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Edward Bushnell
President, ABEC (South)

Message from the ABEC South president

As I enter my second year as president of the Alberta Building Envelope Council (South), I am delighted to be a part of a new and ever-evolving generation of workers and consultants who strive to educate and improve our community.

This year, ABEC South Council has been working hard to grow our relationships to promote education at all levels of our building science industry. To achieve this, we have focused on establishing partnerships with various education institutes and industry leaders who are motivated to educate. We trust that our innovative approach will allow us to provide training for retrofit specialists, which will enable us to make functional and sustainable net zero buildings a reality for our future generations. Being conscious of our impact on the environment and understanding sustainability can propel our industry toward the permanent adoption of less impactful practices.

Speaking of impactful practices, there is currently a government initiative that provides grants and expert advice to small and medium-sized Canadian businesses. It has been named the Canada Digital Adaptive Program (CDAP). This grant intends to help companies transform their business by adopting digital technologies to increase their competitiveness and online presence. Our government has invested four billion dollars into this initiative.

I am proud to be part of an organization that provides many different (and increasing) opportunities to share and absorb knowledge, as well as collaborate with like-minded individuals to advance the positive impact created by our industry. The rapid development of technology we have at our disposal is an essential tool we need to take advantage of to benefit our industry and continue to create positive changes within our community.

Some of you who attended our ABEC South AGM in September are aware of Randy Keiz's departure from our board of directors. We would like to express our sincere appreciation for all the meaningful work Randy has contributed to the executive board for the past 11 years. Thank you, Randy, for your time and guidance to those who will follow after you.

You will find some great pieces within our sixth province-wide publication. You will also discover upcoming events and luncheons, as well as some well-written articles for your enjoyment.

Happy reading!

Edward Bushnell

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Julien St-Pierre
President, ABEC (North)

Message from the ABEC North president

Another construction season is wrapping up in our province and, at the time of this writing, a warm early October belies our annual weather shock of deep freeze.

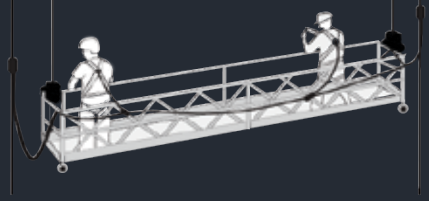
Weather forecasters are predicting that El Niño this winter will result in less cold weather and lower than average snowfall (bad news to winter sport lovers). This weather pattern could also mean more numerous freeze-thaw cycles in our province than typical. Building envelope failures due to discontinuities in the air, vapour, or thermal control layers can be exacerbated during freeze-thaw events. The mandate of our society is to encourage the pursuit of excellence in the design and construction of building enclosures. To that end, we seek for our industry to minimize the risk of weather impacts of constructing buildings in our challenging climate. We ask a lot of our buildings; in 2023, we've seen a high of +32 and a low -34 in Edmonton, meaning we experience among the largest temperature ranges of major cities.

The articles in this edition of *Building Science Perspective* consist of a range of topics of building envelope performance, including performance monitoring, thermal bridging changes coming with the new NECB, discussions on envelope design for high humidity environments, and building envelope commissioning.

We at ABECN have returned our lunch presentations to the lovely setting of the Highlands Golf Course, and we're excited for the upcoming presentation topics over the fall and winter. Your board is also currently working on a new website for our society. Stay tuned! In the meantime, please see ABECN's LinkedIn page for up-to-date information and tickets for our lunch presentation, monthly casual night events, and other networking opportunities.

Julien St-Pierre

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ABEC South Schedule of Events

October Luncheon – Wednesday, October 25, 2023

November Luncheon – Wednesday, November 22, 2023

January Luncheon – Wednesday, January 24, 2024

February Luncheon – Wednesday, February 28, 2024

March Luncheon – Wednesday, March 27, 2024

April Luncheon – Wednesday, April 24, 2024

May Luncheon – Wednesday, May 22, 2024

Golf Tournament (June) - Date TBD

ABEC North Schedule of Events

December 12, 2023 – Ugly Sweater Party

January 9, 2024 – Casual Night Series
Topic: Air barrier membranes

January 18, 2024 – Luncheon
Justin Pill, City of Edmonton Building Envelope
Lessons for NECB 2020 & AGM

February 13, 2024 – Casual Night Series
Topic: Rooms/floors over unconditioned spaces

February 15, 2024 – Luncheon

March 12, 2024 – Casual Night Series
Topic: Non-destructive testing

March 21, 2024 – Luncheon
Robert Wirth, Revay

April 9, 2024 – Casual Night Series
Topic: Waterproofing/dampproofing

April 18. 2024 – Luncheon
Peter Dushenski, GlasCurtain

Casual Night Series: Every second Tuesday

Luncheon presentations: Every third Thursday
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DEEP GREEN BUILDING RETROFITS – THE WHAT, WHERE, WHEN, AND HOW... AND WHY?



By Phillip Parker

Phillip Parker has more than 25 years of progressive experience delivering complex projects and leading diverse teams to solve multi-faceted challenges. Holding roles as a consultant, educator, constructor, and owner, he has wide and varied experience across the industry spectrum. An expert in hygrothermal simulation, Phil is one of a handful of Certified WUFI instructors outside of the U.S. Department of Energy. Phil currently practices at Introba in Calgary where he delivers building envelope commissioning projects, building science, and supports the firm's other practice areas.

As our cities and societies move towards greater energy efficiency, built environment resiliency and shift towards renewable energy sources, retrofitting existing building stock presents considerable opportunities. Building owners can reposition their properties through adaptive renewal or simple life cycle renewals, all while reducing energy use and carbon emissions.

Deep green building retrofits are a special sub-class where considerable energy savings in the order of 40 per cent to 60 per cent are realized through coordinated multi-system renewal. At present, there is no universal definition of a deep green building retrofit and the terminology and targets drift from one organization and jurisdiction to another. The U.S. Department of Energy (USDoE) presents differing targets of energy reduction in the order of 40per cent to 50 per cent compared to existing building use while the International Energy Agency (IEA) defines a deep energy retrofit as:

"Deep energy retrofit (DER) is a major building renovation project in which site energy use intensity (including plug loads) has been reduced by at least 50 per cent from the pre-renovation baseline with a corresponding improvement in indoor environmental quality and comfort."

Sustainable Buildings Canada further defines a deep energy retrofit on an "activity" basis where a reduction in energy use is a target but a building envelope upgrade, important for greenhouse gas (GHG) emissions reduction, is essential. This requirement for an envelope upgrade differs from U.S. and international standards and guidelines that recommend or suggest envelope upgrades but do not explicitly require them as a measure in a deep energy retrofit.

Before we explore deep energy retrofits further, it is useful to compare and contrast such retrofits against other forms of energy retrofits. Again, the targets and nomenclature vary from one standard and jurisdiction to another, but the same general principles apply.

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	MINOR RETROFIT	MAJOR RETROFIT	DER
Approach	Typically consists of low-cost system upgrades with short payback period. For example: lighting retrofits or operational improvements.	Typically consists of mores complex system. Upgrades, with higher costs and longer payback period. For example: heating & cooling systems. Please note that building additions can sometimes be considered as a major retrofit.	A whole building system upgrade, including building enclosure, mechanical, and electrical systems resulting in significant overall energy use reduction.
NBC Code Parts	Part 10 or 11	Part 3, 9, 10, or 11	Part 3, 9, 10, or 11
Energy Performance	Offers small energy saving relatives to the historical baseline (10 per cent).	Offers higher energy savings relative to the baseline (10 to 30 per cent).	Offers at least 50 cent energy saving relative to the historical baseline.
Implementation Cost	Low	Low-Medium (Depends on the project scope).	High
Occupant Disruption During Constuction	Minimal	Minimal-Moderate (Depends on project scope).	Significant
Improvement to Indoor Environment Quality?	Depends on measure being implemented.	Depends on measure being implemented.	Yes

Table 1 above from the *Deep Energy Retrofit – Energy Modelling Guide* presents a concise comparison, in a Canadian code context, of various levels of retrofits, their limitations, and typical metrics. U.S. DoE uses the terms Existing Building Commissioning (EBCx) and Standard Retrofit with energy savings targets up to 25 per cent and 25 per cent to 45 per cent respectively. The IEA uses different terminology opting for "shallow" as the counter description to "deep." Shallow energy retrofits are noted as those that focus on single measures or partial refurbishment of systems.

Regardless of the terms used and the variations in targets, it is apparent that deep energy retrofits, with their more ambitious targets, have unique features and constraints not found in less ambitious energy retrofits.

Constraints, opportunities, and features

In order to capture the synergies and potential energy reductions offered through deep energy retrofits, it is necessary to look at a building holistically as a series of interconnected and dependent systems. This necessitates an integrated design process where numerous subject matter experts collaborate. Comprehensive design workshops or charettes facilitate this process.

DER projects almost always involve a bundle of measures typically focusing on lighting, HVAC, and other mechanical systems, as well as the building envelope. Improvements in envelope performance and daylighting can reduce loads on other systems, allowing for their downsizing (or rightsizing) with consequent reductions in capital cost, operating expenses (in addition to energy savings), and improvements in occupant comfort/satisfaction.

CATEGORY	NAME
Building Envelope	• Roof Insulation • Wall Insulation • Slab Insulation • Windows • Doors • Thermal Bridges Remediation • Airtightness • Water Vapor Barrier • Building Envelope Quality Assurance Protocols
Lighting and Electrical Systems	Lighting retrofit daylight, zoning, and presence control systems
HVAC	• High performance motors, fans, furnaces, chillers, boilers, etc. • Dedicated outdoor air system (DOAS) • Heat recovery (sensible and latent) • Duct Insulation • Duct Airtightness • Pipe Insulation

The exact form and composition of a DER bundle, as well as its implementation strategy, are typically building-specific and climate dependent. To arrive at a suitable bundle of energy, saving measures requires an Energy Audit as one of the initial steps. ASHRAE defines three levels of Energy Audits from Level 1 with a simple walk-through inspection and review of two years of utility bills to Level 3 or "investment grade" being the most detailed using spot measurements, data logging, and computer simulations. Typically, a Level 2 Energy Audit is the minimum level of assessment required for recommending energy efficiency measures. Deep energy retrofits contemplating envelope upgrades or renovations will benefit from an envelope assessment including diagnostic testing, such as IR thermographic surveys or whole building air leakage testing, among others.

The most obvious constraint to deep energy retrofit projects is the cost and complexity. The U.S. DoE considers most DER projects to fall into the major building renovation category where the renovation costs equal or exceed 25 per cent of the building replacement cost. Other barriers can include:

- Lack of consistent government policies – changing incentive programs or authority having jurisdiction-specific priorities.
- Procurement risks and long lead time equipment.
- "Split incentives" in commercial leases.
- Limited capital and competition for resources.
- Bespoke solutions to retrofit older buildings with dated or anachronistic systems to remain, requiring customization.

A key constraint is quite obviously tenant disruption. Renovations on the scale contemplated by DER projects, particularly those with a comprehensive building envelope component, cannot avoid tenant disruption. Relocation and decanting costs, tenant incentives, as well as construction cost premiums for off-hours work are not insignificant and need to be accounted for.

Energy@Work , in writing for Sustainable Buildings Canada, looking at DER for multi-unit residential buildings (MURBs), coined the 6 'A's when looking at barriers:

- Attention: "No time or incentive to change"
- Affordability: "Don't have money to change"
- Awareness: "Don't know opportunities exist"
- Attitude: "Not part of my business!"
- Accountability: "Efficiency is not measured"



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• Apathy: "Why should I care if no one else does?"

While this paints a somewhat dour outlook that is likely not universal nor applicable across all building sectors, it does underscore some of the less tangible barriers that exist.

Risks in deep energy retrofits come in many forms, but we can put them into three general buckets:

A. Reliability of modelling info, meter and log data. Mis-calibrated meters or inaccurate energy modelling inputs can lead to skewed analysis results.

B. Climate change, as weather events (e.g. flooding, extreme temperatures), outdoor air quality, and design considerations (e.g. heating- and cooling-degree days) continue to change. It is no longer appropriate to consider only a single reference year of typical weather data.

C. Reliability of investment cost which is further broken down as:

   a. Fluctuations in macroeconomic conditions

   b. Fluctuations in future energy prices

   c. Accuracy of construction cost data

   d. Building future use and occupancy based on shifting demographics.

The last major barrier to DER projects is the relative ease and reduced capital cost of lower intensity projects, such as single measure "shallow" projects, existing building and retro-commissioning, or even standard "one-for one" type retrofits. These projects present much lower risk, far less planning and coordination, and require much less capital. They are also known to provide energy savings in the order of 25 per cent to 40 per cent with simple payback under five years (often as little as two years) and positive NPV. Essentially "Good" being the enemy of "Great."

So, if the low-hanging fruit of shallow retrofits and EBCx yield fairly good results without a lot of risk and expense, why even bother with deep energy retrofits? The answer: With the right planning and QA process, deep energy retrofits yield substantial reductions in energy use and a more attractive building overall. Studies by Eicholtz and Fuerst show increased rental value in the range of six per cent to 16 per cent and improved occupancy rates for commercial buildings following deep energy retrofits. Analysis of 10,000 buildings in the United States labelled as LEED and/or EnergyStar compliant shows that otherwise identical commercial buildings with an Energy Star certification will rent and sell for considerably higher values.

These benefits and others are tabulated below:

A further side benefit of DER projects is the reduced risk to insurers through the replacement of outdated infrastructure and current building code compliance. These reduced risks are reported to be reflected in reduced premiums for fire and wind damage (35 per cent); ice, water damage (15 per cent); burst pipe insurance (24 per cent); boiler and machinery insurance (12 per cent); and power failures (14 per cent) (Rüdiger et al ii).

A counterbalance to the risks of DER projects is the risk of inaction. As buildings age and industry trends evolve, inaction could result in any or all of the following:

A. Market risk:

   a. Obsolescence or breakdown of critical systems

   b. Energy price escalation

   c. Market gap where the building is eclipsed by more attractive properties.

B. Regulatory risk:

   a. Carbon pricing or punitive taxes on "energy hogs."

Maintenance Costs (Fowleret al 2008; Leonardo Academy 2008, Aberdeen Group (2010))	↓ 9-14%
Occupational Satisfaction GSA (2011)	↑ 27-76%
Rental Premium Elcholtz, Kok & Qugley (2010), Willey et al. (2011) Fuerst & McAllister (2011) Elcholtz Kok et al. (2011), Kok et al (2011, Newel, Kok et al. (2011) Miller, Kok et al. (2011) Pogue et ak. (2011) McGraw Hill/Siemens (2012)	↑ 2-17%
Occupancy Premium Willey et al. (2011), Pogue et al. (2011), McGraw Hill/Siemens (2012)	↑ 3-18%
Property Sale Price Premium Elcholtz, Kok & Qugley (2010), Fuerst & McAllister (2011), Elcholtz Kok et al. (2011), Newel, Kok et al. (2011)	↑ 11-26%
Employee Productivity Lawrence Berkley National Laboratory	↑ 1-10%
Reduced Employee Sick Days Miller, Pogue, Gough & Davis (2009), Cushman, Wakefield et al. (2009), Dunckley (2007), City of Seattle (2005), Room & Browning (1995)	↑ 0-40%

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C. Climate risk:

a. System overloads due to changing energy use profiles over time (e.g. increased cooling demand).

b. Building downtime due to systems without redundancy or resilience.

c. Stranded-asset exposure in the face of changing climate and policy.

Determining what is the right DER bundle and implementation strategy is by no means simple and is almost certainly situationally specific. Considerations have to include owner intent, financing, incentives, impact on operations, and available construction resources among a host of other constraints and opportunities. Two interesting approaches to resolving these questions and more are the Maximum Performance Potential approach and a Matrix based approach.

The Maximum Performance Potential approach proposed by the American Institute of Architects (AIA) uses an open workshop format charette with all project stakeholders to brainstorm all possible energy-saving measures without imposing constraints. After all the technically feasible and mutually reinforcing combinations are identified, then and only then are the constraints overlaid to arrive at the Optimum Achievable Potential and the preferred group of DER bundled measures. While potentially quite powerful, the MPP process can be time consuming and frustrating when some stakeholders are not bought into the process.

The IEA proposes an alternative Matrix based approach where key decision-making metrics are compared and weighed. In this process, metrics such as LCC, NPV, technical merit & risk, CO2 reduction, indoor climate are all evaluated and given a ranking on a sliding scale. Each metric is rated as a percentage and the combined weighted scores are summed.

There are, of course, numerous other assessment methods, and the data can be tabulated, presented as graphs and charts. What is critical is that a rational approach using multiple metrics is employed to assess the merits and risks of proposed DER bundles before settling on a specific set of measures and embarking on design and ultimately implementation.

To put this all in context, we'll explore a selection of case studies.

TECK PLACE

Teck Place is an office to residential conversion in Calgary. Led by Cidex Developments , the project will convert the former 11 storey office building constructed in 1968 into 113 residential units as well as main floor amenity space. The project is driven in part by high office vacancy rates in downtown Calgary (32.6 per cent) and is aided by the Downtown Calgary Development Incentive Program with the project receiving $8.2M in municipal support.

Building systems, including electrical, mechanical, and envelope systems, had far outlived their useful service life. Surveys by the project's mechanical engineers reinforced this. The table below, produced by LEVEL, reveals the age and state of the penthouse mechanical equipment. LEVEL further noted:

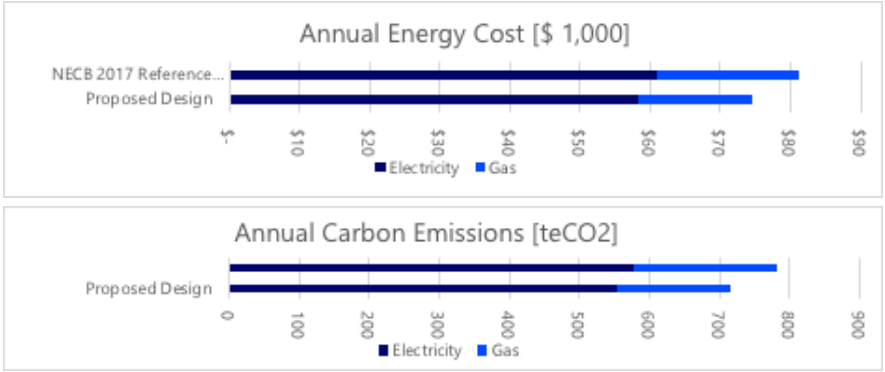
"The chiller has a listed efficiency of 0.579 kW/Ton and we estimate that the steam boiler is likely operating at between 70 per cent and 50 per cent thermally efficient depending on its condition."



DER bundling including envelope replacement – walls, windows, and roofs, as well as boilers for heating and DHW – is proposed to maximize the benefit to the project. The chiller, replaced in 2005, was found in good condition and re-used.

The DER was modelled against the National Energy Code for Buildings (NECB) 2017, which is far more stringent a baseline than the building's original expectations in 1968. Hence the depth of energy savings doesn't appear as substantial as reported in the literature.

With a fairly modest envelope upgrade (Walls R-12, Roofs R-40 main and R-20 penthouse, Fenestration U-2.2 SHGC 0.27) and high efficiency (95 per cent) condensing gas boilers, the project was able to realize an overall energy use savings of 14 per cent (MJ) compared to the NECB 2017 baseline.



TECK BUILDING – PENTHOUSE EQUIPMENT (2023-01-02)					
Piece of Equipment	**Estimates Date of Manufacture**	**Estimates Age (Years)**	**Expected Lifespan (Years)**	**Estimated Remaining Lifespan (Years)**	**Notes**
Steam Boilers	1966	57	30	-27	Equipment is past expected lifespan, has low thermal efficiency, and is oversized. Recommend replacing.
Cooling Tower	1966	57	20	-37	Equipment is past expected lifespan, requires significant maintenance, and does not suit proposed new cooling design. Recommend replacing.
Built-Up Air Handling Unit Fans	1966	57	25	-32	Equipment is past expected lifespan and does not suit proposed new HVAC design. Recommend replacing.
Pumps	1966	57	20	-37	Equipment is past expected lifespan and will not meet required flow characteristics of new HVAC design. Recommend replacing.
Steam Heat Exchanger	1966	57	25	-32	Equipment is past expected lifespan, has low thermal efficiency, and is not suited to revised building loads. Recommend replacing.
Free Cooling Heat Exchanger	2005	18	25	7	Equipment is within expected lifespan and appears suitable for new building loads. Recommend refurbishing/re-using.
Condensor Water System	2012	11	20	9	Equipment is within expected lifespan, is relatively efficient, and appears suitable for new building loads. Recommend refurbishing/re-using.
Chiller	2005	18	25	7	Equipment is within expected lifespan, is relatively efficient, and appears suitable for new building loads. Recommend refurbishing/re-using.

Carbon Performance

8.5 per cent Savings over Reference Building

Carbon Intensity – 0.11 – [$teCO_2/m^2$

Energy Cost Performance

8.3 per cent Energy Cost Savings over Reference Building

THE BARRON BUILDING

The first major development in Calgary following the Great Depression, the 1951 Barron Building was declared a municipal heritage resource in 2005. The estimated $100M project led by Strategic Group and GGA Architects will see the creation of 94 rental housing units. With the façade elements comprising many of the heritage-defining character elements, the project faced constraints not encountered on many DER projects.

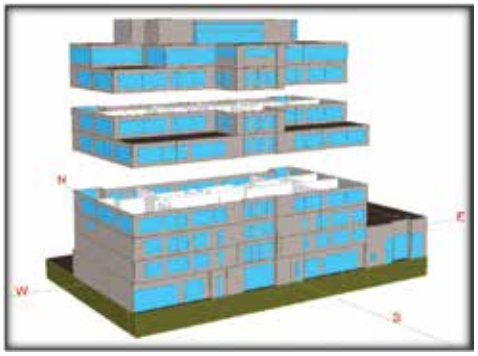
This project was modelled against NECB 2011 with some assumptions and caveats given that the building had been largely vacant since 2007 and no relevant utility data was available. A graphic representation of the energy model is shown below.

The heritage character of the façade ruled out any exterior insulation options and restricted changes in window-to-wall ratio. Given that the original masonry



walls and concrete frame were largely uninsulated, opportunities for envelope improvement were substantial.

A combination of modest envelope improvements, a new high-efficiency boiler (92 per cent), hydronic cooling



(COP=4) with variable frequency drive pumps, high efficiency (92 per cent) gas-fired parkade and corridor make-up air units, and LED lighting generated 43 per cent energy costs savings over the reference building.

Given that the Barron Building will retain much of its heritage character, infiltration (air leakage) of the façade was not adjusted in the models and was left consistent between the reference and proposed design. Sustainable Buildings Canada cautions against manipulating infiltration rates in models and that caution was heeded in this case. (iii)

The table below is extracted from the energy modelling report and shows annual energy cost savings achievable through the DER project. Lighting shows a substantial cost reduction owing to the relatively high cost of electricity in Alberta.

Deep energy retrofit projects present a credible opportunity to reduce building energy use and consequent GHG emissions. When combined with programmed life cycle replacement or building repurposing the capital cost, technical complexity and risk can be justified by NPV and other benefits.

Of course, building repurposing minimizes demolition waste with a consequent reduction in embodied carbon… but we'll leave that for another time.

[i] Buildings Technologies Program, Advanced Energy Retrofit Guides - Office Buildings Pacific Northwest National Laboratory and PECI, U.S. Department of Energy, September 2011 Contract DE-AC05-76RLO 1830 Pacific Northwest National Lab Document PNNL-20761, Page 16.

[ii] Rüdiger Lohse and Alexander Zhivov Deep Energy Retrofit Guide for Public Buildings Business and Financial Models, International Energy Agency Energy in Buildings and Communities Programme, SSN 2191-530X ISSN 2191-5318 (electronic) SpringerBriefs in Applied Sciences and Technology ISBN 978-3-030-14921-5 https://doi.org/10.1007/978-3-030-14922-2

[iii] Deep Energy Retrofit Energy Modelling Guide – 2021Version 1.0 Sustainable Buildings Canada https://sbcanada.org/wp-content/uploads/2021/07/Deep-Energy-Retrofits-Guide-V1.pdf

[iv] ASHRAE Standard 211-2018 – Standard for Commercial Building Energy Audits (ANSI Approved/ ACCA Co-sponsored)

[v] Framework to Achieve a 50% Energy Reduction in the Existing Multi-Unit Residential Condominium Sector: People Process and Products, Sustainable Buildings Canada 2020-07-09 SBC Framework Report

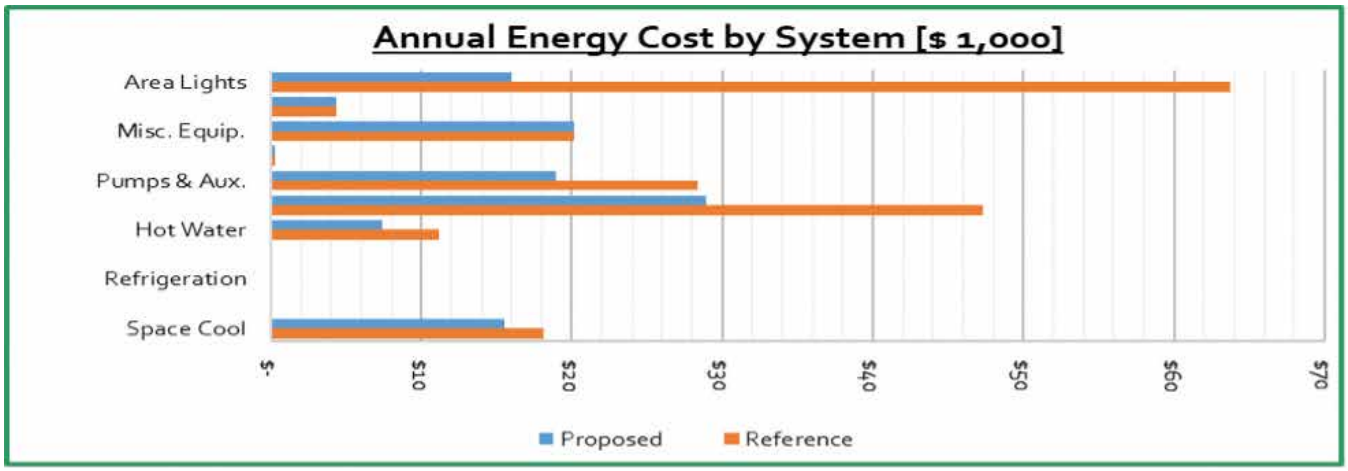
[vi] Eicholtz, P., N. Kok, J. M. Quigley (2009), "Doing Well by Doing Good: Green Office Buildings," University of California, Berkeley.

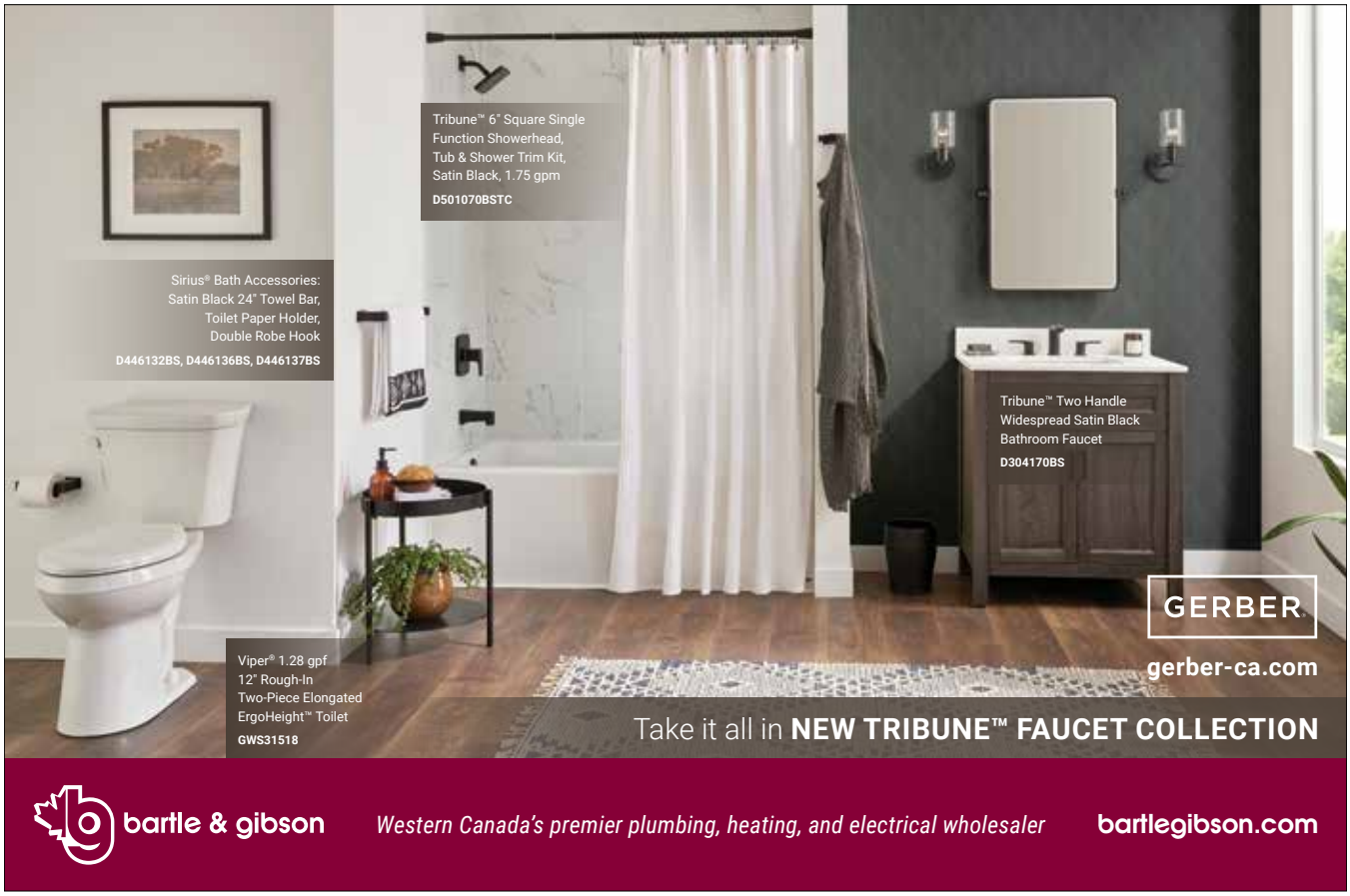
[vii] Fuerst, F., P. McAllister (2009), "An Investigation into the Effect of Eco-labelling on Office Occupancy Rates," Journal of Sustainable Real Estate, Vol. 1, No. 1.

[viii] Figure 3.14 from Page 63 of Reference ii

[ix] Muldoon-Smith, K., Greenhalgh, P. (2019), "Suspect foundations: Developing an understanding of climate-related stranded assets in the global real estate sector," Energy Research & Social Science, Vol 54

[x] Deep Energy Retrofits: An Emerging Opportunity An Architect's Guide to the Energy Retrofit Market, The American Institute of Architects and Rocky Mountain Institute © 2013. ■




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BUILDING CODES: BUILDING BLOCKS FOR THE FUTURE



By Mark Estrada of Centra Windows

Mark Estrada has well over a decade of experience in construction, with many of those years spent being a proud – and integral – member of the Centra Windows family. He's a true master in his field, having worked with over 190 condo boards, driven by a passion for finding long-lasting solutions to efficiency and comfort problems. His primary tools, besides his expertise, are trust, transparency, and respect.





The importance of building codes (and properly understanding them) cannot be overstated. We're all aware that they play an integral role in society, shaping the world around us and laying the foundation for safe and resilient structures. Over the years, architectural and environmental concerns have pushed manufacturers to create innovative solutions and technological advancements to contend with the problems of the day. The implementation of tighter codes and stricter regulations to ensure the safety, sustainability, and longevity of our buildings pose emerging challenges, but also provide new opportunities. In this article, we will explore the importance of preparing for these tightening restrictions, additional factors currently affecting our industry, and the value of us becoming leaders as opposed to followers.

Building codes are discussed, created, and implemented at the federal level, then adopted and modified to suit province-specific requirements then, further down the funnel, municipalities' desires and aims can be incorporated to form a lower level of code. This may seem simple enough, but in actuality, it is creating a patchwork of various rules, requirements, and suggestions that can make life difficult for builders. We generally defer to the most stringent prescriptive approach and forgo performance calculations that could add additional costs to a project. This means that those who fail to understand the overall objectives of each building envelope component, from fenestration





to insulation, will continue making the same choices based on current code knowledge. One thing is certain: code restrictions are becoming more stringent in the effort to create better-performing homes and buildings, and following old practices will not be sufficient.

Two other significant factors that are quickly becoming an issue for the way buildings and building envelopes perform are the increase in extreme weather events and the rising cost of energy. With global temperatures rising, it comes as no surprise that multiple Canadian cities have had their highest energy consumption this past July. In Alberta, there was an increase of 127.8 per cent in electricity prices as a result of increased demand (Statistics Canada, 2023). Combine this with Canada's Net Zero program and our need for sustainable housing, and we see that the construction industry needs to reconsider the way we build these buildings as well as the components and materials that go into them. This includes cooling and heating elements, and we should also take advantage of passive house practices and technological enhancements in building materials. A great example of this is low emissivity glazing coatings. They're now necessary to attain required thermal performance, but codes have already moved on considerably since their introduction and older, single LoE coatings are now no longer enough.

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The government of Alberta has set a goal of "improving energy efficiency standards for building codes that supports greenhouse gas emission reduction and reduces the demand on Alberta's energy resources" (Government of Alberta, 2023). This provides an opportunity for each consultant, manufacturer, and installer in the building envelope community to collaborate and educate in an effort to deliver solutions that can stand the test of time, not only meeting existing coming standards and known future changes, but exceeding them in anticipation of the further tightening of restrictions. The first step toward that is taking the time to properly comprehend every level of code and ensure you remain apprised of any coming changes. Remember the patchwork of regulations? Those regulations can be addressed at the forefront of the project, and having the manufacturers of building envelope components involved in the conversation can harmonize the solution and effectively future-proof a building.

This isn't the Wild West anymore. The technical performance of buildings leading up to 2050 will depend on the leadership of our industry to always push the envelope, and thoroughly preparing for code changes could save in potential design and re-design costs in the future. While the idea of codes constantly being updated can seem like a bit of a headache, this gradual increase is needed to ensure that manufacturers can adjust their products for compliance and are given the time they need to innovate. Dealing with this ongoing change shouldn't be the responsibility of one party – it's the responsibility of all of us. Together, we will provide the necessary solutions to reach some very ambitious and exciting goals. ■



OUR MAN IN BERN: NOTES FROM THE 2022 ABS CONFERENCE



By Atul Paranjape, City of Calgary

Atul Paranjape provides structural and building envelope engineering technical advice and design review services to the various City of Calgary business units, civic partners, and community associations on new, renovation, and retrofit construction projects. His work supports the division's mandate of helping the city in delivering durable, sustainable, and energy efficient infrastructure, and improving the long-term serviceability and anticipated life expectancy of building infrastructure. Since 2013, Atul is proudly serving Calgarians through his work at the City of Calgary.

International conferences are fantastic opportunities for people from all over the world to learn from each other, share knowledge and innovative ideas, and discuss both shared and unique problems. It's an additional bonus for attendees when a conference also happens to take place in a beautiful location! That's why I was thrilled to have the opportunity to attend the globally renowned Advanced Building Skins Conference (ABS) in stunning Bern, Switzerland, last fall.

As I stood at the registration desk gathering my welcome pack, lanyard, and notebook, I noticed how excited everyone seemed. Like me, many attendees had travelled a long distance for their first in-person networking event since the start of the pandemic. As we listened to the welcome address and prepared for our first working sessions, the enthusiasm in the room was palpable.

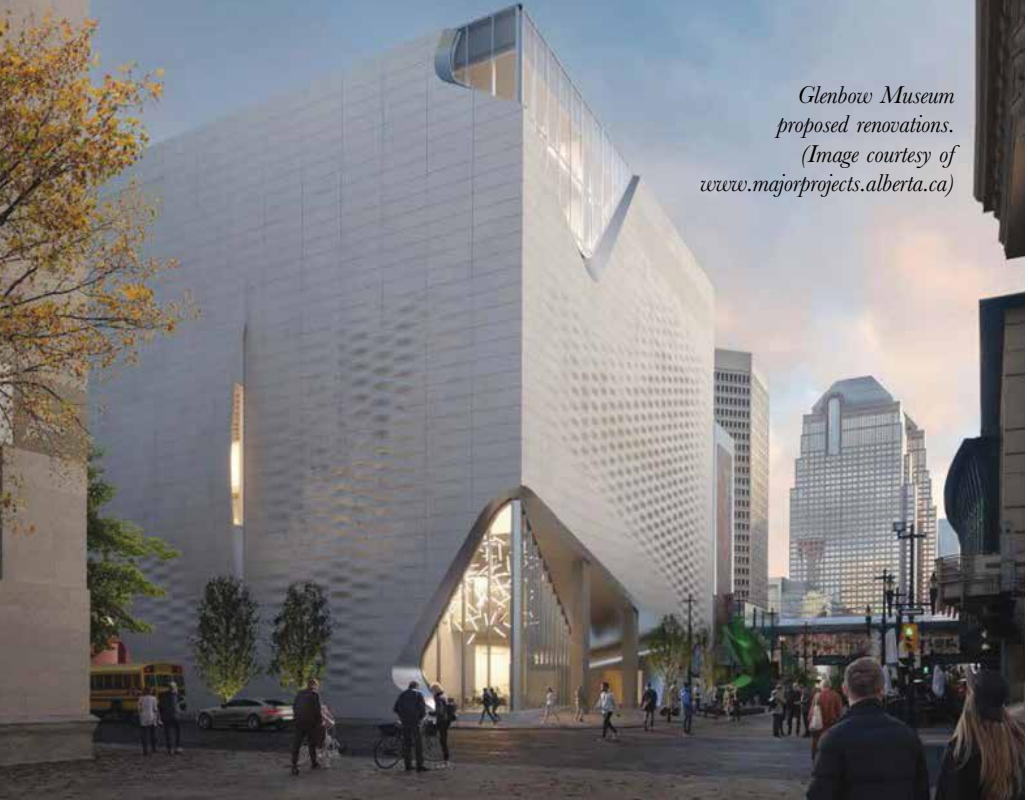
There was an incredible variety of sessions to choose from; in fact, there were around nine sessions taking place at any given time! Given current limitations on human cloning, I had to make some difficult choices. (That said, following the conference, we received conference proceedings and presentations to allow us to revisit material and read about sessions we missed.)



Historic Town of Bern

Day one

I began the conference with an informative session titled "New Forms of Concrete for the Building Envelope," where the speakers discussed the sustainability aspects of carbon concrete as a façade material and the use of polymer concrete to give the façade a unique architectural shape. Later in the afternoon, I enjoyed learning about building-integrated photovoltaics (BIPV) and their widespread application in Western Europe. European case studies were presented to highlight the benefits of BIPV, not only as an electricity generation technology, but also as a building envelope component



Glenbow Museum proposed renovations. (Image courtesy of www.majorprojects.alberta.ca)

that generates a return on investment. There were discussions about the next generation of PV facades, which are expected to include interactive and intelligent PV facades for institutional facilities. During coffee breaks, I had many illuminating conversations about BIPV with members of the design community and specialty envelope contractors representing North American markets. My takeaway from these conversations was that the BIPV industry in North America, and Canada in particular, faces three major challenges:

- Lack of BIPV integration: Awareness of how BIPV can be integrated into the building envelope, for both new constructions as well as retrofits of existing buildings, needs to be increased.
- Perceived high capital costs: Considering the potential for added value and cost-benefits of BIPV need to be made more apparent.
- Regulations: Greater support is needed for the development of building codes and product standards for BIPV.

Day two

I started day two with several presentations on life safety and fire prevention in facades. I was initially concerned that these sessions would be far too technical for me to understand, but was delighted to find that the presenters had made their specialized topics very approachable. We heard about lessons learned from recent fires in high rise buildings and resulting changes to building codes around the world, fire risk assessments of existing facades, and key measures that need to be implemented to reduce risk of fire spread. All of these topics are extremely relevant to my work as senior structural and building envelope engineer with the City of Calgary.

Following a short coffee and networking break, I went into a mid-morning session called "Active Cavity Transition (ACT) façade." ACT is essentially a next generation double-skin façade that efficiently combines typical façade components, such as insulating external glazing, glare control blinds, and mechanical ventilation. I particularly enjoyed the presentation on testing ACT façades in-situ. The session concluded with a talk on how to quantify the performance of an ACT façade, which helped me understand the return on investment of this new technology.

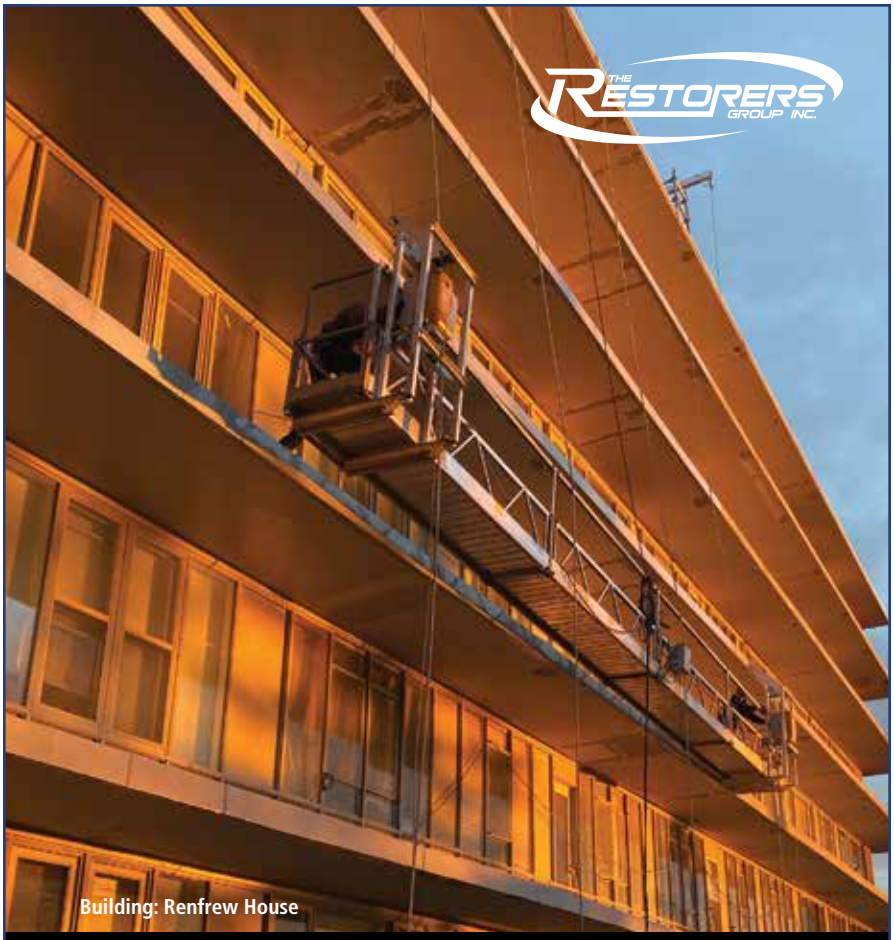
In the afternoon, I attended a session that focused on a project partially funded by the City of Calgary: "Revitalization of the Glenbow Museum." The session started with a presentation on reimagining Calgary's iconic museum and the critical role of the new concrete skin and envelope design in the building's revitalization. This presentation was followed by "Parametric plan + build," where I learned how digital tools and prototypes were used to optimize the design and determine the shape of each panel in the unique, customized façade. Another Glenbow-related presentation addressed how baseline performance for the existing building was evaluated and how the proposed renovations would enhance the overall energy performance of the building. This work was particularly important to establish the viability of the revitalization project, the aim of which was to increase overall energy performance. The session concluded with a presentation by a Calgary fabricator who showed us how the samples were prepared in the shop, the type of testing that was conducted to meet the building code and other safety requirements, and how Building Information Modeling (BIM) tools were used to transform the digital concept into a prototype.

The final session I attended was "Façade Retrofits and Building Emissions," in which the speakers presented case studies of various high-rise buildings in New York City. I was astounded to learn that about one million buildings in NYC contribute

approximately two thirds of the city's total carbon emissions! Given this, it is unsurprising that there is a drive to perform deep retrofits to enhance energy performance and reduce carbon emissions. The case studies demonstrated that, following façade renovation, the energy consumption of the buildings decreased by 41 per cent, and building owners were able to increase average rent by 90 per cent. As with the Glenbow Museum revitalization, energy modeling had been used as a decision-making tool for deep envelope retrofits. The session concluded with a presentation by the owner of a large building asset portfolio who presented a case study showing multiple options for de-carbonizing an existing building to meet local code requirements. The decision-making scenarios and the underlying math were intriguing – a multitude of factors such as project costs, downtime for a space without a cashflow, new leasing economics, the cost of tenant disruption, and tax incentives for de-carbonization had to be contemplated. I found myself considering our own buildings portfolio from this perspective, and I look forward to applying some of what I learned about deep envelope retrofits to our future renovation projects.

So, was the conference worth the long journey? Absolutely!

ABS 2022 was a very informative and collaborative experience, and I would like to thank the City of Calgary and ABEC for giving me the opportunity to attend the event. I was truly inspired by the technological advancements in the field of building envelopes, as well as by the dedication of building science professionals who continue to work hard to improve the quality of our built environment while protecting our natural environment. ■



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WHAT CAN PERFORMANCE MONITORING TELL YOU ABOUT YOUR HOME?

By Yuxiang Chen, Bowen Yang, Alexander Jorgan, and Charlie Shields



Dr. Yuxiang Chen is an associate professor of building engineering and a licensed professional engineer under APEGA. He is an expert in the design, construction, and performance assessment of high-performance buildings, with a focus on thermal energy storage, daylighting, intelligent operation, utilization of renewable energy, and their intelligent and integrated design and operation.



Bowen Yang is a Ph.D. student studying building engineering at the University of Alberta. His research is focusing on short-term demand forecasting and peak demand reduction to foster energy efficiency using machine learning and deep learning techniques.



Alexander Jordan is a registered APEGA E.I.T. in his second year of study as an M.Sc. student at the University of Alberta. His field of research employs state-of-the-art statistical processes to predict peak load behavior of Multi-Unit Residential Buildings (MURBs) using collected consumption data from real households.



Charlie Shields is currently pursuing his Master of Science at the University of Alberta and is in his inaugural year of study. His research concentrates on the simulation and cataloging of thermal performance of building envelopes, with a specialization in masonry type construction. Charlie is driven by a desire to dismantle the socio-economic barriers that inhibit smaller enterprises from constructing energy-efficient buildings readily.

1. Significance of performance monitoring

Being efficient in consuming resources, such as water and electricity, isn't just about saving on bills; it's also about making our homes and buildings smarter and more comfortable and saving natural resources. Have you ever faced unexpected issues with your home appliances or mechanical systems? Often, these problems are small signs pointing to bigger inefficiencies. For example, a tiny leak in an old toilet tank might be wasting more water than initially thought. Or if you have a hybrid heating system (e.g., an electric heat pump and a natural gas boiler working together to heat domestic hot water), and one component stops working, the other might be working overtime without you even noticing. There's also the curious case of homes where heating and cooling systems can sometimes counteract each other, causing unnecessary energy use. But these are just a few examples. From electric heaters that stay on when they shouldn't to air conditioners that work at low efficiency, there's a whole range of small or big issues that can add up.

This is why performance monitoring is a useful tool for household residents. It helps identifying issues early, saving resources and making our living spaces more comfortable. As we explore this topic further, you'll see just how valuable performance monitoring can be. With electricity and other utility prices still on the rise, there's more incentive than ever for individuals to keep better track of their utility consumption.

Traditional utility bills don't tell you where or when energy and water are being consumed in your home. It doesn't tell you what portion of the natural gas being burned in the winter is towards heating your home (if cooking, hot water and space heating are all using natural gas) or how impactful lowering the thermostat by one degree can actually be. The main reasons people are currently buying into energy monitoring systems in their homes are to save energy, effort, time, and money [1]. By reducing resources, you'll not only be saving money, but also be contributing to a sustainable future through less demand on the utility grid.

2. Current practices/state-of-art

While performance monitoring may seem like a new concept, it's actually not a new practice. Some have already been using thermostats in addition to gas, electricity, and water meters for basic performance monitoring in daily life. In Europe, advanced performance monitoring was introduced in the 2010's under the idea of "smart meters," which can provide residents with real-time tracking of their electricity, natural gas, and water usage. Furthermore, with these smart meters, information regarding current utility prices is relayed automatically to households where people can preset systems to turn off or on, or to make changes themselves, based on prices [2]. Using smart meter technologies, it was found in the U.K. that houses overall were able to cut their natural gas consumption by 22 per cent [3], and other studies in Europe have shown electricity reductions of 11-17 per cent [4]. While these examples may be far from home, the technologies and ideas are available in Canada as well, and with savings like this, it will not be surprising to hear more about smart metering in Canada over the next couple of years.

How does performance monitoring work? Performance monitoring all starts with the physical sensors installed in the home, which collect data through various means. This could be current transformers located in the electrical box, a connection to the gas meter, or devices connected to appliances themselves. The data collected through these sensors can then be delivered wired or wirelessly to either an in-home digital panel or to a website for people to access online. Figure 1 shows a network of performance monitoring as well as building operation. The gateway, which can also be a controller, collects data from sensors, user inputs, and the Internet. Through this system, residents can then get access to information, such as the energy consumption of various appliances, natural gas burned over the previous hour, domestic hot water usage, etc. This data can be collected in different time intervals, with minutely and hourly time intervals being the most common. Both options are useful; hourly consumptions can give a good idea as to where and when the most energy was consumed over the previous day, and minutely data is great at capturing how much energy is used by high-energy-intensity activities, such as cooking.

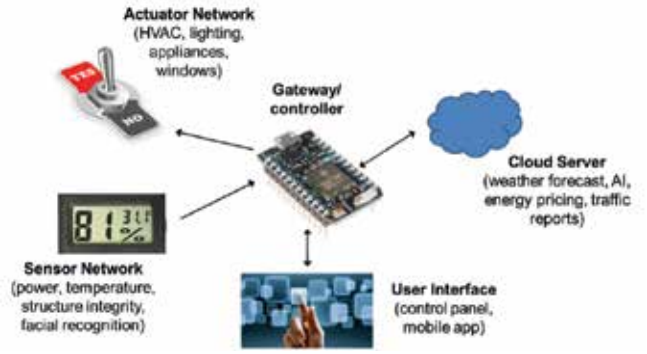


Figure 1: Performance monitoring and building operation.

With performance data available, household residents will have a new level of control over energy consumption within their homes. For example, by looking at electricity and water usage data recorded over the previous night, you could find things that would otherwise be invisible. If there were unexplainable fluctuations in electricity or continuous water usage that popped up overnight, they could be discovered

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through performance monitoring. This is an ideal way to spot phantom usages that would otherwise continue unnoticed. Another example for homes that have hybrid heating systems is getting an accurate look into how often each system is active, how much the operation of each system costs, and detecting if either system begins to malfunction. Of course, fault detections can also be automated and performed by smart electronic housekeepers (e.g., the controller shown in Figure 1), so if something goes wrong, the housekeepers will notify you.

Performance monitoring can also help automate home operations. Many new smart meter systems with a centralized control system have features that allow for furnaces to automatically turn on an hour before residents wake up, so you won't even have to wake up to a cold home to promote energy savings. The gateway/controller shown in Figure 1 can perform analysis based on pre-loaded algorithms and user-defined values, and then control the operation of the house to minimize energy costs (e.g., open windows when natural ventilation is suitable for space cooling). Furthermore, the controller can also benchmark and/or predict power or energy usage, which then can be used for fault detections. For example, something may be wrong if the monitored power consumption is much higher than expected. All these features contribute to the benefits of performance monitoring, which as you can see really can help to save energy, time, and money, all with minimal effort.

3. Case studies

Energy monitoring is far from static; it's a dynamic field that requires constant adaptation and innovation. This is best exemplified in one of our projects, a group of 20 townhomes in southeast Edmonton (Project 1). At the heart of this endeavor, we chose two distinct types of townhomes for our study. Half of these residences shine as models of net-zero living for a sustainable future, equipped with 2kW solar arrays and advanced mechanical systems. In contrast, the remaining homes are of standard construction. But why this mix? Our primary objective extends beyond just cataloging the evident benefits of solar energy and net-zero housing. By juxtaposing these two distinct types, we aim to use the accumulated data to craft algorithms that can predict and optimize energy consumption, leading to smarter, more responsive home systems. We also have another performance monitoring project happening within West Edmonton (Project 2) consisting of a single block of townhomes outfitted with modern peak-performance HVAC (Heating, Ventilation, and Air Conditioning) equipment. Our goal with Project 2 is to compare the performance of newer space heating systems to traditional systems, to better understand usage patterns and to seek a better fit between the power grid and our needs. The costs of the monitoring system, installation, labour, and materials were about $3000 per household.

3.1. PROJECT 1

One unit in Project 1 is selected here to provide a glimpse into the energy and waste heat recovery performance analysis for November 2022. Figure 2 shows the data logger installed next to the electrical panel (left figure) and water meters and water temperature sensors (right figure). Edmonton experiences harsh cold temperatures during the winter, requiring significant amounts of heating to maintain indoor comfort. The primary heat source (for space heating and domestic hot water) in the units of Project 1 is natural gas. The monitored data shows that natural gas accounts for a significant portion of energy consumption during November – 62 per cent as shown in Figure 3. The HVAC system consumes a significant amount of electricity, 16 per cent of the total consumption. Moreover, "Total Plug" consumption refers to the cumulative energy consumption of all plug-in electrical devices. The energy consumption in this category is influenced directly by the number and intensity of devices plugged in and is largely dependent on the occupants' behavior.



Figure 2: (Left) a data logger installed next to an electrical panel. It measures the electrical current and collects data from all sensors; (right) two water meters and water temperature sensors installed on the hot water and cold water lines.

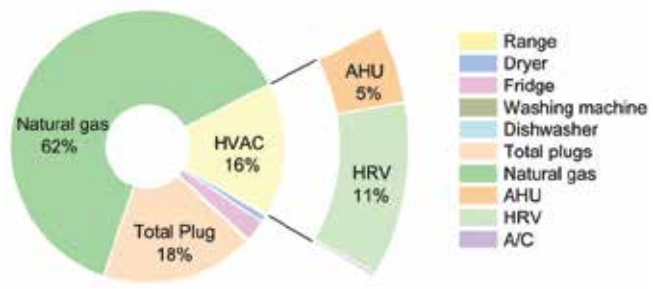


Figure 3: Percentage of energy consumption of a unit of Project 1 in November 2022.

The wastewater heat recovery (WHR) system is crucial in enhancing energy efficiency in the units of Project 1. It is designed to recover the heat from wastewater, which is typically warm or hot water from showers and dishwashing. The recovered heat is used to pre-heat cold water entering the tankless water boiler of the unit, thereby reducing the energy required to heat water. This process contributes significantly to energy savings and reduces energy bills. Figure 4 shows the temperature profiles of cold water, preheated water ("heat recovery water"), and hot water.

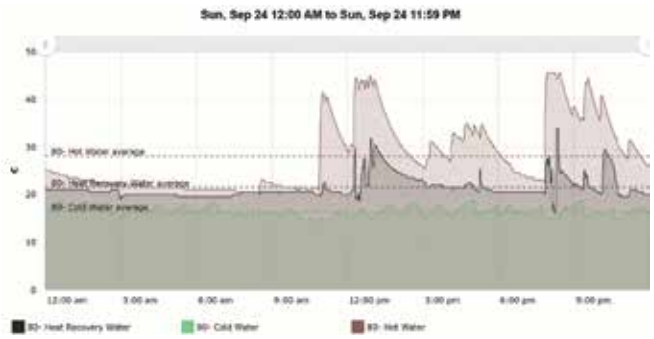


Figure 4: Temperature profiles of cold water, preheated water, and hot water. Eq.(1) is used to quantify the amount of recovered heat:
Saving%= pVC_p (T_r-T_c)/(T_h-T_c) x 100

(1) where Saving% represents the percentage of heat recovered to water heating load, p is the water density (1 kg/L), V is the hot water usage volume (Liter), C_p is the specific heat capacity of water (4.2 kJ/(kg·K), and T_c , T_r, T_h are the temperatures (in degree Celcius) of the cold water, preheated water, and hot water, respectively. There was an energy saving of 37.66 per cent in November 2022.

The long short-term memory (LSTM) neural network technique was used to forecast the short-term demand of the monitored units. LSTM is a type of recurrent neural network that is well-suited for time series prediction and other types of sequential data (e.g., building energy performance). The prediction requires historical data collected from the units by the monitoring system. Using the prediction data, the power demand of the units can be estimated, and the operation of the units can be optimized to reduce the collective peak power demand. Peak power demand typically costs much more than off-peak power demand. Figure 5 shows the predicted and real values of power consumption of the sample unit.

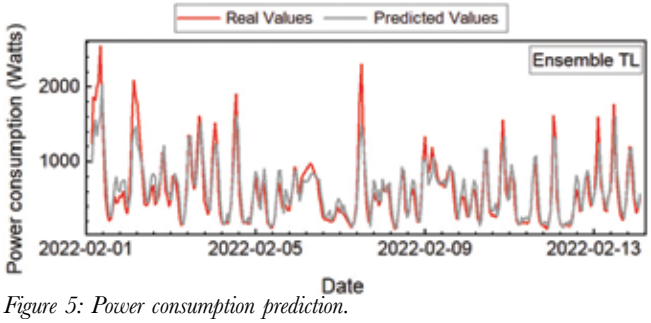


Figure 5: Power consumption prediction.

Every innovative journey has its share of hurdles. When we initiated Project 1, our method of choice for data capture was a Radio Frequency (RF) system. RF systems, with their ability to transmit data wirelessly, seemed like the logical choice, promising efficiency and seamless integration. However, as the project unfolded, we discovered that the realities of our chosen urban environment posed unforeseen challenges to our RF system, turning its advantages into liabilities. The reasons for the RF system's shortcomings were complex and multifaceted:

- ***Population density:*** Our chosen location was bustling with residents, which meant that the airwaves were crowded with signals from a myriad of electronic devices and systems. Each of these devices, whether it be a home Wi-Fi router or a mobile phone, was a contender for the finite RF spectrum that can be used, creating a cacophony of electronic communication. This level of competition meant that our RF system was constantly battling for bandwidth, resulting in degraded signal quality and transmission reliability.

- ***Zigbee protocol congestion:*** Compounding the issues posed by population density, we discovered that a substantial number of surrounding devices operated on the Zigbee protocol, such as smart thermostats, smart locks, smart plugs, etc. Zigbee is renowned for its efficiency in creating low-power, reliable, and secure networks; however, the overabundance of devices utilizing the same protocol created a situation akin to many different radio stations trying to broadcast over the same frequency. This led to significant interference, rendering data transmission unpredictable and compromising the integrity of the data received.

- ***Data integrity:*** This interference wasn't merely an inconvenience. It was a critical impediment to our objectives. In a monitoring project, where accurate, reliable data is paramount, the inconsistencies and losses in data incurred due to the chaotic RF environment jeopardized the validity of our insights and the success of our project. Every piece of lost or corrupted data represented a missed opportunity to understand and optimize energy usage better.

To rectify this, we invested countless hours in diagnostics and optimization efforts, including relocating our devices, modifying antennas, and even installing barriers in an attempt to block interference. We were in a constant battle, trying to extract clarity from the chaos to salvage the integrity of our data. However, every attempted solution seemed like a band-aid

over a wound that required surgery. This extensive, exhaustive troubleshooting process emphasized the need for a more robust solution, leading us to transition to a wired system.

The shift wasn't just a solution – it was a learning experience, illuminating the intricacies of technological interactions in real-world environments and underscoring the importance of adaptability in the pursuit of innovation. It was a testament to our resolve to not just overcome obstacles but to learn from them, ensuring that the knowledge gained would fuel advancements in sustainable living and energy efficiency.

3.1. PROJECT 2

The Project 2 townhomes have been designed and equipped with the latest and greatest in space heating and energy recovery systems, allowing them to operate with peak efficiency. These systems/aspects include:

- A hybrid heating system consisting of a conventional electric air-source heat pump and natural gas tankless water heater (TWH) that can both provide interior space heating.
- The TWH also provides domestic hot water.
- Heat recovery ventilation that's able to recover heat from exhaust air to warm fresh intake air.
- A well-insulated and airtight building envelope.

Figures 6 and 7 depict the monitoring system present within the Project 2 townhomes. Figure 6 shows the flow of data within the performance monitoring system, with total electricity data coming from the house, with further broken-down monitoring for individual HVAC systems such as the heat pump, AHU, and boiler. All data is sent to a data logger (gateway) that then uploads the data to an online cloud database. Figure 7 depicts the installed sensors in each living unit. On the left is the gas meter and the location where the gateway is installed. On the right, the gateway is shown, and below are the current transformers and electrical data logger within the electrical panel. For this project, the gas meter uses a physical connection to the gateway, and the electrical data logger uses a wireless connection.

How does the performance of these new systems compare to other existing systems? In 2022, the average Project 2 unit consumed 5608 kWh of electricity and 9525 kWh of natural gas. According to Alberta Utilities Commission and Alberta Energy Regulator, the average Alberta household consumptions for electricity and natural gas in 2022 were 6786 kWh and 33237 kWh, respectively [5][6]. As seen in Figure 8, that's a 71.3 per cent reduction in natural gas usage when comparing the Project 2 townhomes to the Alberta average.

Additionally, within the block of townhomes, there's still a vast difference in the energy behavior of each townhome. These variations stem from a variety of factors, including thermostat settings, mechanical setpoints within the HVAC equipment, occupant behaviors such as leaving the garage door open, appliance operation, etc. What arises is a difference in the profiles between buildings, which can be captured through performance monitoring to see how each home is performing. This case study is especially important; just because these units have hybrid heating systems installed, this doesn't necessarily mean everything is running as expected. As seen in Figure 9, the random units selected have varying consumption trade-offs seen between electricity and natural gas, which is the direct consequence of units having varying activity levels of the electric heat pump compared to the natural gas tankless water heater. So, if you've installed energy-efficient equipment for your home, performance monitoring is a great way to make sure they work as they are designed to.

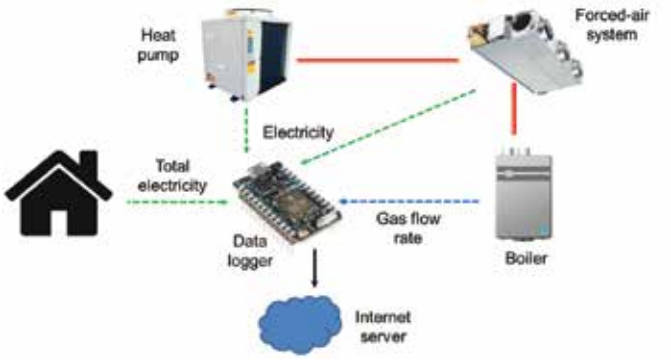


Figure 6: Project 2 performance monitoring system.

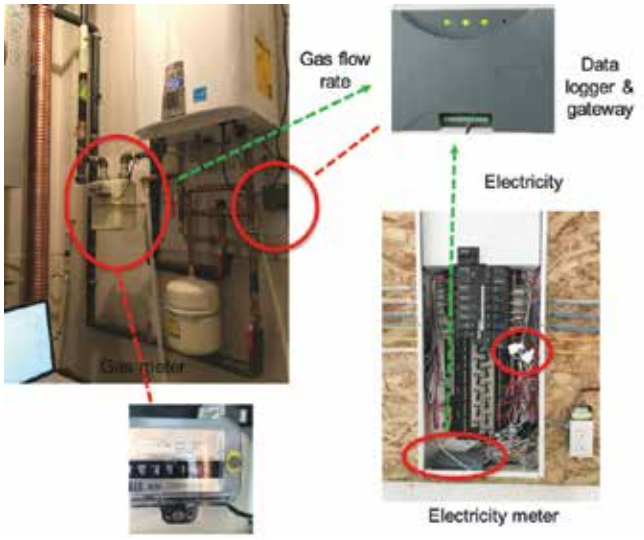


Figure 7: Project 2 installed performance monitoring sensors and equipment.

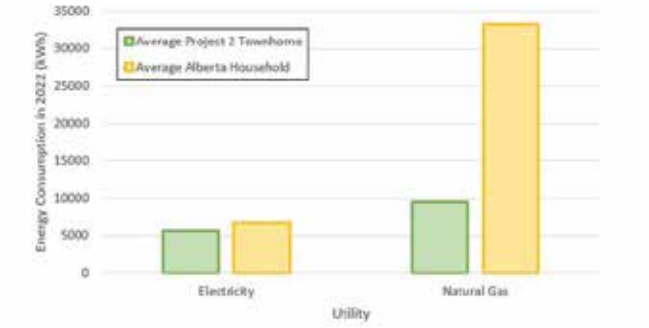


Figure 8: Annual electricity and natural gas consumptions of an average Project 2 townhome versus the average Alberta household.

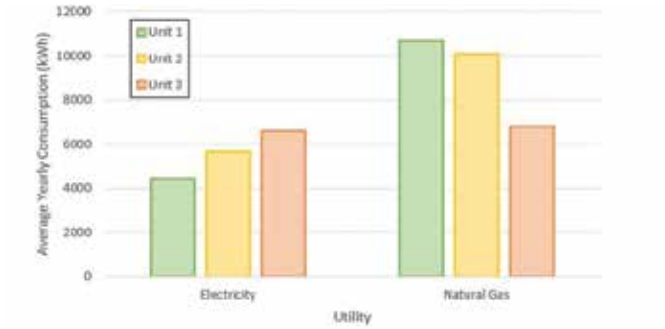


Figure 9: Average annual electricity and natural consumptions of three random Project 2 townhomes.

4. Conclusion and recommendations

As shown above, detailed and more advanced performance monitoring can be a useful add-on to conventional practices of operation and maintenance of houses and other types of buildings. Monitored data can be used to benchmark performance, detect, and diagnose faults, and optimize operations to reduce energy consumption, peak demand, and consequently utility costs. With the advancement of data science (e.g., artificial intelligence), the power of performance monitoring will continue to grow. Performance monitoring is essential to automated building operations. It is a foundational part of future smart homes.

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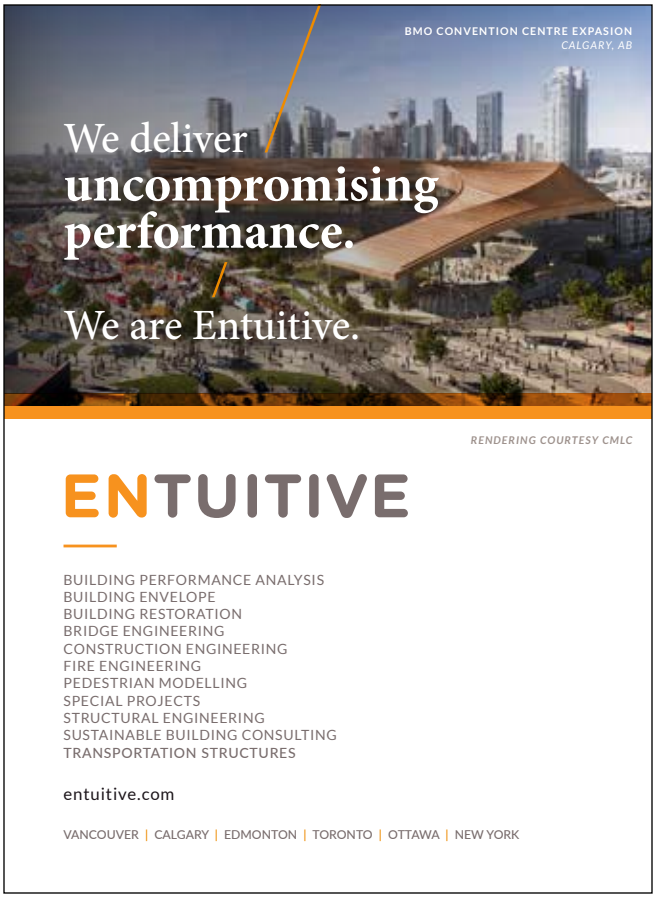
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CAPACITY BUILDING FOR ENERGY CODE THERMAL BRIDGING CALCULATIONS



By Justin Phill, P.Eng, BEMP, LEED® AP BD+C, Senior Engineer, Green Building and Energy Code in the City of Edmonton's Safety Codes Permits & Inspections group

Justin Phill's passion is helping teams design high performance, low emissions buildings by sharing his expertise in building design, energy modelling, capacity building, and policy development. In his current role, Justin provides assistance to internal and external stakeholders on the energy codes, and also provides his expertise in green building initiatives throughout various departments within the City of Edmonton. He is committed to helping the City of Edmonton achieve its goal of becoming an emissions neutral city.

Expectations for building energy performance have increased over the past decades due to owner driven sustainability goals as well as the introduction of energy performance regulations. Design teams are exploring higher performing building envelopes to meet these requirements and this is driving a need for more accurate predictions of real-life heat loss through these building envelopes. This article looks at the increasing complexity building design professionals must navigate specifically through energy code requirements.

Thermal bridging requirements changed significantly between the 2011 and 2017 versions of the National Energy Code for Building (NECB). NECB 2011 required accounting of thermal bridging through closely spaced repetitive structural members (such as studs and joists), ancillary members (such as lintels, sills, and joists), major structural members parallel to the plane of the building envelope, and major structural penetrations such as balcony slabs if the cross sectional area exceeded two per cent of the above ground building envelope area.

The National Energy Code for Buildings (NECB) 2017 revised some of the NECB 2011 requirements, plus introduced new items to account for in thermal bridging calculations. All major structural penetrations had to be accounted for, and the junctions between various materials, components, and assemblies were new additions. Accounting for thermal bridging at junctions of glazing assemblies, spandrel panels, parapets, roof-to-wall junctions, corners, and edges of walls or floors must now be accounted for.

These additional items in NECB 2017 introduced complexity in the thermal bridging calculations and required more advanced knowledge to account for them in a building design. Thermal bridging is accounted for typically by performing calculations and increasing the effective thermal transmittance value (or U value) of a vertical or horizontal assembly. This calculation method is



used in the prescriptive, trade off, and performance paths.

The energy code was introduced to set a minimum level of energy performance for buildings. Buildings of a similar type should have similar envelope constructions when aiming to meet the code minimums. The calculations were simpler under NECB 2011 with less items to account for, and therefore less complex and more consistent calculations between buildings. With the new requirements in NECB 2017, there are many more thermal bridging items to consider which can introduce some inconsistency depending on what is included in the thermal bridging calculations.

Ultimately, it is typically up to a professional, such a building performance specialist, a building envelope specialist, or architect, to use their judgment to determine which thermal bridging items to include, and to decide on appropriate literature or calculations to determine thermal bridge transmittance values. The majority of professionals rely on catalogs of assemblies modeled for thermal performance as these catalogs are less involved than performing 3D thermal modeling.

There are often assemblies in the project that are similar to assemblies in these catalogs, but not an exact match. These situations can be challenging for professionals and the projects they are working on as they determine using their professional judgment if the assembly in the catalog is representative of the assembly in the project. There are professionals to assist with interpretation, but not all projects have the capacity to support a building envelope specialist to assist with interpreting these assemblies. These unique situations can be interpreted differently. Thermal bridging guides and testing performed by other organizations that are publicly available help immensely in assisting these smaller projects and their continued development will help industry properly account for thermal bridging.

There is also an opportunity for further capacity building within the industry to help professionals grow their knowledge around thermal bridging, how to perform the calculations, and the significance it can have on building energy performance. As we progress to higher levels of energy performance the impacts of the thermal bridging become more and more important to consider and mitigate. Standards, such as CSA Z5010, explores ways to establish consistency for thermal bridging calculations. Knowledge and consistency are required to ensure our highest performing buildings achieve the real-life performance set out in the design. ■

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THE BIG IMPACT OF IMPROVING SMALL THERMAL WEAK SPOTS IN BUILDING ENCLOSURES



By Stephen Hunter, P.Tech.(Eng.)

Stephen Hunter is a building envelope specialist at Sense Engineering in Calgary. He provides building envelope engineering services for new and existing buildings.

Thermal weak spots in a building enclosure can contribute significantly to heat loss and gain, even if they make up a relatively small area. Improving those weak spots can thus substantially improve thermal performance overall.

The U-Value of a building enclosure assembly is expressed in watts per square meter-Kelvin (W/m2·K) and represents the heat flow through a 1m2 area for each degree Kelvin in temperature difference across it. Well insulated assemblies have low U-Values, while poorly insulated assemblies have high U-Values.

Multiplying the U-Values of each assembly by their respective areas in m2 and summing the results gives the total thermal transmission through the enclosure per degree temperature difference in W/K, not including that associated with air infiltration and solar heat gain.

Consequently, the amount of thermal transmission contributed to the total by an assembly or component is determined by both its area and U-Value. If the U-Value is sufficiently high it can contribute substantially to total thermal transmission through the enclosure, even if it makes up a relatively small area.



Figure 1: Rendering of the example building.

Figure 2: Effective USI by Assembly Name and Type.

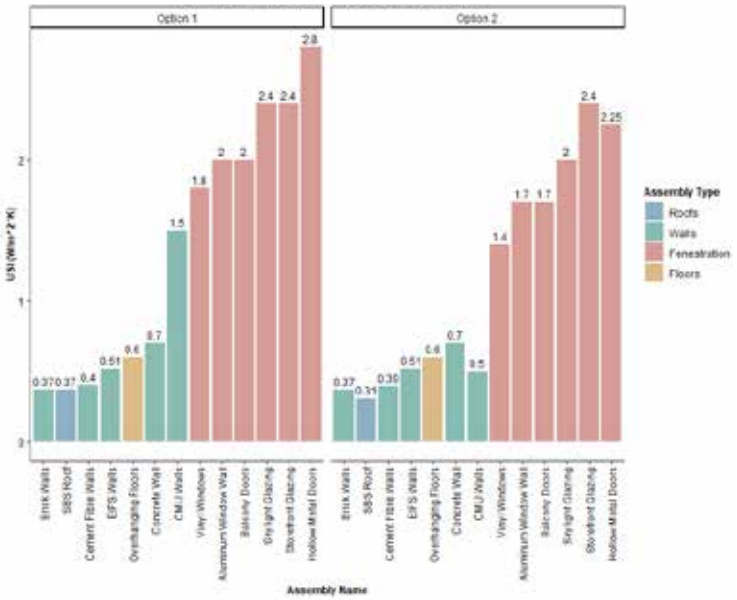
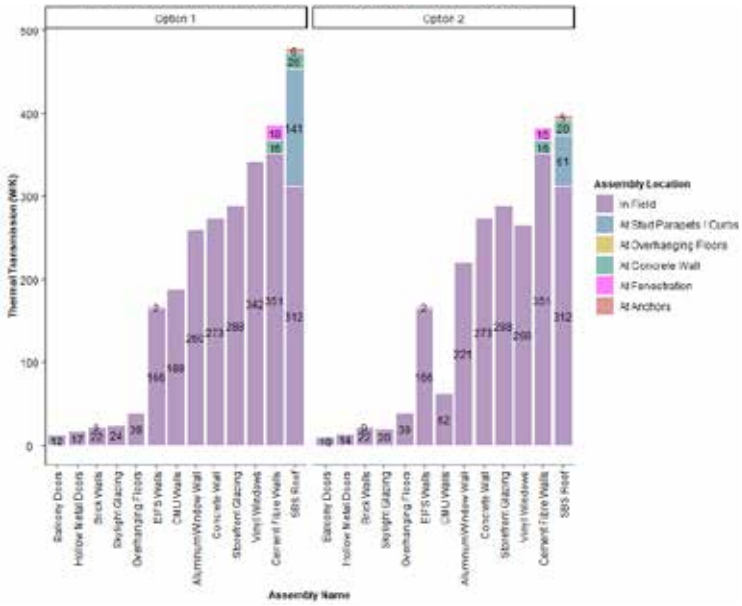


Figure 3: Total Thermal Transmission by Assembly Name and Location



These thermal weak spots are often not given the attention they deserve and are a real opportunity for cost-effective improvements to building enclosure thermal performance.

Take, for example, a design for a building enclosure renovation on a four-storey mixed use building in Calgary (Figure 1). The renovation includes substantial replacement of the low-slope roofing, cladding, and fenestration (windows and doors), so there are many opportunities for improvements.

Building enclosure renovations such as this one are often the best time to make improvements to thermal weak spots in existing buildings. That is when energy conservation measures can be "piggybacked" onto a broader scope for the least possible additional cost.

Two design options are depicted in the plots above (Figures 2 and 3). The first option shows the enclosure design before making improvements to the thermal weak spots. The second illustrates the effects of modest improvements to only the weakest areas. To show the impact of improving the weakest areas only, everything else is kept constant.

In Figure 2, the bars show the U-Values for each above-grade assembly in the building enclosure. The different colours indicate assembly type: roofs, walls, fenestration, or floors.

In Figure 3, the bars show the total thermal transmission through each assembly in W/K. The different colours in each bar indicate where the transmission is occurring: the field of the assembly or thermal anomalies in those assemblies. Anomalies are areas with higher U-Values within assemblies where the insulation is interrupted (also known as thermal bridges).

The weak spots in the first design include whole assemblies that have high U-values, as well as thermal anomalies in otherwise well insulated assemblies.

Thermally weak assemblies include the fenestration and poorly insulated concrete masonry unit (CMU) walls (Figure 2). Within the roof assemblies, excess thermal transmission occurs at the steel stud-framed parapets and curbs due to thermal bridging through the highly conductive steel stud framing (Figure 3).

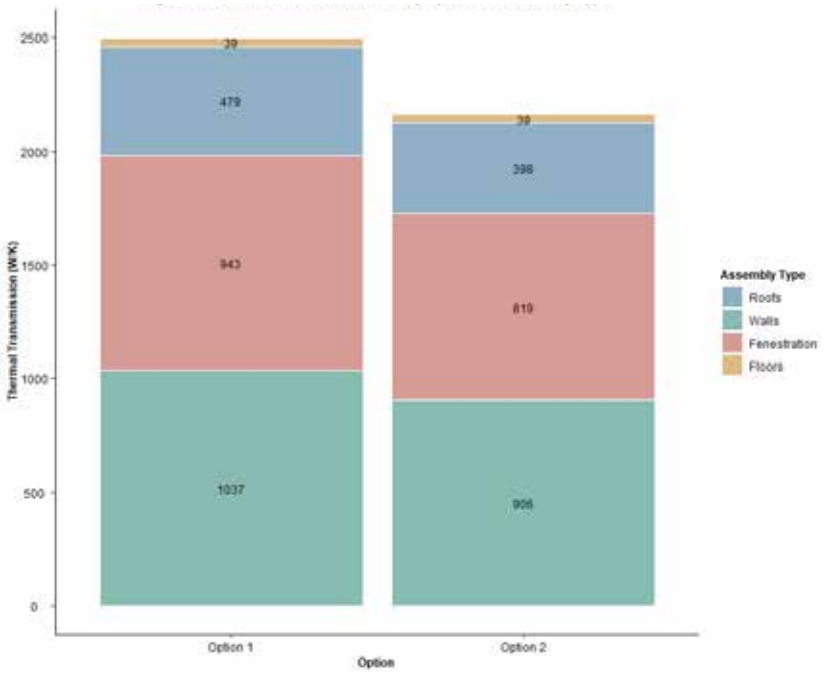
To a lesser extent, additional thermal transmission occurs at other thermal anomalies, including the steel roof anchors, at the interfaces between walls and fenestration, and at the exterior edges of a large interior-insulated concrete wall (Figure 3).

These thermal weak spots make up only about 17 per cent of the above grade building enclosure area but contribute 52 per cent to total thermal transmission through the enclosure. About 70 per cent of that is the fenestration alone.

Improving many of these assemblies thermally is relatively easy to accomplish as part of the broader renovation project. This work also results in only a modest cost increase to the project as a whole.

In the second design option, exterior insulation was added to the CMU walls. Thermal breaks were added below new stud-framed parapets and curbs on the roofs, which are being replaced as part of the renovations. The fenestration was upgraded everywhere except the storefronts, which are

Figure 4: Total Thermal Transmission by Option and Assembly Type.



not being replaced. The edges of the interior insulated concrete wall could not be improved without significant work, unfortunately.

Combined, these modest improvements to the design result in a 13.5 per cent reduction in total thermal transmission through the building enclosure (Figure 4).

While this example is for a building enclosure renovation, the same principles apply to new construction. In fact, there are often more opportunities for improvement in new construction without the constraints imposed by existing conditions.

When it comes to improving the thermal performance of our building enclosures, the thermal weak spots really are the low hanging fruit. Identifying and improving those weak spots in a targeted manner – in new construction or during renovations – can have a big impact on thermal performance without breaking the bank. ■

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CONTINUITY OF AIR BARRIER SYSTEM – LESSON LEARNED FROM A NATATORIUM



By Randy Kiez, CET, EXP Building Science Technician, and
Sathya Ramachandran, Architect, AAA, B.Arch., M.A.Sc.,
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Building envelope design ought to consider the use, occupancy, and interior spatial conditions; exposure to the micro and macro climatic conditions; and the shape, massing, orientation, and articulation of the intended design. This is particularly critical in projects that contain high humid interior conditions built in cold climatic regions, such as a natatorium in a northern British Columbia locale discussed in this article. An error in the design and/or construction in such a building can result in issues related to durability, energy conservation, occupant comfort, and user experience.

Background

A recreation centre in northern British Columbia was reported to be experiencing water ingress mainly along the perimeter at localized areas leaving behind black residue at the underside of the roof deck, structural elements, and interior finishes of the exterior walls (Figures 1, 2). The circa 1997 two-story building contains a large swimming pool, leisure pool, fitness centre, workout stations, and administration offices.

The walls are predominantly exterior insulation and finish system (EIFS). The roof of the building above the large swimming pool is profiled like a wave such that it has both low slope and steep sloped sections with the parapets arching at both ends (Figure 3). The length of the building is oriented on a north-south axis with the high point of the wave form located at the south side. Water was reported to be entering from the roof at some localized locations, most of them in proximity to the parapets and roof dividers. Prior assessments had confirmed the water ingress was not



Figure 1 – typical leak at perimeter staining the interior components.



Figure 2 - typical leak at perimeter staining the interior components.

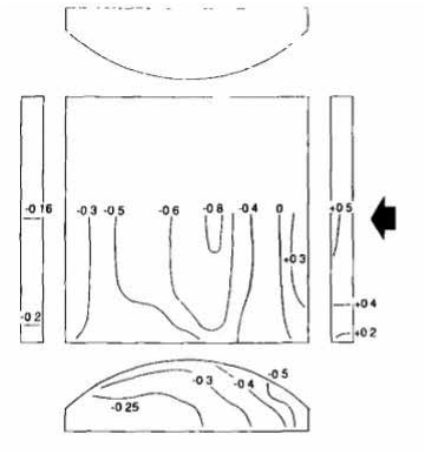


Figure 3 – Depiction of arched roof shape (courtesy of Journal of Wind Engineering and Industrial Aerodynamics) which is similar to the arch shape of the roof on this building.

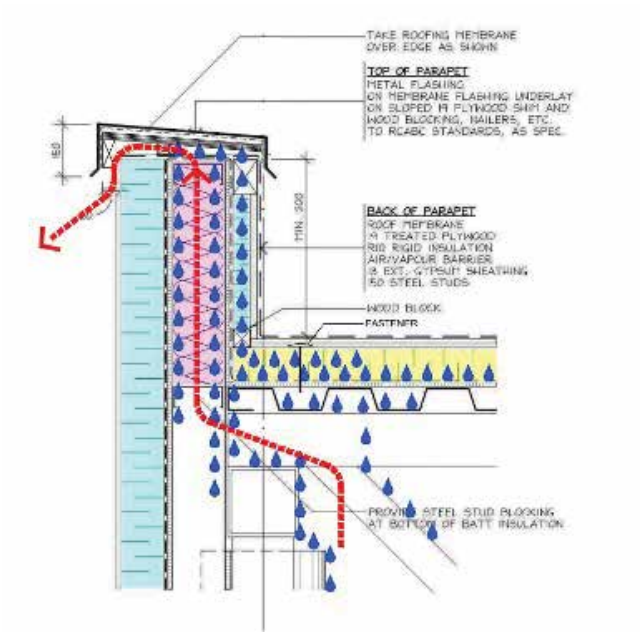


Figure 4 – Parapet detail, note incorrect placement of the self-adhered air barrier and vapour retarder membrane at the top. Depicted is condensation within and exterior to the parapet with the air leakage path shown in red.

related to moisture penetration, whether rain or snow melt.

Assessment methodology

The assessment started with a document review, particularly the as-built architectural drawings, to understand the design intent and identify any potential design issues. A site assessment included a visual review and mapping of the water leak locations from the interior to study the pattern, and review of the visible components on the roof to assess the integrity and continuity of the roofing membrane at the penetrations, terminations, and transitions. Non-destructive, testing – including thermal imaging and moisture meter testing – were utilized to locate and map the extent of wet roof locations. Exploratory openings were conducted at target locations to confirm the as-built and performance conditions of the underlying components, and to form a hypothesis for the cause of the moisture problem. Finally, smoke testing using theatrical fog at the suspect and moisture problem locations was conducted to prove the hypothesis.

Document review

The roof of the building is a sandwich assembly with 2-ply SBS roof membrane and polyisocyanurate (polyiso) rigid board insulation over a self-adhered membrane. The exterior walls up to the parapet cap flashing are clad with EIFS over the same self-adhered membrane. The interior face of the roof parapet is clad in 2-ply SBS membrane over plywood over extruded polystyrene insulation within the cavity of wood blocking. The roof parapet is constructed with the steel stud wall of the exterior wall extended vertically past the roof line with its cavity filled with fibreglass batt insulation.

The function of the self-adhered membrane in the roof and exterior wall assemblies is to act as the air barrier and vapour retarder, and the intent was to maintain its continuity wrapped around the parapet assembly. The expanded polystyrene insulation (EPS) in the EIFS, extruded polystyrene in the interior face of the parapet and polyiso in the roof assembly are intended to function as the thermal barrier. The exterior top of the parapet wall was noted as missing the continuity of insulation, and thus it appeared the fiberglass batt insulation placed within the stud cavity (inboard of the self-adhered membrane) was intended to provide the thermal continuity across the parapet assembly. Immediately evident was that the vapour retarder (the self-adhered membrane) at the top of the parapet is placed on the cold side of the assembly (Figure 4) posing the risk of condensation within the parapet, considering the building is in Climate Zone 6, Building Code requires the vapour control to be on the warm side of the assembly. However, such condensation due solely to the misplaced vapour retarder would have been contained within the stud cavity of the parapet.

Visual review and site interviews

The leak locations in the interior were mapped which corroborated the water ingress as being localized along the perimeter walls and roof dividers. A review of the roof did not show any obvious areas where water could be entering in the pattern and locations observed in the interior and noted on the leak map. Other than the roof

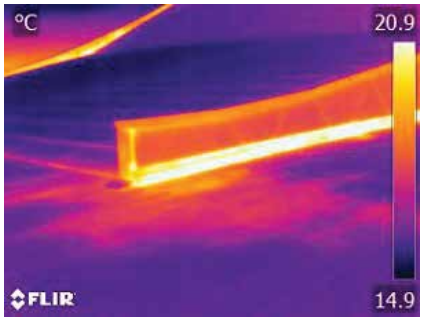


Figure 5 – Thermal pattern consistent with water within the roof at base of sloped roof divider.

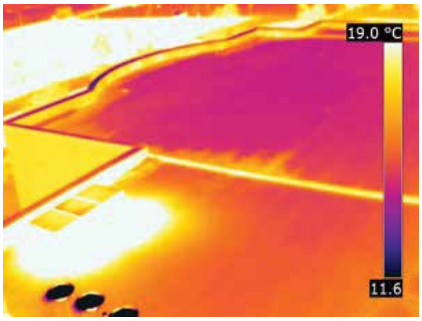


Figure 6 – Thermal pattern consistent with water within the roof at roof divider.

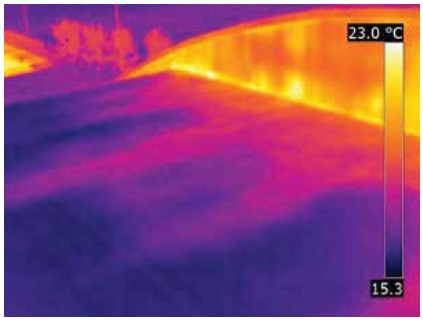


Figure 7 -Thermal pattern consistent with water entrapment within the roof assembly at the top of the arched roof where air leakage was identified by the smoke test.

drains, there were few penetrations of consequence, and the rainwater leaders of the roof drains did not show staining when viewed from the interior. Issues with the continuity of roof membrane below the roof cap flashings were not ruled out and were still suspect.

In the experience of the authors, it is beneficial to interview the users and facility personnel to gain as complete an understanding of the problem as may be known. In this case, useful knowledge was gained from the facilities personnel in that water did not enter the building during rain or snow melt events, and that the dark stains appeared gradually over time.

Non-destructive testing

While exploratory openings (i.e. destructive testing) will typically have to be conducted to acquire the most thorough understanding of the problem at hand, non-destructive testing allows us to identify the typical problem areas and its extent. It is best to gain as much understanding as possible prior to the expensive destructive testing. The type of the subject roof is ideal for non-destructive thermal imaging and supplementary moisture meter testing. Thermal imaging showed patterns consistent with entrapped water adjacent to and extending from the base of the parapet and roof dividers (Figures 5, 6) and that the roof area adjacent to the parapet arch (of the wave shaped roof) showed the moisture extended a further distance inwards as compared to the lower areas (Figure 7). A non-intrusive moisture meter confirmed that water was present within the roof system at locations pinpointed with the thermal scan.

The extent of evidence of water encapsulated within the roofing system as observed using the thermal scan could not be due solely to condensation caused by the incorrectly placed self adhered membrane at the top of the parapet which, as discussed above, would have been contained within the stud cavity of the parapet and exterior wall assemblies. This led to the premise of air leakage causing bulk movement of vapour, which then condenses within the gap between the roof membrane and self-adhered membrane, or the condensed moisture moving past the roof membrane and re-entering into the roof assembly through inconsistencies. The possibility of wind driven rain and inconsistencies in the roof membrane below the cap flashing causing the observed water entry was still not entirely ruled out. See the parapet detail (Figure 4).

Exploratory openings

Thermal imaging and moisture testing provided critical information to facilitate targeted exploratory openings to validate the as-built condition, confirm the presence of moisture in the assembly, and review the extent of damage.

Removal of the parapet cap flashing and a cut-in to the top of the parapet (Figure 8) showed that the roofing membrane was not installed per the detail (i.e. the roof membrane was not directly lapped over the self-adhered membrane) and in turn the roof membrane was installed over the sloped plywood below the cap flashing. The self-adhered membrane tie-in between the roof assembly and the EIFS assembly was continuous at the exploratory opening. While the detail was observed adequately installed to protect the top of the parapet from potential bulk water entry, the missing roof membrane overlap onto the self-adhered membrane allowed condensed water to run down between the roof membrane and the self-adhered membrane along the parapet and onto the base of the roof assembly, eventually pooling at the lower ends of the roof slopes subsequently entering into the steel deck flutes (Figure 9).

Additional openings into the parapets showed extensive water accumulation and damaged materials at several locations, including saturated insulation and wood installed as blocking for the insulation along the slope. The accumulated water was observed entering through the fastener



Figure 8 – Top of parapet showing the air barrier and vapour retarder membrane, and lack of thermal continuity (arrow) exterior to the vapour retarder.



Figure 9 – Water accumulation within the field of the roof adjacent to the parapets at the base of the arch shaped parapet wall.



Figure 10 – Extensive damages within the parapet including deteriorated steel framing and saturated materials.



Figure 11 – Theatrical smoke applied from a lift below the parapet was observed to rise to the top of the arched roof parapet where it exited.

penetrations securing the wood blocking through the self-adhered membrane. The accumulated water was observed to be dirty at the underside of the roof assembly. Soaked fibreglass batt insulation, rusted steel stud framing, evidence of organic growth, and deteriorated gypsum wall boards were observed within the parapet assembly (Figure 10).

The evidence gathered from the exploratory openings established that the parapet and roof assemblies are experiencing moisture problems from both the condensation within the parapet assembly due to misplaced thermal barrier and self-adhered membrane, and condensation of bulk movement of moisture within the roof assembly from air leakage and intrusion into the roof assembly.

Smoke testing

While the evidence leading to form the hypothesis for the cause of the moisture problems was identified, deficiencies showing the discontinuity of air barrier causing the bulk movement of vapour past the self-adhered membrane into the roof assembly leading to condensation, water accumulation and entry into the interior could not be verified. A smoke test using theatrical fog was conducted in the area where most of the interior staining was observed to demonstrate air leakage. As the smoke rose to the top of the arched parapet, it was observed exiting from under the cap flashing (Figures 11, 12). This confirmed the presence of air leakage issues in the parapet and thus the proof of the hypothesis. The smoke test was conducted at night when the facility was closed after temporarily disabling the alarm and informing the local fire and police departments.

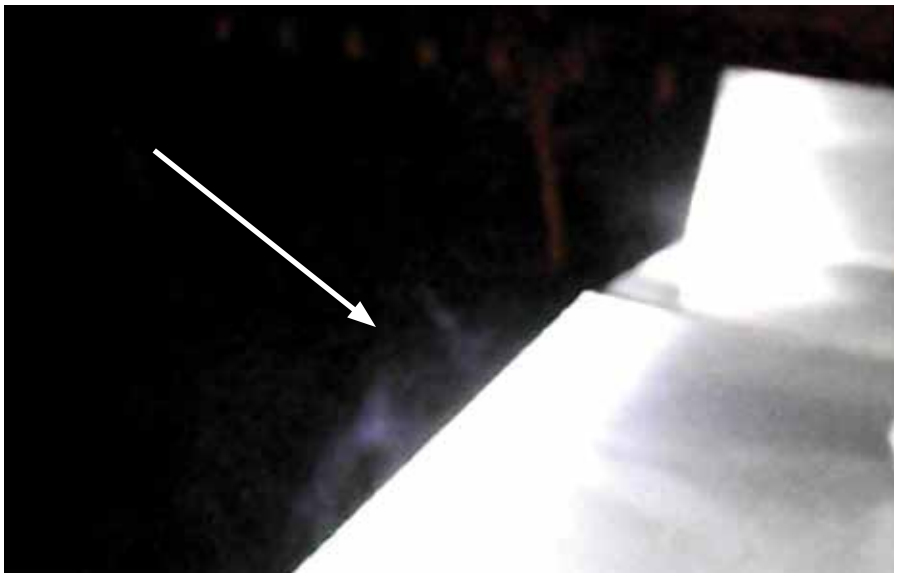


Figure 12 – Smoke observed to exit at the top of the arched roof parapet during the nighttime testing.

Air barrier systems and air leakage

Air movement and leakage, particularly exfiltration as is experienced in this building, transports its constituent water vapour into the building enclosure with the subsequent risk of condensation which can contribute to significant moisture problems only next to bulk water entry from precipitation. Air movement and leakage through the building enclosures are due to differential air pressure between interior and exterior. Air pressure differences may produce infiltration or exfiltration, either of which are detrimental. Air barrier systems are intended to control such air movement and leakage through the building enclosure. Air barriers can be defined as "systems of materials designed and constructed to control airflow between a conditioned space and an unconditioned space." Among other attributes, continuity is a prime requirement for an effective air barrier system, which was confirmed to be missing.

Further, "air barrier systems also typically define the location of the pressure boundary of the building enclosure." This requires an air barrier system to be durable over the lifespan of the building regardless of the constantly varying air pressure exerted between the exterior and interior of the building at any given time.

While the position of the air barrier system in a building envelope assembly is acceptable to be on the warm or cold side, the building use and its interior condition, the building form, and the profile of a particular detail are factors contributing to significant pressure difference across and within the enclosure, and thus the potential of air movement within an assembly requires consideration in placement of the air barrier system and, in fact, a consideration to include a secondary air barrier system. For instance, the placement of an air barrier system along the warm side of the building envelope as was intended in the roof and exterior wall assemblies was appropriate except for the deviation at the parapet.

The intended air barrier system wrapped around the parapet is not an uncommon approach for a building of this age. However, given the extreme interior and exterior conditions and the unusual form of the building, the experienced issues could have been limited by achieving the continuity of air barrier system through the parapet assembly at its base, but of course requiring adequate detailing taking into consideration the penetrations supporting the parapet and constructability challenges.

Differential air pressure

Air pressure differences across the building enclosure may be the result of: (i) mechanical systems which create negative or positive air pressure within the building compared to the exterior air pressure; (ii) wind which can create negative or positive pressure differences on the walls and roof; and (iii) stack effect which is the natural tendency for more buoyant air to rise creating a relatively positive air pressure at the upper reaches of a building.

A computational wind study published in the *Journal of Wind Engineering and Industrial Aerodynamics* states that "the use of curved or arched roofs on low-rise buildings is a structurally efficient way of carrying the loads applied by gravity and wind and allows large clear spans to be obtained for aircraft storage and indoor sports." It goes on to establish that negative (i.e. suction) pressures are produced on arched roofs, like the shape on this building. Given that the thermal imaging at the peak of the arched roof showed the entrapped water pattern had migrated much further inwards than lower areas, it can be hypothesized that increased suction due to roof shape has drawn more moist air through the breaches in the parapet air barrier system where the increased condensation caused increased wetting. While the shape of the building could contribute to the positive pressure on the parapet assembly from inside, the wind effect on this detail from outside may also contribute with a negative pressure.

The prevailing wind map shows that during the critical months of November to February, the wind is southerly about 30 to 35 per cent of the time, which is zero degrees incident to the arch. The study goes on to say when the wind on this shape of roof is incident at zero degrees, "the largest magnitude negative pressures occur just upwind of the apex of the roof." Refer to Figure 3.

Regarding stack effect, Building Science for a Cold Climate states, "stack effect can under certain conditions produce pressure differences comparable to those resulting from the wind." Stack effect air buoyancy is influenced by:

1. Temperature – Greater the temperature difference between the interior (less dense warmer air) and exterior (comparatively denser colder air), greater the potential air pressure differential. A building in this climate zone would be subject to a large interior-exterior temperature difference particularly during the winter months.
2. Building height – Taller the building greater the effects of the stack effect
3. Humidity - Moister air as compared to its drier counterpart is less dense due to a higher concentration of lighter water vapour (atomic weight of H_2O is 18) displacing heavier diatomic oxygen (atomic weight of O2 is 32) and diatomic nitrogen (atomic weight of N2 is 28).

As stated in Building Science for a Cold Climate, "Indoor swimming pools pose a serious humidity problem. They provide large water surfaces for evaporation at temperatures from 23oC to 30oC and act like large humidifiers. The relative humidity must be kept within limits, usually by ventilation, in order to protect the building and to keep the spectators comfortable." While moist air does contribute to stack effect, in swimming pools it is usually the mechanical equipment that causes the biggest pressures, followed by thermal stack effect followed by moisture stack, as confirmed by Professor John Straube, Department of Department of Civil and Environmental Engineering and the School of Architecture at the University of Waterloo, during a private conversation.

Except for not so significant height, the interior conditions in the subject building are conducive to the stack effect causing the air pressure difference across the parapet assembly.

Conclusion

Special purpose buildings, such as natatoriums, especially built-in cold climates, can experience extremes between interior and exterior conditions and thus require careful consideration of potential building envelope issues during design and construction.

In this building, both the flawed design intent, wherein the incorrect location of the vapour control layer has led to condensation and moisture damage within the parapet, and construction deficiency, wherein breaches in the air barrier system, has allowed copious amounts of water vapour escape into the roof system, and subsequently re-enter the building as liquid water.

In addition, its location in a cold environment and the peculiar form of the building required a robust air barrier system, which in principle has been achieved in the field areas but missed at the roof parapet.

At a significant expense and inconvenience to the owner, the parapets were recommended to be rebuilt and the necessary wet insulation removed and replaced as a minimum. ■



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Strengthening building envelope with a multi-pronged approach



By Sarika Nahal

Sarika Nahal, BMO BE Team, currently works as a Senior Building Envelope Specialist in the Entuitive Edmonton office in the building envelope group. She brings nine years of industry experience in Building Envelope Consulting. She is a Certified Passive House Consultant who believes in introducing design principles that can improve building performance. She has worked on previous deep energy retrofit projects bringing in expertise on integrating high performing building envelope systems. She is currently working on new construction and existing buildings, where BECx scopes are being integrated.



By Nicholas Fuss

Nicholas Fuss, BMO BECx Team, is an Associate at Entuitive's Calgary office in the Building Envelope Group. He brings 10 years of experience and industry exposure ranging from the smallest investigation to largescale projects and major recladding efforts. Nicholas has led teams covering both the BE and BECx scopes (but never at the same time on the same project). He is well-versed in the processes for both scopes of work, and advocates for maintaining and enforcing separation between parties when the scope is being performed by a single firm.

ARTICLE BRIEF

A team of Building Envelope (BE) Consulting and Building Envelope Commissioning (BECx) experts examine the differences between Consulting and Commissioning scope, complexities of overlapping scopes between teams, and the key benefits of typical project processes. Through collaborative best practices, and how to best collaborate for optimal results, this article highlights the successes of one qualified company covering both scopes on a single project.

The world of building science is evolving rapidly and, within the AEC industry, this evolution comes with the development of expert sub-disciplines such as carbon capture, lighting design, acoustics and, of course, building envelope. With architectural and product innovation adding complexity to building envelope considerations in new construction, renovation, and heritage restoration projects alike, envelope and enclosure specifications must be established from the outset of design.

These specific "how to instructions" must be fine-tuned throughout the development process in concert with building envelope experts and reviewed closely throughout the early stages of occupancy. Requiring buildings perform to the highest possible efficiency standards has resulted in the need to evaluate in more detail how the building systems function together as a cohesive unit. This requires detailed and thoughtful analysis and direction at the earliest stages of project development.

The building envelope has a critical impact on the success of well-designed, resilient, and energy efficient buildings. As such, projects using multidisciplinary teams to utilize both building envelope consulting and building enclosure commissioning services benefit from a thorough and collaborative approach. The best mechanical systems in the world will never perform to their potential if combined with a poorly designed and implemented building envelope.

Enter BECx - Building Enclosure/Envelope Commissioning

Prior to 2006, the BECx role was relatively unknown. Now, interest in this specialization is helping to ensure that what is designed on paper is confirmed and verified in the real world. As part of the LEED v4 Enhanced Commissioning credit scope, BECx is a project requirement. Outside of pursuing LEED, owners looking to ensure proper verification and documentation of building enclosure performance must pursue BECx to meet their building's goals.

As a driver of change in the building envelope industry, BECx enables the testing and validation of performance to ensure that best practices and industry standards are met.

SIDEBAR DEFINITIONS:

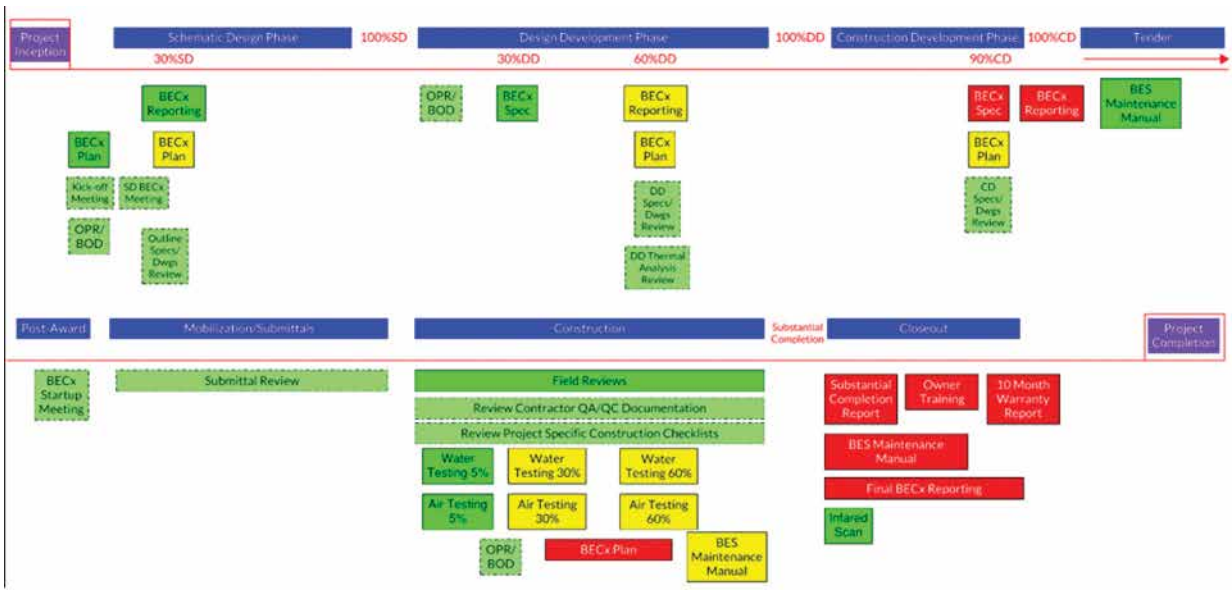
- Building Enclosure/Envelope Commissioning (BECx): The process of inspecting and testing building components and assemblies to validate that the installed performance of the building enclosure meets or exceeds the minimum performance requirements set forth by defined objectives and requirements of the project, as established by the owner.
- Owner Project Requirements (OPR): Owner's project requirements as captured in a written document that details the functional requirements and goals of a project and expectations for how it will be used and operated. The OPR lays the foundation for successful project delivery as defined by the owner and the building users.
- Building Enclosure Commissioning Authority (BECxA): The party retained by the commissioning authority which will manage the BECx process, develop, and stipulate the BECx requirements, and validate that the components and assemblies are designed, constructed, and tested to meet requirements set forth in the contract documents.

Building Enclosure/Envelope Commissioning

BECx teams develop and work according to the Building Envelope Commissioning Plan and the separate BECx Specification, which is essentially a project roadmap developed based on the Owner Project Requirements (OPR). The OPR serves as the guide for the BECx process throughout the entirety of the lifecycle of design, construction, and post-construction.

The process also includes further validation in the form of review of the design documents, field reviews, and field testing to ensure the performance targets are met for the entirety of the project. At project close-out, owner training is completed, as well as development and issuance of finalized documents, a building envelope maintenance manual, and warranty reviews.

Timing is crucial to the overall success of BECx implementation. First engagement ideally takes place at the outset of the schematic design stages so that initial design direction can be factored into BECx considerations and inform project direction. Throughout each stage of design development, associated documentation is updated and tracked, along with integrated reporting at critical milestones to establish the state of the program. When this transitions into mobilization and construction, the plans, roles,



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BMO Centre Expansion Calgary – Entrance promenade progress.

requirements, and approach should all be well defined for all parties.

An important factor in delivering the BECx role is recognizing that the Building Envelope Consulting scope is generally covered by someone else (whether the architect or a separate Building Envelope Consultant). Not only should there be minimal overlap between the delivery of each scope, but it is vitally important to understand the differences between the scopes while working together.

At a high level, the Building Envelope Consulting scope of work is primarily working with the design team, focused on the specifics of building envelope design, implementation, and integration as it relates to code requirements and best practice.

Along a similar vein, but distinctly separate, the BECx role is to act in direct representation to the owner, with the primary mandate of ensuring the OPR requirements are met and maintained throughout the project development and construction. The desire is to create a cohesive partnership where each party works to enhance the other. This can become difficult if OPR are not clearly laid out within the design documents from the outset, so the aim is to have both consulting and commissioning representatives at the table as early as possible – as mentioned, at the conceptual/schematic design phases.

Dual scope/combo scope

As a somewhat unique approach, several projects have been successfully undertaken in our industry where one qualified firm acts in both the Building Envelope Consultant and BECx roles on the same project. This is a delicate approach which requires careful planning to ensure the different needs of each scope are met, without a conflict of interest while still realizing efficiencies. Where LEED is concerned, the ability to undertake both roles is something that depends on creating a separation between the two (and is especially important to maintain if both scopes are undertaken by one company).

A successful example of a dual or combo scope is the BMO Centre Expansion in Calgary, Alt. In this case, the role of both Building Envelope Consultant and Building Envelope Commissioning Agent is currently being undertaken by one structural engineering company with building envelope and commissioning expertise.

Operating with an initial understanding of the difference of the two roles, and the need for separation between them, the teams would collaborate to achieve pre-determined milestones throughout the project.

The company responsible for both scopes for the BMO expansion accomplished this by creating two distinct teams (one for each scope) where deliverables would be reviewed and discussed internally, with each team offering its specialized perspective.

At the outset, the company established two distinct internal streams of workflow, with separate quality management checks at the end of the process. This included developing a comprehensive "chain of custody" internally for submittals, questions, and deliverables.

The lead reviewer for each scope was of course a different person, and teams were even defined by their respective geography (BECx in Calgary, Building Envelope in Edmonton).

Tasks such as submittal reviews assigned to the appropriate BECx team member after the Consulting team's comments had already been completed – not unlike if a third-party firm were involved. With reviews being carried out separately by each team (and never concurrently), the "approach" for each team differed depending on scope. BECx team would not comment on BE items and vice versa.

This allowed each team to independently complete their scope of work unaffected by the other, but also allowed for easier real-time communication, where required, to efficiently facilitate implementation of solutions. This was accomplished while also maintaining distinct, separate transparency between the predefined scopes.

By keeping the Consulting and Commissioning roles distinctly separate, internal collaboration was expedited in real-time, and discussion of issues occurred as they were encountered. The benefits of this workflow were amplified by sharing those efficiencies with the design, construction, and ownership teams, promoting transparency and accountability each step of the way. The resulting materials would include two distinct sets of documentation and deliverables for the project record, as required.





Above left: Example of spray rack (ASTM E1105) assembled on site at grade. Above right: Example of chamber and equipment for ASTM E783 testing (in this instance combined with ASTM E1105).

The future – BE and BECx

The requirement for BECx services is only anticipated to increase as the role of agents shifts from a more "niche" service for well-funded projects, to a dedicated requirement along the same lines as mechanical and electrical engineering. With a push for better performing buildings and an emphasis on planning and realizing envelope designs earlier in construction, the BECx role is destined to evolve to become more mainstream and standardized. As this becomes reality, it is critical to ensure that across the industry there is an understanding of what the role is, how it impacts the project, and what benefits it can bring to any project. When these roles are completed by one qualified firm, it is important to consider how these roles will be serviced and if collaboration can truly be achieved. Clients, consultants, contractors, and other stakeholders involved should have a strong understanding of when to involve a BECx agent, and what impact that brings to the overall team. ■



THE REVAY CORNER

Investing in design and tender development for project certainty



By Suzanne Checkryn, P.Eng., PMP, MBA – Director, Prairies

As discussed in the last Revay Corner, and as seen in numerous other recent publications, the problem of incomplete designs and specifications continues to persist in projects. As design errors and omissions are a common cause of delays and cost overruns in construction, why are some tenders put out to market before they are ready? Is this due to conscious decisions by owners to spend less time and money during the design phase? Or is there, perhaps, an under-appreciation of the consequences of tendering incomplete designs?

This column will explore the issues with tendering incomplete designs and the benefits for owners to invest more time and money in design, as well as the proper development of tender documents.

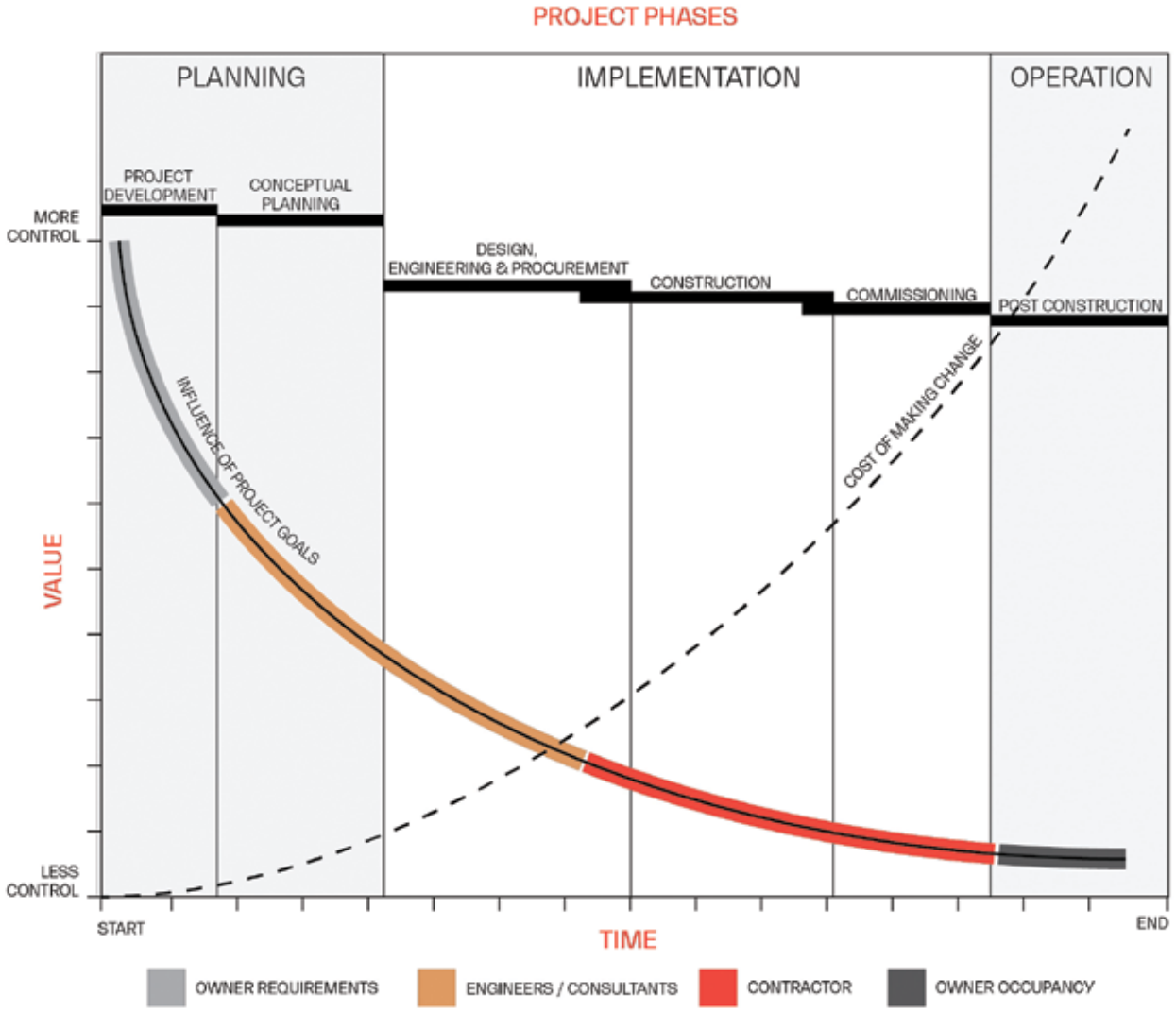
When looking at the total cost of a project, the design phase represents a small percentage of the cost while the construction phase represents a much larger percentage. Additionally, the relative ability to influence project outcomes is much higher at the design phase, and the cost of making changes during this phase is much lower. Conversely, by the time a project is in construction, the ability to influence project outcomes is low, and the cost of making changes is high. It is, therefore, in an owner's interest to have accurate and complete designs and specifications. See the figure below for details.

When considering the design-bid-build project delivery method, the design phase is when the basic project definition is advanced to specifications, drawings, a contract, schedule milestones, and, ultimately, a tender package that bidders will rely upon. Being able to accurately complete a project design requires not only a clear scope definition, but also an understanding of the project-specific needs, features, constraints, risks, and anticipated site conditions. There are many factors which are best discovered during the design phase when changes can be incorporated into a project for far less time and money.

For seasonal projects, it is of particular importance to understand the project requirements, such as level of effort for each activity and available weather windows, to define achievable milestones. For example, a project may require multiple construction seasons whereas the owner prefers to complete the project in one season. If sufficient time is not spent by the owner's engineer to study options and risks, then prepare a complete design, the milestones chosen by the owner may be unachievable. This could increase the likelihood of delay and costs (including expensive unplanned seasonal shutdowns) and lead to disputes.

If an owner fails to spend adequate time and money during the design phase, the probability of changes, delays, and cost overruns during construction will be higher. In Revay's experience, the more planning and design work an owner performs, and the more accurate the information is that goes into the tender documents, the better it is for a project. ■

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