Nicor Gas Energy Efficiency Emerging Technology Program

1001: High Efficiency Heating Rooftop Units (RTUs)

Public Project Report – Executive Summary

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Full Report

The following executive summary is made publicly available by Nicor Gas as part of their Emerging Technology Program (ETP). The detailed Nicor Gas ETP report is available to qualified state and utility run energy efficiency programs upon request. Please contact the Nicor Gas ETP administrator at NicorGasETP@gastechnology.org to find out how to access the full report.

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 high efficiency, condensing rooftop unit and its potential to provide a new energy efficiency measure to Nicor Gas commercial customers.

Background

Condensing combustion technology has been applied to indoor equipment for years, primarily to space heating product lines from gas-fired home furnaces to hot water/steam boilers in the residential through industrial sectors. However, its introduction into outdoor, packaged gas heating and electric air conditioning rooftop units (RTUs), used for space conditioning low-rise commercial and institutional buildings, has been slowed by certain economic and technical challenges. Economically, sufficient net annual operating energy cost savings must be demonstrated to payback the cost premium of the condensing RTU. Gas cost savings during the heating season will be reduced by increased electricity consumption costs year round for the RTU supply fan to overcome the additional in-line pressure drop of the secondary condensing heat exchanger. Additional installation and any ongoing maintenance costs for ancillary equipment for combustion condensate management must also be accounted for in payback calculations. Technically, that combustion condensate management must demonstrate both adequate freeze protection in colder climate rooftop environments and code acceptable sanitary sewer disposal, including any local requirements for neutralization of its acidic content.

Only recently have some smaller heating, ventilating, and air conditioning (HVAC) manufacturers started to apply condensing combustion technology into limited RTU product lines. Their product literature targets larger ventilation or make-up air fraction applications for their emerging, condensing RTU product lines. A specialized class of RTUs, known as dedicated outside air systems (DOAS), used to condition 100% outside air for building ventilation, presents an early market entry point for potential cost effective use of higher efficiency, condensing heating RTUs. Over the heating season, a DOAS warms cold outside air for code required building ventilation and operates continuously during building operating hours. DOAS in "big box" retail stores, in particular those open 24 hours/7 days a week, exhibit both high heating loads and long runtimes. Such an application was selected as the pilot site for testing of condensing RTU technology for the Nicor Gas ETP.

Results

To facilitate the pilot assessment, GTI took advantage of the Nicor Gas ETP applicant and DOAS supplier's relationship with their "big box" retail end user. The pilot design protocol at the host site retail store called for the existing, conventional efficiency DOAS to be retrofitted with upgraded, condensing heating modules, requiring only a limited amount of advance design work to ensure their suitability by their manufacturer and their heating component supplier. Manufacturer factory service personnel were present at this initial demonstration installation. Plans called for retrofitting two (2) of the three (3) DOAS at the host site, focusing on those over the grocery and general merchandise areas, while the third DOAS over the garden center and other areas was not to be retrofitted due to its significantly lower gas use identified during previous monitoring. The advance design work included the delineation of the combustion condensate neutralization and disposal system by ETP. A combustion condensate piping and drain layout was designed, along with specification of the supplier (both a primary and an alternative secondary vendor) of the condensate neutralization system. Given the consistent DOAS sizing and floor plans in place for these “big box” retail stores in the northern states, it was anticipated that the advanced design work for this Chicagoland DOAS retrofit pilot would be directly applicable to the other stores in the Nicor Gas service territory.

The pilot assessment was conducted over the 2012/2013 heating season with two non-condensing DOAS retrofitted with condensing heating modules at a 24/7 “big box” retail store in the Chicago area. Design of the data acquisition system (DAS) installed included remote cellular communications capability to allow real time monitoring of DOAS performance and diagnostics, if needed. Table 1 summarizes the monitored and extrapolated net energy use results broken down for AHU1 and AHU2. It shows the resulting gas savings based on the monitored gas usage of the 90% thermal efficiency (TE) DOAS and the gas usage that would have occurred at the conventional 80% TE. Annual results are extrapolated based on the ratio of the NCDC 1971-2000 average of 6,859 HDD65 over the 6,121 HDD65 of the monitoring period October 26, 2012 through May 31, 2013. An increase in supply fan electricity consumption was identified based on the monitored fan runtime fraction and a standard fan power calculation using a 5.000 cfm airflow, 0.15 inch W.C. incremental pressure drop, and combined fan/motor/belt drive efficiency of 60%. The DOAS supply fans nominally run all 8,760 hours of the year. The performance of AHU1 serves as the basis for determining condensing DOAS economics.

Table 1. DOAS Net Energy Use Summary for AHU1 and AHU2

		Heating Gas Use		711 MBH	Supply Fan Electricity Use	
		@90%TE	Decrease vs 80%TE	EFLH	@90%TE	Increase vs 80%TE
AHU	Period	therms	therms	hours	kWh	kWh
1	Monitored	17099	2137	NA	11401	767
	Annual	19161	2395	2695	19248	1290
2	Monitored	14156	1769	NA	11240	752
	Annual	15863	1983	2231	18615	1265

AHU2 exhibited lower therm savings as the result of a faulty step controller that did not allow the 3rd and 4th stage heating to fire during the time period January 11 through February 4, 2013. Once repaired on February 4, AHU2 resumed the expected therm usage and savings trends exhibited prior to January 11.

The validity of extrapolating therm savings based on HDD65 is demonstrated in Figure 1. For these AHUs operating as DOAS, gas usage relationships to HDD65 are defined by linear regression. The linear regression R^2 value of 0.88 for AHU1 indicates that, when not affected by significant control faults, HDD65 extrapolation can be utilized for projecting out therm usage, and in turn therm savings.

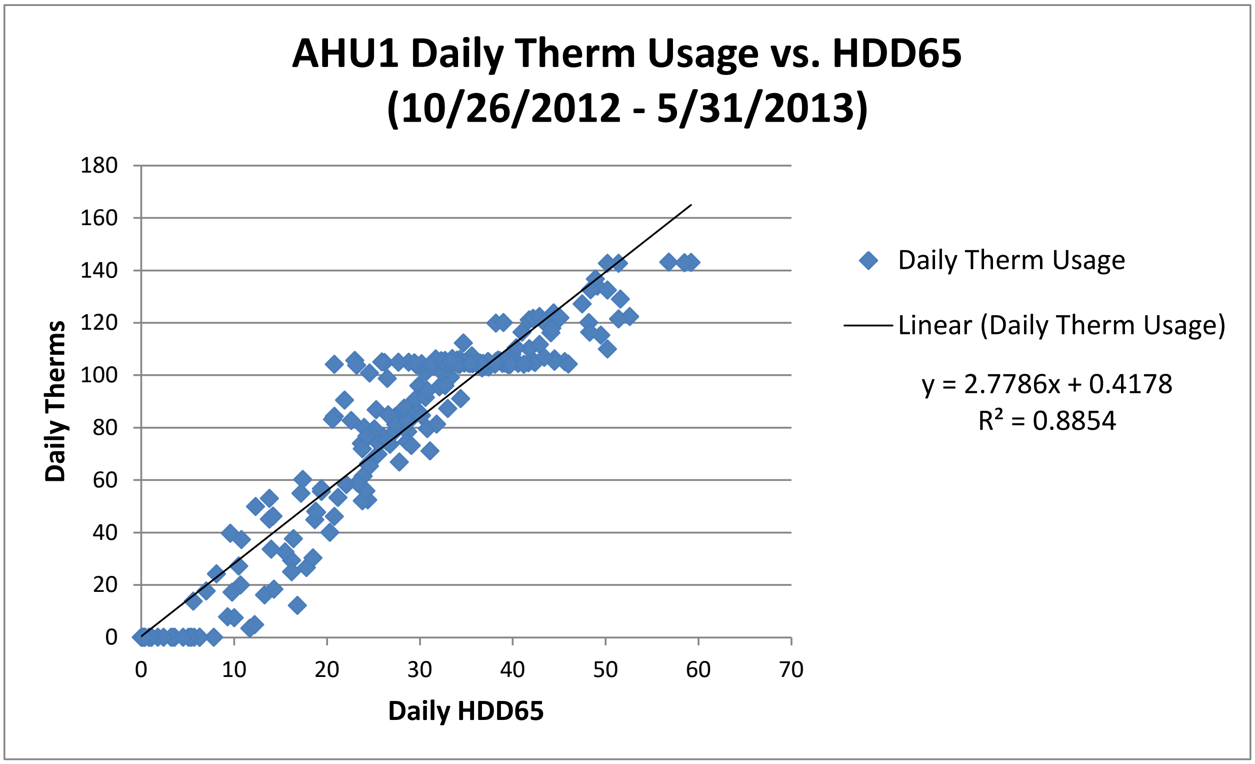

Figure 1. *Linear Regression of DOAS Daily Therm Usage vs HDD65 for AHU1*

Further examination of the detailed monitoring datasets also showed that in addition to the step controller fault with AHU2, both DOAS also showed high supply air temperature limit switch control intervention at times while transitioning firing rates between stages. This phenomenon can be seen in Figure 1 for AHU1, in the horizontal spread of data points slightly above 100 therms/day, during periods of heating stage transitions. This control anomaly affected the quality of the linear regression curve fit and lowered the R^2 value. As a result of these findings, the manufacturer is looking into modifications of its control sequence and logic to improve the operation of its higher efficiency heating modules.

Overall, the condensing DOAS provided annual gas savings of 11%, or up to 2,395 therms, with 1,290 kWh of added fan electricity over a year for an annual net energy savings of $1,704 with gas and electricity costs of $0.7518/therm and $0.0752/kWh, respectively, per the 2013 pricing assumptions of the Nicor Gas Energy Efficiency Program (EEP). Based on an installed cost premium of $6,069 for the condensing DOAS and its condensate system, plus a projected annual combustion condensate neutralizer maintenance cost of $65 for calcium carbonate replenishment, a simple payback of 3.7 years is estimated.