The Retrofit Dilemma: Balancing Deep Energy Goals with the Reality of an Existing Building

ABSTRACT

How far can we push the limits of an existing building to achieve significant energy and carbon savings while navigating the constraints of its structure and function? This paper delves into the challenges of pursuing a deep energy retrofit for a high-rise residential building, with the goal of achieving EnerPHit certification, the version of Passive House with slightly relaxed performance targets, designed for existing buildings. We will examine the design decisions, construction challenges, and necessary compromises made throughout the project, highlighting the delicate balance between ambitious energy targets and the practical realities of working with an existing building. By sharing lessons learned, this presentation aims to provide insights for other design professionals facing similar challenges.

LEARNING OBJECTIVES

- Identify the challenges of balancing extreme energy savings while addressing the needs and experiences of the building residents.
- Differentiate between the installation details and the requirements of mineral wool versus expanded polystyrene foam (EPS) exterior insulation and finish system (EIFS) assemblies.
- Discuss common deficiencies in each system, appropriate repair methods, and how these issues are evaluated.
- Identify common failure points in air/vapour barrier detailing, explore potential causes, and recommend solutions for both pre- and post-cladding installation.
- Discuss the impact of cost on a project, from the design stage through to construction, particularly in the face of inevitable changes.

SPEAKER

Jennifer Hogan, REWC, RRO, CET, CRE, LEED AP, Certified Passive House Consultant
Project Principal
Pretium Engineering Inc.

Jennifer Hogan is passionate about building sciences and energy performance. She has been a building science consultant for over 17 years and uses her experience and knowledge to help clients achieve their energy and carbon goals as the leader of the Energy and Carbon Reduction team at Pretium. A lifelong learner, Hogan has dedicated herself to furthering her craft by obtaining numerous industry certifications. If you asked what her favorite thing is about her career, she would tell you that it is being able to share her love of the built environment with others.

AUTHOR:

Jennifer Hogan, B.Arch.Sci., C.E.T., REWC, RRO, CRE, LEED AP, Certified Passive House Consultant

BES+

As humans, we like to push the limit of what's possible—first striving to design things bigger, and now striving to design them better. To hit our lofty targets for reducing our impact on the planet, we are being asked to push those same limits with our existing building stock. But what are the real-world implications of striving for a deep energy retrofit? Where does our desire to achieve peak performance clash with practicality?

In 2018, Raymond Desmarais Manor was a 43-year-old through-the-wall (TTW) brick building that both looked and performed its age. With significant capital expenditures on the horizon to maintain the building (**Photograph 1**), the owner, Windsor Essex Community Housing Corporation, saw an opportunity to make a change for the better. From that point on, this 20-story, 300-unit high-rise nonprofit housing building began its transformation guided by the EnerPHit standard—the most rigorous energy standard for existing buildings today.[1] EnerPHit is considered the most rigorous energy retrofit standard because it applies the stringent principles of Passive House to existing buildings, with strict performance-based criteria for energy use, airtightness, and thermal comfort, ensuring deep energy savings while accommodating the limitations of retrofit projects. This journey would lead to drastic changes to the interior building systems and, fittingly, a drastic change to the building exterior—worthy of its iconic location on the Detroit River, next to Caesars Palace in Windsor.

Ultimately, the project is modelled as achieving a reduction in energy consumption and greenhouse gas emissions of approximately 65%, which corresponds to an estimated annual savings of 2,717,000 ekWh or 282 tonnes of carbon dioxide equivalent (CO_2e). This equates to taking roughly 200 passenger vehicles off the road, all while saving an estimated $300,000 annually.[2] But what did it take to get there?

STUDYING FEASIBILITY

The goal of achieving EnerPHit Certification became the driving force behind every design decision on the project. A feasibility study was done to determine options for each of the systems requiring renovation. Eighteen scenarios were modelled in Passive House Planning Package (PHPP) with changes to the exterior cladding, balconies, roof assembly, floor slab and foundation walls, ventilation design, domestic hot water system, vent stacks, penthouse, and lighting. The design options were narrowed down based on the EnerPHit requirements, impact on the residents, and price until an optimal recommendation was achieved. The main components of this recommended package included a new semi-centralized energy recovery ventilator (ERV) system, new through-wall air conditioning units, below-grade insulation, new Passive House certified windows and doors, and new EIFS overcladding. Given the size and complexity of the scope, and with all 300 units in the building occupied, a phased approach was planned, as shown in **Fig. 1**.

PHOTOGRAPH 1. 255 Riverside Drive (Raymond Desmarais Manor) before the deep energy retrofit.

FIGURE 1. 255 Riverside Drive took a phased approach to the deep energy retrofit, targeting Step-Wise Certification through EnerPHit.

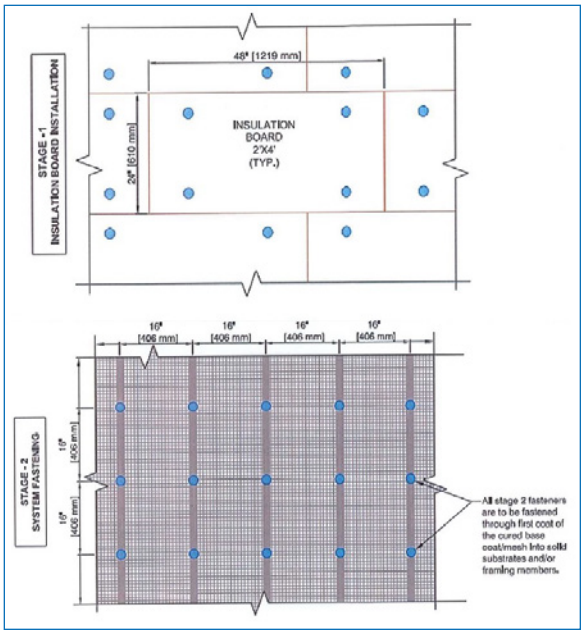


FIGURE 2. Two-stage fasteners for mineral wool EIFS. *Image from shop drawings prepared by Durabond.*

Additional future work was also identified and planned at the roof and domestic hot water system based on their remaining service life.

Throughout both the design and construction phases, the project faced several challenges with detailing that required close collaboration among all parties to balance the energy performance, tenant needs, and budget. The most notable of these include the following:

- Windows with combustible sashes and frames at the north and south elevations
- Thermal bridging at the balconies
- Low-cost, active cooling system
- Overall airtightness

MINERAL WOOL EIFS

At the time of the initiation of this project, options for Passive House certified windows in North America were limited. So, in advance of the feasibility study, along with the purchase and installation of the balcony doors, the windows were selected from a European supplier and are made of vinyl. This created a small challenge for the over cladding; per the 2012 *Ontario Building Code* requirements, since the selected windows are combustible, the exterior walls must remain of non-combustible construction, which precluded the use of EIFS using EPS insulation.[3] Ultimately, the design settled on a combination of EPS and mineral wool, with 150 mm of EPS on the end walls and 100 mm of mineral wool on the north and south elevations, which have windows and balconies.

The use of mineral wool insulation for EIFS construction came with some unique challenges fewer contractors have experience applying EIFS using mineral wool and the techniques required to ensure proper surface flatness and desired appearance.

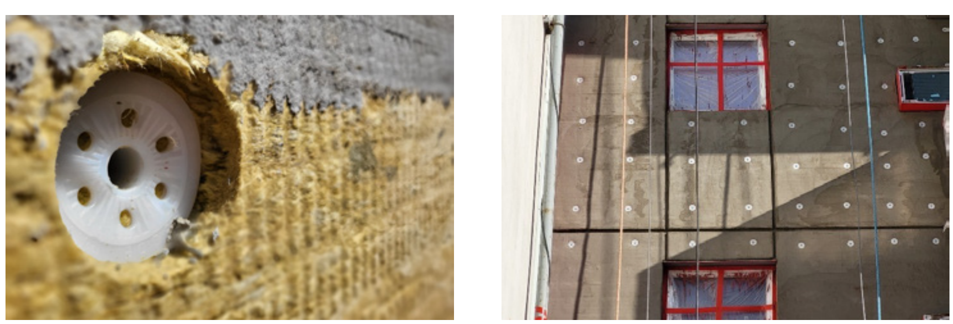
EPS insulation in EIFS is required to be applied using channels of adhesive, which not only secure the insulation to the substrate but also create a drainage gap and plane behind the insulation to manage moisture. In some cases, mechanical fasteners are also used, depending on the type of substrate and its condition. When mineral wool insulation is used in EIFS applications, a two-stage fastening process is recommended. As shown in **Fig. 2**, the first set of fasteners secures the insulation directly to the substrate, while the second set is installed after the application of the base coat and reinforcing mesh to increase wind load resistance. To create the drainage plane for the mineral wool system, you can either use boards with a pre-notched back face or pre-apply the ribbons of adhesive to the back of the board and allow them to cure prior to installation. Since the mineral wool boards are not being set into wet adhesive and cannot be rasped, which allows some "play" and leveling of the boards during application, additional surface preparation may be required to level the substrate in combination with a thicker base coat to level the surface is often necessary in achieving a visibly "flat" finish.

The quantity and placement of fasteners can significantly affect the thermal performance of a wall assembly by introducing thermal bridging. To mitigate this, a thermally broken anchor system was implemented. In the first stage, fasteners were installed with countersunk plastic sleeves, which were then fully covered with a 25 mm cap of mineral wool insulation to minimize thermal conductivity across the assembly (**Photograph 2**). The second stage employed flush-mounted sleeves, each capped with a small insulating plug positioned directly over the screw head (**Photograph 3**).

A few other key differences between the application procedures for EPS and mineral wool EFIS that had to be monitored on site are shown in **Table 1**.

BALCONY THERMAL BRIDGING

The balcony doors were replaced with Passive House certified doors prior to the full feasibility study. The doors were installed within the existing openings or, in some cases, moved to new openings. In either case, the doors were raised



PHOTOGRAPHS 2 & 3. Photographs 2 and 3. Stage 1 fastener through mineral wool insulation, countersunk to allow for insulation plug and stage 2 fasteners installed over the fully cured base coat.

TABLE 1. Additional Differences Between the Application Procedures for EPS and Mineral Wool EFIS.

EPS Insulation	Mineral Wool Insulation
Board joint voids can be filled with spray foam for joints under 3 mm and slivers of EPS for those over 3 mm.	Board joint voids must only be filled with slivers of mineral wool. No spray foam can be used.
Does not readily absorb water	Will absorb water therefore drainage details and terminations of the boards must allow water to drain out and not be restricted by backwrapping the boards with base coat and reinforcing mesh.
Lightweight and easy to cut and shape on site.	Requires specialized tools for cutting, difficult to shape on site.

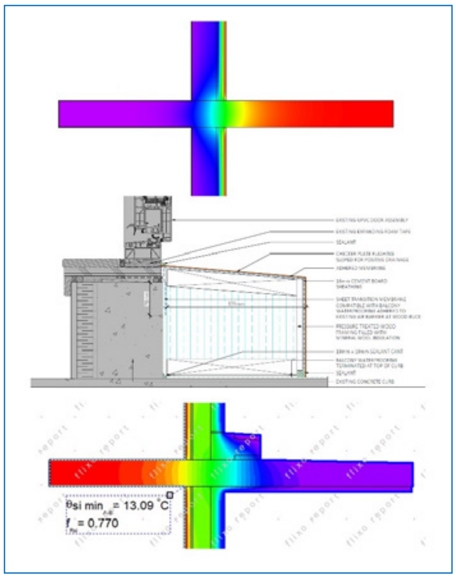


FIGURE 3. Balcony door threshold insulating "step" detail and thermal modelling showing impact with and without.

above the finished slab by approximately 294 mm and, in many locations, had a baseboard heater located below the door threshold.

During the design stage, several options were reviewed to address the thermal bridge at the balcony. However, it was made clear, even from the feasibility stage, that removal of the balconies would not be an option at this building, with the residents frequently enjoying the space. Given that the balcony doors were already elevated from the balcony slab, the addition of an exterior step was proposed. This step would allow for a significant amount of insulation to be added at the slab to wall interface and was acceptable under Part 11 of the *Ontario Building Code*.[3] **Figure 3** shows the design detail, as well as the thermal modelling that was completed.

After several of the steps were installed, some residents noted that the step made it more difficult for them to access the balcony. While a single step may not present a barrier for able-bodied individuals, for many senior residents, the original "step-over" door configuration offered a more manageable means of access compared with stepping up onto an elevated surface. As a result, the project team began exploring additional design options to address the thermal bridging, including reviewing options to lower the new doors, further improving their accessibility (**Fig.4**).

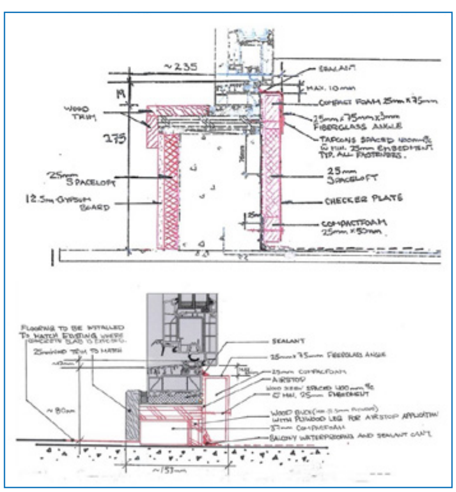


FIGURE 4. Sketches of alternative balcony door threshold details.

Mock-ups of the details were constructed and included the use of a thin aerogel batt insulation, with an RSI value of approximately 1.76 per 25 mm, to achieve the minimum performance required to meet the EnerPHit targets. Once these mock-ups were complete, the contractor provided budgets to complete each option. Regardless of which option was selected, the total estimated cost for the modifications was roughly $2,000,000.

Removing the step without implementing any additional thermal bridging mitigation strategy increased the space heating demand to 26.6 kWh/m^{2}a, which is 1.6 kWh/m^{2}a above the 25 kWh/m^{2}a target.[1] Given the marginal improvement in performance, relative to the high $2,000,000 additional cost, the increase in project scope, and further disruption to tenants, the team felt that this would be impractical and looked for other places—for example, the roof—where the performance could be improved to make up the difference. As a result, the junction at the slab was finished with a combination of the balcony slab waterproofing and a textured finish system (TFS) to match the EIFS.

ACTIVE COOLING SYSTEM

During the design phase several active cooling systems were evaluated, including the use of a variable refrigerant flow system; however, the cost of including a new active cooling system was budgeted over $3,000,000. The building has through-the-wall air-conditioning (A/C) sleeves and through-wall units would be a cost-effective way to provide active cooling to the spaces. However, these openings can be problematic, poorly insulated, and not airtight, particularly in the winter months when the A/C units are not in use. The Passive House Consultant (Peel Passive House) suggested a system that had previously been proposed at a project in New York, but that they had not yet implemented in practice, which included creating a buildout at the interior of the A/C sleeve and installing a Passive House certified window that would be made airtight and provide insulation when the unit is not in use.

During construction, the detail for this installation needed to be refined through mock-ups and diagnostic

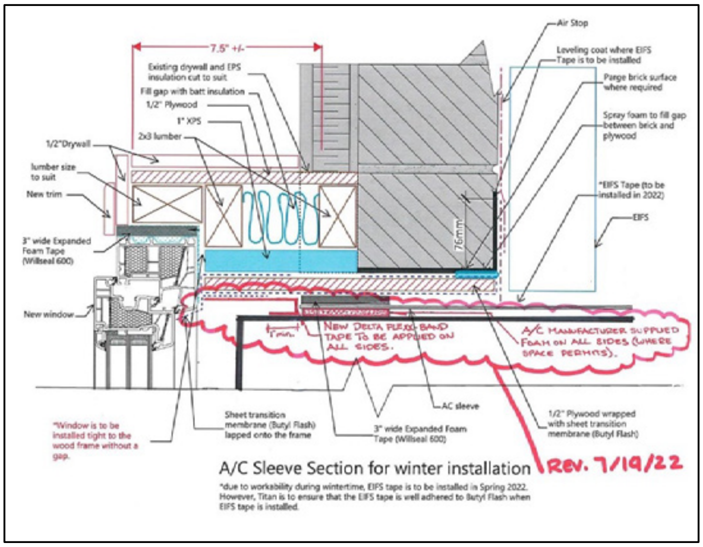


FIGURE 5. Final A/C sleeve section detail, including markups for additional insulation and air sealing measures.

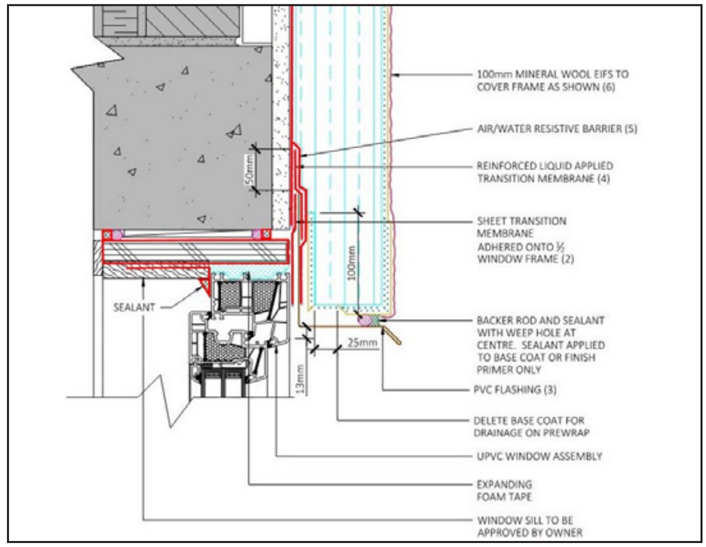


FIGURE 6. Air barrier components at window head highlighted in red.

airtightness testing. The detail shown in **Fig. 5** includes the final configuration, including insulation within the enclosure, as well as the critical expanding foam and tape air barrier system that was installed around the perimeter of the A/C units, connected to the back face of the new window frames, to achieve continuity of the air barrier.

The final installation, which can be seen in **Photograph 4**, is functioning well, with some resident education required to ensure that during the winter months, the unit is disconnected and the window closed and latched. It is interesting that, to ensure that the window cannot be closed while the unit is running, it was decided to leave the electrical connection running through the window opening, in lieu of running it through the base of the new enclosure—a simple but effective failsafe.

AIRTIGHTNESS

Achieving airtightness in existing buildings relies heavily on the precision of detailing rather than just the application of air barrier materials across the wall field. While applying two coats of liquid-applied air barrier to the primary wall surfaces was essential, most observed deficiencies occurred at penetrations and transition areas.

Window perimeters posed a significant risk for air leakage, which was mitigated through a "belt and suspenders" strategy. A combination of a liquid applied air barrier, transition membranes, air barrier tapes, and sealant was used to create a robust detail, with seals connecting to both the interior and exterior of the window frame, as shown in red in **Fig. 6** and **Photograph 5**.

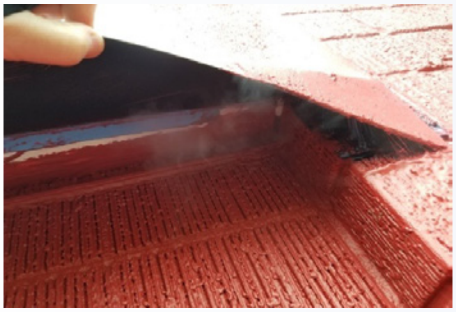
One of the most frequent issues during construction was at the transition membranes, where insufficient pressure rolling prevented full adhesion, and poorly executed cuts (especially at inside and outside corners) left unsealed gaps. These gaps were uncovered during diagnostic airtightness testing, where the building interior was pressurized and tracer gas was released to locate leaks. An example of one such leak is shown in **Photograph 6**.

To achieve either EnerPHit certification, a building must demonstrate that it has achieved an airtightness of 1.0 ACH at 50 Pa.[1] This is verified by completing a whole-building blower door test in accordance with EN 13829 (Method A). With large, occupied buildings, completing one whole-building air leakage test can be challenging. For this reason, Passive House Certifiers will often allow the building to be tested in sections to reduce the impact on the occupants while still achieving the goal of testing 100% of the exterior enclosure.

The plan at Riverside Drive included testing each floor by guarding the floor above and below, as shown in **Photograph 7**, and moving sequentially either up or down the building. The testing is somewhat invasive for the residents, requiring that they not enter or exit the test floor, that their unit doors and all doors within the unit remain open, and that all exterior doors and windows remain closed and latched for the duration of the test, which

PHOTOGRAPH 4. Completed window enclosure for the through-the-wall A/C system.

PHOTOGRAPH 5. Supplemental interior air barrier application at window perimeter.



PHOTOGRAPH 6. Poorly bonded transition membrane, with tracer gas leak during diagnostic airtightness testing.

PHOTOGRAPH 7. Sample of guarding for a whole-floor test, with the test floor in red and the guards in blue.

can take several hours from setup to completion. It would therefore be necessary to provide security on each floor for the duration of the testing to help mitigate resident concerns regarding potential unrestricted access to their unit. With the exterior enclosure only recently completed, this testing has not yet been completed, with the client further evaluating the impact and cost associated with this final step toward certification.

A FUTURE CHALLENGE WITH A TOUCH OF OPPORTUNITY

With the roof replacement on deck for 2026, the realities of the congestion on the rooftop are just now setting in. Because the roof is covered with raised penthouses, long runs of cables, wood walkways, and a plethora of antenna and dishes, the work to coordinate with service providers and prepare for the reroofing project will require significant time and attention. However, the roof has also presented an opportunity to increase the performance to an RSI of 7, which will allow the building to make up the performance lost because of the remaining balcony thermal bridge, and at a much lower price point.

CONCLUSION

While achieving ultra-low energy targets is entirely possible with unlimited budgets or in the controlled conditions of new or unoccupied buildings, the reality of retrofitting existing buildings is far more complex and constrained. Pushing for extreme performance standards can sometimes lead to expensive and impractical details. From an academic perspective, pursuing these targets can be valuable, as it pushes the boundaries of our understanding and forces innovation. However, we must acknowledge the limits imposed by existing structures, budgets, and occupant needs. We should aim for thoughtful, context-sensitive upgrades that significantly improve performance without compromising feasibility.

In the case of Raymond Desmairais Manor, the final decision to certify or not remains to be made. However, with or without it, the seniors who occupy the building can enjoy a significantly improved indoor environment—free from cold exterior walls and drafts and a with noticeable reduction in noise from busy Riverside Drive. Combined with significantly lower utility costs, the final product is one that balances results and reality (**Photograph 8**).

PHOTOGRAPH 8. Original to rendering and design to construction completion—the transformation of 255 Riverside Dr. East.

REFERENCES

1 Passive House Institute. *Criteria for Buildings: Passive House – EnerPHit – PHI Low Energy Building*. Version 10c. Darmstadt, Germany: Passive House Institute, January 2023. Revised January 20, 2023.

2 Natural Resources Canada. Greenhouse Gas Equivalencies Calculator. https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm.

3 Ontario Ministry of Municipal Affairs and Housing. *Ontario Building Code*. Toronto, ON, Canada: Government of Ontario, 2012. Updated as amended.

4 EIFS Council of Canada. *EIFS Practice Manual*. Version 1.0. Richmond Hill, ON: EIFS Council of Canada, 2013.