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Meeting the Texas electricity peak demand conundrum: A case for wind and solar

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A B S T R A C T

Texas electricity production and consumption profiles were reviewed to gain an understanding of the renewable energy role in a high-demand jurisdiction. According to NERC, peak demand on the ERCOT electricity grid is rising at exponential rates, yet the operating reserve margin is still set at 13.75%. The study shows that only recently has Texas been replacing generating units with adequate capacity, primarily wind and solar installations due to an increased offer cap in its competitive electricity market.

1. Introduction

North America's electric grid is one of a kind, and is the largest in the world. The model is unique in its generating, transmitting, and distributing capabilities. The electricity grid consists of three interconnected regions. The eastern region covers states and provinces in the eastern United States and Canada. The western region covers the rest of the states and provinces. The Electric Reliability Council of Texas (ERCOT) covers 75% of Texas land (NERC, 2013). The three electric grids (or "interconnections") serving North America each cover a portion of Texas (Fig. 1). ERCOT supplies 90% of Texas' electricity, which is equivalent to almost 75% of its land area. The El Paso region is served by the western interconnection. Texas' other counties are served by the eastern interconnection. The Public Utility Commission of Texas (PUCT) ensures consumer protection by looking after all aspects of ERCOT's market as well as some other portions. Because of Texas' climate and industrial base, electric power is vital. Electricity plays an essential role in operating the state's residential, leisure, and commercial facilities. Even a quick power outage is considered a serious issue because of its significant economic impact. Texas leads the U.S. in generating and consuming electricity.

In Texas, electricity is the primary energy source used for home heating throughout cold winters and air conditioning during hot summer months. Texas primarily uses fossil fuels for its electricity generation. Texas is also aware of its environmental footprint, as its mandate in 2005 was to construct 5880 MW of power capacity, all from renewable generation by 2015, which is about 5% of its overall 2005 electricity demand (EIA, 2006). This goal was achieved by 2009. According to the new law that was passed at that time, 10,000 MW of power capacity is to be generated from renewable energy by 2025, of which at least 500 MW are non-wind generation. This goal was anticipated to be met by the end of 2017. In 2014, the Environmental Protection Agency (EPA) set state regulations to limit the emissions produced and increase energy efficiency programs, as per the Clean Air Act Section 111(d). However, many states with competitive markets have struggled to achieve these targets. Texas, which is the largest producing state of greenhouse gas emissions, has a Clean Energy Plan to have a 1.5% annual saving rate. To achieve this, a 0.2% yearly increase starting in 2017 is needed. In 2013, an equivalent of 657 million pounds of carbon dioxide emissions were not emitted due to 548 gigawatt-hours energy savings from the previous year (Zarnikau et al., 2015). Wind generation is estimated to be able to reduce the carbon dioxide emissions by 0.523 tons per MWh. Comparatively, generation from fossil fuels produce approximately 0.8 tons of carbon dioxide emissions per MWh (Kaffine et al., 2013). As well, about 98,800 tons of greenhouse gases can be avoided from a 5 MW peak solar generation system during its lifetime.

In January 2002, Texas decided to deregulate its electricity market, which enabled consumers to select their own electricity providers. The retail electricity market restructuring program targeted ERCOT-region investor-owned and –operated utilities. On the other hand, government and cooperative services owned and operated utilities had the choice either to join the competitive market or stay out of competition. ERCOT decided at the time that non-opt-in entities would continue to serve consumers whether they are inside or outside the ERCOT region.

On Aug. 11, 2016, Texas peak demand reached 71,110 MW, a new record for electricity consumption within the state (ERCOT, Electric Reliability Council of Texas, 2016). ERCOT had to immediately reduce

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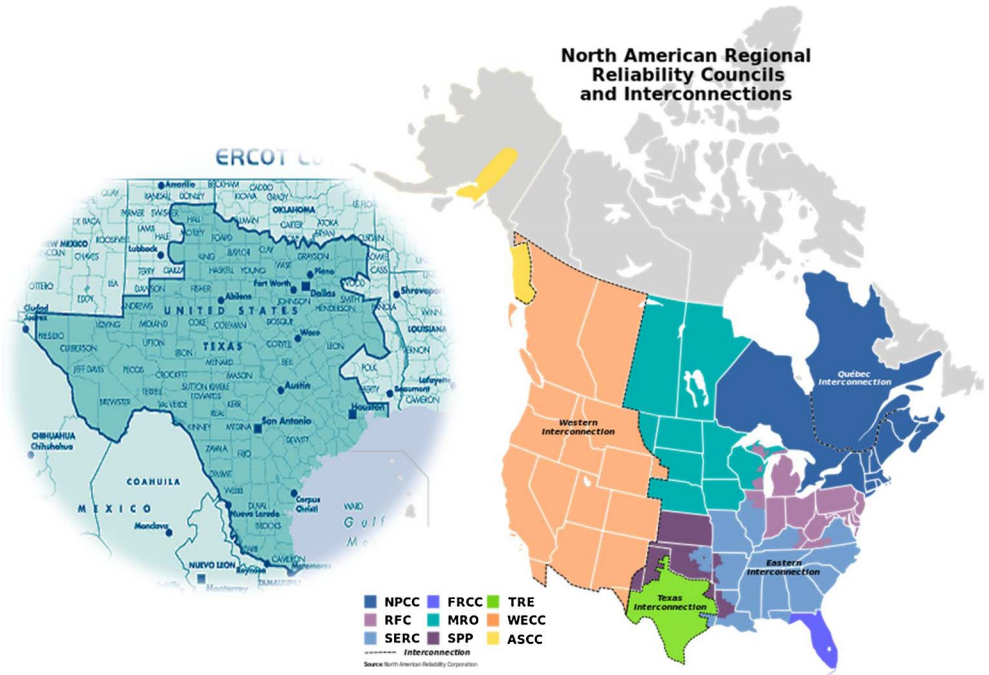

Fig. 1. North American Regional Reliability Councils and Interconnections.
Source: NERC, the North American Electric Reliability Corporation website. Key Players: Regional Entities.

service to industrial customers and rely on the goodwill of residential consumers to voluntarily reduce consumption to avoid brownouts. Supply shortage expectations have caused prices to increase drastically within ERCOT's market (Sioshansi, 2012). Based on previous inquiries, ERCOT's operating reserve margin was set at 13.75%, which protected the Texas electricity grid against unpredicted events and unforeseen force majeure. In the early 2010 s ERCOT was struggling to achieve this margin but in recent years has been able to keep its reserve margin just above that 13.75% figure.

2. The electricity outlook

In 1990, net electricity generation in Texas was 281,560 million kWh (EIA, 2012). As of 2016, net electricity generation in Texas was 455,532 million kWh. A net increase of almost 50% was accomplished. According to March 2017 United States Department of Energy publications, total generation from natural-gas-fired power plants was 14,088,000 MWh, which accounted for 42.6% of electricity produced in Texas. Coal-fired plants generated 8,307,000 MWh, accounting for 25.12%. At least five of Texas' 11 mines are considered among the 50 largest coal mines in the U.S. However, the coal grade is lignite, the lowest grade, and used locally without any surplus for exports. To facilitate transportation and lower the cost of operation, coal-fired power plants are located adjacent to the mines. Lignite coal is lower in energy content than other types of coal, but it is also low in sulfur, which helps to contribute to the state's efforts to lower emissions. Therefore, both sulfur dioxide and carbon dioxide emissions in Texas are considered at the uppermost range in the U.S. Though it only has two nuclear plants, Texas generates a significant amount of nuclear energy. A net generated capacity of 3,288,000 MWh accounted for almost 10% of electric power production. Hydroelectric net electricity generation was 89,000 MWh, which represents 0.27% of the overall electricity generated. Other renewable energy sources generated 7,291,000 MWh, which represents 22.05% of the overall electricity generated. Fig. 2 compares different energy sources from 1990 to 2017.

Total nameplate capacity has increased significantly in Texas from 329,002 MW in 2006 to 381,051 MW in 2015, which is an increase of almost 16% in 10 years (Table 1). Summer nameplate capacity has increased similarly (approximately 16%) in the span of 10 years and now totals 351,432 MW. The total annual net increase of 52,049 MW represents the difference between the capacity of the added units and capacity of retired units. Of the 52,049 MW of net increased capacity, 23,327 MW (nearly 50%) was from two recent years, 2014 and 2015. Also, it is estimated that between 9.6 and 10 GW (depending on the system-wide offer cap) will be retired and between 24.2 and 24.8 GW will be added from 2013 to 2022 (Gülen and Soni, 2013). This would result in a net increase of between 14.6 and 14.8 GW over those 10 years.

Although renewable energy sources provide minimal contributions to Texas' power grid, the state leads the way in wind-powered generation capacity, and new wind turbines are currently built. Currently, Texas produces almost one-quarter of the United States' total amount of wind energy. There are more than 10,000 wind turbines in Texas, and the numbers continue to increase as development costs decrease and wind turbine technology improves. The renewable energy production tax credit has contributed greatly to the growth of wind energy in Texas, resulting in an increase of over 500% in the past decade (Fig. 3). The rise in wind energy has allowed energy generators to realize the potential of wind energy and further invest in it. The Roscoe Wind Farm in central Texas is the largest wind power facility in Texas, with a nominal capacity of 781 MW of electricity.

Research has been conducted over the past few years to analyze how the increase in power generated by wind effects the electricity market prices. Results were conclusive about the fact that, as the percentage of wind energy generation increases, the spot price will decrease but the variance of the price will increase. For example, given a 100 MWh rise in generation from wind power, the market price will decrease by $0.07 for each MWh to $1.18 on average (Woo et al., 2011).

Over the next few years, the production of solar energy is expected to increase in Texas. Bloomberg New Energy Finance projected that there will be an addition of 4 GW of solar energy by 2020. This is expected to decrease the peak hour price by approximately $2.50 per MWh by this time. As more solar energy is supplied to the system (primarily during the day), the prices of peak hours (usually during the afternoon) will decline significantly. These hours, which were typically very profitable hours for natural gas and coal generators, will no longer

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