Renewable Development in ERCOT

2014 ERCOT Long-Term System Assessment (LTSA)
Stakeholder Workshop #1

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Overview

- In this presentation we will discuss the factors that we found to be the major drivers of renewable development in ERCOT, and the challenges that we found with integrating high levels of renewables
- We used the Power System Optimizer (PSO) model to simulate renewables integration from an ERCOT operations perspective over different time horizons from day-ahead to real time for 2017, 2022 and 2032
- The results that we present here are based on analysis that The Brattle Group did for the Texas Clean Energy Coalition (http://www.texascleanenergy.org/2013-research.php)

Major Drivers of Renewable Penetration

Major Drivers of Renewable Penetration – PTC/ITC

PTC/ITC is an important driver of renewable development

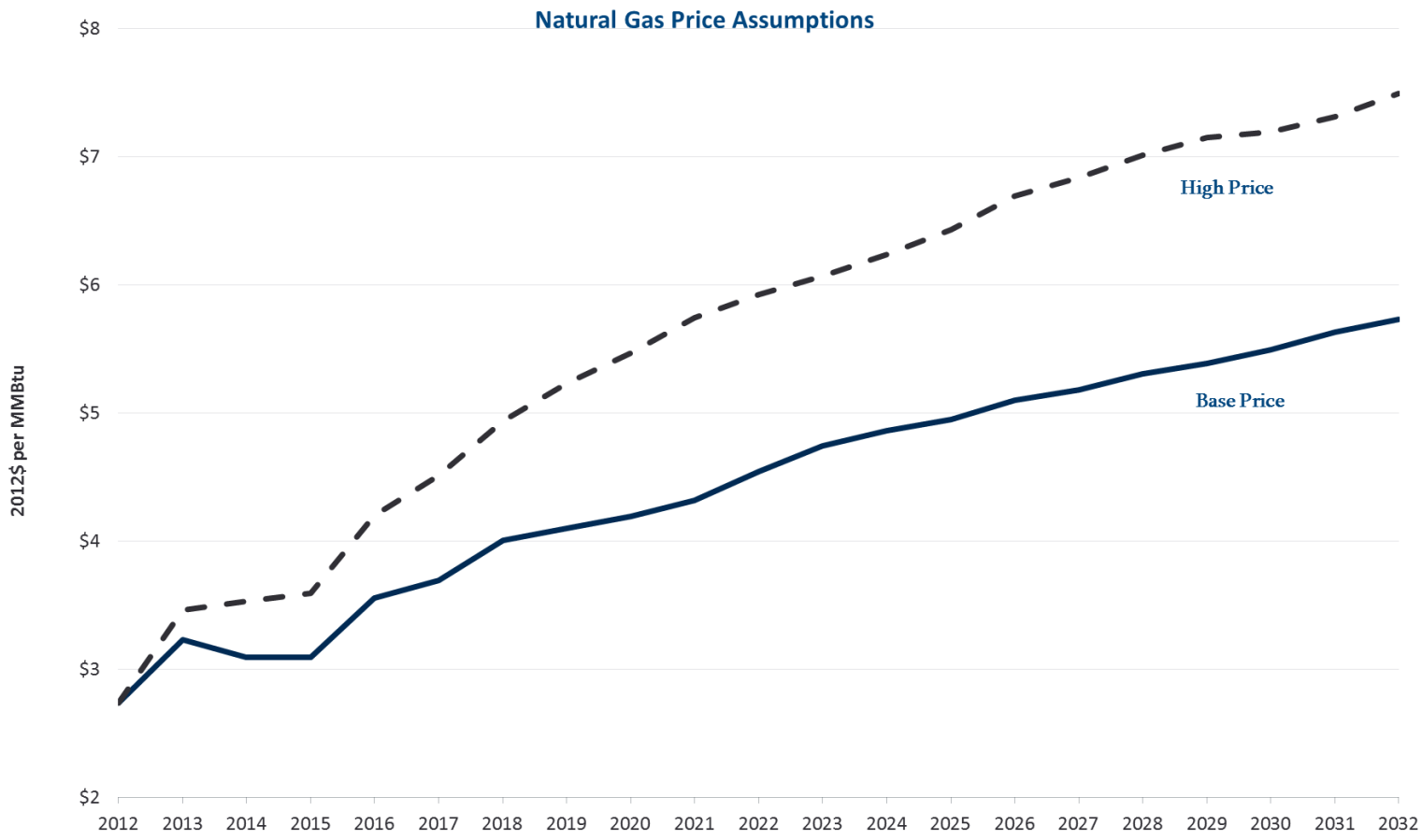
- It has been a significant factor in the past, but will be phased out unless there is Congressional action; proposed federal energy tax overhaul would continue the current PTC (2.3 cents/kWh), and would have an ITC of 20%
- Our simulations show that without these supports, renewable development will likely stall in ERCOT until natural gas prices rise to about $5/MMBtu

Major Drivers of Renewable Penetration – Natural Gas

Higher natural prices are needed to support significant renewable development

- High gas prices result in high wholesale power prices and higher cost of gas generation, making renewables relatively more attractive compared with gas
- A $0.75-$1.50/MMBtu increase in the price trend over the next 20 years might result in 20 GW more wind

Natural Gas Price Forecasts



Major Drivers of Renewable Penetration - Carbon

A stringent carbon policy (modeled as emissions restriction on coal plants) fosters renewable development

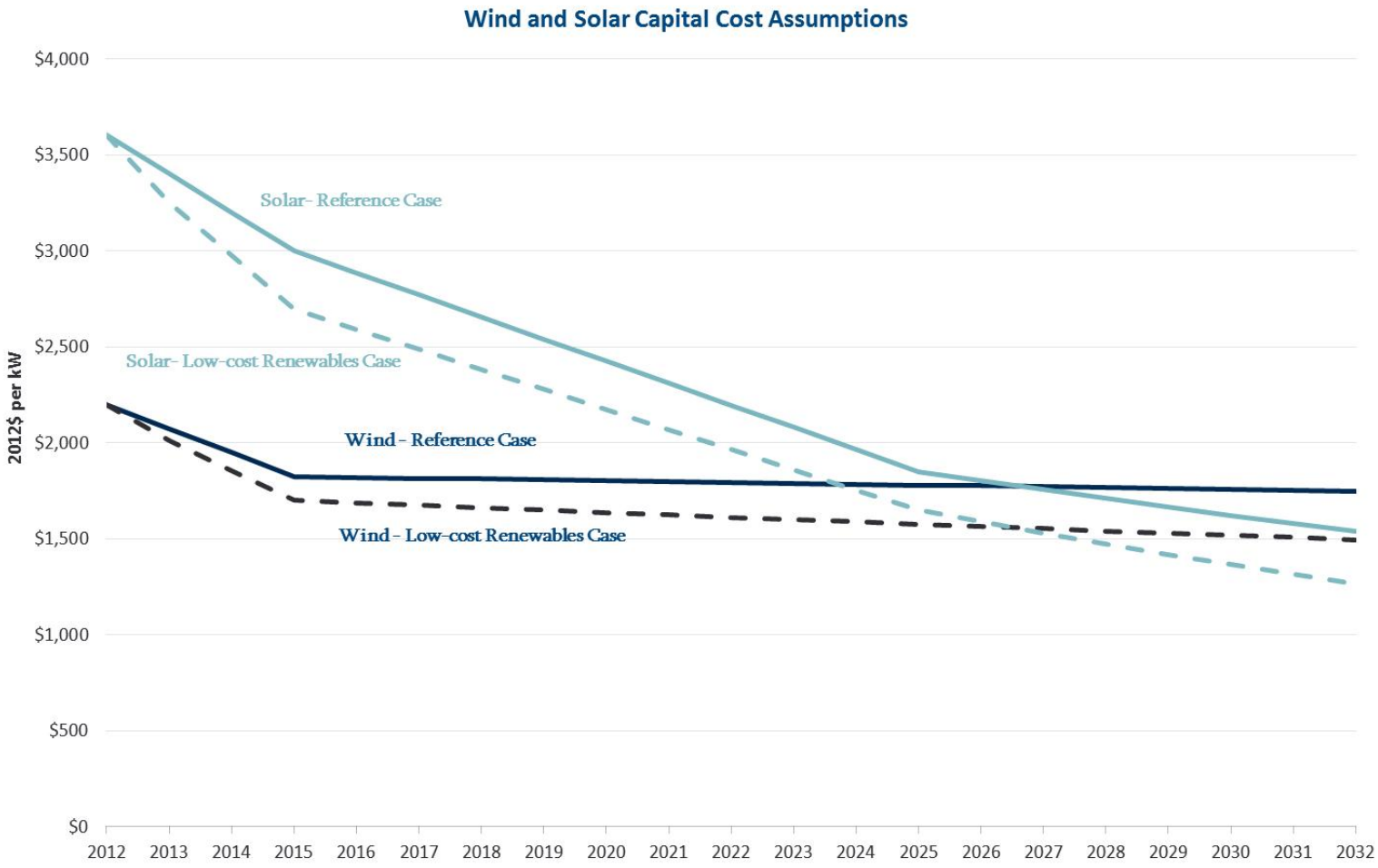
- Results in coal retirements of about 16 GW of coal, which is replaced by 12 GW of wind and 3 GW of solar PV
- In addition, about 13 GW of gas is added, in part to back up the renewables

Major Drivers of Renewable Penetration – Renewable Cost

The cost of renewables is a very important driver

- The cost of wind has generally trended downward and some additional declines are likely, but most projections show only small future declines, which as only a modest impact on future additions
- Solar PV costs have declined dramatically over the last few years and are projected to continue to decline . That cost decline may lead to 5-13 GW of central station solar PV over the next 20 years

Renewable Capital Cost Forecasts



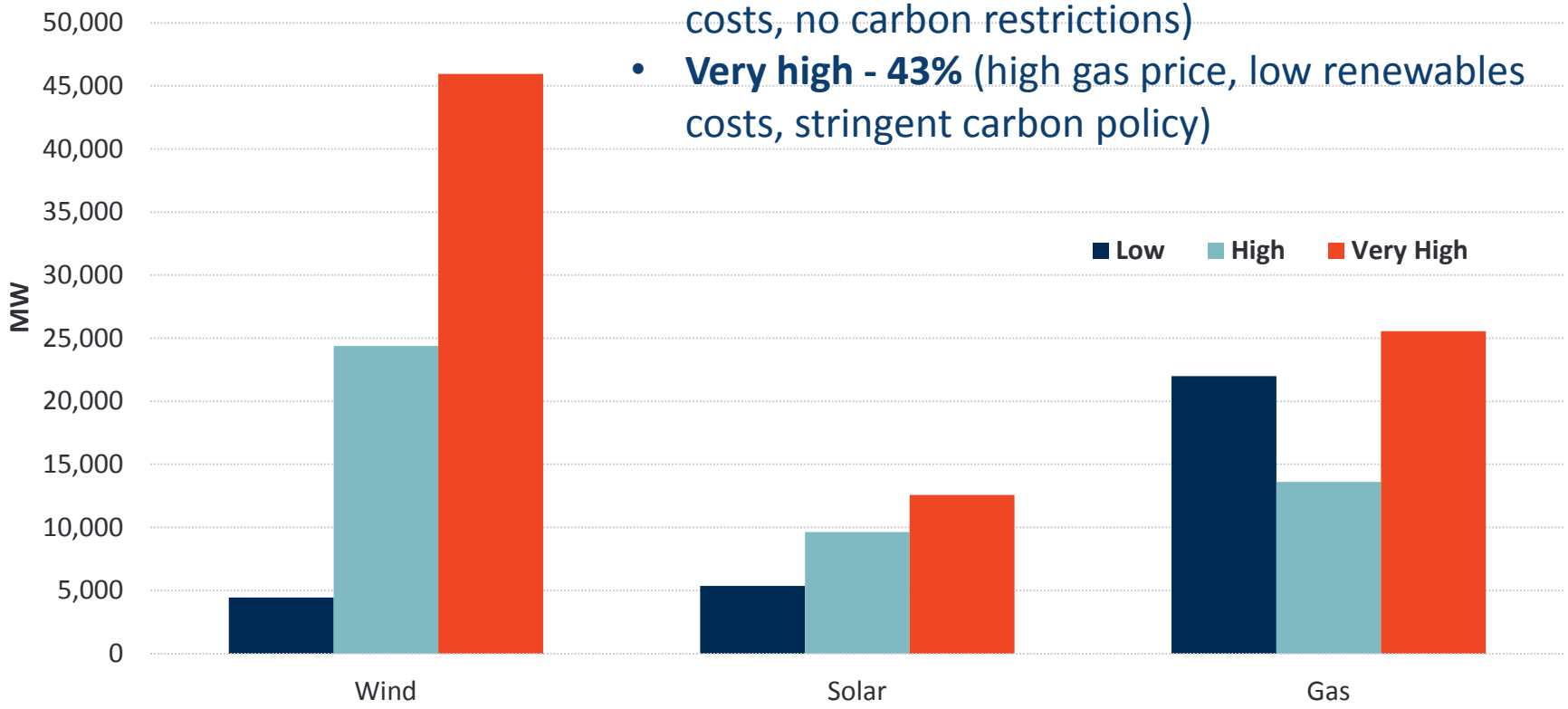
Source: Based on EPRI's *Integrated Generation Technology Options 2012* report

Integration of Renewables

2013-2032 Additions

Renewable penetration (% GWh)

- **Low – 7%** (base gas prices, base renewable costs, no carbon restrictions)
- **High – 26%** (high gas prices, base renewables costs, no carbon restrictions)
- **Very high - 43%** (high gas price, low renewables costs, stringent carbon policy)



Operation Under High Renewables

We found that high renewable penetration requires:

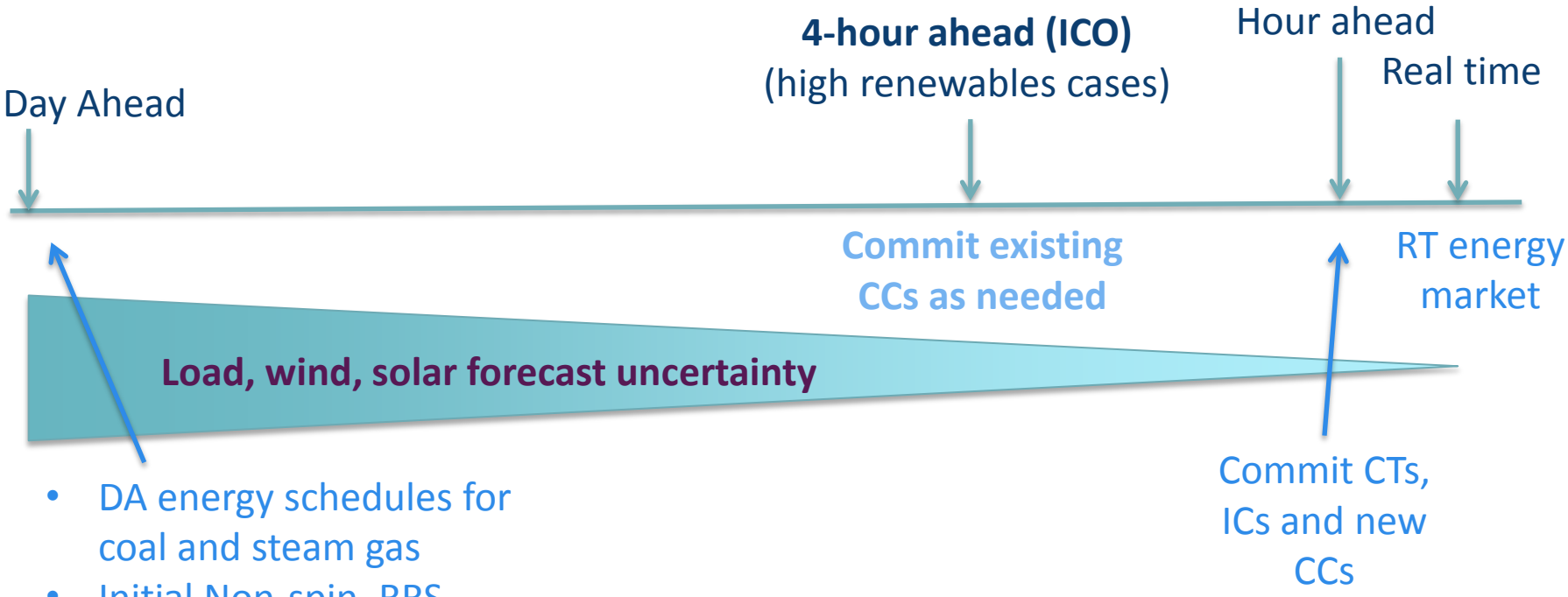
- Increases beyond ERCOT's "standard" formula for A/S requirement levels
- The addition of new A/S service types

A feasible option for a new ancillary service type is what we call "Inter-hour commitment option" or ICO

- ICO ensures that operators have recourse in the event of net load under-forecast
- Generating units that supply this service are those can be brought on line within four hours (generally CT, IC, and CC)
- The combination of needed Non-spin and ICO commitment requirements are a function of renewables and load forecast uncertainty
- The precise specifications for this A/S might be different than what we assumed and modeled, but the general need to set aside additional capacity is clear

Modeling the ICO Service in ERCOT Market

Operational challenges of renewables integration were evaluated with PSO model, simulating multi-level, nested time intervals with a simultaneous optimization of energy and ancillary services dispatch, in an uncertain operational environment



- DA energy schedules for coal and steam gas
- Initial Non-spin, RRS, and Regulation commitments

Ancillary Service Requirements vs. Renewable Penetration in 2032

	Ancillary Service			
Renewable Penetration level	Percent intermittent renewables (%GWh)	Regulation	ICO	30 minute non-spin
Low	7%	600 MW	NA	1,500 MW
High	26%	830 - 1,050 MW	up to 4,700 MW	up to 5,700 MW
Very High	43%	1,145 -1,350 MW	up to 9,700 MW	up to 8,900 MW

In comparison, ERCOT currently sets aside about 600 MW of regulation and 1,500 of other 30-minute non-spin

The Brattle Group

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- Retail Access and Restructuring
- Market Design and Competitive Analysis
- Mergers and Acquisitions
- Transmission

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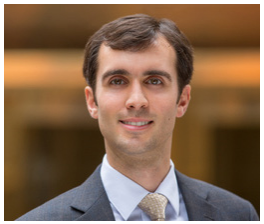
Dr. Shavel is an energy economist specializing in the economics and operations of the U.S. electric power system, generation and transmission investment, and environmental strategy.



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Dr. Ruiz is an electrical engineer with nearly ten years of experience in electric power systems analysis and research. He specializes in renewable power integration and the modeling and analysis of transmission systems and wholesale electricity markets.