PolicyPerspective

October 2019
Life:Powered

A Long and Expensive Road Ahead
Why San Antonio Can't Afford to Make CPS Energy Carbon-Neutral by 2050

by Charles S. Griffey
Principal Researcher

Brent Bennett, Ph.D.
Policy Analyst

Key Points

- Transitioning CPS Energy to zero-carbon electricity generation by 2050, with 80 percent coming from wind and solar, is predicted to increase the cost of generation and transmission nearly three times compared to current costs, after adjusting for inflation. Achieving this goal with 100 percent wind and solar would increase costs by almost four times.
- Under the 100 percent wind and solar scenario, the average San Antonio family would pay at least $1,000 more annually for electricity, after adjusting for inflation.
- The land needed for a 100 percent wind and solar electric grid would reach more than 700,000 acres, more than 2.5 times the size of San Antonio and nearly 10 times the amount of land currently used to power the city's electric grid.
- A comparable scenario that replaces gas and coal assets, based on their current useful lives, with natural gas generation would see the inflation-adjusted cost per MWh of generation and transmission decrease by 5 percent.

Introduction

In 2017, San Antonio embarked on a process to create a Climate Action and Adaptation Plan (CAAP) (City of San Antonio), endorsing the goals of the Paris Climate Agreement and aiming to reach net-zero carbon dioxide (CO_2) emissions by 2050. A key plank of this proposal is to eliminate CO_2 emissions from the city's utility, CPS Energy, which is the largest municipally owned energy utility in the country. This study seeks to explore different scenarios that CPS might follow to achieve this goal and attempts to calculate the cost of reaching carbon-neutral electricity generation compared to pursuing traditional least-cost planning.

The question of how to achieve so-called deep decarbonization and the technology and scale required to transition our current energy system has been debated in academic and industry circles for many years, in particular the question of managing our electric grid with high percentages of intermittent wind and solar energy (Denholm and Hand; Frew et al.; Kroposki et al.). The recent Green New Deal proposal and legislation in a few states, notably New Mexico (SB 489) and California (SB 100), mandating 100 percent zero-carbon electricity generation within the next 10-30 years have brought greater prominence to this question in political circles as well.

It is well known that maintaining modern reliability standards in electricity systems with significant wind and solar penetration imposes high costs due to the need to build excess generation and energy storage (Mai et al.; Sepulveda et al.; Bennett). Even utilizing firm zero-carbon generation such as fossil fuels with carbon capture, hydropower, and nuclear is more expensive than current generation, though less so than using all wind and solar (Sepulveda et al.; van Zuijlen et al.; Luke). In examining the costs of reducing CO_2 emissions, this study considers both a scenario relying on the current lowest-cost technologies (advanced gas turbines and combined-cycle gas turbines) and two different zero-carbon scenarios for CPS Energy: a scenario with 100 percent wind and solar generation (100 percent scenario) and a scenario with 80 percent wind and solar plus 20 percent of electricity provided by combined-cycle natural gas with carbon capture (80 percent scenario).

Overview of Resource Planning Model Results for CPS Energy

Figure 1 outlines the capacity requirements for achieving the two high renewable scenarios. Those scenarios are compared to a "base case" scenario, wherein the lowest-cost technologies are pursued, and the mix of electricity generation in 2018. The base case assumes the current level of wind and solar generation is maintained through 2050 and that one coal unit is maintained past 2050, per its 45-year estimated life. Existing gas steam units are retired at the end of their estimated life and replaced with combined-cycle and simple-cycle gas units, while

continued

Figure 1. 2050 capacity requirements of 80 percent and 100 percent wind and solar generation for CPS Energy compared to 2050 base case and 2018 generation mix.

	2018	2050 base case	80 percent renewables	100 percent renewables
Wind capacity (MW)	1,069	1,069	5,323	8,662
Solar capacity (MW)	546	546	5,828	9,483
Battery capacity (MW)	-	-	2,009	17,993
Nuclear capacity (MW)	1,036	-	-	-
Gas capacity (MW)	3,339	7,275	3,400	-
Coal capacity (MW)	1,345	785	-	-

Source: Life:Powered

existing gas turbines were extended 10 years beyond their current estimated lifetimes.

The 80 percent scenario requires natural gas to use carbon capture and is designed to illustrate the benefit of using firm capacity to achieve the last 20 percent of zero-emission generation. Both the 80 and 100 percent scenarios estimate battery capacity based on meeting July and August needs, under the assumption that CPS would be comfortable buying market power during other months but would be more risk-averse during those peak months and choose to meet its need with its own resources. Both renewable mandate scenarios assume all coal is retired by 2030, with the 100 percent scenario assuming one of the two units is retired by 2025. The South Texas Project (STP) nuclear plant was assumed to retire in 2049 in all three scenarios.

The high renewable scenarios were not run through an optimization routine and represent only two of many possible zero-carbon generation mixes. However, the split between wind and solar resources in these scenarios is based upon ERCOT's Long-Term System Assessment report (ERCOT), which was optimized, and studies (Ziegler et al.) that find a roughly 50/50 wind/solar capacity mix is optimal for the southwestern United States.

The model also assumes a 10 percent reserve margin and 4 percent losses in order to provide a consistent basis for quantifying capacity needs. Another important assumption across all the scenarios is that annual electricity demand growth will rise consistently at 1.25 percent per year. The tremendous cost increases associated with the high renewable scenarios dictate that electricity consumption will likely go down in conjunction with increasing renewable energy use. However, in order to maintain a level comparison with the base case, the study assumes constant electricity demand growth.

2050 Cost Comparison

A fundamental challenge of wind and solar resources is that their intermittent generation must be supplemented with either generation from dispatchable sources, energy storage, or demand reductions. The full implications of this fact are rarely considered in policy and even in utility cost comparisons, which tend to assume that falling costs of installing wind and solar generation assets on the margin (Lazard) and improvements in energy storage and demand response technologies will enable further renewable penetration in the future. The costs of increasing wind and solar penetration in Texas have already affected electricity costs in Texas despite the low wind and solar share of electricity generation (roughly 20 percent of total annual electricity production) and the relative abundance of dispatchable generation. Those costs will rise exponentially if wind and solar are used for a larger share of electricity generation (Bennett). This study seeks to estimate the generation and transmission costs for CPS Energy to reach zero-carbon electricity generation by 2050.

Figure 2 outlines how much the cost of electricity generation and transmission need to serve San Antonio is projected to increase under these different scenarios by 2050. The values are given in 2018 dollars using an annual inflation adjustment of 2 percent. Under the base case scenario, the total annual cost increases about 35 percent compared to 2018, primarily due to the growth in energy demand. The 80 percent renewable scenario sees an increase of nearly three times due to five- and ten-fold increases in wind and solar generation capacity, respectively, and the need for carbon sequestration on gas units and some energy storage. Natural gas generation capacity is still significant, representing 46 percent of the 2050 peak demand, because of the need to provide power during times of low wind and solar generation at peak. The cost of the 100 percent scenario is another billion dollars more than the 80 percent scenario because of the need for additional wind, solar, and battery

Figure 2. 2050 annual cost (in 2018 dollars) of 80 percent and 100 percent scenarios for CPS Energy compared to 2050 base case and 2018

	2018	2050 base case	80 percent renewables	100 percent renewables
Annual cost ($ Billion)	1.02	1.38	2.96	4.00
Annual cost ($/MWh)	42.65	40.64	87.41	118.06
Cost per ton of CO_2 emissions reduction	-	-	115.14	190.59

Source: Life:Powered

capacity. Transmission costs to reach remote wind and solar generation sites are also substantial in each of the high renewable scenarios, contributing nearly 25 percent of the total 2050 cost.

It is important to note that these costs only reflect the incremental cost of generating and transmitting electricity and do not reflect additional costs, such as the recovery of the sunk cost of existing units, administration and distribution operations costs, or payments to the city of San Antonio, the latter of which totaled $373 million in 2018. Under the simplistic assumption that the four-times cost increase in the 100 percent scenario is applied evenly on a per MWh basis to all electricity consumers, the average annual residential electricity bill in San Antonio would rise at least $1,000 by 2050.

Land Use and Environmental Impacts of High Renewable Scenarios

While the CAAP is primarily concerned with CO_2 emissions, there are many other environmental impacts of energy generation, most notably land use. The land needed for siting wind turbines and solar panels is substantial because of the low energy density of these resources, usually tens to more than one hundred times the land needed for fossil fuel extraction and power plants (NREL). The land requirements for wind and solar facilities in the 100 percent scenario are more than half a million acres. About 190,000 acres will be needed for additional transmission lines, bringing the total additional land use to 714,000 acres, more than 2.5 times the size of San Antonio itself and nearly 10 times the amount of land currently used to power the city's electric grid.

It is also important to remember that the material requirements for wind turbines, solar panels, and batteries are substantial. These materials are finite and not themselves renewable, although they can sometimes be recycled. The 100 percent scenario would require 2,900 wind turbines, at 3 MW each, using 870,000 metric tons of steel (NREL 2017) and nearly that much coal to make the steel (WCA). It is assumed that batteries are designed to meet their power rating for four hours, which means San Antonio will need 72 gigawatt-hours of storage capacity—nine times what was installed worldwide in 2018 (Munuera). The environmental impact of this massive buildout of infrastructure cannot be ignored.

Marginal Wind and Solar Generation vs. High-Penetration Scenarios

The high cost of wind and solar energy production highlighted in this study may appear to conflict with other studies that tout the economic benefits of replacing single generating units with wind and solar (Sunrun; Allison et al.) or using wind and solar for small percentages of total electricity production (TXP and Ideasmiths). These studies are often used by renewable energy companies and environmental advocacy groups to advocate for policies that mandate large percentages of electricity production from wind and solar, which entails a whole set of problems that these studies do not address. This difference is often lost on the public and policymakers and creates a situation where renewable energy mandates are promulgated with little knowledge of their potential costs.

A recent study[1] from Synapse Energy Economics and the Sierra Club (Allison et al.) forecasting the benefit of replacing the coal-fired J.K. Spruce power plant with solar or wind has contributed to this information gap in San Antonio. While the CAAP calls only for carbon neutrality, not 100 percent wind and solar, and specifically cites CPS's "Flexible Path" plan (CPS Energy) as a guideline, the Sierra Club and other groups (Sierra Club) continue to advocate for higher levels of wind and solar generation. Hopefully, this report and others can be used as counterpoints to that messaging

Figure 3. 2050 incremental land use of 80 percent and 100 percent renewable scenarios.

	80 percent renewables	100 percent renewables
Miles transmission	3,739	5,609
Land for transmission (acres)	135,974	203,961
Land for solar (acres)	42,254	71,499
Land for wind (acres)	255,257	455,607

Source: Life:Powered

1 Note that this study actually shows a positive benefit to continuing to operate both Spruce units through 2039.

and can highlight the value of dispatchable generation, even in a low- or no-carbon future.

The challenges of wind and solar intermittency are not only a long-term concern for CPS. The utility has historically had excess dispatchable generating capacity, which has allowed it to incorporate renewable energy and benefit from selling into the ERCOT market when prices are high. Retiring dispatchable capacity in favor of intermittent renewables represents a dramatic change in approach and will introduce significant price risk for CPS's customers. If CPS cannot cover its demand during peak hours, it will have to rely on power purchases from the broader ERCOT market. A similar situation caused a price spike for Austin Energy this past August that will flow through to its customers (Jankowski). CPS also might find itself with too much wind and solar electricity during periods of low demand and would have to sell its excess energy at depressed prices. This situation has caused Georgetown, Texas, which often purchases more wind and solar electricity than it consumes, to have the highest electricity rates in Central Texas (Price and Osborn).

Conclusions

No large city or region has successfully achieved the goal of operating an electric grid powered significantly, much less entirely, by wind and solar resources. This fact and the forecasts presented in this paper should give pause to the more than 400 cities across the country (Climate Mayors) that have endorsed the goals of the Paris Climate Agreement. Achieving the carbon-neutral goals of San Antonio's CAAP primarily with wind and solar resources will be difficult in practice and likely politically impossible given consumers' sharp opposition to rapid increases in electricity costs. Lower-cost renewable and battery technologies alone will not solve the problem, as the problem is mostly a function of the scale of the infrastructure required to capture diffuse wind and solar energy and the production profile of intermittent generation relative to consumer demand.

Using nuclear, carbon capture and sequestration, and other zero-carbon or low-carbon resources that have the dispatchability and scale to power the majority of the electric grid, while using wind and solar on the margins, can help bring down the cost of reaching carbon neutrality. Ultimately, however, there are significant tradeoffs involved in mandating aggressive CO_2 reduction goals for a large city like San Antonio that depends on affordable and reliable energy. Further mandates to require CPS to achieve this goal with large amounts of renewable energy, at a much higher cost per ton of CO_2, will make this problem even worse. Increasing the cost of electricity and spending city tax dollars to reduce CO_2 emissions will also divert money that will be needed to improve disaster readiness through improved flood control, wildfire mitigation, and infrastructure upgrades.

Instead of forcing its citizens into an expensive program to dramatically reduce CO_2 emissions from its power generation, San Antonio should instead focus on becoming the most affordable and least regulated city in the country, catalyzing the entrepreneurship and innovation needed to create our energy systems of the future. Our freedom to innovate has made the U.S. a world leader in clean air (WHO) and made us more resilient to climate than ever before. Fostering that freedom—instead of stifling it with higher power costs, taxes, and mandates—is what will enable us to solve the environmental problems of the future.

The methodology used for this paper can be found on the Life:Powered website.

References

Allison, Avi, Jamie Hall, Thomas Vitolo. 2019. *An Updated Look at the Economics of the J.K. Spruce Power Plant*. Synapse Energy Economics Inc.

Bennett, Brent. 2019. *Green New Deal Will Put Texans in the Red: Consequences on Texas Electricity Costs and Energy Production up to 2030*. Texas Public Policy Foundation.

City of San Antonio. 2019. *SA Climate Ready: A Pathway for Climate Action and Adaptation*. City of San Antonio.

Climate Mayors. 2017. "407 US Climate Mayors commit to adopt, honor and uphold Paris Climate Agreement goals." Updated June 1, 2018. Accessed October 2, 2019.

CPS Energy. "Our Flexible Path." Accessed October 4, 2019.

Denholm, Paul, and Maureen Hand. 2011. "Grid flexibility and storage required to achieve very high penetration of variable renewable electricity." *Energy Policy* 39(3): 1817-1830.

ERCOT (Electric Reliability Council of Texas). 2018. *Long-term System Assessment for the ERCOT Region December 2018*. ERCOT.

Frew, Bethany A., Sarah Becker, Michael J. Dvorak, Gorm B. Andresen, and Mark Z. Jacobson. 2016. "Flexibility mechanisms and pathways to a highly renewable US electricity future." *Energy* 101: 65-78.

Jankowski, Philip. 2019. "Sweltering heat, absent wind could trigger increase to Austin Energy bills." *Austin-American Statesman,* August 27. Updated August 28.

Kroposki, Benjamin, Brian Johnson, Yingchen Zhang, Vahan Gevorgian, Paul Denholm, Bri-Mathias Hodge, and Bryan Hannegan. 2017. "Achieving a 100% Renewable Grid: Operating Electric Power Systems with Extremely High Levels of Variable Renewable Energy." *IEEE Power and Energy Magazine* 15(2): 61-73.

Lazard. 2018. *Lazard's Levelized Cost of Storage Analysis*. Lazard.

Luke, Max. 2018. "Getting to Zero Carbon Emissions in the Electric Power Sector." *NERA Economic Consulting*, December 19.

Mai, Trieu, Wesley Cole, and Andrew Reimers. 2019. "Setting cost targets for zero-emission electricity generation technologies." *Applied Energy* 250: 582-592.

Munuera, Luis. 2019. "Energy Storage: Tracking Clean Energy Progress." *International Energy Agency*, June 18.

NREL (National Renewable Energy Laboratory). 2019. "Land Use by System Technology." Accessed October 2.

NREL (National Renewable Energy Laboratory). 2017. *2015 Cost of Wind Energy Review*. National Renewable Energy Laboratory.

Price, Asher, and Claire Osborn. 2019. "Why Georgetown's green energy gamble didn't pay off." *Austin-American Statesman*, February 23. Updated March 4.

SB 100. 2018. Introduced. 2017-2018 California Legislature.

SB 489. 2019. Introduced. 2019 New Mexico Legislature (R).

Sepulveda, Nestor A., Jesse D. Jenkins, Fernando J. de Sisternes, and Richard K. Lester. 2018. "The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation." *Joule* 2(11): 2403-2420.

Sierra Club Lone Star Chapter. 2019. "New Report: Replacing San Antonio's Spruce Coal Plant With Renewables Could Save $1 billion." *Sierra Club*, June 26.

Sunrun. 2019. *Repowering Clean: Gigawatt-Scale Potential for Residential Solar & Battery Storage in Los Angeles*. Sunrun.

TXP, Inc. and Ideasmiths LLC. 2018. "The Economic Value of Renewable Energy in Texas." Wind Solar Alliance. Accessed October 4, 2019.

Van Zuijlen, Bas, William Zappa, Wim Turkenburg, Gerard van der Schrier, and Machteld van den Broek. 2019. "Cost-optimal reliable power generation in a deep decarbonisation future." *Applied Energy* 253.

WCA (World Coal Association). 2019. "How is Steel Produced?" Accessed October 3.

WHO (World Health Organization). 2018. "Global Ambient Air Pollution." Accessed October 3, 2019.

Zeigler, Micah S., Joshua M. Mueller, Gonçalo D. Pereira, Juhyun Song, Marco Ferrara, Yet-Ming Chiang, and Jessika E. Trancik. 2019. "Storage Requirements and Costs of Shaping Renewable Energy Toward Grid Decarbonization." *Joule* 3(9): 2134-2153.

ABOUT THE AUTHORS

Charles S. Griffey is an energy markets consultant at Peregrine Consultants, LLC, whose practice covers the energy value chain from generation to customer sales for both electricity and natural gas. In addition to consulting, he has served as an adjunct professor of management at Rice University's Jones Graduate School of Business. He managed the regulatory planning and government affairs function for one of the nation's leading competitive electricity companies and devised and implemented commercial/regulatory/political strategies to manage risks and position his firm for success in competitive wholesale and retail electric markets. He is recognized as a leader in electric market design and as an expert witness on electric policy and market design matters.

Brent Bennett, Ph.D., is a policy analyst for Life:Powered, a project of the Texas Public Policy Foundation, which seeks to raise America's energy IQ and advance better energy policy across the country. Prior to joining Life:Powered, Bennett worked for a startup company that sold carbon nanotubes to battery manufacturers, and he continues to provide technology consulting to battery companies. He has a B.S. in physics from the University of Tulsa and an M.S.E. and Ph.D. in materials science and engineering from the University of Texas at Austin. His graduate research focused on new chemistries for utility-scale energy storage systems, and he complemented his scientific training with studies of renewable energy technologies and utility markets.

Life:Powered is a national initiative of the Texas Public Policy Foundation to raise America's energy IQ. We educate policymakers and the public about the importance of our abundant, reliable, and affordable energy resources to human flourishing.

Life:Powered

901 Congress Avenue | Austin, Texas 78701 | 512.472.2700 | www.LifePowered.com