Emerging Technology Program

1026: Destratification Fans

Public Project Report – Executive Summary

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Full Report

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Executive Summary

Introduction

The Nicor Gas Emerging Technology Program (ETP), a part of the utility's ongoing energySMART Energy Efficiency Program (EEP), assesses new or underutilized technologies that have the potential to provide natural gas savings for the 2.2 million Nicor Gas customers in Northern Illinois. The Gas Technology Institute (GTI) implements the ETP for Nicor Gas. This report summarizes the findings from an evaluation of a destratification fans and their potential to provide a new energy efficiency measure to Nicor Gas commercial and industrial (C&I) customers.

Background

Thermal stratification in large, open, indoor spaces with high ceilings naturally leads to higher temperatures under the roof deck and lower temperatures down at the occupied floor level. This effect wastes heating energy in two ways. First, heat that is needed at floor level rises toward the ceiling, requiring additional heat to maintain occupant comfort at the floor level. Second, the elevated temperature at the ceiling leads to greater heat loss through the roof deck. The heat loss through the roof deck is primarily driven by the temperature difference between the indoor and outdoor temperatures. The elevated indoor temperature at the ceiling increases heat loss through the roof deck.

Destratification fans serve to break down that natural thermal stratification and even out the temperatures over the full height of a tall, indoor space. The fans constantly circulate the air, bringing warmer temperature air from under the roof deck back down to floor level so that less heating energy is wasted during the heating season. New electricity use introduced by the destratification fans, along with potential decreased fan electricity use for reduced heating equipment runtime, must also be considered when determining the overall net operating energy savings and resulting payback economics.

Results

Two destratification fan equipped sites were studied during this pilot project. The first pilot site was a garden center at a big box retail store in Nicor Gas service territory that is used for seasonal sales activities during the heating season. The garden center already had four high volume low speed (HVLS) fans in place which were originally run only during the cooling season. The second pilot site was a gymnasium at a private university in Nicor Gas service territory. The gymnasium was retrofitted with eight bell shaped fans for destratification. The following data was collected at each site:

- Heating gas valve open/burner firing time
- Destratification fan runtime (on/off)
- Indoor air temperature at 5 foot increments from above the floor to the roof deck
- Outdoor air temperature (nearby local weather stations were used for HDDs)

The gas valve open/burner firing time was used along with the nameplate input rating of the heating units to determine gas consumption. The fan run time in conjunction with a one-time measurement of the power draw was used to determine electricity usage. GTI used data acquisition systems (DAS) at each site to record and transmit the data collected. Each DAS had onboard data storage along with a cellular modem to allow weekly downloading of the data.

Of significant interest early in the pilot during the initial fan operation was whether or not the fans were effectively destratifying the space in order to have the potential for achieving the heating savings described earlier. A representative pair of 24 hour plots under comparable outside air temperature conditions, which exemplify the destratification effect of the fans, are shown in Figures 1 and 2, without and with fan operation respectively, from the big box retail store's garden center.

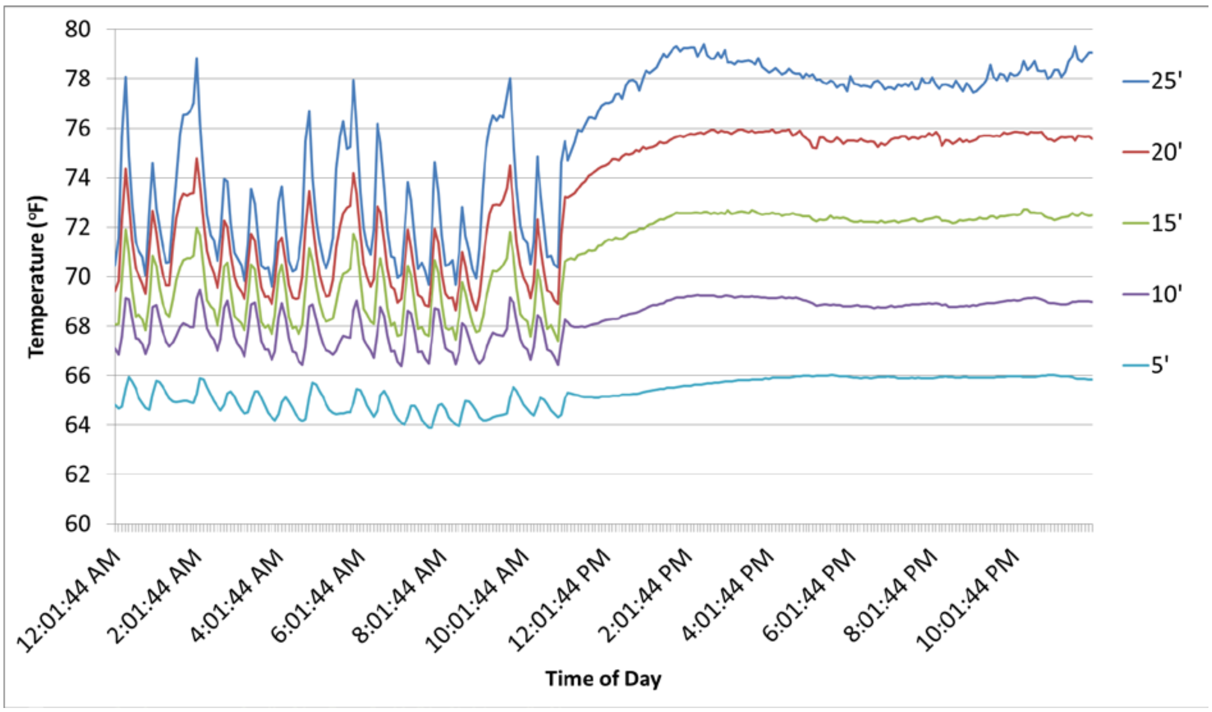

Figure 1. Temperature Profile by Height Over 24 Hours without Destratification Fan Operation at Big Box Retail Store Garden Center

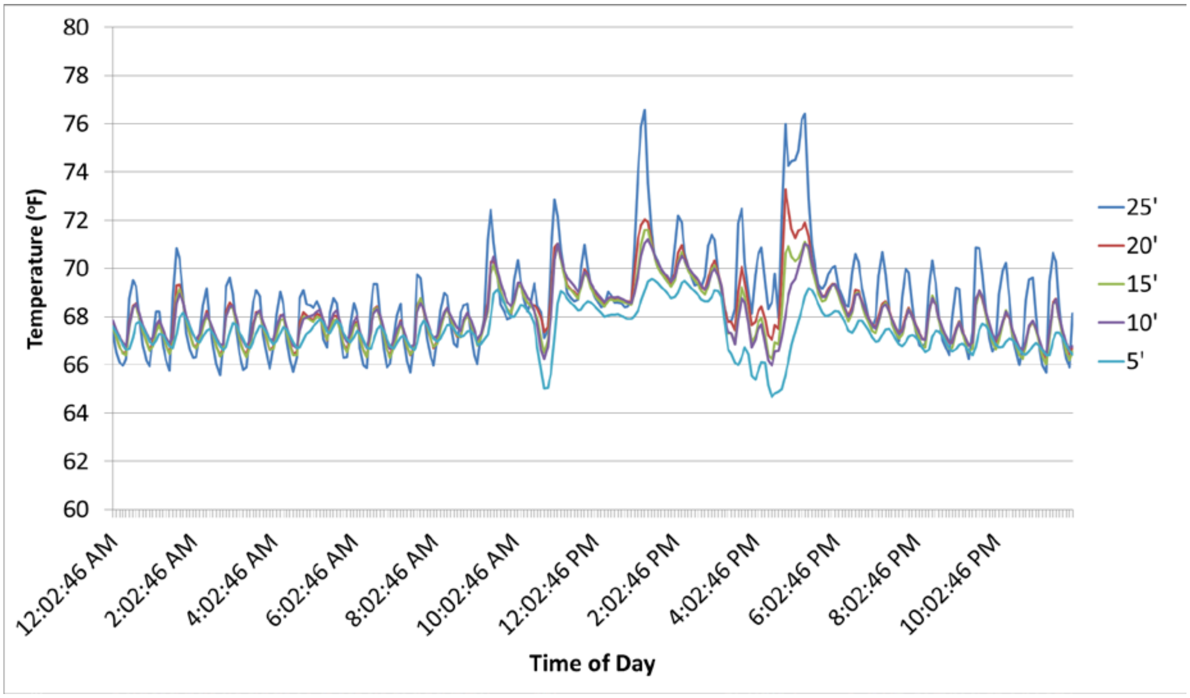

Figure 2. Temperature Profile by Height Over 24 Hours with Destratification Fan Operation at Big Box Retail Store Garden Center

When the temperature profile without destratification fan operation in Figure 1 is contrasted with the temperature profile with destratification fan operation in Figure 2, the following key observations can be made regarding the garden center pilot site.

1. Under normal unit heater (UH) cycling operation seen in the first 12 hours of both plots, the temperature gradient from floor to ceiling is much more pronounced when the destratification fans are not operating. When destratification fans are not operating the temperature differential between 5 and 25 feet peak at 13°F during UH firings and drop to as low as 5°F between unit heater firings.
2. During sustained unit heater operation when destratification fans are not operating as seen in the second 12 hours of the plot in Figure 7, the temperature differential between 5 and 25 feet are consistently on the order of 12 to 14°F.
3. Although sustained UH operation was seen to occur for extended periods multiple times during the monitoring period when destratification fans were not operating, such sustained UH operation was not seen once during the monitoring period when destratification fans were operating.

As observations shift to the temperature profiles for the university gymnasium pilot site in Figures 3 and 4, it is immediately apparent that there are no pronounced peaks and valleys in these temperature profiles, indicating inherently better air distribution with the RTUs and their limited overhead ductwork (even without destratification fan operation) versus the unducted UHs at the garden center. Another point of contrast is the garden

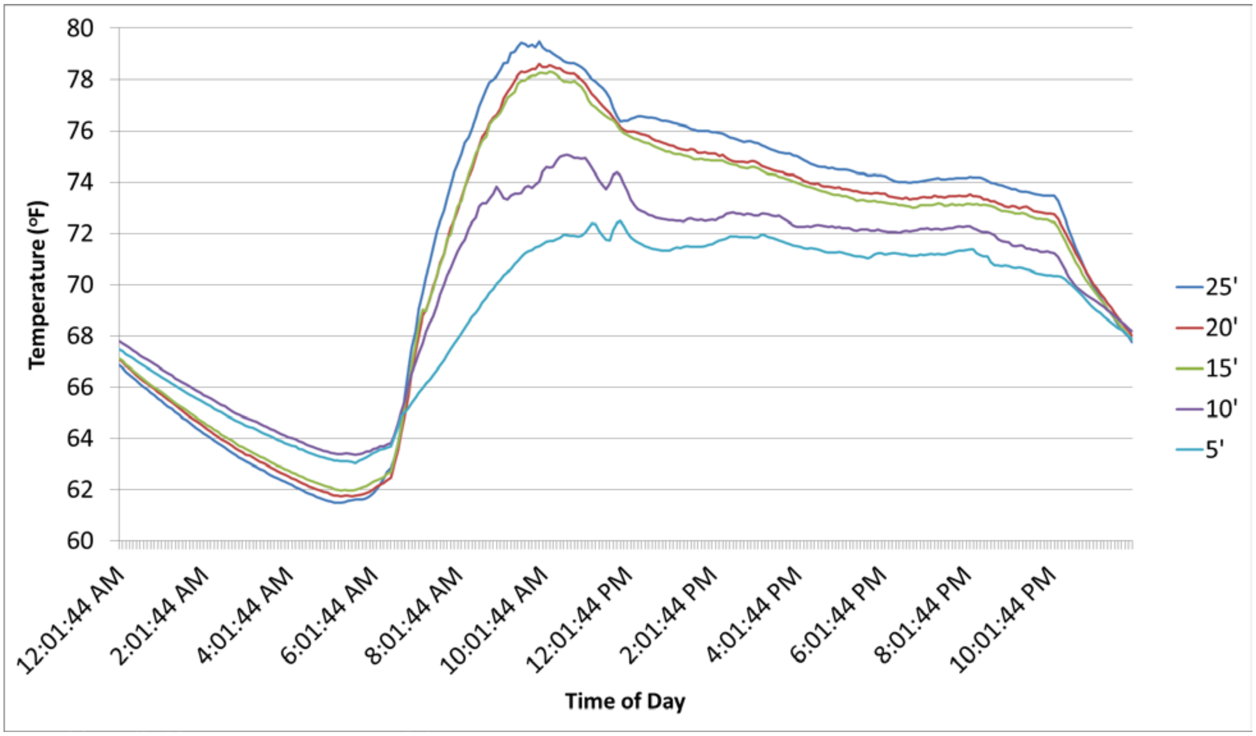

Figure 3. Temperature Profile by Height Over 24 Hours without Destratification Fan Operation at University Gymnasium

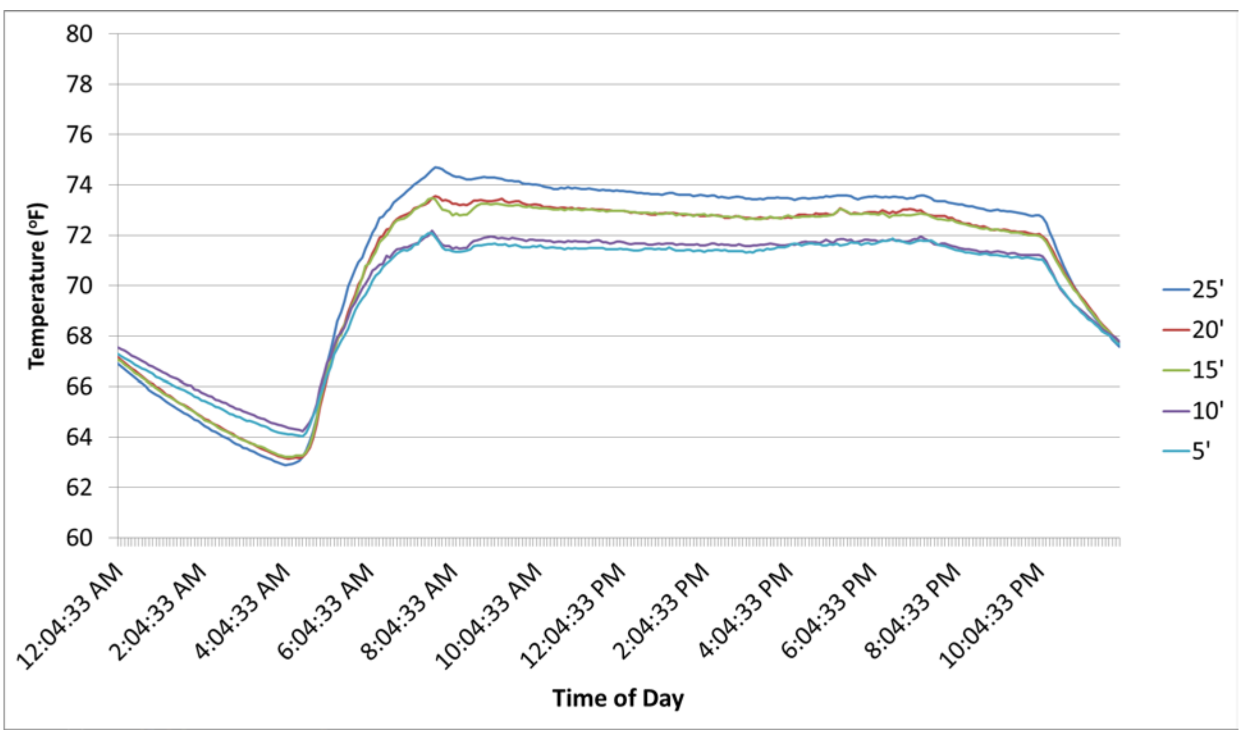

Figure 4. Temperature Profile by Height Over 24 Hours with Destratification Fan Operation at University Gymnasium

center was part of a 24 hour/day, 7 day/week store operation with a constant thermostat setpoint, whereas the gymnasium was subject a night setback/morning startup operation and varying demands of the university activity schedule. Nonetheless, the following key observations can be made regarding the gymnasium pilot site.

1. Temperature profiles actually reverse during night setback as seen in both Figures 3 and 4, with temperatures lower near the ceiling as heat is lost through the roof deck overnight while the RTUs are shutdown.
2. During the morning startup recovery from night setback operation, the temperature overshoot in Figure 3, without destratification fan operation, is significantly greater towards the ceiling, on the order 5°F larger, than with destratification fan operation in Figure 4.
3. That morning overshoot nearer the ceiling is dampened out over the course of RTU operation during the day, even without destratification fan operation, as seen in Figure 3.

During this pilot, the existing HVLS fans in the garden center were run for destratification purposes during the heating season and created a gas savings of 21.4% compared to a baseline time period without destratification fan operation when normalized to heating degree days (HDDs). Based on the original fan installation costs, the estimated simple payback would be 7 years. However, that payback could be shortened with fewer fans applied depending on optimized distribution of HVLS fan locations and speed selections along with consideration of occupant draft perceptions, all of which were beyond the scope of this pilot. If two (2) instead of four (4) HVLS fans could have been applied with the same thermal destratification effect and resulting gas savings, payback would be 3.5 years.

Unfortunately, the gymnasium pilot site underwent changes in the duration of overnight thermostat setbacks that compromised the comparison of gas heating results with and without destratification fan operation. During destratification fan operation, morning startup was as much as 2 and ½ hours earlier leading to longer operating schedules for the heating equipment. There were also variations in levels of occupancy and types of scheduled activities that likely contributed to varying heating loads. As a result this pilot site did not demonstrate significant gas savings with destratification fan operation.