RDH BUILDING SCIENCE LABORATORIES

DER Case Study DRAFT Report | Project 28641.000

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1 Deep Energy Retrofits

According to the World Green Building Council (WGBC), the built environment generates 39% of global energy related carbon emissions, and of this, building operations make up 28%.[1] The remaining 11% is from materials and construction. By reducing the operational energy of buildings, we can reduce the amount of CO_2 that is emitted in an attempt to reach national CO_2 reduction goals.

To achieve significant improvements in CO_2 emissions from existing buildings, we need to make significant changes to our buildings, including upgrading their energy systems, eliminating their dependence on fossil fuels, and incorporating technologies to generate or procure renewable energy.

The best times to make these changes are at the key points in a building's lifespan where there is potential to align and integrate building energy upgrades with existing capital improvements and major renovation cycles. Some of these key points include points of sale, major renovations, and building systems and equipment replacements.

Two-thirds of the buildings that exist today will still exist in 2040,[2] so they will require deep energy retrofits to meet CO_2 reduction goals in Canada and the United States as well as the rest of the world. This means that all types of existing buildings need an extensive deep energy retrofit plan.

This report presents a case study of Kestrel Court—a cold-climate, net-zero energy ready project located in London, Ontario. A net-zero energy ready building is one that has been designed and built to a level of performance such that it could, with the addition of solar panels or other on-site renewable energy technologies, achieve net-zero energy performance annually. The results of the case study provide insight into deep energy retrofit strategies that could contribute to meeting national and global energy targets.

2 NRCan's LEEP

In an effort to accelerate energy efficient construction, Natural Resources Canada (NRCan) developed the Local Energy Efficiency Partnerships (LEEP) program. LEEP enables builders to reduce their time and risk finding and trying innovations that can help them build higher-performance homes better, faster, and more affordably. The program's results include energy savings for homeowners, a competitive advantage for participating builders and manufacturers, and builder-driven enhancements to local building practice. One of the key drivers of LEEP is the knowledge transfer and dissemination of R&D related to the optimization of high-performance walls and mechanical systems. The LEEP program provided vital support to the Kestrel Court project.

3 Project Background

In November 2018, NRCan hosted a LEEP for Renovators Technology Forum in London, Ontario. The objective of the day-long workshop was to present building science

[1] WGBC, "Bringing Embodied Carbon Upfront," https://worldgbc.org/advancing-net-zero/embodied-carbon/. Accessed December 4, 2023.
[2] International Energy Agency (IEA), "Technology and Innovation Pathways for Zero-carbon-ready Buildings by 2030: Introduction," https://www.iea.org/reports/technology-and-innovation-pathways-for-zero-carbon-ready-buildings-by-2030/introduction. Accessed December 7, 2023.

fundamentals and some schematic design options to builders in the London area and facilitate discussion about deep energy retrofit options. The workshop provided opportunities for questions and discussion from builders and design professionals, and allowed different product manufacturers to provide basic schematic details for their retrofit wall enclosure systems. Five insulation product manufacturers attended the event and shared strategies for deep energy retrofit wall assemblies to be installed from the exterior. A secondary workshop was also conducted to explore high-performance mechanical system technologies and options.

One workshop attendee, Tom Davis, P.Eng., a professor at Fanshawe College in London, Ontario, saw an opportunity to apply the workshop information and technical solutions to buildings on the college's main campus. He started an effort to implement a series of deep energy retrofits on a block of student residences called Kestrel Court to meet the net-zero energy ready criteria.

The Kestrel Court student townhomes at Fanshawe College were constructed in 1993 and represent construction practices of their era (see Figure 1). The existing construction is 2x4 wood framing with brick veneer on the first story, and vinyl siding on the second story. The above-grade walls are insulated with R12 batt and R5 insulated sheathing without any structural wood sheathing. The below-grade walls are insulated with R12 batt on the interior of the foundation wall that extends 2' below grade. The air leakage rates of the units are typical at around 5 ACH_{50} (ACH = air changes per hour).

Fanshawe College proposed deep energy retrofits of 11 units (three townhouse buildings) in Phase 1 using five different insulation systems and six HVAC packages to achieve net-zero energy ready. This project was completed as a partnership between Fanshawe College, NRCan's LEEP team, and the Office of Energy Research and Development (OERD). Significant industry in-kind support was provided for the enclosures, windows, and HVAC equipment.

This report presents a high-level overview of the project and is the first in a series of reports on various topics related to the Kestrel Court project.

Figure 1: Fanshawe College existing pre-retrofit student townhomes constructed in 1993.

4 Project Objectives

The Kestrel Court deep energy retrofit project had eight key objectives. The primary and secondary objectives were as follows:

1. Primary objective – Achieve net-zero energy ready measured performance annually on the three townhome blocks with the calculated number of solar photovoltaics (PV) that can be put on the roofs combined with some nearby land that is also available for PV if needed.
2. Secondary objective – Reduce greenhouse gas emissions as much as possible. In Ontario, this objective requires electrification or removing natural gas as much as possible.

The additional objectives included the following:

3. Provide technology transfer to the industry, including design professionals, contractors, code officials, government, students, etc., so they may also benefit from the learning acquired with the Fanshawe College Kestrel Court project.
4. Work with five insulation manufacturers to develop practical and effective net-zero ready deep energy retrofit solutions and monitor the enclosure to demonstrate performance.
5. Work with six HVAC manufacturers to demonstrate technology packages that are effective for low-load houses and monitor these systems to confirm predicted performance.
6. Minimize disruptions to the interior space by installing continuous insulation over the exterior of the building.
7. Monitor the performance of the building for at least one year; measure and report the post-retrofit performance, including the enclosure moisture performance and HVAC energy performance; and determine if the retrofits meet the net-zero energy objective.
8. Meet with the stakeholders post-completion to find opportunities for technical improvement and cost reductions in the systems' design and installation while improving performance and durability.

5 Building Improvements

5.1 Above-Grade Enclosure

The enclosures of the townhomes were retrofit using a combination of exterior insulation strategies and new windows. In a deep energy retrofit, as well as construction of new high-performance buildings, it is critical to have a highly insulated, airtight enclosure to control the heat loss/heat gain between the interior and exterior to reduce the energy required for space conditioning.

All the above-grade wall retrofits were conducted from the exterior, and drywall was only removed from the interior above grade where necessary in small areas to install the required monitoring equipment. Window and door replacements also required access to the interior space. All the retrofits were done in the summer months when the student townhouses were not occupied. Otherwise, these above-grade renovations would not typically require the occupants to vacate. The basements were retrofit from the interior to avoid excavation around the exterior of the building, which would have required the occupants to vacate during the construction.

To focus on the impact of above-grade wall assemblies, all basements and attics were upgraded using the same specifications for insulation levels.

5.1.1 Fenestration

All the original windows and doors were replaced as part of the retrofit. New windows and doors were provided by Centennial Windows. The existing double-glazed windows were replaced with triple-pane insulated glazing units with the following ranges of performance based on the different types of windows.

- Solar heat gain coefficient: 0.24 to 0.32
- T_{Vis}: 0.38 to 0.51 (visible light transmittance)
- U-value: 1.00 to 1.21 W/m^{2}K (0.175 to 0.213 Btu/(hr · ft^2 · °F)
    - R-value: R-4.7 to R-5.7

5.1.2 Above-Grade Wall Retrofit Strategies

Five insulation manufacturers and five specific assemblies were used for the above-grade wall assembly energy retrofits. The five manufacturers were BASF, Dryvit, Owens Corning, Plastifab Insulspan, and ROCKWOOL. Figure 2 shows the townhouse locations identified by the five manufacturers. All of the townhouses, with the exception of the Dryvit units, were to be finished with vinyl siding as a representative and cost-effective finish for the average home. The exterior acrylic stucco finish for the Dryvit system is an inherent part of the system.

Two design charettes were held with participation from Fanshawe College, manufacturers' representatives, NRCan, RDH Building Science, and Building Knowledge to review the basic wall assembly approach as well as detailing and the challenges of the specific site conditions. In addition, reviews were conducted at the 75% and 90% complete construction documents stages, and after the Hot 2000 and Housing Technology Assessment Platform (HTAP) modelling was completed. The model was used to optimize

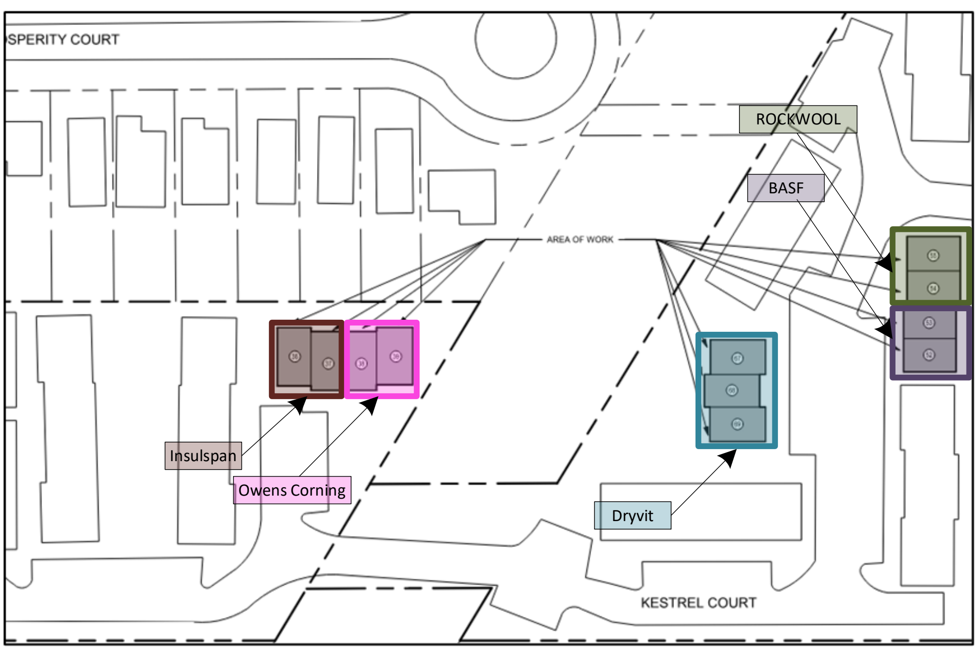

Figure 2: Site plan showing the locations of the townhouses in the retrofit project identified by the insulation manufacturers.

the insulation levels in the attic, walls, and basements given various mechanical systems. It was determined that the insulation levels should be R-60 in the attic, R-28 (effective) in the wall, and R-20 for the full-height basement insulation. The thickness of the insulation, based on each of the wall assemblies was then calculated manually so all buildings would be as close as possible to an above-grade effective R-value of R-28.

Table 5.1 summarizes the main components of the five retrofit strategies.

TABLE 5.1 FIVE ENCLOSURE RETROFIT STRATEGIES

Manufacturer	Kestrel Court Units	Main Components
BASF	52, 53	→ 5 in, 2 pcf closed-cell spray polyurethane foam (ccSPF) in the framed wall from the exterior with horizontal strapping → 2 in (50 mm) Neopor graphite exterior continuous expanded polystyrene (EPS) over framing → Water-resistive barrier (WRB), strapping, and cladding
Dryvit	67, 68, 69	→ Existing masonry, or exterior gypsum where there was no masonry → Dryvit fluid-applied WRB, 3.5 in (89 mm) of EPS foam, exterior insulation finishing system (EIFS) finish → Original R-17 (R-12 batt and R-5 insulated sheathing) remained in the existing wall
Owens Corning	38, 39	→ Two layers of 2 in (50 mm) extruded polystyrene (XPS) with the first layer taped and gasketed as air/water control → Strapping and cladding → Original R-12 fibreglass batt remained in the existing wall
Plastifab Insulspan	35, 37	→ 1 in (25 mm) Durofoam sheathing, taped and sealed for air barrier → 3.5 in (89 mm) EPS and oriented strand board (OSB) Insulspan nailing base panels → WRB, strapping, and cladding → Original R-12 fibreglass batt remained in the existing wall
ROCKWOOL	54, 55	→ 7/16 in (11 mm) OSB sheathing and self-adhered air/water barrier → One layer of 4 in (127 mm) continuous Comfortboard 110 stone wool insulation → Strapping and cladding → Original R-12 fibreglass batt remained in the existing wall

BASF Wall System

The BASF retrofit wall assembly required removing the cladding, insulating sheathing, and cavity insulation.

Horizontal 2x3 strapping was installed on the exterior of the 2x4 framing to increase the installed depth of the closed-cell WallTite spray foam to 5 in (127 mm) and reduce thermal bridging through the structure. WallTite is an air and vapour barrier and can be integrated with the air barrier system of the enclosure. A 2 in (50 mm) thick layer of Neopor EPS insulation was installed over the exterior of the horizontal strapping, and a WRB was installed over the surface of the EPS. Vertical 1x4 strapping was installed through the EPS foam to the horizontal strapping for vinyl siding cladding attachment (see Figure 3).

Figure 3: BASF first-floor insulation in progress (second floor is original).

Dryvit Wall System

The Dryvit Outsulation MD assembly was the only retrofit strategy that did not require the removal of the existing masonry on the first story.

A fluid-applied Dryvit air/water barrier was installed over the masonry and made continuous with all adjoining assemblies and penetrations. Where the assembly had been siding installed directly to the structure through insulated sheathing on the second story and some first-story locations, exterior gypsum was used as a substrate for the EIFS installed over the insulated sheathing. EPS foam 3.5 in (89 mm) thick was installed over the air/water barrier and an EIFS finish coat was installed over the surface of the EIFS. The ground floor had enhanced impact protection with a more durable mesh installed into the coating over the EPS (see Figure 4).

Figure 4: Dryvit wall system with finished EIFS deep energy retrofit enclosure.

Owens Corning Wall System

The Owens Corning assembly is a system of exterior XPS CodeBord insulation and sill gasket membranes for air control installed directly to the exterior face of the framing without any sheathing. Owens Corning refers to this as “CABS” (Codebord Air Barrier System). Two layers of 2 in (50 mm) XPS were installed with the interior layer taped and sealed. On the exterior of the XPS insulation, 1x4 strapping was installed through the exterior insulation for cladding attachment (see Figure 5).

Figure 5: Owens Corning exterior insulation being installed with strapping.

Plastifab Insulspan Wall System

The Plastifab Insulspan wall system included an initial layer of 1 in (25 mm) poly-faced EPS DuroFoam with all joints taped and installed directly against the framing as the primary air control layer of the system.

A nailbase product with 3.5 in (89 mm) of EPS foam bonded to an exterior OSB facer was secured to the structure. This system was the only retrofit solution that provided an exterior sheathing layer for cladding attachment. A sheathing membrane was installed over the OSB for rainwater protection and 1x4 strapping was installed to provide a drained and vented cavity for cladding attachment (see Figure 6).

Figure 6: Plastifab Insulspan deep energy retrofit wall assembly during installation.

ROCKWOOL Wall System

The ROCKWOOL wall system included the removal of the insulating sheathing and installation of new OSB sheathing installed over the framing. A Dorken self-adhered air-permeable air and water barrier was installed over the OSB sheathing. The ROCKWOOL ComfortBoard 110 was installed in a 4 in (102 mm) layer, with exterior vertical 1x4 strapping installed on the exterior of the insulation to provide a drained and vented cavity, and cladding installed to the vertical strapping (see Figure 7).

Figure 7: ROCKWOOL deep energy retrofit wall assembly.

5.2 Below-Grade Enclosure

The below-grade retrofit strategy was to install 2 pcf ccSPF against the interior of the concrete foundation wall as air, vapour, and thermal control. Framing was spaced away from the concrete wall, which allowed for continuous spray foam against the concrete surface. Spray foam was also installed in the basement rim joist around the floor joists because the rim joist is a common location for excessive air leakage in the basement. All of the basements in every unit were constructed in the same way (see Figure 8).

Figure 8: Spray foam installed against the interior of the foundation wall.

5.3 Attic

To make the attics more airtight and energy efficient, the existing insulation was moved away from the top plates around the perimeter of the attic, and a 2 in (50 mm) thick pass of ccSPF 24 in (61 cm) wide was installed at the exterior walls. This helped increase the R-value per inch at the edges where the insulation thickness was limited by the roof, and also helped air seal any penetrations from the wall cavities into the attic space. Following the addition of spray foam, the insulation in the attic was increased to R-60 with loose-fill cellulose insulation on top of the existing insulation. The tops of interior partitions, light fixtures, and party walls were also sealed using manual techniques. All of the attics were retrofit in the same way.

5.4 Enclosure Airtightness

Airtightness testing was conducted on the pre- and post-retrofit units, both guarded and unguarded, to measure the impacts of the deep energy retrofits on airtightness.

To achieve the requirements of the Canadian Home Builders' Association (CHBA) Net-Zero Energy Ready labelling program, the airtightness criterion was a guarded result of either a 1.5 ACH at 50 Pa or a normalized air leakage rate (NLR) of 0.11 CFM/ft^{s} at 50 Pa. Normalized air leakage is the airflow at a given pressure divided by the surface area of the entire space being tested.

All the units were tested prior to renovations and again at the mid-construction mark. The units that did not meet the airtightness requirement at the mid-construction mark were tested again following construction. Table 5.2 shows the test results for all the units prior to the retrofit and then during or following construction.

TABLE 5.2	GUARDED AIRTIGHTNESS TEST RESULTS				
TOWNHOUSE UNIT	**PRE-CONSTRUCTION TESTING**	**POST-CONSTRUCTION TESTING**			
	Unguarded Result ACH @ 50 Pa	**Date (2022)**	**Guarded ACH @ 50 Pa**	**Guarded NLR @ 50 Pa**	**Pass/Fail**
36	4.5	Oct. 13	1.2	0.08	CFM Pass
37	5.7	Dec. 7	1.7	0.11	NLR Pass
38	5.4	Dec. 7	1.6	0.11	NLR Pass
39	5.2	Oct. 13	1.7	0.11	NLR Pass
52	4.1	Dec. 7	0.9	0.06	CFM Pass
53	4.8	Dec. 7	1.7	0.11	NLR Pass
54	5.1	Oct. 13	1.5	0.10	CFM Pass
55	4.2	Oct. 13	1.8*	0.12*	CFM Pass
67	5.1	Oct. 13	1.6	0.11	NLR Pass
68	5.8	Dec. 7	1.5	0.10	CFM Pass
69	5.0	Oct. 19	1.3	0.08	CFM Pass

* Unit 55 used unguarded test results. Pass criteria for an unguarded test was 2.0 ACH @ 50 Pa, or an NLR of 0.15 CFM/ft^2.

6 Mechanical Systems

As a result of the higher thermal insulation values, improved windows, and increased airtightness, the mechanical equipment sizing could be reduced significantly, and lower load HVAC equipment could be used. Several different systems were used in the retrofit units.

6.1 Duct Airtightness

As part of the retrofit, duct air sealing was specified. In most locations in an existing building, the ducts are not accessible from the exterior for air sealing. Aeroseal is a duct sealing technology that can be used in ductwork that improves the airtightness of the ductwork and can lead to increased HVAC efficiency. It works by aerosolizing a proprietary sealant and blowing it through the ductwork. It is made up of polymers that bind together and seal up small leaks and holes in the ductwork.

It is always important that all ductwork is as airtight as possible to get the required space conditioning energy to the required areas, but it is absolutely critical in locations where ducts are run in unconditioned spaces since these unconditioned spaces provide the greatest risk to condensation as well as energy losses.

6.2 Ventilation

Prior to the energy retrofit, the ventilation strategy was typical of buildings this age, consisting only of point source exhaust in the bathrooms and kitchen and operable windows, all controlled by the occupants.

As part of the retrofit, a heat recovery ventilator (HRV) was installed in each of the suites. An HRV was chosen over an energy recovery ventilator (ERV) because of the potentially high production of moisture in the student housing. The HRVs were either a VanEE AI (6 units) or a Lifebreath 205 Max HRV (5 units); see Figure 9.

Figure 9: VanEE AI (left) and LifeBreath 205 Max (right) HRVs.

The exhaust ducts draw stale air from each of the washrooms and the kitchen, and exhaust to the exterior. Outdoor air is provided to the return side of the house duct system. The HRV operates constantly in a low-speed mode to meet the minimum required ventilation rates. Elevated humidity and manual timer controls allow for operation at high speed when required.

6.3 Domestic Hot Water

Drain water heat recovery was installed on all suites to capture drain water heat from the kitchen and upper floor washroom. A Powerpipe R3-66 was installed on the main drain stack located in the mechanical room (see Figure 10). As warm water drains from the shower or sinks, it runs down the surfaces of the pipe and heats the surface. Domestic cold water is connected to the coil wrapped around the drainpipe and will be warmed as it passes through the coil on the way to the hot water tank. This reduces the energy required for water heating by passively heating the water on the way to the water heater.

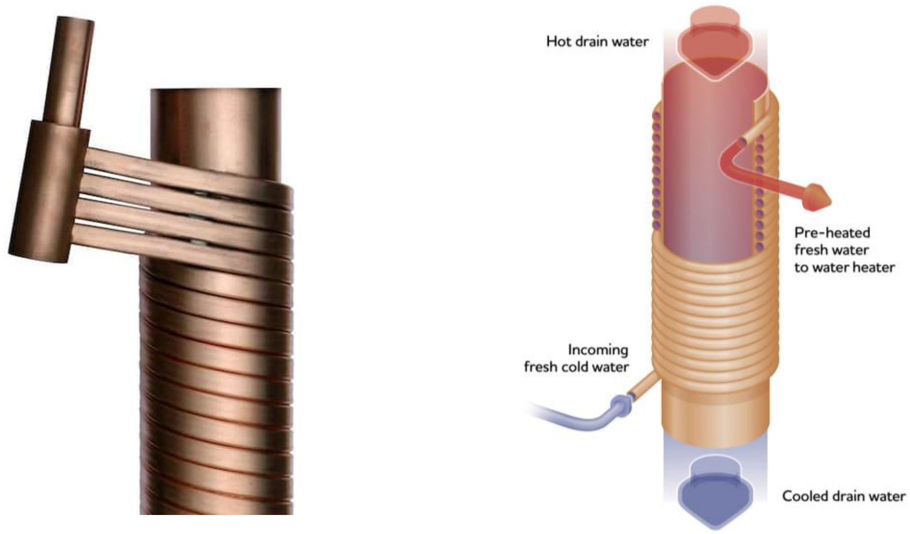

Figure 10: A Powerpipe is shown on the left with multiple square pipes for the greatest surface transfer and less reduction in flow. The generic schematic on the right shows how the system works.

Three different options for domestic hot water were used for this project:

- 80-gallon Rheem electric hybrid hot water heater
- Navien NPE-180A natural gas boiler to provide instantaneous hot water
- NTI GF150 combi natural gas boiler in combination with a storage tank

Both the Navien and NTI boilers were also used as second-stage heating at extreme cold temperatures when the primary heating was a heat pump.

6.4 Heating and Cooling

This project looked at different methods of heating and cooling the space. All of the systems used the existing ductwork in the units for the distribution of the conditioned air. All of the units received a heat pump for heating and cooling. Most of the units received a standard heat pump, expected to heat down to a temperature of -5°C (23°F), and three of the units received a cold-climate heat pump expected to heat down to a temperature of -20°C (-4°F). A secondary heating system was installed for periods of time that the heat pump was unable to meet the heating demand in the coldest winter months.

Several technologies and brands were used for the primary and secondary heating and cooling, including air to air heat pumps, air to water heat pumps, electric furnaces, and gas boilers. Three different cold-climate heat pumps from three different manufacturers were used for this project: Fujitsu, Mitsubishi, and Daikin.

A cold-climate air source heat pump can operate (provide heat) in colder temperatures than a conventional air source heat pump. It removes heat from the outdoor air to supply heat to the interior through the evaporation and condensation of refrigerants (similar to a fridge).

The heat pumps are expected to operate at reduced capacities at extreme cold temperatures (below -20˚C (-4˚F)). A 3 kW electric resistance duct heater will provide supplemental heat when in defrost mode or during calls for heat during extreme cold temperatures. Standard heat pumps were installed in the rest of the units to provide heat down to an exterior temperature of approximately –5°C (23°F).

In three units, an electrical furnace was used to provide additional heating below –5°C (23°F). Dettson provided two Supreme electric furnaces with a two-stage modular heating element and ECM blower. Dettson also provided a third electric furnace option for additional heating on another unit.

In one unit, an iFlow hydronic air handler combined with the Navien natural gas boiler was used for heating below –5°C (23°F). The Navien boiler was previously mentioned in the domestic hot water section because it is also providing instantaneous hot water to the house.

The final heating system relies on the NTI natural gas combi boiler previously mentioned in the domestic hot water section to provide heating to the air handler below exterior temperatures of –5°C (23°F).

As explained above, the variety of heating and cooling technologies and manufacturers will provide an interesting performance comparison following the first winter of use.

7 Monitoring

7.1 Enclosure Monitoring

The enclosures will be monitored for moisture levels at various locations within the enclosure system. In wood-framed construction in cold climates, the most common moisture-related issues are condensation and moisture accumulation on the inside face of the sheathing as a result of exfiltration of warm humid air in the winter months.

By installing an effective air control layer and installing exterior continuous insulation in every wall assembly, the risk of moisture condensation and accumulation within the wall system is very low.

A series of relative humidity, wood moisture content, and temperature sensors were installed in all areas of the enclosure, including the foundation walls, above-ground assemblies, and one attic installation. The objective of the moisture monitoring sensors is to show that all the exterior insulation retrofit strategies employed do not have any risk of moisture accumulation and are all durable, energy efficient wall assemblies.

A typical sensor package installed in the above-grade wall assembly at the interior of the exterior insulation consists of a sensor for relative humidity and temperatures (in the white protective sleeve) and a wood moisture content wafer, as shown in Figure 11.

All the foundations were retrofit using the same strategy, so only three units had foundation sensors installed. Sensors were installed directly adjacent to the concrete before the application of spray foam and were also installed between the spray foam and the interior drywall (see Figure 12).

Since all attics were finished in the same manner, a series of moisture sensors were also installed in one attic unit to measure the temperature and moisture conditions in the attic.

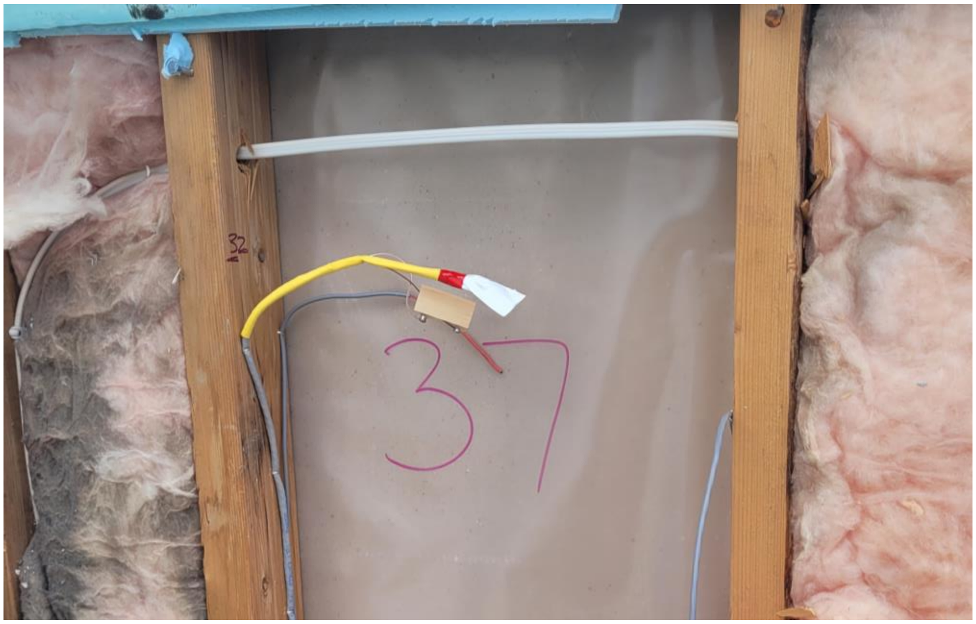

Figure 11: A relative humidity, temperature, and wood moisture content sensor to be installed between the fibreglass batt insulation and the exterior EPS insulation of Unit 37.

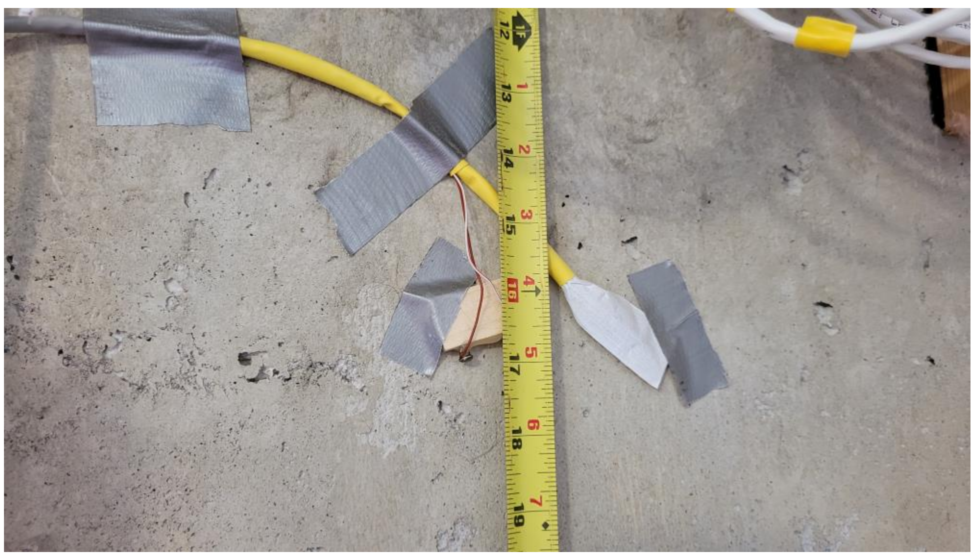

Figure 12: Enclosure moisture monitoring sensors installed against the concrete wall prior to spray foam application.

7.2 HVAC Monitoring

The HVAC monitoring included many different types of sensors for the various pieces of equipment and is summarized here:

- Whole-house electricity consumption
- Interior space temperature and relative humidity
- Heating and cooling equipment gas and electric metres
- Airflows and temperatures

- Domestic hot water system flows, temperatures, and electrical consumption plus drain water heat recovery temperatures
- HRV temperatures, airflows, and electrical consumption
- Weather station for boundary condition data

A more detailed description and analysis of the HVAC monitoring will be written as a subsequent report for the project.

8 Summary

Many studies and published research demonstrate how critical deep energy retrofits will be in the future to meet greenhouse gas emissions reduction goals and energy savings targets.

This report presented a case study of a deep energy retrofit of a total of 11 units in three wood-framed residential townhouses originally constructed in 1993. Deep energy retrofit programs started over a decade ago, so much of the enclosure-related knowledge already exists to complete high-performance low energy retrofits. Continuous exterior insulation has been shown repeatedly to be the best option for low-energy, high-performance enclosures that result in the highest effective R-values, lowest moisture durability risk, improved comfort, etc.

Any deep energy retrofit should start with enclosure improvements using increased insulation, improved windows, and increased airtightness before moving to HVAC replacement. HVAC companies have started offering space conditioning options for low-load, high-performance houses to meet the required demands.

The goal of this project was to produce net-zero ready student townhouses in the cold climate of London, Ontario, using five different insulation manufacturers' strategies and a combination of various mechanical equipment. By monitoring both the enclosure and the mechanical equipment, the study will determine if the townhouses can achieve net-zero ready with the available space for PV.

NRCan intends to share the valuable information gained during this project to inform the industry about different deep retrofit options, to further the industry in deep energy retrofit work, and to provide accessible details and information to architects, contractors, and even homeowners related to different strategies.

9 Future Work

This report is intended to be the first step in a series of reports and presentations that will expand into many areas of the project (HVAC design, moisture monitoring, HVAC monitoring, performance comparisons, etc.) and disseminate additional information and results. The enclosure and HVAC data will be analyzed and presented approximately one year following occupancy with data from all four seasons. In addition, NRCan has planned a video series related to heat pumps using the Kestrel Court buildings.