

The Effect of COVID-19 on Household Utilities Consumption

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Abstract— The purpose of this project is to determine the difference between the utilities consumption in various homes before and during the COVID-19 pandemic, suggest causes for such differences, and present these data and findings to potentially predict utilities consumption after the pandemic. Data collection of electricity, gas, and water consumption for about 30 different college students' homes was utilized to compare pre-pandemic and in-pandemic utilities consumption and to observe any changes. Understanding how the utilities consumption between the two time periods differs will illustrate different reasons as to how energy usage compares year over year and how subsequent knowledge can mediate the potential effects of increased consumption and cost of utilities. Lessening the utility loads for many homeowners is a crucial step closer to becoming net zero as a community, state, and country; the possibilities of renewable energy are endless, but informing the general public and adopting improved energy solutions will further prepare homeowners in unexpected events like COVID-19. In short, this study aims to distinguish major causes of higher utility consumption before and during the pandemic and convey these findings in ways that can reduce the consumption and cost of utilities in the near future.

Keywords— COVID-19 pandemic, electricity usage, natural gas consumption, utilities, household utilities

I. INTRODUCTION

Research shows that prior to the COVID-19 pandemic “roughly five percent of full-time employees with office jobs worked primarily from home” [1]. In contrast, recent figures from “a paper on the impact of Covid-19 on small business outcomes and expectations” show that “43% of surveyed U.S. companies had temporarily shut down a few weeks into the crisis” while a similar “45% of both large and small businesses in the U.S. moved part of their staff to remote work.” [2] This massive shift in working location has forced many to increase their time spent at home, which could disrupt typical energy consumption. It is important to study these changes in household utility consumption because they “could potentially have longer impacts on household energy usage behavior and longer-term environmental impacts” [3]. By studying the impacts of the shift in time spent in households on energy consumption, insight can be gained for homeowners and decision makers for long-term, post-pandemic energy consumption predictions. Understanding that these predictions are based on many notions of job security, family life, wealth, and field of work will help depict how and why utility consumption differs from pre-pandemic consumption. Although many lost their jobs, other families were not affected; these two disparate situations share an uncertainty-increasing similarity: increased energy demand [3]. This paper

reflects on that utility-consumption-uncertainty and is complete with reasoning as to why the utility consumption has changed so drastically as well as what can be done to mitigate those changes.

II. METHODOLOGY

For this study, data was collected from a sample group of 38 households. The sampling spanned 11 different states and 26 different cities across the United States. This sample was chosen from the class participants who provided monthly household utility data. Each participant was asked to provide two years' worth of individual household data which included electric consumption, gas consumption, and water consumption for the years 2019-2020. (An important note to consider here is that data for 2019 begins in March 2019 and goes through February 2020, and data for 2020 similarly begins in March 2020 and goes through February 2021).

After collecting all the data, it was determined that 37 participants provided accurate and usable electric consumption data, 29 participants provided accurate and usable gas consumption data, and 29 participants provided accurate and usable water consumption data. For each household with accurate and usable data for the 2019-2020 period, the utility consumption was compared on a year to year basis to show if the COVID-19 pandemic had any effect on household utilities consumption. For the purpose of this paper, the data from each household is averaged based on each utility usage; comparing the average raw data represents the trends that each house followed before and during the pandemic. A direct comparison for the three utilities being studied was performed on a monthly basis to provide insight on monthly utility usage year over year. All data was compiled in an Excel spreadsheet and processed to show results of year over year differences for each month.

III. DATA AND RESULTS

After all data was collected and compiled, a simple year over year analysis was performed to show the net monthly change in utility consumption. For each month and each utility the 2019 consumption value was subtracted from the 2020 value for the respective month to produce a utility consumption differential value. Those values are plotted in Figures 1-3.

Electricity Consumption

Figure 1 shows the average difference in electricity usage on a monthly basis in kilowatt hours. As seen in Figure 1, the monthly electricity consumption has on average increased from the year 2019 to the year 2020. Peak electricity consumption typically occurs in warmer summer months, and it can be seen

that the months of April to August show the highest averaged increase in year over year consumption. The total average electricity consumption increase across the data sample from the year 2019 to the year 2020 was calculated to be 1297.8 kWh.

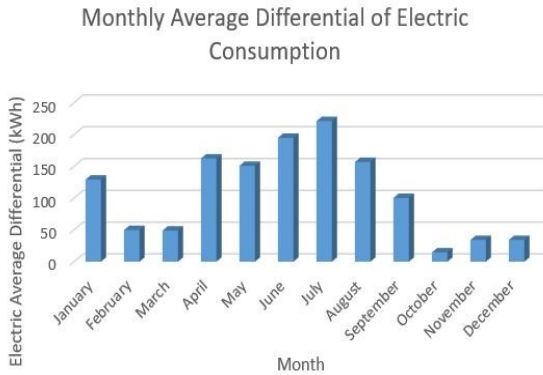


Figure 1: YOY Average Monthly Electricity Consumption Differential (2019-2020)

Gas Consumption

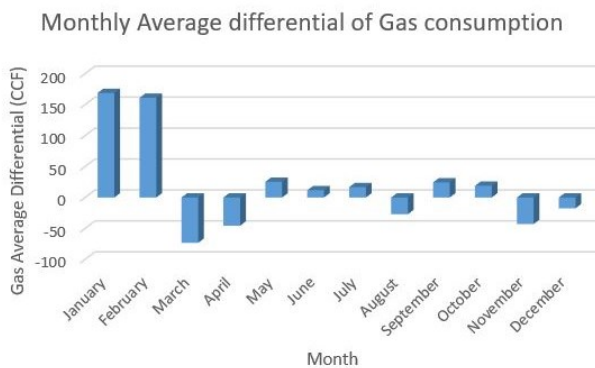


Figure 2: YOY Average Monthly Gas Consumption Differential (2019-2020)

Figure 2 shows the average difference in gas usage on a monthly basis in centum cubic feet (CCF). As seen in Figure 2, on average the monthly gas consumption has remained relatively constant from the year 2019 to the year 2020 with the exception of the months January and February, which compares the two pre-pandemic 2020 months to the in-pandemic 2021 months. Peak gas consumption typically occurs in cooler winter months, and it can be seen that on average the months of January and February show the highest increase in year over year consumption. The total average gas consumption increase across the data sample from the year 2019 to the year 2020 was calculated to be 221.6 CCF.

4.3 Water Consumption

Figure 3 shows the average difference in water usage on a monthly basis in gallons. As seen in Figure 3, on average the monthly water consumption differential varies from month to month from the year 2019 to the year 2020. Peak water consumption typically occurs in warmer summer months when homeowners water their lawns, and it can be seen that on average the month of July shows the highest increase in year

over year consumption. The total average water consumption increase across the data sample from the year 2019 to the year 2020 was calculated to be 2375.1 gallons.

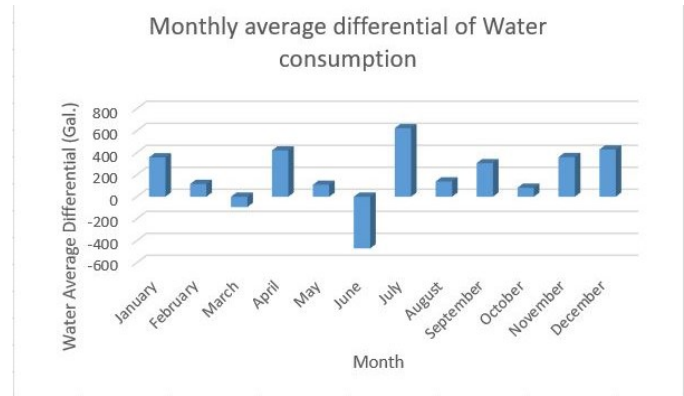


Figure 3: YOY Average Monthly Water Consumption Differential (2019-2020)

IV. CONCLUSION

Electricity Consumption

There are various circumstances that can affect electricity, gas, and water consumption. As seen in Figure 1, the average monthly electricity consumption has increased from the year 2019 to the year 2020 and is clearly a direct result of families working and schooling from home and consuming more electricity than they would if they went to work and school for eight hours of the day, given that presence in the home means at minimum a few lights and a laptop or tablet charger per person being used, if not other electronic devices. In other words, month to month trends for the electricity consumption differential follow usual electricity consumption expectations, and the size of the differential is simply indicative of the increased time present in the home.

Gas Consumption

As seen in Figure 2, gas consumption had a dramatic increase in the in-pandemic months of January 2021 and February 2021 (the two final months of the 2020 in-pandemic data) while comparing the consumption changes from 2019 to 2020. This relationship exists primarily because peak heating occurs during these first months of the year, which is exacerbated by heating being used all throughout the day due to the increased time present in the home; in comparison, pre-pandemic daily peak heating is around 5:00 PM when people come home from work, turn the heat or fireplace on, and start the stove or oven.

Interestingly, the gas consumption during the first in-pandemic month of March 2020 was actually notably less than that of the year prior. The second in-pandemic month of April 2020 and one of the final in-pandemic months analyzed of November 2020 similarly lower gas consumption than those pre-pandemic months in 2019. While the months of May through December (excepting November) do seem to have insignificant differential variance year over year and could be explained by such factors as year over year weather and temperature differences, applying the same explanation to the months of March, April, and November seems presumptuous.

Given that time present in the home should be approximately consistent throughout these months intra-year, one would instead expect a positive year over year average monthly gas consumption differential; this, of course, is not the case. These three months instead reveal a significant negative differential, suggesting some other factor is at play. One possible explanation that seems especially relevant for the March and April differentials is that people capitalized on the transition to working and schooling remotely enabling more lax and informal clothing expectations in-pandemic than pre-pandemic in person working and schooling and instead wore thicker and warmer clothing like sweatpants and sweatshirts more often than they did pre-pandemic. An increased frequency of wearing such comfortable and warm clothing would thereby decrease the need for heating the house and, by extension, gas consumption and may have led some households to switch from heating to cooling their homes much earlier in the year than they would pre-pandemic.

Water Consumption

As seen in Figure 3, the water consumption differential varies throughout the year but demonstrates an overall increase of about 2000 more gallons of water consumed. Similar to the electricity consumption differential, the average monthly water consumption differential follows month to month water consumption expectations and is mostly positive year over year, suggesting that it is most directly related to time present in the home. However, one month stands in stark contrast to that conclusion, the month of June. For some reason, households consumed significantly less water in June 2020 than in pre-pandemic June 2019. Combating these time-in-home-based expectations likely necessitates several factors coincidentally compounded to achieve the negative June water consumption differential.

One likely quite influential factor is the year over year June rainfall. According to the National Oceanic and Atmospheric Administration (NOAA), June 2019 was wetter than usual, with precipitation totaling “3.30 inches, 0.37 inch above average.” [4] In contrast, June 2020 was drier than usual, with precipitation totaling “2.72 inches, 0.21 inch below average.” [5] This 0.58 inch monthly precipitation differential for June would mean that the comparison here involves a pre-pandemic hot month where less water than usual was consumed for lawn maintenance and an in-pandemic month where more water than usual was consumed for that same reason.

The electricity graph shows a noticeable increase in usage during the pandemic year from the previous year. The shape of the electricity usage for each time period is about the same, which indicates the electricity usage followed the same trends on a month to month basis. Electricity is used throughout every household, we need it for lighting, internet connections, air conditioning, power and so much more. Electricity usage for powering our laptops, monitors and connecting to the outside world would have been a large consumer because in today’s society they are necessary for those that worked from home.

During summer months air conditioning is used to cool homes, with more time being spent at home many had their air conditioning on for longer periods throughout the day and at lower temperature setpoints.

The gas graph has a clear shape with the peaks during the winter months. Natural gas is mostly used for hot water and space heating. In residential houses, hot water is primarily used for showers, laundry, and dishes. Residents would not drastically increase or decrease their shower and laundry usage during the pandemic. Hot water used for cooking and cleaning may increase with more people at home, but in our data, there was no increase due to the data being averaged on a per person basis. The natural gas increase during January and February of the pandemic year could be due to the increase in space heating with more time people spent at home and the need for continuous heat and running hot water throughout the day. Pandemic restrictions weren’t implemented until March 2020 so there would not be a large use for space heating. The few differences in usage could be attributed to residents not adjusting their energy usage when they are not home. They may not adjust the temperature in their house when they leave, so the natural gas usage did not change drastically. Other explanations for the increase could be unrelated to the pandemic. The increase could be attributed to a colder winter than the previous year.

Since there could be multiple explanations for changes in utility on a yearly basis, it may be beneficial to gather more data and information from the households, especially related to the gas consumption. The pandemic evenly affected electricity throughout the year, but the gas consumption was about equal to the previous year. The changes in the gas consumption could be explained by variables unrelated to the pandemic like the weather.

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