Reducing Costs of Affordable Housing

DRAINWATER HEAT RECOVERY

Introduction

After space heating, water heating is the second largest energy end use for Canadian households, representing approximately a quarter of the total household energy consumption and almost 20 million tons of CO_2 emissions per year.[1]

Approximately 90 per cent of the energy used to heat domestic hot water is still in the water after it is used. Drainwater heat recovery (DWHR) technologies offer the opportunity to capture some of that heat before it is lost to the sewer.

Although this technology adds to the capital cost of construction projects, the energy savings over the life of the building help make it an ideal application for affordable housing projects.

Description

Drainwater heat recovery (also known as greywater heat recovery) can be configured in several ways but, in many cases, the hot drainwater passes through a heat exchanger that allows it to preheat the incoming domestic cold water.

The simplest configuration consists of a vertical copper drainpipe heat exchanger with copper coils wound around it.

Entering from the top, the drainwater from showers (normally around 37°C [99°F]) falls through the large copper drainpipe, clinging to the inside wall of the pipe as a thin film. At the same time, fresh cold water that may enter as cold as 6°C to 10°C (43°F to 50°F) flows upward through the coils wrapped around the drainpipe and picks up the heat from the drainwater that would have otherwise been lost.

The heat exchanger achieves highest savings when the cold water flow matches the drainwater flow.[2] For this reason, the preheated cold water is often piped to both the water heater inlet and the fixtures' cold water supply lines. At the bottom of the heat exchanger, the cooler drainwater then continues to the sewer.

The two streams are kept separated at all times so there is no risk of contamination, but a significant portion of the heat from the drainwater is efficiently transferred to the fresh water with no energy use, only a slight drop in water pressure. Recovery performance is influenced by many factors, such as heat exchanger dimensions/design, piping configuration and shower duration, but increases of 10°C-12°C (18°F-22°F) in incoming cold water temperature are possible.

DWHR does not require any sort of controls to operate and is maintenance-free.

Application

This technology has been applied at thousands of residential installations. One such installation is the DWHR retrofit at the Cloverdale housing co-operative in Montréal, Quebec.

At Cloverdale, the typical block of dwellings consists of 18 apartments, with 6 apartments on each of three floors. Each block also has a basement in which there are six vertical drain stacks located such that each one captures drainage from the 3 stacked apartments.

In all, 73 DWHR units were installed in Phase I of this housing co-operative.

This residential complex used an experimental set-up, which employs a dedicated variable speed pump for each unit to circulate the fresh water only when heat is available. The pump automatically speeds up as more heat becomes available to recover.

The system was fitted with heat meters to monitor performance and allow for better analysis of its benefits.

[1] Harris N.C. (2006). A National Framework for Solar Hot Water. Greenpeace Canada, Toronto.

[2] Zaloum, C., J. Gusdorf, A. Parekh (2006). *Performance Evaluation of Drain Water Heat Recovery Technology*. Sustainable Buildings and Communities, Natural Resources Canada, Ottawa.

The net total estimated annual savings from the Phase I installation was reported to be 39,657 m^3 (1,397,295 ft^3) of natural gas, or $11,900 assuming a natural gas cost of $0.30/$m^3$ ($0.0085/$ft^3$) (the cost of natural gas at the time of the study in 2007).

Multi-unit residential buildings (MURBs)

This type of building benefits from having more occupants per drain stack than single-family homes. Higher water consumption leads to more energy recovery and more energy savings per unit installed.

Typically, up to three apartments can share a single DWHR unit, so larger buildings will have these installed at regular intervals to cover all the suites.

Benefits and considerations

There are several benefits to drainwater heat recovery. The main benefits of this technology are saving energy and reducing operating costs. Entering cold water may be preheated by about 10°C-12°C (18°F-22°F) as it flows through the heat exchanger, and this reduces the energy required to heat service water in the building.

This technology also allows for an effective increase in heater capacity. In other words, where the heater may have been able to supply enough hot water for a certain shower length, reducing the hot water demand allows for the shower duration to be extended significantly. A study showed that DWHR units increased the maximum shower length from a benchmark of 28 minutes to over 75 minutes.[3]

Retrofitting this technology in buildings with larger families can help alleviate insufficient heater capacity issues. Incorporating DWHR into new construction projects could help to reduce the size requirements of the domestic hot water heater.

Installation is easy in new buildings as long as DWHR is planned into the design of the water heating system.

As DWHR typically relies on gravity to convey the drainwater through the vertical heat exchanger, any showers that are not installed above the heat recovery pipe cannot benefit from this technology. Furthermore, as with any water piping system, extending pipe runs results in a pressure drop that may present a problem for buildings that already have low water pressure. Some manufacturers have addressed this issue by adding multiple outer tubes[4] to their DWHR units. Extra attention should be paid to pressure drop when selecting a DWHR model.

A limitation of this type of heat recovery is that it requires concurrent hot water draw and drainage. Hot water uses such as showers fit this description, but typical installations of DWHR would be unable to save energy from clothes or dishwashing operations or baths unless a storage system is added to hold the drainwater until more hot water is required.

Last, DWHR must be carefully designed to ensure that warmed water is not delivered to faucets where cold drinking water is desired.

Initial cost

Costs can vary widely based on the type of installation. For new construction, manufacturers' advertised installed costs for basic systems can be as low as $500, including labour, for a single-family unit and up to $1,000 to $1,400 shared between two to four units in MURBs (2012 cost data).

More complex installations with custom designs and circulating pumps or storage tanks will result in higher initial costs, but these are difficult to generalize as they are dependent on site conditions and design details.

In retrofit applications, the material costs may be the same, but installation costs could be higher.

One manufacturer reports that typical paybacks are in the order of two to six years[5] depending on the overall hot water consumption, piping layout and utility rates. An online calculator has been developed to predict savings across Canada.[6]

There may be some government and utility programs that help to reduce the initial cost through cash rebates for the installation of DWHR products.

Maintenance requirements

These systems are considered to be maintenance-free given the passive nature of their operation. Periodic inspection and cleaning are recommended to keep them operating at peak efficiency, but the soapy warm water used during showers also serves to clean the inner surface of the drainpipe.

[3] Zaloum, C., J. Gusdorf, A. Parekh (2006). Op. cit 2.

[4] Zaloum, C., M. Lafrance, J. Gusdorf (2007). *Drain Water Heat Recovery Characterization and Modeling*. Sustainable Buildings and Communities, Natural Resources Canada, Ottawa.

[5] RenewABILITY Energy Inc., Residential applications website. Retrieved from http://www.renewability.com/general/residential.html.

[6] CEATI (2007). Drainwater Heat Recovery Energy Savings Calculator. Accessed at http://www.ceati.com/calculator/.

Operating cost

In basic installations without pumps or tanks, this passive type of heat exchange does not require input power to operate. The driving forces are gravity and municipal water pressure. However, taller buildings or those in zones with low municipal water pressure may require supplemental pumping energy, which adds to the operating costs of this type of system.

Installations that depend on additional equipment, such as pumping or storage, will be subject to increased maintenance costs to keep the auxiliary equipment in working order.

The costs associated with the maintenance procedures also depend on the nature of the installation. Where access to the device is restricted, specialized equipment and labour may be required.

Implementation considerations

Since DWHR units impose an added resistance in the domestic water distribution system, it is important to select a unit that will not present flow problems in the building. The added loss of pressure can amount to over 15 PSI (103 KPa) in some cases.[7]

Heat recovery performance is dictated by the entering temperatures of both drainwater and fresh water. For this reason, recovery performance will suffer if the shower drainwater mixes with toilet flushing or lavatory water. Reduced heat recovery efficiency will extend payback periods in MURBs, as the lavatories and toilets share the same drainpipe with the showers.

A solution to this situation is to drain all the showers together through the DWHR device before discharging into the general drainpipe.

Life expectancy

These devices are made with the same materials that are used for distribution piping and have no moving parts; therefore, the drainpipes are as durable as any copper water pipe.

Manufacturers' literature state expected lifespans from 40 to over 50 years.

Manufacturer and industry support

There are four major manufacturers of DWHR systems in Canada.

Third-party evaluations

Studies investigating the efficiency of drainwater heat exchangers have been undertaken and published. Some focus on the theoretical modelling of this type of heat recovery, while others test commercial offerings both at the lab and in closely controlled and monitored model homes.

The Canadian Centre for Housing Technology (CCHT) undertook a two-phase investigation on residential drainwater heat recovery. The first phase focused on quantifying the possible energy savings in a typical home from sample units from three manufacturers and the impact of DWHR on extended shower durations.[8] It found that non-shower savings during the day were negated by a single cycle of the heater burner when there are no hot water draws. It found that all DWHR devices tested resulted in significantly longer hot water availability.

The overall thermal effectiveness of the DWHR units tested ranged from 46 per cent to 67 per cent, depending on size, flow rates and piping configuration. Devices installed with equal drainwater and fresh water flow rates achieved the most savings.

The second phase continued the testing in order to develop a model to predict the performance of DWHR systems.[9] The study found that shorter pipes generally perform best on a per-length basis, but the best performance is from longer units. It also investigated pressure losses and found that the wrapping pattern of the outer copper tube has an impact on the water pressure loss. Units where water travels through multiple tube sections or tubes in parallel had much smaller pressure loss. Results from the performance modelling and testing were used to develop an energy savings calculator[10] that can be accessed at http://www.ceati.com/calculator/.

[7] Zaloum, C., M. Lafrance, J. Gusdorf (2007). Op. cit. 4.
[8] Zaloum, C., J. Gusdorf, A. Parekh (2006). Op. cit. 2.
[9] Zaloum, C., M. Lafrance, J. Gusdorf (2007). Op. cit. 4.
[10] CEATI (2007). Op. cit. 6.

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