Energy Efficient Showerhead and Faucet Aerator Metering Study Multifamily Residences: A Measurement and Evaluation Report

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Executive Summary

In September 1993, the Bonneville Power Administration (Bonneville), in cooperation with Seattle City Light and the Seattle Water Department, began a study to evaluate the energy and water impacts of selected water conservation measures installed in multifamily buildings in the Pacific Northwest. The primary purpose of this study was to quantify the energy savings that were realized from efficient showerheads and faucet aerators that were retrofitted on a sample of multifamily housing units. Occupants of the housing units represented a range of income levels and locations throughout the Seattle City Light service area. Secondary purposes of the study included the evaluation of participant satisfaction with the installed energy conservation measures and the estimation of water savings achieved by water conservation measures installed on leaking toilets in selected housing units.

Six specific objectives were established as the basis for the study. They included:

- Estimation of the electric energy savings achieved by the package of efficient showerheads and faucet aerators installed in a sample of multifamily housing units located in Seattle.
- Estimation of the electric energy savings achieved by the individual components of the installed hot water conservation packages. The installed measures included low flow (2.5 gallons per minute) and very low flow (2.0 gpm) showerheads and faucet aerators in kitchen and bathroom sinks.
- Determination of statistical relationships that exist between the energy savings of the installed hot water

measures and major determinants of hot water consumption.

- Assessment of measurement error associated with short-term measurements made to support the evaluation of savings.
- Determination of participant satisfaction with the installed conservation measures.
- Estimation of water savings achieved by water conservation measures installed on the toilets of selected housing units that were observed to have leaking toilets.

Methodology

This study was the first attempt to quantify annual energy savings for efficient showerheads and faucet aerators using device level flow measurements recorded in a sample of multifamily housing units both before and after installation of the measures. The study was made possible with the recent availability of a non-intrusive in-line flow meter that was capable of making reasonably accurate flow measurements at an affordable cost.

A pre-post or before-after experimental design was chosen to assess the impacts of the energy conservation measures. For each of the 93 participating housing units in a seven building sample, a series of three site visits were performed to collect data before and after the installation of a package of conservation measures. Data collection included occupant and building characteristics and an extensive set of device level, one-time and short-term measurements of water system performance. These data were used to support an analysis of energy savings and customer satisfaction with the measures. The measures consisted of efficient showerheads and faucet aerators in the kitchen and bathroom sinks. In selected buildings toilet water conservation measures were also installed. The analysis was based upon the change in system performance between the pre-retrofit and post-retrofit periods. A separate energy savings analysis was performed for all of the installed energy conservation measures and the subset of measures that resulted in a net flow rate reduction.

Four different analysis methods were used to estimate the electric energy savings from the efficient showerhead and faucet aerator package installed in each housing unit. Three analysis methods were used to evaluate the measures on an individual basis. Each of the methods involved an engineering analysis of the data collected during the site visits. The analysis methods varied in their complexity, cost of application and in the specific data sources that were used as the basis for the savings calculations.

During the third site visit, tenants were interviewed regarding their satisfaction with the installed energy conservation measures. The survey was administered to all tenants who were home and willing to be interviewed. The survey assessed customer attitudes toward three topics that included overall satisfaction with the measures, a comparison of features with the old equipment and changes in equipment operation as a result of the measures. The showerhead and faucet aerator measures were addressed separately in the survey.

Results

The research methodology was successfully applied to each of the 93 participants. Major findings of the research are summarized below.

Building and Occupant Characteristics

The selected sample of participants represented a range of locations and income levels in the Seattle City Light service territory. The average housing unit in the sample contained 1.1 bathrooms, 2.1 sinks and 1.0 showers. The average housing unit also had 2.0 occupants that ranged in age from 19 to 98 years. The average occupant was 45 years old. During the pre-retrofit period, the average household

turnover and an increased vacancy rate during the post-retrofit period, the average number of showers was reduced to 9.7 per week and the shower duration was reduced to about 10 minutes per day. The increased vacancy rate during the post-retrofit period was also reflected in a lower reported number of person days homes.

Conservation Measures

Energy efficient showerheads and faucet aerators were installed in each participating housing unit during the second site visit. The measures were installed comprehensively to all housing units, regardless of the efficiency of the existing hot water system. Exceptions were only made in cases where faucet aerators would not fit properly on the existing fixtures. A total of 21 low flow showerheads (rated 2.5 gpm), 75 very low flow showerheads (rated 2.0 or 2.2 gpm), 89 kitchen faucet aerators (rated 2.0 gpm) and 91 bath faucet aerators (rated 1.5 gpm) were installed across the building sample. Up to four toilet water conservation measures were installed in selected housing units in three of the seven buildings in the sample.

Hot Water System Energy Performance Measurements

Two types of measurements were made during the site visits to support the evaluation of energy and water savings. They included one-time and short-term measurements of parameters that were major determinants of water system performance. One-time measurements were made to determine system temperatures, pressures, flow rates and power characteristics before and after the installation of the conservation measures. The short-term measurements were made to determine system water flows and hot water tank run time for the same periods. A summary of important one-time and short-term measurements is provided in Table S-1.

Table S-1: Hot Water System Energy Performance Measurements

Parameter	Pre-Period	Post-Period

	Min	Max	Mean	Min	Max	Mean
One-Time Measurements (per home)						
Shower User Setting Mixed Flow Temperature (F)	101.7	108.9	104.2	102.4	108.3	106.4
Low-Flow Showerhead Full Throttle Flow Rate* (GPM)	1.1	7.9	4.1	1.2	2.1	1.7
Low-Flow Showerhead User Setting Flow Rates (GPM)	1.1	5.7	2.7	1.0	1.9	1.4
Very Low-Flow Showerhead Full Throttle Flow Rate (GPM)	0.8	7.7	2.8	1.1	2.3	1.9
Very Low-Flow showerhead User Setting Flow Rate (GPM)	0.9	3.9	2.1	0.9	2.2	1.7
Kitchen Faucet User Full Throttle Flow Rate* (GPM)	0.9	4.8	2.4	0.9	2.5	1.8
Kitchen Faucet User Setting Flow Rate (GPM)	0.3	3.5	1.3	0.2	2.1	1.1
Bath Faucet Full Throttle Flow Rate* (GPM)	0.8	4.9	2.1	0.6	1.8	1.3
Bath Faucet User Setting Flow Rate (GPM)	0.1	4.4	1.2	0.1	1.5	0.8
Short Term Measurements (per home)						
Total Hot Water Flow (GPD)	4.7	102.7	32.1	0.0	72.2	24.1
Low-Flow Showerhead (Hot & Cold) Flow (GPD)	0.1	50.7	12.9	0.2	41.2	9.5
Very Low-Flow Showerhead (Hot & Cold) Flow (GPD)	0.0	60.6	13.9	0.0	37.0	8.1
Kitchen Faucet Hot Water Flow (GPD)	0.1	55.3	11.0	0.0	56.5	8.6
Bath Faucet Hot Water Flow (GPD)	0.0	24.1	4.5	0.0	13.3	3.2

Hot Water Tank Run Time (Hrs/Day)	0.0	12.8	2.4	0.0	13.7	1.8

*Full throttle flow rates were measured at equal proportions of hot and cold water.

Package Energy Savings

Energy savings for the package of measures (efficient showerheads and faucet aerators) installed in the housing units were computed using four analysis methods. Energy savings estimated by the four methods, with outliers removed, ranged from 368 to 524 kWh/yr. when all measures were considered. From a detailed review of the alternative estimates, it was recommended that a savings value of 400 kWh/yr. be used for the package that considered all measures. A separate analysis was performed on the subset of measures that resulted in a flow rate reduction. As expected, the savings increased significantly when only these cases were considered. The best estimate of package savings derived from this analysis was 600 kWh/yr.

Individual Measure Energy Savings

Energy savings for the individual conservation measures within the package were computed using three analysis methods. A separate analysis was performed for the low flow showerheads, the very low flow showerheads, kitchen faucet aerators and bathroom faucet aerators. Similar savings were found for the low flow and very low flow showerheads. When all showerheads were considered, the best estimate of energy savings for both showerheads was recommended to be 200 kWh/yr. This result was not surprising, since the measured post-retrofit flow rates for the low flow showerheads were less than the very low flow showerheads. When only flow rate reduction measures were considered, the best estimate of energy savings for both showerheads increased to 250 kWh/yr.

Significant energy savings were realized from both the kitchen and bath faucet aerators. After reviewing the alternative savings estimates, the best estimate of savings was recommended to be 90 kWh/yr. and 80 kWh/yr. for the kitchen and bathroom faucet aerators, respectively, when all aerators were considered. Savings increased to 180 kWh/yr. and 100 kWh/yr. for the kitchen and bathroom aerators when only the net flow rate reduction measures were considered.

Participant Satisfaction

The results of the participant satisfaction survey for the efficient showerheads showed a high degree of overall satisfaction. Most (76 percent) of the respondents were either very satisfied, satisfied or somewhat satisfied with the showerheads. The tenants most frequently found the shower "feel" to be better with the new showerheads. They most frequently saw no change with the new showerhead for spray pattern, amount of water flow, spray adjustment and appearance. An equal number of respondents found the overall performance of the efficient showerhead to be better or about the same as the old showerhead. Twenty percent or less of the tenants found the new showerhead to be less desirable across the six features included in the survey. All or nearly all of the tenants said that their showering habits did not change with the new showerheads.

The survey results for the faucet aerators were similar to the showerheads in that the tenants expressed a high degree of overall satisfaction with the faucet aerators. About 88 percent of the tenants surveyed were very or somewhat satisfied with the new equipment. "About the same" was the most frequent response to the comparison of five features between the old and new aerators. This result was not unexpected since in several cases the new aerator replaced an existing aerator of equal and greater efficiency. The new aerators performed best for the spray pattern and overall performance features. None of the tenants changed their faucet use habits as a result of the new aerator.