Nicor Gas Energy Efficiency Emerging Technology Program

1003: Demand-Based Domestic Hot Water Recirculation

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 an on-demand controller for domestic hot water recirculation and its potential to provide a new energy efficiency measure to Nicor Gas multifamily and commercial customers.

Background

Central domestic hot water (CDHW) recirculation systems in multi-family buildings ensure that hot water is present at the fixture in individual apartment units with minimal delay. This is accomplished by installing a hot water recirculation loop with a pump that constantly runs hot water throughout the system and back to the central boiler or water heater, preventing the water in the pipe from cooling. However, such systems waste energy. Typically the pump runs 24 hours a day, every day even when there is no call for hot water or the water in the pipes is sufficiently hot. As the water is circulated it loses heat which forces additional boiler or water heater firing to add heat back into the system.

The baseline technologies for CDHW systems include no controls (e.g. a continuously operating recirculation pump), time clocks, aquastats, and temperature modulation controls. Each approach has advantages and disadvantages; for example, with a time clock the installer must estimate the times of day when hot water will be needed. In order to keep tenants satisfied and minimize complaints, time clocks are often set to only shut-off the pump in the middle of the night. Although this does save gas, it captures only a fraction of potential savings. Similarly aquastats and temperature modulation controls can save energy but may be limited in their ability to maximize savings.

A demand based recirculation system only runs the circulation pump when there is a call for hot water. Additionally, if the water in the return line is sufficiently heated it will shut the pump down even if there is a call for hot water. This results in significant gas and electric savings. This pilot project validates and quantifies those energy savings. An important benefit of demand control systems is that they consistently provide hot water when tenants require it while still being able to realize savings when there is no demand. Maintaining tenant satisfaction is critical for any CDHW controls to remain installed and operating efficiently. For example, many multi-family building owners have installed controls such as time clocks in their CDHW systems and then bypassed them in response to tenant complaints about lack of hot water at various times. The ability of demand controls to consistently provide hot water when needed minimizes the risk that they will be bypassed in response to tenant complaints. Based on preliminary review and analysis through the ETP, the relatively low cost of demand control systems and their high potential energy savings suggests they are cost-effective and have attractive payback periods. The intent was to validate this through the ETP field-based pilot assessment.

Results

ETP identified two vintage walk-up multi-family buildings in Nicor Gas territory with CDHW systems and dedicated return lines – multi-family building #1 and multi-family building #2 both within Nicor Gas service territory. Both buildings were owned and operated by the same management company. The details are below:

	Multi-family Building #1	Multi-family Building #2
Units	51 units, 3 stories	23 units, 3 stories
Boiler	(1) Laars Mighty Therm Model PW0500	(1) Laars Mighty Therms Model PW0325
Storage	(2) 119 gallon tanks	(1) 119 gallon tank
Insulated DHW pipe	Yes	No

The following relevant data was collected:

1. Domestic hot water boiler gas valve firing time
2. Recirculation pump run time
3. Domestic hot water flow rate (consumption)

The gas valve firing time was used with the nameplate input rating of the DHW boiler to determine gas consumption. The recirculation pump run time in conjunction with the pump input rating was used to determine electric usage. ETP worked with a manufacturer that makes on-demand control systems for multi-family/commercial applications to develop a data acquisition system (DAS) that was able to remotely transmit collected data on a daily basis.

The on-demand recirculating pump was installed with an automatic switching timer for the pilot test period. This timer was designed to switch the system from operating in demand mode to continuous mode (the pump running 24 hours a day, as it would under conventional, baseline conditions) on an alternating one week cycle. A weekly rather than daily cycle was selected since usage patterns vary significantly during weekdays vs. weekends. Additionally, weekly switching followed the protocol established in the Benningfield Group study that was developed for use in the 2008 California Building Energy Efficiency Standards. This method reduces measurement error in comparison data between the on-demand mode that was investigated and industry standard continuous operation.

Switching from demand mode to continuous mode was intended to occur once a week, every Thursday. Unfortunately, switching errors occurred and at times switching did not occur properly. However, the data recorded was still large enough to provide an adequate sample. Multi-family building #1 recorded seven and a half weeks in demand mode and ten and a half in constant mode. Multi-family building #2 recorded ten weeks in demand mode and eight in constant mode. The initial goal was twelve total weeks of monitoring; six demand and six constant. The data collected exceeds those numbers.

The data was retrieved remotely via cellular modem. Occasionally the transmission failed and the data was lost or incomplete. Since the aggregate week was used in calculations, mid-week data loss did not affect calculations. When data loss occurred on a switching day, the missed data was averaged or extrapolated as necessary. The data set is large enough that the integrity of the calculations should not be affected.

Of utmost importance in this pilot project is that the tenants receive hot water as they were accustomed. To that end, the host site management company did not inform them of the change in recirculation system operation. The host site management company accurately recorded all tenant complaints for follow-up and resolution. Multi-family building #2 had no complaints concerning lack of hot water. Multi-family building #1 had three phone-in complaints due to excessive wait for hot water. Two of the complaints occurred when the pump was in constant mode and therefore are not attributed to the demand system. While one complaint did occur during demand mode, it was determined that all three complaints were caused by faulty shower mixing valves. The leaking valves led to bypass of the recirculation line preventing the system from operating properly.

The pilot project results were very positive. The two apartment buildings realized therm savings used for DHW of 28.2% and 19.9%, with simple payback periods of 1.46 and 1.06 years. Yearly therm savings at the two sites are expected to be 1,855 and 2,282 therms. Further results our outlined in Table 1.

Table 1: Estimated Annual Energy Savings at Host Sites

	Multi-family Building #1	**Multi-family Building #2**
Yearly gas savings therms	2,282	1,855
Yearly gas savings $	$1,918	$1,394
Yearly electrical savings kW-hr	725	578
Yearly electrical savings $	$55	$43
Total yearly cost savings $	$1,973	$1,438
Therm savings per apartment	44.75	80.64
Therm saving per input BTUH	0.004564	0.005299
Therm saving per storage gallon	9.58	15.59
Payback with a $2100 installation cost	1.06 years	1.46 years