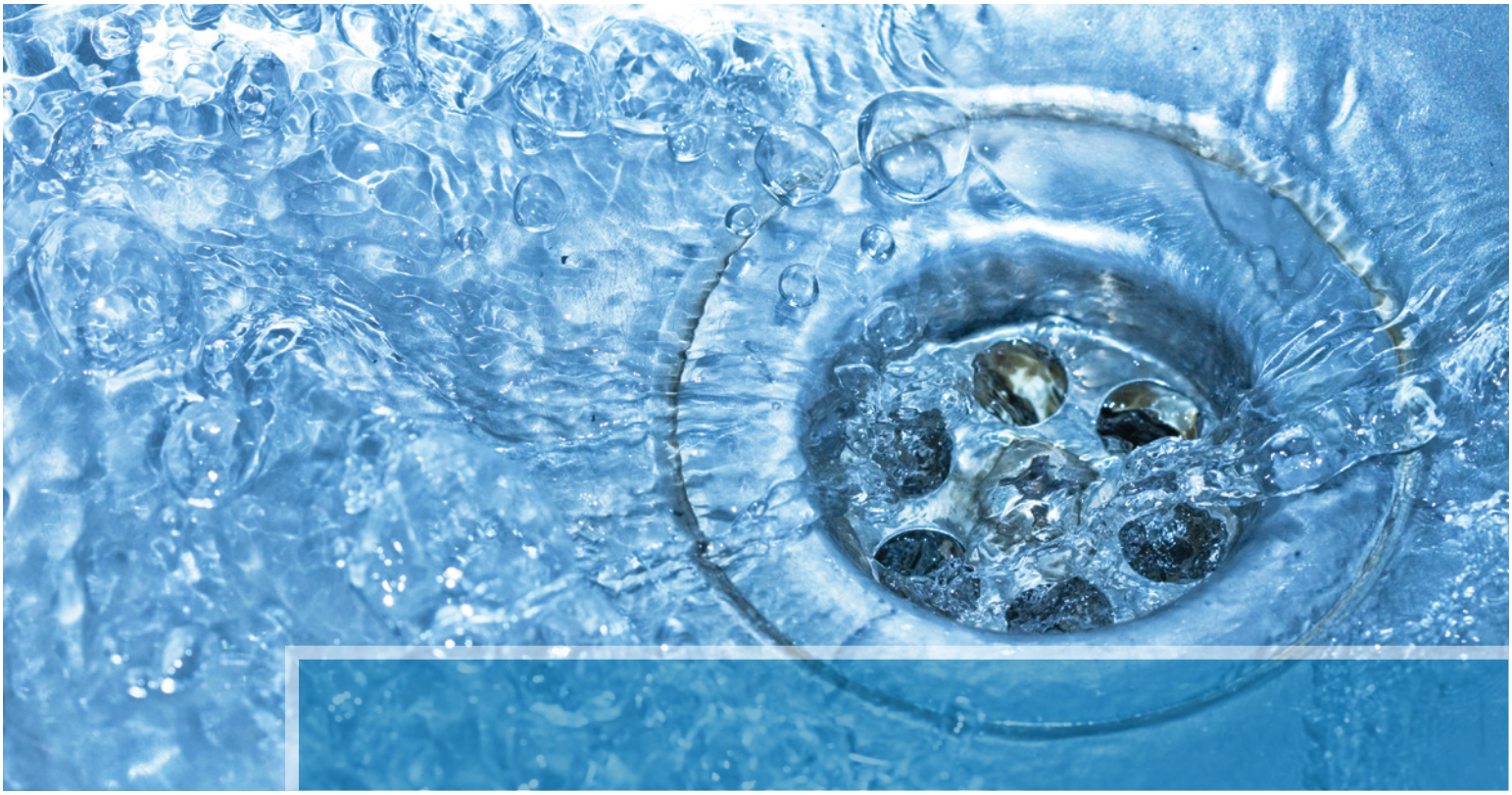


A GUIDE TO SUSTAINABLE PLUMBING IN THE HOME

Canada

CMHC SCHL
HOME TO CANADIANS

CMHC — HOME TO CANADIANS

Canada Mortgage and Housing Corporation (CMHC) has been Canada's national housing agency for almost 70 years.

CMHC helps Canadians meet their housing needs. As Canada's authority on housing, we contribute to the stability of the housing market and financial system, provide support for Canadians in housing need, and offer objective housing research and information to Canadian governments, consumers and the housing industry. Prudent risk management, strong corporate governance and transparency are cornerstones of our operations.

For more information, visit our website at **www.cmhc.ca** or follow us on **Twitter, YouTube, LinkedIn** and **Facebook**.

You can also reach us by phone at 1-800-668-2642 or by fax at 1-800-245-9274.

Outside Canada call 613-748-2003 or fax to 613-748-2016.

Canada Mortgage and Housing Corporation supports the Government of Canada policy on access to information for people with disabilities. If you wish to obtain this publication in alternative formats, call 1-800-668-2642.

Cette publication est aussi disponible en français :
Guide de la plomberie résidentielle durable (68350).

CMHC does not assume responsibility for errors or oversights resulting from the information contained herein. Users must consult with the jurisdiction having authority concerning the design and installation of any of the products, components or systems described in this publication. The content of this publication is for information purposes only. It is not intended for the content to be relied upon as professional or expert advice or opinions. The information in this publication is a result of current research and knowledge. Readers should evaluate the information, materials and techniques cautiously for themselves and consult appropriate professional resources to see whether the information, materials and techniques apply to them. The images and text are guides only. Project and site-specific factors (climate, cost and esthetics) must also be considered.

ISBN 978-0-9948435-2-4

© 2016 Canada Mortgage and Housing Corporation

This document or any discrete portion of this document (such as a chapter or section) may be reproduced for redistribution, without obtaining the permission of the copyright owner, provided that no changes whatsoever (including translation) are made to the text; that the entire document or discrete part is reproduced; that this copyright notice is included in its entirety in any and all copies of the document or any discrete part of the document; and that no use is made of any part of the document or the name or logo of the owner of the copyright to endorse or promote any product or service. For any use of this document other than reproduction or general reference purposes as set out above, please contact the Canadian Housing Information Centre (CHIC) at chic@cmhc.ca; 613-748-2367 or 1-800-668-2642. For permission, please provide CHIC with the following information: publication's name, year and date of issue.

Printed in Canada
Produced by CMHC

TABLE OF CONTENTS

ABOUT SUSTAINABLE HOUSING 1
What Makes a Home Sustainable? 1
Why Water Efficiency, Conservation and Other Green Plumbing Tactics? 2
The Role of Plumbers 2
Appliance and Fixture Labels. 3
Sustainable Plumbing Checklist 4

THE HOUSE AS A SYSTEM. 5
House as a System Checklist. 6
The importance of air barrier systems. 6

WATER-EFFICIENT PLUMBING IN THE KITCHEN 7
1 Kitchen sink faucets 7
2 Sink garbage disposal units 8
3 Dishwasher 8
4 Refrigerators with water and ice features. 9
Kitchen Checklist. 9

WATER-EFFICIENT PLUMBING IN THE BATHROOM 10
1 Bathroom faucets 10
2 Shower head. 11
3 Bathtubs. 11
4 Toilets. 12
Bathroom Checklist 13

WATER-EFFICIENT PLUMBING AND THE HOT WATER SYSTEM. 14
1 Fuel-fired water heater venting. 14
2 Water heaters and hot water storage. 15
3 Hot water piping: distribution and discharge 16
Hot Water System Checklist 17

WATER-EFFICIENT PLUMBING IN THE LAUNDRY AND MECHANICAL ROOMS. 18
1 Washing machines 18
2 Water softeners 19
3 Water pressure regulator valves. 20
Laundry and Mechanical Room Checklist 20
4 Backwater valves. 21
5 Trap primed floor drains 21

RAINWATER AND GREYWATER 22
Rainwater and Greywater Checklist. 25

FOR FURTHER INFORMATION 26
Material and product selection 26
Resource efficiency 26
Sealing plumbing penetrations of air barrier systems. 26

PRIMARY REFERENCE MATERIALS 27

This guide is intended to provide licensed plumbers, building contractors and interested homeowners with an overview of the fixtures, appliances and actions that can help homeowners conserve water and energy in different areas of their house.

ABOUT SUSTAINABLE HOUSING

In Canada, the residential sector uses 43 per cent of municipal water supplies (CMHC 2014) and accounts for 17 per cent of secondary energy use[1] (NRCAN 2012). Sustainable housing aims to reduce the natural resource consumption of homes while keeping them healthy and affordable for Canadians to live in. To date, more than 50,000 higher performance and green homes have been built across Canada and the demand is growing (Industry Steering Committee 2012).

WHAT MAKES A HOME SUSTAINABLE?

CMHC's Healthy Housing™ principles describe the main characteristics of a sustainable home. Plumbers can influence each of these components:

- **Healthy indoor environments:** Plumbers can make sure their systems are properly installed and can help keep them running smoothly.
- **Energy efficiency:** By using water-efficient fixtures and reducing the amount of hot water consumed, plumbers contribute to improving a home's energy efficiency.
- **Resource efficiency:** Conserving water is a plumber's speciality and an area where plumbers have significant influence over their clients' purchasing decisions.
- **Reduced environmental impact:** By selecting durable, high-quality fixtures and fittings, the frequency of replacement can be reduced and fewer materials are wasted. Additionally, reducing water consumption also reduces waste water flow that has to be treated and returned to surface waters.
- **Affordability:** Plumbers can perform audits to demonstrate to homeowners how much water, energy and money can be saved over the long-run by making sustainable choices.

[1] Secondary energy use is energy used by final consumers for residential, commercial/institutional, industrial, transportation and agricultural purposes (NRCAN 2012).

WHY WATER EFFICIENCY, CONSERVATION AND OTHER GREEN PLUMBING TACTICS?

There is increasing strain on urban water sources across the country. Making homes more sustainable will help to reduce energy and water consumption, enhance the indoor environment, reduce the environmental impact and make housing more affordable for Canadians. Using less water means that:

- less water has to be pumped, treated or distributed, which leads to reduced energy consumption;
- existing water supplies and infrastructure can support growing populations and economies (which could avoid having to build bigger storage facilities and treatment plants, or having to secure additional water sources); and

THE ROLE OF PLUMBERS

As one of the skilled experts involved in home building and renovation processes, plumbers play an important role in delivering sustainable housing. Many interact directly with consumers, builders and renovators. During these conversations with their clients they can influence decisions about fixture and fitting purchasing, installation, operation and maintenance. In particular, plumbers can:

- install water-efficient fixtures and appliances, which reduces the amount of water and energy used and water disposed of down the drain;
- support water reuse and rainwater harvesting (where permitted), which can offset some of the treated municipal water used by a home and ease the strain on treatment plants and water sources;
- use high-quality and durable parts to reduce the need for frequent replacement and cut down on wasted materials; and
- provide homeowners with a calculation of utility cost savings associated with green features, including how long it will take to recover the cost of a high-efficiency fixture or appliance.

Innovative builders and renovators need subcontractors, including plumbers, who understand how sustainable housing is designed, built and renovated. Plumbers need to be aware of sustainable technology options so they can offer ways to complement and enhance these projects.

APPLIANCE AND FIXTURE LABELS

A simple way to conserve energy and resources is to look for the ENERGY STAR® and WaterSense® brands when purchasing or replacing appliances and fixtures.

ENERGY STAR® identifies energy-efficient products in the marketplace.

In 1992, the U.S. Environmental Protection Agency (EPA) introduced ENERGY STAR® as a voluntary labelling program. Since then, it has been adopted in Canada and is overseen by Natural Resources Canada's Office of Energy Efficiency.

Certified products must meet energy efficiency specifications. Often this involves using 20 to 30 per cent less energy than required of products by federal standards.

ENERGY STAR® is the most widely recognized and reliable labelling system for identifying strong efficiency performance for clothes washers and dishwashers. However, the symbol also appears on many other products, including major household appliances, consumer electronics, heating and cooling systems, computers and other types of office equipment.

WaterSense® identifies products that reduce water consumption and meet expected performance parameters.

WaterSense® was also developed by the U.S. Environmental Protection Agency (EPA) and continues to be a U.S.-based system. However, it has been widely adopted on a voluntary basis by major manufacturers that market in Canada and is endorsed by many Canadian government agencies.

The system allows consumers to find and select water-efficient products with confidence. WaterSense® labelled products:

- perform as well or better than less efficient models;
- are 20 per cent more water-efficient than average products in that category;
- provide measurable water savings; and
- obtain third-party certification.

SUSTAINABLE PLUMBING CHECKLIST

House As A System

- ☐ Install high-quality shut-off valves on piping and provide easy access to them through walls or floors.
- ☐ Use high-quality materials, fittings and fixtures.
- ☐ Insulate cold and hot water pipes with a minimum RSI-0.7 (R-4) insulation.
- ☐ Run plumbing inside the air barrier system, or, if piping must pass through the barrier, properly seal the joint with acoustical caulking (or other appropriate material), and ensure it is structurally supported.

Kitchen

- ☐ Install WaterSense® tap or faucet aerators (5.7 litres per minute [lpm] / 1.5 gallons per minute [gpm] or less).
- ☐ Ensure aerator or faucet has flow regulation settings or a hands-free faucet.
- ☐ Avoid a sink garbage disposal unit—use compost or kitchen waste programs instead.
- ☐ Select an ENERGY STAR® dishwasher (as little as 15 litres per cycle / 4 gallons per cycle).
- ☐ Choose a dishwasher with a timer, a heat on/off setting, or a smart sensor.
- ☐ Install an ENERGY STAR® fridge.
- ☐ Install shut-off valves in under the sink faucet and dishwasher.

Bathroom

- ☐ Install WaterSense® tap or faucet aerators (5.7 lpm / 1.5 gpm or less).
- ☐ Install a WaterSense® shower head (7.6 lpm / 2.0 gpm or less) and no multiple-head shower systems.
- ☐ Install thermostatic valves at shower, bath and faucet fixtures.
- ☐ Install a drainwater heat recovery unit on the shower drain.
- ☐ Check for leaks: faucets, diverter tub spouts, showers, baths and toilets.
- ☐ Choose WaterSense® high-efficiency toilets (4.8 litres per flush [lpf] or less).
- ☐ Consult MaP testing scores prior to purchasing a new toilet.
- ☐ nsure drainline is clear of defects and not sagging.
- ☐ Install accessible shut-off valves on service pipes to sink taps, toilets, tub and shower.

Hot Water System

- ☐ Set hot water tank to 60°C (140°F or as required to meet building code, safety regulations.) and insulate it.
- ☐ Put heat traps on cold and hot water pipe connections to the water tank.
- ☐ Minimize both the pipe size of the distribution network and the distance between the source of hot water and the fixtures.
- ☐ Install a drainwater heat recovery unit on the shower drain piping.
- ☐ Make new construction solar ready more easily to accept solar water heating systems in the future.

Laundry and Mechanical Rooms

- ☐ Select a CEE Tier 3 washing machine (Water factor of 4.0 or less).
- ☐ Check the Water Softener Buyers Guide prior to choosing a new model.
- ☐ Set water softener to a demand-based regeneration cycle.
- ☐ Install water pressure regulator(s); set to 310-380 kPa (45-55 psi).
- ☐ Install backwater valve on building drain to prevent sewer backup.

Rainwater and Greywater

- ☐ Obtain advanced training in installation of rainwater harvesting and greywater systems.
- ☐ Obtain written approval from appropriate regulatory authority for installation of rainwater or greywater systems.
- ☐ Rough in new builds to accommodate future dual plumbing for non-potable water distribution.

THE HOUSE AS A SYSTEM

Although this guide is primarily about what a plumber can do to enhance water sustainability in residences, a plumber's role extends beyond water. A house can be thought of as a system of many interacting parts, including the basic structure, heating, ventilation, air conditioning, the external environment and the occupants. Plumbers should be aware of how the plumbing system in a house can potentially impact the performance of other systems so they don't undermine the work of others. The following checklist provides some examples of how a plumber can help ensure the overall house works as one well-integrated system.

HOUSE AS A SYSTEM CHECKLIST

Reduce the frequency and cost of future repairs and replacements

- ☐ Install high-quality shut-off valves on water pipes, which will reduce future effort, money and wasted material when repairs or replacements are required.
- ☐ Provide easy access to shut-off valves through walls or floors.
- ☐ Inform homeowners that shut-off valves should be fully-opened and closed every three to four months to prevent them from seizing up.
- ☐ Use high-quality materials and fittings to reduce the frequency of replacement.

Conserve energy

- ☐ Insulate both hot and cold pipes to prevent heat loss, condensation, moisture damage and corrosion of fittings.
- ☐ Minimize the distance between the hot water tank and the location of fixtures that require hot water.

Maintain the integrity of the home's air barrier

- ☐ Run all plumbing inside the air barrier system of the house to help reduce air leakage, heat loss, wall moisture problems and related costs.
- ☐ If plumbing must pass through the air barrier, be sure that the joint between the pipe and air barrier is sealed with appropriate materials and that it is structurally supported. For further information on air sealing plumbing penetrations of air barrier systems, see page 26.

The importance of air barrier systems

Air barriers are installed in houses to hold conditioned air in the home. This helps to keep temperatures at a comfortable level and reduce space heating and cooling costs. Air barriers also prevent moisture that is in the indoor air from finding its way into exterior walls and attics. This is very important as moisture can damage the finishes and structure of a house and lead to mould growth—a known health concern.

When it is necesary to run a pipe through the air barrier system (usually the polyethylene that covers the insulation) plumbers must use techniques that join and seal the pipe to the air barrier system. Otherwise air leakage around the pipe could cause moisture problems and unnecessary heat loss. Keeping the plumbing inside the air barrier system can help reduce the work involved.

It's a good idea for plumbers to ensure they are fully aware of the builder's or renovator's performance objectives for the home. Carefully planning and coordinating the plumbers' work with the work of other subtrades can better support such objectives, prevent problems and reduce callbacks.

WATER-EFFICIENT PLUMBING IN THE KITCHEN

Water use in the kitchen can count for up to 15 per cent of all indoor consumption (CMHC 2014). Kitchen construction and renovations are an opportunity to incorporate high-efficiency fixtures and appliances into the home. To learn about specific water-using features in the kitchen, click on the items in the picture below.

Click on the item in the picture.

1 Kitchen sink faucets

In the kitchen, a specific amount of water is required for most activities (for example, washing dishes, filling cooking pots, etc.). If the flow rate is reduced, people will simply wait longer to complete many of their tasks. For this reason, many homeowners prefer to have higher flows available in the kitchen, and this preference will usually only have a limited impact on the home's total water use.

The maximum flow rate allowed for a kitchen faucet under the CSA B125.1 standard is 8.3 litres per minute (lpm) (2.2 gallons per minute [gpm]). If possible, install a WaterSense® faucet that uses only 5.7 lpm (1.5 gpm) or less, which is more than sufficient for kitchen activities.

If using an older model faucet with higher flow rates, consider installing an aerator on the end of the tap. Aerators typically reduce flows from the industry standard of 8.3 lpm to 5.7 lpm or less, thereby reducing water use and also saving the energy that would have been required to heat it. They are very inexpensive and can be found at hardware stores or sometimes obtained from municipal water service providers.

Some aerators have flow regulation settings, which allows for both normal and restricted flows. For example, some faucets have a lever that can temporarily reduce flow between rinses. Another option is a hands-free faucet, which easily controls flows and is intended to prevent transmission of germs and bacteria at the handle.

2 Sink garbage disposal units

Sink garbage disposal units can reduce the amount of solid waste a house produces. However, these devices require quite a lot of water to operate. As well, organic matter from compost is difficult and expensive to remove from wastewater at the sewage treatment plant. For these and other reasons, garbage disposal units may not comply with local bylaws and regulations, so always check before installation. An alternative to these units is to contribute household organic waste to a backyard composter or to the municipal kitchen waste collection program, where such an option is available.

3 Dishwasher

Dishwashers typically account for less than 2 per cent of residential indoor water use (Mayer et al. 1999). Pre-1994 models can consume 45 to 57 litres per cycle (12 to 15 gallons per cycle), which is almost double today's most inefficient machines but still less than most people use to do dishes by hand. Modern ENERGY STAR® models use as little as 15 litres per cycle (4 gallons per cycle).

There is not a large difference in water consumption between the most efficient model on the market and an industry standard one—about four bathtubs full each year (Econics 2010). Unless the current dishwasher was purchased prior to 1994, it makes little sense to replace a functioning model with a new one for water savings alone. It will typically take longer than the lifespan of the machine for the homeowner to save enough on water and energy

utility bills to pay it off. However, consider installing a dishwasher if dishes are currently washed by hand.

When purchasing a new model, one equipped with a timer allows homeowners to take advantage of off-peak electricity rates (where available) and a heat on/off setting can help to conserve energy. The most efficient dishwashers use smart sensors that adjust the wash cycle and the amount of water to match the load size. About 80 per cent of a dishwasher's energy consumption is to boost water temperature, so models that use less water will also use less energy.

4 Refrigerators with water and ice features

Refrigerators use the most energy of any household appliance outside of the furnace room. In the past few years, they have become much more efficient, using at least 70 per cent less energy than models sold in 1990 (Natural Resources Canada 2014). Homeowners should consider replacing older appliances. When choosing a new model, select one of the ENERGY STAR® rated models available in Canada, which are at least 20 per cent more efficient than the minimum standards required by regulation.

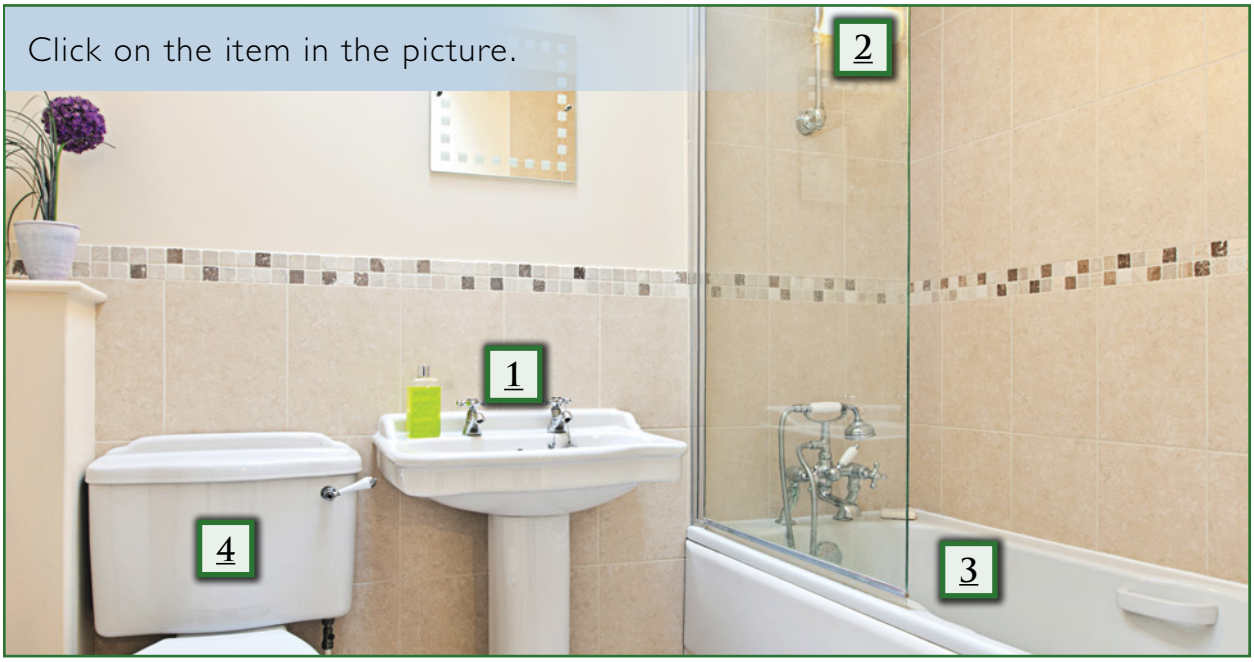
Water and ice features increase a fridge's overall energy consumption by as much as 14 to 20 per cent (Consumer Energy Center 2014). Instead of using these features, cold drinking water can be kept in a covered container in the refrigerator *Household Guide to Water Efficiency* (CMHC 2014).

KITCHEN CHECKLIST

- ☐ Install WaterSense® tap or faucet aerators (5.7 lpm / 1.5 gpm or less).
- ☐ Ensure aerator or faucet has flow regulation settings or a hands-free faucet.
- ☐ Avoid sink garbage disposal unit—use compost or kitchen waste programs instead.
- ☐ Select ENERGY STAR® dishwasher (as little as 15 litres per cycle / 4 gallons per cycle).
- ☐ Choose a dishwasher with a timer, a heat on/off setting, or a smart sensor.
- ☐ Install an ENERGY STAR® fridge.

WATER-EFFICIENT PLUMBING IN THE BATHROOM

Bathrooms can account for approximately 75 per cent of water use inside the home *Renovator's Green Guide – Bathroom Renovations* (CMHC 2014). Bathroom renovations, which are one of the most common interior home improvements, present many opportunities to add green features. New home construction makes it possible to build in high-efficiency fixtures with less trouble and cost. To learn about specific water-using features in the bathroom, click on the items in the picture below.



1 Bathroom faucets

Bathroom faucets are mostly used for activities that do not require a specified volume of water, such as washing hands or brushing teeth. Standard models use 8.35 lpm (2.2 gpm) at 413.7 kPa (60 psi).

For renovations or new construction, a WaterSense® faucet that has a flow rate of 3.0 to 5.7 lpm (0.8 to 1.5 gpm) can save water without sacrificing performance. As well, energy used for heating is conserved when an efficient fixture is installed. Bathroom faucets

are usually not worth retrofitting based on water savings alone, unless the homeowner has much older technology. However, if installing a new fixture, there is not much cost difference between an efficient model and a standard one, and performance is the same.

If a new faucet is not an option, equip an existing tap with a WaterSense® labelled aerator to reduce the flow rate to the equivalent of a high-efficiency faucet. Many aerators spray nicely at 4 lpm [1 gpm] or less. This is usually a simple retrofit and only costs a few dollars.

2 Shower head

Showers are one of the highest water-using fixtures in the home. There are many high-efficiency shower heads on the market that use between 3.8 and 7.6 lpm (1 to 2 gpm), compared with the industry standard of 9.5 lpm (2.5 gpm). Look for the WaterSense® logo. Multiple head systems, although luxurious, use a lot of water and energy. If multiple heads are installed, provide a way of shutting them off when they are not needed.

Under the CSA B125.1 standard, the national standard for plumbing supply fittings, thermostatic valves that balance pressure from hot and cold water supplies are required. These eliminate the risk of unexpected temperature fluctuations (Viola, 2002). In new or properly renovated bathrooms that have this device, high-efficiency shower heads (less than 7.6 lpm [2 gpm]) can be safely used. Until it can be confirmed that this device is installed, a 9.5- lpm (2.5-gpm) model may be preferable to avoid scalding.

Occasionally, homeowners are not satisfied with the performance of their low-flow shower head. In recent years, technology has dramatically improved and most people with even the lowest flow models will probably be satisfied with their experience. Given that shower heads are fairly inexpensive, trying a new high-efficiency model is a relatively low- risk investment for many homeowners.

In the case of an household occupant who turns a shower on and then leaves to do other chores because it seems to take a while for hot water to arrive, new technology is now available that prevents water from spraying and being wasted after it reaches 35°C/95°F. Some shower heads also have a built-in flow control valve, which easily reduces the flow while lathering or shaving and increases it again once water is required to rinse (CMHC 2014). These devices use about half the amount of water compared with conventional shower heads.

3 Bathtubs

Leaky diverter tub can drip water and waste it down the drain. These can be replaced relatively easily and are a simple way to save water. Flow reduction on tub spouts is uncommon. This is because when a person takes a bath, they usually want to fill it to a certain level as quickly as possible. Reducing the flow would only make them wait longer.

To reduce the need for the bather to continuously run hot water into the tub to maintain the temperature, install insulation around the sides and bottom of the tub before it is placed into position. Two-sided tape can help to secure batt-type insulation. Alternatively, spray-applied foam insulation could be used, provided it is installed by a person with the required training.

4 Toilets

It is estimated that one in five toilets leak water from the tanks to the bowl due to leaky flapper valves (IAPMO 2012). To perform a leak test remove the tank lid and add four to five drops of food coloring to the water in the tank and wait 20 to 30 minutes. If there is coloured water in the bowl, the toilet flapper valve is leaking. Some municipalities supply pre-dyed tabs free of charge to test for leaks.

Toilet part replacement tips:

- Bring pictures of the product model number stamping in the porcelain inside the tank and tank lid, as well as pictures of the parts inside the tank that need replacing, to the supply shop. Many components have subtle differences that may be difficult to recall.
- Provide the photos to the homeowner so replacement parts can be more easily found.
- If possible, use replacement parts made specifically for the toilet to ensure performance.

High-efficiency toilets

The maximum flush volume permitted to attain WaterSense® certification is 4.8 litres per flush (lpf). High-efficiency toilets (HETs) use 4.8 lpf or less and have rapidly replaced 6-lpf models as the water-efficient standard. Dual-flush toilets are another efficient option. These models have two flush choices—one with a higher flow (usually 6 lpf or 4.5 lpf) for solids and one with a lower flow (usually 3 lpf) for liquid waste. Combined, the average flush is equal to or less than 4.8 lpf, so these models are also considered HETs. There are over 2,500 different tank-type HET models available, of which over 1,600 are WaterSense® certified.

Maximum performance testing

Some first generation low-flow toilets suffered from poor performance, but advances in technology and the development of performance testing mean that there is now no need to compromise expectations. Today's HETs perform equal to or better than 6-lpf toilets and even old 13- to 20-lpf fixtures.

Until the early 1990s, toilets used 13 lpf or more. Beginning in the mid-1990s, building codes across the country started to require the installation of 6-lpf toilets. The problem was that basic toilet design did not change, only the amount of water used. This led to performance issues and customer dissatisfaction. As a result, inefficient behaviours (for example, holding the handle down and double flushing) became common. As well, flappers were replaced with older designs to allow more water to pass, which defeated the purpose of having a low-flow model.

In 2003, the Maximum Performance (MaP) testing standard was designed to characterize toilet performance. The test is administered by a third party, not the toilet manufacturers, and uses realistic solid waste samples. To pass, toilets must remove a minimum of 350 g of waste. To date, the program has rated more than 2,800 models. It has also identified more than 100 premium models that are almost certain to exceed customer expectations for performance (remove at least 600 g of solid waste in a single flush) and meet high- efficiency standards (use no more than 4.0 lpf and be certified by WaterSense®). Updated results are posted on the MaP testing website and can be found using the searchable database.

Selecting a new toilet

New toilets may have both MaP and WaterSense® labels, depending on performance parameters:

- A MaP label indicates that the toilet removes a minimum of 350 g of solid waste per flush. There is no water volume requirement;
- WaterSense® labeled toilets have a maximum flush volume of 4.8 lpf (or a maximum average flush volume of 4.8 lpf for dual-flush models) and remove a minimum of 350 g of waste per flush;
- A MaP premium model removes at least 600 g of solid waste, uses no more than 4.0 lpf and is certified by WaterSense®.

In selecting a new toilet, there are also other things to consider besides how much waste a toilet will pass. Be sure to also consider the size of the water spot, base size, rough dimensions and seat and tank height, and availability of replacement components.

Drainline carry

Another concern plumbers often have with water-efficient toilets is their ability to carry waste all the way to the sewer.

Various studies have addressed this and all have concluded that drainline carry is unlikely to be an issue in residential settings for HETs. The possible exception is for single-flush, 3-lpf models where further research is required (PERC 2012). However, most drainline carry tests are performed without supplemental flows from appliances and fixtures (for example, baths, laundry, showers, etc.) upstream of the toilet connection. These testing conditions are therefore more conservative than most typical real-life situations (EPA WaterSense® 2014).

A CMHC study found that efficient toilets were able to transport test media 20 metres (65.6 feet) in a 75-mm (3-inch) pipe installed at a 2-per-cent slope (these represent normal conditions found in most single-family settings), also without supplemental flows.

If drainline carry is an issue at a residence, inspect pipes for defects, root intrusions, sagging or other physical conditions that could result in clogging. The type of toilet paper has also been found to be a significant factor in how far waste is carried toward the sewer.

BATHROOM CHECKLIST

- ☐ WaterSense® tap or faucet aerator (5.7 lpm / 1.5 gpm or less).
- ☐ WaterSense® shower head (7.6 lpm / 2.0 gpm or less).
- ☐ Install thermostatic valves at shower, bath and faucet fixtures.
- ☐ Install a drain water heat recovery unit on the shower drain.
- ☐ Check for leaks: faucets, diverter tub spouts, showers, baths and toilets.
- ☐ WaterSense® high-efficiency toilets (4.8 lpf or less).
- ☐ Consult MaP testing scores prior to purchasing a new toilet.
- ☐ Ensure drainline is clear of defects and not sagging.
- ☐ Install accessible shut-off valves on service pipes serving each fixture.

WATER-EFFICIENT PLUMBING AND THE HOT WATER SYSTEM

Water heating is the first or second largest residential energy use, accounting for 15 to 30 per cent of total consumption (IAPMO 2012). Hot water systems are composed of the heater, the distribution system, fixtures and the drainage system. Energy efficiencies can be found along each step of the way.

1 Fuel-fired water heater venting

Gas water heaters require proper venting. Consider using models with sealed combustion venting systems to avoid backdrafting of harmful flue gases. This is particularly important if renovation work reduces air leakage, if new construction is energy-efficient or if there are high-capacity, exhaust-only fans inside the house.

Also, if a furnace and a water heater were both connected to a chimney at one point but the furnace has been converted to a side wall-vented unit, the chimney may be oversized for the hot water tank alone and it may not vent properly. It may be necessary to upgrade the water heater to a side wall-vented system.

2 Water heaters and hot water storage

Hot water can be produced using natural gas, liquefied petroleum gas, electricity, heat pumps, geothermal oil, or even solar energy. With both the energy source and the type of storage (that is, tank or tankless), there are pros and cons that need to be balanced, some of which are outlined below.

All water heaters lose energy in the standby mode through the side walls, top and bottom of the tank even though they are insulated. A typical gas-fired storage water heater also loses energy from the centre of the tank through the flue. Heat traps installed in the cold and hot water pipes where they connect to the hot water tank can help reduce heat losses when the tank is not in use. Tankless water heaters can save energy by minimizing the standby losses associated with keeping a full tank of water heated whether it is needed or not.

Tankless water heaters can provide an almost unlimited supply of hot water, but may not get hot water to a fixture as fast as storage heaters. They may therefore increase water use, as residents let water run down the drain until it is hot at the fixture. Consumption may also increase with behavioural changes if users take advantage of the "endless" hot water supply.

In some energy-efficient new build or renovation projects, a solar water heater for space heating and domestic hot water may be part of the plan. Properly designed, installed and maintained, these devices can produce 1,500 to 3,000 kWh of energy each year, which can reduce a household's hot water heating-related utility costs by 40 to 50 per cent. The actual savings depend on the size of the solar collectors and water storage tank, appliance efficiency, the amount of sunlight received and how much water the household uses. Technology has advanced so that new models have mechanisms that prevent them from freezing during the winter and overheating during the summer, making them a viable option for most Canadian climates (Natural Resources Canada 2003).

Solar water heaters are specialty devices installed by trained contractors. They can be retrofitted to existing water heaters, which are kept as a backup so there is always a supply of hot water.

Consider installing water heaters in antiflood pans. This can reduce or eliminate the risk of water damage in the house should the tank fail at some point in the future.

In some new build or renovation projects, all the necessary wiring, piping and supports may be put in, but not the actual system. This is called a "solar ready" house and makes system installation more affordable for the homeowner in the future.

3 Hot water piping: distribution and discharge

The key to saving water and energy in the distribution system is to reduce the time it takes hot water to be delivered to fittings and appliances. Insulating hot water pipes minimizes heat loss through the delivery system (the temperature loss over 30.5 metres [100 feet] of uninsulated pipe is about 2.8°C/5°F). It also increases the time pipes stay hot between uses: RSI-0.7 (R-4) insulation doubles cool-down time in the case of a 12.7-mm (½-in.) pipe and triples it in the case of a 19-mm (¾-in.) pipe. Insulating cold water pipes also discourages condensation from forming, which helps to prevent moisture damage, mould growth and corrosion.

Another way to be more energy-efficient is to maintain the water heater temperature at the factory setting of 60°C/140°F. This is the minimum temperature recommended by the World Health Organization to prevent legionella (a potentially dangerous bacterium) from growing in the tank (Levesque, Lavoie and Joly 2004). Although there is some risk of scalding at this temperature, this can be managed with proper placement of mixing valves to limit the temperature of the water delivered to faucets, tubs and showers. For this reason, the National Plumbing Code requires a maximum temperature of 49°C/120°F at shower and bathtub fixtures (CASH ACME 2008).

Characteristics of an efficient distribution system include:

- the shortest buildable trunk line;
- the shortest buildable branches;
- the fewest plumbing restrictions;
- the smallest diameter of pipe practical;
- stacked bathrooms and kitchen;
- no pipes installed on exterior walls; and
- minimum RSI- 0.7 (R-4) insulation on all hot water pipes.

During and after use, heated water that contains energy goes down the drain. Drain water heat recovery devices use the warm wastewater to preheat the incoming supply of water and thereby reduce the amount of energy required to raise the temperature to a set level. The cool incoming water passes through a series of coils wrapped around the drain stack and heat is transferred through the copper walls of the heat recovery fitting. Although they can be installed on any vertical drain, they are typically found on pipes serving showers. These devices could recover 40 to 75 per cent of drain water heat, depending on the shower flow rate, plumbing system and type of fitting installed (World Plumbing Review 2008).

HOT WATER SYSTEM CHECKLIST

- ☐ Set hot water tank to 60°C (140°F) and insulate it.
- ☐ Put heat traps on cold and hot water pipe connections to the water tank.
- ☐ Minimize both the pipe size of the distribution network and the distance between the source of hot water and the fixtures.
- ☐ Properly locate service water and drain water piping to protect building envelope air barrier system.
- ☐ Install a drainwater heat recovery device on the shower drain piping.
- ☐ Make new construction ready to accept solar water heaters at some point in the future.

WATER-EFFICIENT PLUMBING IN THE LAUNDRY AND MECHANICAL ROOMS

Mechanical areas of the home can contain appliances that consume large quantities of water and energy.

1 Washing machines

Most families do multiple loads of laundry each week. Water and energy savings from using efficient machines can add up quickly. In general, front-loaders are more water-efficient than top loaders; however, there is a wide range of efficiency. As well, top-loading machines are now using new technology and, in some cases, have efficiency ratings that are competitive with front-loaders.

To attain the ENERGY STAR® rating, a machine must meet two standards. The first is a Modified Energy Factor test (MEF), which looks at how much energy is used to wash and dry one load of laundry. The second is a Water Factor (WF) test, which measures water efficiency by calculating how many gallons of water are used per cubic foot of drum capacity. For example, if a machine uses 113 litres (30 gallons) per cycle and has a tub volume of 0.08 m^3 (3.0 cubic feet), then the water factor is 10. The lower the WF, the more efficient the clothes washer will be (Econics 2010). To be certified as ENERGY STAR®, a machine must have a WF of 6.0 or lower.

Older washing machines use up to 170 litres (45 gallons) per cycle and have a WF of about 13.3. New machines only use up to 57 litres (15 gallons) per cycle. The Consortium for Energy Efficiency (CEE) also rates washing machines using the same criteria and metrics as ENERGY STAR®, but further classifies models as Tier 1 (WF of 6.0), Tier 2 (WF of 4.5), or Tier 3 (WF of 4.0). Tier 3 models are the most efficient products on the market.

Unfortunately, manufacturers do not usually provide very specific information about the amount of water their machines use, either on their websites or in product literature. An ENERGY STAR® label is a good indication that a model is water-efficient, but the best way to find out actual performance is through the most recent qualifying product list available on the CEE website.

Consider installing a water hammer arrestor on the clothes washing machine service pipe to help reduce the chance of pipe rupture and flooding.

Washing machine maintenance tip: Some owners of front-loading machines complain about mould and mildew odours, as well as growth in the fold of the rubber seal around the door. This is preventable by following the manufacturer's directions and leaving the door open for ventilation when the machine is not in use. It is also recommended that damp laundry not be left in the machine. If mould and mildew are still a problem, special cleaning products are available.

2 Water softeners

Water softeners are popular in areas that have very hard water. Most are ion-exchange models, meaning they replace the calcium and magnesium found in hard water with sodium. These machines have to "regenerate" to keep the resin ready to do its job of softening the water. During this process, a salty solution recharges the resin bed while backwash water flushes down the drain. Where the use of softeners is widespread, the increased salt content of wastewater can create water quality problems in surrounding lakes and rivers.

Regenerating the resin more frequently reduces the amount of salt discarded in each cycle, but increases the quantity of water used to maintain the machine. Cycling less often can save water but increases the amount of salt in the waste, which is hard on the lakes and rivers it eventually flows into. Each cycle can use up to 568 litres (150 gallons) of water.

Regeneration cycles can be based on time or demand. Demand-based models regenerate after a certain quantity of water passes through the system and typically use less water than time-based systems. Time-based models allow the owner to determine the frequency of regeneration and so may be refreshing more often than necessary.

Currently, proportional brining systems (single tank) or dual/twin tank models are typically preferred for water quality and efficiency reasons. Manufacturers are in

fairly advanced research and development phases for alternatives to ion-exchange systems that do not require salt addition. A water softener buyer's guide and additional information can be found at www.watersoftenerfacts.ca.

When installing a device, make sure the inlet and outlet sizes are the same or larger than the diameter of the piping serving the softener. This will avoid pressure drops throughout the distribution system.

3 Water pressure regulator valves

Water pressure may have to be corrected to make sure newly installed efficient fixtures and appliances operate properly.

While a pressure regulator valve (PRV) is required by code when pressure exceeds 550 kPa (80 psi) (NPC 2.6.3.3.), it can also be installed at lower pressures. PRVs are typically pre-set by the manufacturer at 345 kPa (50 psi); adequate pressure for most homes is 310 to 380 kPa (45 to 55 psi). With a PRV, water is pushed less forcefully through end-use fixtures, so less is consumed by the user. Moreover, this change is typically not noticed.

New code language may require the installation of an expansion tank if PRVs are installed. Check with your local government or building authorities to confirm requirements in your area. On their own, PRVs are the least obtrusive water-savings device in areas with higher water pressure.

LAUNDRY AND MECHANICAL ROOM CHECKLIST

- ☐ Select a CEE Tier 3 washing machine (Water factor of 4.0 or less).
- ☐ Check the Water Softener Buyers Guide prior to choosing a new model.
- ☐ Set water softener to a demand-based regeneration cycle.
- ☐ In areas with high service water pressure, install water pressure regulator(s); set to 310 to 380 kPa (45 to 55 psi).

4 Backwater valves

Consider installing a backwater valve in the basement drainline to help prevent flooding from sewer backup especially for finished basements.

5 Trap primed floor drains

Install trap primed drains in floor drains and other applications that may see infrequent water use (for example, guest shower drain, basement floor drain). This will help prevent sewer gas from finding its way into the house.

RAINWATER AND GREYWATER

Rainwater and greywater are considered to be non-potable or alternative water sources. If they are clean enough, they can sometimes be used instead of potable water for certain uses (for example, flushing toilets); however, always check with the local building or health authorities prior to installation to find out what is permitted in your area. Potable water from a municipal source or a private well should always be used for drinking, washing food, cooking and bathing.

Rainwater harvesting: The practice of intercepting rainfall from a roof or similar hard surface and diverting the flow to storage. A roof is the only hard surface permitted in some jurisdictions, as rainwater from paved surfaces may be very contaminated.

Greywater: Water that comes from showers, baths, bathroom sinks and clothes washers. It does not include wastewater from toilets or kitchen wastewater, which is more highly contaminated.

The benefits of using alternative sources, such as rainwater and greywater, may include:

- reducing potable water consumption and costs;
- reducing the amount of potable water taken from municipal sources or private wells, which may also relieve pressures on the infrastructure required to store, treat and deliver water;
- saving energy by decreasing water pumping and distribution requirements; and
- saving chemicals used to treat potable water.

Rules for using rainwater and greywater

What rainwater and greywater can be used for differs from jurisdiction to jurisdiction. Always check with your local government official. The National Plumbing Code, which is adopted in whole or in part by most Canadian provinces and territories, indicates that non-potable water systems should only be used to supply toilets, urinals and underground irrigation systems. They should also be designed, fabricated and installed in accordance with good engineering practices, such as those described in the *ASHRAE Handbooks, ASPE Handbooks and the CAN/CSA-B128 standard*.

The CSA B128.1/B128.2 standards specify the requirements for non-potable water systems in a home. They require proper labelling of pipes, backflow prevention, cross-connection prevention and pressure leakage testing. They also specify standards for pumps and storage tanks, as well as maintenance and field testing requirements.

The CSA B128.3 standard specifies performance standards for technology used to treat non-potable water before it is reused. It is applicable to systems with a capacity to treat 10,000 litres (2,650 gallons) per day or less, which would include most household set-ups.

The CSA B126 standard specifies material and structural requirements for prefabricated cisterns used to store all types of water, including potable, rain or greywater.

There are often local requirements for rainwater and greywater capture, storage, treatment and use. Always consult with the local government's building approval department before starting a project.

Rainwater harvesting

Conventional, small-scale rainwater harvesting systems typically involve a rain barrel, approximately 200 litres (52.8 gallons) in size, which is connected to the eavestrough downspout. The collected roof water is almost always used exclusively for outdoor purposes such as garden watering. However, given their relatively small size and limited use (most gardening occurs only in the summer months), rain barrels do not significantly contribute to water conservation around the home (Econics 2010) and quickly run short of water during periods of low rainfall.

Larger rainwater harvesting systems collect sufficient volumes of rain that can be stored and used for a number of non-potable uses, such as toilet flushing, clothes washing and outdoor irrigation. Rainwater is collected via eavestroughs and stored in large above-ground tanks or buried cisterns, typically with a capacity of 2,000 to 5,000 litres (528 to 1,321 gallons) or more. These systems are connected to a home's internal plumbing system and require separate, labelled piping designed to prevent cross-connection with the drinking water supply system. A qualified plumber will typically oversee installation. Since this is expensive to achieve during renovations, it is suggested that new builds provide a plumbing rough-in so that an alternative water system utilizing rainwater harvesting or other non-potable sources can be more easily installed at a later date. See CMHC's *Make Your House "Alternative Water Ready"* (CMHC 2015).

For more information on how to design, install, and manage rainwater harvesting systems, refer to the *Guidelines for Residential Rainwater Harvesting Systems Handbook* (CMHC 2012). The Guidelines are a comprehensive technical manual that references the codes, standards and guidelines applicable to rainwater harvesting systems.

Greywater systems

Greywater contains many contaminants and creates an attractive environment for growth of bacteria and other pathogens. Therefore, caution is required and its use is often highly regulated. Without treatment, it cannot be stored for periods much longer than 24 hours before it becomes septic. Untreated greywater is typically only permitted for watering inedible plants by hand.

Treatment options include physical filtration (with sand, charcoal or membrane filters) and disinfection with chlorination or UV light, or both. Following treatment, greywater may be used for toilet and urinal flushing, clothes washing and garden irrigation in some locations. Several proprietary, packaged residential greywater treatment systems are available, but may not be permitted by local codes and regulations. Always check with a local government official for the applicable rules in your area.

Capturing greywater requires having separate drainlines to an isolated storage and treatment system, and usually a pump to supply the water to its intended use. As a result, it can be quite difficult and prohibitively expensive to retrofit a greywater system in an existing dwelling. Roughing in separate drainlines in new builds can reduce costs if it is decided to pursue this option in the future. Greywater systems are typically installed by a professional plumber.

For more information about using domestic reclaimed water (wastewater or greywater) to flush toilets or urinals in domestic settings, refer to the *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing* (Health Canada 2010).

Water quality precautions

Using non-potable water sources involves a variety of hazards, including possible exposure of people to pathogens and viruses.

Avoiding cross-connections (an actual or potential connection between a potable water system and any source of pollution or contamination), including backflow, back-siphonage, and back-pressure is imperative, as is the use of pipe marking to identify non-potable water pipes. An **air gap** is the only form of backflow prevention that will not fail (IAPMO 2012).

As well, pressurizing any water source, including through an above ground irrigation system, can create small airborne water droplets. This is called aerosolizing. These droplets can contain pathogens and if they are inhaled they may cause serious health problems, such as Legionnaires' disease. Make sure that if water is being aerosolized that extra precautions are taken and that the water source is free of pathogens.

RAINWATER AND GREYWATER CHECKLIST

- ☐ Obtain advanced training in installation of rainwater harvesting and greywater systems.
- ☐ Obtain written approval from appropriate regulatory authority for installation of rainwater or greywater systems.
- ☐ Rough in new builds to accommodate future dual plumbing for non-potable water distribution.

FOR FURTHER INFORMATION

MATERIAL AND PRODUCT SELECTION

- The online GreenSpec® product guide (listing over 2,200 environmentally preferable products selected by editors at BuildingGreen, LLC)
- A Builder's Guide to Green Product Claims, by the Canadian Home Builders' Association
- ENERGY STAR® product list
- WaterSense® product list
- Maximum Performance (MaP) testing searchable database of high-efficiency toilets and high-efficiency urinals
- Water Softener Facts and Buyers Guide by the Region of Waterloo and the City of Guelph

RESOURCE EFFICIENCY

- *Renovator's Green Guide*, by Canada Mortgage and Housing Corporation
- Natural Resources Canada Office of Energy Efficiency
- Homeowners' Guide to Green Renovation, by the Canadian Home Builders' Association
- *Household Guide to Water Efficiency*, by CMHC
- *Understanding Energy Efficiency Retrofit Options for Your Home*, by CMHC
- *Collecting and Using Rainwater at Home: A Guide for Homeowners*, by CMHC

SEALING PLUMBING PENETRATIONS OF AIR BARRIER SYSTEMS

- Building America. Sealing Air Barrier Penetrations for all Climates. BSC Information Sheet 405. (accessed February 12, 2015).

Local and provincial government websites often have additional information about sustainable housing practices and programs. Occasionally, energy and resource efficiency rebates or incentives may be offered and are typically advertised on these websites.

PRIMARY REFERENCE MATERIALS

California Urban Water Conservation Council (2011).
Drainline Studies Resource Center. (accessed March 17, 2014).

Canada Mortgage and Housing Corporation (2000).
Household Guide to Water Efficiency.

Canada Mortgage and Housing Corporation (2007).
Evaluation of Water-Efficient Toilet Technologies to Carry Waste in Drainlines.
Research Highlight – Technical Series 07-106. (accessed March 17, 2014).

Canada Mortgage and Housing Corporation (2007).
Drainwater Heat Recovery Performance Testing at CCHT.
Research Highlight – Technical Series 07-116.

Canada Mortgage and Housing Corporation (2013).
Canadian Wood-Frame House Construction. (accessed March 17, 2014).

Canada Mortgage and Housing Corporation (2013).
Rainwater Harvesting (RWH) Guidelines. (accessed March 17, 2014).

Canada Mortgage and Housing Corporation (2014).
Renovator's Green Guide. (accessed March 17, 2014).

Cash Acme (2008).
Canadian Plumbing Code – Maximum Hot Water Temperature.
Technical Bulletin TB007. (accessed July 7, 2014).

Consortium for Energy Efficiency (2011).
CEE *Super Efficient Home Appliances Initiative: High Efficiency Specifications for Residential Clothes Washers*. (accessed March 17, 2014).

Consumer Energy Center (2014).
Residential: *Refrigerators and Freezers*. Published by the California Energy Commission. (accessed July 7, 2014).

Econics (2010).
Costs and Benefits of Homeowner Investment in Residential Water Efficiency Technology in British Columbia, prepared for The British Columbia Real Estate Association, Vancouver, BC.

EPA WaterSense (2014).
Response to Comments on Labeling of Tank-Type High-Efficiency Toilets: Appendix A – WaterSense Drainline Carry Testing Results. (accessed July 7, 2014).

Health Canada (2010).
Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing. (accessed March 17, 2014).

IAPMO (2012).
GreenPlumbers® Reference Manual. Ontario, Canada. First edition.

Industry Steering Committee for the Sustainable Housing Technology Roadmap (2012).
Housing for a Changing World: A Sustainable Housing Technology Roadmap for Canada. (accessed March 17, 2014).

Lévesque, Benoît, MD FRCPC, Michel Lavoie, MD FRCPC, and Jean Joly, MD FRCPC (2004).
Overview of the tension between hot water efficiency and safety and the need to prevent Legionnaire's Disease. *Canadian Journal of Infectious Disease*. 15(1): 11–12. (accessed March 17, 2014).

Maximum Performance Testing (2010-2013).
What is MaP? (accessed March 17, 2014).

Mayer, Peter, et al. (1999).
Residential End Use of Water data. prepared for the American Water and Wastewater Association Research Foundation.

Natural Resources Canada (2003).
Solar Water Heating Systems: A Buyer's Guide. (accessed March 17, 2014).

Natural Resources Canada (2012).
Improving Energy Performance in Canada. Report to Parliament Under the *Energy Efficiency Act* for the Fiscal Year 2010-2011. (accessed July 8, 2014).

Natural Resources Canada (2014).
Refrigerators/wine chillers. (accessed March 17, 2014).

Plumbing Efficiency Research Coalition (2012).
Drainline Transport of Solid Waste in Buildings. (accessed March 17, 2014).

Viola, David (2002).
Water Temperature Control and Limitation, prepared for the Plumbing Manufacturers Institute, Schaumburg, Il.

World Plumbing Review (2008).
Don't Let a Valuable Resource Go Down the Drain. Issue 1: 12-15. (accessed July 17, 2014).

29-01-16
68349

twitter YouTube LinkedIn facebook

www.cmhc.ca