

Denton Renewable Resource Plan

Enterprise Risk Consulting, LLC

Presented to:
Public Utilities Board of the City of Denton
October 23, 2017

The Denton City Council
October 24, 2017

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Presentation Outline

- Planning Goals
- Data and Data Sources, and Evaluation factors
- Portfolio Modeling
- Summary Analysis
- Recommendations

Planning Goals

Five Objectives:

1. Least-cost supply
2. Uncertainty (risk) reduction
3. Sustainability
4. Competitiveness
5. Efficient management of a renewable resource power supply portfolio

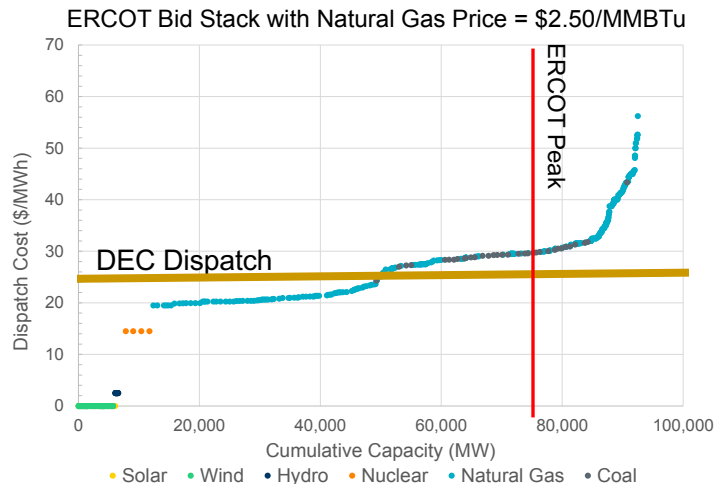
DATA & EVALUATION FACTORS

Data Sources and Inputs

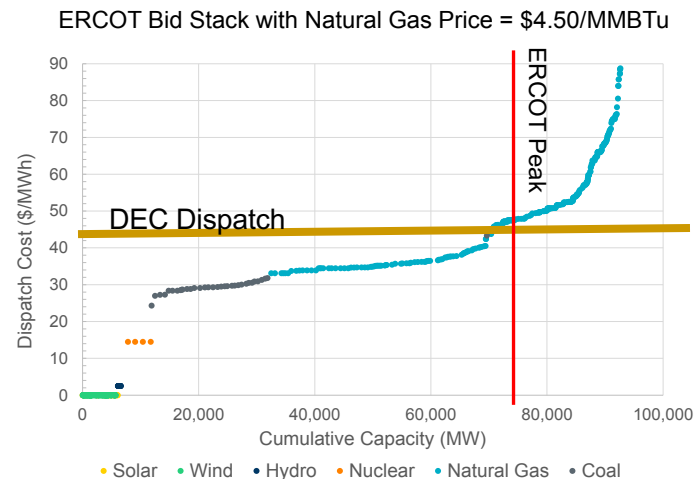
- Denton: load, current supply resources, DEC performance data
- ERCOT:
 - Day Ahead market (DAM), Real Time market (RT) prices, and Congestion Revenue Rights (CRR) market data
 - Historical heat rates
 - Market dispatch modeling
 - Resource adequacy studies
- Other sources:
 - The U.S. Energy Information Agency (EIA) for historical natural gas prices and production/consumption
 - “Least-Cost Electric Utility Planning” Stoll, Harry G. 1989
 - The Texas Public Utility Commission
 - Texas Renewables website
- NYMEX and other industry sources for forward natural gas and power price data

ERCOT – Resource Price Stack

Changes in the Resource Price Stack



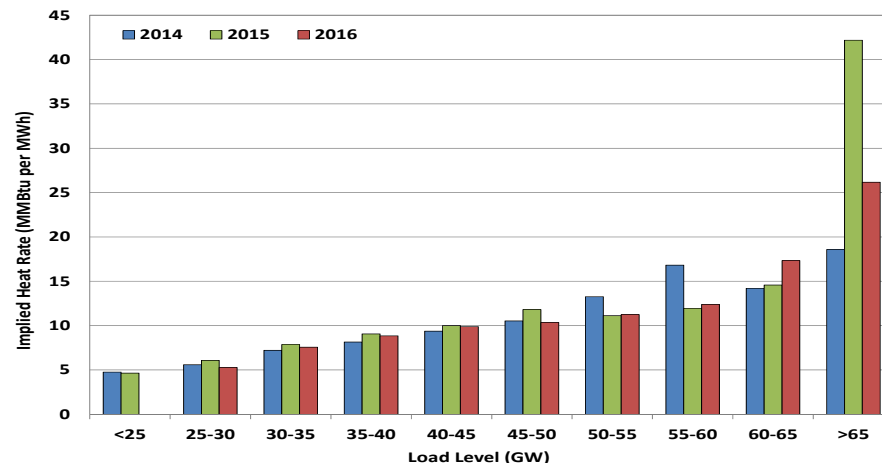
Changes in the Resource Price Stack



- If gas prices are \$4.50, then coal-fired generation is dispatched first, before natural gas-fired units. The DEC would be in a position to earn a high margin, but the number of hours to earn that high margin is small.
- If gas prices are \$2.50, then coal-fired generation is hardly ever dispatched. The DEC would be dispatched earlier in the queue, but there would be very little profit margin because of substantial competition with other gas-fired generation resources.

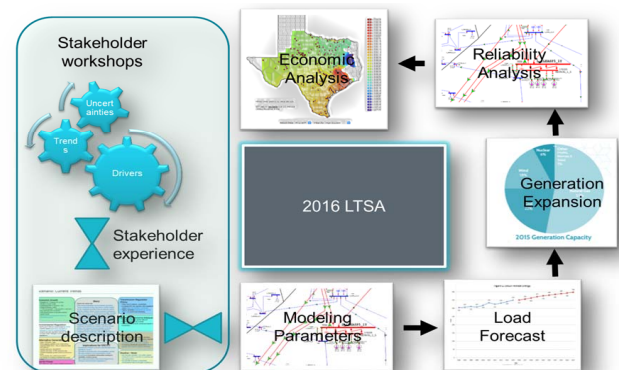
ERCOT Data

Figure 13: Implied Heat Rate and Load Relationship



- The shape of the curve and the relative heat rates don't change much year to year. Extraordinary events (extreme weather or transmission outages) are necessary to get outside of the typical heat rate curve.
- The DEC's heat rate is high and requires lower probability events to warrant dispatch.

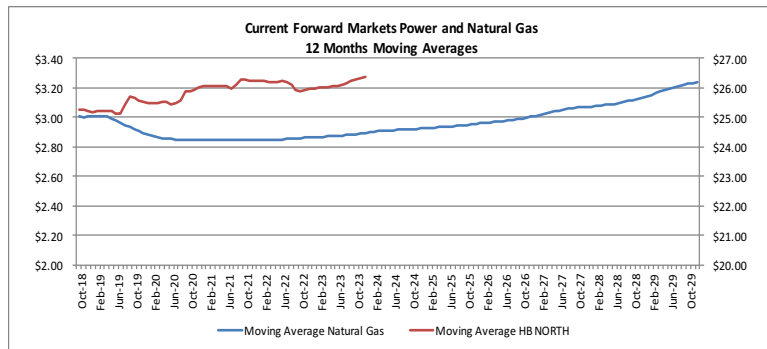
ERCOT Long Term System Assessment



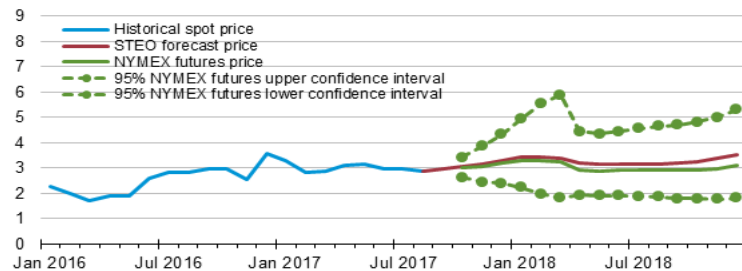
LTSA key findings:

- Load continued to grow in ERCOT in seven of the eight scenarios.
- All scenarios showed a significant amount of solar generation additions and the retirement of coal and natural gas generation.

Market Data



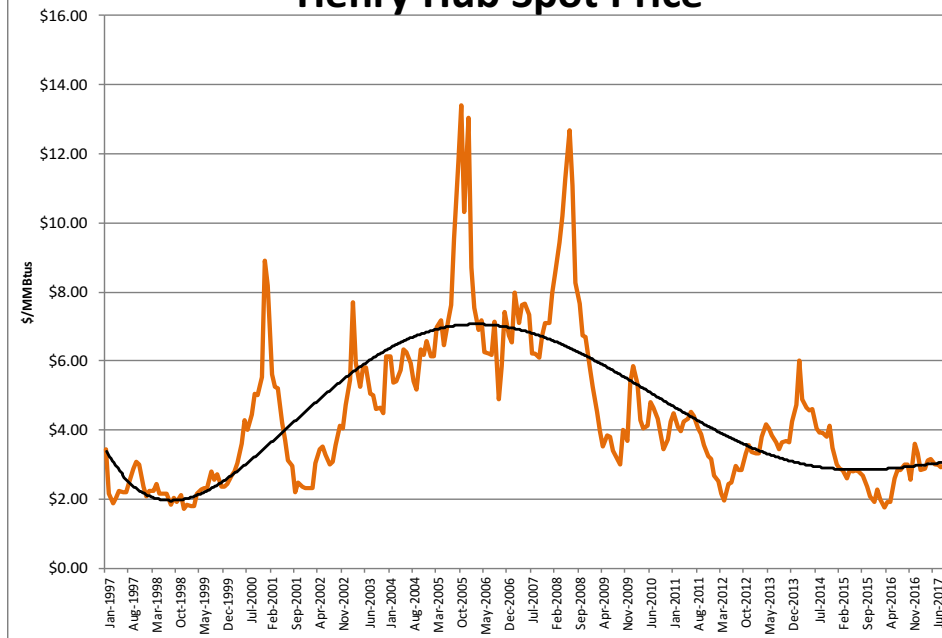
Henry Hub natural gas price
dollars per million Btu



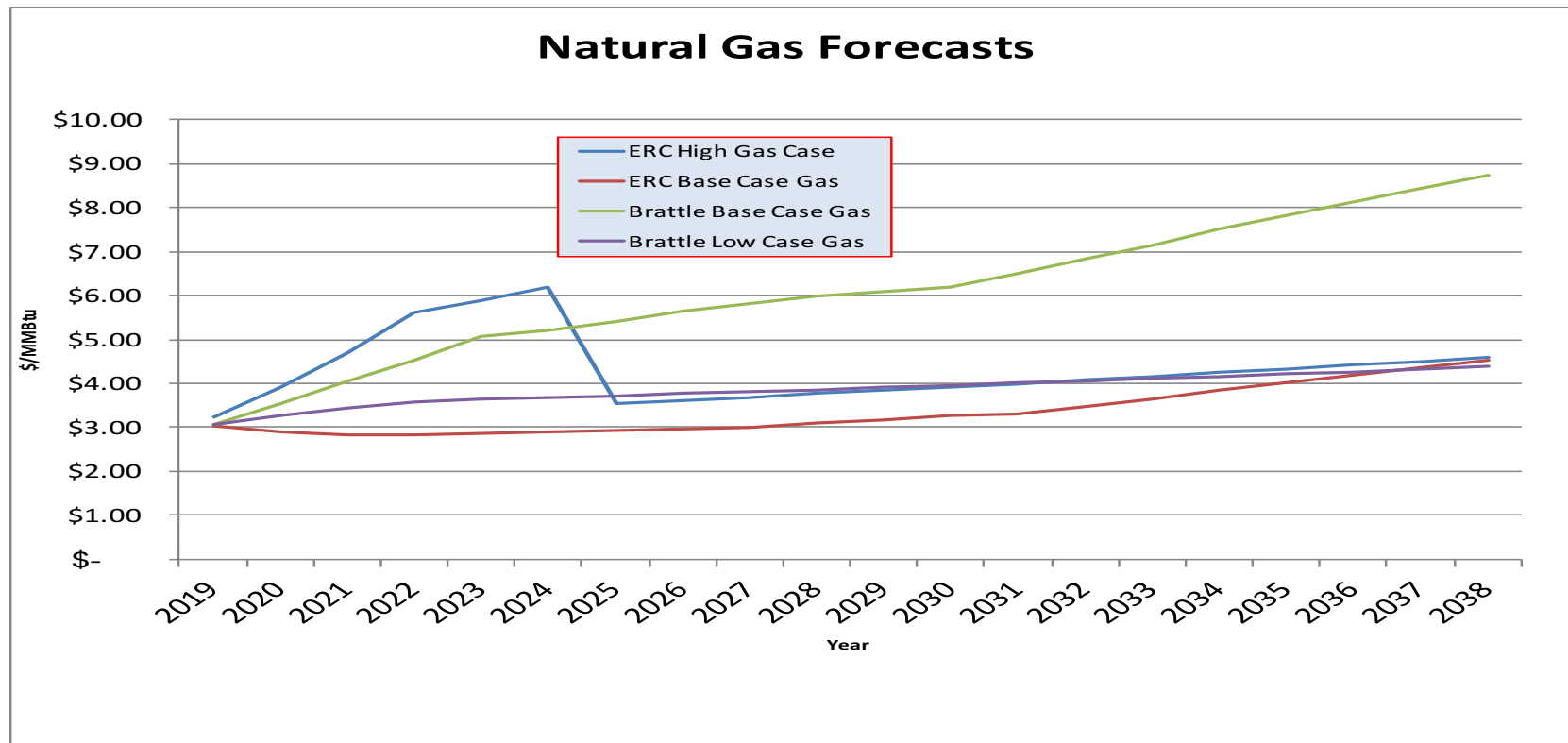
Note: Confidence interval derived from options market information for the 5 trading days ending Sep 7, 2017. Intervals not calculated for months with sparse trading in near-the-money options contracts.

Source: Short-Term Energy Outlook, September 2017.

Henry Hub Spot Price



Natural Gas Price Projections



Evaluation Factors

- Least-cost supply
- Uncertainty (risk) reduction
 - Matching resource production profiles to Denton's daily and seasonal load profiles
 - Balancing the need for selling excess supply and purchasing shortages,
 - Quality of each resource's production
 - Access to transmission interconnections
 - Minimizing transmission issues with a particular focus on avoiding or reducing exposure to congestion risk.

Denton Load Scenarios:

1. Slightly negative growth rate
2. Mean annual growth of 1.6%
3. High annual growth case of 3%

Supply Gap Analysis

Definition of renewable percentage: the number of annual MWhs of renewable production compared to Denton's annual MWhs of load.

Current supply portfolio:

Generator Name	Type	Location	Capacity (MW)	Official Contract Date	Start Date	End Date	Annual Production (MWh)
WhiteTail (Nextera)	Wind	West Texas	30	5/1/09	7/1/11	12/31/23	262,800.00
BlueBell	Solar	West Texas	30	1/1/19	1/1/19	1/1/39	76,212.00
Santa Rita	Wind	West Texas	150	1/1/19	4/1/18	4/1/38	591,300.00
Landfill	Landfill Generation	Denton	1.6	?	1/1/17	12/31/24	14,016.00

- Denton's annual load for 2019 = 1,550,000 MWhs
- Counting Whitetail as a renewable resource leaves Denton at approximately 61% renewable. Without counting Whitetail as a renewable resource results in approximately 44% renewable resources.
- Depending on the classification of Whitetail, Denton needs between 9% and 26% in additional renewable resources to meet its minimum goal of 70% renewable, or between 39% and 56% to meet the target of 100% renewable.

Renewable Supply Alternatives – RFP Results

Resource Prices and Delivery Points

	Delivery at Node	Delivery at HB North	Location
Solar	\$22 to \$26	\$28 to \$32	West Texas
West Texas	\$12 to \$20	\$19 to \$25	West Texas
Coastal	\$22 to \$31	\$23 to \$33	Texas Coast
North Texas	\$15 to \$18	\$18 to \$21	North Texas
South Texas	\$21 to \$22	\$22 to \$23	South Texas
Panhandle	\$12 to \$14	\$20 to \$23	North Texas

- These are the prices used to estimate the costs of the supply, and are further adjusted to production profiles to calculate effective costs.
- Example: solar produces during the higher priced on-peak hours while wind production drops off, thus a buyer would need at least a 20% lower price for West Texas wind to compete with a Solar resource.
- There are also limits of any one type of resource that can be placed into the portfolio given Denton's load shape.
 - Denton will start receiving a large West Texas wind supply in the spring of 2018 and a Solar resource in 2019.
 - For this reason, the North Texas and Coastal wind regions will be recommended as additions to Denton's portfolio.

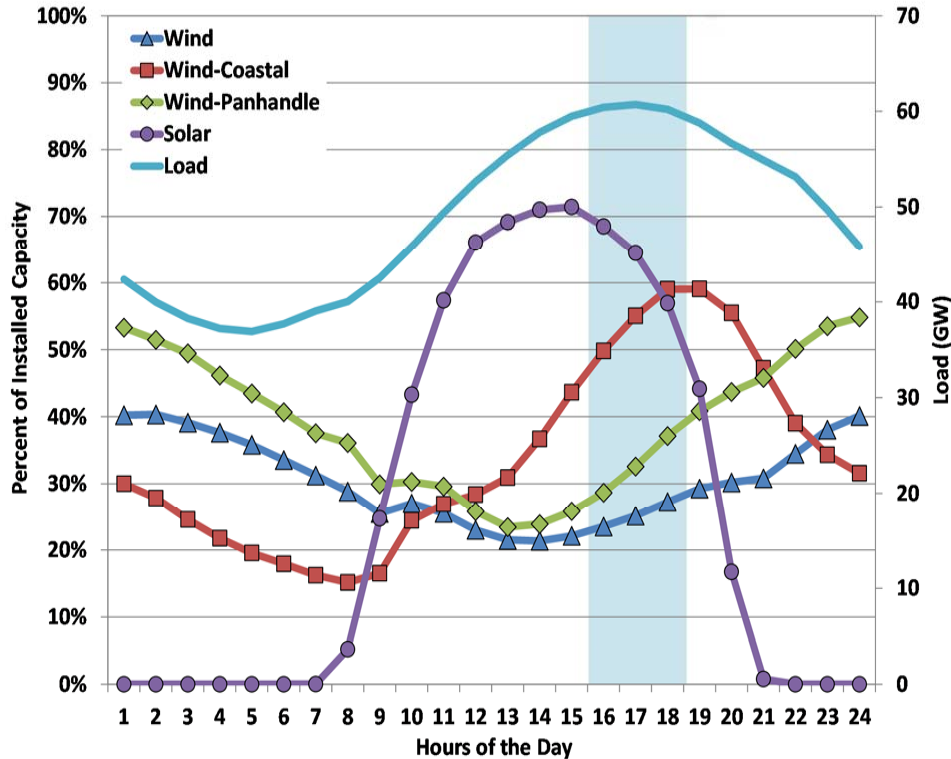
Least Cost Comparison

Approximate Annual Prices	Approximate Renewable Savings	Renewable Equivalent Price	Approximate Heat Rates	Natural Gas Equivalent
\$31 MWh On-Peak	Solar = \$8 MWh	\$23.0 MWh	On-Peak = 10.5	\$2.20 MMBtu
\$27 MWh RTC	Wind = \$5.5 MWh	\$21.5 MWh	RTC = 9.8	\$2.20 MMBtu

Natural Gas = \$2.92 MMBtu

Power (\$/MWh)	Natural Gas (\$/MMBtu)	Heat Rate (MWh/MMBtu)	North Hub Wind Price (\$/MWh)	Renewable Equivalent Price (\$/MWh)	Renewable Benefit vs. Natural Gas (\$/MWh)
\$20.36	\$2.00	10.2	\$17.50	\$21.50	\$(1.14)
\$29.85	\$3.00	9.9	\$17.50	\$21.50	\$8.35
\$38.87	\$4.00	9.7	\$17.50	\$21.50	\$17.37
\$47.43	\$5.00	9.5	\$17.50	\$21.50	\$25.93

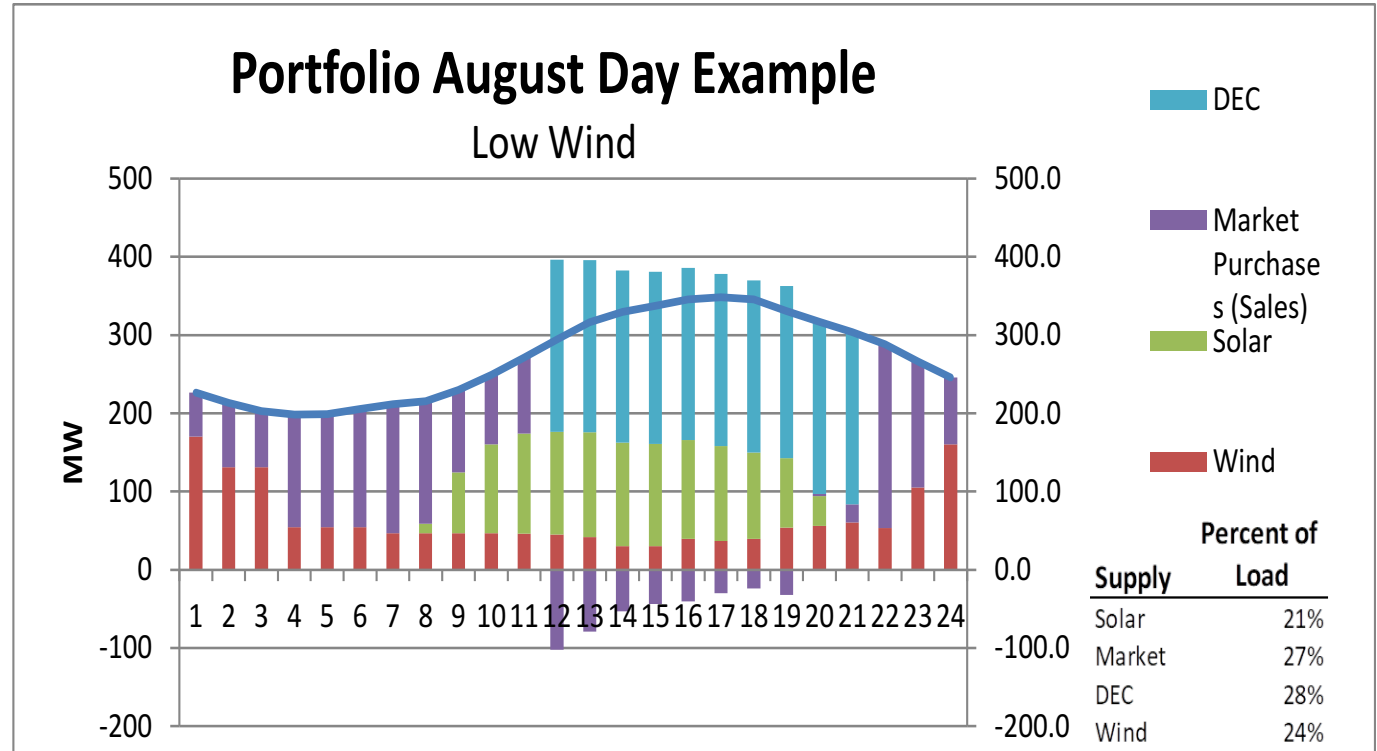
Production vs. Load Profiles: Daily



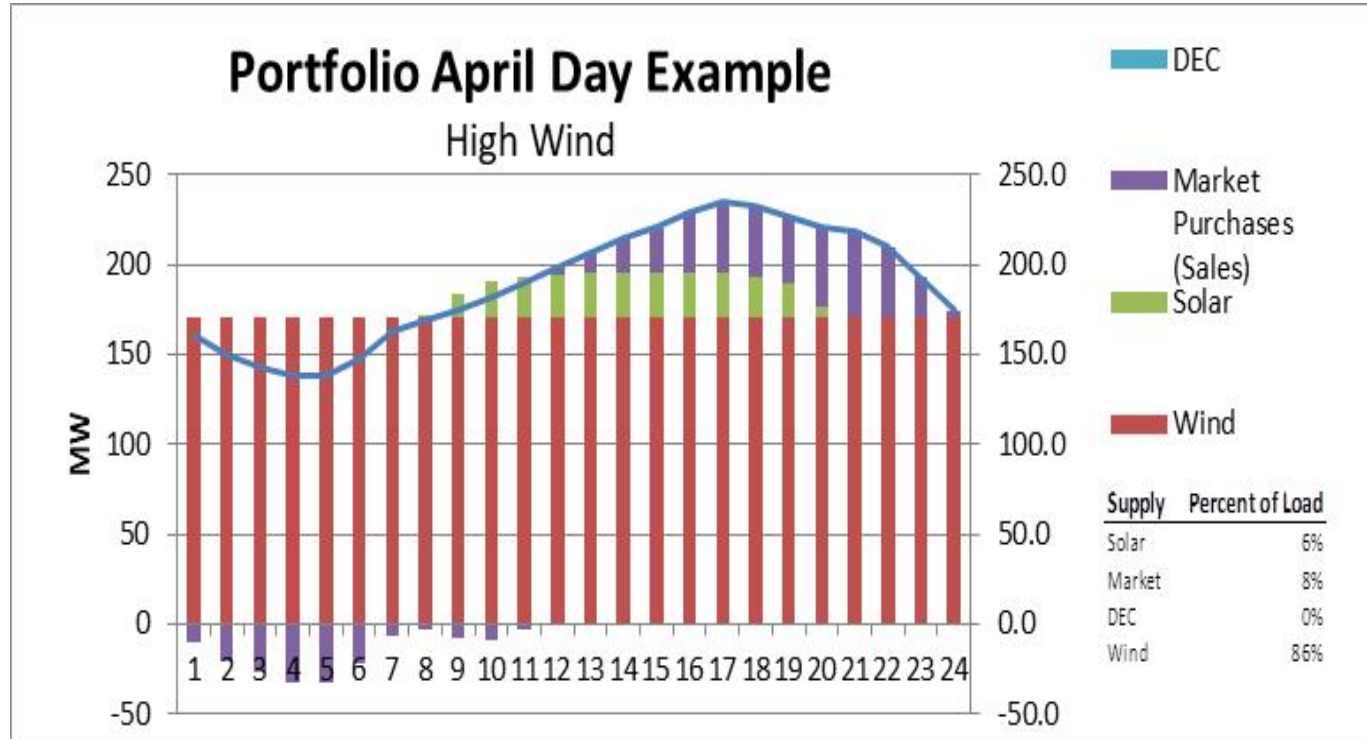
- West Texas wind is the worst match against load.
- Solar and Coastal wind offer the best (on-peak) match against load, and can displace market purchases of more expensive on-peak energy.
- Panhandle wind is somewhat superior to West Texas wind.
- Coastal wind production is at a low point during lower priced hours (i.e., it offers the benefit of producing less when production is less valuable).
- Coastal wind and Solar:
 - Current low prices are attractive
 - Production profiles are a better fit for Denton's load, and are a better complement to Denton's existing renewable resources.

Production vs. Load Profiles: Seasonal (Summer)

- Seasonally low wind output would necessitate market purchases during off-peak hours.
- The combination of solar production and DEC production could cause an excess of supply during certain on-peak hours and would necessitate market sales.



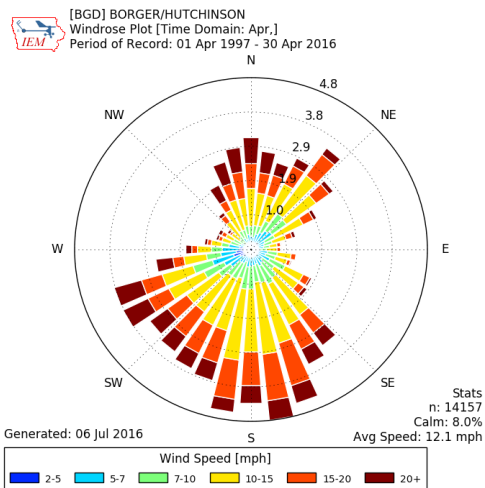
Production vs. Load Profiles: Seasonal (Spring)



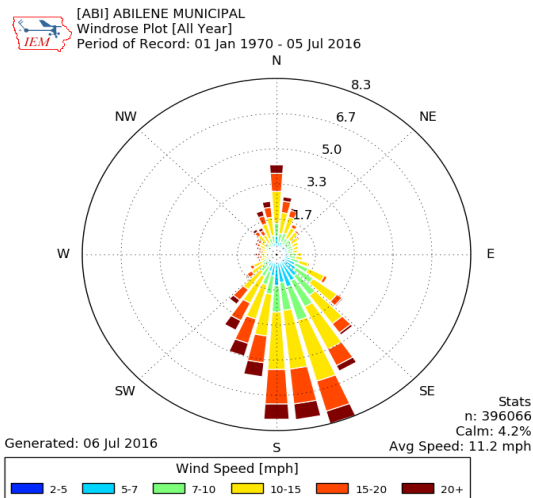
- Seasonally high wind output would necessitate market sales during off-peak hours.
- The combination of only modest solar production and lack of DEC production could cause a shortage of supply during certain on-peak hours and would necessitate market purchases for supply/demand balancing.

Wind Location

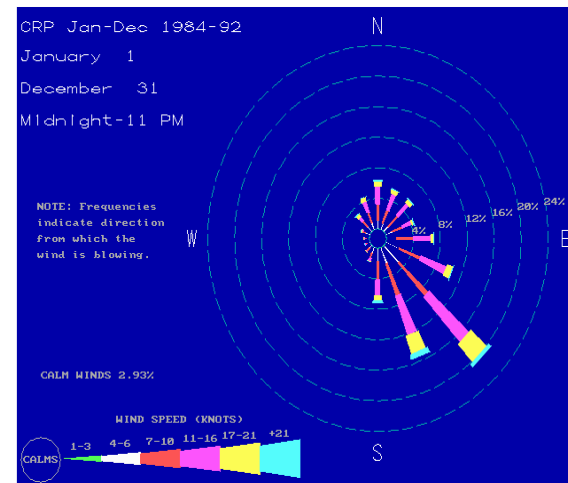
TX/OK Border



Abilene



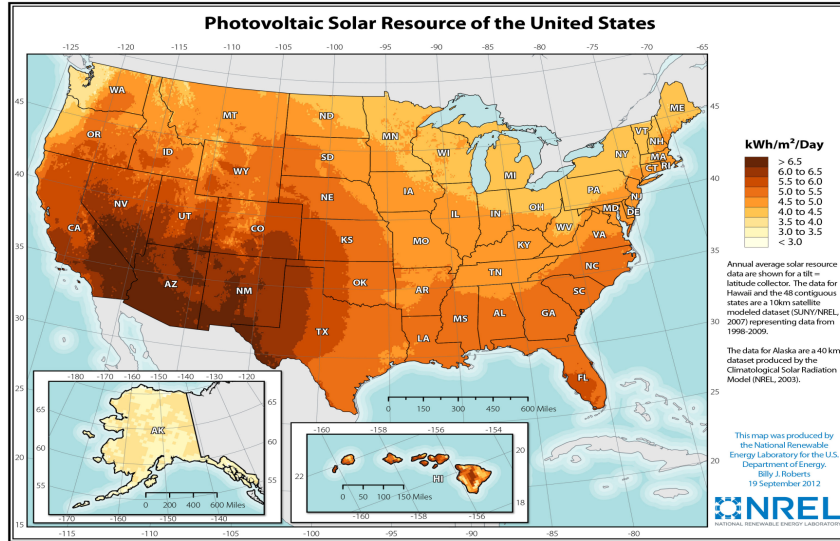
Coastal



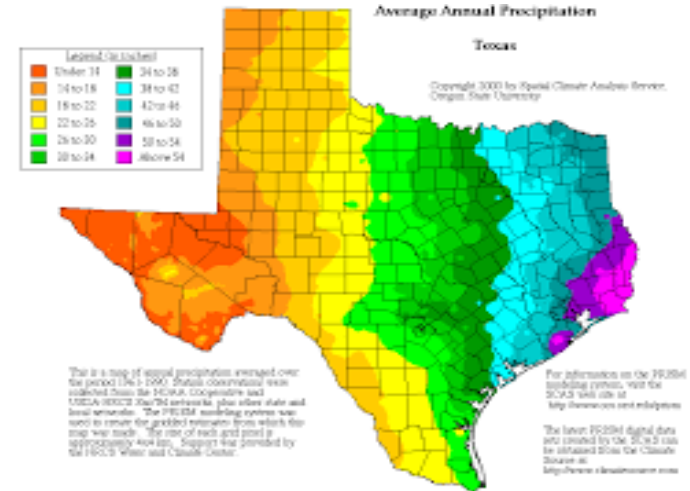
- 6 different wind regions in ERCOT - not well correlated because of the distance between them - because Denton owns a large resource in West Texas, other regions will need to be considered.
- Both Panhandle and Coastal wind resources are not well correlated with System-wide output.
- Coastal wind is superior to other types of wind due to a higher capacity factor and greater production during more valuable on-peak hours
- Wind resource capacity factors are often over estimated because it is difficult to include site-specific losses due to wind shift turbulence and topographic effects.

Solar Location

Solar Irradiance

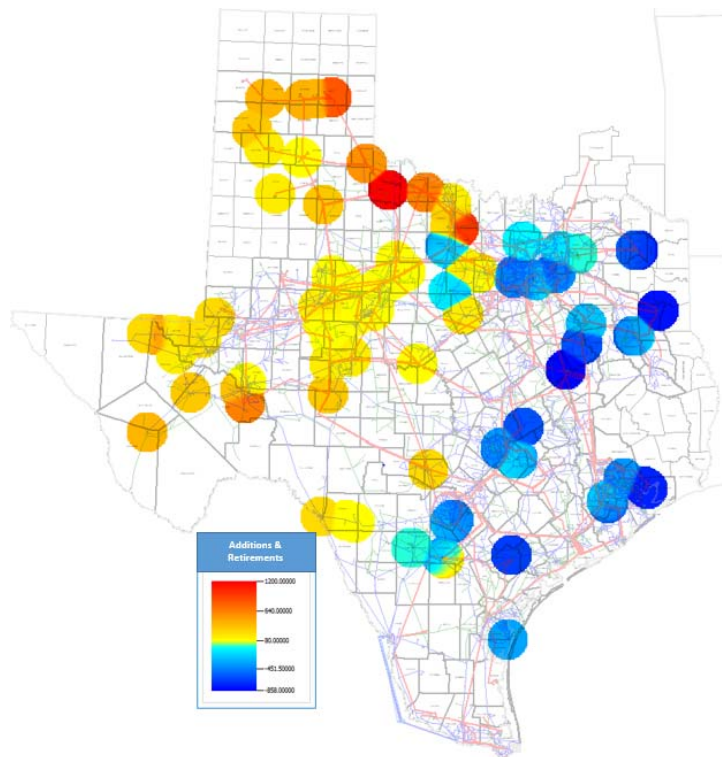


Rainfall in Texas

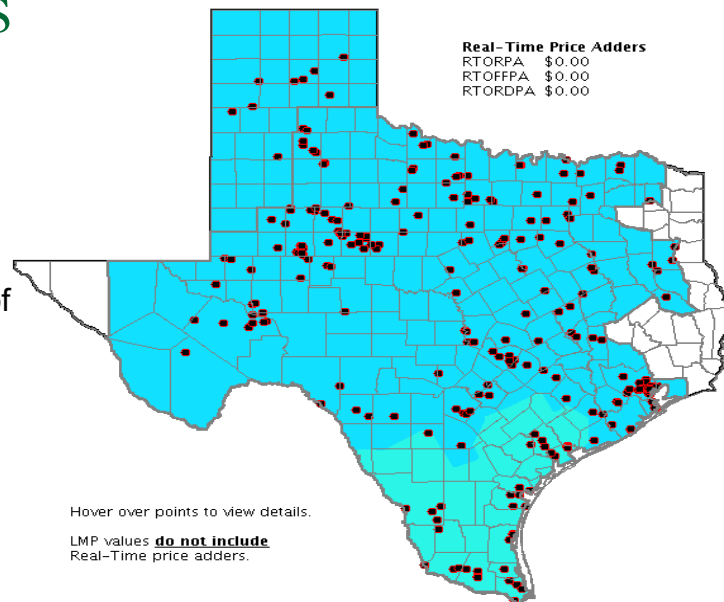


- Solar irradiance is impacted by longitude and latitude, potential for cloud cover, and temperature factors.
- For optimal irradiance, the best location in Texas would be all the way west to El Paso.
- Another limiting factor is congestion – going too far can entail too much transmission congestion.
- An optimal location representing a balance of sufficient irradiance, limited cloud cover, and manageable congestion would be close to Midland.

Other Location Considerations



- ERCOT LTSA: generation additions and retirements will create a decisive West to East flow of production.
- Coastal wind is not facing heavy competition.
- Adding resource capacity in an area with retiring conventional generation, and closer to load than the majority of renewable resource additions, presents several advantages.



- Best locations for renewable resources are between the transmission interconnection pricing clusters and urban areas, east of the clusters in the western region, and along the coast closer to Corpus Christi than Brownsville.

SUPPLY PORTFOLIO MODELING

Portfolio Modeling Variables

- Natural gas prices
- Power prices
- ERCOT Hub North heat rates
- DEC heat rate plus estimate of variable costs
- Denton load growth
- Renewable resource production profiles
- Renewable Prices
- Basis costs (CRRs and locational basis floating price exposure)
- CRR prices, Point to Point prices
- Regulation changes (e.g., incorporation of Marginal Losses, Local Reserves, potential federal Solar tariff)
- PTC and ITC effects on supply and prices (curtailment frequency)
- Coal and natural gas plant retirements
- Renewable saturation in certain regions
- Lubbock ERCOT integration
- Proposed new resources

ANALYSIS SUMMARY

ERCOT and the Role of “Firming”

Using a specific power plant to “firm” intermittent resources is necessary in a bilateral market where a utility is responsible for its own control area.

ERCOT is not a bilateral market – it is an Energy-Only power pool that is managed as a single control area.

The ERCOT market is designed to use the DAM for supply balancing, including the firming of intermittent resources, and the RT market for DAM to RT imbalances.

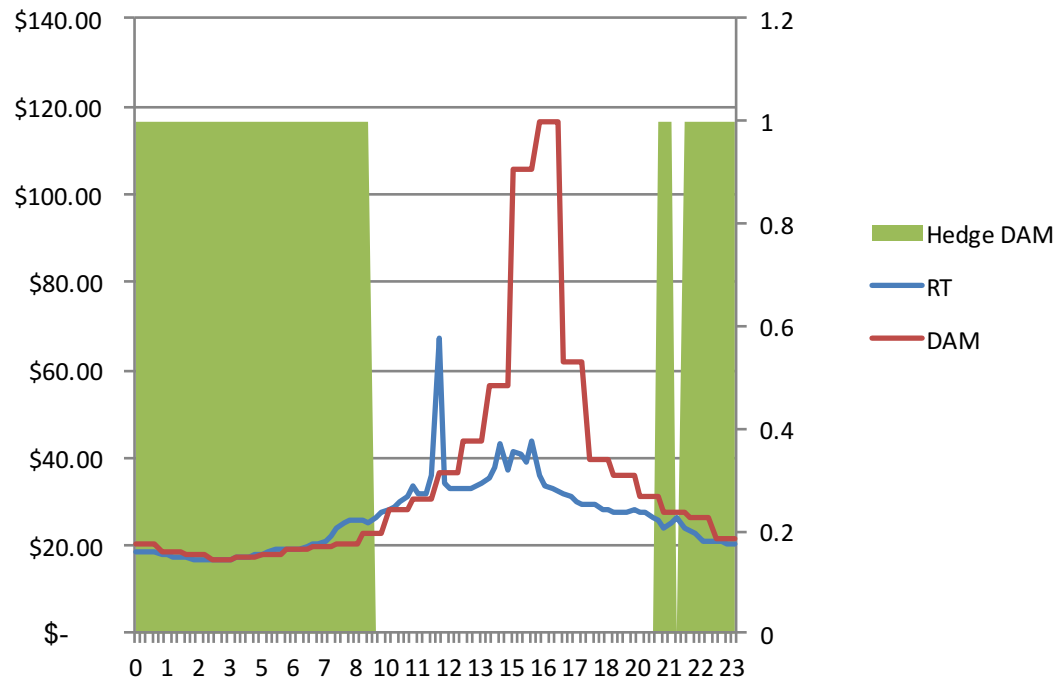
The primary issue with using market purchases for firming is managing the potential cost.

The DEC will play a role in Denton’s renewable resource portfolio as a cost hedge during certain super high-priced hours, but for the majority of the time it will be less risky and more cost efficient to use market purchases for firming.

The DEC

- Using the DEC as a sole hedge or source for “firming” is not the least-cost and lowest-risk option for over 75% of the hours in a year.
- The low heat rate associated with most of the hours in the DAM will allow Denton to firm intermittent renewable production with spot market purchases at a lower cost than the DEC, while avoiding congestion and price risk.

August Day Example



The DEC

Advantages

- The DEC is a heat rate hedge.
- It will reduce cost risk for Denton because at certain times it will be dispatched during price spikes.
- It also provides a long-term hedge benefit in the event of accelerated retirement of conventional fossil fuel generation resources.

Disadvantages

- As a higher heat rate generator, it offers no pricing power and offers no competitive advantage.
- ERCOT manages the system so that heat rates don't vary much.
- Its value to Denton requires that natural gas prices go up substantially in the future.

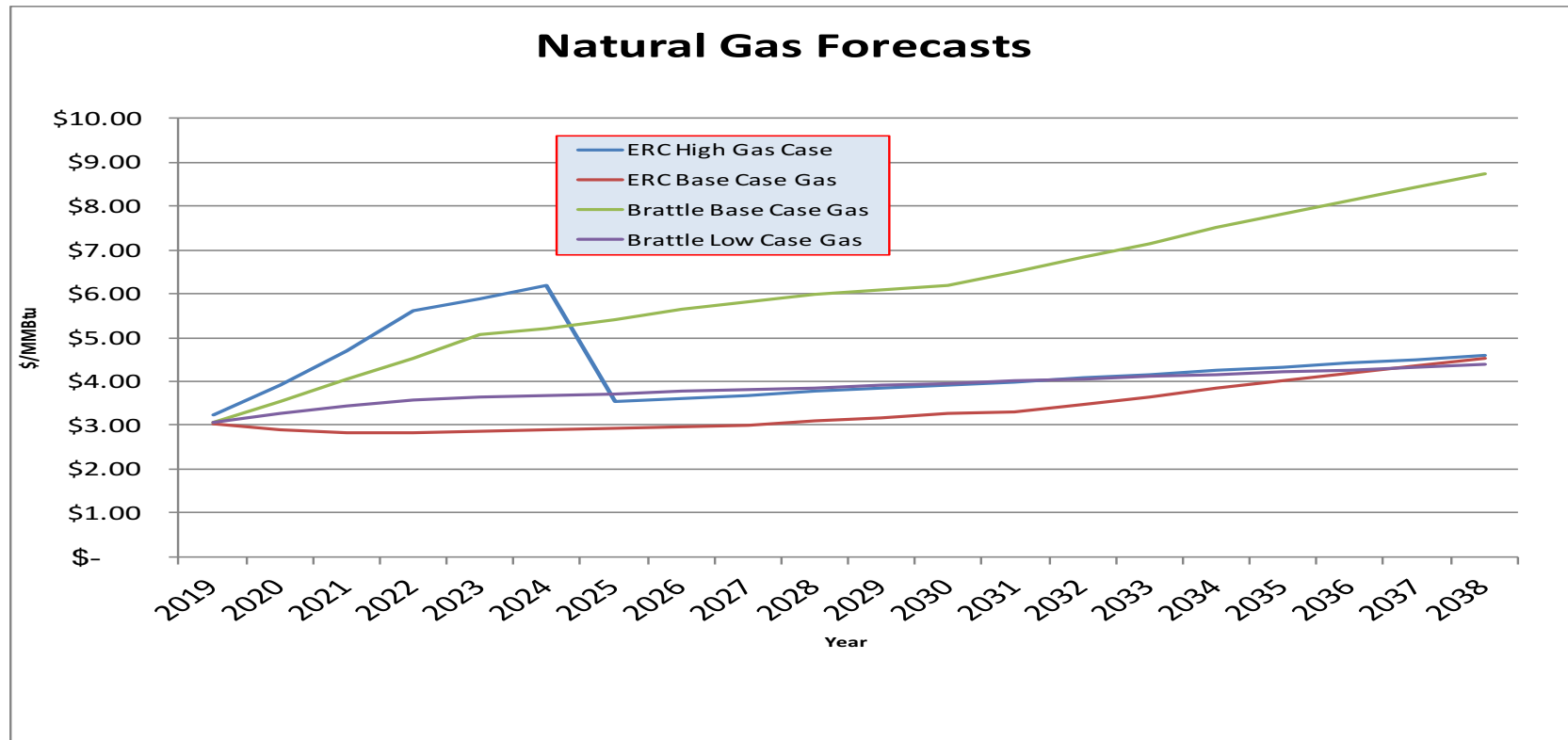
DEC Run-time Estimation

Based on the natural gas price projections used in the analysis for the resource plan, the DEC is projected to run between 12% and 20% of the time, equivalent to between 1300 and 1700 hours per year.

Getting Additional Value from the DEC

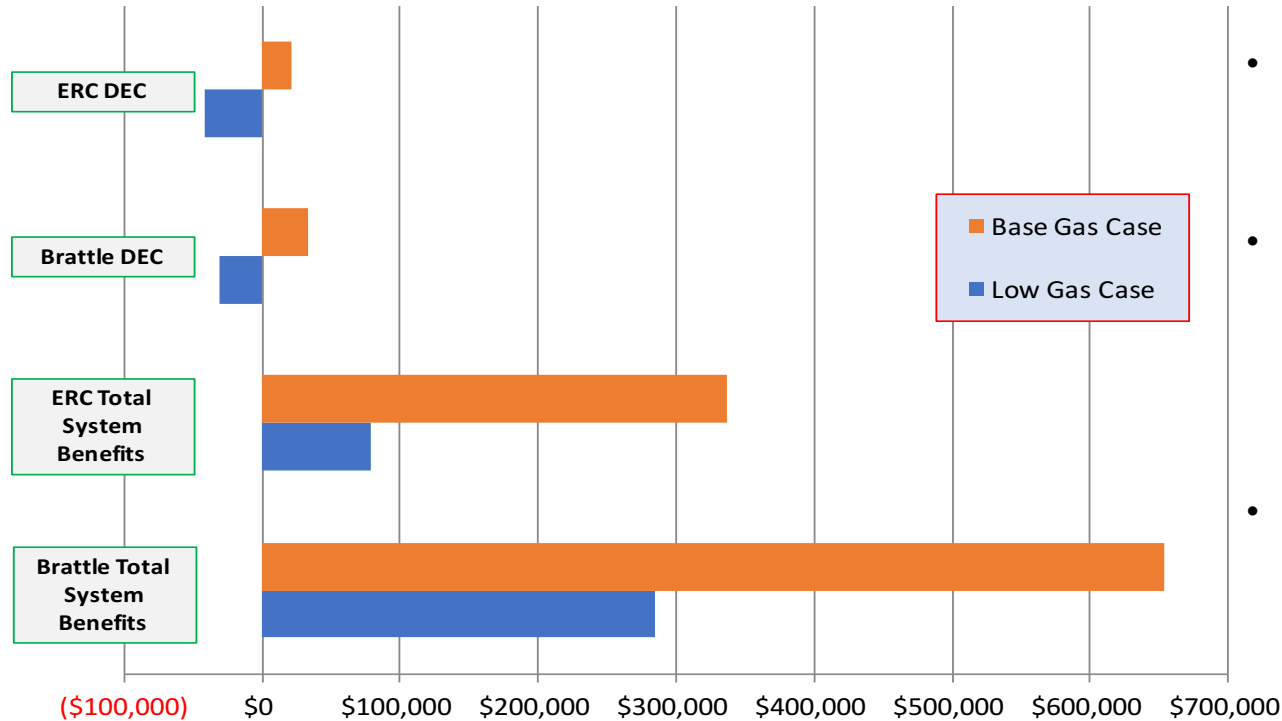
- Denton should be prepared to sell DEC output forward when or if there is a spike in natural gas prices.
- If Denton has an excess of supply, the DEC can be sold into the DAM during high-priced hours.
- The DEC can be used to sell firming services to other organizations looking to add renewable resources (contingent financial hedge).
- It may be beneficial to sell excess renewable power during periods of excess supply (e.g., Spring) using the DEC to firm the transaction.

Natural Gas Price Projections



Benefits of the Denton Renewable Portfolio (\$000s)

ERC and Brattle Total Benefits of Denton Renewable Portfolio (\$000s)



- 70% goal reached by 2023 & additional Wind and Solar then purchased to reach 100%.
- Positive benefits result through avoided additional costs if prices rise in the future / negative values result from low price outcomes.
- Total System Benefits are completely dependent on the price of natural gas.

Renewable Resource Selection Considerations

Denton can reach its 70% renewable goal with additional renewable resources from the current RFP submissions.

The additional energy to reach the goal ranges from approximately 9% (140,000 MWh) of its load to 27% (400,000 MWh) of its load. This range depends on whether or not the Whitetail resource is designated as a renewable resource.

The current energy supply portfolio falls far short of a balanced and diversified portfolio because solar is only 30 MWs.

The portfolio is also unbalanced because a large amount of the renewable supply is a low on-peak West Texas wind profile (Santa Rita). Adding the Bluebell solar (30 MW) resource will still produce very little summer on-peak production.

The resource plan assumes that Gibbon's Creek will be decommissioned by 2018.

Renewable Resource Selection Considerations (cont.)

The DEC is a heat-rate resource and therefore does not contribute an energy hedge during peak hours (i.e., it is a heat rate hedge only until the price of natural gas is fixed).

This leaves Denton with an on-peak energy supply gap. A minimum of 90 to 120 MWs of solar would help balance the portfolio.

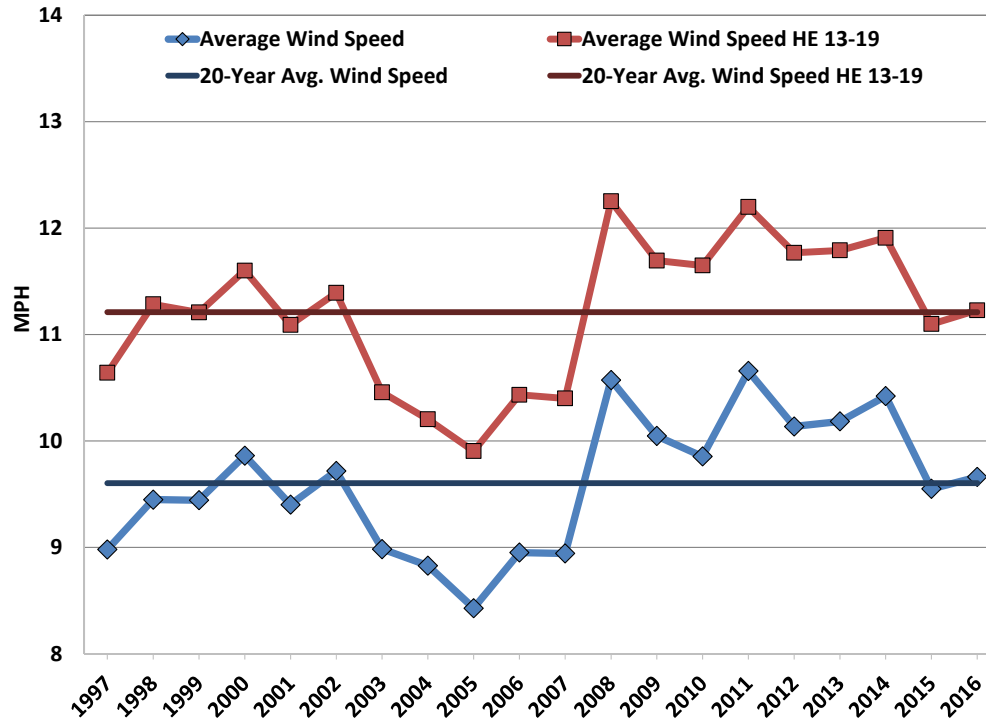
To reach the 70% goal at a minimum, another 70 MWs of Solar should be considered as an addition to the portfolio. If Whitetail is not counted, an addition of another 120 MWs of Solar should be considered, with wind representing the balance of energy needed to reach the 70% level.

Risk Considerations

- Potential federal solar tariff – potential alternatives:
 - ❑ Denton accepts no tariff outcome risk.
 - ❑ Acquire more Coastal wind resources that feature the characteristic summer peak production profile.
 - ❑ Utility-scale wind resources with a storage component.
 - ❑ Denton can wait after reaching the 70% goal as the tariff prices and supplies readjust to market conditions or the tariff is no longer an issue.
- Potential purchase accelerators
 - ❑ Retirement of conventional fossil-fuel generation
 - ❑ Reduction in the Producer Tax Credit (PTC)
 - ❑ Low natural gas prices

Overshooting the Targets?

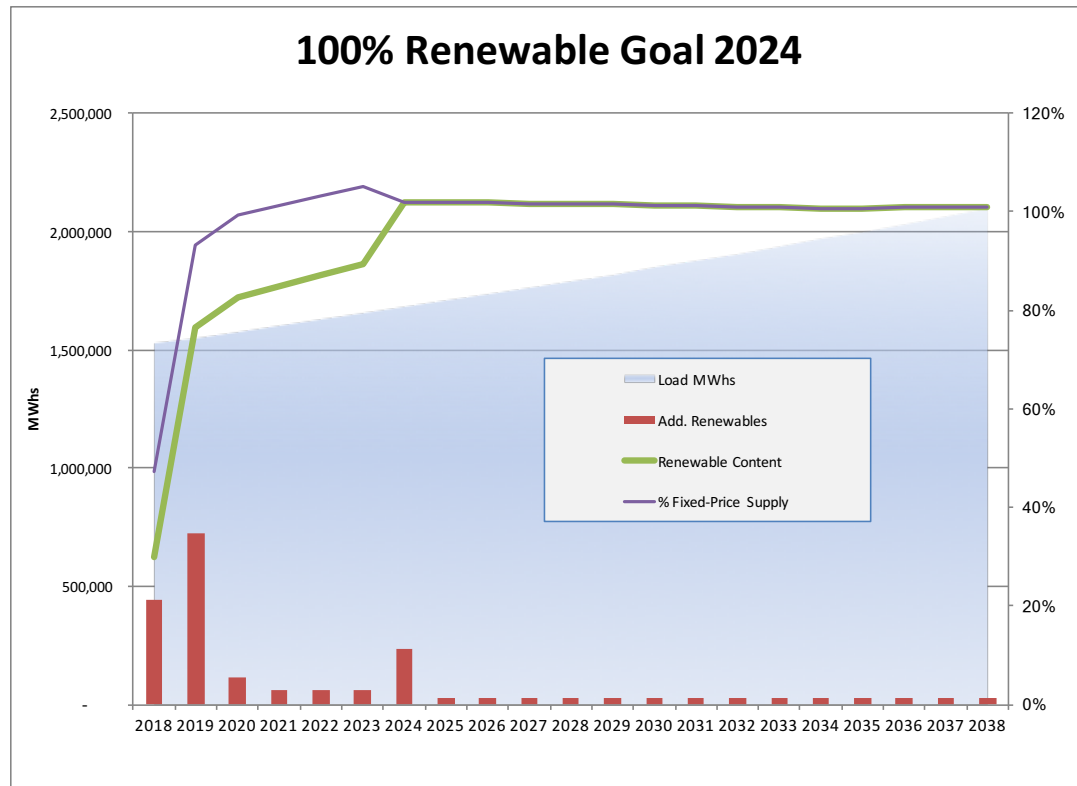
Figure 67: Historic Average Wind Speed



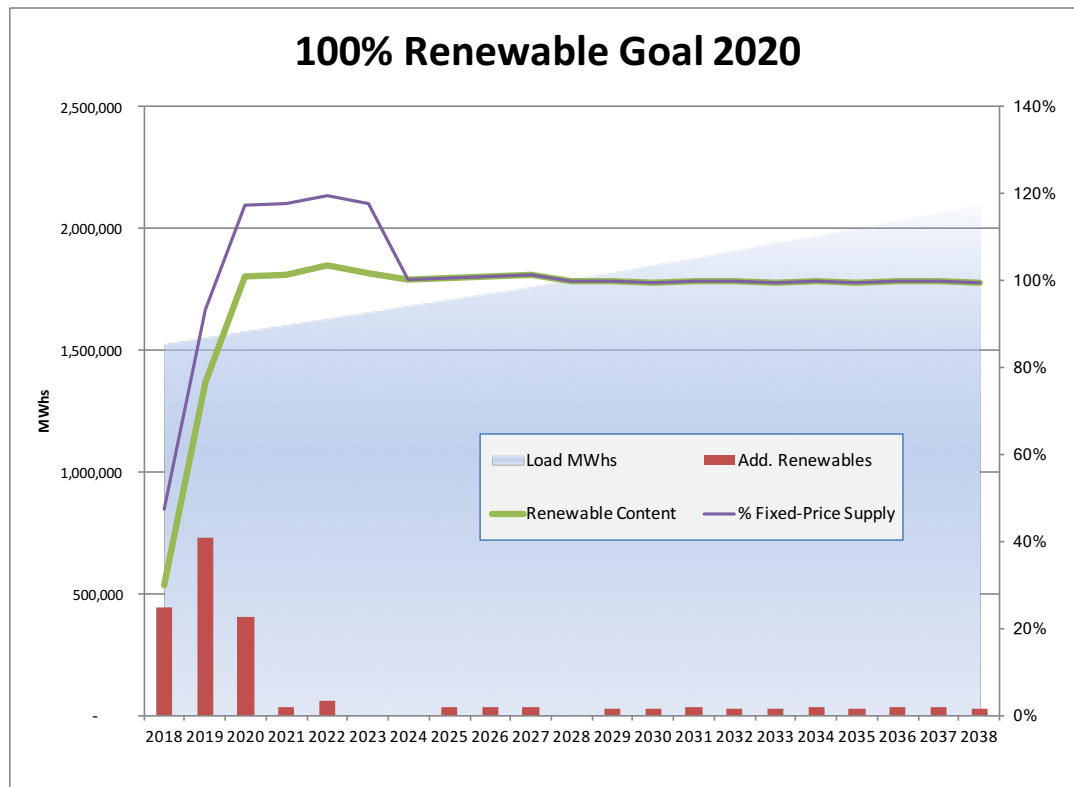
- Renewable resource production is uncertain year to year.
- Amount of wind production can easily vary by 15% on an annual basis.
- If Denton wants to make sure that it has at least 70% at a minimum in every year, it may need to buy additional supplies above the goal, taking into account the annual production variability.

Gradual Adoption Path

- Execute on low-cost alternatives in current RFP to get to 70%.
- Additional renewable purchases to reach 100% by 2024 (1st year without Whitetail).
- In this example, Whitetail is not included as a renewable resource.



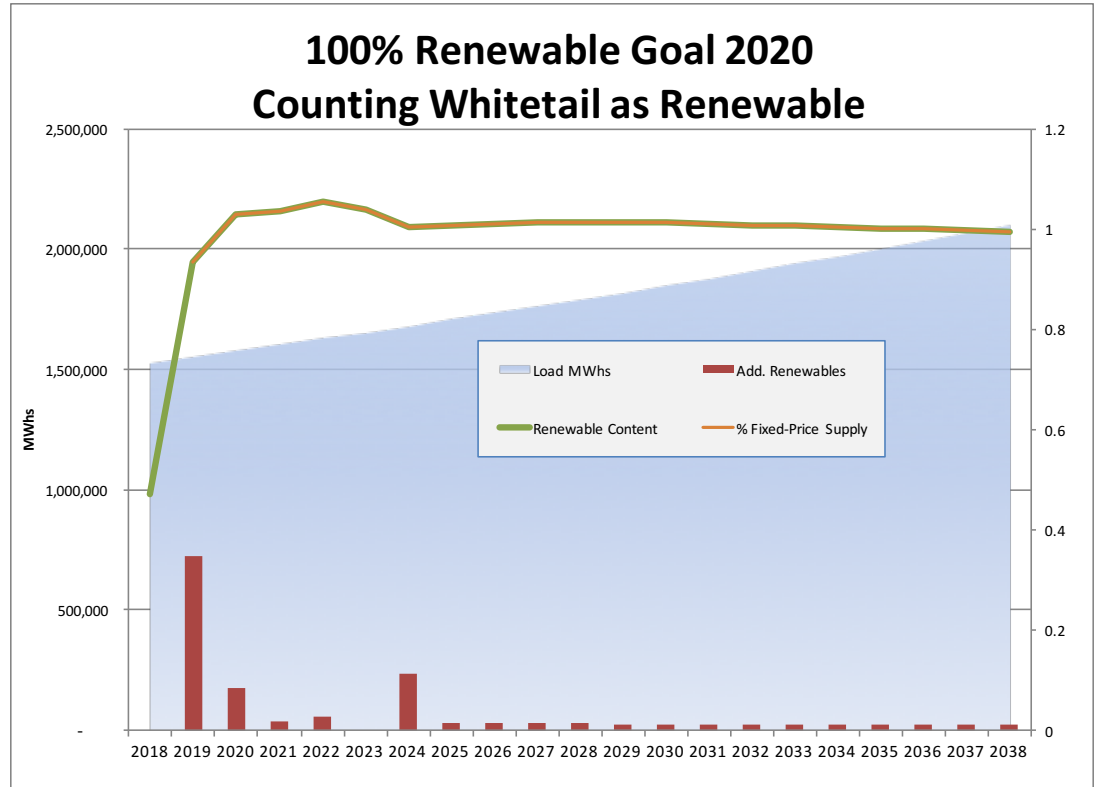
Early Adoption Path



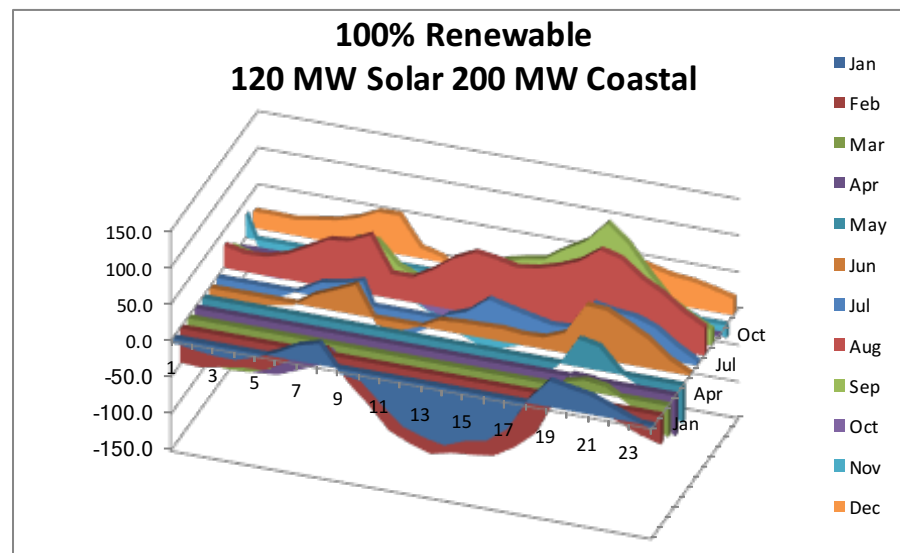
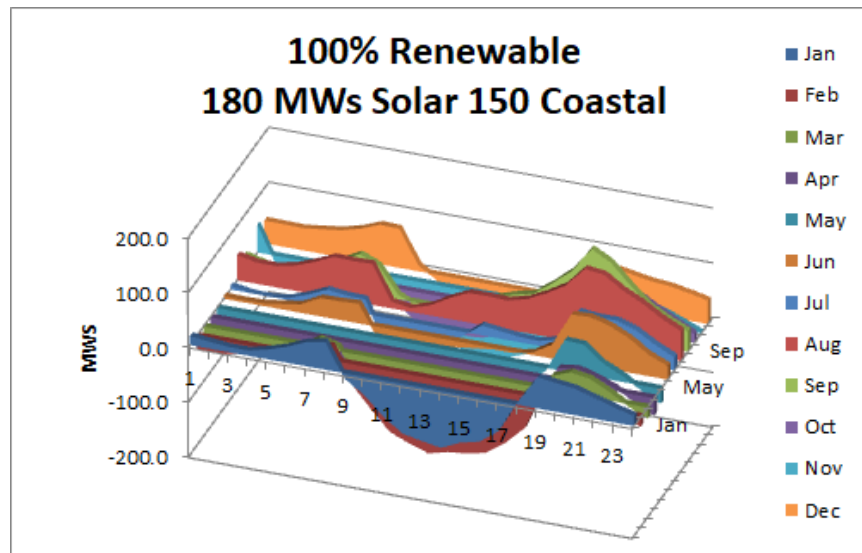
- In light of the PTC reduction, Denton may choose to accelerate the acquisition of wind PPAs to produce the renewable 100% goal by 2020.
- Would result in excess power supply of excess power supply would be approximately 18% for the years 2020 through 2023 (end of Whitetail).
- **This is ERC's recommended path.**

Early Adoption Counting Whitetail

- Including Whitetail supply as renewable will also accelerate the 100% goal to 2020, requires replacement in 2024.
- Principal advantage is that it doesn't produce additional fixed-price supply of 18%.



Other Considerations



RECOMMENDATIONS & DECISION REQUIREMENTS

Recommendations

- Purchase approximately 30% to 40% of load in 2019 with additional renewable resources. Useful portfolio diversification would be approximately 75 MW to 100 MW of Coastal wind and approximately 90 MW to 120 MW of additional Solar resources to meet or exceed the 70% renewable goal.
- Some amount of North Texas wind could be substituted for Coastal wind because the two resources are close in cost. This would reduce the potential Regulation risk of market changes such as the introduction of Marginal Losses, and would reduce congestion risk and CRR hedging costs.
- **ERC's preference is 200 MW West Texas Solar, 150 Wind (possibly split between locations, depending on cost equivalency).**
- Optimal solar location: close to Midland, east of the more congested western region.
- DME needs to hedge both its load with HB North to LZ North CRRs and its resources with Resource Node to HB North CRRs for the upcoming Santa Rita Wind as well as the Blue Bell Solar farm.

Specific RFP Offers	Renewable Resource	Price at Busbar	Price at North Hub	Profile
Bidder 1	Wind	\$ 12.13	\$ 17.15	West Texas
Bidder 2	Wind	\$ 13.35	\$ 30.00	Panhandle
Bidder 2	Wind	\$ 24.75	\$ 26.45	West Texas
Bidder 2	Wind	\$ 20.20	~\$21.75	Coastal
Bidder 3	Solar	\$ 21.50	\$ 23.00	Panhandle/North
Bidder 1	Solar	\$ 20.99	\$ 24.89	West Texas

Decisions ...

- Count Whitetail as a renewable resource?
- Will Denton choose to delay solar purchases because of a potential federal solar tariff?
- Should Denton accelerate renewable purchases, especially of wind resources?
- Should Denton move forward the date of the 100% renewable goal?