PERC DATA POINTS

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TEXAS: LEADING THE WAY ON WIND POWER

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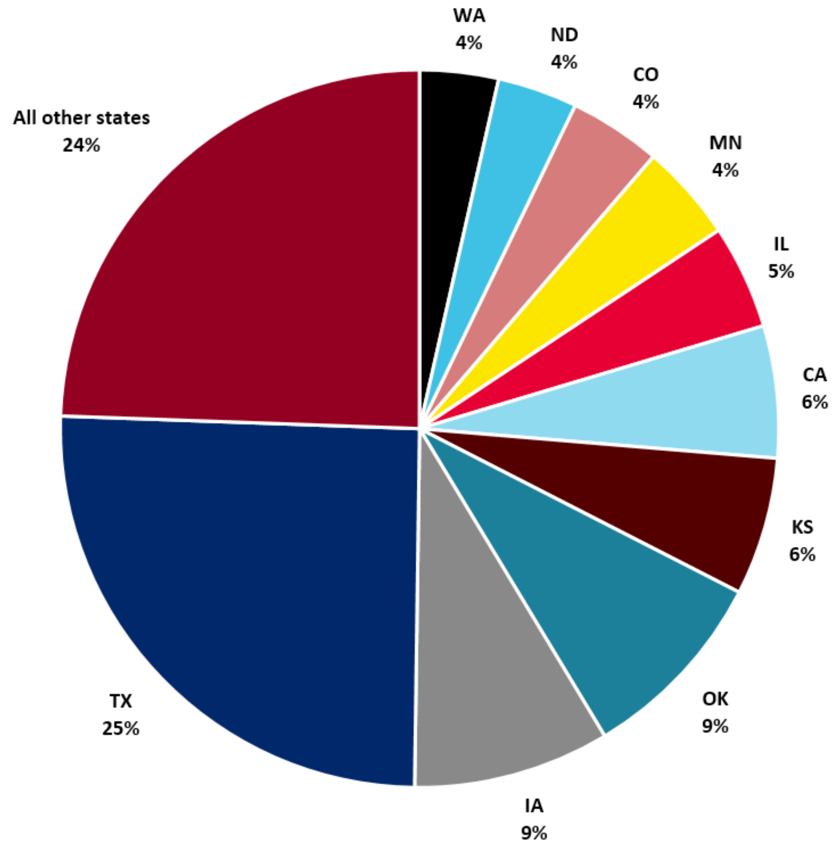
Wind power as a source for electricity generation is a growing feature of energy production in the United States. The U.S. Energy Information Administration reports that in 2017, wind power provided 6.3% of the electricity generated in the U.S., nearing the production level of hydropower (7.5%) and far above solar (1.3%). For comparison, natural gas was the source for 31.7% of our electricity generation, and coal, 30.1%.[1] The U.S. is a world leader in the wind generation of electricity and second only to China in installed wind power capacity.[2]

Discussions of wind power often focus on issues of reliability. In an important demonstration on February 22, 2017, the nation of Denmark achieved the singular milestone of powering the entire country solely from wind power for a 24 hour period.[3] This event was made possible by a confluence of favorable conditions that to date has not been repeated, but highlights Denmark's role as a leader in wind energy. Denmark obtains 40% of its energy supply from wind power.[4] Of course, Denmark is a relatively small country, about 6% as large as Texas geographically, and its annual energy consumption is below 1% of the U.S. level.[5]

While U.S. wind production is significant, the distribution of wind power is not equal across the U.S. In fact, four states make up nearly half of the total wind power produced. Figure 1 shows the full breakdown by state. Texas is the largest producer and responsible for 25% of U.S. wind energy generation. Iowa and Oklahoma come in essentially tied for second at about 9% each of total U.S. wind energy production. Kansas and California are tied for fourth place at about 6%.

[1] https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
[2] China has apparently used its installed wind power capacity inefficiently. It has more installed capacity but less production than the U.S. See http://iopscience.iop.org/article/10.1088/1748-9326/aaadeb
[3] Walker, 2017.
[4] http://denmark.dk/en/green-living/wind-energy
[5] International Energy Agency, 2018, United States and Denmark: Electricity and Heat for 2015.

FIGURE 1. WIND ENERGY CONTRIBUTION BY STATE, 2016



Source: U.S. Energy information Administration (2017) Electric Power Annual 2016, Net Generation by State by Sector.

We can learn more by studying wind energy's largest producers. Table 1 provides total net electricity generation for the U.S. and for the five leading producers of wind power in 2016. Overall, the U.S. produced 6.3% of its electricity via wind power, and wind power generation grew 12% from 2016 to 2017. Texas had the largest amount of wind generation and produced almost 15% of the state's total electricity generation from wind power. Wind generation in Texas is also growing; it was almost 17% higher in 2017 than in 2016. Iowa stands out as the state closest to Denmark in terms of percent of wind generation, with almost 37% of its electricity generated by wind power in 2017. Kansas was a very close second, with 36% of its electricity from wind power.

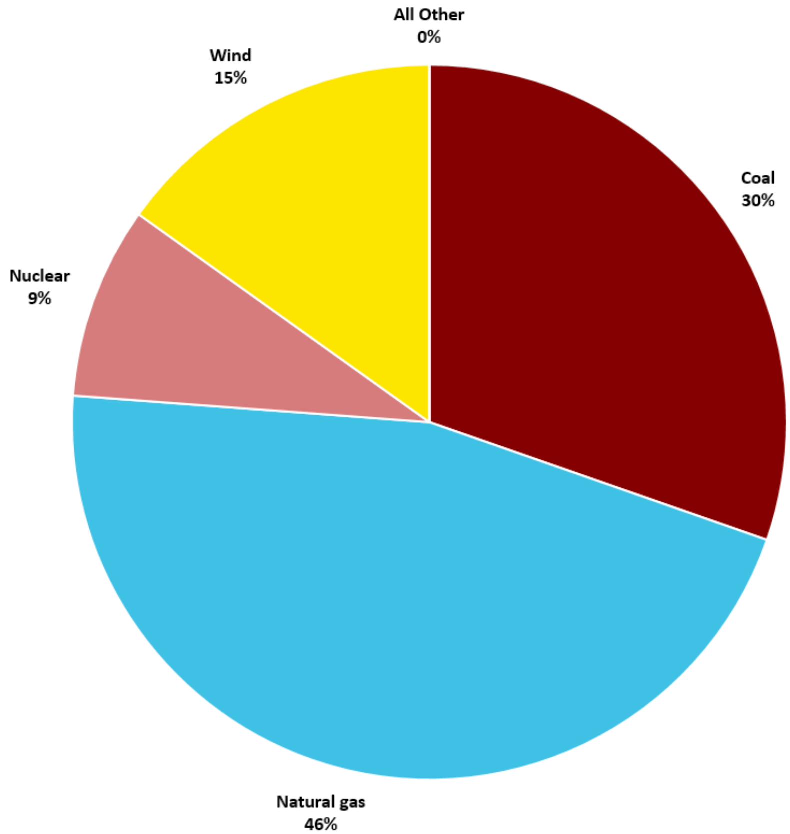
TABLE 1. NET TOTAL & WIND-GENERATED ELECTRICAL POWER

Entity	Wind-Generated Power, 2017	Total Electricity Produced, 2017	Percent Wind Power in 2017	Growth in Wind Power,from 2016-2017
USA	254,254	4,014,804	6.3%	12.0%
Texas	67,092	452,235	14.8%	16.6%
Oklahoma	24,404	76,545	31.9%	21.6%
Iowa	20,816	56,478	36.9%	3.7%
Kansas	18,504	51,366	36.0%	31.1%
California	13,971	206,107	6.8%	3.4%

Notes: For Utility Scale Facilities, 1000 Megawatt hours. Source: https://www.eia.gov/electricity/monthly/archive/february2018.pdf , Tables 1.3B and 1.14B.

In addition to being the largest producer of wind energy in the U.S., Texas is the only state that has its own electricity grid. While the rest of the contiguous states are served by either the Eastern or Western Interconnections, the "Texas grid" is operated by the Electricity Reliability Council of Texas (hereafter ERCOT) and serves 90% of the electric load in Texas.[6] Texas essentially operates as an isolated entity in the US electricity grid with only limited interconnectivity with the rest of the country.

FIGURE 2. TEXAS ELECTRICITY GENERATION BY SOURCE, 2017



Source: U.S. Energy information Administration (2018) Electricity Data Browser| Net Generation for all Sectors, Annual.

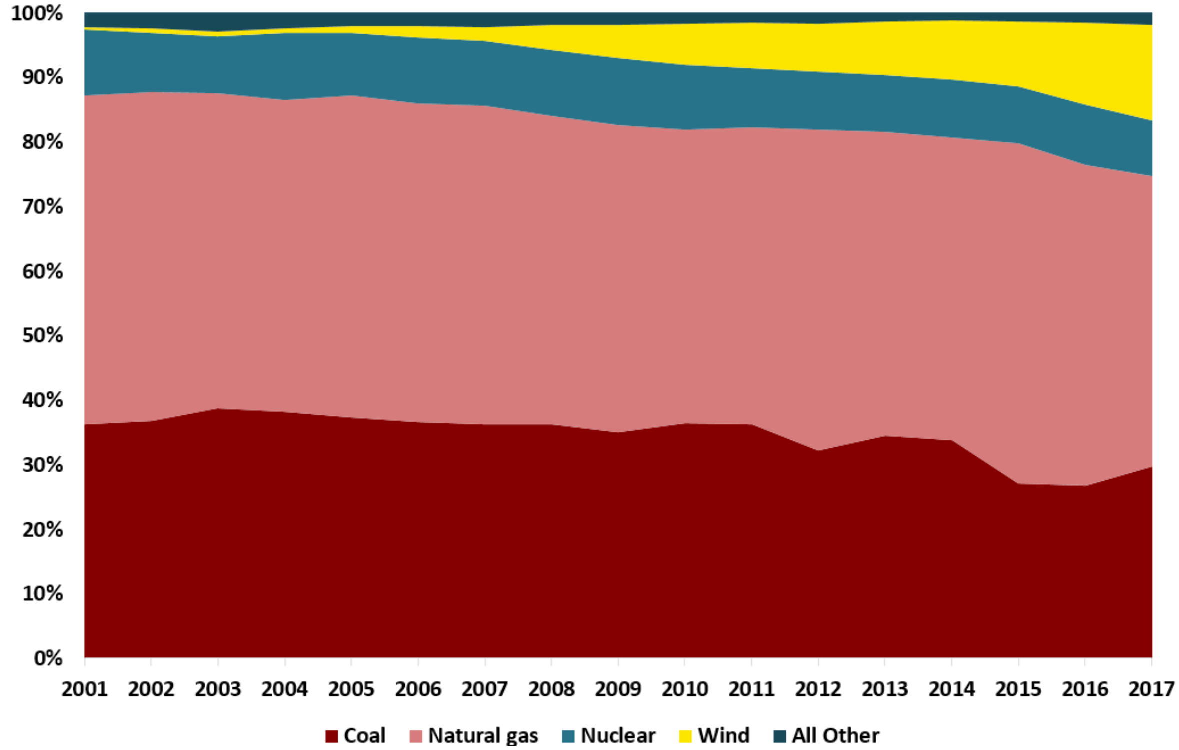
While Texas produces more wind energy than any other state, wind only makes up a portion of the state's total electricity supply. Figure 2 shows the mix of sources used to generate electricity in Texas in 2017. Wind-generation is responsible for 15% of total electricity generation, larger than nuclear at 9%. Coal is responsible for 30% of electricity generation and natural gas is 46%.

Though natural gas and coal continue to dominate electricity generation, wind power has seen impressive, steady gains. Figure 3 graphs total electricity generation in Texas by source from 2001 to 2017, and illustrates the growth in the importance of wind production that occurred starting about 2006 and appearing to accelerate recently. In 2014, wind surpassed nuclear to become the third largest source of electricity in Texas. The graph also illustrates the increased usage of natural gas, especially in recent years, and the decline in the use of coal.

As the economic viability of wind energy improves, more and more wind farms are being built in Texas, alleviating the dependence on coal and natural gas as sources of electricity. However, one of the factors limiting adoption of wind energy is the random nature of wind — turbines can only generate electricity when the wind blows. As the entity responsible for providing electricity to Texas, ERCOT needs to make sure that when a consumer flips a light switch, there is power to turn on that light. These concerns about reliability and fluc-

[6]About Ercot, 2018.

FIGURE 3. TEXAS ELECTRICITY GENERATION BY SOURCE, 2001 - 2017 PERCENT OF TOTAL PRODUCTION



Source: U.S. Energy information Administration (2018) Electricity Data Browser, Net Generation for all Sectors, Annual

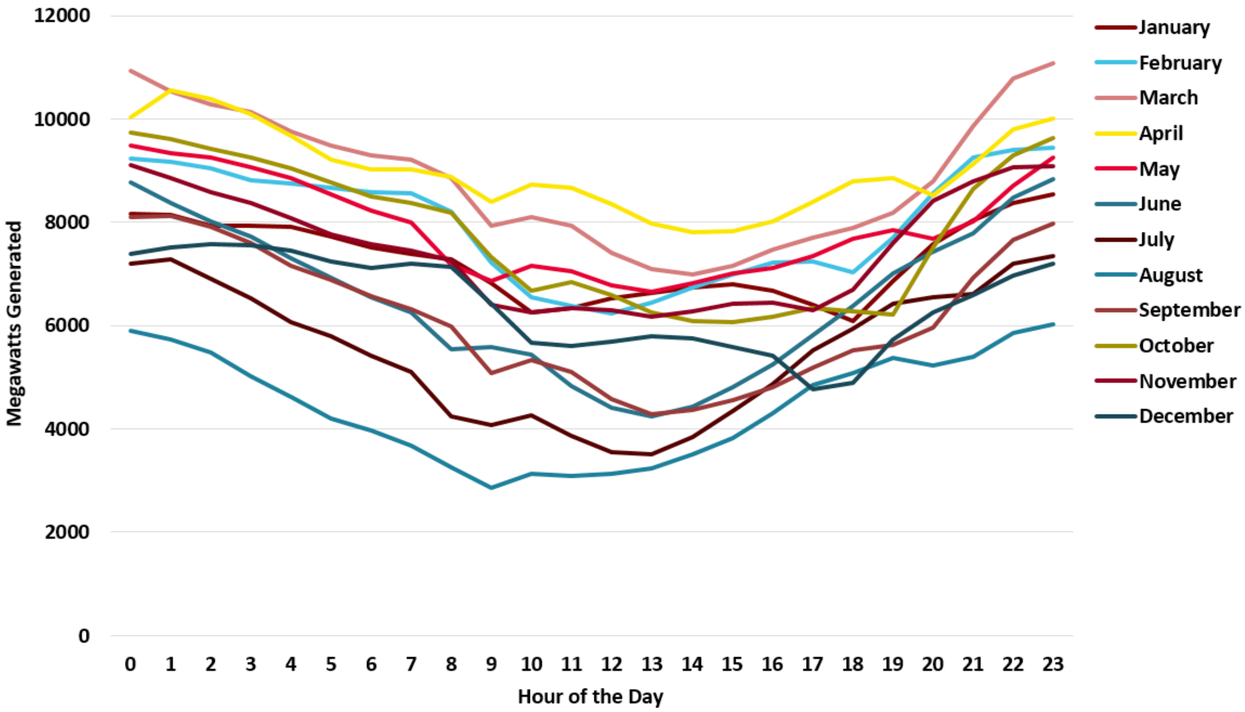
tuating production permeate the conversation over wind energy. At the same time, changes in the wind are somewhat predictable, and Texas's large geography allows some degree of hedging – when winds are calm in the panhandle, they might not be calm on the coastal plains, and vice versa. Finally, the increased reliance on wind energy, with its inherent variability, has led to an increased interest and use of backup power in the form of reciprocating engines, quick-starting and fast-ramping units often powered by natural gas.

ERCOT matches electricity generation with demand, and electricity use in Texas follows a predictable pattern with the lowest usage being around 4 a.m. each morning and the highest in the late afternoon. However, the amount used each day varies greatly between months, with June, July, and August being the months with the greatest amount required, and February, March, and April with the least. This variation is large. The amount of electricity used on a July afternoon is nearly double that of a February afternoon.[7] Figure 4 shows the average hourly data on wind-generated electricity on the ERCOT grid over the course of 2017 compared with a graph showing the total average energy supplied from all sources on the ERCOT grid.

While there is usually a great deal of fluctuation, several notable patterns provide some ability to forecast future production. First, no matter the month, wind energy generation peaks on average around midnight. Conversely, there are predictable dips that occur usually in the afternoon. Though no two days will be identical, the pattern of peaks and troughs in these averages provide some predictability, regardless of the season. Second, throughout the course of 2017, June, July and August had the most total electricity generated (all sources) of any month, regardless of the time of day. On the other hand, June July, and August were also the months with the lowest level of wind energy production. For example, no matter the month, the amount of electricity generated by wind at midnight averages between 6,000 and 11,000 megawatts, while at 4 p.m., this range is 4,300 to 8,000 megawatts. This pattern allows grid operators some ability to forecast when to scale back production by other sources to best take advantage of cheap and abundant wind energy. Still, these patterns are monthly averages, and each day can have significant variation in these monthly averages.[9]

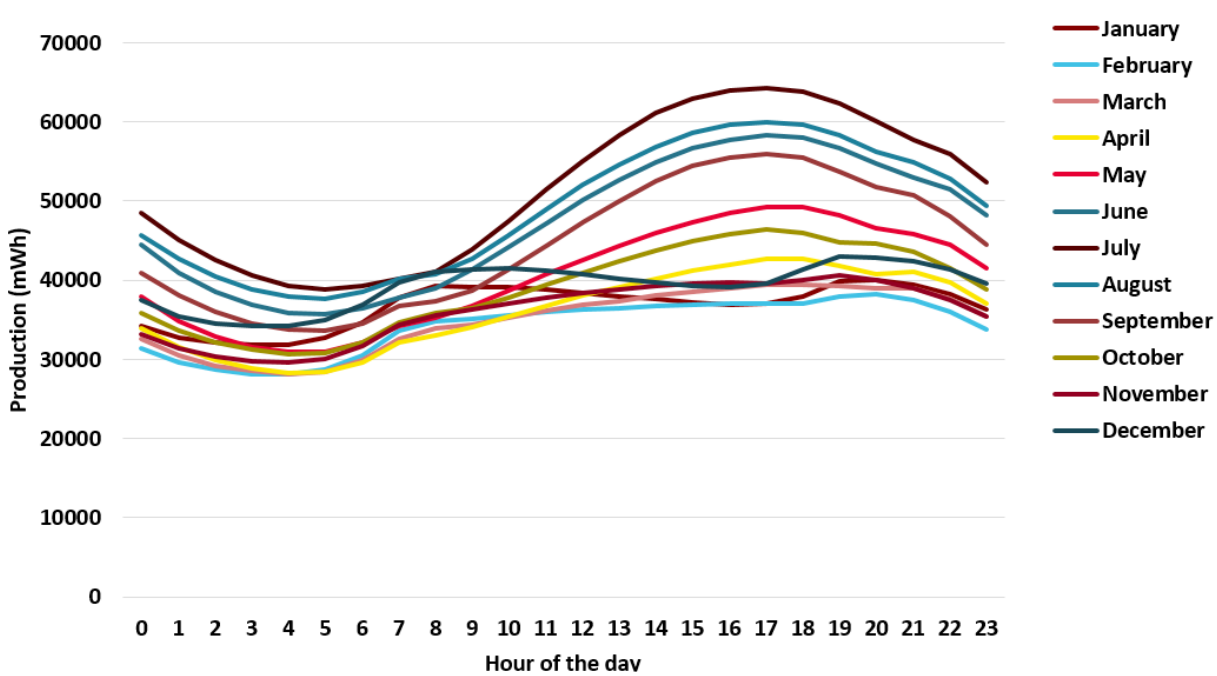
[7]Energy Reliability Council of Texas (2018) Hourly Load Data Archives.

FIGURE 4. WIND ENERGY PRODUCTION ON THE ERCOT GRID BY HOUR, 2017



Source: ERCOT (2018) "Hourly Aggregated Wind Output"

FIGURE 5. TOTAL ELECTRICITY PRODUCTION ON THE ERCOT GRID, 2017



Source: ERCOT (2018) "Hourly Load Data Archives"

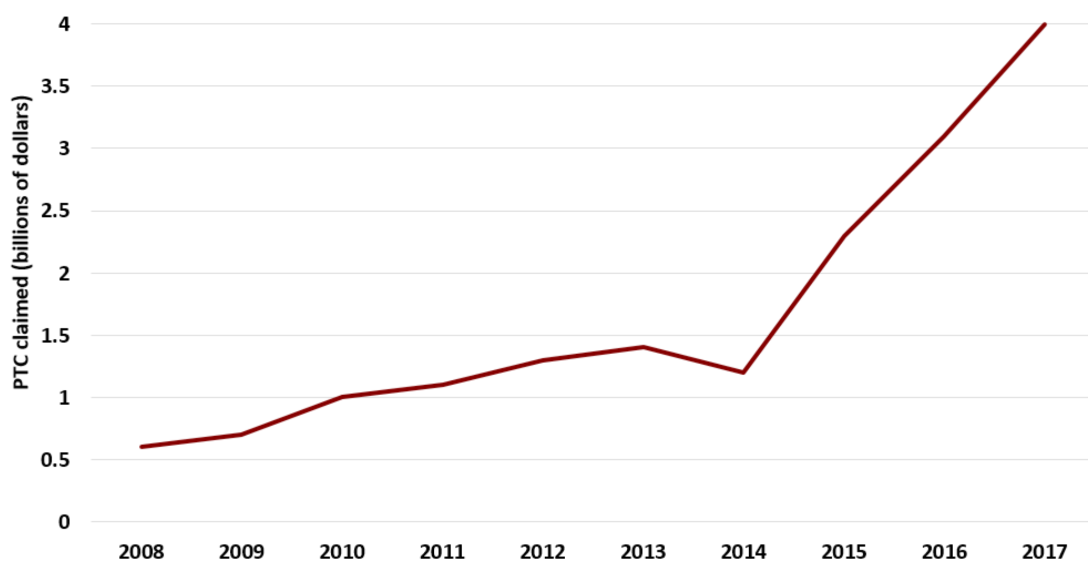
[9]Winter and summer are both low because of more static daily temperatures. January is not entirely unexpected to be low, whereas temperature changes in spring and fall cause more wind.

Wind presents many challenges for ERCOT. The wind is only somewhat predictable and the average wind production is lower in the summer when ERCOT faces the highest demand for power. There is always the possibility, however small, of very low wind energy production. The daily peaks of wind energy production don't line up with the peaks in energy use. Wind energy requires backup sources of fast-start electricity generation, something the traditional coal fired plants are not good at achieving. Despite these issues, wind power continues to grow in Texas and across the nation.

SUBSIDIES FOR WIND ENERGY

A significant factor behind the increase in wind energy production, both nationwide and in Texas, is the federal production tax credit. This is a tax credit paid to wind energy production facilities for every kWh of electricity they produce. In 2017, the U.S. Department of Energy listed that this credit was worth $0.019 per kWh, or $19.00 per mWh. This production credit is especially high considering that in Texas, the average wholesale price of electricity in 2017 was around $27.[10] Producers earn the credit in addition to the sales price of electricity. As wind energy has become more prevalent, these tax credits have become increasingly significant expenditures by the United States government. Figure 6 below shows total tax expenditures on the Production Tax Credit for wind in the United States from 2008 to 2017. All amounts are in nominal or current dollars and are not adjusted for inflation.

FIGURE 6. TOTAL PRODUCTION TAX CREDIT CLAIMED EACH YEAR, 2008 - 2017



Source: EveryCRSReport.com (2017) The Renewable Electricity Production Tax Credit: In Brief.

In 2017 alone, the production tax credit for wind energy represents $4 billion in subsidies. These subsidies will decrease by 40% for facilities that begin construction in 2018, and 60% for facilities that begin construction in 2019.[11] This planned decrease in subsidy levels for new construction has spurred a large flow of investment into wind facilities prior to the reductions.

BENEFITS OF WIND GENERATION

There are several reasons in addition to subsidies that explain why wind energy is being embraced so widely. First, wind energy can be extremely competitive with other electricity generation resources when it comes to cost. Figure 7 shows the levelized cost of energy (LCOE) in the U.S. for 2017. According to the Energy Information Administration (EIA) an LCOE analysis "represents the per-megawatt hour cost (in discounted real dollars) of building and operating a generating plant over an assumed financial life and duty cycle.[12] Key

[10] U.S. EIA, Electricity Historical wholesale Market Data. For comparison, the average retail price of electricity in Texas was $113.60 per mWh in 2017.
[11] Production Tax Credit, U.S. Department of Energy.
[12] Levelized Cost and Levelized Avoided Cost of New Generation Resources, EIA, 2018.

inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant type." This type of analysis allows a cost comparison between different energy sources and is used by government agencies and top financial firms alike.

Lazard's analysis provides levelized costs for renewable energy with and without subsidies. Figure 7 shows the costs of building and operating an electricity-generating plant, and is made with retail prices in mind. In 2017, the average retail price of electricity in Texas was $85.50 per MWh for all sectors of the economy.[13] In comparison with the levelized cost estimates, household prices came in even higher at $111.80 per MWh. Looking only at the cost of generating electricity, wind power is enticing and has been getting more competitive through the years. Compared to Lazard's 2009 LCOE analysis, wind energy has had a 67% decrease in costs over the past 8 years. Technological improvements have accompanied increased interest and use of wind energy.

FIGURE 7. LEVELIZED COST OF ELECTRICITY IN THE U.S., 2017

Source: Lazard (2017) Lazard's Levelized Cost of Energy Analysis Version 11.0.

This analysis has its critics, and major omissions are that it excludes costs like network and infrastructure upgrades, as well as some of the special costs that accompany reliance on wind energy. One of the most important of these costs is the cost of intermittency. Wind generating plants cannot produce power on demand, and therefore have costs associated with their inability to supply power when it may be needed. Grids relying on wind power must also invest in dispatchable plants that can provide electricity on demand, an additional capital cost that accompanies reliance on wind energy. Further, with dispatchable plants, such as gas plants, shown in Figure 7, the production costs are very high when compared to other alternatives.

These levelized cost estimates also come with assumptions about the capacity at which wind plants operate. Other plants can operate closer to maximum capacity, whereas wind plants operate at a fraction of capacity depending on the weather. Oftentimes wind energy generation, as a percent of capacity, will be low, and may be lower than the assumed production level relative to capacity that is used in the levelized cost estimates.

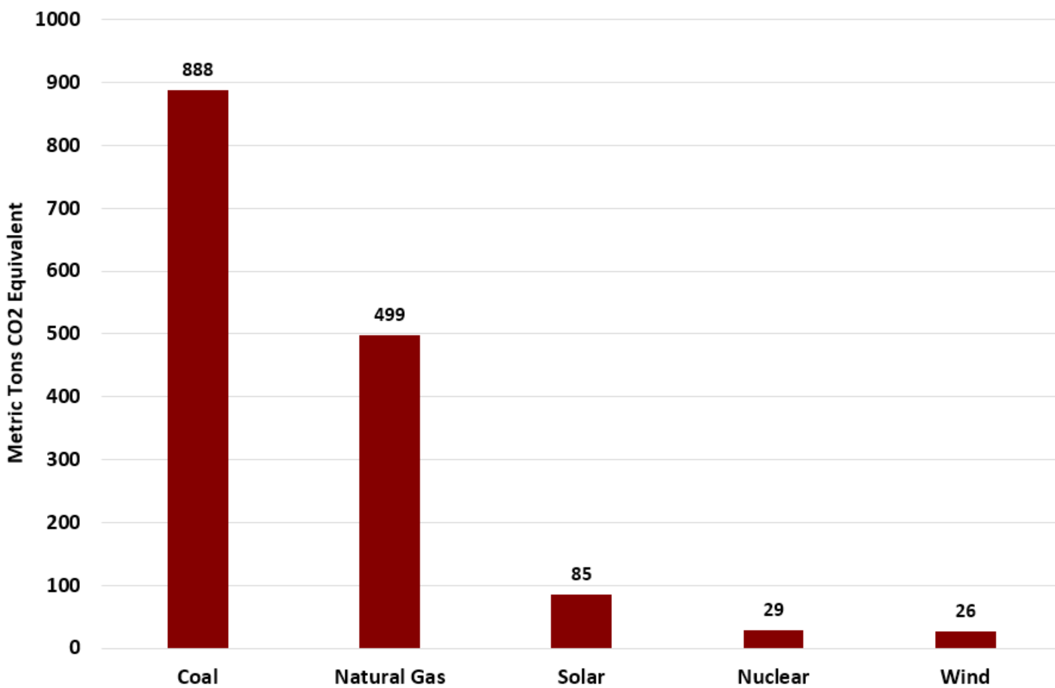
[13]U.S EIA, Electricity Data Browser, Average Retail Price, Annual.

Still, wind energy has no fuel costs and the variable costs are largely maintenance and depreciation. In an area that has ample wind potential and does not require infrastructure upgrades, wind farms provide one of the cheapest large-scale electricity generating resources, even without government subsidies. Unfortunately, most areas where wind has been installed were not complete with all necessary infrastructure such as transmission lines, and upgrading infrastructure can be very expensive.[14]

A large factor behind the boom of wind energy production and the government subsidies to encourage wind energy production is the low environmental impact of wind energy. In comparison to fossil fuel-powered generation, wind production does not pollute the air, nor does it contribute greenhouse gasses to the atmosphere. Wind is also environmentally competitive when it comes to other renewables such as solar because the production of wind turbines is relatively environmentally friendly, something not so true with solar panels.

Figure 8 below shows the estimated lifetime emissions of the most popular electricity generating resources. The data used in constructing the figure includes construction and materials, and the numbers show the all-in carbon footprint of each gWh produced by each source. The graph shows that the only generation source that can compete with wind in terms of carbon emissions is nuclear. Even solar, another popular renewable resource, struggles to compete as production of photovoltaic cells use rare metals that are not particularly environmentally friendly.

FIGURE 8. AVERAGE ESTIMATED LIFETIME CARBON EMISSIONS PER GWH



Source: World Nuclear Association (2011) Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources

Nuclear energy, while producing very little greenhouse gasses, also generates long-lived nuclear waste. In a report for the *International Journal of Sustainable Manufacturing*, researchers conducted a life cycle assessment of the carbon footprint of wind turbines and found that, in terms of cumulative energy payback, a wind turbine will be net energy positive within 5-7 months of operating.[15] This includes all manufacturing, transport, operating, maintenance, and end of life energy costs. For a wind turbine with a 20 year life span, this means that the turbine operates at a positive energy payback for about 97% of its life. This leaves wind energy as the

[14] S&P Global, a leading market analysis firm, asked experts their opinion on Lazard's report. Some energy economics specialists have found them to be in line with their expectations, while others see them as too optimistic for renewable energy (Watson, 2017). Much of the criticism tends to stem from Lazard's findings on solar energy and not necessarily wind.

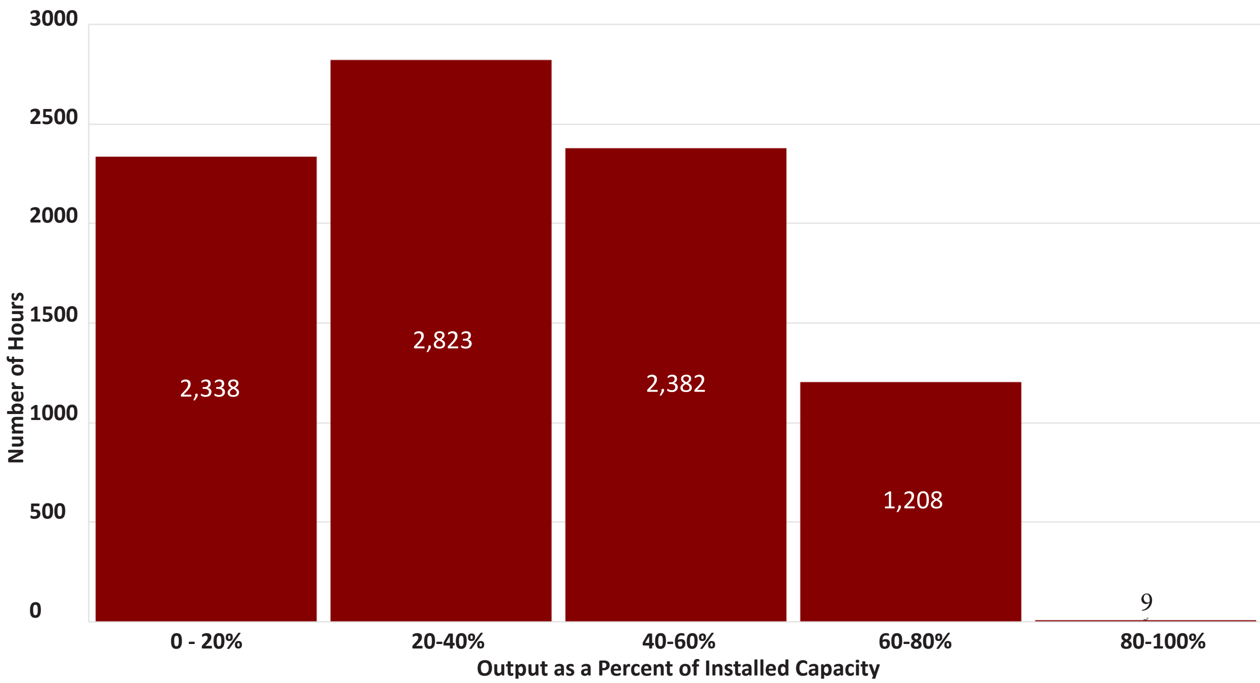
[15] Haapala, Karl R., and Preedanood Prempreeda.

best source for generating electricity without producing greenhouse gasses or generating toxic waste. Wind energy also does not require large amounts of water to function, while other energy sources require water to drive steam turbines and for cooling purposes. This also makes siting wind power plants more versatile as wind farms can be built in areas that are not near rivers, lakes, or oceans.

CHALLENGES OF WIND ENERGY

Wind energy has many benefits, but it also presents many challenges. Perhaps the biggest challenge is the inherent intermittency in wind generation due to weather. While the average amount of wind at any time of the day or year tends to follow predictable patterns, as seen in Figure 4, the actual amount of wind at any given time is much less predictable. Furthermore, the wind speeds necessary to reach a turbine's rated maximum capacity seldomly occur. That is, the rated capacity of a wind turbine is seldom achieved, and the percentage of the rated capacity that is achieved is a random variable not under the control of producers. Figure 9 below displays this phenomenon for Texas in 2017.

FIGURE 9. OUTPUT AS A PERCENTAGE OF INSTALLED WIND CAPACITY



Source: Energy Reliability Council of Texas (2018) Hourly Aggregated Wind Output.

As this graph shows, only 9 hours in 2017 had wind speeds across the state high enough to hit 80% or more of the installed wind energy-generating capacity in Texas. The modal range was 20% - 40% of rated capacity. On nearly 27% of the hours of production in 2017, wind output was less than 20% of installed capacity. Wind power producers incur costs of installing turbines designed to take advantage of periods of high wind, but most often the turbines produce far below rated capacity. And, unlike more conventional power sources, the producers of wind power have very little ability to directly increase output as a percent of capacity.

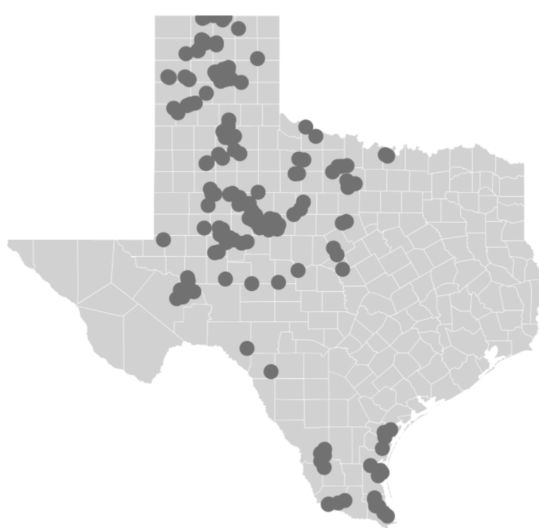
When the wind is not blowing, other means must be brought online in order to supply the demanded electricity. As grids across the nation and the world transition to higher proportions of electricity from wind, the ability to fill the gaps left by intermittent wind energy are increasing as well. This means that there is an increased demand for fast-starting (and high cost) gas peaking plants.

There is always talk of storing excess wind energy, but storing electricity is neither inexpensive nor efficient. Lazard provided a Levelized Cost of Storage (LCOS) analysis in addition to the LCOE, and found that the cheapest means of storage to be a compressed air system, which cost between $116-140 per megawatt hour, nearly tripling the LCOE of wind energy. Additionally, compressed air energy storage systems work by pumping compressed air into underground caverns and using that compressed air to power turbines when the stored energy is needed. This method of storage, while cheapest, cannot be adopted on a large scale because it requires very specific geologic formations. An alternative storage system would include pumping water uphill into dams or other storage facilities to use to generate electricity as needed. Finally, there is the long-range hope for various battery technologies. These are currently infeasible on economic grounds, and perhaps on engineering grounds. The estimated LCOE for batteries can be over a thousand dollars per megawatt hour, making them prohibitively expensive.

This situation leaves secondary electricity-peaking plants as the backup to wind. These plants must be capable of starting up quickly to meet the demand, which rules out nuclear plants and most coal fired plants, as they require long startup times. ERCOT uses natural gas-peaking plants, which are specially designed to be able to start up quickly act as the marginal plant brought online when electricity production cannot otherwise meet demand. Due to their special design and limited use, these plants can be very expensive, with estimated LCOE above $200 per mWh. While a small number of such plants might be necessary even with conventional electricity generation, a greater number of these secondary plants is an important consideration when deciding on the 'total' cost of an electric grid. Grids end up with a portfolio of production from cheap wind power and expensive gas turbine power, and perhaps a larger investment in plant and equipment per gWh of production.

An additional challenge for wind energy generation has been the uneven geographical distribution of wind resources. The main reason that Texas is the number one producer of wind energy in the U.S. lies in its size and in the fact that it has more wind blowing across the state. This also helps explain how a small state, such as Iowa, can outrank a larger one like California in wind production, as shown in Figure 1. In a paper for the National Academy of Sciences, Harvard researchers Lu, McElroy, and Kiviluoma used a combination of meteorological data, weather/climate modeling, and satellite data to map the wind energy potential across the globe.[16] In the United States, they found that wind energy potential is highly concentrated in Texas and the Midwest, with comparatively little potential along the East and West coasts, as well as very little in the South.

FIGURE 10. TEXAS WIND GENERATION PLANTS



Source: U.S. Energy information Administration (2018) Electricity Data Browser| Number of Plants for Wind, Texas, All Sectors

[16]Lu et al, 2009.

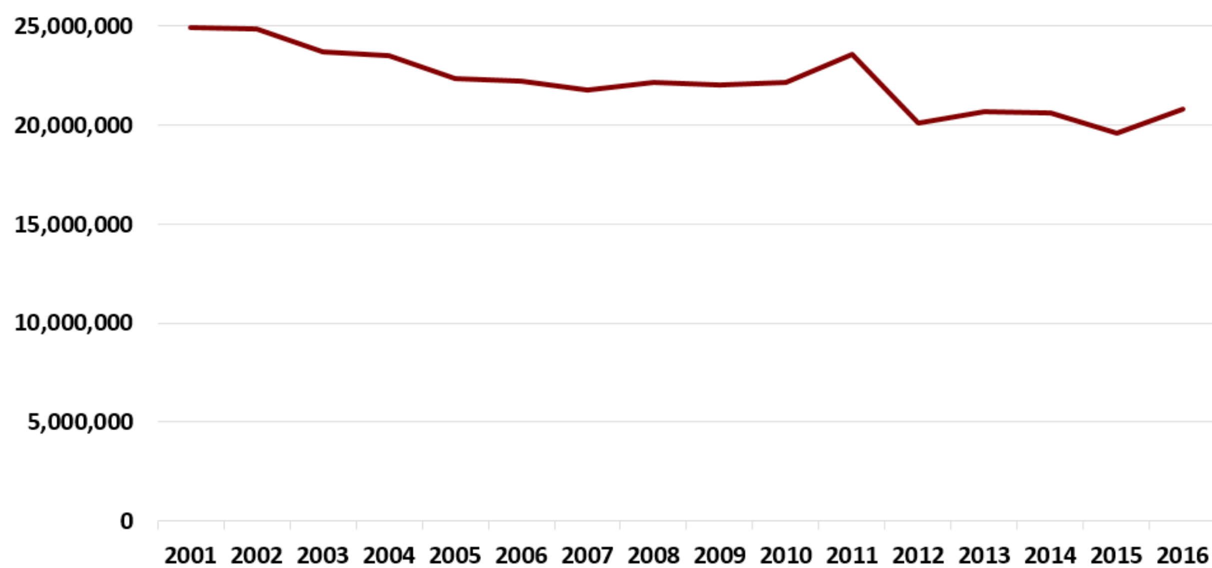
To put this into numbers, Texas had an estimated annual wind energy potential of over 10,000 Terawatt hours, compared to Georgia's potential of only 0.25 Terawatt hours, a four million percent difference! Wind energy potential is very much a feast-or-famine issue across the United States, and any large scale adoption of wind energy will necessarily take this into account. Even Texas has an uneven distribution of wind energy within its borders. Figure 10 shows the locations of all wind farms operating within Texas as of April 2018.

Wind energy generation in Texas is concentrated in several areas, with the majority of plants located in west Texas and in the panhandle, along with plants along the southern Gulf Coast. This initially posed a problem because the major population centers of Houston, Austin, Dallas, and San Antonio are located in the central and eastern portions of the state, so that the new wind generation facilities required new transmission facilities to move electricity from where it is produced to where it is consumed. These transmission lines also allow Texas to benefit from diversifying its reliance on wind power across wider geographic areas, to take advantage of regional variations in wind speeds at any point in time.

Transmission infrastructure is crucial to all forms of electricity production, but the geographic distance from production to consumption is higher with renewables, especially wind. Wind plants are constrained to be built where there are high and reliable winds, regardless of their proximity to cities. Traditional power plants were typically built in or near cities. The increased reliance on wind power resulted in a need for improved transmission between wind plants and consumers.

Some electricity tends to be lost due to transmission, and longer transmission lines usually incur greater losses. However, these losses are not as large as feared, and have been falling, at least in Texas. Figure 11 below shows these losses on the ERCOT grid in Texas as a percent of electricity generation over time. Losses have been steadily decreasing for years as technology has improved and as Texas has improved its transmission infrastructure.

FIGURE 11. ESTIMATED ELECTRICITY LOSSES PER YEAR IN TEXAS, MWH



Source: U.S. Energy information Administration (2018) Texas Electricity Profile 2016.

Texas recently implemented its Competitive Renewable Energy Zones (CREZ) initiative in order to increase transmission infrastructure by adding thousands of miles of high voltage cable to link wind farms with consumers. This solves several critical issues with wind, namely the geographical concentration of wind resources, and curtailment. Curtailment exists on the opposite side of the spectrum of wind energy shortages. This occurs when wind farms are making more electricity than is needed on the grid at any given moment. When grid operators cannot accept this excess energy, this event is known as curtailment. Issues of excess energy also lead to wholesale energy prices dropping negative. Wind energy producers find the production tax credit more than sufficient to cover their costs of production (at least their marginal costs) and hence will, at times, actually pay grid operators to take their electricity. This is of course an example of economically inefficient subsidies. An EIA report on this project found that the expansion of these transmission lines not only allows electricity to be transported further, but it helps minimize curtailment and negative prices.[17] This was the goal of the CREZ project, and it has proven very successful. Wind curtailment in Texas was at a high of 9-17% between 2009 and 2011 before the project began. After completion, wind curtailment in Texas has fallen to less than 1%. (US. Department of Energy, 2017)

Transmission infrastructure upgrades also helped reduce transmission losses on the ERCOT grid even as wind has become more prevalent. While effective, this grid expansion came at a large cost. In total, Texas taxpayers paid over $7 billion for the project, a total that is higher than the total wind energy production tax credits claimed in the U.S. for all of 2017. This was a one-time expense, but the cost of this necessary infrastructure investment is also something to include in considering the costs and benefits of wind generation.

There are other complaints as well. Wind turbines can be considered unsightly. They are large and obvious on the skyline. Some claim that this reaction is because they are new and that people will get used to seeing them. Others claim that wind turbines create a strobing effect caused by flickering lights from sun shining through the blades. There are also signal lights on the turbines to warn airplanes, which some find objectionable. Wind turbines can kill wildlife, birds and even bats. Wind turbines can be noisy, and some complain of noise from the rotors. Each wind turbine takes about ½ acre of land. In areas with fertile land (perhaps especially Iowa), this reduces farm output. Finally, there is evidence that the very existence of wind farms changes the local climate.[18]

WIND RELIABILITY MAY INCREASE WITH USE (TO A POINT)

While wind in any particular place may be insufficient to supply energy, when hundreds of plants are available across thousands of miles on a single grid, there are tremendous gains from diversification. A study done by the American Association of Wind Energy or AWEA found that as more wind energy is added to the grid, intermittency becomes less of an issue.[19] Wind plants producing less energy at one location are offset by plants producing more energy at another location. When this effect is spread over an area the size of the western U.S., it has vast effects on reliability. The study found that at this scale, total power system variability actually decreases when renewable use increases above 30% of total generation. As the U.S. only gets a bit over 6% of its energy from wind, there is a lot of room to increase wind energy nationwide and reap the benefits of increasing reliability. In the context of an entire grid, the variability in one single wind plant, or even all wind resources, matters much less than the reliability of the grid as a whole. Modern power grids are set up so that every resource acts as a backup to all other resources. This is what makes the transmission infrastructure improvements, such as the CREZ lines, so important. In the United States, there is great geographic diversity and a large grid, increasing the ability for renewable energy to make up a significant portion of total electricity generation. The biggest constraint is transmission— diversifying works when regions are connected. With proper investment in transmission, the AWEA study claimed that grid operators have found no reliability issues with renewables providing as much as 40 to 50 percent of total electricity generation.

CONCLUSION

While Denmark's achievement of 100% wind power for an entire day is certainly impressive, a grid run entirely on wind is not a realistic goal. Since the U.S. currently obtains just over 6% of electricity from wind power, however, there seems to be room to expand. Wind generation faces issues of reliability due to intermittent winds, but diversifying wind generation capacity across wide geographic regions helps mitigate this problem. Wind power requires reworking of transmission facilities and the consideration of ways to balance grids and

[17]Source: Fewer Wind Curtailments and Negative Power Prices Seen in Texas After Major Grid Expansion: EIA.
[18]https://www.washingtonpost.com/news/energy-environment/wp/2017/12/11/wind-energy-is-supposed-to-fight-climate-change-but-climate-change-is-fighting-back/?noredirect=on&utm_term=.d1bf968bf737
[19]Wind Energy Helps Build a More Reliable and Balanced Electricity Portfolio: AWEA.org.

coordinate production across large areas. It also requires investment in additional secondary-source peaking plants. However, modern electricity grids are complex and maintain their reliability by using a diverse mix of generating resources, both non-renewable and renewable. The future holds an increased reliance on renewable resources as both consumers and regulatory bodies demand cleaner electricity. Wind energy excels in being among the lowest cost of the available renewables. It is unrealistic to think that wind will ever make up the entire electricity grid, but wind brings many benefits along with its challenges, and will continue its growth as a major source of electricity in Texas, in the U.S. and abroad.

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