Resource-Efficient Laundry Room Demonstration and Evaluation: A Holistic Approach to Maximizing Energy, Water and Cost Savings In Multifamily Laundry Rooms

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ABSTRACT

The Focus on Energy (Focus)/Apartment & Condo Efficiency Services program identified the multifamily sector as both underserved and a difficult market to reach for energy efficiency services. In response, the Focus Apartment program manager 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 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 efficient (and properly sized) equipment. All energy and water inputs of the baseline and efficient equipment were end-use metered.

Summary

A resource efficient laundry (REL) room demonstration was undertaken in the laundry rooms of three multifamily apartment buildings in La Crosse, Wisconsin. The objective of the demonstration was to evaluate the cost-effectiveness of Energy Star® high-performance front- and top-loading clothes washers, matching clothes dryers, efficient room lighting, lighting occupancy controls, and efficient and properly sized water-heating technologies for private multifamily sector laundry rooms.

Based on the average incremental costs of efficient equipment of $1,345 and average savings of 2,682 kWh/year 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 being used an average of 1.5 cycles/washer/day, two lighting fixtures, a 50-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 Apartment & Condo Efficiency Services program. If this program was 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.

Technical Approach

The approach was to undertake baseline metering of three multifamily laundry rooms. The baseline equipment in the three rooms is given in Table 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.

Table 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; one with two 34-W and one with two 40-W T-12 lamps; both with electronic hybrid ballast; 172 W/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 two 34-W T-12 lamps with rapid start magnetic ballast; 172 W/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 - 40-W incandescent bulbs in porcelain fixtures; 120 W/room	1 - toggle

Each laundry room was retrofit 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-October 2003; the water heaters were metered for an extended period (until Mid-February 2004) due to some metering difficulties. Table 2 gives the characteristics of the efficient equipment.

Table 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 two 32-W T-8 lamps with generic electronic ballast; 116 W/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 two 32-W T-8 lamps with generic electronic ballast; 116 W/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 two 32-W T-8 lamps with generic electronic ballast; 116 W/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.

Baseline and High-Performance Clothes Washer Characteristics

The baseline washers were all relatively new Maytag top-loading, standard-efficiency, commercial coin-op soft-mount washers of the same vintage. The high-performance washers (and matching dryers) were purchased new from local and regional vendors. Table 3 gives the characteristics of the baseline and high-performance washers.

Table 3. Features and Characteristics of Clothes Washers in the 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 MAH12PDSAW	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.

Methodology

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 was identical.

- **Clothes Washer and Dryer Metering**: The baseline clothes washers were metered over a 4-month period starting in early February 2003 and concluding in mid-May 2003. The Energy Star® high-performance washers were installed in early June 2003 and were metered from mid-June 2003 through mid-October 2003.
- **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 were 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 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, 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 were manually downloaded. Because the water heaters were co-located with the washers in the laundry rooms, line loss was assumed to be minimal and not calculated. Hot and cold water temperatures were measured with spot measurements using a digital thermometer. Hot water temperatures ranged between 118°F to 123°F, cold water temperatures were consistent over the study period, ranging between 57°F and 59°F.

- **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.

Discussion

The findings from data collected on the baseline and high-performance clothes washers installed in the three laundry rooms are presented in Tables 4 and 5. Table 4 presents the measured water and energy consumption for the high-performance clothes washers over the period of the demonstration. Table 5 presents the measured water and energy savings of the high-performance washers by clothes washer manufacturer.

Table 4. Summary Energy and Water Consumption for Baseline and High-Performance Washers

Clothes Washer Manufacturer/ Model (# washers/#total cycles)	Average Cycles/Day per Washer	Average Total Water Use (gal/cycle)	Average Hot Water Use (gal/cycle)	Average Cold Water Use (gal/cycle)	Average Motor & Controls Energy Use (kWh/cycle)	Average Total Energy Use (kWh/cycle)
Maytag MAT12 PD baseline top load ***(9 washers/619 cycles)***	1.4	30.9	6.9	24.4	0.13	1.17
Maytag MAH21PDAWW ***efficient front load*** (3 washers/362 cycles)	1.6	13.7	2.1	11.6	0.075	0.40
Maytag MAH12PDSAW ***efficient top load*** (1 washers/139 cycles)	1.8	32.1	5.2	26.9	0.142	0.93
Speed Queen SWR261 ***efficient front load*** (3 washers/316 cycles)	1.4	17.8	2.1	15.7	0.09	0.41
Speed Queen SWTT21NW ***efficient top load*** (1 washer/143 cycles)	2.0	22.8	6.0	16.8	0.187	1.10
Whirlpool Resource Saver CAW2762KQ ***efficient top load*** (1 washer/110 cycles)	1.3	28.8	7.4	21.4	0.280	1.40

Table 5. Per-Machine Energy and Water Savings of High-Performance Washers Compared with Baseline Clothes Washers

Clothes Washer Manufacturer/Model (# washers/# total cycles)	Average Electricity Savings (kWh/cycle)	Average Electricity Savings/Machine (kWh/year) [1]	Average Water Savings/Machine (gal/cycle)	Average Water Savings/Machine (gal/year) [1]
Maytag MAH21PDAWW ***Efficient front load*** ***(3 washers/362 cycles)***	0.78	426	17.6	9,636
Maytag MAH21PDAWW ***Efficient top load*** (1 washer/139 cycles)	0.24	132	-0.08	-438
Speed Queen SWR261 ***Efficient front load*** (3 washers/316 cycles)	0.76	418	13.5	7,391
Speed Queen SWTT21NW ***Efficient top load*** (1 washer/143 cycles)	0.08	42	8.5	4,654
Whirlpool Resource Saver CAW2762KQ ***Efficient top load*** (1 washer/110 cycles)	-0.23	125	2.6	1,424

[1]Annual (365 day) savings based on 1.5 cycles/day/machine.

Clothes Dryer Energy Consumption

The energy consumption of the baseline and retrofit dryers is given in Table 6. Note that in Room #3, there are three different brands of washers and their matching dryers. The metering strategy was not developed to determine which dryer is used for any given washing machine or washer load.

Energy consumption of coin-operated dryers is largely controlled by vend amount.[1] From the data it is apparent that 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. It should be noted that on the residential versions of new dryers, moisture sensors control the drying time. When receiving clothes that are drier from the washer (a lower RMC), the dryer will use less energy to achieve the desired level of drying.

From the data presented here, this same control technology does not seem to be employed, or not employed to the same extent. This is an important finding given the relative significance of dryer energy use as a function of total room energy. In the baseline case, dryers make up roughly 60% of total room energy – excluding HVAC-related energy use.

[1] The vend amount is the amount of money required for each clothes washing or drying cycle.

Table 6. Baseline and Retrofit Clothes Dryer Energy Consumption

Laundry Room	Clothes Dryer	Total Cycles Measured	Electricity Consumption kWh/cycle
All 3 rooms	Baseline 9 - Maytag MDE16PD	592	3.74
#1	3 - Speed Queen SDET07FW	258	3.60
#2	3 - Maytag MDE16PDAYW	292	3.42
#3	1 - Maytag MDE16PDAYW 1 - Whirlpool CEM2760KQ 1 - Speed Queen SDET07FW	349	3.65

The relatively large energy use of coin-operated dryers and the decoupling of washer and dryer interaction, presumably due to the vend nature of the equipment, presents a significant opportunity for further research and potential savings.

Water Heater Energy Consumption

Table 7 summarizes the water heater energy consumption and savings for the baseline and retrofit water heaters in each laundry room (total of three washing machines in each room). The interaction between the reduced requirement of hot water by the efficient clothes washers and the ability to now undersize water heaters was an important element of this study. In two of the three rooms the water heaters were downsized from 120 gallon to 52 gallon; in the third room the water heater was downsized to a more conservative 80 gallon unit.

As shown in Table 7, significant energy savings resulted at the water heater. The data presented are for savings associated with reduced standby energy use. These reductions result from the smaller and more efficient water heater replacements. The savings associated with the reduced hot water demand are credited at the clothes washer as shown in Tables 4 and 5.

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

Table 7. Baseline and Retrofit Water Heating Energy Consumption and Savings

Laundry Room	Baseline Water Heater	Average Electricity Consumption kWh/day	Retrofit Water Heater	Average Electricity Consumption kWh/day	Electricity Savings kWh/yr[1]
#1	A.O.Smith 120 gal	8.0	A.O. Smith 52 gal high efficiency	2.2	933
#2	A.O.Smith 120 gal	7.9	A.O. Smith 80 gal high efficiency	2.6	740
#3	A.O. Smith 120 gal	9.5	A.O. Smith 52 gal high efficiency	6.5	914

[1]Savings presented here are for reduction in standby loss due to smaller, more efficient water heaters. Savings from reduced hot water consumption are reflected in clothes washers in Table 5. Savings are projected for 365 days/year.

Laundry Room Lighting Consumption Summary Data

Table 8 shows summary data of lighting energy consumption during the monitoring period for the baseline lighting system and for the retrofit system with efficient fixtures and occupancy sensors. These data are presented by room number for both the baseline and the efficient fixture cases. 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.

Table 8. Baseline and Retrofit Lighting Energy Consumption and Savings

Laundry Room	Baseline Lighting System	% On-Time & Average Electricity Consumption	Retrofit Efficient Lighting System	% On-Time & Average Electricity Consumption	Electricity Savings[1]
#1	1 - surface wrap with two 40-W T-12 lamps; 1 - surface wrap with two 34-W T-12 lamps; toggle switch	22.6% 929 Wh/day	2 - surface wrap with two 32-W T-8 lamps + occupancy sensor	7.4% 209 Wh/day	263 kWh/yr
#2	2 - surface wrap with two 34-W T-12 lamps; toggle switch	22.9% 946 Wh/day	2 - surface wrap with two 32-W T-8 lamps + occupancy sensor	8.9% 244 Wh/day	256kWh/yr
#3	3 - 40-W incandescent bulbs; toggle switch	55.7% 1,608 Wh/day	2 - surface wrap with two 32-W T-8 lamps + occupancy sensor	10.1% 281 Wh/day	484 kWh/yr

[1]Projected for 365 days (1-year).

Summary and Conclusions

The purpose of this monitored demonstration was to measure and verify the expected energy and water savings from the combination of technologies installed in a REL room compared with 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 9 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 with the baseline laundry room. Also included in Table 9 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). For the dryers, the energy consumption of the retrofit dryers nominally *increased* over the baseline dryers. However, this increase fell within the error margin of the monitoring equipment and therefore, was not deemed significant. An important finding regarding dryer energy use is the significant opportunity for further research and energy savings through the deployment of moisture-sensing technology. This technology, already used in residential dryers, would serve to couple the washer and dryer (i.e., take advantage of the lower RMC of clothes from most front-load washers) and afford reduced dryer energy use.

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 9, the simple payback for a REL is 4.1 years. If the washers 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]

Table 9. Estimated Cost and Savings for a REL

Technology	Incremental Cost of Technology	Energy Savings kWh/yr/room	Water Savings gal/yr/room	Total Savings $
High-Performance Washers (3)	$1,500	1,265[1]	28,400	$207[1]
Downsized High-Efficiency Water Heater	($250)	933[1]	NA	$79[1]
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.

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 9, 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).

[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 Focus on Energy Apartment & Condo Efficiency Services program design future programs for their multifamily-sector customers to obtain laundry room energy and water savings.

References

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