Net Zero Carbon Might Be Easier Than You Think

By Steven Murray, P.Eng., Principal & Senior Building Envelope Engineer, Morrison Hershfield

Achieving certification to the Canada Green Building Council's (CAGBC) Zero Carbon Building (ZCB) Standard can seem like a daunting task, particularly on a retrofit project. The relative impact of thermal bridging and envelope transitions are amplified in low-energy buildings and can be particularly challenging to resolve in a retrofit scenario.

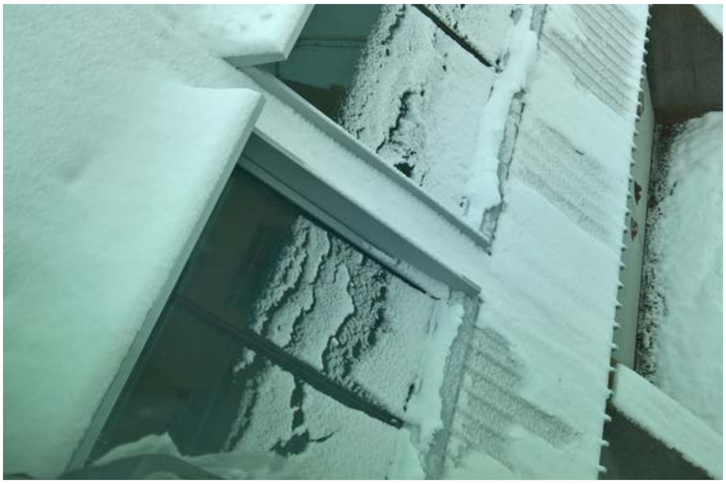
As an example, the Thermal Energy Demand Intensity (TEDI) requirement for Passive House Institute (PHI) is so low compared to the actual usage of many existing buildings that the heating loads must be reduced by 95 per cent or more to meet the requirements. The good news is that Zero Carbon buildings aren't quite that demanding.

The TEDI requirement in the Toronto area for Zero Carbon buildings is 30 kWh/m^2 compared to just 15 kWh/m^2 for PHI. Even so, how do you go about reducing heating demand by a factor of five, or even 10, from an average building? The key issue is important for us in the Ontario Building Envelope Council (OBEC) community, since it all hinges on envelope performance.

Significant heating demand reduction was exactly the challenge faced by Humber College's Deep Energy Retrofit Project for the NX Building. We started with the envelope design targets:

- Really, really good glass and window frames;
- R-40-effective cladding and R-50-effective roofing; and
- An almost fanatical devotion to controlling thermal bridging (this is where PHI is very demanding).

How do we achieve these in reality? The easy part is defining excellent glazing and a well-thermally broken cladding system. The hard part comes with controlling thermal bridging, so the critical details don't allow much heat flow to reduce the overall performance. When you improve the main field performance, the previous thermal bridges, which may have only represented 20 per cent to 30 per cent of the total heat flow, may now be responsible for more than the entire main field heat losses. For example, a one-metre length of poorly insulated grade slab and foundation wall may be equivalent to two-square-metres of cladding losses in an existing building. When the new cladding reduces the main field heat flow by 80 per cent, this same grade slab now represents 10-square-metres of cladding, or nearly three full storey heights of wall above.



Humber Building N high-performance glass with a non-melted fresh snowfall on its surface. Images in spread courtesy of Steven Murray.

It becomes clear how important it is for the envelope designer to develop high-performance details at slab edges, parapets, and window transitions. Just a handful of poorly performing details can derail the overall performance of the whole building. On the bright side, we now have many tools at our disposal to guide us in achieving the necessary performance such as the *BC Hydro Building Envelope Thermal Bridging Guide*, which now has a library of around 400 modelled details, and Passive House Institute certification details related to window transitions.

Borrowing from the PHI approach and wrapping the insulation over the window frames is one example of virtually eliminating thermal bridging at window transitions, which can be a large quantity of linear transmittance losses (see Figure 1 on page 25). However, the real challenge is constructing transitions like this to stay true to the assumptions of the modeling and not introduce miscellaneous clips and fastening elements. These may seem like minor components, and may even be ignored by unsophisticated modelling, but minimizing or eliminating these elements may determine whether the detail actually performs as intended.

Even architectural details such as sun-shade elements, which are often an important feature of high-performance buildings, can be designed into the cladding to take advantage of thermally broken cladding supports. This can prevent the introduction of heat losses that undermine the other value of these elements, like solar heat gain control. This integration may create challenges, so a robust shop drawing and mock-up process involving multiple trades is essential to achieve the required performance. These are not unique challenges, but the impact can be amplified in low-energy buildings, so their importance is also amplified.

The wonderful benefit of achieving a truly high-performance envelope is it allows the mechanical designers to do things that used to seem impossible, like designing a building where the biggest energy loads are directly related to the actual use of the building—lighting and plug loads. At Humber College Building NX, the design team reached a counter-intuitive "a-ha" moment, where they realized that slightly more high-performance glass was an energy benefit since the daylighting benefit could reduce lighting loads and, therefore, the overall building energy use. Starting with a great envelope provided the design team and building owner with benefits we hadn't anticipated.

I fully expect there are more of these pleasant surprises waiting for us as the industry keeps advancing and that low carbon retrofits will become the norm, as owners recognize the major financial benefits of operating low-energy buildings. ■

Steven Murray, P.Eng., is a principal and senior building envelope engineer at Morrison Hershfield and a BSSO instructor from program founding to 2016. He has experience in the rehabilitation and retrofit of existing buildings and has also developed expertise with six-storey timber framed and mass timber buildings, and the unique envelope challenges they entail.

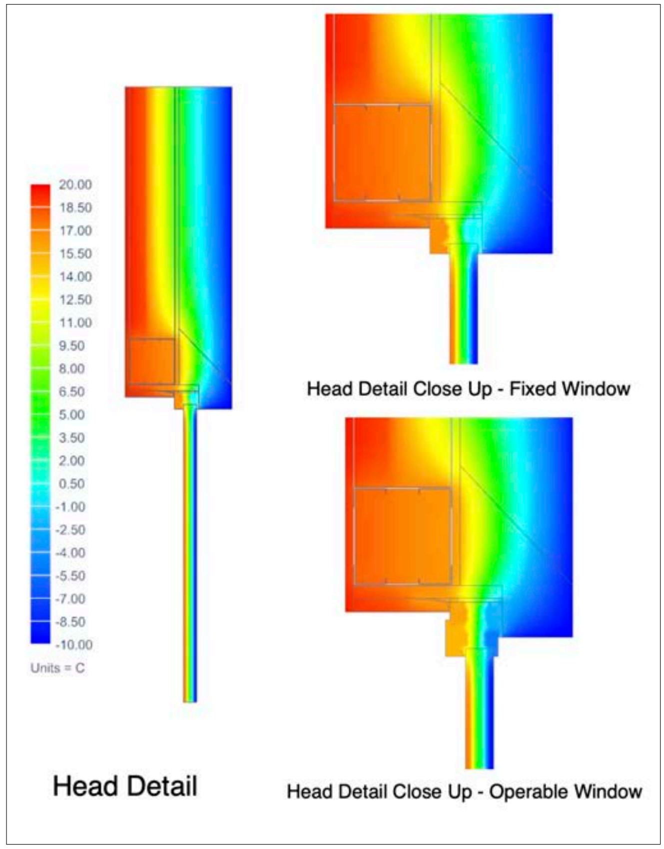


Figure 1: Humber College Building NX window transition thermal modeling demonstrates the impact of thermal bridging control.

A mock-up of sun-shade elements supported on a thermally broken cladding support system.