

Exploring Natural Gas and Renewables in ERCOT, Part IV

The Future of Clean Energy in ERCOT

PREPARED FOR

The Texas Clean Energy Coalition

PREPARED BY

Ira Shavel
Yingxia Yang
Roger Lueken

Andrew O'Brien
Colin McIntyre

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THE **Brattle** GROUP

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Agenda

I. Executive Summary

II. Modeling Scenarios and Key Assumptions

III. Scenario Results – Low Natural Gas/Low Solar PV

I. Executive Summary

Exploring Natural Gas and Renewables in ERCOT

Over the past three years, the Texas Clean Energy Coalition has engaged Brattle for a series of original, Texas-specific reports to explore the future of clean energy in ERCOT.

June 2013 – Part I: Natural gas and renewables can work together to create a cleaner power grid in Texas, depending on market and policy factors including long-term prices for natural gas price and renewable energy technologies.

December 2013 – Part II: Over the next 20 years, all new power plants built in ERCOT will use natural gas, wind and solar power. While the actual mix of fuels will vary based on price and other factors, ERCOT's grid can accommodate any of the likely combinations without sacrificing reliability.

June 2014 – Part III: Clean energy from renewables and natural gas, combined with expanded energy efficiency (EE) and demand response (DR) programs, could cut the projected growth of peak electric demand in ERCOT by up to 50% over the next 20 years. By reducing the growth in our maximum power demand, EE and DR can help the ERCOT grid become cleaner and more reliable over time.

I. Executive Summary

Exploring Natural Gas and Renewables in ERCOT

May 2016 -- Part IV:

How might market and regulatory factors affect how electricity will be generated in ERCOT, how much it will cost and how much CO₂ will be emitted?

I. Executive Summary

Results: Key Findings

If:

- Natural gas prices remain low (<\$4/MMBtu)
- Solar PV prices continue to decline as forecast

Over the next 20 years market forces will likely result in an ERCOT electric grid that will:

- Be much cleaner, resulting in less carbon pollution in Texas
- Rely primarily on Texas' own natural gas, wind and utility-scale solar PV power
- Cost virtually the same wholesale price as 2014 (other than inflation)
- Make proposed new federal regulations (CPP and Regional Haze Rule) largely irrelevant

I. Executive Summary

Results: Highlights of a Low Gas/Low PV Scenario

- **Market Forces Drive The Transition:** The price of natural gas is driving change in the ERCOT grid, much more than any other factor.
- **Natural Gas Displaces Older Coal Plants:** Persistently low natural gas prices could cause the retirement of sixty percent (12 GW) of ERCOT's current fleet of coal-powered plants by 2022.
- **Natural Gas, Wind and Solar PV Will Largely Power ERCOT:** By 2035, about 85% of ERCOT power generation will come from natural gas, wind and solar power, with NGCC plants providing the lion's share of new generation.
- **Wind and Solar PV Will Grow:** Both wind and large-scale solar PV power will see swift, major additions of new generating capacity – 9 GW for wind by 2019 and 13 GW for solar by 2021.

I. Executive Summary

Results: Highlights of a Low Gas/Low PV Scenario

- **ERCOT Will Get Much Cleaner:** Annual CO₂ emissions in ERCOT will drop by an average of 28% below 2005 levels – an average of 61 million tons less of CO₂ in Texas air every year.
- **A Cleaner ERCOT Grid Will Cost The Same As Today:** Wholesale electricity prices will stay around \$41/MWh, similar to 2014 prices – virtually no price increase (other than for inflation).
- **Currently Proposed Environmental Regulations Will Be Largely Irrelevant:** Market forces will reduce CO₂ emissions in ERCOT below the requirements of proposed new standards in the EPA's controversial Clean Power Plan through 2035. Likewise, the EPA's Regional Haze Rule (if implemented) would have only a marginal impact (<15%) on projected coal plant retirements through 2022.
- **Energy Efficiency Can Save Money, Cut Carbon Pollution:** By accounting for enhanced energy efficiency to reduce demand for electricity an additional 5% by 2035, the need for electric plants on the ERCOT grid could be reduced by 4.7 GW, cutting CO₂ emissions and holding down power prices.

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II. Modeling Scenarios and Key Assumptions

Modeling Scenarios

The impact of market forces in the ERCOT grid is captured in four Reference Case scenarios:

- Low/high natural gas price
- Low/high cost of utility-scale solar PV
- These assumptions are based on natural gas futures, and forecasts from ERCOT and NREL

To explore the potential impact of state and federal policy, three policy scenarios are evaluated for each Reference Case:

- Enhanced state energy efficiency (EE) programs
- An emission cap similar to the CPP requirement (mass cap with new source complement)
- An emission rate standard similar to the CPP requirement (state average rate standard)

Four Reference Cases

	Natural Gas Price	PV Cost
Reference Case 1	Low	Low
Reference Case 2	Low	High
Reference Case 3	High	Low
Reference Case 4	High	High

II. Modeling Scenarios and Key Assumptions

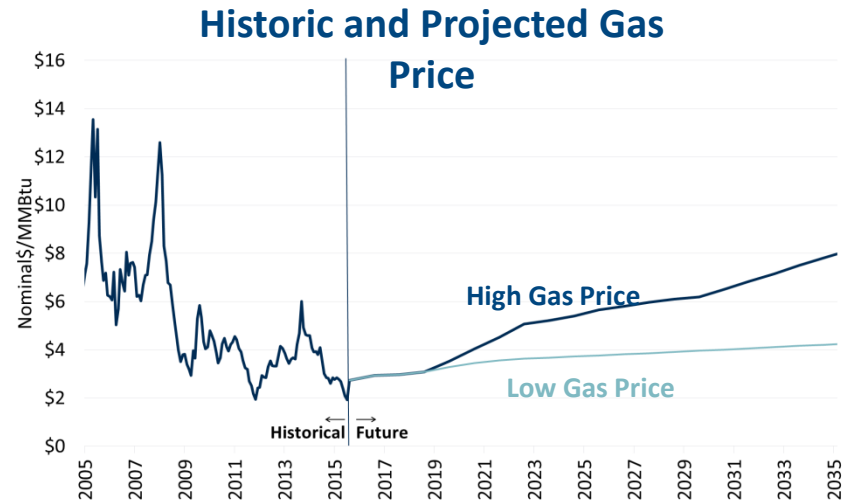
Natural Gas Prices

Near term (2016-2019) natural gas price forecasts are based on NYMEX gas futures.

For the long term, two natural gas price scenarios are modeled, based on ERCOT's 2016 LTSA gas price assumptions:

- **High Gas Price Forecast:**
 - Consistent with ERCOT's 2016 LTSA "Current Trends" forecast
 - Average of the 2015 AEO "Reference" and "High Oil and Gas" cases
 - Increases to \$8/MMBtu (nominal) by 2035
- **Low Gas Price Forecast:**
 - Consistent with ERCOT's 2016 LTSA "Low" forecast
 - Grows slowly over time and reaches about \$4/MMBtu (nominal) by 2035

2020-2023 is the transition period from NYMEX futures to ERCOT LTSA gas price assumptions.



Sources and Notes:

Historic data is Henry Hub spot price from SNL. Futures data are NYMEX Henry Hub monthly forwards as of 10/27/2015.

II. Modeling Scenarios and Key Assumptions

Renewable Power Prices

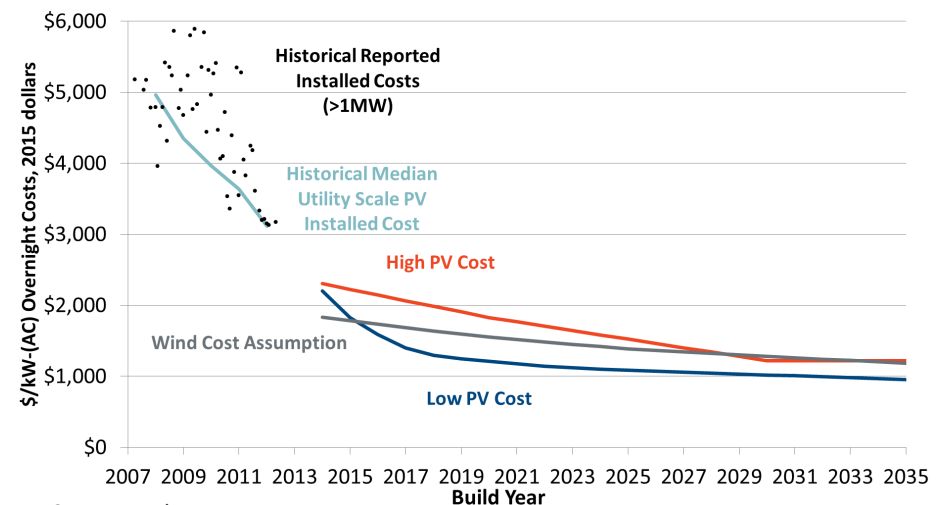
Utility-Scale Solar PV:

- The installed cost declines over time and is modeled in two trajectories:
 - The high PV cost projection is NREL's mid case
 - The Low PV cost is ERCOT's 2016 LTSA projection
 - We constrain the rate of PV additions and model the reduction of PV capacity value as penetration increases
- The model does not include additional high voltage transmission costs that might be required with high solar PV penetration

Wind:

- Installed cost projections are from ERCOT's 2016 LTSA base case assumptions.
- We model three different wind profiles based on the location: Coastal, Inland, and Panhandle.
- Wind capacity additions are limited by the capacity of the CREZ system; coastal wind capacity is limited to 4,600 MW

Renewable Power Installed Cost Projections



Sources and Notes:

Historical PV costs: reported costs from NREL and median from LBNL;

Forecasts: ERCOT 2016 LTSA Base Case; NREL

Modeling of the Production Tax Credit (PTC) for wind and the Investment Tax Credit (ITC) for solar PV are based on the 2016 Consolidated Appropriations Act.

II. Modeling Scenarios and Key Assumptions

Future Electric Demand and Energy Efficiency

The forecast for future electric demand is the average of ERCOT's 2016 "frozen efficiency" load forecast and the ERCOT load implied by the EIA 2015 AEO Reference Case growth rate. AEO2015 accounts for new standards and known EE programs.

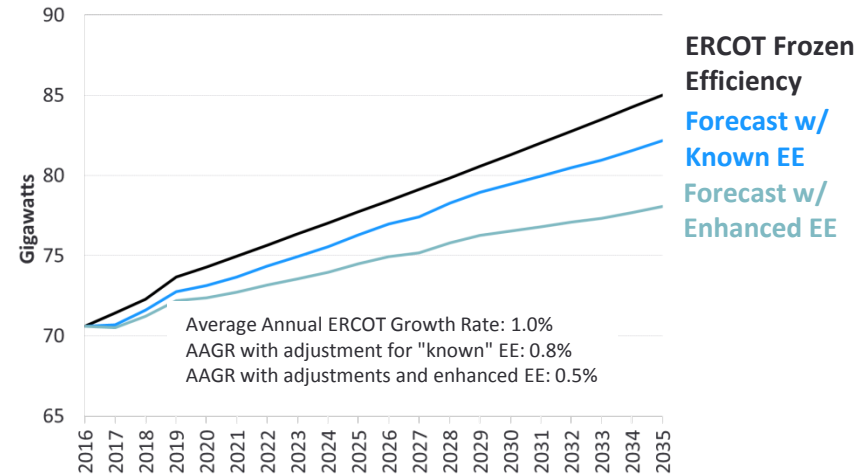
- This approach leads to a 3.4% reduction in total energy demand and peak demand from **known EE programs** in 2035, comparable to ERCOT LTSA assumptions of 3.5% by 2031.

For enhanced EE programs, we assume an additional 5% reduction in electric demand by 2035 beyond the known EE programs, based on ERCOT's analysis of proposed CPP.

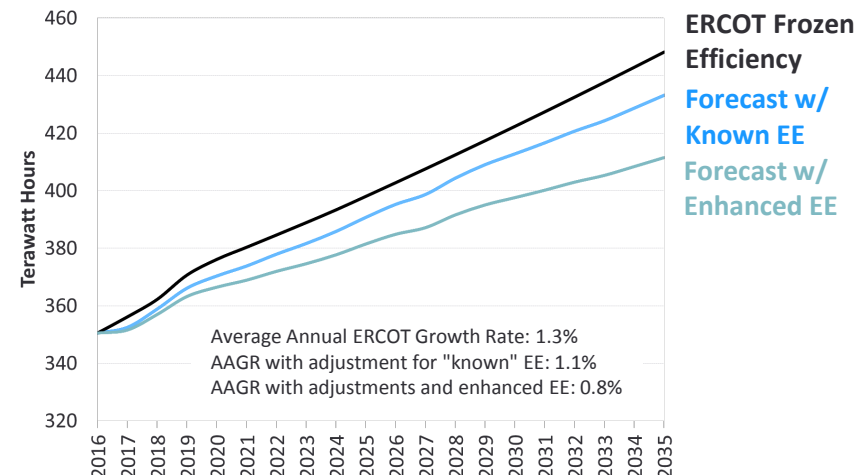
- This is more than what ERCOT assumes in its analysis of final CPP, but less than the EE potential reported by several studies of future EE potential in Texas.

In total, known and enhanced EE programs together would reduce electric demand by 8.2% compared to ERCOT's "frozen efficiency" forecast.

Peak Electric Demand Forecast



Energy Forecast



Sources and Notes:

2016 Long-Term Load Forecast, EIA 2015 AEO forecasts.

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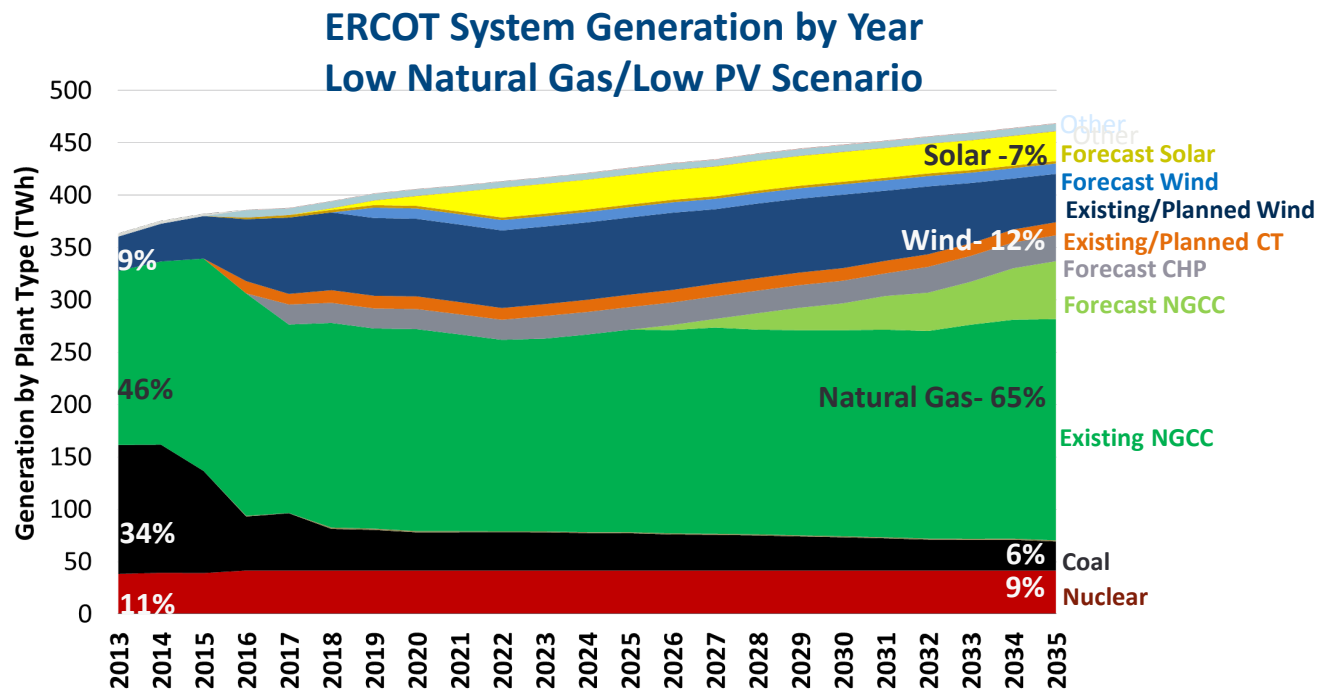
III. Scenario Results -- Low Natural Gas/Low Solar PV

III. Scenario Results: Low Natural Gas/Low Solar PV

ERCOT System Energy Use 2013-2035

With low prices for natural gas and utility-scale solar PV, 12 GW of coal generation is retired by 2022. It is replaced by natural gas generation (existing and new) and new solar PV.

By 2035, natural gas plants and renewable power would provide about 85% of all energy used in ERCOT; coal plants would provide 6%.



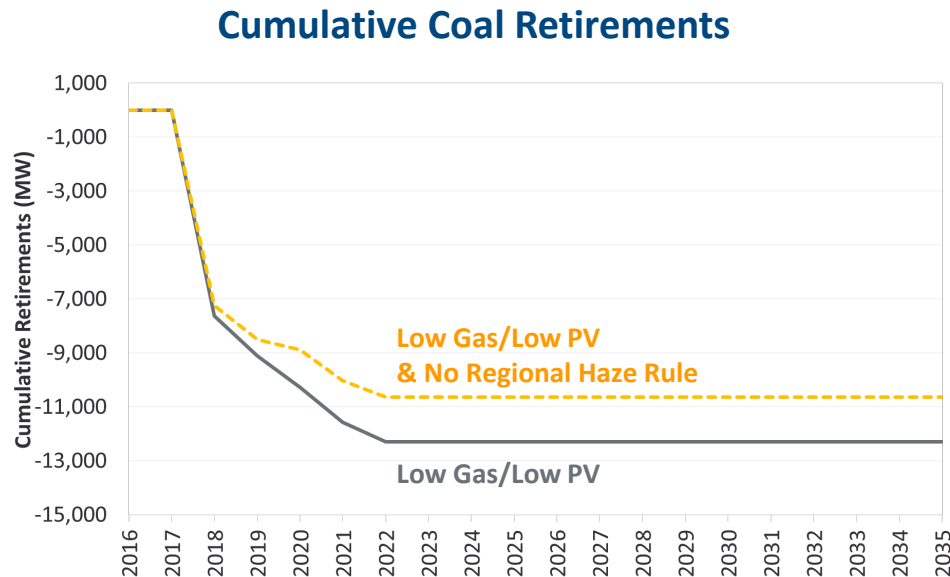
Notes: (1) 2013-2015 values are from ERCOT historical generation data and adjusted to include self-serving generation from PUNs which is not included in ERCOT's data. (2) The natural gas percentage groups NGCC, CHP, and Combustion Turbine (CT) generation.

III. Scenario Results: Low Natural Gas/Low Solar PV

Coal Retirements

Low natural gas prices are the main driver of coal retirements.

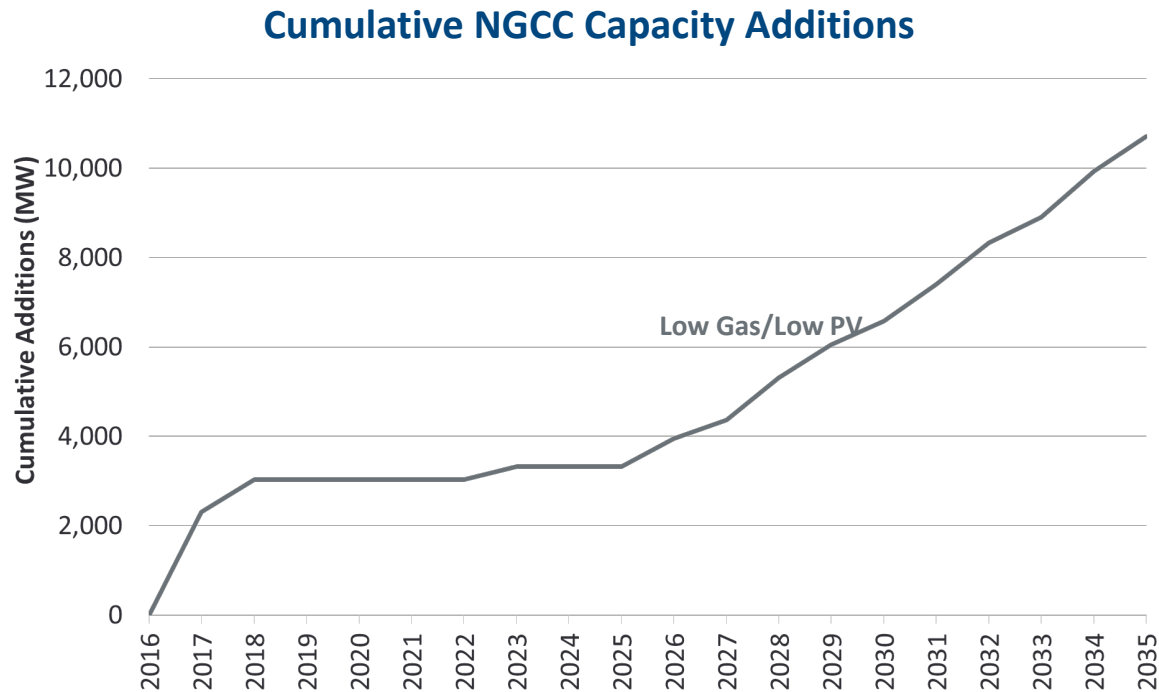
- Of the 19.6 GW of coal currently online in ERCOT, approximately 12 GW of coal would retire by 2022. (CPS has announced that it will retire the 900 MW JT Deely plant in 2018.)
- Only 1.7 GW (<15%) of the projected 12 GW of retirements is due to the proposed Regional Haze rule.



III. Scenario Results: Low Natural Gas/Low Solar PV

NGCC Generating Capacity

With low natural gas prices, a total of 10.7 GW of natural gas combined cycle (NGCC) generating capacity will be added by 2035 to replace retiring coal plants and meet increased electric demand. This includes 3.0 GW of CHP and 7.7 GW of NGCC plants.



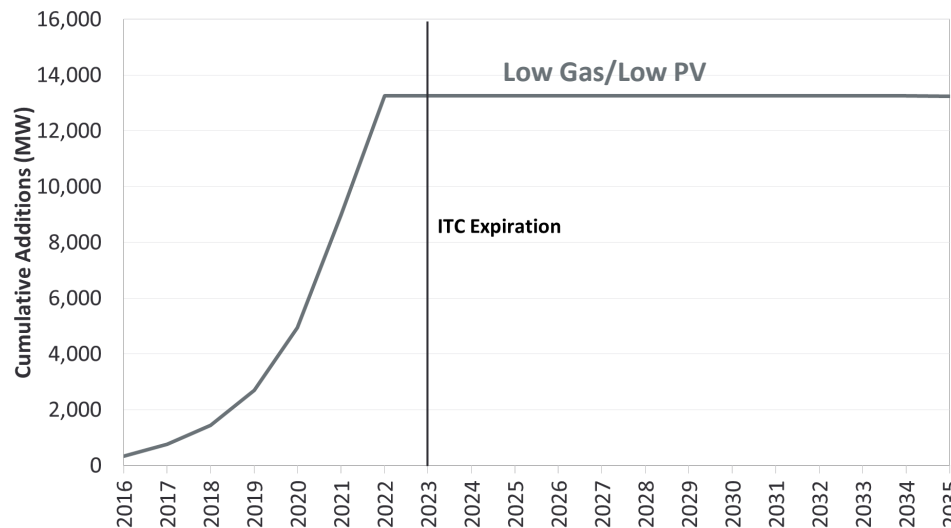
III. Scenario Results: Low Natural Gas/Low Solar PV

Utility-Scale Solar PV Generating Capacity

Declining prices for utility-scale solar PV drive the installation of 13.3 GW of new solar PV capacity, which is a significant increase over the 288 MW of installed solar capacity in ERCOT as of 2015.

All of the new solar PV capacity is added before the ITC expires in 2021.

Cumulative Utility-Scale Solar PV Capacity Additions



Sources and Notes:

ITC expiration date set to 2023 to account for a 2 year assumed construction time (ITC actually expires in 2021) The capacity factor for utility-scale solar PV is 26%.

III. Scenario Results: Low Natural Gas/Low Solar PV

Wind Generating Capacity

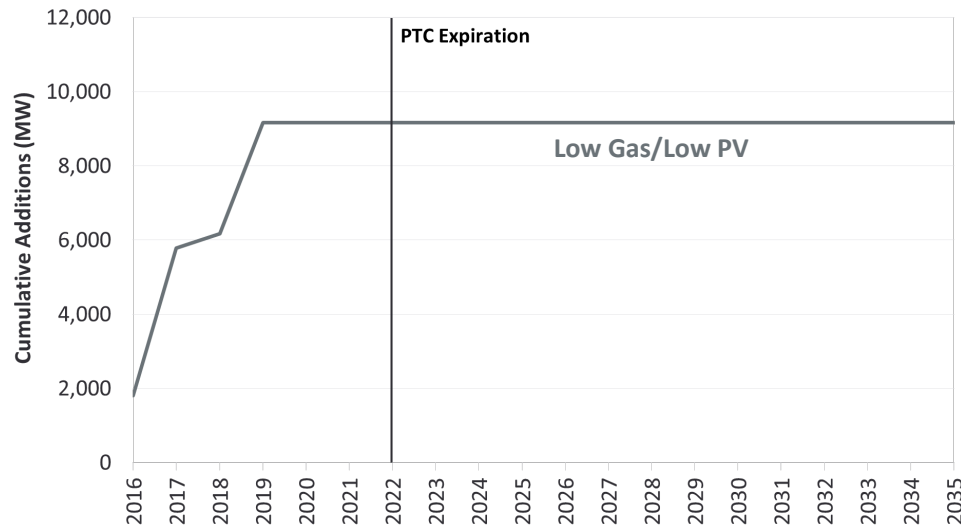
A total of 9.2 GW of new wind capacity would be added before 2019, including 3 GW of projected new coastal wind. In 2015 ERCOT had nearly 16 GW of installed wind capacity.

The model includes 6.2 GW of new wind projects that are already planned:

- 2.9 GW under construction or in site testing (Velocity Suite, ABB Inc.)
- 3.3 GW (50%) of permitted new wind capacity awaiting construction (ERCOT CDR, December 2015)

Existing wind is assumed to retire after a 25 year lifespan.

Cumulative Wind Capacity Additions



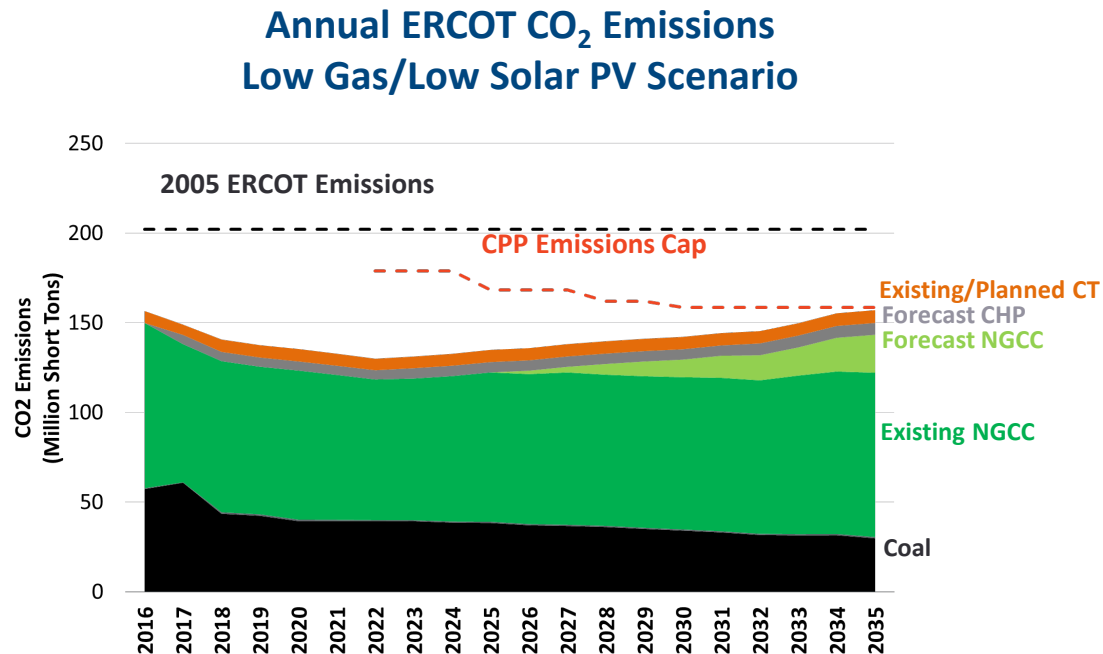
Sources and Notes: PTC expiration date set to 2022 to account for 3 year assumed construction time (PTC actually expires in 2019). The capacity factor for coastal wind is 37%, inland wind is 35%, and panhandle wind is 42%.

III. Scenario Results: Low Natural Gas/Low Solar PV

Declining CO₂ Emissions

As market forces drive the ERCOT grid to cleaner generation from natural gas NGCC, solar PV and wind power, CO₂ emissions will drop dramatically.

- CO₂ emissions in ERCOT would be about 28% below 2005 levels on average from 2016-2035, reducing emissions by an average of 61 million tons per year.
- CO₂ emissions would remain below the requirements of proposed new standards in the EPA's Clean Power Plan through 2035.



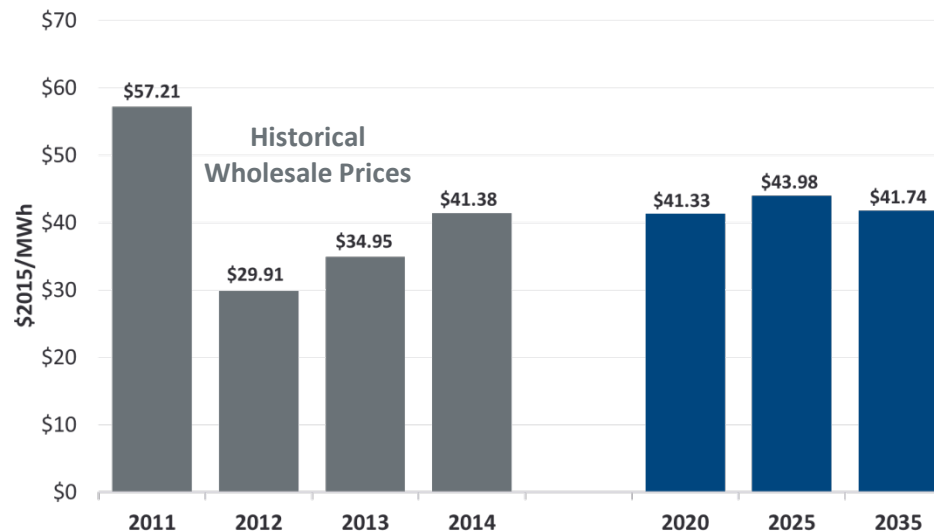
Sources/Notes: 2005 emissions from Velocity Suite.

III. Scenario Results: Low Natural Gas/Low Solar PV

Customer Costs Would Remain at 2014 Prices

If natural gas prices stay below \$4/MMBtu for a prolonged period, wholesale electricity prices would be around \$41/MWh by 2035 in real terms, similar to prices observed in recent years (except for inflation).

**Average Wholesale Electricity Prices
Low Natural Gas/Low Solar PV Scenario**



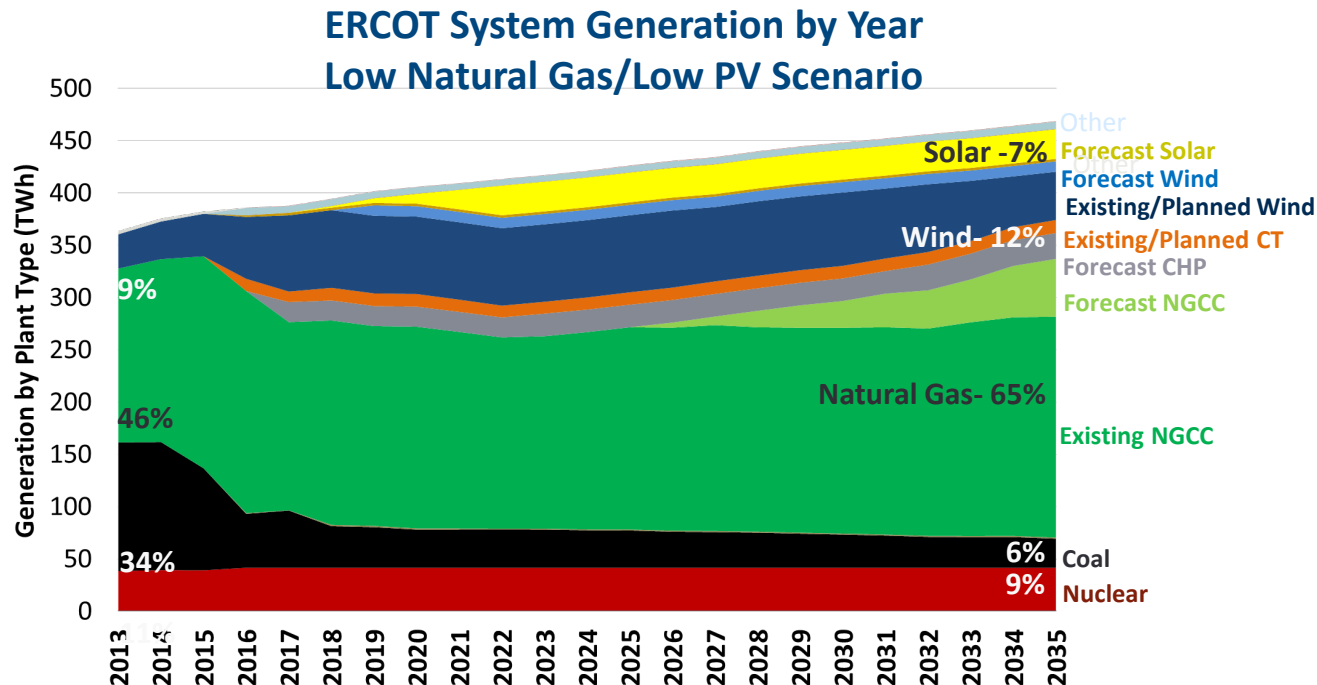
Sources: Historical whole electricity prices are from "2014 State of the Market Report for the ERCOT Wholesale Electricity Markets" ; 2013 Texas retail prices are from State Energy Data System.

III. Scenario Results: Low Natural Gas/Low Solar PV

Recap: ERCOT System Energy Use 2013-2035

Over the next 20 years, most coal generation in ERCOT will be replaced by natural gas (NGCC), utility-scale solar PV and wind power.

Air pollution from CO₂ will decline dramatically, and customer costs will remain flat at 2014 prices (except for inflation).



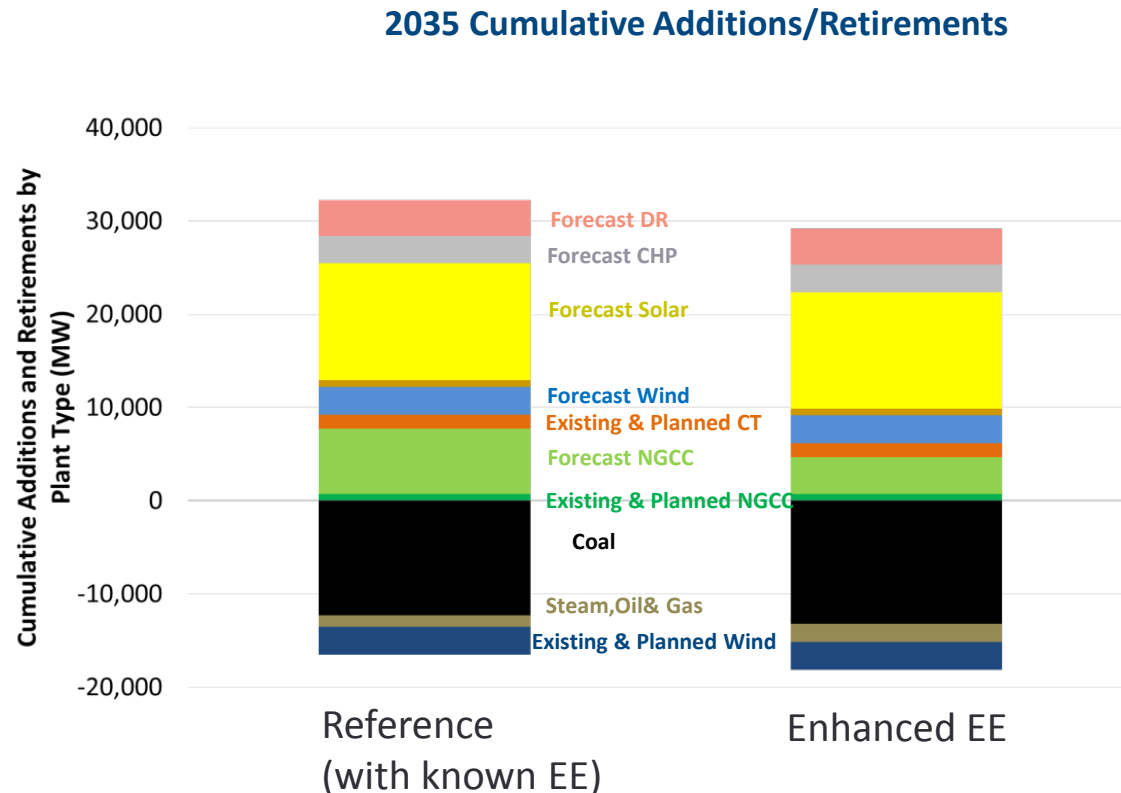
Notes: (1) 2013-2015 values are from ERCOT historical generation data and adjusted to include self-serving generation from PUNs which is not included in ERCOT's data. (2) The natural gas percentage groups NGCC, CHP, and Combustion Turbine (CT) generation.

III. Scenario Results: Low Natural Gas/Low Solar PV

Effect of Enhanced Energy Efficiency (EE)

By using enhanced energy efficiency (EE) programs to reduce demand for electricity by an additional 5%, ERCOT can reduce the projected fleet of electric plants, reduce CO₂ emissions and keep electric prices down.

- Shrink the projected fleet of electric plants by 4.7 GW in 2035, avoiding the need for new plants and retiring more old steam units.
 - 3 GW less NGCC, 0.9 GW of more coal retirement, and 0.7 GW of more steam oil and gas retirement.
- Reduce cumulative CO₂ emissions by 98 million short tons, or 3.5% between 2016 and 2035.
- Help keep wholesale electric prices down with about a \$0.20/MWh decrease in 2035.



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Presenter Information



IRA SHAVEL

Principal | Washington, DC

Ira.shavel@brattle.com

+1.202.419.3381

Dr. Shavel is an energy economist with over 30 years of experience in the energy industry, specializing in the economics and operations of the U.S. electric power system, generation and transmission investment, and environmental strategy. He has performed work for a wide range of clients, including generation and transmission companies, natural gas pipelines, marketers, developers, industry research groups, and as federal agencies. Recently he co-authored a study for the Texas Clean Energy Coalition on the future of renewable and natural gas generation in ERCOT.

Dr. Shavel has broad experience developing models of North American power systems, including the Integrated Planning Model by ICF International. He has also directed significant assignments for major electric utilities, independent transmission companies, RTOs, independent power producers and private equity on matters such as coal plant retirements, fuel price forecasting, the benefits of new transmission lines and power plant valuation. Dr. Shavel has testified before the Federal Energy Regulatory Commission (FERC), state regulatory agencies, and the Ontario Energy Board. Prior to joining Brattle, Dr. Shavel was a Vice President at Charles River Associates (CRA). While at CRA, he led the development of the National Energy and Environment Model (NEEM) and contributed to its integration with the Multi-Region National Macroeconomic Model.

Presenter Information



YINGXIA YANG

Associate | Washington, DC

Yingxia.Yang@brattle.com

+1.202.419.3389

Dr. Yingxia Yang is currently an associate in the Utility Practice Area of Brattle. Her experience is focused on developing and using economic models to conduct the economic and policy analysis of energy and environmental issues in the energy industries with a focus on the power and natural gas sectors. She has performed the economic and policy analysis of the power system and generation technologies to consult energy industry companies for integrated operation planning and environmental strategies as well as the impact of shale gas production on the electric sector and the whole economy.

Before she joined Brattle, she worked for CRA, where Dr. Yang led the modeling effort of MRN-NEEM (Multi-Regional National model-North American Electricity and Environment Model). Prior to joining CRA, Dr. Yang worked at MIT Energy Initiative during her postdoctoral research where she participated in a large interdisciplinary MIT study entitled “The Future of Natural Gas” and led the quantitative analysis of the impacts of a US climate policy on natural gas consumption in the power sector by employing the MARKAL model and contributed to the chapter, “Demand for gas in the power sector.”