Technological Alternatives to The Renewable Denton Plan

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Denton Municipal Electric

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- **Fuel Cells**
  A fuel cell converts chemical energy from a fuel into electricity through a chemical reaction of positively charged hydrogen ions with oxygen. Unlike batteries, the fuel cells can produce electricity continuously for a long as they have a fuel source and oxygen. The high cost of materials such as platinum and the lack of fuel availability prevent this technology from being a viable option for Denton at this time.

- **Energy Storage**
  One of the main challenges of renewable energy is that it is intermittent. Unlike traditional sources of generation, it cannot be dispatched to meet demand. One potential solution to this issue is utility-scale energy storage. Various types of energy storage are considered below.

  - **Battery Storage**
    While lithium ion batteries have made great strides in electric vehicles and show promise for residential energy storage, battery storage facilities have a much shorter life span than typical natural gas generators, about 10 years compared to 30 years. This means that the installed cost per kW of capacity for battery storage needs to be about 1/3 of the capital cost of a natural gas plant to be cost competitive. Flow batteries are far superior to lithium ion for utility-scale storage applications. Flow batteries can be cycled more deeply (100% compared to about 60% for lithium ion), have a longer cycle duration (less than 6 hrs. vs. 2 hrs. for lithium ion) and have more cycles (longer battery life) than lithium ion. However, flow batteries are in the R&D phase and are at least 8-10 years away from being proven and economical for utility scale applications. Currently flow battery technology is ~$2,500 / kW compared to around $800 / kW for highly efficient quick-start natural gas generation. For these reasons, this technology is not considered to be a viable solution for Denton's energy needs at this time.

  - **Compressed Air Energy Storage (CAES)**
    Excess energy can be stored in underground caverns or salt domes as compressed air when electric price and demand are low and then released to drive a turbine to generate electricity when demand rises and the value of electricity is higher. The limited availability of the geologic formations in the Denton area and scale of this technology, as well as a relatively small market price differential between high and low demand periods prevent it from being an economic solution for Denton.

  - **Surface Reservoir Pumped Hydroelectric Storage**
    This technology works by pumping water from a lower lake to a lake with a higher elevation using electric pumps at off-peak times and then releasing the water back into the lower lake. The flowing water turns turbines to generate electricity at times of high demand. The cost and scale of this technology, lack of suitable locations with adequate differences in lake elevation and relatively small market price differential between high and low demand time periods, prevent it from being an economic solution for Denton.

- **Liquefied Air Energy Storage (LAES)**
  Converting air to liquid to be used for energy storage is a technology that is still in early stages of deployment. It entails cooling air to -342° F by means of an electric air liquefier. At this time, this technology would be a significant energy user. The cost and scale of this technology prevent it from being a viable solution for Denton.

- **Biomass**
  Biomass generation burns a renewable organic energy source such as wood or agricultural waste products to produce steam for generating electricity. While having a fuel source that can be stored allows biomass plants to generate electricity at any time of the day, fuel handling, storage and transportation costs make these biomass-fueled power plants currently uneconomic to operate in Texas. Additionally, the emissions generated when burning wood pellets for instance, are far worse than those from operating a modern, highly efficient and low emitting quick start gas plant. Additionally, a considerable amount of water will be used in most biomass forms of generation. Based on increased emissions and high water usage, this organically-sourced energy generation appears to be disproportionately expensive and not a viable option for Denton.

- **Small Coal Plant**
  A coal fired facility would not meet the quick-start needs of DME to back up the renewable energy purchased from the market. As a small facility, the fuel and the transportation of fuel would be costly. Costs and operational limitations prevent a local coal plant from being a viable option.

- **Combined Cycle**
  Combined cycle plants are typically much less flexible in their operations than a quick-start plant. They must be constantly operating unless it makes financial sense to incur the maintenance costs associated with starting and stopping the steam turbine. Small combined cycle plants (75-250 MW) have a heat rate that is slightly lower than the quick-start plant proposed by Denton, but they lack the operational flexibility needed to back up renewables and to start and stop frequently. Because they run more hours, they also use much more water than the quick-start plant and therefore produce much higher emissions. Large combined cycle plants (>300 MW) have an even lower heat rate than the smaller combined cycle plants, but they still lack flexibility and are much larger than Denton needs, and consequently very expensive.

- **Renewable Generation**
  Additional renewable generation from alternate sources has been considered to offset the variable and intermittent generation from utility scale wind and solar farms. These sources were evaluated based on their cost, output, and feasibility.

  - **Geothermal**

Use of geothermal energy to generate electricity require large quantities of water or steam at high temperatures (300 to 700 degrees F). Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface of the earth. In the United States, that is generally along major tectonic plate boundaries where earthquakes and volcanoes are located. Lack of proximity to a known geothermal reserve would prevent building a geothermal power plant as a viable option for Denton.

- **Solar Roadways**
  Solar roadways involves placing hexagonal glass panels over parking lots, streets, and walkways that produce solar energy. Because the panels would be in a fixed position, the system would not be able to generate at full capacity. This technology is not yet proven to be effective in large scale deployments and so is not a viable option for Denton.

- **Rooftop Solar**
  Installing a 5 kW solar array on every rooftop in Denton would cost in excess of $1 billion. The combined total output of all these systems would provide about one-third the energy necessary for Denton. The capital investment by DME would need to be passed through to each rate payer at more than $80 per month for 20 years. Decreased sales to customers by DME, and having electricity readily available as backup would necessitate significant base rate increases for DME to recover current revenue requirements.

- **Concentrating Solar**
  Concentrating solar collectors use mirrors and lenses to focus and amplify sunlight, to heat water to very high temperatures that can be converted to steam to drive a power plant. Linear concentrator panels heat fluid in a tube that runs the length of the panels. The heated liquid is used to create steam which is used to drive a turbine. Power Towers also heat a molten salt solution by focusing solar energy from ground based mirrors to heat a central collector which create steam to drive a turbine. Cost, availability, and questionable environmental friendliness prevents these generation sources from being viable solutions for Denton at this time.

- **Tidal Energy**
  Tidal energy generation is a form of hydropower that is produced by capturing the power of tides or currents. Like geothermal energy, the feasibility of this type of generation is highly dependent on location. Because of our distance from coastlines and suitable ocean currents, tidal energy is not a viable solution for Denton.

- **Water Pipe Turbines**
  This technology involves the installation of small electric turbines in gravity fed waterlines. Denton does not have many waterlines where this technology would be

effective. This technology is in its early stages of development. The cost and scale of this technology prevent it from being a viable solution for Denton.

- **Waste-to-energy (WtE)**
  This process typically involves the burning of organic material as a fuel source for electric generation. The waste incineration process may emit fine particulate, heavy metals, trace dioxin and acid gas as well as fly ash, which is considered a hazardous waste and requires hazardous waste disposal. One form of WtE is the harvesting of methane from landfills. At this time, most harvested methane from the Denton Landfill is under contract.

- **High Voltage DC Transmission (HVDC)**
  The use of HVDC lines to connect the ERCOT grid which DME operates in to the Western Interconnection grid and/or to the Eastern Interconnection grid would facilitate the receipt of renewable power from other areas of the country that have excess to sell.

Strategic Proposals to Increase Renewable Portfolio

- **100% renewable**
  - No quick-start back up capabilities
  - Immediate 9.5% rate increases
  - Approximately $220 Million more expensive than Renewable Denton Plan
  - Excess energy purchased that must be sold at market prices (900,000 MWh / year)

- **83% renewable (w/out gas backup)**
  - No quick-start back up capabilities
  - Immediate rate increases
  - More expensive than RDP
  - Excess energy purchased that must be sold at market prices
  - Market energy purchased will likely include State averages for emissions, which are far greater than the RDP.

- **Conservation/efficiency**
  - No quick-start back up capabilities
  - At this time, such an option is both difficult to rely on as controllable and effective in overall load management
  - Attempts at conservation in the ERCOT market have not received the levels of response that Denton would require to have material control of overall Denton load, minute by minute. Consequently, a conservation and efficiency plan remains a priority and focus for DME towards its customers, however, it is not a viable solution to RDP.

- **Backed up by others/market**
  - 2 hour call option allows for market pricing vulnerability

- More expensive than proposed Renewable Denton Plan
- A fully flexible quantity and timing of delivery back up call option will be considerably more expensive than other choices considered. A less flexible option, would still be more expensive than other options and would expose Denton to selling of excess supply at unknown prices.

- **Wait and See**

  It has been proposed that the City wait and see what advances in future technology will bring with regards to increasing the renewable portfolio and decreasing the dependency on fossil fuels. The proposed Renewable Denton Plan will decrease the emissions from the current DME portfolio 75% by increasing renewables to 70% while lowering rates and maintaining reliability. While some opportunities are intriguing and worth continued monitoring, waiting possibly years for nascent technology to develop delays the opportunity to start decreasing emissions and saving on energy expenses. The proposed increase of renewables in the energy portfolio requires quick start generation to be the most cost effective, and the proposed facility will be among the cleanest and most efficient in the nation. As future growth in Denton necessitates additional resources, it is anticipated that the emerging technology of today will be appropriate for deployment. Of these technologies, it is anticipated that battery storage has the most promise.

Renewable Denton Plan (RDP)

- **Capital Expenditure**

  The cost of the quick start power plants in the RDP are included in comparison to and analysis of all considered options. The cost of the proposed quick start power units plus the cost of producing energy at the plants results in a lower net cost to Denton than procuring the energy from the market place or 3rd parties.

- **Cleaner Air**

  The operation of a quick start power plant under RDP proposal will reduce emissions from power plants not just in Denton but in the State of Texas also. When the proposed plant is operational, it is by definition, preventing the need to generate electricity from other, more emitting power plants elsewhere. RDP considered the consequences to others, of buying market energy to back up renewables.

- **Reduced Resource Consumption**

  RDP provides for considerably less water consumption than other choices considered. RDP considerations were mindful of prudent stewardship to resources in Denton as well as in the entire State.