



ARCHITECTURAL
RECORD

Record
Products
2014

WINNER

ecodrain™

Cost Competitive Horizontal Drain Water Heat Recovery – An opportunity to save energy in many homes and commercial buildings.

ACEEE HOT WATER FORUM 2017 PRESENTATION

What is similar?

Drain water enters through drain, heat exchanger installed along drain line.

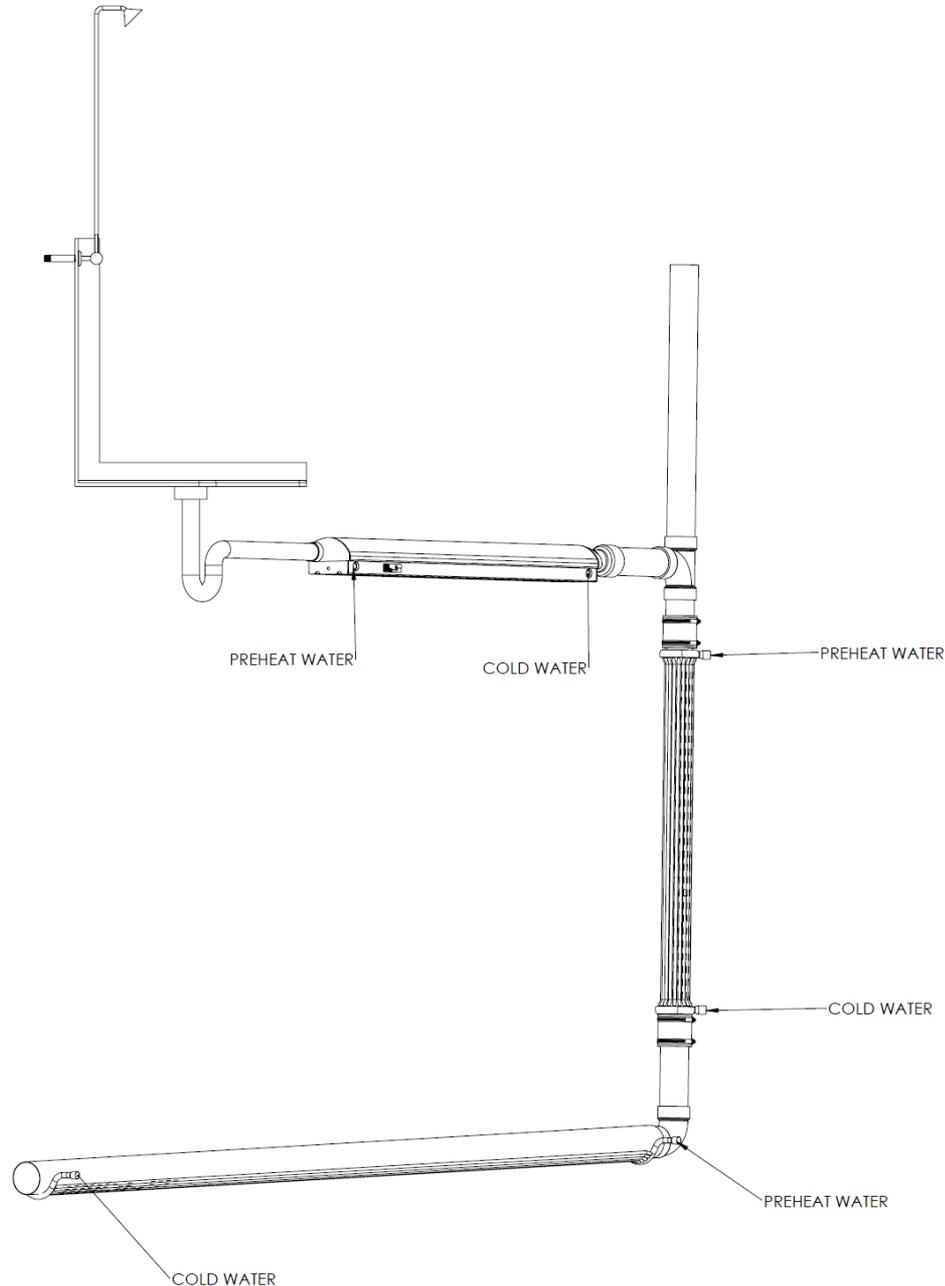
Fluids.

Flow rates.

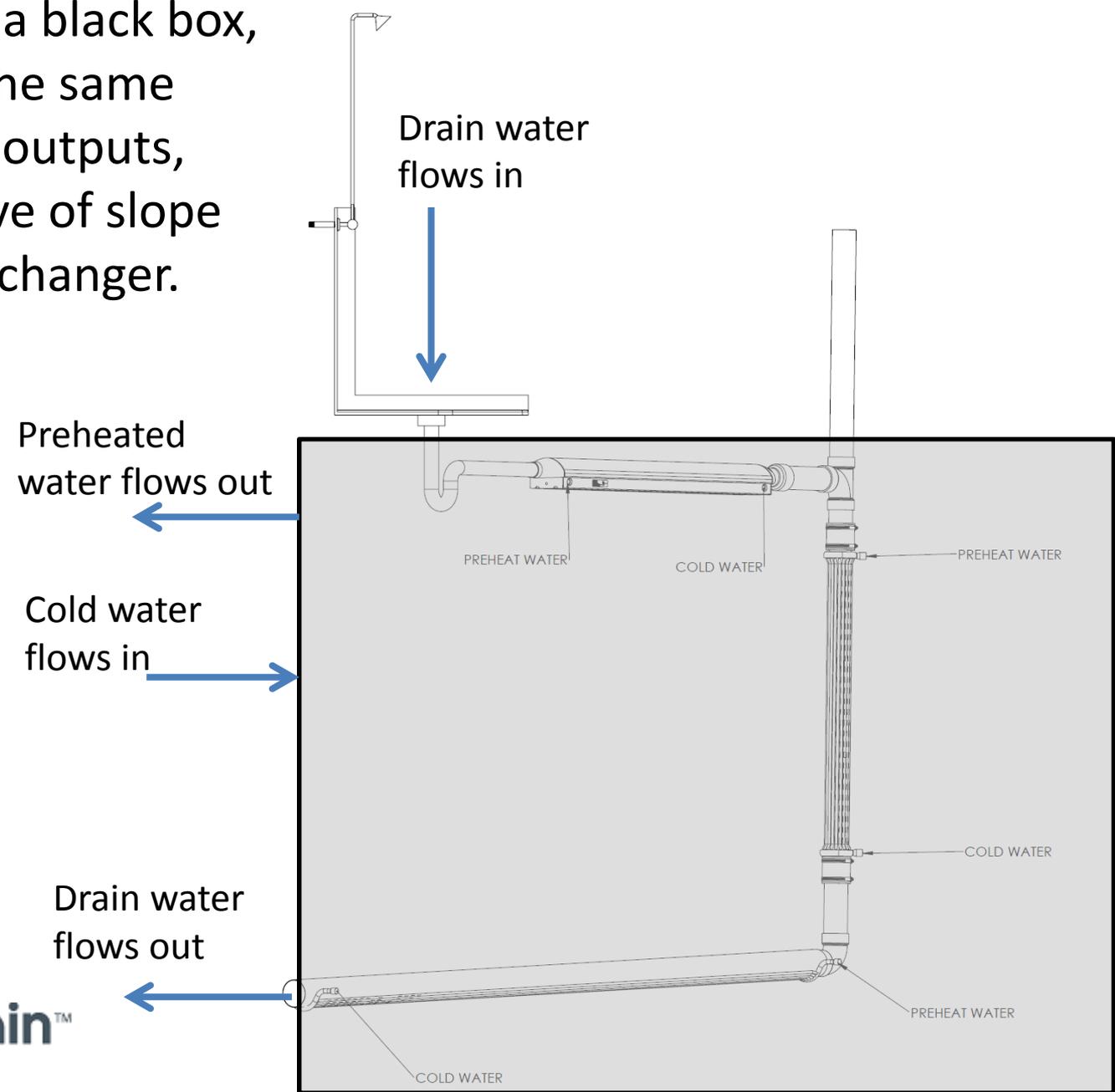
Temperature

Ranges.

Usage / Duty Cycle.



If we look at the system as a black box, we have the same input and outputs, irrespective of slope of heat exchanger.

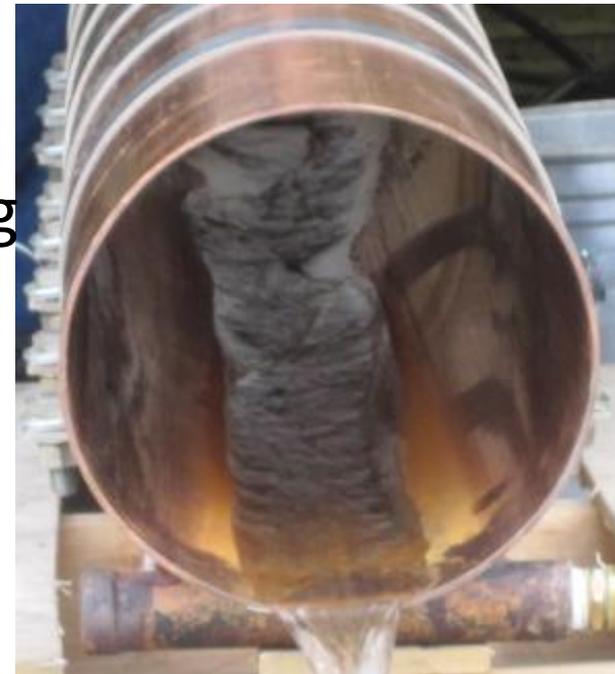


What is different?

In a sloped pipe, drain water flows on the bottom section of the pipe, resulting in less surface area for heat transfer. Note that all heat exchangers are sloped. Horizontal is a misnomer.

In a vertical pipe, drain water clings to the walls as it descends in a falling film. This provides a larger surface area for heat transfer.

That is why we developed engineered solutions for cost competitive horizontal drain water heat recovery.



People keep asking for a horizontal (sloped) DWHR.

“Hey guys, you’re probably well aware that the 2017 Ontario building code is changing to include the use of drain water heat recovery units. We are looking for a unit that can be installed horizontally - does the A1000 unit meet that code? I couldn’t find the info on line. I see that the vertical V1000 unit does conform to CSA B55 but the A1000 does not? Thanks,”

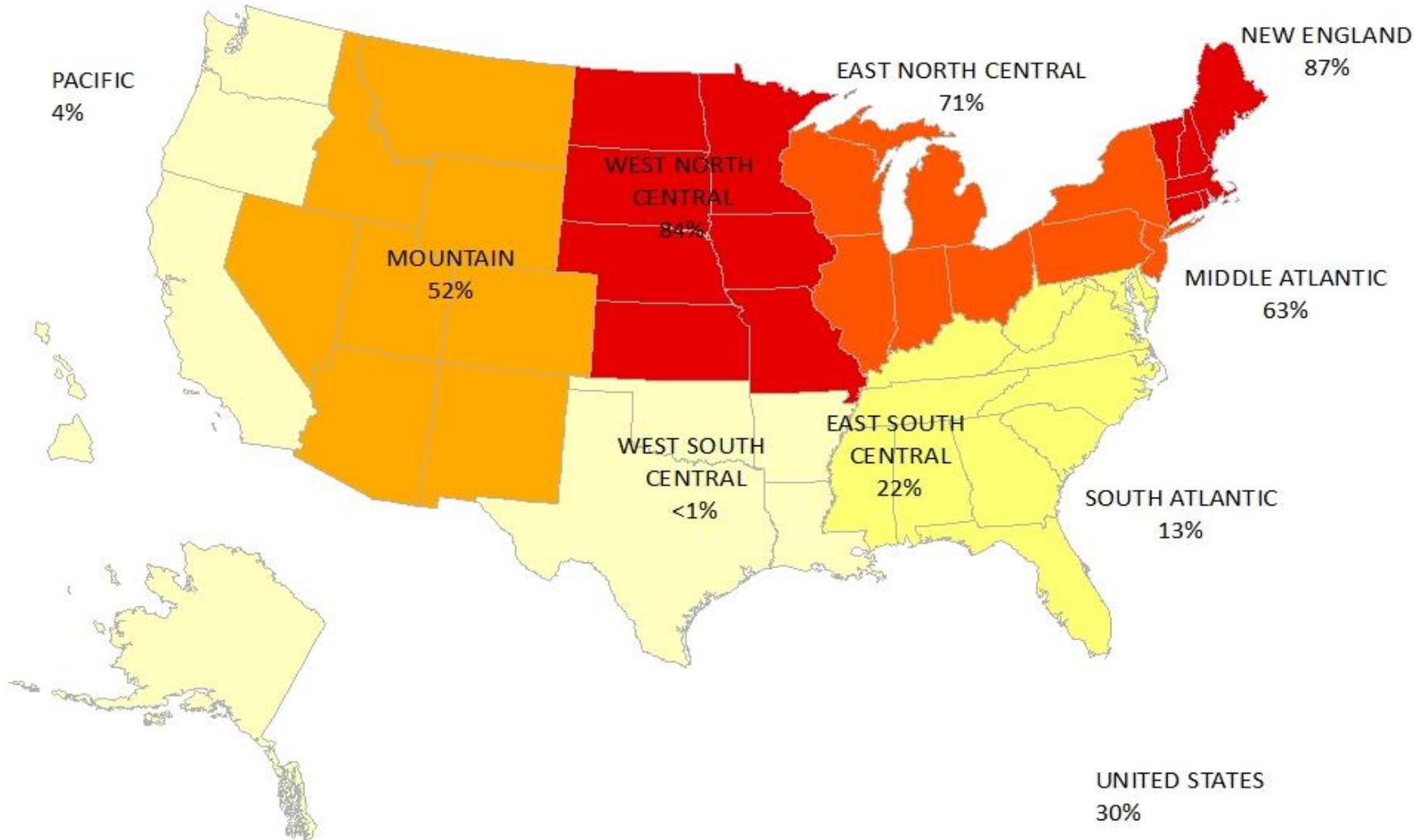
- Ontario Homebuilder

From Washington State

“The Washington State Energy Code, Energy Credits require minimum efficiency of 40% if installed for equal flow and minimum efficiency of 52% if installed for unequal flow. Are you able to meet these efficiency percentages?”

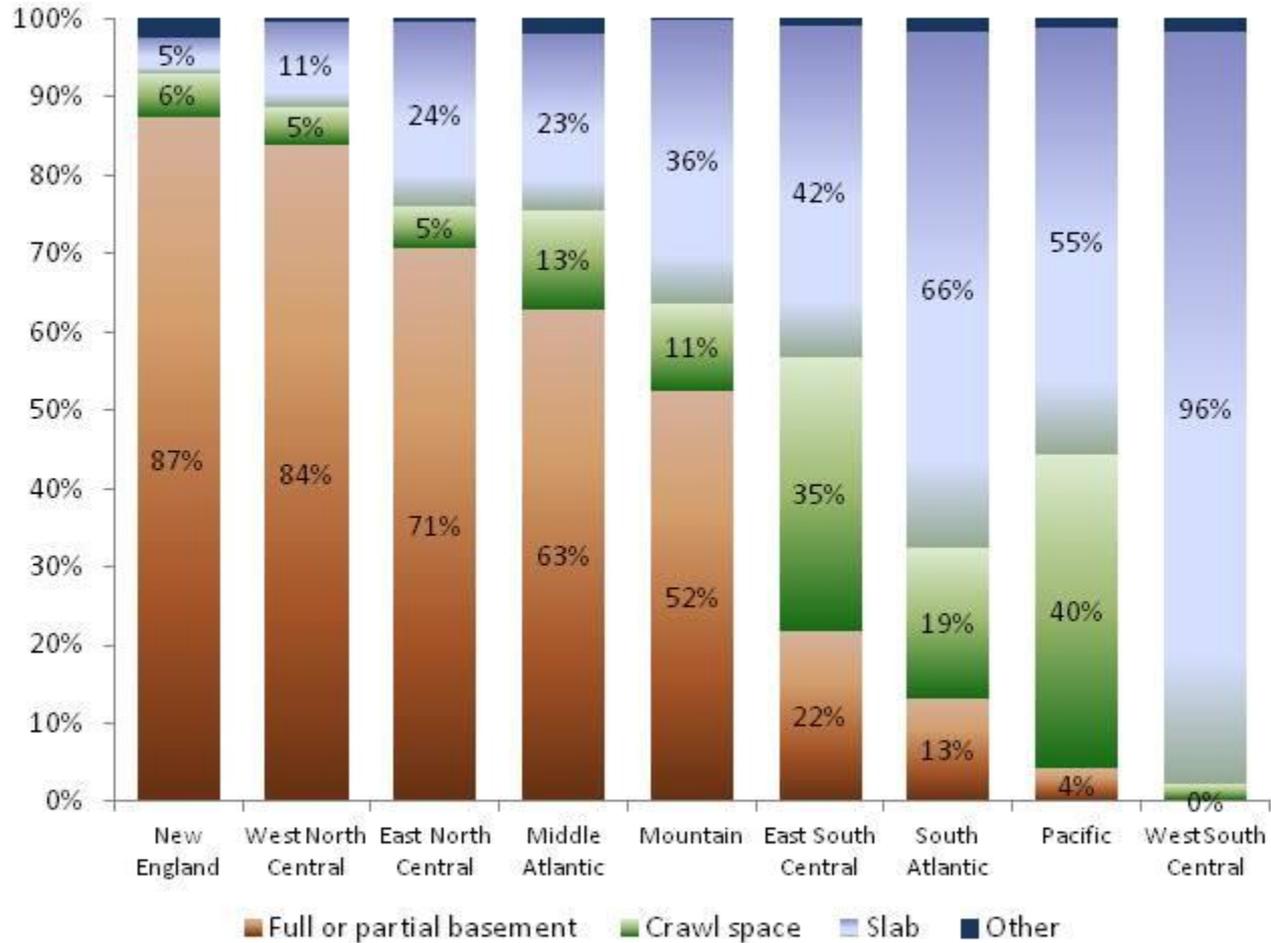
- Homebuilder in Washington State

70% of new single family home starts in the US in 2013 did not have any basement.



Foundation Type by Division

New Single-Family Homes Started in 2013



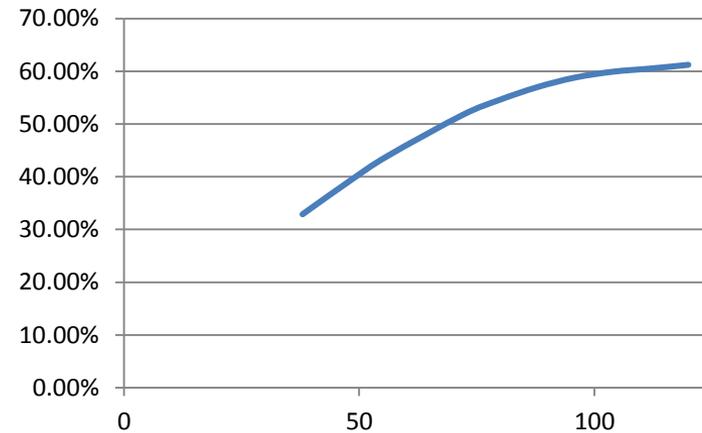
Source: Survey of Construction, 2013, NAHB Estimates

Optimal Balance Between Performance and Size.

It was also found that there is an optimal balance between performance and size, as the {DWHR units} get longer they tend to only add marginal benefits to the performance; shorter {DWHR units} perform best on a per foot basis.

- From conclusion section of report.

Source: Drain water heat recovery characterization and modelling. Zaloum, LaFrance, Gusdorf, Natural Resources Canada, 2007.



2" vertical coil recovery versus length
Source: NRCAN website

How do we measure cost effectiveness?

DWHR cost effectiveness is driven by the cost of copper.

Copper price is quoted by weight not length.

Recovery % per pound of copper is a better indicator of cost effectiveness than recovery % per foot when the weights per foot of different models are not the same.



In response to a question “Why is the scope limited to vertical systems?” in the public record of the title 24 DWHR discussion, it was stated “*Vertical units are about twice as cost effective*”

If performance of vertical unit is cut in half when put horizontal and weight stays the same, unit will either have very low performance or very low cost effectiveness depending on length.

Model	Slope	Ø	Length	Recovery @9.5 lpm equal	Weight	Recovery % / lb copper
		inch	inch		lbs	
Coil	Vertical	2	38	32.90%	15.8	2.1%
Coil	Vertical	2	48	39.2%	20.03	1.96%
Coil	Vertical	2	56	43.9%	23.4	1.88%
Coil	Vertical	2	72	51.7%	30.15	1.71%
Coil	Vertical	2	80	54.6%	33.53	1.63%
Coil	Vertical	2	120	60.5%	50.4	1.21%

↓ Longest vertical 2” model
43% less cost effective

Source: NRCAN website.

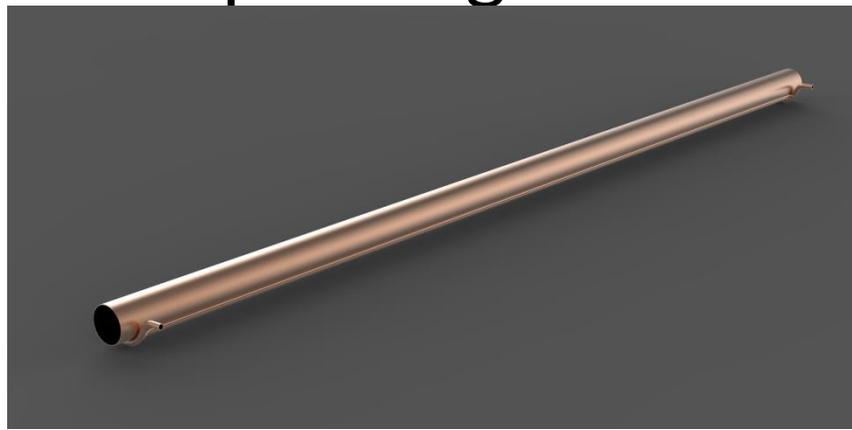
Keys to Cost Competitive Horizontal DWHR

Either increase the surface area (A1000)

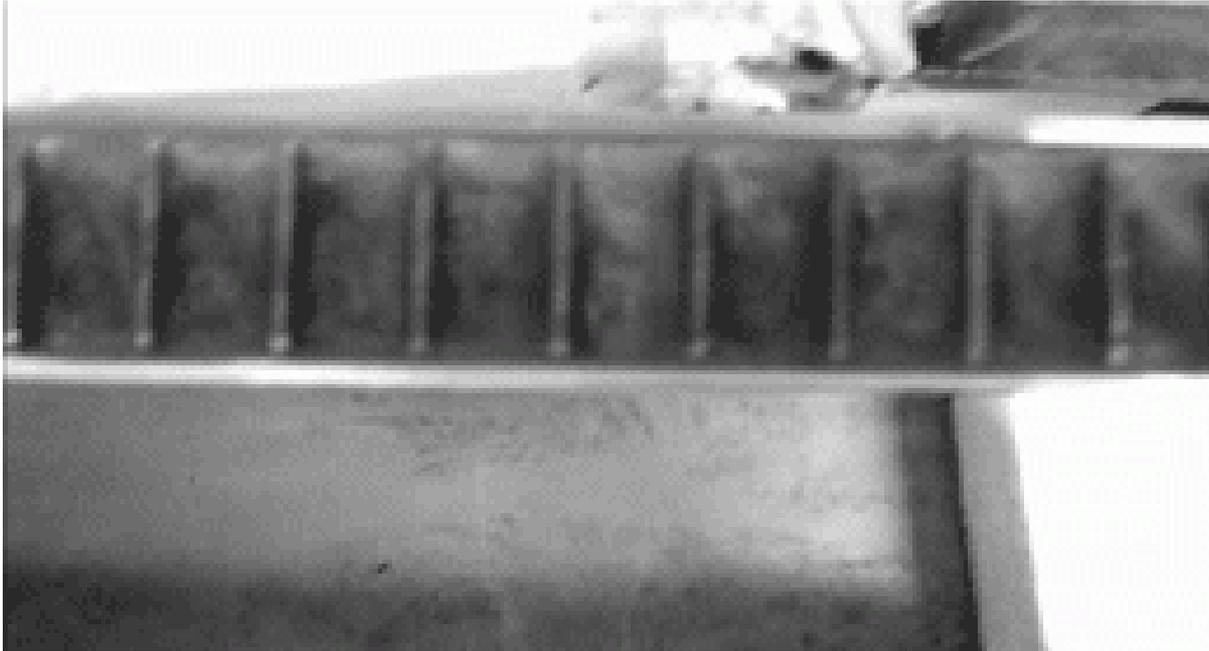
or



Reduce the cost per length versus vertical (B1000)



A key innovation – the result of many experiments



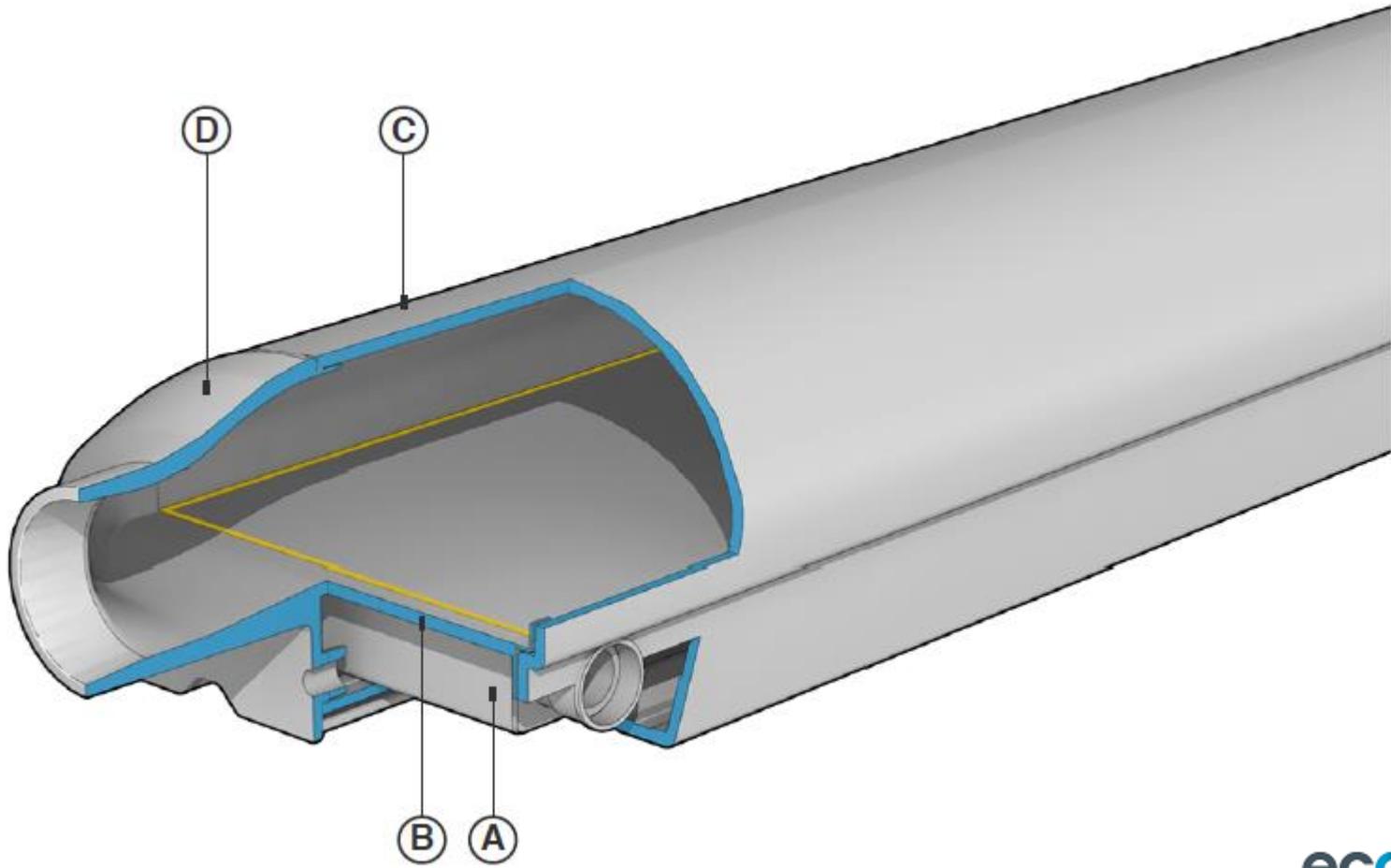
Ecodrain turbulator increases heat transfer coefficient and distributes water evenly in a series of tubes.

Allows for the construction of a family of products with the same core.

Turbulator can be adjusted to get maximum performance for an allowable pressure loss.

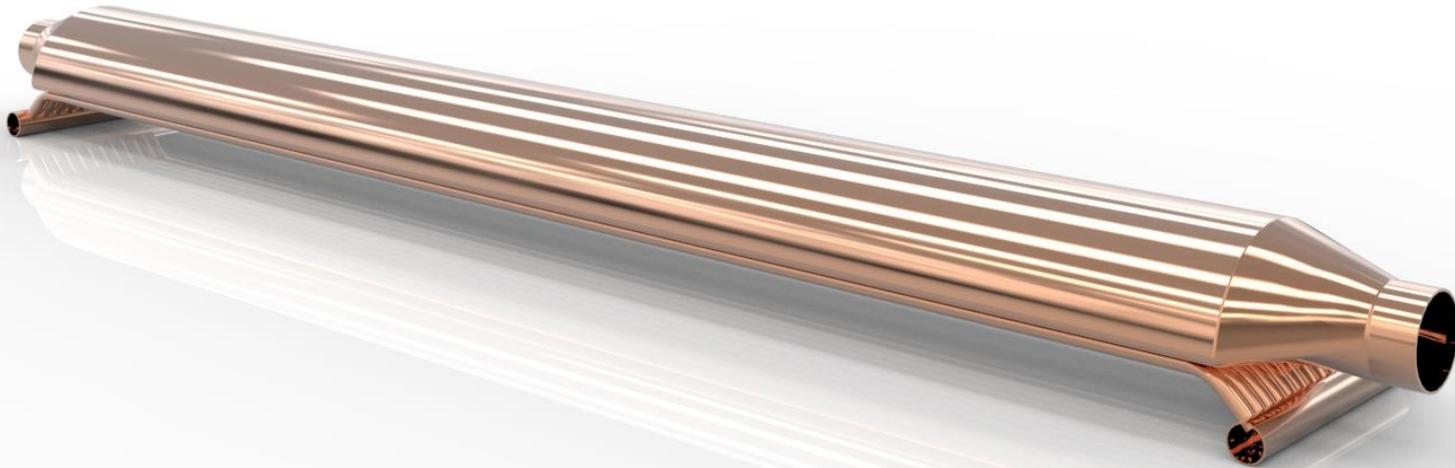
First generation was injection molded plastic. New generation is copper.

Ecodrain™ A1000 horizontal grey water heat recovery system.



Drain water travels over flat plate.
Much shorter horizontal heat exchanger for same performance.

All Copper Next Generation A1000



A next generation A1000 with a seamless all copper drain line is designed. This model would provide further cost reductions and allows for high volume production.

This unit is all copper and the same materials used in CSA B55, i.e. standard B306 drain pipe, and standard type L ASTM B88 copper cold water tubes.

Cost Effectiveness Comparison

Model	Slope	Ø	Length	Recovery @9.5 lpm equal flow	Weight	Recovery % / lb copper
		inch	inch		lbs	
A1000	Horizontal	2	56	37.5%	15.4	2.44%
A1000	Horizontal	2	80	44.5%	22.3	2.00%
Coil	Vertical	2	48	39.2%	20.03	1.96%
Coil	Vertical	2	56	43.9%	23.4	1.88%
Coil	Vertical	3	34	37.5%	16.13	2.33%
Coil	Vertical	4	32	36.9%	21.33	1.72%

A1000 heat transfer surface is 12" shorter than overall length due to manifolds and end caps. The 56" unit has a 44" heat transfer length. Vertical DWHR requires at least 6" of straight pipe above the unit for the falling film to develop, horizontal does not require any additional length. Therefore comparison of the of the 56" A1000 with the 48" vertical coil is appropriate.

80" A1000 is optimized for low pressure drop of 1.5 psi at 9.5 lpm.

Source for coil data is NRCAN website.

Cost Effectiveness Comparison

Model	Slope	Ø inch	Length inch	Recovery @9.5 lpm equal flow	Weight lbs	Recovery % / lb copper	
A1000	Horizontal	2	56	37.5%	15.4	2.44%	
Coil	Vertical	2	48	39.2%	20.03	1.96%	

Ecodrain A1000 provides better recovery % per pound of copper than comparable sized vertical coil when coil is installed vertically and tested under its optimum conditions.

Ecodrain A1000 test results are at low slope, as the slope is increased, the results are even more favorable because the performance of horizontal units increases with increasing slope.

What about Fouling?

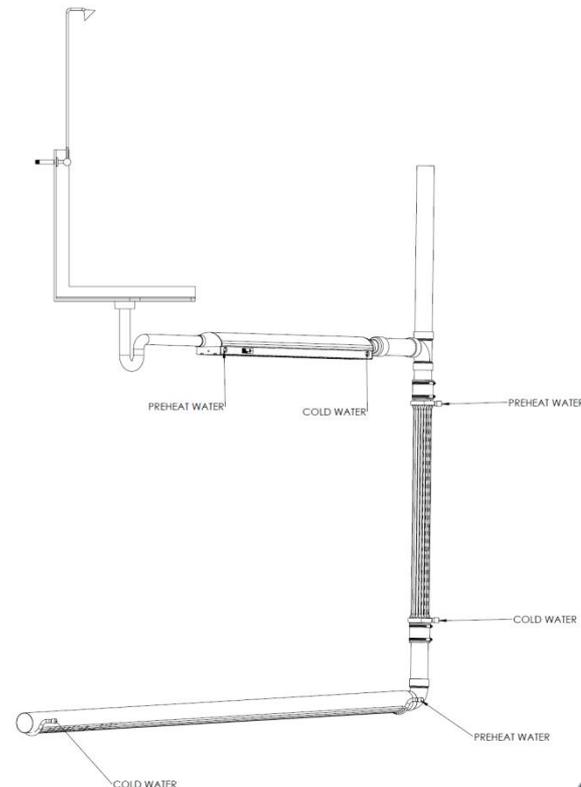
Statement during title 24 discussion in response to question as to why only vertical.

“There is also a lack of proof of persistency of savings over life cycle period. Further, a lack of maintenance cost information (assumed 0 for vertical, but horizontal can have issues due to clogging and/or reduced performance as soap builds up). We are not discounting it as an effective technology, we just do not have enough information to analyze it as a measure at this time.”

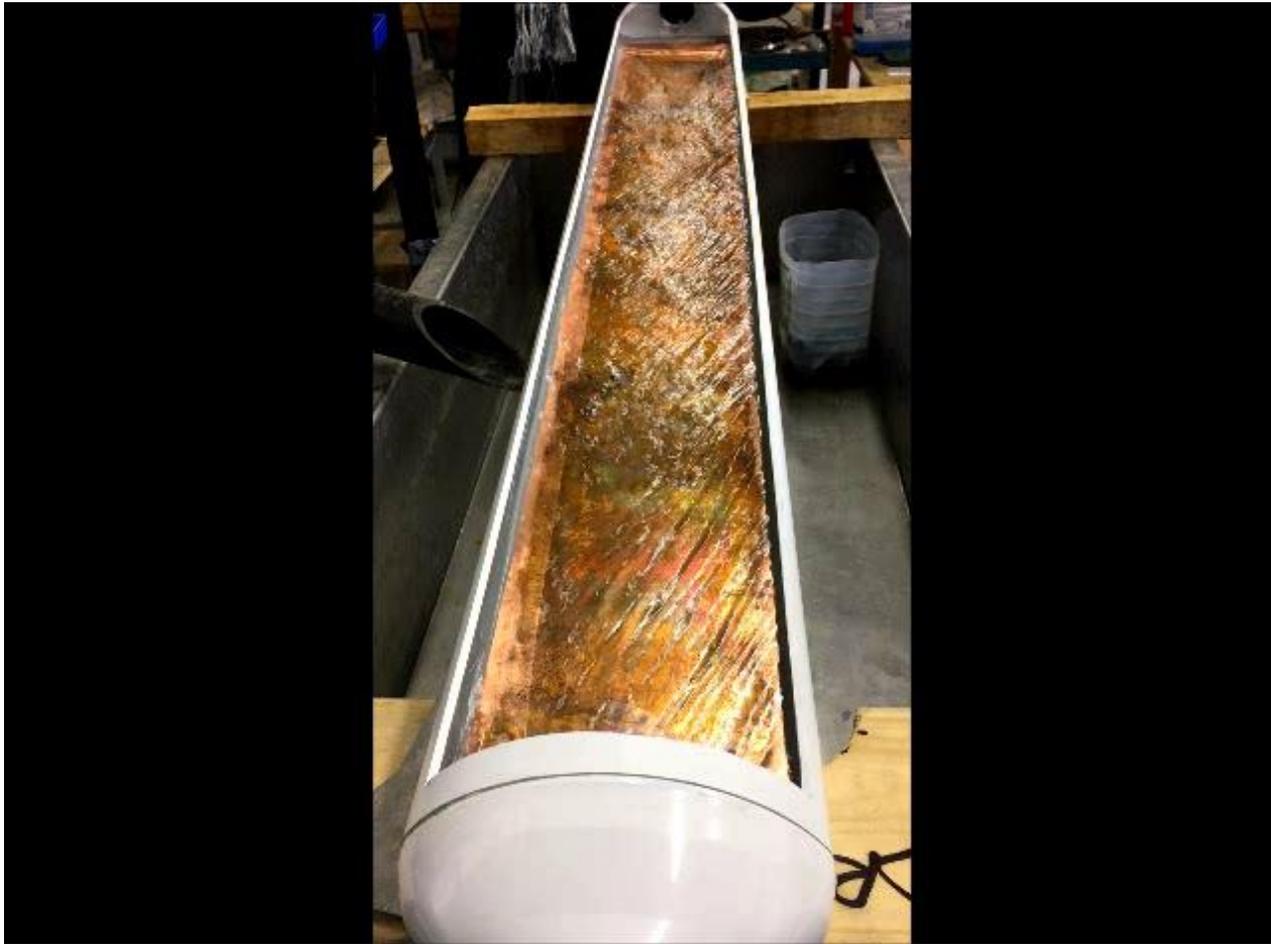
Fouling is an extremely complex phenomenon characterized by combined heat, mass, and momentum transfer under transient conditions.

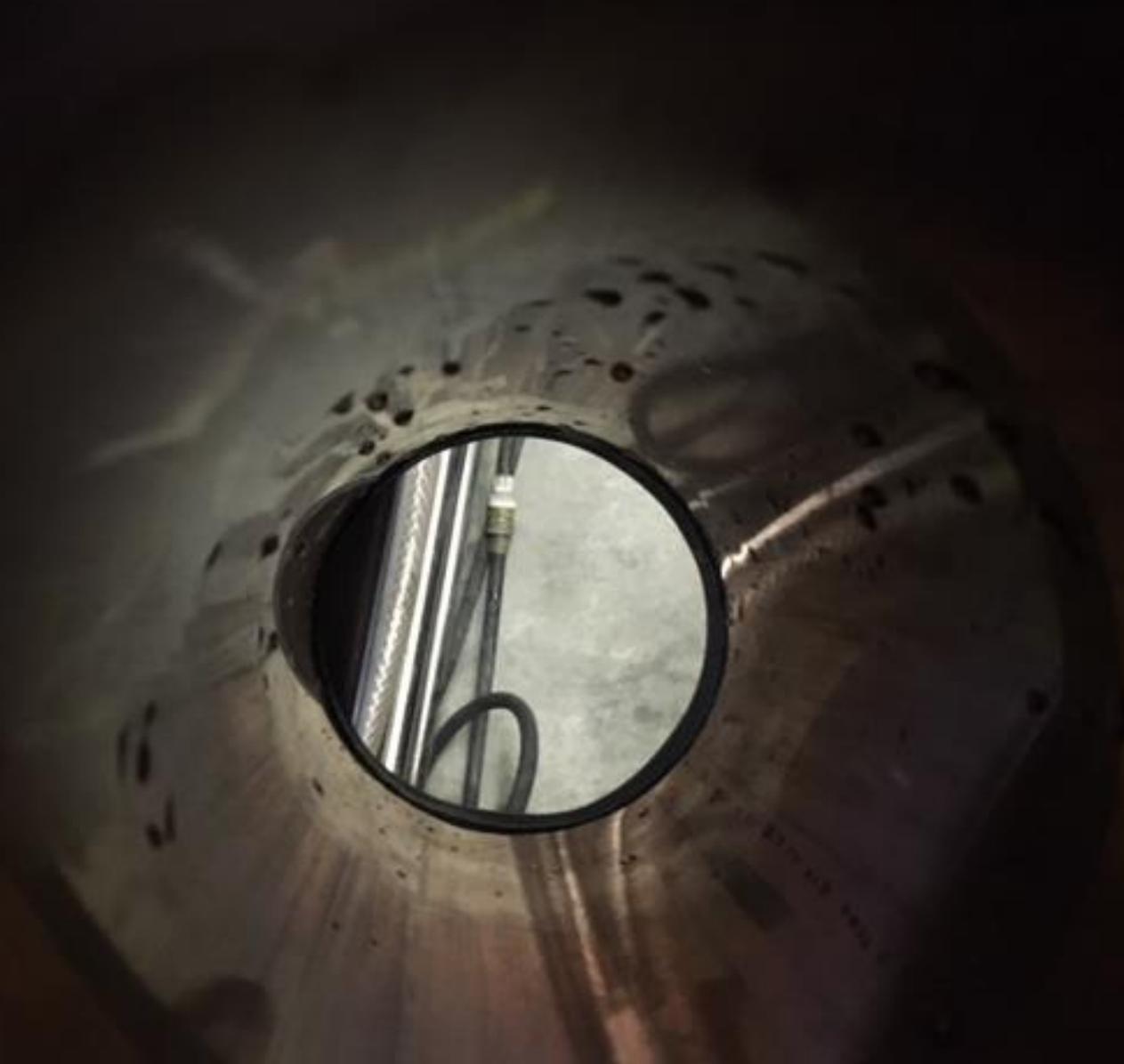
There are six liquid side fouling mechanism (1) precipitation or crystallization fouling, (2) particulate fouling, (3) chemical reaction fouling, (4) corrosion fouling, (5) biological fouling, (6) freezing fouling.

-Fundamentals of Heat Exchanger Design, Shah, Ramesh and Susulic, Dusan, 2003, John Wiley and Sons.



When drain water is shut off, water evacuates surface of sloped DWHR.





Beads of water remain on walls of vertical pipe long after drain water flow is shut-off.



What happens when large quantities of Shampoo, Conditioner and Hand Soap are applied directly to the heat transfer surface and left overnight? When water is first applied heat transfer is reduced. As shower runs, temperature ramps up as debris is removed. By end of first 10 minutes, heat transfer is 85% of maximum, i.e. recovery is 32% instead of 37.5% at 2.5 gallons per minute equal flow. Hot Water (180F) applied through the drain line before p-trap restores the heat exchanger to its original condition.



To date, there have been zero complaints about clogging.

Extensive testing was conducted to ensure that anything that enters the drain water chamber leaves the other side. A mixture of human hair, hair conditioner and liquid soap scum was repeatedly tested according to IAPMO PS-92-2012 section 5.5.1. The end cap was optimized through multiple iterations using a 3D printer to ensure a smooth transition and eliminate the possibility of clogging.

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Unit retested after two years in service in high use rental home.

We removed one ecodrain from service after 2 years installed in a rental home with up to 10 people showering per day. Unit was removed in order to evaluate performance. The performance was found to match the original test result.



In response to why is the scope limited to vertical systems?

“There is a CSA technical specifications and test methods only applies to vertical systems. There are no technical specifications or test methods for horizontal units, which means there is no standardized means to evaluate the energy performance or quality of horizontal units.”

“ There is also no proper test and labelling standard for horizontal. ”

There is a rigorous quality and safety standard for horizontal DWHR called IAPMO PS-92-2012.

List of acceptable materials from which device can be manufactured.

Hydrostatic test for drain chamber.

Hydrostatic test for cold water chamber at 350 psi.

Double wall leak by test.

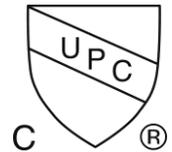
Hair test for Heat exchangers intended for Gray Water Applications.

Markings and Accompanying Literature Requirements.

IAPMO certification requires factory audit twice per year to ensure quality.

IAPMO R&T is North America’s premier plumbing and mechanical product certification agency. www.iapmort.org

PS-92-2012 updates PS-92-2008, the standard has been in effect for 9 years in it is current form.

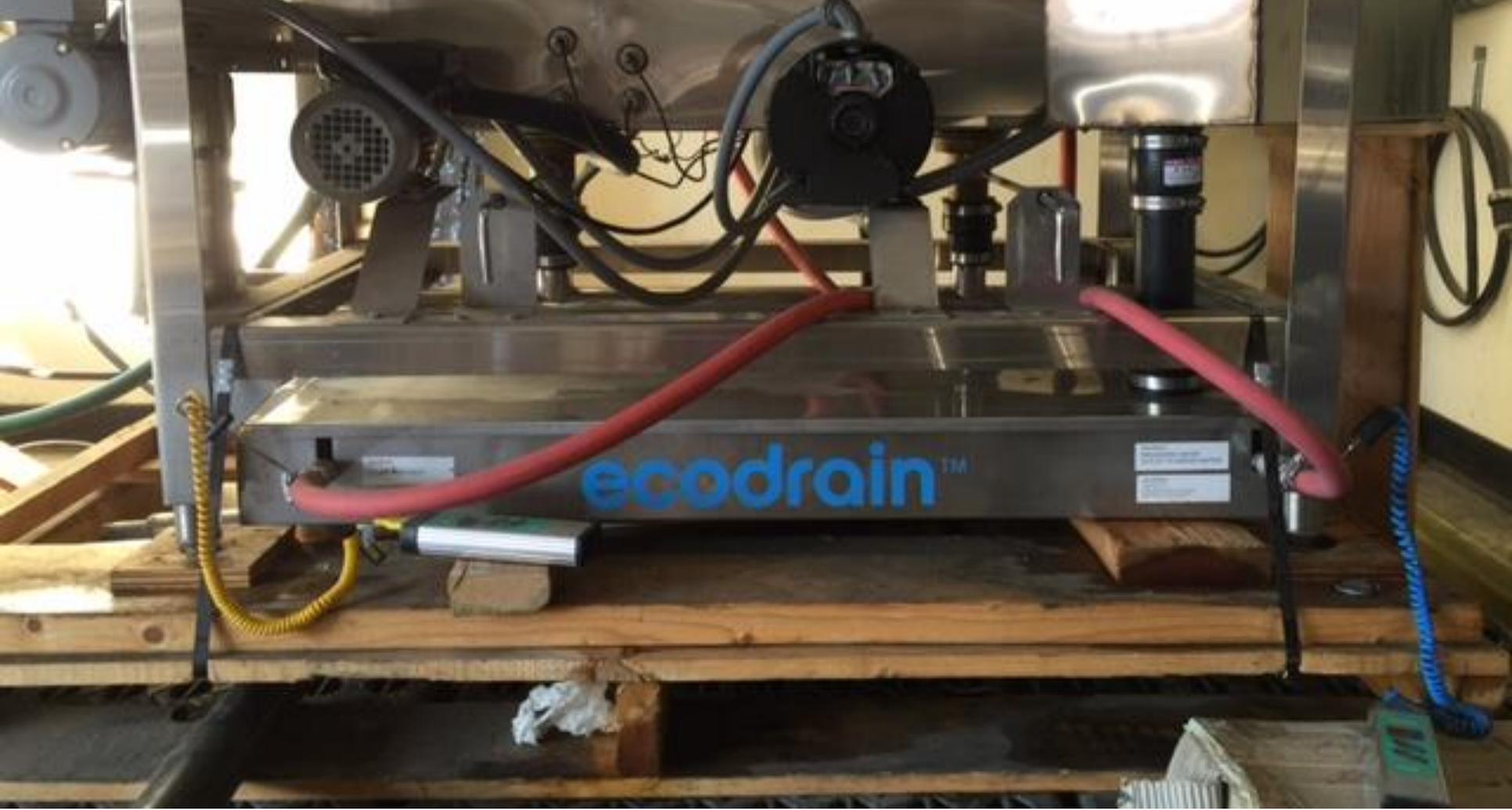




IAPMO Product Certification Committee

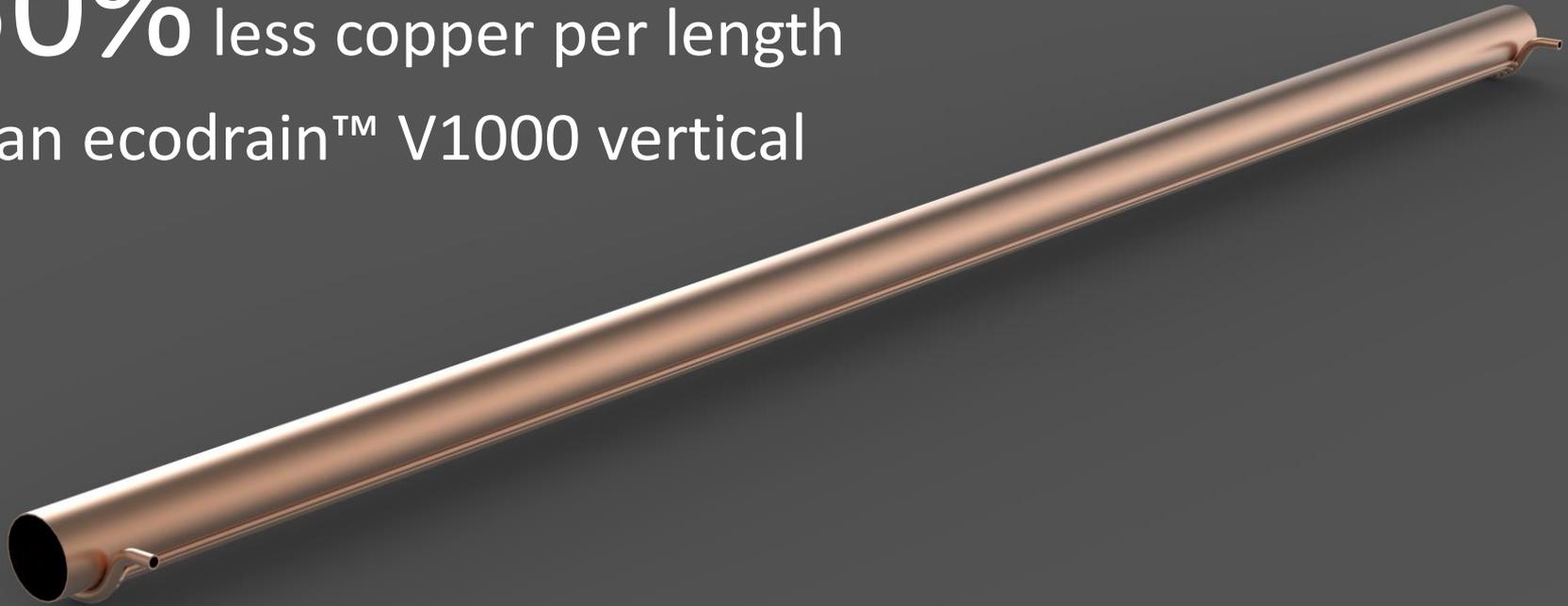
The Product Certification Committee reviews applications for product certification and makes the certification decision based on test reports and supporting data provided by the applicant along with the recommendation of the Product Review Engineer. The committee considers not only the applicable product standard, but also relevant provisions of the applicable code. This committee meets 12 times per year in person. Due to the nature of the work performed by this committee, those employed in the manufacturing field may pose a conflict of interest. – From IAPMO website.

IAPMO = International Association of Plumbing and Mechanical Officials. HQ in California.



This picture shows a custom unit designed for a commercial dishmachine manufacturer to fit into an standard commercial dishwasher. Horizontal technology has the potential to be integrated into other equipment such as dishwashers and shower stalls, which can reduce the cost of installation.

50% less copper per length
than ecodrain™ V1000 vertical



B1000 horizontal mixed water drain water heat recovery system.

Heat exchanger only on bottom section of drain pipe.

Much lower cost per length than vertical.

Available in 2", 3", 4", 5", 6" and 8". Current DWHR CSA standard does not allow a vertical DWHR unit to be installed horizontally.

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Cost Effectiveness Comparison – B1000 model

Model	Slope	Ø	Length	Recovery	Weight	Recovery % per pound of copper
		inch	inch	@9.5 lpm equal flow	lbs	
Coil	Vertical	4	38	41.1%	25.23	1.62%
B1000	Horizontal	4	130	41%	44.6	0.92%
Coil	Vertical	4	120	73%	78.54	0.93%
Coil	Horizontal	4	120	36.5%	78.54	0.47%

The B1000 unit is similarly cost effective to a similar length coil unit when the coil is installed vertically.

The B1000 unit is twice as cost effective as a similar length coil unit when the coil is installed horizontally.

The B1000 is 43% less cost effective than a short coil with similar performance.

B1000 with partial plastic drain boosts
cost competitiveness.



Cost Effectiveness Comparison – B1000 with partial plastic drain line

Model	Slope	∅	Length	Recovery @9.5 lpm equal flow	Weight of copper lbs	Recovery % per pound of copper
B1000	Horizontal Plastic Drain	4 inch	130 inch	41%	25	1.62%

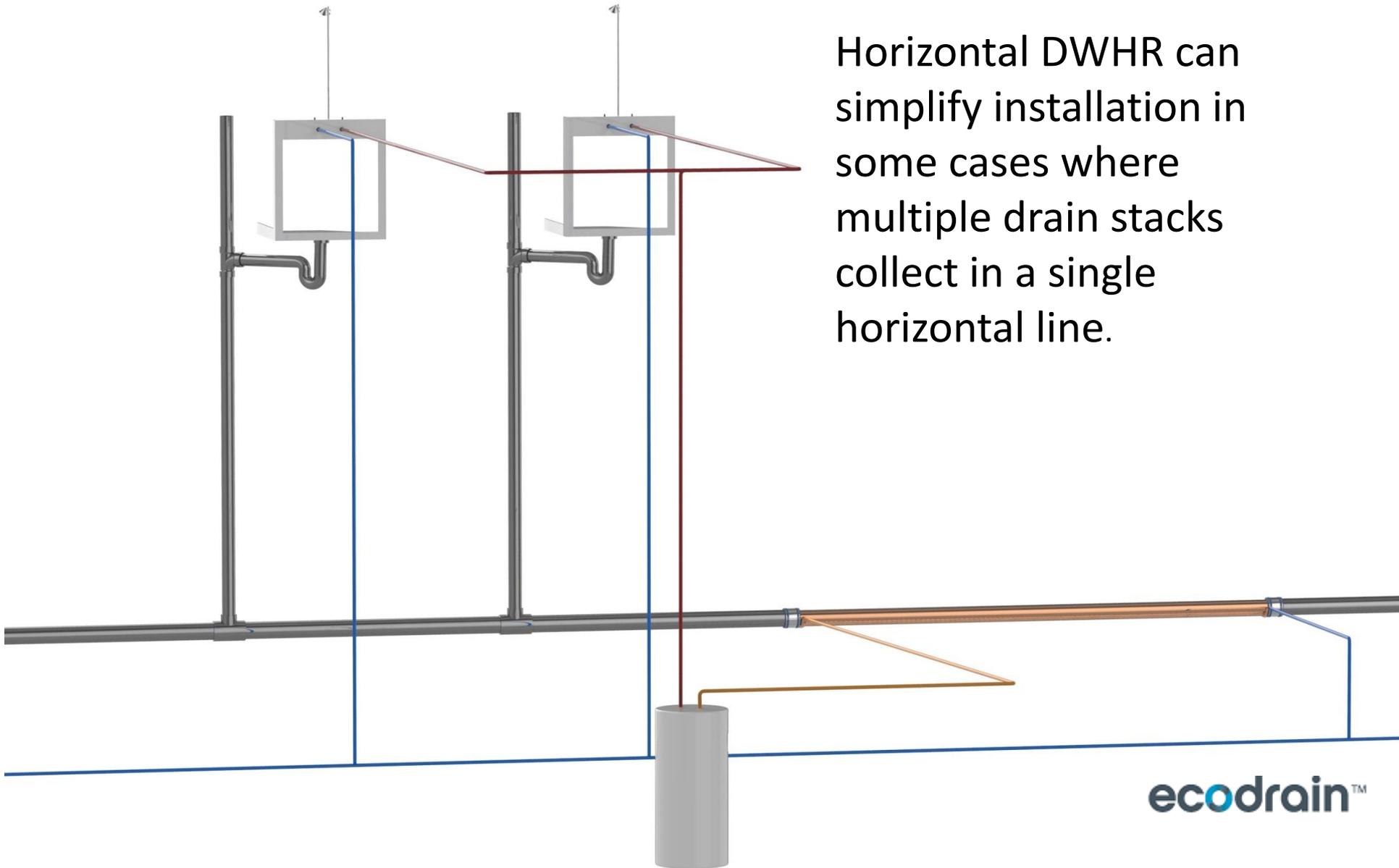


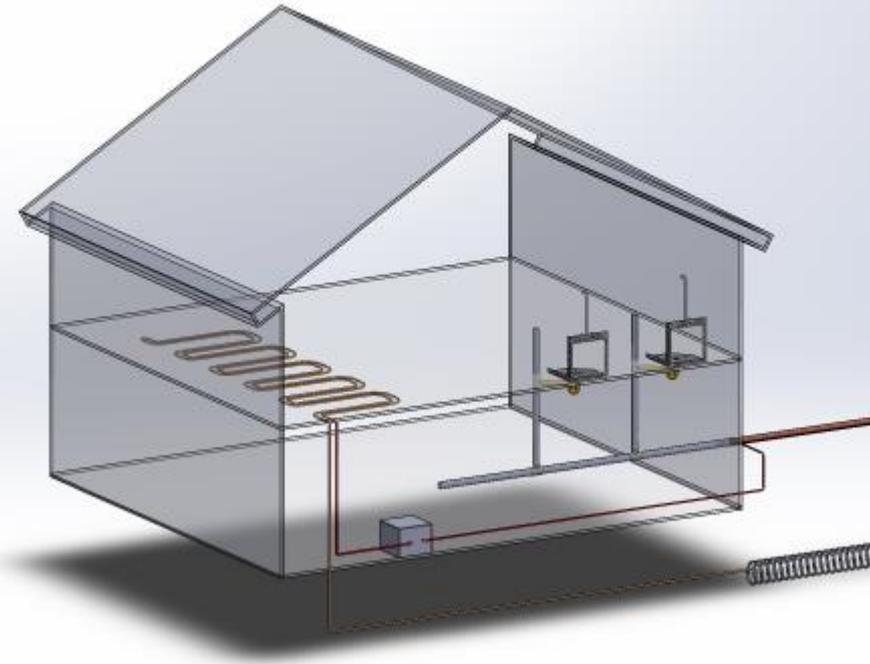
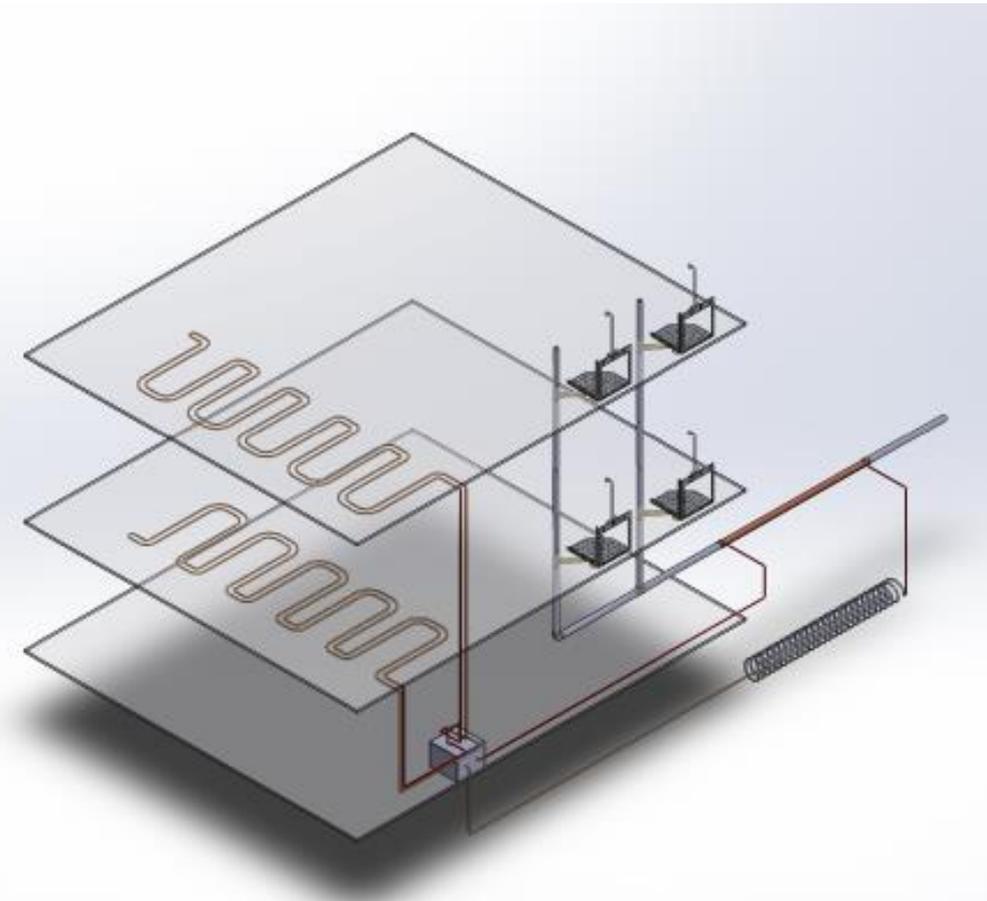
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B1000	Horizontal All Copper	4	130	41%	44.6	0.92%
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Horizontal DWHR can simplify installation in some cases where multiple drain stacks collect in a single horizontal line.





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Can be integrated with a heat pump to reduce the size of the ground loop. Energy from all drain water (cold and hot) is useful as heat pump loop runs at lower temperature than unheated water.

There is a research report available (in French but can be translated) of a case study of an integration of DWHR and a heat pump.

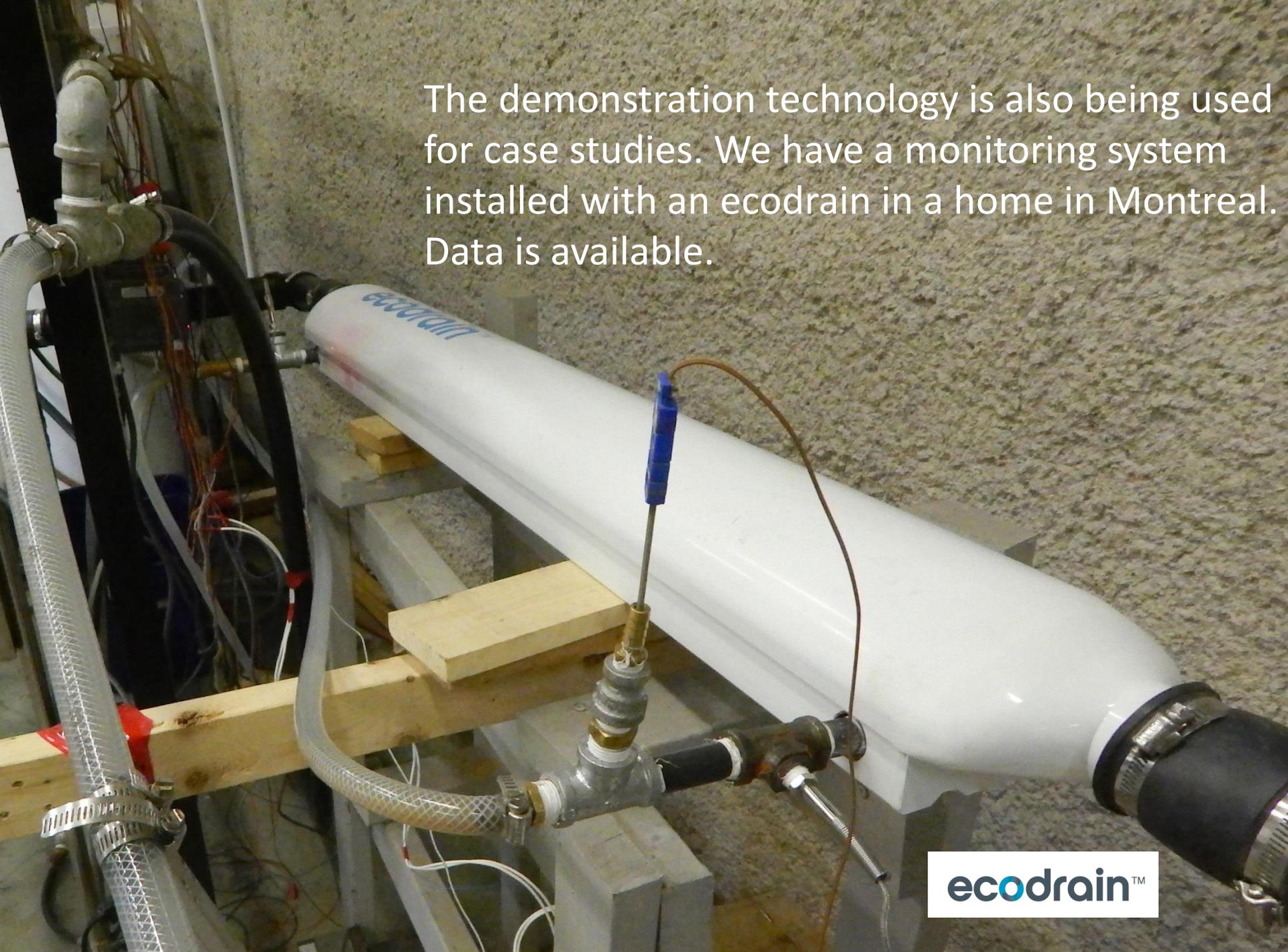
Multi-family project in Bend, Oregon in design phase. Ideal for a case study.

Monitoring

Live demonstration allows internet users to turn on shower at ecodrain and see performance data in real-time.



The demonstration technology is also being used for case studies. We have a monitoring system installed with an ecodrain in a home in Montreal. Data is available.



Takeaways

Cost effectiveness varies with length. A discussion of cost effectiveness must be specific to be meaningful.

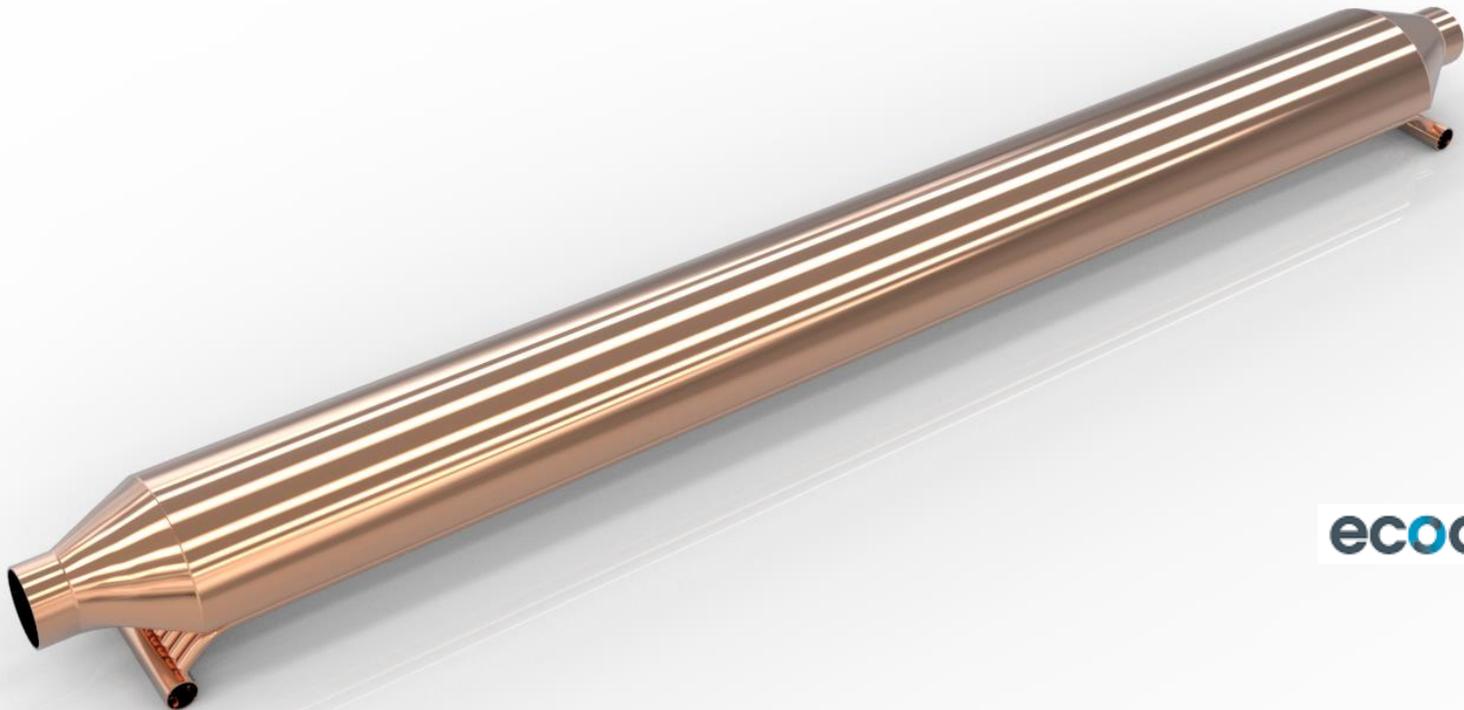
Recovery % per pound of copper serves as a useful metric for comparison of cost effectiveness of different styles of DWHR.

We have shown that horizontal can be cost effective when compared to the most cost effective vertical units.



Takeaways

Horizontal DWHR is safe, reliable and easy to use.

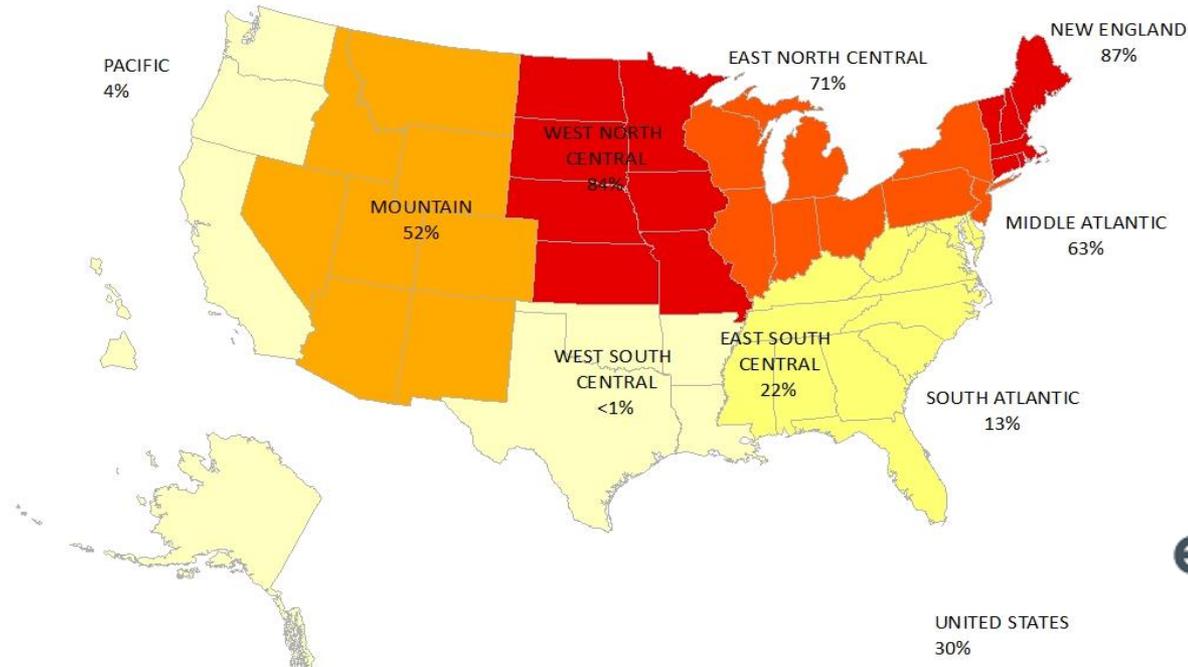


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Takeaways

Horizontal makes the DWHR market bigger, it does not simply shift how the market is divided. Support of horizontal will lead to more energy saved.

Full or Partial Basement
New Single-Family Homes Started in 2013



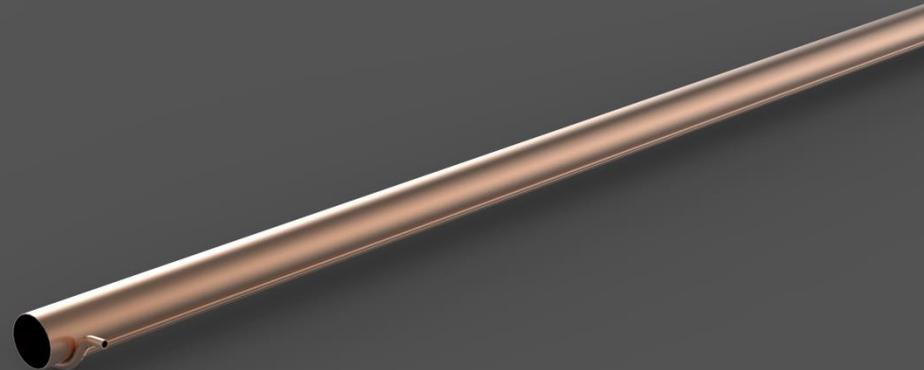
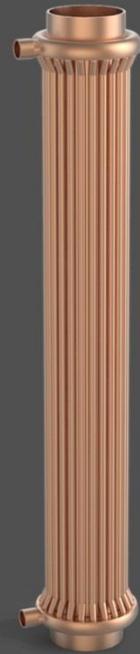
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THANK YOU



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Comment on article: Drainwater Heat Recovery Comes of Age

No NRCAN test data listing yet?
by Dana Dorsett from Massachusetts

Natural Resources Canada maintains lists of the efficiency of drainwater heat recovery units when performed by third party test houses under a standardized set of conditions, so that one can compare apples-to-apples. There are very few horizontal mount units out there competing, but I'd think it worthwhile to actually test the EcoDrain to the NRCAN standard to get a better handle on it.

It would be an easier sell with more data and fewer code-hoops to jump through. For homes with shallow crawl-space or slab on grade foundations it would be about the only option going.

Running the numbers purely on the energy cost savings may make sense in a retrofit scenario, but ignores potential offsetting of cost on the size/capacity of the hot water heating mechanicals, which is often significant.

Source: GreenBuildingAdvisor.com

Specific Comments

“a lot of the time the drain to the septic system is located {quite} a distance above the basement floor. Most of the vertical units are too long to gravity drain so the only way to make it work is to install a tank & pump – adding a ton of cost. More confirmation that the code boys are all from the city. It only makes sense that if they are going to force this, then they have to look at the horizontal units.”

-Ontario Builder A

“So in rural bungalows that are on septic (like my own) there usually isn't enough vertical drain pipe to connect a DWHR so does that mean I would be exempt on a new build?”

-Ontario Builder B

“They still may force me to service the single bathroom upstairs with a {vertical} DWHR as it is now mandatory, what a waste as there are three bathrooms and the upstairs will only be for guests (little use).”

-Ontario Builder C

From the Northwest Territories where water is cold and there are no basements.....

Good Day,

*I was very impressed to learn of your product. At Arctic Energy Alliance, we administer a rebate program for energy efficient products, and we promote products that help people to reduce their energy use. **In the NWT, most homes do not have basements and therefore do not have the height to install a vertical Drain Water Heat Recovery unit.***

We would like to be able to promote and provide rebates for your product in addition to the vertical units, however for DWHR products we require a Natural Resources Canada rating of 42% Heat Recovery Efficiency using the ratings listed on the NRCan website:

Your products are not listed.

-Arctic Energy Alliance

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Cost effectiveness of which model do we compare? Equal size or performance?

Model	Slope	Ø inch	Length inch	Recovery @9.5 lpm equal	Weight lbs	Recovery % / lb copper	Vertical coil advantage over horizontal coil	
Coil	Vertical	2	120	60.50%	50.41	1.2%	1.8	Equal Size
Coil	Horizontal	2	120	30.3%	50.41	0.60%		
Coil	Vertical	2	38	32.90%	15.81	2.08%	3.2	Equal Recovery Rate

In response to a question “Why is the scope limited to vertical systems?” in the public record of the title 24 DWHR discussion, it was stated “*Vertical {coil} units are about twice as cost effective {as horizontal coil units}*”.

For this reason, ecodrain developed engineered solutions for cost competitive horizontal drain water heat recovery. We will use the recovery % per pound of copper metric to show that horizontal can be as cost effective as the most cost effective vertical units.