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Division of Energy

Resource Efficient Laundry (REL) Room Demonstration

June 2004

Contractor: Battelle – Pacific Northwest Division

focus on energy[sm]

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Apartment & Condo Efficiency Services Technical Report 3

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Wisconsin Focus on Energy Resource Efficient Laundry (REL) Room Demonstration

Final Report

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Richland, Washington 99352

Executive Summary

The Wisconsin Focus on Energy (Focus on Energy) Apartment & Condo Efficiency Services program identified the multifamily sector as both underserved and a difficult market to reach for energy-efficiency services. In response, Focus on Energy asked Battelle to research and evaluate novel energy-efficiency programs and technologies. One area that Battelle recommended evaluating was a Resource Efficient Laundry (REL) room concept.

The goal of the REL program was to verify, through *in situ* demonstration, the performance of commercial ENERGY STAR® coin-operated clothes washers, matching clothes dryers, efficient room lighting and controls, and efficient and properly sized water heating technologies for multifamily laundry room operations. This demonstration was important since multifamily owners/operators are generally not early adopters of new technology (Currie, Parker, and Elliott 1998).

To meet the program goals, Battelle designed and implemented a research agenda that included baseline metering of nine conventional washers and dryers, room lighting, and standard efficiency 120-gallon electric water heaters in three laundry rooms. Baseline metering was followed with replacement of the conventional washers/dryers, lighting, and water heating equipment with water- and energy-efficient (and properly sized) equipment. All energy and water inputs of the baseline and efficient equipment were end-use metered.

Based on the average incremental costs of efficient equipment of $1,345 and average projected savings of 2,682 kWh/yr and 28,400 gallons/yr water, the simple payback for a retrofit REL room is 4.1 years. These savings are based on three washers/dryers that are used 1.5 cycles/ washer/day, two lighting fixtures, a 52-gallon water heater, and lighting occupancy controls. If the washers are used the multifamily-industry-average of 2.5 cycles/day, the savings would increase to 3,525 kWh/year and 47,400 gal/yr, giving a simple payback of 2.9 years for a REL room.

The data from this demonstration will be used in the design of future laundry-room equipment programs under the Focus on Energy Apartment & Condo Efficiency Services program. If the Focus on Energy program were successful in converting one-fourth (25%) of the estimated 6,800 common-area laundry rooms in Wisconsin to REL rooms, the estimated annual savings (assuming all electric) would be more than 4.5 GWh of electricity and over 48 million gallons of water.

Approach

The approach was to undertake baseline metering of three multifamily laundry rooms. The baseline equipment in the three rooms is given in Table S.1. Metered parameters were identical in the three rooms and included clothes washer hot and cold water and electricity, clothes dryer electricity, water heater electricity, and lighting on-hours. The washers and dryers were

coin-drop-operated. The vend price of the clothes washers and dryers was $1.00/cycle and remained this price throughout the demonstration. Baseline equipment metering was conducted from February 2003 through mid-May 2003.

Each laundry room was then retrofitted with efficient equipment. Equipment included high-performance clothes washers and matching dryers from each of three companies: Maytag, Speed Queen, and Whirlpool; efficient and downsized electric water heaters, energy-efficient lighting fixtures, and lighting occupancy controls. The metering of the efficient equipment was conducted from mid-June 2003 to mid-February 2004. Table S.2 gives the characteristics of the efficient equipment.

Table S.1. Baseline Equipment in the Three Laundry Rooms

Laundry Room	Clothes Washers	Clothes Dryers	Water Heaters	Light Fixtures	Light Switch
#1 Interior room	3-Maytag MAT12PD soft-mount top-load	3-Maytag MDE16PD, electric	1-A.O. Smith EES 120 911 120 gallon electric	2-surface-mount wrapped-lens; 1 with 2-34W and 1 with 2-40W T-12 lamps; both with electronic hybrid ballasts 172W/room	1-toggle
#2 Interior Room	3-Maytag MAT12PD soft-mount top-load	3-Maytag MDE16PD, electric	1-A.O. Smith EES 120 911 120 gallon electric	2-surface-mount wrapped-lens with 2-34W T-12 lamps with rapid start magnetic ballasts 172W/room	1-toggle
#3 Small window on one wall	3-Maytag MAT12PD soft-mount top-load	3-Maytag MDE16PD electric	1-A.O. Smith EES 120 914 120 gallon electric	3-40W incandescent bulbs in porcelain fixtures; 120W/room	1-toggle

Table S.2. Efficient Retrofit Equipment Installed in the Three Laundry Rooms

Laundry Room	Clothes Washers(1)	Clothes Dryers	Water Heaters	Light Fixtures	Light Switch
#1 Interior room	3-Speed Queen SWRT61HW soft-mount front-load	3-Speed Queen SDET07FW electric	1-A.O. Smith PEH-52 52 gallon electric 0.93 EF	2-Lithonia LB 232 surface- mount wrapped-lens with 2-32W T-8 lamps with generic electronic ballast; 116W/room	1-Watt Stopper® WS-200 automatic wall switch; 20-sec time delay
#2 Interior room	3-Maytag MAH21PDAWW soft-mount front-load	3-Maytag MDE16PDAYW electric	1-A.O. Smith PEH-80 80 gallon electric 0.92 EF	2-Lithonia LB 232 surface-mount wrapped-lens with 2-32W T-8 lamps with generic electronic ballast; 116W/room	1-Watt Stopper® WS-200 automatic wall switch; 20-sec time delay
#3 Small window on one wall	1-Maytag MAT12PDSAW soft-mount top-load, 1-Whirlpool CAW2762KQ soft-mount top-load, 1-Speed Queen SWTT21NW soft-mount top- load	1-Maytag MDE16PDAYW electric, 1-Whirlpool CEM2760KQ electric, 1-Speed Queen SDET07FW electric	1-A.O. Smith PEH-52 52 gallon electric 0.93 EF	2-Lithonia LB 232 surface-mount wrapped-lens with 2-32W T-8 lamps with generic electronic ballast; 116W/room	1-Watt Stopper® WS-200 automatic wall switch; 20-sec time delay & 20f.c. sensitivity for daylighting offset

(1) All clothes washers are ENERGY STAR® rated.

Clothes Washers

Figure S.1 presents the clothes washer water use in gallons per cycle. Four of the five high-performance washers showed a reduced total water use when compared to the baseline Maytag washers. The baseline average water use was 31.3 gallons/cycle, while the Maytag front-loading (Maytag Front) used 13.7 gallons/cycle, the Maytag top-loading (Maytag Top) used 32.1 gallons/cycle, the Speed Queen front-loading (Speed Queen Front) used 17.8 gallons/cycle, the Speed Queen top-loading (Speed Queen Top) used 22.8 gallons/cycle, and the Whirlpool top-loading (Whirlpool Top) used 28.7 gallons/cycle. As shown in the figure, hot water use was reduced in four of the five high-performance clothes washers.

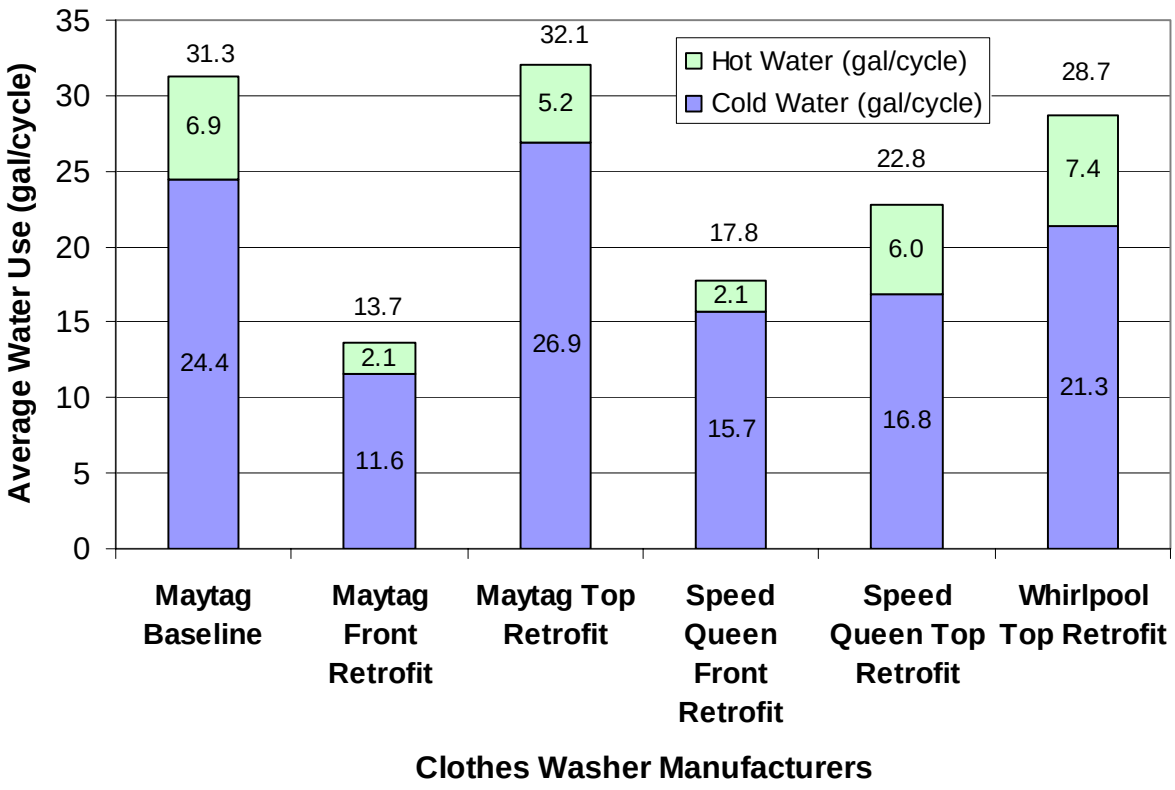

Figure S.1. Average Clothes Washer Water Use (gallons/cycle) for Baseline and Retrofit

Figure S.2 presents the average clothes washer energy use (hot water and motor/controls energy use) in kilowatt-hours (kWh) per cycle. Four of the five high-performance washers showed a reduced energy use when compared to the baseline Maytag washers. The baseline average energy use was 1.17 kWh/cycle, while the Maytag Front used 0.40 kWh/cycle, the Maytag Top used 0.93 kWh/cycle, the Speed Queen Front used 0.41 kWh/cycle, the Speed Queen Top used 1.10 kWh/cycle, and the Whirlpool Top used 1.40 kWh/cycle.

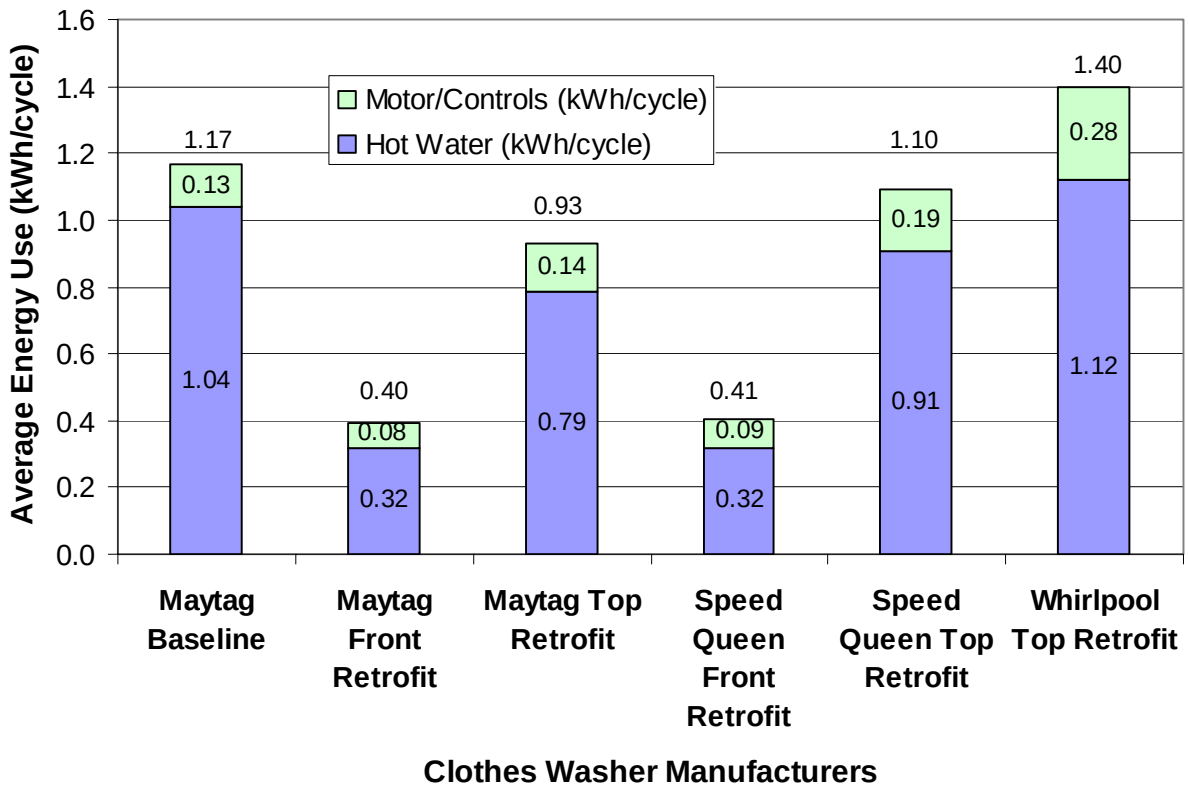

Figure S.2. Average Clothes Washer Energy Use (kWh/cycle) for Baseline and Retrofit

Clothes Dryers

Figure S.3 presents the average clothes dryer energy use in kilowatt-hours (kWh) per cycle.

It was somewhat surprising to note the insignificance of the differences in energy use from the baseline equipment to the new equipment; in fact, none of these differences show statistical significance given the uncertainty of exogenous variables such as differences in clothing type washed/dried during the baseline period (winter into spring) versus the clothing type washed/dried during the efficient period (spring into summer).

Energy consumption of coin-operated dryers is partially controlled by vend amount. That is, the vend amount purchases a drying time and the dryer runs for the duration of that time. The manufacturers of the dryers in this study report the use of temperature and/or moisture sensors to control the heating elements. These sensors cycle the heating element based on either exhaust temperature or humidity. In the case where the user has paid for more time than necessary (i.e., clothes are dry with time remaining), the dryer runs, turning the drum and cycling the heating element as needed. It is not entirely clear why, even though the remaining moisture content (RMC) of clothes from the front-loading washers is reduced (a well-documented result and one used by manufacturers in selling the residential versions of this equipment), the dryers (on average) did not use less energy. In addition to the continued operation of the dryer with dry

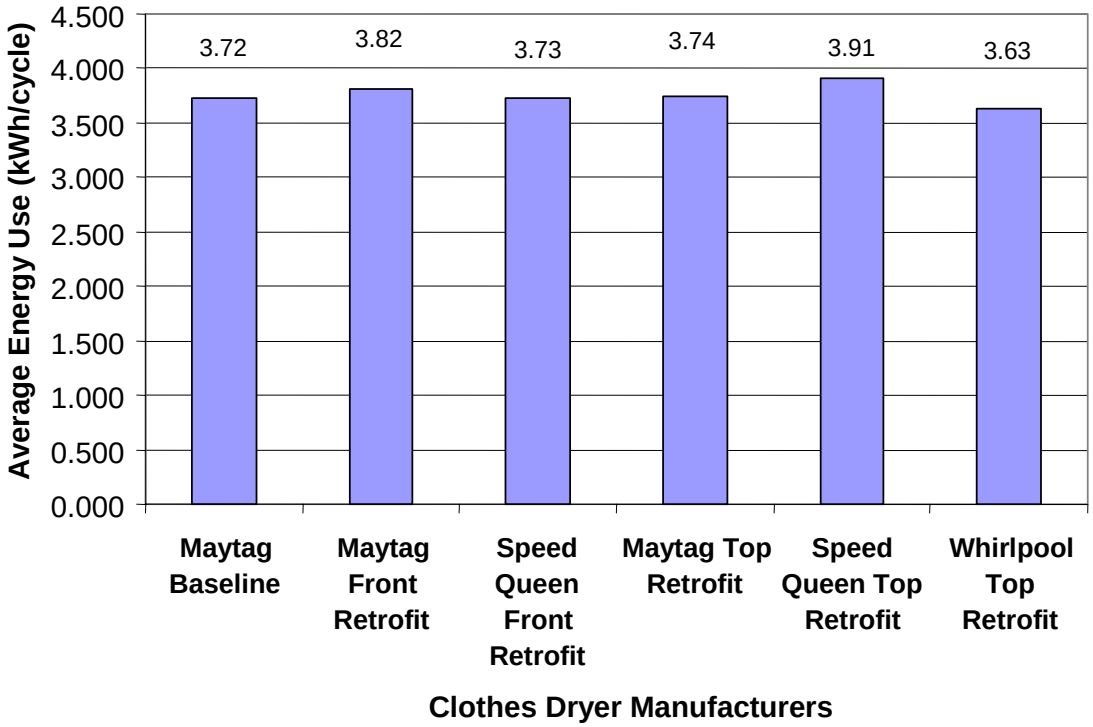

Figure S.3. Average Clothes Dryer Energy Use (kWh/cycle) for Baseline and Retrofit

clothes (albeit at a reduced-energy state), a number of exogenous variables may account for the lack of recorded savings. These variables could include a difference in load size from the baseline washer/dryers to the retrofit washer/dryers (the front-load washers are 12-15% larger). Another possibility could be the difference in clothing type washed during the baseline period (February through May) with that of the retrofit period (June through October).

An important finding regarding dryer energy use is the significant opportunity for further research for validation of energy savings through the use of the existing moisture-sensing technology. This may lead to the development of next-generation sensors and controls that further reduce energy use once clothes drying is confirmed.

Water Heaters

Figure S.4 presents the average annual energy use of the water heaters. These data are presented by room number for both the baseline and the efficient equipment cases. Per Tables S.1 and S.2 it is important to note that Room #1 was retrofit from a 120-gallon to a 52-gallon water heater and received Speed Queen *front-loading* washers. Room #2 was retrofit from a 120-gallon to an 80-gallon water heater and received Maytag *front-loading* washers. Room #3 was retrofit from a 120-gallon to a 52-gallon water heater and received three different brands of *top-loading* washers.

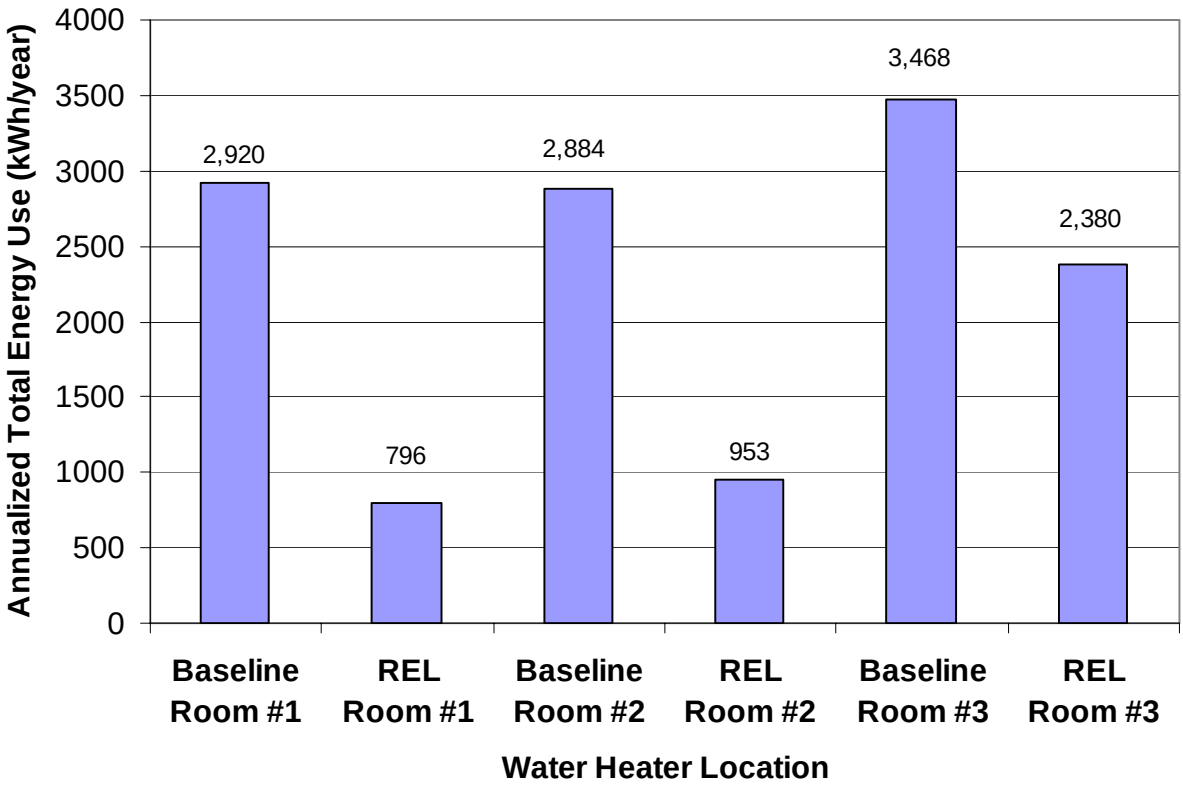

Figure S.4. Average Water Heater Energy Use (kWh/yr) for Baseline and Retrofit

Energy use was monitored at the water heater and includes clothes washer hot water use, water heater stand-by loss, and any piping line losses. While each room was equipped with a utility sink, there were no attempts to quantify this hot water use as it was assumed this use was similar in the baseline and efficient scenarios.

Lighting

Figure S.5 presents the average annual energy use of the lighting fixtures. These data are presented by room number for both the baseline and the efficient fixture cases. Per Tables S.1 and S.2 it is important to note that Rooms #1 and #2 (both interior rooms without windows) were retrofit with T-8 lamps and electronic ballasts as well as controlled with an occupancy-based wall switch. Room #3, having a window, also was retrofit with the same fixtures, but the occupancy-based wall switch also has a daylight threshold setting implemented at 20 foot candles.

As a result of the efficient fixtures and controls, the annualized average lighting savings per room was greater than 74%.

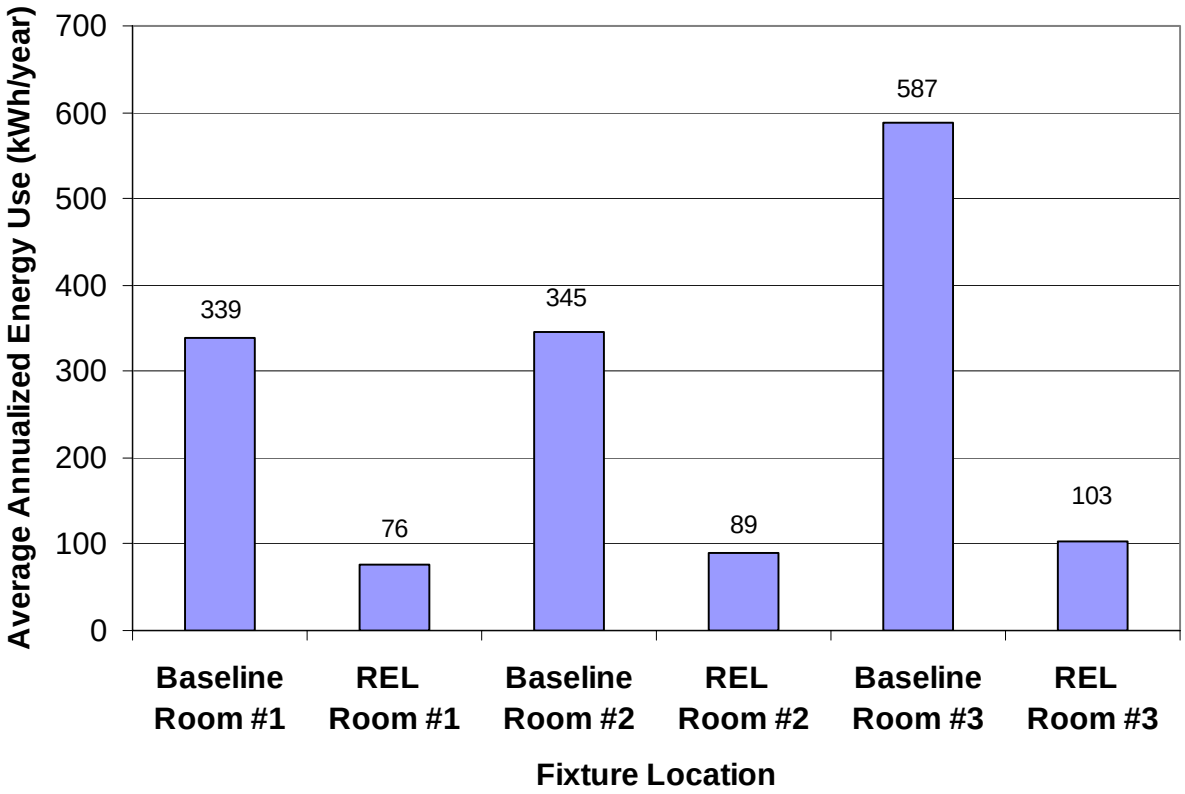

Figure S.5. Average Lighting Energy Use (kWh/yr) for Baseline and Retrofit

Conclusions

The purpose of the demonstration was to measure and determine the expected energy and water savings from the combination of technologies installed in a REL room compared to a "standard" (baseline) common-area multifamily laundry room. The savings from the efficient technologies are quantified, and, based on average utility rates in Wisconsin, the cost-effectiveness – in terms of simple payback – is determined.

Table S.3 summarizes the energy and water savings, and the incremental installed costs (or incremental installed cost *savings*) for each efficient retrofit measure based on the average across all three rooms in the demonstration compared to a baseline laundry room.[(1)] Also included in Table S.3 are the total room annualized electricity savings, water savings and total savings based on the measured efficient equipment performance (average of the three rooms). The savings are based on 1.5 cycles/day/washer.

(1) The baseline laundry room is equipped with three standard efficiency coin-operated washers (and dryers – not included in the analysis), one 120-gallon water heater, two surface mount 2-tube T12 fluorescent fixtures with magnetic ballast, and a single wall switch.

For this demonstration, simple payback is evaluated from the perspective of the multifamily owner/operator. Depending on the individual measure savings and overall payback, programs can then be designed to reduce the payback to encourage multifamily owner/operators to undertake retrofits.

Based on the incremental costs and savings from Table S.3, the simple payback for a REL is 4.1 years. If the washers were used the multifamily industry average of ~2.5 cycles/day, the savings would increase to 3,525 kWh/year and 47,400 gal/year, giving a simple payback of 2.9 years.[(2)]

Typically, the multifamily sector is interested in improvements and technologies that will give a very short payback (simple payback), generally 2 years or less (Sullivan, Parker, and Schmelzer 1999; Sullivan and Parker 1999; Sullivan and Parker 2000). Based on Table S.3, an incentive (rebate, tax credit, etc.) of ~$700 would be needed to bring the simple payback to 2 years.

At 2.5 cycles/day/washer, the incentive would need only to be ~$400 to give a minimum payback of 24 months. This incentive is well within typical incentives (rebates and tax credits) for high-performance clothes washers found in many regions of the country (see www.lightwash.com, www.cee1.org/com/cwsh/01comwsh_progsum.pdf). It should be noted that simple payback calculations presented here do not include possible utility rate increases – higher utility rates will shorten payback periods.

Table S.3. Estimated Costs and Savings for a REL Room

Technology	Incremental Cost of Technology	Energy Savings kWh/yr/room	Water Savings gal/yr/room	Total Savings $
High-Performance Washers (3)	$1,500	1,2651	28,400	$2,071
Downsized High-Efficiency Water Heater	($250)	9331	NA	$791
High-Efficiency Lighting Fixtures (2)	$20	484	NA	$41
Lighting Occupancy Control	$75	Included in lighting fixture savings	NA	-
Totals	$1,345	2,682	28,400	$327

(1) Savings based on 1.5 cycles/day/washer; $0.085/kWh and $3.50/1,000 gal water/wastewater cost.

(2) These results can be used to estimate the savings and payback for a gas water heating scenario. The data required for this analysis are the incremental cost of a 52-gallon high-efficiency gas water heater and the standby losses for both a baseline/standard and high-efficiency gas water heater.

These results show that there are significant cost-effective water and energy savings that can be achieved from a resource efficiency multifamily laundry room. These data indicate that it is important to treat a multifamily laundry room as a *system* and give careful consideration to the suite of technologies in the room.

These data, and the supporting data from the REL demonstration, will enable the Wisconsin Focus on Energy/ACES program design future programs for their multifamily-sector customers to obtain laundry room energy and water savings.

Acknowledgments

This report is the result of numerous people working to achieve a common goal of improving energy and water efficiency in the multifamily sector in the state of Wisconsin. The authors wish to acknowledge the significant contribution and valuable assistance provided by Jack Jenkins, Manager, Focus on Energy Apartment & Condo Efficiency Services, Wisconsin Energy Conservation Corporation, who supported and assisted in the design and development of this demonstration; and Cindy Moubry, Executive Assistant, Wisconsin Energy Conservation Corporation, who provided guidance in contractual and procurement activities.

Next, we would like to thank the REL site owner, Mark Mertens of Regal Investments, LLC, for his participation in this project. In addition, we would like to thank the residents of the buildings in which the REL demonstrations were conducted—405 Alexander Street, 411 Cook Street and 2010 Steel Street. We appreciated their patience and willingness to help in our demonstration of this equipment.

Integral to the success of this demonstration was the coordination and support of the participating clothes washer manufacturers—the Mac Gray Corporation (Maytag and Whirlpool distributor), and Excalibur Laundry Systems (Speed Queen distributor), as well as local La Crosse vendors Kish and Sons Electric (lighting and installation) and Cargill Heating and Plumbing (water heaters and installation).

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Finally, the third Battelle author of this report, Dr. J.W. (Bill) Currie, was a key contributor to this body of work starting with suggesting the need for a REL demonstration. Bill was the Program Manager for Battelle's work with Focus on Energy and passed away September 2003 before this study was completed. Bill's vision and passion for identifying and deploying new and emerging energy and water saving technologies was only surpassed by his dedication to the conduct of high quality and groundbreaking research in the field of energy supply and end-use. Bill is greatly missed by his colleagues and friends.

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1.0 Introduction

This multifamily resource efficient laundry (REL) room program targets the replacement of family-sized soft-mount commercial coin-operated washers and dryers, water heaters and lighting systems that are owned by multifamily owners and operators with high-performance energy- and water-saving equipment. As part of the overall program, this report presents the evaluation findings of a demonstration conducted at three multifamily apartment buildings in La Crosse, Wisconsin.

The REL demonstration included the baseline metering (Phase I) of clothes washers and dryers, water heaters, and lighting systems in three laundry rooms located in three apartment buildings. Each laundry room contained three top-loading coin-operated Maytag clothes washers. The Phase I metering effort lasted about 12 weeks. The Phase II effort followed with the installation of nine high-performance clothes washers, three from each of three different manufacturers, three high-efficiency and properly sized water heaters, and new efficient lighting and lighting controls. The Phase II metering effort lasted about 12 weeks for the washers, dryers and lighting. Due to an unexpected disconnection of metering equipment by a security-system vendor, the water heater Phase II metering effort lasted about 6 weeks. The metering for Phase I and Phase II captured the same parameters.

The goal of this project was to demonstrate and verify the performance, energy, water, and monetary savings of the high-efficiency REL equipment.

The balance of this report is organized as follows:

- Section 2 provides some background on the project and the equipment.
- Section 3 provides the technical approach used in this analysis.
- Section 4 presents the results of the energy and water analysis.
- Section 5 provides the summary and conclusions of this study.
- Section 6 contains the references cited in this report.
- Appendix A provides details on the REL Call for Participants documents.
- Appendix B provides details on the REL equipment and technical data.
- Appendix C provides details on the metering equipment technical details.

2.0 Background

Multifamily properties typically provide a variety of amenities and onsite services for tenants, including laundry rooms having coin-op washers and dryers. Research conducted over the past 5 years (Kaszczij and Liotta 2000; Currie and Parker 1999; Currie and Parker 1998; Edgemon and Parker 1998; and CH2M-Hill & Hill and Knowlton 1997) has led to three important findings:

1. There is a significant lack of data regarding multifamily laundry room equipment saturation and ownership.

2. There is a lack of understanding of the various forms of ownership/lease arrangements for this equipment, predominantly the washers and dryers.

3. There is a lack of understanding of the performance and cost-effectiveness of the different high-performance coin-op washers currently available, how these washers interact with the other laundry room equipment (dryers and water heaters), and what opportunities exist for efficient and well-controlled lighting. Understanding which washers are most cost-effective is vitally important because commercial clothes washers are not subject to Federal appliance efficiency testing standards (10 CFR 430 1998) and thus are not sold with a Federal Trade Commission (FTC) Energy guide label indicating their efficiency. Therefore, no substantial body of independent performance data on commercial washers is available to make informed decisions.

To affect these findings, the Wisconsin Focus on Energy (Focus on Energy) commissioned Battelle—Pacific Northwest Division (Battelle) to evaluate the energy and water efficiency of this high-performance energy and water-saving equipment installed in a multifamily setting in La Crosse, WI. The sites selected were laundry rooms in three similar and neighboring apartment buildings. The building characteristics are presented in Table 2.1.

Table 2.1. REL Demonstration Building Characteristics

Building Number	Building/ Laundry Room Characteristics	Number of Apartments	Average Occupancy
#1	1970s vintage, 2-story. Laundry room located in interior space	18	27
#2	1970s vintage, 2-story. Laundry room located in interior space	20	30
#3	1970s vintage, 2-story. Laundry room located in room with window in exterior wall.	24	36

It should be noted that based on guidelines established by the Multi-housing Laundry Association (http://www.mhla.com), the recommended ratio of multifamily occupants-to-washer/dryer pair is 15-to-1. In other words, an apartment building with an occupancy of 30 people should have two washer/dryer pairs. All three of the apartments in the REL demonstration apartments have three washer/dryer pairs, for an average ratio of about 10-to-1. This lower ratio of occupants-to-washer/dryer pairs became evident in the data where we noticed a lower than average daily cycles per machine of 1.5 cycles/day/washer; industry standard is approximately 2.5 cycles/day/machine.

3.0 Technical Approach

The objective of this study was to evaluate and quantify the energy and water efficiency of high-efficiency energy and water-saving equipment in the multifamily setting. Our approach included baseline metering and tracking (Phase I) of the three laundry rooms. Each laundry room contained three top-loading coin-operated Maytag clothes washers and dryers, one 120-gallon electric water heater, and laundry rooms #1 and # 2 contained two surface-mounted T-12 fluorescent lighting fixtures with wrapped lens controlled with a single wall switch, and laundry room #3 had three 40-W bare-lamp incandescent ceiling-mounted porcelain sockets, also with a single wall switch. The clothes washers and dryers were each equipped with a coin-drop box with a $1.00 vend for washing and $1.00 vend for drying. The Phase I metering effort lasted about twelve weeks. Table 3.1 describes the baseline equipment in the three laundry rooms.

Table 3.1. Baseline Equipment in the Three Laundry Rooms

Laundry Room	Clothes Washers	Clothes Dryers	Water Heaters	Light Fixtures	Light Switch
#1 Interior room	3-Maytag MAT12PD soft-mount top-load	3-Maytag MDE16PD, electric	1-A.O. Smith EES 120 911 120 gallon electric	2-surface-mount wrapped-lens; 1 with 2-34W and 1 with 2-40W T-12 lamps; both with electronic hybrid ballast 172W/room	1-toggle
#2 Interior Room	3-Maytag MAT12PD soft-mount top-load	3-Maytag MDE16PD, electric	1-A.O. Smith EES 120 911 120 gallon electric	2-surface-mount wrapped-lens with 2-34W T-12 lamps with rapid start magnetic ballast 172W/room	1-toggle
#3 Small window on one wall	3-Maytag MAT12PD soft-mount top-load	3-Maytag MDE16PD electric	1-A.O. Smith EES 120 914 120 gallon electric	3-40W incandescent bulbs in porcelain fixtures; 120W/room	1-toggle

The Phase II effort followed with the installation of nine high-performance clothes washers, three from each of three different manufacturers (three Maytag front-loading and one Maytag top-loading, three Speed Queen front-loading and one Speed Queen top-loading, and one Whirlpool top-loading), three high-efficiency and properly sized (downsized) water heaters, and new efficient lighting and lighting controls. The Phase II metering effort lasted about 12 weeks for the washers, dryers and lighting. Due to an unexpected disconnection of metering equipment by a security system vendor, the water heater Phase II metering effort lasted about 6 weeks. The metering for Phase I and Phase II captured the same parameters. Table 3.2 describes the efficient equipment in the three REL rooms.

Table 3.2. Efficient Retrofit Equipment Installed in the Three Laundry Rooms

Laundry Room	Clothes Washers[1]	Clothes Dryers	Water Heaters	Light Fixtures	Light Switch
REL #1 Interior room	3-Speed Queen SWRT61HW soft-mount front-load	3-Speed Queen SDET07FW electric	1-A.O. Smith PEH-52 52 gallon electric 0.93 EF	2-Lithonia LB 232 surface-mount wrapped-lens with 2-32W T-8 lamps with generic electronic ballast; 116W/room	1-Watt Stopper® WS-200 automatic wall switch; 20-sec time delay
REL #2 Interior room	3-Maytag MAH21PDAWW soft-mount front-load	3-Maytag MDE16PDAYW electric	1-A.O. Smith PEH-80 80 gallon electric 0.92 EF	2-Lithonia LB 232 surface-mount wrapped-lens with 2-32W T-8 lamps with generic electronic ballast; 116W/room	1-Watt Stopper® WS-200 automatic wall switch; 20-sec time delay
REL #3 Small window on one wall	1-Maytag MAT12PDSAW soft-mount top-load, 1-Whirlpool CAW2762KQ soft-mount top-load, 1-Speed Queen SWTT21NW soft-mount top- load	1-Maytag MDE16PDAYW electric, 1-Whirlpool CEM2760KQ electric, 1-Speed Queen SDET07FW electric	1-A.O. Smith PEH-52 52 gallon electric 0.93 EF	2-Lithonia LB 232 surface mount wrapped-lens with 2-32W T-8 lamps with generic electronic ballast; 116W/room	1-Watt Stopper® WS-200 automatic wall switch; 20-sec time delay & 20f.c. sensitivity for daylighting offset

(1) All clothes washers are ENERGY STAR® rated.

The approach included the following steps:

1. select candidate laundry buildings to study
2. select high-performance equipment to demonstrate
3. develop an end-use metering plan and install metering equipment
4. collect and analyze data
5. report findings.

3.1 Selection of Buildings/Laundry Rooms

In this demonstration, three La Crosse, WI, apartment laundry rooms were selected. These buildings were chosen after a general call for participants circulated across the State of Wisconsin by Focus on Energy and their partner organizations. A copy of the call for participants and the selection criteria are included in Appendix A. These specific buildings were chosen because they met most of the selection criteria, are relatively the same style, size, and serve roughly the same number of residents. The physical layout of the three chosen laundry rooms is nearly identical.

By design, each laundry room was meant to serve between 35 and 45 people. The current occupancy of each apartment building varies between about 25 to 35, thus the clothes washers and dryers are currently underutilized. Figure 3.1 is a picture of one of the selected apartment buildings.

F**igure 3.1**. Apartment Building for the REL Demonstration

3.2 Selection of High-Performance Equipment for Demonstration

3.2.1 Clothes Washers/Dryers

After a careful review of the recent ENERGY STAR® commercial clothes washers on the market, Battelle identified three manufacturers of high-performance clothes washers and dryers for participation. This equipment included washer/dryer pairs from the Maytag Corporation, Alliance Laundry LLC (Speed Queen), and the Whirlpool Corporation. The Maytag and Speed Queen washers are front-loading (three of each) and top-loading (one from each), while the Whirlpool (one washer/dryer pair) was the top-loading style. The equipment purchased for the REL resulted from a regional competition among manufacturers and distributors serving the La Crosse area. At the end of the REL demonstration, ownership of all equipment was transferred to the building owner. Appendix B contains product literature for each high-performance washer in the REL.

With the front-loading design, the washer drum rotates about a horizontal, rather than a vertical, axis. The benefit to the front-loading washer is that the drum only partially fills with water during the wash and rinse cycles; as the drum turns about its horizontal axis, the clothes are tumbled into and out of the water. For the high-performance top-loading design, different technologies are employed to achieve added efficiency, including a “spray-rinse” (Whirlpool design) system used to rinse the clothes, reducing the amount of water used in the rinsing operation. All of these high-performance designs are in contrast to the standard top-loading design that requires the clothes to be fully immersed in water and moving about a central agitator for proper washing and rinsing. Because most of a clothes washer’s energy use is tied to hot water use, any savings in hot water translate to energy savings. Additional energy savings result from higher-efficiency motors and the higher spin speeds achieved in the front-loading designs. These higher spin speeds reduce the water content in the clothes at the end of the wash cycle, thus potentially saving dryer energy. Table 3.3 presents the characteristics of the participating manufacturers’ clothes washers.

Table 3.3. Features and Characteristics of Clothes Washers in the REL Demonstration

Clothes Washer Manufacturer/Model	Tub Volume (cubic feet)	Axis of Drum Rotation	Loading Direction	CEE Tier[(1)]
Maytag MAT12PD (baseline)	2.5	Vertical	Top	Not applicable
Maytag MAH21PDAWW	2.9	Horizontal	Front	3B
Maytag MAH21PDAWW	2.4	Vertical	Top	Not listed
Speed Queen SWR261	2.8	Horizontal	Front	3A
Speed Queen SWTT21NW	2.52	Vertical	Top	1
Whirlpool Resource Saver CAW2762KQ	3.0	Vertical	Top	Not listed

(1) Consortium for Energy Efficiency; see www.cee1.org/com/cwsh/cwshspec.pdf.

Figures 3.2 through 3.5 present photographs of all equipment from the demonstration. Figure 3.2 is the baseline top-loading washer and the washer/dryer pairs (Maytag). Figure 3.3 is the Maytag efficient front-loading washer and washer/dryer pairs. Figure 3.4 is the Speed Queen efficient front-loading washer and washer/dryer pairs, and Figure 3.5 are the efficient top-loading Maytag, Speed Queen and Whirlpool clothes washers.

Prior to this demonstration, the users of these clothes washers received notification of the demonstration, its goals and purpose. In addition, as the new washers were installed, instructions on the important differences between the baseline and the high-performance clothes washers were made into signs and hung in each laundry room. The instructions included details on proper loading, unloading, operation, and detergent use for the washers. A sample of one of the wall signs is provided in Figure 3.6.

Figure 3.2. Maytag Baseline Top-Loading Clothes Washer and Washer/Dryer Pairs

Figure 3.3. Maytag Efficient Front-Loading Clothes Washer and Washer/Dryer Pairs

Figure 3.4. Speed Queen Efficient Front-Loading Clothes Washer and Washer/Dryer Pairs

Figure 3.5. Maytag, Speed Queen, and Whirlpool Efficient Top-Loading Clothes Washers

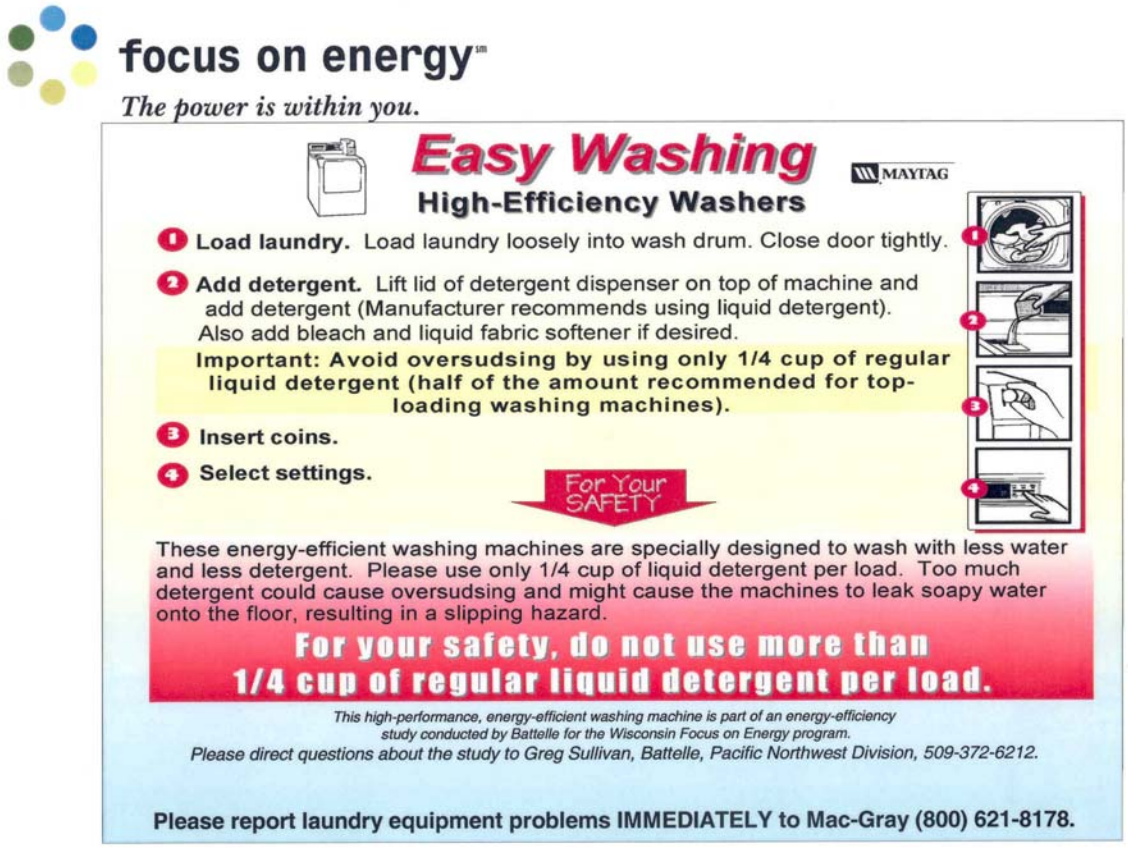

Figure 3.6. Wall Sign Used in the Focus on Energy REL Demonstration

3.2.2 Water Heaters

As previously mentioned, all three laundry rooms had standard-efficiency 120-gallon electric water heaters. It is our hypothesis that these water heaters are oversized for both modern top-loading and front-loading clothes washers. Significant potential for energy savings exists from two mechanisms. First, increased efficiency though the installation of high-efficiency (energy factor >0.91) water heaters and second, the physical reduction in water heater size resulting in reduced surface area and thus reduced standby loss. Two of the REL laundry rooms were retrofit with high-efficiency 52-gallon water heaters; the third was retrofit with a high-efficiency 80-gallon water heater. Figure 3.7 presents the baseline 120-gallon water heater and the efficient 52-gallon water heater, respectively.

Figure 3.7. 120-Gallon (Baseline) and 52-Gallon (Efficient) Electric Water Heaters

3.2.3 Lighting and Lighting Controls

In the baseline case, two of the laundry rooms (rooms #1 and #2) had two surface-mount wrapped-lens 2-tube fluorescent fixtures with a mix of T-12 34 and 40-watt lamps with hybrid-electronic and/or magnetic ballasts (see Table 3.1 for details). The third room (room #3) had three 40-watt bare-lamp incandescent ceiling-mount porcelain sockets. All fixtures in each room were controlled with a single wall-mounted toggle switch located near the door.

The retrofit technology for each of the REL rooms included two surface-mount wrapped-lens 2-tube fluorescent fixtures using T-8 lamps and electronic ballasts. Each room was also retrofit with an occupancy-based wall switch and in one case (REL #3, which has a window) set to turn off based on available day-lighting. Figure 3.8 presents the existing and retrofit technology as installed in REL #3. Figure 3.9 presents the T-12 and T-8 lamps and shows the occupancy-based wall switch as installed.

The technical details of all lighting equipment and operations are provided in Section B.5 of Appendix B.

Figure 3.8. Existing and Retrofit Laundry Room Lighting Technologies

Figure 3.9. T-12 and T-8 Lamp Comparison and Occupancy-Based Wall Switch

3.3 End-Use Metering Plan Development

Each of the three laundry rooms received identical end-use metering equipment. In each laundry room four stand-alone data loggers were installed to record and store the relevant per-cycle energy and water data for each washer and dryer. A description of each monitored parameter is included below; baseline and new high-performance equipment monitoring is identical. Figure 3.10 details the metering arrangement common to each clothes washer/dryer pair and water heater. Appendix C presents the technical details of the metering equipment.

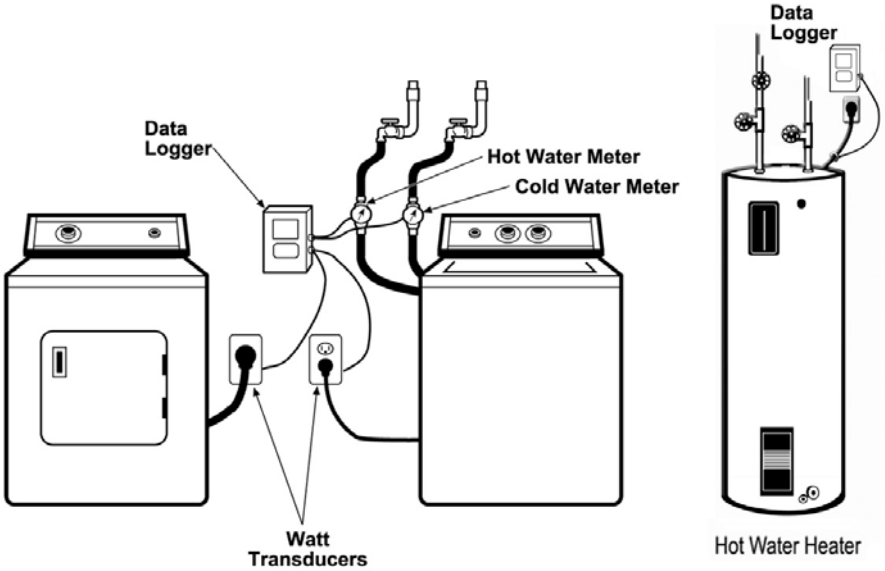

Figure 3.10. REL Demonstration Metering Equipment

3.3.1 Metered Parameters

Clothes Washer Water Use: Water use was monitored by water-flow meters installed on the hot and cold supply line to each machine. The water meters are installed in-series with the standard washer-hose connections and placed on the floor behind the washers. The meters provide per-cycle (hot and cold) water use data to the central data logger where it is stored in a time-series format.

Clothes Washer Electrical Energy Use: Electrical energy use (washer motor and controls) was monitored by a watt transducer. The watt transducer is designed to be plugged into an existing electrical outlet and for the washer to be plugged into it. The watt transducer provides per-cycle electricity use data to the data logger where it is stored in a time-series format.

Clothes Dryer Electrical Energy Use: Similar to the clothes washer, the dryer electrical energy use (dryer motor, heating element, and controls) was monitored by a watt transducer. This watt transducer is designed for the dryer's 220-volt configuration. As with the washer, the dryer watt

transducer is designed to be plugged into an existing electrical outlet and for the dryer to be plugged into it. There was however no means by which the clothes dryer energy use was directly associated—via the metering strategy—with any particular washer or wash load.

Clothes Washer and Dryer Utilization: The total number of cycles per machine was captured by the watt transducer in the form of run-time data. The watt transducer provides the run-time data to the data logger where it is stored in a time-series format.

Clothes Washer and Dryer Data Collection and Storage: A data logger was used to record and store the energy and water use data for the washers and dryers. These data were then downloaded by Battelle staff remotely, via a modem over a dedicated phone line, on a weekly basis.

Water Heater Metering: Electrical energy use of the water heater was monitored using a current transformer installed on the water heater circuit in the circuit panel and connected to a stand-alone data logger. The data logger records electricity used by the water heater and stores this in a time series format. Data from this data logger are manually downloaded. Hot water temperatures were measured with spot measurements in the laundry rooms using a digital thermometer. Temperatures ranged from 118°F to 123°F over the period of the demonstration.

Lighting Metering: Lighting use is recorded using a light-activated data logger to record run-time (on-time) of the lighting system. These data, coupled with known electrical energy use of the specific fixture/lamp combination, provided a time series record of the lighting electrical energy use.

3.4 Collect and Analyze Data

All data stored in the data loggers were retrieved on a weekly basis. By design, these data loggers communicate, via telephone lines, with a central polling computer located at Battelle. In addition to this polling arrangement being convenient, it also allowed Battelle staff to look at clothes washer/dryer use in a real-time format. As mentioned previously, the hot-water and lighting data were collected with stand-alone data loggers and downloaded manually.

The data integration interval (time interval over which data was summed and stored) was 5 minutes. A 5-minute integration period is a compromise between the desire to minimize the volume of data collected and the need to be able to discern individual equipment use events.

4.0 Energy and Water Data Collection Results

The results presented below are from data representing more than 300 clothes washing cycles from each manufacturer's sets of washers and dryers. The average number of cycles per day per washer varied between 1 and 3. The overall average was 1.5 cycles/day/washer. As previously mentioned, 1.5 cycles/day/washer is well below the multifamily industry average of 2.5 cycles/ day/washer. This underutilization of washers is reflective of the lower-than-average ratio of occupants to washer found in these three apartments. The industry standard ratio is 15 residents (or users) to every washer. The ratio in the three REL apartments was closer to 10 residents to every washer. This ratio, and resulting average cycles per day per washer, is important because it directly impacts the economics of savings and retrofit cost per washer and per REL room.

4.1 Water Use

Figure 4.1 presents the clothes washer water use in gallons per cycle. Four of the five high-performance washers showed a reduced total water use when compared to the average water use for the baseline Maytag washers. The baseline average water use was 31.3 gallons/ cycle, while the Maytag front-loading (Maytag Front) used 13.7 gallons/cycle, the Maytag top-loading (Maytag Top) used 32.1 gallons/cycle, the Speed Queen front-loading (Speed Queen Front) used 17.8 gallons/cycle, the Speed Queen top-loading (Speed Queen Top) used 22.8 gallons/cycle, and the Whirlpool top-loading (Whirlpool Top) used 28.7 gallons/cycle.

Figure 4.1 also breaks out the average water use into the hot and cold-water components. As with the total water consumption, hot and cold-water use reductions were found in four of the five high-performance washers. The baseline average hot water use was 6.9 gallons/cycle. The four of five high-performance manufacturers with reduced average hot water use were: 2.1 gallons/cycle for the Maytag Front, 5.2 gallons/cycle for the Maytag Top, 2.1 gallons/cycle with Speed Queen Front, 6.0 gallons/cycle for the Speed Queen Top. The Whirlpool Top washer used an average of 7.4 gallons of hot water per cycle.

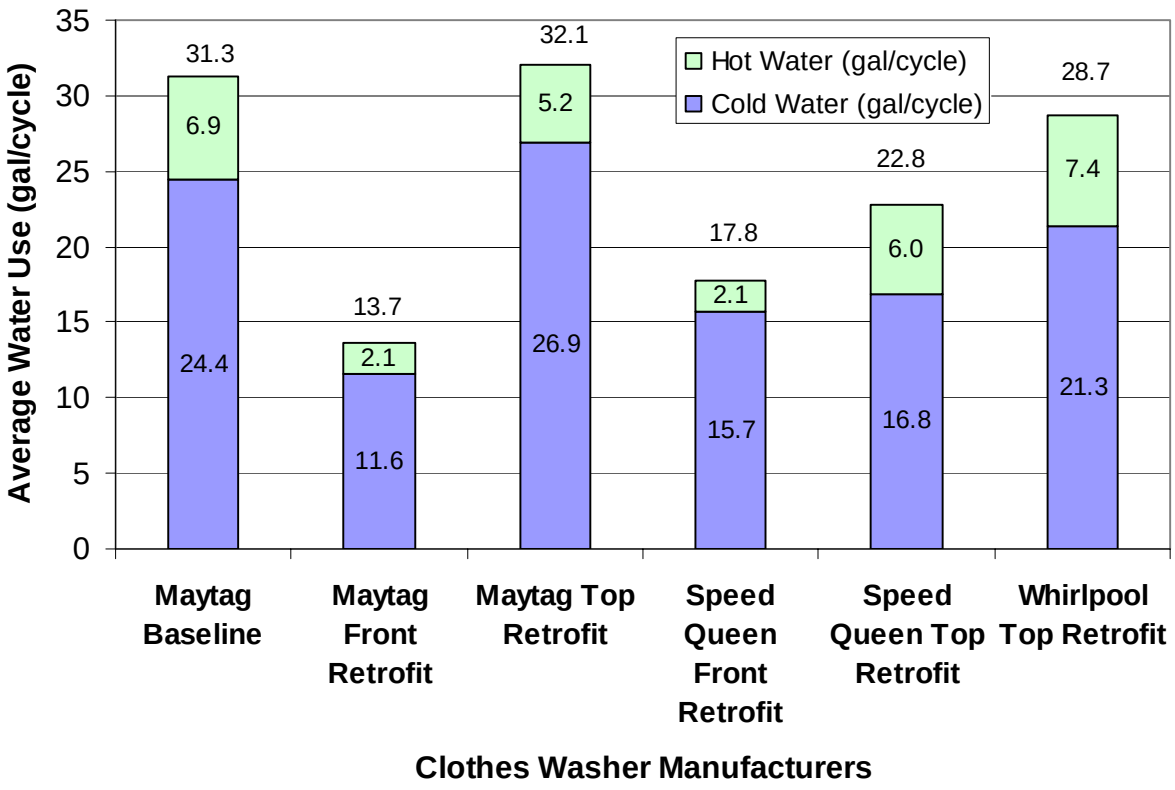

Figure 4.1. Average Clothes Washer Water Use (gallons/cycle) for Baseline and Retrofit Equipment

4.2 Energy Use

Energy use in the laundry rooms is presented by metered component for the baseline and for the REL equipment. Heating, ventilation, and air conditioning energy was not tracked nor affected by this demonstration.[3]

4.2.1 Clothes Washer Energy

Figure 4.2 presents the average clothes washer energy use (hot water and motor/controls energy use) in kilowatt-hours (kWh) per cycle. Four of the five high-performance washers showed a reduced energy use when compared to the baseline Maytag washers. The baseline average

(3) Though not included in the scope of the REL demonstration, dedicated and efficient heating, ventilation and air conditioning systems for a laundry room can significantly impact the overall energy savings of the laundry room and the overall cost-effectiveness (and payback) for a REL.

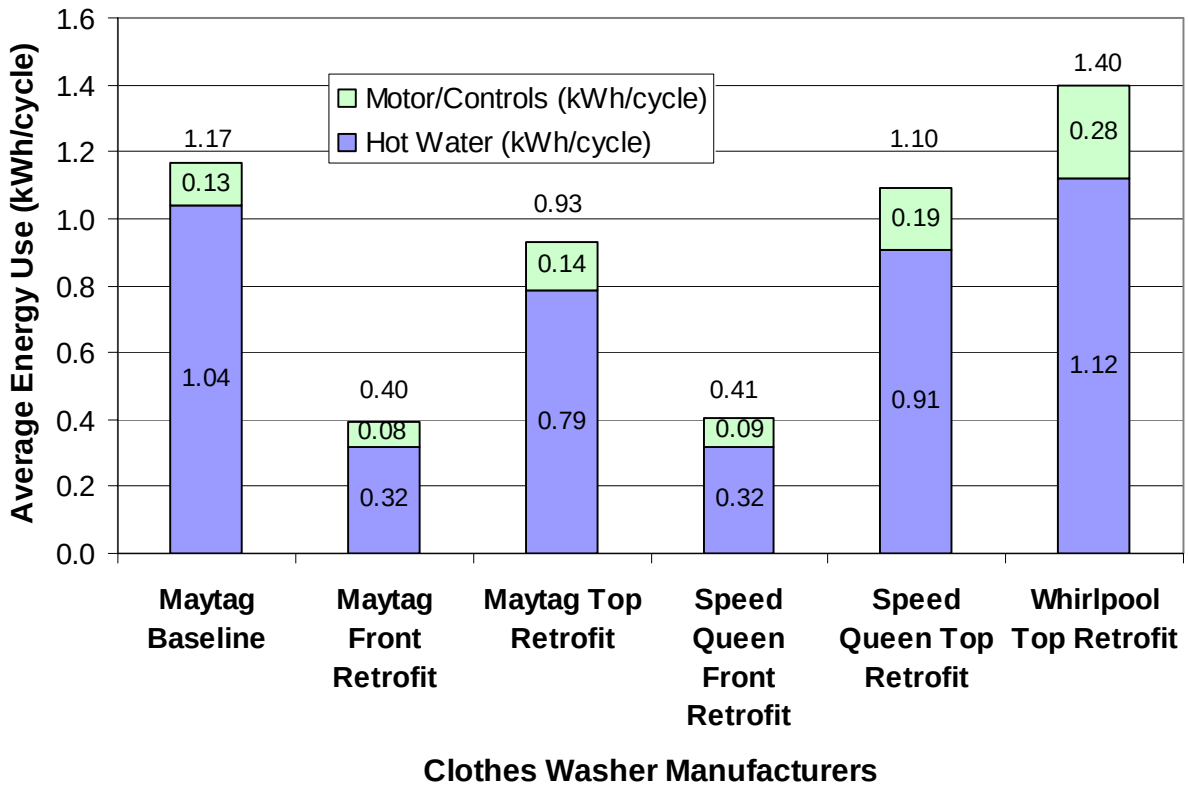

Figure 4.2. Average Clothes Washer Energy Use (kWh/cycle) Before and After Retrofit

energy use was 1.17 kWh/cycle, while the Maytag Front used 0.40 kWh/cycle, the Maytag Top used 0.93 kWh/cycle, the Speed Queen Front used 0.41 kWh/cycle, the Speed Queen Top used 1.10 kWh/cycle and the Whirlpool Top used 1.40 kWh/cycle.

4.2.2 Clothes Dryer Energy

Figure 4.3 presents the average clothes dryer energy use in kilowatt-hours (kWh) per cycle.

It was somewhat surprising to note the insignificance of differences in energy use from the baseline equipment to the new equipment; in fact none of these differences show statistical significance given the uncertainty of exogenous variables such as differences in clothing type washed/dried during the baseline period (winter into spring) versus that washed/dried during the efficient period (spring into summer).

Energy consumption of coin-operated dryers is partially controlled by vend amount. That is, the vend amount purchases a drying time and the dryer runs for the duration of that time. The manufacturers of the dryers in this study report the use of temperature and/or moisture sensors to control the heating elements. These sensors cycle the heating element based on either exhaust temperature or humidity. In the case where the user has paid for more time than necessary (i.e., clothes are dry with time remaining), the dryer runs, turning the drum and cycling the heating

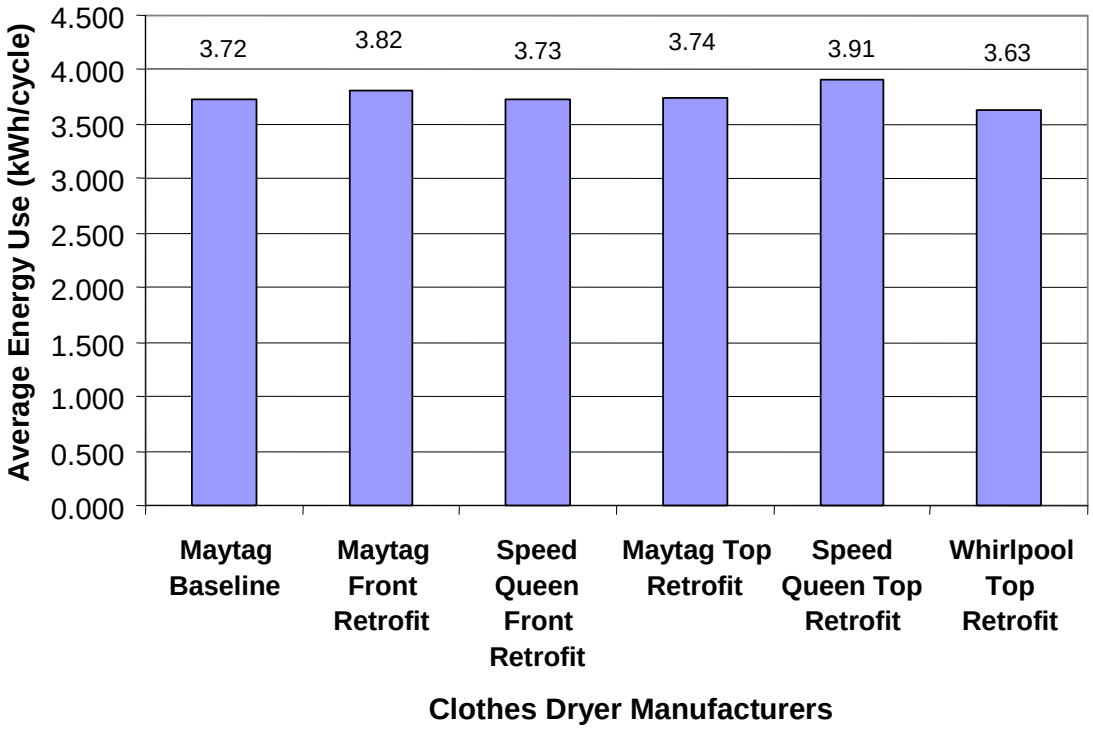

Figure 4.3. Average Clothes Dryer Energy Use (kWh/cycle) Before and After Retrofit

element as needed. It is not entirely clear why, even though the remaining moisture content (RMC) of clothes from the front-loading washers is reduced (a well-documented result and one used by manufacturers in selling the residential versions of this equipment), the dryers (on average) did not use less energy. In addition to the continued operation of the dryer with dry clothes (albeit at a reduced-energy state), a number of exogenous variables may account for the lack of recorded savings. These variables could include a difference in load size from the baseline washer/dryers to the retrofit washer/dryers (the front-load washers are 12-15% larger than the baseline top-load washers). Another possibility could be the difference in clothing type washed during the baseline period (February through May) with that of the retrofit period (June through October).

An important finding regarding dryer energy use is the significant opportunity for further research for validation of energy savings through the use of the existing moisture-sensing technology. This may lead to the development of next-generation sensors and controls that further reduce energy use once clothe drying is confirmed.

4.2.3 Water Heater Energy

Figure 4.4 presents the average annual energy use of the water heaters. These data are presented by room number for both the baseline and the efficient equipment cases. Per Table 3.1 and Table 3.2, it is important to note that laundry room #1 was retrofit from a 120-gallon to a

52-gallon water heater and received Speed Queen *front-loading* washers. Laundry room #2 was retrofit from a 120-gallon to an 80-gallon water heater and received Maytag *front-loading* washers. REL #3 was retrofit from a 120-gallon to a 52-gallon water heater and received 3 different brands of *top-loading* washers. While the original program plan called for the 80-gallon water heater to be placed in the REL #3 because the top-loading washers were (correctly) assumed to use more hot water than the front-loading washers, our installation contractor had other ideas. Unbeknownst to us, the water heater installation contractor erroneously placed the 80-gallon heater where a 52-gallon heater was specified and vice versa. Due to unanticipated mid-project budgetary changes for the demonstration, we were not able to be present during installation, as originally planned. Therefore, this error was not noticed until the majority of metered data had been collected. At the time of discovery and after reviewing the metered data, we determined the error had not been detrimental to system performance and the resulting energy impact relatively minor, thus the water heaters were left as configured.

The data presented in Figure 4.4 were monitored at the water heater and includes clothes washer hot water use, water heater stand-by loss, and any piping line losses. While each room was equipped with a utility sink, there were no attempts to quantify this hot water use as it was assumed this use was similar in the baseline and efficient scenarios.

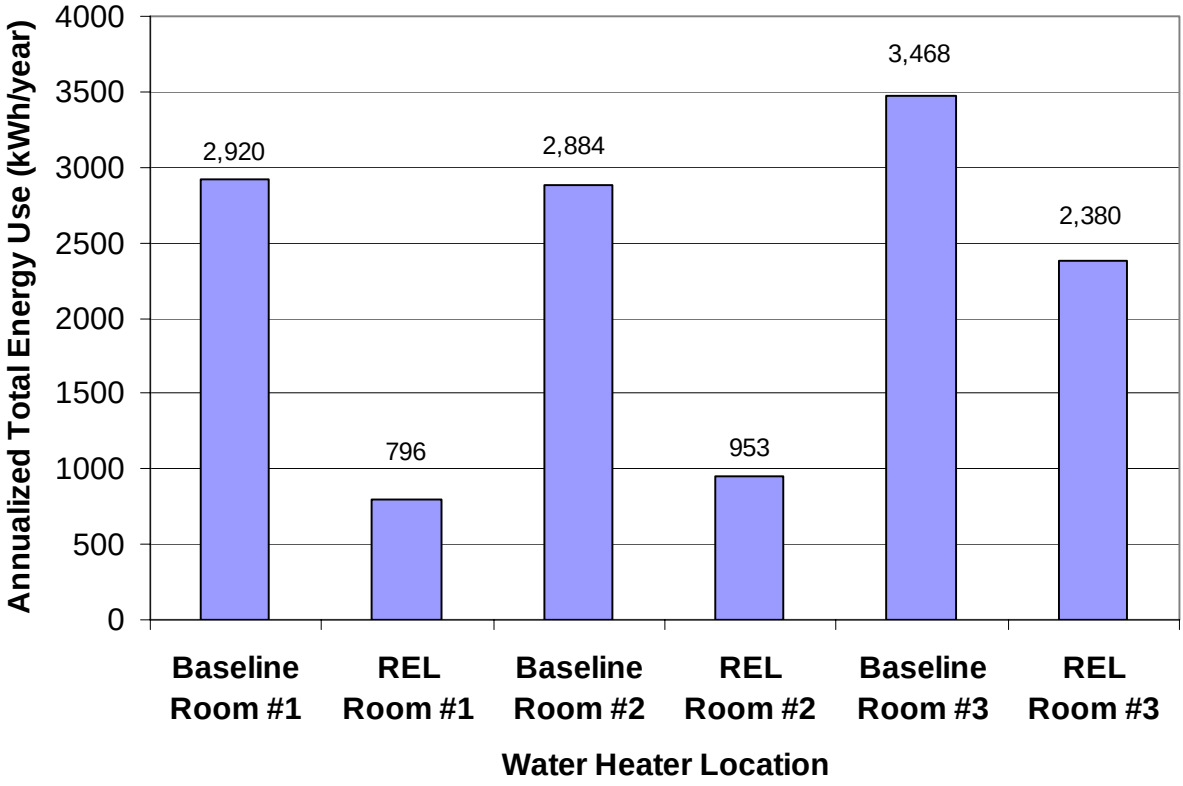

Figure 4.4. Average Water Heater Energy Use (kWh/year) Before and After Retrofit

Table 4.1 summarizes the water heater energy use associated with standby losses. As expected, when the laundry rooms were retrofit with smaller and more efficient water heaters, the energy use associated with standby loss was also reduced. The interaction between the reduced requirement for hot water by the efficient clothes washers and the ability to now undersize that water heater was an important element of this study.

In addition to the important energy savings is the reduced water heater size and resulting capital cost. Our market data report a reduced capital cost of $250 in downsizing from a 120-gallon to a 52-gallon water heater.

Table 4.1. Baseline and Retrofit Water Heating Stand-by Energy Use and Savings Before and After Retrofit

Laundry Room	Baseline Water Heater	Average Stand-by Energy Use kWh/day	Retrofit Water Heater	Average Stand-by Energy Use kWh/day	Stand-by Energy Savings kWh/yr(1)
#1	A.O.Smith 120-gal	3.3	A.O. Smith 52 gal high-efficiency	0.8	912
#2	A.O.Smith 120-gal	3.2	A.O. Smith 80 gal high-efficiency	1.2	730
#3	A.O. Smith 120-gal	3.4	A.O. Smith 52 gal high-efficiency	1.0	876

(1) Savings presented here are for reduction in standby loss due to smaller, more efficient water heaters. Savings are projected for 365 days per year.

4.2.4 Lighting Energy

Figure 4.5 presents the average annual energy use of the lighting fixtures. These data are presented by room number for both the baseline and the efficient fixture cases. Per Table 3.1 and Table 3.2, it is important to note that laundry rooms #1 and #2 (both interior rooms without windows) were retrofit with T-8 lamps and electronic ballasts as well as controlled with an occupancy-based wall switch. Laundry room #3, having a window, was retrofit with the same fixtures but the occupancy-based wall switch also has a daylight setting implemented at 20 foot candles.

The relatively high baseline lighting energy use in laundry room #3 was attributed to the low light output of the existing incandescent fixtures and the relatively high day-lighting levels. This combination led to higher baseline on-time because most occupants did not notice the lights were on due to the high day-lighting levels.

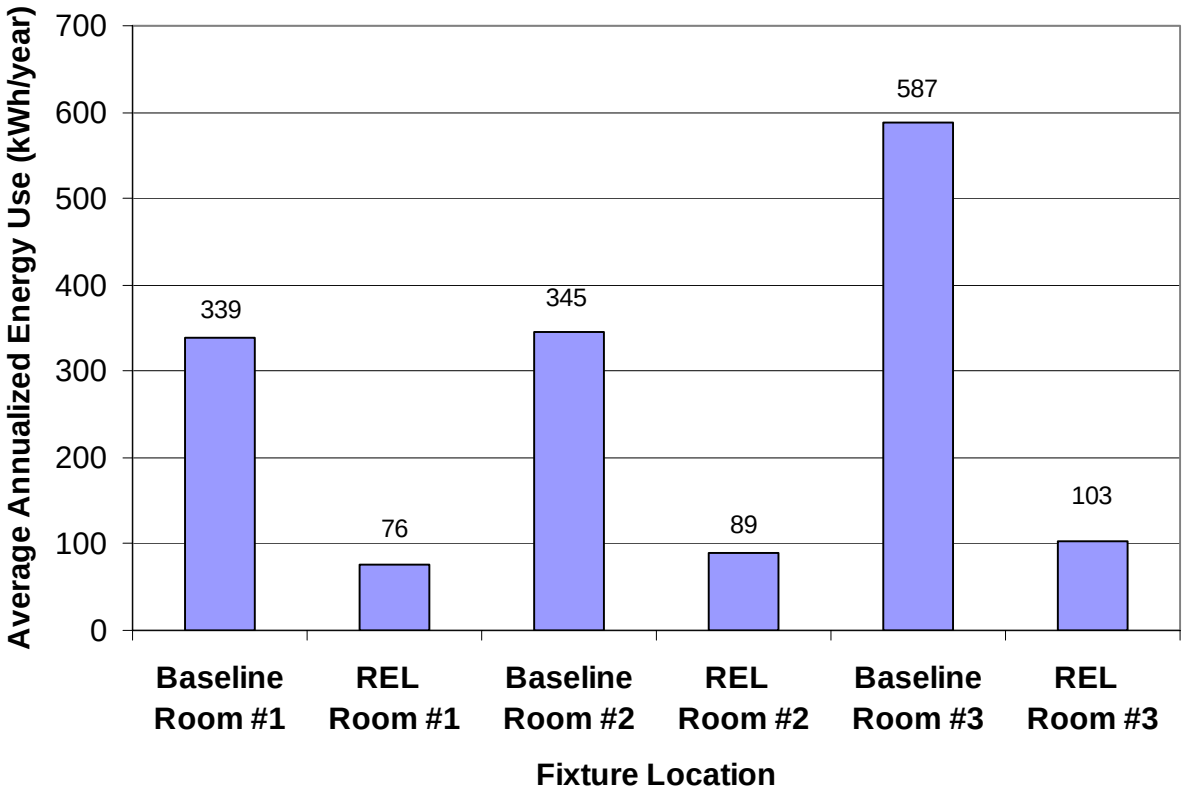

Figure 4.5. Average Lighting Energy Use (kWh/yr) Before and After Retrofit

Table 4.2 presents laundry room-specific baseline and retrofit equipment, average lighting levels, fixture on-time, and energy-savings data. It is important to note that not only are the new fixtures more efficient, but they provide better quality and quantity light. Light readings were taken on the top center of each washer and dryer for both the baseline and efficiency fixtures. As the data show, Laundry room #1 had an intensity increase of 24 foot candles (fc), for a 57% increase in light intensity. Laundry room #2 had an intensity increase of 19 fc, for a 52% increase in light intensity. Laundry room #3 showed the greatest improvement in light intensity increasing from an average of 3 fc to 35 fc, for a 1,363% increase in light intensity. The light readings for laundry room #3 were taken at night so as not to bias the results by day-lighting through the window. It is interesting to note that laundry room #3 also showed the greatest energy savings.

Table 4.2. Baseline and Retrofit Lighting Energy Consumption and Savings

Laundry Room	Baseline Lighting System	% On-time, Ave. Elec. Use (watt-hrs/day), Ave. intensity (foot candles)	Retrofit Efficient Lighting System	% On-time, Ave. Elec. Use (watt-hrs/day), Ave. intensity (foot candles)	Electric. Savings[(1)]
#1	1-surface-mount wrapped lens with 2-40W T-12 lamps; 1-surface-mount wrapped-lens with 2-34W T-12 lamps; electronic hybrid ballast; toggle switch	22.6% ---------- 929 Wh/day ---------- 43 fc	2-surface-mount wrapped-lens with 2-32W T-8 lamps, occupancy sensor	7.4% ---------- 209 Wh/day ---------- 67 fc	263 kWh/yr
#2	2-surface wrap with 2-34W T-12 lamps; rapid start magnetic ballast;toggle switch	22.9% ---------- 946 Wh/day ---------- 38 fcd	2-surface–mount wrapped-lens with, 2-32W T-8 lamps, occupancy sensor	8.9% ---------- 244 Wh/day ---------- 57 fc	256 kWh/yr
#3	3-40W bare-bulb incandescent bulbs; toggle switch	55.7% ---------- 1,608 Wh/day ---------- 3 fc	2-surface-mount wrapped-lens with, 2-32W T-8 lamps, occupancy sensor	10.1% ---------- 281 Wh/day ---------- 37 fc	484 kWh/yr

(1) Projected for 365 days per year.

5.0 Summary and Conclusions

The purpose of the demonstration was to measure and determine the expected energy and water savings from the combination of technologies installed in a REL room compared to a "standard" (baseline) common-area multifamily laundry room. The savings from the efficient technologies are quantified, and, based on average utility rates in Wisconsin, the cost-effectiveness – in terms of simple payback – is determined.

Table 5.1 summarizes the energy and water savings, and the incremental installed costs (or incremental installed cost *savings*) for each efficient retrofit measure based on the average across all three rooms in the demonstration compared to the baseline laundry room.[(4)] Also included in Table 5.1 are the total room annualized electricity savings, water savings, and total savings based on the measured efficient equipment performance (average of the three rooms). The savings are based on 1.5 cycles/day/washer.

The retrofit technologies in each of the laundry rooms, with the exception of the new dryers (on average), reduced the consumption of utilities (energy/water). Retrofit dryer energy use did not show a statistically significant difference potentially due to the vend configuration and differences in clothing types washed and washer sizes. However, an important finding regarding dryer energy use is the opportunity for further research and validation of energy savings of the existing moisture-sensing technology. This may lead to the development of next-generation sensors and controls that further reduce energy.

For this demonstration, simple payback is evaluated from the perspective of the multifamily owner/operator. Depending on the individual measure savings and overall payback, programs can then be designed to reduce the payback to encourage multifamily owner/operators to undertake retrofits.

Based on the incremental costs and savings from Table 5.1, the simple payback for a REL is 4.1 years. If the washers were used the multifamily industry average of ~2.5 cycles/day, the savings would increase to 3,525 kWh/year and 47,400 gal/year, giving a simple payback of 2.9 years.[(5)]

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(4) The baseline laundry room is equipped with three standard efficiency coin-operated washers (and dryers – not included in the analysis), one 120-gallon water heater, two surface mount 2-tube T12 fluorescent fixtures and a single wall switch.

(5) These results can be used to estimate the savings and payback for a gas water heating scenario. The data required for this analysis are the incremental cost of a 52-gallon high-efficiency gas water heater and the standby losses for both a baseline/standard and high-efficiency gas water heater.

Table 5.1. Estimated Cost and Savings for a REL Room

Technology	Incremental Cost of Technology	Energy Savings kWh/yr/room	Water Savings gal/yr/room	Total Savings[(1)] $
3-High-Performance Washers	$1,500	1,2651	28,400	$207[(1)]
Downsized High-Efficiency Water Heater	($250)	9331	NA	$791
2-High-Efficiency Lighting Fixtures	$20	484	NA	$41
Lighting Occupancy Control	$75	Included in lighting fixture savings	NA	-
Totals	$1,345	2,682	28,400	$327

(1) Savings based on 1.5 cycles/day/washer; $0.085/kWh and $3.50/1,000 gal water/wastewater cost.

Typically, the multifamily sector is interested in improvements and technologies that will give a very short payback (simple payback), generally 2 years or less (Sullivan, Parker, and Schmelzer 1999; Sullivan and Parker 1999; Sullivan and Parker 2000). Based on Table 5.1, an incentive (rebate, tax credit, etc.) of ~$700 per room would be needed to bring the simple payback to 2 years.

At 2.5 cycles/day/washer, the incentive would need only to be ~$400 to give a minimum payback of 2 years. This incentive is well within typical incentives (rebates and tax credits) for high-performance clothes washers found in many regions of the country (see www.lightwash.com, www.cee1.org/com/cwsh/01comwsh_progsum.pdf). It should be noted that simple payback calculations presented here do not include future utility rate increases—higher utility rates will shorten payback periods.

These results show that there are significant cost-effective water and energy savings that can be achieved from a resource efficiency multifamily laundry room. These data indicate that it is important to treat a multifamily laundry room as a *system* and give careful consideration to the suite of technologies in the room.

These data, and the supporting data from the REL demonstration, will enable the Wisconsin Focus on Energy/Apartment & Condo Efficiency Services program design future programs for their multifamily sector customers to obtain laundry room energy and water savings.

6.0 References

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