

City of Morris LCCMR Activity #3: Thermal Imaging of Public and Residential Buildings

Authored by Talitha Anderson, City of Morris Sustainability Project Coordinator

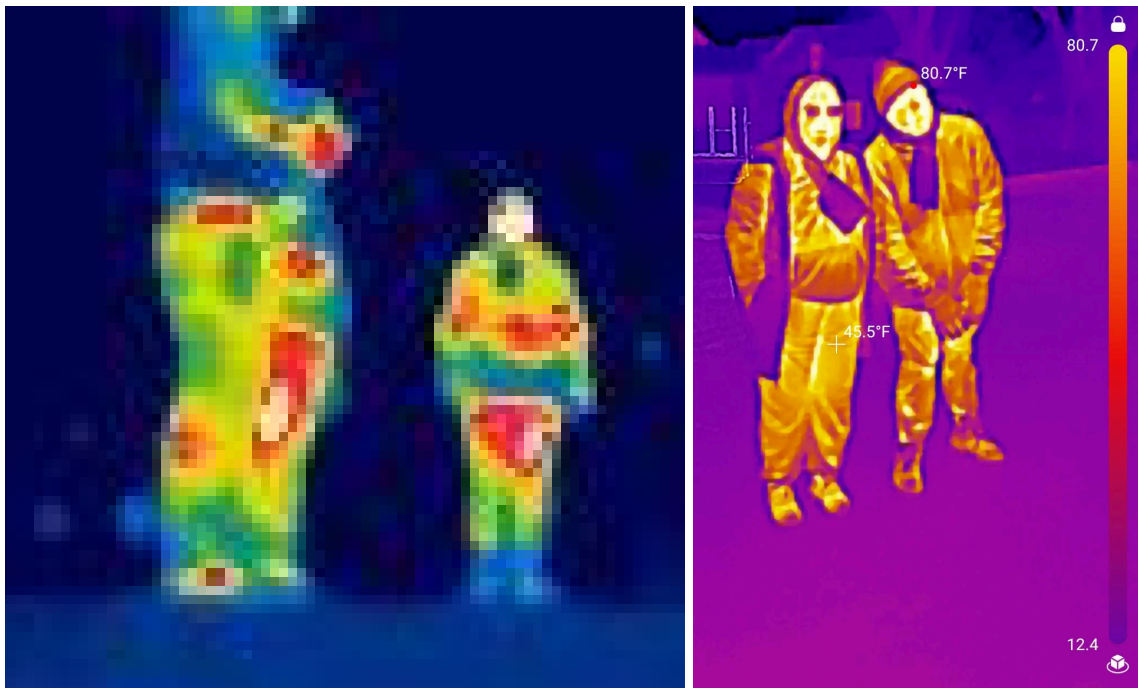


Figure 1. Two thermal images of the researchers The left picture is from the drone thermal camera at ground level before taking off and shows lower temperatures in blue and higher temperatures in yellow and red. The right picture is from the phone-attached thermal camera and shows a temperature scale from 12.4 Fahrenheit (purple) to 80.7 Fahrenheit (yellow-white).

What Is Thermal Imaging?

Thermal imaging is similar to taking regular pictures or videos of a place, person, or object, but instead of using the visual light, thermal imaging uses infrared radiation to capture surface temperature and show it through a color code: blues and purples for lower/colder temperatures to oranges and reds for higher/warmer temperatures. When thermal imaging is done on or in buildings, it can show where heat is leaking out because these areas will show as warmer than the other areas in the image. For instance, in **Figure 1**, the silhouettes of people are visible because they are in different colors than the background because their bodies are warmer than the surrounding area captured in the photo.

Because thermal imaging can help determine where heat loss is happening in a building or home, it is a useful tool for homeowners, renters, landlords, business owners and city professionals to use when figuring out how to make their respective buildings more energy efficient and save on heating and cooling bills. Knowing where the leaks are happening is the first step to properly weatherizing a home and thermal imaging can provide a relatively non-expensive option for those unable to get a full energy audit done by their utility.

Public Building Imaging – Process, Interview, and Takeaways

The Process

Three public buildings were imaged as a part of this process, two of which are included in this report. Imaging of the roof and sides of the buildings were done using a Yuneec H520 Survey drone equipped with a Yuneec cGOet thermal camera. The phone-attached thermal camera was not used for this round of imaging. The camera required calibration to the ambient temperature. The imaging was done between 6 and 7 am to allow for the buildings to have cooled off from the previous day, and the images were taken before sunrise so there was no heat gained by Sun radiation. After the imaging was done, an interview was conducted with the library director to discuss the results from the library thermal imaging.

City Hall Imaging

The Morris City Hall was the first building imaged as a part of this project. The exterior wall is brick. It has solar panels on the roof, which account for almost all of the building's energy usage. It is one story with windows located on the front and left side of the building. There are no windows along the back and right side. It was thought that there would be more heat loss on the roof, but the only heat loss was from the vents and air intakes in the center (**Figure 2**). Since the building was built, there was some interior construction to create closed offices out of an open space, and it is possible to see the office partitions on the thermal camera (**Figures 3, 4**).

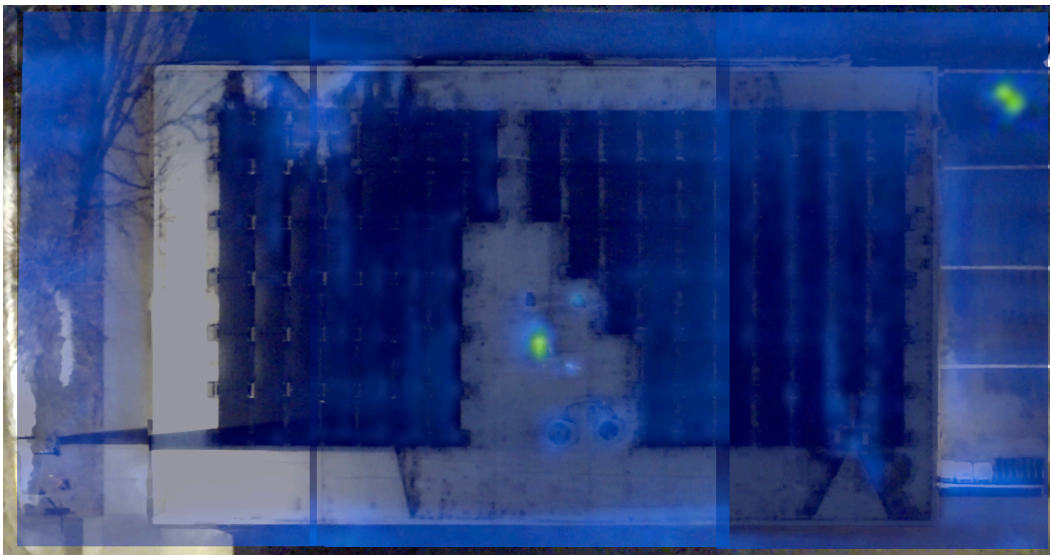


Figure 2. A bird's eye view taken from the drone of the Morris City Hall. The thermal image shows lower temperatures in blues and higher temperatures in green. In the middle of the building, there are three green dots where the vents and air intakes are on the roof. The two green dots on the upper right side of the image are the researchers. The solar panels are also visible on the city hall roof.



Figure 3: A thermal image taken by the drone of the back wall of the Morris City Hall The thermal image shows lower temperatures in darker blues and higher temperatures in lighter blues. The interior office partitions are visible in light blue on the left and right of the image. The ceiling is also visible in light blue.



Figure 4: A thermal image taken by the drone of the right wall of the Morris City Hall The thermal image shows lower temperatures in darker blues and higher temperatures in lighter blues. The outline of the door on the left and the outline of the room partitions and ceiling are in light blue. The solar inverters are visible on the right side of the wall.

Library Imaging

The library building is where the old armory in Morris used to be and was built after the armory burned down in 1970. In the 1990s, a geothermal system was put in and in 2022, a solar array was added on the roof. The main heat loss occurred around the windows and doors (**Figure 5 & 6**). The windows themselves did not have major heat loss but the aluminum frames did. The front door area is all windows and had the highest heat loss of any part of the building. After the thermal imaging, an interview was done with the library director about the images and what the next steps looked like after viewing the images and seeing where heat loss was happening. The

library board wanted to look at the images and make a plan for what comes next, but they have been searching for a grant to renovate the front doors of the library. They may also put up some plastic sheeting on the windows during the winter to see if that will help retain more heat inside the building.

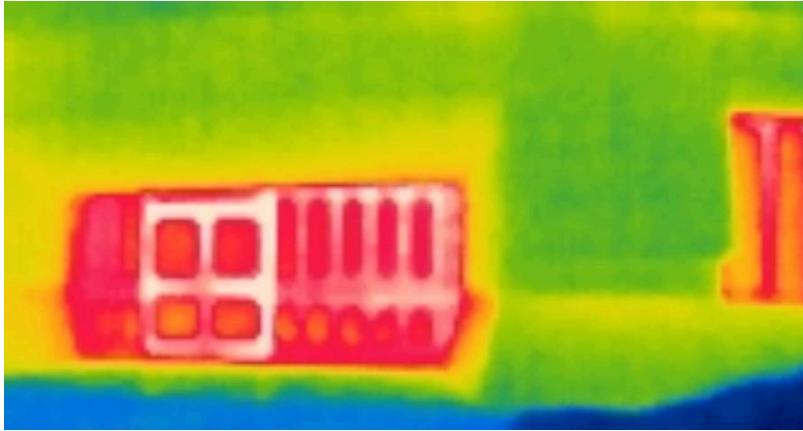


Figure 5. A thermal image taken by the drone of the front of the Morris Public Library The thermal image shows lower temperatures in blues and green and higher temperatures in yellow, red, and white. The front doors are shown in red and white. The outline of the front windows is visible on the right side of the picture in red-orange.

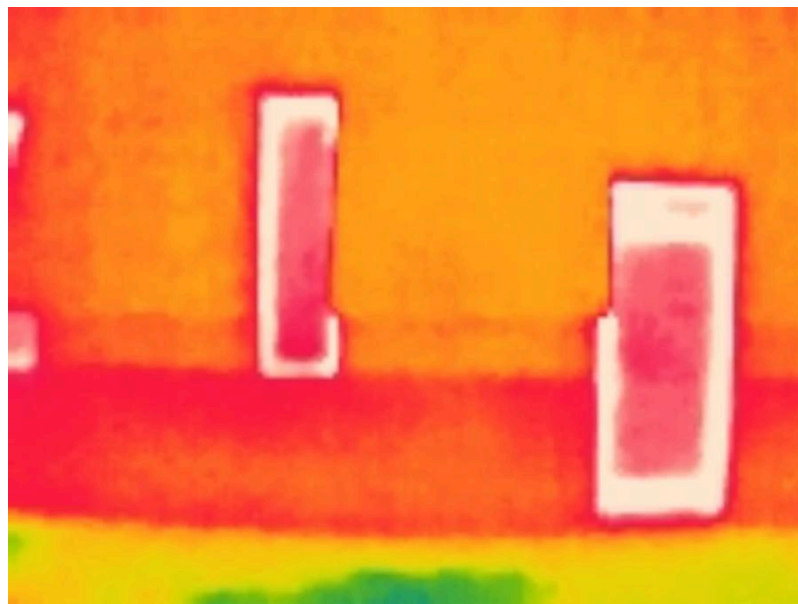


Figure 6. A thermal image taken by the drone of the back door of the Morris Public Library The thermal image shows lower temperatures in green and yellow and higher temperatures in red-orange and white. The door and window frames are shown in white.

Why is imaging public buildings important?

Thermal imaging of public buildings allows elected officials and staff to have a better understanding of where heat is being lost and what renovations or actions could save money by making the building more energy efficient. For smaller cities with tight budgets, every dollar counts, so ensuring the heat in buildings stays in buildings puts money back into a city's budget. Weatherizing public buildings can also make them more solar-ready by lowering the building's energy usage.

Residential Home Imaging – Process, Resident Surveys/Interviews, and Takeaways

The Process

Four residential homes were imaged as a part of this process. Imaging of the roof was done using a Yuneec H520 Survey drone equipped with a Yuneec cGOet thermal camera and ground imaging was done with a Topdon infrared camera attached to a phone or tablet and used a companion app to take the pictures. Both cameras required calibration to the ambient temperature. The imaging was done between 6 and 7 am to allow for the buildings to have cooled off from the previous day, and the images were taken before sunrise so there was no heat gained by Sun radiation.

After their homes were imaged, the residents were sent the images of their home and asked to complete a survey about their home and experience. The questions asked were:

1. What year was the house built?
2. How many stories does the house have?
3. Is the basement finished?
4. Do you know what kind and where the insulation is?
5. How old are your windows?
6. Do you know what your roof insulation is?
7. What are your exterior walls made of?
8. Why were you interested in looking at your thermal footprint?
9. What were you hoping to get out of thermal imaging?
10. What were your biggest surprises looking at this data?
11. Will you be making changes based on what you saw? If so, what changes?

Three of the four residents provided answers to the questions above. Their answers, along with example thermal images from their homes, are included below.

Resident #1 House Imaging

Built in 1962, it is a one story house with a finished basement. The house has insulation in the wall cavities (rock wool) and the roof (blown cellulose or vermiculite). The windows are original from 1962, and the exterior walls are fiberboard sheathing with cedar siding. The resident was interested in looking at his thermal footprint to find out how tight his house was and if there were any areas where performance could be improved. The biggest surprise was seeing

how much heat the house is losing through the uninsulated portion of the basement walls (**Figure 7**), specifically the part above the basement ceiling. The resident is planning to add some fiberglass batts insulation to that area.

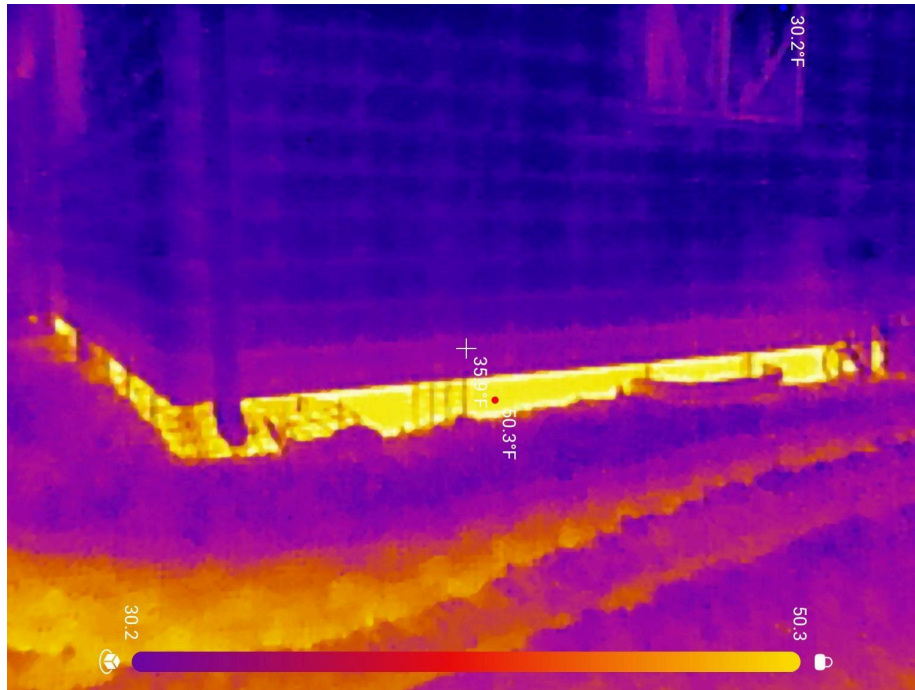


Figure 7. A thermal image taken of Resident #1's house There is a temperature scale on the bottom with 30.2 Fahrenheit being the lowest (purple) and 50.3 Fahrenheit being the highest (yellow-white). The yellow and white on the image are where the basement is exposed above ground. The main house is a deep purple color.

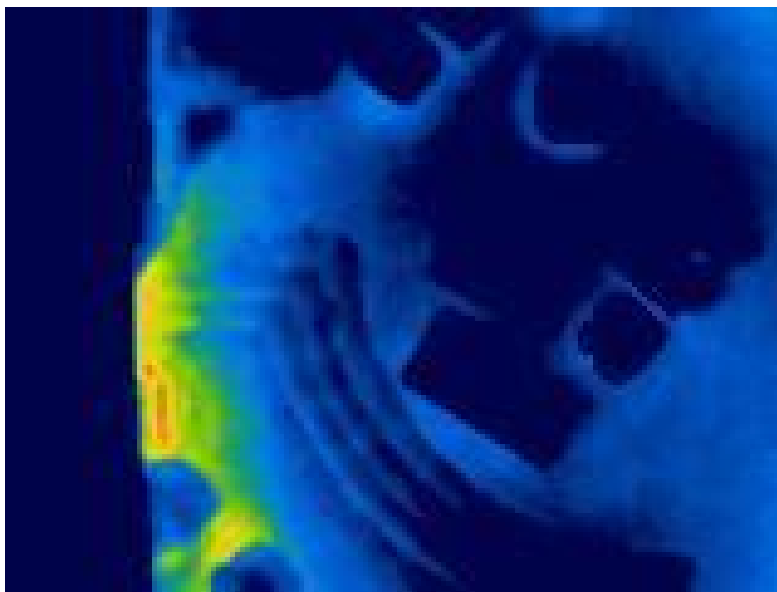


Figure 8. A bird's eye thermal image taken by the drone of Resident #1's backyard area
The thermal image lower temperatures in blues and higher temperatures in green and red/orange.
Towards the left of the screen, the heat coming from the back entrance is visible through the green, yellow, and orange blob.

Resident #2 House Imaging

Built in 1959, it is a one story house with a half-finished basement. It is assumed that the house has fiberglass batts insulation in the walls and cellulose or fiberglass in the ceiling. The windows are 65 years old and the exterior walls are steel siding. The resident was interested in looking at their thermal footprint to find out if one could see the wintertime ice buildup inside the windows in the data, and is hoping to get new windows after going through the thermal imaging process. The biggest surprise for them was how much heat was leaking out at the door seals (**Figure 9**); they have mentioned to their landlord in the past that the door seal is falling apart and will keep advocating to have them fixed after seeing the energy loss. The resident will also continue to put up window plastic during the winter months.



Figure 9. A thermal image of Resident #2's front steps and door There is a temperature scale on the bottom with -11.6 Fahrenheit being the lowest (purple) and 29.0 Fahrenheit being the highest (yellow-white). The frame of the front door is a warm yellow while the door itself and the main house is a pink-purple.

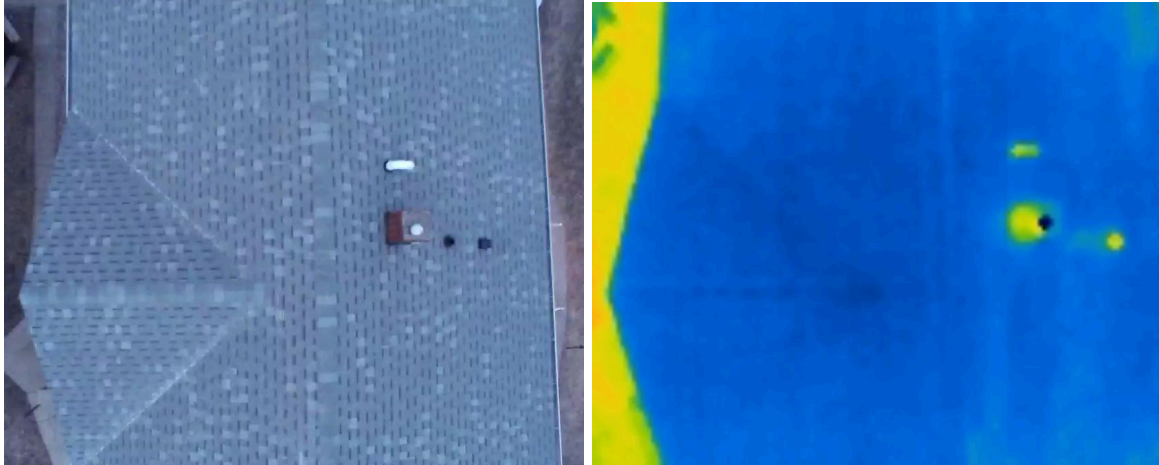


Figure 10. Side-by-side bird's eye view taken by the drone of Resident #2's roof - regular (left), thermal (right) The thermal image shows lower temperatures in blues and higher in yellow and green. The vents on the roof are shown in yellow and green on the right of the image. The left of the thermal image shows the front yard in yellow and green as well.

Resident #3 House Imaging

Built in 1908, it is a two story, 1,902 square foot house with an unfinished basement. There is no material insulation in the walls or roof, instead air gaps are used for insulation, with the exterior walls being made of wood, lathe, and plaster. Several windows were replaced in the bedrooms, dining room, and living room in 2009 when federal incentives became available, and the remaining windows are original. The resident was interested in looking at his thermal footprint to see if the improvements made to the house were detectable and if there were any areas that indicated a lot of energy leaking through heat loss as there have been some ice dam issues in the past. Through thermal imaging, he was able to see the impacts of replacing the windows by the difference in heat loss (**Figure 11**). One surprise was the insulated bedroom door at the back of the house because it was clear where the insulation stopped three quarters of the way up the door (**Figure 12**) - this was a pleasant surprise because it means the batting insulation works. Based on this, the resident is planning to put up more fiberglass batting to reduce heat loss and continue to replace old windows in the home.



Figure 11. A thermal image of the side of Resident #3's home The temperature scale on the right of the image shows the lowest temperature as 2.7 Fahrenheit (purple) and the highest temperature as 26.1 Fahrenheit (yellow). The upper left window is purple-pink color while the other three windows are shades of yellow. The upper left window is not original to the house.

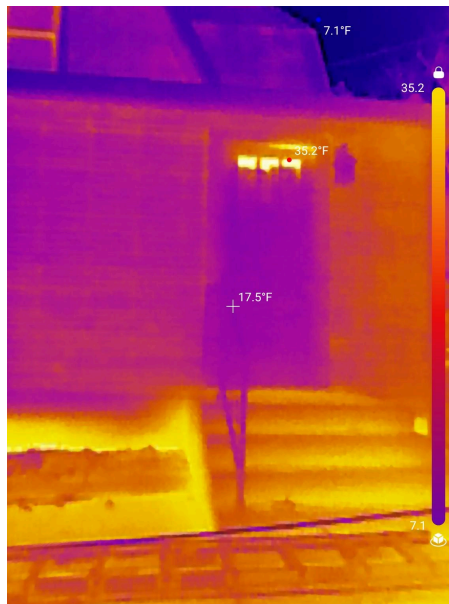


Figure 12. A thermal image of Resident #3's back bedroom door The temperature scale on the right of the image shows the lowest temperature as 7.1 Fahrenheit (purple) and the highest temperature as 35.2 Fahrenheit (yellow). Most of the back door is a pink-purple color (17.5 Fahrenheit) but the top of the door is glowing yellow-white (35.2 Fahrenheit).

Why is imaging residential buildings important?

Imaging residential buildings is important because it allows homeowners, renters, and landlords to be able to see where they are losing heat from their home. Knowing where heat is being lost is the first step to creating an effective weatherization plan and working towards a more energy efficient house. In rural communities, it can be difficult to get an energy audit – either there is no one available to do them or they are too expensive for the average household. This project showed that with the right resources, a group could provide inexpensive and/or free thermal imaging to supplement part of an energy audit in order to get community members on the right path to weatherize their homes.

Next Steps

Looking forward, the next steps for thermal imaging in the City of Morris are investing in more attachable thermal cameras to teach high school and college students how to use them and creating a free thermal imaging program for the residents of Morris and potentially Stevens County. This would provide a hands-on educational opportunity for students at the Morris Area High School and University of Minnesota Morris, and a needed community resource for those who may not have the funds readily available to get a full energy audit done by their utility. In future years, the program could expand to include more or all elements of an energy audit, further providing training that students can use in the real-world.

Additionally, this project has been used to inform the City of Morris and multiple Morris residents on where they are losing heat in their buildings/homes. A follow up study in a few years and/or after actions are taken based on these findings would be an appropriate next step to measure the impact on heat loss for these buildings.

Project Credits

Thermal imaging (drone & handheld): Joel Tallaksen, Energy & Agriculture Scientist, UMN West Central Research & Outreach Center

Project manager: Talitha Anderson, Sustainability Project Coordinator, City of Morris

Public building interviewee: Anne Hennen Barber, Library Director, Morris Public Library

Residential interviewees: Syd Bauer, community member; Eric Buchanan, Renewable Energy Program Director, UMN West Central Research & Outreach Center; Troy Goodnough, Sustainability Director, University of Minnesota Morris