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Renewable Resource Plan for the City of Denton, Texas

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Executive Summary

Introduction & Goals of the Resource Plan

This resource plan incorporates the addition of the Denton Energy Center ("DEC") to Denton's power supply portfolio, and focuses on analysis and recommendations for meeting Denton's targets for completing its power supply portfolio through the acquisition of a diversified set of power purchase agreements from renewable energy resource providers.

The focus of this plan is on the examination of the effects and risks of various locations of renewable resources, of how the various types of renewable resource production profiles blend with existing portfolio supply assets to achieve as much diversification as possible (to reduce cost and supply variability), and of a variety of pricing factors including least-cost resources and manageable transmission congestion exposures.

This resource plan also focuses on the strategic design and tactical daily management requirements to efficiently and economically operate a power supply portfolio comprised of renewable resources. Because of the intermittent nature of energy production from renewable resources, and the much wider geographic footprint of power generation resources than is usual for an electric utility, a daily supply portfolio and risk management process involving production forecasting, supply balancing transactions, and seasonal, monthly and daily congestion (basis) hedging becomes paramount to the successful operation of a power supply portfolio of renewable resources.

Planning Goals

The main goal of the resource plan is to identify and recommend least-cost renewable resources so that Denton can meet its resource goal of 70% to 100% renewable energy.

The goal can be broken down into five objectives: least-cost supplies, uncertainty (risk) reduction, sustainability (environmental and production), competitiveness, and the efficient management of a renewable resource power supply portfolio.

Successfully achieving Denton's renewable resource goals involves several critical strategic planning and tactical operational elements:

1. Location and production profile of the renewable resource(s)
2. Managing the supply portfolio by completing an industry best practice opposition hedge, including:
    - Scheduling of the resource output,
    - Avoiding double purchasing (i.e., "monetizing" the renewable resource by selling it into the market while simultaneously purchasing energy to serve load), and
    - Managing basis (congestion) risk

An important goal and guiding principle for this resource plan is that the design and management of a renewable resource supply portfolio must to take into account the structure and conceptual design of the ERCOT market. This resource plan is based on managing Denton's renewable resource power supply portfolio in concert with the intent and design of the ERCOT market, through the use of industry best practice risk management techniques and ERCOT-specific market instruments.

ERCOT is an "energy-only" market. Load in ERCOT does not need to acquire and meet a capacity requirement to ensure that adequate resources on the grid are available so that the demand for electricity can be met at all times. The ERCOT market design requires that load only needs to acquire adequate energy schedules, and most of the supply risk is then neutralized.

In the ERCOT energy-only market, firming is not an explicit requirement. ERCOT automatically "firms" inadequate supplies to meet all load requirements – the important risk management focus is on managing the "firming" in a least-cost manner, both in terms of energy balancing purchases/sales and managing congestion price risk.

Evaluation Factors

The evaluation factors for this resource plan are grouped around the two of the resource plan objectives: 1) least-cost and 2) reducing uncertainty (risk).

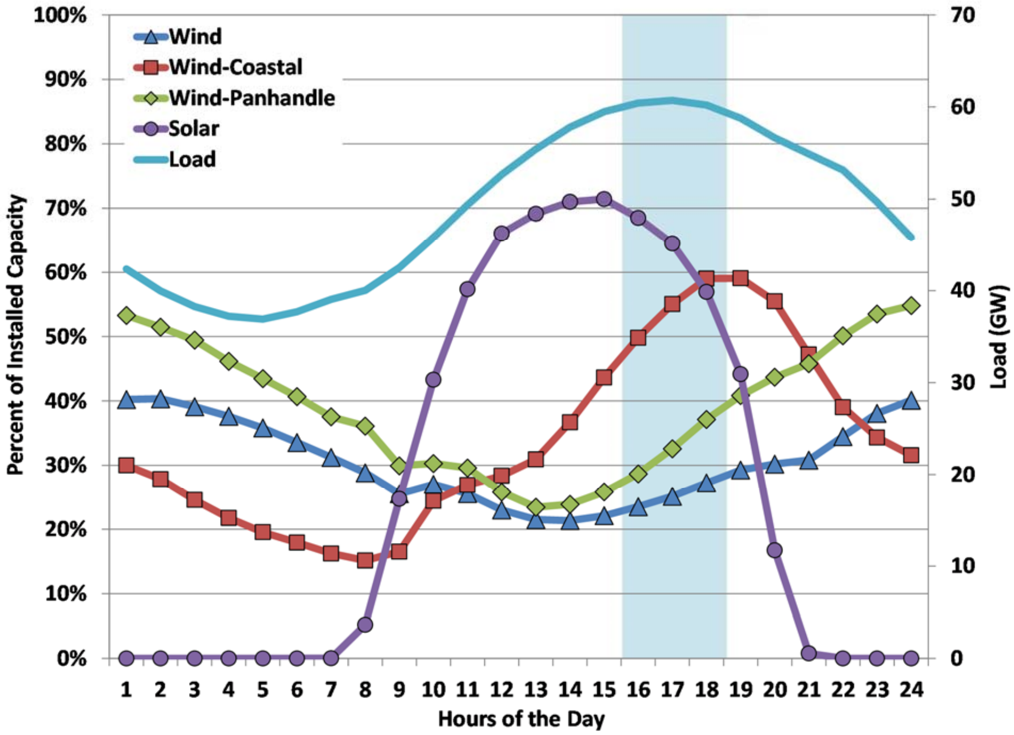
Regarding goal 2) reducing uncertainty (risk), the primary focus from the perspective of evaluation factors for various renewable resources is on best-fit factors for Denton's energy supply portfolio. These best-fit factors include the production profile match relative to Denton's daily and seasonal load profiles, balancing the need for selling excess supply and purchasing shortages, the quality of each resource's production, access to transmission interconnections, and minimizing transmission issues with a particular focus on avoiding or reducing congestion exposure.

The recommendations in this resource plan will range in quantity based on the uncertainty of counting Whitetail as a renewable resource. This leaves Denton needing 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.

<u>Production versus Load Profiles</u>

Figure ES-1 shows ERCOT data with representative production and load profiles for a typical summer day. Represented are production profiles for "Wind", which would be West Texas wind, plus Coastal wind, Panhandle wind, and Solar. These are plotted against a typical summer load profile for a load-serving entity with a substantial amount of residential and commercial customers.

Figure ES-1- ERCOT Summer Renewable Production Profiles (source: 2016 State of the Market Report for the ERCOT Electricity Markets)



Takeaways on daily production profiles:

- West Texas wind offers the worst match against load. The production increases during less valuable, lower priced hours for energy.
- 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 have traditionally commanded a premium in terms of market pricing, but with overall prices for renewable resources falling, the cost premiums versus other renewable resources have compressed, making the assets more compelling:
    - Current low prices are attractive
    - Their production profiles are a better fit for Denton's load, and are a better complement to Denton's existing renewable resources such as Santa Rita (West Texas wind), as opposed to adding more West Texas wind to Denton's supply portfolio, or adding Panhandle wind.

Seasonal variations in both production and load profiles will require active portfolio management to balance Denton's supply portfolio. Daily management will involve forecasting renewable resource production and then transacting in the ERCOT DAM to sell power during hours with excess supply, and purchasing power during hours with a supply shortage. The optimal balance between excess and shortage is one of Denton's decision criteria for determining renewable resource acquisitions.

During a typical summer day, wind output is typically low, while solar output is high (but not necessarily at its highest during a calendar year), and the DEC has a higher likelihood of being dispatched. Assuming a portfolio with a blend of wind and solar renewable resources, seasonally low wind output will 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.

During a typical spring day, wind output is typically at its highest, while solar output is modest, and the DEC is unlikely to be dispatched. Assuming a portfolio with a blend of wind and solar renewable resources, 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.

An important consideration in evaluating renewable resources is to verify and correct production output claims of renewable resource developers. Both solar and wind developers typically include a bias to expected performance. Producers typically over-estimate the efficiency of their installations to attract investors. To adjust for these biases, independent data from the National Renewable Energy Laboratory ("NREL") and ERCOT was used in this resource plan. NREL tools allow verification by specifying what type of PV cell is involved, along with the tilt of the PV cells mounts, including fixed, single or dual axis mounting. These tools can be used to produce hourly production curves for various seasons and at various locations across the state. For wind resources, ERCOT has an extensive database of wind production profiles across the state.

The reduction (correction) to developers' claims for wind resources are on the order of 5% to 8%. The reduction in actual performance of solar production is 15% or more depending on the equipment type and installation design.

<u>Location Considerations</u>

In terms of location preferences for wind and solar locations, the following conclusions were reached.

More consistent output and a higher capacity factor supports the choice of Coastal wind.

Advantages of Coastal wind:

- Uncorrelated with ERCOT System wind, producing higher output during the summer afternoons.
- Lower congestion risk with lower output during the spring and fall when high West Texas Winds increase congestion.
- More reliable for forecasting because it depends on the land, ocean effect.
- Coastal wind resources in the ERCOT South Zone are away from resources built in West Texas, and they are closer to retirements of generation in East and South Texas.

Disadvantages of Coastal wind:

- Coastal wind PPAs usually command a cost premium compared to other wind resources.
- Coastal environmental considerations (e.g. hurricanes, sensitive habitat).
- Subject to build restrictions (e.g., near U.S. Air Bases).
- A great deal of additional load being added in the area.

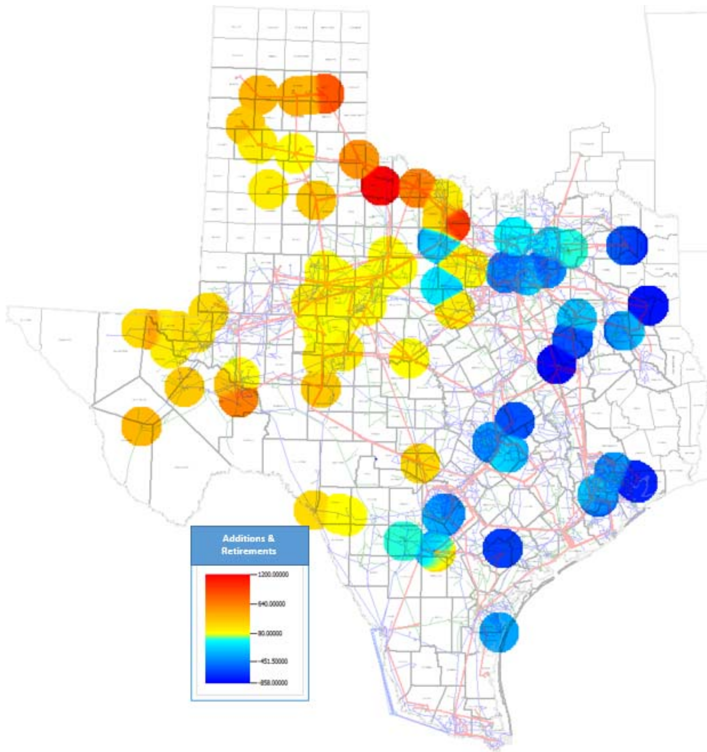
Despite these disadvantages, the advantages of Coastal wind, especially regarding the fit to Denton's supply portfolio, outweigh the disadvantages.

Solar irradiance (the power per unit area received from the Sun) as a function of location is a primary evaluation factor for solar renewable resources. Solar irradiance is impacted by latitude, potential for cloud cover, and temperature factors. An optimal location representing a balance of sufficient irradiance, limited cloud cover, and manageable congestion would be close to Midland.

An additional consideration for evaluating optimal resource locations is the projection of generation additions and retirements in ERCOT. With more renewable resources expected to be developed, and with conventional resources such as coal-fired generation expected to experience increased retirements, congestion issues may be exacerbated.

ERCOT projects an increase in generation in the West and a decrease in generation in the East as can be seen in Figure ES-2. Yellow to orange circles indicate generation additions, while blue circles indicate projected retirements. This will create a decisive West to East flow of production.

Figure ES-2



In considering resource additions, 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. Optimal site selection is more limited for solar however, due to the need to maximize irradiance while minimizing rainfall and cloud cover.

Lastly, another location consideration is the access to transmission. Pricing points cluster at wind resources near big substations and 345 kv interconnects. Ideally, the better locations are in between the pricing clusters and urban areas, east of the clusters in the western region that are dominated by wind resources, and along the coast closer to Corpus Christi than Brownsville.

Congestion Hedging Considerations

Congestion hedging is an important component of completing the opposition hedge, and of carrying out an efficient internal portfolio management operation for renewable resources, as discussed previously. Congestion hedging is like insurance - it is important to insure exposures in a complete manner.

ERC’s extensive experience with CRR management and hedging for several clients indicates that not only is the net cost of congestion hedging acceptable, but CRRs often pay for themselves when exposure risk increases.

The use of CRRs should not be avoided because of possible curtailments or derations. In fact, the principal hedging method in the market to limit curtailment risk is the purchase of a CRR. A CRR will make the owner indifferent to curtailment because it will fix the price between two points.

Regulatory Considerations

The potential for changes in ERCOT is another factor in the resource plan analysis. ERCOT continually changes the way the system operates.

An example is the proposal to change the market design to incorporate marginal line losses. This will add costs to resources that are farther from load zones. A change in the ERCOT market design to incorporate costs associated with marginal line losses would favor Coastal and North Texas wind resources because they would be closer to a load zone. These two wind resources would reduce the potential risk from the adoption of marginal losses, and CRRs would still be available to mitigate the risk to some degree.

Renewable Resource Portfolio Modeling

The following is a list of variables considered in qualitative and quantitative modeling:

- Natural gas prices
- Power prices
- ERCOT Hub North heat rates
- DEC heat rate and estimate of variable O&M
- 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

An important aspect of modeling portfolio costs and developing a portfolio mix that meets the twin resource plan goals of least-cost and uncertainty (risk) reduction is to achieve as much diversification as possible in the supply portfolio. One important measure of diversification is the correlation of various renewable resource production profiles. The goal is to assemble a portfolio with a mix of uncorrelated resources so that the overall portfolio production is more consistent. Combining renewable resources with lower correlations reduces risk and improves overall supply portfolio correlation with Denton's load, and it improves forecast reliability.

An additional diversification factor is the location of resources especially in regard to congestion exposure. Diversifying the supply portfolio reduces overall congestion risk exposure and also contributes to more consistent economic performance.

The portfolio modeling for this resource plan was based on a blend of correlation analysis and scenario valuation. Various mixes of renewable resource quantities, constrained by the results of the correlation analysis, were valued according to the ranges of natural gas and power price projections, along with related DEC dispatch scenarios, with the objectives of finding the least-cost portfolios with the lowest cost variability.

The production profiles of various renewable resource were screened to determine how the profiles performed against historical prices. This involved calculating the balancing costs for each profile to determine the net effective cost of each resource type. Balancing costs are a blend of spot market purchases of market power when renewable production fell short of load requirements, or DEC production when the DEC was a lower priced alternative to DAM purchases, and spot market sales of excess power when renewable production exceeded load requirements.

Reporting & Summary Analysis

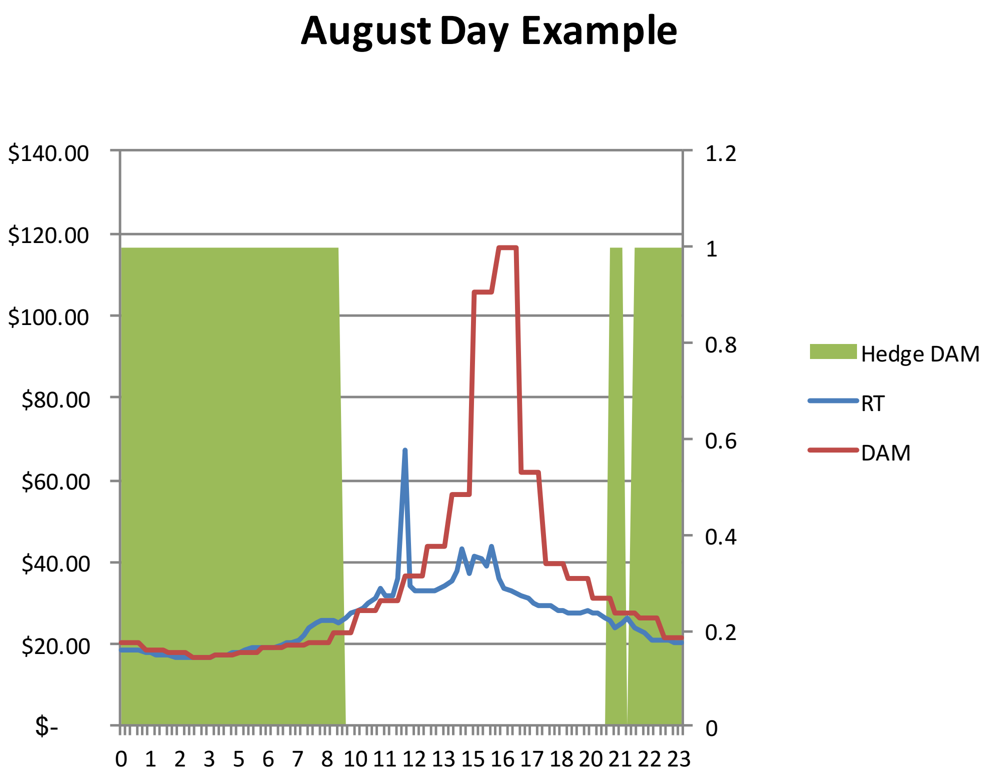
The DEC will play a role in Denton's renewable resource portfolio as a cost hedge during certain super high-priced hours.

As discussed previously, the greatest challenge in managing a power supply portfolio comprised of renewable energy resources is balancing the supply portfolio around the intermittent production of renewable power plants. Balancing the supply portfolio is often referred to as "firming" inadequate supplies. As explained previously, in the ERCOT energy-only market, firming is not an explicit requirement. ERCOT automatically "firms" inadequate supplies to meet all load requirements – the important focus is on managing the "firming" in a least-cost manner, both in terms of energy balancing purchases/sales and managing congestion price risk.

The results of the quantitative modeling employed for this resource plan show that the DEC should not be the sole resource used to "firm" a renewable resource portfolio. Using the DEC as a sole hedge 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.

An example of when the DEC would be dispatched rather than using DAM purchases to hedge a supply shortfall is in Figure ES-3. During a peak demand month such as August, the DEC might be dispatched about half of the time (the periods of time without the green shading). But in this example, even in a month like August, using the DEC as a hedge is likely not to be the least cost and lowest risk alternative for approximately 50% of the time. Figure ES-3 also shows that during DAM purchase hours (the hours shaded in green) the difference between the DAM fully-hedged price and the variable RT price is negligible (average of $0.44). Participating in the RT would be a large disadvantage to Denton because of higher risk but little-to-no benefits.

Figure ES-3



Advantages and Disadvantages of the DEC

Advantages:

- The DEC is a heat rate hedge (note that it is not an energy cost hedge unless the price of natural gas is fixed)
- 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 in ERCOT that may elevate heat rates.

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.

Additional Alternatives for Extracting Value from the DEC

- Based on the last bullet point under disadvantages, Denton should be prepared to sell DEC output forward when or if there is a spike in natural gas prices. Natural gas prices tend to revert to the long-term mean after price spikes, so that increased value due to a price spike may be transitory and should be taken advantage of.
- The DEC can be used to sell firming services to other organizations looking to add renewable resources. This can mean that the DEC is not used as a producing generator, but as a contingent financial hedge (i.e., the actual dispatch and fuel use may be unchanged but the revenue from the resource will be increased). This is because at the time Denton might be obligated to provide firming energy, market purchases are more likely than the DEC to be the least cost alternative.
- As previously discussed, because of the mismatch in seasonal production profiles of renewable resources versus Denton's load profile, there are likely to be periods of time when Denton will have excess supplies (e.g., in the Spring). It may be beneficial to sell excess renewable power during these periods using the DEC to firm the transaction.

Takeaway: The DEC will serve a role as a supply cost hedge to firm Denton's renewable resource portfolio, but based on the financial evaluation in this resource plan, the majority of firming the supply portfolio will be more economically efficient through purchases in the DAM. Denton should look for opportunities to sell a portion of the DEC forward during natural gas or heat rate spikes, and for opportunities to sell firming services or to firm sales of excess renewable supplies.

Benefits of the Denton Renewable Portfolio ("DRP")

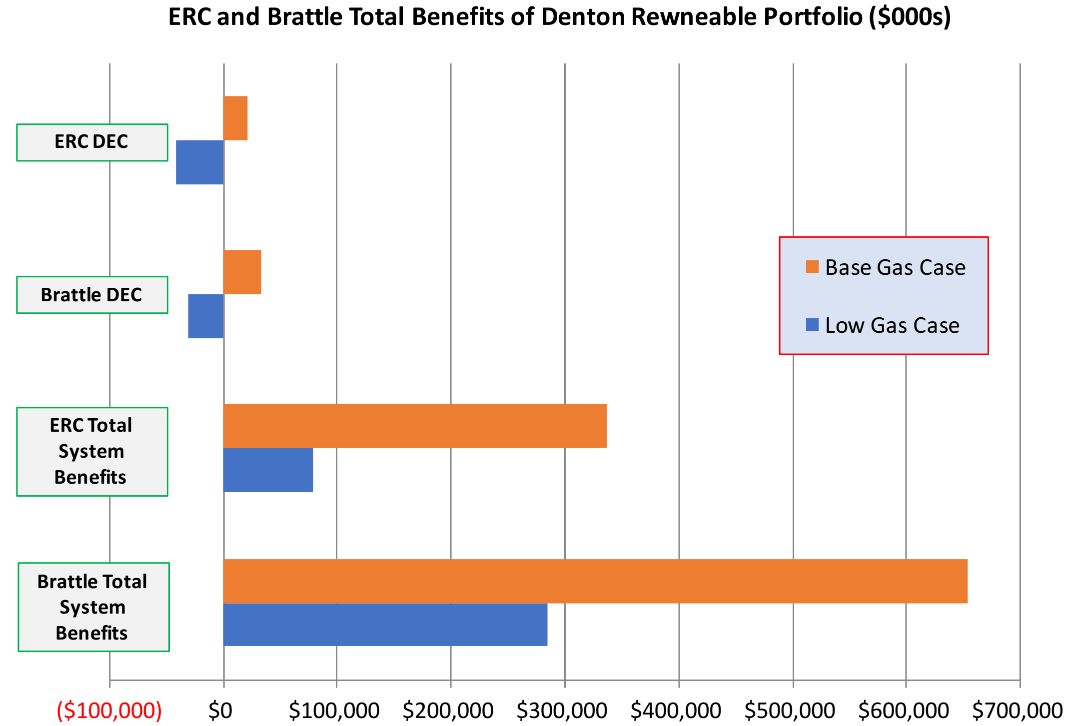
Figure ES-4 shows the projected financial benefits of the DRP based on the range of price projections used in the analysis for this resource plan. This is based on a portfolio where the 70% goal reached and maintained until 2023, and then additional Wind and Solar are purchased to reach 100%. Every year enough renewables are purchased to keep up with load growth.

The chart projects the financial performance of Denton's supply portfolio based on a range of future prices. Positive benefits would result through avoided additional costs if prices rise in the future. Negative values would result from low price outcomes.

The main takeaway is that the Total System Benefits are completely dependent on the price of natural gas. If gas prices rise, power prices will rise as a result, and over time Denton's fixed-price renewable resource supply portfolio would result in avoided costs from the higher power prices. That is the measure for benefits for both Brattle and ERC evaluations. But if gas prices do not rise, power prices will stay around the current prices and as a result, Denton's fixed-price renewable resources will not avoid higher market prices and fewer benefits would result.

This is the biggest uncertainty in the entire evaluation. This difference between high natural gas prices and lower natural gas prices is a change in total benefits of approximately $575 million in 2018 dollars.

Figure ES-4



<u>Considerations for Selecting Renewable Resources</u>

The analysis and evaluation for this resource plan assumes that Gibbon's Creek will be decommissioned by 2018.

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 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.

There is a series of known risks that could drive Denton to accelerate reaching the 100% goal, or decelerate reaching the 100% goal past 2024. A particular risk in the acquisition plan is that there is a possibility of a federal solar tariff. It is not clear how the tariff will affect prices or the term of the additional costs, but preliminary estimates are that it could increase average costs of solar from the current $25/MWh up to $40/MWh. Under the current price environment $40/MWh is not competitive with wind resources.

Alternatives to avoiding the solar tariff:

- Acquire more Coastal wind resources that feature the characteristic summer peak production profile. This is the closest substitute for solar among the renewable resources.
- Utility-scale wind resources with a storage component, now or in the future. Altering the profile of West Texas wind into a more on-peak production profile will improve hedge effectiveness.
- Purchase solar as the tariff prices and supplies readjust to market conditions or the tariff is no longer an issue. Denton can wait and test the market prices after reaching the 70% level. Waiting on solar would decelerate reaching the 100% goal.

Potential purchase accelerators:

- Announced coal retirements totaling 4.2 GW of generation capacity from Vistra Energy (Monticello, Sandow, and Big Brown) may increase power prices during the next few months. This is likely to have much less impact on the price of wind versus the price of solar. This could accelerate the amount of wind purchased by Denton, especially Coastal wind as a substitute for solar.
- PTC reduction lowers the subsidy to wind producers. The supply of wind may be at its maximum now because of the rush to beat the expiration date of the PTC. Because the supply of available PPAs is highest now, this could be an inducement to accelerate the acquisition of wind in a buyer’s market.
- The potential for rising natural gas prices. The low number of drilling rigs, increasing demand for exports, and the large substitution of the natural gas for coal in the electric power sector could drive price increases. In the past, when steady increases in demand for natural gas have met with a lower number of drilling rigs over a several-year period, natural gas prices have increased dramatically (e.g., the early 2000s saw prices double and then triple over a few-year period).

The Path to 100% Renewable Resources

The evaluation in this resource plan indicates that Denton's 100% renewable goal ("RE 100") is achievable much earlier than 2035. There is no financial penalty or premium to moving from a 70% renewable resource goal ("RE 70") to a 100% renewable goal.

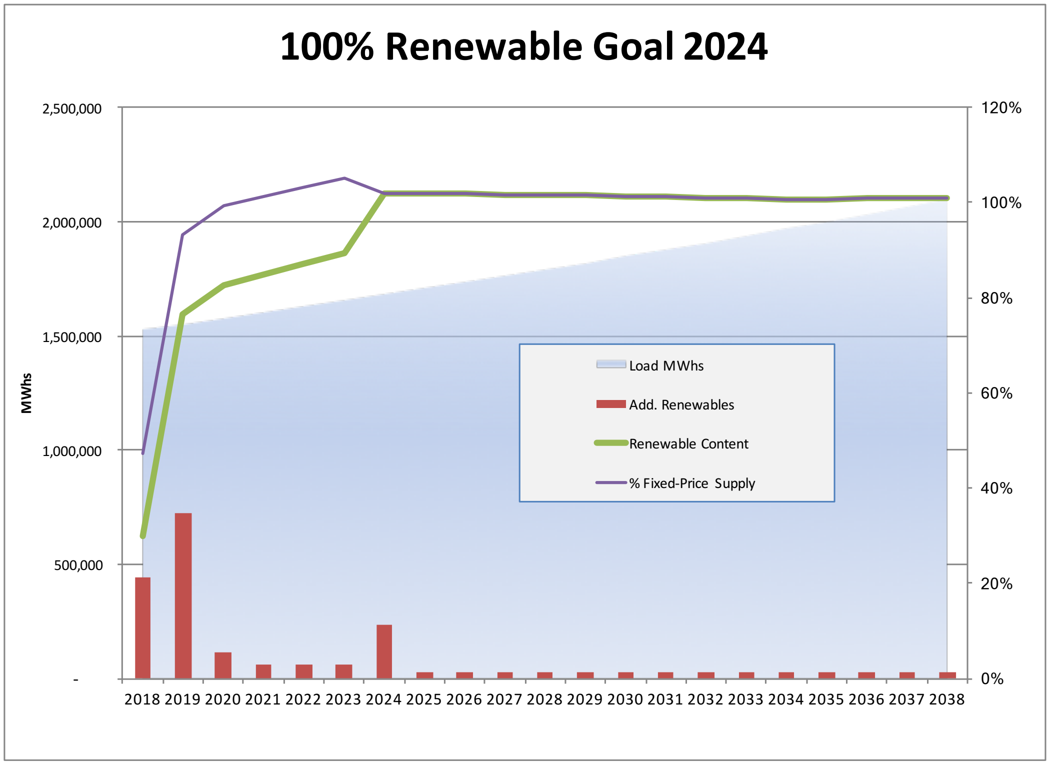
Gradual Adoption Path

Denton has several paths to choose from to reach its RE 100 goal. But the first Denton Renewable Portfolio (DRP) goal is RE 70 by the end of 2019.

The RE 70 level can be achieved by executing PPAs for low-priced supplies that have been offered in the current Renewable RFP (Oct 4, 2017). Figure ES-5 shows a possible outcome to achieve this 70% goal, and eventually the 100% goal by 2024. The chart includes Denton's load, seen as a gradual increase in the light blue shaded area, additional renewable purchases labeled "Add. Renewable" and depicted by the red vertical bars, and lines showing the progression of the proportion of renewable resources and of the amount of supply with fixed prices.

In the chart, the NextERA Whitetail supply is not counted as a renewable source because it is not a physical renewable source, but uses Renewable Energy Credits (RECs) to claim renewable status. An alternative scenario is included later in this discussion that counts the NextERA Whitetail supply as a renewable energy supply. In either case, additional physical renewable supplies are required. Depending on the location, price, congestion environment, and the production profile of the resource, more supply may be added above the additional 47% of load in energy purchases that are needed to achieve the RE 70% goal by 2019.

Figure ES-5



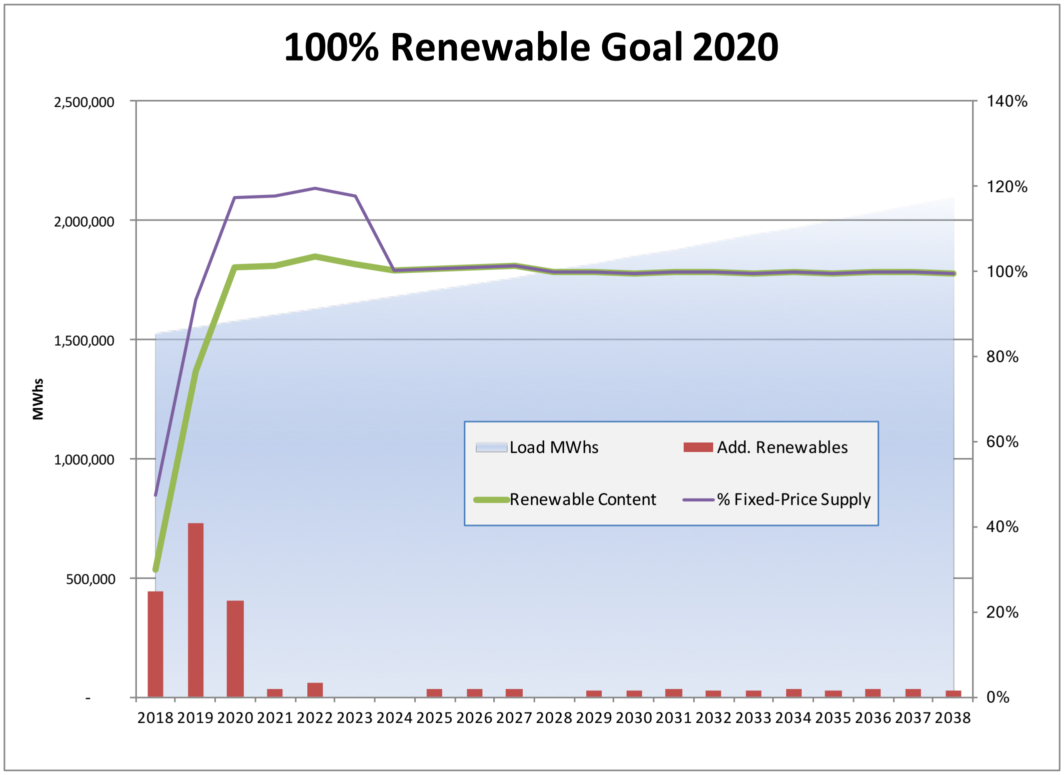
Why possibly purchase more than the 47% needed to meet the RE 70 goal? The amount of additional supply is a function of the uncertainty of renewable production. The amount of wind production can easily vary by 15% on an annual basis. If Denton wants to make sure that it has at least 70% ***at a minimum in every year***, it may need to buy additional supplies above the goal, taking into account the annual production variability.

Another part of the acquisition path depicted in Figure ES-6 is the assumption that Denton will purchase shorter term (1 to 4-year duration) renewable resources to adjust the RE goal to reach 100% and to constantly maintain that level. Constantly maintaining a target level can be done with a variety of renewable resources and demand-side management programs. Besides the new acquisitions that are needed by next year to reach the RE 70 goal, another larger supply is the replacement of the Whitetail NextERA supply in 2024 because the contract ends in December of 2023.

Early Adoption Path

A second path for achieving the RE 100 goal is earlier adoption. Denton would accelerate the wind PPAs acquisition to produce the RE 100% goal four years earlier, in 2020 rather than in 2024, as shown in Figure ES-6.

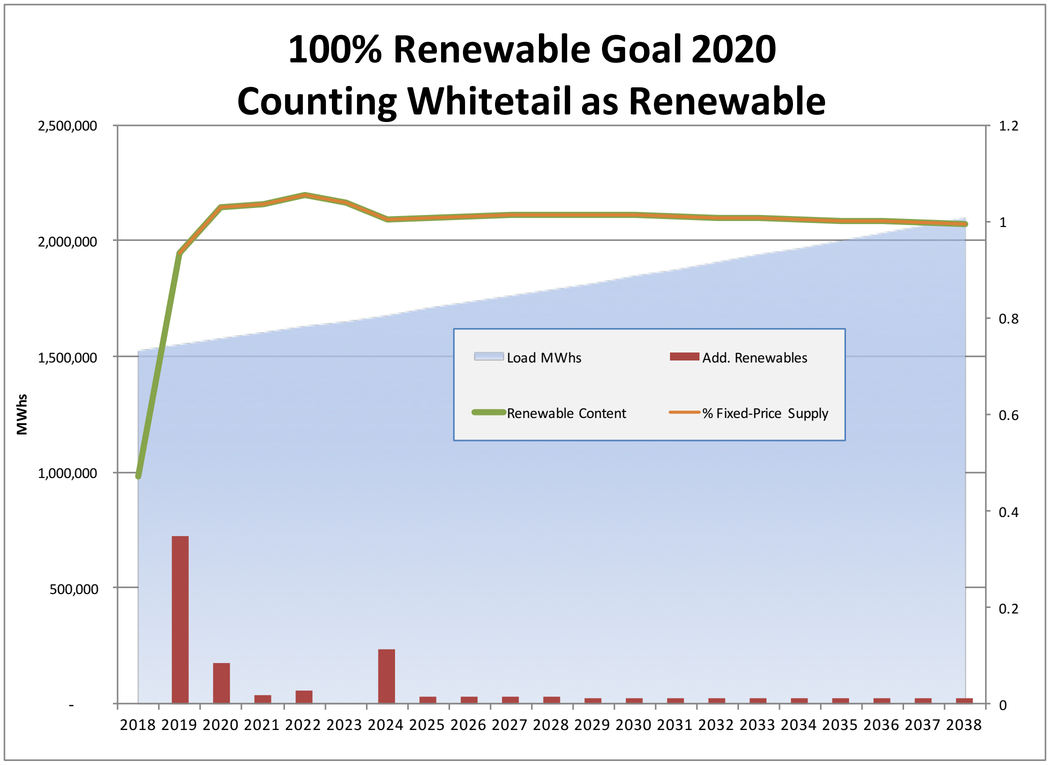
Figure ES-6



This accelerated wind acquisition would result in excess power supply over the next few years due to the Whitetail non-renewable resource, and Denton would have to manage fixed-cost risk (the risk of market prices falling because Denton would have more supply than its load for 4 years). If the Early Adoption path is selected, the excess power supply would be approximately 18% for the years 2020 through 2023. The excess supply would end with the Whitetail contract expiration.

Including the NextERA Whitetail supply in the renewable category will also accelerate the RE 100 goal to 2020. But it also requires replacement of this energy in 2024. This is depicted in Figure ES-7. The principal advantage of this scenario is that it doesn't produce additional fixed-price supply (the 18% excess supply discussed previously). The principal disadvantage with including Whitetail in the supply portfolio is that it could cause an audit risk as to the validity of its renewable status.

Figure ES-7



Summary of Recommendations

Several different portfolio combinations will allow Denton to achieve its renewable targets.

To reach its goals, Denton should purchase approximately 30% to 40% of load in 2019 with additional renewable resources. The evaluation conducted for this resource plan indicates that the least-cost combination that provides 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% RE goal. Final selection of the ratio will depend on actual proposals and terms and conditions from the RFP offers. Given specific proposals, variations to this "ideal" diversification may result in other least-cost portfolio makeups.

An optimal location representing a balance of sufficient irradiance, limited cloud cover, and manageable congestion for would be close to Midland.

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.

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. This may already be in the works, but the data shows inadequate hedge levels in early 2018 for Denton's load and no CRRs related to these renewable resource purchases.

<u>Decision Summary</u>

In addition to the recommended amounts, types and locations of renewable resources, Denton will need to make several decisions that will shape the development of its renewable resource supply portfolio.

- Count Whitetail as a renewable resource?
    - If not, is Denton willing to handle the additional fixed-price risk of the Whitetail supply in addition to the fixed-price quantity of renewable resources necessary to meet Denton's goal(s)?
- Will Denton choose to delay solar purchases because of a potential federal solar tariff?
    - If so, potential alternatives include:
        - Purchase additional amounts of Coastal wind as a substitute?
        - Alter the profile of wind resources with storage?
        - Delay solar purchases until the issue is resolved, or solar prices and supplies adjust to the tariff
- Should Denton accelerate renewable purchases, especially of wind resources, because of:
    - increasing retirements of conventional fossil fuel generation capacity?
    - scheduled reduction in the PTC?
    - risk of rising natural gas prices?
- Should Denton move forward the date of the 100% renewable goal?
- Should Denton purchase additional renewable supplies above its target levels because of the annual variance in production amounts?
- Portfolio allocation decisions – there are various allocations between Coastal wind and Solar to meet Denton's goals (e.g., 180 MW of Solar and 150 MW of Coastal to meet a 100% goal, or 120 MW of Solar and 200 MW of Coastal). What is the preferred allocation?

1.0 Introduction

The City of Denton, Texas ("Denton") engaged Enterprise Risk Consulting, LLC ("ERC") to provide strategic support by assisting with resource planning, and the design and implementation of a revised long-term power supply portfolio and portfolio management strategy.

This resource plan incorporates the addition of the Denton Energy Center ("DEC") to Denton's power supply portfolio, and focuses on analysis and recommendations for meeting Denton's targets for completing its power supply portfolio through the acquisition of a diversified set of power purchase agreements from renewable energy resource providers.

This document is similar to a typical resource plan, except that the goal of the plan – Denton's goal of developing a 70% to 100% renewable resource supply portfolio -- has already been established. Instead of a typical resource plan's focus on evaluating resource and fuel types, and various types of contracts, the focus of this plan is on the examination of the effects and risks of various locations of renewable resources, of how the various types of renewable resource production profiles blend with existing portfolio supply assets to achieve as much diversification as possible (to reduce cost and supply variability), and of a variety of pricing factors including least-cost resources and manageable transmission congestion exposures.

Another important factor that makes this plan unique is the focus on the short time window to make decisions. ERCOT is an evolving market, and the rapid development and integration of renewable resources creates a new world of power supply and transmission challenges. The development of renewable resources, and their rapidly falling costs, have been driven to a large extent by the federal producer tax credit ("PTC") and the investor tax credit ("ITC"). These tax advantages are being phased out, and this shortens the time window for securing resources at current prices. And recent developments with the accelerating retirement of coal and natural gas-fired generation adds another element that may affect the current low prices on renewables. For other types of beneficial renewable resources, such as demand-side management (Demand Response) programs and assets, a much longer timeframe can be used for planning and decision-making.

This resource plan also focuses on the strategic design and tactical daily management requirements to efficiently and economically operate a power supply portfolio comprised of renewable resources. Because of the intermittent nature of energy production from renewable resources, and the much wider geographic footprint of power generation resources than is usual for an electric utility, a daily supply portfolio and risk management process involving production forecasting, supply balancing transactions, and seasonal, monthly and daily congestion (basis) hedging becomes paramount to the successful operation of a power supply portfolio of renewable resources.

2.0 Goals of the Resource Plan

The main goal of the resource plan is to identify and recommend least-cost renewable resources so that Denton can meet its resource goal of 70% to 100% renewable energy.

The goal can be broken down into five objectives: least-cost supplies, uncertainty (risk) reduction, sustainability, competitiveness, and the efficient management of a renewable resource power supply portfolio.

2.1 Plan Objectives

Least-Cost Supplies – The goal is to acquire a long-term fixed price power supply that is lower than any other market alternative.

Uncertainty (Risk) Reduction involves reducing future uncertainty and exposure to adverse supply cost outcomes. Risks and mitigation factors include:

- Effectively matching load with supply reduces risk
- Diversifying supply resources
- Reducing regulatory risk (including the potentially adverse effects of structural changes to the ERCOT market)
- Technological risk, and
- Economic risk
    - Energy price and congestion price risks
    - Transaction costs and execution risk
    - Supply portfolio management operational risks

Additional renewable resource purchases will reduce the long-term cost volatility of Denton's energy supply.

Diversifying supply sources by incorporating renewable resource technologies with different production profiles reduces supply volumetric uncertainty across multiple timeframes (e.g., reducing volumetric variability by avoiding multiple wind resources with positively correlated production profiles). Securing low fixed-costs for a substantial amount of supply resources, while leaving open a portion of the supply portfolio to remain competitive, requires a delicate balance.

Sustainability - the objective of sustainability covers several areas. It includes environmental sustainability as well as the production sustainability of a generation resource. Stable economics and minimal operations and maintenance ("O&M") costs contribute to sustainability. Renewable resources offer superior sustainability because they don't degrade over time and they require less maintenance, they require less regulatory and legal permitting review, and they avoid potential carbon costs. Fossil fuel resources involve fuel adjustments over time because of substantial fuel cost variability and the depletion of resources. Fossil fuel resource technologies require more overhauling and maintenance compared to renewable resources. Renewable resources use minimal water and emit no particulates, and other polluting gases, compared to fossil fuels.

2.2 Customer Preference & the Competitive Market

A typical integrated resource plan includes identifying customer preferences and describing the competitive market in which the utility operates. As mentioned previously, this resource plan is unique because the customer preference for a power supply portfolio comprised of renewable energy resources has already been selected.

With regard to competition, Denton doesn't have direct competition per se because it is a Non Opt-In Entity ("NOIE"). Yet NOIEs need to stay competitive to the degree that they can avoid pressure to open up to competition. Denton still needs to be sensitive to competitive pressures, as the city is surrounded by competitive areas, and new ratepayers moving in to the city will expect similar rates.

2.3 Efficient Management of a Renewable Resource Power Supply Portfolio

2.3.1 The Treatment and Management of Renewable Resources as an Energy Supply Hedge

Unfortunately, the track record of many public power entities in ERCOT regarding the efficient management of renewable energy resources is poor. Many municipal utilities and electric cooperatives have not done a good job with their power supply portfolio management in terms of implementing renewables to offset load requirements.

The primary challenge is due to the intermittent nature of renewable resources. They are not "dispatchable" in the sense of the traditional utility generation commitment and dispatch process. Because they consider renewable resources as non-dispatchable, many of these entities simply sell the output into the local market (local resource node pricing) rather than manage around the intermittent production. This is termed "monetizing' the asset. But then they purchase energy at a Hub or at a load zone to meet their load requirements.

This approach results in a double purchase because the energy has been purchased in the first place via a power purchase agreement ("PPA"), which offsets future load requirements, and then the renewable energy is sold in the market while market energy is simultaneously purchased to serve load. This results in a less efficient three-step process (energy purchase, then energy sale, then energy purchase) where inefficiencies and additional costs at each step can add up to higher supply costs.

And this leaves the entities exposed to the substantial price risk of the uncertain locational price differences between the Resource Node and the entity's Load Zone. Double purchasing is almost always very costly and unnecessary.

This is effectively treating the renewable resource as if it were a perfect financial hedge for an energy consumer (offsetting the cash flow from floating price spot market purchases with the cash flow from a fixed-price purchase made in advance), yet via a PPA the resource is effectively a fixed-price physically-delivered forward purchase. It is more efficient to use the physical delivery characteristics from the PPA as an offset to load requirements. This results in a more efficient two-step process involving just the initial purchase from a PPA and then a second balancing transaction (purchase of shortage or sale of excess).

An additional element to the successful management of a renewable resource power supply portfolio is to complete the opposition hedge by financially tying resources to load via

Congestion Revenue Rights ("CRRs"). The pricing at the resource node for the physical production from a PPA and pricing at the load are tied together through forecasts and schedules matched with a CRR (an economic locational basis transaction). By using CRRs, the two-step process is governed by the same type of basis transaction that is required in any resource to load transaction in ERCOT.

Successfully achieving Denton's renewable resource goals involves several critical strategic planning and tactical operational elements:

3. Location and production profile of the renewable resource(s)
4. Managing the supply portfolio by completing an industry best practice opposition hedge, including:
    - Scheduling of the resource output,
    - Avoiding double purchasing (i.e., "monetizing" the renewable resource by selling it into the market while simultaneously purchasing energy to serve load), and
    - Managing basis (congestion) risk

Item 1 will be addressed as a result of the resource recommendations of this resource plan.

Item 2 involves the design of a daily supply balancing strategy, and the daily operational guidelines and processes for supply portfolio management.

The key to efficiently managing a renewable resource power supply portfolio is understanding (forecasting) when an intermittent asset is likely to produce, and counting that production as supply to offset load, and then purchasing energy from the market only during those hours when the intermittent resource is not likely to produce (and selling excess energy during those hours where resource production is likely to exceed load requirements).

The technical definition of an opposition hedge is the establishment of one or more positions to reduce financial uncertainty or risk from a floating price exposure (more detail on this concept can be found in Appendix A – Hedging 101). In Denton's context, this involves the following elements:

1. <u>Denton's uncertain or "floating" supply price exposure</u> - this results from its native obligation to serve energy to its ratepayers. Unless it purchases fixed-price supplies of energy in advance, Denton would be obligated to purchase energy in the ERCOT Day Ahead ("DAM") or Real Time ("RT") markets at a variable cost to meet its obligation to serve energy to its ratepayers.
2. <u>"Hedging" Denton's floating price exposure with a fixed-price purchase</u> – this is accomplished by purchasing electric energy to be delivered in the future at a fixed-cost today through PPAs. This is a primary focus of this resource plan. A fixed-price hedge established a known cost in advance avoids exposure to floating prices.
3. <u>Hedging Denton's locational price exposure with CRRs</u> - to complete and perfect the opposition hedge, additional transactions are necessary to translate or tie the pricing of

Denton's PPAs at ERCOT resource nodes to the pricing of Denton's load at its Load Zone. This is accomplished through the use of ERCOT CRRs. As will be addressed in multiple sections of this document, a power supply portfolio comprised of multiple and diverse renewable resources results in a variety of delivery locations across Texas. CRRs will be necessary to tie the pricing at various delivery locations to the pricing of energy in Denton's Load Zone.

To summarize, a typical opposition hedge for Denton would include the following components:

1. A floating price exposure for Denton's load at its Load Zone (this is Denton's native energy market exposure),
2. A fixed-price hedge(s) in the form of a PPA delivered to a Resource Node(s), and
3. A CRR hedge(s) to fix the price differential between a Resource Node and Denton's Load Zone.

Of course, renewable resource power supply providers may offer PPAs that are priced at locations closer to Denton, such as at a Hub or Denton's Load Zone. This could obviate or reduce the need for CRRs to close the locational price gap. But this also introduces additional supplier credit risk (contract replacement risk) into the evaluation equation. The greater credit risk comes from how the supplier will provide a delivered price to a Hub or Load Zone. The supplier is going to assume congestion risk, and if not managed properly, could jeopardize its long-term financial viability.

Comparing the costs of renewable energy delivered to Denton's Load Zone or a nearby Hub to the cost of energy delivered to a Resource Node is one of the primary cost evaluation factors of this resource plan.

2.3.2 Managing a Renewable Resource Supply Portfolio in the ERCOT Market

An important goal and guiding principle for this resource plan is that the design and management of a renewable resource supply portfolio must to take into account the structure and conceptual design of the ERCOT market.

ERCOT is an "energy-only" market. Load in ERCOT does not need to acquire and meet a capacity requirement to ensure that adequate resources on the grid are available so that the demand for electricity can be met at all times. The ERCOT market design requires that load only needs to acquire adequate energy schedules, and most of the supply risk is then neutralized.

In the ERCOT energy-only market, firming is not an explicit requirement. ERCOT automatically "firms" inadequate supplies to meet all load requirements – the important risk management focus is on managing the "firming" in a least-cost manner, both in terms of energy balancing purchases/sales and managing congestion price risk.

In a bilateral market, utilities build and operate a generation portfolio and transmission grid to produce and deliver power to loads in their service territories. In this type of market structure, it makes sense to have a specific generating plant, as part of a diversified generation portfolio, to meet variable demand requirements. If generation resources are intermittent, a power plant that can be dispatched quickly to fill in the gaps in intermittent production is known as a "firming" plant.

But in a power pool like ERCOT, specific power plants do not discretely serve local load. Rather, generation resources are "pooled" to balance load requirements over a larger grid. The pooling of generations assets results in several benefits, including reduced costs through more efficient marginal dispatch of generation units, savings in reserve capacity requirements, more reliable operation, and minimizing the adverse impacts of maintenance.

Thus, the intent of the ERCOT market design is that "firming" is accomplished using the entire pool of generation assets, not by one or more specific plants in a local service territory. This leads to a primary objective for Denton in the design of a power supply portfolio management strategy where firming of renewable resources is managed in a least-cost manner through forward and spot market purchases and CRR hedges.

The ERCOT market is designed so that generation is offered to the market and load requirements are scheduled on a day-ahead basis. The market is intended for load and generation to primarily participate in the DAM. Given the limitations and inherent error of demand forecasting, and given a variety of other factors that can affect transmission capacity and the availability of generation, ERCOT operates a RT market where it dispatches generation resources based on economics and reliability requirements to meet system demand affected by resource and transmission constraints. The RT market is intended as a balancing market, to adjust for demand, generation and transmission uncertainties that cannot be completely factored-in to the DAM.

Some load-serving entities in ERCOT rely on the RT as their primary source of energy supply because prices are lower **on average** compared to the DAM. Producers often use this approach because it requires less collateral than the DAM and they are typically credit-challenged counterparties. On average, the DAM trades at a premium to the RT because it reduces risk (i.e., revenue or cost uncertainty) and this risk reduction benefit commands a premium. However, relying on the RT as a primary source of supply is antithetical to the intent and design of the ERCOT market. ERCOT is designed for all generation and load to clear in the DAM, with the RT being used to address imbalances.

In summary, the ERCOT market is designed for load-serving utilities without sufficient generation assets to:

- purchase power in advance through PPAs
- schedule the delivery of the purchased power into the DAM
- purchase any short-term shortages / sell any short-term excess power in the DAM

- use CRRs to hedge
  - Resource Node to Hub locational price differentials
  - Hub to Load Zone locational price differentials
  - DAM to RT price differentials

This resource plan is based on managing Denton's renewable resource power supply portfolio in concert with the intent and design of the ERCOT market, through the use of industry best practice risk management techniques and ERCOT-specific market instruments.

3.0 Information Gathering

This resource plan is based on an evaluation using a variety of types of data from multiple sources. Where useful, specific examples of data and information are presented, along with important takeaways.

Note – figure numbers in this document are based on the presentation order and may conflict with an embedded figure number from the source document.

Information and data for this resource plan was gathered from a variety of sources, including but not limited to Denton, ERCOT, the Texas Public Utility Commission, the U.S. Energy Information Administration, the Chicago Mercantile Exchange and other industry sources. Examples of key data are presented in order within separate sections based on the source.

<u>Denton:</u>

- Load
- Resources (capacity, production, contract start and end dates):
  - Whitetail
  - BlueBell
  - Santa Rita
  - Landfill
- DEC performance data (heat rate and variable operating costs)

<u>Various Sources:</u>

- The U.S. Energy Information Agency (historical spot natural gas prices and natural gas production and consumption data)
- "Least-Cost Electric Utility Planning" Stoll, Harry G. 1989, Wiley-Interscience, ISBN-13: 978-0471636144, ISBN-10: 0471636142
- The Texas Public Utility Commission: various workshops and Rule Makings
- Texas Renewables website (ERCOT) Senate Bill 7 and Subsection (a) of Substantive Rule 25.173, Goal for Renewable Energy

ERCOT:

- DAM, RT prices, and CRR market data from recent years
- historical heat rates
- market dispatch modeling
- resource adequacy studies

ERCOT information was sourced from:

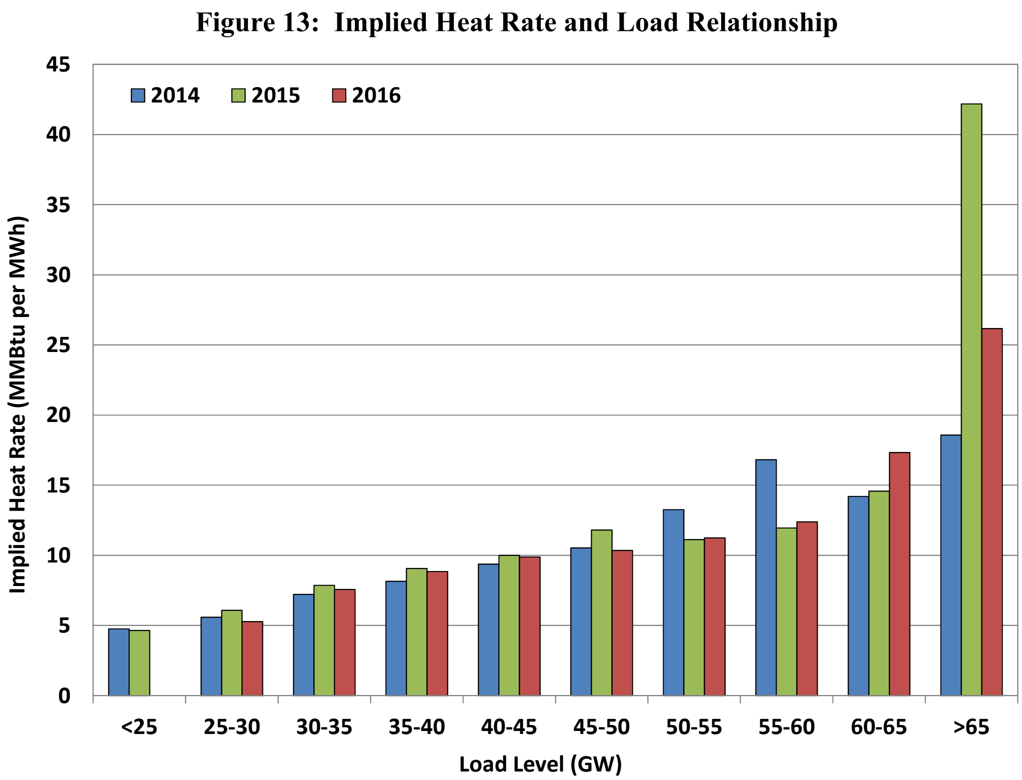
- ERCOT website (ercot.com)
- 2016 ERCOT State of the Market Report
- 2016 Long Term System Assessment for the ERCOT Region
- ERCOT August 2017 Board of Directors Item 4.2.5: Grid Impacts of Natural Gas Price

Heat Rates

Figure 3-1 shows the implied heat rate and load relationship in ERCOT over the last three years.

Takeaway: the curve for the heat rate is almost the same curve that fits very easily over multiple years. Heat rates are generally stationary. The progressive shape of the curve and the relative heat rates don't change too much, because the units that are dispatched operate the same way year after year. Extraordinary and lower probability events, such as hot weather or transmission outages, such as in 2015, are necessary to get outside of the typical heat rate curve. The heat rate of the DEC does not offer a competitive advantage in ERCOT and will require lower probability and lower frequency events to warrant dispatch.

Figure 3-1



ERCOT Dispatch Curves

Figures 3-2 and 3-3 show the ERCOT resource price stack at $4.50 per MMBtu and $2.50 per MMBtu respectively. With an effective heat rate of approximately 10 MMBtu/MWh, the DEC's dispatch cost would be about $45/MWh on the graph in Figure 2, and about $25/MWh on the graph in Figure 3-3. The DEC dispatches later in the dispatch queue when gas prices are higher. This is because there is an inverse relationship between natural gas and heat rates. The higher the gas price, the lower the heat rate.

Figure 3-2

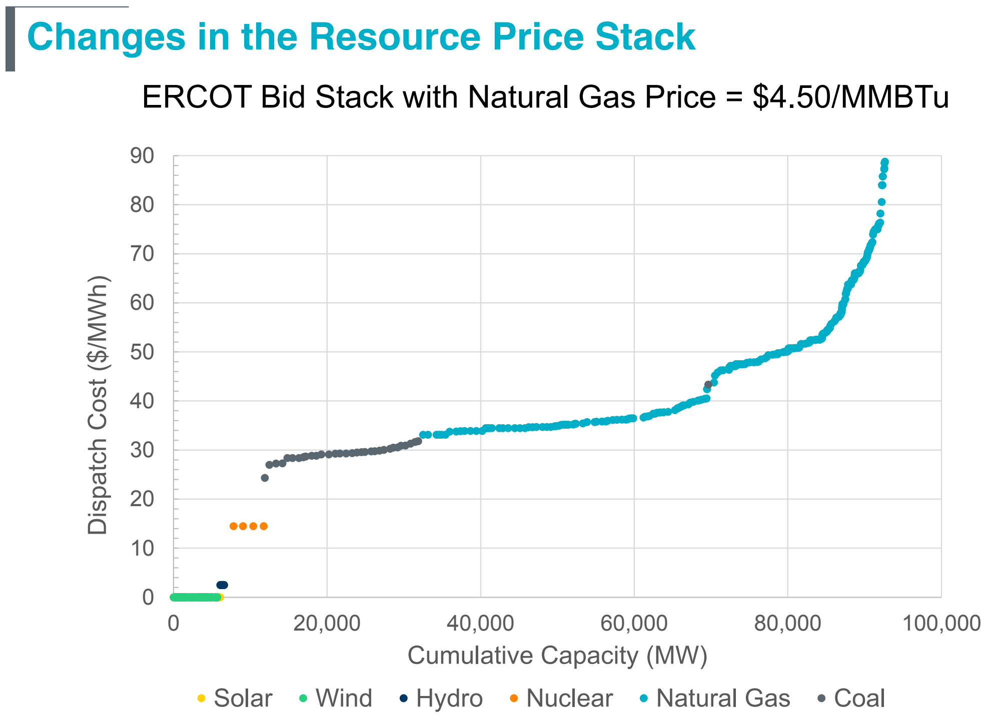
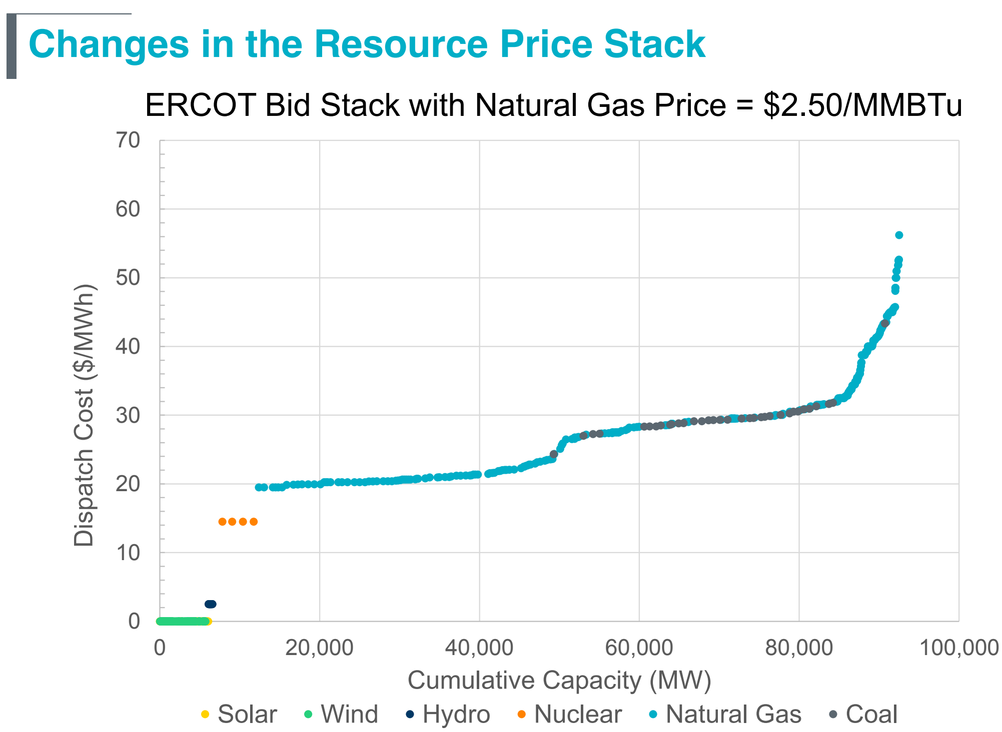


Figure 3-3

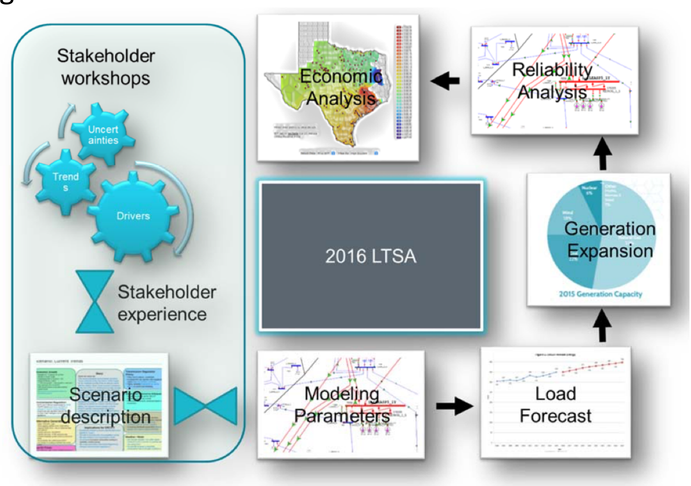


Takeaway: if gas prices are $4.50, then coal-fired generation is dispatched first, before natural gas-fired units. The DEC would be in a position to earn a high margin, but the number of hours to earn that high margin is small. If gas prices are $2.50, then coal-fired generation is hardly ever dispatched. 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.

<u>ERCOT Expectations</u>

Figure 3-44 comes from ERCOT's Long Term System Assessment ("LTSA")

Figure 3-4



The LTSA is a composite study made up of various processes and analyses such as scenario development, generation expansion analysis, load forecasting analysis, and transmission expansion analysis.

The scenario-based planning approach provided a structured way for participants/stakeholders to identify the most critical trends, drivers, and uncertainties for the upcoming ten- to fifteen-year period. Scenario-based planning considers sufficiently different, yet plausible futures and is used to evaluate transmission plans across multiple future states.

Among their key findings are two that impact this resource plan:

- 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.

In addition to the ERCOT LTSA, this resource plan takes into consideration several studies and recommendations for potential improvements in the ERCOT market. These are discussed in section

<u>The New York Mercantile Exchange ("NYMEX") Division of the Chicago Mercantile Exchange (CME") and other industry sources:</u> power and fuel price data.

Figures 3-5 and 3-6 presents charts of current power and natural gas forward curves. Figure 3-5 shows forward prices as 12-month averages, while Figure 3-6 shows current forward curves with monthly prices along with best-fit lines to better demonstrate overall values through time.

Figure 3-5

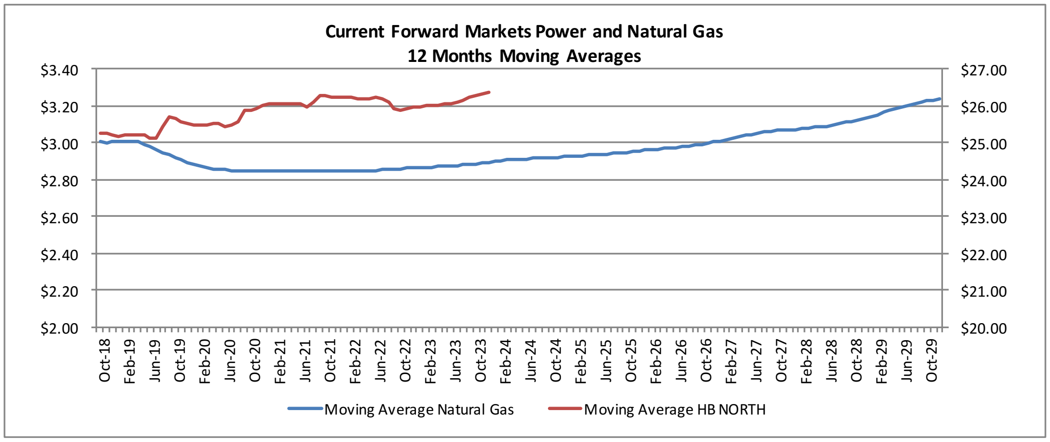
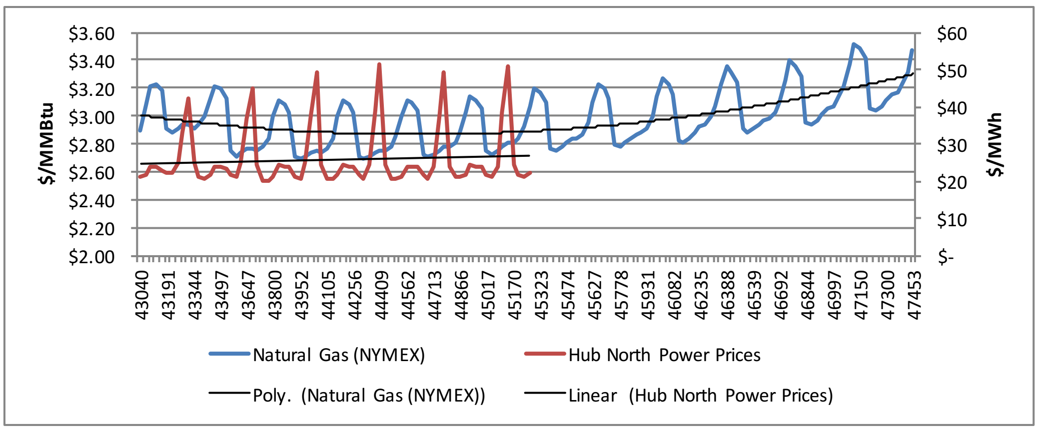


Figure 3-6



A variety of natural gas price curves were considered for use in the evaluation. Those used in the Brattle Report ("Review of the Renewable Denton Plan") are generally much higher than those from other sources.

Figure 3-7 shows the Brattle Base Case and Low Case compared to the current NYMEX forward curve. Although a forward curve for a commodity market like NYMEX is not predictive of future prices, it is indicative of the clearing price that buyers and sellers are effectively recognizing as a fair future value. Valuations using natural gas price projections should always include the current forward curve as a reference case.

Figure 3-7

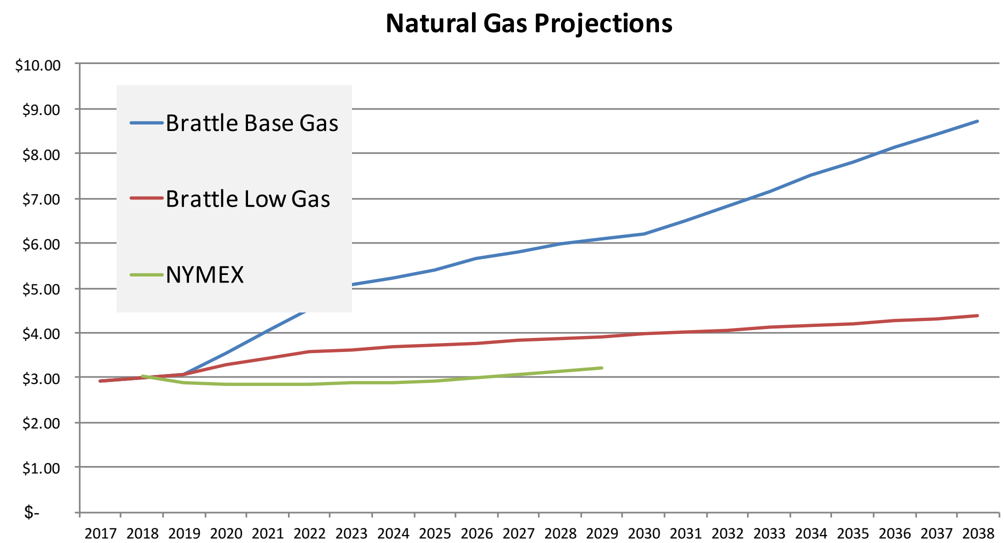


Figure 3-8 includes the last three years of U.S. Energy Information Administration ("EIA") forecasts. Note the lower trend across the three years. The "HOG" forecast is their high oil and gas production forecast.

Figure 3-8

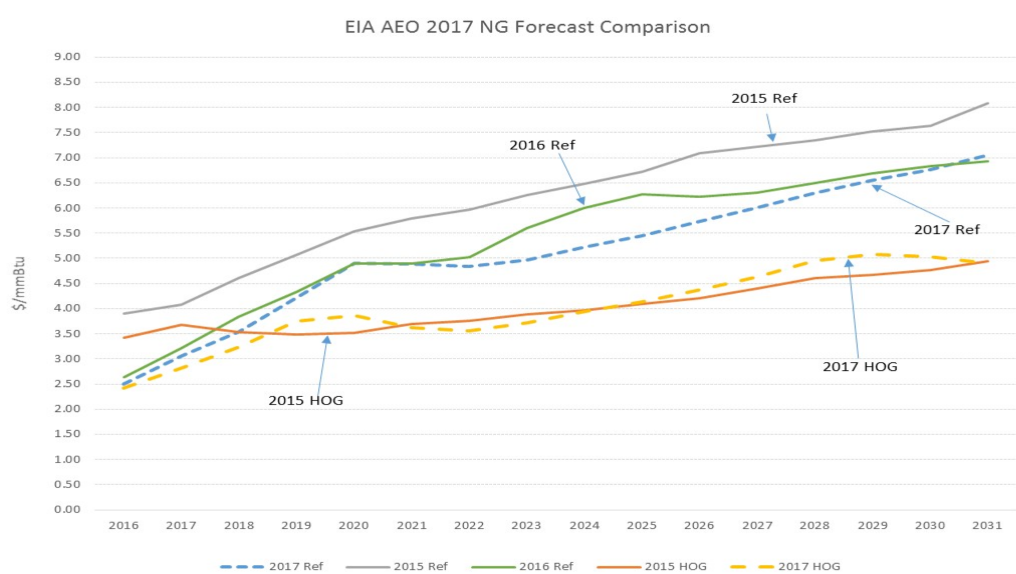
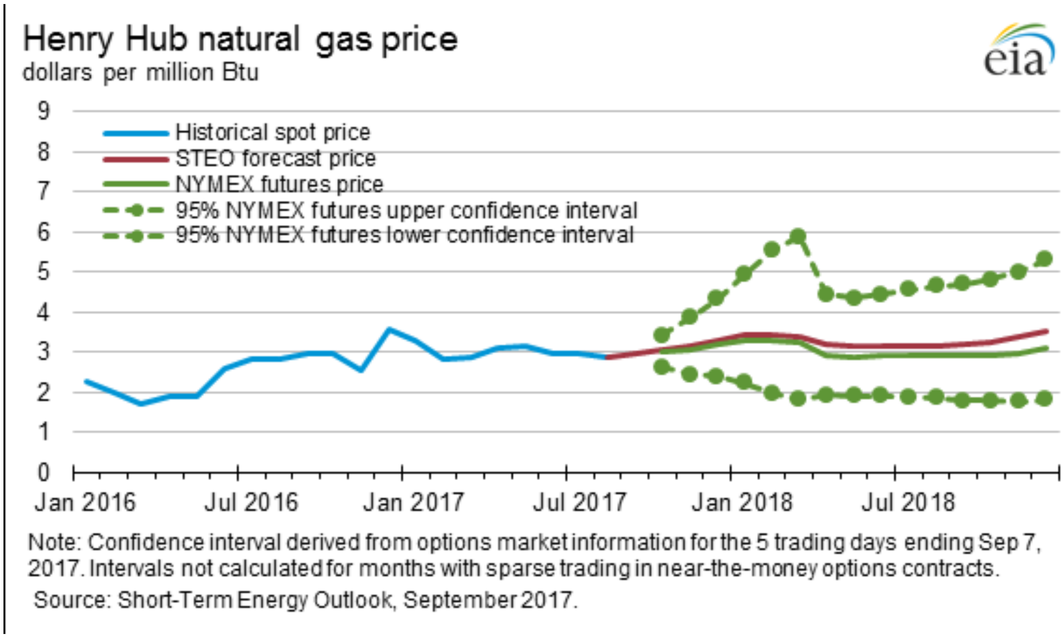


Figure 3-9 offers a somewhat different look at potential gas prices, combining historical spot Henry Hub natural gas prices with the most recent confidence intervals. The confidence intervals expand in the first few months because of higher volatility for winter futures months.

Figure 3-9



<u>Natural Gas Market Expectations</u>

The EIA Annual Energy Outlook is an important source for fundamental supply/demand data on natural gas. EIA's expectations are for increased natural gas trade is dominated by liquefied natural gas ("LNG") exports in the Reference case, which can be seen in Figure 3-10. The increase in exports via pipelines and LNG represents an increase of approximately 4 TCF. This is an increase of approximately 15% that does not have an historical precedence. In the past, unexpected increases of demand of only 5% to 6% due to weather have caused natural gas prices to double. This expected increase in natural gas exports is triple this amount.

Figure 3-10

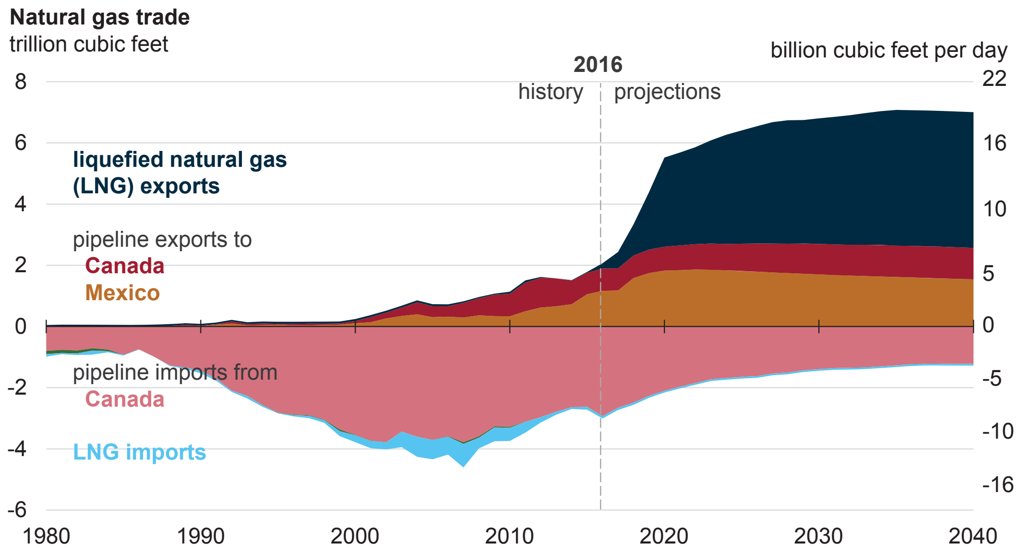
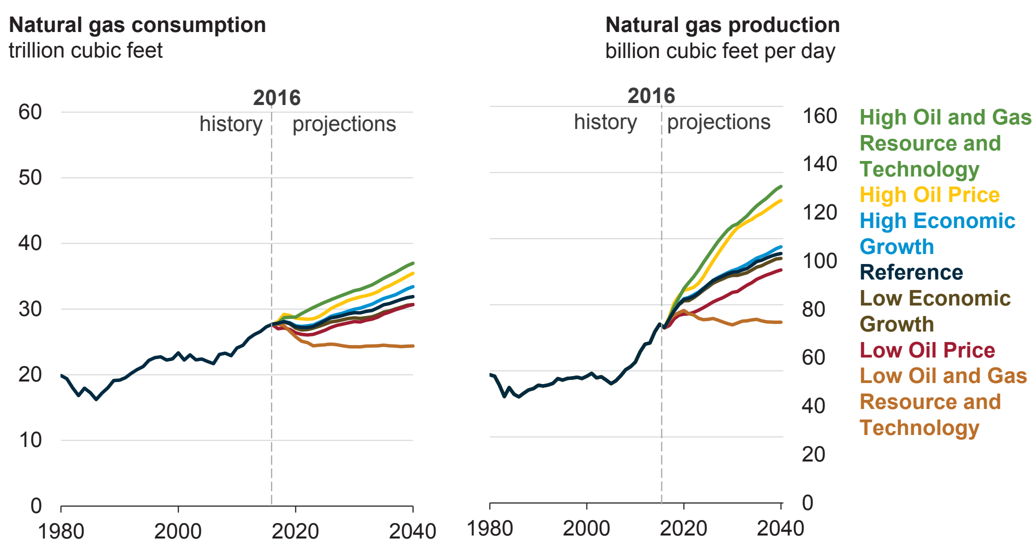


Figure 3-11 shows expectations of increased natural gas consumption in most cases. These analyses point to a potential for increasing natural gas prices, which could put upward pressure on prices for renewable resources targeted by Denton. Longer term though, the substantial overhang of potential supply increases from shale reserves, plus falling drilling costs, is likely to produce a reversion to the long-term lower priced mean for natural gas.

Figure 3-11



Price Projections

The following charts illustrate the price projections used in the economic evaluations in this resource plan. Figure 3-12 shows natural gas price projections, Figure 3-14 shows power price projections.

The economic evaluations in this resource plan use four price scenarios including two from the Brattle Report ("Review of the Renewable Denton Plan"), and two developed by ERC:

- ERC base case
- ERC high case
- Brattle base case
- Brattle low case

The Brattle report was missing a lower natural gas price case that represented the current market environment. In other words, the Brattle report assume that natural gas prices would only rise from the current environment. The ERC base case is important to add to the evaluation mix because it adds a reasonable case that is lower than the Brattle gas price projections.

The ERC base gas case is the linear extension of the current forward natural gas price (NYMEX) as traded on the CME. The ERC high gas case mirrors the escalation and return to the mean seen during the decade of the 2000s, as seen in Figure 3-13.

Figure 3-12

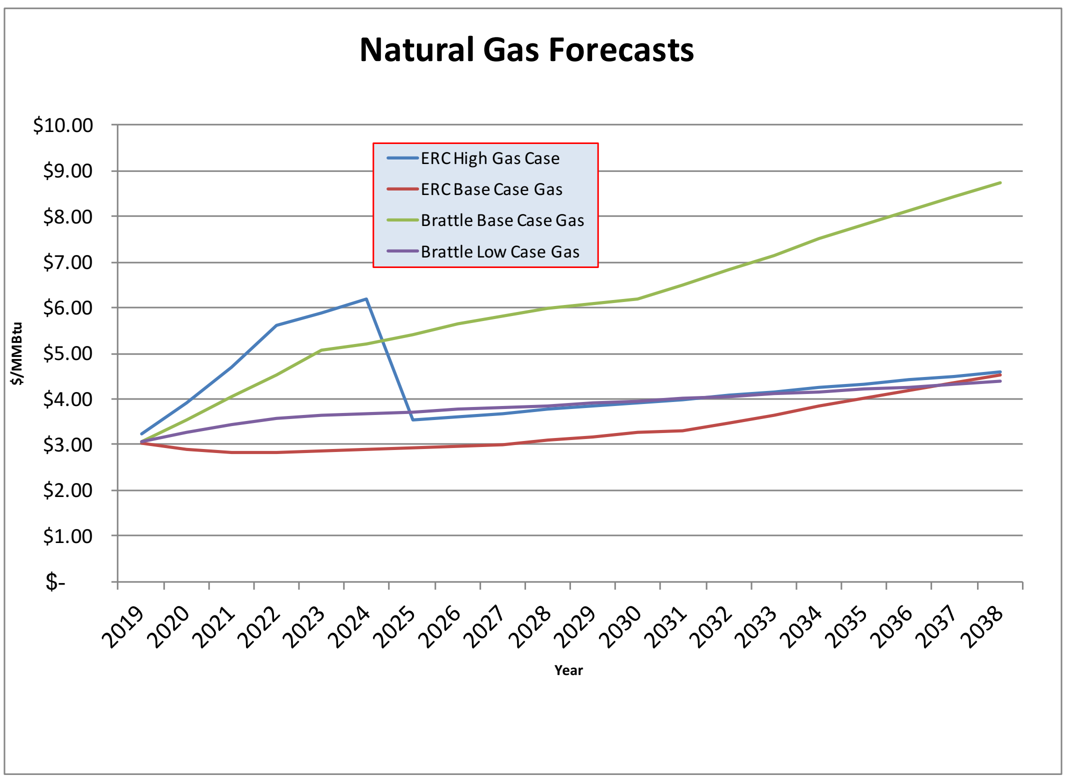
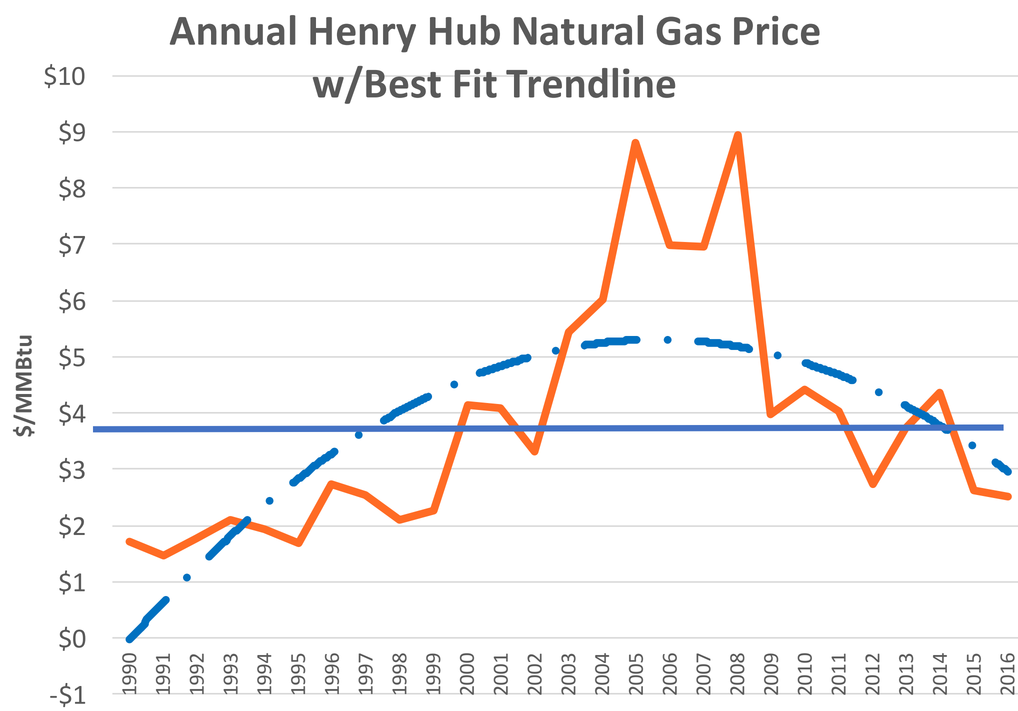
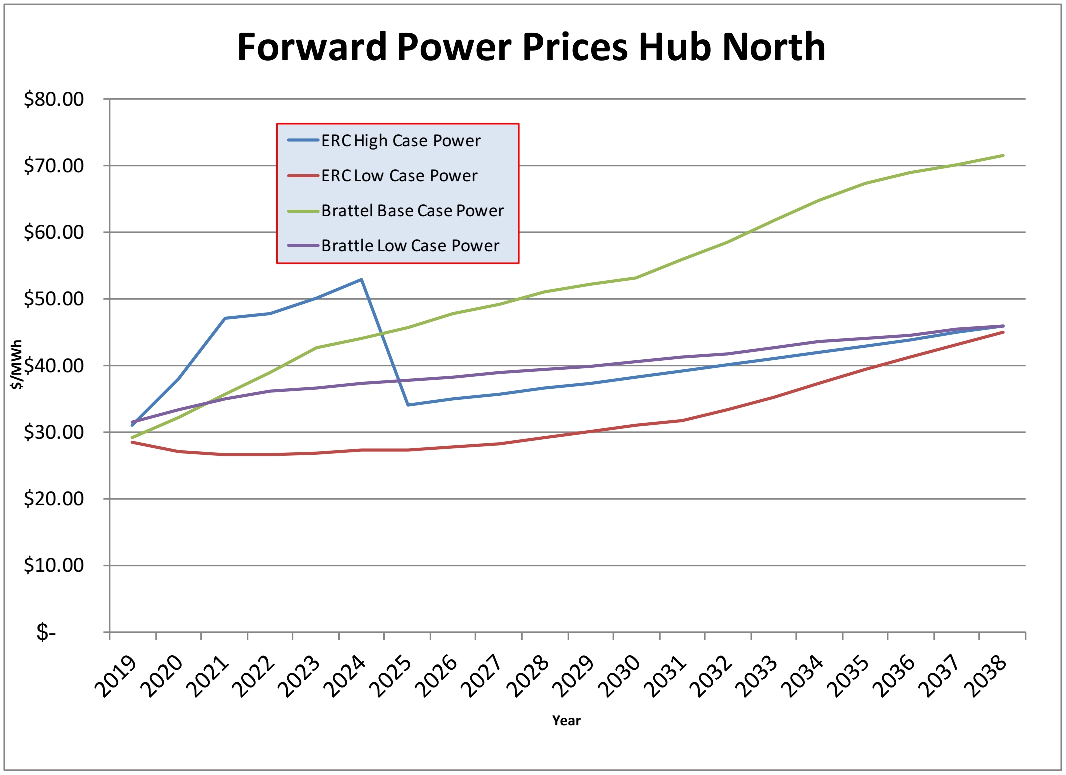


Figure 3-13



Power price forecasts were developed using actual market heat rates over the last few years in ERCOT at Hub North applied to the natural gas price forecasts. Multi-variable regressions were used to reflect the negative correlation of natural gas to power. This produces a forecast that recognizes the relationship that is part of the ERCOT economic dispatch: as natural gas rises heat rates decline.

Figure 3-14



Load Scenarios

The following load scenarios were used for portfolio modeling:

1. A slightly negative growth rate
2. Mean annual growth of 1.6%
3. A high growth case of 3%.

4.0 Renewable Resource Plan Inputs & Analysis

4.1 Evaluation Factors

The evaluation factors are grouped around the two of the resource plan objectives: 1) least-cost and 2) reducing uncertainty (risk).

Regarding goal 1) least cost, Figure 4-1 presents a summary list of renewable resources that have been considered for the renewable resource plan. These are grouped according to primary technologies (e.g., wind, solar), secondary technologies (e.g., West Texas wind, coastal wind), and geographic location.

The table in Figure 4-1 shows the expected ranges of prices at the resource node and then at the HB_North. HB_ North is the resource delivery point for Denton. To transfer the resources to the LZ_North, a cost in the basis is $0.75/MWh. These are the prices used to estimate the costs of the supply. These costs are further adjusted as to profile. For example, a West Texas wind and a Solar resource produce approximately 20% difference in revenue. Solar produces during the higher priced on-peak hours while wind production drops off. Therefore, one would need at least a 20% lower price for West Texas wind to compete with a Solar resource. If a solar resource were priced at the North HUB at $25/MWh, a wind resource would need to be priced at the same location at $20/MWh or less. There are also limits of any one type of resource that can be placed into the portfolio given Denton's load shape. Additional resource selections recommended in this resource plan take into account the resources that are already in Denton's supply portfolio and scheduled for delivery. 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. These wind regions are farther away from the central West Texas wind belt that is located between Abilene and Big Spring, Texas.

Figure 4-1

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

Regarding goal 2) reducing uncertainty (risk), the primary focus from the perspective of evaluation factors for various renewable resources is on best-fit factors for Denton's energy supply portfolio. These best-fit factors include the production profile match relative to Denton's daily and seasonal load profiles, balancing the need for selling excess supply and purchasing shortages, the quality of each resource's production, access to transmission interconnections, and minimizing transmission issues with a particular focus on avoiding or reducing congestion exposure.

4.2 Gap Analysis

A critical driver of the quantity of recommended renewable resources is how to quantity Denton's target of 70% to 100% renewable power supply.

Although this can be defined from multiple perspectives, for the purpose of this resource plan the definition of the amount of renewable supplies is the proportion of Denton's load that is offset by renewable supplied over a given time period. Because of seasonal variations in load and in renewable resource production, the most appropriate time period is a year. Thus, the target will be a percentage of annual load in megawatt-hours ("MWhs").

Comparing the quantity in MWhs of Denton's planned resources with its load allows the quantification of the gap that needs to be filled to meet renewable energy targets.

The reference year and target for increasing the amount of renewable resources in Denton's supply portfolio is 2018, so the target amount will begin with this year.

Denton's annual load for 2019 is 1,550,000 MWh.

The gap that needs to be filled can be defined in more than one way. A major difference is in the classification of the Whitetail PPA. According to data provided by Denton, the Whitetail PPA was originally a 60 MW deal for wind power. The original transaction was subsequently modified, resulting in the conversion of the PPA to what looks like a conventional energy "'round-the-clock" ("RTC") (24 hours per day for 7 days a week) product, a 30 MW RTC transaction matched with renewable energy credits ("RECs"). The open question is this: should the Whitetail PPA still be considered a renewable energy resource?

Several years ago, before renewable resource targets were exceeded in Texas, RECs offered value as an incentive to develop more renewable resources, and could be used to "clean" conventional electric energy when paired with conventional power transaction.

However, in the meantime, several factors worked together to undermine the value and significance of RECs in ERCOT. Texas happens to be an ideal state for both wind and solar generation. And with attractive PTC and ITC tax incentives, the falling cost and increasing productivity of technology (e.g., photovoltaic cells), early targets for the expansion of renewable resources were greatly exceeded, based mainly on least-cost economics, not primarily on the economic incentives of RECs. Thus, RECs are no longer considered a viable way to "green wash" convention generation resources so that they would be classified as renewable resources.

The decision on whether or not to count Whitetail as a renewable resource is up to the decision-makers at Denton, taking into account the optics and potential reputation risk for a city with a substantial renewable resource target.

Figure 4-2 presents a listing of Denton's power supply resources.

Figure 4-2

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

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.

The recommendations in this resource plan will range in quantity based on the uncertainty of counting Whitetail as a renewable resource. This leaves Denton needing 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.

4.3 Production versus Load Profiles

One of the primary challenges in developing a renewable resource plan is the substantial difference between the periodic production profile of various renewable energy resources and Denton's load profile. This issue is not necessarily unique to renewable resources. Fixed-block market purchases also exhibit a substantial difference compared to load, as the fixed-block provides the same quantity for every time unit versus differing load levels for those same time units. Only by purchasing a load-following contract, at a substantial premium to fixed-block energy, can a production profile match that of a load profile.

As opposed to the mismatch of a fixed-block supply shape versus a variable load shape, renewable resources present the challenge of mismatches between variable production profiles and variable load profiles. These will be examined from both daily and seasonal perspectives.

4.3.1 Daily Profiles

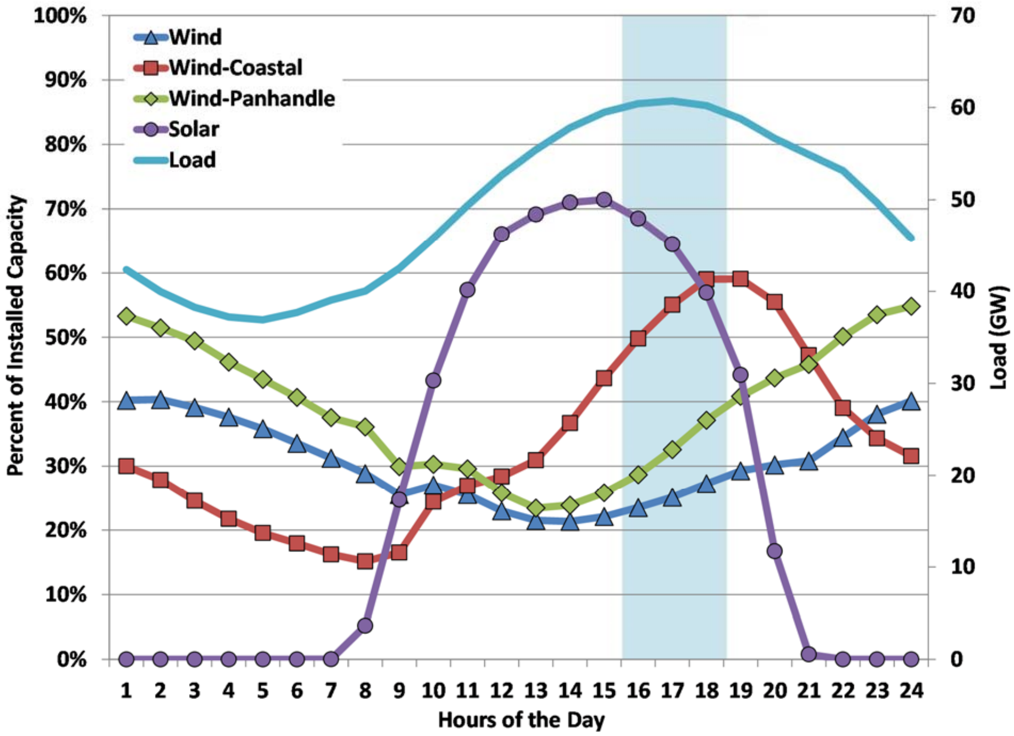
Figure 4-3 shows ERCOT data with representative production and load profiles for a typical summer day. Represented are production profiles for "Wind", which would be West Texas wind, plus Coastal wind, Panhandle wind, and Solar. These are plotted against a typical summer load profile for a load-serving entity with a substantial amount of residential and commercial customers.

Takeaways:

- West Texas wind offers the worst match against load. The production increases during less valuable, lower priced hours for energy.
- 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 have traditionally commanded a premium in terms of market pricing, but with overall prices for renewable resources falling, the cost premiums versus other renewable resources have compressed, making the assets more compelling:
    - Current low prices are attractive
    - Their production profiles are a better fit for Denton's load, and are a better complement to Denton's existing renewable resources such as Santa Rita (West

Texas wind), as opposed to adding more West Texas wind to Denton's supply portfolio, or adding Panhandle wind.

Figure 4-3 - ERCOT Summer Renewable Production Profiles (source: 2016 State of the Market Report for the ERCOT Electricity Markets)



Additional Profiles

In addition to West Texas wind, Panhandle wind and Coastal wind, responses to Denton's current request-for-proposals ("RFP") for renewable resources include wind resources in North Texas and South Texas. The production profile of North Texas wind is similar to that of West Texas wind. The profile for South Texas wind is between that of West Texas wind and Coastal wind. A major difference is not the production profile but the timing coincidence of the profiles. If they are far enough apart they may have the same profile but will not produce at the same time of day. Lack of coincidence lowers the positive correlation of production and lowers the likelihood of curtailment.

4.3.2 Seasonal Profiles

Continuing the theme of mismatched renewable resource production profiles versus Denton's load profile, seasonal variations in both production and load profiles will require active portfolio management to balance Denton's supply portfolio. Daily management will involve forecasting renewable resource production and then transacting in the ERCOT DAM to sell power during hours with excess supply, and purchasing power during hours with a supply shortage. The optimal balance between excess and shortage is one of Denton's decision criteria for determining renewable resource acquisitions and is discussed in Section 6.0 Reporting & Summary Analysis.

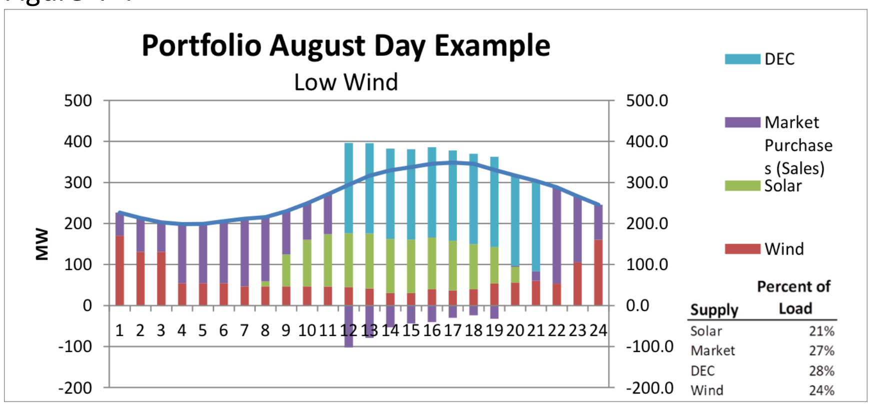
Examples:

Figure 4-4 illustrates the daily supply/demand balance for a typical day in August. During this season, wind output is typically low, while solar output is high (but not necessarily at its highest during a calendar year), and the DEC has a higher likelihood of being dispatched. Specific quantities of renewable resources are used for illustration purposes only.

The horizontal axis in Figure 4-4 represents the 24 hours of a day. The vertical axis is quantity in Megawatts.

- Load is represented as the blue horizontal curved line that looks like a wave shape.
- Wind resource output is represented by the red vertical bars.

Figure 4-4



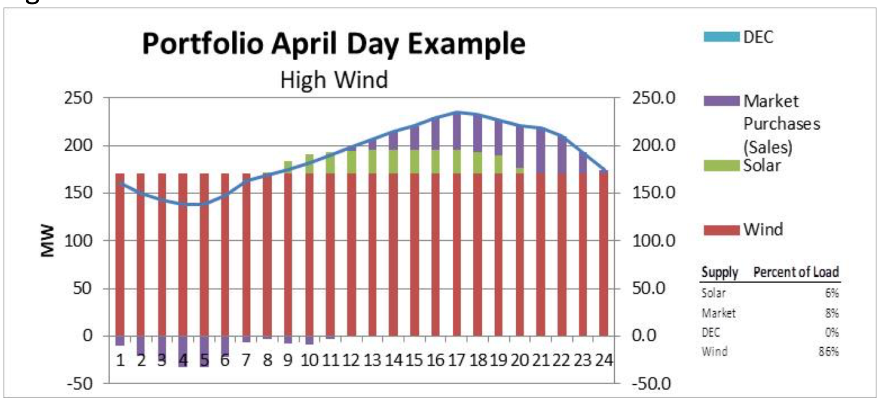
- Solar resource output is represented by the green vertical bars.
- The DEC is represented by the light blue vertical bars.
- Market purchases are represented by purple vertical bars above the 0 level / market sales are represented by purple vertical bars below the 0 level

Takeaways:

- 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.

Figure 4-5 illustrates the daily supply/demand balance for a typical day in April. During this season wind output is typically at its highest, while solar output is modest, and the DEC is unlikely to be dispatched. Again, specific quantities of renewable resources are used for illustration purposes only.

Figure 4-5



As with Figure 4-4, the horizontal axis in Figure 4-5 represents the 24 hours of a day. The vertical axis is quantity in Megawatts.

- Load is represented as the blue horizontal curved line that looks like a wave shape.
- Wind resource output is represented by the red vertical bars.
- Solar resource output is represented by the green vertical bars.
- The DEC is represented by the light blue vertical bars.
- Market purchases are represented by purple vertical bars above the 0 level / market sales are represented by purple vertical bars below the 0 level

Takeaways:

- 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.

4.3.3 Quality of Specific Renewable Resources

Another critical evaluation factor is the quality of specific renewable resources. As can be seen in Figure 4-3, the "quality" of wind differs depending on the location. Panhandle wind tends to have a higher capacity factor than West Texas wind. Coastal wind offers much greater on-peak production than Panhandle and West Texas.

The location of wind resources also affects the quality of the output in terms of the consistency of the direction of wind and the lack of wind turbulence.

The location of solar affects the degree of power output relative to a given type of photovoltaic ("PV") cell.

Location also affects the ability to connect to the ERCOT grid in an economically efficient manner, as well as the potential impact of additional costs in the form of charges for transmission congestion.

These location factors are discussed in the following sections.

4.3.3.1 Producer Production Data Bias

An important consideration in evaluating renewable resources is to verify and correct production output claims of renewable resource developers. Both solar and wind developers typically include a bias to expected performance. Producers typically over-estimate the efficiency of their installations to attract investors. They often used idealized models that overlook important details. For sellers of renewable resources, this outcome is not a surprise. A good analogy is the miles per gallon ("MPG") claims for new cars. They can be achieved under specific and idealized circumstances, but everyday driving rarely achieves the promoted MPG. Something similar occurs with renewable resource developers.

Wind producers cannot predict wake effects well, and typical amounts of reduction (correction) to developers' claims are on the order of 5% to 8%.

Solar developers often use average values that do not reflect hourly temperature effects, for example, the warmer the ambient conditions, the poorer the PV performance. This can reduce actual performance by 15% or more depending on the equipment type and installation design.

To adjust for these biases, independent data from the National Renewable Energy Laboratory ("NREL") and ERCOT was used in this resource plan. NREL tools allow verification by specifying what type of PV cell is involved, along with the tilt of the PV cells mounts, including fixed, single or dual axis mounting. These tools can be used to produce hourly production curves for various seasons and at various locations across the state.

For wind resources, ERCOT has an extensive database of wind production profiles across the state.

Using these sources of independent data, the following output reductions have been calculated for Denton's current renewable resources (Whitetail is not included because it has been converted to a fixed 30 MW RTC block) in Figure 4-6:

Figure 4-6

Denton Resource	Original Production Estimate (MWhs)	Revised Production Estimate (MWhs)	Reduction
Santa Rita	643860	52560	8.16%
Bluebell	81468	5256	6.45%
Total Reduction		57816 (3.7% of Load)	

4.3.3.2 Wind Location Considerations

Figure 4-7

There are at least six different wind regions in ERCOT that are 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.

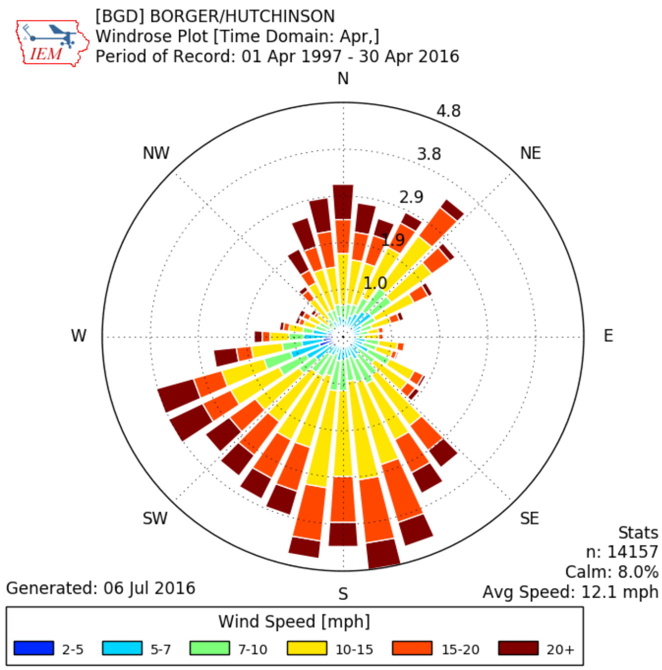
Both Panhandle and Coastal wind resources are not well correlated with System-wide output.

As previously mentioned, 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. Wind turbines in the wake of other wind turbines suffer from reduced output. A natural illustration of this effect is in Figure 4-7.

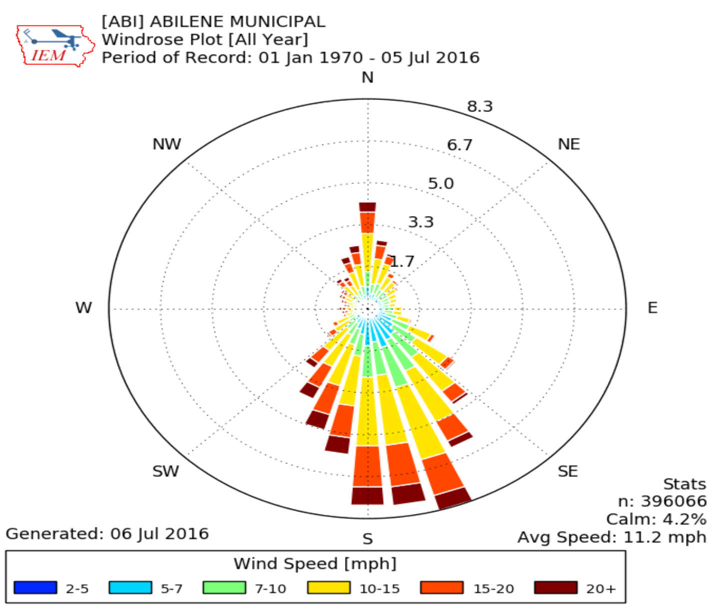
Figures 4-8, 4-9 and 4-10 illustrate three different locations of wind resources. Figure 4-8 shows wind resource and directional diffusion for a wind farm near the Texas/Oklahoma border (Borger), Figure 4-9 shows the output for a wind farm near Abilene, and Figure 4-10 shows the output for a coastal wind resource.

Figure 4-8



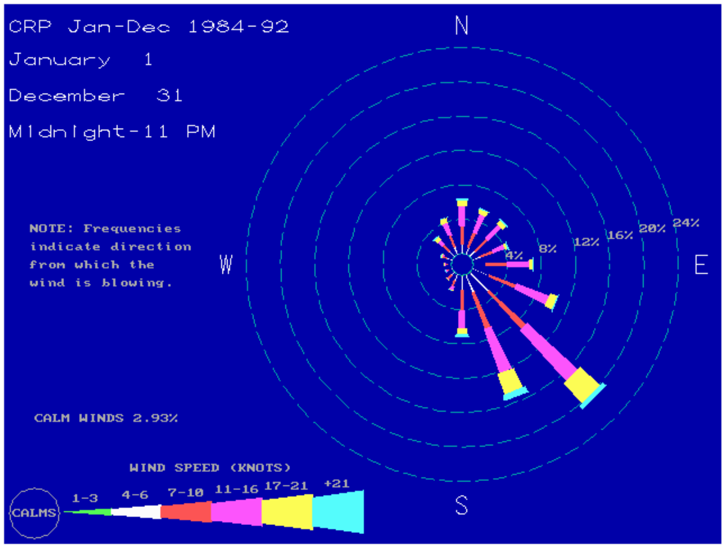
A tighter diffusion pattern and a more consistent wind direction are preferable for more consistent output and a higher capacity factor.

Figure 4-9



This factor supports the choice of Coastal wind.

Figure 4-10



Additional coastal wind factors include the following:

Advantages of Coastal wind:

- Uncorrelated with ERCOT System wind, producing higher output during the summer afternoons.
- Lower congestion risk with lower output during the spring and fall when high West Texas Winds increase congestion.
- More reliable for forecasting because it depends on the land, ocean effect.
- Coastal wind resources in the ERCOT South Zone are away from resources built in West Texas, and they are closer to retirements of generation in East and South Texas.

Disadvantages of Coastal wind:

- Coastal wind PPAs usually command a cost premium compared to other wind resources.
- Coastal environmental considerations (e.g. hurricanes, sensitive habitat).
- Subject to build restrictions (e.g., near U.S. Air Bases).
- A great deal of additional load being added in the area.

Despite these disadvantages, the advantages of Coastal wind, especially regarding the fit to Denton's supply portfolio, outweigh the disadvantages.

4.3.3.3 Solar Location Considerations

Solar irradiance (the power per unit area received from the Sun) as a function of location is a primary evaluation factor for solar renewable resources.

Solar irradiance is impacted by latitude, potential for cloud cover, and temperature factors.

Figure 4-11 presents an overview of solar irradiance.

Figure 4-11

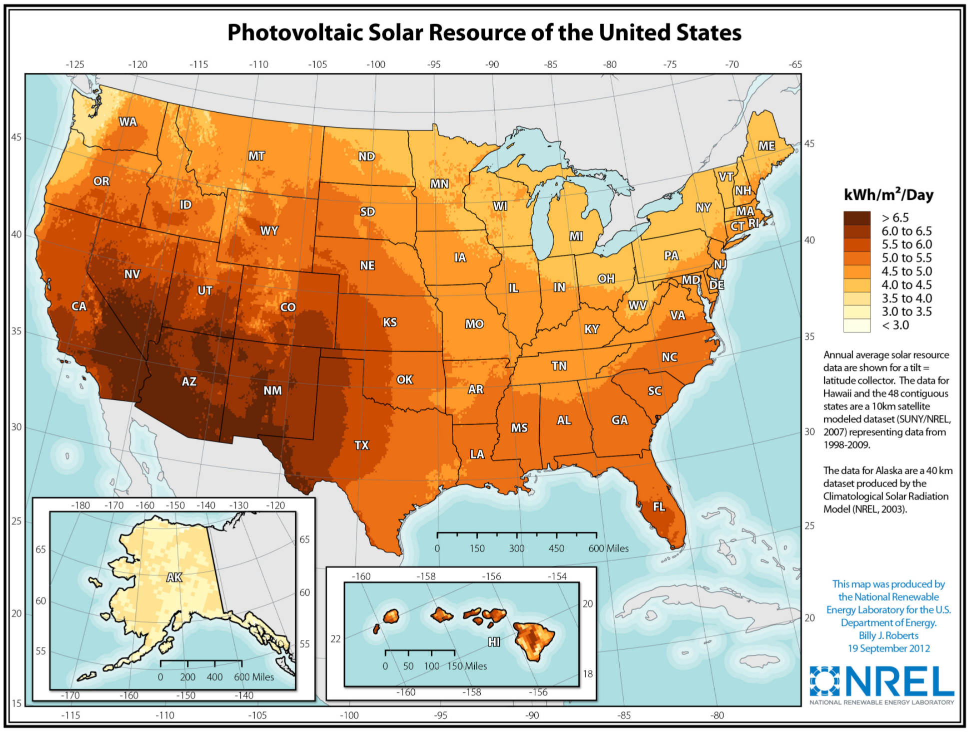
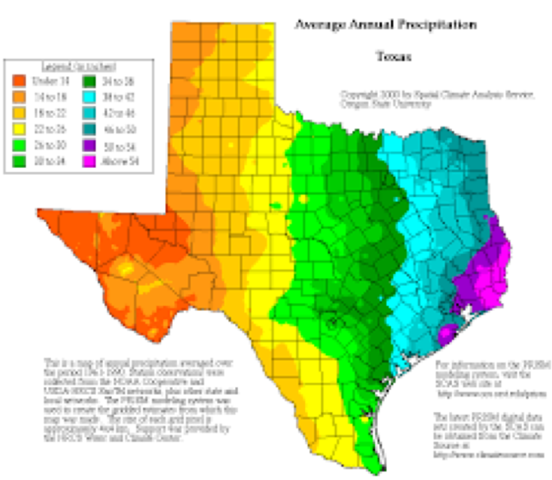


Figure 4-12 shows a map of rainfall in Texas. Rainfall is correlated with cloud cover, which reduces solar output.

Figure 4-12 Rainfall in Texas



Temperatures are also a factor. High temperatures instigate atmospheric convection which causes less energy to reach the ground, thereby reducing solar output. Warmer temperatures also raise the temperature of PV cells driving down efficiency.

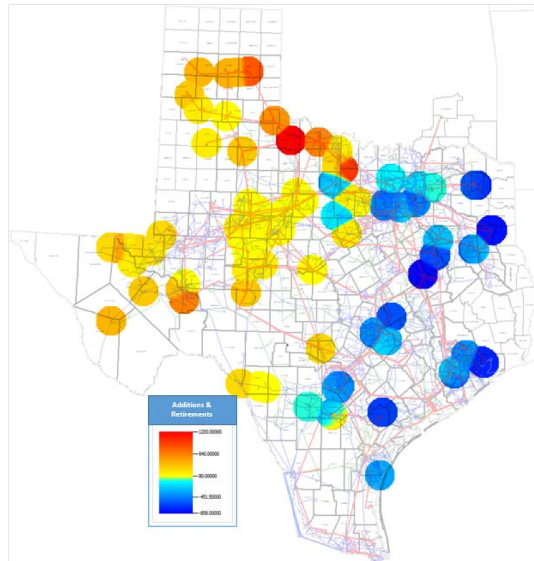
Typically, the month of June has more solar production than in August, not because it has longer days and a higher sun angle, but because August is usually hotter. Sometimes the month of May can be better than June because of higher temperatures in June.

For optimal irradiance, the best location in Texas for solar would be all the way west to El Paso, but that's outside of ERCOT. 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.

4.3.3.4 Additional Location Considerations

An important consideration for evaluating optimal resource locations is the projection of generation additions and retirements in ERCOT. With more renewable resources expected to be developed, and with conventional resources such as coal-fired generation expected to experience increased retirements, congestion issues may be exacerbated.

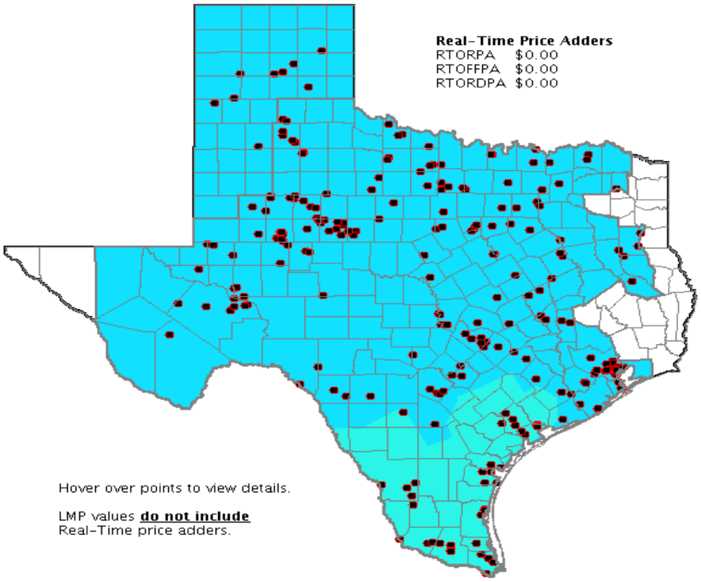
Figure 4-13



Periodically, ERCOT conducts a long-term system assessment. Data from ERCOT's "2016 Long-Term System Assessment for the ERCOT Region", shows a projected increase in generation in the West and a decrease in generation in the East. This can be seen in Figure 4-13. Yellow to orange circles indicate generation additions, while blue circles indicate projected retirements. This will create a decisive West to East flow of production. In considering resource additions, 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.

Optimal site selection is more limited for solar however, due to the need to maximize irradiance while minimizing rainfall and cloud cover. Although there is some solar production in the southeast of Texas, irradiance isn't very good in that region.

Figure 4-14 (source: ERCOT)



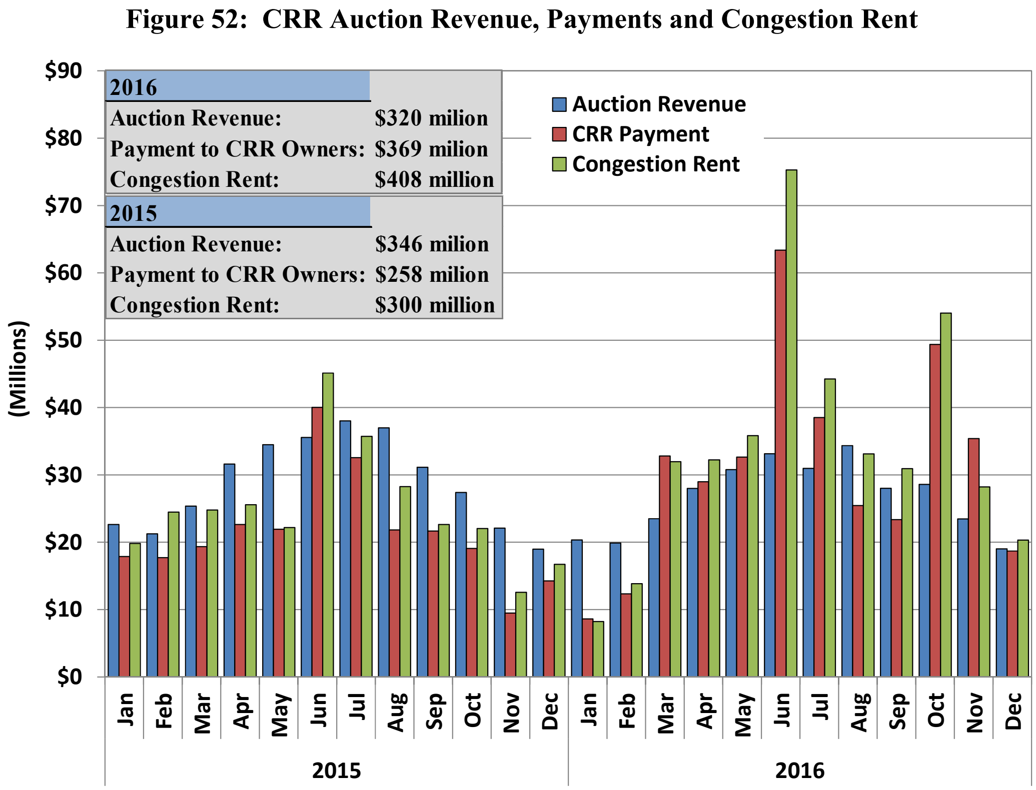
Another location consideration is the access to transmission. Pricing points cluster at wind resources near big substations and 345 kv interconnects. The location for renewable resources shouldn't be way out in the middle between the pricing points as illustrated on the map in Figure 4-14. Ideally, the better locations are in between the pricing clusters and urban areas, east of the clusters in the western region, and along the coast closer to Corpus Christi than Brownsville.

4.4 Congestion (Location Basis) Considerations

Congestion hedging is an important component of completing the opposition hedge, and of carrying out an efficient internal portfolio management operation for renewable resources, as discussed in Section 2.3 Efficient Management of a Renewable Resource Power Supply Portfolio. Congestion hedging is like insurance - it is important to insure exposures in a complete manner.

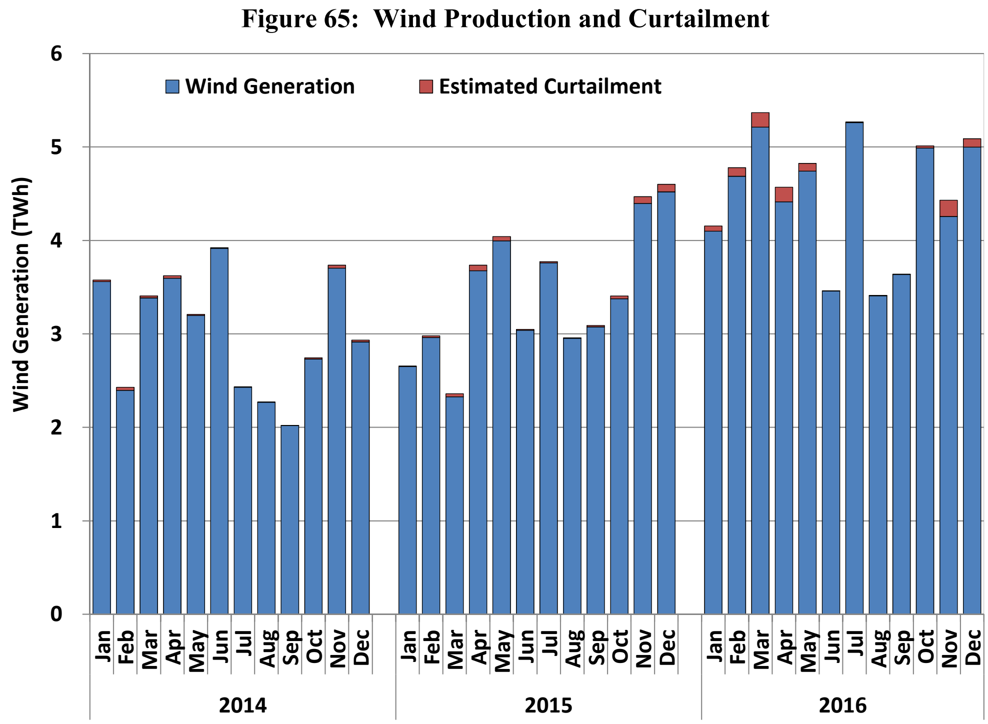
ERC's extensive experience with CRR management and hedging for several clients indicates that not only is the net cost of congestion hedging acceptable, but CRRs often pay for themselves when exposure risk increases. Notice in Figure 4-15 that when congestion rent in the DAM increased in 2016, the payment to CRR owners exceeded CRR auction revenue. And in addition to congestion rent in the DAM, the total congestion costs experienced in the ERCOT real-time market in 2016 were $497 million, an increase of 40 percent from 2015. Transmission outages were the primary causes for this increase.

Figure 4-15



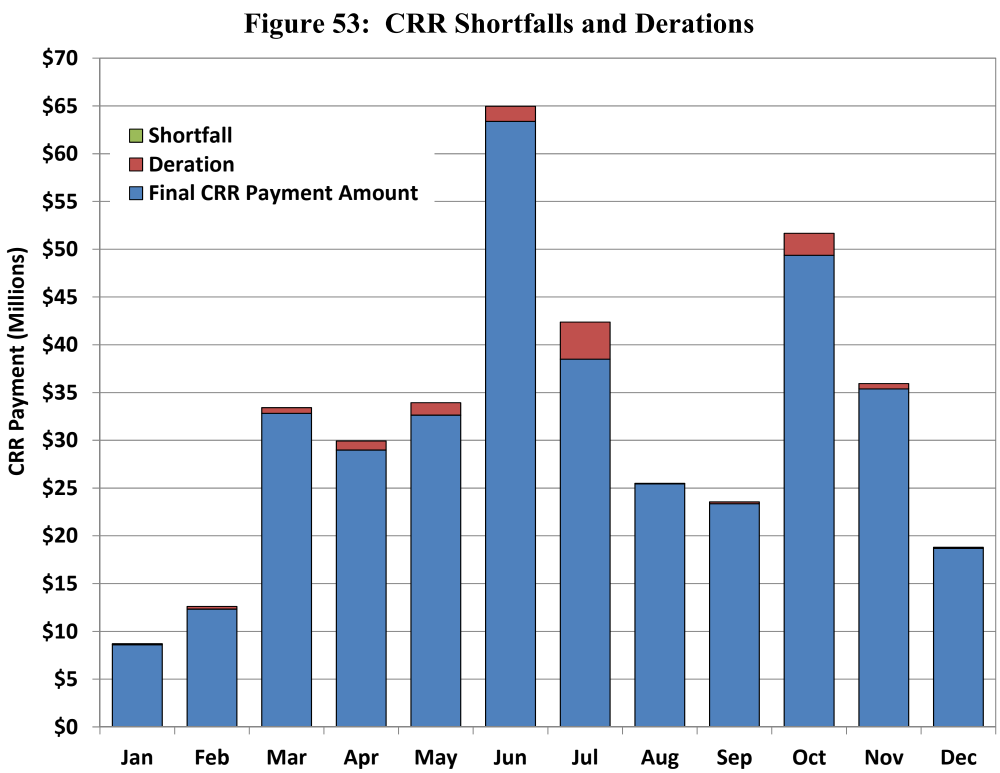
The use of CRRs should not be avoided because of possible curtailments or derations. In fact, the principal hedging method in the market to limit curtailment risk is the purchase of a CRR. A CRR will make the owner indifferent to curtailment because it will fix the price between two points. This is an economic hedge. It is anticipated that curtailments will rise, but will remain modest in most wind regions, as shown in Figure 4-16.

Figure 4-16



Derations are local and less than 3% of the CRR market as can be seen in Figure 4-17.

Figure 4-17



The data in Figure 4-18 shows that congestion hedging with CRRs is a mainstream activity in the ERCOT market. The chart shows the volume of CRR hedging activities brought into the RT market via Point to Point ("PtP") congestion hedges, as represented by Net System Flow. The Net System Flow exceeds the volume of purchases in the DAM and is more than the average RT load. Figure 4-19 shows that in two of the last three years, revenues from PtP obligations exceeded charges. Informed marketers use CRRs and PtPs to limit their basis risk for their energy portfolios. As can be seen in Figure 4-15, the payment to CRR owners is greater than the cost of ownership. The exposure (basis risk) is higher than the CRR costs. This means that the non-congestion hedging load is paying congestion rents to loads with CRRs. That is where the revenue comes from to pay for any imbalances caused by claims from the CRR owners.

Figure 4-18

Figure 27: Volume of Day-Ahead Market Activity by Hour

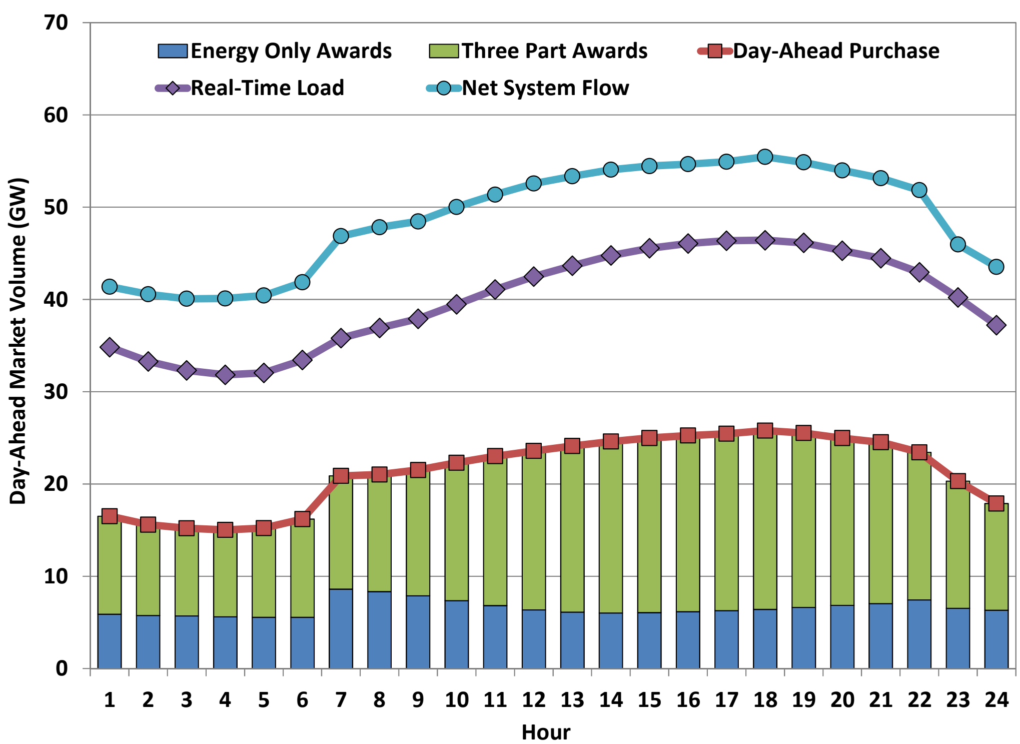
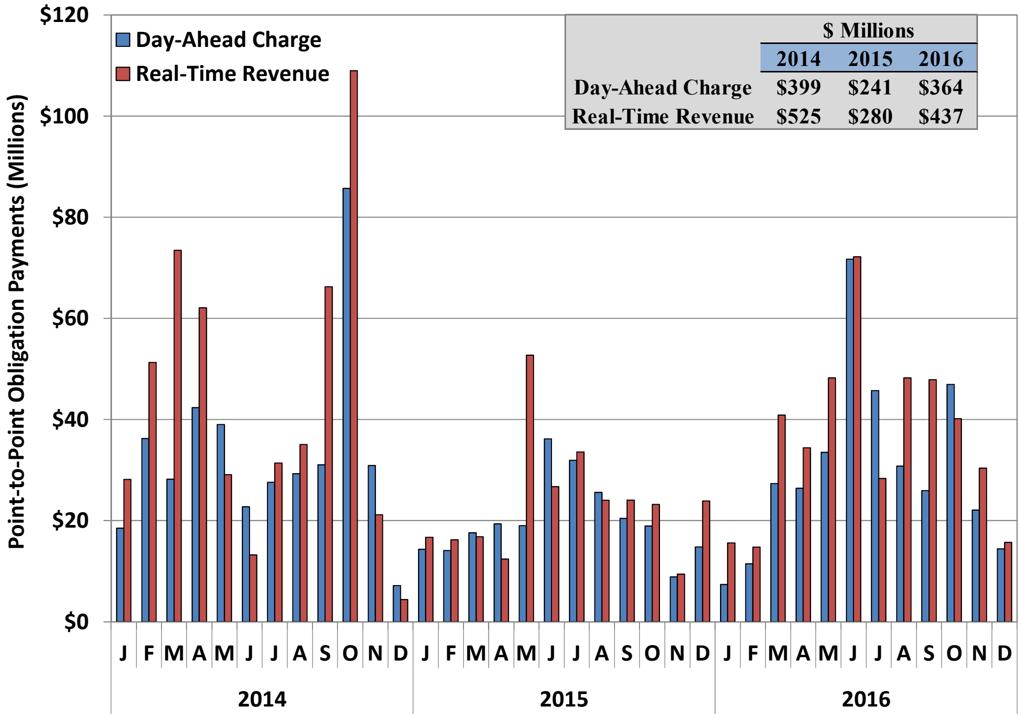


Figure 4-19

Figure 28: Point-to-Point Obligation Charges and Revenues



4.5 Regulatory Environment

The potential for changes in ERCOT is another factor in the resource plan analysis. ERCOT continually changes the way the system operates. For example, the following studies and recommendations for several potential improvements to the ERCOT markets that appear in the 2016 ERCOT State of the Market Report:

1. Evaluate policies and programs that create incentives for loads to reduce consumption for reasons unrelated to real-time energy prices, including: (a) the Emergency Response Service (ERS) program and (b) the allocation of transmission costs.
2. Modify the real-time market software to better commit load and generation resources that can be online within 30 minutes.
3. Implement real-time co-optimization of energy and ancillary services.
4. Price future ancillary services based on the shadow price of procuring the service.
5. Ensure that the price of any energy deployed from a reliability must run (RMR) unit reflects the shortage conditions that exist by the fact that there is an RMR unit.
6. Evaluate the need for a local reserve product.
7. Consider including marginal losses in ERCOT locational marginal prices.

It is not known if any of these improvements will be adopted soon, or ever. Each one has a potential effect on the recommendations for Denton's renewable resources, although mitigating actions aren't available for all of them.

An example is the proposal to change the market design to incorporate marginal line losses. This will add costs to resources that are farther from load zones. A change in the ERCOT market design to incorporate costs associated with marginal line losses would favor Coastal and North Texas wind resources because they would be closer to a load zone. These two wind resources would reduce the potential risk from the adoption of marginal losses, and CRRs would still be available to mitigate the risk to some degree.

5.0 Renewable Resource Portfolio Model Development

5.1 Modeling Factors

The following is a list of variables considered in qualitative and quantitative modeling:

- Natural gas prices
- Power prices
- ERCOT Hub North heat rates
- DEC heat rate and estimate of variable O&M
- 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

5.2 Portfolio Modeling

<u>Correlation Analysis (Diversification)</u>

An important aspect of modeling portfolio costs and developing a portfolio mix that meets the twin resource plan goals of least-cost and uncertainty (risk) reduction is to achieve as much diversification as possible in the supply portfolio.

One important measure of diversification is the correlation of various renewable resource production profiles. A portfolio comprised of renewable resources that are highly positively correlated would suffer from a lack of diversification. When one resource would not be producing, other resources would also not be producing. The goal is to assemble a portfolio with a mix of uncorrelated resources so that the overall portfolio production is more consistent. An excellent example of this is the match between Solar and a traditional wind resource like West Texas wind. West Texas wind typically produces more during off-peak (nighttime) hours and produces very little during summer on-peak hours (daytime), whereas Solar production is not existent at night and ramps up during the day, peaking during some of the most highly-priced on-peak hours.

Combining renewable resources with lower correlations reduces risk and improves overall supply portfolio correlation with Denton's load, and it improves forecast reliability. The main risk reduction is the combination of solar resources and wind resources. A typical correlation between the two ranges between -70% to -95%. Wind resource combinations have varying correlations due to differences in quality (e.g., higher capacity factor Coastal wind vs. West Texas wind) and location (e.g., West Texas vs. Panhandle). Very few commodity portfolios have the opportunity of such advantageous pairing of assets.

An additional diversification factor is the location of resources especially in regard to congestion exposure. Diversifying the supply portfolio reduces overall congestion risk exposure and also contributes to more consistent economic performance. An example is avoiding having all of Denton's renewable resources in the western part of ERCOT because it is the region with the highest congestion risk, second only to the Panhandle region.

<u>Quantitative Approach</u>

Portfolio modeling was based on a blend of correlation analysis and scenario valuation. Various mixes of renewable resource quantities, constrained by the results of the correlation analysis, were valued according to the ranges of natural gas and power price projections, along with related DEC dispatch scenarios, with the objectives of finding the least-cost portfolios with the lowest cost variability.

The production profiles of various renewable resource were screened to determine how the profiles performed against historical prices. This involved calculating the balancing costs for each profile to determine the net effective cost of each resource type. Balancing costs are a blend of spot market purchases of market power when renewable production fell short of load requirements, or DEC production when the DEC was a lower priced alternative to DAM purchases, and spot market sales of excess power when renewable production exceeded load requirements.

5.3 Demand Response Side (Demand-side Management)

ERC strongly supports and advocates Demand Response and Demand-side Resources. These include residential, commercial and institutional solar, community solar, ERCOT's Emergency Response Service ("ERS") program, and battery storage. Storage is particularly intriguing because the lack of it is one of the main distinguishing characteristics of electricity as a commodity, and is one of the main drivers of electricity's high price volatility. The industry is just on the cusp of commercially viable battery storage, in terms of battery performance capability and cost.

This resource plan and its supply portfolio modeling does not incorporate the potential benefit of demand-side renewable resources for the present, although demand-side resources will be an important part of the future.

In the compressed project timeline for this resource plan, the best course of action is to follow the Pareto Principle (aka the 80/20 rule) and address the small set of issues/variables that will have the greatest impact on Denton's goals. The primary focus in this resource plan is on the issues that will have the greatest near-term impact and benefits for Denton.

The main issue is that Denton is facing near-term critical path issues and multiple risk factors in the present and near future regarding renewable resources. The fuse has already been lighted on a renewable resource acquisition strategy, and specific large-scale issues must be addressed in short order, including the initiation of delivery for a large wind PPA in early 2018, and near-term purchase decision deadlines taking into account the lead time necessary in securing PPAs for renewable resource projects to meet Denton's initial goal of 70% renewable resources.

An immediate gap analysis was needed to identify best-fit renewable resources to achieve as much diversification as possible in Denton's supply portfolio. And this resource plan played catch-up with a RFP process for renewable resources that was already underway. Other near-term issues that demand primary focus in the compressed evaluation timeframe include the potential for a federal tariff on imported solar PV panels, the uncertain future of low renewable resource prices in the wake of announced curtailments of conventional generation, and the pricing effect of the scheduled reduction and eventual elimination of federal tax credits.

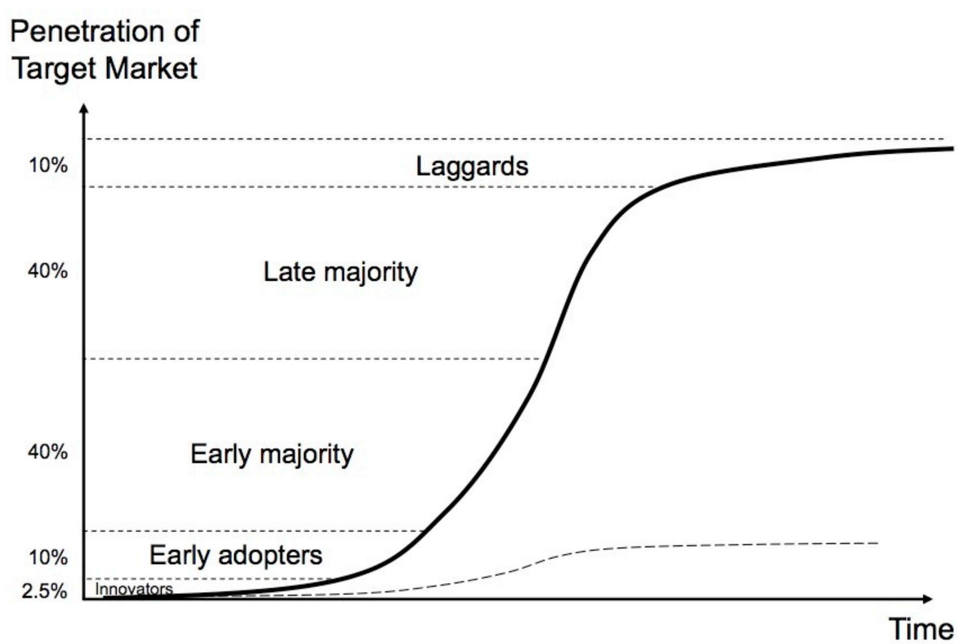
Critical path issues also include developing the operational process requirements to optimally manage a renewable resource power supply portfolio in order to avoid the substantial risks of suboptimal and inefficient portfolio management.

As mentioned previously, Demand Response and other demand-side management programs and assets have an important role to play, and will benefit from a longer timeframe for planning and decision-making. How a utility chooses to incentivize demand-side resources in order to reduce and not increase operations risk requires careful coordination with rate design. For example, some utilities have found that limited penetration of residential solar is the best fit for portions of its distribution system, and thus require irradiation studies to target optimal rooftops within neighborhoods as well as a rate incentive mechanism designed to cap roof-top solar at acceptable levels.

Demand-side distributed generation also requires careful planning based on potential ERCOT interconnection requirements, special NOIE reporting requirements, Resource Entity registration, and specific metering requirements.

Careful consideration must be given to the cost impacts of demand-side resource development. Storage is an intriguing option, but it is just now on the cusp of commercial viability. Figure 5-1 represents a typical adoption curve for new technologies. Enormous increases in battery storage capability (storage capacity and duration) and substantial decreases in cost will occur as the technology transitions into the Early Majority stage. At present, the technology is in the Early Adopter stage. Denton should carefully consider the cost impact of early adoption. A useful example is Austin which has been an early adopter of renewable resources, and has high-priced wind and solar resources in its portfolio. Current prices for wind resources are in the $12 to $22/MWh range, and solar resources are in the mid-$20/MWh range, whereas just a few years ago wind prices were offered between $40 to $65/MWh and solar was as much as 5 to 7 times the price of current offers. Austin's Webberville solar project has a cost of $165/MWh.

Figure 5-1



A potential offset to early adopter cost premiums could be financial assistance from the Texas Emissions Reduction Plan ("TERP") program which offers financial incentives to local governments, among other entities, for new equipment that contributes to pollution reduction. They have several grant programs including a New Technology Implementation Grant ("NTIG") program to "provide incentives to assist in the implementation of new technologies to reduce emissions of pollutants from facilities and other stationary sources." More information can be found at https://www.tceq.texas.gov/airquality/terp.

Demand Response programs and other demand-side resources, with careful planning and design, can make a useful and important contribution along the timeline as Denton moves from its near-term goal of 70% renewable resources up to its longer-term goal of 100%. An additional discussion of this subject is in the "Gradual Adoption Path" portion of section 6.4 The Path to 100% Renewable Resources.

6.0 Reporting & Summary Analysis

6.1 The Denton Energy Center

The DEC will play a role in Denton's renewable resource portfolio as a cost hedge during certain super high-priced hours.

As discussed previously, the greatest challenge in managing a power supply portfolio comprised of renewable energy resources is balancing the supply portfolio around the intermittent production of renewable power plants.

Balancing the supply portfolio is often referred to as "firming" inadequate supplies. As explained previously, in the ERCOT energy-only market, firming is not an explicit requirement. ERCOT automatically "firms" inadequate supplies to meet all load requirements – the important focus is on managing the "firming" in a least-cost manner, both in terms of energy balancing purchases/sales and managing congestion price risk.

The results of the quantitative modeling employed for this resource plan show that the DEC should not be the sole resource used to "firm" a renewable resource portfolio. Using the DEC as a sole hedge 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.

According to DEC performance data provided by Denton, the DEC variable cost at today's Heat Rate is 9.7 MMBtu per MWh. This assumes an 8.3 fixed heat rate at the high sustained limit and variable operating costs of $3.8 per MWh. At current natural gas prices the variable cost translates to a 1.4 heat rate.

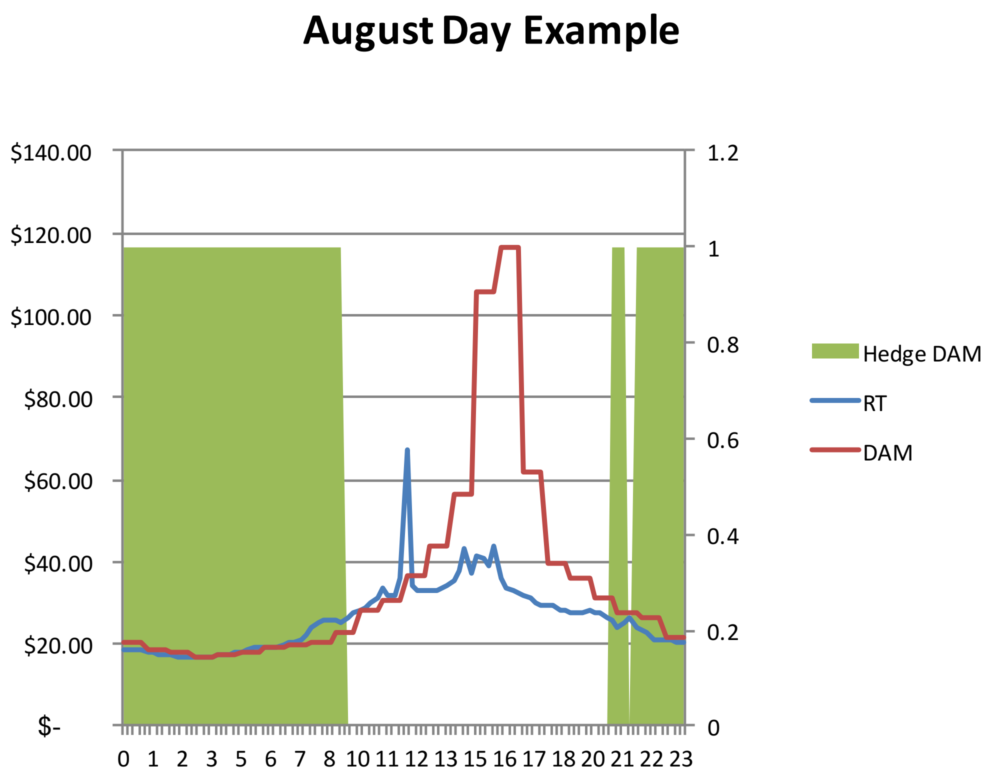
As can be seen in the ERCOT resource price stack data in Section 3.0 Information Gathering, many hours of the day are likely to be below the effective heat rate of the DEC. For example, considering the ERCOT load and price projections used for this resource report, at a marginal heat rate of 8 and natural gas prices of $3 per MMBtu, a market price of $24 per MWh would be available for purchases to supplement intermittent renewable resource production. Because this is lower than the expected cost of the DEC, a market purchase at Load Zone North would be made to balance Denton's portfolio. The DEC would not be used to hedge this risk because it would result in an increased supply price of over 1.7 heat rate or $5.10 per MWh before the Dec would dispatch.

The cost of dispatching the DEC and not using market purchases to hedge the supply risk could produce an increased cost of over 20%. The Dec cost would be 9.7 heat rate at a $3 gas price ($29.1/MWh) versus a DAM price of an 8 hear rate at a $3 gas price ($24/MWh).

In addition, the DAM is a fully hedged price, whereas the DEC would include the potential of basis loss because the DEC would need Point to Point purchases that match exactly the energy amount consumed by Denton in the RT. Because the dispatch is unknown, the Point to Point would have to be purchased against an energy dispatch. A DAM at Load Zone North does not need the purchase of a Point to Point basis hedge. It would settle the resource CRR in the DAM. And note that this is a conservative difference because of the ramping and effective heat rate of the DEC will be higher than the 9.7 heat rate until the DEC is running long enough to reach its high sustained limit.

An example of when the DEC would be dispatched rather than using DAM purchases to hedge a supply shortfall is in Figure 6-1. During a peak demand month such as August, the DEC might be dispatched about half of the time (the periods of time without the green shading). But in this example, even in a month like August, using the DEC as a hedge is likely not to be the least cost and lowest risk alternative for approximately 50% of the time. Figure 6-1 also shows that during DAM purchase hours (the hours shaded in green) the difference between the DAM fully-hedged price and the variable RT price is negligible (average of $0.44). Participating in the RT would be a large disadvantage to Denton because of higher risk but little-to-no benefits. This begs the following question – is taking the higher risk in the RT worth saving the 44-cent difference? Conservative hedgers and risk managers would answer that question with a resounding “no!”.

Figure 6-1



<u>Advantages and Disadvantages of the DEC</u>

Advantages:

- The DEC is a heat rate hedge (note that it is not an energy cost hedge unless the price of natural gas is fixed)
- 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 in ERCOT that may elevate heat rates.

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 (see Figure 1)
- Its value to Denton requires that natural gas prices go up substantially in the future.

Additional Alternatives for Extracting Value from the DEC

- Based on the last bullet point under disadvantages, Denton should be prepared to sell DEC output forward when or if there is a spike in natural gas prices. Natural gas prices tend to revert to the long-term mean after price spikes, so that increased value due to a price spike may be transitory and should be taken advantage of.
- The DEC can be used to sell firming services to other organizations looking to add renewable resources. This can mean that the DEC is not used as a producing generator, but as a contingent financial hedge (i.e., the actual dispatch and fuel use may be unchanged but the revenue from the resource will be increased). This is because at the time Denton might be obligated to provide firming energy, market purchases are more likely than the DEC to be the least cost alternative.
- As previously discussed, because of the mismatch in seasonal production profiles of renewable resources versus Denton's load profile, there are likely to be periods of time when Denton will have excess supplies (e.g., in the Spring). It may be beneficial to sell excess renewable power during these periods using the DEC to firm the transaction.

Takeaway: The DEC will serve a role as a supply cost hedge to firm Denton's renewable resource portfolio, but based on the financial evaluation in this resource plan, the majority of firming the supply portfolio will be more economically efficient through purchases in the DAM. Denton should look for opportunities to sell a portion of the DEC forward during natural gas or heat rate spikes, and for opportunities to sell firming services or to firm sales of excess renewable supplies.

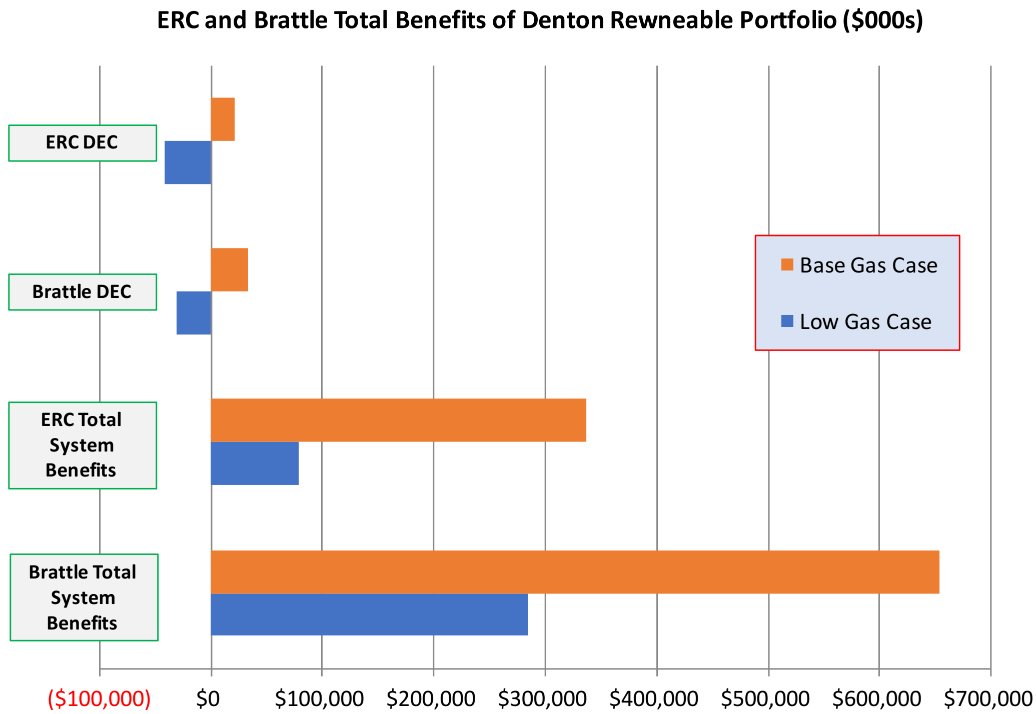
6.2 The Benefits of the Denton Renewable Portfolio ("DRP")

Figure 6-2 shows the projected financial benefits of the DRP based on the range of price projections used in the analysis for this resource plan. This is based on a portfolio where the 70% goal reached and maintained until 2023, and then additional Wind and Solar are purchased to reach 100%. Every year enough renewables are purchased to keep up with load growth.

The chart projects the financial performance of Denton's supply portfolio based on a range of future prices. Positive benefits would result through avoided additional costs if prices rise in the future. Negative values would result from low price outcomes.

The main takeaway is that the Total System Benefits are completely dependent on the price of natural gas. This is true because natural gas sets the power price in most markets because it is the marginal fuel in most markets. This is especially true in ERCOT because of its large fleet of natural gas units. If gas prices rise, power prices will rise as a result, and over time Denton's fixed-price renewable resource supply portfolio would result in avoided costs from the higher power prices. That is the measure for benefits for both Brattle and ERC evaluations. But if gas prices do not rise, power prices will stay around the current prices and as a result, Denton's fixed-price renewable resources will not avoid higher market prices and fewer benefits would result. This is the biggest uncertainty in the entire evaluation. This difference between high natural gas prices and lower natural gas prices is a change in total benefits of approximately $575 million in 2018 dollars.

Figure 6-2



6.3 Risks and Opportunities in Selecting Renewable Resources

6.3.1 Resolving the Renewable Status of the Whitetail Supply

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. More renewable energy is needed if Whitetail is considered a conventional resource. In terms of energy, a single wind resource could cover either the additional energy needed (100 MWs of wind is equal to approximately 400,000 MWhs). Or additional solar could be selected along with a wind resource (100 MWs of solar is equal to approximately 220,000 MWhs of energy).

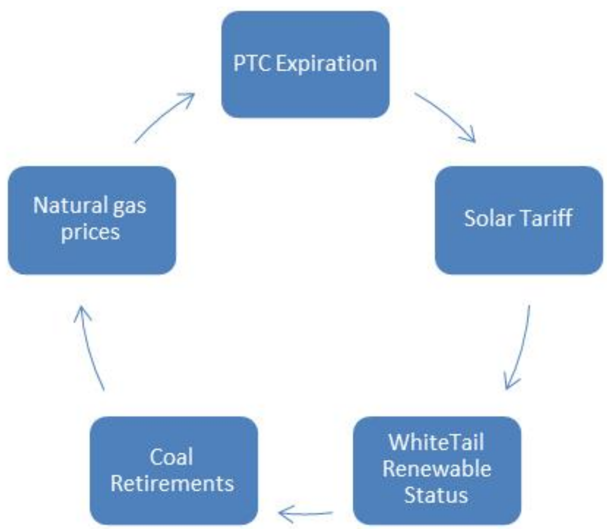
The current energy supply portfolio falls far short of a balanced and diversified portfolio because solar is only 30 MWs. The portfolio is also unbalanced because a large amount of the renewable supply is a low on-peak West Texas wind profile (Santa Rita). Adding the Bluebell solar (30 MW) resource will still produce very little summer on-peak production. The 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 against a scenario where natural gas price increases raise the power price and lower the market heat rate. Therefore, 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.

6.3.2 Planning Risks

There is a series of known risks that could drive Denton to accelerate reaching the 100% goal, or decelerate reaching the 100% goal past 2024. These risks are labeled in Figure 6-3. The next section will discuss some of these risks.

Figure 6-3



A particular risk in the acquisition plan is that there is a possibility of a federal solar tariff. It is not clear how the tariff will affect prices or the term of the additional costs,, but preliminary estimates are that it could increase average costs of solar from the current \$25/MWh up to \$40/MWh. Under the current price environment \$40/MWh is not competitive with wind resources.

An alternative to avoiding the solar tariff is that Denton could acquire more Coastal wind resources that feature the characteristic summer peak production profile. This is the closest substitute for solar among the renewable resources. A second alternative is utility-scale wind resources with a storage component, now or in the future. Altering the profile of West Texas wind into a more on-peak production profile will improve hedge effectiveness. A third alternative is to purchase solar as the tariff prices and supplies readjust to market conditions or the tariff is no longer an issue. Denton can wait and test the market prices after reaching the 70% level.   Waiting on solar would decelerate reaching the 100% goal.

A recent spate of announced coal retirements totaling 4.2 GW of generation capacity from Vistra Energy (Monticello, Sandow, and Big Brown) may increase power prices during the next few months. This is likely to have much less impact on the price of wind versus the price of solar because baseload coal plants count in the market at their full rated capacity amount. Solar counts at only 77% of its installed capacity in ERCOT and West Texas wind counts only 18% of its installed capacity. This could accelerate the amount of wind purchased by Denton, especially Coastal wind as a substitute for solar.

A second accelerator that should be considered is that the PTC has already reduced the subsidy to wind producers. The supply of wind may be at its maximum now because of the rush to beat the expiration date of the PTC. Because the supply of available PPAs is highest now, this could be an inducement to accelerate the acquisition of wind in a buyer's market.

The current natural gas market is reacting to low commodity prices. Natural gas is a byproduct in many regions. This means that it is a product that does not stand on its own economics for production, but depends on the crude oil (natural gas is frequently produced in association with crude oil) or natural gas liquids markets to provide revenue from production. The number of drilling rig dedicated to drilling for gas has declined to a multi-year low. At the same time, demand for exports of this low-cost commodity has been driven up to levels never seen before. Low prices have caused large substitution of the natural gas for coal in the electric power sector. Coal-based power plants are closing all over the country. In the past, when steady increases in demand for natural gas have met with a lower number of drilling rigs over a several-year period, natural gas prices have increased dramatically (e.g., the early 2000s saw prices double and then triple over a few-year period). This recognition of the risk to natural gas prices could act as an accelerator to Denton's acquisition plan.

6.4 The Path to 100% Renewable Resources

Denton has adopted the goals of 70% renewable resources ("RE 70") in its power supply portfolio by the end of 2019, and 100% ("RE 100") by 2035. The evaluation in this resource plan indicates that the RE 100 goal is achievable much earlier than 2035. There is no financial penalty or premium to moving from a 70% renewable resource goal to a 100% renewable goal. This is a decided advantage of ERCOT's energy-only market design. In the ERCOT energy-only market, PPAs are needed by all consumers without sufficient generation resources if they wish to lower their supply cost volatility. It is standard practice for consumers to hedge up to 100% in this market to avoid price risk.

Not only is there no penalty, but because wind and solar PPAs and conventional PPAs are both composed of the same product (i.e., they are all composed of electric energy priced in $/MWh), they are substitutable. If a consumer wants to establish a 100% supply hedge, it is easier to achieve through daily portfolio balancing with a renewables portfolio than with conventional block purchases. Both renewables and conventional block purchases need to have DAM purchases and real-time sales to match the variable weather-influenced load profile. The difference between the two is just a matter of degree as to the ratio of solar and wind PPAs acquired and the spot market disposition of the supply. Because solar PPAs cover on-peak supply exclusively, spot market balancing transactions are less risky and costly than the on-peak load-following purchases required with a supply portfolio of conventional forward block purchases. And if wind resources are matched with solar, the combined production profile offers less risk than that of a convention block, with the resulting production better matching the profile of load.

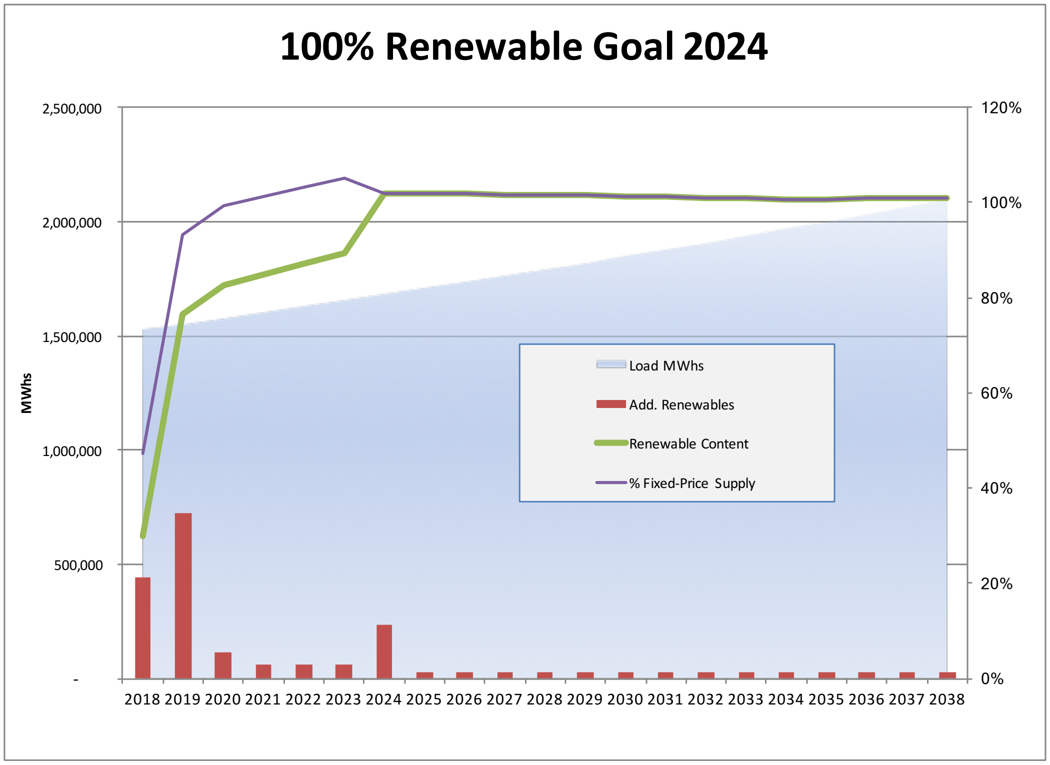
Gradual Adoption Path

Denton has several paths to choose from to reach its RE 100 gal. But the first Denton Renewable Portfolio (DRP) goal is RE 70 by the end of 2019.

The RE 70 level can be achieved by executing PPAs for low-priced supplies that have been offered in the current Renewable RFP (Oct 4, 2017). Because this RFP has several viable low-cost supply options, Denton can easily achieve the 70% level by selecting the lowest cost and lowest risk supplies for its current supply portfolio. Figure 6-4 shows a possible outcome to achieve this 70% goal, and eventually the 100% goal by 2024. The chart includes Denton's load, seen as a gradual increase in the light blue shaded area, additional renewable purchases labeled "Add. Renewable" and depicted by the red vertical bars, and lines showing the progression of the proportion of renewable resources and of the amount of supply with fixed prices.

In the chart, the NextERA Whitetail supply is not counted as a renewable source because it is not a physical renewable source, but uses Renewable Energy Credits (RECs) to claim renewable status. An alternative scenario is included later in this discussion that counts the NextERA Whitetail supply as a renewable energy supply. In either case, additional physical renewable supplies are required. Depending on the location, price, congestion environment, and the production profile of the resource, more supply may be added above the additional 47% of load in energy purchases that are needed to achieve the RE 70% goal by 2019.

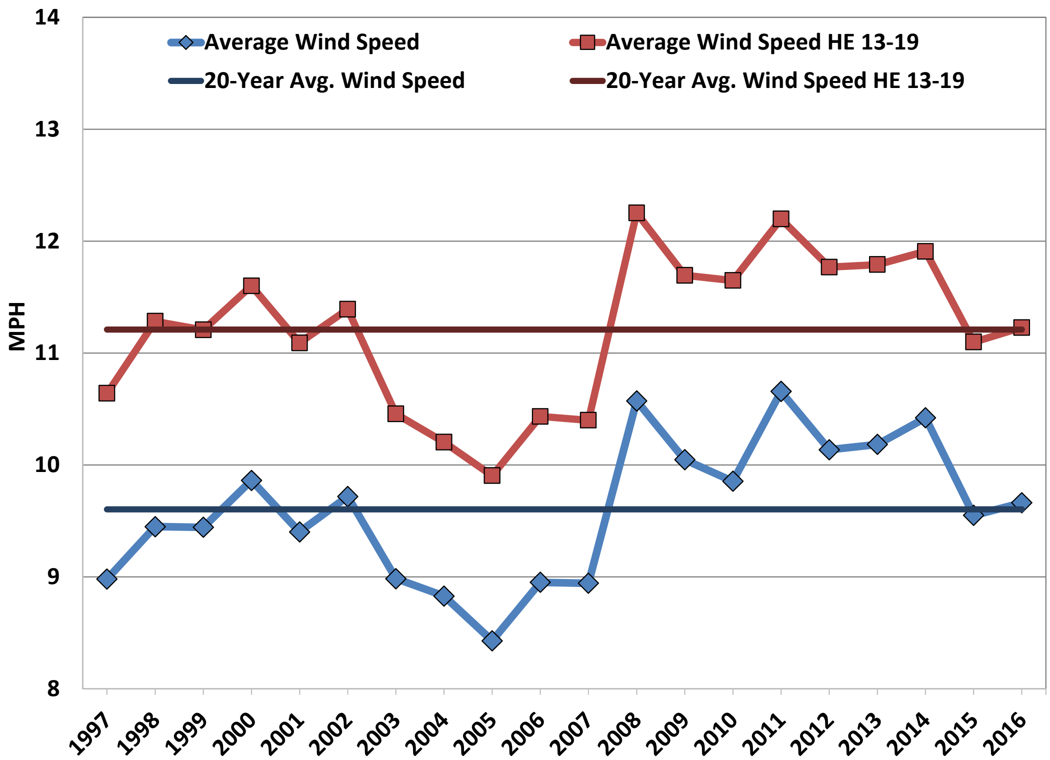
Figure 6-4



Why possibly purchase more than the 47% needed to meet the RE 70 goal? The amount of additional supply is a function of the uncertainty of renewable production. The amount of wind production can easily vary by 15% on an annual basis. Figure 6-5 show historic average wind speed in ERCOT over the last 20 years. The chart shows the 20-year average for both a 24-hour period and a 7-hour on-peak period, as well as the annual deviation from the 20-year average. This variability in wind speed will affect the amount of wind production. Some years may be 10% over expected production, others may be 10% under, and 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.

Figure 6-5

Figure 67: Historic Average Wind Speed



Another part of the acquisition path depicted in Figure 6-6 is the assumption that Denton will purchase shorter term (1 to 4-year duration) renewable resources to adjust the RE goal to reach 100% and to constantly maintain that level.

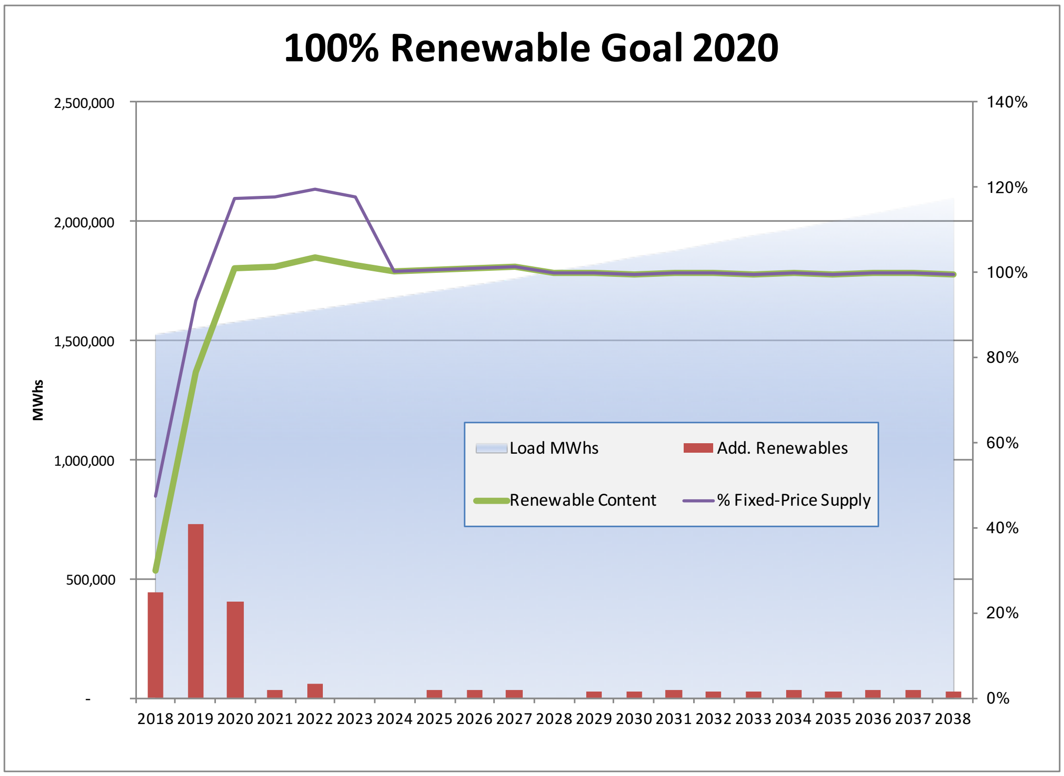
Constantly maintaining a target level can be done with a variety of renewable resources and demand-side management programs. These should include energy efficiency and adjustments to load from rooftop solar installations, battery (storage) installations, Demand Resource programs and any other influences that affect demand. This is a lower-risk strategy because it is flexible, and allows new technology and commercial programs like household battery storage and electric vehicle introduction that are uncertain as to the rate of adoption and cost impact. The magnitude of adoption might be far larger and faster than currently expected. This could be termed a "Wait and See" strategy.

Besides the new acquisitions that are needed by next year to reach the RE 70 goal, another larger supply is the replacement of the Whitetail NextERA supply in 2024 because the contract ends in December of 2023. This acquisition is seen under the "Add. Renewables" category which shows the annual RE PPAs acquired in each year.

Early Adoption Path

A second path for achieving the RE 100 goal is earlier adoption. This path is predicated on the fact that the PTC that benefits wind development is ending. The loss of the subsidy will substantially reduce the number of future wind installations in the state under current regulations and economic conditions. The current low-cost PPAs for wind may not be available in the future. Denton would accelerate the wind PPAs acquisition to produce the RE 100% goal four years earlier, in 2020 rather than in 2024, as shown in Figure 6-6.

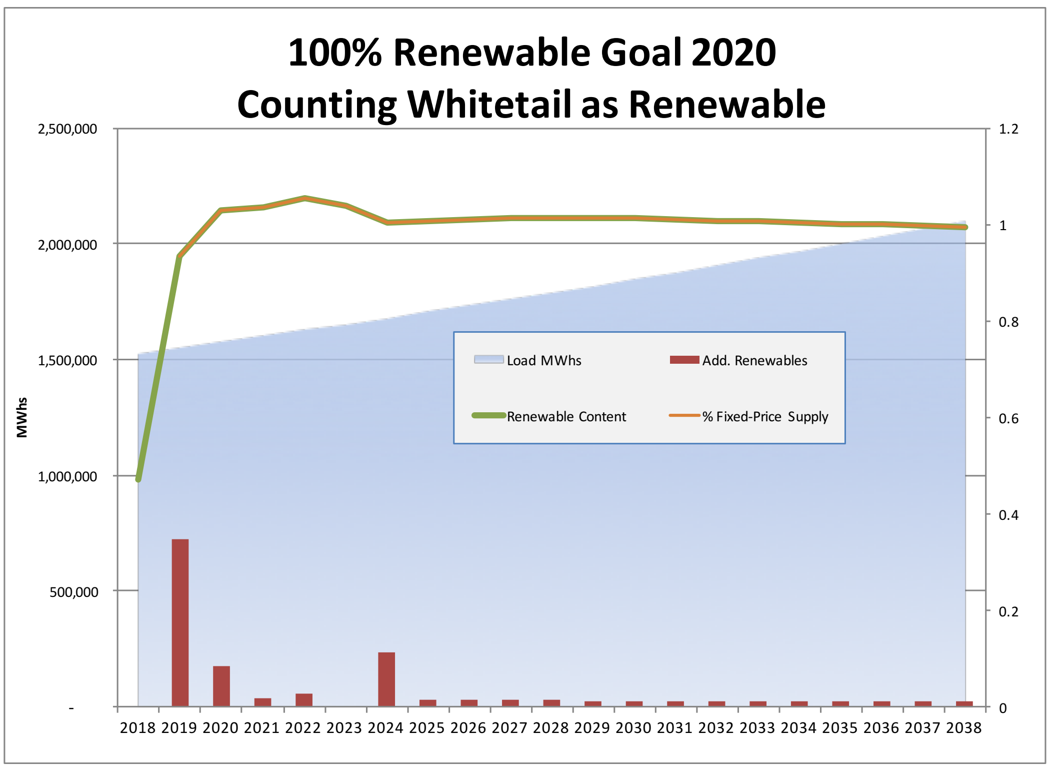
Figure 6-6



This accelerated wind acquisition would result in excess power supply over the next few years due to the Whitetail non-renewable resource, and Denton would have to manage fixed-cost risk (the risk of market prices falling because Denton would have more supply than its load for 4 years). If the Early Adoption path is selected, the excess power supply would be approximately 18% for the years 2020 through 2023. The excess supply would end with the Whitetail contract expiration. This is a potential advantage because it removes the additional demand for a renewable resource purchase in 2024 if renewable resources are more expensive in the future. This path corresponds to the potential for a natural gas rate shock in the next few years as the low rig counts could cause a natural gas price shock while the industry spins up to meet the large increases in demand that will be driven by growth of liquefied natural gas(“LNG”) exports and by the increasing retirements of coal-fired generation units in the grid.

Including the NextERA Whitetail supply in the renewable category will also accelerate the RE 100 goal to 2020. But it also requires replacement of this energy in 2024. This is depicted in Figure 6-7. The principal advantage of this scenario is that it doesn't produce additional fixed-price supply (the 18% excess supply discussed previously). The principal disadvantage with including Whitetail in the supply portfolio is that it could cause an audit risk as to the validity of its renewable status. The REC program does not require load to be tied to actual contemporaneous renewable production. It can be from any renewable resource or combination of resources. It can be used in an abstract financial sense. The credits could be used to represent production in previous years and do not represent a contemporaneous physical offset. Because these RECs are not tied to renewable costs, there is a great deal of controversy about their use. This is particularly problematic for a municipal utility that is exempt from the Renewable Portfolio Standards that enabled this program, and it could increase the organization's reputation risk.

Figure 6-7

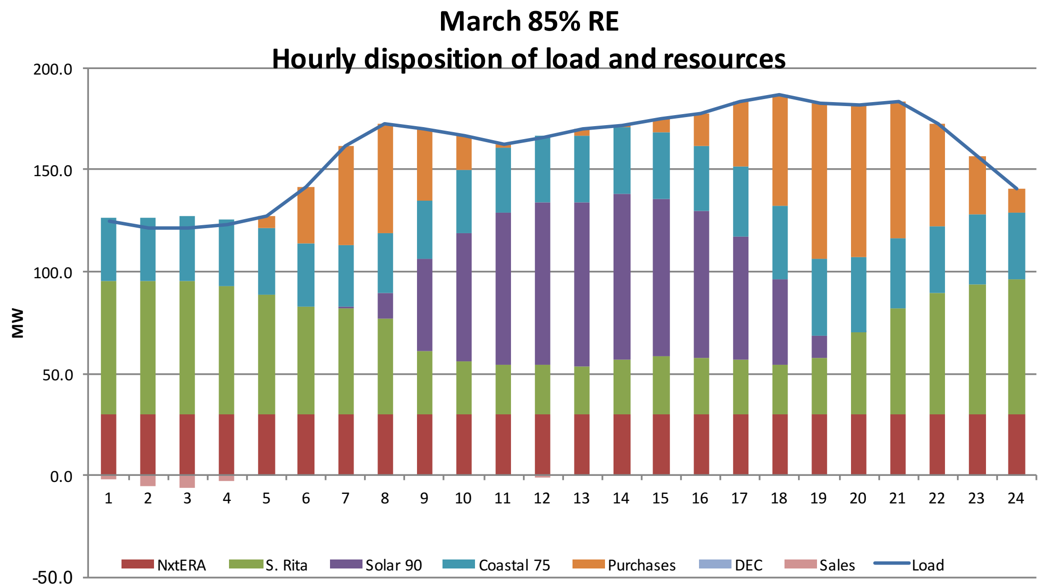


6.5 Additional Considerations

The analysis and evaluation for this resource plan assumes that Gibbon's Creek will be decommissioned by 2018.

An 85% renewable goal may be a natural fit based on Denton's load and the daily and seasonal production profiles of renewable resources.

Figure 6-8



For example, consider the month of March. The chart in Figure 6-8 shows a typical disposition of resources in the month of March at an 85% renewable goal. March is the time of year that would typically require a lot of excess sales of energy due to seasonally high wind production. But at 85% renewable (which would leave open 15% of Denton's load), only minimal sales in some early-morning hours would be required as can be seen by the bars in the chart that extend below 0. "Solar 90" and "Coastal 75" represent prospective purchases of those resources at 90 MW and 75 MW respectively. At a 100% renewable goal, there would be much more excess sales in certain hours. So, an 85% renewable goal may be a more natural fit to reduce the impact of sales of excess supply.

Potential risk is affected by how Denton chooses to reach its renewable goal. Different combinations of renewable resources will change where Denton will be long and short in certain hours and during certain times of year. For example, a greater amount of Coast wind could be substituted for Solar. This could reduce the potential risk to Denton of a retroactive Solar tariff.

Figure 6-9

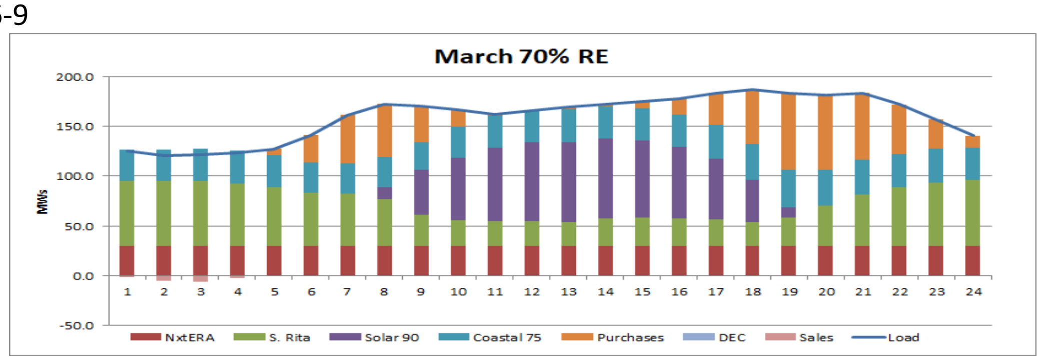


Figure 6-9 shows a daily profile from the Month of March at a 70% renewable goal with the addition of 75 MW of Coastal wind and 90 MW of Solar. Excess sales are reduced in the early morning hours, and a greater amount of purchases are necessary in the earlier and later parts of the day to match load requirements.

Figure 6-10

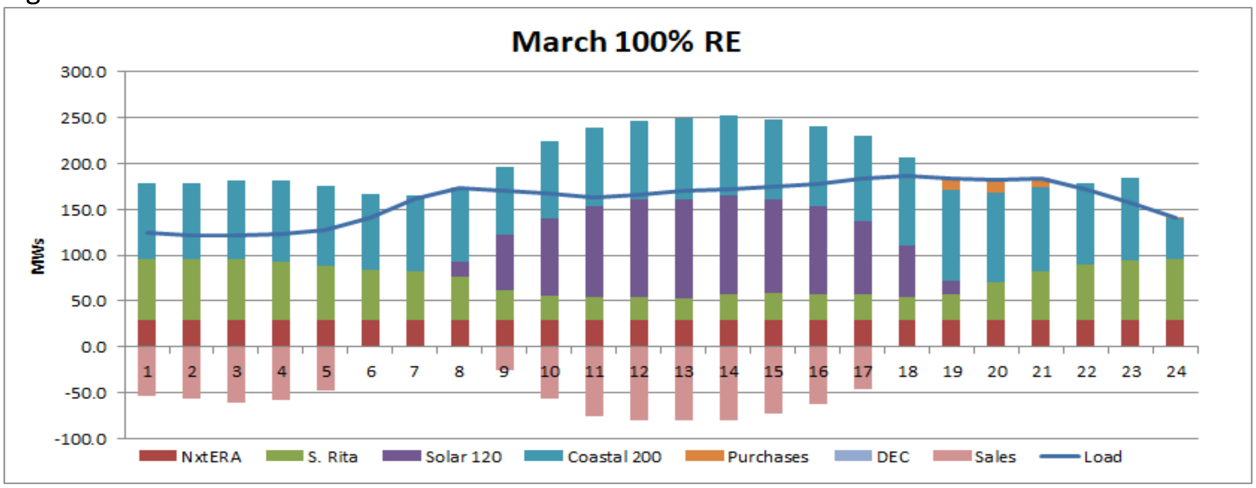


Figure 6-10 show the March profile at a 100% renewable goal, reached by adding 200 MW of Coastal wind and 120 MW of solar. Sales of excess power increase, and would occur in the early morning hours and during on-peak hours.

Figure 6-11 shows the 12 monthly production profiles at a 100% renewable level reached by adding 150 MW of Coastal wind and 180 MW of Solar. An alternative is shown in Figure 6-12, showing the 12 monthly production profiles at a 100% renewable level, reached by adding 200 MW of Coastal and 120 MW of Solar.

Figure 6-11

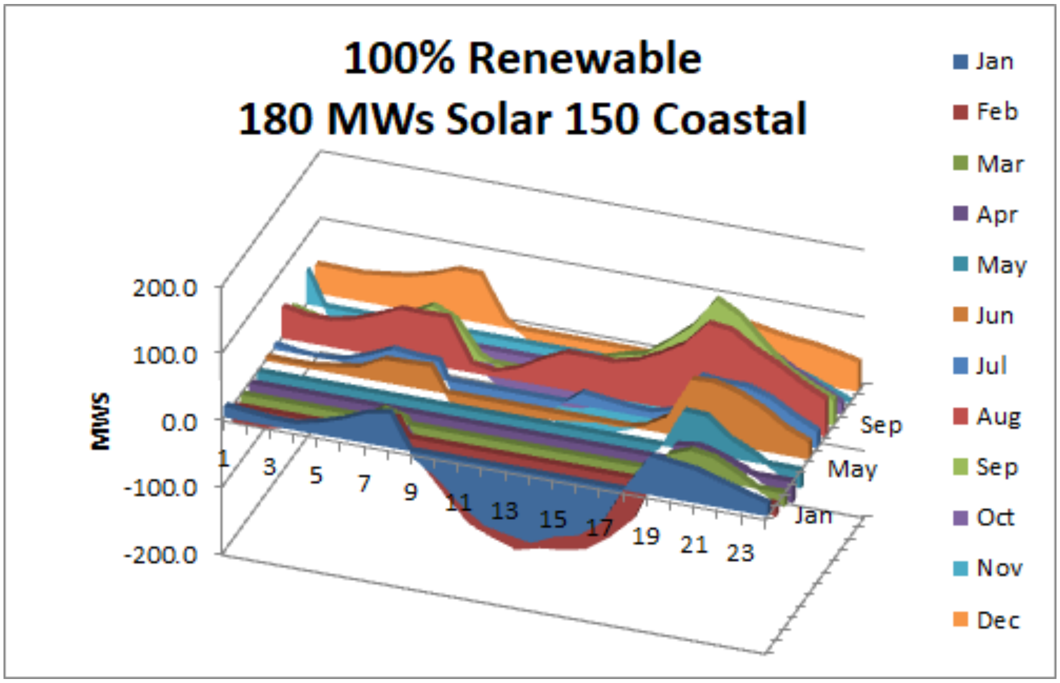
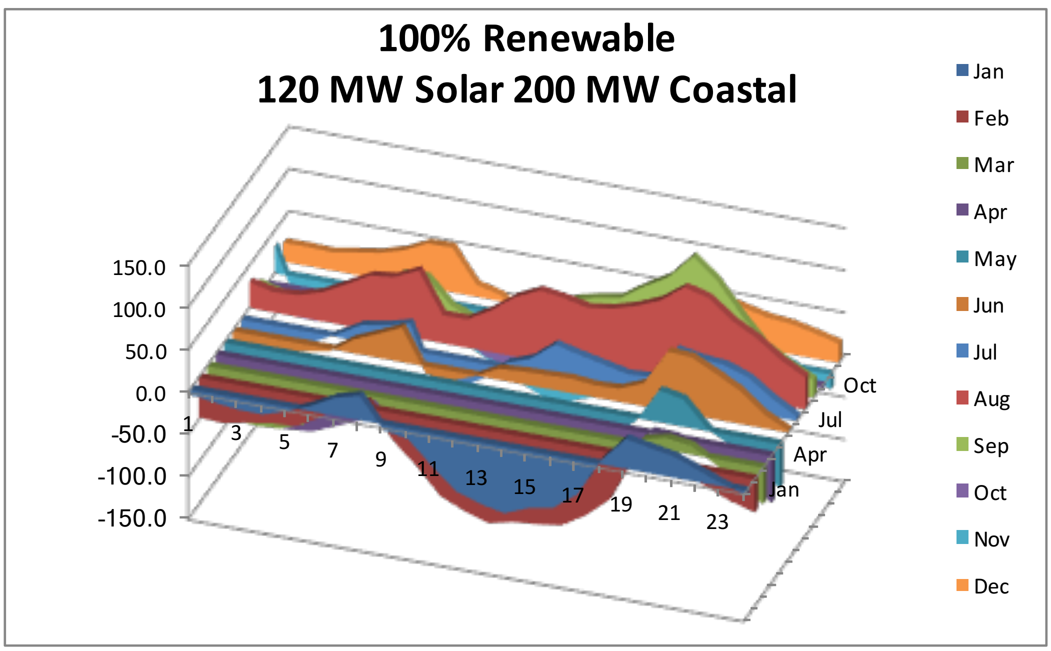


Figure 6-12



200 MW of Coastal and 120 MW of Solar is a different configuration to get to 100% Renewable. This is a configuration where additional Coastal substitutes for some Solar. This combination would be more attractive depending on the degree of concern about a potential federal Solar tariff. It would be possible to substitute even more Coastal wind for Solar.

If it seems less risky to wait to purchase Solar at a later time, to wait for resolution on the Solar tariff issue, Denton could substitute more Coastal wind for Solar. Coastal wind could be featured to get Denton up to the near-term renewable goal of 70%, with the quantity dependent on the decision of how to classify Whitetail, and then wait on a resolution of the Solar tariff issue, and then purchase more Solar in the second stage of purchases to get up to 100% renewable.

The concern is that Solar could go from prices in the mid-$20 per MWh to the low-$40s per MWh, and at that level it would no longer be a least-cost supply alternative.

<u>PTC and ITC Reduction and Elimination Schedules</u>

Figure 6-13 shows the reduction and elimination schedules for the federal PTC and ITC. Wind tax subsidies go away by 2019. The wind PTC is already being reduced. Construction needed to have started in 2016 to avoid the first reduction of 20%.

The reduction schedules also reinforce the idea that it is less risky to wait on Solar, whereas earlier action on wind ensures better pricing because of the remaining PTC subsidy.

Figure 6-13

Consolidate Appropriations Act 2016

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Future
Wind PTC		Full	Full	80%	60%	40%	0%	0%	0%	0%	0%	0%	0%
	Utility	30%	30%	30%	30%	30%	26%	22%	10%	10%	10%	10%	10%
Solar ITC	Commercial/ Third Party Owned	30%	30%	30%	30%	30%	26%	22%	10%	10%	10%	10%	10%
	Residential Host-Owned	30%	30%	30%	30%	30%	26%	22%	0%	0%	0%	0%	0%

7.0 Summary of Recommendations

Several different portfolio combinations will allow Denton to achieve its renewable targets.

To reach its goals, Denton should purchase approximately 30% to 40% of load in 2019 with additional renewable resources. The evaluation conducted for this resource plan indicates that the least-cost combination that provides 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% RE goal. Final selection of the ratio will depend on actual proposals and terms and conditions from the RFP offers. Given specific proposals, variations to this "ideal" diversification may result in other least-cost portfolio makeups.

An optimal location representing a balance of sufficient irradiance, limited cloud cover, and manageable congestion for would be close to Midland.

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.

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. This may already be in the works, but the data shows inadequate hedge levels in early 2018 for Denton's load and no CRRs related to these renewable resource purchases.

Decision Summary

In addition to the recommended amounts, types and locations of renewable resources, Denton will need to make several decisions that will shape the development of its renewable resource supply portfolio.

- Count Whitetail as a renewable resource?
    - If not, is Denton willing to handle the additional fixed-price risk of the Whitetail supply in addition to the fixed-price quantity of renewable resources necessary to meet Denton's goal(s)?
- Will Denton choose to delay solar purchases because of a potential federal solar tariff?
    - If so, potential alternatives include:
        - Purchase additional amounts of Coastal wind as a substitute?
        - Alter the profile of wind resources with storage?
        - Delay solar purchases until the issue is resolved, or solar prices and supplies adjust to the tariff
- Should Denton accelerate renewable purchases, especially of wind resources, because of:
    - increasing retirements of conventional fossil fuel generation capacity?
    - scheduled reduction in the PTC?
    - risk of rising natural gas prices?
- Should Denton move forward the date of the 100% renewable goal?
- Should Denton purchase additional renewable supplies above its target levels because of the annual variance in production amounts?
- Portfolio allocation decisions – there are various allocations between Coastal wind and Solar to meet Denton's goals (e.g., 180 MW of Solar and 150 MW of Coastal to meet a 100% goal, or 120 MW of Solar and 200 MW of Coastal). What is the preferred allocation?

Appendix A - Hedging 101 & Applications for Denton

Introduction and Definitions/Concepts

The purpose of commodity hedging is to mitigate the risk of adverse financial exposures resulting from the commodity-based business operations of the hedging party. Hedging is typically focus primarily on price risk, but with demand-driven commodities like natural gas and power, it also focuses on the adverse financial exposure from volume risk.

Before discussing the objectives and mechanics of hedging, it is important to introduce some concepts and definitions:

- ***Floating price exposure*** – an exposure to variable market prices resulting from an obligation to supply a commodity without sufficient resources to do so, or ownership of commodity resources (or an obligation to take delivery) without known sales revenues. Floating price exposures involve a volumetric obligation that has a yet-to-be-determined price.

- ***Fixed price exposure*** – the opposite of a floating price exposure: an obligation to purchase or sell a quantity of a commodity for delivery in the future at a known price today, or a paid inventory of a commodity.

- ***Native exposure*** (or ***native physical exposure***) – one or more floating price exposures that are native to the ongoing market operations of the hedging party. An example is an electric distribution utility that has an obligation to provide energy to its customers but lacks the fixed-price generation resources to do so. Because it has a lack of generation resources it must acquire the needed energy supplies in the open market.

  It is exposed to price uncertainty during any measurable period in the future when it has insufficient energy resources while maintaining its obligation to serve its customer base. Relative to its fixed rate structure (fixed sales revenues), falling power prices in the future would benefit the utility, whereas rising power prices in the future would hurt the utility. Yes, utilities often have some degree of control over changing rates, which can allow adjustments for changing supply prices, and in the long run can substantially reduce supply cost risk, but the ability to raise rates may be limited for various reasons, and thus a utility may seek to reduce its exposure, completely or to some degree, to potentially higher prices.

  For illustrative purposes, additional examples of a native exposure include:
  - the risk of falling prices for a natural gas producer
  - the risk of reduced margins for a petroleum refiner that has exposures to both rising and falling prices. A refiner is detrimentally exposed to rising crude oil prices and falling prices for oil products (e.g., gasoline, diesel, jet fuel).

    - *Note – a natural gas-fired power plant has a native exposure similar to that of a petroleum refinery. A gas-fired plant is exposed to falling power prices **and** rising natural gas prices. This is the native physical exposure of the DEC.*

- ***Short*** position – a short position refers to a native exposure where the hedging party has an obligation to sell to end users at a fixed price, but ***lacks sufficient supply*** to meet its sales obligation, and thus is exposed to the floating price risk of potentially rising prices for supplies it will be obligated to purchase in the future. A *short* position is a label for a native exposure based on a ***shortage of supply***.

  Denton's native physical exposure is a short position. One part of the DEC's native physical exposure is a short fuel position.

- ***Long*** position – a long position is the opposite of a short position. It is a native exposure where the hedging party has an ***excess of supply***, or has a greater quantity of ownership compared to its fixed price sales obligations, and is exposed to the floating price risk of potentially falling prices for inventory that it plans to sell in the future. Natural resource commodity producers typically have a native long position.

  The other part of the DEC's native physical exposure is a long power position (combined with its native short fuel position).

- ***Opposition hedge*** – a useful definition of hedging is the following: *the establishment of one or more positions* to reduce financial uncertainty or risk from a floating price exposure*.

  *******In this context, the definition of a <u>*position*</u> is a fixed-price contractual obligation to make or take physical delivery, or to make or take a financial settlement based on a commodity price differential. The key to risk reduction is that the hedge position has a fixed-price that offsets the floating price exposure of the native physical position.

  An ideal opposition hedge would be both <u>***equal***</u> and <u>***opposite***</u> of the native exposure being hedged:
    - <u>*Equal*</u> in terms of the quality, quantity and duration of the exposure being hedged (or the chosen quality, quantity and duration based on the risk tolerance or risk preference of the hedging party), and
    - <u>*Opposite*</u> in terms of market direction:
        - a long position to hedge a short native exposure
        - a short position to hedge a long native exposure

  A producer hedges its exposure by making fixed-price sales in the future to offset excess supply. A consumer (like DME) hedges its exposure by making fixed-price purchases in the future to offset the floating price exposure of a native shortage of supply.

A perfect hedge would result when long positions (or exposures) exactly balance short positions (or exposures) in terms of quantity, quality and duration. A perfect match would result when the financial exposure is completely balanced (no net short or long exposure), and no credit risk exists with any counterparties to any unsettled positions. Of course, no such thing as a perfect hedge exists.

Hedging for Denton

For Denton to hedge its native short position, it needs to purchase fixed-price energy for delivery in the future. These energy purchases (e.g., PPAs, forward purchases from the market) are long positions that hedge Denton's short market exposure. Denton's supply portfolio management operation is a *hedging* operation to manage the price risk (and volumetric risk) of its native short physical position.

*Note – it is important to understand that the DEC is an incomplete hedge. The DEC can produce power at a fixed heat rate, but until a supply of natural gas has been procured **at a fixed price**, the DEC still results in a floating short exposure to natural gas prices. Only when a fixed price for natural gas is paired with the fixed heat rate of the DEC will the result equal fixed-price power.*

Basis Risk / Basis Hedging

Hedges frequently come in two parts, or require two separate transactions to make up a complete opposition hedge: a commodity hedge and a basis hedge. Unless the market pricing of the hedge position perfectly tracks the price exposure of the native exposure, a basis risk exists. This leads to another concept and definition:

- ***Basis*** – there are two definitions of basis. There is a narrow, textbook, futures market-oriented definition, and a broader definition for markets where non exchange-traded instruments are used for hedging (DME's circumstance).

  The textbook definition: the basis is the difference between the local cash price of a commodity and the price of a specific futures contract of the same commodity at any given point in time. Basis = local cash price – futures price.

  A perfect example of this comes from the natural gas market. A primary hedging instrument in natural gas is the Henry Hub natural gas futures contract based on a delivery point in Louisiana, and traded on the New York Mercantile Exchange (NYMEX) division of the Chicago Mercantile Exchange. Yet the vast majority of hedgers using NYMEX natural gas futures are exposed to a local cash price based on a pipeline pricing point other than the Henry Hub. For example, an electric utility with natural-gas fired generation in northern California will pay a local cash price for natural gas typically based on the PG&E city gate natural gas price index. If it uses Henry Hub natural gas futures contracts as a hedging instrument, it is exposed to the basis of PG&E city gate prices versus Henry Hub prices (geographic price differential).

The correlation between PG&E city gate prices and Henry Hub prices is positive, but not that highly positive, and this results in a substantial price and value tracking error. The financial payoff of the futures contract hedge will not match the price change over the life of the hedge of a physical exposure based on the PG&E city gate price index, resulting in a suboptimal and imperfect (aka "dirty") hedge.

If a hedger can tolerate the financial uncertainty (risk) of a price index mismatch (e.g., PG&E city gate index vs. Henry Hub index), it may choose not to hedge the basis. But if the hedger decides that it needs to manage the basis risk, it may choose to execute a separate, second transaction to hedge just the basis. For example, a gas-fired electric utility in northern California might hedge its risk of rising natural gas prices by a) purchasing natural gas futures contracts (commodity hedge) and b) by purchasing a basis swap contract that will financially settle based on the difference between the PG&E city gate index and the Henry Hub index (basis hedge). This two-component hedge is commonplace in the natural gas industry.

Thus, a complete opposition hedge requires hedging both the commodity risk and the basis risk.

Fortunately, ERCOT offers a separate instrument for hedging basis risk – Congestion Revenue Rights (CRRs), with two types that pay off like swaps (CRR obligations) or options (CRR options). CRRs will be addressed further in the next section of this document.

The broader and more useful definition of basis is that it is the difference between the local cash price of a commodity and the price of the hedging instrument of the same commodity at any given point in time. In Denton's terms, it would be the difference between the local cash price of energy that Denton needs to meet its load requirements versus the price of its hedging instruments (e.g., PPAs and forward energy purchases).

<u>Denton's Basis (Congestion) Risk & Basis Hedging</u>

To further explore this topic, it is important to recall how ERCOT prices energy. Consumers purchase energy at load zones and power plants sell energy at resource nodes. Generally, the prices of resource nodes do not match those of load zones because of congestion in the transmission system. Energy purchased from ERCOT to meet Denton's obligation to meet its customer load requirements is priced at Denton's load zone (its "local cash price" in the definition of basis) whereas energy produced from Denton's generation resources (e.g., PPAs) is priced at generation resource nodes. This means that in addition to Denton's native short position vis a vis electric energy, it also has a basis risk exposure.

As previously mentioned, ERCOT operates a viable market for hedging basis risk: CRRs. CRRs come in two types: obligations and options. Obligations are like swaps – they have a symmetrical pay off that can be positive or negative. On the other hand, options have an asymmetrical payoff profile – they pay off positively for the option holder, but the option holder is not exposed to a negative payoff. NOIEs can link CRRs to an option to hedge DAM to RT congestion.

ERCOT congestion (basis) risk can be hedged for years forward by consistent participation in the CRR market. It is important to realize that not hedging basis (congestion) risk is implicit speculation on the basis. It is a conservative hedging and risk management practice to perfect hedges as much as possible, and this includes hedging basis risk

Note – although it is recommended to pursue a conservative approach and hedge the basis (congestion risk), not hedging the basis is fine, IF it is a conscious decision by senior management and is explicitly acknowledged as an un