Service Water Heating Savings for Low-Flow Fixtures

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Prepared for:
Sustainable Buildings Canada

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Background

Sustainable Buildings Canada (SBC) delivers the Savings by Design incentive program on behalf of Enbridge Gas Distribution. The program facilitates the use of the integrated design process with the goal of achieving energy savings beyond the Building Code Reference Building, as demonstrated by an energy model.

In some sectors (notably multi-residential buildings), the energy required to heat service hot water can represent a large portion of building energy consumption.

The Ontario Building Code currently mandates maximum water fixture flow rates. There are several commercially available fixtures with flow rates that are below these maximums:

Table 1 - Code and Low-flow Fixture Flow Rates

	OBC 2012 (LPM)	Commercially Available Low-Flow Fixtures (LPM)
Lavatory Sink	8.35	1.9 - 5.7
Showers	7.6	5.7 – 6.6
Kitchen Sink	8.35	5.7 – 7.6

The Ontario Building Code does not currently allow low-flow domestic water fixtures to be considered as a creditable measure when applying the performance path for energy saving compliance, i.e., the low-flow fixtures cannot be used as a trade-off measure to enable performance compliance.

Some green building rating systems, such as LEED, do consider low-flow fixtures to be an efficiency measure, and encourage their use by allowing designers and energy modelers to consider them as a credit in energy calculations. SBC believes that consideration should be given to allowing the use of water savings measures in the accrual of energy savings as part of the SBD program and requested that EQ undertake a study to determine if this was appropriate based on the research. SBC further requested that EQ undertake energy modelling and supporting analysis to provide estimates of hot water savings.

With this mandate, the study addresses the following key questions:

1. How are low-flow fixtures credited under current energy standards or energy efficiency incentive programs?

2. Is there evidence that low flow fixtures actually save water and, if so, by how much?

3. Do energy models appropriately predict annual hot water usage?

4. What are the appropriate energy savings measure inputs to use in the SBD modelling activity?

Eligibility for Water Savings in Selected Standards and Green Building Programs

A review of current industry energy standards and green building programs was conducted to assess whether the use of low-flow plumbing fixtures was recognized as a creditable savings measure. The findings are presented in Table **2**. A more detailed commentary is available in Appendix A to describe how each standard approaches the issue.

Table 2 - Eligibility of Low-Flow Fixtures for Energy Credit

Standard / Reference	No Credit	Credit Available	Not Specifically Addressed
90.1-2010 (Sec. 11)*	X		
90.1-2007/2010 (App. G)		X	
90.1-2013 (Sec. 11)	X		
90.1-2013 (App. G)	X		
MNECB-1997*	X		
EE4 Modeling Guide		X	
NECB-2011*	X		
HPNC			X
Toronto Green Standard (EEO energy modeling terms of reference)			X
LEED Canada		X	

The standards marked with an (*) in Table 1 are the current compliance options available for the Ontario Building Code. As part of the delivery of the SBD program, SBC uses the ASHRAE 90.1-2010 Section 11 (as amended by SB-10) as the baseline for the analysis. All current Ontario Building Code performance paths (i.e. 90.-2010 Sec 11, MNECB-1997, or NECB-2011) do not recognize low-flow fixtures as a creditable measure for minimum code compliance.

When energy codes do not allow credit for low-flow plumbing fixtures, it is usually due to the standard's intent. Both ASHRAE 90.1-2010/2013 Section 11 and NECB 2011 are generally intended to show overall compliance with a minimum performance threshold rather than to credit high performance design. In these types of standards, many features of design are considered neutral between the reference and baseline buildings. This represents a particular limitation for programs such as SBD wherein the general intent of the program is to advance energy performance through better design.

Standards and reference guides that were developed for the purpose of awarding improved building performance (such as the EE4 Modelling Guide and LEED) often do allow credit for low flow fixtures. In the case of LEED, low-flow fixtures are encouraged as a water savings feature. For energy credits, LEED references ASHRAE 90.1-2007 Appendix G (LEED 2009) or ASHRAE 90.1-2010 Appendix G (LEED v4), which recognize low-flow fixture credit using calculations, as described in Table G3.1.11(i) Exception 1.

HPNC and the Toronto Green Standard exist to award improved performance over the Ontario Building Code. To that end, they tend to refer to the rules of the individual code compliance path being used for compliance rather than defining their own allowances.

Literature Review of Low-Flow Fixture Research

A literature review was conducted to find publications that attempt to quantify the impact of low-flow fixtures on either water or energy consumption. During this review, it was found that there were limited papers that quantify how much energy or water is saved through the use of low-flow fixtures. The following papers were identified as they most closely aligned with the purposes of this study:

1. "Water and Energy Savings from High Efficiency Fixtures and Appliances in Single Family Home, Volume 1". US EPA – Combined Retrofit Report, March 28, 2005. [1]

While focused on a slightly different demographic (single family homes vs MURBs), detailed water savings calculations were available.

2. "Measures and Assumptions for Demand Side Management (DSM) Planning", Navigant Consulting. Presented to Ontario Energy Board, April 16, 2009. [2]

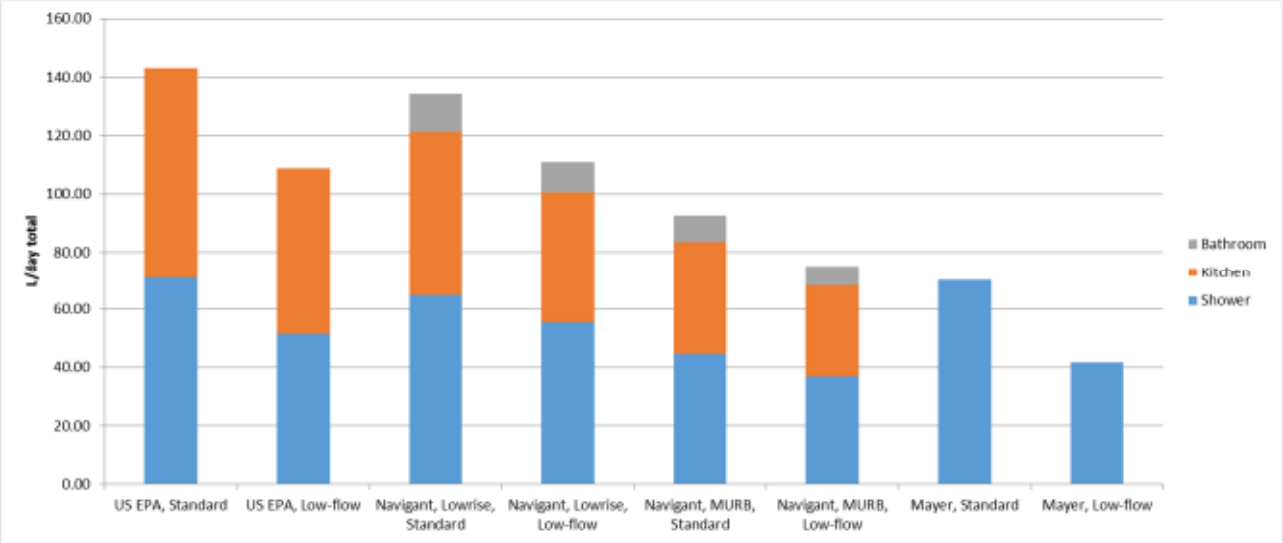
Focusing on both low-rise residential and multifamily applications, detailed water and DHW fuel savings were presented.

3. "Residential End Use of Water", Mayer et al., Aquacraft Inc, Prepared for AWWA Research Foundation, 1999.[3]

The third paper is an older study that primarily sought to quantify whether the use of low flow fixtures resulted in differences in fixture use with varying flow rates.

Calculated savings using data from each of the three studies for the three main domestic hot water end uses are summarized in Figure **1**.

Figure 1 - Water Savings from Literature Review



Although the definition of low-flow fixtures varied in the referenced studies, there appeared to be a consistent and quantifiable savings of approximately 20-30% associated with low-flow fixtures in all cases studied. In studies where the kitchen and bathroom fixtures are separated, it appears that the majority of the savings is attributable to showers. Given that showers typically have higher flow rates and duration of use than other fixtures, this result was as expected. It is further noted that kitchen and bathroom fixtures may have usage that is volume based (i.e. wherein a sink is filled and the flow rate does not impact the usage) which may impact expected savings for low flow measures.

Modeled vs Metered Data

Provident Energy Management Inc has a sub-metering practice and its sustainability division has recently become EQ Building Performance Inc. As part of the sub-metering business, Provident has installed and continuously monitors suite-level domestic hot water meters in approximately 5000 high-rise residential suites in the Greater Toronto Area.

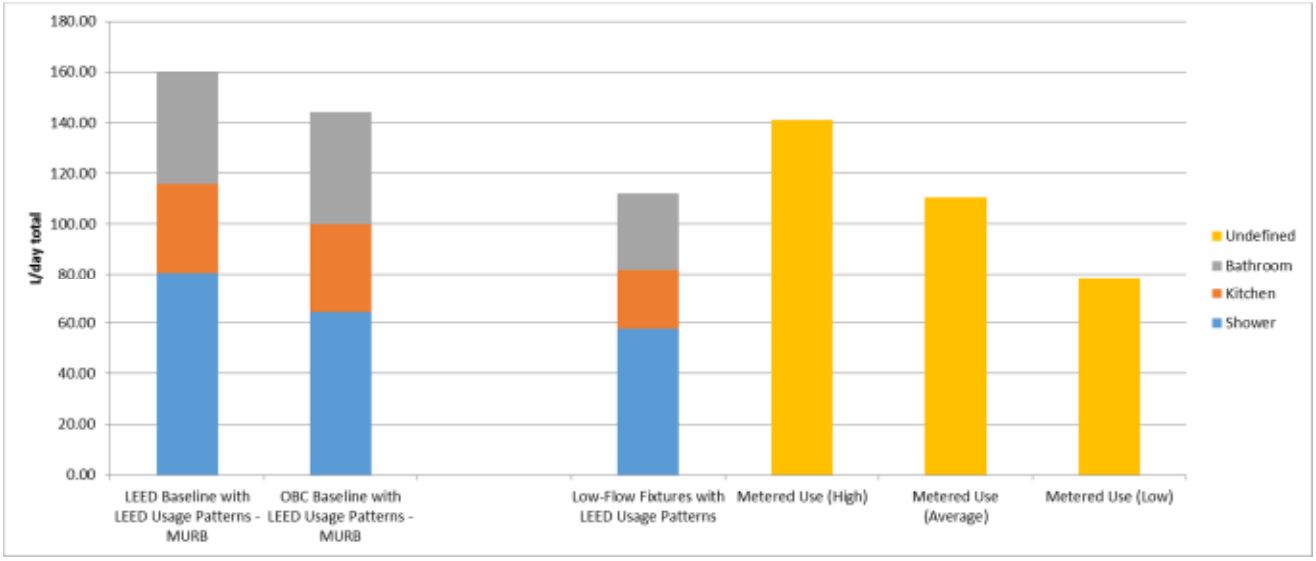
In an effort to investigate whether typical modeling conventions appropriately represent actual hot water consumption patterns, modeled hot water consumption was compared to actual metered data.

The calculated (modeled) values were based on the LEED 2009 Reference Guide's WEp1 methodology. This is a widely accepted and adopted methodology within the modeling community. It outlines predicted uses per day for various fixtures for both residential and non-residential applications. A recent study by Tysoe et al. attempted to quantify which methodology most accurately reflected water use and found LEED 2009's methodology to be the most accurate[4].

The metered data is based on a 14-building, 1-year database of measured hot water consumption. It is noted that all of the metered buildings are fitted with what would typically be classified as low-flow domestic water fixtures, with some specific flow rate variability among buildings. While not able to directly compare metered standard flow and low-flow fixtures, Provident's metered data can be used to validate current modeling methodology.

The data for all buildings was aggregated and compared against modeled data. Results appear in Figure 2.

Figure 2 - Modeled vs Metered Hot Water Data



In the three left-most bars LEED WEp1 methodology was used to estimate water usage patterns with three different sets of fixture flow rates:

1. LEED WEp1 baseline rates,
2. OBC 2012 maximum rates, and
3. Low-flow fixture rates.

The flow rates used for each case were as follows:

Table 3 - Flow Rates Used in Water Use Calculation

	LEED Baseline (LPM)	OBC 2012 (LPM)	Low-Flow Fixtures (LPM)
Lavatory Sink	8.3	8.35	5.7
Showers	9.5	7.6	5.7
Kitchen Sink	8.3	8.35	5.7

The three bars on the right show the actual measured water usage from Provident's database of metered buildings with low-flow fixtures. By comparing the "Low Flow Fixtures with LEED Usage Patterns" and "Metered Use (Average)", the two usage rates are very similar. This suggests that the current LEED methodology is a very strong indicator of actual hot water demand.

Summary

Low-flow plumbing fixtures are not treated consistently in all energy codes and standards currently used in the building industry. All of the standards used for Ontario Building Code compliance do not allow credit for low-flow fixtures. When working to encourage enhanced building performance (rather than just compliance), various green rating systems give credit and do recognize energy savings from low-flow fixtures.

The literature review performed for this study seems to back up the approach that buildings are able to see a reduction in both water and gas use through the use of low-flow plumbing fixtures.

By comparing calculated flow rates to actual metered data for low-flow fixture use, it was confirmed that the current methodology used for modeling energy associated with domestic hot water is accurate to real-life usage.

Recommendations

Based on the results of this study, EQ would recommend that SBC allow credit for low-flow fixtures in the Savings by Design program. In order to ensure consistency, EQ further recommends that SBC require the use the LEED WEp1 methodology to estimate these savings as outlined in the Tables below.

Table 4 - Recommended Residential Service Water Inputs

	OBC 2012 Flow Rate (LPM)	Use Duration (seconds)	Uses / Day
Lavatory Sink	8.35	60	5
Shower	7.6	480	1
Kitchen Sink	8.35	60	4

Table 5 - Recommended Non-Residential Service Water Inputs

	OBC 2012 Flow Rate (LPM)	Use Duration (seconds)	Full Time Uses / Day	Visitor Uses / Day	Retail Customer Uses / Day
Lavatory Sink	8.35	15	3	0.5	0.2
Shower	9.6	300	0.1	0	0
Kitchen Sink	8.35	15	1	0	0

References

1. "Water and Energy Savings from High Efficiency Fixtures and Appliances in Single Family Home, Volume 1". US EPA – Combined Retrofit Report, March 28, 2005.

2. "Measures and Assumptions for Demand Side Management (DSM) Planning", Navigant Consulting. Presented to Ontario Energy Board, April 16, 2009.

3. "Residential End Use of Water", Mayer et al., Aquacraft Inc, Prepared for AWWA Research Foundation, 1999.

4. "Disparate Standards: Comparing Standard Domestic Hot Water Modeling Methods for Multi-Residential Buildings" Brian Tysoe and Xiangjin Yang, 2016

5. "LEED® Canada Reference Guide for Green Building Design and Construction 2009", Canada Green Building Council, 2010

Appendix A – Detailed Standard / Reference Allowances

ASHRAE 90.1-2010 Section 11

- Per Table 11.3.1.12: All process loads shall be modeled identical in the proposed and reference buildings. No credit is allowed.

ASHRAE 90.1-2007/2010 Appendix G

- Per Table G3.1.11.i. Exception 1: Service hot-water usage can be demonstrated to be produced by documented water conservation measures that reduce the physical volume of *service* water required. Examples include low-flow shower heads. Such reduction shall be demonstrated by calculations..

ASHRAE 90.1-2013 Section 11

- Per Table 11.3.1.12: All process loads shall be modeled identical in the proposed and reference buildings. No credit is allowed.

ASHRAE 90.1-2013 Appendix G

- Per Table G3.1.11.i.: Service water loads and usage shall be the same for both the baseline building design and the proposed design. No credit is allowed

MNECB 1997

- Per MNECB 1997 5.4.13.2: The service water load shall be the same in proposed and reference.

EE4 modeling guide

- Section 1.5: Credit is available for fixtures that limit flow to below MNECB maximum flow rates.

NECB 2011

- Per 8.4.4.3:The reference building's internal and service water heating loads shall be identical between the proposed and reference buildings.

HPNC

- No specific documentation has been published. Credit for low-flow plumbing fixtures had been approved on multiple projects.

Toronto Green Standard

- Refers to OBC 2012 baseline allowances (ASHRAE 90.1-2010, NECB 2011, MNECB 1997)

LEED Canada 2009

- Credit can be taken using LEED WEc3 calculation methods.

LEED v4

- Credit can be taken using LEED WEc3 calculation methods.