Stakeholder-Driven Scenario Development for the ERCOT 2014 Long-Term System Assessment

PREPARED FOR

ERCOT

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This report was prepared for the Electric Reliability Council of Texas, Inc. (ERCOT). All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group, Inc. or its clients.

We acknowledge the valuable contributions of ERCOT staff, members of the ERCOT Long Term Study Task Force (LTSTF), and several external experts who contributed their time and expertise throughout the scenario development process.

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Executive Summary

The Electric Reliability Council of Texas (ERCOT) engaged The Brattle Group consultants to facilitate a stakeholder-driven process for developing future scenarios for the 2014 Long-Term System Assessment (LTSA) study. The engagement was motivated by findings from an earlier report by the Brattle consultants on the ERCOT 2012 LTSA that identified stakeholder input on the scenarios to be crucial for acceptance of the results of the study.[1]

This report on the 2014 LTSA scenario development process is divided into two parts. In Part I we summarize the scenario development process, the resulting scenarios, and the planning assumptions considered for the 2014 LTSA. In Part II, we review aspects of the scenario development process that worked well and those that could be improved in future iterations, as well as recommend a process for updating the scenarios for the 2016 LTSA, if ERCOT chooses a shorter process to do so.

The 2014 LTSA scenario development process facilitated by the Brattle consultants aimed to provide ERCOT's Long-Term Study Task Force (LTSTF) stakeholders with a structured, inclusive, and efficient process for developing future scenarios based on the input of the stakeholders and input from internal and external experts on important issues for consideration in long-term transmission planning. Both the structure of the process and the information presented to stakeholders sought to respond to the issues stakeholders raised about the previous scenario development processes. The process, as shown in Figure ES-1, included a series of three workshops conducted in January and February of 2014 and involved a total of 58 participants, representing 31 organizations.

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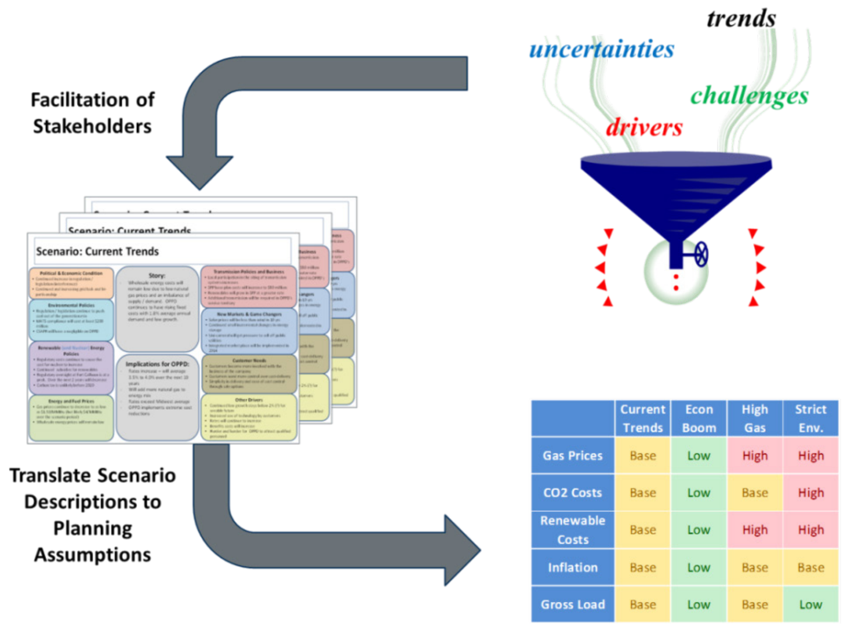
1 Judy W. Chang, Johannes P. Pfeifenberger, Samuel A. Newell, Bruce Tsuchida, and J. Michael Hagerty, *Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process*, October 2013. ("LTSA Review Report") Available at: http://www.brattle.com/system/publications/pdfs/000/004/964/original/Recommendations_for_Enhancing_ERCOT%E2%80%99s_Long-Term_Transmission_Planning_Process.pdf

Figure ES-1
2014 LTSA Scenario Development Process



The key steps in the process included discussion on:

- **Trends, Drivers, and Uncertainties**: The Brattle consultants and ERCOT identified experts (both internal and external to the electric power sector) who presented their understanding of the most relevant information to stakeholders to supplement their own knowledge of the system. These informative presentations and discussions included key factors in economic development and population growth, fuel costs, environmental regulations, water resources, and renewable growth and integration. The stakeholders discussed each topic and identified the key drivers for the future ERCOT system, which are shown in Table ES-1 and described in detail in Section III of the report.

Table ES-1
2014 LTSA Key Drivers Developed by Stakeholders

Key Drivers
Economic Conditions
Environmental Regulations and Energy Policy
Alternative Generation Resources
Natural Gas and Oil Prices
Transmission Regulation and Policies
Generation Resource Adequacy Standards
End-Use/New Markets
Weather and Water Conditions

- **Scenario Descriptions**: Working from the expert presentations and key drivers, stakeholders identified a list of distinctive future scenarios through a facilitated discussion, which are shown in Table ES-2. By working in small breakout groups, the stakeholders developed detailed and internally-consistent descriptions of the key drivers for each scenario. Each breakout group presented the scenario descriptions to the other stakeholders to ensure consistency across scenarios and a summary of the key drivers across all scenarios were reviewed to identify potential overlap and prioritize scenarios for simulating in the 2014 LTSA. The detailed scenario descriptions and summary of the key drivers across scenarios are included in Section IV of the report.

Table ES-2
2014 LTSA Scenarios Developed by Stakeholders

Candidate Scenarios
Current Trends
High Economic Growth
Global Recession
Stringent Environmental Regulation/Solar Mandate
High Efficiency/High DG/Changing Load Shape
Low Global Oil Prices
High Natural Gas Prices
LNG Export Growth
High System Resiliency
Water Stress

- **Input Assumptions:** ERCOT staff with assistance from the Brattle consultants developed input assumptions for simulating each scenario in the 2014 LTSA based on the detailed scenario descriptions and data provided by stakeholders. ERCOT presented the input assumptions at Regional Planning Group (RPG) meetings following the conclusion of the workshops and requested feedback from stakeholders. The input assumptions developed by ERCOT to simulate the stakeholder-developed scenarios are included in Section V.

ERCOT is currently in the process of completing its capacity expansion analysis and has presented the initial results to stakeholders at RPG meetings. ERCOT will release the results of its transmission analysis in the final 2014 LTSA report.

In Part II, we highlight the key roles that stakeholder feedback and input from outside the electric industry played in completing a successful scenario development process, and the opportunities for improving the process in the future in regards to sustained stakeholder participation and translating the scenario descriptions into input assumptions. We recommend a process for updating scenarios for the 2016 LTSA that maintains the overall structure and stakeholder-driven nature of the process used in 2014.

Part I: Summary of 2014 LTSA Scenario Development Process

I. Introduction

A. Background

Based on the requirements of the Texas Public Utility Regulatory Act, the Electric Reliability Council of Texas (ERCOT) must complete transmission plans that provide a reliable electric grid and facilitate efficient electricity markets. The transmission planning effort is led by ERCOT staff with input from stakeholders that participate in the ERCOT Regional Planning Group (RPG). The RPG participants include generation developers, Transmission Service Providers (TSPs), and representatives from non-profit organizations (*e.g.*, environmental groups and land owners). A list of stakeholders who participated in the workshops is included in Appendix A. Through the RPG, ERCOT conducts a near-term (6 years) planning effort every year and the result of that effort is provided in the Regional Transmission Plan (RTP). The long-term (15–20 years) planning effort, called the Long-Term System Assessment (LTSA), is completed on a biennial basis. The primary purpose of the LTSA is to inform ERCOT's transmission plan with the longer term needs of the system, particularly taking into consideration future uncertainties.

In the 2012 LTSA, ERCOT included, for the first time, an analysis of ERCOT's transmission needs over a twenty year horizon. Prior LTSAs covered ten years. The 2012 LTSA also included improvements to several aspects of ERCOT's planning and modeling capabilities, funded by U.S. Department of Energy (DOE). Also for the first time, ERCOT with its stakeholders developed a range of future scenarios for the 2012 LTSA based on expected market conditions at that time. ERCOT then used those future scenarios to analyze the transmission needs over the 20-year horizon.[2]

In 2013, ERCOT engaged The Brattle Group to review the LTSA process for assessing economic transmission needs and to recommend improvements to its "business case" for transmission investment in future studies. As part of that assessment, based on stakeholder feedback, we recommended that ERCOT improve its process for developing the future scenarios and sensitivities upon which the long-term transmission plans are based.[3] Subsequently, ERCOT

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[2] Electric Reliability Council of Texas, *Long-Term System Assessment for the ERCOT Region*, December 2012. ("2012 LTSA") Available at: http://www.ercot.com/content/news/presentations/2013/2012%20Long%20Term%20System%20Assessment.pdf

[3] Judy W. Chang, Johannes P. Pfeifenberger, Samuel A. Newell, Bruce Tsuchida, and J. Michael Hagerty, *Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process*, October 2013. ("LTSA Review Report") Available at:

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requested our assistance in improving the scenario development process for the 2014 LTSA by addressing the concerns raised by stakeholders and facilitating scenario development workshops with stakeholders through its long-term planning process.

B. Objective of the 2014 LTSA Scenario Development Process

The objective of the 2014 LTSA scenario development process was to directly engage stakeholders and ERCOT staff in developing the future scenarios that will be used for analyzing the ERCOT system over the long term. For the 2014 LTSA, ERCOT chose to analyze a 15 year period. The scenario development process aimed to incorporate the collective knowledge of the participants of the Long-Term Study Task Force (LTSTF), which consists of industry representatives who work closely with system planning. The 2014 LTSA Scenario Development Process provided interested stakeholders an opportunity to participate in developing the future scenarios and associated planning assumptions that are ultimately used in the LTSA study.

C. Approach

In working with various electric utilities and regional system planners, the Brattle consultants have found that scenario-based planning is one of the most effective long-term tools to develop and organize ideas about the direction and challenges associated with the future of the electricity systems. As part of the engagement with LTSA, the Brattle consultants solicited the involvement of those who work most closely with the power system to help articulate the main drivers of future trends and uncertainties that affect the value of long-term investments in power transmission.

The main deliverable of the scenario-based planning approach is the detailed descriptions of the future scenarios that are fully specified with internally consistent outlines of the most significant trends, drivers, and uncertainties identified by stakeholders. Each scenario developed for the long-term transmission plan incorporates the most relevant factors that drive electricity usage, costs of electricity, environmental effects of the power system, choices for future generation expansion, *etc.* The aggregation of each individual potential future scenario is intended to provide an ample range of futures. Through our scenario development process, we seek to build off of the existing knowledge of stakeholders and supplement that experience with information that expands their understanding of areas in which they are less familiar and provides a common set of information that enables collaboration amongst the participants that have diverse perspectives and experience.

The distinction between the use of "scenarios" and "sensitivities" is also important to system planning. Sensitivity analyses are commonly conducted to understand how adjusting a single variable may affect results and outcomes. For example, with no other changes to a base set of

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http://www.brattle.com/system/publications/pdfs/000/004/964/original/Recommendations_for_Enhancing_ERCOT%E2%80%99s_Long-Term_Transmission_Planning_Process.pdf assumptions, a higher than expected load growth (that deviates from the base assumption) may affect the future value of certain investments. On the other hand, a future scenario is a future state of the world, with many factors occurring jointly, driving a certain direction in the industry. For example, a world with high economic growth in Texas may be driven by high world oil prices and high natural gas prices, which drive significant industrial growth and therefore load electric usage in particular geographic locations. In that future, renewable generation becomes more economical relative to gas-fired generation, and thereby further increases the development of wind generation in western and coastal Texas. Both the industrial growth and the wind power development will increase the need and the geographic location for new transmission build out.

Since no one knows what future will actually materialize, the scenarios developed need to cover a reasonable and credible range of the future. Ultimately, the range of future scenarios will be used to assess the need and value of future transmission investments. For instance, if a particular transmission investment is valuable under all future scenarios, then such a project would be a "robust investment" regardless of future uncertainties. On the other hand, if a transmission investment is only valuable under one scenario, it may be beneficial to postpone the investment decision until future direction becomes more obvious.

An important part of scenario development is also the credibility of the scenarios to the stakeholders. From the feedback we heard, it had become apparent that planning results and conclusions are not credible unless stakeholders can concur and agree with the scenarios used in the planning analyses. This means that no matter how much effort is put into the detailed analyses of certain transmission projects, unless stakeholders "believe" that the scenarios are credible and are useful depictions of future states of the world, stakeholders are unwilling to rely on the results of the planning studies. Thus, for the ERCOT 2014 LTSA scenario development process, in response to previous stakeholder feedback we focused on:

- Soliciting input from and involving experts or entities that have not historically (or not consistently) participated in ERCOT stakeholder meetings, including oil and gas experts, landowner groups, and environmental policy experts;

- Gathering input from transmission owners and developers that have already conducted analyses of sub-regions and the local transmission systems with which they are most familiar; and

- Documenting the messages gathered from each workshop in preparation for subsequent workshops and for drafting the report.

In the rest of this report, we provide a summary of the scenario development process for the 2014 LTSA and the input assumptions that ERCOT decided to use based on the scenarios developed by the stakeholders to simulate the ERCOT system. We also provide suggestions of how the process can be improved in the future and options for a shortened version for updating the scenarios for the next LTSA.

II. Use of Future Scenarios in ERCOT's Long-Term Transmission Plans

ERCOT has used scenarios in its long-term transmission planning process to capture the uncertainties in the planning horizon. In the 2012 LTSA, ERCOT stated that the goal of using scenarios in the LTSA is to "identify upgrades that are robust across a range of scenarios or might be more economic than the upgrades that would be determined considering only near-term needs."[4] The transmission upgrades and expansions identified by the LTSA across the different scenarios and longer timeframe are meant to guide analysis in the near-term RTP, in which actionable projects are identified.

ERCOT has historically developed five to six scenarios for modeling the electric power system over a ten-year period, commonly including a scenario based on the load projection in the most recent Capacity, Demand, and Reserve report and additional scenarios that modify different assumptions, such as fuel (gas and coal) prices, nuclear and renewable generation capacity additions, and environmental regulations. Generally the scenarios adjust one or two assumptions from the base case in the generation expansion analysis to see how the change in generation capacity will impact the future operation of the power system. The aim historically has been to capture a range of scenarios that "provide a likely boundary for future market conditions."[5]

A. Scenarios Used in the 2012 LTSA

For the 2012 LTSA, ERCOT reviewed a number of publicly available studies and reports to identify the potential changes and trends in the markets and policies that affect the ERCOT system.[6] Through a series of meetings with LTSTF stakeholders, ERCOT summarized the findings from their review and requested comments from the stakeholders for developing the scenarios and sensitivities for the long-term study. Through this process, the stakeholders requested that ERCOT create a business as usual (BAU) case consistent with the EIA Annual Energy Outlook (AEO) reference case, which projects future market conditions assuming the current policies and regulations remain in place. ERCOT developed the BAU load forecast using an internal model based on Moody's 2011 Base Economic Forecast and 15-year average weather conditions. After an initial definition of the BAU case, ERCOT expanded the technologies considered in the generation expansion analysis and termed the new scenario "BAU All Technologies."

Ultimately, ERCOT and the stakeholders developed a total of ten additional cases to evaluate how changes in specific input assumptions would impact the generation expansion analysis. Together, with the BAU case, ERCOT developed eleven cases, each with a distinct set of future generation resources mix based on the scenario descriptions over twenty years. Subsequently,

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4 2012 LTSA, p. 6.

5 2012 LTSA, p. 9.

6 2012 LTSA, p. 14. ERCOT reviewed studies published by the Energy Information Administration (EIA), the International Energy Agency (IEA), Shell, and ExxonMobil. ERCOT also reviewed historical data published by the EIA and BP.

ERCOT chose to analyze the long-term transmission needs based on the six scenarios listed in Table 1. For each of the six scenarios, ERCOT identified future transmission investments needed and assessed the commonalities across the scenarios.

Table 1
2012 LTSA Scenarios Modeled

Scenario	Change to BAU Scenario
BAU All Technologies (S1)	Base Case
BAU All Tech with Retirements (S2)	Retirement of 13,000 MW of older natural gas-fired units
BAU All Tech with Updated Wind Shapes (S3)	Increased output of wind turbines based on recent experience
Extreme Drought (S5a)	Water cost adders and capacity de-rates developed for each technology
BAU All Tech with High Natural Gas Price (S7)	Natural gas price is $5/MMBtu higher than Base Case in all years and the PTC continues beyond 2012
Environmental (S8)	Higher natural gas prices, continuation of PTC, increased emissions costs, no new coal builds except IGCC

B. Results of the 2012 LTSA

In the 2012 LTSA, ERCOT's findings included the need for:

- New transmission lines, such as import lines for Houston and the Lower Rio Grande Valley;
- Transmission most sensitive to the level of generation retirements and added new renewable generation; and
- Continued analyses to analyze system reliability with increasing renewables and under persistent drought conditions.

III. 2014 LTSA Scenario Development Process

A. Stakeholder Input

During discussions with stakeholders for our 2013 review of the LTSA, we received significant feedback on the 2012 LTSA scenarios and the scenario development process. We found that the stakeholders' understanding and acceptance of the inputs for the scenarios strongly influenced how they viewed the results.[7]

Much of the stakeholder feedback on the 2012 scenarios was positive. Stakeholders thought that analyzing scenarios over the long term is an effective approach to address a large number of

7 See Brattle's LTSA Review Report for a full discussion of stakeholder feedback.

system planning challenges. Most were satisfied with the range of scenarios considered in the 2012 LTSA. Many stakeholders appreciated the process ERCOT had taken in developing the scenarios and highlighted the need for future scenarios to be developed through a process informed by the wide range of ERCOT stakeholders.

There were several concerns raised by stakeholders as well. A few stakeholders felt that the breadth of scenarios was too narrow and did not reflect enough of the potential stresses that could be expected in the future. They also felt that perspective from beyond the electric power industry should be included, especially in light of the recent spike in demand from the oil and gas sector. Several of the Transmission Service Providers (TSPs) felt that the specific knowledge they have about local system limitations was not reflected in the scenarios considered by ERCOT.

For the 2014 LTSA, we developed a stakeholder scenario development process that considered these concerns directly to ensure that the scenarios developed reflect the best information available.

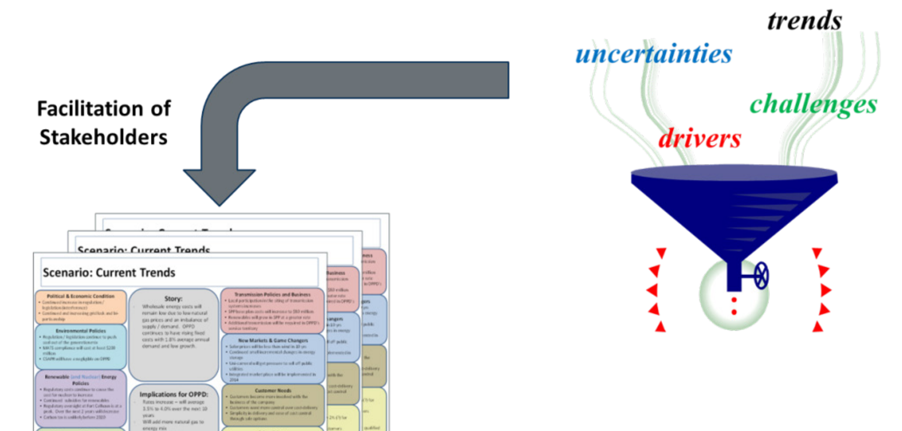
B. Scenario Development Process Overview

Based on recommendations from the 2013 study, Brattle worked with ERCOT to outline a process for developing scenarios for the 2014 LTSA that addressed stakeholder concerns. The process centered on the stakeholders taking on a larger and more hands-on role in developing the scenarios through a facilitated process that allowed all interested parties to participate and provide their input into the scenarios modeled in the 2014 LTSA. To do so, ERCOT invited stakeholders from the larger RPG and encouraged involvement from additional stakeholders who had not traditionally been involved in transmission planning (*e.g.*, landowners, renewable energy developers, and professionals from outside the electric power sector).

Our goal in structuring the 2014 LTSA scenario development workshops, as shown in Figure 1, was to provide an opportunity for stakeholders to:

1. Identify the trends, drivers, and uncertainties that are most critical to the future ERCOT system;
2. Brainstorm and select scenarios that are best suited for ERCOT's transmission planning process;
3. Describe future scenarios that capture a wide range of uncertainties in a structured manner; and
4. Develop modeling parameters for each scenario.

Figure 1
Overview of Scenario Development Process



	Current Trends	Econ Boom	High Gas	Strict Env.
Gas Prices	Base	Low	High	High
CO2 Costs	Base	Low	Base	High
Renewable Costs	Base	Low	High	High
Inflation	Base	Low	Base	Base
Gross Load	Base	Low	Base	Low

The approach employed in facilitating this process begins first with collecting and discussing a wide range of perspectives on the trends, drivers, uncertainties, and challenges of the future ERCOT system. While each individual stakeholder may have direct experience with several of these factors, it is important for the participants as a whole to be presented with a full set of information to establish a common level of understanding and appreciation of their relative importance. From this information, the stakeholders were asked to identify what they consider to be the most important drivers in developing potential scenarios (*e.g.*, "High Gas Prices," "Stringent Environmental") that would capture the full range of futures.

Next, for each scenario identified, stakeholders worked within small teams to describe the details of an internally consistent "story." Each team then presented the scenario description to the larger stakeholder group to ensure all stakeholders have a chance to provide input and feedback for each scenario.

Once defined, converting each scenario into planning assumptions required adapting the qualitative descriptions into relative inputs (low, medium, high). For instance, stakeholders discussed what scenarios should have high, average, or low load growth and the reasons for such. The stakeholders also compared and contrasted the scenarios described by various teams to determine whether the scenarios provided a sufficiently broad spectrum of possible futures and whether scenarios can be eliminated or merged.

Lastly, the specific planning assumptions used to represent each scenario in system simulations were developed jointly by stakeholders and ERCOT to ensure that the parameters that ERCOT uses reflect the intentions of the stakeholders in the scenario descriptions.

The following sections provide the details associated with each step of the scenario development process.

C. Industry Trends, Drivers, and Uncertainties

1. Industry Expert Presentations

The first set of agenda items for the workshops for the scenario development process focused on collecting information from a broad set of industry practitioners and experts on key topics that would impact ERCOT's electricity system and therefore transmission needs. The topics were jointly identified by ERCOT and Brattle consultants based on the issues identified by stakeholders as the most critical for the system. We then invited the practitioners and experts to prepare materials and lead the discussions on the most relevant topics, including presenters from both inside and outside the electric power sector. Each presenter was asked to give their perspective on the trends, drivers, and uncertainties that the electric power sector faces in relation to their areas of expertise. Stakeholders were encouraged to ask questions and discuss the issues to ensure a common understanding of the topics as they relate to ERCOT's transmission needs. The presentation topics and speakers are shown in Table 2.

Table 2
Presentations on Industry Trends, Drivers, and Uncertainties

Topic	Speakers
Economic and Population Growth in Texas	• Eric Clennon, Texas Economic Development Office • Lloyd Potter, Texas State Demographer
Natural Gas Supply and Market Prices	• Svetlana Ikonnikova, University of Texas, Austin, Bureau of Economic Geology • Gabe Harris, Wood Mackenzie
Potential Effects of Environmental Regulations on Existing Baseload Generation	• Metin Celebi, The Brattle Group
Energy/Water Nexus in Texas	• Michael Webber, Deputy Director, University of Texas, Austin, Energy Institute • Bridget Scanlon, University of Texas, Austin, Bureau of Economic Geology
Renewable Energy Potential and Economics	• Alan Comnes, SunPower Corporation representing Solar Energy Industries Association • Jeff Clark, The Wind Coalition • Julia Matevosyan, ERCOT • Ira Shavel, The Brattle Group
Electricity Usage by Oil & Gas Developers	• Toni Gordon, Pioneer

Below we briefly summarize the main messages from each topic:

- **Texas Population Estimates and Projections (Lloyd Potter)**:[8] Dr. Potter presented his analysis of recent population trends in Texas, which shows that Texas has seen population growth above the national average and that 92% of Texas' population growth in 2011–2012 has occurred along and east of the I-35 corridor. Dr. Potter explained that population growth occurs for two reasons: natural increase among the current population and net migration. While natural increase rates are relatively stable, net migration is closely tied to job growth. Dr. Potter considers the most recent rate of net migration to be at the high end of the range of possible future growth rates, with net migration at 50% of recent rates to be likely.

- **Texas Economic Growth Trends (Eric Clennon):**[9] Mr. Clennon presented a summary of the major drivers of economic and job growth across Texas. The presentation focused on oil & gas extraction, manufacturing (fabricated metal products, machinery, refined petroleum & chemicals), and professional services, such as IT services and data centers, as the largest drivers of future economic growth in Texas. Mr. Clennon highlighted that each sector is expected to lead to job growth in different geographic regions of Texas. For example, an increase in oil & gas extraction will lead to job growth in the region that stretches from Dallas to west Texas and along the gulf coast. Professional services would be expected to be primarily in urban centers, such as Houston, Dallas, and Austin. Mr. Clennon highlighted that continued increases in oil & gas extraction will also increase job growth in adjacent manufacturing sectors.

- **Shale Gas Resources and Reserves (Svetlana Ikonnikova):**[10] Dr. Ikonnikova presented her research into future production of natural gas in Texas in the Barnett and Haynesville shale gas formations. Dr. Ikonnikova explained that although geologic parameters tend to be the primary driver of well production, there is still significant uncertainty in the production of any given well even in resource-rich locations. Shale gas economics are highly dependent on the ability to drill multiple wells from a single drilling pad and the degree of improvements in drilling techniques to increase success rate. Within Texas, the Barnett shale is expected to remain the lowest cost gas resource with annual production dropping from 2.0 to 1.5 trillion cubic feet (tcf) by 2020, if prices remain around

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8 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/1._14_01_13_2014_ERCOT_Long-Term_System_Assessment_(LTSA)_St.pdf

9 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/ERCOT_Presentation_-_Eric_Clennon_-_1-13-20141.ppt

10 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/2._Ikonnikova_ERCOT2014.pdf

$4/MMBtu. While the Haynesville shale has similar resource potential, the breakeven gas price is significantly higher.

- **North America Natural Gas Outlook (Gabe Harris):**[11] Mr. Harris presented an overview of the main drivers of natural gas prices through 2025. The presentation showed that U.S. domestic gas prices have been significantly below international prices and are expected to remain low into the future. Shale gas resources will continue to grow and increase their share of total production with the Marcellus and Utica formations adding the most growth through 2020. In these regions, production of natural gas liquids and condensate drives much of the new gas resource growth. The Permian Basin is expected to provide the most growth within Texas.

  The drivers for continued low gas prices include continued increases in efficiency and introduction of new extraction technology. Additional shale resources are available even with no market price increase, which limits the price impact of incremental demand. Demand is expected to continue to rise due to increased gas-fired power generation to meet increasing loads (although energy efficiency has significantly hampered growth) and to replace coal plant retirements. Lumpy load growth is also expected from the introduction of LNG exports in 2016–2020 and other industrial growth, such as petrochemical facilities. Gas price projections remain below $5/MMBtu through 2022.

- **Environmental Regulations and Plant Retirements in ERCOT (Metin Celebi):**[12] Dr. Celebi presented a summary of the environmental regulations that are expected in the near-term to increase the pressure on existing fossil fuel generation plants to retire. Several upcoming rules were summarized with particular focus on the Mercury and Air Toxics Standard (MATS) and the greenhouse gas (GHG) regulations. MATS is expected to be the single most impactful regulation as coal plants will be required to install equipment that provides the maximum available control technology (MACT) for compliance by April 2015. GHG standards have also been set for new power plants. Subsequent to Dr. Celebi's presentation and discussion, the U.S. Environmental Protection Agency issues a set of proposed standards for existing power plants, with compliance requirements to begin in 2016.

  The analyses in the presentation show that despite the regulations, a limited amount of coal power plants are expected to retire in ERCOT through 2020 in the base case, high gas price case, and GHG standards case. In the low gas price case however, 6 GW of coal

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11 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/2._Harris_-_ERCOT_Workshop_Jan13_2014_.pdf

12 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/3._Celebi_ERCOT_Workshop_Environmental_Regs_and_Retirements_.pdf

capacity is expected to retire by 2020. The presentation also notes that cooling water regulations may have a significant impact on older natural gas-fired steam units with 5–10 GW at risk through 2020 if required to add cooling towers. Such assessment may change based on the implementation of EPA's new GHG regulation on existing power plants.

- **Water and Power in ERCOT (Michael Webber):**[13] Dr. Webber provided a comprehensive review of the water issues that should be considered over the long term for the electric power system in Texas. Thermoelectric power generation is highly dependent on water availability, often either requiring significant water withdrawals (0.2–42.5 gallons/kWh) for open-loop systems or water consumption (0.1–0.8 gallons/kWh) for closed-loop systems. Both configurations can be problematic with increasing scarcity of water resources. Air cooled systems significantly reduce water withdrawals and consumption (depending on what is being replaced) but will reduce the net efficiency of the generation facilities by approximately 10%. Dr. Webber highlighted that even accounting for the water usage associated with natural gas drilling, natural gas generation remains less water intensive than coal generation. Looking forward, increasing requirements for environmental controls and carbon capture will require additional water usage. Solar and wind generation both have limited water usage and can provide opportunities to co-locate with water desalination and waste treatment facilities to provide benefits for both the water and electricity systems.

- **ERCOT Vulnerability and Resilience to Drought (Bridget Scanlon):**[14] Dr. Scanlon presented a review of the impacts that the 2011 drought had on the ERCOT system and the ability of the electric power system to increase its drought resilience. During the 2011 drought, electricity demand increased by 6% and water demand increased by 9%. In addition, the drought resulted in 30% of the water storage capacity being consumed by the state. Due to population growth, the per-capita quantity of water storage has been reduced over the past decade as there has been no capacity added. The increase in power generation from combined-cycle gas turbines has increased the resiliency of the ERCOT system to drought conditions due to the reduced water consumption relative to coal and gas-fired steam units. The increase in generation from renewable sources, especially wind, has also increased the system resilience to future droughts.

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13 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/20140113_Webber_ERCOT_Water_for_Powerplants_LowRes.pdf

14 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/4._Scanlon_ERCOT_Jan_13_2014_2nd_Ver.pdf

- **Solar in Texas (Alan Comnes):**[15] Mr. Comnes presented an overview of the potential for growth in solar capacity in Texas. Nationally, the Solar Energy Industries Association (SEIA) projects sustained growth of solar capacity of 2 GW per year and noted that while there is currently just 136 MW installed in Texas, there is 1,800 MW in the queue. The quality of solar resources in Texas range widely across the state with lower potential in the coastal region (where the fixed tilt capacity factor is 21%) and greater potential in West Texas and the Panhandle (25–26% for fixed tilt). Mr. Comnes states that the existing transmission lines built through the CREZ process are well positioned for connecting the solar-rich regions of the state to load centers. The presentation provided information on the recent decline in solar capital costs with utility scale installed costs currently close to $2/Watt. A key takeaway from the presentation is the importance and difficulty of providing up-to-date solar costs for modeling solar capacity in the LTSA and projecting the costs into the future since the costs have been declining so significantly over the previous years.

- **Wind Energy Trends in ERCOT (Jeffrey Clark):**[16] Mr. Clark presented an overview of the growth of the wind industry in Texas, highlighting in particular the advances in wind generation technology over the past several years. Texas remains the state with the largest installed wind capacity, largely due to the high quality of wind resources and the availability of transmission from the CREZ projects. The presentation notes that communities continue to seek out additional wind investment, that wind capacity is becoming more geographically diverse, and that wind technology continues to improve the amount of output per turbine. The next generation turbines will be taller, increasing from 100 meters to 175 meters by 2020, with the output per turbine increasing from 2 MW to 4 MW. The technology improvements will enable the turbines to capture more energy at lower wind speeds and increase their capacity factor. Wind costs are increasingly competitive with other sources of generation as the average PPA in 2012 was $38/MWh and wind capacity provides a natural hedge against future gas price fluctuations.

- **Application of KERMIT in the DOE LTS Process (Julia Matevosyan):**[17] Dr. Matevosyan presented ERCOT's analysis of system reliability and the need for operating reserves due to increasing levels of intermittent wind generation. ERCOT is able to simulate second-by-second changes in load and wind generation levels to ensure that resources are

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15 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/5._SEIA_Solar_in_TX_Presentation_(ERCOT_LTSA_Wkshp)-_1_13_14.pdf

16 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/5._2014_01_13_-_Wind_Coalition_Presentation_at_ERCOT_Long_Te.pdf

17 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/5._2014_LTSA_Kermit.ppt

available to balance the system and maintain reliability. The analyses that ERCOT is conducting are directed at ensuring that the full cost of operating increasingly greater amounts of wind generation is included in the analysis of the future transmission system. Overall, the analysis found that increasing wind generation requires more operating reserves and may require a new ancillary service product to ensure sufficient reserve capacity.

- **Renewable Development in ERCOT (Ira Shavel):**[18] Dr. Shavel presented analysis from a 2013 report on renewables growth in ERCOT, highlighting the drivers of renewable capacity additions and the issues with integrating it into the ERCOT system.[19] The main drivers for additional renewable development included the production tax credit (PTC) and investment tax credit (ITC), the price of natural gas, the stringency of the upcoming GHG standards, and the capital costs of wind and solar capacity. The analysis assumed three levels of renewables penetration that result in renewables providing 7%, 26%, and 43% of total generation by 2032. The highest renewable penetration scenario included an additional 46 GW of wind capacity and 13 GW of solar capacity. In performing detailed simulation of the ERCOT system, Dr. Shavel's analysis found that the amount of ancillary services procured (currently set at 600 MW of regulation and 1,500 MW of 30-minute reserves) will need to increase at the 26% and 43% levels as well as adding an additional ancillary service product termed the "inter-hour commitment option" that would be procured four hours ahead. His analysis found that with these changes, the power system could be operated reliably at the high levels of renewables penetration simulated.

- **Electricity Usage by Oil & Gas Developers (Toni Gordon):** Ms. Gordon presented information about the rate of growth in Pioneer's oil & gas production in Texas and the challenges they face in choosing whether to operate using power from the grid or by generating it themselves on-site. Since the oil & gas production is often rapidly developed, it can be difficult for the utilities to keep up with the pace of development. For that reason, oil & gas producers/operators have to work closely with the utilities to try to ensure the distribution systems are upgraded in time to serve the upcoming and future load. Although on-site generation is very costly for operators and not the preferred method to power a facility, a generator will be used on a case by case emergency basis until grid power is made available. The majority of electric load required for the increasing oil and gas activity in Texas is for the operation of pumps during production that run constantly and are not weather sensitive, and is not for the drilling process itself.

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18 Available at: http://www.ercot.com/content/meetings/lts/keydocs/2014/0113/5._ERCOT_01_13_14_shavel.pdf

19 Shavel, Ira, Jurgen Weiss, Peter Fox-Penner, Pablo Ruiz, Yingxia Yang, Rebecca Carroll, Jake Zahniser-Word, Exploring Natural Gas and Renewables in ERCOT Part II: Future Generation Scenarios for Texas, Prepared for The Texas Clean Energy Coalition, December 10, 2013. Available at: http://www.brattle.com/system/publications/pdfs/000/004/970/original/Exploring_Natural_Gas_and_Renewables_in_ERCOT-_Future_Generation_Scenarios_for_Texas.pdf

For those reasons, the load shape tends to be flat across all hours. Once in production, wells are expected to continue producing for up to 30 years.

Overall, the presentations by the experts on trends, drivers, and uncertainties of key elements of the electric power sector provided a base level of knowledge on critical issues for the ERCOT stakeholders to consider in developing future scenarios. While some of the information may not have been new to every stakeholder, the presentations and discussions allowed the stakeholders to review the information in a comprehensive format and to begin to prioritize the factors that are most critical in developing scenarios. In addition, the presentations allowed subject matter experts who are not traditionally involved in the process to take part in the transmission planning process by interacting and discussing the above topics with stakeholders and to provide the most relevant and up to date information for the LTSA.

2. Transmission Service Provider Presentations

The second workshop included presentations by three transmission service providers (Oncor, CenterPoint, and Lower Colorado River Authority) to provide their local perspective on factors that impact the long-term transmission plan.

- **Oncor (Ken Donohoo, Director, System Planning, Distribution, and Transmission):** Mr. Donohoo presented highlights of advances in transmission technology that Oncor has implemented recently, such as dynamic reactive devices and synchrophasor monitoring. He also provided a review of the benefits to the recent build out in their territory associated with the CREZ projects and reliability upgrades in west Texas. Mr. Donohoo concluded his presentation with several considerations for long-term transmission planning, including changes in customer expectations and load shape, control challenges due to lower system inertia and increased variability of load and generation, and the impact of generation being located further from load centers.

- **CenterPoint (Bill Sumner, Finance and Asset Management):** Mr. Sumner provided a summary of CenterPoint's view on load growth in their territory around Houston and the coastal region. The most significant drivers Mr. Sumner identified included the impact of energy efficiency codes and standards on distribution level load and the potential for load growth from large industrial customers at the transmission level. CenterPoint sees continued growth across the oil & gas sector in their territory, from upstream metals and fabrication industries to downstream chemical plants and refineries. LNG facilities, such as the Freeport LNG terminal under development, could have significant impact on their load. Generally, Mr. Sumner states that the load growth in CenterPoint's service territory is expected to remain close to 2% per year, absent a significant decrease in oil prices.

- **Lower Colorado River Authority (Charles DeWitt, Systems Planning and Project Management):** Mr. DeWitt highlighted issues facing long-term transmission planning in general, including the need for identifying potentially high growth areas in weak portions of the transmission system (*i.e.*, areas that could be impacted in ways similar to the impact caused by the recent Eagle Ford Shale development). He also suggested that one focus should be identifying opportunities for transmission upgrades that reduce high east to west power flow from the I-35 corridor into the fastest growing region in ERCOT. He also highlighted the need to review the costs of incremental reliability upgrades versus the costs of pursuing larger projects that can provide multiple benefits.

3. Key Drivers for Future Scenarios

Following the presentations on the industry trends, drivers, and uncertainties, the Brattle consultants facilitated a brainstorming session amongst the LTSTF stakeholders regarding the issues they found to be the most critical for the future ERCOT electric power system. The stakeholders were encouraged to think through the wide range of issues discussed during the prior presentations and the key points from each presentation earlier in the process.

Through facilitated discussions, the stakeholders developed a list of potential drivers to consider in the 2014 LTSA. These included world oil prices; domestic gas prices; changes in the population of Texas; future weather conditions; the cost of generation capacity (including solar, wind, and CHP); Texas law and regulatory policies around transmission development; potential resource adequacy decisions; and federal environmental regulations, such as MATS and GHG standards. The stakeholders focused on the factors that are expected to impact new generation and future load growth as well as regional variations that can occur with respect to each scenario driver.

From the long list of the potential drivers, the Brattle consultants worked with the stakeholders to categorize the Key Drivers. The resulting Key Drivers are shown in Table 3 below along with a description of the stakeholder-identified details associated with each Key Driver.

Table 3
2014 LTSA Key Drivers Developed by ERCOT Stakeholders

Key Drivers	Description
Economic Conditions	U.S. and Texas economy, regional and state-wide population, oil & gas, and industrial growth, LNG export terminals, urban/suburban shifts, financial market conditions and business environment
Environmental Regulations and Energy Policy	Environmental regulations including air emissions standards (*e.g.*, ozone, MATS, CSAPR), GHG regulations, water regulations (*e.g.*, 316b), and nuclear safety standards; energy policies include renewable standards and incentives (including taxes/financing incentives), mandated fuel mix, solar mandate, and nuclear re-licensing
Alternative Generation Resources	Capital cost trends for renewable resources (solar and wind), technological improvements affecting wind capacity factors, limits on likely annual capacity additions, storage costs, other distributed generation costs, and financing methods
Natural Gas and Oil Prices	Gas prices are a function of total gas production, well productivity, LNG exports, industrial gas demand growth, and oil prices. Oil prices are dependent on global supply and demand balance and spread of horizontal drilling technologies. Oil and gas prices will affect drilling locations within Texas
Transmission Regulation and Policies	New policies around transmission build-out, desire and feasibility for interconnections to neighboring regions and methods for cost recovery
Generation Resource Adequacy Standards	Economically-determined versus mandated reserve margins and flexible resource requirements
End-Use/New Markets	End use technologies, efficiency standards and incentives, demand-response, changes in consumer choices, DG growth, increase interest in microgrids
Weather and Water Conditions	Weather and water availability may affect load growth, environmental regulations and policies, technology mix, average summer temperatures and therefore load variability, frequency of extreme weather events, water costs

D. Scenario Development

1. Candidate Scenarios

Following the discussion of key drivers, the Brattle consultants worked with stakeholders to identify candidate scenarios for ERCOT to consider in the 2014 LTSA. The candidate scenarios naturally followed the discussion of key drivers and the stakeholders used the drivers to describe the features of each scenario. Through structured discussions, the stakeholders analyzed a wide range of ideas about future scenarios and consolidated the diverse ideas into ten scenarios, as summarized below in Table 4.

Table 4
2014 LTSA Candidate Scenarios Developed by Stakeholders

Candidate Scenarios	Description
Current Trends	Trajectory of what we know and is knowable today, including anticipated LNG export terminal development, continued growth in west Texas, and prolonged high global oil prices
High Economic Growth	Significant population and economic growth from all sectors of the economy, increasing load growth from residential, commercial and industrial customers
Global Recession	Significant reduction in economic activities in the U.S. and abroad
Stringent Environmental Regulation/Solar Mandate	On top of current regulations, EPA also regulates GHG emissions. Federal or higher Texas renewable standards; more stringent water regulations; Texas legislative mandate on utility-scale and distributed solar development
High Efficiency/High DG/Changing Load Shape	Reduced *net* demand growth due to increase in distributed solar, CHP and higher building and efficiency standards
Low Global Oil Prices	Sustained low oil prices globally
High Natural Gas Prices	Sustained high domestic natural gas prices
LNG Export Growth	Significant additional building of LNG terminals (beyond those expected in Current Trends)
High System Resiliency	Severe climate and system events lead to new policies that require more stringent reliability and system planning standards
Water Stress	Low water availability across the ERCOT footprint

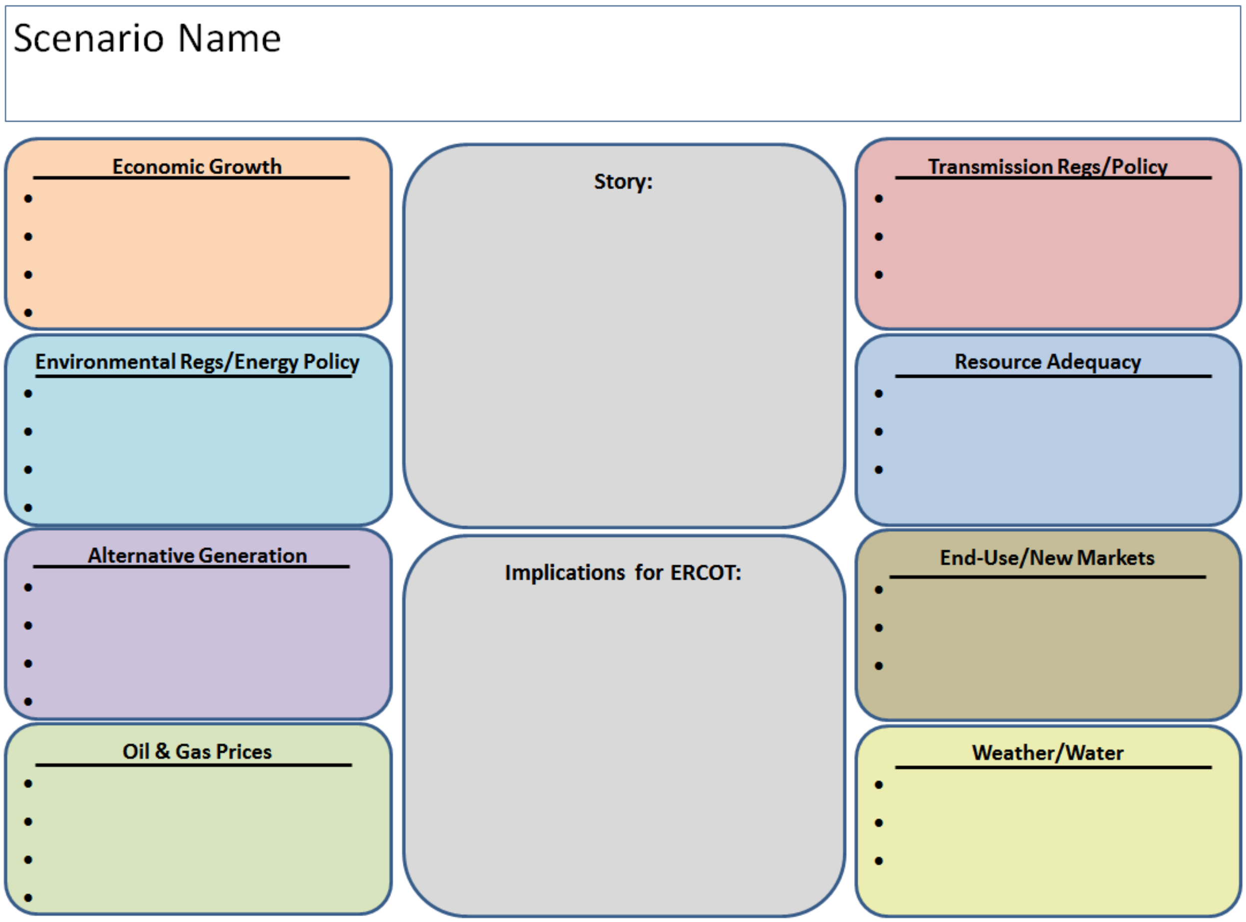
A few of the candidate scenarios were combined with another scenario when the stakeholders agreed that the scenarios appeared to be sufficiently similar. For example, a Solar Mandate scenario was identified as being unlikely without the drivers that would be expected to occur in the Stringent Environmental case; for that reason, the two are combined into one scenario.

2. Scenario Descriptions

The next step in developing the detailed scenario descriptions highlights the difference between scenarios and sensitivities, discussed previously. In the 2012 LTSA, ERCOT modeled a sensitivity of high gas prices relative to the assumed gas prices in the BAU (business-as-usual) case, in which all other variables remained the same except for the gas price. Our approach in the 2014 scenario development process is to encourage stakeholders to provide a comprehensive description of each future scenario; for example, the stakeholders are requested to describe what conditions are likely to coincide with high gas prices. The Brattle consultants worked with ERCOT to identify a mix of stakeholders to form small sub-teams.

The Brattle consultants provided each small sub-team with a structured template for describing the details of each scenario (sample shown in Figure 2) based on the key drivers identified earlier. The stakeholders were also asked to provide a high level "story" for each scenario and describe the potential implications of each scenario on ERCOT. The small sub-teams were provided a packet of information that provided suggested ranges of key planning assumptions, such as load growth projections, fuel price projections, and capital cost estimates. These suggested ranges help anchor the stakeholder's discussions when considering the possible parameters that correspond to the Key Drivers.

Figure 2
Scenario Description Template



Each small sub-team presented their detailed scenario descriptions to the entire stakeholder group to (again) provide everyone in attendance an opportunity to review the scenario descriptions, raise questions and concerns, provide specific input and feedback, and understand how each scenario is different or similar to the others.

Stakeholders began the scenario descriptions at the January 24 workshop and completed the additional descriptions at the February 14 workshop. Following the workshops, the scenario descriptions were presented in the structured template with additional questions highlighted for stakeholders to follow-up on concerning items that were not fully defined or gaps in the descriptions.

The scenario descriptions developed by stakeholders are summarized in the next section.

IV. Stakeholder-Developed Scenarios

A. Current Trends

The Current Trends scenario represents the best understanding of how the stakeholders view the future evolving under the currently anticipated circumstances. This scenario is often referred to as "business as usual" in other contexts. However, the "current trends" in the industry may in fact be quite different from what is currently considered as "usual." For example, the current trends indicate that LNG export terminals will be built and start operating in the next few years. A business as usual scenario may not include such expected additions simply because it is under the current situation. For that reason, "Current Trends" is a more useful baseline case than "Business-As-Usual."

As shown in Figure 3, the Current Trends scenario assumes that the economic and population growth in Texas continues into the future, including continued industrial and oil & gas sector growth. The EPA environmental regulations that are progressing towards becoming legal requirements are expected to proceed, including the implementation of the impending greenhouse gas standards for new and existing power generators. New generation capacity is assumed to come online by economic entry, although there are limits set on how much wind and solar capacity can be built in any given year. Fuel prices are to be based on current baseline forecasts. Transmission policy is assumed to remain focused on reliability upgrades under higher NERC standards with an additional focus on reducing system constraints and increasing DC ties with neighboring regions. For generation, an energy-only market is expected to continue without a capacity market in ERCOT, with an increased need for ancillary services and penetration of demand response and distributed generation. The recent droughts are not assumed to continue into the future, although water supply continues to be a concern.

Figure 3
Current Trends Scenario Description

1. Scenario: Current Trends

Economic Conditions
- ERCOT averages ~1.5% per year load growth with higher growth in near term tapering off in long-term
- Migration to TX continues, especially along I-35 corridor
- Industrial demand see growth in Houston, I-35, Midland/Odessa, Lower Rio Grande Valley
- LNG growth based on plants with approved permits
- Oil production rates follow trend similar to EIA reference case

Environmental Regs/Energy Policy
- EPA implements MATS and 316B by 2016
- EPA implements a hybrid form of CSAPR
- EPA sets greenhouse gas regulations with flexibility
- No other major changes in environmental regulations
- No change to existing PTC or ITC policy

Alternative Generation
- Renewable growth driven by economic entry, not subsidies
- Wind capital costs: ~$2,000/kW
- Wind capacity addition limit: 3,000 MW/yr.
- Wind capacity factors similar to historical data
- Solar capital costs: ~4.4% reduction/year
- Solar addition limit: 1000 MW / year in the near term

Gas & Oil Prices
- EIA reference case or best available gas and oil price forecasts

Story:
The recent population and economic growth in Texas continues in the near future, fueled largely by the continued growth of the oil and gas sector and the relative robust Texas economy compared to the rest of the U.S. World oil prices remain high enough to keep increasing oil production in the short-term, while keeping domestic natural gas prices relatively low due to associated gas production. With low gas prices, several LNG export terminals are built between 2014 and 2024. Modest wind capacity growth continues based on economics without production tax credits. Capital costs for solar continues to decline at a slower rate than recent history. No required reserve margin is set for ERCOT and the environmental regulations continues to be moderate, with no explicit federal carbon tax or required national cap and trade, but greenhouse gas emissions become regulated by the EPA through a flexible approach beyond 2016.

Implications for ERCOT:
- ERCOT continues to see modest economic growth and load growth
- Growth in oil production and population continues across the state leading to new transmission needs
- Continued increase in renewable capacity leads to reliability (inertia) issues

Transmission Regulations/Policy
- Transmission planning focused on reducing constraints
- Interest in increased DC-tie capacity with neighboring region
- Higher reliability standards are set by NERC to avoid load shedding

Generation Resource Adequacy
- No reserve margin set for ERCOT
- ERCOT maintains energy-only market
- Economic retirements continue with no major generation retirements triggered by stringent environmental regulations

End-Use
- Increased need for ancillary services
- Increase penetration of demand response relative to historical rates
- Increasing distributed generation

Weather/Water
- There is no long-term drought situation, but water supply continues to be a concern to existing and new generators
- No increase in electricity consumption due to drought conditions

B. Global Recession

The Global Recession scenario depicts a future where the economic and population growth in ERCOT is limited, particularly from the industrial (including future LNG terminals) and the oil & gas sectors due to a reduction in global demand. The anticipated impact is little to no net electricity load growth in the planning horizon. Environmental regulations are similar to under Current Trends, but the government incentives for high efficiency appliances and subsidies for renewables increase relative to those under Current Trends. Lower gas and oil prices reduce the exploration and production activities in the oil and gas rich regions. The lower gas prices also put additional pressure on existing coal plants to retire faster than under Current Trends. New generation additions are mostly gas-fired generation and subsidized renewables. However, solar costs do not decline as rapidly as under Current Trends due to the reduced global demand. Customers become more cost conscious during a global recession and therefore are even more conscientious of energy usage and are more efficient than under Current Trends. Thus there are further reductions in net load.

Figure 4
Global Recession Scenario Description

2. Scenario: Global Recession

Economic Conditions
- Little to no GDP growth or net load growth
- No industrial growth in ERCOT
- Net population growth in Texas is ~1%
- Trend towards urbanization with growth concentrated in the major cities
- Capital for new generation is difficult to obtain

Environmental Regs/Energy Policy
- Modest environmental regulations continue with no significant changes from assumptions under Current Trends
- Government incentives continue for high efficiency appliances
- Continued subsidies for renewables (PTC/ITC) as economic stimulus

Alternative Generation
- Limited development of wind and solar due to low energy prices
- Nuclear re-licensing encouraged
- Slower solar cost decline due to reduced global demand

Gas & Oil Prices
- Natural gas prices are ~$1/MMBtu lower than assumptions under Current Trends
- Less oil exploration and production
- No LNG export terminal development

Story:
Global recession limits growth in Texas, with low energy prices especially threatening the Texas economy. With limited load growth, resource expansion remains focused on gas-fired plants and subsidized renewables. Stimulus programs help create incentives for consumers to replace old appliances and increase conservation. Coal plants that rely on coal by rail retire due to lower energy margins.

Implications for ERCOT:
- Slow to no load growth
- Growth in urban areas greater than in rural areas
- Limited generation development, but predominantly gas-fired, subsidized renewables when needed
- Import/export issues between urban areas will need to be addressed
- Stability issues continue to increase due to low system load

Transmission Regulations/Policy
- Same as Current Trends
- Transmission faces lower construction costs per mile

Generation Resource Adequacy
- Coal plants retire due to low energy margins
- System inertia issues increase

End-Use
- Customers are more cost conscience, resulting in more conservation measures adopted
- Low load growth due to increased efficiency and changed customer behavior
- Limited growth of new technologies that are still high costs, such as storage

Weather/Water
- Same as Current Trends

C. High Economic Growth

The High Economic Growth scenario depicts a higher rate of growth than in Current Trends with growth across all sectors of the economy, especially in the oil & gas and related industrial sectors. Generally, renewable energy resources are expected to be more economic than in Current Trends due to higher gas prices, associated high power prices, and accelerated renewable energy technology improvements that can be expected with greater demand for renewable energy resources.[20] The costs of transmission and fossil generation capacity are expected to be higher in this scenario due to greater demand for them. A resource adequacy requirement is assumed to be put into place to ensure sufficient generating capacity to meet the growth in demand. The booming economy leads to fast adoption of new demand-side technologies and energy-efficient homes. These in turn place some downward pressure on the net energy and

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[20] When conducting the system simulation, ERCOT decided *not* to include aggressive energy and demand reduction associated with faster adoption of demand response and energy efficiency relative to the Current Trends scenario as described in this scenario because ERCOT wanted to test an "upper bound" case on energy demand. The High Economic Growth without downward pressure on demand-side resources helps depict that upper bound.

demand growth. The high economic growth in this scenario also leads to higher water usage and costs, but the higher cost does not rise to a level that limits the growth in demand.

Figure 5
High Economic Growth Scenario Description

3. Scenario: High Economic Growth

Economic Conditions
- High Texas GDP growth
- Industrial growth concentrated in Houston, I-35 corridor, Midlands/Odessa, Lower Rio Grande Valley
- Higher LNG exports than under Current Trends
- High population growth (2.5%/yr)
- Pro-business environment
- Capital is available to support new generation and transmission

Environmental Regs/Energy Policy
- Continued modest environmental regulations
- No significant changes from assumptions under Current Trends
- U.S. is more focused on developing domestic energy sources

Alternative Generation
- Due to higher gas prices, renewables are economic and growth in renewable capacity occurs
- For renewables and storage, more technological improvement than under Current Trends
- Cap on annual wind capacity growth similar to Current Trends

Gas & Oil Prices
- Modestly higher (+$1.5/MMBtu) gas prices than under Current Trends
- Same oil prices as under Current Trends

Story:
Economic growth within ERCOT is higher than under Current Trends. Growth occurs throughout Texas driven in large part by activity in the oil and gas sector and related upstream and downstream industries.

Implications for ERCOT:
- High load growth
- High urban growth
- High industrial growth, concentrated through I-35 corridor, Midlands/Odessa, and Lower Rio Grande Valley
- Higher costs for new generation and transmission due to elevated commodity prices
- Potential challenges with generation portfolios keeping pace with load profile changes

Transmission Regulations/Policies
- Same as under Current Trends
- Higher cost for new transmission (for both materials and labor)

Generation Resource Adequacy
- Likely to impose a resource adequacy requirement

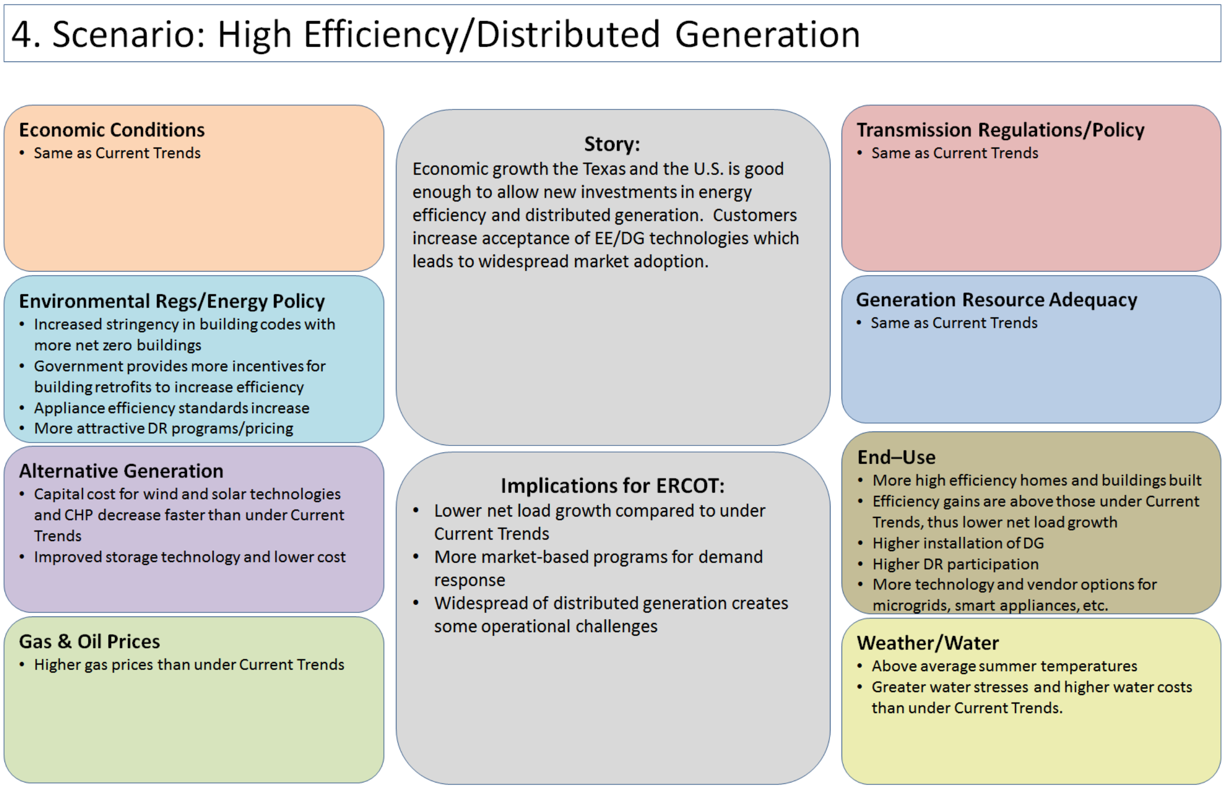
End-Use
- Growth of household income leads to increased demand
- However, more energy-efficient new homes are built
- Overall efficiency gains are similar as under Current Trends
- Fast adoption of new demand-side technologies

Weather/Water
- Higher water costs, but does not limit growth (e.g., potentially more dry cooling for new generation)

D. High Efficiency/Distributed Generation

The High Efficiency/Distributed Generation scenario depicts a future world where there is widespread adoption of energy efficiency and distributed generation. In this scenario, even though the economic growth in Texas is assumed to be similar to the Current Trends scenario, the net electric usage will be lower than under Current Trends due to the adoption of these resources. The lower net load growth comes from building standards, the use of smart and efficient appliances, and an increased desire for distributed generation and microgrids because their economics have improved either through subsidies or programs. In addition, demand response is more prevalent as a new capacity resource. A reduction in solar PV costs and an increase in gas prices (further incentivizing efficiency) also contribute to improving the relative economics of distributed generation, energy efficiency, and demand response; thereby reduce the net load served by conventional central generation resources.

Figure 6
High Efficiency/Distributed Generation Scenario Description



E. High Natural Gas Prices

The High Natural Gas Prices scenario depicts a world away from the continued low gas prices in Current Trends. Instead, the domestic natural gas prices are $3.50/MMBtu above the current forecasts over the long term. In this scenario, natural gas prices increase due to the combination of increased demand (which are typically associated with high economic growth), growth in LNG export from the U.S., higher than currently anticipated costs of gas production, and higher water or other environmental mitigation-related costs. As a result of the high gas prices, demand from downstream industries that rely on natural gas for feedstock decreases and therefore puts some downward pressure on load growth in some areas of ERCOT.

Figure 7
High Natural Gas Prices Scenario Description

5. Scenario: High Natural Gas Prices

Economic Conditions
- GDP growth slightly higher than Current Trends
- Population growth ~2.3%/yr.
- Pro-business environment
- Higher LNG exports than Current Trends
- Reduced Industrial growth (downstream facilities)
- Increased gas exploration in Texas

Environmental Regs/Energy Policy
- Modest environmental regulation, same as in Current Trends
- Environmental regulations lead to increased natural gas production costs
- No regulatory impediments to LNG exports
- Lower coal plant retirements due to higher margins

Alternative Generation
- Renewables are more economic and thereby expect more growth than Current Trends
- Annual limit on wind development
- More technological improvements for renewables

Gas & Oil Prices
- Natural gas prices $3.50/MMBtu above Current Trends by 2020
- Oil prices same as Current Trends

Story:
- Natural gas prices are high due to increased demand and production costs, but are below global natural gas prices such that LNG exports are higher than Current Trends.
- No impediments to LNG exports
- High gas prices reduce the downstream industrial growth compared to Current Trends

Implications for ERCOT:
- High load growth
- Reduced downstream industrial growth (in the Houston, Corpus, and coastal areas)
- Increase in renewable development compared to Current Trends, due to higher gas and wholesale energy prices

Transmission Regulations/Policy
- Same as Current Trends

Generation Resource Adequacy
- Same as Current Trends

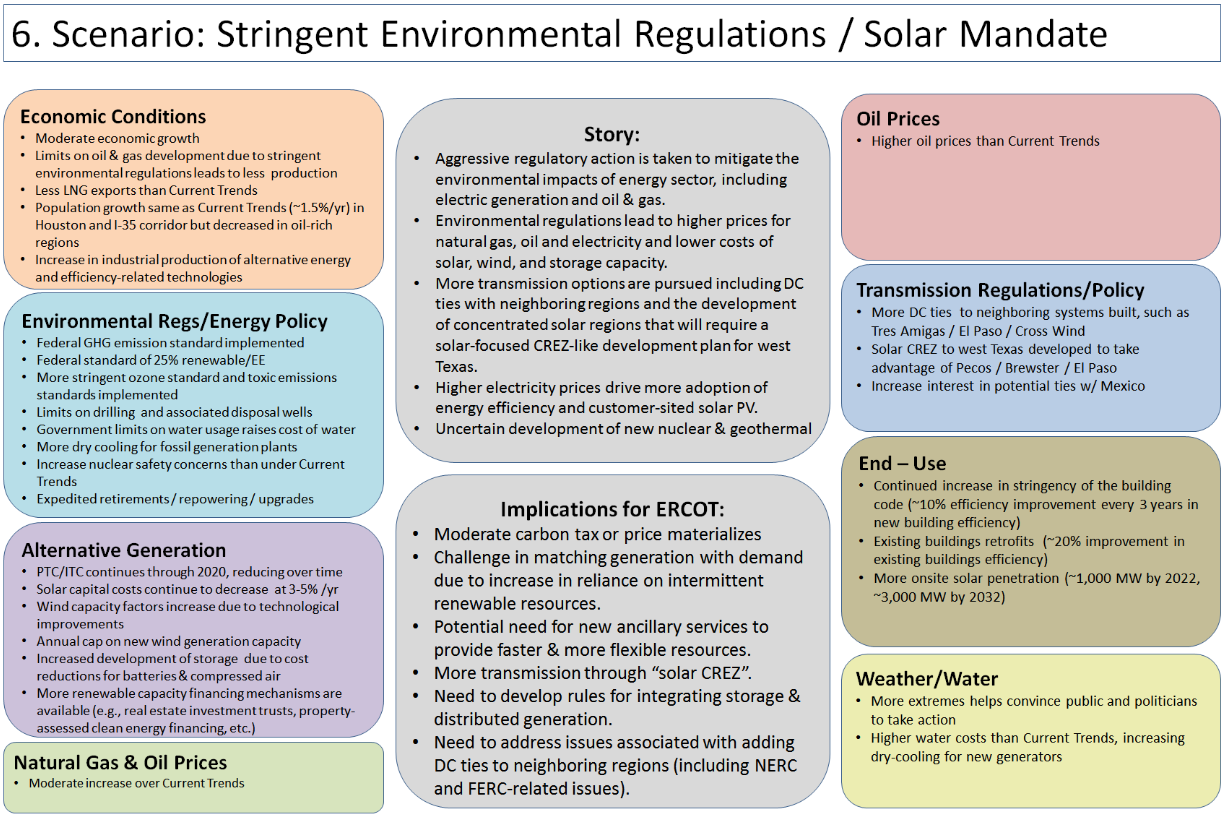
End-Use
- Higher natural gas prices motivate energy efficiency adoption at a faster rate than Current Trends

Weather/Water
- Increased water costs contribute to the higher cost of producing natural gas

F. STRINGENT ENVIRONMENTAL REGULATIONS/SOLAR MANDATE

Stakeholders decided to combine the Stringent Environmental Regulations and Solar Mandate into one scenario. This scenario depicts a future where environmental regulations are more stringent than expected under Current Trends, including increased compliance requirements for generation, electric transmission, and the oil & gas sectors. Further, additional government solar mandate increases the deployment of utility-scale and distributed solar resources across the ERCOT system. In this scenario, the economic growth is moderate. Federal greenhouse gas standards, renewable portfolio standards, and renewables subsidies are greater in this scenario than in Current Trends. Thus, the adoption of renewable generation and energy efficiency also increases relative to Current Trends. In addition, environmental regulations significantly increase costs of operating coal plants, which accelerates their retirement. Limits on water usage lead to the adoption of dry cooling on water-intensive generation units and reduced drilling activity. To support the growth of solar generation, Texas implements a transmission plan similar to CREZ for west Texas. In addition, DC-ties to the solar-rich areas to the west and in Mexico increase.

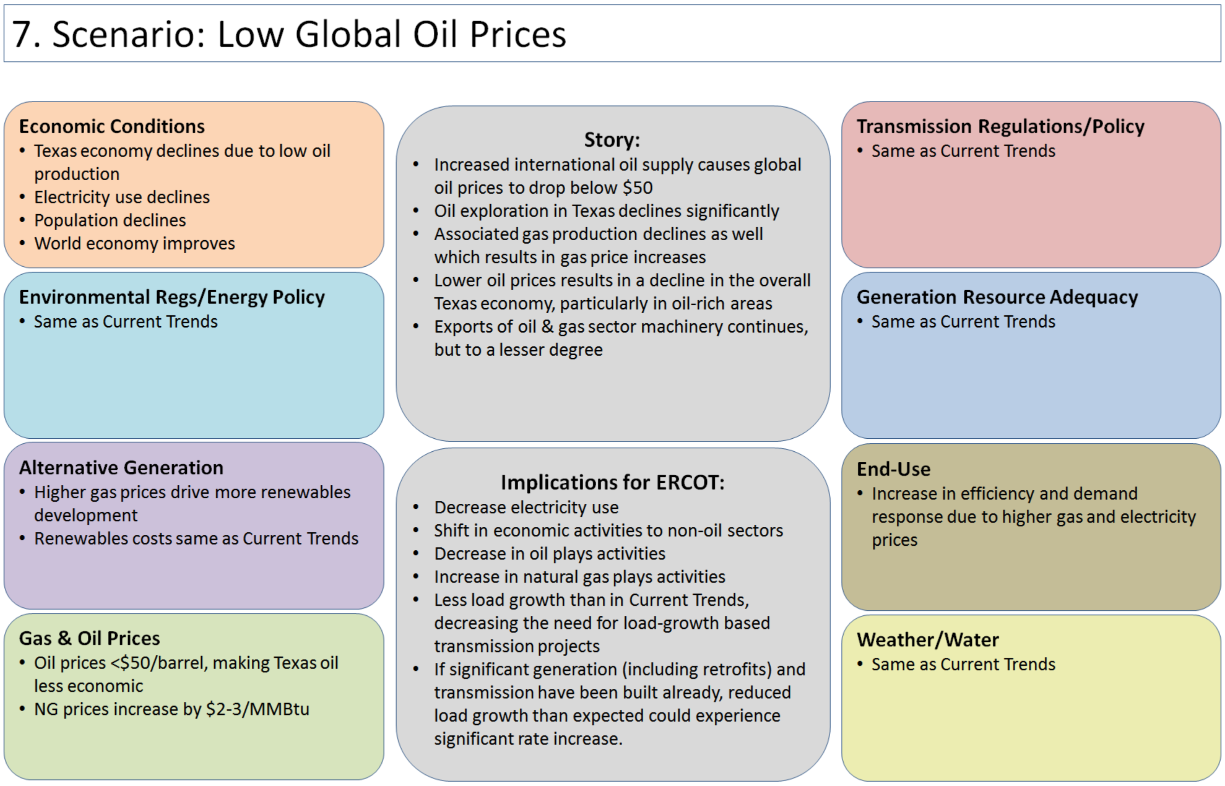
Figure 8
Stringent Environmental Regulations/Solar Mandate Scenario Description



G. Low Global Oil Prices

The Low Global Oil Prices scenario depicts a future where a glut of oil production materializes on the global market that significantly reduces global oil prices. Such a drop in oil price reduces the economic growth in Texas. Due to the decline in oil & gas production, load growth is significantly lower than Current Trends. The reduction in oil production also reduces associated gas production and leads to an increase in gas prices by $2–3/MMBtu relative to Current Trends. The environmental regulations and renewable energy policies remain the same as under Current Trends. However, higher gas prices causes higher electricity prices, which improves the economics of renewable resources and energy efficiency investments. Transmission policies also remain the same as under Current Trends.

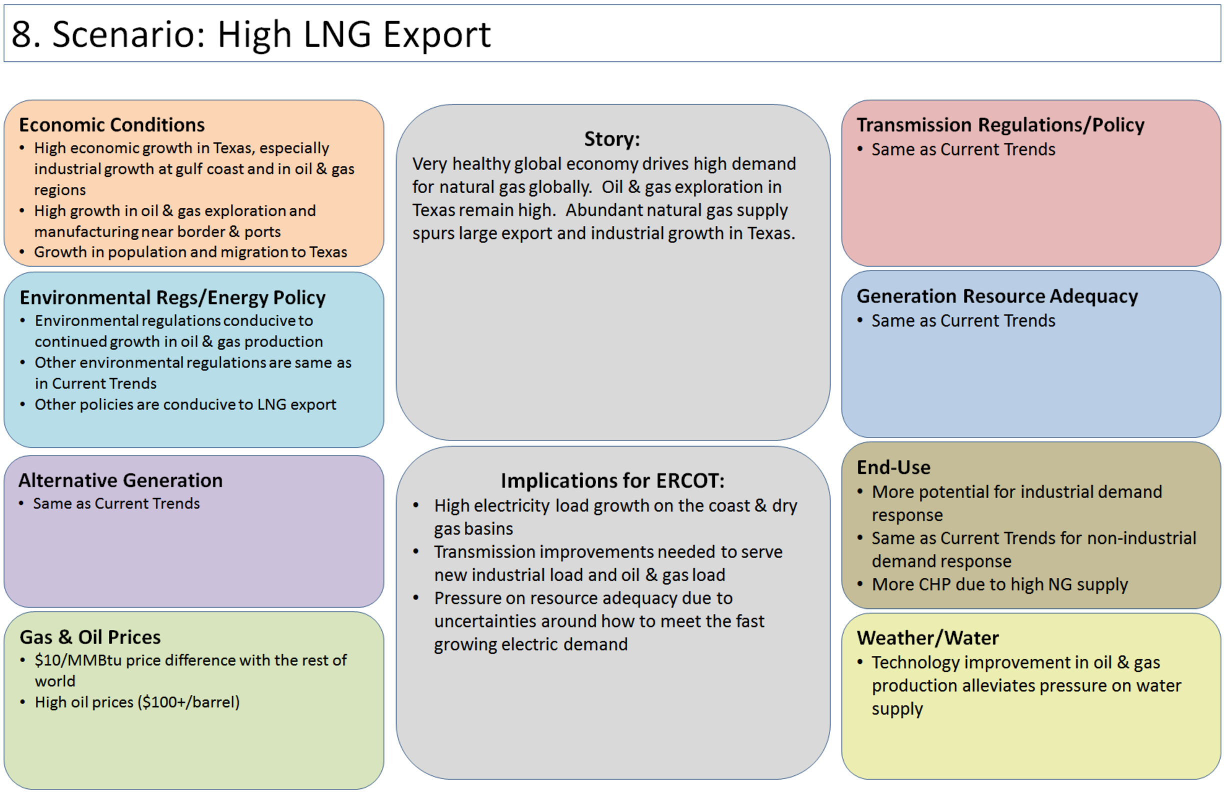
Figure 9
Low Global Oil Prices Scenario Description



H. High LNG Exports

The High LNG Exports scenario depicts a future where domestic natural gas prices are significantly lower than world prices for gas. Increased LNG exports and high oil prices lead to high economic growth and industrial activity, particularly along the coasts. The environmental policies are similar to Current Trends, but not stringent enough to limit the development of LNG terminals. The LNG export activities also induce growth in other related sectors. Increased LNG exports puts upward pressure on natural gas prices in Texas, but prices remain low enough to maintain the export market. Some of the high-electricity-usage customers are likely to explore demand response and combined heat and power (CHP).

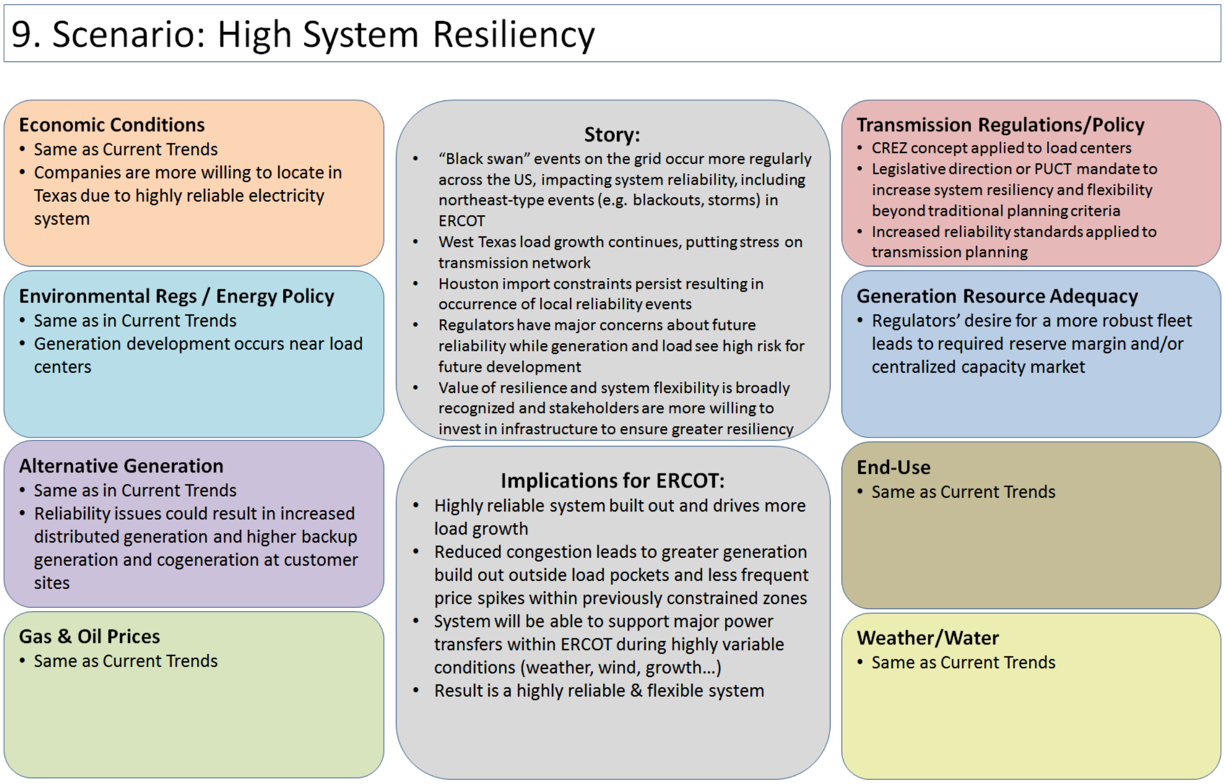
Figure 10
High LNG Export Scenario Description



I. High System Resiliency

The High System Resiliency scenario depicts a future where system planners and regulators focus strongly on providing a reliable system due to several “black swan” events similar to the 2003 northeast blackout. The emphasis on system resilience means that ERCOT will be mandated by the Texas legislature and the PUCT to design the transmission system with much higher reliability criteria. In addition, a resource adequacy requirement is mandated and generation is built close to load (either distributed solar or central power stations) and is valued at a premium. The environmental and renewable energy policies will remain the same as under Current Trends. The fuel prices are also similar to those in Current Trends.

Figure 11
High System Resiliency Scenario Description



J. WATER STRESS

The Water Stress Scenario depicts a world with sustained drought and hotter temperatures in Texas. The most significant negative impact on the Texas economy is on water-intensive sectors such as agriculture and oil & gas exploration, reducing their electricity usage. At the same time, hotter summers that coincide with drought conditions increase electricity demand for cooling. In addition, water-intensive generation plants are impacted by higher water costs, which lead to a significant increase in dry cooling on thermal generation. Higher cost of generation in turn increases power prices and improves the economics of renewable energy resource. Other non-water related environmental policies remain similar to under Current Trends. The impact on the existing generation fleet leads to a mandated reserve margin. In addition, due to higher power prices and customers' awareness of constraints around water availability, customers engage in greater adoption of energy efficiency, conservation, and demand-side resources.

Figure 12
Water Stress Scenario Description

10. Scenario: Water Stress

Economic Conditions
- Moderate decline in population and economic growth with higher impacts on localities with water intensive industry
- Productivity and job losses in agriculture
- Potential negative impact on oil & gas extraction

Environmental Regs/Energy Policy
- Drought management plans and water conservation required by Texas legislature
- Stringent requirements on power generation water use leads to wide-spread adoption of dry cooling
- Tax breaks for drought resistant generation
- Other environmental regulations are same as Current Trends

Alternative Generation
- Continued investments in renewables and storage with federal PTC/ITC
- Development of co-location desalination and power plants
- Renewable costs same as Current Trends

Gas & Oil Prices
- Moderate increase in natural gas prices relative to in Current Trends (+$1 – 2/MMBtu) due to increased water costs
- Moderate impact on local oil production, but prices are set internationally at the same price as Current Trends

Story:
- Due to sustained, multi-year drought conditions, the rate of population and economic growth moderately declines.
- The sustained drought conditions impact water-intensive generation resources (nuclear/coal/steam units) and lead to significant increase in capacity of renewables and storage compared to Current Trends as well as dry cooling on thermal generation and transmission expansion.

Implications for ERCOT:
- Units de-rated based on water resource limitations and water-intensive generation retirements lead to challenges in meeting capacity targets which results in mandated reserve margin.
- Potential need for new ancillary services to meet the needs of integrating new renewable energy generation.
- More transmission needed for expansion of renewables over those in Current Trends.
- Seriously consider more interconnections outside ERCOT.

Transmission Regulations/Policy
- More DC ties to neighboring regions
- Interest potentially in transmission plan for high solar regions ("solar CREZ")
- Increase in transmission due to policy/ regulatory changes resulting from drought

Generation Resource Adequacy
- Mandated reserve margin and increased operating reserves
- Demand response plays a larger role than in Current Trends

End–Use
- Increased development of demand-side management tools increases EE penetration beyond those in the Current Trends
- Greater market penetration of time-of-use rates and water smart devices

Weather/Water
- More drought than in the Current Trends
- Hot summers
- Limited water supply
- Increased water costs

K. Comparison of Scenario Descriptions

After the LTSTF stakeholders drafted the descriptions for the ten scenarios, the Brattle consultants offered revisions to those descriptions to improve internal consistency within each scenario and to ensure that they depict the intended range of scenarios. A draft of the scenarios was shared with all shareholders (including suggested revisions) to solicit additional feedback and suggestions for changes.

The Brattle consultants then compiled a summary table of drivers for the ten scenarios based on the descriptions. The summary helped to condense the scenario descriptions and place the drivers on a range of "high, medium, and low" scale so that stakeholders could efficiently assess if there were any significant overlaps between scenarios. Table 5 below shows the summary table for all ten scenarios and the scale of drivers.

During the third workshop (on February 14), we presented the scenario summary matrix to the stakeholders and discussed whether it reflects the scenarios properly and whether the scenarios provide sufficient contrast in the Key Drivers across the scenarios. The stakeholders discussed in detail how the ten scenarios compare and contrast with each other and reached consensus that none of the ten scenarios could be obviously combined but some may be paired during the system simulation. Below is a list of how some stakeholders and ERCOT staff believe the scenarios may be grouped.

Table 5
Comparison of 2014 LTSA Scenario Descriptions

Input Assumptions	1. Current Trends	2. Global Recession	3. High Econ Growth	4. High Efficiency/DG	5. High Gas Price	6. Stringent Environmental	7. Low Global Oil Prices	8. High LNG Exports	9. High System Resilience	10. Water Stress
Economic Growth										
System Load Growth (Peak and Total Energy)	Med	Low	High	Low	Med	Med	Low	High	Med	Low
Local Load Growth (deviations from system growth)										
I-35	Med	Low	High	Low	Med	Med	Med	High	Med	Med
Houston	Med	Low	High	Low	Med	Med	Med	High	Med	Med
Midland/Odesaa	Med	Low	High	Med	Med	Low	Low	High	Med	Low
Lower Rio Grand Valley	Med	Low	High	Med	Med	Med	Low	High	Med	Low
Dry Gas Basins	Low	Low	High	Low	High	Low	High	High	Low	Med
Capital availability/business environment	Med	Low	High	High	High	High	Med	Med	Med	Med
Env Regs/Energy Policy										
Fossil plant retirements	Med	High	Low	High	Low	High	Med	Med	Med	High
GHG Regulations	Flexible	Flexible	Flexible	Flexible	Flexible	GHG Standard	Flexible	Flexible	Flexible	Flexible
Renewable incentives	Med	High	Med	Med	Med	High	Med	Med	Med	High
Nuclear relicensing	Med	Low	High	Low	High	Med	Med	Med	Med	Med
Limits/regulations on oil & gas development	Med	Med	Low	High	High	High	Med	Low	Med	High
Alternative Generation										
Renewable and storage capital cost reductions	Med	Low	High	High	High	High	Med	Med	Med	High
Annual renewable capacity total additions	Econ.	Subsidized	Econ.	Econ.	Econ.	Subsidized	Econ.	Econ.	Econ.	Subsidized
Natural Gas/Oil Prices										
NG price forecast	Low	Low	Med	Low	High	Med	Med	Low	Low	Med
Oil price forecast	Med	Low	Med	Med	Med	Med	Low	High	Med	Med
Transmission Regulation										
DC-tie capacity increases	Med	Low	Med	Med	Med	High	Med	Med	High	High
Transmission costs per mile	Med	Low	High	Med	Med	High	Med	Med	Med	Med
CREZ-like program	No	No	No	No	No	Solar	No	No	Load-Based	Solar
Generation Resource Adequacy										
Reserve margin	None	None	Yes	None	None	None	None	None	Yes	Yes
End Use/New Markets										
DG Growth	Med	Low	High	Very High	High	High	Med	Med	Med	High
EE Growth	Med	High	Med	Very High	High	High	Med	Med	Med	High
DR Growth	Med	Med	High	Very High	High	High	Med	Med	High	High
Water/Weather										
Climate Impacts	Med	Med	Med	Med	Med	High	Med	Med	Med	High
Water Stress/Costs	Med	Low	High	Med	High	High	Med	Low	Med	High

- **Current Trends:** Current Trends sets the baseline case for all other cases. It is a standalone case and should be simulated independently.

- **High Growth Scenarios (High Economic Growth, High LNG Exports):** The most significant difference noted between High Economic Growth and High LNG Exports is the type and location of growth expected. While the High Economic Growth scenario depicts growth across the Texas economy, the High LNG Exports scenario would focus primarily on the development of numerous LNG export terminals in the coastal regions. Some stakeholders suggested that the High LNG Export scenario could be treated as a sensitivity around the location of the load growth, instead of as a scenario on its own.

- **Low Growth Scenarios (Global Recession, Low Global Oil Prices):** Some stakeholders noted that the main difference between Global Recession and Low Global Oil Prices is how widespread the low growth would be felt across Texas. While the Global Recession scenario depicts low load growth across ERCOT, the Low Global Oil Prices scenario would impact the oil producing and downstream industrial regions more significantly than others within ERCOT. This means that in the Low Global Oil Prices scenario western Texas and the Houston area, where most of the industries that support oil operations are located, would be negatively affected more than others.

- **High Penetration of Alternative Technologies (Stringent Environmental/Solar Mandate, High Efficiency/DG, Water Stress):** The Stringent Environmental/Solar Mandate, High Efficiency/DG, and Water Stress scenarios describe futures that require a further shift in resources away from the current fossil generation fleet toward more renewable energy, energy efficiency, and other distributed generation resources. Stakeholders initially discussed in great detail the differences between the Stringent Environmental/Solar Mandate and High Efficiency/DG scenarios with several stakeholders highlighting that the issues and motivations that lead to support for certain technologies might be similar across the scenarios but the technologies supported are quite different and would have important impacts on the transmission system. The Stringent Environmental/Solar Mandate scenario depicts a future that is likely to yield significant retirement of existing fossil plants and a great penetration of new renewable technologies, while the High Efficiency/DG scenario focuses more significantly on new resources from demand-side technologies. Another important difference between these scenarios is that the Stringent Environmental/Solar Mandate scenario includes a reduction in the oil & gas industry-related load growth whereas the High Efficiency/DG scenario may primarily result with *net* load growth reduction from residential, commercial, and industrial sectors due to an increase in efficiency and a greater penetration of DG.

  The Water Stress scenario also depicts a future where renewable resources and demand-side technologies are likely to increase, but also considers a more significant impact on existing fossil generation that may need to switch to dry cooling. The Water Stress scenario also depicts a world with water-constrained economic growth and therefore downward pressure on load growth.

From the discussion, the stakeholders indicated that the geographic distribution of load growth and changes in generation would be sufficiently large between the Stringent Environmental/Solar Mandate and the High Efficiency/DG scenarios that the transmission needs between the two scenarios could be different enough to warrant separate scenarios considerations. On the other hand, the stakeholders felt that the Water Stress scenario may be sufficiently similar to Stringent Environmental/Solar Mandate to consider accounting for the issues captured in the Water Stress scenario as a sensitivity of the Stringent Environmental/Solar Mandate scenario, by requiring dry cooling to be installed on all fossil plants.

- **High Natural Gas Prices:** The High Natural Gas Price scenario is very similar to the High LNG Exports scenario or the Current Trends scenario, but with high gas prices. It could be treated as a sensitivity to both of those scenarios.

- **High System Resiliency:** Since this scenario considers the possibility that transmission is *not* only built to meet the current minimum reliability requirements, but rather built to maintain a more resilient system, it can be treated as a sensitivity case around Current Trends and other High Growth or Stringent Environmental scenarios.

V. Transmission Planning and System Simulation Assumptions

One of the primary objectives of the scenario development process for the 2014 LTSA was to provide ERCOT system planners with internally consistent planning assumptions for simulating the ERCOT system over a 15-year horizon. The simulations have been designed to capture the wide range of possible futures developed by the LTSTF stakeholders, taking into consideration the trends, drivers, and uncertainties discussed throughout the process. To translate the scenario descriptions to planning assumptions, the Brattle consultants worked with ERCOT staff to translate and develop new model input assumptions, including reviewing the 2012 planning assumptions and evaluating how they should be altered for the 2014 LTSA. ERCOT staff presented all proposed draft planning assumptions to stakeholders through the monthly RPG meetings to allow stakeholders adequate opportunities to provide comments and suggest changes.

In this section, we briefly summarize how ERCOT staff utilized the scenario descriptions developed by stakeholders to develop planning assumptions for simulating each scenario in the 2014 LTSA. In the summary below, we focus on the assumptions that required the most adjustments relative to those used in the 2012 LTSA as they demonstrate the value of stakeholders' contributions through the scenario development process.[21]

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21 The final 2014 LTSA will provide full details on the input assumptions for each case. The purpose of this section in the Scenario Development report is to provide insight into the approach ERCOT has taken in adapting the detailed descriptions into input assumptions for modeling the ERCOT system.

A. Load Forecast

Projecting peak load and total energy demand over a 15-year horizon requires analyses of historical trends and considerations of how the future might differ from the past. In developing the future scenarios, stakeholders discussed and identified several important drivers of load growth over the planning horizon and how they may differ from historical trends in each scenario, including:

- Population growth
- Local, national, and global economy
- Consumer preferences
- Energy efficiency standards and retrofits
- Oil and gas exploration and production
- Drought conditions
- Environmental policies

To capture the details depicted in the stakeholder-developed scenarios, ERCOT staff set the baseline load forecast to the 2014 Long-Term Hourly Peak Demand and Energy Forecast.[22] Where assumptions in the scenarios (including in the Current Trends scenario) differ from the information incorporated into the baseline forecast, ERCOT adjusted the load forecast accordingly.

Stakeholders highlighted throughout the scenarios the importance of regional changes in growth across the scenarios. Since TSPs provide load growth assumptions to ERCOT through the Steady State Working Group (SSWG), those assumptions form the basis of the geographic distribution of the load growth across the various ERCOT weather zones.[23]

For the Current Trends scenario, ERCOT adjusted the baseline load forecast based on the details of the scenario descriptions that are not captured in ERCOT's baseline load forecast methodology. For example, ERCOT increased the load in the Coast weather zone by 235 MW in 2018 and 706 MW in later years based on the assumed development of LNG export terminals that are not captured in the ERCOT baseline forecast. ERCOT also decreased load by 668 MW in total ERCOT load to account for the growing impact of energy efficiency measures based on an internal review of the existing load forecast.

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22 ERCOT, 2014 ERCOT Planning: Long-Term Hourly Peak Demand and Energy Forecast. March 31, 2014. Available at: http://www.ercot.com/gridinfo/load/forecast/Docs/2014_Long-Term_Hourly_Peak_Demand_and_Energy_Forecast.pdf

23 As the load forecast is for a 10-year horizon, ERCOT extrapolated beyond 2024 by assuming the 2024 growth rate of 1.3% continues to 2029.

The patterns of load growth in each scenario reflect the potential variations in future states of the world and therefore are an important outcome of the scenario development process. Using the descriptions of the growth patterns in each scenario, ERCOT modified either the system-wide or region-specific growth patterns. For example, as the Global Recession scenario depicts an economic downturn, ERCOT chose to assume a one-year 5% drop in total energy demand in 2021 followed by sustained lower load growth than in the Current Trends scenario. In the scenarios that reflect more optimistic economic conditions, ERCOT assumed accelerated load growth in the regions that had been highlighted as potential high growth regions in the scenario descriptions (summarized in Table 5 above).

In addition to the overall growth in ERCOT, the potential expansion and contraction of the oil & gas industry along with associated upstream and downstream industrial development are considered in two scenarios: the High Economic Growth scenario reflects increased activity relative to the Current Trends scenario and the Stringent Environmental scenario reflects decreased activities. Similarly, the High Economic Growth and High LNG Exports scenario descriptions noted increased load due to additional LNG export terminals being built relative to the Current Trends scenario.

The advancement of demand-side technologies to levels beyond those in the Current Trends is also considered by ERCOT in the load forecasts used in the Global Recession, High Efficiency/DG, and Stringent Environmental scenarios. In each of these three scenarios, the *net* load growth reflects the impact from high penetration of energy efficiency and distributed generation. Although the High Economic Growth scenario also envisions an accelerated adoption of energy efficiency and distributed generation (because economic health also provides additional opportunities for the new technologies), ERCOT chose not to decrease the load projections in the High Economic Growth scenario so that a high load growth bookend case would be included in the 2014 LTSA.

Table 6 below summarizes the methodologies used for developing the load forecast in each scenario.[24]

[24] The values in the table are based on research ERCOT into the assumptions into their base forecast and industry trends. More details will be included in the 2014 LTSA report.

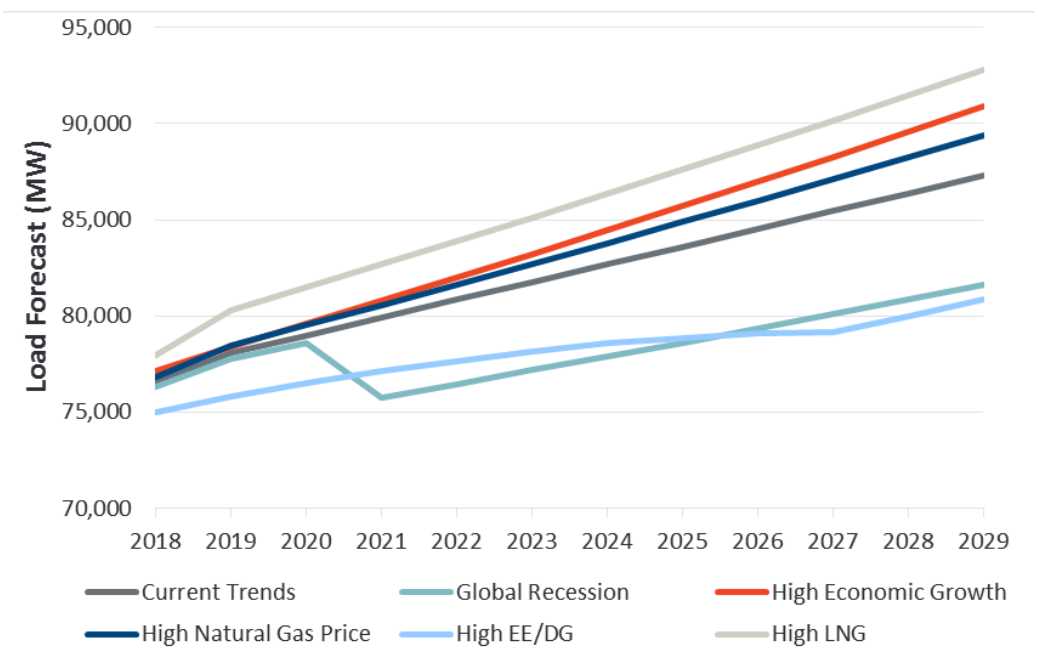
Table 6
Load Forecast Assumptions

Load Forecast Components	1. Current Trends	2. Global Recession	3. High Econ Growth	4. High Efficiency/DG	5. High Gas Price	6. Stringent Environmental	8. High LNG Exports
Growth Adjustments		One time 5% reduction 2021 and lower growth in later years than in Current Trends	Increased load growth in COAST, NCENT, and SCENT weather zones		Increased load growth in COAST, NCENT, and SCENT weather zones, but less than High Econ Growth	Reduced growth in FARWEST due to impact on oil and gas activity	Increased load growth in COAST, NCENT, and SCENT weather zones similar to High Econ Growth
LNG Growth	Increased load based on addition of currently approved terminals	Increased load based on addition of currently approved terminals	Assume additional terminals beyond Current Trends, but less than High LNG Exports	Increased load based on addition of currently approved terminals	Increased load based on addition of currently approved terminals	Increased load based on addition of currently approved terminals	Assume additional terminals beyond Current Trends
Energy Efficiency and Load Management	~700 MW of peak reduction throughout study period	EE impact grows by 3.3% per year relative to Current Trends	~700 MW of peak reduction throughout study period	EE impact grows by 20% per year relative to Current Trends	~700 MW of peak reduction throughout study period	EE impact grows by 3.3% per year relative to Current Trends	~700 MW of peak reduction throughout study period
Solar PV Distributed Generation		~1 GW of peak reduction by 2029		~1 GW of peak reduction by 2029		~1 GW of peak reduction by 2029	

Source: ERCOT. All other scenarios used the Current Trends load forecast.

Based on the adjustments described in Table 6 above, ERCOT reflected the range of the scenarios through different system-wide load forecasts as shown in Figure 13 below.

Figure 13
Scenario Load Forecasts



Source: ERCOT. All other scenarios used the Current Trends load forecast.

B. CAPITAL COSTS

The generation and demand-side capacity resources that meet the ERCOT peak load and energy demand will adapt over the time horizon of the 2014 LTSA depending on several factors considered by stakeholders in each scenario. The relative economics of generation technologies is very sensitive to capital cost assumptions and thus requires particular care to ensure that the most up-to-date and relevant information is used in ERCOT's generation expansion modeling.

While fossil-fuel-fired generation capital costs are relatively stable, changes in technology, labor rates, and commodity prices can impact the capital costs of new facilities. On the other hand, renewable generation continues to increase in capacity and advance its technology leading to more significant changes in costs (*e.g.*, economies of scale).

1. Natural Gas Generation

Relying on several publicly available sources that have recently calculated the capital cost of new gas-fired capacity, ERCOT has reduced its values for the cost of new capacity from natural gas-fired combustion turbines (CTs) and combined-cycle gas turbines (CCGTs) to account for lower costs of building new facilities in Texas relative to other parts of the country.[25] The assumed capital costs for natural gas-fired generation are shown in Table 7. The columns labeled "2014 LTSA" show the assumptions that ERCOT has used in the current analyses and the column labeled "2012 LTSA" reflects the assumptions used two years ago to show the change ERCOT has implemented. The updated values for the 2014 are roughly 4–5% lower than the assumptions used in the 2012 LTSA.

Table 7
Comparison of 2012 and 2014 LTSA Natural Gas-Fired Generation Capital Costs

Technology	2014 LTSA Base *2018$/kW*	2014 LTSA High *2018$/kW*	2012 LTSA Base *2018$/kW*
Combustion Turbine	869	1,087	904
Combined Cycle Gas Turbine	1,055	1,318	1,111

Notes: High capital cost values were used in the High Growth scenario. All other scenarios used Base values.

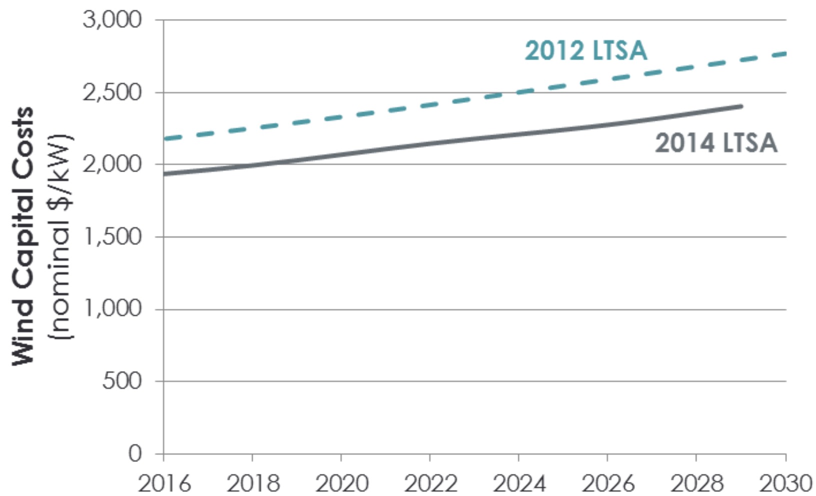
[25] Sources for gas-fired capital costs include the August 2013 Lazard levelized cost of electricity analysis, Ventyx Energy Velocity Suite, and the EIA AEO 2013.

The “High” capital costs assumption is 25% above the “Base” capital costs based on a review of assumptions made in recent capital cost projections.[26]

2. Wind Generation

The capital costs for wind generation, in terms of dollars per kilowatt of capacity, have decreased slightly over the past few years, based on our review of recent capital cost trends. Figure 14 below show the 2014 LTSA wind cost assumptions, compared to the 2012 value.

Figure 14
Wind Capital Cost Assumptions



While the capital cost per kW has remained stable, as highlighted in the presentation by Mr. Clark on wind technology developments during the first workshop, significant improvements in wind turbine technologies allow each MW of wind generation capacity to produce more energy, particularly during low wind periods, as compared to earlier technologies. Using taller towers has also increased energy production per MW of wind installed. However, because improved wind profiles are not yet available to ERCOT, ERCOT will continue to use the wind energy production levels used in the 2012 LTSA, which does not incorporate any of the impact of increased wind capacity factors in the capacity expansion simulations. The Brattle consultants recommend that future analyses include updated wind generation profiles based on the latest performance characteristics because such technical advancements can have significant effects on both the MW installed and the actual MWh of wind generation over the planning horizon.[27]

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26 Black & Veatch, Cost and Performance Data for Power Generation Technologies, prepared for the National Renewable Energy Laboratory, February 2012. Available at: http://bv.com/docs/reports-studies/nrel-cost-report.pdf

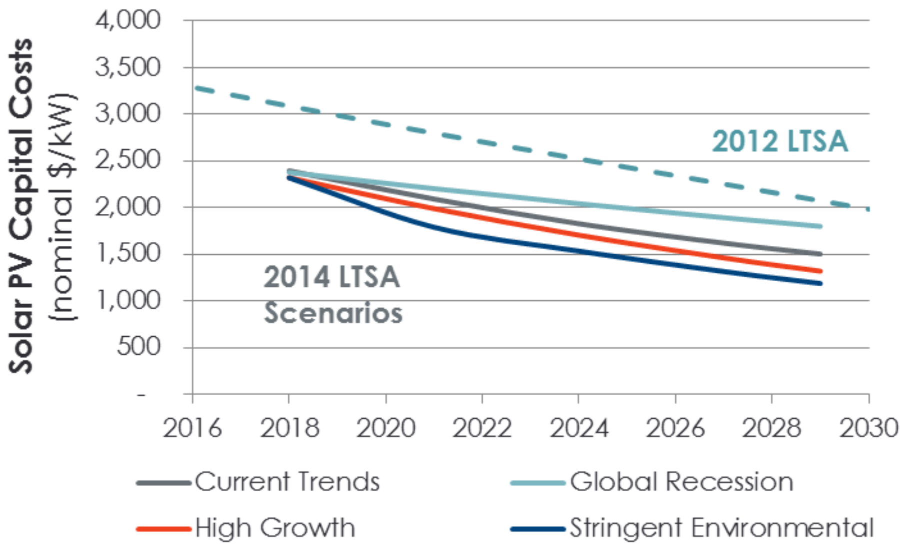
27 For a discussion of the impact that technology improvements can have on wind generation costs, see Eric Lantz, *et al.*, IEA Wind Task 26: The Past and Future Cost of Wind Energy, Work Package 2,

Continued on next page

3. Solar Generation

The Brattle consultants and ERCOT staff reviewed solar capital cost assumptions from several sources and requested additional input from LTSTF stakeholders. From the information reviewed, ERCOT developed the solar capital cost assumptions across the planning horizon for the 2014 LTSA based on the data received from the Solar Energy Industry Association (SEIA) and assumptions utilized in a 2013 ERCOT report titled, "Exploring Natural Gas and Renewables in ERCOT Part II: Future Generation Scenarios for Texas," as shown in Figure 15. For comparison purposes, the capital costs used for solar in the 2012 LTSA were included as well.

Figure 15
Solar Photovoltaic Capital Cost Assumptions



Notes: All other scenarios used Current Trends values.

4. Addition of Demand-Side Resources

The method employed to add demand response, energy efficiency, and distributed solar PV ("DG solar") is based on ERCOT's interpretation of the scenario descriptions. ERCOT has assumed that energy efficiency and distributed solar would reduce the *gross* peak load as described in the previous section on load forecasts for each scenario. ERCOT does not simulate DR as economic additions in the capacity expansion simulation, instead assuming DR capacity in each scenario as shown in Table 8.

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Technical Report NREL/TP-6A20-53510, May 2012. Available at: http://www.ieawind.org/task_26_public/PDF/WP2_task26.pdf

Table 8
Total Demand Response Capacity Assumptions

Scenario	2021 *MW*	2024 *MW*	2027 *MW*	2029 *MW*
Current Trends	1,591	1,688	1,792	1,865
High EE/DG	1,686	1,897	2,133	2,401
High NG Prices	1,736	2,010	2,326	2,565

Notes: Demand response capacity is the sum of Industrial and Residential Demand Response assumed by ERCOT. The Current Trends assumption was also used for High Economic Growth, High LNG, Water Stress, and Stringent Environmental. High EE/DR was also used for Global Recession. High NG Prices was also used for High System Resiliency.

C. Natural Gas Prices

The stakeholders identified the cost of natural gas as a key driver in developing future scenarios due to its impact on energy prices and generation capacity expansion choices. During the scenario development process, natural gas analysts from Wood Mackenzie provided a summary of future natural gas supply and demand trends and uncertainties, which were considered by the stakeholders in developing the scenarios.

Based on ERCOT's review of the scenario descriptions and several sources, ERCOT developed four different natural gas price projections to correspond with the descriptions developed by the stakeholders for the various scenarios, as shown in Figure 16.[28]

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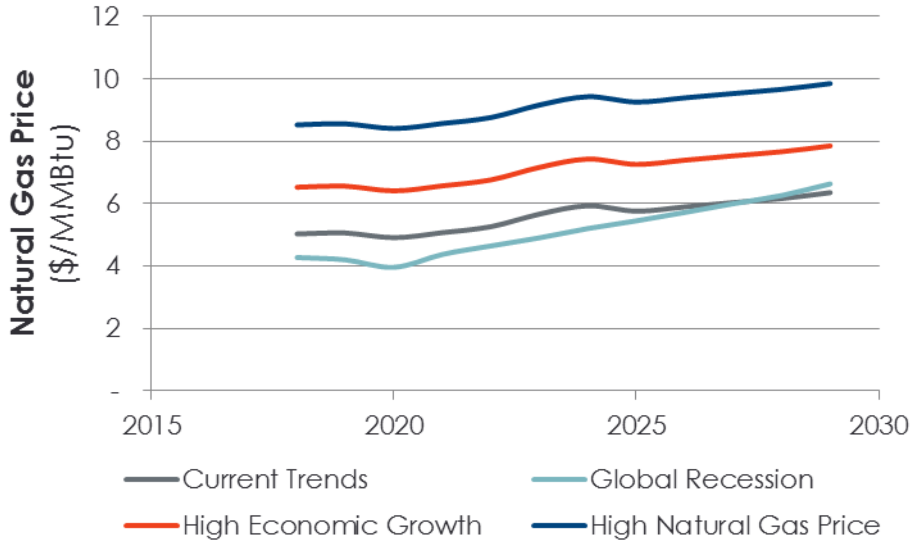
[28] The natural gas price projections reflect the information contained in the Wood Mackenzie projection, the Department of Energy's Energy Information Administration's 2014 Annual Energy Outlook, and the prices from NYMEX traded natural gas futures.

Figure 16
Natural Gas Price Assumptions



Notes: The Current Trends price was also used for High LNG Export and High System Resiliency. The High Economic Growth price was also used for High EE/DG, Stringent Environmental, and Water Stress.

As described by the stakeholders, the High Natural Gas Price scenario includes natural gas prices that are \$3.50/MMBtu above the Current Trends projection and the High Economic Growth projection is \$1.50/MMBtu above Current Trends.

D. Energy and Environmental Policies

The stakeholders also identified energy and environmental policies as key drivers for ERCOT's future generation mixes and locations, The key topics of discussion amongst stakeholders was the future extension of the production tax credit ("PTC") and investment tax credit ("ITC"), the stringency of the EPA's environmental regulations, and the possibility of a carbon dioxide (CO_2) emissions cap. For scenarios in which the descriptions included renewable generation subsidies and incentives, such as Global Recession, Stringent Environmental, and Water Stress scenarios, ERCOT assumed the continuation of the PTC and the ITC at their 2013 levels.

The stakeholders also largely agreed that the environmental regulations that the EPA is currently promulgating will be implemented in the Current Trends. However, stakeholders discussed that only in the Stringent Environmental scenario will a CO_2 emissions cap be implemented, which ERCOT has modeled by assuming a price on CO_2 emissions, as shown in Figure 17.[29]

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[29] ERCOT reviewed several sources for developing the CO_2 price, including a CO_2 price forecast done by Synapse Energy Economics in 2013 (Luckow, *et al.*, 2013 Carbon Dioxide Price Forecast, November. 2013), the CO_2 allowance price assumption in Levelized Cost of Electricity Renewable Energy Technologies study done by Fraunhofer Institute for Solar Energy Systems in 2013 (Kost, *et al.*, Levelized Cost of Electricity Renewable Energy Technologies, November 2013), and projected

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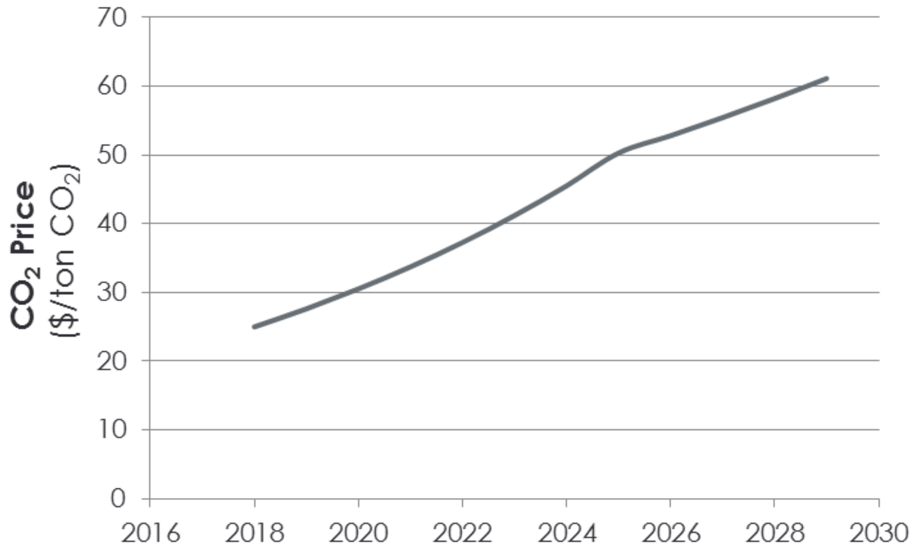
In addition, only in the Stringent Environmental case will there be additional costs for sulfur dioxide (SO_2) and nitrogen oxides (NOx) emissions. The SO_2 and NOx emissions costs for this scenario are assumed to be the same as they were in the cases in the 2012 LTSA in which an emission cost was assumed to exist.

Figure 17
Carbon Dioxide Emissions Price Assumption Used in the Stringent Environmental Scenario



Notes: A CO_2 price is included only in the analysis of the Stringent Environmental case.

E. Transmission and Resource Adequacy Policies

The stakeholders also considered several other regulatory policies and initiatives that affect resource adequacy in ERCOT. In general, assuming that ERCOT would implement a resource adequacy requirement in certain future scenarios is intended to reflect requirements that are outside of the current market rules but could have a significant impact on transmission planning if implemented.

Although the Public Utility Commission of Texas is not currently pursuing a resource adequacy requirement, stakeholders considered that they may do so in the future, which would result in a certain level of capacity resources to be available relative to the projected load. The scenarios in which a resource adequacy requirement is assumed includes High Economic Growth, High System Resiliency, and Water Stress, with the anticipation that an energy-only market might not be sufficient to provide the necessary price signals for meeting ERCOT's generation adequacy needs.

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allowance prices done by EPA in 2006 (EPA Office of Air and Radiation, Estimating Future Air Emissions Allowance Values, November 2006).

Further, the stakeholders also considered the possibility of a future policy that would increase the need or desire for more interties with surrounding regions. Reflecting the scenario descriptions, ERCOT assumed 3,000 MW of additional DC interties with SPP are built in the Stringent Environmental and High System Resiliency scenarios.

Part II: Recommendations for Future LTSA Scenario Development Processes

VI. Suggestions for Future LTSA Scenario Development

We developed the 2014 LTSA scenario development approach to provide ERCOT and its stakeholders a structured, inclusive, and efficient process that facilitated ERCOT stakeholders—those who work closely with the ERCOT system—in creating scenarios that reasonably capture the most relevant range of futures for transmission planning over a 10–20 year time horizon. We assisted the stakeholders in collecting information by ensuring that stakeholders had ample opportunities to gather data, contribute insights, discuss potential long term issues, and develop detailed descriptions of future scenarios. We have observed that the participants were able to explore beyond "today's expectations" that can often narrow one's views of the future and develop internally-consistent assumptions about market conditions across the range of potential futures.

There were several aspects of the ERCOT 2014 LTSA scenario development process that enhanced the scenarios, and thereby the planning assumptions, and should be reiterated for future LTSA studies. These include collecting feedback from stakeholders, considering the views of certain subject area experts, and conducting workshops and breakout sessions with stakeholders to develop the Key Drivers and the Scenario Descriptions. There are also aspects that can be improved, including sustained stakeholder participation and the process used to translate scenario details into planning assumptions. Below, we first discuss "what went well," followed by some recommendations for future improvements.

A. Stakeholder Feedback on Process

We received extensive feedback from ERCOT stakeholders during our review of the 2012 LTSA. The feedback we requested and received was related to the entire LTSA process, not only focused on the scenario development process, which allowed us to understand how stakeholders viewed the scenarios in the context of the results as well as the process for developing the scenarios themselves. Requesting feedback solely on the scenario development process would not likely have resulted in providing as much insight into how the scenarios impact the stakeholders' view of the rest of the study, especially the results, and the importance of improving the scenario development process.

Based on the feedback we received, stakeholders voiced a need to have a larger role in developing and establishing the scenarios used for the LTSA. Some of that feedback came from stakeholders who felt they should have played a more significant role in the scenario development process. Stakeholders who did not find the assumptions sufficiently credible also tended to think the results were not credible.

For these reasons, we developed a process that provided ample opportunities for stakeholder to participate. The 2014 LTSA scenario development process included input from 58 individual participants, representing 31 organizations.

We worked closely with ERCOT staff during the development of the future scenario and planning assumptions with stakeholders. We found ERCOT staff to be very thoughtful in deliberating through suggestions from stakeholders and from the Brattle consultants, aiming to be as responsive to the stakeholders' suggestions as possible, while maintaining ERCOT's best practices for system planning. Even though limited time and resources might affect the number of system simulations ERCOT staff can conduct, we have observed that ERCOT staff continues to simulate as many of the scenarios as possible and put effort towards reflecting stakeholder input as much as possible into their simulations.

Recommendation: *For future LTSAs, we recommend starting the study by collecting feedback from stakeholders and ERCOT staff regarding how the entire LTSA process can be improved, including the scenario development. Collecting feedback from ERCOT staff and presenting those results to the stakeholders is equally as important as collecting feedback from stakeholders. Such feedback is best collected through interviews as most people are less likely to provide written responses even if valuable advice can be gathered.*

B. EFFECTIVE INPUT FROM OUTSIDE OF THE ELECTRIC INDUSTRY

The second aspect that worked well was incorporating the views of subject area experts who would not otherwise participate in creating future scenarios, and most likely have not previously done so. Careful selection of the subject area experts provided significant payoff as they brought new and relevant information to ERCOT and enhanced stakeholders' understanding of factors outside of the immediate experiences of those typically involved in transmission planning.

During the first and second workshops, we specifically requested presentation of the most relevant information from experts on: (1) Texas' economic development and population growth; (2) existing and projected future oil and gas development along with resource potential in the state; and (3) issues specific to the State's water resources. The topics were largely based on stakeholder input from the previous study.

In addition, from the power sector, we also involved experts in renewable energy costs and cost trajectories, renewable integration challenges, natural gas price forecasts, and costs associated with environmental retrofits for existing coal and nuclear facilities. The information presented and the associated discussions helped inform the stakeholders about the trends, drivers, and uncertainties that are essential for developing relevant scenarios and planning assumptions for the ERCOT system.

Recommendation: *For future LTSAs, we recommend that ERCOT continue to identify the areas where input from experts outside of the power sector may be useful, and arrange workshops to ensure that all stakeholders benefit from new and updated information about the Texas economy, electricity users preferences, any relevant technology breakthroughs, environmental* *and other regulatory policies, plus any other information that might help ERCOT planners better project the future transmission needs in ERCOT.*

C. Sustained Stakeholder Participation

Engaging stakeholders to allow for sufficient discussion around key topics was central to the development of the 2014 LTSA scenarios. Over the course of the scenario development process, ERCOT staff and Brattle consultants continually gathered and summarized key discussions, edited materials developed by stakeholders, and requested further input (*e.g.*, corrections and clarifications) in the scenario descriptions. A few stakeholders provided very valuable data for developing relevant and up-to-date input assumptions.

However, for the most part, we received very limited feedback outside the structured workshop discussions. For example, after we shared the edited scenario descriptions and draft planning assumptions with stakeholders via emails and through presentations at later workshops or RPG meetings, stakeholders provided very little feedback in return. ERCOT and Brattle consultants interpreted the silence as an "approval" of the assumptions to be used, even though such silence may mean neither approval nor disapproval.

Recommendation: *For future processes, we recommend continuing to engage stakeholders by spending time in workshops to review the relevant materials and requesting direct feedback. We also suggest that sufficient time be dedicated during the workshop discussions to finalize scenario descriptions and planning assumptions. This will be particularly important if a shorter process is selected for future LTSAs, as discussed further in the following section. Stakeholders will be the most engaged and provide the best insight when they are required to create and discuss the content as opposed to being asked to respond to emailed documents or materials presented to them at other stakeholder meetings (i.e., Regional Planning Group meetings).*

D. Translating Scenario Descriptions to Planning Assumptions

In the Volume I of this report, we summarized the planning assumptions (based on the scenario descriptions developed by the stakeholders) that ERCOT used to simulate the ERCOT system. Overall, we observed that the ERCOT staff has put considerable effort in capturing the scenario descriptions as accurately and precisely as possible. For example, if a scenario describes different economic and load growth rates in geographic areas across Texas, ERCOT staff has tried to capture such distinctions in its system simulations (as shown in Table 6 in Volume I). In some instances, ERCOT staff has not fully incorporated certain aspects of the scenario descriptions due to data limitations.

Recommendation: *In future LTSA studies, we recommend that ERCOT allocate specific time in a workshop for stakeholders to simultaneously review the details of the edited scenarios and then the translation of scenario descriptions to planning assumptions. Comparing the detailed scenario descriptions against the planning assumptions to be employed by ERCOT staff in system simulations will allow stakeholders to consider the most relevant and differentiating scenario drivers that they wish to capture and thereby improve the scenario descriptions in the future as* *well as allow the stakeholders to increase their understanding of the degree of influence of certain drivers. Due to the time requirements for developing the input assumptions, the workshop will need to be scheduled after sufficient time has been given to ERCOT to do so.*

Recommendation: *For future LTSA studies, we recommend stakeholders and ERCOT staff incorporate more of the details included in the scenario descriptions. For example, stakeholders developed a "Water Stress" scenario for the 2014 LTSA that incorporated some of the suggested details around the potential impact of a long-term drought on the power sector. This scenario is an important future for ERCOT to consider but aspects of the scenario description are challenging to incorporate into the system simulations, such as the higher costs of dry cooling and the impact on performance of generation units of dry cooling. Thus, more effort may be needed in future LTSA to further capture the details of that scenario as well as details included across all scenarios.*

VII. Recommended Process for the 2016 LTSA and Beyond

The long-term scenario development process should be seen by ERCOT and its stakeholders as the first step to each LTSA. The process will continue to be improved through future iterations by revising, updating, and building upon the scenarios and results of the previous LTSAs and through continued engagement with stakeholders. As the market conditions and available information change over time, the perspectives of the stakeholders and ERCOT staff on future scenarios will also change. Thus, the future scenarios, including the key drivers, list of scenarios, and detailed descriptions, should be updated at the start of every LTSA.

Some aspects of long term planning are expected to change on a regular basis, such as natural gas prices, and some change less frequently, such as state and federal policies and economic conditions. During the time period of the 2014 LTSA scenario analysis, for example, the ERCOT forecast of peak load changed significantly due to adjustments in the projection methodology. Over the next two-year period between the 2014 LTSA and the 2016 LTSA, many more changes will occur that require future LTSA scenarios to be modified from their current form. At the same time, development of new key drivers and scenarios may also be needed as conditions change.

We anticipate that the 2016 LTSA may require a more modest and efficient update process. As such, we describe below a brief outline of how we would expect a shorter, less time-intensive update to the future scenario descriptions and planning assumptions for the 2016 LTSA may be completed by ERCOT and its stakeholders, if ERCOT chooses to do so. The 2018 LTSA may require a full re-examination of the relevance of the scenarios developed for the 2014 and 2016 analyses. The 2018 scenario development process can begin in a similar manner as the 2014 LTSA, as outlined in Volume I, with a review of all drivers and unknowns and followed by development of the future scenario descriptions with the stakeholders.

We recommend that the 2016 LTSA scenario development process start with stakeholder and ERCOT staff interviews, followed by three workshops, with each workshop beginning with a review of the input from either the feedback from stakeholders or the previous workshop before moving on to the next phase of the process. For that reason, each workshop will not be solely dedicated to any single area outlined below but should follow the outline in Table 9. The length of each workshop will depend on the number of topics and the depth expected to be covered in the workshop, and the number of participants. However, in general, we anticipate each workshop to be roughly 1 to 2 days.

Table 9
Outline of LTSA Scenario Development Workshops

Workshop	Topics of Discussion	Material for Review to Prepare for the Workshop
Interviews (individual discussions, not workshop)	Interview select stakeholders and ERCOT staff involved in the 2014 LTSA process	2014 LTSA assumptions and results
Workshop #1	Significant changes in industry trends	Stakeholder and ERCOT staff feedback
	Trends, Drivers, Uncertainties and Key Drivers	Prior presentations on important industry trends; relevant drivers of ERCOT market dynamics, and industry trends
Workshop #2	Range of Scenarios and Scenario Descriptions	Trends, Drivers, Uncertainties and Key Drivers (*additional presentations, as necessary*)
Workshop #3	Modeling Input Assumptions	Range of Scenarios and Scenario Descriptions

A. Request Feedback from Stakeholders and ERCOT Staff

As suggested above, before starting future LTSA studies, we suggest that ERCOT request feedback from both stakeholders and ERCOT staff on how the entire LTSA process can be improved, including the scenario development process. ERCOT will receive the best feedback through individual meetings and by requesting feedback on the specifics about the scenarios developed and used in the 2014 LTSA, the planning assumptions, the modeling process, and the results. We anticipate that stakeholders and ERCOT staff will likely have suggestions about what could be improved or what may have been missing from the 2014 LTSA that are worth considering in developing scenarios for the 2016 LTSA.

B. Workshop #1: Update and Identify New Trends, Drivers, and Uncertainties

Similar to the 2014 LTSA, we suggest that the first scenario development workshop be devoted to a review of the state of the ERCOT electric power sector and the most pertinent drivers for planning the system over the long term. ERCOT staff should prepare by reviewing the 2014 materials and workshop presentations and determining what information should be revisited, updated, and/or added with stakeholder input. Then, we suggest that each aspect of the system discussed during the 2014 LTSA be reviewed, with the focus on topics that have changed since 2014, and/or areas that require discussion with stakeholders.

Specifically, we suggest the following draft agenda items for the first workshop:

1. Summarize feedback received about prior LTSA processes
2. Presentations from experts on topics identified as gaps in prior scenarios and analyses
3. Lead discussion about key Trends, Drivers, and Uncertainties
4. Break into sub-groups to identify the Key Drivers for the new LTSA process, with the focus on what has changed from the scenarios developed in the 2014 LTSA
5. Agree on Key Drivers to be used in describing the scenarios

If information beyond the expert presentations at the start of the workshop is necessary, we suggest that ERCOT discuss with stakeholders what additional analyses or presentations may help inform the LTSA stakeholders about the factors that are expected to affect electricity usage and transmission needs. During the next workshop, ERCOT will provide time for additional presentations, as necessary, and review the Key Drivers developed at the previous session. Any additional discussion for incorporating new information provided in the presentation should be done prior to moving on to developing the scenarios.

C. Workshop #2: Develop Scenario Descriptions

In Workshop #2, ERCOT will review the scenarios from the 2014 LTSA with the stakeholders and request ideas for new or revised scenarios. We suggest the following agenda items:

1. ERCOT and stakeholders will review the Current Trends scenario and discuss what changes are necessary. (Changes in the outlook of the key drivers that were highlighted during the review of the trends, drivers, and uncertainties will be incorporated into the new Current Trends scenario. ERCOT and stakeholders will consider whether a scenario other than the 2014 Current Trends may align closer to the 2016 Current Trends and thus provide a better starting point for discussion.)

2. Break into small groups to review the details of the remaining scenarios and modify them as necessary based on the updated list of key drivers. If new and/or revised scenarios have been identified for the 2016 LTSA, some of the groups will develop scenario descriptions for the new scenarios.

3. Each breakout group will present their modifications to the scenarios or newly developed scenario descriptions to the larger group and discuss if further changes should be made.

Following the second workshop, ERCOT will summarize the scenarios using the key drivers matrix used during the 2014 process and provide it to stakeholders for their review.

D. Workshop #3: Transforming Scenarios into Planning Assumptions

We suggest that Workshop #3 begins with reviewing the changes to the scenarios and the scenario summary matrix prepared after Workshop #2. As during the 2014 LTSA process, the review of the scenario summary matrix will provide an opportunity to discuss with stakeholders whether to consolidate scenarios and which scenarios to prioritize in the generation expansion modeling.

The goal of Workshop #3 then is to convert the scenario descriptions into planning assumptions that stakeholders believe would be most effective. Below are suggested agenda items:

1. Review the scenario descriptions developed in Workshop #2 in detail
2. Discuss the parameters in the planning assumptions in the 2014 LTSA scenarios
3. Breakout sessions for stakeholders to develop specific planning assumptions or changes to 2014's assumptions so that all new and updated scenarios have correspondingly consistent planning assumptions to be used in ERCOT simulations.
4. Present and discuss the updated assumptions for each scenario
5. Reach agreement on the updated assumptions

We anticipate that the planning assumptions will be based on similar or equivalent sources on which ERCOT relied for the 2014 LTSA, unless better information is available. In addition, there may be new information through the earlier portions of the stakeholder sessions that can be incorporated into the planning assumptions to better reflect the quantitative descriptions of each scenario. Workshop #3 is new relative to the 2014 LTSA process. We anticipate that convening the stakeholders and asking them to conduct a hands-on analysis of the proposed planning assumptions would be a productive and effective way to reach agreement on the assumptions that ERCOT staff should use in the system simulation phase.

Appendix A: 2014 LTSA Scenario Development Workshop Participants

Name	Company
Bevill, Jennifer	AEP
White, Lauri	AEP
Ryan, Brion	Austin Energy
Beckmann, Dwight	Brazos Electric Cooperative
de Arizon, Paloma (Maria)	CenterPoint Energy
Sumners, Robert (Bill)	CenterPoint Energy
Kasalita, Erica	CPS Energy
Such, Chris	E.ON COR
Wagner, Marguerite	Edison Mission Marketing and Trading
Bernecker, John	ERCOT
Billo, Jeff	ERCOT
Borkar, Sandeep	ERCOT
Chatlani, Varsha	ERCOT
Chunlian, Jin	ERCOT
Lasher, Warren	ERCOT
Matevosyan, Julia	ERCOT
Murray, Doug	ERCOT
Ramasubbu, Priya	ERCOT
Rowe, Evan	ERCOT
Simaan, Peter	ERCOT
Warnken, Peter	ERCOT
Xiao, Hong	ERCOT
Fitzpatrick, Tom	ESL
Macias, Michael	ETT
Schwarz, Brad	Hunt Power/Sharyland
LaValle, Kathleen	Jackson Walker LLP
Doerr, Christina	LCRA TSC
DeWitt, Charles	LCRA-TSC
Giffin, Blair	Lone Star Transmission
Gomes, Matt	Lone Star Transmission
Le, Don	Lone Star Transmission
Wittmeyer, Bob	Long Horn Power
Hampton, Brenda	Luminant Energy
Lane, Rob	Luminant Energy
Pieniazek, Adrian	NRG
Donohoo, Ken	Oncor
Treichler, David	Oncor
Woodruff, Taylor	Oncor
Juricek, Michael	Oncor
Gordon, Toni	Pioneer Natural Resources USA, Inc.
Power, David	Public Citizen

Name	Company
Coleman, Diana	Public Utility Commission of Texas
Cobos, Lori	SEIA/Klein Energy
Reed, Cyrus	Sierra Club
Lehmberg, Tim	SOSHCE
Comnes, Alan	SunPower
Pitts, John	SunPower
Woods, Brad	Texas RE
Trevino, Eddy	Texas SECO
Celebi, Metin	The Brattle Group
Chang, Judy	The Brattle Group
Hagerty, Mike	The Brattle Group
Pfeifenberger, Hannes	The Brattle Group
Shavel, Ira	The Brattle Group
Scanlon, Bridget	University of Texas at Austin – Bureau of Economic Geology
Cook, Margaret	Webber Energy Group
Reimers, Andrew	Webber Energy Group
Webber, Michael	Webber Energy Group
Ghash, Prasit	Wood Mackenzie
Harris, Gabe	Wood Mackenzie
Nease, Nelson	—