THE IMPACT OF AN ADDITIONAL 10 GW OF UTILITY-SCALE SOLAR IN ERCOT DURING WINTER STORM URI

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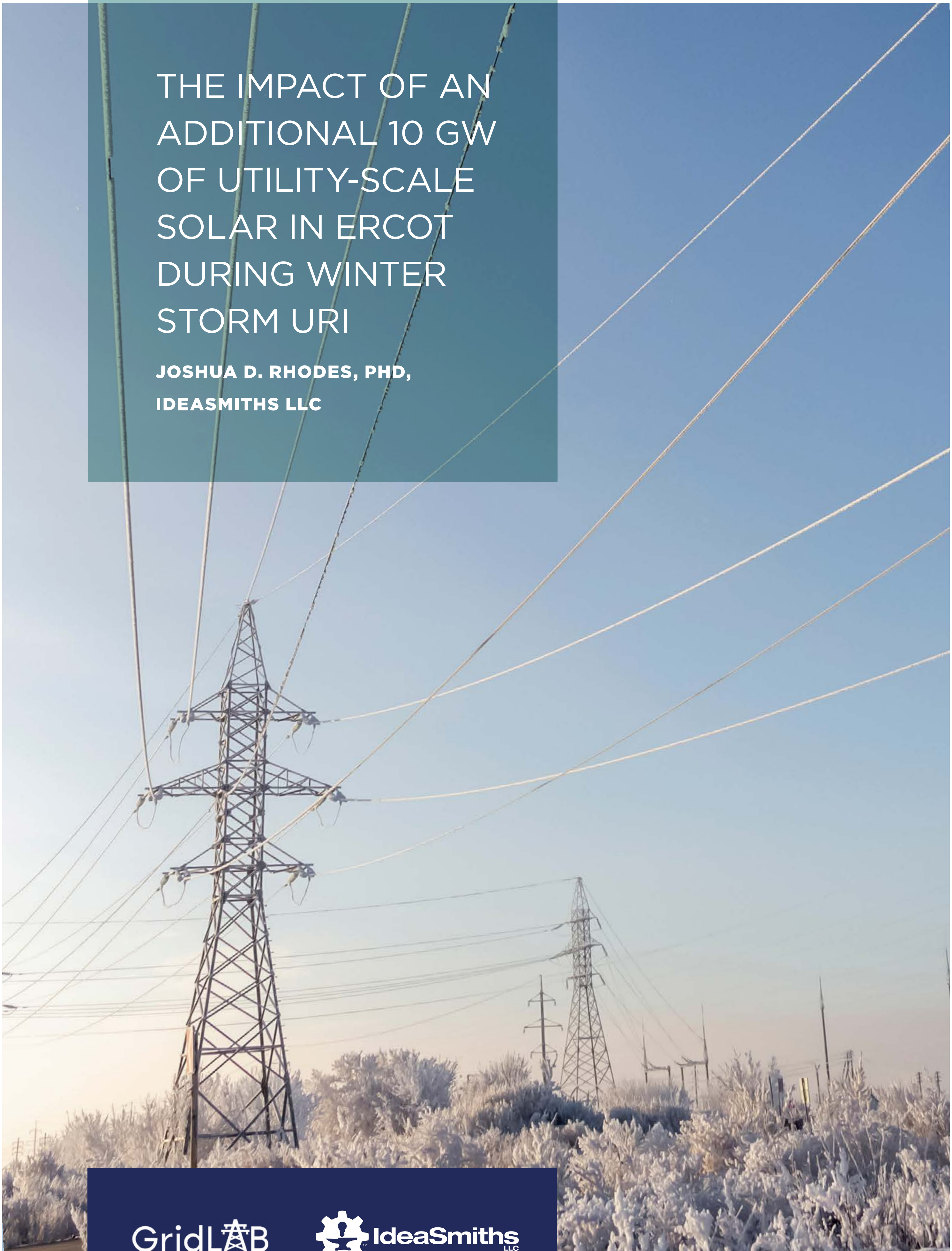

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INTRODUCTION

The winter storm that hit Texas and the surrounding regions in February 2021 (often referred to as Winter Storm Uri) triggered one of the worst blackouts in recent history. In Texas, it was the first time that all 254 counties were under a winter storm warning at the same time. The extreme levels of cold (for the region) drove electricity demand to levels that would have surpassed the existing summer peak demand records at the time. This same widespread cold weather also resulted in the record loss of over 50,000 MW of power plant capacity, including over 30,000 MW of natural gas, coal, and nuclear capacity. The simultaneous high demand and critically low supply forced the grid operator, the Electric Reliability Council of Texas (ERCOT), to call for up to 20,000 MW of load shed which left millions of customers without power for multiple days, costing over $100 billion in electricity costs and damages as well as the deaths of hundreds of people.

While every form of generation experienced issues and outages during the storm, solar was one of the only resources to perform above ERCOT's worst case expected output. However, at the time, ERCOT's solar capacity was much lower than today and thus its ability to take up the slack for the rest of the system was limited. Solar is often viewed as having a limited winter benefit. However, because ERCOT was energy and fuel constrained during the winter storm, the ability to produce energy without being tied to a limited fuel source would have been valuable.

This analysis considers how the system would have performed had there been an additional 10 GW of utility-scale solar PV capacity on the system that behaved similarly to the solar capacity that did exist during the storm. Specifically, we assess how much of the load shed might have been able to be reversed and for how long and discuss how this additional energy would have changed how customers in ERCOT experienced the storm and its effects.

While 10 GW of additional solar during the February 2021 winter storm would not have stopped the blackouts, we find that this additional solar would have provided enough energy to power over 1 million homes for between 4 and 8 hours per day of the storm. We find that the additional solar would have been able to cover between 25% and 50%+ of the total load shed for multiple hours per day making the outages much more bearable for those customers experiencing them.

While dealing with daily outages would still have been challenging, having power for at least part of the day would have made the storm much more bearable and potentially much less costly and deadly.

RESULTS AND DISCUSSION

The blackout began early on Monday February 15, 2021 and lasted for three days until the night of February 17. Figure 1 shows the amount of load met during the winter storm, load met by the solar that existed during the winter storm, and the load shed (unserved load or blackouts).

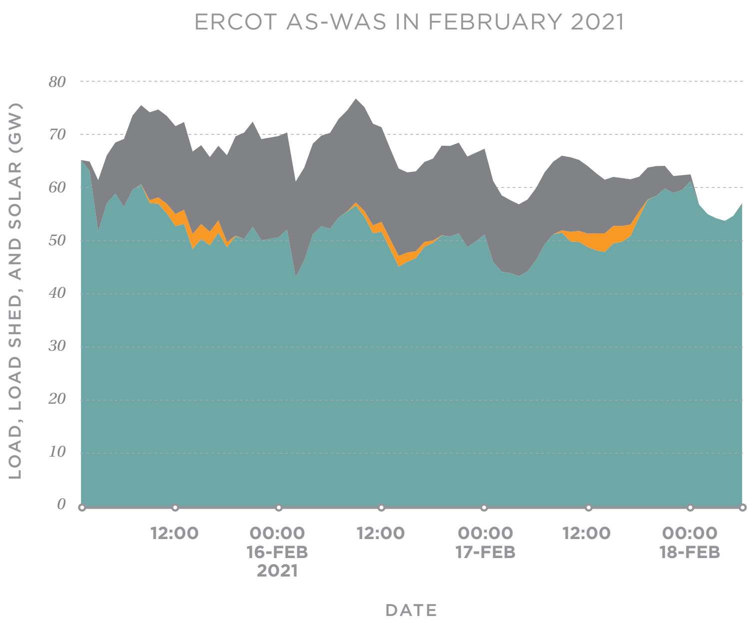

FIGURE 1.

Graph showing the amount of load (bottom, green color), including the amount of load met by solar (middle, orange color), as well as the amount of unserved load (top, gray color) during Winter Storm Uri.

During the winter storm, ERCOT estimated that just under 1 TWh (1,000,000 MWh) of energy was not provided to approximately 4.5 million Texas homes and businesses that would have otherwise wanted to consume energy.[1] Of the approximately 4,132,000 MWh of energy actually served to customers during the storm, the existing solar fleet contributed about 56,000 MWh, or about 1.4%. However, more solar capacity would have contributed more energy.

Figure 2 shows the same data as in Figure 1, but includes the estimated output from an additional 10 GW of solar in orange.

1 https://energy.utexas.edu/sites/default/files/UTAustin%20%282021%29%20EventsFebruary2021TexasBlackout%2020210714.pdf

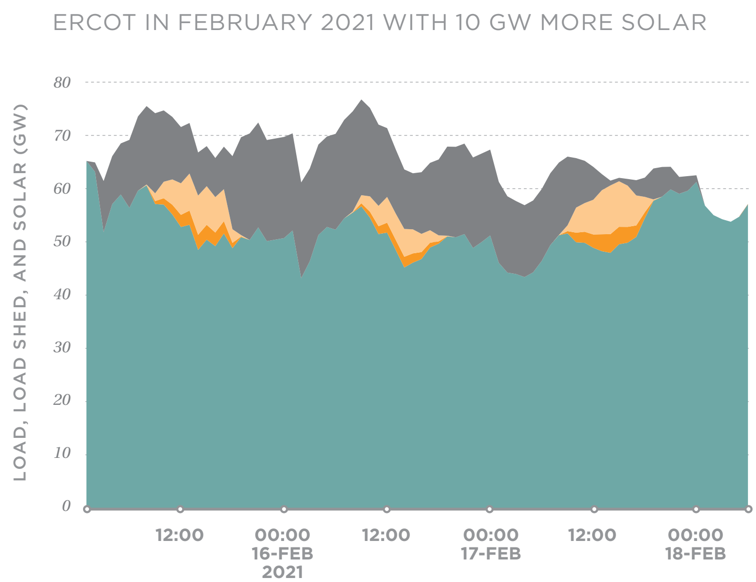

FIGURE 2.

Graph showing the amount of load (bottom, green color), including the amount of load met by solar (2nd from bottom, ornage color), the estimated amount of additional load that would have been met by 10 GW of more solar (3rd from bottom, light orange color), as well as the estimated reduced amount of unserved load (top, gray color) that would have happened.

In this scenario, the amount of unserved load drops by almost 15% to about 850,000 MWh, driven by the additional ~150,000 MWh of energy from the additional solar that was able to flow to customers.

However, because solar only produces energy for part of the day, this energy is concentrated over a limited number of hours. Thus, it is important to also consider the temporal aspects of the additional solar energy on the system. Figure 3 shows the additional solar generation shown in Figure 2 as the number of homes that we estimate would be able to be powered in each hour that the solar was producing.

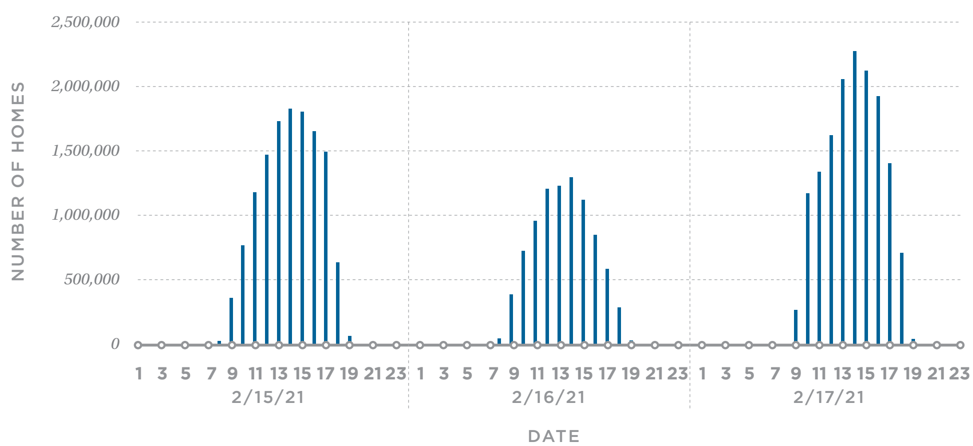

FIGURE 3.

Chart showing the estimated number of homes that could have been powered by an additional 10 GW of solar during the winter storm.

Because we are not considering energy storage in this analysis, we assume that the energy from the additional solar is only available during times when the solar is actually producing electricity. The amount of power produced during the solar hours is significant. Using a weighted average estimate of 4 kW of power draw per home during the storm, we estimate that an additional 10 GW of solar would have provided enough power to turn on over 1 million homes between 4 and 8 hours per day.

One of the main criticisms of the winter storm blackouts was that, for many Texans, the blackouts did not roll (turning groups of electricity customers off for a short amount of time before turning them back on) as initially promised. The blackouts were not able to roll because turning a group of customers back on during an active rolling blackout requires first turning another group off. Many utilities said that they did not have any additional non-critical circuits[2] that they could turn off that would have allowed them to turn others back on. This inability to roll led to some customers being without power for multiple days in a row, leading to tens of billions of dollars in insured damages from such things as water damage to homes caused by frozen pipes leaking.[3]

It is also the case that individual circuits might have a mix of hundreds or thousands of residential and commercial loads and it is generally not possible to just turn off residential or commercial loads from the utility side of the meter. Given this coarseness of the distribution feeder network, it likely would not have been possible to just turn on homes while the solar was available, but it is possible that heavily residential circuits might have been able to be given preference. Thus, we also considered the impact of the additional solar on the total amount of load shed as well as an estimated residential share of that load shed.

Even in the worst solar day of the storm (February 16), this analysis found that the additional solar would have been able to support at least 25% of the total load shed for at least 4 hours or over 50% of the estimated residential load shed share. The additional energy would have been able to cover at least a third of the total load shed for six hours on the first day (February 15) and over half on the last day of outages (February 17).

2 Electricity feeders that did not contain critical loads like hospitals, 911 call centers, and other loads that need to stay on for life and safety services.

3 https://www.dallasfed.org/research/economics/2021/0415

DATA AND METHODOLOGY

This section outlines the data and methods used to generate the results of this analysis. To calculate the impact of an additional 10 GW of solar on grid conditions during the winter storm, it was first necessary to calculate how the existing utility solar fleet fared during the storm. Hourly solar generation data[4] for the ERCOT region were divided by the capacity of utility-scale solar (~3.8 GW)[5] on the system at that time. These hourly capacity factors were used to scale the output of an additional 10 GW of solar for every hour. This analysis is focusing on utility-scale solar because data for two reasons: 1) accurate aggregate production data for residential scale solar in ERCOT are not readily available and 2) due to back-feed protections for the grid, rooftop solar would not be producing unless the system had batteries and was able to island or if the building was on a circuit that was powered on. During the winter storm, between approximately 320 MW and 1,500 MW of solar experienced some type of forced outage.[6] However, these outages were not deducted from the capacity available when calculating the hourly capacity factors and thus we assumed that the extra 10 GW of solar would have experienced similar outage levels as the then existing solar fleet.

The energy output of the additional solar was then compared to the estimated load shed data provided by ERCOT.[7] Because most Texans experienced the winter storm through the loss of power at home, we used this excess solar generation to estimate the number of homes that could have been powered for at least part of each day of load shed as well as the estimated percentage of residential load shed that could have been reversed, again for a least part of each day. Note that this analysis did not consider the use of energy storage to shift any additional solar generation, but just considered its impact of being available in real time.

4 https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/regional/REG-TEX
5 https://www.ercot.com/files/docs/2020/11/05/SARA-FinalWinter2020-2021.pdf
6 https://www.ercot.com/news/february2021
7 https://www.ercot.com/news/february2021

This analysis estimated the number of homes would have been able to have been energized and for how long using a weighted average estimate for the amount of power that the average home would draw on peak. Comments provided to the Texas Public Utility Commission showed that homes with electric heating used about 4-6 kW of power during the depth of the storm.[8] A similar analysis found that homes using natural gas for heating pulled about 1.5-2.5 kW of electricity during the same time period.[9] About 61% of homes in Texas utilize electricity for heating and the rest mostly utilize natural gas or propane.[10] Assuming that electric consumption patterns for all homes that utilize fossil fuels for heating are similar, we calculated a weighted average, with a 25% increase on top, of about 4 kW of power draw per home during the storm.

In addition to calculating the number of homes that could have been powered by the additional solar, we also calculated the percentage of total and residential load shed that could have been alleviated. We estimated the residential sector load share to be about 51% of the total load shed based on historical sectoral breakdowns during winter peaking events.[11] That is, we treated the entire event as a winter peaking event.

ABOUT US

IdeaSmiths LLC[12] was founded in 2013 to provide clients with access to professional analysis and development of energy systems and technologies. Our team focuses on energy system modeling and assessment of emerging innovations, and has provided support to investors, legal firms, and Fortune 500 companies trying to better understand opportunities in the energy marketplace.

8 https://interchange.puc.texas.gov/Documents/52373_109_1152444.PDF
9 https://twitter.com/TKavulla/status/1469408659058868229
10 https://www.eia.gov/todayinenergy/detail.php?id=47116
11 https://www.sciencedirect.com/science/article/pii/S1040619023000210#fig0005
12 https://www.ideasmiths.net/

APPENDIX

The following figures show the data used to estimate the average electricity use per home during the winter storm for homes that primarily use electricity (Figure 4) and natural gas (Figure 5) for heating.

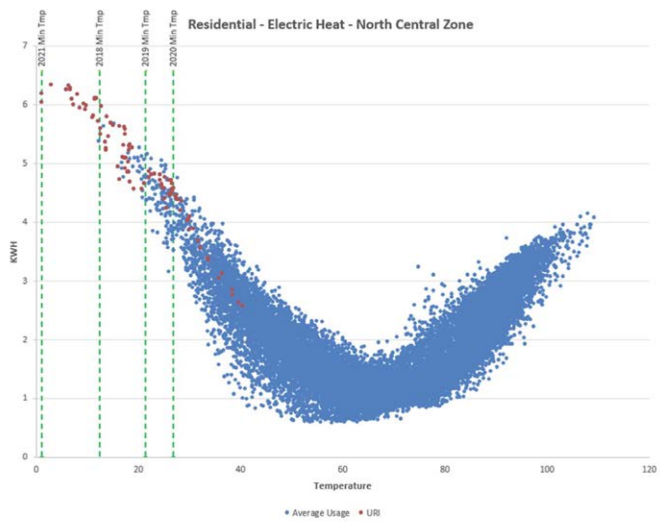

FIGURE 4.

Graph of electricity use by ambient temperature for homes that primarily use electricity for heating.[12]

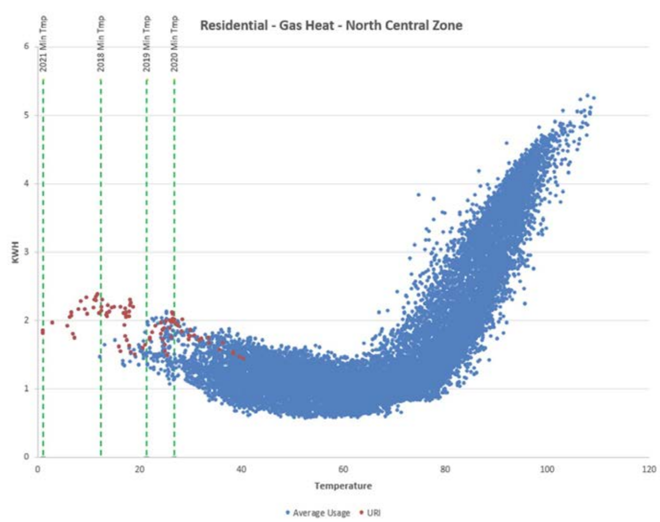

FIGURE 5.

Graph of electricity use by ambient temperature for homes that primarily use natural gas for heating.[13]

13 https://interchange.puc.texas.gov/Documents/52373_109_1152444.PDF
14 https://twitter.com/TKavulla/status/1469408659058868229