High-Performance Building Enclosures in the Anthropocene

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In the past century, builders used giant resources of energy and new chemical-based materials to conquer the vagaries of nature through power and mechanical engineering. An unintended consequence of these methods is that, today, our buildings contribute approximately 40% of total global greenhouse gas emissions. In the Anthropocene, human carbon emissions are driving global warming. Because of this, we can no longer default to past industry norms.

In the early 21st Century, we find ourselves in a race against time. By 2050, we need to reduce carbon emissions by 80-90% globally to mitigate the worst effects of climate change. The decisions we make today will determine our success in 2050. Our goalposts have shifted, and our buildings need to become a part of the solution, not perpetuate the problem.

By Erika Mayer, 475 High Performance Building Supply

What Defines a High-Performance Enclosure Today?
Fortunately, the tools we can use to mitigate climate change will also promote the health, comfort and safety of occupants, provide new opportunities for aesthetic and environmental delight, and equip us to achieve a new advanced high performance.

High performance today is not about making buildings less bad, but about making life better. High performance is not about complex technological systems that compensates for poor design, but about the the building fabric itself, the architecture. To accomplish this, we don't need to reinvent architecture, just acknowledge relevant foundational principles which are immediately actionable.

1 - TeamMTL's collaborative entry of McGill + Concordia Universities in 2018 Solar Decathlon, using high performance membranes and cellulose insulation in prefabricated panels developed by Ecocor. Credit: Ecocor.

These principles and actions include:

PRINCIPLE 1: LOWER EMBODIED CARBON
The harvesting and manufacturing of building materials alone is responsible for approximately 10-20% of all human-made greenhouse gas emissions. Depending on a building's efficiency, the embodied carbon of construction materials can account for between 20 and 100% of the building's total lifetime emissions. And even when a building is moderately energy efficient, embodied carbon can easily exceed the total operations emissions for 25 years - severely limiting the potential near term positive impact.
Action:
• Use fewer construction materials and ensure that the materials used have low embodied energy to significantly reduce short-term emissions.
• Utilize less processed and more natural materials. Using more timber based construction, that is harvested with sustainable forestry will reduce the use of steel and concrete structures and foam insulations.
• Use existing structures whenever possible. Because the structure of a building can account for as much as 50% of total embodied emissions, retrofits are a huge opportunity to create a high-performance building with a very small upfront carbon cost.

PRINCIPLE 2: MORE CARBON SEQUESTRATION
A building should become a storage container of carbon. By utilizing materials, like wood, that absorb atmospheric carbon over their growing life, we can lock-away that carbon in the building structure itself and provide greater long-term emissions security for generations to come.
Action:
• Use more wood and harvested carbon-based materials such as hemp, straw, CLT, wood fiber insulation, and cellulose. This depends on good forestry practices that support greater biodiversity and ecosystem health to be a sustainable solution.

PRINCIPLE: MORE NATURAL MATERIALS
Natural materials typically require minimal processing and therefore have significantly lower embodied carbon. They are a healthier choice for indoor air quality, as they often help buffer humidity levels and, when properly selected, have no VOCs.
Action:
• Source more natural materials such as wood fibre, wool and cellulose insulations, timber structures and lime plaster finishes.

PRINCIPLE 3: LOWER TOXICITY
Human-made, bioaccumulative, and persistent toxic chemicals are now found the world over - even in the most remote locations. By reducing toxic chemicals in building materials we can help protect the health of the biosphere as well as the health of construction workers and building occupants. We don't want to chemically sensitize people and the indoor environments need to be safe for people already chemically sensitive. The enclosure should not just not make us sick, but help make us healthier.
Action:
• Use the precautionary principle to avoid poisoning our environment, buildings and occupants.
• Avoid materials that can produce toxic VOCs like uncured spray foam and other off-gassing materials.
• Choose, more natural, no VOC materials, like wood or wool, which can also remove contaminants from the indoor air.

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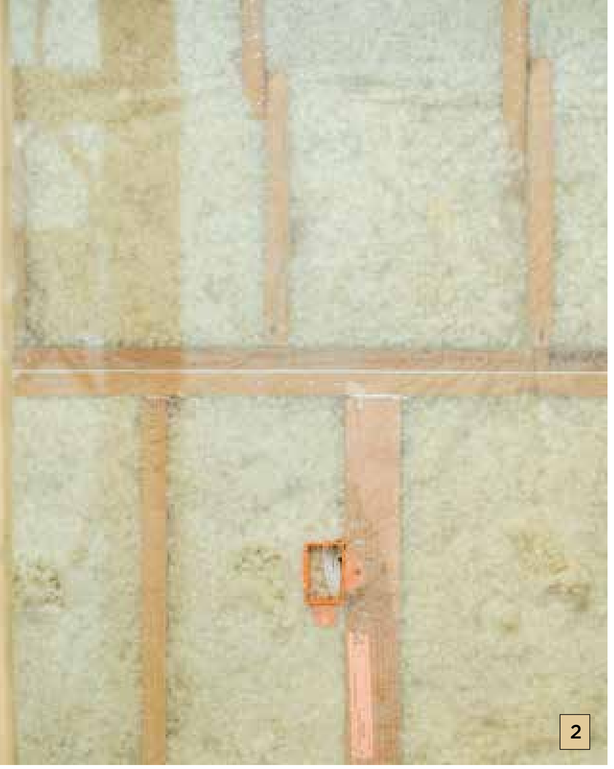
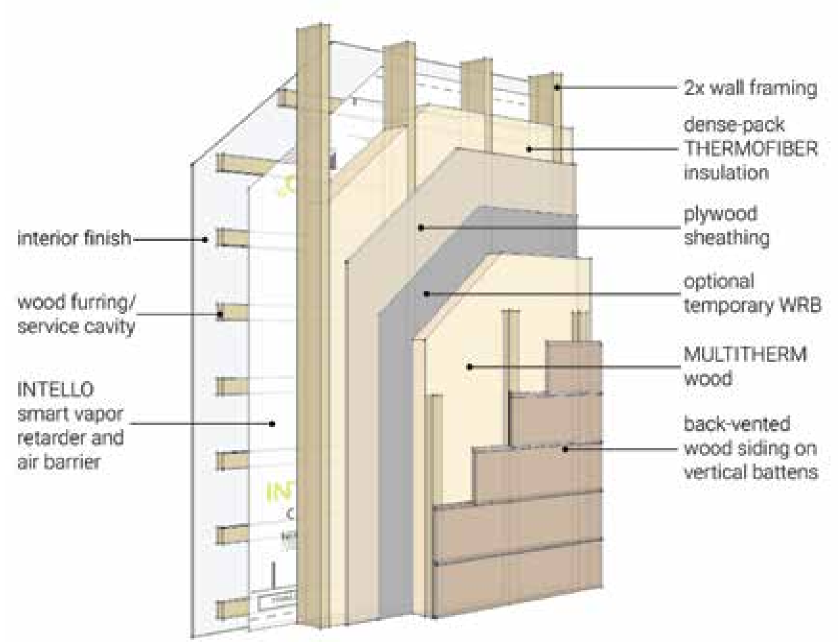
PRINCIPLE 5: SMART VAPOUR, AIR AND THERMAL CONTROL
Vapour, air and thermal control are inherent to the basic function of an enclosure: providing shelter. A high level of thermal control, with thermal bridge free detailing will ensure thermal comfort. Durable, smart vapour and air control help optimize the building's energy efficiency, provide comfortable and healthy interior environments, and ensure the long-term durability of the construction. These control layers, systematically addressed, should reach for Passive House levels of energy efficiency and predictability.
Action:
• Smart vapour control ensures that highly insulated assemblies, which tend to stay wetter, longer - have maximum drying potential over the course of seasons. In cold climates, this typically means providing a vapour-open layer outboard of the insulation, and a vapour-variable layer inboard of the insulation, preventing wetting of assembly in winter and allowing drying inward in the summer. Wood, wool and cellulose insulations help buffer moisture levels.
• Airtightness maximizes the effectiveness of the insulation and optimize occupant comfort. The insulation should be surrounded in airtightness. This is done with a continuous inboard air barrier, which doubles as a smart vapour retarder, and a continuous, vapour open air barrier outboard of the insulation. We can achieve "wind tightness", sufficient to protect the insulation from the outside, with tongue-and-groove wood fiberboard insulation.
• Thermal control is fundamental to comfort and energy efficiency. It must be continuous, connecting at joints, junctures and penetrations. Where the insulation is discontinuous, thermal bridges result, causing discomfort, inefficiency, condensation, and ultimately moisture damages.

PRINCIPLE 6: 100+ YEAR DURABILITY
To maximize the building's climate mitigation effectiveness, it should be functional for generations. Having to replace or rebuild portions of the enclosure can add significant additional embodied emissions over the building's lifetime. To ensure durability, we not only need to achieve a high level of vapour, air and thermal control, but need to use reliable components that are put together correctly are repairable and protected from damages for the life of the building.
Action:
• This can be accomplished by using materials that have been laboratory tested for 100+ year durability - particularly the adhesive connections that come under long-term stresses. Materials like spray foam that will degrade and lose their effectiveness do not belong in a high performance enclosure.
• Blower door test the enclosure for airtightness. By pressurizing and depressurizing the building, leaks can be identified and repaired, making the building more tight after each test.
• Protect the vapour, air and thermal control layers with a service cavity inboard, and a back-vented rainscreen outboard.



2 -Wool insulation in process of installation. Credit: Havelock Wool.



PRINCIPLE 7: INTEGRATION OF ENCLOSURES INTO WHOLE BUILDING DESIGN

An architectural design fulfills a dizzying array of objectives, and a high-performance enclosure is just one. To fully leverage the enclosure system to support the overall building goals, it must be fully integrated into the whole building design.

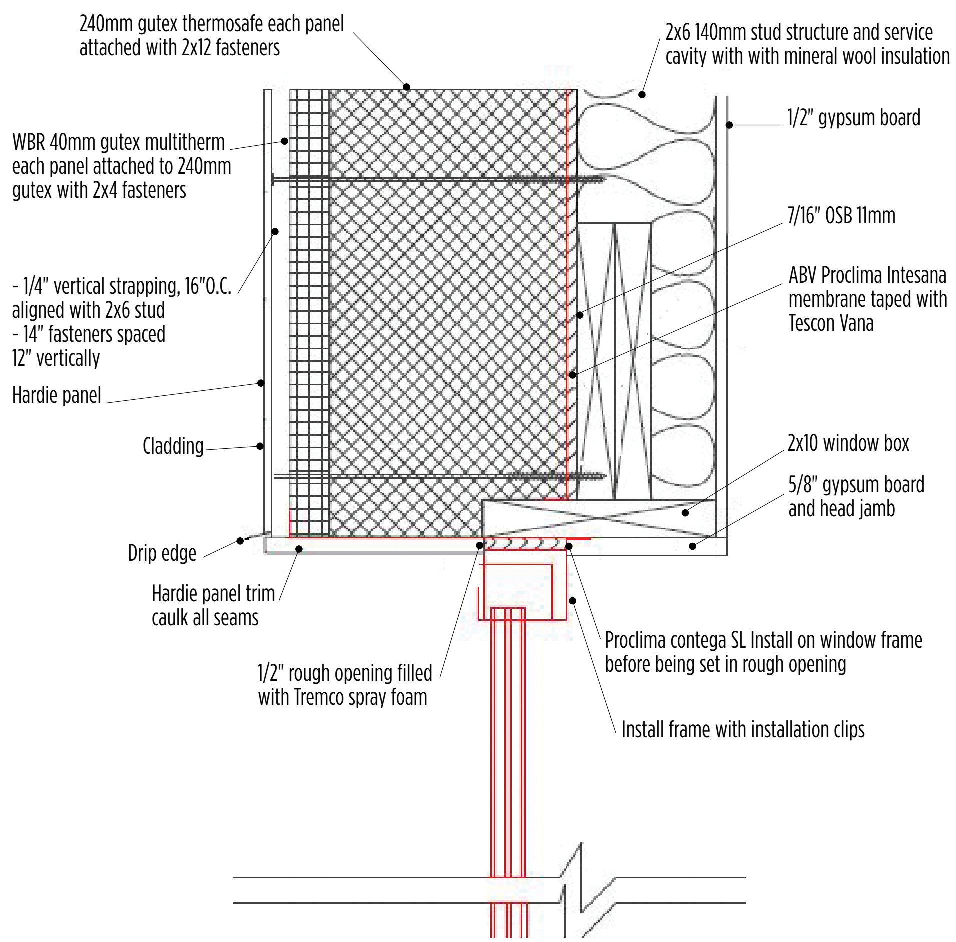
Action:

• The design should be ambitious - provide beauty, delight and utility, Passive House energy efficiency, and a positive energy and carbon emissions balance.

New Habits: A Smart Enclosure

The more we realize these principles, the smarter the enclosure becomes. The enclosure is a complete system, a system whose intelligence is built into the structural fabric. Smart qualities are not about tech gadgets that require rebooting, repairs and worse. The smarts should passively reside in the architecture.

To make a high-performance enclosure today, we don't need to reinvent the way we build. We need to focus on the fundamental principles to update typical details, standard specifications and traditional means and methods. In our continuous paths of improvement, it's just a course correction to integrate these new habits.



Detail of the Radiance Co-Housing Project in Saskatoon, an example of a smart enclosure system

A smart enclosure system acknowledges its profound relationship with both the outside environment and the occupants within. By combining the basics of natural principles with highly selective material and manufacturing innovation, smart enclosures work in greater harmony with nature, not in greater opposition.

Conclusion

High performance today means that we build like our future depends on it. Architects have tremendous power to mitigate climate change - to not only do less bad, but to fix systems and make a better, more beautiful future.

A new architecture is not required. A revolution in building capabilities is not required. What's required are smarter, more intentional choices that improve the environment. A smart enclosure system is a framework that makes those smart choices easier.

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3. The Radiance Co-Housing Project in Saskatoon, wrapped in both smart vapour retarding airtight membranes, and wood fiberboard insulation, credit: Radiance Co-Housing.
4. Wool insulation in process of installation. Credit: Havelock Wool.

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Overview

As a human race, we find ourselves in a race against time as we look to drop our carbon emissions to mitigate the effects of climate change. Our buildings play an important role and how we build can have a significant impact. It's in our hands as to whether our buildings have a positive contribution or a negative one when it comes to the environment. In this technical article you will learn about what constitutes a high-performance building enclosure, how you can achieve this without the need for foam, and why smart building enclosures are the future of high-performance buildings.

Learning Outcomes

On completion of this learning unit, the reader will be able to:

1. Define what constitutes a high-performance building enclosure.
2. Describe the fundamental principles of a smart building enclosure.
3. Identify solutions to achieve a smart building enclosure.
4. Understand the concerns with using foam in high-performance buildings.

1. According to the article, approximately what percentage of human-made greenhouse gas emissions is the harvesting and manufacturing of building materials responsible for?

a. 5%
b. 20%
c. 40%
d. It's negligible.

2. High-performance buildings is all about making buildings less bad. True or False?

a. True
b. False

3. Lower embodied carbon, more natural materials, smart vapour, air & thermal control are all what?

a. Good ideas
b. Specification guidelines
c. Principles of Passive House
d. Actionable foundational principles of high-performance enclosures

4. Which of the following is a reason spray foam is not considered a durable material?

a. Spray foam is toxic for those installing it
b. Spray foam has high levels of embodied carbon
c. Spray foam is a highly processed chemical compound
d. Spray foam degrades in thermal value over time

5. Which of the following is NOT the focus of a smart enclosure system?

a. Building science
b. Gadget-based technology
c. Using passive architectural systems
d. Combining basics of natural principles with technology

6. If you are using a blower door on your building enclosure, you are testing for what?

a. Airtightness
b. Vapour drive
c. Thermal breaks
d. Insulation performance

7. After keeping rain out, what are the next most important systems and in what order of priority?

a. Thermal, vapour, and air control
b. Air, thermal, and vapour control
c. Vapour, air, and thermal control
d. They all have equal importance

8. Sheep's wool insulation can remove contaminants from the indoor air. True or False?

a. True
b. False

9. Smart vapour control looks to do what in cold climates?

a. Prevent wetting in the winter and promote drying in the summer
b. Prevent wetting in the winter and prevent wetting in the summer
c. Promote drying in the winter and promote drying in the summer
d. Prevent wetting in the summer and promote drying in the summer

10. Discomfort, energy inefficiency, and condensation and moisture damages can be a cause of what?

a. Too much insulation
b. Not enough insulation
c. Discontinuous insulation
d. Insulation is not the cause of the problem