# 2015 Integrated Resource Plan

IRPWG Meeting

Session 5

March 27-28, 2014

# IRPWG Meeting – March Agenda (Day 1)

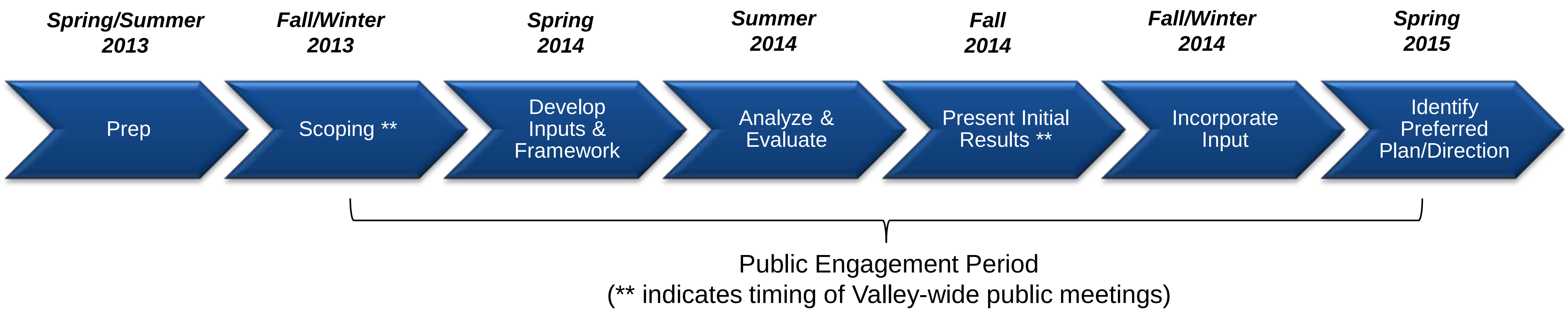
| | | |
|---|---|---|
| 9:00 | Welcome – IRP Status and Session Objectives | Gary Brinkworth |
| 9:15 | Update on the Scoping Report | Chuck Nicholson |
| 10:00 | Overview of TVRIX and EEIX Teams | Patty West<br>Ed Colston |
| 11:00 | Break | |
| 11:15 | Overview of the modeling Process | Gary Brinkworth |
| 12:15 | Lunch | |
| 1:15 | 2015 IRP Strategy Design – Comments and Initial Ranking Results | Gary Brinkworth |
| 2:45 | Break | |
| 3:00 | Overview of Resource Options | Gary Brinkworth |
| 4:00 | Adjourn | |

# IRPWG Meeting – March Agenda (Day 2)

| | | |
|---|---|---|
| 8:30 | Overview of IRP Metrics and Score Cards | Gary Brinkworth |
| 10:00 | Break | |
| 10:15 | IRP Benchmarking: modeling Process and Metrics | Gary Brinkworth |
| 10:45 | Overview of 2015 IRP EIS Scope | Chuck Nicholson |
| 11:15 | Next Steps and Wrap-up | Joe Hoagland |
| 11:30 | Lunch | |

# 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)

# March 27th-28th IRPWG Meeting Objectives

**RERC Briefing**

**January 2014**
- Initial ranking of scenarios
- Review comments and new proposed scenarios by the group
- Strategy concepts
- Ranking of Scenarios

**TVA Board Members Briefing**

**February 2014**
- Short list of Scenarios
- Review candidate strategies
- Resource options
- Planning assumptions
- Strategy ranking

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

**TVA Board Members Briefing**

**April 2014**
- Short list technology options
- Review scorecard metrics

**RERC**

**TVA Board Members Briefing**

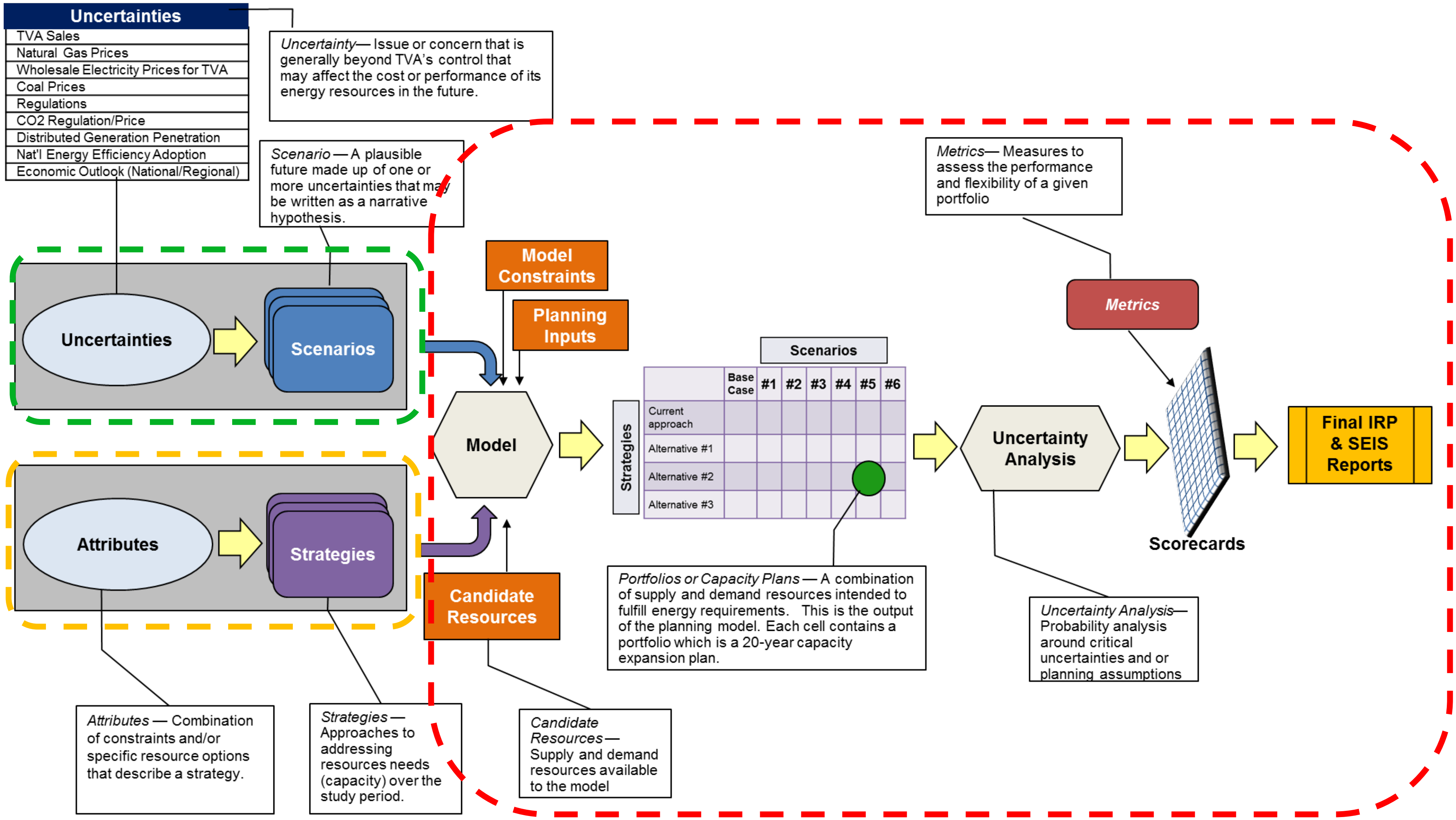
**May 2014**
- Review of model assumptions and forecasts
- Discuss the design of the scorecard

**June 2014**
- Modeling runs begin
- **No meeting planned for this month**

During today's meeting we aim to accomplish the following objectives:

- Share the comments and questions received from the group about the strategies proposed during February's session as well as the answers from the TVA's team
- Review the current list of strategies and present the preliminary ranking based on stakeholder input
- Discuss some new strategies proposed by some members of the group and the response from TVA
- Provide an overview of the study methods and a detail description of modeling constraints and assumptions
- Explain the resource options that will be considered in the study incorporating the input from the TVRIX and EEIX groups
- Introduce concepts around metrics and scorecards for evaluating portfolios
- Introduce the scope and requirements for SEIS
- Explain the next steps in order to prepare for the April session

# 2015 IRP Status



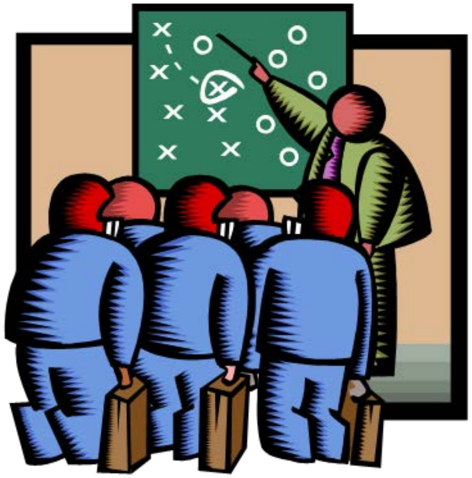

**Completed**

**In process**

**Next steps**

# The Purpose of Public Scoping

- Scoping is a process to define how the IRP study will be done with help from the general public, TVA customers, organizations and agencies
- Agenda of the Public Scoping Sessions:
  - An overview of the IRP process
    - TVA's methodology for resource planning
    - Why resource planning is important and the rational behind doing the 2015 IRP
    - How the results will be used
  - The schedule for the 2015 IRP study
  - An overview of the environmental impact assessment method
  - Questions and comments from attendees
- The results of the scoping are being used to help define:
  - The sources TVA will use to generate power
  - How TVA will manage the demand for power
  - How conditions in the TVA territory could change during the planning period
  - The important environmental topics to be evaluated



# 2015 IRP Public Scoping Effort and Responses

- Scoping began on October 21 and ended on November 22, 2013
- News releases issued to 200+ media outlets throughout the TVA region
- Scoping notices sent to 350 people, agencies, and organizations on 2011 IRP mailing list
- Two scoping meetings held, October 24 in Knoxville and November 6 in Memphis
- Both meetings broadcasted as webinars
- Meeting attendance – 45 in person and 50 by webcast

***Meetings Responses***

- Total of 1156 scoping comments received
  - Comments from all 7 Valley states (78% from TN) and 6 other states
  - Comments from 19 organizations, 21 businesses and 3 agencies
- Major Themes:
  - 980 form email comments thanking TVA for recent decision on coal plant retirements, urging TVA to prioritize use of solar and wind energy and increase energy efficiency, and to work to reduce the local economic impacts of coal plant retirements
  - 50 form letters, as well as several letters from businesses, organizations, and individuals supporting continued use of coal, citing its abundance and stable cost, high capacity factor of coal plants, local jobs, and low and stable rates

# Scoping Comments:  Energy Resources

- **Coal:**
  - Continue the use of coal generation
  - Accelerate coal plants retirements and replace them with cleaner technologies
- **Natural Gas:**
  - Increase the use due to abundant supplies, stable price forecast, good pipeline network access, high efficiency and easy integration with renewables
  - Evaluate the existing uncertainties around the impacts of hydraulic fracturing, competition from gas exports and historic price volatility
- **Nuclear:**
  - Nuclear energy provides important baseload energy with no GHG emissions
  - Risks of nuclear energy are unacceptable and TVA should reduce its use
  - Consider future use of safer nuclear designs such as thorium and traveling wave
- **Hydroelectric:**
  - Increase the use by modernizing existing hydro plants and installing hydro on suitable non-power dams
- **Renewable Energy - General:**
  - Increase the use of renewable energy
  - Provide long-term predictability for TVA’s renewable energy purchasing programs
  - Establish a renewable energy target (5%, 20%)

# Scoping Comments: Energy Resources

- **Solar Energy:**
  - Use a transparent Value of Solar calculation in the IRP modeling
  - Encourage solar on brownfield sites, rooftops, and other developed areas instead of greenfield sites and prime farmland
  - Remove cap on purchases from residential solar installations
  - Explore alternative financing and purchasing arrangements
- **Energy Efficiency and Demand Response:**
  - Set increased annual energy efficiency targets to make TVA a leader in this area
  - Utilize targeted public-private partnerships and other innovative mechanisms to implement energy efficiency programs
- **Energy Storage:**
  - Proceed with the second pumped hydro storage system
  - Develop smaller scale, dispersed energy storage systems to better integrate distributed renewable generation
- **Combined Heat and Power:**
  - Combined Heat and Power / Waste Heat and Power are readily available zero-emissions and economical power sources
  - Remove barriers of discriminatory standby rates, streamline interconnection standards and provide long-term power purchase agreements
- **Transmission System:**
  - Evaluate transmission system upgrades to import renewable energy

# Scoping Comments: IRP Assumptions & Method

- Comments on the IRP analysis itself addressed the following themes:
  - ***Climate change*** impacts & risks
  - General ***scenario design*** goals
  - Adequate evaluation of ***environmental costs*** for technologies and fuel types
  - Treatment of ***debt level and rate impacts***
  - Inclusion of more ***risk analysis*** on technologies & fuel options
  - Recognition of ***macroeconomic and socioeconomic aspects*** of the strategies
  - Request for more ***transparency*** in the analytics
  - Recommendations for testing ***specific planning strategies***
  - Ideas around the evaluation of ***transmission alternatives***

- Commenters also raised questions about some operational and business planning topics that are outside the scope of the IRP

- Questions were also submitted seeking clarification or comment on changes to assumptions and program goals outlined in the 2011 IRP study

# Scoping Comments - The Supplemental Environmental Impact Statement (SEIS)

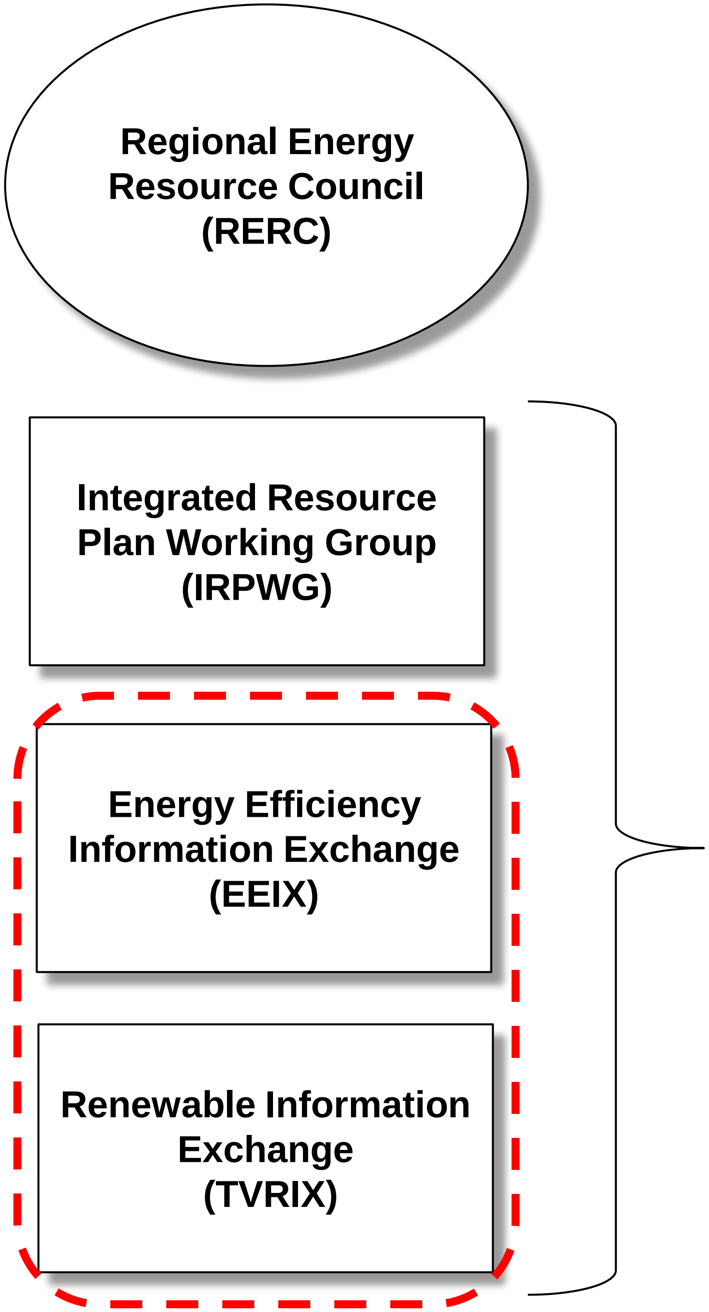
- Fully analyze the effects of climate change especially in relation to water use  and the availability of cooling water
- Include detailed analysis of socioeconomic consequences, including impacts on local communities, local/regional governments and on regional employment including “green jobs”
- Include an evaluation of fuel cycle impacts (extraction, processing, transport, disposal)
- Include more detailed information on the environmental characteristics of TVA’s existing generating units

# Next Steps

- TVA is compiling a report summarizing the scoping input
- The scoping report will describe how TVA is responding to scoping input during the development of the IRP and the SEIS
- The scoping report is scheduled for posting to the IRP website in late April

*Overview of TVRIX and EEIX Teams*

# TVA Stakeholder Groups: TVRIX and EEIX




- *FACA Committee*
- *Provides Council's advice to TVA Board External Relations Committee on energy policy matters*

- *Working stakeholder groups*

  *(not formal FACA committees)*
- *Provides input/counsel into various work efforts and initiatives within TVA*
- *Stakeholder group members speak in "many voices" no consensus required*

# TVRIX Overview

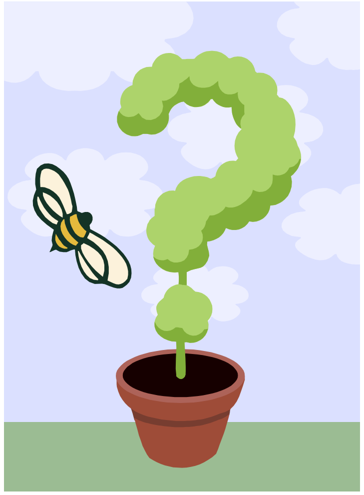
| Group | Agencies / Organizations |
|---|---|
| **Renewable Interest Groups** | ◆ TenneSEIA, SACE, SELC, TREEDC, Sierra Club |
| **State Government** | ◆ TN, KY, MS, AL |
| **National/Regional Expertise** | ◆ EPRI, ORNL, UT, Georgia Tech |
| **Utility** | ◆ TVPPA, LPCs, TVIC |

- Total Participants = 17
- Group established September 2012

  *A result of 2011 IRP 'Next Steps' to further analyze renewable technologies, business models, and market trends*

- Primarily focused on IRP renewable inputs since March 2013

# TVRIX Participant Perspective



The journey began with two questions:

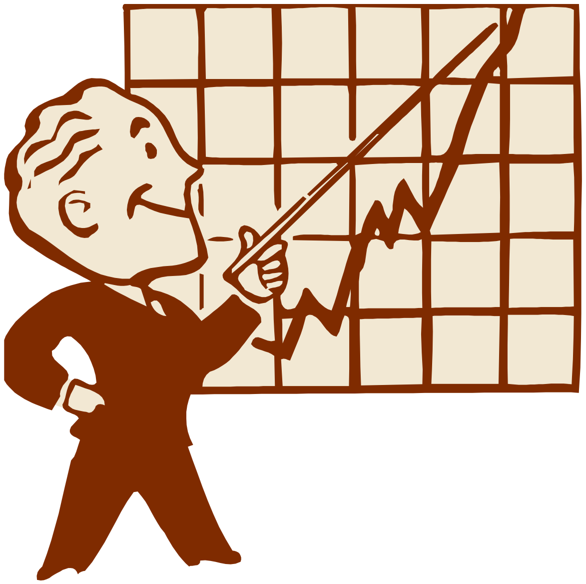
1. What would you like to get out of TV- RIX?
2. What contribution do you bring to the TV-RIX?

| Group | Contribution & Benefit to Stakeholder |
| --- | --- |
| **Renewable Interest Groups** | ◆ Provide and review information to help shape renewable strategy and provide recommendations for the next IRP |
| **State Government** | ◆ To be kept up to speed on renewable issues to help shape future state energy policy |
| **National/Regional Expertise** | ◆ Participate and promote collaboration leading to renewable advancement and implementation |
| **Utility** | ◆ Acquire a better understanding of TVA's renewable direction and the associated impact on ratepayers, industry, and commercial businesses |

# The Schedule of the Exchange is Focused on the IRP

***TVRIX Schedule***

- **March 2013**
  - Intro to IRP Process & Renewables inputs
- **April 2013**
  - Wind & Biomass "Deep Dives" (1 ½ day)
- **June 2013**
  - Solar & Hydro "Deep Dives" (1 ½ day)
- **July 2013**
  - Renewable Programs (Current & Future)
- **December 2013**
  - Initial IRP renewable input discussion
- **February 2014**
  - Finalize TV-RIX renewable inputs for IRP



# Renewable Inputs Overview

- The inputs were broken down into four primary resource types along with an appropriate amount of utility-scale technology "buckets"

| Resource Type | Technology "Buckets" | | | |
|---|---|---|---|---|
| Biomass | Solid Biomass - Co-firing (10% separate injection) | Solid Biomass - IGCC | Solid Biomass - New Direct Combustion | Solid Biomass - Repowering Existing |
| Hydro | HMOD | Power Dam Addition # 1 | Power Dam Addition # 2 | Run-of-River (via small dams, weirs, diversions) |
| Solar | Utility Scale - Large (1-Axis Tracking) | Utility Scale - Small (Fixed Tilt) | Large Commercial (Rooftop) | |
| Wind | MISO/SPP Wind | In-Valley Wind | HVDC Wind | |

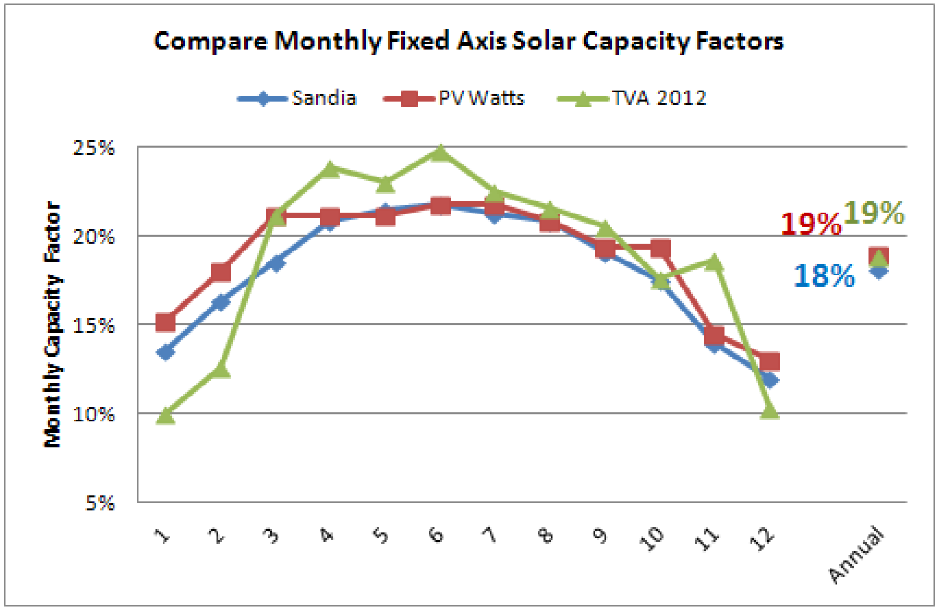
14 selectable renewable energy options + 21 specific data inputs = Nearly 300 data inputs!

# Example of Renewable Input

- Solar Energy Profiles were an important discussion topic

***TVA Analysis***

| Annual Solar Capacity Factor (AC) - Nashville | | | |
|---|---|---|---|
| | TVA 2012 Aggregate | Sandia | PV Watts (TMY) |
| **Fixed Axis** | 19% | 18% | 19% |
| **1-Axis Tracking** | N/A | 21% | 20% |



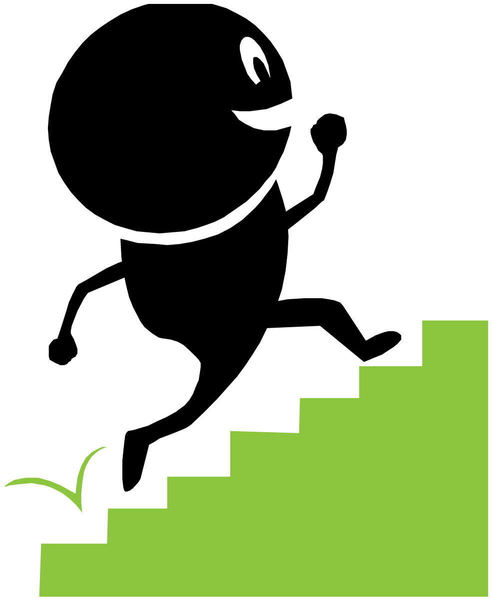

***3rd Party Analysis***

| Annual Solar Capacity Factor (AC) | | | |
|---|---|---|---|
| | Top 10 Sites | Full 26 Sites | Nashville |
| **Fixed Axis** | 20.5% | 20.1% | 19.7% |
| **1-Axis Tracking** | 23.2% | 22.8% | 22.2% |

- Studied 26 - 1 MW AC systems, sited near transmission and generation
- Provides a representative “look” across the Valley (not only Nashville)

# TVRIX - Next Steps

- External data collection of renewable inputs through the TV-RIX platform concluded (end of February)
- TVA renewable staff will review inputs with modeling team to refine and finalize data
- Renewable inputs will be shown in IRP working group



# EEIX Overview

**Purpose:**

- To provide input on energy efficiency and demand response modeling efforts to TVA EEDR staff in support of TVA's mission to "help lead the Tennessee Valley region and the nation toward a cleaner and more secure energy future."

**Scope:**

- Provides a forum to exchange information and ideas on energy efficiency and demand response
- This group is not:
  - A formal advisory group under the Federal Advisory Committee Act (FACA)
  - A decision-making body for the next Integrated Resource Plan (IRP)
  - An approval authority for program design, program development or budget management
- Feedback from this group will be used to create simple, flexible and cost-effective portfolios that can easily fit into the Integrated Resource Plan (IRP) analysis and selection process

# EEIX Members

- Total stakeholder participants = 13
- Group established – October 2013
- Primarily focused on exchange of ideas on adoption rates of energy efficiency

***Local Power Companies***

***State Energy Offices***

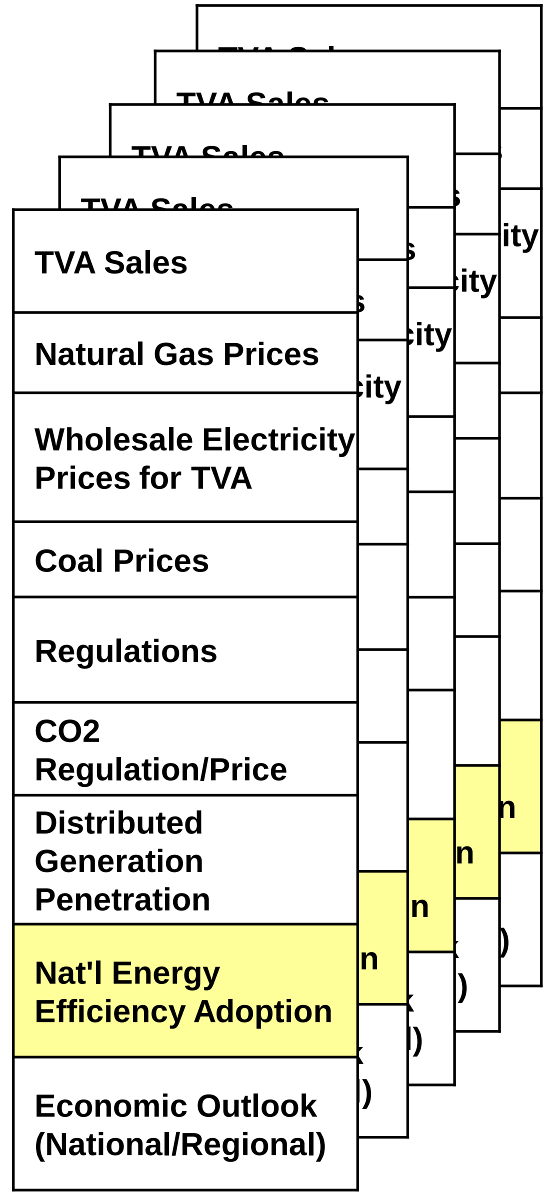
***Non-Government Organizations***

# EEIX Timeline

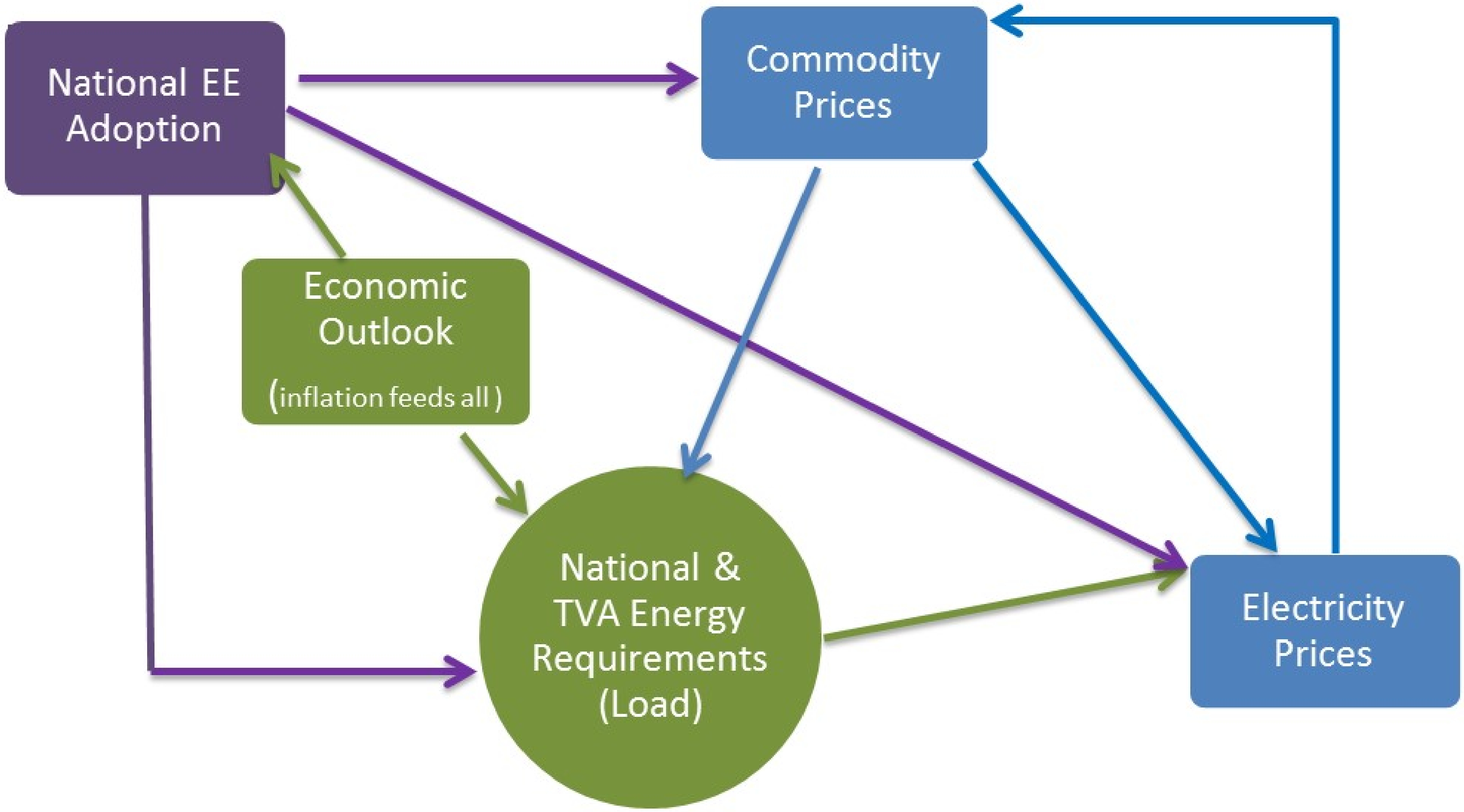
- **November 2013**
  - — Overview of TVA EnergyRight® Solutions Portfolio
- **January 2014**
  - — National, Regional, and State Perspectives
  - — Assigned "homework" requesting projections of EE Adoption rates
- **March 2014**
  - — Finalize National and Regional EE Adoption
- **TBD**
  - — Review outputs from IRP's modeling runs

# Modeling Framework Inputs

- Two distinct types of energy efficiency inputs are considered in aspects of modeling
  - National and regional energy efficiency adoption are key uncertainties that will help define the **Scenarios**
  - Energy efficiency as a resource, along with demand response options, will be included in each of the planning **Strategies** that will be tested across five Scenarios



# Implications of EE Adoptions




- In resource planning, key variables have dependencies
- 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

# EEIX Inputs and Status Update

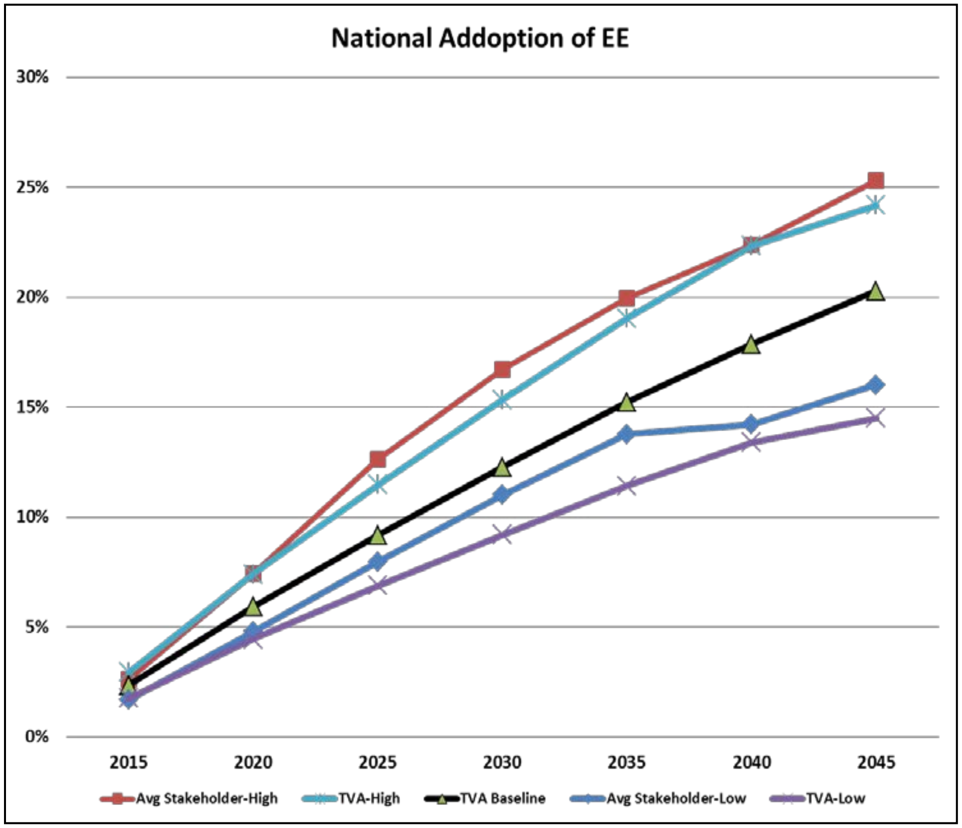
Stakeholders were asked to develop:

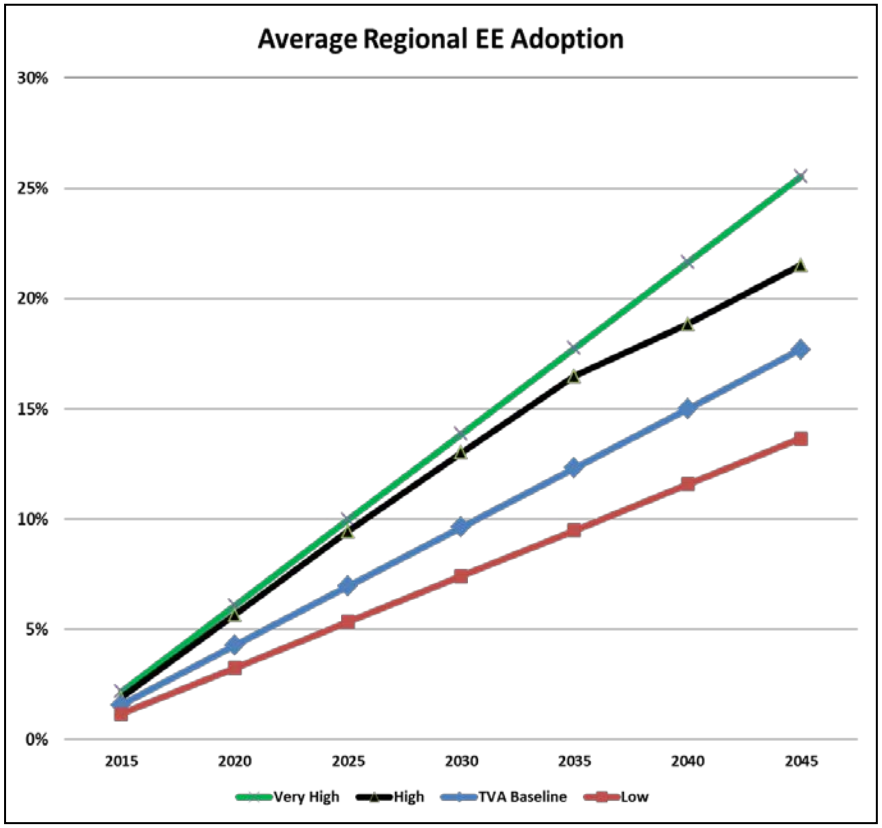
- Numerical estimates of cumulative savings from 2013-2043 for national and regional adoption of energy efficiency (low and high)
- List drivers for projected rates of increase at both national and regional levels (i.e., cost of gas, cost of electricity, legislative impetus, etc.)

**Current Status**

- We are currently validating different modeling techniques consistent with the software architecture
- This validation work is ongoing; our intent is to move toward a more dynamic optimization of EEDR by allowing the models to choose elastic portfolios that are more modular than the ones developed for the 2011 IRP
- This “block selection” method should allow for more dynamic optimization of EE by enabling this resource to compete more directly with other options in the IRP
- The modeling approach will be discussed in more detail with the IRP stakeholders prior to the start of case runs

# Summary of EEIX Inputs Received

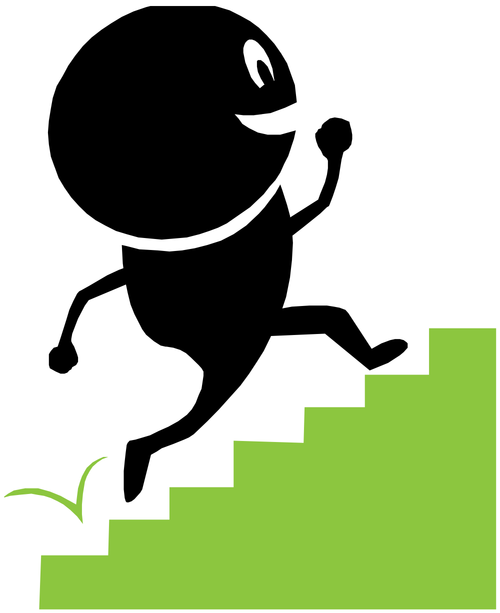


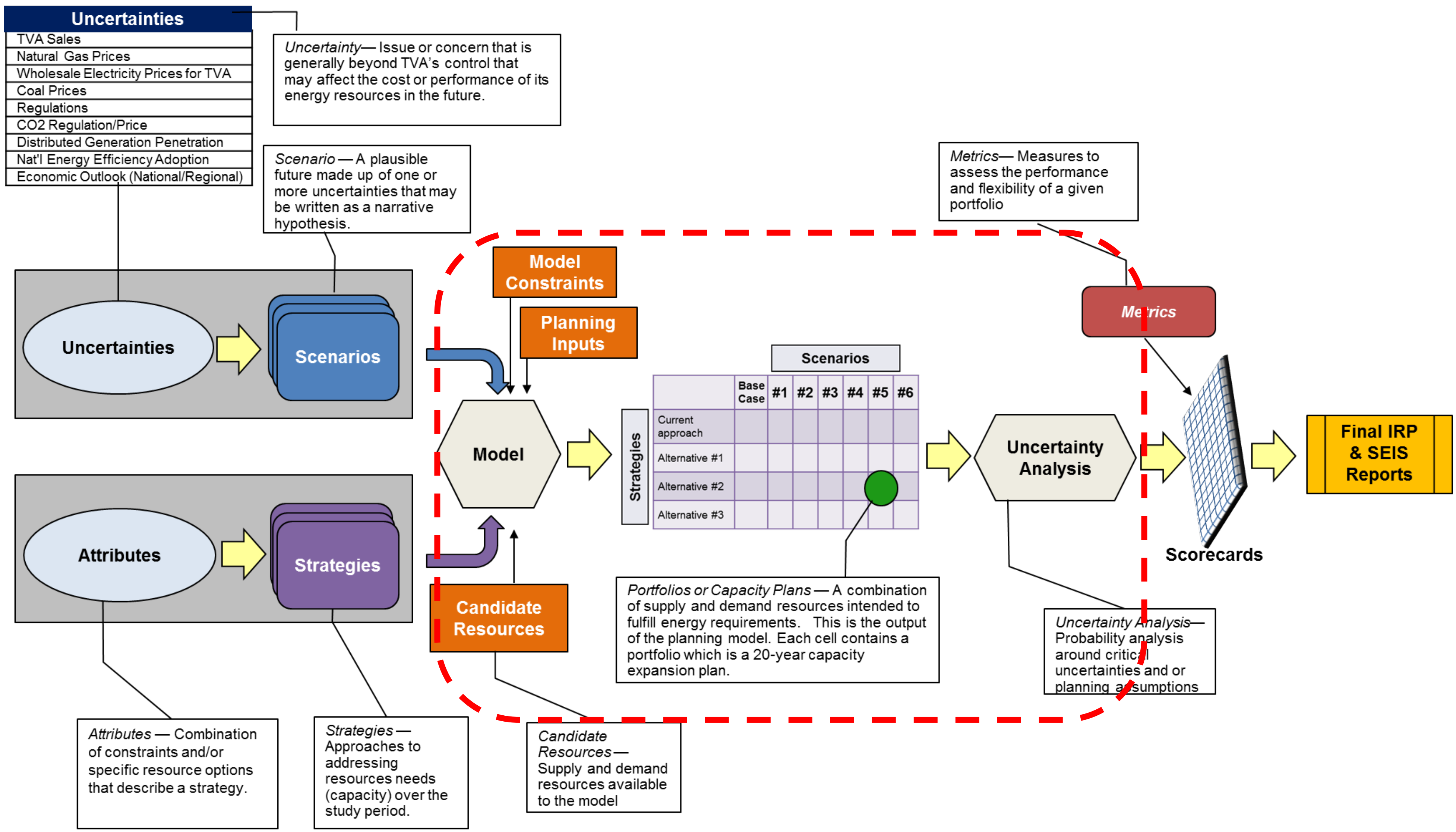

- In general, the views on potential national adoption rates "clustered" rather closely; yet views on the drivers varied
- The views on the Southeast adoption rates reflect a wider disparity

# EEIX - Next Steps

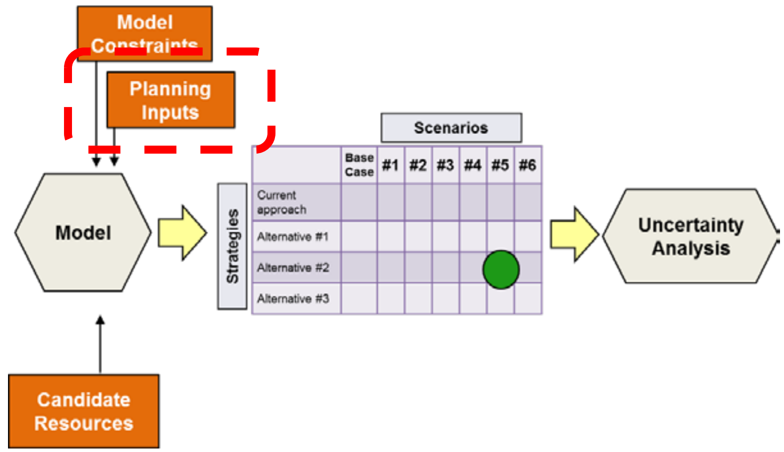
- Develop adoption rates for each scenario based on stakeholder feedback
- Socialize inputs with Modeling Team
- Review inputs with IRP Working Group



# Overview of the modeling Process

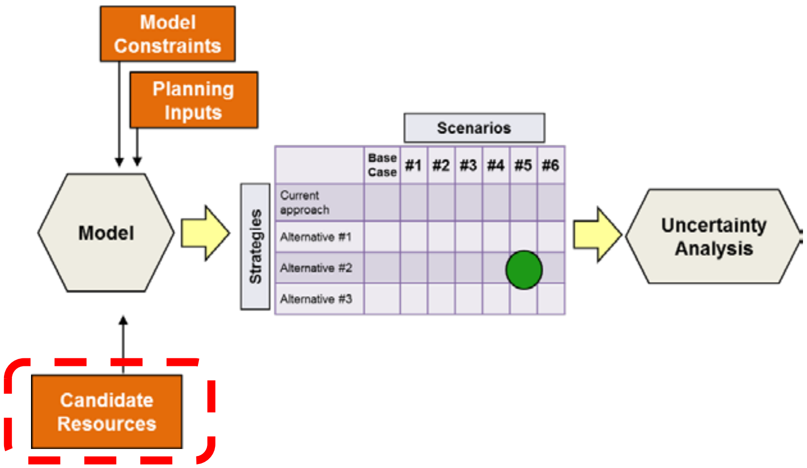


# *Overview of the modeling Process*
# Planning Inputs



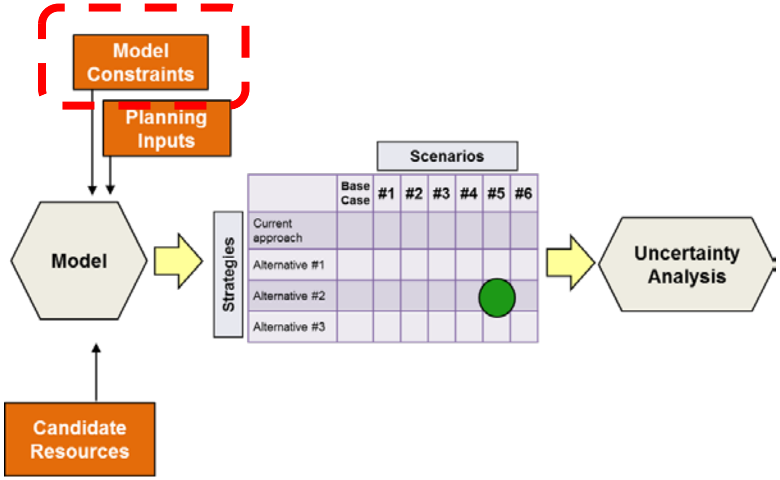

- Total energy forecast
  - Projects the total energy required to meet customer demands by sector (residential, commercial and industrial, and directly served)
  - Includes transmission and distribution line losses
- Peak load forecast
  - Converts energy forecast to hourly load shapes for 8,760 hours of each year based on typical weather patterns and reflect typical hourly usage for TVA customers
  - Identifies the highest hourly load, which becomes the peak forecast for each year
- Commodity prices forecasts
  - Include forecasts for commodities such as natural gas, coal, electricity, and emissions offsets
  - Represent the expected market price for a given commodity
- Financial parameters
  - Forecast inflation which is used to escalate constant-dollar values to nominal
  - Consider interest rates which are used as a guide in the TVA long-term financing rate

# *Overview of the modeling Process*
# Candidate Resources




- Supply-side options
  - Develop a list of candidate technology options
  - Apply multiple screening steps to identify likely (candidate) technologies
  - Input unit characteristics and costs into capacity planning model
- Renewable options
  - Develop candidate list of technology options consistent with proposals from TVRIX group
  - Performance and cost parameters loaded into the capacity planning model
- Demand-side
  - EE program bundles representing selectable program increments are input to the capacity planning model based on projected market penetration and adoption rates
  - Bundles are represented as transactions with defined energy shape (schedule), program costs and duration that represents measure life so that all energy benefits are captured
- Purchased Power Agreements (PPA)
  - Include conventional and renewable PPA characteristics
  - Consider capacity schedule (MW), price (by season/year), and duration of the transactions
  - Include costs for transmission expansion and/or interface capability increases (if required) in total cost of the transaction

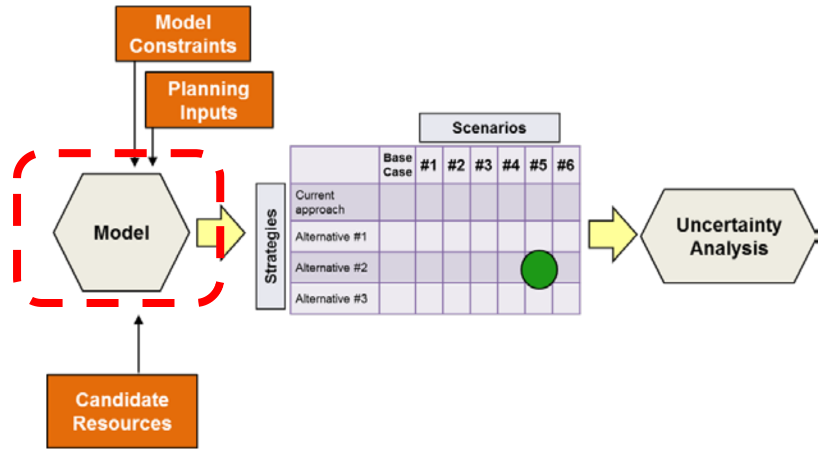
# Model Constraints




- Operational constraints
  - Constructability – limits the first year a resource is available in order to reflect the timeline to bring a unit online and/or set minimum time between units
  - Deliverability – timeline required to ensure transmission system can support unit (or purchase)
  - Fuel supply – any limitations in fuel delivery routes or infrastructure
  - Capability changes – incremental adjustments to existing generating fleet and/or planned idling (coal units)
- The model solves the load and supply balance subject to a reliability requirement – for TVA this is a reserve margin target of 15%
  - This target is applied to the system peak hour for each month of the study period (the annual margin target is usually a summer load hour)
  - The margin is determined based on a probabilistic assessment of reliability that balances the cost of reliability (supply) with the cost of outage (customer/social cost of outage)
- Other constraints are reflected in the design of particular planning strategies

# Capacity Planning Model

- The capacity planning model finds the "optimum" combination of resources to meet projected demand/energy requirements over the study period subject to constraints

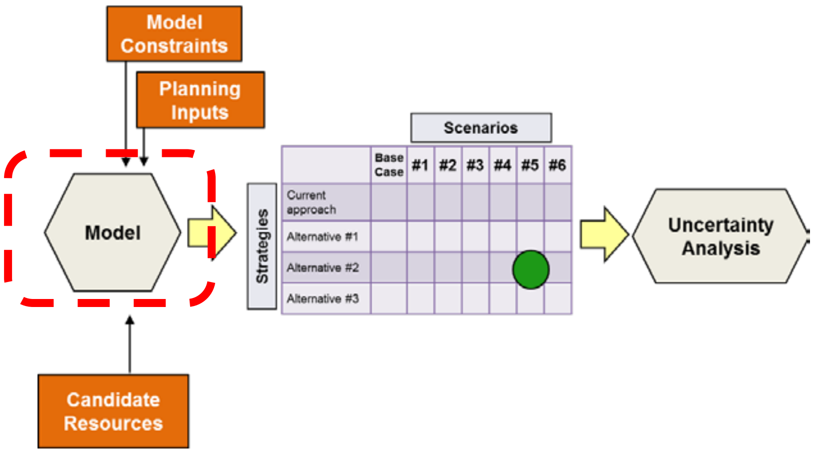



- The model optimizes resource mix based on a single objective function – minimize the Present Value of Revenue Requirements (PVRR) subject to the following constraints:
  - Energy balance (all load is served)
  - Reserve margin (reliability)
  - Generation and transmission limits
  - Any other user-defined solution boundaries

- The model generates multiple combinations of resource additions for each year of the study period and computes costs for each combination
  - All operating and contract/transaction costs are computed on an annual basis
  - Capital costs for supply-side options are amortized for investment recovery
  - This method eliminates the "end effect bias" and avoids the need for residual value accounting or modeling extension periods to capture the full asset cost.
    - End effects generally occur when the asset life is greater than the remaining study period

# Capacity Planning Model

- PVRR includes system production costs. Capacity optimization tools use a simplified dispatch algorithm to compute production costs because of the number of possible states evaluated
  - The model uses a “representative hours” approach, in which average generation and load values in each representative period in a week are scaled up appropriately to span all hours of the week and days of the months

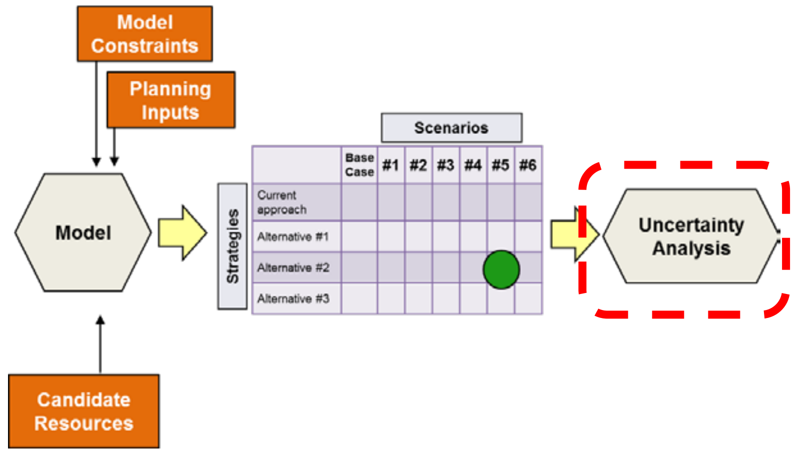


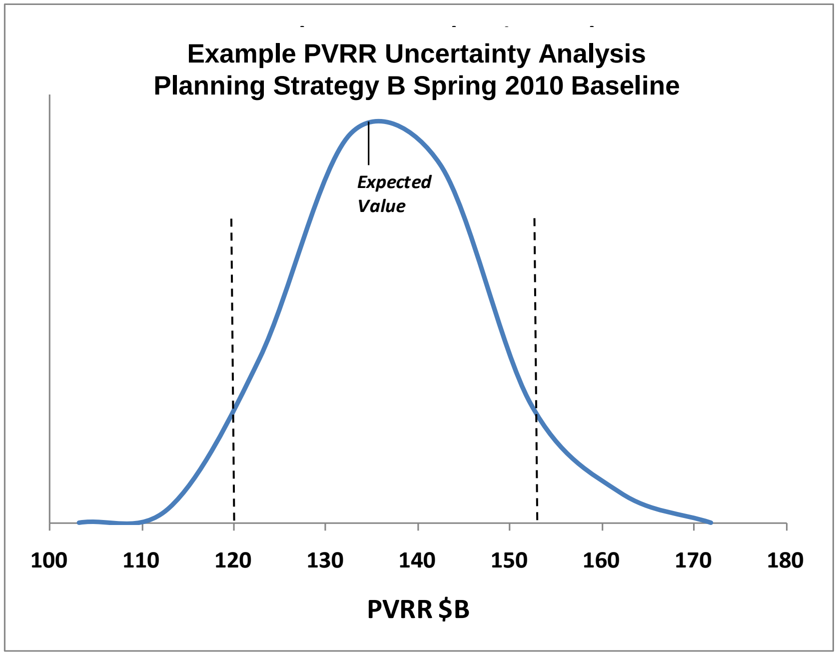

- Year to year changes in resource mix are then evaluated and infeasible “states” are eliminated
  - For example, if the total number of resources decreased from one year to the next, that state is deemed infeasible and eliminated from further consideration

- The least cost (i.e., lowest PVRR) path through the possible states in the study period is the optimized capacity plan
  - The model actually solves two separate but linked objective functions: on an annual basis the model identifies the combination of resources with the lowest cost; over the study period, the model retains each annual least cost feasible combination and maps a path that connects each least cost state to produce a resource plan

# Uncertainty Analysis

- Detailed analysis of operating costs and related characteristics are needed when selecting a preferred resource plan
  - An hourly production costing model is used to compute those costs for plan evaluation/comparison
- The optimized capacity plans selected by the capacity planning model are inputs to production cost and financial analysis
  - Consistent assumptions are used in the capacity planning and production cost models
- A separate model estimates probability distributions of potential outcomes by allowing for simultaneous "random-walking" variation in many inputs over time to better simulate future uncertainty and evaluate risk
- A representative probability distribution comprised of 72 randomly drawn iterations is developed for each of the portfolios
  - An example stochastic result for planning is shown to the right
  - If the study matrix is 5 scenarios x 5 strategies, then a total of 1,800 cases will be generated (25 x 72)



*Overview of the modeling Process*

# Capacity Planning Results Framework

- The scenario planning approach applied to the IRP, and the modeling that supports it, will generate a substantial amount of data and results; for example:
  - Total portfolios = 25 (5 scenarios x 5 planning strategies); these portfolios represent the base case resource plan in each scenario using expected forecasts and cost assumptions
  - Total stochastic iterations = 1,800 (72 iterations x 25 portfolios); each stochastic iteration is a full 20-year resource plan developed under a different set of uncertainty variables for a given scenario

- A set of key metrics is selected prior to case modeling to represent the characteristics that are deemed most important to decision-makers; these metrics are used to identify the "preferred" resource plan or general planning direction
  - Metrics typically include cost and risk factors along with other indicators that reflect important aspects of the TVA mission, such as stewardship and economic development
  - The results of the iterations from the probability modeling are used to produce the metrics
  - These indicators are combined into a scorecard – one for each strategy being studied.
  - The design of the scorecard is based on recommendations from stakeholders and guidance from TVA executive management

- Strategy scorecards are an effective method to summarize the large volume of actual case data and enable dialog among stakeholders about trade-offs that could be considered when identifying the preferred resource plan
  - The working group will be reviewing case details in addition to the strategy scorecards

# TVA's Process for Building Strategies

**1** Brainstorming – resource mix goals & objectives ↓↑ Identification of key attributes

- The key questions in developing our list of potential strategy attributes are
  - Is this attribute something we want to evaluate in this IRP?
  - Is this attribute something we need to define? Or can this aspect of the resource portfolio be an outcome of the modeling?
  - Does this attribute capture an existing policy of TVA?
  - Does this attribute capture work done outside the IRP to meet goals or objectives of TVA?

**2** Development of strategies using the attributes

- Describe the intent of each candidate strategy by defining the "value" of each attribute for that strategy

---

**3** Review candidate strategies for robustness & feasibility

- Review attributes within the strategy for correlation; also compare attribute variability across all candidate strategies to ensure robust resource portfolios will be possible
  - Discuss draft strategies with stakeholders, collect their input and ranking

**4** Determine list of proposed planning strategies

- TVA selects a short list of strategies to be modelled
  - Define each of the proposed planning strategies including objectives and key characteristics

# During the February Session, TVA Proposed 10 Strategy Attributes

| Attributes | Description |
|---|---|
| Existing Nuclear | Constraints related to the existing nuclear fleet; EPU's are considered part of existing nuclear |
| Nuclear Additions | Limitations on technologies and timing related to the addition of new nuclear capacity; Watts Bar 2, SMRs, A/P 1000s and BLN are considered in this category |
| Existing Coal | Constraints related to the existing coal fleet; the current schedule plan of coal unit idling is considered as an input |
| New Coal | Limitations on technology and timing on new coal-fired plants; includes CCS on conventional coal plus IGCC technology |
| Gas Additions | Limitations on technologies and timing related to the expansion options fueled by natural gas (CT, CC) |
| EEDR | Considers energy efficiency and demand response programs that are incentivized by TVA and/or LPC's (excludes impacts from naturally occurring efficiency/ conservation) |
| Renewables (Utility Scale) | Limitations on technologies and timing of renewable resources; considers options that would be pursued by TVA or in collaboration with LPC's |
| Purchased Power Agreements (PPA) | Level of market reliance allowed in each strategy; no limitation on the type of energy source (conventional or renewable) |
| DG/DER | Includes customer-driven resource options or third party projects that are distributed in nature |
| Transmission | Type and level of transmission infrastructure required to support resource options in each strategy |

# TVA Also Proposed Eight Strategies

| STRATEGY | DESCRIPTION |
|---|---|
| **A - "Traditional" Least Cost Planning** | • All resource options available for selection; traditional utility "least cost optimization" case |
| **B- Meet an Emission Target** | • Resources selected to create lower emitting portfolio instead of focusing only on a traditional least cost approach<br>• This lower emissions plan will be based on an emission rate target or level using CO2 as the emissions metric (the target will be set as a reduction from current emissions forecast)<br>• Additional existing unit retirements may be included in the plan. |
| **C - Lean on the Market** | • Most new capacity needs are met using market resources and/or third-party assets acquired through PPA or other bilateral arrangements<br>• TVA makes a minimal investment in owned assets (deployment of EEDR to meet resource needs will continue) |
| **D – Do Gas Only** | • Allows only gas-fired resource expansion after WBN2 unit comes online. Allowed EEDR contribution based only on EPA requirements |
| **E - Doing More EEDR** | • In order to establish TVA as a regional energy efficiency leader, a majority of capacity needs are met by setting an annual energy target for EEDR (e.g., minimum contribution of 1% of sales)<br>• Renewable energy and gas are secondary options with no coal or nuclear additions permitted |

# TVA Also Proposed Eight Strategies (Cont'd)

| STRATEGY | DESCRIPTION |
|---|---|
| **F – Embracing Renewables (*)** | • In order to establish TVA as a regional renewable leader, a majority of new capacity needs are met by setting immediate and long-term renewable energy targets (e.g., 20% by 2020 and 35% by 2040), including hydroelectric energy<br>• A utility-scale approach is targeted initially with growing transition to distributed generation as the dominant renewable resource type by 2024<br>• EEDR and gas are secondary options with no coal or nuclear additions permitted |
| **G - Energy-Water Nexus** | • Reducing water use becomes a higher priority in resource planning<br>• Mitigate energy resource risk due to water dependence and promote integrated resource stewardship by restricting energy resource and cooling system technologies to options with lower water impacts with preference for air-cooled methods<br>• Additionally, preferentially target energy efficiency efforts in local water treatment infrastructure |
| **H - No Nuclear** | • Pursue an orderly, but prompt, shutdown of the current nuclear fleet<br>• WBN2 allowed to go commercial as part of a bridging strategy to facilitate early shutdown of older nuclear units<br>• Development work is terminated at BLN |

* Note: This strategy has been renamed

# Strategies & Portfolios: An Example from the 2011 IRP

This table summarizes the attribute values developed for Strategy C from the 2011 IRP Study. These assumptions and other constraints are combined with the other inputs (unit data) for the optimization model runs

| Attributes | Strategy C<br>Diversity Focused Resource Portfolio |
|---|---|
| EEDR | 3,600 MW & 11,400 annual GWh reductions by 2020 |
| Renewable Additions | 2,500 MW & 8,600 GWh competitive renewable resources or PPAs by 2020 |
| Fossil Asset Layup | 3,200 MW total fleet reductions by 2017 |
| Energy Storage | Add one pumped-storage unit |
| Nuclear | First Unit online no earlier than 2018<br><br>Units at least 4 years apart |
| Coal | New coal units are outfitted with CCS<br><br>First unit online no earlier than 2025 |
| Gas-Fired Supply (Self-Build) | Meet remaining supply needs with gas-fired units |
| Market Purchases | Purchases beyond current contracts and contract extensions limited to 900 MW |
| Transmission | Increase transmission investment to support new supply resources and ensure system reliability<br><br>Pursue inter-regional projects to transmit renewable energy |

Defined model inputs | Optimized model inputs

When the strategy is tested in a scenario, the result is a schedule of resource additions over the study period, called a resource portfolio. The table to the right shows the portfolio for Strategy C in Scenario 1 (high growth) from the 2011 IRP.

| Year | Defined Model Inputs | | | |
|---|---|---|---|---|
| | EE/DR | Renew-ables | Fossil Layups | SC1 |
| 2010 | 298 | 35 | - | PPA's & Acq |
| 2011 | 389 | 48 | (226) | |
| 2012 | 770 | 145 | (226) | JSF CC |
| 2013 | 1,334 | 286 | (935) | |
| 2014 | 1,596 | 442 | (935) | NE MS CT |
| 2015 | 2,069 | 515 | (3,252) | GL CT Ref CT JOF CC |
| 2016 | 2,537 | 528 | (3,252) | CT |
| 2017 | 2,828 | 715 | (3,252) | |
| 2018 | 3,116 | 768 | (3,252) | BLN1 |
| 2019 | 3,395 | 822 | (3,252) | |
| 2020 | 3,627 | 883 | (3,252) | BLN2 PSH |
| 2021 | 3,817 | 896 | (3,252) | CT |
| 2022 | 3,985 | 911 | (3,252) | CC |
| 2023 | 4,143 | 922 | (3,252) | CC |
| 2024 | 4,295 | 935 | (3,252) | NUC |
| 2025 | 4,412 | 942 | (3,252) | IGCC |
| 2026 | 4,502 | 947 | (3,252) | NUC |
| 2027 | 4,561 | 948 | (3,252) | CT |
| 2028 | 4,602 | 953 | (3,252) | CT |
| 2029 | 4,638 | 954 | (3,252) | IGCC CT |

# Questions and Comments Presented by the IRPWG

For clarity purposes, we have classified the questions and comments received for the IRPWG on Strategy Design in the following categories (*):

1. **Modeling Methodology and Approach**
   - *What is the objective function of the optimization model? Is it "PVRR" or "risk adjusted PVRR?*
   - *Metrics need to be understood by the IRP working group, and TVA needs to resolve any major issues before selecting strategies*
2. **Proposed Strategies Design**
   - *Some of the strategies (Lean on the Market, Do Gas Only, No Nuclear) seem better considered as sensitivities*
   - *In strategy D, as with Strategy C, the "Existing Coal" attribute should pay special attention to the additional investments that will be required to meet environmental regulations and clean air goals*
3. **General Model or Resource Attributes**
   - *What is the "current fleet strategy"?*
   - *Will the model be allowed to select coupled storage as a resource in all strategies?*
4. **Specific Values for Model or Resource Parameters**
   - *If an annual EEDR portfolio in excess of 1% per year is selected in Strategy A, then what will Strategy E accomplish?*

- **During today's session we will explain in detail the modeling process, how resources and metrics will be considered as well as doing a new review of the proposed strategies**
- **All questions should be answer during the March, April and May sessions**

* Note: The questions on this slide are just examples, a full list of the questions received is included in the Appendix

# Initial Ranking Results by IRPWG

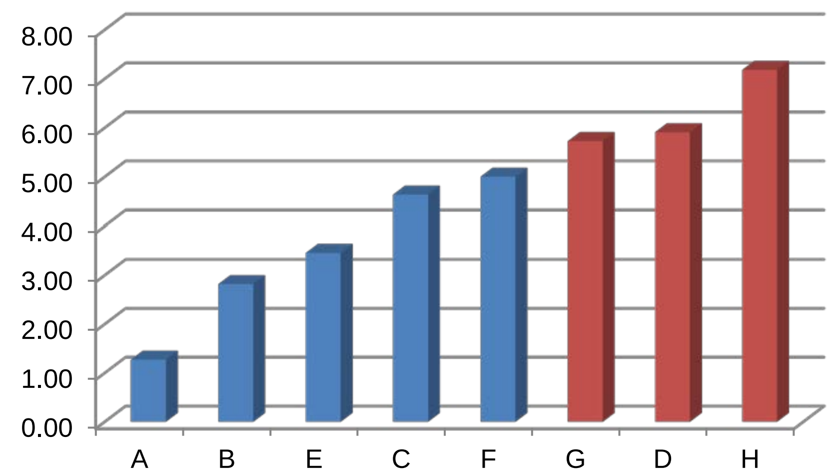
- The histogram below summarizes the rankings performed by the stakeholders of the 8 strategies proposed during the February session
  - The maps report the number of occurrences of each rank for each of the strategies - for example, in the IRPWG table, strategy A was ranked #1 nine times; strategy H was ranked last eight times
- The Average Rank Order is calculated as the sum of ranking values (between 1 and 8) received by a particular strategy divided by the number of people performing the ranking (16 in the case of IRPWG)
  - Since strategies are ranked with values between 1 and 8, the lower the Average Rank Order reflects a higher preference for a particular strategy

***Histogram Map – Sum of Occurrences by Rank Order*** (*)

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | 9 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1 | 5 | 1 | 0 | 2 | 1 | 1 | 0 |
| 3 | 1 | 3 | 1 | 1 | 5 | 0 | 0 | 0 |
| 4 | 0 | 1 | 1 | 1 | 1 | 4 | 2 | 1 |
| 5 | 0 | 0 | 2 | 2 | 3 | 1 | 2 | 1 |
| 6 | 0 | 0 | 4 | 2 | 0 | 3 | 1 | 1 |
| 7 | 0 | 1 | 1 | 4 | 0 | 2 | 3 | 0 |
| 8 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 8 |

| | |
|---|---|
| *A* | *"Traditional" Least Cost Planning* |
| *B* | *Meet an Emission Target* |
| *C* | *Lean on the Market* |
| *D* | *Do Gas Only* |
| *E* | *Doing More EEDR* |
| *F* | *Embracing Renewables* |
| *G* | *Energy-Water Nexus* |
| *H* | *No Nuclear* |

***Strategies Average Rank Order***




- The IRPWG show a strong preference for strategies A, B and E and a strong non preference for G , D and H
- Strategies C and F show a similar preference

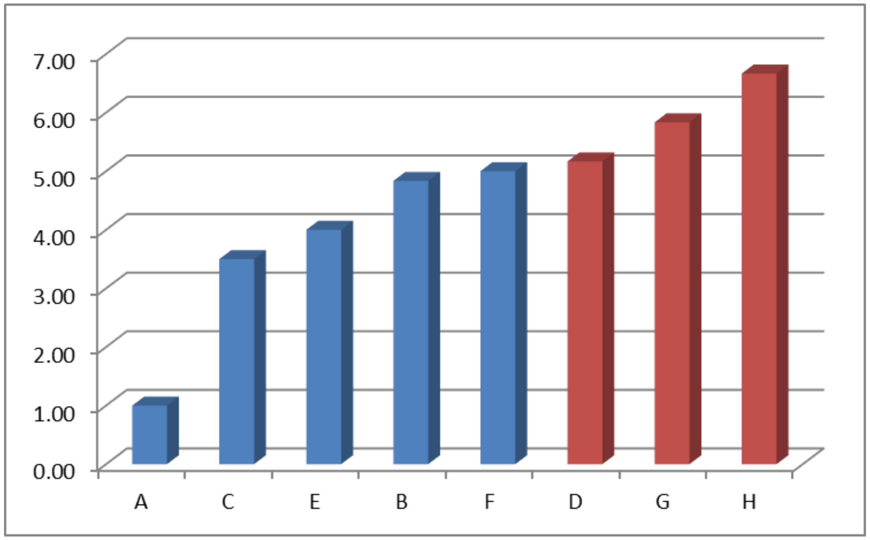
* Note: The IRPWG results are based on 11 of 18 members participating. The TVA results are based 6 members participating.

# Initial Ranking Results by TVA

***Histogram Map – Sum of Occurrences by Rank Order*** (*)

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 2 | 3 | 0 | 1 | 0 | 0 | 0 |
| 3 | 0 | 0 | 1 | 2 | 2 | 1 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 1 |
| 5 | 0 | 1 | 1 | 1 | 0 | 0 | 2 | 1 |
| 6 | 0 | 2 | 0 | 1 | 0 | 0 | 3 | 0 |
| 7 | 0 | 0 | 1 | 2 | 0 | 1 | 1 | 1 |
| 8 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 3 |

***Scenarios Average Rank Order***



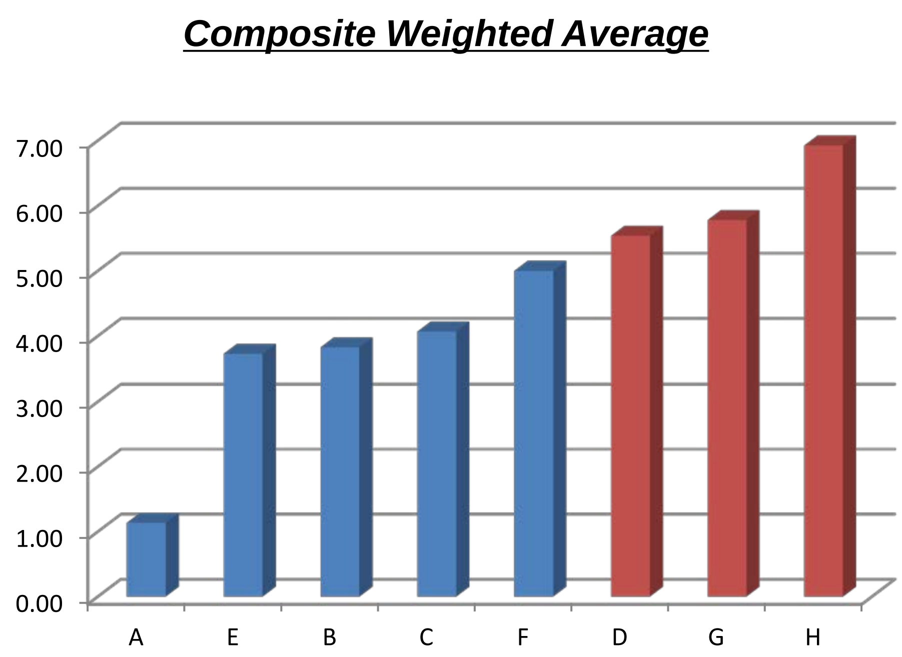

| | |
|---|---|
| *A* | *"Traditional" Least Cost Planning* |
| *B* | *Meet an Emission Target* |
| *C* | *Lean on the Market* |
| *D* | *Do Gas Only* |
| *E* | *Doing More EEDR* |
| *F* | *Embracing Renewables* |
| *G* | *Energy-Water Nexus* |
| *H* | *No Nuclear* |

- TVA show a strong preference was shown for strategies A, C and E and a strong non preference for G and H
- Strategies B, D and F show a similar preference
- There is a consensus with the IRPWG on the top 5 strategies

* Note: The IRPWG results are based on 11 of 18 members participating. The TVA results are based on 6 members participating.

# Initial Composite Ranking Results

- The graphics below show the composite results considering the rankings from the 17 participants (11 IRPWG and 6 TVA )
- The Weighted Average score is based on a 50/50 split between IRPWG and TVA




| | |
|---|---|
| *A* | *"Traditional" Least Cost Planning* |
| *B* | *Meet an Emission Target* |
| *C* | *Lean on the Market* |
| *D* | *Do Gas Only* |
| *E* | *Doing More EEDR* |
| *F* | *Embracing Renewables* |
| *G* | *Energy-Water Nexus* |
| *H* | *No Nuclear* |

- The composite ranking shows a strong preference for strategy A and an strong non-preference for strategies D, G and H
- Once again, there is consensus around the top 5 ranking strategies

* Note: The IRPWG results are based on 11 of 18 members participating. The TVA results are based on 6 members participating.

# Additional Strategies Proposed by the IRPWG

- Following the February session, TVA received two suggested strategies along with the preliminary ranking results. These strategies were offered by SACE:
  - "More Predictable Rates"
  - "Distributor-Led Resources"

- In addition to these strategies, Sierra Club had previously proposed a scenario that was actually a strategy:
  - Sierra Club Scenario – Coal Retirements, Clean Energy Replacement, Aggressive Efficiency

- These strategies will be discussed by the full working group and considered for inclusion as candidate strategies for the IRP
  - TVA has also reviewed these proposed strategies and will offer some initial observations

# Proposed Strategy: More Predictable Rates

- We (SACE) are suggesting a strategy to explicitly moderate rate volatility be developed. This strategy would be optimized by setting attributes designed to ensure that rate risks do not exceed a specific level. Specific resources would not be constrained or promoted.

- More predicable rates can be achieved through a resource plan that minimizes metrics related to risks. In the 2011 IRP, TVA created two risk metrics: PVRR Risk/Benefit and PVRR Risk. SACE is recommending a new risk metric be added, described as “climate risk” which would be modeled on the 2011 IRP risk metric, but instead of considering cost outliers driven mainly by fuel cost or load growth as the basis for risk, the cost driver would be an “extreme weather” index score. While there are several technical options for developing a “climate risk” metric, the additional risk metric is designed to ensure that the resulting plan addresses concerns about TVA's long term ability to respond to a changing climate.

# Proposed Strategy: Distributor-Led Resources

- We (SACE) are suggesting that TVA work with distributors to develop a strategy that would identify a range of resources that distributors might develop independently of TVA. This would alter the distributor-TVA relationship in some ways.

- TVA would remain the sole developer and contractor for central station resources, but distributors would have the opportunity to develop local resources in partnership with customers or developers operating within their service territory. Examples might be solar, microgrids, fuel cells, or CHP.

- The specifics of this strategy should be developed by the distributor community if it is supportive. That community should identify what types of resources might be developed, which distributors (i.e., representing what share of TVA load) might participate, and what might be a feasible schedule for such development. Then TVA and the distributors should work together to identify reasonable cost estimates for the resource package.

# Proposed Strategy (Sierra Club): Coal Retirements, Clean Energy Replacement, Aggressive Efficiency

- This scenario represents a commitment by TVA to prioritize reliable power, affordable electric bills, environmental stewardship, resource diversity, economic development, and technological innovation. TVA's baseline demand growth is expected to be 0.7% for the 15 years from 2014-2028. In this scenario, it is assumed that the Watts Bar nuclear plant is completed, but no additional nuclear investments are required.

- In an effort to lower customer's electric bills, decrease environmental footprints, and hedge against fossil fuel price risk, TVA invests sufficient resources to meet the achievable levels of energy efficiency identified by its own analysis conducted by GEP. This amounts to an annual energy savings of 1.1% until 2028. The effective growth rate is reduced to -0.4%.

- In addition to existing requirements pursuant to the consent decree and MATS for TVA to retire, retrofit, or repower coal plants, each TVA coal plant must fully comply with the 1-hour SO2 NAAQS, 316(b) requirements, Effluent Limitations Guidelines, and a commitment to reduce carbon pollution from its system an additional 15% from 2020-2028. This is expected to cause retirements of John Sevier (pre-planning period), Johnsonville by 2015, Colbert by 2016, Gallatin and Shawnee by 2017, Allen by 2018, Widows Creek 7-8 by 2020, Kingston by 2024, and Bull Run by 2027. This amounts to 27,638,667 or 49% of TVA's current coal generation in 2012.

# Proposed Strategy (Sierra Club): Coal Retirements, Clean Energy Replacement, Aggressive Efficiency

- Due to concerns about fuel diversity and fossil fuel price risk, the declining cost of wind and solar, and the commitment to reduce carbon pollution from its system by an additional 15% from 2020-2028, TVA adds sufficient wind and solar to fully replace the generation from the retiring coal plants after increasing energy efficiency is taken into account.
  - EE amounts to a reduction in demand in 2028 of 6.3% relative to 2012 (9,168,459 MWhs).
  - To replace the coal taken offline, there is a rough 80% mix of wind and 20% solar: 4,000 MWs of imported wind (13,315,200 MWhs) and 500 MWs of new builds in the region (1,664,400 MWhs) and 1,897 MWs of new solar (3,490,608 MWhs).

- If new capacity is needed due to the retirements after energy efficiency and the renewable additions are taken into account, TVA first utilizes demand response, followed by highly efficient and flexible ramp rate natural gas combined cycle units. The likely resulting system from TVA includes a nearly even balance of generation from efficiency, wind/solar, hydro, natural gas, nuclear, and coal by 2028: a commitment to true resource diversity. TVA's commitments on economic development are as new industries are created, environmental impacts are significantly reduced, and the investments in energy efficiency and wind/solar as coal and natural gas prices rise from 2020-2028 result in more affordable electric bills for TVA customers. TVA's mandate for technological innovation is met by designing and deploying the organizational and built infrastructure for facilitating western wind and distributive energy.

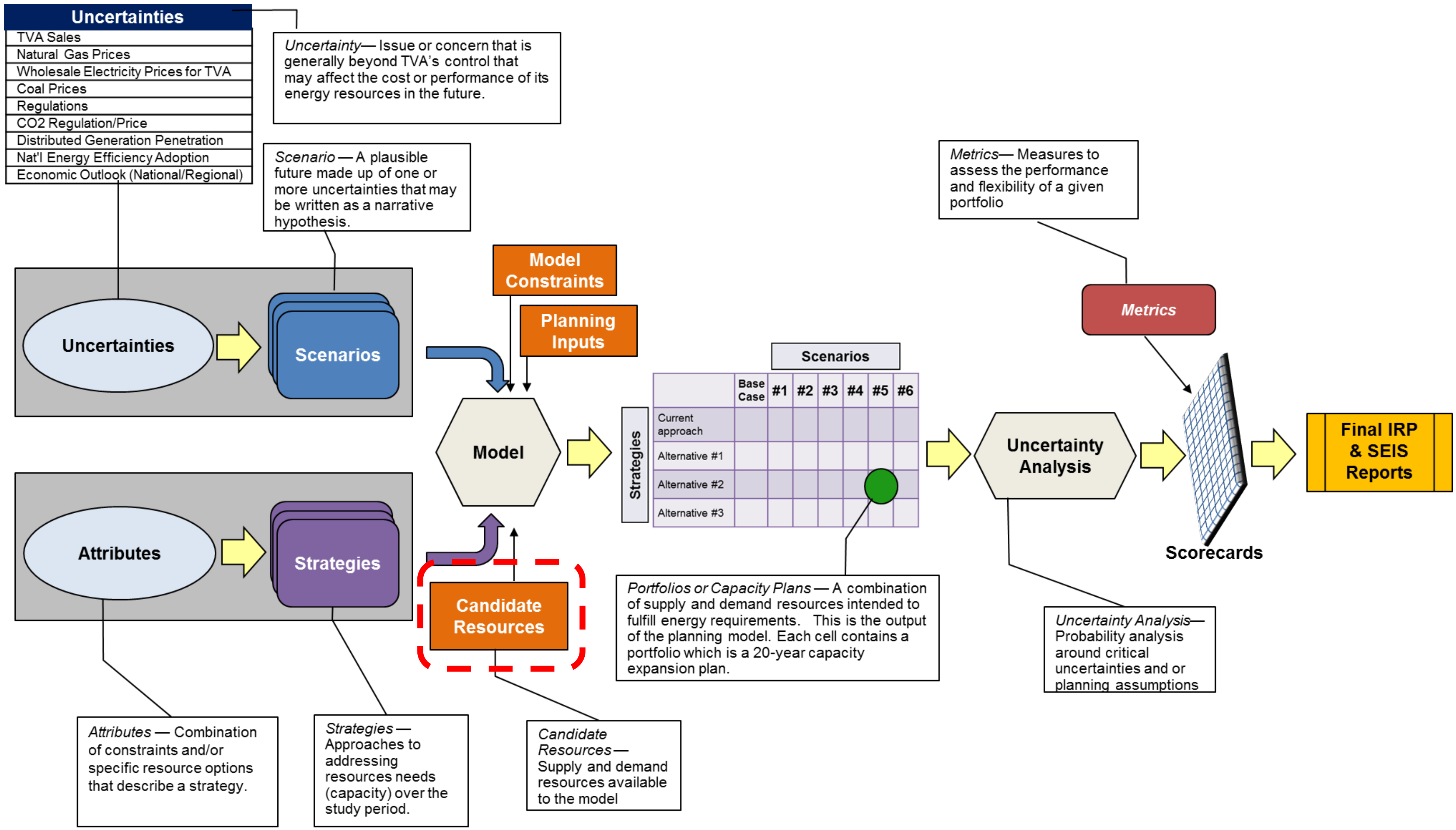
# Summary of IRPWG Proposed Strategies

| Proponent | Strategy | TVA'S RESPONSE |
|---|---|---|
| **Sierra Club** | • Coal Retirements, Clean Energy Replacement, Aggressive Efficiency: This strategy represents a commitment by TVA to prioritize reliable power, affordable electric bills, environmental stewardship, resource diversity, economic development, and technological innovation | • This strategy is aligned with TVA's strategic objectives and should be the end result of the IRP<br>• The proposed strategies are design to identity this end result |
| **"More Predictable Rates" Southern Alliance for Clean Energy** | • A new risk metric should be added, described as "climate risk" which would be modeled on the 2011 IRP risk metric but with the cost driver being an "extreme weather" index score<br>• Specific resources would not be constrained or promoted<br>• The objective will be to optimize the portfolio based on minimizing risk (especially rate volatility) | • Under analysis by TVA<br>• This is more about selection of an evaluation metric than defining a planning strategy<br>• The general objective of the study is to minimize risk consistent with other targets |
| **"Distributor-Led Solutions" Southern Alliance for Clean Energy** | • TVA would remain the sole developer and contractor for central station resources, but distributors would have the opportunity to develop local resources in partnership with customers or developers operating within their service territory<br>• The specifics of this strategy should be developed by the distributor community if it is supportive<br>• That community should identify what types of resources might be developed, which distributors (i.e., representing what share of TVA load) might participate, and what might be a feasible schedule for such development | • This suggestion requires some policy analysis; TVA is considering how this might be included in the planning framework<br>• Some impacts from this concept should be captured in the customer-driven competitive resources scenario (CP1) |

# Feedback from the Working Group

- There is consensus around the preliminary list of strategies proposed by TVA:
  - *A - "Traditional" Least Cost Planning*
  - *B - Meet an Emission Target*
  - *C - Lean on the Market*
  - *E - Doing More EEDR*
  - *F - Embracing Renewables*
- Any additional thoughts on these strategies? On the additional strategies offered by working group members?
- Other questions/comments from the group?

# IRP Methodology: Candidate Resources



# A Wide Variety of Both Supply-Side and Demand-Side Candidate Resources Are Considered for the IRP

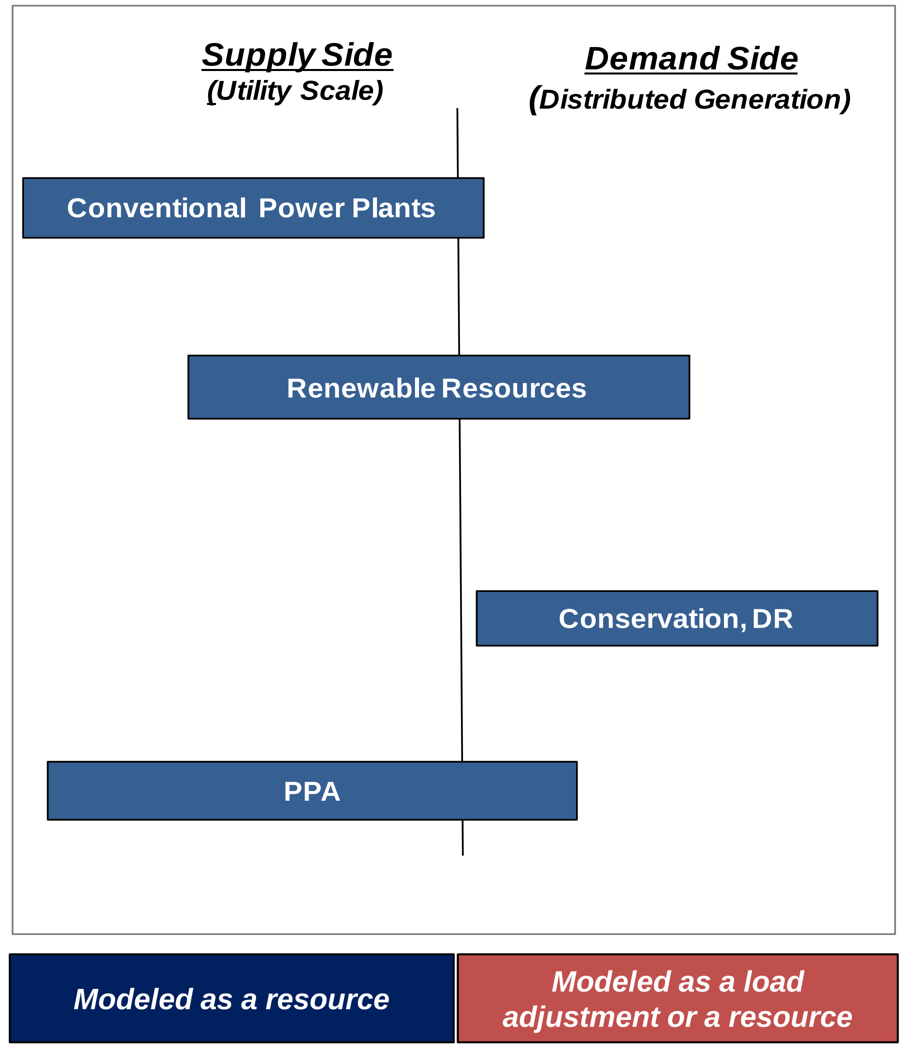
***Candidate Resources Categories***

**Conventional Power Plants**
- Nuclear, coal and gas
- Ranked based on feasibility, technology maturity, and life-cycle cost by type and duty cycle

**Renewable Resources**
- Hydro, wind, solar, biomass and storage resources
- Ranked based on feasibility, technology maturity, and life-cycle cost by type and duty cycle

**Conservation, Demand Management (DR)**
- Energy Efficiency and Demand Response Programs
- End-use generation (DG) options

**Purchase Power Agreement (PPA)**
- Reflects proposals submitted to TVA, from resources of any kind, inside and outside the Valley
- Includes transmission costs and limitations if applicable
- Excludes generic market purchases

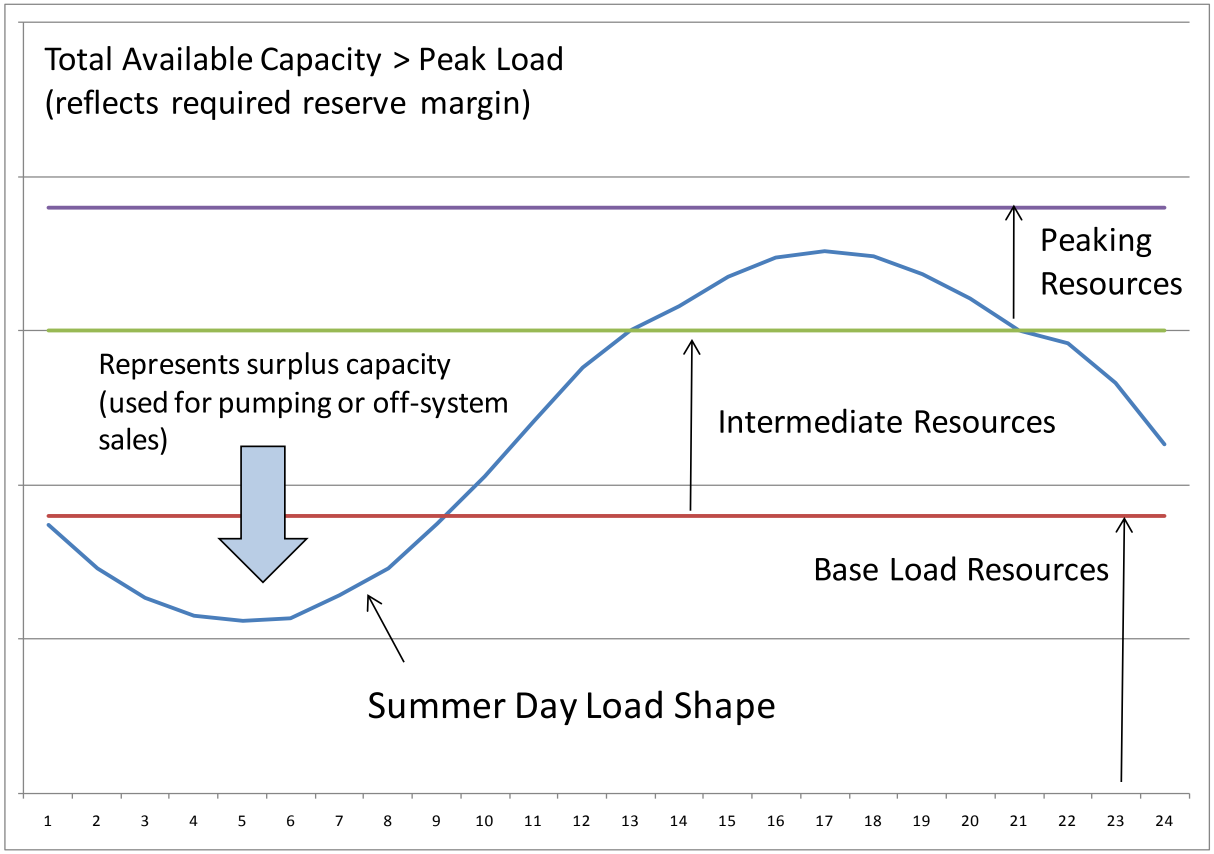



Resource options are evaluated based on multiple criteria:

- Policy considerations
- Technological viability and maturity
- Economic (based on life-cycle cost)

# Understanding Resource Needs

***24 Hours Demand***



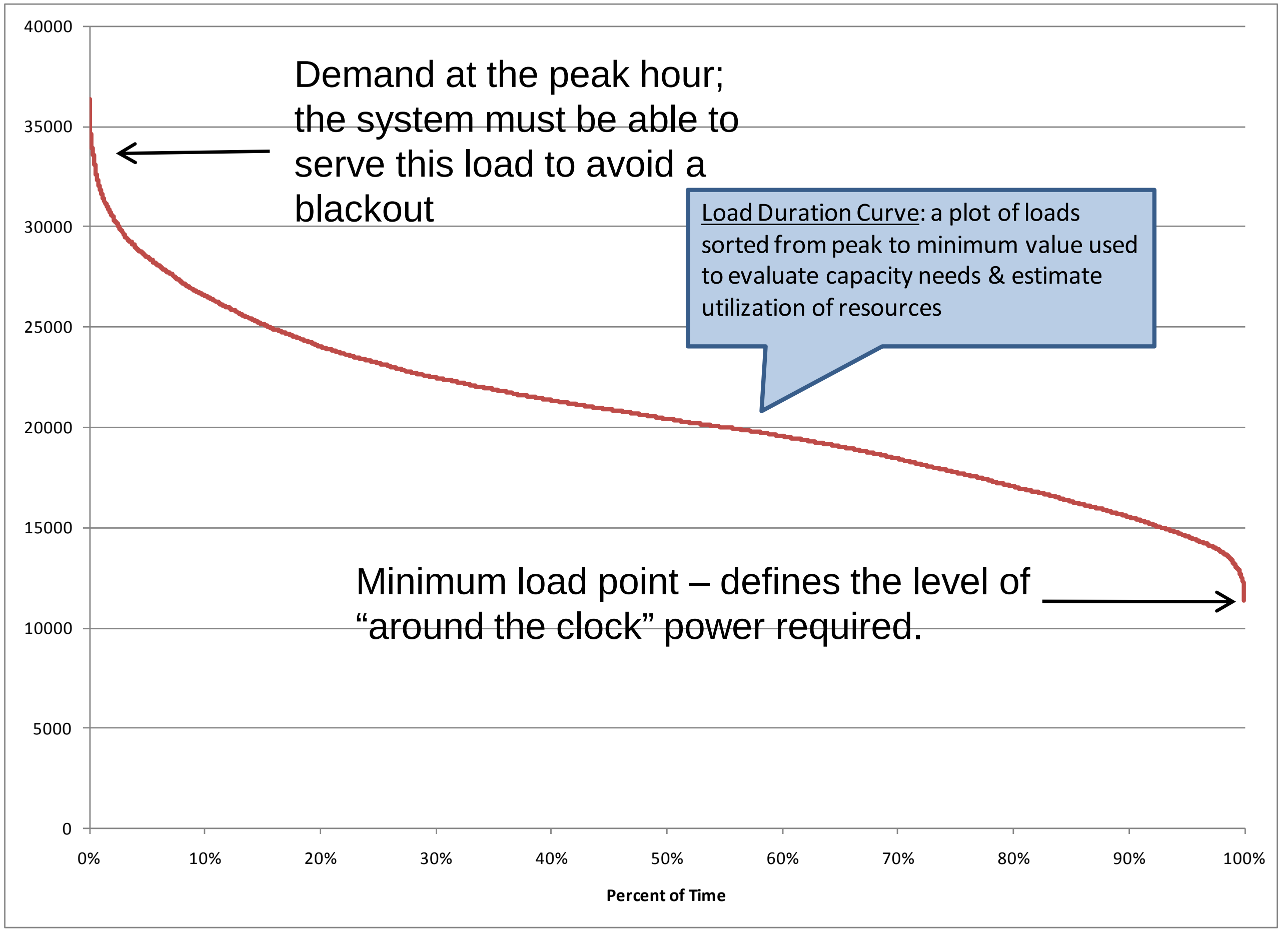

***Types of Resources by Duty Cycle***

- **Base load resources –** lowest overall operating costs (low heat rate and variable cost); units designed to remain online virtually around the clock
- **Intermediate resources –** moderate operating costs and the ability to “swing” with changes in load
- **Peaking resources –** highest operating costs; designed to be used only when loads are highest and other resources already committed

# Another View of System Demand

- A Load Duration Curve is another way to view the load to be served.
- The LDC allows quick assessment of both peak and minimum load and can give a general indication of how much a resource might be utilized based on the number of hours loads are at or above a certain level

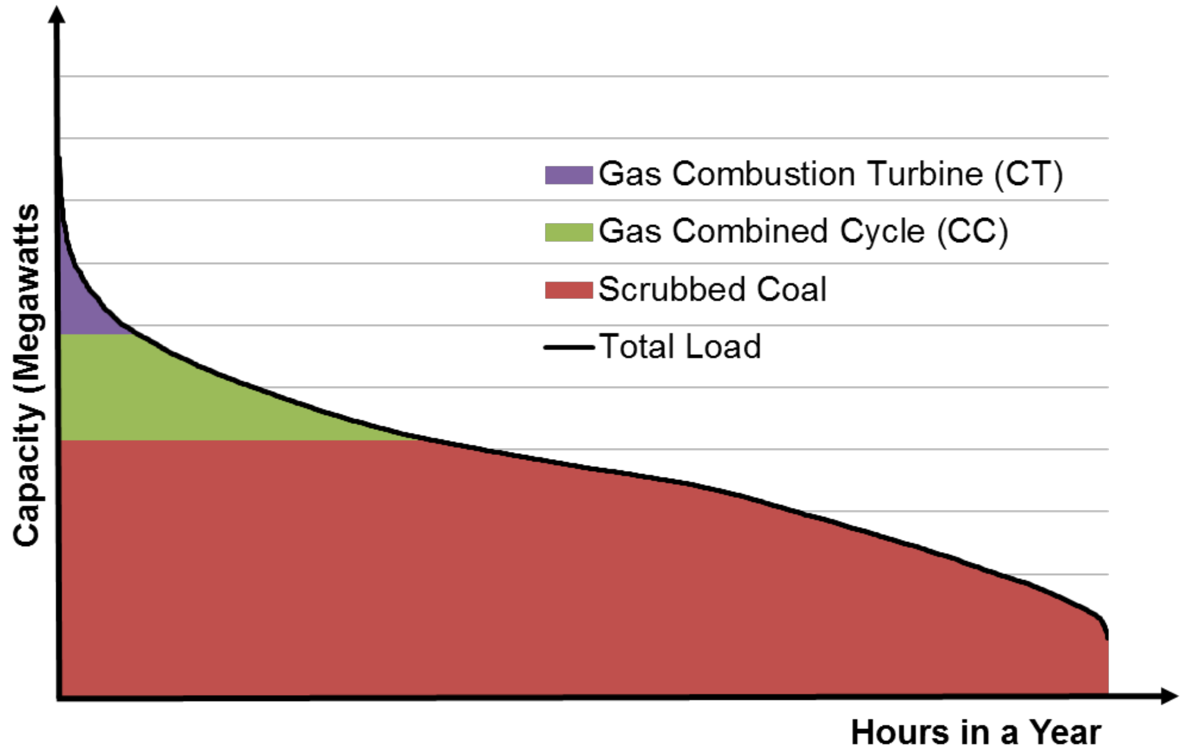
***Load Duration Curve***



# How Operating Cost Impacts Resource Choices

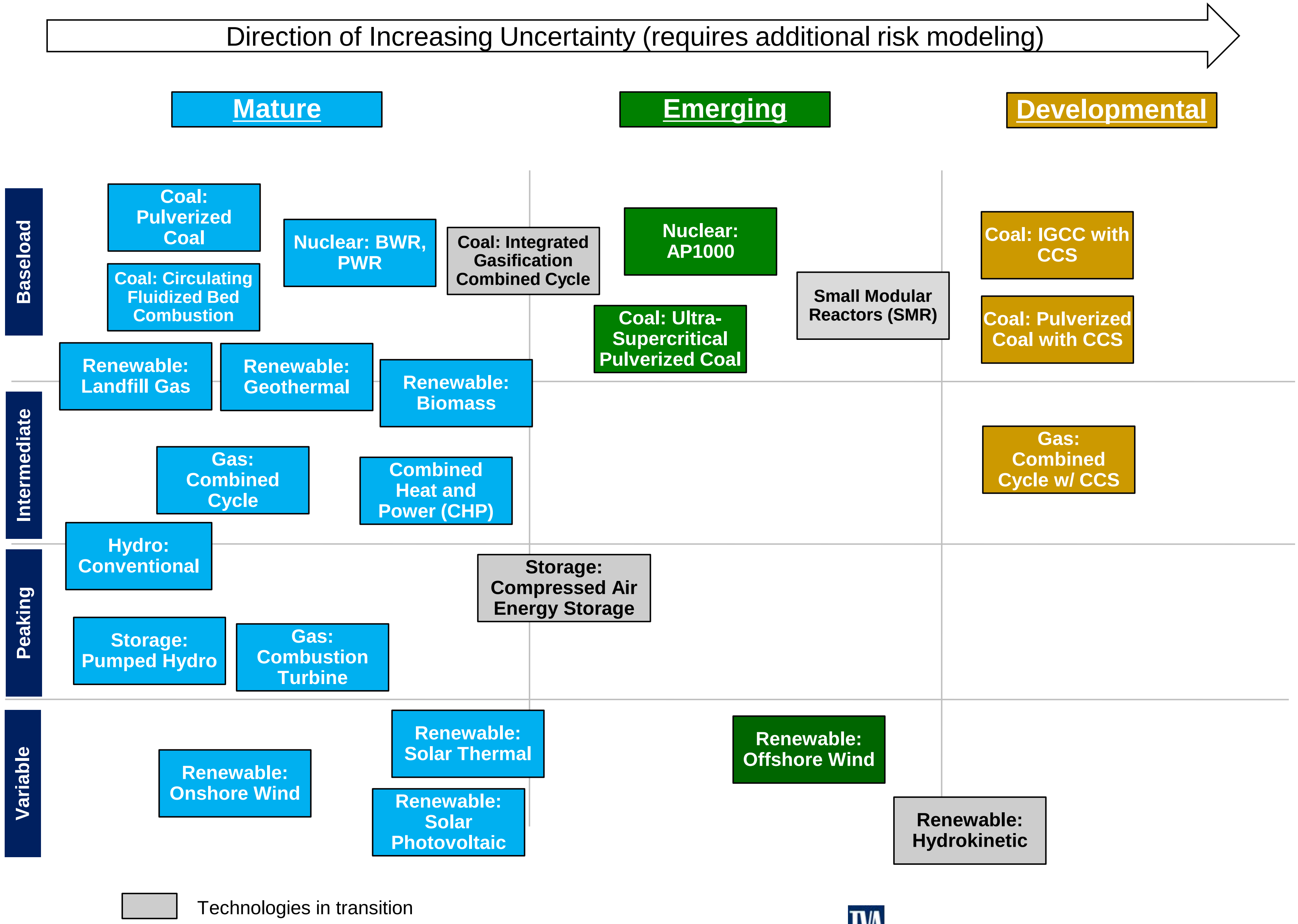
- Load shape is a key factor in selecting the type of resource based on how it will be utilized to meet expected customer demand

- Variables that are needed for operating cost projections include:
  - Unit operating efficiency ("heat rate")
  - Fuel and variable operating costs
  - Unit operating characteristics
  - Commitment/dispatch constraints




- Cost of resources generally classified according to "duty cycle:
  - Baseload Resources : lowest overall operating costs, units designed to remain online around the clock
  - Intermediate Resources : moderate operating costs and high flexibility
  - Peaking Resources : highest operating costs, designed to be used only in peak hours

# Evaluating Technology Maturity is Part of Sound Resource Planning



# Making the "Right" Resource Choice

- To properly evaluate the choice of a resource option in a given year, the model must be able to determine:
  - Capital cost; usually expressed as a "mortgage payment" expense stream over the life of the asset, which includes items like equipment, labor, financing charges, etc
  - Other fixed capital costs; including routine maintenance expenses, firm gas reservation charges, etc.
  - Fuel cost; based on dispatched energy, fuel type/price and fuel conversion efficiency (heat rate)
  - Other variable or production-related expenses; including raw water, waste/wastewater disposal fees, chemicals/catalysts, etc.

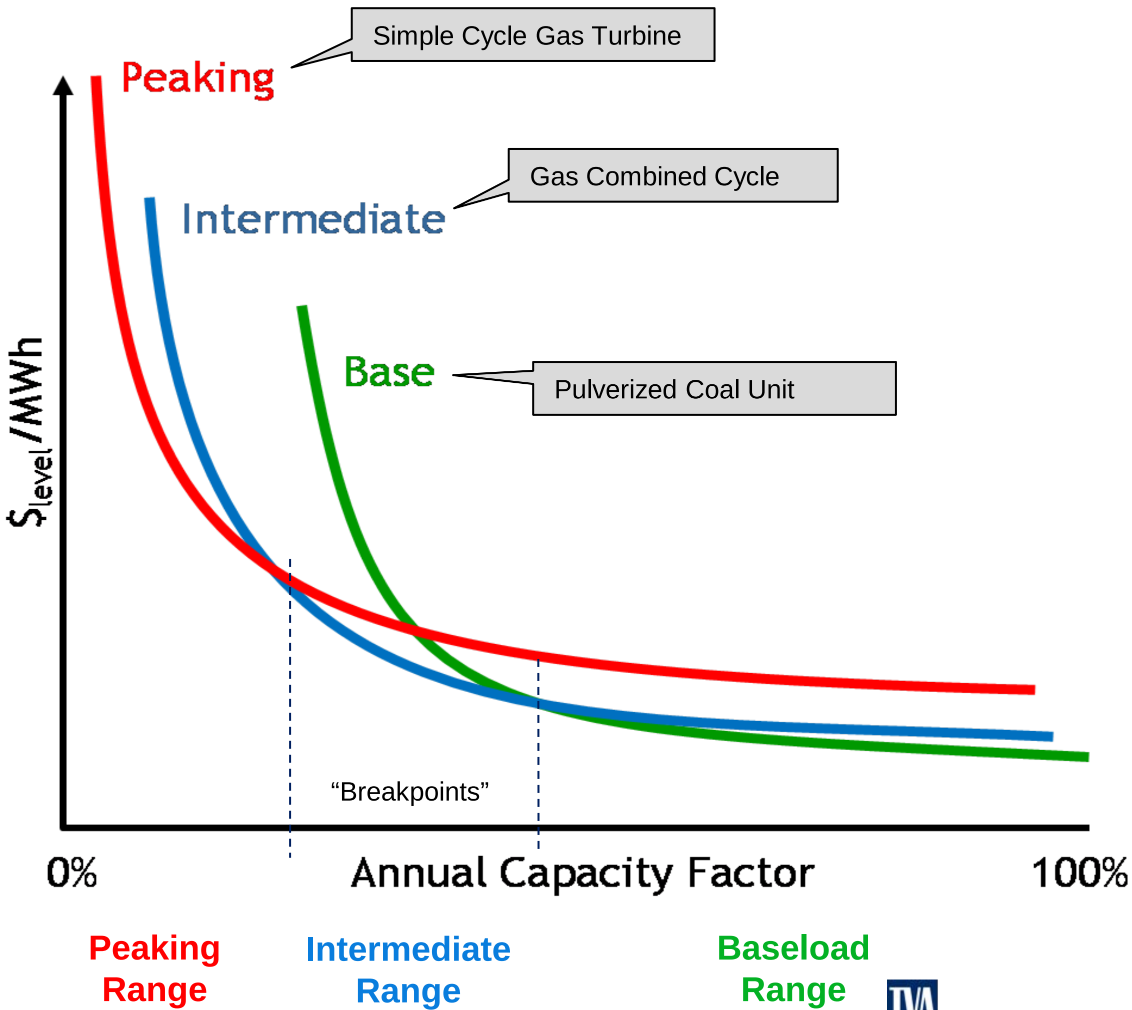
- These costs have to be projected over the duration of the planning study

- If the resource under consideration is a power purchase, the data is different
  - The offer being considered usually includes specifics about capacity amount, price, dispatch limits or must-take levels, variable expenses and duration of the deal
  - The model cannot utilize the power purchase in a way that is inconsistent with the offer

- Sometimes a resource option is energy limited or has a fixed schedule (energy pattern)
  - In those cases, an energy shape is provided to the model and the resource is treated as fixed; that is, the model will not re-dispatch the resource to optimize utilization in combination with other resources
  - TVA's conventional hydro fleet power production is an example of this type of resource; another example might be certain types of renewable options where energy profiles are important; DSM options are currently represented as fixed energy transactions

# Choosing a Resource Depends on Life Cycle Costs

- Resource selection is driven by an unmet need for capacity & energy supply consistent with the characteristics of a given resource
- In evaluating what resource(s) can meet this need, the modeling exercise has to consider the full (life cycle) cost of each resource – the initial capital investment, the ongoing costs to maintain and operate the resource, and any refurbishment or replacement costs over the life of the asset



# Preliminary List of Resources Being Considered for the 2015 IRP

<table>
<tr><th colspan="4">Units Available for Selection</th></tr>
<tr><th>Conventional</th><th>Renewables/Storage</th><th>Conservation/DR</th><th>PPA</th></tr>
<tr>
<td>Coal<br>• Supercritical Pulverized Coal 800/1600 MW<br>• Supercritical Pulverized Coal with CCS 800/1600 MW<br>• IGCC 561 MW<br>• IGCC with CCS 467 MW<br>• Circulating fluidized bed 750 MW<br>• Ultra Supercritical Pulverized Coal 750 MW<br><br>Nuclear<br>• Nuclear AP1000 1117 MW<br>• Small Modular Reactors 334 MW<br>• Bellefonte Units 1&2 (B&W design) 1260 MW each<br>• Electric Power Uprates MW; as identified<br><br>Gas<br>• Combustion Turbine (3x) 590 MW<br>• Combustion Turbine (4x) 786 MW<br>• Combined Cycle (2 on 1) 768 MW<br>• Combined Cycle (3 on 1) 1152 MW</td>
<td>Storage<br>• Pumped Storage 850 MW<br>• CAES 330 MW<br><br>Solar PV Options<br>• Large 1-axis tracking (25MW)<br>• Small fixed tilt (2.5MW)<br>• Large Commercial Rooftop (0.25MW)<br><br>Wind Options<br>• MISO/SPP (200MW)<br>• In-Valley (120MW)<br>• HVDC wind (200MW)<br><br>Biomass Options<br>• Co-firing (25MW)<br>• IGCC (40MW)<br>• New Direct Combustions (50MW)<br>• Repowering (75MW)<br><br>Hydro Options<br>• HMOD (5MW)<br>• Power Dam (30/40MW)<br>• Run-of-River (1MW)</td>
<td>EE Options<br>• Blocks by market segment; variable block size & duration<br>• Fixed portfolios for EPA commitment<br><br>DR Options<br>• Third-party and TVA programs<br>• Modeled as phantom unit (CT)</td>
<td>• Options are based on proposals submitted to TVA from resources inside and outside the Valley and are usually tied to a specific project for a defined term at a negotiated price<br><br>• Transmission costs and import limitations are included in the PPA characteristics, if applicable<br><br>• PPA’s are not screened<br>o They are included in the database as proposed<br>o The model treats these PPA’s as a fixed transaction that can only be selected based on terms defined in the offer<br>o PPA’s cannot be rescheduled or selected in amounts that do not conform to the proposal<br>• Currently evaluating 7/8 contracts</td>
</tr>
<tr><th colspan="4">Fixed or Scheduled Assets</th></tr>
<tr>
<td>• Existing Coal –some units will be evaluated<br>• Existing Nuclear<br>• Existing Gas</td>
<td>• Existing hydro<br>• Existing pumped storage<br>• Existing Renewable PPAs (Wind, RSO, LFG, SEPA, etc)<br>• End use generation programs<br>• Existing solar</td>
<td>• Existing EEDR programs<br>• Interruptible programs<br>• In –house interruptible programs</td>
<td>• Non-renewable existing PPAs ( Red Hills, DEC, diesels, etc)</td>
</tr>
</table>

*Note: grayed-out resources are still under review (sourced from TVRIX, EEIX)*

# *IRP Benchmark*

# Screening of Peers' Generation Alternatives

| Technology Evaluated for Planning Purposes | DEC 2013 | FPL 2013 | GPC 2012 | PCQ 2013 | PEC 2012 | DOM 2013 | ETR 2012 | APS 2012 |
|---|---|---|---|---|---|---|---|---|
| ***Coal Fired*** | | | | | | | | |
| Circulating Fluidized Bed ("CFB") | | | X | | | X | ✓ | |
| Pulverized Coal | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| IGCC | | | ✓ | ✓ | X | ✓ | | X |
| ***Gas Fired*** | | | | | | | | |
| Gas Fired Combustion Turbine | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Gas-Fired Combined Cycle | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Internal Combustion Reciprocating | | | X | ✓ | | | | |
| Small Scale Aeroderivitives | | | | | | | ✓ | |
| ***Nuclear*** | | | | | | | | |
| Nuclear | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X |
| Nuclear Fusion | | | | | | X | | |
| Small Modular Reactors ("SMR") | X | | | | | X | | |
| ***Renewables*** | | | | | | | | |
| Biomass | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Concentrating Solar | | | ✓ | ✓ | | X | | X |
| Fuel Cell | X | | ✓ | | X | ✓ | | |
| Geothermal | X | | X | ✓ | | X | | ✓ |
| Hydro | | | | | X | X | | |
| Landfill Gas | | | ✓ | | ✓ | | | |
| Offshore Wind | X | | ✓ | ✓ | X | ✓ | | |
| Onshore Wind | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Poultry and swine waste digesters | X | | | | | | | |
| Solar PV | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tidal and Wave Power | | | ✓ | | | X | | |
| ***Storage*** | | | | | | | | |
| Battery | X | | ✓ | | | X | | ✓ |
| Compressed Air | X | | ✓ | | | X | | ✓ |
| Flywheel | | | X | ✓ | | X | | |
| Pumped Storage | | | ✓ | | | | | |

FPL: Detailed Screening Information Not Available

✓ = Resource was evaluated and included in the planning process
X = Resource was evaluated and excluded from the planning process

**Observations:**

- Only APS excluded nuclear as a potential generation alternative
- Evaluation of renewables was mixed, but most companies included biomass, solar PV, and onshore wind
- Storage resources were not heavily considered
- Technologies included most often by category are:
  - Coal: pulverized coal
  - Gas: combined cycle and combustion turbine
  - Nuclear: traditional nuclear
  - Renewables; biomass, Wind, Solar PV
  - Storage: batteries, compressed air

# Primary Resource Database Records

| Data Categories | Contents |
|---|---|
| **Expansion Parameters** | First month available, first/last year available, min/max annual units, max cumulative units |
| **Capacity Data** | Summer/winter total capacity (MW), planning capacity factor, min capacity (MW) |
| **Capital Cost** | Total capital cost (MM$), overnight capital cost, transmission costs, AFUDC rate, non-escalated construction spend, escalation rate, book & service life, capital cost with AFUDC ($/kW), capital recovery factor |
| **Fixed & Variable Costs** | Variable O&M rate ($/MWh), fixed O&M rate ($/kW-yr), firm gas charge, escalation rates |
| **Fuel Data** | Fuel type, fuel cost ($/MMBtu), fuel transportation, escalation rates |
| **Outage & Maintenance Data** | Forced and planned outage rates |
| **Heat Rate Data** | Summer & winter full-load heat rate (Btu/kWh) |
| **Energy Limits (Thermal)** | Max daily, monthly and annual energy, energy pattern |
| **Emission Control Factors** | % control for SO2, NOx, CO2, Hg |
| **Max Emission Rates** | For SO2, NOx, CO2, Hg |

# Resource Assumptions Due Diligence

- Input data for each resource type of resource will be evaluated for reasonableness
  - TVA will be engaging a third party to assess the input data and compare to other sources
  - This benchmarking task is similar to an effort undertaken in the 2011 IRP

- The results of this assessment will be presented to the stakeholders for comment prior to the start of modeling
  - Stakeholders with executed NDA's will be able to see estimates for key resource characteristics

**Resource data and benchmarking results are scheduled for review during the April & May stakeholder sessions**

# 2015 Integrated Resource Plan

IRPWG Meeting

Session 5 – Day 2

March 28, 2014

# Recap of Day 1

**Update on the Scoping Report**

Overview of TVRIX and EEIX Teams

Overview of the modeling Process

2015 IRP Strategy Design – Comments and Initial Ranking Results

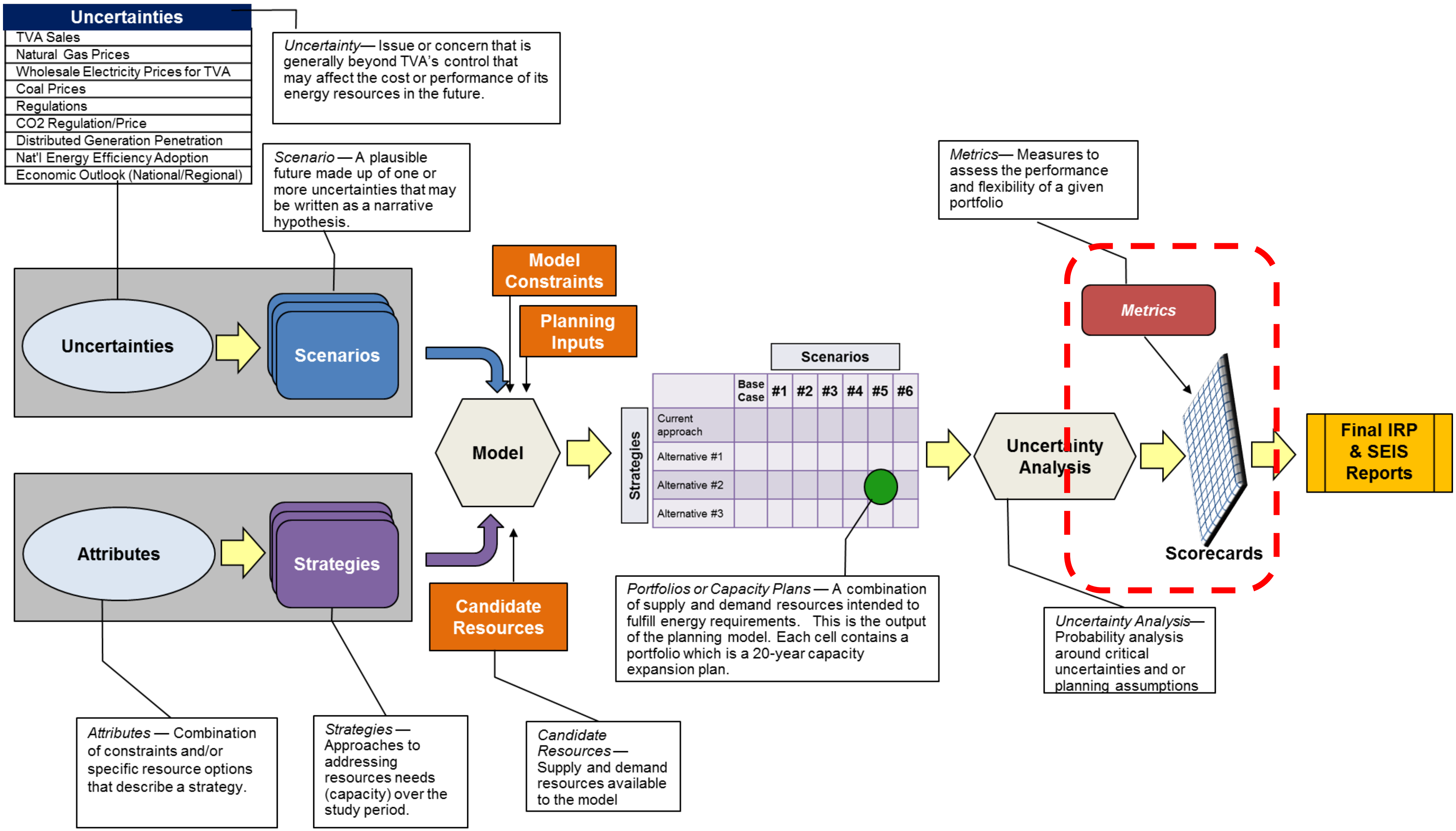
Overview of Resource Options

Comments or Observations from yesterday?

# IRPWG Meeting – March Agenda (Day 2)

| | | |
|---|---|---|
| 8:30 | Overview of IRP Metrics and Score Cards | Gary Brinkworth |
| 10:00 | Break | |
| 10:15 | IRP Benchmarking: modeling Process and Metrics | Jose Salas |
| 10:45 | Overview of 2015 IRP EIS Scope | Chuck Nicholson |
| 11:15 | Next Steps and Wrap-up | Joe Hoagland |
| 11:30 | Lunch | |

# IRP Methodology: Metrics and Scorecards



# IRP Studies: Drowning in a Sea of Information

- An IRP study can produce an overwhelming amount of case data
  - In TVA's 2011 IRP Study, we evaluated over 3,000 simulations
- How do you begin to sort out all that data and identify the preferred resource plan?
- What sort of ranking or filtering algorithm would you employ?
  - Present value of revenue requirements?
  - Risk tolerance?
  - P/L ratio or other balance sheet indicator?
  - All of these?
- How do you engage stakeholders and decision-makers in the plan selection process?

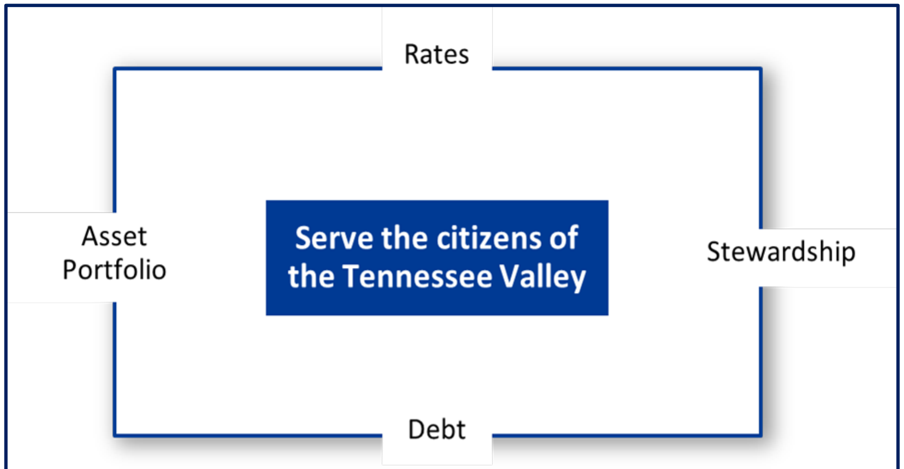
# Good, Better, Best: Choosing the Right Resource Plan

- The challenge is not insufficient data, but rather sorting through all the results to identify the preferred resource plan
- So how do you know when the plan is “good”? When is it “best” or “preferred”?
- And who decides that? Are the decision-makers well-grounded in the fundamentals of resource planning? In the assumptions and uncertainties around input data? Will stakeholder opinions be considered in the final selection of a resource plan?
- The solution to this dilemma is – METRICS!

# Metrics Facilitate Plan Selection Consistent With Goals

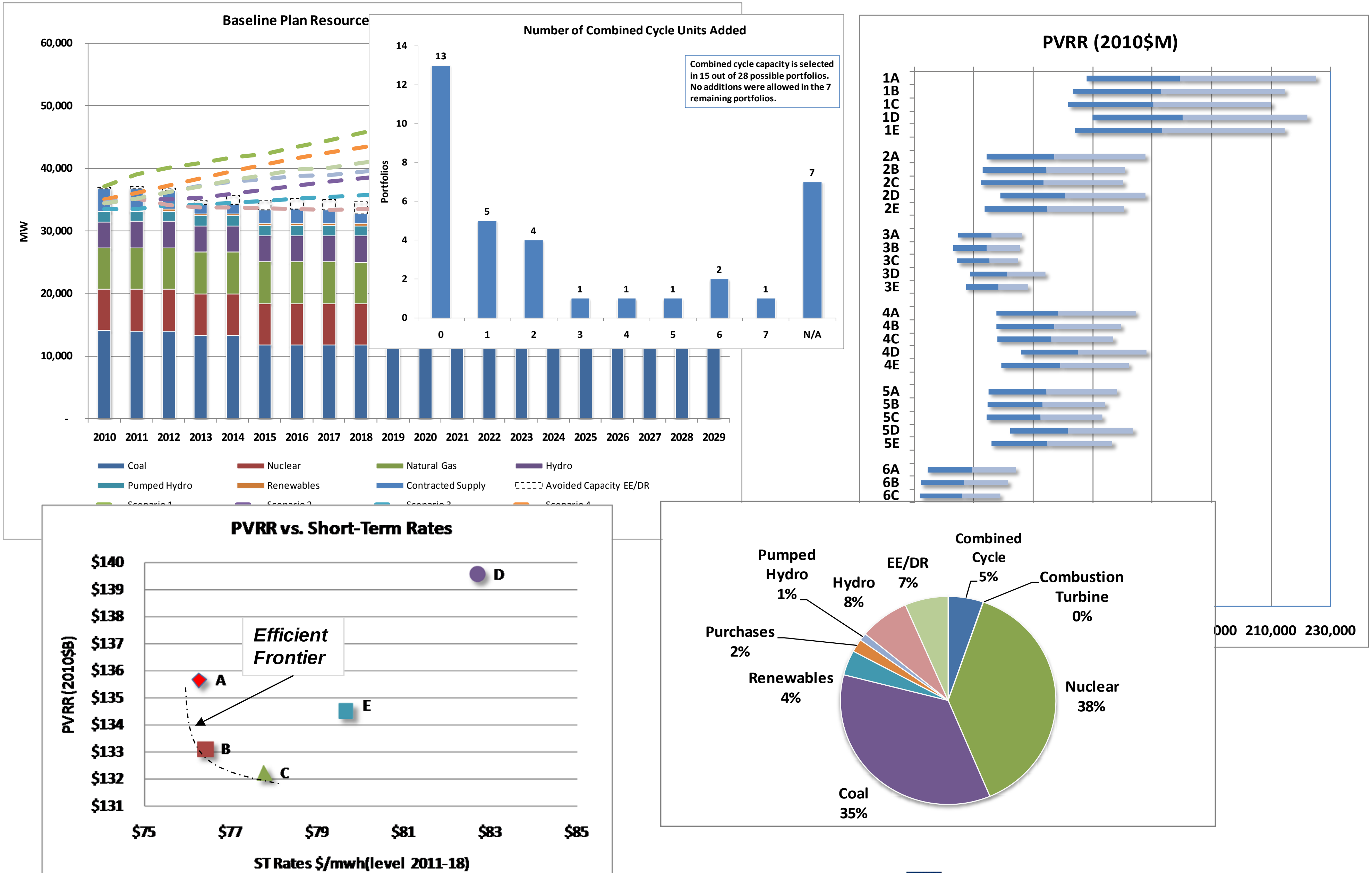
- Metrics do help focus the evaluation of plan results, if done correctly
- Metrics need to reflect the utility's (and the stakeholder's) goals and priorities
  - TVA's broader mission required the use of metrics that went beyond typical resource planning values to include stewardship and economic development factors.
- Metrics need to be clear and easy for stakeholders and decision-makers to understand, which implies that metric design needs to consider these groups
  - Internal teams at TVA developed candidate metrics
  - Stakeholders made other suggestions and helped to shape the final set of evaluation metrics
- And how metrics are described and presented makes a big difference in how effective they are.

***TVA Strategic Imperatives***




- ***Rates:*** *rates and the impact on economic development are assessed indirectly in the IRP study through scorecard metrics*
- ***Debt:*** *the debt limit is explicitly considered in the financial modeling for each planning strategy*
- ***Asset Portfolio:*** *the optimization of asset choices is the central task of the IRP*
- ***Stewardship:*** *the consideration of environmental impacts and stewardship obligations are included both directly in the system modeling and through scorecard metrics*

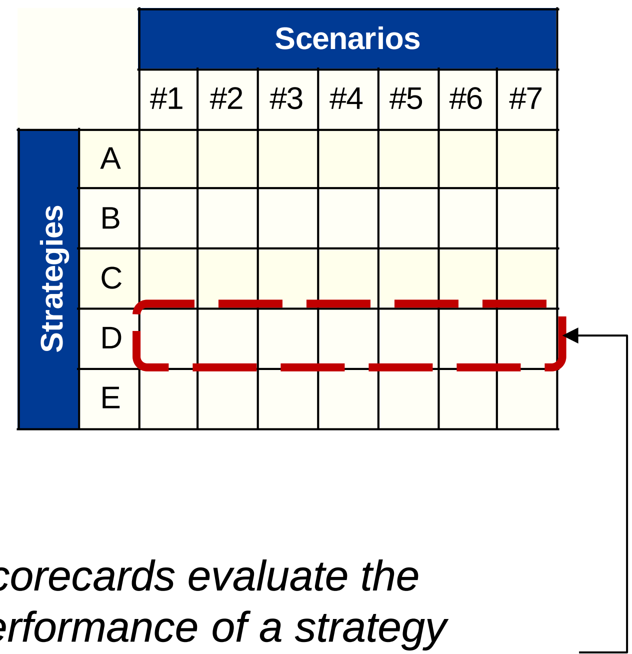
# But Metrics Can Simply Repackage the Confusion



# To Be Effective, Metrics Need a Scorecard

- Metrics need to be presented in a way that facilitates a discussion/debate about trade-offs that lead to the selection of the preferred resource plan
- At TVA, we use a scorecard approach to packaging the metrics, so that stakeholders and decision-makers can be fully engaged in the identification of what makes a resource plan "preferred"
- IRP scorecards were developed to reflect components of TVA's mission and strategic principles
  - Cost and risk metrics evaluated quantitative values that reflect traditional utility measures
  - Environmental and economic metrics considered possible impacts of both quantitative and qualitative assessments
- No regrets considerations were used in addition to the scorecard to represent broader implications that can be described, but are not fully represented in the analysis

*Scenario Analysis*




*Scorecards evaluate the performance of a strategy across many different scenarios*

# But All Metrics Are Not Created Equal

- The scorecard is intended to facilitate a trade-off analysis by displaying key metrics that capture aspects of cost, risk, environmental stewardship and economic development impacts
- Based on discussions with stakeholders, two types of scorecard metrics were developed for use in the 2011 IRP Study
  - Ranking Metrics were used to quantify the financial impacts of a portfolio (20-year resource plan).
  - Strategic Metrics were developed to capture other parts of TVA's mission that would not be fully captured in the Ranking Metrics.
- Ranking Metrics were weighted and used to establish rank order of portfolios , reflecting greater analytical rigor needed to develop these values. Strategic Metrics were used to provide additional insight in the trade-off analysis.

| RANKING METRICS | | STRATEGIC METRICS | |
|---|---|---|---|
| Costs - both long term and short term metrics based on plan costs | Risk – both upside exposure & risk/benefit balance | Environmental – $CO_2$ footprint, water (thermal), waste disposal | Economic Impacts – total employment & growth in personal income |

# IRP Scorecard Components (2011 Draft IRP)

Each portfolio is generated by applying a planning strategy in a scenario

Ranking metrics (financial) are proposed to rank planning strategies

Strategic indicators are paired with ranking metrics to complete the IRP scorecard

| | Low-Cost Power | | | Environmental Stewardship | | Economic Development | |
|---|---|---|---|---|---|---|---|
| Portfolios | Cost | Risk | Ranking Metric Score | Carbon Footprint | Composite Impact | Total Employment | Growth in Personal Income |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | Total | | | | | |

Ranking Metric Score = 0.65(Cost score) + 0.35(Risk score)

**Definitions**

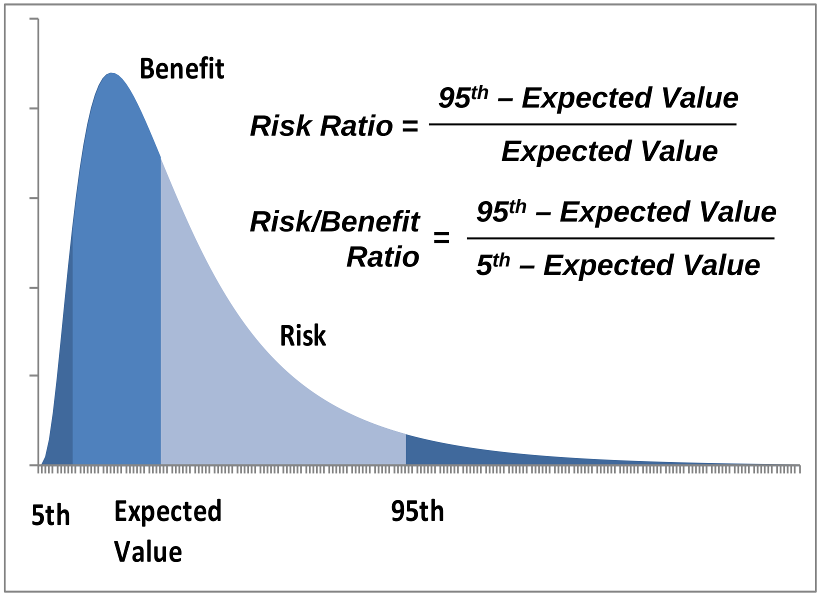
- **Cost (65%):** based on combination of total plan cost (65%) and short-term rate impacts (35%)
- **Risk (35%):** a combination of a risk ratio (65%) and a risk/benefit score (35%)
- **Carbon Footprint:** average annual tons $CO_2$
- **Composite Impact:** a factor that combines air, water, and waste impacts
- **Economic Development**: differential impacts from a reference case level intended to capture relative growth in regional economic activity.

# IRP Scorecard – Cost & Risk Metrics (2011 IRP)

- The cost score is based on a combination of Present Value of Revenue Requirement (PVRR) and short-term system cost impacts
  - PVRR represents the total revenue required to cover TVA's costs, operating expenses, taxes, and interest paid on debt for the period
  - Short-term system costs are the total revenue derived from both Base and Fuel Cost Adjustment (FCA) rates expressed per MWh of native sales (levelized 2011-2018)

| | Ranking Metrics | | | Strategic Indicators | | | | |
|---|---|---|---|---|---|---|---|---|
| | Energy Supply | | | Environmental Stewardship | | Economic Development | | Technology Innovation |
| Portfolios | Cost | Risk | Ranking Metric Score | Carbon Footprint | Composite Impact | Total Employment | Growth in Sustainable Business | Technology Indicator |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | Total | | | | | | |

- The risk score is quantified by a combination of risk ratio and risk/benefit ratio
  - Risk ratio is represented by the potential of exceeding the expected PVRR ("risk averse")
  - Risk/benefit ratio is the potential of exceeding the expected PVRR versus the potential benefit of not exceeding the expected PVRR expressed as a ratio ("risk seeking")



# Combining Metrics in the Scorecard Requires Conversion

**The following is an example calculation of raw ranking metric values to scores**

***Ranking Metric Values***

*Raw ranking metric values for short-term rate impacts in scenario 1 are shown to the right*

| | Strategy | Scenario 1 |
|---|---|---|
| **Average of ST Rates $/mwh(level 2011-18)** | A | 76.82 |
| | B | 78.67 |
| | C | 79.95 |
| | D | 84.61 |
| | E | 80.41 |

*The "best" (in this case lowest) value within a scenario gets a score of 100*

*Strategy D is 10.13% higher than the "best" value and receives a score of 89.87*

***Converted Scores***

*Scores are computed from the raw values as shown and are included in the planning strategy scorecard*

| | Strategy | Scenario 1 |
|---|---|---|
| **Average of ST Rates $/mwh(level 2011-18)** | A | 100.00 |
| | B | 97.59 |
| | C | 95.93 |
| | D | 89.87 |
| | E | 95.34 |

*All other scores are assigned a value based on their relative position to the "best" score*

# Using Strategic Metrics: Scoring for Qualitative Impacts

- The following is an example of how the "Harvey ball" ratings will be applied to the Carbon Footprint strategic metric
- Expected values for average annual $CO_2$ emissions from stochastic analysis are shown to the right

**Average Annual $CO_2$ Emissions (Million Tons)**

| | Scenarios | | | | | | |
|---|---|---|---|---|---|---|---|
| **Strategy** | **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 |

- Planning strategies are ranked based on their performance within each scenario
  - In this example, 1=highest and 5=lowest
- In this example, quantitative data is available to support the ranking, however, other strategic metrics may require qualitative assessment for ranking

**Carbon Footprint Rankings Within Scenarios**

| | Scenarios | | | | | | |
|---|---|---|---|---|---|---|---|
| **Strategy** | **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 |

- The appropriate "Harvey ball" is assigned based on the rankings

| Legend | |
|---|---|
| ○ | |
| ◔ | ↓ |
| ◑ | ↓ |
| ◕ | ↓ |
| ● | *Better* |

**Populated Carbon Footprint Strategic Metric**

| | Scenarios | | | | | | |
|---|---|---|---|---|---|---|---|
| **Strategy** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| A | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| B | ◔ | ◔ | ◔ | ◔ | ◔ | ◔ | ◔ |
| C | ◑ | ◑ | ◑ | ◕ | ◑ | ◑ | ◑ |
| D | ● | ● | ● | ● | ● | ◕ | ● |
| E | ◕ | ◕ | ◕ | ◑ | ◕ | ● | ◕ |

# The Scorecard Gets Key Metrics Together

| | Ranking Metrics | | | | | Strategic Metrics | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Energy Supply | | | | | Environmental Stewardship | | | Economic Impact | |
| Scenarios | PVRR | Short-Term Rate Impact | PVRR Risk/Benefit | PVRR Risk | Total Plan Score | $CO_2$ Footprint | 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 (colours: red, orange, yellow, light green, green) ↓ Better

Legend: ○ ◔ ◑ ◕ ● ↓ Better

- The scorecard helped facilitate a discussion about trade-offs and identified the strengths & weaknesses of various resource planning strategies thru use of numerical values, color coding and qualitative ranking methods
- Using this type of scorecard allows stakeholders and decision-makers who are not technical experts (or lack sufficient familiarity with resource planning methods) to participate more fully in the debate around selecting a preferred resource plan

# Scorecards Make Dialogue & Engagement Possible

## Recommended Planning Strategy

| | Ranking Metrics | | | | | Strategic Metrics | | |
|---|---|---|---|---|---|---|---|---|
| | Energy Supply | | | | | Environmental Stewardship | | |
| Scenarios | PVRR | Short-Term Rate Impact | PVRR Risk/Benefit | PVRR Risk | Total Plan Score | $CO_2$ Footprint | Water | Waste |
| 1 | 99.00 | 95.13 | 100.00 | 99.53 | 98.36 | ◕ | ◕ | ◕ |
| 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 | ◕ | ◕ | ◕ |
| 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 | | | |

## Former Planning Strategy C

| | Ranking Metrics | | | | | Strategic Metrics | | |
|---|---|---|---|---|---|---|---|---|
| | Energy Supply | | | | | Environmental Stewardship | | |
| Scenarios | PVRR | Short-Term Rate Impact | PVRR Risk/Benefit | PVRR Risk | Total Plan Score | $CO_2$ Footprint | Water | Waste |
| 1 | 99.22 | 94.09 | 97.68 | 100.00 | 98.04 | ◑ | ◑ | ◑ |
| 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 | 95.03 | 94.41 | 97.83 | 93.22 | 94.82 | ◑ | ◑ | ◑ |
| 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 | 782.87 | | | |

## Former Planning Strategy E

| | Ranking Metrics | | | | | Strategic Metrics | | |
|---|---|---|---|---|---|---|---|---|
| | Energy Supply | | | | | Environmental Stewardship | | |
| Scenarios | PVRR | Short-Term Rate Impact | PVRR Risk/Benefit | PVRR Risk | Total Plan Score | $CO_2$ Footprint | Water | Waste |
| 1 | 100.00 | 100.00 | 96.78 | 95.46 | 98.57 | ● | ● | ● |
| 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 | ● | ● | ● |
| 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 | | | |

## Former Planning Strategy B

| | Ranking Metrics | | | | | Strategic Metrics | | |
|---|---|---|---|---|---|---|---|---|
| | Energy Supply | | | | | Environmental Stewardship | | |
| Scenarios | PVRR | Short-Term Rate Impact | PVRR Risk/Benefit | PVRR Risk | Total Plan Score | $CO_2$ Footprint | Water | Waste |
| 1 | 96.93 | 95.47 | 96.26 | 97.26 | 96.59 | ◔ | ◔ | ◔ |
| 2 | 94.34 | 96.12 | 100.00 | 100.00 | 96.72 | ◔ | ◔ | ◔ |
| 3 | 95.15 | 96.29 | 91.37 | 83.79 | 92.36 | ◔ | ◔ | ◔ |
| 4 | 95.73 | 98.53 | 96.41 | 93.79 | 96.01 | ◔ | ◔ | ◔ |
| 5 | 97.32 | 98.14 | 96.07 | 98.10 | 97.53 | ◔ | ◔ | ◔ |
| 6 | 92.92 | 95.29 | 88.18 | 78.46 | 89.59 | ◔ | ◔ | ◔ |
| 7 | 96.87 | 99.24 | 95.93 | 94.26 | 96.70 | ◔ | ◔ | ◔ |
| 8 | 98.42 | 96.26 | 94.88 | 94.74 | 96.65 | ◔ | ◔ | ◔ |
| | | | | Total Ranking Metric Score | 762.16 | | | |

# Preparing for the 2015 IRP – Metrics & Scorecard Design

- TVA is just beginning the process of revisiting the metrics and scorecard used in the 2011 IRP to determine how applicable those metrics and scorecard structure are for the current study
  - Will we want to retain cost & risk metrics for scoring purposes? And what sort of metrics should those be (different from what was computed for the prior IRP)?
  - How do we want to incorporate the stewardship and economic development aspects of TVA's mission?
  - What sort of weighting factors do we want to use in this study to produce the total score for each strategy?
- A discussion of candidate metrics and basic scorecard design concepts is planned for the April 29-30 meeting
- Prior to that meeting, TVA would like general feedback from the IRPWG about metrics and/or scorecard design

**What initial comments or suggestions do members of the IRPWG have on metrics and scorecard design for the IRP?**

# Utility IRP Benchmarking

TVA is in the process of benchmarking the IRP filings of 8 comparable utilities. During this session we will review the findings surrounding modeling processes and evaluation criteria (metrics)

- The companies being benchmarked include:

| Company | Filing Date | Planning Horizon |
|---|---|---|
| **Duke Energy Carolinas (DEC)** | Oct 2013 | 2014 - 2028 |
| **Florida Power & Light (FPL)** | Apr 2013 | 2013 - 2022 |
| **Georgia Power Company (GPC)** | Apr 2012 | 2013 - 2028 |
| **PacifiCorp (PCQ)** | Apr 2013 | 2013 - 2032 |
| **Progress Energy Carolinas (PEC)** | Nov 2012 | 2013- 2027 |
| **Dominion (DOM)** | Aug 2013 | 2014 - 2038 |
| **Entergy (ETR)** | Oct 2012 | 2012 - 2031 |
| **Arizona Public Service (APS)** | Oct 2012 | 2012 - 2031 |

- These companies were selected based on the following characteristics:
  - Similar generation mix and size (nuclear, coal, gas, hydro, etc.)
  - Regional player (e.g., Georgia Power)
  - Recently completed IRP (late 2012 or 2013)
  - Inclusion in previous (2009-2010) TVA IRP benchmarking study

# Modeling and Evaluation

| | DEC | FPL | GPC | PCQ |
|---|---|---|---|---|
| *Approach* | ◆ Assess resource needs<br>◆ Identify and screen generation alternatives<br>◆ Develop portfolio configurations<br>◆ Perform portfolio analysis<br>◆ DEC does not discuss any sensitivity analysis | ◆ Determine magnitude and timing of resource needs<br>◆ Identify resource options to meet need (strategies)<br>◆ Evaluate competing options with regard to economic and non-economic factors<br>◆ Select resource plan and commit to near-term options | ◆ Use PROVIEW to develop least cost option based on primary inputs (current world view)<br>◆ Subject "benchmark plan" to sensitivity and scenario analysis | ◆ Define input scenarios for portfolio development<br>◆ Optimize with System Optimizer for cases w/out RPS<br>◆ Develop renewable resource floor and optimize RPS cases<br>◆ Conduct stochastic Monte Carlo production cost simulations<br>◆ Select top performing portfolios based on cost and risk assessment measures<br>◆ Choose final portfolio |
| *Tools* | ◆ DSMore (DSM/EE modeling)<br>◆ System Optimizer | ◆ MatrixND (load forecast modeling)<br>◆ PMArea (production cost model)<br>◆ Fixed Cost Spreadsheet<br>◆ Strategist Model | ◆ PROVIEW<br>◆ Strategist<br>◆ PROSYM | ◆ System Optimizer<br>◆ Enterprise Production Model (EPM) – combines optimizer and Planning and Risk components<br>◆ RPS Scenario Maker (Excel based) |
| *Analysis* | ◆ Scenario Analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis | ◆ Scenario Analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis | ◆ Single variable sensitivities<br>◆ Scenario Analysis (multi-variable sensitivities) | ◆ Single variable sensitivities<br>◆ Scenario analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis<br>◆ Stochastic (Monte Carlo simulation) |
| *Evaluation Criteria* | ◆ Fuel Diversity<br>◆ Environmental Footprint<br>◆ Flexibility<br>◆ Rate Impact | ◆ Present value of revenue requirement<br>◆ Fuel Diversity<br>◆ Emission levels<br>◆ Load/Gen capacity balance | ◆ Cost<br>◆ Flexibility<br>◆ Reliability<br>◆ Long-Term Viability<br>◆ Environmental Compliance<br>◆ Risk<br>◆ Shareholder Value | ◆ Risk-adjusted portfolio cost<br>◆ CO2 emissions<br>◆ Supply reliability |
| *Scorecard* | ◆ PVRR comparison only<br>◆ Screenshot included in the appendix | ◆ None disclosed | ◆ None disclosed | ◆ Separate rankings for each criterion<br>◆ No combination ranking system<br>◆ Screenshot included in the appendix |

*IRP Benchmark*

# Modeling and Evaluation (Cont'd)

| | PEC | DOM | ETR | APS |
|---|---|---|---|---|
| *Approach* | ◆ Identify key drivers through sensitivity analysis<br>◆ Develop potential portfolios<br>◆ Conduct scenario analysis<br>◆ Rank each plan in each scenario based on scoring criteria<br>◆ Choose final IRP | ◆ Devise alternate plans (strategies) based on base case assumptions<br>◆ Run plans through scenarios and sensitivity analysis to determine optimal portfolio | ◆ Model capacity expansion alternatives given base case assumptions and sensitivities<br>◆ Conduct initial portfolio design and risk assessment<br>◆ Complete final risk assessment<br>◆ Identify preferred portfolio design | ◆ Analyze portfolios by subjecting them to rigorous modeling process<br>◆ Produce dispatch sequences based on available resources for each scenario<br>◆ Evaluate performance against key metrics<br>◆ Stress test portfolios through sensitivity analyses<br>◆ Choose final portfolio |
| *Tools* | ◆ Strategist | ◆ Strategist | ◆ AuroraXMP Electric Market Model | ◆ PROMOD IV |
| *Analysis* | ◆ Single variable sensitivities<br>◆ Scenario analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis | ◆ Single variable sensitivities<br>◆ Scenario analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis | ◆ Single variable sensitivities<br>◆ Scenario analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis | ◆ Single variable sensitivities<br>◆ Scenario analysis (multi-variable sensitivities)<br>◆ Portfolio Analysis |
| *Evaluation Criteria* | ◆ Customer Cost (70%)<br>– Total cost (PVRR) (40%)<br>– Fuel price volatility (30%)<br>– Price growth (CAGR) (30%)<br>◆ Environmental (30%)<br>– Emissions: summed over the period<br>– CO2 (70%); SO2 (10%); NOx (5%); Mercury (15%) | ◆ Least cost (PVRR) | ◆ NPV of Revenue Requirements<br>◆ Levelized cost of power ($/MWh for fixed and variable costs) | ◆ Affordability<br>– Present value of revenue requirement<br>– Cumulative CapEx<br>◆ Fuel Diversity<br>– Gas burn<br>◆ Environment<br>– CO2 emissions<br>– Water use |
| *Scorecard* | ◆ Detailed scorecard<br>◆ Numerical values are normalized and weighted to create final rankings<br>◆ Screenshot included in appendix | ◆ Ranked based on average percent over/under base case PVRR across all sensitivity cases<br>◆ Screenshot included in the appendix | ◆ Compared PVRR of each combination of portfolio and scenario. Picked lowest cost<br>◆ Screenshot included in the appendix | ◆ Quantitative and qualitative analysis informed the final decision making process. However, no systematic scoring or rankings were disclosed<br>◆ Screen shots included in appendix |

- PCQ provides the most detail on the evaluation process including discussion of monte carlo simulation results
- Most utilities include detailed discussion of the evaluation criteria, but fail to explain the rationale behind the final choice
  - Only PEC developed an integrated scorecard to systematically rank alternative plans, combining scores across multiple criteria
- While reliability and environmental concerns are considered and analyzed, final IRP selection is typically based on lowest cost (PVRR)

*IRP Benchmark*

# Modeling and Evaluation (Cont'd)

**The table below provides a comparison of the IRP evaluation criteria used by each of the utilities.**

- On average, utilities consider three to four criteria when evaluating potential IRP portfolios
- All utilities include some measure of cost in the evaluation (PVRR at a minimum)
- Most utilities include reliability metrics and environmental metrics as well
- The most common measure of environmental impact is emission levels
- APS is the only company to specifically consider water use in the evaluation

| Evaluation Criteria | DEC 2013 | FPL 2013 | GPC 2012 | PCQ 2013 | PEC 2012 | DOM 2013 | ETR 2012 | APS 2012 |
|---|---|---|---|---|---|---|---|---|
| **Financial Measures** | | | | | | | | |
| Present Value of Revenue Requirement (PVRR) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Cummulative CapEx | | | | | | | | ✓ |
| Levelized Cost of Power (fixed & variable costs) | | | | | | | ✓ | |
| Price Growth | | | | | ✓ | | | |
| Shareholder Value | | | ✓ | | | | | |
| **Risk Measures** | | | | | | | | |
| Risk | | | ✓ | ✓ | | | | |
| Fuel Price Volatility | | | | | ✓ | | | |
| Fuel Diversity | ✓ | ✓ | | | | | | |
| Reliability | | | ✓ | ✓ | | | | |
| Flexibility | ✓ | | ✓ | | | | | |
| Long-term Viability | | | ✓ | | | | | |
| Load/Generation Capacity Balance | | ✓ | | | | | | |
| **Environmental Impact Measures** | | | | | | | | |
| Environmental Footprint | ✓ | | | | | | | |
| Emission Levels | | ✓ | | ✓ | ✓ | | | ✓ |
| Environmental Compliance | | | ✓ | | | | | |
| Water Use | | | | | | | | ✓ |

# NEPA Requirements

- The National Environmental Policy Act (NEPA) requires federal agencies, including the Tennessee Valley Authority (TVA), to consider the potential environmental impacts of actions they propose to take that will impact the physical environment before making a final decision to proceed
- The purpose of an Environmental Impact Study (EIS) is to assess the potential environmental impacts of the proposed action and alert the federal agency decision maker and the public to those impacts before a final decision to proceed with the action is made
- EISs are comprehensive, detailed documents often exceeding 300 pages exclusive of appendices and typically take 12 to 36 months or longer to complete
- EIS processes provide opportunities for public comment, including a minimum mandatory 45-day comment period on draft EISs
- The IRP EIS summarizes TVA's analyses of the environmental impacts of alternative strategies using different combinations of energy resources
  - Effects of climate change, especially in relation to water use / availability of cooling water
  - Socioeconomic consequences, including impacts on local communities and governments and on regional employment including "green jobs"
  - Evaluation of fuel cycle impacts (extraction, processing, transport, disposal)
  - Environmental characteristics of TVA's existing generating units

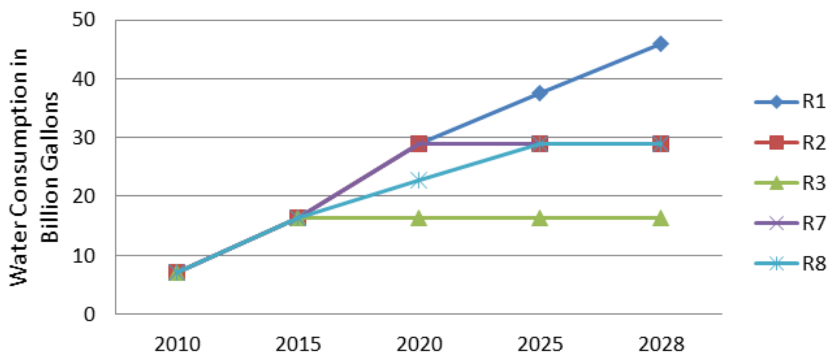
# 2015 IRP EIS Approach

- TVA will file a Supplemental Environmental Impact Study (SEIS) that will supplement the 2011 EIS
- The current IRP Recommended Planning Direction selected in 2011 (as modified by subsequent management/Board decisions) will be the No-Action Alternative
- The SEIS will contain 4 or 5 Action Alternatives (the proposed strategies)

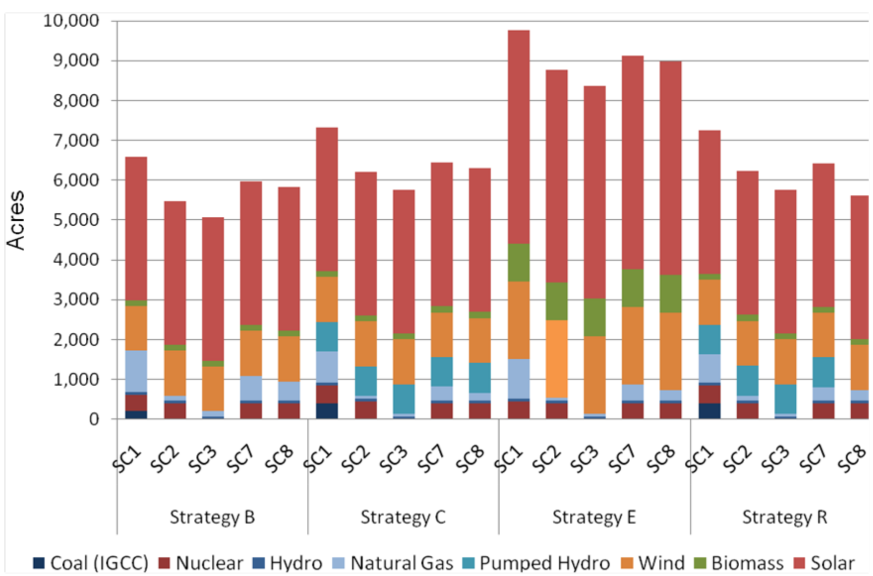
# SEIS Impact Analysis Process Example

Analysis in the SEIS is based on modeling results (like resource mix & energy production by resource type) from the IRP study. Examples include:

- Water Consumption by Alternative/Strategy
- Inputs: Capacity Planning Model outputs (energy by resource type) & water consumption rate (gals/MWh)
- Output Example (from 2011 IRP EIS)



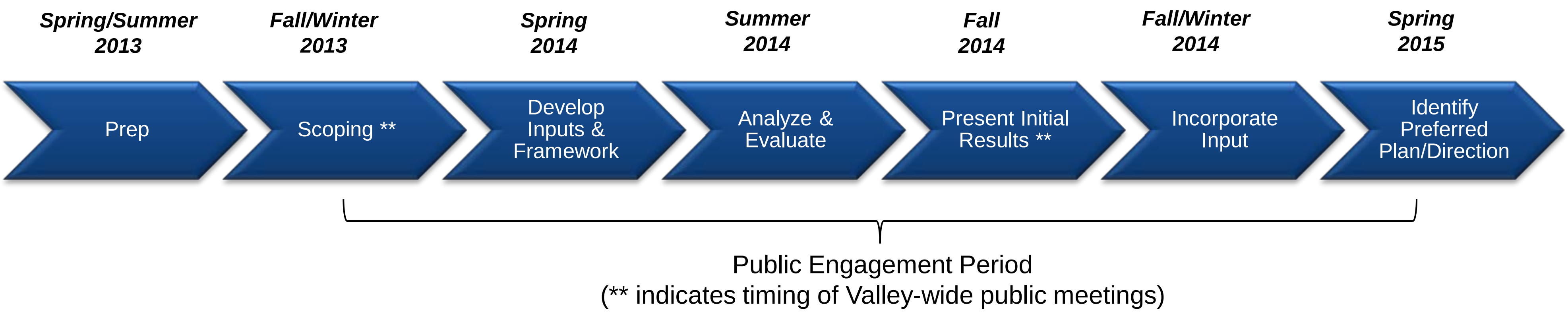

- Land Use Requirements for New Generating Facilities
- Inputs: Capacity Planning Model outputs & land requirements for selected new generating facilities
- Output Example (from 2011 IRP EIS)



# IRP EIS Table of Content

1. **TVA'S RESOURCE PLANNING** *(Updated from 2011)*
   - Peak Load and Net System Energy Forecasts
   - Power Supply Resources (Energy Resource Options)
   - Scenario Development
   - Planning Strategies
   - Portfolio Development
   - Portfolio and Strategy Evaluation Metrics
2. **TVA POWER SYSTEM** *(Updated from 2011)*
3. **AFFECTED ENVIRONMENT** *(Updated from 2011)*
   - Climate
   - Air
   - Regional Geology
   - Groundwater
   - Water Quality
   - Water Supply
   - Aquatic Life
   - Vegetation and Wildlife
   - Endangered and Threatened Species
   - Wetlands
   - Parks, Managed Areas, and Ecologically Significant Sites
   - Land Use
   - Cultural Resources
   - Solid and Hazardous Waste
   - Availability of Renewable Resources
4. **ENERGY RESOURCE OPTIONS** *(Mostly new)*
   - Options Evaluation Criteria
   - Options Excluded from Further Evaluation
   - Options Included in IRP Evaluation
5. **ALTERNATIVE STRATEGIES (***Mostly New)*
   - Strategies and Associated Resource Plans
   - Strategies and Alternatives
   - Preferred Alternative
6. **ANTICIPATED ENVIRONMENTAL IMPACTS** *(New)*
   - Facility Siting and Review Processes
   - Environmental Impacts of Supply-Side Resource Options
   - Environmental Impacts of Demand-Side Options
   - Environmental Impacts of Transmission Facility Construction and Operation
   - Environmental Impacts of Alternative Resource Strategies and Portfolios
   - Potential Mitigation Measures
   - Unavoidable Adverse Environmental Impacts
   - Relationship between Short-Term Uses and Long-Term Productivity of the Human Environment
   - Irreversible and Irretrievable Commitments of Resources

# EIS Process and the 2015 IRP Schedule




**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)

# Meeting Objectives for IRPWG Through June 2014

- Next meeting will be on April 29/30 (Knoxville, TVA Building)

**January 2014** (RERC Briefing)
- Initial ranking of scenarios
- Review comments and new proposed scenarios by the group
- Strategy concepts
- Ranking of Scenarios

**February 2014** (TVA Board Members Briefing)
- Short list of Scenarios
- Review candidate strategies
- Resource options
- Planning assumptions
- Strategy ranking

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

Details:
- Discuss any strategies proposed by the WG
- Identify “consensus” top 5 strategies
- Overview of study methods & modeling constraints
- Complete the discussion of planning assumptions and resource options

**April 2014** (TVA Board Members Briefing)
- Short list technology options
- Review scorecard metrics

Details:
- Review proposed short-list of technology options
- WG individually send comments and proposals on technology options
- Review and discuss proposed scorecard metrics
- WG individually send comments and proposals on scorecard metrics

**May 2014** (RERC; TVA Board Members Briefing)
- Review of model assumptions and forecasts
- Discuss the design of the scorecard

Details:
- Review model assumptions values and TVA’s forecast
- Discuss and agree of the final design of the scorecard

**June 2014**
- Modeling runs begin
- **No meeting planned for this month**