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ENERGY EFFICIENT SHOWERHEAD AND FAUCET AERATOR METERING STUDY MULTIFAMILY RESIDENCES AND EVALUATION REPORT

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EXECUTIVE SUMMARY

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

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 ae a sample of multifamily housing units located in Seattle.
- Estimation of the electric energy savings achieved by the individual components of the installed hot wate packages. The installed measures included low flow (2.5 gallons per minute) and very low flow (2.0 gpm) faucet aerators in kitchen and bathroom sinks.
- Determination of statistical relationships that exist between the energy savings of the installed hot wate major determinants of hot water consumption.
- Assessment of measurement error associated with short-term measurements made to support the evalu
- Determination of participant satisfaction with the installed conservation measures.
- Estimation of water savings achieved by water conservation measures installed on the toilets of selectec were observed to have leaking toilets.

METHODLOGY

This study was the first attempt to quantify annual energy savings for efficient showerheads and faucet aerato level flow measurements recorded in a sample of multifamily housing units both before and after installation of study was made possible with the recent availability of a non-intrusive in-line flow meter that was capable of m 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 m of the 93 participating housing units in a seven building sample, a series of three site visits were performed to and after the installation of a package of conservation measures. Data collection included occupant and buildin and an extensive set of device level, one-time and short-term measurements of water system performance. Th used to support an analysis of energy savings and customer satisfaction with the measures. The measures con showerheads and faucet aerators in the kitchen and bathroom sinks. In selected buildings toilet water conserv were also installed. The analysis was based upon the change in system performance between the pre-retrofit a periods. A separate energy savings analysis was performed for all of the installed energy conservation measur 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 showerhea aerator package installed in each housing unit. Three analysis methods were used to evaluate the measures o basis. Each of the methods involved an engineering analysis of the data collected during the site visits. The ana varied in their complexity, cost of application and in the specific data sources that were used as the basis for th calculations.

During the third site visit, tenants were interviewed regarding their satisfaction with the installed energy conse The survey was administered to all tenants who were home and willing to be interviewed. The survey assessec

attitudes toward three topics that included overall satisfaction with the measures, a comparison of features wit equipment and changes in equipment operation as a result of the measures. The showerhead and faucet aera addressed separately in the survey.

RESULTS

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

Building and Occupant Characteristics

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

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

Conservation Measures

Conservation Measures
Energy efficient showerheads and faucet aerators were installed in each participating housing unit during the s
The measures were installed comprehensively to all housing units, regardless of the efficiency of the existing h
Exceptions were only made in cases where faucet aerators would not fit properly on the existing fixtures. A tot
showerheads (rated 2.5 gpm), 75 very low flow showerheads (rated 2.0 or 2.2 gpm), 89 kitchen faucet aerator
and 91 bath faucet aerators (rated 1.5 gpm) were installed across the building sample. Up to four toilet water
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 sa
included one-time and short-term measurements of parameters that were major determinants of water system
time measurements were made to determine system temperatures, pressures, flow rates and power character
after the installation of the conservation measures. The short-term measurements were made to determine sy
and hot water tank run time for the same periods. A summary of important one-time and short-term measurem
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 housi
computed using four analysis methods. Energy savings estimated by the four methods, with outliers removed,
524 kWh/yr. when all measures were considered. From a detailed review of the alternative estimates, it was re
savings value of 400 kWh/yr. be used for the package that considered all measures. A separate analysis was p
subset of measures that resulted in a flow rate reduction. As expected, the savings increased significantly whe
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 analys
separate analysis was performed for the low flow showerheads, the very low flow showerheads, kitchen fauce
bathroom faucet aerators. Similar savings were found for the low flow and very low flow showerheads. When a
were considered, the best estimate of energy savings for both showerheads was recommended to be 200 kW
not surprising, since the measured post-retrofit flow rates for the low flow showerheads were less than the ve
showerheads. When only flow rate reduction measures were considered, the best estimate of energy savings
showerheads increased to 250 kWh/yr.

Significant energy savings were realized from both the kitchen and bath faucet aerators. After reviewing the alt
estimates, the best estimate of savings was recommended to be 90 kWh/yr. and 80 kWh/yr. for the kitchen an
aerators, respectively, when all aerators were considered. Savings increased to 180 kWh/yr. and 100 kWh/yr. f
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
(76 percent) of the respondents were either very satisfied, satisfied or somewhat satisfied with the showerhea
most frequently found the shower "feel" to be better with the new showerheads. They most frequently saw no
new showerhead for spray pattern, amount of water flow, spray adjustment and appearance. An equal numbe
found the overall performance of the efficient showerhead to be better or about the same as the old showerhe
or less of the tenants found the new showerhead to be less desirable across the six features included in the su
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 hig
satisfaction with the faucet aerators. About 88 percent of the tenants surveyed were very or somewhat satisfie
equipment. "About the same" was the most frequent response to the comparison of five features between the
aerators. This result was not unexpected since in several cases the new aerator replaced an existing aerator o

efficiency. The new aerators performed best for the spray pattern and overall performance features. None of th their faucet use habits as a result of the new aerator.