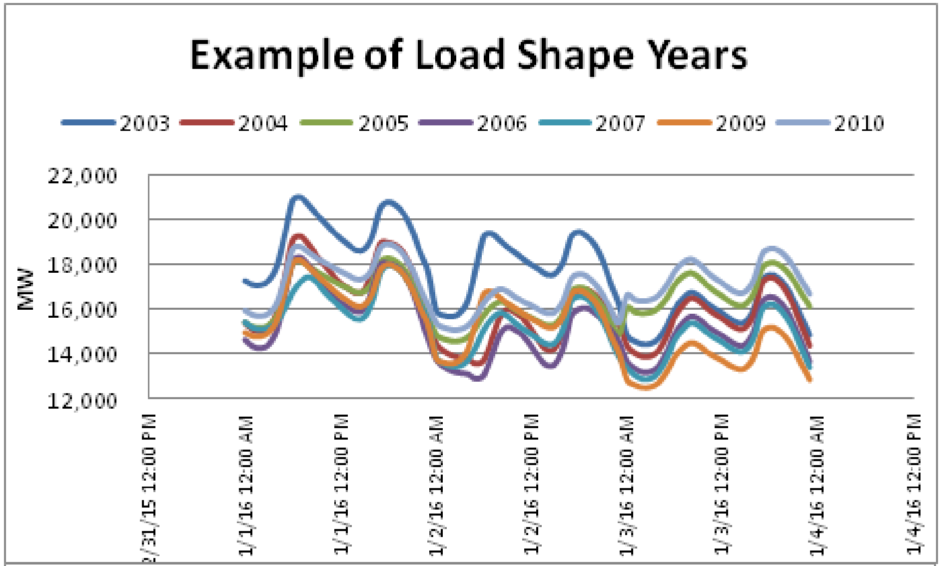
# *Additional Variables Stochastic Ranges*
# Hydro Generation Distribution

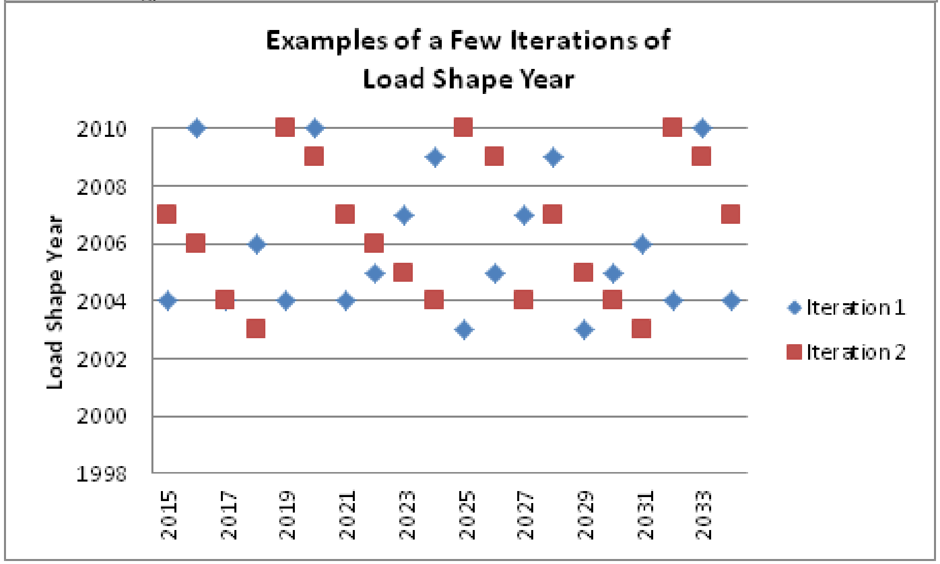
- Hydro generation does not vary by scenario, but it does vary stochastically.
- Hydro generation varies based on historical generation. A simulation model takes historical rainfall and run-off and simulates the current dam operating policies and generator configurations.
- Correlations are considered between hydro generation and load where there is a strong negative correlation.
  - Historical correlation analysis shows TVA tends to vary between cool and wet or warm and dry



# *Additional Variables Stochastic Ranges*
# Load Shape Year adds Daily Weather Variation

- Randomly chooses years 2003 – 2010, excluding 2008 which had an unusual load pattern due to the recession
- This variable creates variation in the daily load patterns.
- Load Shape Year variation creates **diversity** in the relationship between hourly loads and other fixed hourly patterns including wind and solar.

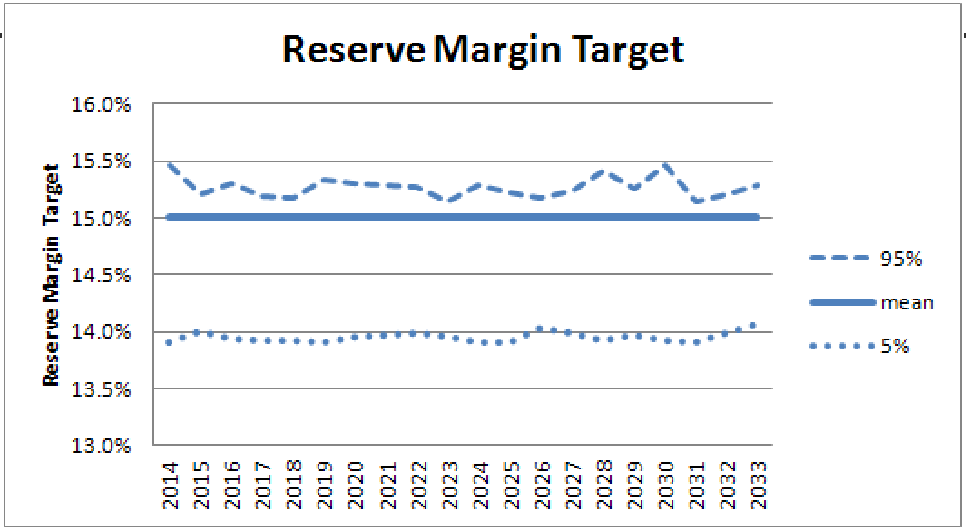


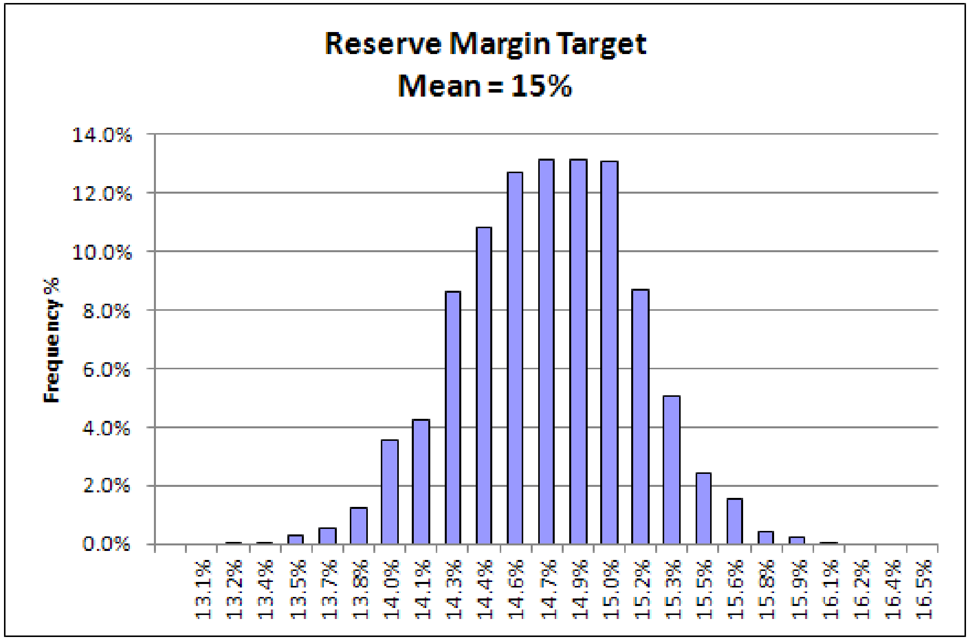
*Additional Variables Stochastic Ranges*

# Reserve Margin Target

- The reserve margin target scalar negates the impact of the weather variation on meeting the reserve margin since the target of 15% already includes a margin for weather uncertainty




| Example | | | | |
|---|---|---|---|---|
| | peak load | | monthly load scalar for weather | scaled peak |
| Jan | 30,835 | max | 1.04 | 31989 |
| Feb | 29,211 | | 0.95 | 27737 |
| Mar | 25,981 | | 1.00 | 25993 |
| Apr | 22,472 | | 1.00 | 22471 |
| May | 25,634 | | 1.02 | 26132 |
| Jun | 28,555 | | 1.06 | 30192 |
| Jul | 29,792 | | 1.08 | 32299 |
| Aug | 29,914 | | 1.02 | 30443 |
| Sep | 27,136 | | 1.01 | 27273 |
| Oct | 21,344 | | 1.03 | 22029 |
| Nov | 23,356 | | 1.05 | 24408 |
| Dec | 26,162 | | 1.03 | 26913 |
| | | | | |
| | | reserve margin scaler | Mean Reserve Margin | Scaled Reserve Margin |
| max peak load = | 30,835 | 0.955 | 15% | 14.3% |
| max scaled load | 32299 | | | |



# Group’s Feedback on Scenario Forecasts

| | **Day 1** | |
|---|---|---|
| 8:30 | **Welcome** | Randy McAdams |
| 8:45 | **Description of Selected Scenarios**<br>**Orientation About Today’s Session** | Gary Brinkworth |
| | **Assumptions and Projections of Critical Uncertainties:** | |
| 9:15 | Economic and Financial Assumptions | Nathan Donahoe |
| 9:45 | Environmental Regulations and CO2 Prices | John Myers |
| 10:15 | *Break* | |
| 10:30 | EE Adoption | James Linder |
| 11:00 | DG Penetration | Neil Placer |
| 11:30 | *Lunch* | |
| 12:15 | Demand and Energy Forecasts | Nathan Donahoe |
| 12:45 | Coal and Gas Price Forecasts | Connie Trecazzi |
| 1:15 | Electricity Price Forecasts | Patrick Obrien |
| 1:45 | *Break* | |
| 2:00 | Additional Variables Stochastic Ranges | Scott Jones |
| 2:45 | Integrated View of Uncertainties by Scenario ranges | Gary Brinkworth |
| 3:15 | **Group Feedback on Scenario Forecasts** | Randy McAdams |
| 3:45 | **Overview of Day 2** | Randy McAdams |
| 4:00 | *Adjourn* | |

***Fundamental Assumptions***

Input? Reaction? Observations?

***Key Scenario Uncertainties***

Input? Reaction? Observations?

***Uncertainty Forecasts by Scenario***

Input? Reaction? Observations?