Number 18

BUILDER INSIGHT

BC HOUSING RESEARCH CENTRE

Builder Insight is a series of bulletins and companion videos designed to provide practical information on new technologies, research results, good building practices and emerging technical issues in residential construction to Licensed Residential Builders and others in the industry. This bulletin was prepared based on research conducted by Morrison Hershfield.

Contents

Improving Efficiency in Hydronic Radiant Heating Systems

Background

A pilot study of 12 existing multi-unit residential buildings was conducted by BC Housing in 2018 and 2019, testing the impact of the hydronic heating system additive EndoTherm. Data was gathered and analyzed to control for weather and other factors outside the pilot study. The intent of the additive is to provide heating energy savings by improving heat transfer from hydronic heating systems.

Two Hydronic Boilers in MURB Building

The study analyzed the impact of EndoTherm on building types commonly found in residential housing in the Lower Mainland, British Columbia.

Building Energy Consumption

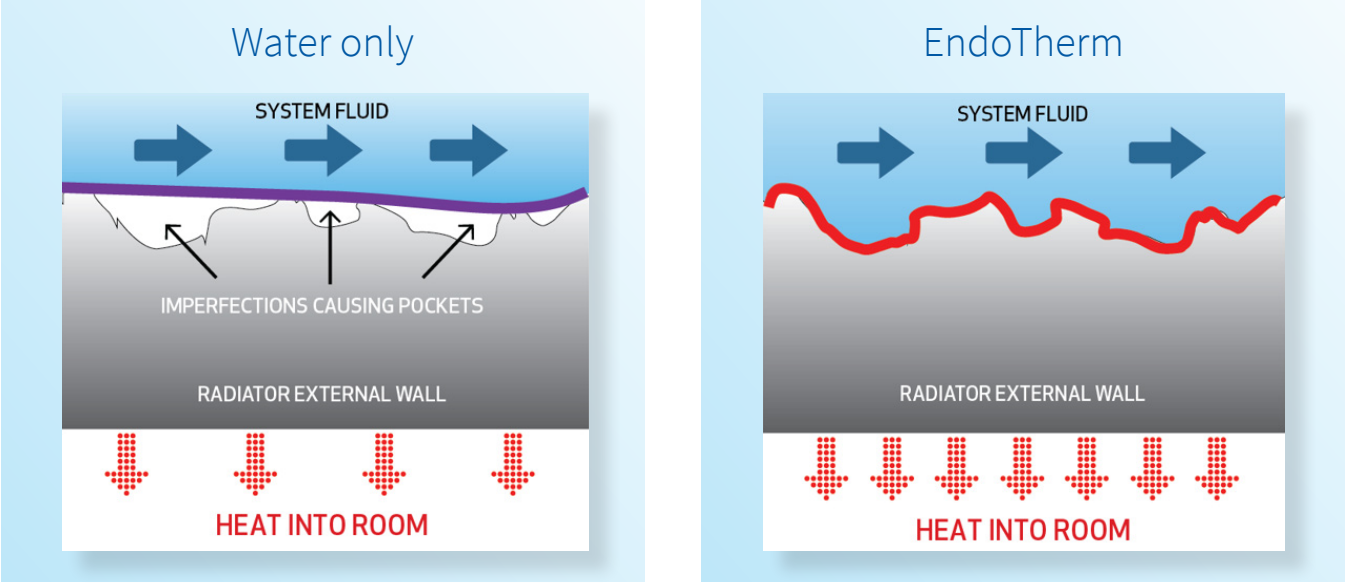
Space heating accounts for between 67% and 84% of the total natural gas consumption for the buildings in this study. In B.C., space heating with natural gas represents the largest source of greenhouse gas (GHG) emissions from buildings.

BC Housing currently has a GHG emissions reduction target of 50% from 2005 levels by 2030, and 80% by 2050.

EndoTherm on Site

EndoTherm

EndoTherm is an additive that targets water-based (hydronic) heating systems and thus their energy use and GHG emissions. Water is used in all hydronic boilers as a delivery method to move heat from the boiler to the building. EndoTherm reduces the boiler water's surface tension, which increases the water's contact surface area available for heat transfer. As shown in the diagram, without EndoTherm, surface imperfections in the hydronic radiators leads to microscopic air pockets, which reduces the overall rate of heat transfer to the building. Improving the heat transfer rates allows for more heat energy to be transferred from the water into the building with each cycle. The water returns to the boiler containing less heat energy and is therefore colder, which leads to more efficient boiler operation.



The Improvement in Thermal Contact Area Caused by the Addition of EndoTherm

Pilot Study

Approach

The additive was installed in the hydronic system of 13 multi-unit residential buildings at different times beginning in February 2018; one building has been excluded from the study due to a leak leading to a total of 12 buildings studied. Analysis of the efficacy of this energy conservation measure was done by comparing whole-building natural gas use (daily and monthly consumption data as available) from before and after the installation, normalized for weather.

The 12 buildings included in the study were selected to represent common residential building types in the Lower Mainland, and all use hydronic boiler-based heating systems. Out of these 12 buildings, 10 buildings are two-four storey wood-framed low to mid rise construction and 2 buildings are concrete high-rises. Buildings were also selected to not have undergone recent retrofits that would impact heating loads, such as envelope upgrades or changes to mechanical systems, as these factors would make it impossible to establish a reliable baseline of existing building performance.

Results

On average, the 12 buildings analyzed (results from one building were discarded due to a leak) show greater than 5% savings in natural gas for space heating compared with the predicted value based on previous years and test period weather data.

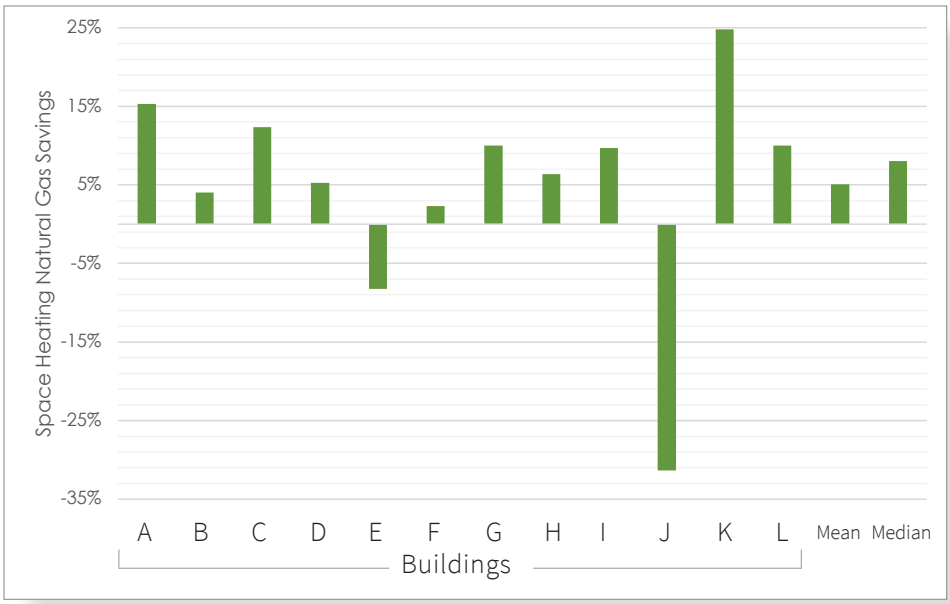


Figure 1 – Space Heating Natural Gas Savings During the Study Period

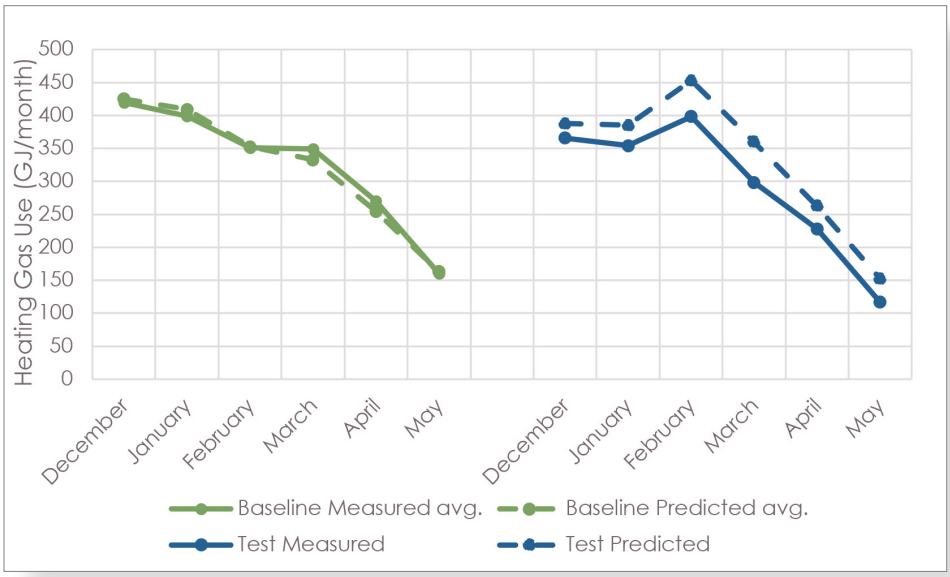


Figure 2 – Building C Baseline (Left) and Study (Right) Periods

While most of the 12 buildings included in the pilot study showed savings, and overall the pilot study indicated savings were expected, some buildings showed an increase in natural gas use compared with predicted results. While those increases, such as the 28% increase at building J seen in Figure 1, are attributable to factors other than EndoTherm, this data does indicate that there may not be measurable savings in all cases due to other factors that could be impacting energy consumption in a more significant manner.

Using the energy consumption during the baseline years, an energy model was produced to predict the expected energy consumption of each building. The left side of the Figure 2 shows the predicted versus actual energy consumption based on weather normalized data for one example building prior to EndoTherm addition; the right side shows the predicted weather normalized energy use versus the actual use following the addition of EndoTherm into the system. The figure shows clear energy savings compared with the predicted value.

Study Limitations

The results are within the range of uncertainty for this type of analysis. Building energy use in operations is typically complex, with factors including occupant behaviour, thermostat setpoints, use of operable windows as well as equipment operation and maintenance. The energy use of a building is expected to fluctuate over time and it is impossible to normalize to weather with perfect accuracy, leading to some uncertainty in the predictive model.

Costs

The table below summarizes the initial installation cost, and natural gas cost, and GHG savings associated with EndoTherm. The analysis includes all charges and taxes. Based on the heating gas savings range of 5 – 8.4%, EndoTherm has a simple payback period in the range of 2.7 – 4.5 years. Beyond this period, EndoTherm will continue to result in reduced natural gas consumption and the associated energy cost and GHG savings.

Metric	Value	Unit
Natural Gas Price	$8.26	$/GJ
Annual Total Gas Use	37,924	GJ/year
Annual Total Gas Cost	$313,263	$/year
Annual Space Heating Gas Use	27,343	GJ/year
Annual Space Heating Gas Cost	$225,861	$/year
EndoTherm Initial Cost	$50,964	$
Estimated Space Heating Gas Savings	5% - 8.4%	%
Annual Gas Savings	1,370 - 2,300	GJ/year
Annual Cost Savings	$11,300 - $19,000	$/year
Simple Payback Period	2.7 - 4.5	years
Natural Gas Emissions Factor	51.4	kg CO_2e/GJ
Annual GHG Savings	70 - 118	t CO_2e/year

Typical HVAC Hydronic Boiler Systems

Operation and Maintenance Impact

Corrosion inhibitor is added to the water in new boiler systems to prevent water from corroding the system from the inside out. Regularly scheduled water testing and treatment by a trained water treatment professional will reduce the impact of corrosion, minimize unnecessary repairs, and help maintain even heat performance of the hydronic HVAC system.

EndoTherm can be implemented as a one-time addition to the hydronic heating system without the need for downtime or equipment changes. As an option and as pursued in BC Housing's pilot program, the PACE Eco Program combines the one-time EndoTherm treatment followed by regular scheduled site visits by a water treatment technician, who tests the boiler water for EndoTherm levels, active corrosion, inhibitor levels and/or freeze protection. This gives the building owner an online report for all hydronic systems with the ability to trend reports. If levels are low, the program includes additional inhibitor to maintain the correct corrosion protection. Programs are structured with 24 or 36 monthly payments, with no upfront costs. After the 24 or 36 month period, the building retains the EndoTherm and associated energy savings and can opt to renew the building's service and water treatment coverage at a reduced monthly cost. The costs used to calculate the payback period in the study include only the initial addition of EndoTherm, and exclude ongoing PACE Eco Program costs.

More information

EndoTherm - Energy Saving Additive, available at www.pacechem.com/water-and-energy-conservation/endotherm.

About BC Housing Research Centre

BC Housing's Research Centre works in collaboration with housing sector partners to foster excellence in residential construction and find innovative solutions for affordable housing in British Columbia. Sharing leading-edge research, advances in building science, and new technologies encourages best practice. The Research Centre identifies and bridges research gaps to address homelessness, housing affordability, social housing challenges and the needs of distinct populations. Mobilizing knowledge and research expertise helps improve the quality of housing and leads to innovation and adoption of new construction techniques, Building Code changes, and enhanced education and training programs. Sign up to receive the latest news and updates from BC Housing's Research Centre at www.bchousing.org/subscribe.

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