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Deep Energy Retrofit:

Over-cladding Case Study

The intelligent construction choice

Steligence®

About Steligence®

Steligence® is a global initiative by ArcelorMittal using scientific evidence to show the benefits of steel design in building construction. Using a holistic analysis concept, competitive steel building solutions are identified.

It allows building owners, architects, and engineers a fact based approach to view building construction, for collaboration to build sustainable, more cost-effective buildings.

Smarter steels for people and planet

ArcelorMittal is one of the world's largest steel and mining companies. Guided by a philosophy to produce safe, sustainable steel, it is a leading supplier of quality steel products in all major markets including automotive, construction, energy, household appliances and packaging. ArcelorMittal is present in more than 60 countries and has an industrial footprint in more than 20 countries.

With a strong presence in North America, Europe, South America and South Africa, and an emerging presence in China, ArcelorMittal delivers a large scale of products, solutions and services to customers with the same quality focus in all regions. ArcelorMittal is a leader in steel technology, both in the breadth and depth of our product portfolio, and in our ability to supply a range of grades throughout the world. ArcelorMittal is a supplier of choice for all markets, a testament of our commitment to working collaboratively with our customers to engineer advanced steel grades to meet their needs.

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Introduction

Building owners of properties with over 30 units, constructed between the 1960s and 1990s, are increasingly concerned about rising building costs and are exploring retrofitting solutions that offer a net-positive return on investment (ROI).

A deep energy retrofit (DER) involves a holistic approach combining different retrofitting techniques that yield the highest energy savings and overall performance improvements. Typically, DER performance is targeted to improve energy usage by 50% or more compared with the baseline. A DER considers the energy performance of the whole building as opposed to only upgrading to more efficient mechanical systems; the performance of the building envelope plays a unique role.

This study focuses on the thermal improvement of solid, clear-field wall area by over-cladding. Over-cladding involves abandoning the existing façade system and covering the exterior wall system with new cladding, thus reducing disruption to building residents.

Building Overview & Functionality

Target buildings for this study are high-rise (greater than 8 stories) residential buildings constructed between 1960 and 1990 with a cast-in-place structure and concrete block infill exterior walls in climate zones 5 or 6, which are defined as having 3000 to 3999 and 4000 to 4999 Heating Degree Days respectively. Heating Degree-Days (HDD) represent the total number of degrees Celsius by which the daily average temperature falls below 18°C annually. Retaining and improving these existing buildings is critical to the overall strategy for decarbonizing the built environment. Multi-unit residential buildings and offices represent the largest building stock available for green retrofits.

Design Scenarios

McCallumSather Architects was the external partner that contributed to this case study and conducted the wall assembly development and assessment.

For opaque exterior walls, there are two categories of exterior retrofit assemblies: barrier enclosures and rainscreen or cavity walls. Rainscreens and cavity walls are exterior wall assemblies where the air, water and vapor barrier are applied internally from the insulation to the sheathing to create a capillary break and to allow drainage and evaporation. The wall cladding is a secondary skin that sheds most of the water but is not the primary means of weather-tightness. Barrier enclosures are external wall assemblies that generally maintain weather-tightness by preventing the intrusion of air, water, and vapor on the exterior side of the envelope's insulation layer. The most common barrier enclosure is an exterior insulation and finishing system (EIFS). Barrier walls rely on the integrity of the outermost surfaces and construction joints and are considered a cost-effective alternative to cavity or rainscreen walls. Eight-panel assemblies (four from each category) were selected for the purpose of this study to be analyzed against several Steligence KPIs, illustrated on page 5.

Assembly 1: Rainscreen - Galvanized Z-Girt

Assembly 2: Rainscreen - Clip and Rail

Assembly 3: Rainscreen - Thermally Isolated Clip and Rail

Assembly 4: Rainscreen - Long Screw

Assembly 5: Barrier Enclosure - EIFS - EPS

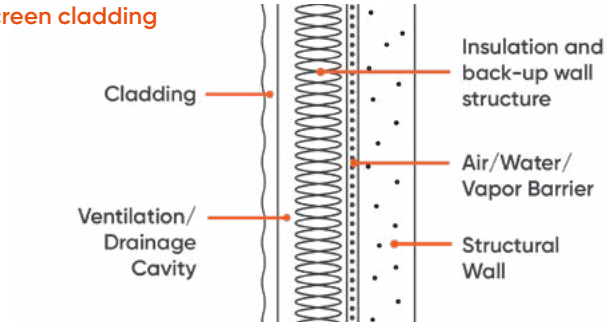
Assembly 6: Barrier Enclosure - EIFS - Mineral Wool

Assembly 7: Barrier Enclosure - Insulated Metal Panel

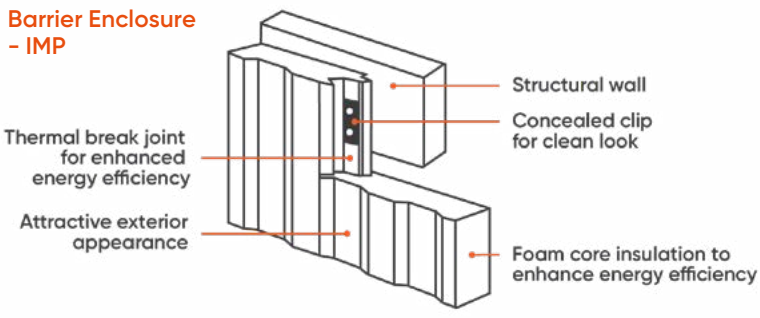
Assembly 8: Barrier Enclosure - Pre-Fabricated EIFS Panels

Types of cladding

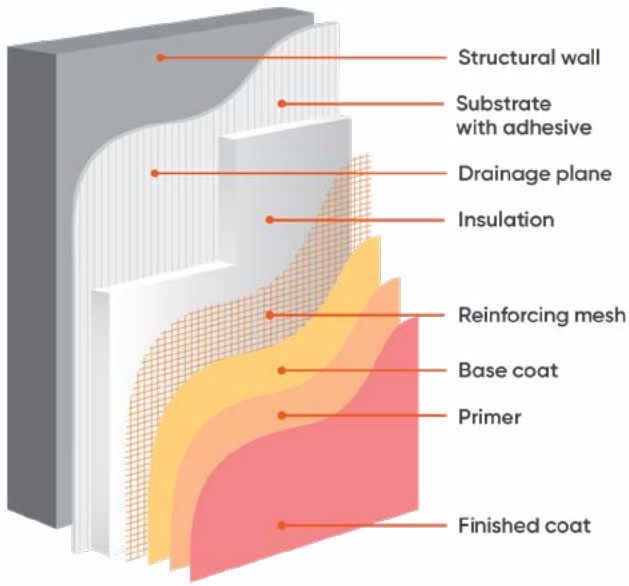
Rainscreen cladding



Barrier Enclosure - IMP

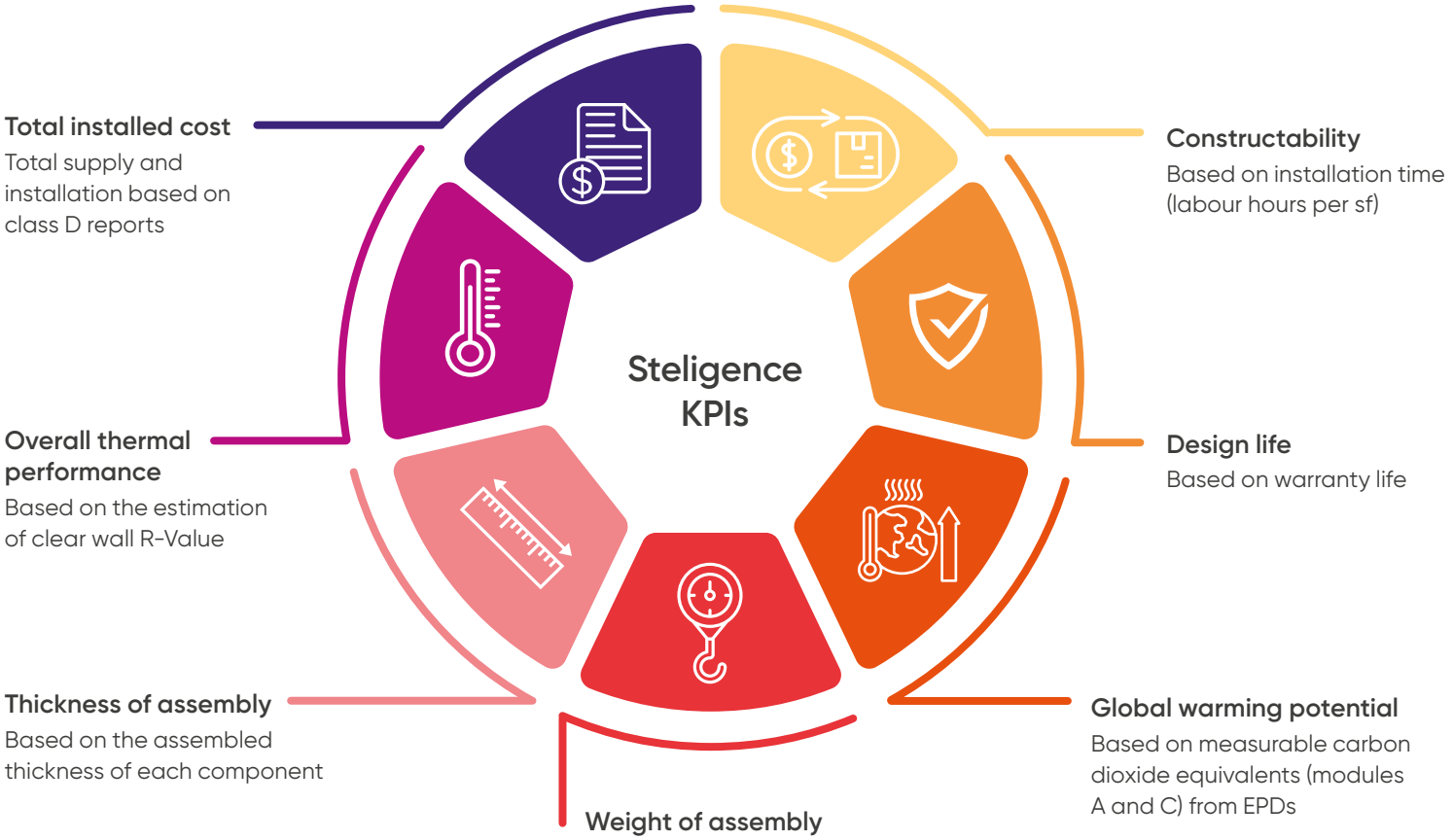


Barrier Enclosure - EIFS



Steligence KPIs

The Steligence KPIs analyzed in this study focused on performance, environmental, financial, and constructability indicators, as follows:

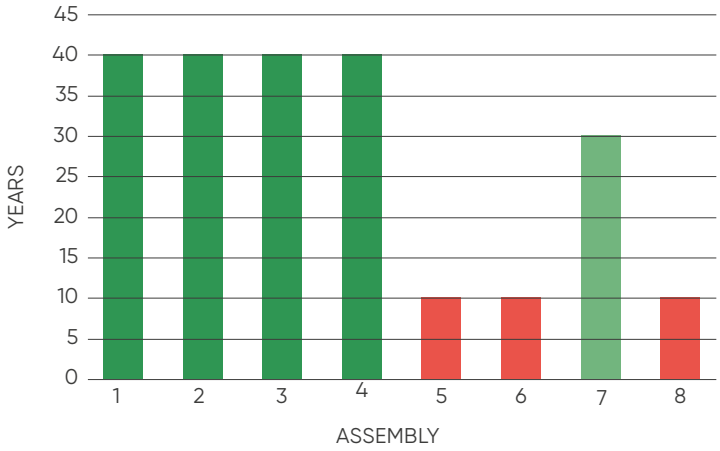


Thermal Design Assumptions

- Evaluated through an estimation of clear wall R-Value. Fenestrations, corners, or connections between envelope elements were excluded.
- Thermal performance was evaluated using reported thermal conductivity for each assembly component by various product manufacturers in a tuned THERM analysis.
- Project Design Temperatures:
  - Exterior = -18°C
  - Interior = 21°C
  - Relative Humidity Interior = 35%
- For meaningful comparisons, different wall assemblies designed for nominal R-values ranging from R-30 to R-35 were analyzed, using typical material thicknesses and a maximum outboard insulation thickness of 203mm (8 inches).

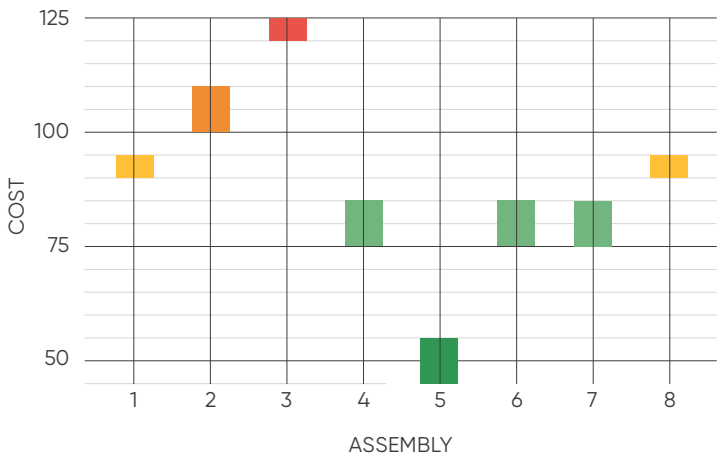
Key Findings

Design Life (years)



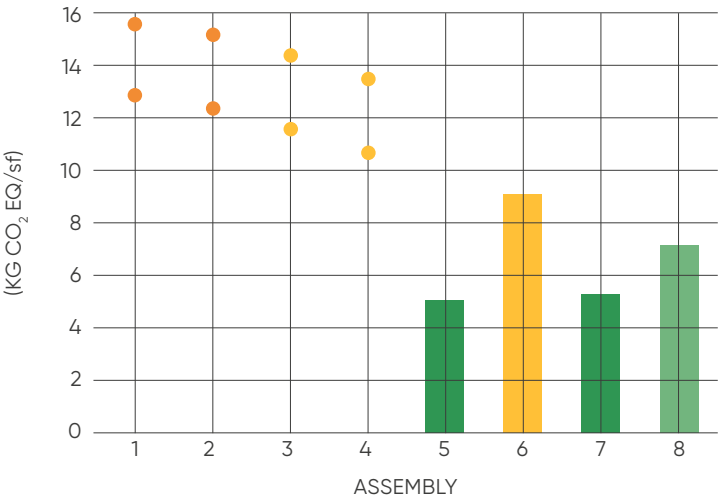
A wide range of design life was observed across the eight systems examined. 40 year design lives were observed across all the rainscreen systems. For the barrier enclosures, the insulated metal panel is projected to have the longest design life of 30 years, which is triple the design life of the other three EIFS.

Total Installed Cost (CAD/sf)



Total installed cost varied from as little as $45/sf with the EIFS system (Assembly 5) to as high as $125/sf with the thermally isolated clip and rail rainscreen system (Assembly 3). In general, the rainscreen assemblies were more expensive than the barrier enclosed assemblies. This can primarily be attributed to the labour required to install the rain screen system. Generally, it takes longer to install a rainscreen assembly when compared to securing a prefinished panel such as the insulated metal panel or pre-fabricated EIFS panels to the structure. Systems that use pre-fabricated panels are typically more expensive in terms of materials when compared to an EIFS but are faster to install thus there's a savings on the labour cost.

GWP



The rainscreen assemblies exhibited the highest global warming potential per square foot, while barrier enclosures exhibited more favourable GWP results. The insulated metal panel assembly had a GWP result of 5.3 kg CO_2 eq/sf which is 42% lower than the EIFS with mineral wool assembly and 26% lower than the pre-fabricated EIFS panel assembly.

All Results

	Thermal Efficiency (%)	Thickness (mm)	Weight (lbs/sf)	Design Life (years)	GWP (kg CO_2 eq/sf)	Total Installed Cost (CAD/sf)	Constructability (Labour hrs/sf)
Assembly 1: Rainscreen - Galvanized Z-Girt	40-50%	455-503	8.5-10.5	40	12.9-15.6	$90-$95	0.8
Assembly 2: Rainscreen - Clip and Rail	55-65%	455-503	8.5-10.5	40	12.4-15.2	$100-$110	0.8
Assembly 3: Rainscreen - Thermally Isolated Clip and Rail	75-85%	455-503	8.5-10.5	40	11.6-14.4	$120-$125	0.8
Assembly 4: Rainscreen - Long Screw	80-90%	455-503	6-7.8	40	10.7-13.5	$75-$85	0.45
Assembly 5: Barrier Enclosure - EIFS - EPS	85-95%	385	10	10	5.1	$45-$55	0.28
Assembly 6: Barrier Enclosure - EIFS - Mineral Wool	85-95%	433	10.5	10	9.1	$75-$85	0.25
Assembly 7: Barrier Enclosure - Insulated Metal Panel	85-95%	347	4.65	30	5.3	$75-$85	0.45
Assembly 8: Barrier Enclosure - Pre-Fabricated EIFS Panels	85-95%	394	12.5	10	7.2	$90-$95	0.45

Low Performer — High Performer

Conclusions

Rainscreen Systems

Advantages: Superior water, air, and vapor control with extra redundancy. Especially ideal in retrofits with challenging moisture control. Large range of aesthetic, Enhanced durability, long-term flexibility. Low maintenance.
Disadvantages: Cost, lower thermal efficiency, more complex system installation.

EIFS

Advantages: Most cost-effective solution with high thermal efficiency for initial cost
Disadvantages: Short lifespan, less redundancy in water control, limited aesthetics, challenging installation in cold conditions. Difficult removal at end-of-life.

Composite Metal Panels

Advantages: Exceptional thermal efficiency for thickness. Especially ideal in retrofits with challenging existing conditions. Enhanced durability, long-term flexibility. Low maintenance.
Disadvantages: Cost, more complex system installation and fire protection required.

Pre-Fabricated EIFS Panels

Advantages: Higher quality control, faster erection times.
Disadvantages: Longer lead-times, difficult installation/applications in unique field conditions. Limited aesthetics.

Recycling rate of steel at the end of life is

92%

Benefits of Steel

Insulated Metal Panels bring significant advantages in terms of weight, cost, efficiency, and durability. Its thermal performance and longevity make it a favourable option for retrofit projects. It not only contributes to enhanced insulation but also offers robust protection against environmental elements.

The Long Screw Rainscreen system performed considerably well for all KPIs against other systems, specifically for design life evaluation. In cases where the durability of rainscreen systems is preferred, lightweight steel cladding can be an effective way to reduce overall weight and cost for enhanced durability.

Lightweight: Steel's lightweight nature makes it practical for retrofit applications without adding excessive load to existing structures.

Longer Lifespan: Steel is known for its durability and longevity, ensuring the retrofit solution's lasting performance.

Higher Durability: Steel coatings can withstand harsh environmental conditions and provide robust resistance to wear and tear.

Longer Warranties: Retrofit projects involving steel components often come with longer warranties, providing peace of mind for building owners.

Flexibility for Unique Conditions: Steel can be adapted to fit various architectural and structural requirements, making it versatile for retrofit projects in diverse settings.

High Recyclability: Steel has a high recycling rate (92%) at the end of its life cycle, promoting sustainability and reducing waste.

Aesthetics: Steel offers aesthetic versatility, allowing for a wide range of design options to enhance the building's appearance.