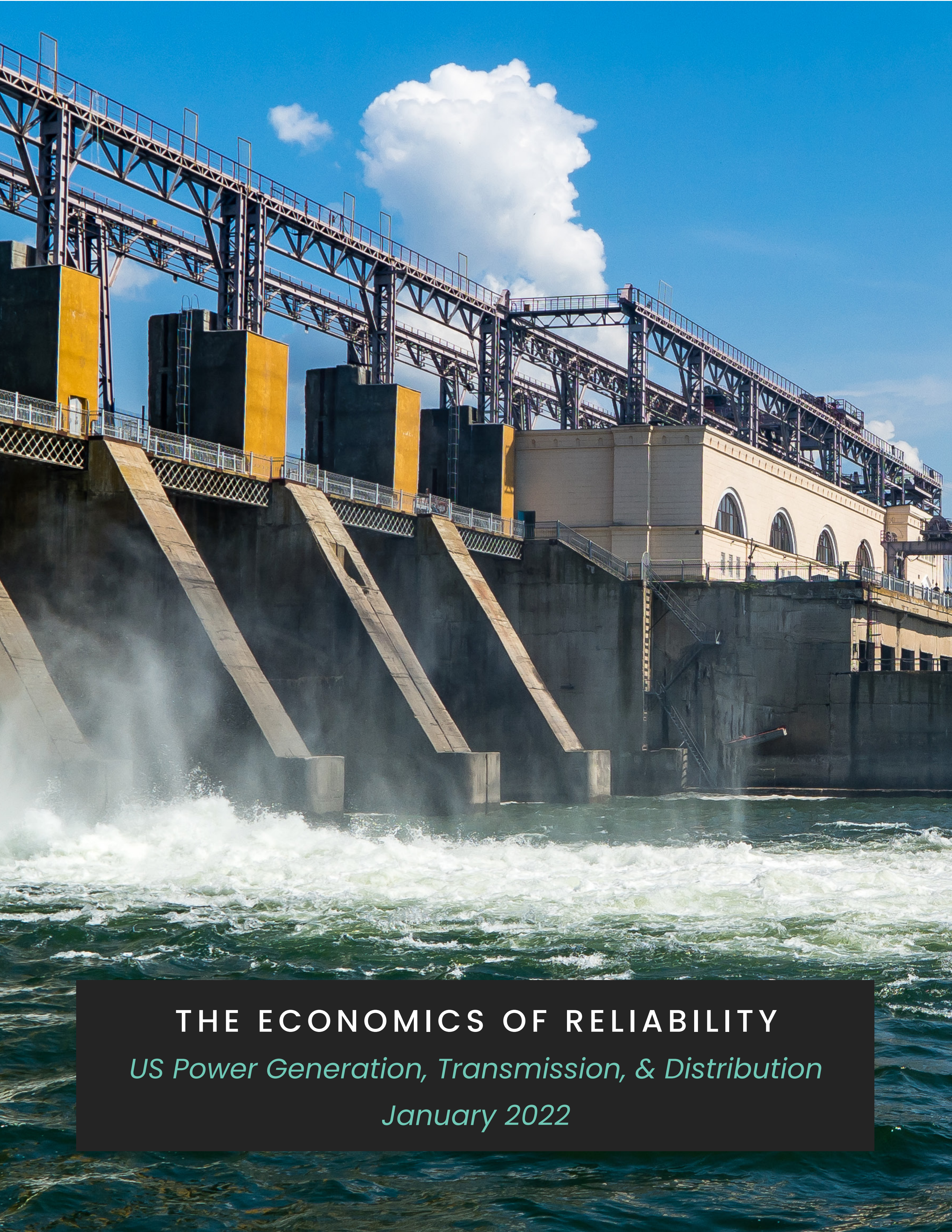
The Economics of Reliability

US Power Generation, Transmission, & Distribution

PINNACLE
DATA-DRIVEN RELIABILITY



THE ECONOMICS OF RELIABILITY

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January 2022

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LETTER FROM THE CEO

About one year ago, a historic freeze hit the southern region of the United States which caused Texas' self-contained electric grid to fail. As a result, Texas experienced power outages that it had never seen before. Unseasonably cold temperatures caused demand for electricity to skyrocket and forced many power generation, transmission, and distribution facilities to unexpectedly shut down, further exacerbating the strain on functioning facilities. At one point, nearly 46,000 megawatts (MW) of electricity were forced offline.

Texas' electric grid is an extremely complicated system that is managed by the Public Utility Commission of Texas and the Electric Reliability Council of Texas (ERCOT). ERCOT plays a crucial role in forecasting power needs, regulating electricity pricing, and monitoring the amount of generation at any given time. So, if ERCOT is normally involved in the management of electricity across Texas, why did this massive failure occur?

The widespread electrical outages were caused by a combination of frozen wind turbines and the shutdown of natural gas, coal, and nuclear plants that experienced mechanical failures. These types of facilities, and Texas' electric grid, were not built to sustain these types of temperatures. While many people debated the root cause of the grid failure, this crisis exposed the vulnerability of Texas' electric grid and identified a lack of calculation of system-wide risk.

As we've discussed in our previous Economics of Reliability reports, the reliability of complex systems is critical to the way our society functions. We often don't think about reliability until these systems don't have it – in fact, many people had not even heard of ERCOT prior to the freeze. After millions of Texans were without power, many were left to wonder - how can we improve these systems to prevent future catastrophic failures?

Our analysts estimate that the US power generation, transmission, and distribution industry spends about US$20 billion annually on reliability, which equates to about 7% of revenue. However, the most efficient operators spend less than 5% of revenue on their reliability programs. In our report, we study 32 publicly traded US power companies. We see that this group of companies is investing a large amount of capital to expand their asset bases while minimizing ongoing operating expenses and earning more revenue.

So, what changes can these companies make to prevent future failures? There are four primary questions to think about. First, how can power plants re-think their approach to planned maintenance and outages? Second, what can we do to anticipate any increase in demand, and how do we supply extra power once we've identified the need? Third, what tactics can companies implement to address some of the mechanical problems these facilities face without increasing costs – both to the facility and to ratepayers - to improve reliability? And finally, how much more are we willing to spend to ensure that these facilities stay online at all times?

As power companies face stricter carbon emissions regulations and the pressure of having to always be on, the need for reliability will become even more important to the long-term success of this industry.

Sincerely,
Ryan Sitton | *Founder and Chief Executive Officer*

US power companies spend US $20 billion annually on reliability, which equates to about 7% of revenue.

INTRODUCTION

The US power network received attention for tragic reasons in 2021. From February 10 through 20, the state of Texas suffered a severe power crisis due to a confluence of catastrophic winter storms[1]. Failures occurred across all types of electricity generation facilities – natural gas, coal, and nuclear plants shut down, and wind turbines froze. Problems cascaded, as the compressors required to pump natural gas through pipelines suffered during the initial power shutdown, which cut the natural gas supply for those facilities that remained active. According to the University of Houston Hobby School of Public Affairs, "[m]ore than two out of three (69%) Texans lost electrical power at some point February 14-20, for an average of 42 hours, during which they were without power on average for one single consecutive bloc of 31 hours, rather than for short rotating periods"[2].

Electricity plays a pivotal role in matters of life and sometimes death. While some of our critical infrastructure has a degree of failure mitigation – hospitals with their onsite generators, for example – many power generation facilities and much of the transmission and distribution network is exposed. Many key facilities in Texas were vulnerable to extreme cold temperatures and when such an unexpected, widespread weather event struck, the power infrastructure broke down in painful ways.

In February 2021, Texans learned firsthand the price to be paid when electrical systems fail. The cost of failure can be lethal. Power system operators and regulators have since refocused their efforts on identifying economically effective ways of improving the reliability of US power infrastructure, from the plants that generate electricity to the transmission and distribution lines that carry power to our homes, schools, and businesses. In this report, we study the economics of the reliability of this infrastructure. We start with a market-wide view, and then zoom in on operator-specific performance. In the next section, we list the data sources we use and describe our approach to the subsequent analysis.

ANALYSIS METHODOLOGY

In our analysis of the US power generation, transmission, and distribution sector, we rely on two primary data sets:

1. Reports from the US Energy Information Administration (EIA), which tracks market-wide parameters like total electricity generation, electricity generation capacity, electricity pricing and consumption, and the cost of fuels used to generate electricity, among others.
2. Quarterly and annual reports from publicly traded US power generation, transmission, and distribution companies, which provide information like revenue, costs, cash flows, asset valuations, etc.

In the next section, we use the US EIA data to understand the dynamics of US electricity generation. Specifically, we chart how electricity generated from natural gas, coal, nuclear, wind, hydroelectric, and solar sources have changed over the past decade. We also examine the history of carbon dioxide emissions in this sector, with a specific focus on emissions intensity, measured in pounds of carbon dioxide per kilowatt-hour of electricity. Finally, the US EIA also supplies us with estimated all-in utility operating revenues and expenses, of which we pay particular attention to the estimated maintenance cost.[3]

After these high-level, market-wide views, we dive into company-specific data sets. We analyze the financial and operational performance of 32 publicly traded US companies with power generation capacity, listed in Table 1. Some of these companies are regulated utilities. Others are unregulated power producers. Some of these companies have a sizeable footprint in power transmission and distribution. Others focus more heavily on power production. These companies do share two important elements, though. First, they are publicly traded, which means we have visibility into the state of their financial health and operational performance. Second, they all have power generation capacity, which is an important driver of reliability-related activity across the broader power system.

Alliant Energy	DTE Energy	IdaCorp	Portland General Electric
Ameren	Duke Energy	NextEra Energy	PPL
American Electric Power	Edison International	NISource	PSEG
Berkshire Hathaway Energy	Entergy	NorthWestern	Sempra Energy
CenterPoint Energy	Evergy	NRG Energy	Southern Company
CMS Energy	Eversource	PG&E	Vistra Energy
Consolidated Edison	Exelon	Pinnacle West Capital	WEC Energy
Dominion Energy	First Energy	PNM Resources	Xcel Energy

Table 1. List of publicly traded US companies with power generation capacity analyzed in this report.

When we analyze these publicly traded companies, we track specific data points:

- Revenue
- Other operations and maintenance costs, i.e., operating costs excluding the cost of fuel, depreciation and amortization, taxes, restructuring and impairment charges, and other miscellaneous items
- Capital expenditures
- Net property, plant and equipment asset values

Our last step is to estimate the maintenance spend for each operator. From the US EIA, we have the estimated ratio of maintenance spend to operating revenue for all major US investor-owned electric utilities. We assume our portfolio of 32 companies spends the same amount on maintenance in proportion to revenue as the US EIA estimates for the market as a whole. Then we estimate company-specific maintenance spend weighted by that company's other operations and maintenance spend relative to the total other operations and maintenance spend for all 32 companies.

US ELECTRICITY GENERATION MARKET – SIZE, STRUCTURE, AND RELIABILITY SPEND

From 2011 through 2020, the US generated between 4,000 and 4,200 terawatt-hours (TWh) of electricity annually.[4] The peak came in 2018 at 4,178 TWh. The trough came during COVID-impacted 2020 at 4,007 TWh. Figure 1 shows how different energy sources contributed to total electricity generation over this 10-year period.

TOTAL ELECTRICITY GENERATION BY ENERGY SOURCE, 2011-2020

Units Are Terawatt-Hours (TWh); Only Showing Sources with >50 TWh in 2020

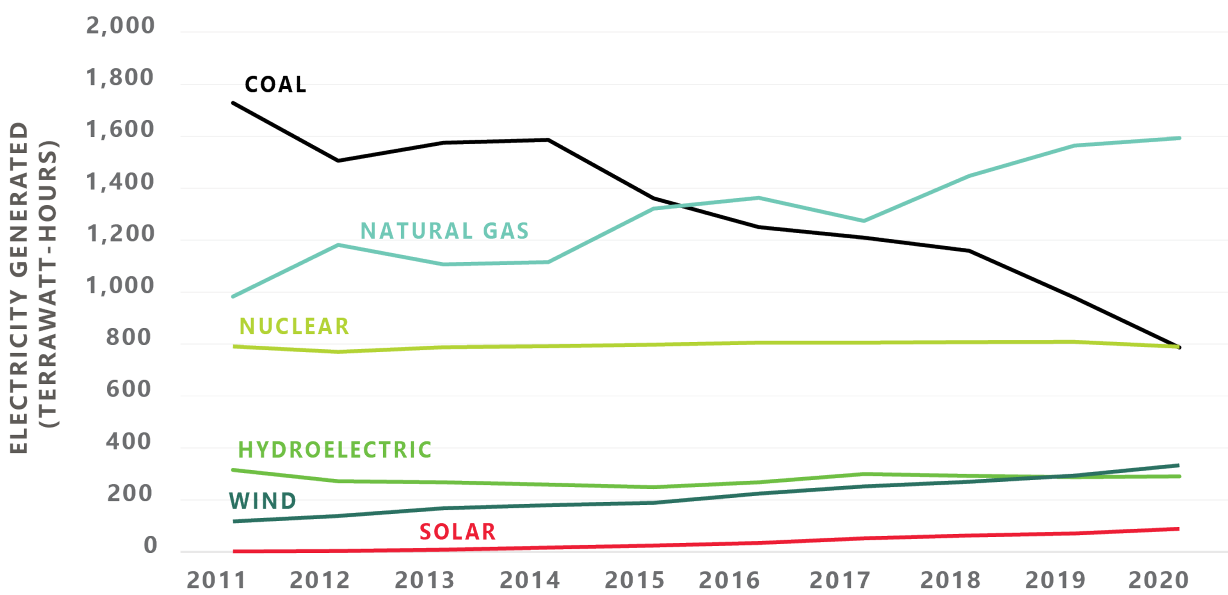

Figure 1. Total electricity generation by energy source, 2011-2020.

We see the dominant theme from the past decade in US electricity markets – the rotation out of coal and into natural gas. In 2011, coal generated over 1,700 TWh of electricity, but by 2020, that number was cut by more than half, down to just below 800 TWh. The natural gas trajectory went the opposite direction, with nearly 1,600 TWh of electricity generated in 2020, compared to under 1,000 TWh in 2011. Nuclear and hydroelectric sources were flat during this period. Energy harvested from wind nearly tripled, from a little over 100 TWh in 2011 to over 300 TWh in 2020. Solar power also grew aggressively, contributing next to nothing to electricity production in 2011 but supplying nearly 100 TWh in 2020.

Figure 2 offers a more direct visualization of how the US electricity generation mix has changed from 2011 to 2020. The switch from coal to natural gas is clear. Coal generated 43% of the US total in 2011, but only 20% of the 2020 total. Natural gas went from 24% of the 2011 total to 40% of the 2020 total. Nuclear and hydroelectric were both nominally flat, as we saw in Figure 1. The growth from wind and solar is clearer in these pie charts, with wind and solar going from a combined 3% in 2011 to a combined 10% in 2020. The US electricity mix is still predominantly fossil fuel-driven, with important secondary support from nuclear, followed by a collection of renewable sources.

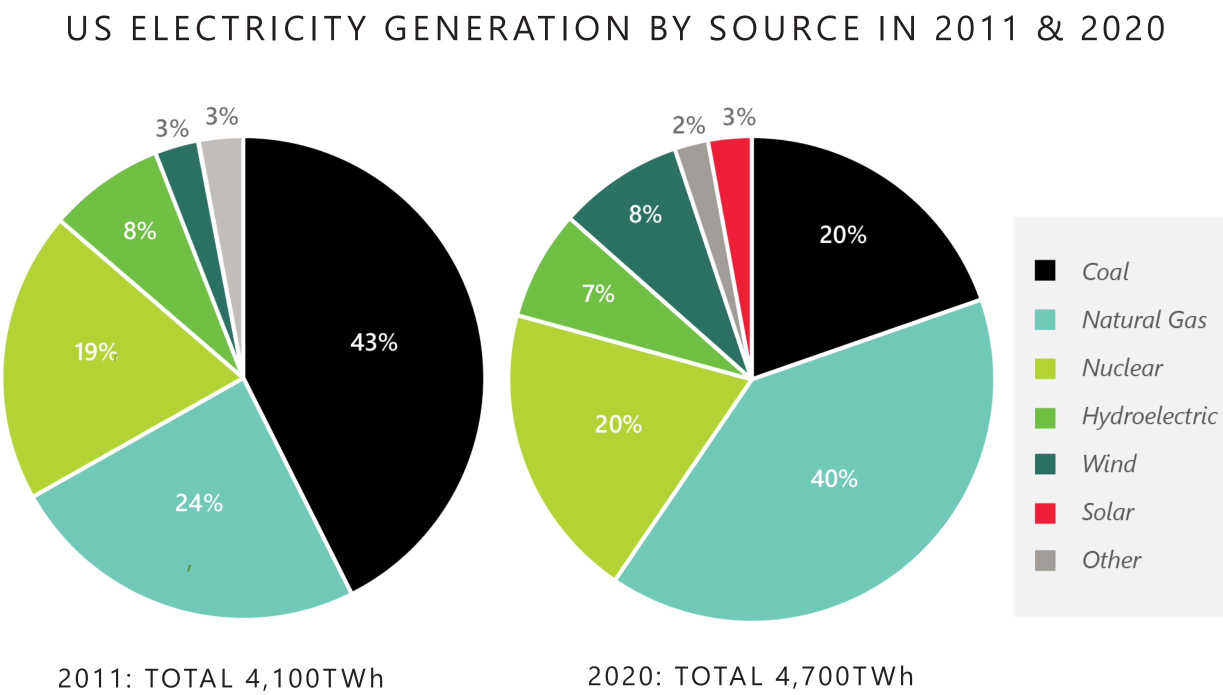

Figure 2. Fraction of total US electricity generation by source, 2011 vs. 2020.

This change in energy source mix has occurred as power companies have sought to improve their environmental sustainability. Figure 3 shows how CO2 emissions, electricity generation, and CO2 emissions intensity evolved from 1991 through 2020.[5] Emissions intensity equals emissions divided by electricity generation and is shown in units of pounds of emissions per kilowatt-hour (kWh) of generated electricity.

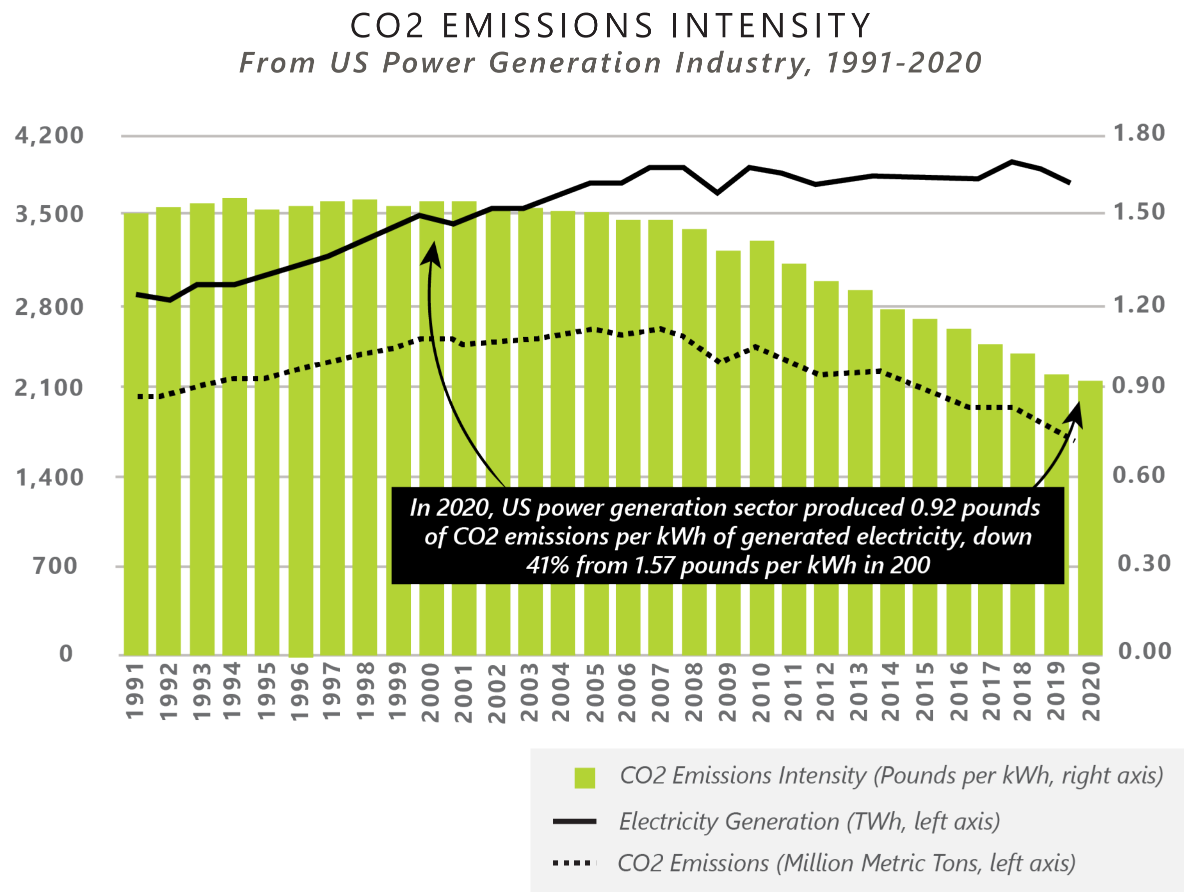

Figure 3. CO2 emissions from US power generation industry, 1991-2020.

The solid line shows electricity generation in TWh and maps to the left axis. We see electricity generation growing from 1991 through 2007, then remaining more or less flat through 2020. The dotted line shows aggregate CO2 emissions in million metric tons and also maps to the left axis. We see the same rise from 1991 through 2007, but instead of plateauing, total emissions are on a steady downward trend through 2020. Dividing emissions by electricity generation leaves us with emissions intensity, the bars that map to the right axis, shown in units of pounds of emissions per kWh. Emissions intensity slowly rises from 1991 through 2001, then falls steadily, and increasingly aggressively, as we move through 2020.

Figure 3 shows one measure of the environmental impact of moving away from coal for power and moving more toward natural gas and renewables. Economics explain some of this shift, as annual average gas prices from 2009 through 2020 were lower than in any year from 2003 through 2008.[6] Regulation also explains some of the shift, as stricter rules drove power companies to decommission some coal-fired plants. Capital markets contributed as well, as investors paid greater attention to the environmental, social, and governance (ESG) performance of businesses and shifted investments accordingly.

Finally, we want to understand the total dollars spent on reliability by electricity producers. Here we will make an appeal to authority. The US EIA relies on a combination of survey data and market models to estimate that major US investor-owned electric utilities spent US$20 billion on maintenance in 2020.[7]

The EIA breaks down operating expenses into four buckets:

1. Operation
2. Maintenance
3. Depreciation
4. Taxes and Other

The operation bucket includes the cost of fuel, cost of purchased power, and costs related to transmission and distribution, in addition to general and administrative expenses. With this taxonomy in mind, we have confidence in using "maintenance" as a conservative estimate of total reliability spend for operators. Some fraction of total capital expenditures is spent on sustaining efforts meant to promote the reliability of existing assets. The "maintenance" cost bucket, as defined by US EIA, might not capture these expenses, which means this estimate could be conservative for our purposes.

Relying on the US EIA estimate, we assume US power companies spend US$20 billion annually on reliability, which equates to about 7% of revenue. We can compare these numbers to the results we found in previous installments of our *Economics of Reliability* reports, which cover the global petroleum refining, US municipal water and wastewater, global metal and fertilizer mining, and global chemicals industries.

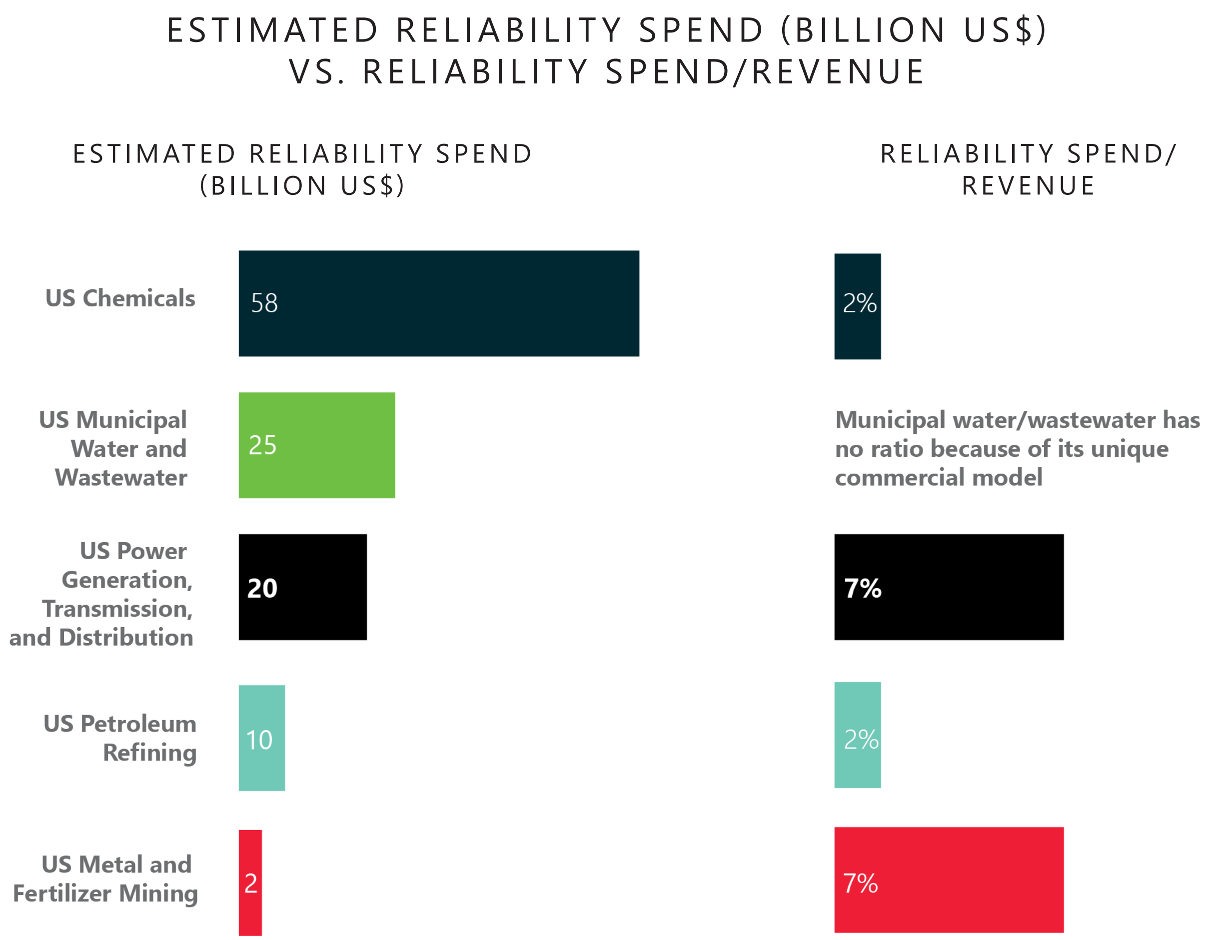

Figure 4. Estimated total reliability spend and ratio of reliability spend to revenue for US sectors analyzed across Pinnacle's Economics of Reliability report series.

We see that the chemicals industry still absorbs the most reliability spend of these US sectors, at US$58 billion. The US$20 billion for power generation, transmission, and distribution falls in third place, behind municipal water and wastewater at US$25 billion. In terms of the ratio of reliability spend to revenue, power generation, transmission, and distribution ties metal and fertilizer mining for the greatest intensity, at 7%. Operators in the petroleum refining and chemicals spaces only spend about 2% of revenue in areas related to reliability.

We do not report a ratio of reliability spend to revenue for the US municipal water and wastewater sector. The other sectors we studied broadly share a commercial model, where finished products are sold to customers, and feedstock costs absorb a material fraction of the revenue stream. In municipal wastewater specifically, operators are paid to receive feedstock, i.e., the wastewater itself, which the operators then process and dispose of, generally with little to no added compensation. This difference in commercial model, combined with the heavy regulatory involvement around rate-setting and the lack of profit motive seen in the other sectors, means we do not have a useful ratio of reliability spend to revenue for the US municipal water and wastewater space.

Power companies had a turbulent decade. The energy source mix has shifted dramatically. Coal is in steep decline, having largely been replaced by natural gas. Solar and wind are growing quickly. Solar is still very much in the margins, but wind is picking up a meaningful share of the US energy mix, having exceeded the contribution of hydroelectric sources. Total electricity supplied has been mostly flat for the past decade, but emissions are falling fast, given the changing mix of energy sources. In the rest of our report, we will analyze how these shifts in the US electricity generation landscape have impacted industrial reliability in this sector.

RECENT TRENDS IN OPERATIONS AND MAINTENANCE SPENDING

We kick off our analysis of specific operators by studying trends in their operations and maintenance spending. We talk specifically about "other operations and maintenance costs". In this context, we mean operating expenses that do not include the cost of fuel, depreciation and amortization, taxes, restructuring and impairment charges, and other miscellaneous items. In other words, we focus on the cost of running and maintaining the plants that generate electricity, and all the surrounding infrastructure that eventually carries electricity into our homes, schools, and businesses.

Figure 5 shows the ratio of other operations and maintenance costs to revenue for the 32 publicly traded US power companies we studied. Here we use quarterly data from fourth quarter of 2019 (2019 Q4) through the third quarter of 2021 (2021 Q3), i.e., the eight most recent quarters available at the time of this report's publication. In addition to the ratio of cost to revenue, the chart also shows the year-over-year change in this ratio for 2020 Q4 through 2021 Q3. The year-over-year change is measured in basis points, where 100 basis points equals 1 percentage point. Keep in mind that we are looking at a ratio of cost to revenue, which is the mirror image of profitability. Lower numbers reflect lower cost intensity, which is preferable when holding all else equal.

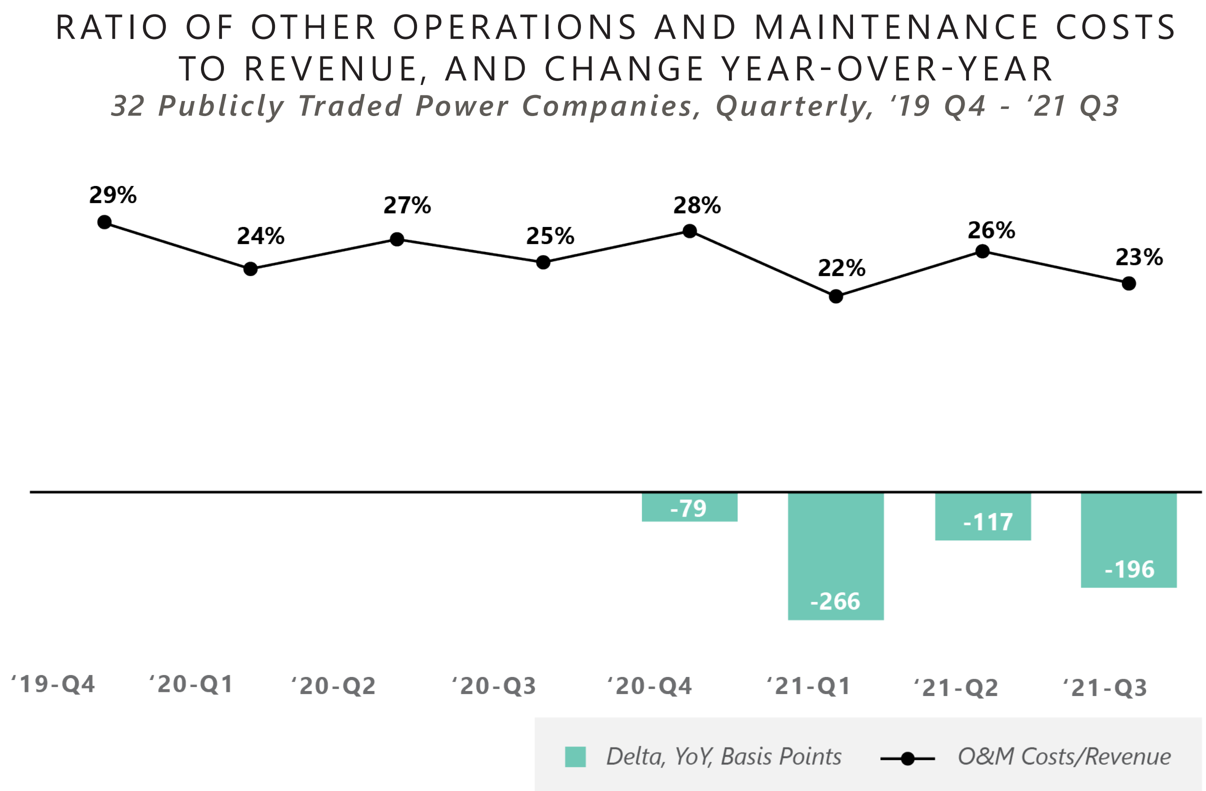

Figure 5. Ratio of other operations and maintenance costs to revenue and change in this ratio year-over-year.

We see that other operations and maintenance costs have been falling since the last quarter of 2019. Seasonality very likely plays a role in the variability of the results. Still, we see a downward trajectory, where each of the four quarters from 2020 Q4 through 2021 Q3 have cost intensities below their prior year levels. Other operations and maintenance costs relative to revenue have fallen around 100 to 300 basis points, or 1 to 3 percentage points, from the prior year.

When searching for an explanation, we need to remember the two moving parts of this equation – (1) other operations and maintenance expenses and (2) aggregate revenues. In most cases, revenue increased, due to increases in both rates and the volume of electricity supplied. While total costs also increased, they did not rise as quickly as revenue, which resulted in a lower cost-to-revenue ratio, as seen in Figure 5. One big reason costs did not increase as quickly as revenue is the continuation of cost containment measures implemented during the onset of the COVID-19 pandemic. As the macroeconomy continues to recover, revenues have risen more quickly than costs, on average, across our chosen set of power companies, driving down their aggregate cost intensity.

CAPITAL SPENDING PROFILES FOR OPERATORS AND IMPACT ON TANGIBLE ASSET BASES

Operating costs are one important performance measure for US power companies. We also want to track the investment trajectory of these operators. Figure 6 below shows the recent history of capital expenditures and net property, plant and equipment values for our chosen publicly traded power companies.

The solid bars show total capital expenditures by quarter, from 2019 Q4 through 2021 Q3. The circles show net property, plant and equipment values for this portfolio of companies for the same period of time.

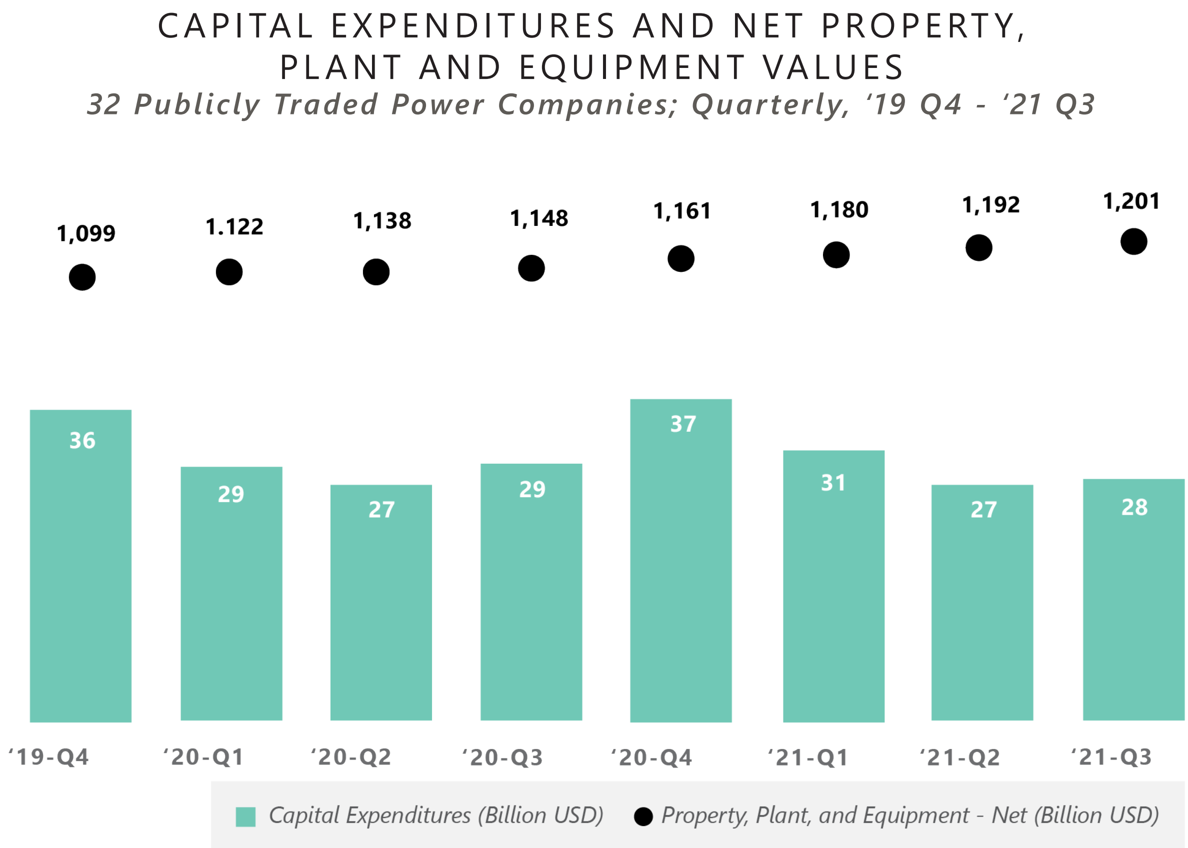

Figure 6. Capital expenditures and net property, plant and equipment value for 32 publicly traded power companies for 2021 Q1 through 2021 Q3.

We see these companies spend between US$27 and US$37 billion quarterly on capital expenditures, which includes the cost of acquired businesses and assets. The net property, plant and equipment asset base is slowly trending upward, from around US$1.1 trillion at the end of 2019 Q4 to US$1.2 trillion at the end of 2021 Q3. In other words, these operators are investing sufficient capital to grow their asset bases, which we would expect in an economy that is becoming increasingly electrified.

What is the relevance for reliability? Large US power companies are investing robustly in their assets. We would not expect to see profound reliability challenges as a result of under-investment. The reliability challenges we would expect to see, though, come in two forms. First, as electric vehicles continue to capture more share of the aggregate US automotive fleet, our electrical systems will experience larger average loads.[8] Second, severe weather events like the 2021 statewide freeze of Texas will continue to strain legacy infrastructure. These two factors, combined with the reality of "always on" expectations from customers and regulators, will impose new reliability challenges that will require more investment dollars from electricity generators, along with the optimized deployment of today's already earmarked investment dollars.

VARIABILITY IN RELIABILITY SPEND OF POWER COMPANIES

We have seen that US power companies have reduced their ongoing operating expenses, and they continue to invest sufficiently to sustain and grow their asset base. Figure 7 shows our estimate of what each of our chosen 32 publicly traded operators spend on reliability. The y-axis is owned electric generation capacity in megawatts (MW). The x-axis is the ratio of estimated reliability spend to operating revenue. We see that, on average, this group of operators spends 7% of operating revenue on reliability. The range is considerable. The lightest spenders dedicate less than 5% of revenue toward reliability; the heaviest spenders dedicate over 9% of revenue toward reliability.

OWNED ELECTRIC GENERATION CAPACITY (MW) VS. ESTIMATED RELIABILITY SPEND / OPERATING REVENUE

32 Publicly Traded US Power Companies; '21 Q1-Q3

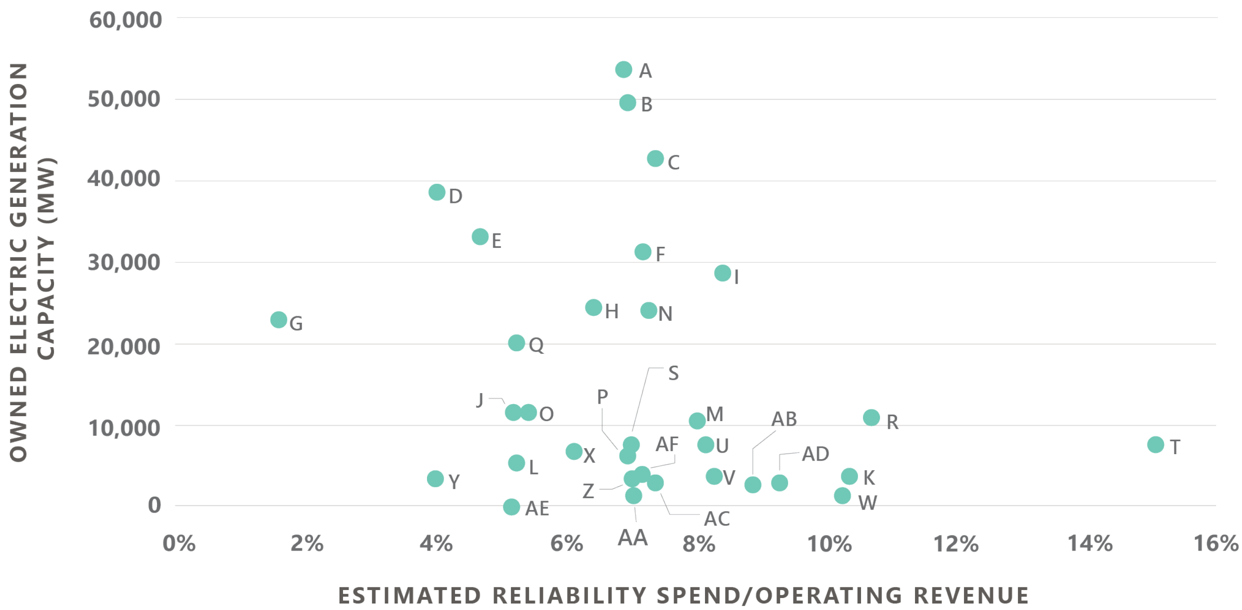

Figure 7. Owned electric generation capacity (MW) versus estimated reliability spend divided by operating revenue for 32 publicly traded US power companies.

We need to keep in mind the disclaimers from earlier in our report. These are not strictly apples-to-apples comparisons. These operators have different power generation mixes. Some rely more heavily on fossil fuels. Others rely more heavily on nuclear or renewable sources. Some are utilities with a larger footprint in the transmission and distribution space. Others focus more on generating power that they can then sell to utilities via purchased power agreements. Geographical effects also exist, where labor costs are higher for power plants close to tight labor markets.

Still, the range of spend is instructive. We have seen similar ranges across our other *Economics of Reliability* reports. For example, global metal and fertilizer miners spend 7% of revenue on reliability, much like we see for US power companies.

The range of spend for these large miners was around 4% to 10% of revenue, which is consistent with what we see in Figure 7 for US power companies. As another example, we saw that US petroleum refiners spent US$1.60 per barrel of crude oil throughput on average on reliability. Several refineries spent less than $1.00, while several others spent over $2.00. Finally, large global chemical manufacturers spent nearly 2.0% of revenue on average on reliability. We saw some operators spend less than 1.5%, while others spent more than 2.5%.

These distributions are reasonably consistent. Whatever the average spend level is for the group of operators we study, we see the lightest spenders spend 25% or more below the average level, while the heaviest spenders spend 25% or more above the average level. Interestingly, the industries we have studied to this point involve flows of mass – crude oil, petroleum products, raw chemical feedstock, mined earth, etc. The power generation space is built around flows of energy, and yet the distribution of reliability spending is similar to what we observed in other industries.

The lightest spenders dedicate less than 5% of revenue toward reliability; the heaviest spenders dedicate over 9% of revenue toward reliability.

CONCLUSIONS

Operators responsible for the generation, transmission, and distribution of power in the US are in the midst of considerable disruption. Even before the pandemic, environmental concerns have driven these operators to drastically reduce their carbon footprint. Our economy is also becoming increasingly electrified, motivating these operators to expand capacity. The result is an aggressive shift in energy sources, largely away from coal and toward natural gas. Solar and wind are growing quickly. The intermittency of these renewable sources highlights the importance of nuclear and hydroelectric sources, which offer a steadier base of lower carbon energy. Intermittency challenges have also raised the profile of energy storage, where capital is flowing toward larger scale research and development efforts. The COVID-19 pandemic only exaggerated the disruption, as labor became more scarce and more expensive. After lockdown-induced drops in fuel prices, the economic recovery has brought inflation that is pressuring the income statements of these operators.

Over the course of our analysis, we found four key insights around the impact that reliability has on the performance of US power generation, transmission, and distribution operators.

1. Operators have been navigating a decade-long transition and are in position to adopt new approaches to asset investment and maintenance.

We mentioned the sector-wide push to reduce greenhouse gas emissions and increasingly electrify the economy. This push has required operators to analyze life-cycle asset costs in new ways. The future costs of carbon-rich energy sources have increased, not just because of rising commodity prices, but also because of the expectation of more costly future regulation and reduced access to capital markets. As a result, operators have been nimble in assessing their existing asset portfolios and proactively shifting those portfolios where necessary. This mindset and associated flexibility are important in reimagining how these assets should be optimally maintained. Some legacy complex process operators have firmly entrenched approaches to their run and maintain programs. US power companies have already overcome this entrenchment and are well positioned to build best-in-class reliability programs.

2. Operators have realized margin expansion through stricter cost controls but need to set aggressive reliability targets to achieve their next big improvement.

The COVID-19 pandemic forced operators to manage around an increasingly challenging labor market. Workers were less available, and those that were available were more expensive. These dynamics pushed operators even further toward automation and relying on third parties for labor support. These were understandable and necessary immediate reactions to an unforeseen public health crisis. Now, these operators are in position to rethink how their assets will be inspected and maintained. Players in this space have a strong prevailing affinity for data. The next step is to utilize existing data and capture high-value data that is being overlooked today, all in service of building a rigorous, quantitative understanding of how system-wide performance depends on specific assets. The combination of models and subject matter expertise involved will unlock new avenues for deploying repair and maintenance dollars toward their highest return outcomes.

3. Operators are slowly and steadily growing their asset bases, meaning excess capital is not required to close historical investment gaps.

We saw in Figure 6 that our chosen group of 32 publicly traded US power companies have spent between US$100 and US$150 billion annually on capital expenditures in 2020 and 2021. This level of investment has caused the property, plant and equipment asset base to grow US$1.1 trillion to US$1.2 trillion over a two-year period. This trajectory means that this collection of operators is investing at a level to account for the ongoing depreciation of their equipment. Not all economic sectors have responded similarly. For example, in our *Economics of Reliability* report on the global chemicals industry, we found that falling profitability led to collective under-investment in 2019 and 2020. This under-investment created gaps in asset management that needed to be filled before these operators could effectively overhaul their approach to maintenance. Power companies have avoided this investment shortfall, which puts them in great position to design and implement high-return, data-driven reliability workflows.

4. On average, operators spend 7% of revenue on reliability programs, though the most efficient operators spend less than 5% of revenue.

Like with all economic sectors, we see a clustering of operators near the average spend intensity, with some notable outliers on either side, as shown in Figure 7. US power companies spend about 7% of their revenue on reliability, which is equivalent to what we saw for metal and fertilizer miners. This spend intensity is notably higher than the 2% of revenue we see in petroleum refining and chemicals manufacturing. In the power space, we see some of the lightest reliability spenders come in at less than 5% of revenue. The heaviest spenders dedicate over 9% of revenue to reliability programs. Each single percentage point of revenue dedicated to reliability, without the necessary corresponding performance improvement, eats away at margin. In an increasingly disrupted world, where power companies will need more and more capital to transition to a lower carbon, more electrified future, optimized, data-driven reliability programs are more important than ever.

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In February 2021, a historic freeze hit the southern region of the United States causing power outages that had never been seen before. As power companies face stricter regulations and the pressure of always having to operate, the reliability of their assets will become even more important to the industry's long-term success and the prevention of future catastrophic events.

In this report, Pinnacle analysts dive into the impact that reliability has on the power generation, transmission, and distribution industry. Throughout this report, we analyze the financial and operational data of 32 publicly traded power companies and identify the key trends that are driving reliability.

pinnaclereliability.com
info@pinnaclereliability.com
(281) 598-1330