PEP

# POWER EFFICIENCY PROJECT

*Professor Max Powers' Power Efficiency Project (PEP) is brought to you by the Kansas Corporation Commission and Kansas State University Engineering Extension. Funding provided by a grant from the U.S. Department of Energy.*


# Attic Insulation

The Kansas Energy Program (KEP) aims to teach others about energy efficiency, and we take pride in being energy efficient in our own homes. In this study, we compare electricity and natural gas consumption before and after adding new insulation to the home of KEP's David Carter.

Carter's house was built in the 1950s, well before energy efficiency initiatives. In 2016, Carter participated in a program called "The Attic Report Card," in which a local utility examined energy loss in residential attics. Carter's attic earned an F+. In addition to the attic space being severely under insulated (R-20 compared to ENERGY STAR-recommended R-60), there were multiple areas where one could see from the attic down into the house through cavities behind the walls (**Figure 1**), a big reason the house got so cold in the winter.

Figure 1:

Open area from attic to house space below.

Carter decided to have more insulation added to improve energy efficiency. Due to the number of attic openings and the amount of poorly insulated air conditioning ductwork in the attic, the installer recommended an unvented attic in which the existing insulation would be removed and replaced with 6" open cell spray foam on the underside of the roof, essentially making the attic a conditioned space. A month prior to installation, Carter installed a temperature/relative humidity (RH) data logger in the attic. He kept the data logger in the attic for approximately a year. Using data collected from November 12, 2018 to November 7, 2019, KEP produced a series of graphs documenting the move from a vented to unvented attic.

## Attic Temperature/RH vs. Exterior Temperature/RH

**Attic temperature/RH** was collected using a temperature/RH data logger. The data logger was installed November 12, 2018 and collected hourly readings. **Exterior temperature/RH** was obtained from the Kansas State University Weather Library, which compiles weather data from weather stations throughout the State of Kansas.

The insulation was installed on December 10 and 11, 2018, when the low air temperature reached 17.5 and 29.9 degrees Fahrenheit (°F), respectively. In **Figure 2**, you can see the abrupt shift in attic temperature after the insulation was installed. To conserve

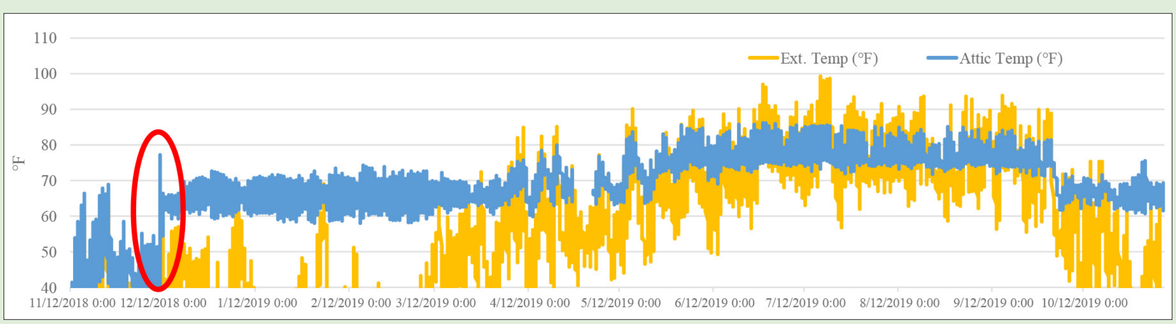



Figure 2:

Attic temperature and relative humidity verses exterior temperature and relative humidity; red circle indicates period when spray foam attic insulation was installed.

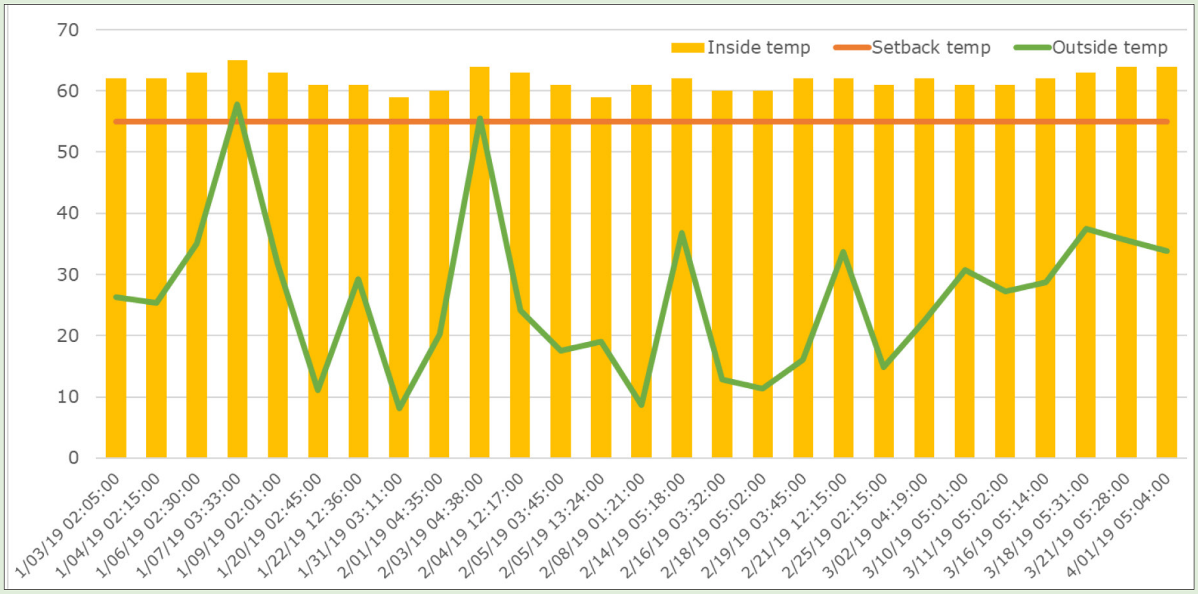



Figure 3:

Inside and outside temperature vs. setback temperature (°F) during winter months.

energy at home, Carter uses a programmable thermostat and, during the winter, sets it to 55°F from 8:00 a.m. to 3:30 p.m. when the house is unoccupied, and again from 10:00 p.m. to 7:00 a.m. After the insulation project, Carter tracked the inside temperature versus the outside temperature from January 3, 2019 to April 1, 2019, and discovered the inside temperature NEVER reached the setpoint of 55°F, even when the outside temperature was below 10°F (**Figure 3**)! This means the furnace never turned on during the setback times, saving Carter energy and money.

Electricity costs start soaring in Kansas during the summer months due to the increased use of air conditioners. Various internet sources (e.g., Texas A&M University) indicate attics can reach temperatures of 150-160°F during a summer day. The attic temperature after the insulation project never exceeded 86° F, even when outside temperatures approached 100° F (**Figure 2**). Similar to the winter months, Carter uses a programmable thermostat to conserve energy and, during the summer, sets it to 80°F from 8:00 a.m. to 3:30 p.m. when the house is unoccupied. After the insulation project, Carter tracked the inside temperature versus the outside temperature from June 4, 2019 to July 22, 2019, and discovered the inside temperature NEVER reached the setpoint of 80°F, even when the outside temperature was approaching 90°F (specifically, 87.2°F) (**Figure 4**). This means the air conditioner never turned on during the setback times, again saving Carter energy and money.

So did this really result in energy and money savings? Absolutely! As you can see in **Figure 5**, electricity consumption has decreased almost every month after the attic insulation project (December 2018), and the electricity consumption

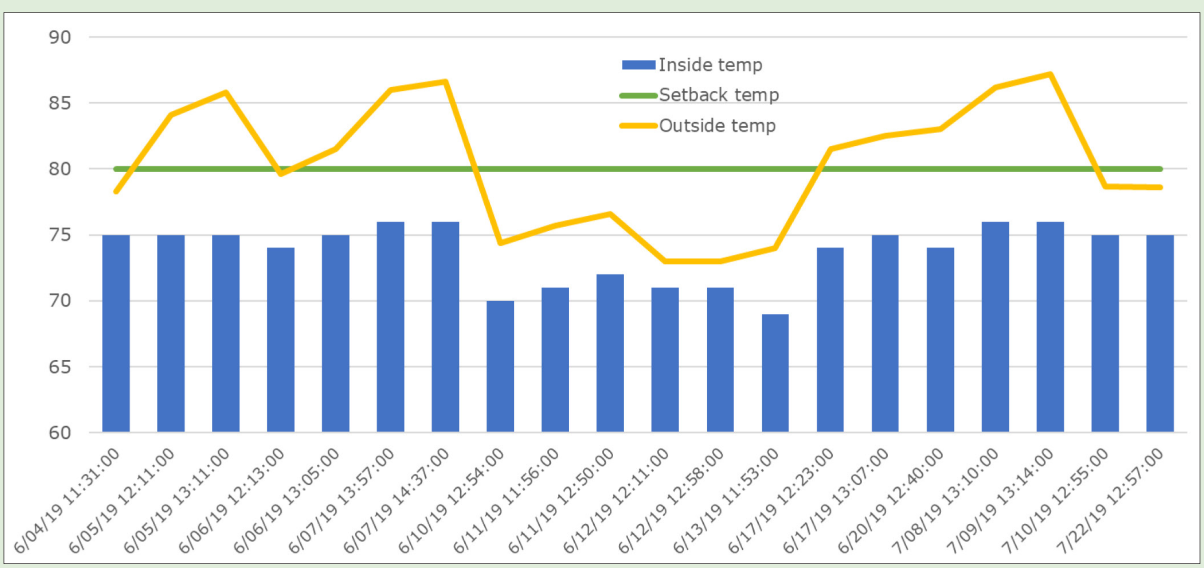



Figure 4:

Inside and outside temperature vs. setback temperature (°F) during summer months.

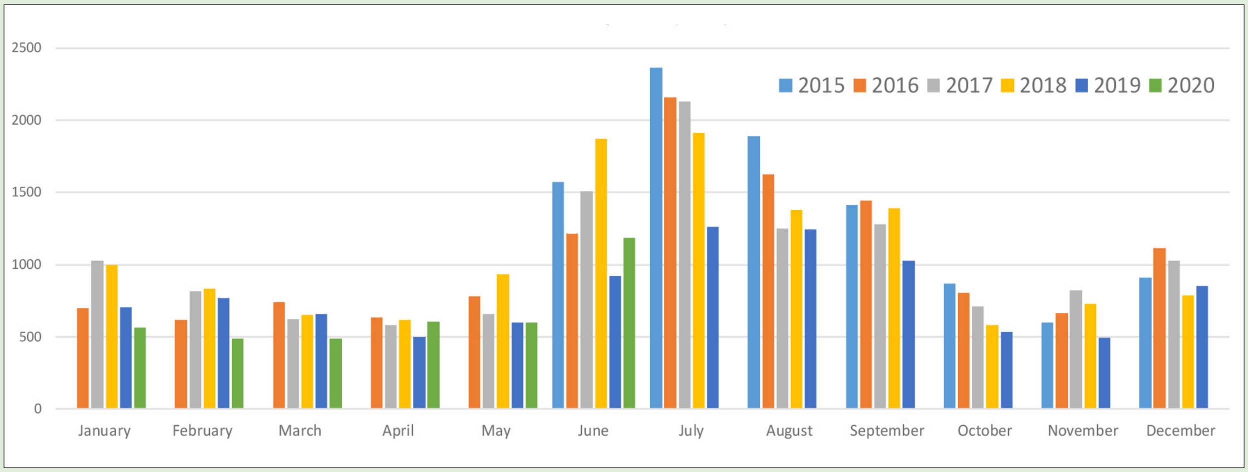



Figure 5:

Electricity consumption (kWh) per month per year.

during the months of June, July, and August dropped 33% from 5,164 kWh in 2018 to only 3,428 kWh in 2019. June 2019 was the lowest electricity consumption since June 2015, and was 51% less than June 2018.

Although natural gas consumption exhibits less of a downward trend than electricity consumption, there were still significant savings in the first full year with the new attic insulation (**Figure 6**).

The picture becomes much clearer when you look at the total energy (electricity and natural gas) consumption **(Figure 7)** and cost **(Figure 8)** over the total year. These graphs show total energy consumption dropped from 201.3 MMBtu to 143.0 MMBtu (29%), resulting in $809 savings in 2019.

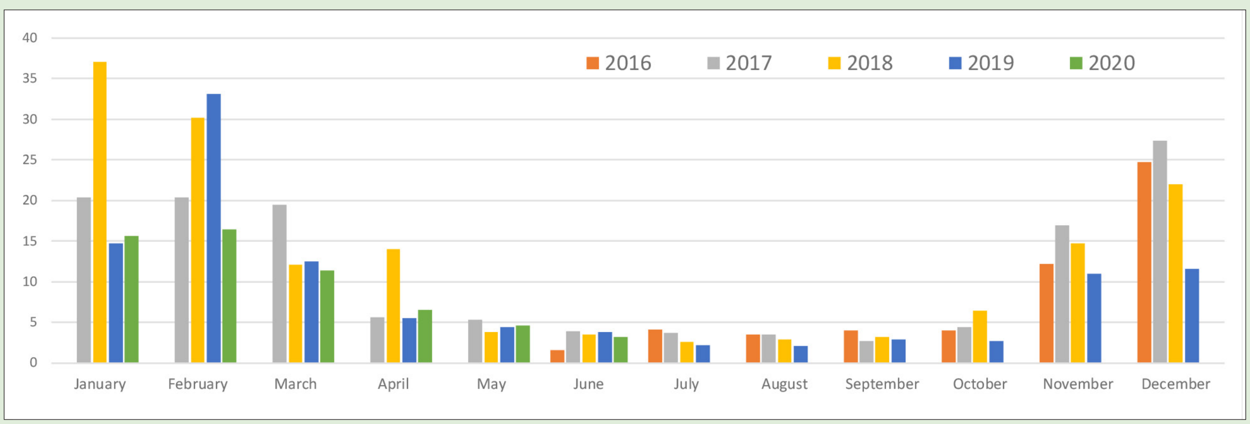



Figure 6:

Natural gas consumption (McF) per month per year.

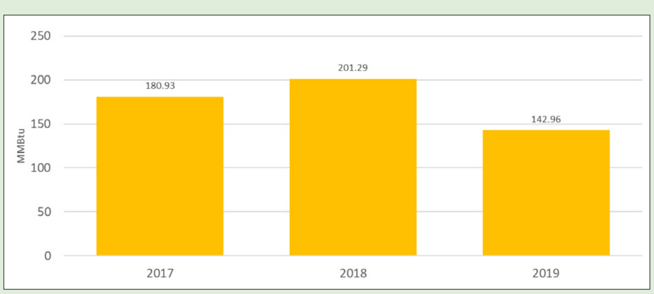



Figure 7:

Total energy use (mmBtu) - combined electricy + natural gas.

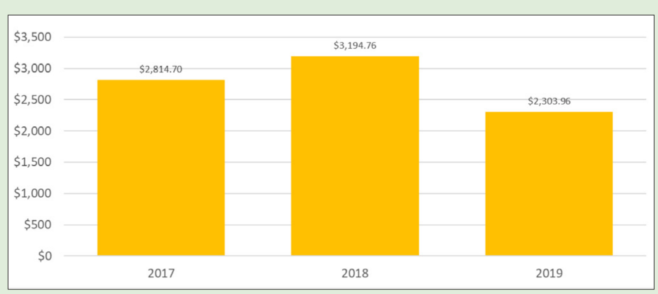



Figure 8:

Total energy cost - combined electricty + natural gas.

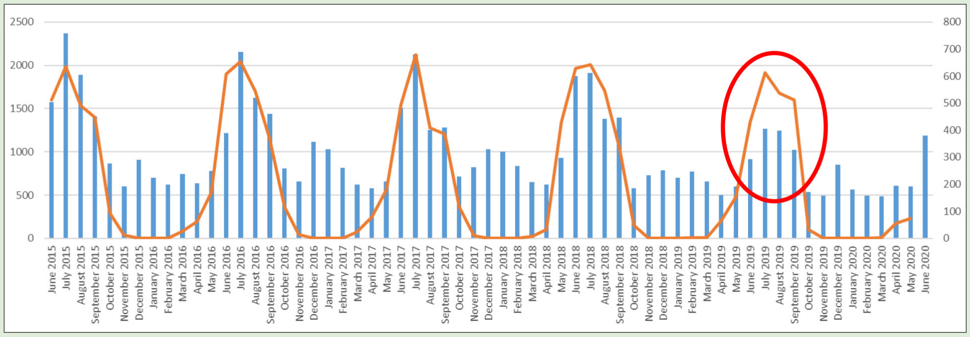



Figure 9:

Electricity Use (blue bars) vs. Cooling Degree Days (orange line).

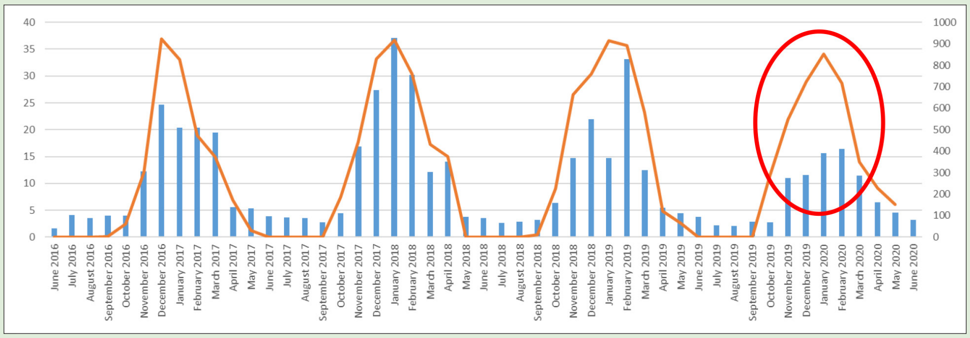



Figure 10:

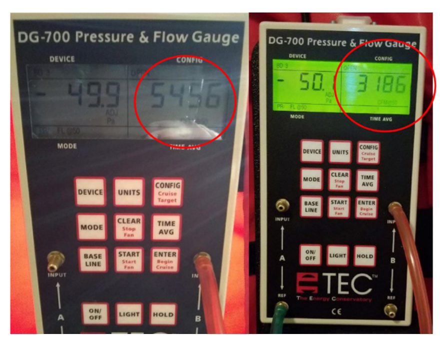
Natural Gas Use (blue bars) vs. Heating Degree Days (orange line).

## Electricity Use vs. Cooling Degree Days and Heating Degree Days

Given the energy savings, it's fair to wonder whether these savings are really due to the attic insulation or simply better weather. To show the impact of weather on energy consumption, KEP used data from Weather Data Depot to determine the **Cooling Degree Days (CDD)** and **Heating Degree Days (HDD)** during the relative time period. As emphasized by the red circles in the graphs above in **Figures 9 and 10**, the reduced energy consumption in June 2019 cannot be solely explained by reduced CDD. Even when the CDD degrees were similar to 2018, the energy consumption was much lower.

Likewise, the reduction in natural gas consumption cannot be explained in terms of HDD only. Notice the growth in the gap between HDD and natural gas use from December 2017 to December 2019 (**Figure 10**).

Another reason for the overall energy reduction is the fact that the house is tighter and does not interact with the environment as much as it did prior to the insulation project. **Figure 11** shows the results of a blower door test conducted in Carter's home before and after the project. A **Blower Door Test** measures how airtight or leaky a home is. When conducting a blower door test, you want to pay attention to the number on the right of the screen that measures cubic feet per minute (CFM) of air lost to the environment. A higher number means a more "leaky" home. We can see that Carter was able to significantly reduce the air leakage in his home by 2,270 CFM after completing the project (5,456 - 3,186 = 2,270). Generally, a good score is a number equivalent to the square footage of the home. The square footage at Carter's house is approximately 3,500, so the insulation project definitely improved the blower door test.




*(Before)* *(After)*

Figure 11:

Before and after results blower door test results.

## Conclusion

As this study shows, the added insulation and moving from a vented to unvented attic has resulted in significant energy savings. Homeowners can easily duplicate this project and track their own savings over time.

**For more information on attic insulation**, contact Kansas State University Engineering Extension at 785-532-4998 or dcarter@ksu.edu.