NAVIGANT

Multi-Family Behavioral Program Cold Wash Laundry Study Impact Evaluation Report

Energy Efficiency Plan: Plan Year 6 (PY6) (6/1/2016-12/31/2017)

Presented to
Nicor Gas Company

FINAL

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1. INTRODUCTION

This report presents the results of the impact evaluation of the Nicor Gas PY6 Multi-Family Behavioral Pilot program. It presents a summary of the energy impacts for the total program and broken out by relevant measure and program structure details. The appendix presents the impact analysis methodology. PY6 covers June 1, 2016 through December 31, 2017.

2. PROGRAM DESCRIPTION

There are two program components for the Nicor Gas Multi-Family Behavioral Pilot program: 1) a cold water washing machine competition and 2) an overall behavioral program targeted at multi-unit buildings designed to be implemented with the pre-existing multi-family direct install program. The purpose of the pilot program is to determine if laundry habits could be influenced by education and literature. In PY6, behavioral projects were implemented at two multi-family facilities which included 133 total washing machines as shown in the following table. The two facilities which participated in this pilot program are referred to here as Site A and Site B.

Table 2-1. PY6 Volumetric Summary

Participation	Site A	Site B	Total
Number of Washing Machines	27	106	133
Mass of hot-to-warm water conversion (lbs.)*	888	3,557	4,445
Mass of hot-to-cold water conversion (lbs.)*	25,175	29,095	54,270

Source: Nicor Gas tracking data and Navigant team analysis.
**Data recorded over a one-month period at both facilities. Savings were extrapolated to yearly savings. Hot-to-warm water conversion assumes a reduction of 10 gallons of hot water per wash cycle, and hot-to-cold water conversion assumes a reduction of 30 gallons of hot water per wash cycle.*

3. PROGRAM SAVINGS SUMMARY

Table 3-1 summarizes the energy savings the Multi-Family Behavioral program achieved by path in PY6.

Table 3-1. PY6 Annual Energy Savings Summary

Program Path	Ex Ante Gross Savings (Therms)	Verified Gross RR†	Verified Gross Savings (Therms)	NTGR‡	Verified Net Savings (Therms)
Site A	209	109%	227	1.00	227
Site B	633	103%	649	1.00	649
Total	841	104%	876	1.00	876

Source: Nicor Gas tracking data and Navigant team analysis.
† Realization Rate (RR) is the ratio of verified gross savings to ex ante gross savings, based on evaluation research findings.
‡ Net-to-Gross Ratio (NTGR) is the ratio of verified net savings to verified gross savings. The NTGR is a deemed value. Source: Nicor_Gas_GPY6_NTG_Values_2016-02-29_Final.xlsx, which is to be found on the Illinois SAG web site: http://ilsag.info/net-to-gross-framework.html.

4. Program Savings by Measure

The program includes one measure which is the behavioral use of washing machines, influenced by educational events and literature. Savings detail are provided in Table 3-1.

5. Impact Analysis Findings and Recommendations

Impact Parameter Estimates

Table 5-1 shows the unit therm savings and realization rate findings by measure from our review. The realization rate is the ratio of the verified savings to the ex ante savings. Following the table, we provide findings and recommendations, including discussion of all measures with realization rates above or below 100 percent. Appendix 1 provides a description of the impact analysis methodology.

Table 5-1. Verified Gross Savings Parameters

Measure	Unit Basis	Ex Ante Gross (therms/unit)	Verified Gross (therms/unit)	Realization Rate	Data Source(s)
Washing Machine (Behavioral Use) †	Each	841.35	875.53	104%	Nicor Gas Program Tracking Data (PTD*), Navigant research

* Program Tracking Data (PTD) provided by Nicor Gas, extract dated February 27, 2018.
† No new efficient measures were installed as part of this program. Behavioral use of the existing washers at the facility was altered by educational events and literature focused on reducing hot water wash cycles.

All assumptions and calculations by the implementation contractor were confirmed except the density of water, used to calculate the mass of water which was reduced in temperature by 60°F. The implementation contractor assumed an average density of water of 60.6 lb./ft^3. Below is the unit conversion to calculate the density of water assuming water density equals 1 gram per cubic centimeter:

$$1\frac{g}{cm^3}^{1} * \frac{1\ lb.}{453.58\ g} * \frac{1\ cm^3}{0.000035347\ ft^3} = 62.371\ lb./ft^3$$

The density of water in lb./ft^3 should be around 62.4 lb./ft^3.[2] Although the density of water is slightly temperature dependent, the initial value used of 60.6 lb./ft^3 would be the density of water at around 180°F[3], much higher than the hot water temperature on the washing machines. Updating the density of water value increased the overall program realization rate to 104 percent. This density value, used in context of the program's energy savings calculation, is further explained in Appendix 1 of this report.

Recommendation 1. Navigant recommends that the implementation contractor reference all deemed energy savings calculation assumptions.

[1] Handbook of Chemistry and Physics, 53rd Edition, p. F4 (http://jupiter.plymouth.edu/~jsduncan/courses/2012_Spring/Techniques/Exams/DensityOfWater-vs-Temp.pdf)
[2] https://www.engineeringtoolbox.com/water-density-specific-weight-d_595.html
[3] https://www.simetric.co.uk/si_water.htm

6. APPENDIX 1. IMPACT ANALYSIS METHODOLOGY

Metering was conducted by CLEAResult before and after the washing machine educational events and literature distribution were implemented at both facilities. The metering was conducted on washing machines at both facilities and determined how often the washing machines were run at hot wash and warm rinse cycles, warm wash and warm rinse cycles, and cold wash and cold rinse cycles. As described by the implementation contractor, the assumed usages of the different washing machine cycles are described below:

- Hot wash and warm rinse = 30 gallons of hot water and 10 gallons of cold water
- Warm wash and warm rinse = 20 gallons of both hot and cold water
- Cold wash and cold rinse = 40 gallons of cold water

The implementation contractor also confirmed the hot- and cold-water temperatures. The hot-water assumes 120°F and the cold-water setting assumes 60°F. Based on the values provided by the implementation contractor, tenants switching from hot wash and warm rinse to warm wash and warm rinse reduce 10 gallons of 60°F water, and switching from hot wash and warm rinse to cold wash and cold rinse reduces 30 gallons of 60°F water. The program savings are calculated using the total volume of water that achieved the reduction ΔT of 60°F (Hot water (120°F) – Cold water (60°F) = ΔT 60°F).

The metering results provided from both facilities were used to calculate the total mass of water which achieved the ΔT of 60°F. Navigant conducted file reviews on all implementer-provided metering documentation. The total mass of water which achieved the ΔT of 60°F was then used to calculate the annual natural gas savings through the equations below.

$$Mass\ of\ H_20\ = \#\ of\ loads * gallons\ per\ load * H_20\ density\ \div\ (gal.to\ ft^3)$$

$$Monthly\ Nat.Gas\ Savings\ (\frac{Btu}{month})\ = Mass\ of\ H_20 * Specific\ Heat\ (H_20) *\ \Delta T * Boiler\ Eff.$$

$$Annual\ Nat.Gas\ Savings = Monthly\ Nat.Gas\ Savings * \frac{months}{yr} * (Btu\ to\ therm)$$

$$Natural\ Gas\ Savings\ per\ Machine = Annual\ Nat.Gas\ Savings \div\ \#\ of\ \ washing\ machines$$

Where:

Mass of H_20 = Mass of water which reduced ΔT by 60°F by switching washer settings
# of loads = Number of washing machine loads run at specific washing machine settings
Gallons per load = Gallons of water reduced from 120°F to 60°F based on settings switching
H_20 Density = 62.4 lb./ft³
(gal. to ft³) = volume conversion from gallons of water to ft³
Specific Heat (H_20) = 1.00 Btu/lb.°F*
ΔT = 60°F – difference in temperature between hot and cold water settings
Boiler Eff. = 80% (assumed for both facilities. The implementer provided detailed information that justified this value, including photographs of the boilers from the facilities.)
Months/yr. = 12
(Btu to therm) = 100,000 – Conversion between BTUs and therms
# of washing machines = Number of washing machines at respective facilities

Table 6-1 shows the variables used in the Site A and Site B energy savings calculations, along with their respective sources.

Table 6-1. Savings Calculation Variables and References

Variable	Site A	Site B	Data Source(s)
Mass of hot-to-warm water conversion (lb.)*	898.10	3,556.74	On-Site Measurement and Verification
Mass of hot-to-cold water conversion (lb.)*	24,277.28	29,095.14	On-Site Measurement and Verification
Total Mass of Water Reduction†	25,175	32,652	On-Site Measurement and Verification, Conducted by Nicor Gas/CLEAResult
Specific Heat (Btu/lb*°F)	1	1	Deemed
Temperature Difference (°F)	60	60	On-Site Measurement and Verification
Boiler Efficiency	80%	80%	On-Site Measurement and Verification, Conducted by Nicor Gas/CLEAResult
Monthly Natural Gas Savings (Btu/month)	1,888,153	2,448,891	Project File Review
Annual Natural Gas Savings (Therms/year)	227	649	Project File Review
Total Number of Washing Machines at Facility	27	106	On-Site Measurement and Verification
Savings per Washing Machine (Therms/year per machine)	8.39	6.12	Project File Review

Source: Navigant analysis and Program Tracking Data (PTD) provided by Nicor Gas, extract dated February 27, 2018.

Engineering Review of Project Files

For both facilities in this program, an in-depth application review is performed to assess the engineering methods, parameters and assumptions used to generate all ex ante impact estimates. For each measure in the two projects, engineers estimated ex post gross savings based on their review of documentation and engineering analysis.

To support this review, the implementation contractor provided project documentation in electronic format for each project. Documentation included some or all scanned files of hardcopy application forms and supporting documentation from the applicant (invoices, measure specification sheets, and vendor proposals), pre-inspection reports and photos (when required), post inspection reports and photos (when conducted), and calculation spreadsheets.

On-Site Data Collection

On-site metered data was collected by Nicor Gas to determine washing machine cycle data for both facilities in the program. The washing machines were metered to determine how frequently the machines were run at different temperature settings, as well as the hot- and cold-water temperatures.

7. Appendix 2. Program-Specific Inputs for the Illinois TRC

Table 7-1 the Total Resource Cost (TRC) variable tables, only include cost-effectiveness analysis inputs available at the time of finalizing the PY6 impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in the tables and will be provided to evaluation later.

Table 7-1. TRC Test Inputs for Nicor Multi-Family Behavioral Pilot Program

Research Category (e.g. Measure)	Units	Quantity	Effective Useful Live (EUL)	Ex Ante Gross Savings (Therms)	Verified Gross Savings (Therms)	Verified Net Savings (Therms)
Washing Machine (Behavioral Use) †	Each	133	2*	841	876	876

† No new efficient measures were installed as part of this program. Behavioral use of the existing washers at the facility was altered by educational events and literature focused on reducing hot water wash cycles.

* Assumption matches similar temperature setting measures in the Illinois TRM, Version 5.0: Section 5.4.6, Water Heater Temperature Setback, and Section 5.3.11 Programmable Thermostat Reprogramming. Available at http://www.ilsag.info/il_trm_version_5.html.