Exhibit No.:
Issue: Coal Plant Retirement Trends
Witness: Christopher R. Rogers
Type of Exhibit: Rebuttal Testimony
Sponsoring Party: KCP&L Greater Missouri Operations Company
Case No.: EC-2019-0200
Date Testimony Prepared: May 23, 2019

MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. EC-2019-0200

REBUTTAL TESTIMONY

OF

CHRISTOPHER R. ROGERS

ON BEHALF OF

KCP&L GREATER MISSOURI OPERATIONS COMPANY

Kansas City, Missouri
May 2019

REBUTTAL TESTIMONY

OF

CHRISTOPHER R. ROGERS

CASE NO. EC-2019-0200

I. Introduction and Qualifications

Q: Please state your name and business address.

A: My name is Christopher R. Rogers and my business address is Power Engineers, Inc., 16041 Foster Street, Overland Park, Kansas 66085.

Q: What is your position at Power Engineers?

A: I am a Corporate Markets Analyst. I also serve as a senior project manager for various consulting assignments from time to time, as requested by clients to support POWER Engineers production divisions.

Q: On whose behalf are you testifying?

A: I am testifying on behalf of KCP&L Greater Missouri Operations Company ("GMO" or the "Company").

Q: What is the purpose of your testimony?

A: The purpose of my testimony is to respond to the direct testimonies of Robert E. Schallenberg on behalf of the Office of the Public Counsel ("OPC") and of Greg R. Meyer on behalf of the Midwest Energy Consumers Group ("MECG") regarding their opinions that the retirement of the three coal units at the Sibley Generating Station by GMO was "extraordinary" and "premature."

Q: Please describe your educational background, professional training and experience.

A: Since graduating from Kansas State University in 1974 with a Bachelor of Science in Mechanical Engineering, I have practiced engineering, principally in the power industry, for 45 years. During the first decade of my career, I performed design, construction contracting, scheduling, and resident construction management services for new coal-fired electric generating stations with a nationally-recognized architect/engineer firm in Kansas City. During this interval I completed in 1981 a Master of Science in Civil Engineering, specializing in construction management from the University of Missouri-Columbia.

From 1983 through 1986 I served as the Manager of Generating Facilities on the Staff of the Missouri Public Service Commission ("Commission" or "PSC") and participated in several major rate cases, including cases related to the Callaway Nuclear Plant owned by Ameren and the Wolf Creek Nuclear Plant co-owned by Kansas City Power & Light Company ("KCP&L"). Later while employed as a consultant, I provided testimony on behalf of Aquila, Inc. in the South Harper Generating Facility certificate of convenience and necessity case before the PSC.

I served as Vice President of Sega, Inc., an engineering and technical services firm located in Overland Park, Kansas from 1994 to 2017, until it was acquired by Power Engineers. Among other things, I provided consulting and project management services for Sega's and initially Power Engineers' electric power generating clients. In my current role with Power Engineers, I routinely review, research, and track developing energy market and other economic trends for their potential impact on Power Engineers and its

customers. In addition, I perform ad hoc research projects for the various divisions within Power Engineers.

Q: What work have you performed for GMO and its affiliates?

A: While at Sega I over saw numerous plant betterment engineering projects on the generation stations of GMO and KCP&L. For example, I provided pre-filed testimony on behalf of GMO and KCP&L in their 2016 general rate cases before the Commission (No. ER-2016-0156 and No. ER-2016-0285, respectively) regarding the near-term costs of retirement and the potential future costs for dismantlement of the GMO and KCP&L fossil-fueled electric generating units. I'm generally familiar with Westar Energy's generation fleet but have not worked on specific Westar projects.

Q: Are you familiar with GMO's generating fleet, including the units at Sibley?

A: Yes. I assisted with flue gas emissions testing of Sibley 1 and 2 in 1972 while an intern at a local engineering firm. My knowledge of Sibley and its units was updated while I was working at the Commission and became familiar with the operations of Missouri Public Service Company, one of the corporate predecessors of GMO. As noted above, in GMO's 2016 rate case (No. ER-2016-0156), I oversaw and contributed to the Sega Report on the Costs of Retirement and Dismantlement of GMO's operating units which was attached to my Direct Testimony as Schedule CRR-2. Among other projects for GMO's predecessor, I was Sega's project manager for siting, design, procurement and contracting for Aquila's South Harper Generating Station, and site manager during construction and commissioning of the plant. Thereafter, I supported Aquila in hearings before the Commission regarding the need for the plant and its siting. (Case No. EA-2006-0309).

Q: Do you hold any professional licenses?

A: Yes. I am a licensed professional engineer in the States of Kansas (License No. 8200) and Hawaii (License No. 12314). I also hold a Certificate of Record from the National Council of Examiners for Engineering and Surveying (No. 19249).

Q: Have you prepared an appendix that describes your training, licenses and power industry experience?

A: Yes. My professional qualifications are provided in Schedule CRR-1.

Q: Have you previously testified in proceedings before the PSC or any other utility regulatory agency?

A: Yes, I have previously testified before the PSC, the Kansas Corporation Commission, and Hawaii Public Utilities Commission. The subject matter and references for the cases in which I participated are provided at the back of Schedule CRR-1.

II. Purpose and Overview of Testimony

Q: In analyzing the opinions of Mr. Schallenberg and Mr. Meyer regarding the retirement of the three coal units at the Sibley Generating Station ("Sibley"), what did you review?

A: I studied a wide range of facts and trends regarding the retirement of coal and other carbon-based electric generating plants over the past 30 years which I describe in greater detail below. Based upon this information, as well as my knowledge and experience in the electric utility industry, I analyzed whether the retirement of GMO's Units 1, 2 and 3 at Sibley in rural Jackson County was an extraordinary or a premature event.

Q: What facts, trends and other information did you review with regard to your testimony in this case?

A: As detailed in Section III below, I primarily reviewed:

(1) S&P Global Market Intelligence reports and analysis, including data compiled by its affiliate SNL Financial and

(2) U.S. Department of Energy (DOE) reports and statistics published by the U.S. Energy Information Administration (EIA).

Q: Is the information that you reviewed national in its scope with regard to the retirement of carbon-based electric generating plants?

A: Yes. The information from SNL's data base covered all U.S. generating plants of all types that included nearly 5,000 fossil-fueled generating units that have been retired since the beginning of 1970.

Q: What else have you reviewed or studied with regard to your opinions in this case?

A: As part of my regular current duties, I scan industry news sources daily for notable developments affecting power generation. These include SNL and EIA, but also GlobalData, The C Three Group and a number of publicly available industry journals, newsletters and blogs.

Q: Have you reviewed the Direct Testimonies of Mr. Schallenberg and Mr. Meyer, including the schedules attached to Mr. Schallenberg's testimony?

A: Yes, I have. I confirmed their citation to General Instruction 7 of the Uniform System of Accounts (USOA) regarding what would be considered an "extraordinary" event, an analysis which, I am advised by counsel, this Commission has used for many years to

determine whether to grant an accounting authority order with respect to specific events or items.

Q: Did either Mr. Schallenberg or Mr. Meyer cite national or regional data regarding the retirement of coal plants and other carbon-based plants in the recent past?

A: No, they did not. They did not provide any context or industry-wide trends to support why they determined that the retirement of the Sibley coal-fired generating units should be considered extraordinary during this time when tens of gigawatts of coal-fired capacity have been retired in the United States.

Q: Why did you believe it was appropriate to review such data regarding the retirement of coal and other carbon-based plants?

A: In order to express an opinion on whether the retirement of the Sibley units was an event that was unusual or infrequent and, therefore, extraordinary under the USOA definition as interpreted by the Commission, it is not only appropriate but essential to analyze recent data on plant retirements.

Q: What are your conclusions?

A: Based upon the data and reports that I have reviewed, as well as my professional knowledge and experience, the retirement of the Sibley coal-fired units was not an extraordinary event because in the past 20 years the retirement of coal units by electric utilities was not an unusual or an infrequent occurrence. Federal and state regulatory policy changes, technological and operational developments, and consumer demand for renewable energy have resulted in a significant transformation of the economics that affect the business of generating electricity. As a result, coal plants across the United States have been retired more frequently and in the ordinary course of business.

Therefore, the retirement of the Sibley units was not extraordinary. The combined effect of all these factors also indicates that their retirement was not premature.

III. Trends in the Retirement of Generating Units in the United States

Q: What data did you review that was published by S&P Global Market Intelligence (SNL)?

A: I reviewed SNL statistics compiled as of March 29, 2019 that summarized the retirement of coal units, natural gas-fired units, and fuel oil units. The SNL statistics also presented consolidated data that summarized the retirement of all carbon-fueled plants from 1970 to the spring of 2019. Finally, the SNL data summarized recent carbon-based generation retirement announcements through 2018. I reviewed separate statistics as of May 15, 2019 regarding the retirements of wind power and solar resources. These data are contained in Schedule CRR-2.

Q: Did the SNL data contain information regarding public announcements that have been made regarding future coal plant and other carbon-based plant retirements?

A: Yes. SNL compiled information that regarding public announcements of such plant retirements from 2019 through 2028. The data categorized coal, gas and oil generating plants that are to be retired by number, nameplate capacity, average capacity and average age. This information is contained in Schedule CRR-2.

Q: How did SNL obtain this data?

A: SNL collects data from various sources, including but not limited to EIA 860, NERC Summer/Winter assessments, EIA 923 (previously EIA 906, EIA 423 and EIA 767), FERC Form 1, SEC Forms 10-K and 10-Q, industry publications, company websites and press releases, plus various newspaper and web site articles.

Q: Are these reliable sources that can be used to analyze national trends regarding the retirement of carbon-based generation units?

A: Yes. The data that SNL collects and compiles is the type of data that is customarily relied upon by engineers, auditors, and other public utility executives, as well as policymakers and financial professionals to analyze such trends in the electricity industry and to plan for the future. This information, as well as other information described below, is of a type that is reasonably relied upon by experts and professionals in the electric utility industry and is reliable.

Q: Comparing the SNL data compiled in the last 10-20 years with data from 20-50 years ago, what has been the trend with regard to the retirement of coal plants?

A: As shown on page 1 of Schedule CRR-2, the rate of coal-fired plant retirements has accelerated during the last decade compared to the prior 40 years. 543 coal-fired generating units with a combined capacity of 76,526 MW retired since the beginning of 2010. That was more than double the 238 coal units retired from 2000 through 2009 and about 7 times the capacity (10,958 MW) for that decade. For the three decades from 1970 through 1999 only 34 coal units totaling 2,248 MW retired. In nearly 50 years since 1969, a total of 815 coal-fired units have retired, with 543 units or two-thirds of the total having retired during the last 9 years.

Q: How does the number of coal plant retirements compare with the retirement of coal-based generating capacity?

A: The increasing retirement trend is more pronounced in terms of generating capacity. A total of 89,731 MW of coal-unit capacity retired since 1969. About 85 percent (76,526 MW) of that total retired during the most recent decade (2010 to present).

Q: Using these similar comparison points, what has been the trend regarding the retirement of other carbon-based plants?

A: A similar trend was observed for retirements of oil- and gas-fired units. Slightly more gas-fired capacity than coal fired capacity has retired over the last 50 years. As found on page 2 of Schedule CRR-2, a total of 51,489 MW of capacity from 916 gas-fired units retired since the beginning of 2010. However, 1,136 gas-fired units totaling 39,086 MW of capacity retired during the four previous decades (from 1970 through 2009). All told 90,575 MW of gas-fired capacity has retired since the beginning of 1970. More than half that amount (51,489 MW) retired in the last decade (since 2010).

Similar trends were observed for oil-fired units, although much fewer in number of units and total capacity. Since 2010, 784 oil-fired units with a total capacity of 13,442 MW retired. During the four prior decades, 897 oil-fired units retired with a combined capacity of 9,135 MW.

Q: Comparing these trends in the retirement of coal plants and other carbon-based plants with non-carbon resources, what did you find?

A: Overall, 4,548 fossil-fueled generating units have retired since 1969, taking 202,883 MW of generating capacity out of service. Almost 70 percent of this capacity or 141,456 MW was retired in the last decade, beginning in 2010. SNL data for wind turbine and photovoltaic solar units indicates that only 94 units with a combined capacity of 1,173 MW retired since 1996. Since the beginning of 2010, 72 wind and photovoltaic solar units with a combined capacity of 1,078 MW retired. For nuclear units, SNL reports that 14 units with a combined capacity of 11,265 MW retired so far since 1992. Since the beginning of 2010, a total of 9 nuclear units with 7,289 MW of capacity retired.

Q: What did you conclude regarding the retirement of U.S. generating facilities?

A: It is clear overall that the rate at which the all types of power generating units are being retired is increasing. Retirement of generating units has become routine in the last 10 years.

Q: Given these national trends, what did you conclude regarding the retirement of coal plants compared with other resources?

A: It is equally clear that generating units fueled by coal and oil are retiring at a more frequent and regular rate than gas-fired units, and that units producing renewable energy are retiring at a much slower rate.

Q: What did the U.S. Energy Information Administration reports that you reviewed indicate regarding the pace of coal plant retirements, as compared with other carbon-based plant retirements and non-carbon resources?

A: Since much of the SNL data is derived from raw information collected by the U.S. DOE that is also used in EIA reports, there is not much difference between the two references. However, EIA compiles periodic topical reports that provide different views of the same information. For example, on January 9, 2018, EIA published a report as part of its daily "Today in Energy" briefings noting "almost all power plants that retired in the last decade were powered by fossil fuels." EIA said reported U.S. utility-scale electric generating capacity retirements from the beginning of 2008 to November 2017, as well as planned retirements for November and December of 2017 were "nearly all fueled by fossil fuels."

EIA pointed out that the Eastern Region (for which the Dakotas, Nebraska, Kansas and Oklahoma form the western boundary) contains most of the U.S. generating capacity. EIA reported the Eastern Region contained 736 gigawatts (GW) of the nation's

1,076 GW of operating capacity, as of October 2017. The Eastern Region also had the largest share of capacity retirements over the decade ending in 2017 compared with the rest of the country. About 10 percent of the Eastern Region's capacity was retired during that decade. However, coal-fired capacity was "disproportionally" affected in the Eastern Region where 19 percent of the coal capacity retired during that decade, compared with 17 percent of the overall national coal-fired capacity. During 2015 alone, almost 15 GW of coal-fired capacity in the Eastern Region retired. This is consistent with the data from the SNL data bases that I previously presented.

Q: What is the source of the EIA information?

A: EIA obtains information through electric generator reports filed with the U.S. DOE within which both EIA and the Federal Energy Regulatory Commission (FERC) reside, as well as with other federal agencies. Such reports include, but are not limited to, EIA 860, NERC Summer/Winter assessments, EIA 923 (previously EIA 906, EIA 423 and EIA 767), FERC Form 1, and SEC Forms 10-K and 10-Q.

Q: What resources does the EIA employ to analyze such data?

A: According to its website (https://www.eia.gov/about/), the EIA "collects, analyzes and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment." The EIA publishes daily, weekly, monthly, quarterly and annual reports and briefings on all forms of energy affecting the U.S., including electricity, coal, natural gas, and petroleum liquids. Perhaps EIA's most notable publication is the Annual Energy Outlook (https://www.eia.gov/outlooks/aeo/) that provides modeled long-term projections of domestic energy markets. EIA also

publishes the Short -Term Energy Outlook (STEO) which provides periodic updates of developments and forecast changes for the next one to two years. The next STEO is scheduled for publication on June 11, 2019.

Q: What other reports and resources did you survey regarding national trends in coal plant retirements?

A: I reviewed, as I routinely do, Standard & Poor's Global Market Intelligence (and its SNL), GlobalData's Power and Oil & Gas sector platforms, The C Three Group, and The Wall Street Journal to keep abreast of such trends, as well as general market developments. I subscribe to daily and weekly news aggregator services, newsletters, and blogs from various publicly-sourced trade and interest groups, including but not limited to POWER (magazine), Power Engineering (magazine), Electric Light & Power, Distributed Energy, U.S. Energy News, Energy Central, Wood Mackenzie, Institute for Energy Economics and Financial Analysis, Microgrid Knowledge, North American Wind Power, Smart Electric Power Alliance, and T&D World. I also review on a regular basis reports and articles published by Lazard Ltd. and BloombergNEF. Most of these publications highlight breaking developments, provide background, and summarize trends in the power industry. For this engagement, I primarily relied upon SNL and EIA for specific information.

Q: What did the information that you reviewed show as far as trends in coal plant retirements in the Midwest?

A: Generally, the retirement of coal and other carbon-based plants is similar to the overall national trends, although retirements have occurred at a faster pace in states like

California, New York, and Massachusetts that have aggressive renewable portfolio standards and carbon-free energy plans.

Q: What caused the increase in the number of coal plant retirements in the last 10-20 years compared with earlier periods.

A: The significant increase in the retirement of coal plants generally, and the Sibley units in particular, was caused by a combination of changes in regulatory policy and consumer demand, technological breakthroughs, and operational costs that resulted in a shift in electric utility generation economics that made many coal plants too expensive to operate as the price of renewable generation resources has fallen and the price of natural gas has remained low.

Q: What trends have you observed regarding decreasing prices in wind, solar and other renewable generation resources?

A: While not at complete parity across the country, research and industry reports indicate that renewables, especially wind and photovoltaic solar, are competitive with the cost of conventional fossil-fueled resources. Ultimate parity will depend on the changing price of natural gas, but costs are competitive enough that many investor-owned utilities are adding renewables to their generating portfolios because it makes economic sense. The basis for this opinion is provided in a white paper that I authored in February of this year, "*Power Parity: Have Renewable Resources Become Less Expensive than Fossil-fueled Generation?*" It is provided in Schedule CRR-3. I believe these trends are likely to continue for some time.

Q: What are the reasons for the decline in the price of renewable generation resources?

A: Market prices for wind and solar generation have been declining for several years, and regulations and legislation at both the federal and state levels have promoted expansion of wind and solar generation. Once established in the marketplace, economies of scale, experience, technology advancements, and competition have reduced the costs of renewable generation to the point of parity, or nearly so, with conventional generation in many regions of the U.S.

Q: Have there been significant technological breakthroughs in the components of wind turbines, especially the design and size of the turbine blades, and the height of the turbine towers?

A; Yes. Turbine capacity, rotor diameter, and hub height have continued to increase. This optimizes wind project cost and performance, according to the U.S. DOE 2017 Wind Technologies Report published on August 8, 2018. The report notes that in 2017 the average nameplate capacity of newly installed wind turbines in the U.S. was 2.3 MW, up 8 percent from the previous year and up 224 percent since 1988 -1999.

The average rotor diameter in 2017 was 113 meters, a 4 percent increase over the previous year and a 135 percent increase over 1998-1999. Average hub height in 2017 was 86 meters, up 4 percent over the previous year and up 54 percent since 1998-1999. Growth in average rotor diameter and turbine nameplate capacity has outpaced growth in average hub height for the last two decades, and rotor scaling has been significant. In 2008 there were no turbine rotors employed in the U.S. with 100-meter diameter or larger rotors. By 2017, 99 percent of newly installed turbines had rotors of at least that size,

while 80 percent of newly installed rotors were greater than 110-meter diameter and 14 percent were greater than or equal to 120 meters.

Turbines that were originally designed for lower wind speed sites have gained market share and are being deployed in a range of wind resource conditions. As growing swept rotor area outpaced the growth in nameplate capacity, turbines became more suitable for lower wind speed sites. Developers are planning for the continuing trend of ever-taller turbines. The sum of such developments is that fewer, but larger turbines can be employed to suit varying wind regimes more efficiently.

Q: Have these developments in wind generation technology affected the price of wind generation?

A: Yes. With the pressure of competition from multiple suppliers, costs have continued to decline. DOE reported wind turbine costs declining to as low as $750/kW with installed project costs as low as $1,550/kW or below. Similar improvements are occurring for solar PV developments. In Schedule CRR-3, the paper cites a recent Lazard study that compared the costs of subsidized and unsubsidized wind and solar versus conventional generating technologies. Lazard found that unsubsidized wind and solar generation were competitive with coal nuclear and natural gas generation. Reports from BloombergNEF and EIA (cited in Schedule CRR-3) indicate the same conclusion. Technology improvements and competition are expected to overcome the loss of subsidies for wind and solar.

Q: Have there been similar technological breakthroughs for coal generation and other carbon-based resources?

A: No. The cost of carbon capture and storage (also known as carbon capture and sequestration or CCS) is quite high. Development efforts to pursue CCS solutions have not resulted in a competitive economic alternative to renewable generation. The addition of CCS to existing or new generation can only increase the capital cost, complexity, and operating and maintenance costs of fossil fuel units that already struggle to compete with the all-in costs for newer renewable resources, as previously noted.

Q: What effect would advances in battery storage and other storage technologies have on coal-fired units and other carbon-based generation?

A: As energy storage prices decline, and tariffs and interconnection arrangements for energy storage are worked out (as called for by FERC Orders No. 841 and 845), Battery Energy Storage System (BESS) installations are expected to increase. Utility-scale BESS is beginning to compete with gas turbine peakers and reciprocating internal combustion engines for short-run time applications where BESS can typically provide nearly instantaneous 4-hour duration backup and peaking, as well as ancillary services.

Q: Beyond technological advances in renewable generation, have public policy decisions contributed to this decline in the cost of production of renewable energy and its ultimate price in the marketplace?

A: Yes. Although changes in federal policy have occurred with the current Administration which has halted efforts to implement the previous Administration's Clean Power Plan and has instead proposed the Affordable Clean Energy Rule, the vast majority of states have continued their renewable energy portfolio standards. Many states, including

California, Washington, New Mexico, Illinois, New York, and Massachusetts have established aggressive goals to reduce greenhouse gases through a zero-carbon generation portfolio that would eliminate coal and other fossil-fuel generation from their energy mix. California's goal is to be 60% carbon-free by 2030 and 100% carbon-free by 2045. There is currently pending in the Illinois legislature the "Path to 100 Act" that proposes the state to become 40% carbon-free by 2030. The Governors of Wisconsin and Michigan are proposing that their states become 100% carbon free by 2050.

Q: What has been the effect on coal-based generation of changes in state law in Illinois, New Jersey, and New York to support generation that produces electricity without any carbon emissions?

A: These changes in state law make nuclear generation more competitive than coal-based generation and contribute to the pace of coal plant retirements. They grant zero-emissions credits (ZECs) to nuclear generators in the form of a financial subsidy that supports the sale of nuclear power in wholesale energy markets. As a result, nuclear units operating in these and other states that that receive ZECs will have a price advantage over other competitive energy producers that do not receive ZEC payments. Similar proposals are being considered by legislators and regulators in Ohio and Pennsylvania.

Q: Have coal-based generation and other forms of carbon-based generation faced increasing operating and maintenance (O&M) costs in recent years?

A: Yes. Coal units continue to face increasing O&M costs as a result of environmental and other regulations regarding emissions, fuel storage, fuel disposal, and related issues.

Q: What changes have you observed in customer demand, particularly from major U.S. corporations?

A: The 1H Corporate Energy Market Outlook, published by BloombergNEF on January 18, 2019, found that 8.5 GW of clean energy contracts were signed by corporations in the U.S. in 2018, nearly triple the capacity signed just the year before. BloombergNEF cited 34 new companies that signed their first clean energy power purchase agreements in the U.S. in 2018, which was 31 percent of the total corporate clean energy activity. A number of U.S. companies like Wal-Mart, Inc., Wells Fargo, Procter & Gamble, General Motors, 3M and Google have joined an international group known as the "RE100" that has made a commitment to 100% renewable energy. BloombergNEF reported that as of the end of 2018, 160 companies had signed on to RE100 internationally. These companies were reported to have consumed 189 TWh of electricity in 2017. This is a growing trend that is boosting the growth of renewable generation and putting more pressure on fossil fueled generation.

Q: What recent reports of coal plant retirements are you aware of?

A: Several recent reports of coal plant retirements are worth noting.

SNL reported on May 13, 2019 that American Electric Power Co. (AEP) plans to shut down two coal-fired units totaling 750 MW at its Conesville plant in Ohio at the end of this month. In 2018 AEP announced its plan to shut down these units by 2020. Conesville Unit 5 began service in 1976 and Unit 6 went in service in 1978. Each unit had an original nameplate rating of 444 MW, but carried current ratings of about 375 MW, each. These units are somewhat younger than Sibley Unit 3, but comparable in size.

DTE Energy Co. announced on March 28, 2019 it plans to retire more than 6,000 MW of coal-fired generation, according to SNL. As part of DTE's integrated resource plan filed on March 29, 2019 with the Michigan Public Service Commission in Case No. U-20471, DTE plans to retire the St. Clair and Trenten Channel plants by 2022. DTE will end the use of coal at the River Rouge Unit 3 in 2020, which will continue to operate until 2022 on recycled industrial gases and natural gas.

On May 20, 2019 Northern States Power Company, d/b/a Xcel Energy ("Xcel"), announced that pursuant to a settlement agreement with environmental and labor groups, it will retire two large coal plants and put a third coal plant on a seasonal basis in exchange for the other parties' support of Xcel's acquisition of the two-unit combined cycle Mankato Energy Center. The settlement agreement was filed with the Minnesota Public Utilities Commission ("PUC") in Docket no. IP6949, E002/PA-18-702.

Xcel agreed to seek to seek PUC approval to retire the 511 MW Allen S. King plant in 2028 or earlier, and to retire the 876 MW Sherburne County ("Sherco") Unit 3 by 2030 or earlier. Xcel also agreed to offer the 680 MW Sherco Unit 2 into the Midcontinent ISO market on a seasonal basis until its retirement in 2023.

Q: Are these retirements consistent with the trends that you have observed in the data you studied?

A: Yes, they are all consistent with the recent trends I have seen regarding the pace of coal plant retirements in the last 20 years.

IV. Conclusion

Q: Based upon the foregoing, what are your conclusions regarding whether the retirement of the Sibley units was extraordinary and whether they were premature?

A: From the data that I studied, which shows a striking contrast between the past 10-20 years with the preceding 20-30 years, there is no factual basis to conclude that the retirement of the Sibley coal-fired units in 2017-18 was an unusual event or an infrequent occurrence. Public utilities have been and are retiring coal plants retirements on a regular and steady basis, and will continue to do so, in response to the factors I described above. GMO, as well as its affiliates KCP&L and Westar Energy, all subsidiaries of Evergy, Inc., have retired and are scheduled to retire fossil-fueled generating units, consistent with these national and regional trends. Given what has occurred and will continue to occur in the field of electric generation, the retirement of the Sibley units was not an extraordinary event.

Similarly, in light of recent and continuing regulatory, technological, consumer and economic trends, it would not be reasonable to describe the Sibley retirements as premature. The retirement of the Sibley units simply reflects the realities of the electric generation business that all public utilities must face.

Q: Does this conclude your testimony?

A: Yes.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

The Office of the Public Counsel and Midwest Energy Consumers Group	)	
v.	)	Case No. EC-2019-0200
KCP&L Greater Missouri Operations Company	)	

AFFIDAVIT OF CHRISTOPHER R. ROGERS

STATE OF KANSAS)
) **ss**
COUNTY OF JOHNSON)

Christopher R. Rogers, being first duly sworn on his oath, states:

1. My name is Christopher R. Rogers. I am employed by Power Engineers, Inc. as a Corporate Markets Analyst and have been retained as a witness on behalf of KCP&L Greater Missouri Operations Company

2. Attached hereto and made a part hereof for all purposes is my Rebuttal Testimony on behalf of KCP&L Greater Missouri Operations Company consisting of twenty (20) pages, having been prepared in written form for introduction into evidence in the above-captioned docket.

3. I have knowledge of the matters set forth therein. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded, including any attachments thereto, are true and accurate to the best of my knowledge, information and belief.

Christopher R. Rogers

Subscribed and sworn before me this 22 day of May 2019.

Notary Public

My commission expires: 4-11-23

NOTARY PUBLIC - State of Kansas
JAMIE L. POZZUOLO
My Appt. Expires 4-11-23

Professional Qualifications

Chris R. Rogers, P.E.

POSITION Corporate Markets Analyst for POWER Engineers, Inc.

EDUCATION B.S.M.E., 1974
Kansas State University
Manhattan, Kansas

M.S.C.E. Civil Engineering – Construction Management, 1981
University of Missouri-Columbia
Columbia, Missouri

LICENSES Professional Engineer in Kansas and Hawaii, with NCEES Record Certification

EXPERIENCE SUMMARY

Mr. Rogers a licensed professional engineer with 45 years of experience, primarily in the power industry. He is the Corporate Markets Analyst for POWER Engineers, Inc. which acquired his predecessor engineering firm, Sega, Inc. on July 1, 2017. He performs market research, identifying and following developing trends in the energy sector for potential impacts on the company's future business. In addition, he performs ad hoc research projects for the various divisions within the company and as requested by the firm's clients.

He has provided planning, engineering and management services for many types of electric generating projects, including simple and combined cycle combustion turbine units, coal and waste coal-fired fluidized bed boiler plants, pulverized coal units, and biomass-fired plants. He has performed engineering and feasibility reviews for financing, construction monitoring, and performance testing of numerous generating facilities.

Mr. Rogers was the Manager of Generating Facilities in the Electric Department of the staff of the Missouri Public Service Commission from 1983 through 1986. He supervised the construction management audits in the rate cases for the Callaway Plant and Wolf Creek Nuclear Generating Station, had limited participation in the Grand Gulf Nuclear Station rate case, and performed other assignments concerning regulated generating facilities throughout the State of Missouri.

During the first decade of his career, Mr. Rogers performed mechanical engineering design services for large utility-owned coal-fired central generating facilities while employed by a nationally recognized consulting engineering firm. He served on project design teams in the main office and as the chief mechanical resident engineer on a green-field, coal-fired power plant construction site.

SELECTED PROJECT EXPERIENCE

- **Kansas City Power & Light Company, Kansas City, Missouri** – Project manager of study for the 2016 Kansas City Power & Light – Greater Missouri Operations Company (GMO) Missouri rate case providing opinion of probable costs of retirement and dismantlement of 25 fossil-fueled generating units totaling approximately 1,720-MW of capacity, including six (6) coal-fired units, and fifteen (19) combustion turbines. Prepared direct testimony for filing with the Missouri Public Service Commission sponsoring report in Case No. ER-2016-0156.

  Project manager of study for the 2014 Missouri rate case providing opinion of probable costs of retirement and dismantlement of 24 fossil-fueled generating units and 99 wind turbine generators totaling 5,306-MW of capacity, including eight (8) coal-fired units, one (1) combined-cycle plant, and fifteen (15) combustion turbines. Submitted pre-filed direct testimony before the Missouri Public Service Commission sponsoring report in Case No. ER-2014-0370.

  Project manager of study for the 2014 Kansas rate case providing opinion of probable costs of retirement and dismantlement of 24 fossil-fueled generating units and 99 wind turbine generators totaling 5,306-MW of capacity, including eight (8) coal-fired units, one (1) combined-cycle plant, and fifteen (15) combustion turbines. Prepared direct testimony for filing with the Kansas Corporation Commission sponsoring report for Docket No. 15-KCPE-116-RTS.

  Project manager of study for the 2012 Kansas rate case providing opinion of probable costs for retirement and dismantlement of 24 fossil-fueled generating units totaling 5,260-MW of capacity, including eight (8) coal-fired units, one (1) combined-cycle plant, and fifteen (15) combustion turbines. Provided pre-filed direct and rebuttal testimony before the Kansas Corporation Commission sponsoring report in Docket No. 12- KCPE-764-RTS.

- **Kansas City Power & Light Company, Kansas City, Missouri -** Project manager for 2014 power plant siting study to identify and evaluate multiple candidate sites for potential location of a new combined-cycle plants, simple-cycle peaking turbines, and reciprocating engine generating plants. Provided detailed report of findings to Kansas City Power & Light Company Resource Planning Department.

Officer-in-charge and project manager for 2010 Great Plains Energy combined cycle plant siting study to identify and evaluate multiple candidate sites for potential location of new 600-MW class combined-cycle plant. Provided detailed report of findings to Kansas City Power & Light Company Resource Planning Department.

- **Kansas City Power & Light Company - GMO, Lake Road Generating Station, St. Joseph, Missouri** – Project manager for a study that assessed the feasibility of the KCP&L industrial steam generation and delivery system to serve its industrial steam customers.

- **Kansas City Power & Light - GMO (Formerly Aquila), South Harper Peaking Facility, Peculiar, Missouri** – 315-MW simple-cycle peaking plant. Project manager of Owner's Engineer for siting, permitting support, detailed installation design, balance of plant procurement, construction management services, commissioning, and documentation support. Engineer's resident site manager for construction and commissioning.

- **Kansas City Power & Light, West Gardner and Osawatomie Generating Stations** – Two simple-cycle peaking projects. Preliminary engineering and turnkey proposal manager for engineer-led EPC proposal for 400-MW nominal simple cycle GE 7EA gas turbine generator sets.

- **Independence Power & Light Department, Independence, Missouri** – Master plan study for a nominal 320-MW municipal utility. Project manager for five-year planning study including existing generation assessment, transmission system assessment, load forecast, alternative power supply analysis and economic evaluation.

- **State of Hawaii Division of Consumer Advocacy** – Investigated island-wide blackouts that occurred on Oahu and Maui after the earthquakes on October 15, 2006 and again on Oahu after lightning events on December 26, 2008. Project manager of team investigating causes of the outages, assessing utility outage recovery operations and identifying potential improvements to prevent or minimize future outages.

- **Utah Municipal Power Agency, Spanish Fork, Utah** – Project manager for due diligence assessment of a simple cycle 200-MW peaking plant consisting of five GE LM6000 combustion turbine generator sets.

- **Utah Municipal Power Agency, Spanish Fork, Utah** – Project manager for a study assessing the feasibility of potential sites and development of opinions of probable cost for installation of simple-cycle combustion turbines and reciprocating engine generating sets as a subcontractor to Sawvel and Associates of Findlay, Ohio.

- **Kansas City Board of Public Utilities, Nearman Creek CT4, Kansas City, Kansas** – 85-MW simple-cycle peaking unit. Engineer's site manager for construction completion and commissioning, including checkout, performance testing, emissions testing and management of construction completion closeout activities.

- **Trigen – Kansas City Energy Corporation, Kansas City, Missouri** – Engineer's project manager for feasibility study to repower a district heating plant with an 80-MW combustion turbine and heat recovery steam generator cogeneration project.

- **Conserve Energy System, Centralia, Illinois** – Engineer's project manager on a technical feasibility study for a 215-MW coal-fired atmospheric circulating fluidized bed boiler steam electric generating plant.

- **Cargill, Inc., Blair, Nebraska** – Project manager for feasibility study for a 100-MW net combustion turbine and heat recovery steam generator cogeneration project.

- **Independence Power & Light Department, Independence, Missouri** – Engineer's project manager for major refurbishment program on six GE Frame 5 and one GE 7B-regenerative, oil and gas-fired gas turbines. Project included condition assessments, specifications, and contracting for renewal and upgrade components, unit controls replacement, remote digital controls addition, and major overhaul of each unit.

- **Somerset Generating Station, Somerset, Massachusetts** – Project manager on independent engineering review, performing condition assessments for Montaup Electric Company's divestiture of a 40-MW net, oil-fired combustion turbine (2 x FT4) black start peaking unit, a 100-MW coal-fired power plant, a total of 16-MW of diesel generators (8 x 2-MW GM-EMD) and a 2-MW hydroelectric plant.

- **Constellation Energy, Freehold, New Jersey** – Project manager for review of project proforma and preparation of testimony before the New Jersey Board of Public Utilities concerning net present value of a 110-MW net, gas-fired combined cycle cogeneration project.

- **Cherokee County Cogeneration Project, Gaffney, South Carolina** – Independent engineer's project manager for an 80-MW net, gas-fired combined cycle (GE 106FA) cogeneration project in Gaffney, South Carolina for Prudential Power Financing. Performed technical review of project during design, permitting, contracting, and financing. Conducted construction monitoring for lender. Also served as interim president of project development entity during lender's takeover of project and equity sale to FP&L.

- **Independence Power and Light, Independence, Missouri** – Project manager for study of 100-MW coal-fired steam electric unit, including conceptual design and estimating performance and cost for client's comparison to participation in Iatan II Project. Compiled and compared capital and operation and maintenance cost of alternative 100-MW coal-fired steam electric plants including pulverized coal and CFB plants, and natural gas-fired combined cycle and simple cycle units of the same size.

- **Florida State Correction Facility**, Starke, Florida – Project manager for independent review for potential equity investor, KLT Power, Inc. on a 23- MW, wood gasification and natural gas-fired, combined-cycle cogeneration project proposed near Starke, Florida.

- **Indeck-Oswego Energy Center, Oswego, New York** – Project manager on independent engineering review for BA Securities, Inc. regarding the power sales agreement during term of financing of 51-MW, gas-fired combined-cycle (GE6B) cogeneration project in Oswego, New York.

- **North Carolina EMC**, Raleigh, North Carolina – Project manager of Owner's Engineer team that wrote specifications and evaluated EPC proposals for a 330-MW gas-fired combined-cycle project and 100-MW gas-fired simple-cycle project in North Carolina.

- **Indeck-Olean Energy Center, Olean, New York** – Project manager on independent engineering review for bank group consisting of Canadian Imperial Bank of Commerce, BOT Financial, Inc., Westpac Banking Corporation, and Toronto Dominion Bank. Project was a 79-MW, gas-fired combined-cycle (GE 6B) cogeneration project in Olean, New York. Scope included review of technical feasibility and economic viability of project for financing, construction progress monitoring and oversight of performance demonstration tests.

- **Orlando CoGen Limited, L.P, Orlando, Florida.** – Project manager for independent engineering review for senior lender, the Sumitomo Bank, Limited of a 120-MW gas-fired, single-shaft combined cycle (ABB11N1/VAX) cogeneration project in Orlando, Florida developed by Air Products and Chemicals, Inc. and Utilicorp United.

- **ACE Cogeneration Project, Trona, California** – Project manager for independent engineering assessment for equity investor, US West Capital, Inc., including design, permit status, operations and maintenance of an existing 96-MW, coal-fired CFB steam electric plant.

- **Arroyo Cogeneration, Escondido, California** – Project manager for engineering review of project for development financing for Heller Financial, Inc, including alternate site selection program for a 49.9-MW, gas-fired, combined cycle (GE LM6000) cogeneration project.

- **Nestles Freehold Cogeneration Project, Freehold, New Jersey** – Project manager for independent engineering review for development financing by Heller Financial, Inc. of a proposed 110-MW, gas-fired, single-shaft combined cycle (ABB11N1/VAX) cogeneration project by Constellation Energy.

- **Intercontinental Energy, Bellingham, Massachusetts and Sayreville, New Jersey** – Project manager for independent engineering review for potential equity investor, American Energy Division of Potomac Capital Investment Corporation, for two 300-MW, gas-fired combined cycle (2 x W501D) cogeneration projects.

- **Sunnyside Cogeneration Project, Carbon County, Utah** – Project manager for independent engineering review for senior lender, Swiss Bank Corporation, of the design and permitting review of a 50-MW waste coal-fired circulating fluidized bed boiler electric generating plant.

- **North Branch Power Project, Bayard, West Virginia** – Project manager on independent engineering review for financing and construction monitoring for senior lender, Security Pacific Bank of a 80-MW waste coal-fired, circulating fluidized bed boiler project.

- **Unocal Geothermal, Monterey, California** – Engineer retained by Unocal to provide independent third-party oversight and monitoring of biennial performance tests by Pacific Gas and Electric Company at the Moss Landing Power Station (two 750-MW super-critical, gas and oil-fired steam electric generating units) related to geothermal steam pricing at Unocal's Geysers Geothermal projects.

- **St. Nicholas Power Project, Mahanoy Township, Pennsylvania** – Project manager on independent engineering review for financing, construction monitoring and performance test monitoring for senior lender, Bank of New England for an 80-MW waste coal-fired steam electric plant.

- **Callaway Nuclear Generating Station, Fulton, Missouri** – Manager of Generating Facilities for the Missouri PSC staff, investigated and/or provided testimony concerning project construction management, in-service criteria, net electric capability, decommissioning funding, and in-service completion in rate case for an 1150-MW, PWR nuclear generating station.

- **Wolf Creek Nuclear Generating Station, Burlington, Kansas** – Manager of Generating Facilities for the Missouri PSC staff, investigated and/or provided testimony concerning project construction management, in-service criteria and startup, related fossil-fuel plant retirements, related plant accreditations, depreciation, and net electric capability in rate case for an 1120-MW PWR nuclear generating station.

- **Grand Gulf Generating Station I, Grand Gulf, Mississippi** – Manager of Generating Facilities for the Missouri PSC staff, investigated and provided testimony concerning in-service criteria, in-service status, and overall project NRC inspection and licensing status for a 1250-MW BWR nuclear generating station.

- **Plains-Escalante Generating Station, Unit 1, Prewitt, New Mexico** – Senior mechanical design engineer for mechanical equipment and systems, equipment procurement, construction contracting and coordination; and chief resident mechanical engineer during construction of a 220-MW pulverized coal power plant.

- **Basin Electric Power Cooperative, Inc., Laramie River Station, Wheatland, Wyoming** - Mechanical design engineer for equipment and systems, equipment procurement, and construction contracting and CPM scheduler for coordination of construction completion of systems with sequenced system start-up program for three, 600-MW, pulverized coal-generating units for the Missouri Basin Joint Power Project Agency, led by the Basin Electric Power Cooperative, Inc.

TESTIMONY BEFORE THE MISSOURI PUBLIC SERVICE COMMISSION

Issue Description	Exhibit No.		Transcript Vol. No.	Page Nos.
AMEREN				
CASE NOS. EO-85-17 & ER-84-168 (on behalf of the MO PSC Staff)				
Phase I – Inservice Criteria	Direct	A-7		
	Rebuttal	A-12		
	Surrebuttal	A-14	7	492-83
Phase II – Net Electric Capability	Direct	C-76		
	Surrebuttal	C-77	30	2852-2868
Phase III – Funding Decommissioning	Surrebuttal	C-38	28	2434-2440
Phase III – Inservice Review	Supplemental (1-28-85)	NA	NA	NA
AMEREN				
CASE NO. ER-85-20 (on behalf of the MO PSC Staff)				
Status of Grand Gulf 1 and Waterford 3	Supplemental	12	4	118-181
KANSAS CITY POWER & LIGHT				
CASE NO. ER-85-128 & EO-85-185 (on behalf of the MO PSC Staff)				
Phase I – Inservice Criteria Startup	Affidavits Direct (filed 1/10/85)		NA	NA
Phase IV – Fossil Plant Retirement Dates	Direct	262		
	Surrebuttal	266	23	1798-1817
Phase IV – Depreciation – Wolf Creek	Rebuttal	259		
Phase IV – AWS Structural Steel Welding	Direct	301		
	Surrebuttal	302	26	2294-2329
Phase IV – Net Electric Capability	Direct	399		
	Surrebuttal	400	33	3682-3699
Phase IV – Accreditation Overview	Direct	262	23	1798-1817
	Surrebuttal	436	7	4451-4483
	Appendices (9/10/82)	263		

TESTIMONY BEFORE THE MISSOURI PUBLIC SERVICE COMMISSION (Cont'd)

Issue Description	Exhibit No.		Transcript Vol. No.	Page Nos.
AMEREN				
CASE NO. ER-85-265 (on behalf of the MO PSC Staff)				
Functionalization and Classification of Costs (Jurisdictional Allocations)	Surrebuttal	89	6	844-848
KANSAS CITY POWER & LIGHT (Formerly AQUIL INC.)				
CASE NO. EA-2006-0309 (on behalf of the Company)				
South Harper Peaking Facility Site Selection	Direct (filed 01/27/06)		N/A	N/A
KANSAS CITY POWER & LIGHT COMPANY, INC.				
CASE NO. ER-2014-0370 (on behalf of the Company)				
The Costs of Retirement and Dismantlement: Decommissioning KCP&L Fossil-Fueled Generating Units	Direct Testimony	131	N/A	N/A

TESTIMONY BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF HAWAII

Issue Description	Exhibit No.		Transcript Vol. No.	Page Nos.
HAWAII ELECTRIC LIGHT COMPANY, INC.				
DOCKET NO. 99-207 (on behalf of Consumer Advocate)				
Keahole Projects or Facilities:	Direct Pre-filed CA-T-			288 – 301
1. Shop/Warehouse Building	12		II	301 – 309
2. Fire Protection System	Direct Examination		II	309 - 313
3. Water Treatment System	Commissioners' Exam			
4. Inclusion in Rate Base Amounts				

HAWAII ELECTRIC COMPANY, INC.,
MAUI ELECTRIC COMPANY, LTD., AND
HAWAII ELECTRIC LIGHT COMPANY, INC.
DOCKET NO. 2006-0431 (on behalf of Consumer Advocate)

Consumer Advocates Statement of Position:	Filed August 24, 2007
Consumer Advocate's Supplement	Filed: September , 19, 2008

TESTIMONY BEFORE THE KANSAS CORPORATION COMMISSION

Issue Description	Exhibit No.	Transcript Vol. No.	Page Nos.

KANSAS CITY POWER & LIGHT COMPANY, INC.
DOCKET NO. 12-KCPE-764-RTS

The Costs of Retirement and Dismantlement: Decommissioning KCP&L Fossil-Fueled Generating Units	Pre-filed Direct Testimony Pre-filed Rebuttal Testimony

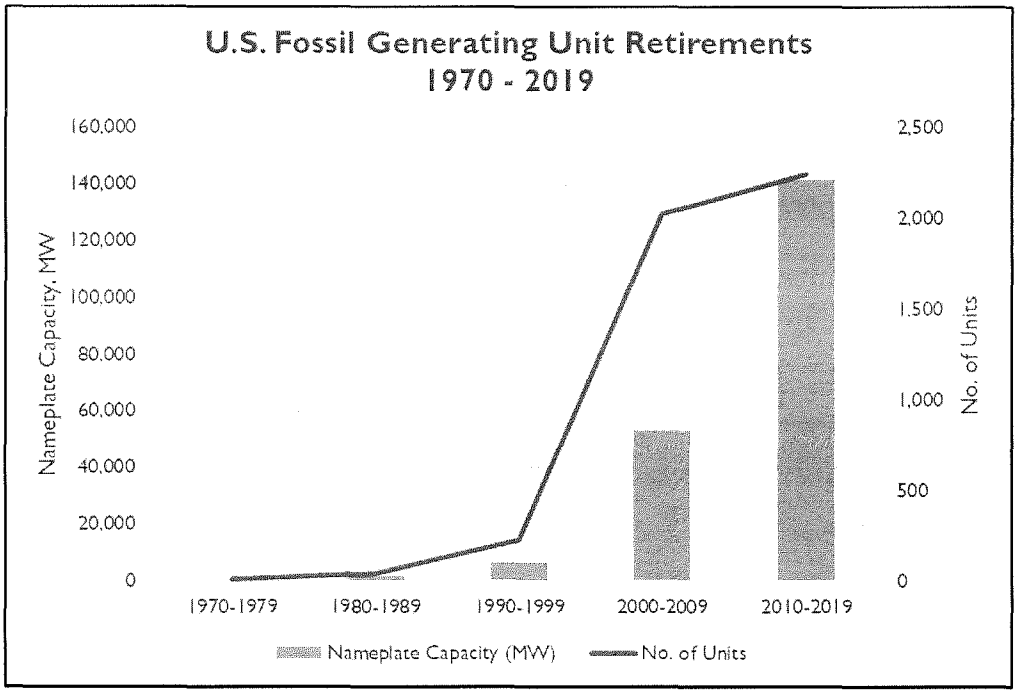


Figure 1 – U.S. Fossil-Fueled Generating Unit Retirements (1970 – 2019)

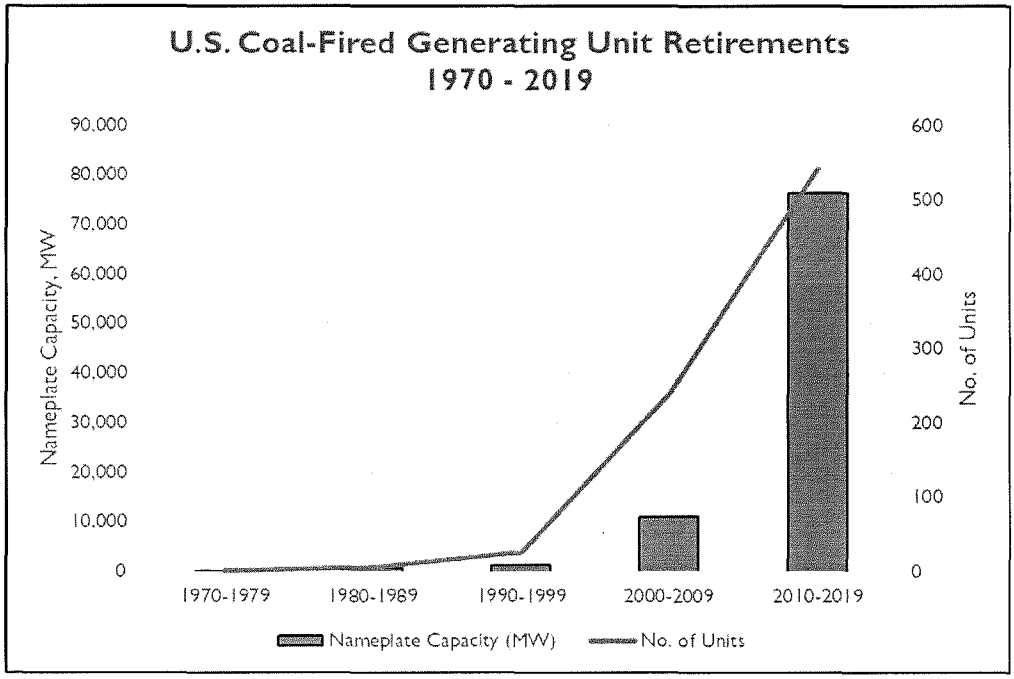


Figure 2 – U.S. Coal-Fired Generating Unit Retirements (1970-2019)

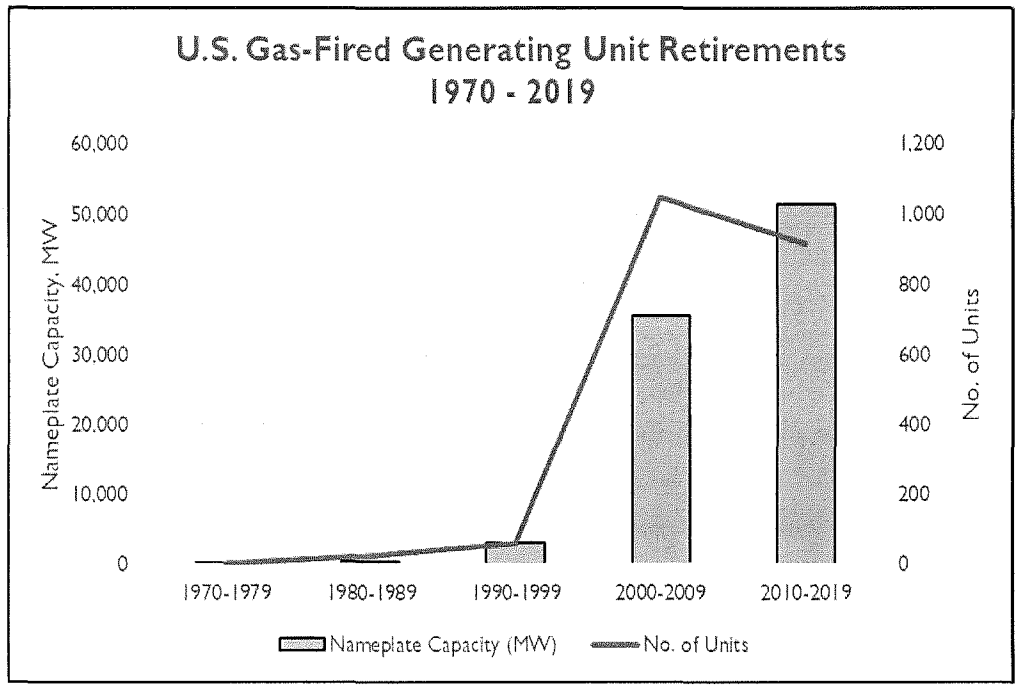


Figure 3 – U.S. Gas-Fired Generating Unit Retirements (1970 – 2019)

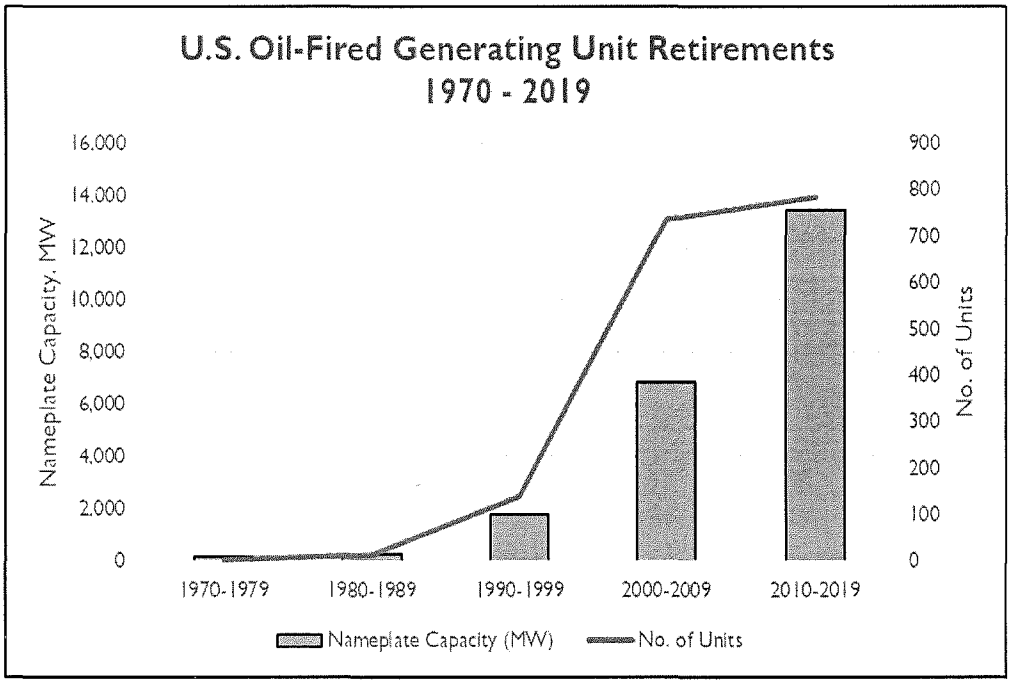


Figure 4 – U.S. Oil-Fired Generating Unit Retirements (1970 – 2019)

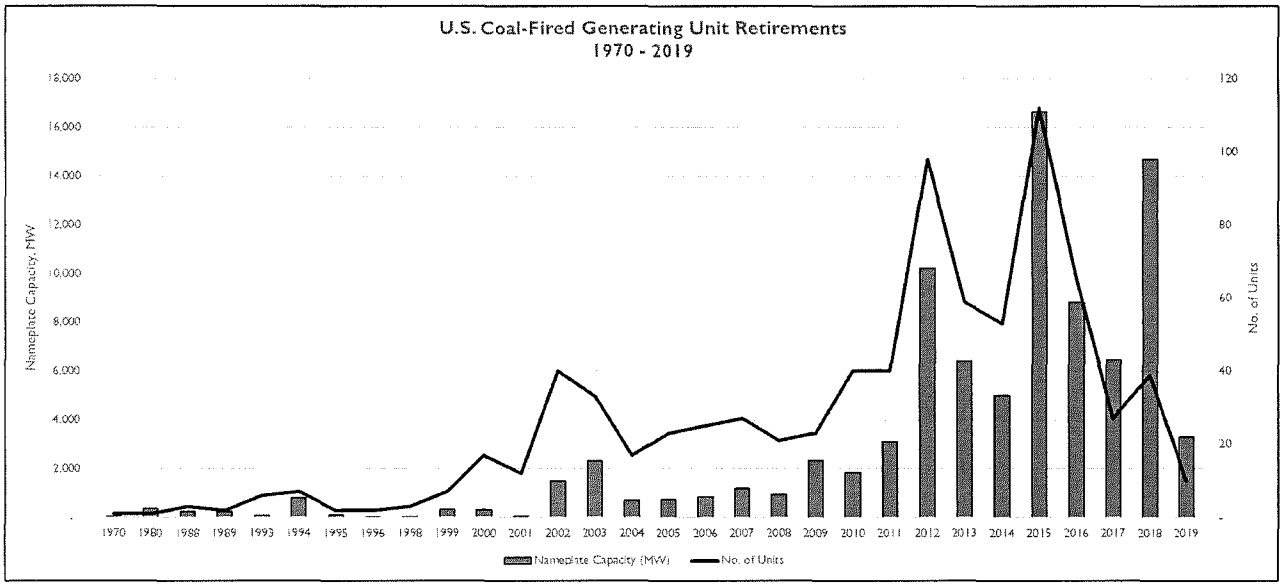


Figure 5 – Annual U.S. Coal-Fired Generating Units (1970 – 2019)

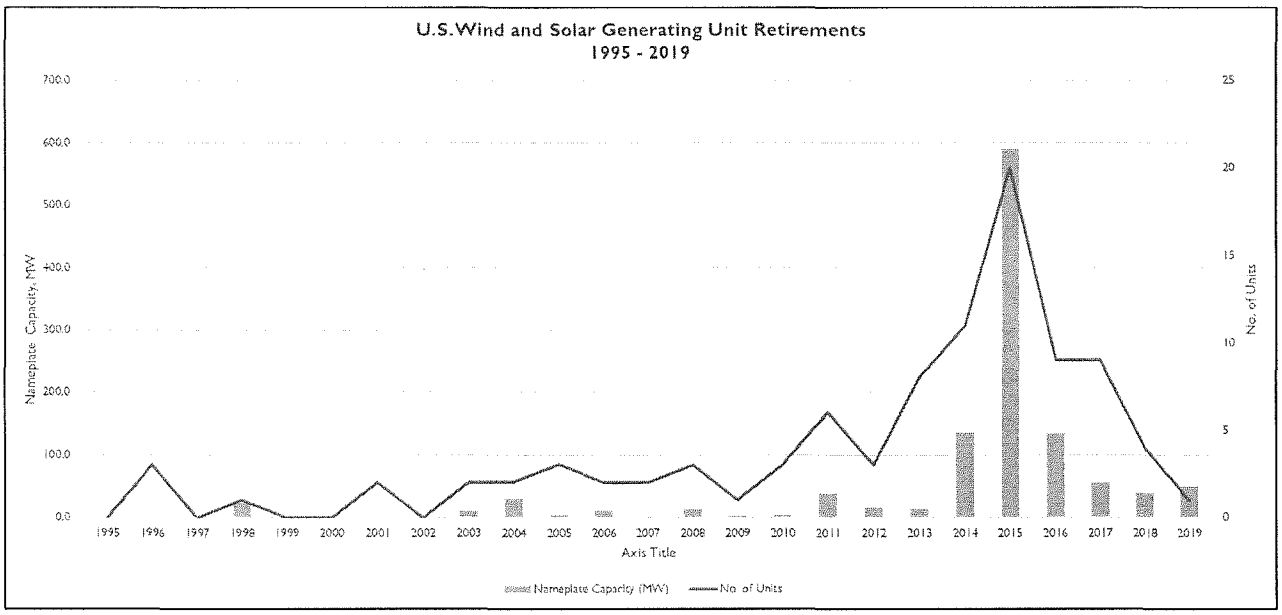


Figure 6 – Annual U.S. Wind and Solar Generating Unit Retirements (1970 – 2019)

US Fossil Generation Retirement Summary Tables

Source: SNL 3/29/2019

All Fossil Fuels

Decade	No. of Units	Nameplate Capacity (MW)	Avg Capacity (MW)	Avg Age per MW
1970-1979	10	198	19.8	50.5
1980-1989	44	1,642	37.3	31.9
1990-1999	228	6,281	27.6	34.7
2000-2009	2,023	53,305	26.3	37.4
2010-2019	2,243	141,456	63.1	47.5
Total	**4548**	**202,883**	**44.6**	**44.3**

Coal

Decade	No. of Units	Nameplate Capacity (MW)	Avg Capacity (MW)	Avg Age per MW
1970-1979	1	2	1.5	33.0
1980-1989	6	862	143.6	28.5
1990-1999	27	1,384	51.3	38.3
2000-2009	238	10,958	46.0	47.2
2010-2019	543	76,526	140.9	50.1
Total	**815**	**89,731**	**110.1**	**49.3**

Gas

Decade	No. of Units	Nameplate Capacity (MW)	Avg Capacity (MW)	Avg Age per MW
1970-1979	4	30	7.5	30.3
1980-1989	24	481	20.1	34.1
1990-1999	61	3,094	50.7	32.7
2000-2009	1,047	35,481	33.9	33.8
2010-2019	916	51,489	56.2	44.4
Total	**2052**	**90,575**	**44.1**	**39.8**

Oil

Decade	No. of Units	Nameplate Capacity (MW)	Avg Capacity (MW)	Avg Age per MW
1970-1979	5	167	33.3	54.3
1980-1989	14	299	21.4	37.9
1990-1999	140	1,803	12.9	35.5
2000-2009	738	6,866	9.3	40.5
2010-2019	784	13,442	17.1	44.7
Total	**1681**	**22,577**	**13.4**	**42.7**

Coal Generation Retirement Summary By Years

Source: SNL 3/29/2019

Year	No. of Units	Summer Capacity (MW)	Winter Capacity (MW)	Nameplate Capacity (MW)	Avg Nameplate Capacity (MW)	Avg Age per MW
1970	1	2	2	2	2	33.0
1980	1	250	250	358	358	21.0
1988	3	225	235	264	88	32.3
1989	2	190	190	240	120	35.5
1993	6	89	89	90	15	46.8
1994	7	798	800	802	115	35.9
1995	2	112	112	125	63	49.5
1996	2	20	20	20	10	40.9
1998	3	21	21	21	7	54.6
1999	7	326	326	326	47	36.1
2000	17	311	310	316	19	43.5
2001	12	65	65	66	6	50.1
2002	40	1,317	1,280	1,481	37	50.7
2003	33	2,088	2,087	2,317	70	43.4
2004	17	662	662	696	41	54.0
2005	23	660	680	744	32	52.3
2006	25	823	835	844	34	52.7
2007	27	1,127	1,138	1,197	44	49.4
2008	21	902	902	948	45	50.4
2009	23	2,287	2,301	2,351	102	41.4
2010	40	1,691	1,688	1,833	46	49.6
2011	40	2,853	2,894	3,112	78	54.3
2012	98	9,291	9,596	10,231	104	51.4
2013	59	5,761	5,979	6,394	108	49.3
2014	53	4,436	4,497	5,016	95	52.6
2015	112	14,916	15,121	16,668	149	54.7
2016	65	8,004	8,097	8,826	136	51.1
2017	27	5,868	5,979	6,454	239	49.8
2018	39	13,353	13,543	14,692	377	42.8
2019	10	2,908	2,916	3,302	330	47.1
Grand Total	**815**	**81,353**	**82,613**	**89,731**	**110**	**49.3**

Wind and Solar Generation Retirement Summary

Source: SNL 05/15/2019

Year	No. of Units	Nameplate Capacity (MW)	Avg Nameplate Capacity (MW)
1995	0	0.0	0.0
1996	3	0.2	0.1
1997	-	-	-
1998	1	23.8	23.8
1999	-	-	-
2000	-	-	-
2001	2	0.4	0.2
2002	-	-	-
2003	2	9.8	4.9
2004	2	29.7	14.9
2005	3	4.8	1.6
2006	2	10.4	5.2
2007	2	1.4	0.7
2008	3	12.4	4.1
2009	1	2.1	2.1
2010	3	3.2	1.1
2011	6	39.0	6.5
2012	3	15.7	5.2
2013	8	13.8	1.7
2014	11	135.8	12.3
2015	20	589.5	29.5
2016	9	135.3	15.0
2017	9	55.9	6.2
2018	4	39.8	10.0
2019	1	50.4	50.4
Grand Total	**95**	**1,173**	**12.3**

POWER ENGINEERS

POWER PARITY

HAVE RENEWABLE RESOURCES BECOME LESS EXPENSIVE THAN FOSSIL-FUELED GENERATION?

POWER PARITY: HAVE RENEWABLE RESOURCES BECOME LESS EXPENSIVE THAN FOSSIL-FUELED GENERATION?

Chris R Rogers, P.E.
POWER Engineers, Inc.

The subject of the relative costs of renewable energy versus fossil-fueled generation is one of great interest to utilities, energy-related consulting firms, ratepayers, and politicians. Market prices for wind and solar generation have been declining for several years, and regulations and legislation at both the federal and state levels have promoted expansion of wind and solar generation. Once established in the marketplace, economies of scale, experience, technology advancements,and competition have reduced the costs of renewable generation to the point of parity, or nearly so, with conventional generation in many regions of the United States.

This paper provides a survey of recent studies and anecdotal references from publicly available sources to compare the costs for wind and solar generating resources to fossil-fueled and other conventional electricity sources.

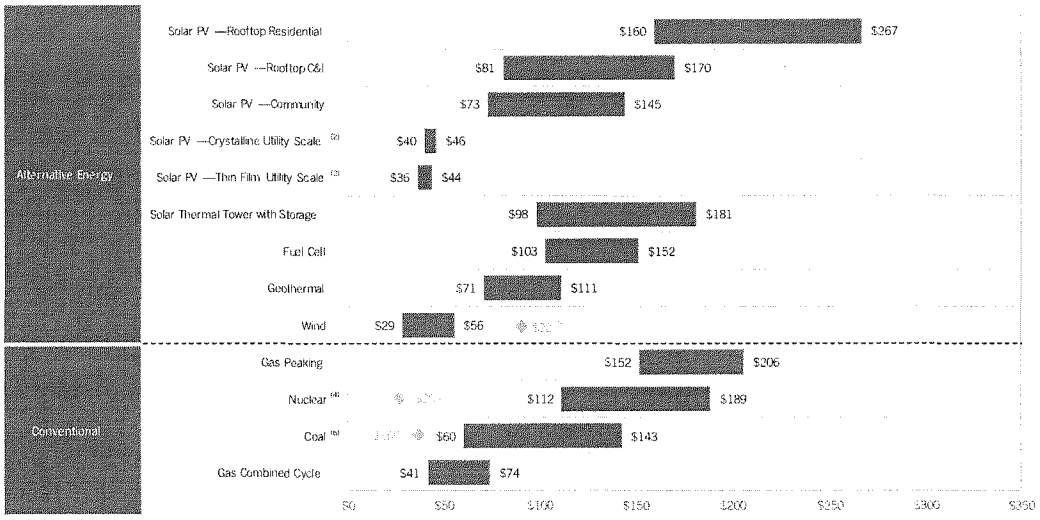
The referenced studies indicate generalized trends in the industry and are neither directly comparable to each other nor considered sufficiently accurate for budgeting or evaluating specific projects. They are likely based on differing assumptions, although complete information is not provided. These summaries are provided only for discussion purposes. Attribution is provided for each study and citation at the end of this report.

Levelized Cost of Electricity

Energy prices in units of dollars per megawatt-hour ($/MWh) of electric energy are typically used in evaluating the costs of comparative generation technologies. The Levelized Cost of Electricity (LCOE) in $/MWh usually includes the total costs of installing, operating, and maintaining a given generation plant over an assumed financial life and duty cycle. LCOE indicates the average revenue per unit of generation needed for a generating plant to be economically viable[1] Several sources provide LCOE comparisons of renewable versus conventional generation with and without federal and state subsidies and tax incentives or credits. Federal subsidies and tax treatments for renewable energy resources will be winding down over the next few years, unless extended by Congress. Therefore, comparisons were sought that considered the unsubsidized LCOE for wind and solar resources versus fossil-fueled generation now as an indication of future rankings once the subsidies expire.

LAZARD LCOE Comparison – Unsubsidized Analysis

Certain Alternative Energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances [1]



Source: *Lazard estimates.*

Note: Here and throughout this presentation, unless otherwise indicated, the analysis assumes 60% debt at 6% interest rate and 40% equity at 12% cost. Please see page titled "Levelized Cost of Energy Comparison—Sensitivity to Cost of Capital" for cost of capital senstivities.

(1) Such observation does not take into account other factors that would also have a potentially significant effect on the results contained herein, but have not been examined in the scope of this analysis. These additional factors, among others, could include: import tariffs; capacity value vs. energy value; stranded costs related to distributed generation or otherwise; network upgrade, transmission, congestion or other integration-related costs; significant permitting or other development costs, unless otherwise noted; and costs of complying with various environmental regulations (e.g., carbon emissions offsets or emissions control systems). This analysis also does not address potential social and environmental externalities, including, for example, the social costs and rate consequences for those who cannot afford distribution generation solutions, as well as the long-term residual and societal consequences of various conventional generation technologies that are difficult to measure (e.g., nuclear waste disposal, airborne pollutants, greenhouse gases, etc.).

(2) Unless otherwise indicated herein, the low end represents a single-axis tracking system and the high end represents a fixed-tilt design.

(3) Represents the estimated implied midpoint of the LCOE of offshore wind, assuming a capital cost range of approximately $2.25 – $3.80 per watt.

(4) Unless otherwise indicated, the analysis herein does not reflect decommissioning costs or the potential economic impacts of federal loan guarantees or other subsidies.

(5) Represents the midpoint of the marginal cost of operating fully depreciated coal and nuclear facilities, inclusive of decommissioning costs for nuclear facilities. Analysis assumes that the salvage value for a decommissioned coal plant is equivalent to the decommissioning and site restoration costs. Inputs are derived from a benchmark of operating, fully depreciated coal and nuclear assets across the U.S. Capacity factors, fuel, variable and fixed operating expenses are based on upper and lower quartile estimates derived from Lazard's research. Please see page titled "Levelized Cost of Energy Comparison—Alternative Energy versus Marginal Cost of Selected Existing Conventional Generation" for additional details.

(6) Unless otherwise indicated, the analysis herein reflects average of Northern Appalachian Upper Ohio River Barge and Pittsburgh Seam Rail coal. High end incorporates 90% carbon capture and compression. Does not include cost of transportation and storage.

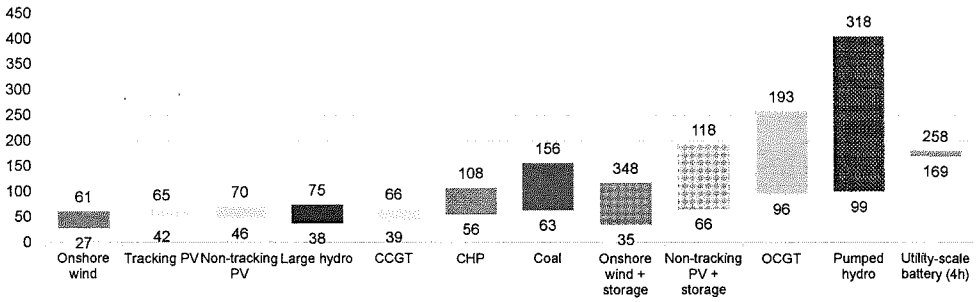
Lazard [2]

Lazard is an international financial advisory firm that provides investment banking, asset management, and other financial services primarily for institutional clients. Lazard has published an annual LCOE analysis since 2008. In November 2018, Lazard published its annual Levelized Cost of Energy Analysis – Version 12.0, providing a comparison of the LCOE of wind and utility-scale solar to the marginal cost of selected conventional generation technologies. Lazard's report also included a comparison of historical LCOE prices for utility-scale generation technologies as well as the historical declines in LCOE for wind and utility-scale solar technologies. A comparison to gas-fired peaker technologies was also included.

Lazard's "Unsubsidized Analysis," shown above, demonstrates that the LCOE of wind and all solar technologies except residential rooftop photovoltaic (PV) are less than or equal to the LCOE for gas peaking, nuclear, and coal generation technologies.[3] When subsidies were included, Lazard found that the LCOE for wind and solar declined from 5% to 8% further, beating out conventional generating technologies except for fully depreciated nuclear and coal facilities. Lazard's LCOE range for subsidized wind generation was only $14/MWh to $47/MWh. Even when Lazard considered natural gas price sensitivity, the lowest LCOE for combined cycle was $35/MWh. Wind and solar PV were competitive, if not at complete parity with coal, nuclear, and natural gas generation.

Lazard found that alternative generating technologies, such as wind and solar PV generation, are **"complementary to conventional generation technologies" and expects that "their use will be increasingly prevalent for a variety of reasons,"** including **"continually improving economics as underlying technologies improve and production volumes increase."**[4]

BloombergNEF U.S. Levelized Cost of Electricity (Unsubsidized) for New Construction[6]



- Levelized cost of electricity (LCOE) is a metric for comparing the relative costs of different generating technologies. It measures the all-in, lifetime costs of operating a plant, accounting for upfront costs as well as anticipated ongoing expenses.
- At $27-$61/MWh *without accounting for tax credits*, the LCOE for onshore wind is lower than for new gas-fired plants for bulk electricity generation in many areas of the U.S. Meanwhile, combined-cycle gas turbines (CCGTs) offer the lowest cost *dispatchable* power in the U.S., with an LCOE of $39-$66/MWh.
- Photovoltaic (PV) systems outfitted with mechanisms to track the sun's progress across the sky offer an LCOE of $42-$65/MWh and are nearly at parity with new CCGTs. PV without tracking is getting cheaper, with an LCOE of $46-$70/MWh.
- The levelized cost of paired onshore wind-plus-battery (with four hours of storage) systems ranges from $36-$118/MWh, while solar-plus-battery (four hours) is $57-$169/MWh.

Source: BloombergNEF. Note: LCOE range represents a range of costs and capacity factors. Battery storage systems (co-located and stand-alone) presented here have four-hour storage. In the case of solar- and wind-plus-battery systems, the range is a combination of capacity factors and size of the battery relative to the power generating asset (25-100% of total installed capacity). All LCOE calculations are unsubsidized. Categorization of technologies is based on their primary use case. Nuclear not included due to insufficient data and lack of project development. Large hydro projects are those greater than 50MW of capacity

BloombergNEF

A more recent report from BloombergNEF found a closer degree of parity for onshore wind and solar PV resources constructed in the second half of 2018 compared to natural gas-fired combined cycle, coal-fired generation, and several other technologies.[5] Bloomberg NEF provided a range of LCOE for onshore wind from $27/MWh to $61/MWh **without subsidies or tax credits** compared with a range of $39/MWh to $66/MWh for natural gas-fired combined cycle generation. Natural gas-fired combined cycle generation was cited as the lowest-cost dispatchable power in the U.S. on an LCOE basis. BloombergNEF had coal-fired generation higher at a range of $63/MWh to $156/MWh.

Surprisingly, onshore wind plus storage (4-hour BESS) was indicated at $35/MWh to $348/MWh – **less at the low range than for combined cycle.** Similarly, BloombergNEF found the low range of LCOE for non-tracking PV plus BESS to be only $66/MWh, which is within the range of LCOEs for coal, CHP, combined cycle, and large hydroelectric generation.

US EIA Estimated Levelized Cost of Energy (Capacity Weighted Average[1]) for New Generation Resources Entering Service in 2020 (2017 $/MWh)

Plant type	Capacity factor (%)	Levelized capital cost	Levelized fixed O&M	Levelized variable O&M	Levelized transmission cost	Total system LCOE	Levelized tax credit[1]	Total LCOE including tax credit
Dispatchable technologies								
Conventional CC	87	11.5	1.5	34.1	1.1	48.1	NA	48.1
Advanced CC	87	13.1	1.3	31.1	1.1	46.7	NA	46.7
Conventional CT	30	33.9	6.7	49.9	3.1	93.6	NA	93.6
Advanced CT	30	21.7	2.6	55.8	3.1	83.2	NA	83.2
Non-dispatchable technologies								
Wind, onshore	40	40.4	13.7	0.0	2.5	56.6	-17.5	39.1
Solar PV[2]	29	51.3	8.7	0.0	3.2	63.2	-15.4	47.8

[1]The tax credit component is based on targeted federal tax credits such as the PTC or ITC available for some technologies. It reflects tax credits available only for plants entering service in 2020 and the substantial phase out of both the PTC and ITC as scheduled under current law. Technologies not eligible for PTC or ITC are indicated as NA or not available. The results are based on a regional model, and state or local incentives are not included in LCOE calculations. See text box on page 2 for details on how the tax credits are represented in the model.

[2]Costs are expressed in terms of net AC power available to the grid for the installed capacity.

CC=combined-cycle (natural gas). CT=combustion turbine. PV=photovoltaic.

Source: U.S. Energy Information Administration, *Annual Energy Outlook 2018* .

U.S. Energy Information Administration

The U.S. Energy Information Administration (EIA) publishes an analysis of the LCOE and the levelized avoided cost (LCAE) of new generation resources for its Annual Energy Outlook (AEO). While the 2019 AEO was just released in January, the Levelized Generation Cost Study for 2019 has not yet been published. However, the 2018[7] study provides the estimated LCOE for new generating resources entering service in 2022, albeit in 2017 $/MWh, with and without renewable tax credits.[8]

The EIA results are very similar to those of BloombergNEF and Lazard. Although for different years and using different sampling techniques, EIA data indicate a capacity-weighted average LCOE for unsubsidized new wind generation nearly equal to the LCOE for new natural gas-fired combined cycle generation coming online in 2020. Solar PV LCOE was found to be somewhat higher. However, when applicable levelized tax credits are added, wind and solar PV are less costly than natural gas-fired combined cycle at this time.

Anecdotal References

Numerous reports of renewable resources have indicated increasingly lower price levels. Typically, results are reported as a purchased power agreement (PPA) price or an average price over the term of a PPA, rather than LCOE. Therefore, anecdotal prices are not directly comparable to LCOE prices from studies, but the reports seem to indicate downward price trends. A few recent examples are sampled below as anecdotal evidence of trending renewable energy price decline.

» New Braunfels Utilities in Texas announced a new PPA for 255 MW of solar PV generation at less than $25/MWh in December 2018.[9]

» Kauai Island Power Cooperative commissioned the Lawai Solar and Energy Storage Project in December that combines 28 MW of PV with a 100 MWh Li-ion battery system (20 MW for five hours) with a PPA price of $110/MWh including the energy storage.[10]

» Hawaiian Electric Company (HECO) submitted seven new PV plus BESS contracts to the state PUC for approval.[11] Six of the contracts were reported with PPA prices at less than $10/MWh. The projects would total 262 MW of PV with 1,048 MWh of storage distributed over three islands. HECO compared these prices to current coal- and oil-fired generation at the equivalent of $150/MWh.

» MGM Resorts in Las Vegas, Nevada, signed a PPA to provide solar PV power for 13 casinos for less than $30/MWh.[12]

» The average price of wind generation in the central U.S. has fallen from about $55/MWh in 2009 to below $20/MWh in 2017, a $35 decline in an eight-year period.[13]

Conclusion

During a 2018 speech in Denver, Xcel Energy CEO Ben Fowke III explained the utility's decision to incorporate more renewable resources on the road to becoming carbon-free:

"The surprising thing is that when you do the math, it's cheaper to build the wind and not use your coal and gas plants as much. Most of our customers want a cleaner energy product. All of them want an affordable energy product."[14]

Fowke is not alone. The relative prices of renewable resources compared to coal and gas have in some cases, made it cheaper for utilities to build new renewable electric generating resources rather than continuing to maintain aging coal and natural gas plants.

While not yet at complete parity, research and industry reports indicate that renewables, especially wind and photovoltaic solar, are competitive with the cost of more conventional resources. Ultimate parity will depend on the changing price of natural gas, but costs are competitive enough that ratepayer-focused utilities such as Xcel find that adding renewables to their generating portfolio makes economic sense—a trend likely to continue into the foreseeable future.

Sources

[1] "Annual Energy Outlook 2019 with projections to 2050", U.S. Energy Information Administration Office of Energy Analysis, U.S. Department of Energy. January 24, 2019. https://www.eia.gov/outlooks/aeo/?src=email.

[2] Lazard's Levelized Cost of Energy Analysis – Version 12.0, November 2018. https://www.lazard.com/media/450773/lazards-levelized-cost-of-energy-version-120-vfinal.pdf. Accessed November 13, 2018.

[3] Ibid, page 2.

[4] Ibid, page 19.

[5] "2019 Sustainable Energy in America Factbook," BloombergNEF, Bloomberg Finance L.P. in partnership with the Business Council for Sustainable Energy. Released February 12, 2019.

[6] Ibid, page 39.

[7] "Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018," U.S. Energy Information Administration Office of Energy Analysis, U.S. Department of Energy. March 2018. https://www.eia.gov/outlooks/aeo/electricity_generation.php.

[8] Ibid, page 12.

[9] Merchant, Emma Foehringer. "Texas Utility Signs New Super-Low PPA." Greentech Media, December 14, 2018. https://www.greentechmedia.com/articles/read/utility-signs-new-low-solar-ppa-in-texas?utm_medium=email&utm_source=Solar&utm_campaign=GTMSolar#gs.dYTX1do Accessed December 17, 2018.

[10] Spector, Julian. "AES Completes Record-Breaking Solar and Battery Plant on Kauai". Greentech Media, January 8, 2019. https://www.greentechmedia.com/articles/read/aes-completes-its-record-breaking-solar-and-battery-plant-on-kauai?utm_medium=email&utm_source=Daily&utm_campaign=GTMDaily#gs.rzkvei4a Accessed January 9, 2019.

[11] Merchant, Emma Foehringer. "Hawaiian Electric Announces 'Mind-Blowing' Solar-Plus-Storage Contracts." Greentech Media, January 4, 2019. https://www.greentechmedia.com/articles/read/hawaiian-electric-industries-announces-mind-blowing-solar-plusstorage-cont#gs.3odg4m9Z Accessed January 8, 2019.

[12] Puko, Timothy. "From Beer to Casinos, Businesses Turn to Solar, Wind Power," The Wall Street Journal, January 30, 2019. https://www.wsj.com/articles/climate-change-pushes-companies-to-buy-renewables-11548849602? Accessed January 30, 2019.

[13] Merchant, Emma Foehringer. "Average U.S. Wind Price Falls to $20 per Megawatt-Hour." Greentech Media, August 24, 2018. https://www.greentechmedia.com/articles/read/us-wind-prices-20-megawatt-hour#gs.qAIkGIjE. Accessed August 28, 2018.

[14] Mullaney, Tim. "Why switching to a Green New Deal may not make your electric bill spike." CNBC.com, February 22, 2019. https://www.cnbc.com/2019/02/22/why-switching-to-a-green-new-deal-may-not-make-your-electric-bill-spike.html. Accessed February 26, 2019.

ABOUT POWER ENGINEERS: POWER Engineers is a global consulting engineering firm specializing in the delivery of integrated solutions for energy, food and beverage facilities, environmental and federal markets. POWER Engineers offers complete multidiscipline engineering and program management services. Founded in 1976, it is an employee-owned company with more than 2,500 employees and 45 offices throughout the United States and abroad.

www.powereng.com

Jim Haynes
Chief Administrative Officer
james.haynes@powereng.com
208.288.6664