Business & Technology Strategies

TechSurveillance

Growth of Wind Generation in the Electric Cooperative Community

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JUNE 2017

SUBJECT MATTER EXPERTS FOR QUESTIONS ON THIS TOPIC

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ARTICLE SNAPSHOT:

What has changed in the industry?
The wind industry is growing rapidly and is the fastest growing renewable in total megawatts installed. Electric cooperatives are on the front lines of this trend with more than 5,400 MW of wind capacity — about 7 percent of total U.S. wind capacity — and continued growth is expected. But the Production Tax Credit (PTC), a federal tax credit that has been a key driver of U.S. wind developments is being phased-out by 2020.

What is the impact on cooperatives?
Cooperatives that already own and purchase wind energy may be affected by increasing amounts of wind on the grid, but the PTC phase-out could open new opportunities for co-ops to own more wind farms. In fact, with 100 percent debt financing, low cost-for-capital, and the PTC dropping by 20 percent, 2017 may be the year that it becomes more economical for electric cooperatives to finance their own wind farms. The additional PTC decrease in 2018 will favor cooperative-owned wind farms even more. However, as discussed in a previous *TechSurveillance* article (***Variability and Uncertainty in Renewables' Generation: Creates Operational, Reliability, and Cost Challenges for G&T Cooperatives***), the intermittent and non-dispatchable nature of renewables presents operational, reliability, and economic challenges for generation and transmission (G&T) cooperatives requiring development of fossil generation and other options to integrate this lowest-cost renewable generation option.

What do co-ops need to know or do about it?
This is the first in a series of NRECA *TechSurveillance* reports on Wind Generation that will promote what cooperatives have done to date; and support, inform, and connect those who seek to add additional wind resources to their generation mixes. This report provides an overview of how much wind generation capacity electric cooperatives currently own and purchase, and how they do it. Future reports will cover current and advanced wind technologies, and failure and maintenance issues.

NRECA
America's Electric Cooperatives

STATUS OF WIND GENERATION IN THE U.S.

Wind power has seen massive growth in the U.S. over the past decade. In 2005, there was less than 10,000 MW of installed wind capacity nationwide (see Figures 1 and 2) . By the end of 2016, that had increased to more than 81,000 MW, outpacing existing hydroelectric dams — previously the largest source of installed renewable capacity — by more than 1,300 MW.[1] In 2016, wind provided more than 5.5 percent of U.S. electricity, up from less than 1 percent in 2006.[2] These changes are felt across the country. Today, forty-one states have utility-scale wind farms; and Rhode Island now has the country's **first off-shore wind farm**.

"Robust wind deployment in the United States since 2008 has been driven by substantial advancements in wind technology and cost reductions, coupled with continued state and federal policy support" (U.S. DOE, 2015, Wind Vision, p. xxxvi).

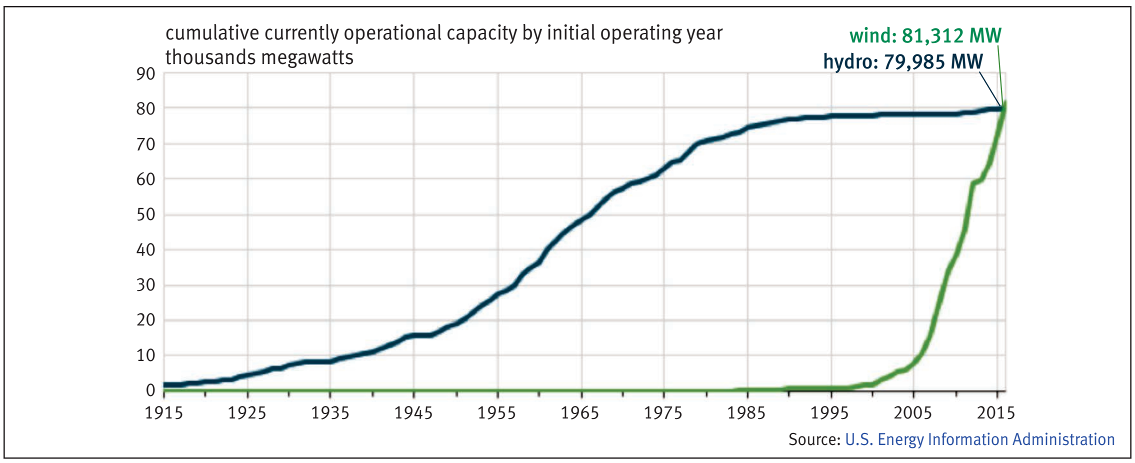


FIGURE 1: U.S. Utility-Scale Wind and Hydro Electric Generating Capacity, as of Dec 2016

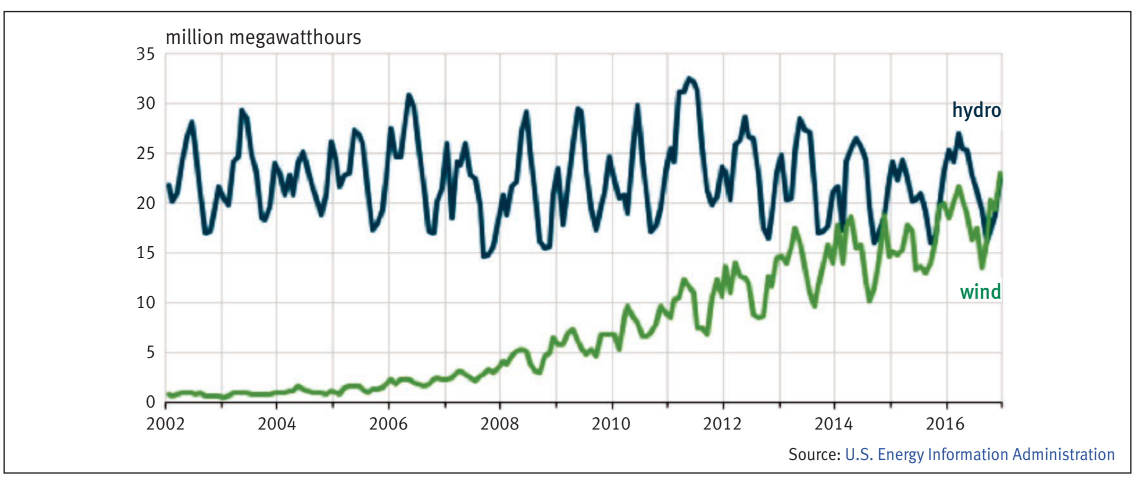
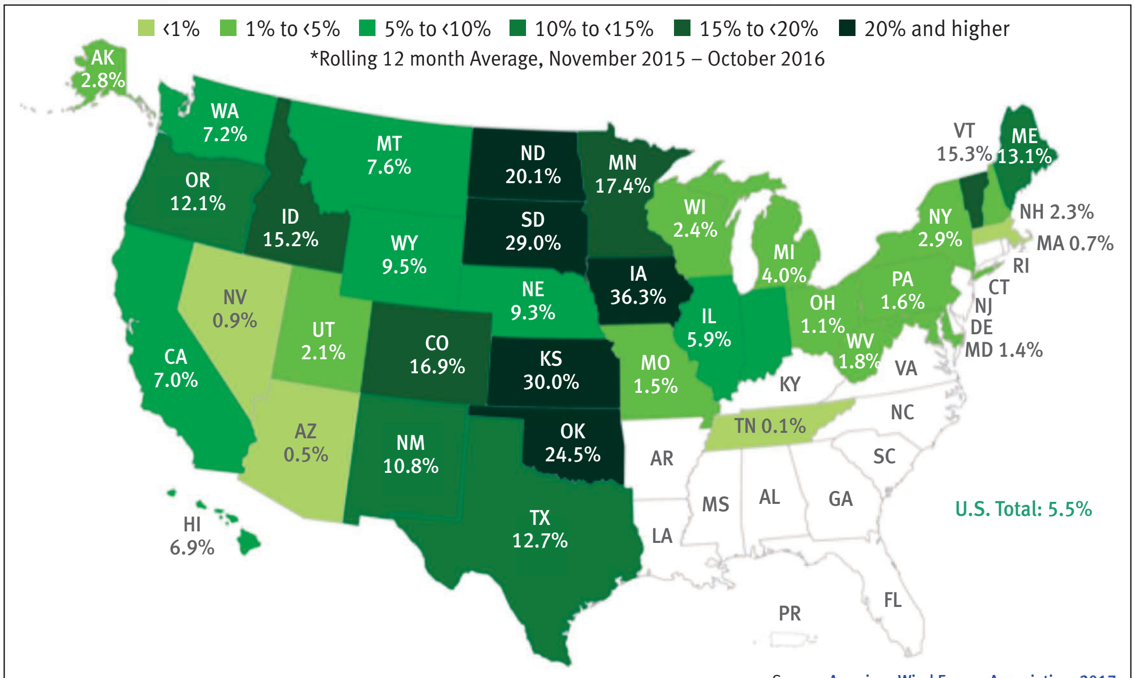


FIGURE 2: U.S. Utility-Scale Wind and Hydro Monthly Electricity Generation Capacity (Jan 2002–Dec 2016)

1 But due to capacity factors, the EIA still expects hydro to edge out wind in 2017 in terms of total energy production.

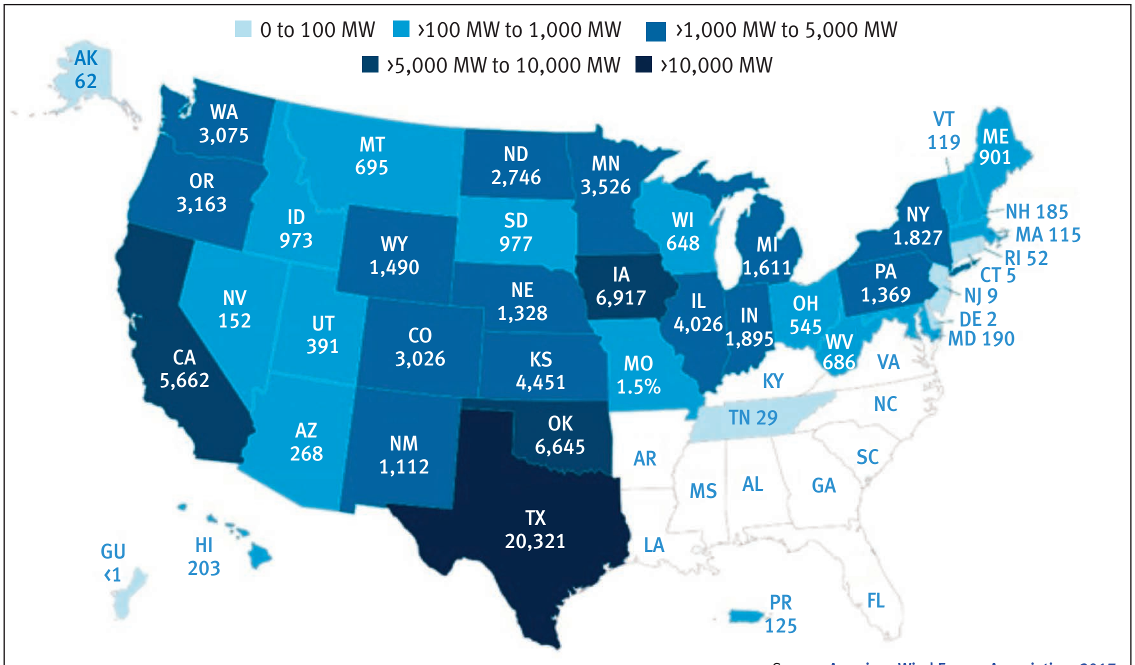
2 https://www.eia.gov/electricity/data.cfm

Texas, Iowa, Oklahoma, California, and Kansas lead the nation in installed capacity,[3] while Iowa, Kansas, Oklahoma, and the Dakotas have the highest shares of wind energy in their statewide electricity generation (as shown in Figures 3 and 4).



Source: American Wind Energy Association, 2017

FIGURE 3: U.S. Wind Energy Share of Electricity Generation by State



Source: American Wind Energy Association, 2017

FIGURE 4: U.S. Installed Wind Capacity by State (2016 year end)

[3] https://www.energy.gov/eere/articles/why-corporations-are-buying-us-wind-power

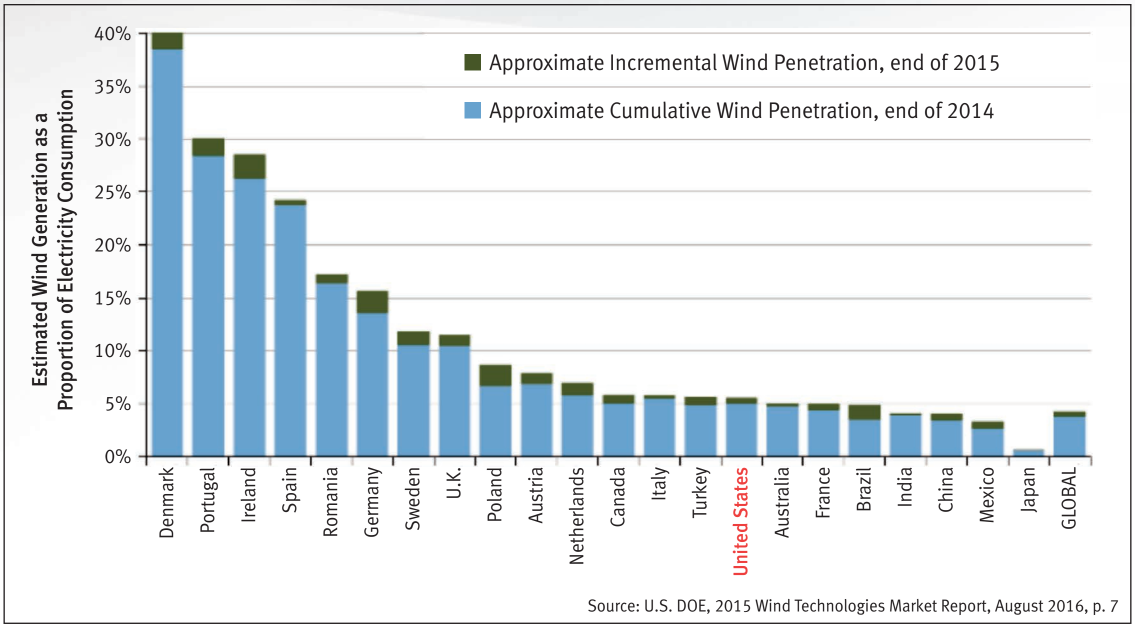


FIGURE 5: International Wind Energy Share of Electricity Generation by Country

TABLE 1: International Ranking of Wind Capacity

Cumulative Capacity (end of 2015, MW)	
China	145,053
United States	73,992
Germany	44,986
India	25,352
Spain	22,665
United Kingdom	13,388
Canada	11,190
France	10,243
Brazil	9,346
Italy	8,851
Rest of World	68,464
TOTAL	**433,530**

Source: U.S. DOE, 2015 Wind Technologies Market Report, August 2016, p. 6

Despite these achievements, the U.S. still lags behind many countries in wind energy utilization (see Figure 5 and Table 1). At the end of 2015, total U.S. wind capacity (74 GW) was second only to China's (145 GW), but fourteen countries, including Turkey, Italy, and Canada, exceeded the U.S. in terms of wind's share electricity generation — estimated to be 5.5 percent at the end of 2015. For comparison, Spain, Ireland, Portugal, and Denmark meet from 25 to 40 percent of their electricity needs with wind.

ELECTRIC COOPERATIVES AND WIND

Electric cooperatives are not standing on the sidelines — 561 co-ops in 37 states now use wind power.[4] Thirty-five distribution co-ops and 25 G&T companies own and/or purchase wind power directly. The majority is acquired through power purchase agreements (PPAs), due to the significant production tax credit of $23/MWh that will be phasing out by 2020. As of February 2017, electric cooperatives purchased

4 http://www.electric.coop/wp-content/Renewables/wind.html

nearly 5,600 MW of wind power capacity through PPAs and owned nearly 460 MW of wind capacity. This represents more than three-quarters of electric cooperatives' renewable capacity and about 7 percent of total US wind capacity.[5] Tennessee Valley Authority, a U.S. corporate agency that supplies many cooperatives with electricity, contributes an additional 390 MW of wind capacity. Going forward, seven G&Ts and three distribution cooperatives have announced plans to purchase about 990 MW from new projects that will be commissioned between 2017 and 2020. (See Figure 7.)

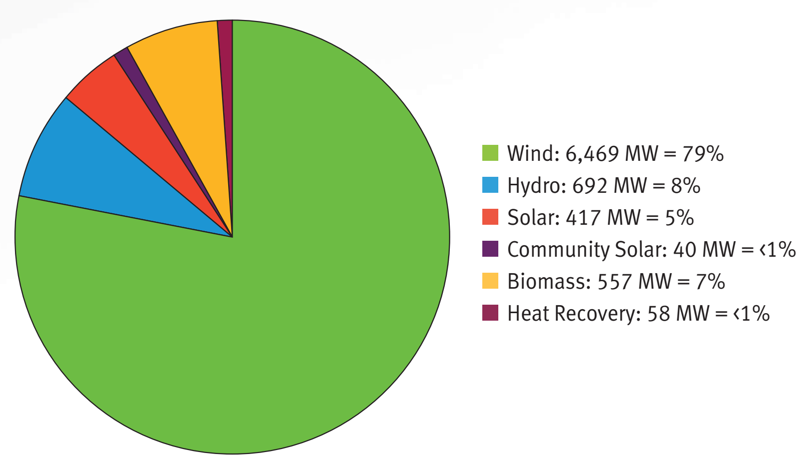


FIGURE 6: Electric Cooperative Renewable Capacity Mix.
Source: NRECA data[6]

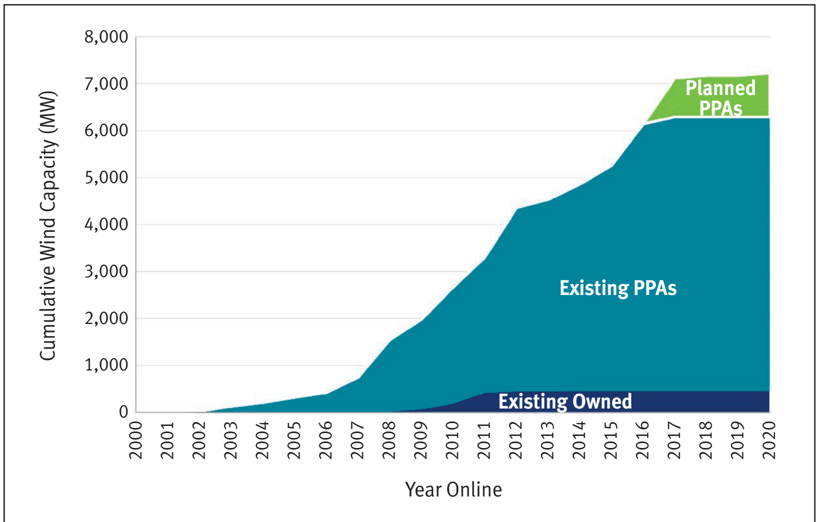


FIGURE 7: Cumulative Wind Capacity Owned and Purchased by Electric Cooperatives. *Source: NRECA data*

Like all electric utilities, electric cooperatives can acquire wind energy by owning their own wind farms and/or purchasing it from separate entities through PPAs. All G&Ts that own wind power also have PPAs for additional wind capacity, with the exception of Buckeye Power, Inc., an Ohio G&T that owns one wind turbine at a high school demonstration project. Distribution electric cooperatives tend to either own wind capacity or purchase it, but not both. According to NRECA data, the only distribution electric cooperative that both owns wind farms and has PPAs is Golden Valley Electric Association in Fairbanks, Alaska.

Power Purchase Agreements

The vast majority — 92 percent — of electric co-op wind capacity comes from PPAs with wind farms owned by Independent Power Producers (IPP). These 5,600 MW are purchased by 15 distribution co-ops and 24 G&Ts. Most PPAs are long-term contracts — twenty years is common, but terms range from 10 years up to 30.

It is also typical for contracts to have "must-take" clauses, so that the buyer agrees to purchase all energy produced at fixed fees regardless of demand. While this can be quite profitable at some times, it can be less so at others. According to Natasha Henderson, Manager of Strategic Planning at Golden Spread Electric Cooperative, if a wind resource

[5] For context, electric cooperative generate about 11% of total U.S. electricity supply.

[6] http://www.electric.coop/wp-content/Renewables/index.html, includes TVA wind, biomass, and solar capacity, and April 2017 updated information from Basin Electric Power Cooperative

is under curtailment, a cooperative could incur costs for negative rates (–$35/MWh is typical) if the wind turbines continue to operate, as well as lost tax incentives at around $23/MWh grossed up at the appropriate corporate tax rate as specified by the seller. However, most co-ops have opted for PPAs instead of ownership. Overall, PPAs seem less risky than developing and maintaining a wind farm, and as Tom Burke, Golden Spread Electric's Director of Regulatory and Transmission Policy points out, "cooperatives are not well-structured to utilize PTCs. For-profit entities can capture those tax benefits and deliver the savings to co-ops." A recent development is that some utilities are starting to co-plan projects with utilities — a collaborative process that removes risk for the developer (which lowers cost), allows the utility to pick the best locations with the developer, and helps ensure the project is sized properly.

Electric cooperative wind PPAs began in early 2000s, and more than 1,500 MW is currently planned to come online between 2017 and 2020. The average G&T PPA is about 50 MW, whereas the average distribution cooperative PPA is 20 MW, but individual contracts range from less than 1 MW to greater than 100 MW. The largest of these is an agreement between Associated Electric Cooperative Inc., a G&T headquartered in Springfield, MO, and BP Wind Energy for 314 MW of wind capacity from the Flat Ridge Wind Farm in Kingman County, KS. With more than 550 MW of new capacity coming online in 2016 and early 2017, Basin Electric purchases the most wind among G&Ts — 1,086 MW (see Table 2).

In addition to utility-scale PPAs, many distribution co-ops purchase wind energy from distributed sites — often small, single turbines owned by individual members. NRECA does not maintain a comprehensive dataset on these purchases, but Basin Electric, for example, purchases energy from more than 100 small wind turbines throughout their service territory.

Cooperative Profiles — PPAs

PPA between a G&T and a distribution member

Corn Belt Power Cooperative, a G&T that serves nine distribution co-ops and one municipal cooperative in northern Iowa, began purchasing wind power relatively early. Developers of the Hancock Wind Energy Center in Hancock, IA approached the G&T, and in 2002, their first PPA for just over 11 MW of wind capacity went into effect. In 2007, Corn Belt Power entered into another PPA with the Crosswind Energy project for 21 MW, and in 2009, the cooperative agreed to purchase an additional 21 MW generated at two wind farms owned by Iowa

TABLE 2: Top Five Cooperatives that Purchase the Most Wind

G&T	Total MW	Distribution	Total MW
Basin Electric Power Cooperative (ND)	1,086	Midwest Energy Cooperative (KS)	106
Associated Electric Cooperative (MO)	771	Pedernales Electric Cooperative (TX)	90
Western Farmers Electric Cooperative (OK)	534	People's Electric Cooperative (OK)	74
Great River Energy (MN)	464	Southern Maryland Electric Cooperative (MD)	50
Minnkota Power Cooperative (ND)	375	Lea County Electric Cooperative (NM)	42

Lakes Electric Cooperative, one of Corn Belt Power's distribution members. According to Mike Thatcher, Vice President, Generation, Corn Belt "felt wind energy was beneficial to members, renewable energy was becoming more popular, and the economics of wind energy worked." The cooperative chose PPAs instead of owning wind farms because it was less risky and, as a non-taxable entity, Corn Belt did not benefit directly from the PTC.

Under its PPAs, the G&T purchases all generation from these sites at fixed prices. Since Corn Belt became a full member of Basin Electric Power Cooperative in 2009, Basin now purchases the wind energy from Corn Belt. Corn Belt then buys it back from Basin bundled as wholesale power. All Renewable Energy Credits (RECs) associated with Corn Belt's PPAs are pooled with Basin's.

Overall, the wind PPAs are working well. Since Basin places load in the Southwest Power Pool (SPP) and the Midcontinent Independent System Operator (MISO), and the projects are relatively small, curtailment has not been an issue. Corn Belt Power does not experience any power quality issues, but does have to ensure power lines are not overloaded in times of high wind. For co-ops considering wind PPAs, Thatcher advises to evaluate contractual obligations to take all of the power all of the time. If there is more supply than demand, "low to negative prices could hurt you."

Too much of a good thing?

Sunflower Electric Power Corporation, Inc., a G&T headquartered in Hays, KS, serves six distribution cooperatives in western Kansas. Five of those distribution cooperatives and a wholly-owned subsidiary of the sixth formed Mid-Kansas Electric Company, LLC in 2007. The two G&Ts currently have PPAs for a total of 178 MW of nameplate wind capacity. According to Mike Thompson, Senior Manager of Generation Engineering & Environmental Compliance, Kansas previously had a renewable energy requirement that the G&Ts were attempting to meet with wind power. However, over time, circumstances changed. What used to be a state renewable energy requirement is now optional, and the regional grid operator, SPP, began day-ahead pricing, which can cause the market value for wind energy to fluctuate widely. Furthermore, because Kansas has an excellent wind resource, many other projects were simultaneously developed that also feed into SPP. The result is that when the wind is blowing, "there is an excess of produced power and not enough transmission capacity to serve the east [part of Kansas], where the large load centers are." Because of this, western Kansas often experiences negative market energy pricing.

In addition, Thompson noted that the amount of wind power on their system has introduced some power quality issues. The quantity of wind energy has enabled the G&T to turn off some of their traditional sources. But, because wind can ramp up and down quickly and sometimes unpredictably, grid voltage, Volt Ampere reactive (VAr), and frequency can be negatively impacted in the absence of reliable and dispatchable sources like coal and natural gas fired generation. To address this, Sunflower built Rubart Station in the fall of 2016. Composed of twelve 9.5 MW Caterpillar reciprocating engines, the 114 MW plant is one of only six of its kind in the nation. Its fast-ramping capabilities were designed to complement and manage the intermittent and non-dispatchable wind production and improve grid reliability, and so far, the plant is performing as expected. While the wind PPAs have turned out to be less economical than originally expected, Rubart Station is a success that could be replicated at other electric utilities facing similar circumstances. Fossil generation options for managing the intermittency of integrating renewables is further discussed in another *TechSurveillance* article — "**Integrating Renewables: Fossil Generation Options Available to G&T Cooperatives**."

Cooperative-Owned Wind Farms

G&T-owned wind capacity totals just over 355 MW, and this is primarily from two G&Ts (see Table 3). Basin Electric accounts for the majority — 275 MW — with five sites in North and South Dakota. The largest of these is Crow Lake Wind, a $343 million project that consists of a hundred 1.5 MW GE turbines and began operation in 2011. Golden Spread Electric Cooperative of Amarillo, TX, owns 78 MW of wind capacity. Their farm, located near Wildarado, TX, consists of thirty-four 2.3 MW Siemens turbines and has a capacity factor of just over 50 percent, according to Henderson. The remaining 2 MW of G&T-owned capacity comes from individual turbines and demonstration.

Twenty distribution co-ops own a total of 83 MW of wind capacity. Distribution cooperative-owned wind projects range from individual demonstration turbines to small wind farms, with an average capacity of 2 MW per site. Nearly half (41 MW) of distribution-owned capacity is from 21 sites throughout Alaska. The other distribution cooperative-owned wind farms are in Colorado, Illinois, Iowa, Maine, Minnesota, Ohio, Oregon, Texas, and Wyoming.

Cooperative Profiles — Wind farm ownership

Early-adopter

Kotzebue Electric Association (KEA), which serves 3,200 members north of the Arctic Circle, was an early pioneer of wind energy. Like all electric cooperatives in Alaska, Kotzebue Electric is islanded — not connected to a grid. Therefore, KEA is technically a *generation and distribution* cooperative. Since its founding in 1954, the cooperative generated electricity from diesel fuel. But, according to Brad Reeve, retired General Manger, KEA was interested in diversifying their generation mix and sought "solutions that accelerate the integration of technology that increases the use of renewable energy and reduces diesel fuel consumption, not only for Kotzebue, but the rest of the region."

In 1997, the cooperative commissioned three 66 kW turbines and added seven more two years later. By 2011, KEA had built up their wind farm to 17 turbines and owned the first MW of total wind capacity in Alaska. The next year, they commissioned two 900-kW turbines which tripled their wind capacity. This enabled the cooperative to meet 20 percent of their load with wind and reduce their diesel consumption by 250,000

TABLE 3: Top Five Cooperatives that Own the Most Wind

G&T	Total MW	Distribution	Total MW
Basin Electric Power Cooperative (ND)	275	Golden Valley Electric Association (AK)	25
Golden Spread Electric Cooperative (TX)	78	Iowa Lakes Electric Cooperative (IA)	21
Minnkota Power Cooperative (ND)	1.8	Kodiak Electric Association (AK)	9
Great River Energy (MN)	0.2	Fox Islands Electric Cooperative (ME)	4.5
Hoosier Energy (IN)	0.02	Alaska Village Electric Cooperative (AK)	3.5

gallons each year. In addition to saving money for members and reducing dependence on fossil fuel, the Kotzebue Electric Association Wind Farm boasts several claims to fame:

- Northernmost wind farm in the U.S.
- First utility-scale wind farm above the Arctic Circle
- First utility-scale wind farm in Alaska
- Developed the first use of “freeze-back pilings” as the permafrost foundation for wind turbines

One of the utility’s goals is to turn off diesel generation this summer when there is enough wind. With the addition of a 1.2 MW utility-scale Saft lithium-ion battery and power convertor, they now have a grid-supporting wind/battery storage solution. Even before they added a battery, KEA had developed solutions to generate 70 to 80 percent of their instantaneous electricity with wind. With the addition of the two large turbines, there are times when the battery is in a full state-of-charge and there is excess energy. Currently, that excess meets hot water needs at a local hospital with thermal boilers and at times even heats the entire facility. KEA’s wind project benefits their community in numerous ways. Reeve encourages other cooperatives to consider wind farm ownership, especially given the opportunity to finance them with Clean Renewable Energy Bonds (CREBs).

Harvesting wind for ethanol

Iowa Lakes Electric Cooperative (ILEC), a distribution cooperative that serves 12,650 accounts in northwest Iowa, achieved notoriety for their two wind farms that went online in 2009. Combined, they have a capacity of 21 MW, which made this the largest wind project owned by any distribution electric cooperative at that time. According to Aaron Ruschy, Vice President of Operations and Engineering, the decision to own wind farms was originally driven by the co-op’s board of directors. At that time, there was “a lot of buzz around the environment, and a new administration that promoted clean energy. And, we have *a lot* of wind.”

The co-op installed fourteen 1.5 MW GE turbines (21 MW total) that generate about 77,000 MWh each year, about 12 percent of ILEC’s electricity supply. Annual capacity factor is approximately 42 percent,[7] and they do not experience problems with power quality or curtailment.

Iowa Lakes made several key decisions that have contributed to their wind farms’ viability. First, the co-op financed the $43 million project with zero percent interest CREBs, which are available for electric cooperatives and other public entities for many of the same kinds of renewable energy developments that the PTC covers. Second, they sited the farms strategically right next to two very large load centers in their territory — ethanol plants. Because the plants had existing sub-stations, ILEC was able to use relatively short 3-Phase underground distribution lines to feed wind energy right to the sub-stations. While their G&T, Corn Belt Power Cooperative (and ultimately Basin Electric Power Cooperative) purchases all generation, much of the wind energy ends up being used right at the ethanol plants.

Finally, Iowa Lakes does all their own operations and maintenance at the wind farms with three full-time wind generator technicians. “You get much better attention to detail when there’s ownership.” Al Zeitz, Manager of Renewable Energy Services, has more than 20 years experience in the wind industry, and ILEC is able to

[7] 21 MW of turbines generating 24/7, 365 days (non-leap year) would produce 183,960 MWh/year. 77,000 MWh / 183,960 MWh = 41.86% or 42%, rounded

hire technicians with industry experience and/or training from the Wind Energy and Turbine Technology program at nearby Iowa Lakes Community College. Because the turbines' warranties have now expired, ILEC does hire an independent service provider for non-scheduled maintenance and repairs. Operation and maintenance expenses for both sites combined are about $70,000 per year.

Nearly ten years after the project began, Iowa Lakes is pleased with the outcome. According to Zeitz, "the landowners who lease land to the wind farms are all very positive; we don't get any complaints." The community benefits from clean energy that powers a local industry, and the economics are favorable for the co-op.

The cooperative has been setting aside funds for repairs as the turbines are nearly ten years old, but future plans are up in the air. "[We're] keeping our options open," said Ruschy. "The most likely scenario is to repower [the turbines] as the industry has done in the past. If technology allows at that point to increase both capacity and energy (capacity factor) with the existing turbine structure, then it becomes a very viable option." In the meantime, he offers some thoughts for other co-ops considering getting into wind — "Large wind farms may have curtailment issues, if the transmission system can't support the size of the farm. Size your project for where you are and where the load is."

GRID IMPACTS

As mentioned in the section in the beginning on the impact on cooperatives, among the operational issues identified is the need to cycle fossil-fuel-fired generating plants. Such cycling could entail two-shifting (shut down at night and hot restart in the day) or even *double two-shifting* (shutdown at night, hot restart in the morning, shutdown in midday due to increasing solar penetration, hot restart in late afternoon, and shutdown in the evening hours) when the wind blows at night and in the future when there is high penetration of solar PV in the middle of the day. As coal-fired power plants and natural gas-fired combined cycle gas turbines increase two shift operations, it is expected that there will be significant increases in operation and maintenance expenses, significant reduction in the reliability, increased need for replacement energy and power, increased need for new backup capacity, reduced system reserves, etc.

The levelized cost of electricity for the wind generation will not reflect all of the costs and the ultimate impact on the wholesale price of electricity to the G&T electric cooperative power system. In a previous *TechSurveillance* article, NRECA noted that, since wind generation typically occurs at night for on shore wind, any existing coal-fired generation or natural gas-fired generation will ultimately suffer damage due to fatigue, creep rupture, and the interaction of fatigue and creep; corrosion, exfoliation of corrosion products, etc. that will significantly impact and increase the equivalent forced outage rates for both coal-fired generation and natural gas-fired generation. This will lead to approximately 20 percent increase in operation and maintenance costs of per year for coal-fired power plants. In addition, forced outage rates are expected to increase from 5 percent per year to 15 percent per year — or even as high as 30 percent per year depending upon the number of starts and stops for the coal-fired power plant. This will increase the reserve requirements for additional new capacity and result in higher replacement energy costs. Similar impacts will occur at heavy-duty gas turbines and heavy-duty combined cycle gas turbines, if they are subject to weekly or daily starts and stops (referred to as two shift operation) which will increase forced outage rates from 2 to 12 percent or more, and more than double the operation maintenance costs. In addition, as the percent of wind generation increases or decreases on the system, the power system will be subject to rapid changes in ramping in the system load seen by existing coal-fired or natural gas-fired generation. The existing fossil generation may not be able to respond as quickly as the wind generation increases or decreases, which can in some cases occur in minutes. Thus, as has been mentioned in a previous TechSurveillance article, many G&Ts have already added reciprocating internal combustion engines to respond to the rapid ramps (which are also available should the overall system loads increase over time).

Other reliability issues for G&Ts and distribution electric cooperatives include voltage spikes and dips and, at very high penetration of renewables, fluctuations in voltage can cause inadvertent tripping of relays and circuit breakers, possibly resulting in unintended islanding and other consequences. Other issues for electric distribution cooperatives and G&Ts include:

- more frequent operation of voltage regulators/ tap changers,
- volatile and negative market prices resulting from wind generation that bids into the market at a very low or zero cost due to production tax credits, reducing market prices for G&Ts to a level that can prematurely cause the shutdown of base-load power plants (needed for system reliability and system inertia to mitigate potential transient instabilities),
- increase in wholesale power costs to cover the costs of building new flexible and fast start generation to fill the gaps, and
- new transmission lines or upgraded transmission lines and substations, to reduce or eliminate congestion caused by variable renewable generation that typically is located in remote areas with insufficient transmission capacity to bring to load centers.

A major issue that should never be forgotten is that if too much wind is built in a location with insufficient transmission assets to export the wind energy to load centers, then congestion will occur on the transmission lines, driving the wholesale prices negative and resulting in the “spilling” and loss of wind energy that typically is going to be paid for anyway under a take-or-pay PPA.

CURRENT ECONOMICS FOR WIND ENERGY

Based on the DOE EIA Annual Energy Outlook 2017[8] report on capital costs for power plants completed in November 2016,[9] the overnight capital cost for a new 100 MW wind farm was $1,877/kW, and the fixed operation and maintenance costs were about $40 per kW per year. By April of 2017, the overnight capital cost had decreased to $1,576/kW.[10] Assuming that the annual capacity factor will be 40 percent (although capacity factor varies by region), property taxes and insurance is 2 percent, the debt services is over 30 years, return on 100 percent debt financing for an electric cooperative is 2.3 percent (unless zero percent CREBs financing is available); then the levelized cost of electricity in 2016 would be about 4.1 cents per kilowatt hour (and, thus, wind energy still remains the cheapest renewable energy option). However, with the towers for wind turbines increasing in height (120 m or higher), the capacity factors in the future will be 50 percent or higher. With increase in size of the wind turbine generator and improved technologies, in a few years the capital cost for large-scale wind farms

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8 https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf

9 https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capcost_assumption.pdf (See page 8)

10 https://www.eia.gov/outlooks/aeo/assumptions/pdf/table_8.2.pdf

could decrease to below $1,500/kW, then the levelized cost of electricity could drop to 2.8 cents per kilowatt hour and wind energy will continue to be the cheapest renewable energy option. An Xcel Energy project that is under construction now will cost $1,667/kW, including $180M for a new transmission line. Capacity factor at this location is 45 percent.[11]

TABLE 4: Overnight Capital Costs for Onshore Wind Farms

	Overnight Capital Costs for 100 MW Onshore Wind Farm ($/kW)	Percent Decrease from Previous Period	Percent Decrease from 2010
2010	$2,534	–	–
2013	$2,213	13%	13%
2016	$1,877	15%	26%
2017 (April)	$1,576	16%	38%
Source: DOE EIA Annual Energy Outlook 2017			

Tax Credits

A key driver of the wind industry in the U.S. has been the availability of tax credits for developers — the Renewable Electricity Production Tax Credit (PTC) and the Business Energy Investment Tax Credit (ITC). The PTC, a federal incentive originally authored by Chuck Grassley (R-IA) as part of the Energy Policy Act of 1992, offers an incentive per kilowatt-hour of electricity generated from some renewable energy sources, including wind, allowable for ten years after a project is developed. However, Congress has let the PTC expire and renew many times since 1992, causing pricing uncertainties and several rounds of “boom-and-bust” cycles for wind development (see Figure 8). The ITC was enacted in 2008, and has been amended several times.

In December of 2015, Congress provided the wind industry some continuing certainty by passing five-year ramp-downs of both credits

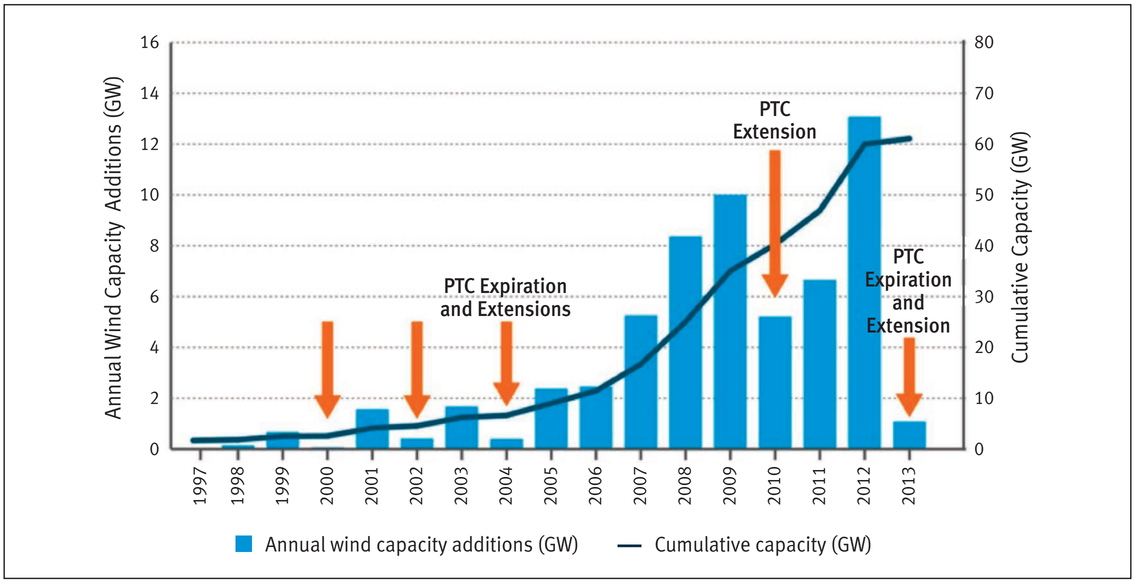

FIGURE 8: Impact of Production Tax Credit Expiration and Extension on U.S. Annual Installed Wind Capacity. *Source:* ***U.S. DOE, Wind Vision, 2015***

[11] http://www.denverpost.com/2017/02/02/xcel-energy-jumps-last-hurdles-for-massive-rush-creek-wind-project

(see Tables 5 and 6). For wind, the PTC lasts for 10 years after the facility is placed in service and the ITC is based on the year construction starts. Only one credit may be taken per project.[12, 13] A "safe harboring" option allows a project to take the credit based on the first year that it spends 5 percent of the total budget if the project is completed within four years.[14]

TABLE 5: Production Tax Credit Phase-Out Schedule

Construction Start Date	PTC Value	PTC Amount
2015	100%	2.3¢ /kWh
2016	100%	2.3¢/kWh
2017	80%	1.8¢/kWh*
2018	60%	1.4¢/kWh*
2019	40%	0.9¢/kWh*

*Approximate. Actual values will be determined based on the inflation adjustment factor used by IRS in each year.

TABLE 6: Investment Tax Credit Phase-Out Schedule

Construction Start Date	ITC Value
2016	30%
2017	24%
2018	18%
2019	12%

Despite the past uncertainties, both tax credits have encouraged substantial growth of wind energy and numerous economic benefits. For example, by the end of 2016, the wind industry employed more than 100,000 American workers.[15] Of those, 25,000 work in the 500+ U.S. factories that produce wind energy components in all 50 states.[16]

Tax-Exempt Bonds

Because the PTC and ITC are tax credits, electric cooperatives typically cannot take these credits directly, since they are non-profit organizations. However, electric cooperatives and other public entities may use tax-exempt clean renewable energy bonds (CREBs) to finance wind and other qualified renewable energy facilities — the same set of technologies covered by the PTC.[17] Available since 2005, CREBs provide qualified borrows a very low to interest-free rate. Kotzebue Electric Association, Iowa Lakes Electric Cooperative, and Kansas Electric Power Cooperative, among others, have financed wind farms with them. As of March of 2017, the remaining available volume cap for electric cooperatives was just over $178 million.[18] Application instructions are available from the Internal Revenue Service at **https://www.irs.gov/pub/irs-drop/n-15-12.pdf**.

WHAT'S NEXT WITH WIND?

Wind energy is expected to keep growing in the U.S. and abroad (see Tables 5 and 6). The U.S. DOE estimates that U.S. wind capacity could potentially reach 10 percent of total U.S. power supply by 2020 and 30 percent by 2030, assuming that sufficient transmission capacity

12 https://energy.gov/savings/renewable-electricity-production-tax-credit-ptc

13 https://energy.gov/savings/business-energy-investment-tax-credit-itc

14 See: https://www.awstruepower.com/ptc-safe-harbor-clause

15 https://energy.gov/articles/doe-releases-second-annual-national-energy-employment-analysis-0

16 http://www.aweablog.org/wind-power-surges-first-place-americas-largest-renewable-resource

17 https://energy.gov/savings/clean-renewable-energy-bonds-crebs

18 https://www.irs.gov/tax-exempt-bonds/published-volume-cap-limits-and-available-amounts-of-volume-caps-for-new-clean-renewable-energy-bonds

can be permitted in time and funded to transmit the wind energy to market.[19] And, China recently announced firm plans to have 200 GW of wind by 2030, as part of the country's renewable energy goals, but they have had significant difficulty in getting transmission lines permitted, constructed, and operational (in some cases wind farms have been built without transmission access in the frenzy to get windfarms built. For instance, China is rapidly expanding access to the remote wind resources in western China and transmitting the electricity over distances greater than 1,000 km 800,000 V high-voltage DC lines).[20] New wind turbine and tower technologies are improving efficiency and reliability, and viable storage technologies are being developed and tested. NRECA will continue to support its members with technical and market reports on the wind industry. Stay tuned for upcoming NRECA *TechSurveillance* reports in this series, which will discuss advances with wind energy technology and operational and maintenance concerns, and visit us on **cooperative.com** for additional resources. ■

[19] https://energy.gov/eere/wind/maps/wind-vision

[20] https://www.washingtonpost.com/news/energy-environment/wp/2017/03/29/as-trump-reverses-obamas-climate-plans-chinas-leadership-moment-arrives/?utm_term=.d5edd76addaf

RESOURCES

American Wind Energy Association (AWEA),
"The American Wind Energy Association (AWEA) is the premier national trade association that represents the interests of America's wind energy industry."

National Renewable Energy Laboratory (NREL), National Wind Technology Center,
"The National Wind Technology Center comprises the necessary infrastructure, highly experienced staff, and state-of-the-art equipment needed to provide its partners and stakeholders with a full spectrum of research and development capabilities to develop everything at one location."

National Rural Electric Cooperative Association, Cooperatives and Renewables,
Informational website on electric cooperatives' renewable sources. For updates to data presented here, electric cooperatives should contact Michael Leitman, **michael.leitman@nreca.coop**

U.S. Department of Energy (DOE), Wind Energy Technologies Office,
"The U.S. Department of Energy's (DOE's) Wind Energy Technologies Office (WETO) invests in energy science research and development (R&D) activities that enable the innovations needed to advance U.S. wind systems, while continuing to address market and deployment barriers, i ncluding siting and environmental impacts. WETO is dedicated to driving down the cost of wind energy with more efficient, more reliable, and more predictable wind energy systems".

Utility Variable-Generation Integration Group (UVIG),
"The Utility Variable-Generation Integration Group (UVIG) is the leading source of global expertise for wind and solar operations and power system integration." (Previously known as the Utility Wind Integration Group)

About the Author

Laura Moorefield consults for utilities, state and federal governments, and non-profits on lighting, energy efficiency, renewables, and program design. Since 2005, she has been influential in the development of innovative programs and policies to spur energy savings. In addition to her background in consulting, public speaking, technical writing and project management, Laura draws on industry experience from prior positions in manufacturing and product engineering. She founded Moorefield Research & Consulting in 2013 after holding positions with Ecova, Ecos Consulting and Rejuvenation. Laura is Lighting Certified by the NCQLP, holds an MA in Renewable Energy from Appalachian State University (Boone, NC), and currently lives in Durango, CO where she is a member of La Plata Electric Association. lmoorefield@gmail.com

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- Business and Technology Strategies feedback line.
- To find more *TechSurveillance* articles on business and technology issues for cooperatives, please visit our website archive.

BUSINESS AND TECHNOLOGY STRATEGIES
GENERATION, ENVIRONMENT AND CARBON WORK GROUP

The Business and Technologies Strategies — Generation, Environment, and Carbon Work Group is focused on identifying the opportunities and challenges associated with electricity generation. *TechSurveillance* research relevant to this work group looks at the various aspects of electricity generation technology, including market status, related policies and regulations, and business models to assist cooperatives in making operational and investment decisions. For more information about technology and business resources available to members through the Generation, Environment, and Carbon Work Group, please visit www.cooperative.com, and for the current work by the Business and Technology Strategies department of NRECA, please see our Portfolio.

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