Drain Water Heat Recovery

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Drain Water Heat Recovery

A review of performance, economics, practical issues and applications

CEEN 596 Final Project
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Executive Summary

This project evaluates the economics of Drain Water Heat Recovery (DWHR), more specifically the performance of a horizontal DWHR device manufactured by EcoDrain, the A1000. The device was tested in a rig that mimics a typical real world installation. The temperature increase and flow rate of fresh water passing through the device was recorded to determine the energy saved while showering. Both the transient and steady state performance of the device was determined. By combining the testing results with a dataset of Canadian household sizes, showering habits, and energy costs, a recommendation is made for the conditions under which the installation of an EcoDrain would be economically advantageous.

The testing simulates an installation where the fresh water being preheated supplies only the associated fixture, which would be the easiest installation for an existing building. Testing showed an average temperature increase of 12.2°C with a flow rate of 3.87 L/min of fresh water passing through the DWHR device, which corresponds to a heat transfer rate (power savings) of 3.29 kW, and a total of 0.43 kWh saved per shower.

The average Canadian household has a size of 2.59 people, with each person showering once a day for 8.5 minutes each. Energy costs vary significantly around the country, but the average electricity rate is 9.41¢/kWh and 7.13 $/GJ. For the average household, the NPV of DWHR is -$203.68 for homes with electric water heaters and -$464.88 for homes with natural gas water heaters.

DWHR is much more economical for households with electric hot water heaters as their energy costs are much higher. A household of 4 or more people with an electric hot water heater would benefit from installing a DWHR device such as the EcoDrain. Locations with natural gas heaters would benefit from DWHR if there are more than 14 users a day, or if natural gas prices return to more historic levels.

Acknowledgements

I would like to thank Dr. Eric Mazzi for finding this project opportunity and continuous help along the way, and also for all the work he does for the CEEN program and its students. I would also like to thank David Velan, who manages EcoDrain. David provided the EcoDrain A1000 for testing, as well as support in securing an installation location and technical support regarding installation, testing, and general information.

I would also like to thank Brenda Sawada, Lillian Zaremba, Jeff Giffin, and everyone at UBC Campus + Community planning for their time and efforts in finding a location on campus to install the EcoDrain. Although we weren’t able to secure a location for installation due to time constraints, the experience was valuable and hopefully we’ve laid some groundwork for a future student.

Finally, I would like to thank those closest to me. My parents, who have shown me how much is possible with hard work and have inspired me to follow my dreams no matter how challenging that journey may be. Babcia, for your continuous support and endless kindness throughout my life. Dianne, you’ve brought us to where we are today, thank you.

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Introduction

Background

Drain water heat recover (DWHR) is the process of transferring heat from an effluent flow to another flow that requires heating, thereby utilizing energy that would have otherwise been wasted. A DWHR device is a heat exchanger that allows this heat transfer to occur, while ensuring that the two flows do not mix. This project analyzes the use of a DWHR device in a residential setting where the effluent stream is greywater from a bathroom shower that is used to heat fresh water. A DWHR device must be designed to withstand an effluent stream with irregular flow containing a mixture of various liquids and solids, with little to no maintenance. This durability comes as a sacrifice of performance and size.

All of the DWHR devices currently eligible for Natural Resources Canada's incentives (ThermoDrain, Power-Pipe, and Watercycle) consist of a similar design including copper tubing wrapped around a copper drain pipe that is to be installed in a vertical portion of drain piping. This project reviews the performance of the A1000 DWHR device made by EcoDrain, which is a horizontal DWHR device. Horizontal DWHR devices have several advantages over vertical DWHR devices including more flexible installation options and opportunities for innovation and cost reductions. Installation options for a vertical DWHR device are limited to perfectly vertical pipe. If the pipe is not perfectly vertical, the tested heat transfer rate will not be achieved because the water will not completely and evenly cling to the inside wall of the pipe as is necessary. Horizontal DWHR devices can be installed on horizontal or sloped runs, which occur more frequently (installation is feasible in more locations), are closer to the fixture (higher efficiencies due to lower heat loss, and lower likelihood of having cold effluent streams running through the DWHR device), and are more accessible generally (construction will have a smaller and more contained footprint).

The design of vertical DWHR devices has changed very little over the time that they've been available, and it is unlikely that the design can be significantly improved or for drastic cost savings to be achieved. The horizontal DWHR device from EcoDrain has more components but contains less copper. The modular design has more opportunities for design improvements and variety, for example varying performance for a variety of acceptable pressure drops. By having a smaller portion of the price attributed to material costs there are greater opportunities for cost savings through larger scale production and the cost will be less affected by rising copper prices.

A DWHR device can be plumbed in multiple configurations depending on the location of the DWHR device relative to the water heater and the fixture. The choice of configuration will affect installation costs as well as the energy savings achieved. The three most common configurations are shown on the following page in Figure 1. Configuration A has the fresh water exiting the DWHR device running directly to the shower fixture. Configuration B has the fresh water exiting the DWHR device running directly to the water heater. The last option, configuration C, is a combination of the two other configurations. Fresh water is piped through the DWHR and then splits to both the fixture as well as the water heater. Configuration A is the easiest to install in an existing building as plumbing modifications will only need to occur close to the fixture. Configuration C is the most efficient as it has the largest fresh water flow through the DWHR device, matching the volume of water flowing through the drain side. The temperature gain will be the lowest, but it is applied to a large volume of water. Both options B and C require running the main cold water line through the DWHR device and back to the water heater, which in most cases will be separated by a large distance, and in existing homes would require a large amount of construction. Since this project will be considering retrofitting DWHR devices into existing homes, configuration A will be used to determine savings.

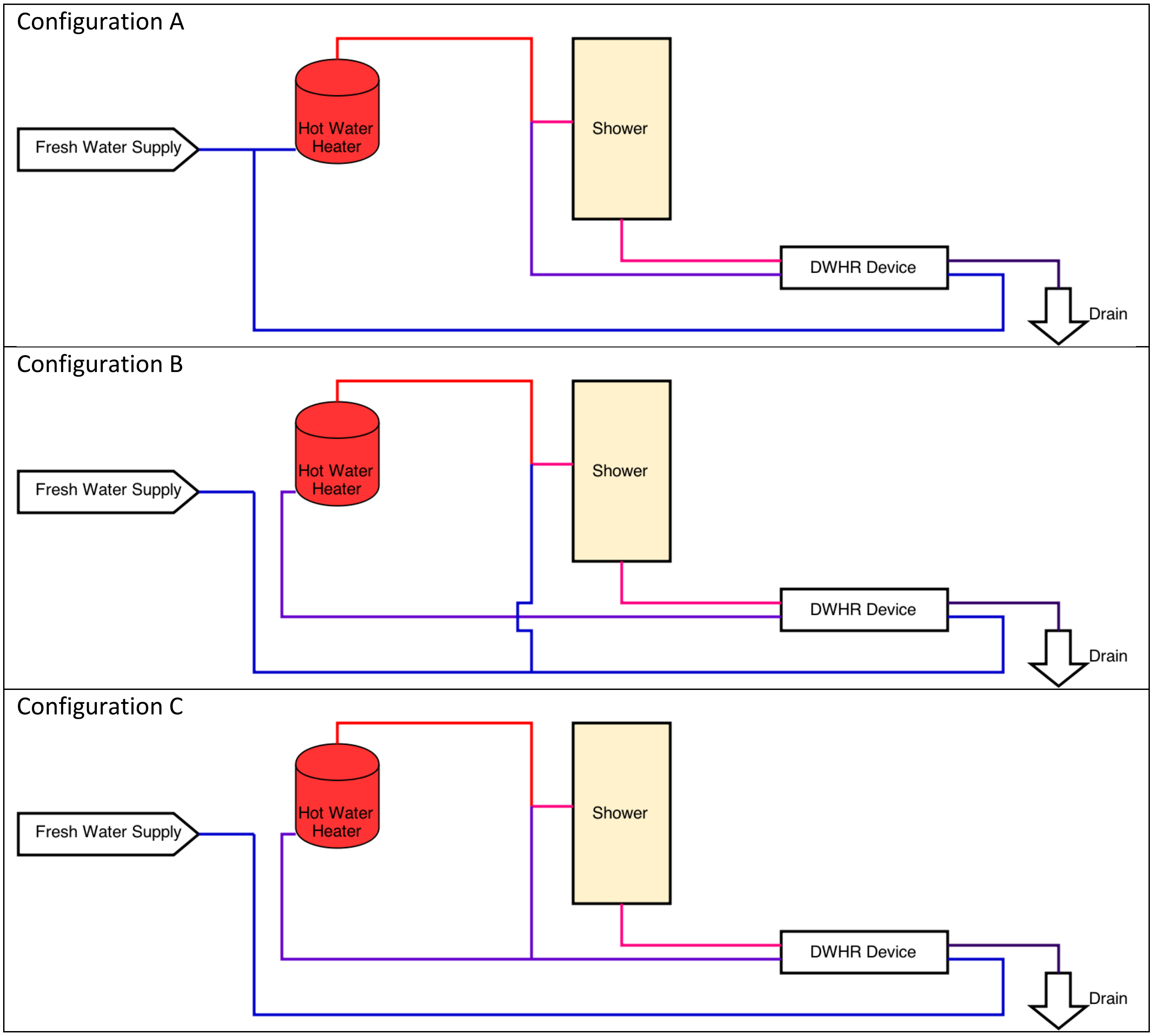

Figure 1: Installation configurations for DWHR devices

The DWHR device that is being studied in this project is the EcoDrain A1000. It is shown on the next page in Figure 2. The device has a heat exchanger length of 122 cm (48’’), a total length of 142 cm (56’’), a width of 13 cm (5’’), and a height of 11 cm (4.5’’). The body of the device is made of plastic. The device consists of the upper drain water region where the effluent steam flows, having a flat copper bottom. A photograph of the interior of the device is shown on a following page in Figure 3. The lower region of the device is for the fresh water flow, and contains a turbulator to increase the heat transfer coefficient of the fresh water passing through it. Most building and plumbing codes require a double wall construction to ensure that grey water does not cross over into the fresh supply water. The A1000 has a double wall design and also features a vent connected to the interface between the double wall, which provides an indication if either of the walls of the heat exchanger begin to leak. More information, including dimensions, connection options, and installation schematics are available in Appendix C, the datasheet for the EcoDrain A1000.

Figure 2: The EcoDrain A1000

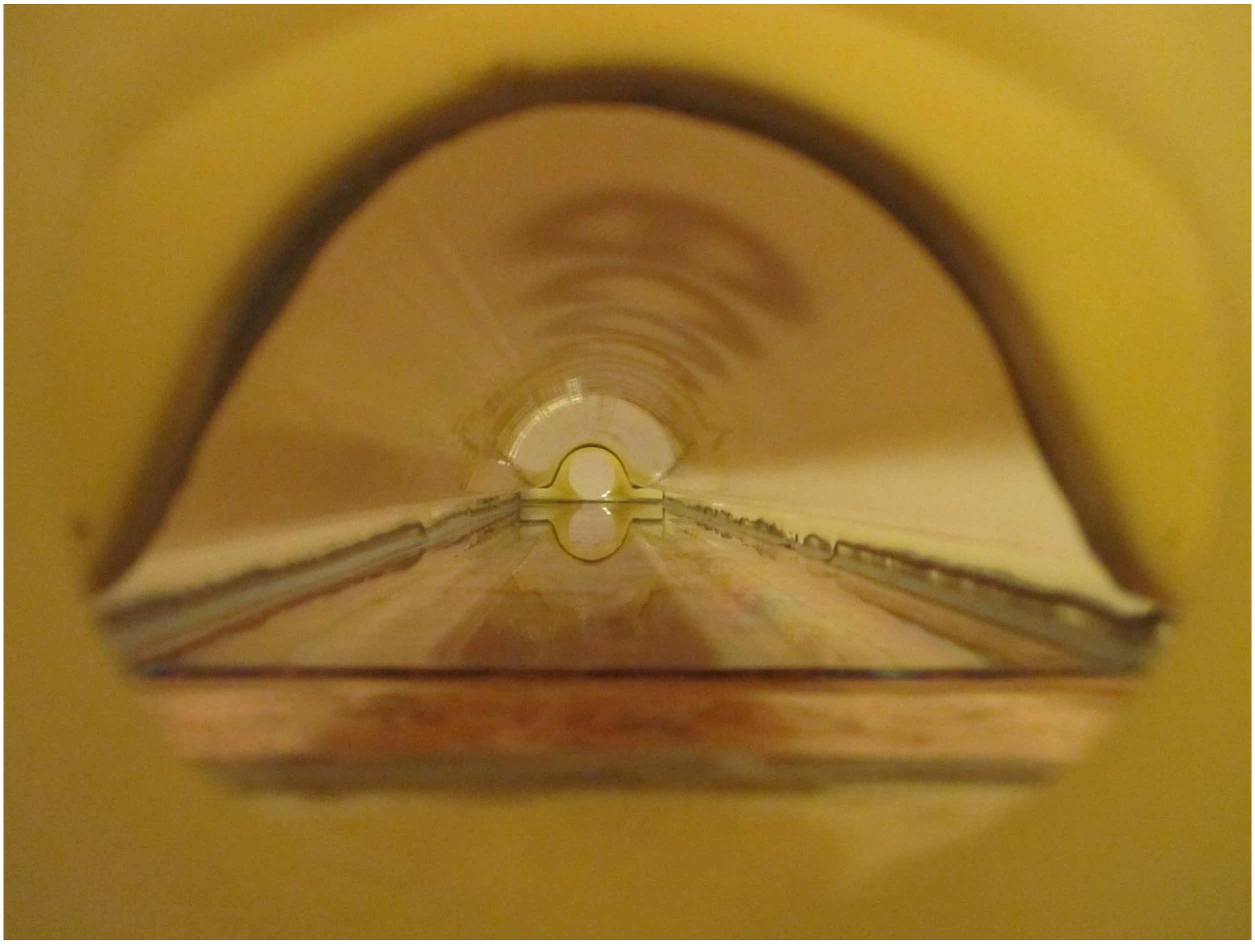

Figure 3: The interior of the EcoDrain A1000

Installation at UBC

The initial scope of this project included the installation of the EcoDrain in an actual shower on UBC campus. A suitable location would have a shower with heavy use that also had easy access to the DWHR device while installed for testing purposes. Multiple locations were scouted over a three week period including the Student Recreation Centre, War Memorial Gymnasium, UBC Aquatics Centre, and the Chemical & Biological Engineering Building. The UBC Aquatic Centre was the best candidate because of the high frequency of shower use and access below the showers, but an installation was unable to be organized within the time constraints. The remainder of the buildings have their showers located on the lowest level with drainage piping in the floor, which would have made testing difficult and installation costs prohibitively high, making them unviable candidates.

Another concern with installing the DWHR device on campus was receiving approval of the UBC plumbing inspector. The feedback that was given to a demo installation focused on health and safety concerns regarding cross connection. Approval was given for a trial installation on the condition that a reduced backflow device was required for potable water connections and that the leak vent indicator needed to be plumbed to a high visibility drain. Certification of the device was a requirement for larger scale deployment. At the time of this writing, the EcoDrain is in the process of being listed for the Uniform Plumbing Code (UPC) by the International Association of Plumbing and Mechanical Officials (IAPMO) in California, and the Canadian UPC (cUPC) by the Canadian Advisory Council on Plumbing (CACP).

Purpose and Objectives

The purpose of this project is to evaluate the performance of a DWHR system in a real world setting in order to assess the economics and practicality of using DWHR systems to reduce energy consumption. A commercially available unit, the EcoDrain A1000, will be installed in a rig that mimics typical showering plumbing and piping and the performance characteristics of the unit will be measured. This information will form the basis of an economic assessment, including the net present value, of installing a DWHR system under different conditions.

The key variables in the economic assessment of this system will be the capital and installation costs of the device, the volume of drain water that flows through the system (which is the product of the flow rate of the showerhead and the total length of showers taken), and the cost of heating water (energy costs and heater efficiencies). The testing will find the conditions necessary for a DWHR system to be economically viable and will produce a calculator tool that finds the net present value given an estimated operating environment. A recommendation will be made with suitable applications for DWHR systems and a consideration of employing incentives to increase DWHR system installations as a form of demand side management (DSM).

Motivation

Heating water is the second biggest household energy use (after space heating) in Canada, accounting for 17% of residential energy use in 2010 [1]. Canadians use approximately 347 PJ of energy to heat water for residential and commercial use, and emit 18 megatons of CO_2 equivalent greenhouse gases to do so [2]. Other research finds that 25% to 41% of this hot water use can be attributed to showering [3], [4]. Finally, 80-90% of the energy added in a water heater is still contained in the water going down the drain of a shower [5]. These facts represent a massive opportunity for energy use and greenhouse gas emissions reductions which can be realized by transferring energy from the hot drain water to cold incoming fresh water using a heat exchanger.

It is my personal belief that the carbon and energy crises will be the greatest challenges faced by humanity. Our societies have developed in the presence of cheap and abundant energy, and have created infrastructure and lifestyles that rely on it. With the fast approaching end of conventional fossil fuels and the need to drastically reduce carbon emissions, we must change the existing infrastructure and lifestyles to work in a low carbon and low energy world. Effective DSM is critical to making this transition.

Literature Review

There is a lack of significant research in the field of DWHR systems, and the studies that have been completed are based on laboratory testing or computer simulation. The research is focused primarily on efficiencies of different designs and does not address the practical and economic implications of installing such a system.

A report titled “Drain Water Heat Recovery Characterization and Modeling” compared eight different models (2 from 4 different manufacturers) of DWHR systems in terms of the Number of Thermal Units (NTU) and effectiveness and found that NTU per wrapped foot ranged from 0.17 to 0.33 and that effectiveness ranged from 0.1 to 0.16 per foot of wrapped length between the different models [6]. The report focused on theoretical efficiencies and did not do a broad economic evaluation of DWHR systems.

A 2011 ASHRAE journal article covers DWHR systems in the Emerging Technologies section, and mentions efficiencies of up to 40% with payback ranging from 2-5 years [5].

Research from the Hong Kong Polytechnic University titled “Shower water heat recovery in high-rise residential buildings of Hong Kong” showed that only 4-15% of shower water heat can be recovered using a 1.5m long single-pass counter–flow heat exchanger on a 50 mm drainage pipe.[7]. The experiment was performed using a lab setup and a custom DWHR unit with thermocouples at all inlets and outlets and flow meters on both flows.

Another prototype built for testing purposes generated annual savings of $160, but was based on a standard heat exchanger and not a commercial product specifically for DWHR [8]. A valid economic assessment could not be made as real world costs were not included, and performance data could have been potentially skewed due to the ideal conditions that the unit was operated under (not used in an actual shower). No assessment of maintenance issues was made in any of the studies.

Natural Resources Canada (NRCan) has a protocol established to standardize testing procedures for DWHR, but it is limited to vertical DWHR devices (Appendix B). The testing procedure stipulates even flow conditions (drain water flow rate matches fresh water flow rate, configuration C described earlier). The protocol employs an energy balance to ensure accuracy (the heat gained by fresh water must match the heat loss on of the drain water within 5% for the results to be valid). The performance is based on the steady state heat transfer, and the pressure drop of fresh water across the DWHR device is measured.

Data Sources and Methodology

The economic analysis of DWHR units that is performed is the product of two sets of data. The first set of data describes the conditions that a DWHR device will be exposed to in an average Canadian home. This includes water heater type and efficiency (electric / natural gas), energy costs, showering water temperatures, shower head flow rates, and the frequency and duration of showers. The second data set is derived from the testing performed as part of this project. A test rig will be constructed that mimics the plumbing associated with showers and the DWHR unit will be exposed to the conditions described in the first data set. By combining these two data sets, the economics of installing a DWHR will be determined.

The effectiveness of the system will be quantified by measuring the amount of energy added to the cold water supply. This can be calculated by recording the inlet and outlet temperatures and flow rate of fresh water through the DWHR system.

The temperature transfer efficiency can be calculated using the formula:

$$\mu_t = \frac{(t_2 - t_1)}{(t_3 - t_1)}$$

Where: μ_t is the temperature transfer efficiency, and t_1, t_2, and t_3 are the temperatures of the incoming fresh water, incoming drain water, and outgoing freshwater, respectively.

The equipment used to measure temperature and flow rates during testing is presented below in Table 1. The temperature measurement has an accuracy of ±0.1°C.

Device	Description
Drain Water Heat Recovery Unit	EcoDrain A1000
Temperature Sensors	Omega Thermistors, TH-10-44034-1/8-4-40
Temperature Logger	Omega Logger, OM-USB-TEMP
IR Temperature Sensor	SKF TMTL 260 ThermoLaser
Portable Water Meter	Endress&Hauser Prosonic Flow 93P

Table 1: Equipment used to measure DWHR system performance

Statement of Typical Conditions

In order for an accurate assessment to be made on the impact of installing a DWHR device in a Canadian home, a summary of typical hot water systems, energy costs, and showering habits must be made.

Electricity and natural gas prices vary province to province, and even city to city, and include various connection, demand, time of use, and delivery charges. For this analysis, savings will only be considered for consumption charges, and a simplified summary of those costs are presented by province in Table 2 and Table 3 below.

Province	City	Provider	Comment	Rate (¢/kWh)	Rate ($/GJ)
BC	Vancouver	BC Hydro	Step 2	10.34[9]	28.72
AB	Calgary	Enmax	5 year fixed rate	8.90[10]	24.72
SK	Saskatoon	Saskatoon Light and Power		12.24[11]	34.00
MB	Winnipeg	Manitoba Hydro		6.94[12]	19.28
ON	Toronto	Toronto Hydro	Mid-peak Price	9.90[13]	27.50
QC	Montreal	Hydro Quebec	Above 30kwh/day	7.78[14]	21.61
NB	Saint John	Saint John Energy		9.05[15]	25.14
NS	Halifax	Nova Scotia Power		13.79[16]	38.31
PE	Charlottetown	Maritime Electric		12.41[17]	34.47
NL	St. John's	Newfoundland Power		11.17[18]	31.03

Table 2: Provincial electricity costs

Province	City	Provider	Comment	Rate ($/GJ)
BC	Vancouver	Fortis BC		7.86[19]
AB	Calgary	Enmax	5 year fixed	5.99[10]
SK	Saskatoon	SaskEnergy		5.71[20]
MB	Winnipeg	Manitoba Hydro	Primary Gas	6.12[21]
ON	Toronto	Enbridge Gas	"Next 55"	6.37[22]
QC	Montreal	Gaz Metro	Rate D	6.41[23]
NB	Saint John	Enbridge Gas New Brunswick		17.29[24]
NS	Halifax	Heritage Gas		18.15[25]
PE	Charlottetown		Not available in PE	N/A
NL	St. John's		Not available in NL	N/A

Table 3: Provincial natural gas costs

As is shown in Table 2, the rate for the equivalent amount of energy in electricity is much higher than it is for natural gas. This is caused by the inefficiencies of the conversion of thermal energy to electric energy. The National average energy cost for electricity and natural gas were calculated by performing a weighted average of provincial costs by provincial population. The weighted average costs were found to be 9.41 ¢/kWh for electricity and 7.13 $/GJ for natural gas.

Hot water boilers fuelled by electricity and natural gas are both very common. The proportion of each by province is shown below in Table 4, along with populations and household sizes. Electric hot water heaters use immersed resistance coils and transfer nearly all of the electric energy to the water. Efficiencies of natural gas boilers vary significantly depending on design and age, from 60% to 95%. For the economic analysis performed in this project, a boiler efficiency of 80% is used.

	Population	Households	People/Household	% Electric HWH	% Natural Gas HWH
Canada	34,484,000	13,320,610	2.59	41.2	48.2
B.C.	4,576,600	1,764,635	2.59	33	58.7
Alta.	3,778,100	1,390,275	2.72	5.2	84.2
Sask.	1,057,800	409,645	2.58	30.7	63
Man.	1,251,700	466,140	2.69	30.7	63
Ont.	13,366,300	4,887,510	2.73	22.1	67.9
Que.	7,978,000	3,395,340	2.35	89.1	2.7
N.B.	755,300	314,010	2.41	72.6	*
N.S.	948,500	390,280	2.43	72.6	*
P.E.I.	145,700	56,460	2.58	72.6	0
N.L.	512,900	208,845	2.46	72.6	0

Table 4: Canadian population, households, and HWH mix from Statistics Canada[26] **and NRCan**[27]

The duration of an average shower is difficult to determine, but based on research of showering and water use, the average shower was found to be 8.5 minutes long [28] with a frequency of approximately once a day. The temperature of a shower will also vary by user preference. To keep things consistent, the temperature of 36°C from the NRCan DWHR testing protocol is used in this testing.

The lifetime of the DWHR device was evaluated at 15 years based on the “Measure of Life” study for energy evaluation performed for the state of Wisconsin[29].

DWHR Performance Evaluation

Testing Setup

A test rig was constructed in order to replicate the conditions that would be experienced by a DWHR unit installed in an actual shower. More specifically, the system was in configuration A, as described earlier, where the cold water supplying the shower mixing valve passes through the DWHR unit where it recovers heat from the drain water. A schematic of the layout and instrumentation is shown on the following page in Figure 4

In order to measure the heat gained by the fresh water in the DWHR device, the temperature was measured at the inlet and outlet. Immersion thermistors were used, which offer ±0.1°C accuracy. The flow rate was measured at the inlet to the DWHR device using a clamp-on ultrasonic flow meter.

The temperature of the hot water supply was periodically checked using an infrared temperature sensor to ensure that it remained at 45°C.

Following the mixing valve, the water was poured into a basin that slopes slightly towards a drain, as would be present in an actual shower. The temperature and flow rate are measured to ensure conformance with Canadian averages, 36°C and 9.5 L/min.

The drain plumbing replicates that of building code standards, including a p-trap. The drain connects to the EcoDrain which is sloped at 3/8’’ per foot (1.79°). The line then releases into an open building drain. A photograph of the actual testing rig is shown in Figure 5.

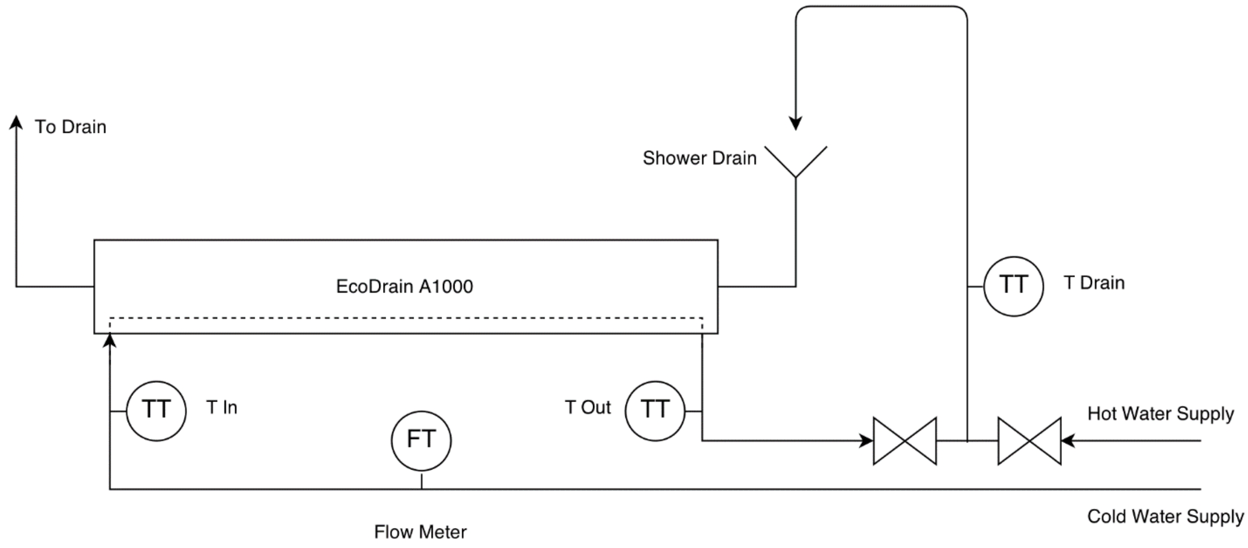

Figure 4: Schematic of testing setup

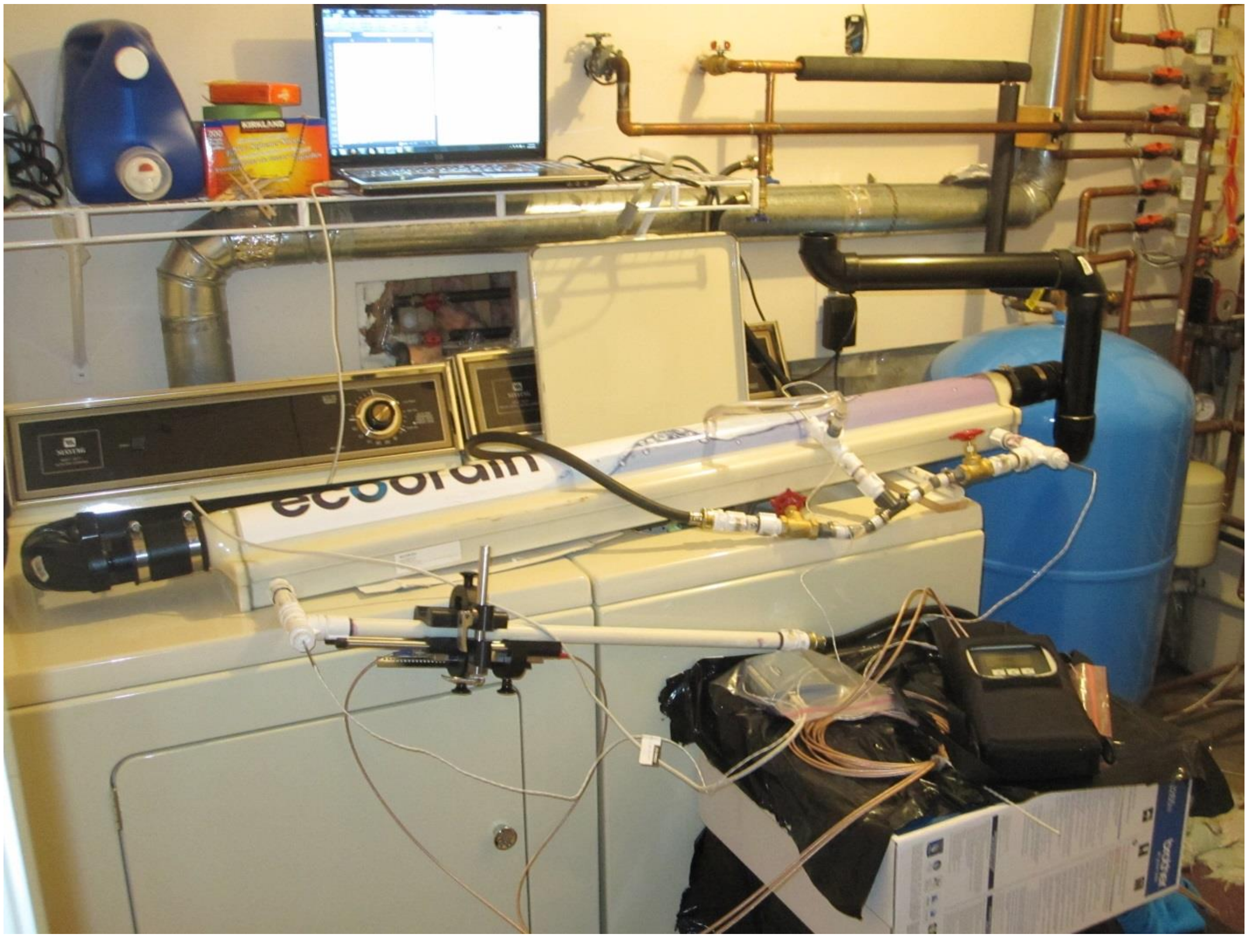

Figure 5: The testing setup

Testing Methodology

The system was kept in a room temperature (20°C) environment for 30 minutes before each trial in order to incorporate the effects of warming up the parts of the system. Including these transient effects more accurately represent an actual shower system where showers are short and/or infrequent.

Before running the shower water through the system, the temperate and flow rate were set to their target values. The temperature was measured via a thermistor probe inserted into the flow. The flow rate was measured by timing the filling of a container of known volume, in this case a bottle that was 2L. Adjustments were made until both values reached their target. Both measurements were then repeated to confirm they were at their target. Next, the logging was started on the flow meter and the temperature probes.

Finally, the shower flow was put into the shower drain system. With the shower water running through the drainage piping and DWHR device, the system warmed up. As the DWHR system warmed up, it transferred energy to the cold water supply, increasing its temperature which would have raised the temperature of the shower water. The mixing valve was adjusted to increase the cold water flow rate to maintain the temperature in the shower, and the hot water flow rate was decreased to maintain the flow rate at 9.5 L/min.

The system was run until a steady state was reached and maintained for 5 minutes.

The water flow was turned off and the system was left for 30 minutes to allow the components to return to room temperature before performing additional trails. The data processing and analysis are described in the results section below. The test was repeated 3 times to ensure accuracy by verifying the consistency of the results. The average energy transfer of the 3 tests was used in the following economic analysis.

Results and Discussion

Testing Results

The following results are for the performance of the EcoDrain A1000 running in configuration A described earlier. The shower water temperature was set at 36°C with a flow rate of 9.5 L/min. The device was installed at a slope of 3/8'' per foot (1.79°). According to EcoDrain Performance can be improved by 5-10% by installing the device at a larger slope, up to 75° [30].

Steady State Performance

The steady state conditions for the three runs are shown in Figure 6 on the following page and are summarized below in Table 5. The average steady state values will be used in all further analysis.

	Run 1	Run 2	Run 3	Average
Temp In (°C)	11.1	11.3	10.9	11.1
Temp Out (°C)	23.3	23.1	23.5	23.3
Drain (°C)	36.2	35.8	36.0	36.0
Flow (L/min)	3.83	3.94	3.83	3.87

Table 5: Summary of steady state characteristics

Based on the values in Table 5 above, the steady state heat transfer rate is 3284 W (calculation shown in appendix A). For the average 8.5 minute shower, the DWHR device would save 0.465 kWh of water thermal energy.

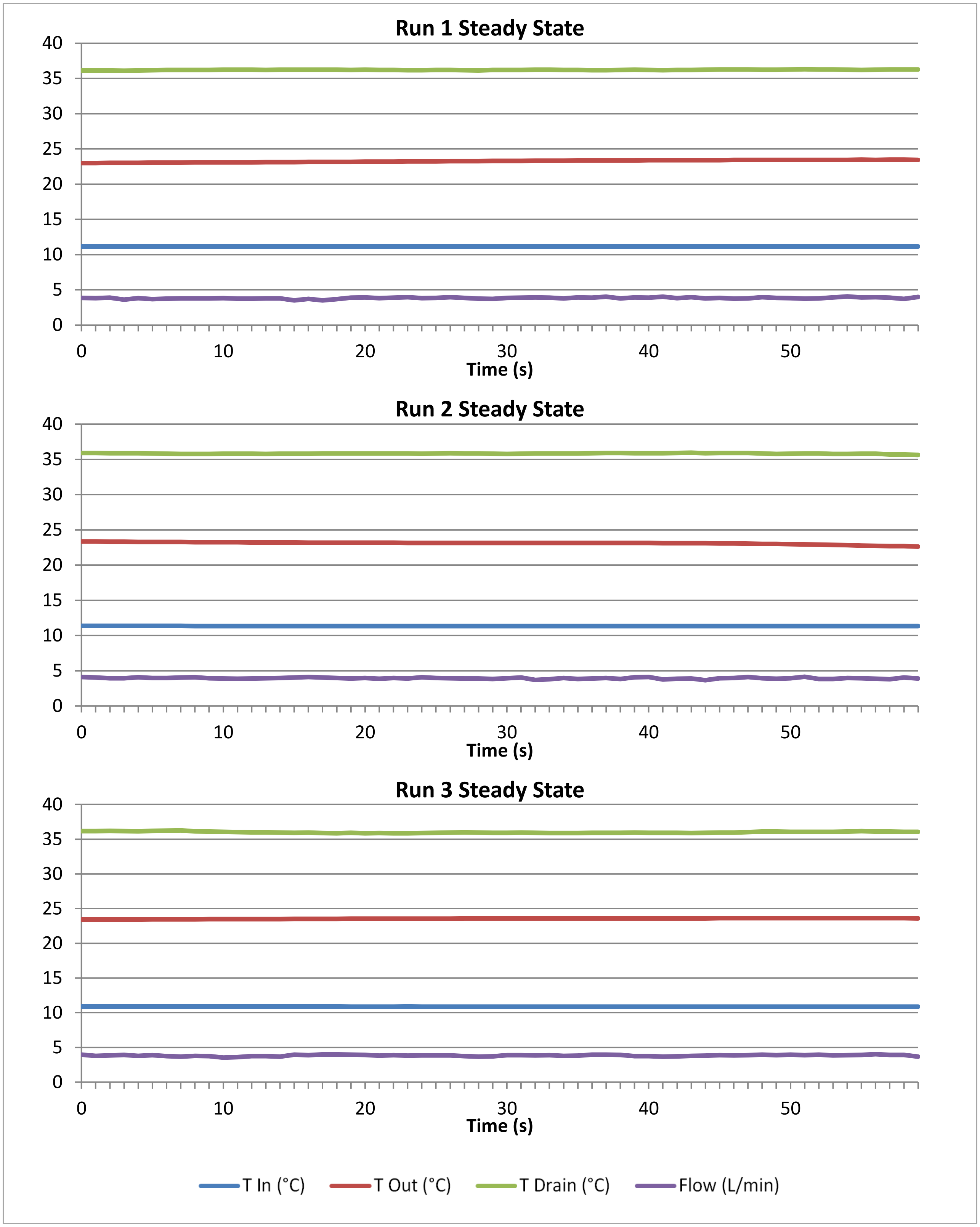

Figure 6: The steady state conditions of the 3 runs

Transient Response

The transient response of the three runs is shown in Figure 7 on the following page and in Table 6 below. There is a delay of approximately 10 seconds after beginning the shower before there is an increase in the temperature of the fresh water exiting the DWHR unit. A further 60 seconds are required before the temperature of the water exiting the DWHR device reaches the steady state value. During those 72 seconds, the DWHR device transfers 46.4% of the energy it would have if it were operating a steady state levels.

	Run 1	Run 2	Run 3	Average
Warm Up Time (min)	1:16	1:10	1:09	1:12
Average Heat Transfer (kW)	1.55	1.57	1.44	1.52
SS Heat Transfer (kW)	3.23	3.23	3.38	3.28
Transient % of SS	48.0%	48.6%	42.5%	46.4%

Table 6: Summary of transient response characteristics

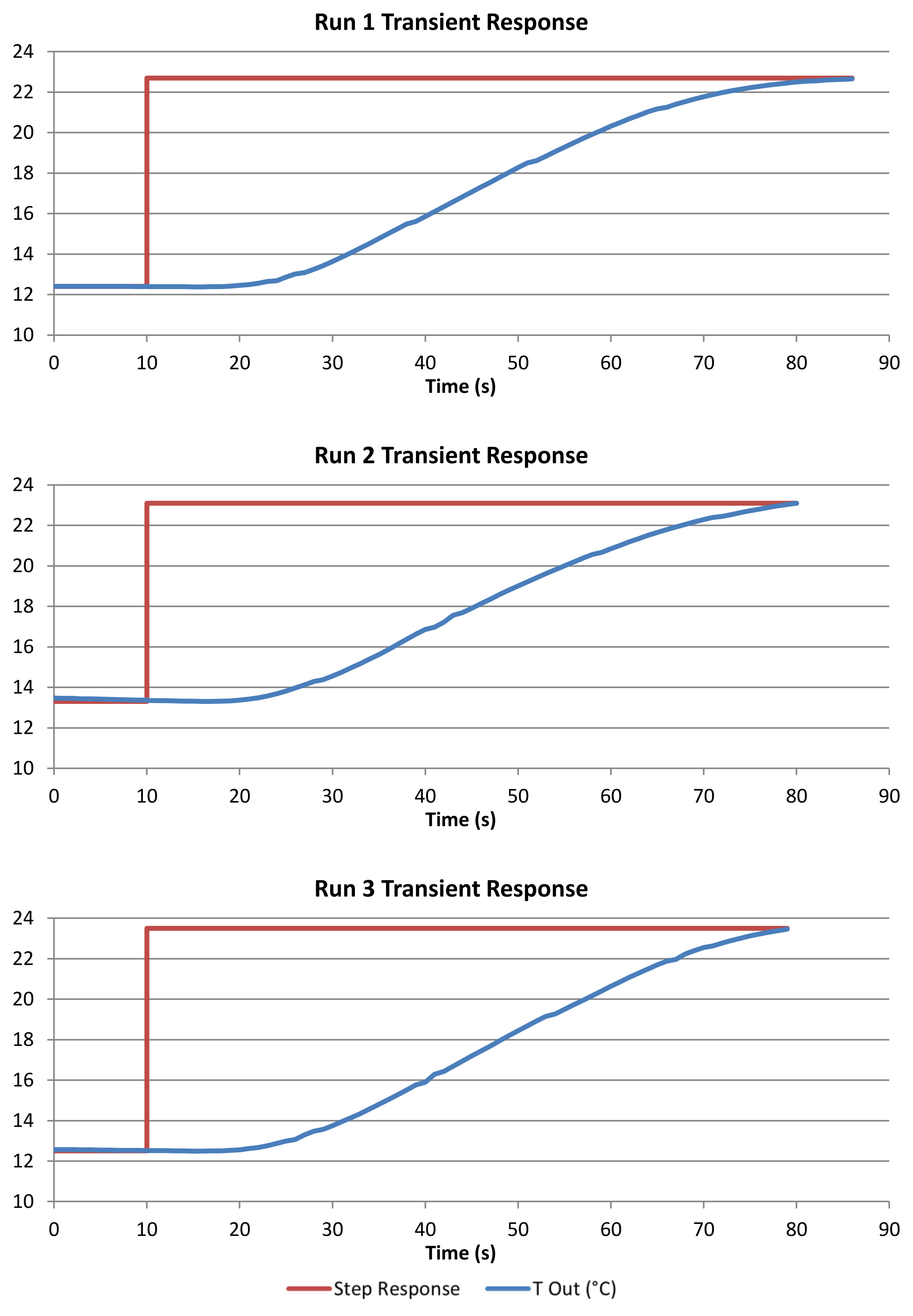

Figure 7: The transient response of the 3 runs

Installation and Maintenance Costs

The economic analysis assumes that the installation of the DWHR device occurs during a major renovation of a bathroom. Under these circumstances, the marginal cost of installing the DWHR device will be negligible compared to the remainder of the renovations being done. If an extremely conservative approach is to be taken, then an installation cost of $200 can be applied, which will decrease the NPVs presented in the following sections by $200.

The grey water side of the EcoDrain was designed to not add any additional restrictions to the effluent flow compared to a 2’’ drain pipe. As a result, the maintenance cost of a shower with a DWHR device will not be any different from a shower without one. If a shower clogged frequently before the installation of a DWHR device, it will continue to clog frequently. If a shower did not normally clog, the addition of a DWHR device should not increase the likelihood of clogs. Once again, taking an extremely conservative approach, we can add an hour of maintenance every 3 years to correspond to a cleaning of the drainage piping and DWHR device, which would decrease the NPVs in the following sections by $267.76

NPV

The net present value of installing the EcoDrain A1000 was calculated based on the values in Table 7 below. The results by province are presented in Table 8 below. Example calculations are in Appendix A. Values differ by province due to varying energy costs and household sizes. Note that natural gas is not available in PEI and Newfoundland and Labrador.

	Base case
Discount rate	5%
Cost ($)	600
Steady state heat transfer (kW)	3.28
Shower Length (minutes)	8.5
Electricity rate (¢/kWh)	9.41
Natural Gas rate ($/GJ)	7.13
Lifetime (years)	15

Table 7: NPV parameters

	Annual Savings ($)		NPV ($)		Payback (years)	
	Electric	Natural Gas	Eletric	Natural Gas	Electric	Natural Gas
Canada	38.18	13.02	-203.68	-464.88	15.71	46.09
B.C.	42.04	14.38	-163.63	-450.73	14.27	41.72
Alta.	37.92	11.48	-206.44	-480.81	15.82	52.25
Sask.	49.55	10.40	-85.69	-492.03	12.11	57.68
Man.	29.21	11.59	-296.76	-479.66	20.54	51.75
Ont.	42.44	12.29	-159.44	-472.48	14.14	48.84
Que.	28.66	10.63	-302.54	-489.71	20.94	56.47
N.B.	34.13	29.34	-245.78	-295.43	17.58	20.45
N.S.	52.54	31.12	-54.66	-276.99	11.42	19.28
P.E.I.	50.21		-78.88		11.95	
N.L.	43.01		-153.58		13.95	

Table 8: NPV and payback results

The NPV of installing a DWHR device is not positive for the average Canadian household. The NPV is highest for homes with electric water heaters and high energy costs (Saskatchewan, Nova Scotia, and PEI)

Sensitivity Analysis

Here a sensitivity analysis is performed to determine the variables that have the most significant impact on the NPV of a DWHR system. Each variable from the base case NPV calculation is modified one at a time to a value 20% higher and 20% lower than the base case, as shown in Table 9 below. The NPV and % change from base case are calculated and shown below in Table 10 and Table 11

	-20%	Base case	+20%
Discount rate	4%	5%	6%
Cost ($)	480	600	720
Steady state heat transfer (kW)	2.62	3.28	3.94
Number of users	2.07	2.59	3.11
Electric rate (¢/kWh)	7.53	9.41	11.29
Natural Gas rate ($/GJ)	5.70	7.13	8.56
Lifetime (years)	12	15	18

Table 9: Variable values for sensitivity analysis

For systems with electric water heaters, the NPV is most sensitive to the capital costs. Since a relatively low discount rate was selected, the 20% increase or decrease does not have a significant impact on the NPV. Since the steady state heat transfer, number of users, and energy rates are all linearly related to the annual savings, the % change is the same for those 3 variables.

	NPV			% Change	
	-20%	Base Case	+20%	-20%	20%
Discount rate	-175.39	-203.61	-229.09	14%	-13%
Cost ($)	-83.61	-203.61	-323.61	59%	-59%
Steady state heat transfer (kW)	-282.88	-203.61	-124.33	-39%	39%
Number of users	-282.88	-203.61	-124.33	-39%	39%
Electric rate (¢/kWh)	-282.88	-203.61	-124.33	-39%	39%
Natural Gas rate ($/GJ)					
Lifetime (years)	-261.52	-203.61	-153.58	-28%	25%

Table 10: NPV response to sensitivity analysis for electric HWH

The lower energy costs of natural gas water heaters decrease the significance of the variables that contribute to annual savings, further emphasizing the importance of capital cost in the final NPV value of a DWHR unit.

	NPV			% Change	
	-20%	Base Case	+20%	-20%	20%
Discount rate	-484.18	-491.87	-498.83	2%	-1%
Cost ($)	-371.87	-491.87	-611.87	24%	-24%
Steady state heat transfer (kW)	-513.50	-491.87	-470.25	-4%	4%
Number of users	-513.50	-491.87	-470.25	-4%	4%
Electric rate (¢/kWh)					
Natural Gas rate ($/GJ)	-513.50	-491.87	-470.25	-4%	4%
Lifetime (years)	-507.67	-491.87	-478.23	-3%	3%

Table 11: NPV response to sensitivity analysis for natural gas HWH

Break-Even

The break even analysis below is performed for each variable of the NPV calculation. The variable is adjusted while keeping the other variables as base case until an NPV of 0 is reached, if possible. The results of the analysis are shown below in Table 12. The analysis shows that energy rates above 14.24¢/kWh for electricity and 39.56 $/GJ for natural gas create a positive NPV under the conditions of an average household. Households with electric hot water heaters having 4 or more people would also be viable candidates for having DWHR installed. The breakeven for cost shows that a price of less than $400 would create a positive NPV for the average household with an electric heater, but a much lower cost is required for homes with natural gas water heaters. It is not possible to achieve a positive NPV by varying discount rate alone.

	Electric HWH		Natural Gas HWH	
		NPV ($)		NPV ($)
Discount rate	0%	-27.16	0%	-443.74
Cost ($)	396.39	0.00	108.13	0.00
Steady state heat transfer (kW)	4.96	0.00	18.20	0.00
Number of users	3.92	0.00	14.37	0.00
Electric rate (¢/kWh)	14.24	0.00		
Natural Gas rate ($/GJ)			39.56	0.00
Lifetime (years)	31.56	0.00	1167	-391.66

Table 12: Break-even analysis for electric and natural gas HWH

Scenarios

Although the NPV calculation for provincial averages was negative, there are many cases where installing a DWHR would provide a positive NPV. Below are 3 examples of cases where DWHR would provide economic benefit.

High Use

This scenario describes an installation in a location where the DWHR device would receive much higher usage then average, for example in a dormitory with common showers, or in recreational facility showers. The number of users was increased to 48 (6 an hour for 8 hours). Maintaining all other variables at base case settings, the total savings would be $1,800 for locations with natural gas water heaters, and over $8,000 for locations with electric water heaters. Results are shown in Table 13 on the following page.

		NPV	
		Natural Gas	Electric
Discount rate	5%	$1,807	$8,224
Cost ($)	600		
Steady state heat transfer (kW)	3.28		
Number of users (people)	48		
Electric rate (¢/kWh)	9.41		
NG rate ($/GJ)	7.13		
Lifetime (years)	20		

Table 13: NPV for high use scenario

Atlantic Canada

This scenario describes a household of 4 or more people in Atlantic Canada. According to Statistics Canada, there are more than 3 million households in Canada with 4 or more people[26]. The combination of above average usage and higher electrical (natural gas not available in parts of Atlantic Canada) costs result in a positive NPV, as shown in Table 14 below.

		NPV
		Electric
Discount rate	5%	$337
Cost ($)	600	
Steady state heat transfer (kW)	3.28	
Number of users (people)	4	
Electric rate (¢/kWh)	14.4	
Natural Gas rate ($/GJ)		
Lifetime (years)	15	

Table 14: NPV for Atlantic Canada scenario

Improvements

This scenario is based on further improvements to the EcoDrain A1000 design and performance, cost reductions through mass production, and installation at a higher angle for a higher heat transfer rate. With a 30% increase in performance and a 30% decrease in price, the DWHR device would be economically beneficial for the average household with an electric hot water heater. The results are shown in Table 15.

		NPV	
		Natural Gas	Electric
Discount rate	5%	-$284.26	$77.64
Cost ($)	420		
Steady state heat transfer (kW)	4.264		
Number of users (people)	2.5		
Electric rate (¢/kWh)	9.41		
Natural Gas rate ($/GJ)	7.13		
Lifetime (years)	15		

Table 15: NPV for improvements scenario

Use for DMS and Implications

The use of a DWHR device reduces the amount of energy a household uses to heat water for showering. Utilities looking to reduce household energy demand could incentivise the installation of DWHR devices by providing a rebate of the purchase price. Since the NPV calculation for the average house is negative, the average homeowner would not realize a savings by installing a DWHR device based on current conditions. A rebate could lower the cost and create a positive NPV, making the installation of a DWHR device beneficial for the average Canadian.

The difficulty is in ensuring that the location where the device is installed will receive sufficient usage to justify the incentive from the utility provider’s point of view. Most showers take place in the early morning[28], so a DWHR device could also serve as method of peak shaving.

There is the possibility that the installation of a DWHR device could drive higher consumption rates. If the user knows that the shower has a DWHR device installed, they may be more inclined to take a longer shower. If users normally wait until the hot water temperature begins to fall as a result of the water heater tank emptying, this would take longer to occur if a DWHR device is being used. It may be possible for a HWH to keep up with a shower if a DWHR device is installed.

Other Considerations

There are some additional factors that should be considered when looking at this analysis. The amount of use that the DWHR device receives is treated as a factor of household size. The analysis assumes that all members of a household use a common shower where the DWHR device is installed. The number of showers within a home will generally scale with the number of bedrooms, so a larger household will not necessarily mean that an individual shower will be used more frequently. Newer homes are also more likely to have a higher number of showers within them. The analysis also assumes that each member of the household bathes by showering. While this is common for Western cultures, in many parts of the world taking baths is more common. For the installation that was described in this project, there would not be any energy savings realized with taking a bath due to the temporal gap between fresh water flow and drain water flow. Lastly, the efficiencies of how water systems and flow rates of showers that were used in the analysis reflect the standard for modern homes. Older homes with original equipment and fixtures would receive greater benefits due higher energy consumption for equivalent heat production out of the water heater, and also higher shower head flow rates.

Conclusions

Based on the preceding analysis, the conditions necessary for the economic use of a DWHR device have been determined. Based on the configuration of the analysis, the average Canadian household would not see a benefit from installing this DWHR device. Generally speaking, the current low costs of natural gas make the economics of using a DWHR device in a household with a natural gas water heater difficult. If natural gas prices return to more historical rates, this could change. The break-even analysis revealed that a household size of 4 or more with an electric hot water heater would benefit from installing a DWHR device. Canada has more than 3 million households of 4 or more people [26], which would benefit from the installation of a DWHR device under current conditions. This analysis was specific to the conditions mentioned, and broader adoption could be possible (ex. different installation configuration).

Significance of Work

Preceding this work, little research has been done on the practicality of installing DWHR devices. The scope of this project was limited to one set of tests performed on one model of horizontal DWHR device. Changes to installation options such as slope, or installation configurations, could potentially increase the performance of the DWHR device to the point where it would be economically advantageous to be installed in the average Canadian home. There is a large opportunity for energy and cost savings which could be achieved if DWHR devices are installed in suitable locations.

Recommendations

My recommendation for further work to be done in this area would be to have the device installed in an actual shower for real world test results. While the setup of the testing performed attempted to mimic actual shower conditions as closely as possible, it is still not an exact match. The drain water contains other additives other than water, including soaps and shampoos, as well as dirt and debris. Furthermore, my assessment did not monitor the pressure drop through the DWHR unit, which is part of the NRCAN testing protocol for vertical DWHR system. Future research should include pressure drop through DWHR units to ensure they do not negatively impact the remainder of the system.

Monitoring an installation in an actual shower will also allow an assessment of maintenance issues and costs and the lifetime of a DWHR device. The economic assessment was based on a lifetime of 15 years with no maintenance costs, and it is unknown whether this is representative of actual conditions. Maintenance fees or a shorter (or longer) lifetime will impact the economic assessment of installing such devices.

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Appendix A – Calculations

Heat transfer rate

$$(23.1℃ - 11.1℃) \times \frac{3.87\ L}{60\ s} \times \frac{4.185\ kJ}{L \cdot ℃} = \frac{3.284\ kJ}{s} = 3.284\ kW$$

Per shower energy savings

$$(Warm\ up\ time\ \times warm\ up\ rate) + (8.5\ \mathrm{min} - warm\ up\ time) \times steady\ state\ rate$$

$$\frac{72}{60} minutes \times 1.52kW + 7.3\ minutes \times 3.284\ kW = 25.8\ kW \cdot min = 0.43kWh$$

Annual energy savings

$$0.43kWh \times 2.59\ \frac{showers}{day} \times 365\ days = 406\ kWh$$

Annual electric cost savings

$$406\ kWh\ \times \frac{9.41¢}{kWh} \times \frac{\$}{100¢} = \$38.25$$

Annual natural gas cost savings

$$406\ kWh\ \times 3.6 \frac{MJ}{kWh} \times \frac{GJ}{1000\ MJ} \times \frac{\$7.13}{GJ} = \$10.42$$

Appendix B – NRCAN DWHR testing procedure

Testing Method for Measuring Efficiency of Drain Water Heat Recovery Units
December 2008

Preface
This Natural Resources Canada (NRCan) Standard specifies requirements for measuring the thermal (i.e., recovery) efficiency and pressure drop on drain water heat recovery (DWHR) units. The intent of the test apparatus is to simulate conditions in which DWHR units will be installed. This Standard is only intended to rate the performance of DWHR units with equal supply and drain flows.

1 Scope
1.1
This NRCan Standard specifies requirements for measuring the thermal efficiency and pressure drop for vertically mounted DWHR units. Only 75 mm (3”) and 100 mm (4”) diameter DWHR units are covered by this standard, and the configuration results are for units where supply and drain flow is equal. Units tested to this NRCan Standard must also bear a label or stamp of an approved certifying agency for potable water and drain conveyances (e.g., ULC, Intertek).
1.2
Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publication
This NRCan Standard makes no references to any other specific publications except any identified in clause 1.1.

3 Definitions
The following definitions apply in this Standard:

Drain Water Heat Recovery (DWHR) Unit - A drain water heat recovery unit is a passive, double-wall heat exchanger designed to transfer heat from drain water to supply water.

Equilibrium test condition - The stabilized condition during tests performed using this Standard wherein the measured values of all flows and temperatures during a test do not vary by more than the tolerances indicated in Table 5.9 over three sets of measurements that are taken two minutes apart.

Installation Configurations:

Configuration A – DWHR unit piped to preheat cold water supply to water heating equipment only.
Configuration B – DWHR unit piped to cold water supply and water heating equipment. This configuration results in equal supply and drain flow.
Configuration C – DWHR unit piped to cold water supply line only.

Note: Only Configuration B performance is covered by this Standard

4 General requirements

The DWHR unit testing apparatus shall simulate conditions in which the heat exchangers are intended to be installed. The apparatus shall:

a) test only DWHR units intended for mounting in a vertical position; and
b) be capable of testing both 75 mm (3") and 100 mm (4") diameter DWHR units;

5 Testing

5.1

Tests shall be set up and performed, and test calculations carried out, as specified in this Standard.

5.1.2

Test instruments shall be in good working order and properly calibrated. Calibration records shall be kept and shall specify, at a minimum, the date of calibration, method of calibration, and reference Standard used.

Note: *Instruments should be calibrated at least as often as recommended by the manufacturer.*

5.2 Heat recovery efficiency

5.2.1 Procedure

Each test point shall be recorded once the apparatus has reached equilibrium conditions. Flow rates measured and mass of the DWHR being tested will affect time required to reach steady state conditions.

5.2.2

Tests shall be performed at nominally 4, 8, 11 and 14 L/min.

5.2.3

Water entering the drain shall be controlled to 36°C and the cold water entering the coil shall be controlled to 8°C.

5.2.4

Upstream drainage connections (i.e., transition) to the DWHR unit shall:

a) use identical interior dimension (diameter) pipes at the transition into the DWHR unit, and
b) be smooth to reduce disruption in the water film flow at the inlet to the DWHR unit.

5.2.5

The transition piece that connects the test apparatus to the DWHR shall be designed and installed to incorporate an internal surface mounted thermocouple to measure the water film temperature.

5.3 Effectiveness equation

The effectiveness of a heat exchanger is the ratio between the actual heat transfer and the theoretical maximum possible heat transfer,

$$\varepsilon = \frac{q}{q_{\max}} = \frac{C_c (T_{co} - T_{ci})}{C_{\min} (T_{hi} - T_{ci})}$$

where

ε = heat exchanger effectiveness;
C_c = capacity rate for the cold fluid;
C_h = capacity rate for the hot fluid;
C_{min} = smaller capacity rate;
q = heat transfer rate;
q_{max} = theoretical maximum heat transfer rate;
T_{ci} = fresh water inlet temperature;
T_{co} = fresh water outlet temperature;
T_{hi} = drain water inlet temperature.

For the DWHR units that are covered by this Standard, where the mass flow rate of both the fresh water and drain water are the same, the effectiveness is

$$\varepsilon = \frac{(T_{co} - T_{ci})}{(T_{hi} - T_{ci})}$$

5.4 Pressure drop

The pressure drop across the DWHR unit is measured with gauges. The static pressure difference between the gauges is subtracted from the difference in the pressure displayed on the gauges to determine the pressure drop across the DWHR unit.

5.5 Equal flow implementation

In order to compare the performance of different DWHR units, they must be compared under the same operating conditions. Standard reporting conditions for an equal flow configuration used are indicated in Table 5.5. Note that these conditions are the reported test conditions. The testing does not require these temperatures be present to determine the effectiveness at these temperatures. The primary requirement is that the temperature difference be 28°C.

Table 5.5 Standard Reporting Conditions for Equal Flow Configuration.

Parameter	Value
Fresh Water Inlet Temperature	8°C
Drain Water Inlet Temperature	36°C
Flow Rate	9.5 L/min

5.6 Test duration

Each test shall be conducted until stabilized conditions are obtained. Test results shall be determined only for the time period when stabilized conditions (water flows, inlet and outlet temperatures, ambient temperature) are obtained.

5.7 Calculations

Heat recovery in kW, effectiveness and pressure drop on the potable water side of the exchanger shall be determined for each minute of the test at each flow until equilibrium values are achieved.

5.7.1

The effectiveness shall be determined for each test from the equilibrium values using the equation provided in clause 5.3.

5.7.2

The energy recovery (in kW) shall be calculated from the measured water flow rate and temperature rise on the potable water side of the DWHR exchanger after equilibrium conditions are obtained.

5.8 Energy Balance and acceptability of result

The energy balance for each test shall be determined by measuring the temperature rise on the potable water side of the exchanger and the temperature drop on the drain water side of the exchanger under equilibrium, balanced flow conditions. If the temperature drop on the drain water side of the system is not within ± 5% of the temperature rise on the potable water side, the test result shall not be accepted as valid.

5.9 Test parameters for equal flow configuration

To ensure repeatability and to characterize the DWHR units, a set of test parameters and tolerances is listed in Table 5.9. It includes the recommended set of test parameters and in addition, some test apparatus configurations are listed to ensure test repeatability.

For the horizontal run from the shower drain to the DWHR (Annex A, shown as 'B' on the schematic), the total centre-line to centre-line distance between the shower drain and DWHR is 0.5 metres, and the straight run as represented by 'B' should be no less than 305 mm. The vertical straight distance from the bottom of the wye to the DWHR (shown as 'A') should be 610 mm.

All drainage piping and fittings shall be ABS DWV plastic with solvent connections.

The measurements taken on the DWHR units assume steady state conditions. Due to the thermal mass of the units, time is required to reach steady state. Multiple measurements shall be taken at each flow rate until a steady state condition is reached. This will typically require between 5 and 10 minutes, depending on the flow rates being measured and the mass of the unit being tested.

An energy balance check shall be performed if temperatures at each of the inlets and outlets of the DWHR are recorded. In an equal flow configuration, the temperature drop through the drain water would be equal to the temperature rise on the supply water if there were no heat or evaporative losses to the environment.

Table 5.9 Test parameters for equal flow configuration.

Parameter	Value	Tolerance	Comments
Inlet Water Temperature Difference	28°C	± 1°C	Maximum hot water temperature 48°C.
Tested Flow Rates	4, 8, 11 and 14 L/min	± 0.5 L/min	Tests at higher rates are desirable.
Unit Orientation	Vertical	± 2°	Applicable only for vertically oriented units.
Ambient Temperature	Equal to average temperature of DWHR unit	± 5°C	
Insulation Wrap	RSI 0.5	Minimum value	
Pipe Section Above DWHR Unit	50 cm Cu, equal to DWHR diameter	Minimum value	Orientation restriction same as unit orientation. Specially designed transition element considered acceptable substitute.
Temperature Measurement Accuracy	± 0.2°C	Maximum value	Temperatures should be taken in the water stream, not on the outside of the pipes.
Pressure Measurement Accuracy	± 0.25%	Maximum value	Correction for static head required.
Flow Measurement Accuracy	± 2%	Maximum value	
Energy Balance	± 5%	Maximum value	For equal flow configuration, temperature changes are the same in an ideal condition.

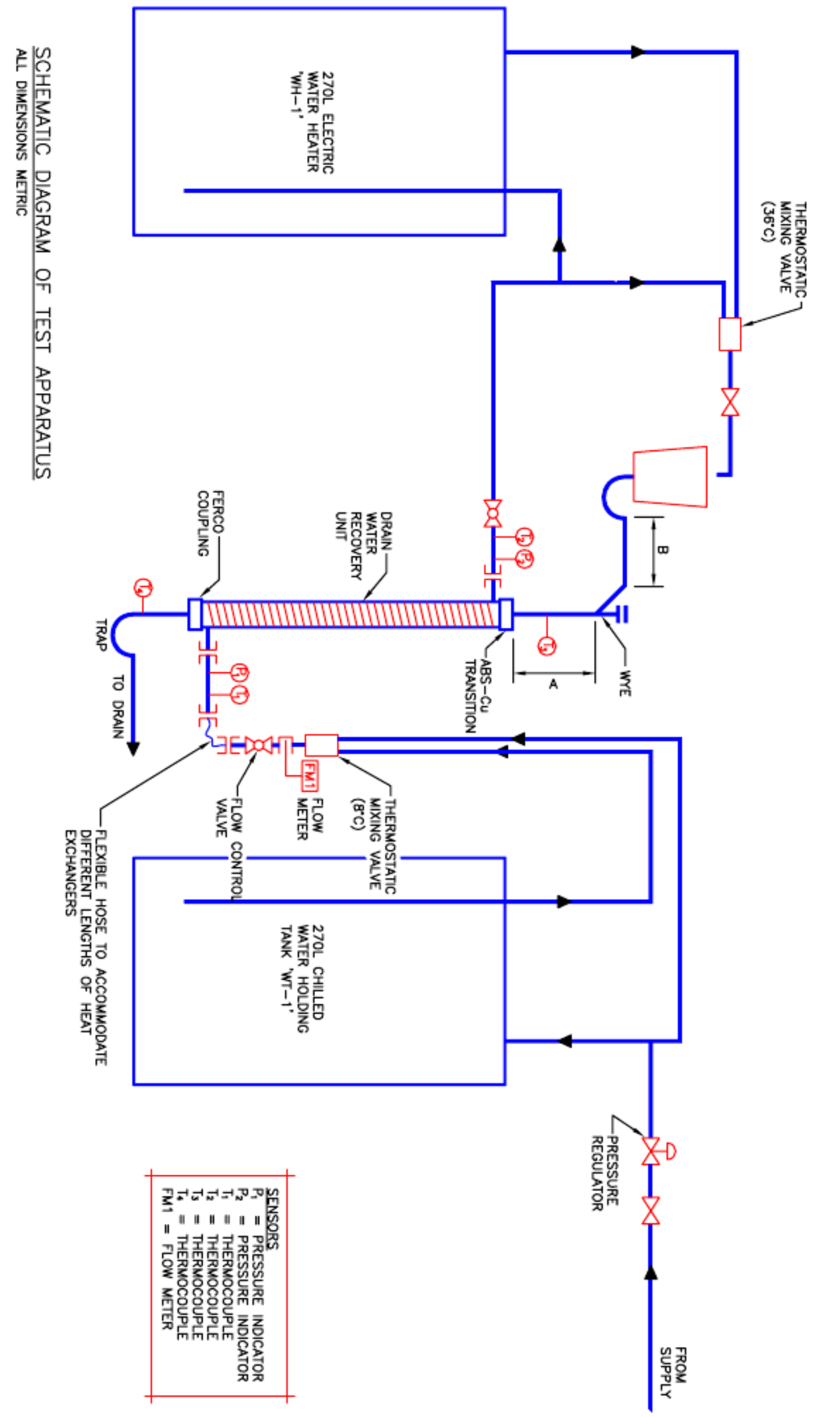
5.10 Reporting

The following shall be reported:

a) manufacturer and model,
b) diameter, length and mass of DWHR (mm and inch, kg and lbs),
c) flow rates (L/min),
d) heat recovery efficiency (%) rounded to one decimal point,
e) pressure drop (kPa and psi), and
f) An example DWHR unit test report template is provided in Annex C

Annex A
(Informative)

Figure 5.1 DWHR Example Test Apparatus Schematic.



Annex B
(Normative and Informative)

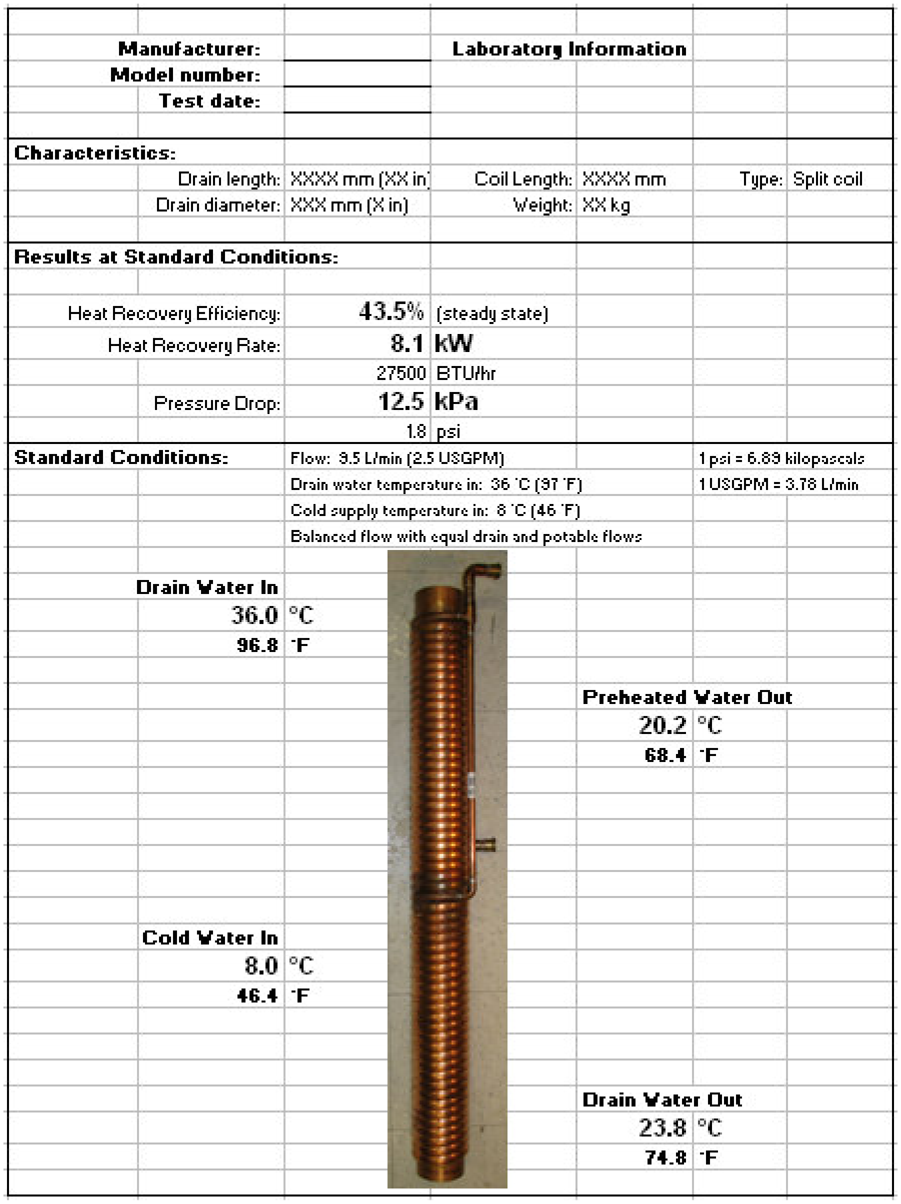
Test instrumentation and control equipment

Equipment noted in brackets was equipment used in previous test set up. The following are in compliance with Section 5.6.

1. (Normative) Temperature sensors. Accuracy of +/- 0.1ºC over the operating temperature range is required.
2. (Normative) Flow meters. A digital instantaneous flow rate readout meter (e.g., Omega FTB 4605). The accuracy of the meter shall be within +/- 1%.
3. (Normative) The pressure drop through the potable water side of the drain water heat recovery unit shall be measured using two precision pressure gauges (e.g., Omega DPG 1000B-100G). Gauges shall have an accuracy of +/- 0.25% over the full scale range of 0 to 100 psig. As the two pressure gauges that measure the inlet and outlet pressure are located at different heights, a static head difference must be compensated for.
4. (Informative) Cold and hot water reservoirs. Two similar electric water storage type tanks provided reservoirs for the hot and cold water to control temperatures for the test (e.g., Giant model 172ETE 270 L). Only the hot tank needs to be wired to provide heat.
5. (Informative) Temperature control devices. A thermostatic mixing valve was used to control the temperature of the hot water supply flow. This mixing valve was used to provide warm water to the shower head, resulting in 36°C water at the top of the heat exchanger (e.g., Thermixer 5-120 or Powers E240).
6. (Normative) Pressure control devices. A regulator was installed in the system to provide a constant pressure to the system regardless of the pressure coming from the supply. Regulators shall be sized to permit appropriate test flows. An expansion tank was implemented in the system to reduce pressure (and flow) fluctuations.
7. (Informative) A de-stratification pump was installed on the hot water heaters to initially pre-mix the hot water to increase quantity of desired temperature hot water. The pump was turned off once the tank came to temperature to permit normal use during test.
8. (Informative) Water in the cold water tank was chilled when the building supply temperature was higher than 8°C by passing the water through an ice bath. A de-stratification pump was installed in the cold tank to reduce temperature fluctuations.
9. (Informative) To improve water film development into the DWHR, the 0.6 m pipe directly above the DWHR may be replaced with a copper coupling and copper pipe, moving the transition higher up in the system. The change from ABS pipe to copper must be accounted for during the test.

Annex C
(Informative)

DWHR Test Report Template as per Section 5.7.f)



Manufacturer: ____________

Model number: ____________

Test date: ____________

Laboratory Information

Characteristics:

Drain length:	XXXX mm (XX in)	Coil Length:	XXXX mm	Type:	Split coil
Drain diameter:	XXX mm (X in)	Weight:	XX kg		

Results at Standard Conditions:

Heat Recovery Efficiency:	43.5%	(steady state)
Heat Recovery Rate:	8.1	kW
	27500	BTU/hr
Pressure Drop:	12.5	kPa
	1.8	psi

Standard Conditions:

Flow: 9.5 L/min (2.5 USGPM)

Drain water temperature in: 36 °C (97 °F)

Cold supply temperature in: 8 °C (46 °F)

Balanced flow with equal drain and potable flows

1 psi = 6.89 kilopascals

1 USGPM = 3.78 L/min

Drain Water In
36.0 °C
96.8 °F

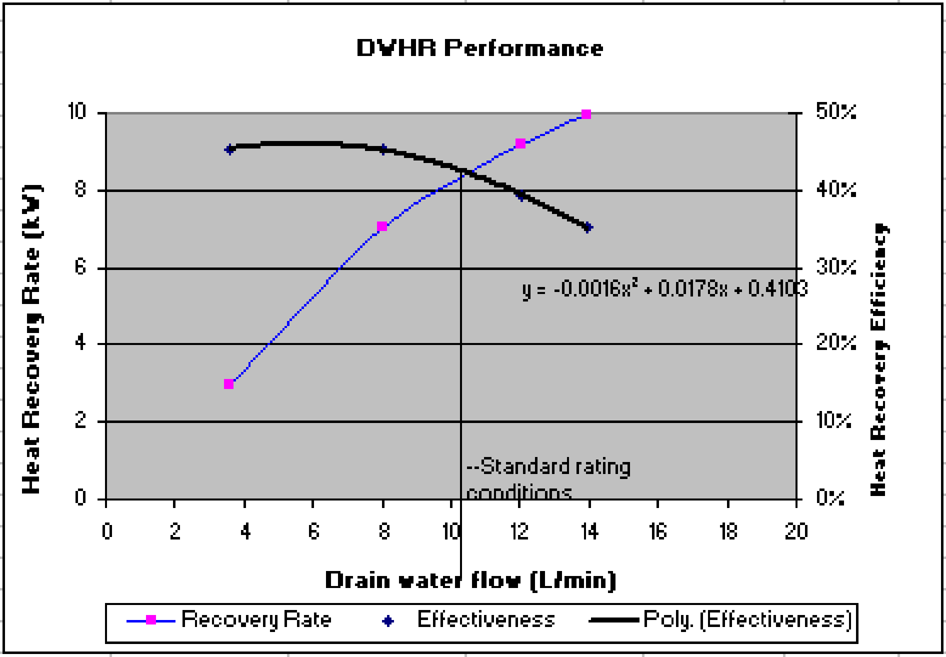
Preheated Water Out
20.2 °C
68.4 °F

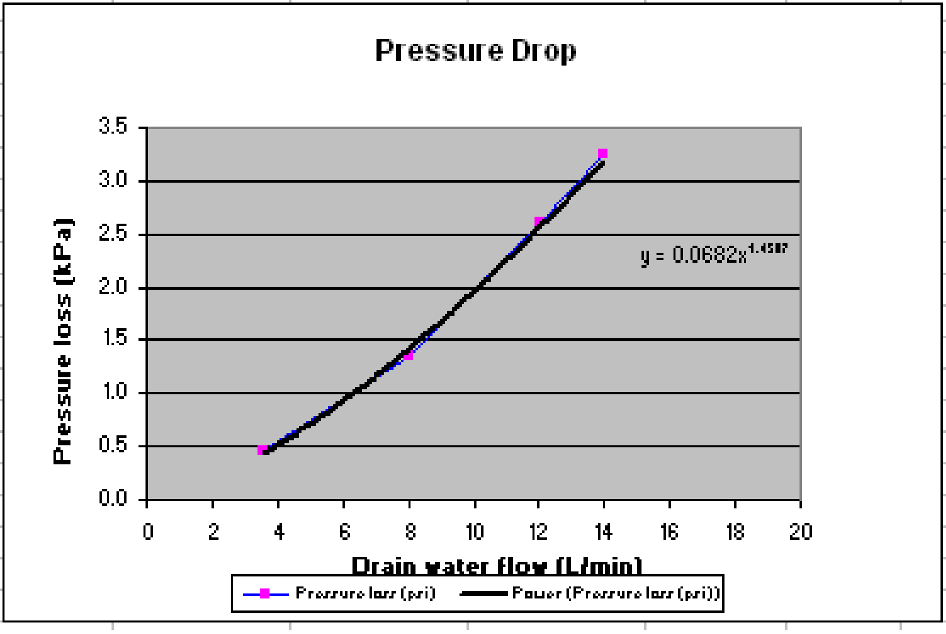
Cold Water In
8.0 °C
46.4 °F

Drain Water Out
23.8 °C
74.8 °F

Detailed results:

	Flow	Effectiveness	Recovery Rate	Pressure Drop	
	(L/min)	(%)	(kW)	(kPa)	(psi)
	3.60	45.3%	2.98	3.1	0.5
	8.05	45.2%	7.03	9.3	1.4
	12.02	39.3%	9.16	17.9	2.6
	13.95	35.2%	9.91	22.4	3.3
Standard Conditions	9.5	43.5%	8.06	12.5	1.8





Appendix C – EcoDrain A1000 DataSheet

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HIGH PERFORMANCE HEAT EXCHANGER

A1000 HEAT EXCHANGER

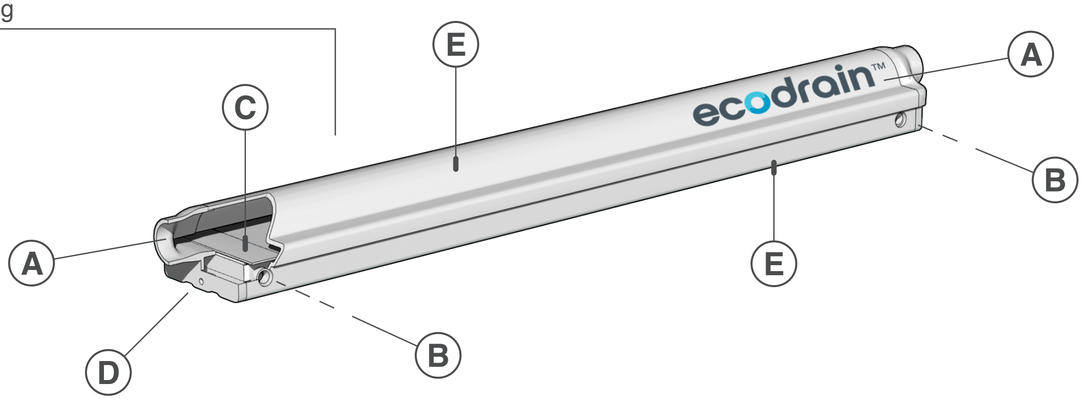
DATA SHEET

The **A1000 Heat Exchanger** is symmetric.
Either grey water connector can function as the grey water inlet.
Either cold water connector can function as the cold water inlet.
For best performance, the cold water line should be connected such that cold water enters the device at the end opposite from which grey water will enter the device.

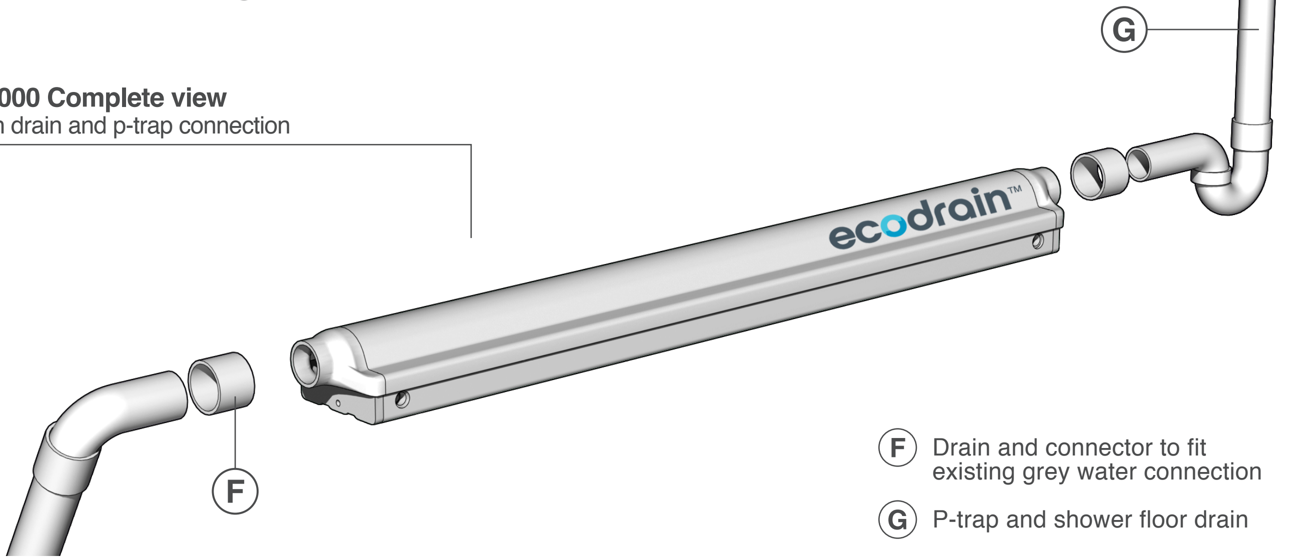
Design Part identification

- Ⓐ Grey water connection
- Ⓑ Cold water connection
- Ⓒ Double wall tube assembly
- Ⓓ Atmospheric vent
- Ⓔ Shell

A1000 Cut out view
with interior tubing



A1000 Complete view
with drain and p-trap connection



- Ⓕ Drain and connector to fit existing grey water connection
- Ⓖ P-trap and shower floor drain

Ecodrain Inc. offers a 10 YEAR limited performance warranty and a four year guarantee free of factory defects, provided the device is used under normal shower drain water heat recovery applications (and no other application) and is used with potable water, free of excessive iron or hardness inducing salts and minerals. Defects from shipping, installation, repackaging, lack of proper maintenance of adjoining appurtenances and system connected fluid flow devices, alterations, misuse, mishandling even by plumbing contractors, the house owner or other service personnel, will not be covered.

Ecodrain Inc. will not accept liability or responsibility for any value of consequential damages (no matter what is the source) resulting in whatever replacement value, caused by whatever reason.

It is the responsibility of the Installation personnel to ensure full compliance to local codes and laws.

No other warranties/guarantees are implied or suggested beyond what is stated above.

In order to avail of additional accessories, like filter baskets, attachments, or types of connectors, the company is available for further consultation.

Warning:
Preheated cold water from a shower water heat exchanger can accidentally cause scalding if not properly adjusted for temperature before use. Hot water can cause third degree burns in 6 seconds at 60C (140F), and in 30 seconds at 54C (130F). In households where there are children, physically challenged individuals, or elderly persons, mixing valves at the point of use are recommended as a means to reduce the scalding potential of hot water. For your safety and to avoid damage caused by improper installation, this shower heat exchanger should be installed by a Certified Licensed Professional, and meet all applicable building codes. Ecodrain Inc.cannot be held responsible for accidental injuries resulting from improper or careless use of hot water.

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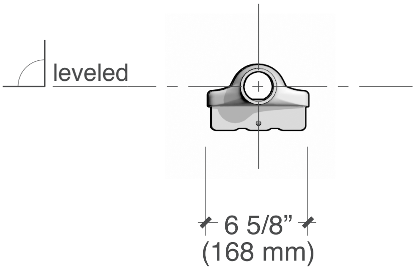
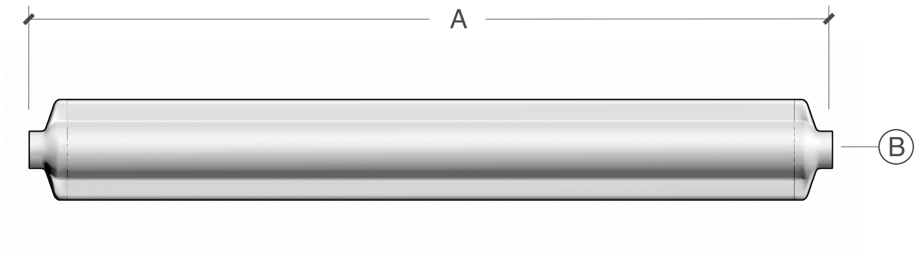
HIGH PERFORMANCE HEAT EXCHANGER

A1000 HEAT EXCHANGER

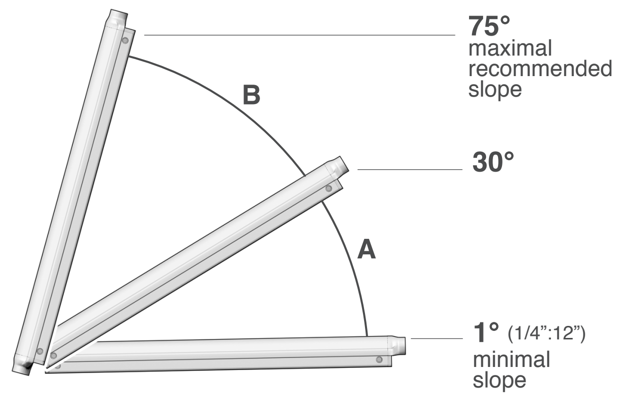
DATA SHEET





A1000 Heat Exchanger to be installed leveled in order to deliver optimal performance

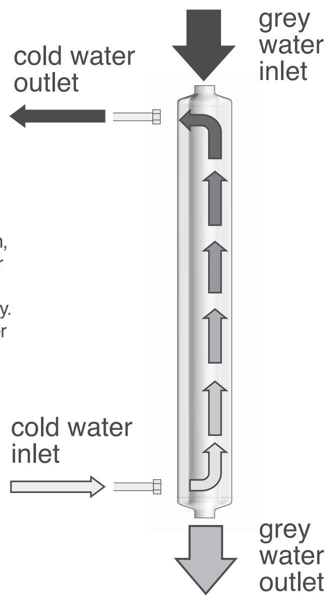
INSTALLATION SLOPE



Check with local codes in order to validate the minimum angle required. Note that heat transfer performance will increase as the tilt angle increases. This can boost heat exchanger performance by 5%-10%. The reason is that at a higher tilt angle, the waste water travels faster.
This generates turbulence in the waste water flow and as a result the waste water gives off heat at a higher rate. With the A1000 unit, a maximum slope of 75° is recommended to allow an efficient heat transfert. Beyond that slope, some of the grey water will travel down the center of the exchanger and will have reduced contact with the heat transfer tubes.

PERFORMANCE CHARACTERISTICS

Heat exchanger performance varies based on several factors including installation configuration, cold water temperature, shower temperature, shower usage, type of water heater and cost of energy. Please consult website for greater performance details.



MATERIALS AND DIMENSIONS OPTIONS

Model	Box	Tube	Heat Transfer Length	Overall Length	Connector (B)
A1000	**A** ABS	**MC** type M copper	**48** inches	**56** inches	**2** inches
	C Copper	**LC** type L copper	**72** inches	**80** inches	**3** inches
	P PVC	**SS** Stainless Steel	**96** inches	**104** inches	**4** inches

HOW TO SPECIFY

Model Box Tube

A1000 - A - MC - 48 - 2

Length

Connector