ADVANCING BUILDING RETROFITS

Final Report
January 21, 2020

CENTRE FOR URBAN GROWTH AND RENEWAL
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About The Centre for Urban Growth + Renewal

The Centre for Urban Growth and Renewal (CUG+R) is a non-profit research organization founded in 2009 with the mission to engage in cross-disciplinary research initiatives fundamental to achieving livable and sustainable urban, suburban and rural environments. The Tower Renewal Partnership is CUG+R's primary initiative.

About The Tower Renewal Partnership

Tower Renewal is a model to transform Canada's remarkable stock of postwar apartment towers and their surrounding neighbourhoods into more complete communities, resilient and healthy places, fully integrated into their growing cities. Led by the Centre for Urban Growth + Renewal and supported by a group of core partners, the Tower Renewal Partnership is a collaborative initiative working to preserve and enhance this key housing through research, advocacy and demonstration projects. The Tower Renewal Partnership's goal is to enable reinvestment into these dynamic neighbourhoods, working toward building lower-carbon, healthier and more complete communities.

This report was produced with the generous support of the Canada Mortgage and Housing Corporation.

Introduction

Introduction & Context

The funding attached to the National Housing Co-Investment Fund supports the delivery of the first tranche of housing currently in need of renewal. The NHS program will kick-start nationwide demonstration projects over the next 10 years. Achieving the goal of renewing 240,000 units will require a broadened set of tools and additional funding. Furthermore, there are up to 800,000 units in apartments built before 1985 that either need renewal immediately or will need it in the near term future.

This research has identified replicable solutions and tools to technical challenges facing the Canadian retrofit industry related to the retrofit of critical housing in the form of aging high-rise residential towers generally, and specific challenges of renewal including thermal bridging, ventilation and building envelopes specifically. Further, this research engaged with industry stakeholders to further identify ways of transforming the Canadian retrofit market.

These three aspects (thermal bridging, ventilation and building envelopes) represent current critical technical barriers to broad uptake of deep retrofits across Canada. The research identified challenges around how to implement specific retrofits in multi-unit residential buildings (MURBs) and considers both the technical solutions (different technologies, materials, etc.) as well as policy solutions to transform the retrofit industry and market (building code updates, incenting development of local technology, etc.) This research represents a significant opportunity to address barriers that have been pervasive throughout the Canadian retrofit industry over the last decade.

The aim of this research is to identify industry gaps and outlines potential solutions in advancing the retrofit industry to aid in facilitating achieving the critical NHS goal of the repair and renewal of 240,000 units of affordable housing. The goal of this research is to identify paths to innovation that will catalyze the renewal of crucial affordable rental housing stock; reduce GHG emissions; improve housing quality and accessibility; and maintain the affordability of this core housing. The results will enable the social, economic and environmental goals of the NHS to be met at scale and in a cost-effective manner.

Research Methodology

This research focused on identifying replicable solutions and tools to technical challenges facing the Canadian retrofit industry related to the retrofit of critical housing in the form of aging high-rise residential towers generally, and specific challenges of renewal including thermal bridging, ventilation and building envelopes specifically. Further, this research engaged industry stakeholders to further identify ways of transforming the Canadian retrofit market.

This research posed two primary challenges:

Challenge 1: How do we enable faster, cheaper and more cost-effective holistic retrofits in multi-unit residential buildings?

- What technical solutions can help to accelerate retrofits in the Canadian market through products, materials, knowledge and training?
- What policy solutions will support and transform the retrofit market and guide this acceleration, such as building code updates, research and design programs, training requirements and certifications, or data collection?

Challenge 2: How can we ensure successful tower retrofits in occupied buildings in a way that is efficient and effective for builders and respectful for tenants?

- What resources and training do constructors need to execute high performance envelope refurbishments and systems upgrades with minimal resident disruption?
- What planning, consideration, and specialized workforce is required to work efficiently in occupied buildings in a way that is respectful of tenants?
- What technology, materials or other construction techniques and innovations can make retrofits quicker, faster and cheaper?

Research Methodology Process

In order to address, identify and promote solutions to the questions posed above, a variety of research activities occurred. The research was designed to identify challenges around how to implement specific retrofits in multi-unit residential buildings (MURBs) and consider both the technical solutions (different technologies, materials, etc.) as well as policy solutions that could transform the retrofit industry and market (building code updates, incenting development of local technology, etc.) The research was divided into three phases:

Phase 1

- *Establish Advisory Group:* An advisory group of housing stakeholders and professionals was established to review and guide the research, refine methodologies, review findings

and vet final recommendations. An advisory group's terms of reference was circulated and assisted in refining research questions and methods. The advisory group list and terms of reference can be found in Appendices A and B.

- *Conduct Gap Analysis:* Using the results of CUG+R's "Standards for Healthy, Safe, and Resilient Housing Retrofit" report, the project team conducted a gap analysis to identify barriers to addressing thermal bridging, ventilation and building envelopes in tower retrofits.

Phase 2

- *Conduct Jurisdictional Scan & Case Studies:* Jurisdictional scans of Germany, the United Kingdom and British Columbia were completed. This selection was based on CUG+R team experience with which jurisdictions that have successfully supported robust retrofit industries. Jurisdictional scans included evaluating government policies, programs and legislation to understand the role that different levels of government play when encouraging or requiring retrofits. Scans will also include evaluating local industry's technology, design and material use. Within each jurisdiction, a specific case study was identified:
    - Germany: Güterstrasse 30, Pforzheim
    - United Kingdom: Five Tower Blocks (council estates), Oxford
    - British Columbia, Canada: Grandview Terrace, East Vancouver
- *Create Draft Recommendations:* A set of draft technical and policy recommendations will then be presented to the advisory group. Their input will be used to refine and create a final set of recommendations. A progress report was sent to CMCH on September 30, 2019 that reflected the research progress up to this stage.

Phase 3

- *Conduct Industry Engagement & Workshops:* Conducting the gap analysis and jurisdictional scans/case studies led the research towards broader "State of the Industry" questions and issues within the Retrofit Ecosystem. This led to hosting two industry stakeholder workshops, one in Toronto, ON and the other in Vancouver, BC as well as several One-on-one interviews. Stakeholders included manufacturers, contractors, industry associations, consultants and engineering firms. These activities proved pivotal to developing actionable market transformation recommendations.
- *Develop Market Transformation Models*: Develop models for retrofit industry market transformation
    - Building Retrofit Theory of Change
    - High Rise Retrofit Innovation Adoption Model
- *Consult Advisory Group:* Final recommendations shared and vetted with Advisory Group.
- *Create Final Report:* Produce the final report featuring supporting infographics, charts, construction details and other supplementary material.

What is a retrofit?

To understand what technical and policy solutions are needed to accelerate the Canadian retrofit industry, an understanding of what is involved in comprehensive retrofits is needed. However, there is a range of retrofits that achieve a range of performance-based outcomes.

All retrofits are not created equal. Retrofits vary from core state of repair investments, upgrades to meet current health and housing quality standards, and a range of energy retrofits from modest to near-net zero. Further, buildings with substantive repair backlogs can create wider implementation challenges.

The following provides an understanding of what is needed at various levels of retrofit and the construction scope required to achieve retrofit outcomes.

Deep Energy and Comprehensive Retrofit (Levels 1 - 4):
These four scenarios describe various degrees of energy retrofits. Scope for these retrofits include modernizing the building envelope and mechanical and electrical systems for enhanced building performance, inclusion of in-suite thermostat controls and updated building automation systems, as well as related enabling works and other modernization measures not related to energy retrofits, such as life safety systems and elevator replacements. These levels are cumulative.

Level 1: Light Energy Retrofit
The Light Energy Retrofit focuses on reducing water and electricity consumption, as well as like-for-like replacements of HVAC equipment for modest reductions in natural gas usage. Scope includes LED lighting retrofits, water-conservation fixtures, as well as complete replacement of mechanical air handling units and heating and domestic hot water boilers. Envelope upgrades are limited to re-caulking existing windows and exterior doors.
Level 1 retrofits achieve GHG reductions in the range of 10-20%. Due to short-term paybacks on utility costs, this level of retrofit is becoming more common in properties throughout Canada.

Level 2: Medium Energy Retrofit
The Medium Energy Retrofit is a combination of capital repair and energy retrofit enhancements. It includes a comprehensive HVAC system retrofit including provision of direct in-suite ventilation, the provision of window shading and ceiling fans for cooling, and window and exterior door replacement. This retrofit also includes envelope maintenance and repair items, including balcony guard replacement and life safety upgrades including sprinklers. Level 2 retrofits achieve GHG reductions in the range of 35% with significant improvements to

resident comfort. Currently, a select but growing number of properties across Canada have undergone or are undergoing a similar level of retrofit.

Level 3: Deep Energy Retrofit

The Deep Energy Retrofit scenario includes a comprehensive building upgrade, inclusive of building overcladding, high performance windows and the elimination of thermal bridges at balconies for the substantial reduction of heat loads, resized HVAC equipment, the installation of low-temperature radiators, as well as the provision of direct in-suite ventilation systems, and passive cooling measures. This scenario engages in life safety measures as well as elevator upgrades. This comprehensive retrofit achieves GHG reductions greater than 75% and provides significant improvements to resident health, comfort and climate resilience. Across Canada some marquee projects have undergone or are undergoing this level of retrofit.

Level 4: Complete Retrofit

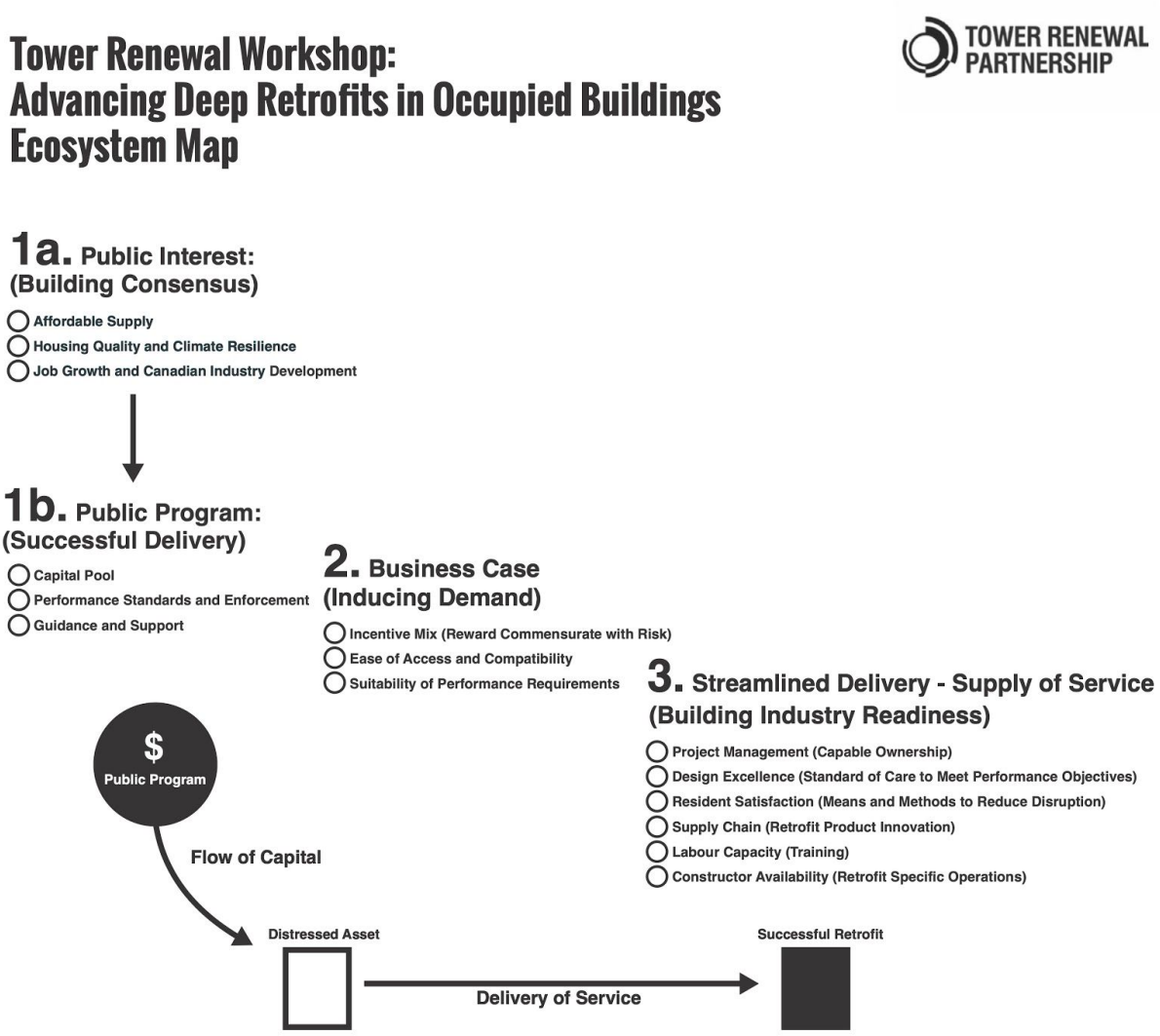
The Complete Retrofit combines State of Repair and Energy Retrofit Levels 1 - 3. This scenario represents the transformation of a distressed asset in need of full systems replacement into state-of-the-art modernized housing. While this level of retrofit is currently rare, limited to one known example in Canada, it is used here for the purpose of comparison. This ‘complete’ retrofit achieves GHG reductions greater than 90% and demonstrates significant improvements to resident health, comfort and resilience, as well as comprehensive asset modernization.

Achieving a ‘deep’ retrofit with a buildings systems approach that will need NHS performance goals and prolong asset longevity will require Level 2 retrofits and above, with a focus on level 3 and 4. Solutions to high performance envelopes calibrated with ventilations systems are critical in achieving these outcomes.

The Repair and Renewal Ecosystem

An assessment of the “Repair and Renewal Ecosystem” identifies several areas for innovation and optimization to accelerate the retrofit industry in Canada. This analysis provides further understanding of where and how changes in the system can further catalyse the retrofit industry and, by extension, assist the federal government in achieving their public policy goal of ensuring a resilient and affordable housing stock the meets 21st Century expectations and, importantly, meeting CMHC’s 2030 housing goal of 240,000 renewed units.

Figure 1: Ecosystem Map



Factor 1: Public Framework:

1a. Public Interest:
A primary driver of deep retrofits that meet resiliency targets is the public interest. From that, public policy is then developed in such a way that new expectations for housing quality and performance are created. Through the National Housing Strategy Act, and stated government policy, a public interest in resilient, sustainable, equitable and affordable housing has been declared. Additionally, a national commitment has been made to become carbon neutral by 2050, with related commitments to Green Industry advancement.Through the NHS, CMHC and other Ministries, this public interest is being manifested through a suite of public programs.

Core Areas of Public Interest Include:

- Affordable Housing Supply
- Housing Quality and Climate Resilience
- Job Growth and Canadian Industry Development

1b. Public Programs:
A series of public programs in service of public goals for an affordable and resilient housing stock has set large scale targets, chief among which is the repair and renewal of 240,000 units of housing over the next ten years. Program design in achieving these goals work to address market failures through positive and negative incentives, directing investment toward housing renewal. Considerations in program design include:

- size of capital pool;
- performance standards and enformancement; and
- guidance and support for applicants,

Together, these factors balance ease of access with meeting public policy goals and performance targets. The NHS Co-Investment Fund Repair and Renewal stream is the primary Federal program funding to support NHS Repair and Renewal goals.

Factor 2: Business Case - Inducing Demand

A second key factor is inducing demand: calibrating public frameworks to ensure broad participation. For housing repair and renewal, the applicants are housing owners and providers. Consideration of owners for program participation include:

- Incentive mix (ensuring reward is commensurate with project risk and/or Return on Investment);
- Ease of access and compatibility with other funding activities; and

- Suitability of performance requirements (Are program expectations achievable?)

Motivations for retrofit activity, i.e. the reward, are different for various owner types, particularly between not-for-profit providers and for profit owners. Whereas asset renewal and stabilization can be motivation for not-for-profits, ROI and base in-force code compliance is the primary motivation for private for profit owners, making the demand profile different across the sector.

Currently, program design is generating demand primarily in the not-for-profit sector. As programs are in their early stages, demand is emerging from ‘early adopters’ willing to take on a degree of project risk.

Factor 3: Streamlining Delivery – Supply of Service

The final factor in engaging in successful repair and renewal is the supply of services and the industry readiness for the delivery of retrofits. While building owners are the program applicants, successful delivery of a complex retrofit rests in the ability of the owners to engage with designers, constructors and suppliers who can engage in the work, delivering project performance standards with minimal friction, on time and on budget.

However, as the majority of Canadian construction activity is in new construction, the retrofit industry is a small segment of the market, and as this study outlines, is less mature than in other jurisdictions. As public programs induce demand by owners to engage in retrofits, ensuring the availability of capable and competitive retrofit industry is critical in ensuring project success. There is currently a risk that in current market conditions, project delivery at scale will be a challenge.

The NHS and related programs present a significant opportunity to advance the Canadian retrofit industry, increasing competitiveness, creating jobs, and ensuring smooth delivery of complex retrofit projects.

Factors impacting industry readiness include:

- Project Management Capability;
- Depth of Supply Chain (retrofit product innovation) ;
- Labour Capacity (Training);
- Constructor Availability (Retrofit specific operations); and
- Design Excellence (Standard of care to meet performance objectives).

A further critical consideration is the means and methods to ensure resident satisfaction – minimal disruption and high quality of care while living through a complex construction project in an inhabited building.

It is Factor 3 that is the primary focus of this study.

Building Industry Readiness: State of Canadian Market

The NHS proposes a program of retrofit critical to the longevity and resilience of Canada's housing stock. However, the retrofit industry is still in its nascency in Canada, with lack of knowledge, skills, and specialized products leading to inflated costs and perceived risk. Recent research conducted by CUG+R identifies three persistent technical challenges related to the low-energy renewal of older apartment tower buildings in Canada: addressing thermal bridging; upgrading ventilation systems; and cost-effective and non-combustible building envelopes (described below). In order to meet the NHS targets, identifying and scaling cost-effective Canadian solutions is critical.

Building Envelope: Overcladding projects in Canada are rare. Where they are undertaken, they primarily rely on insulated stucco systems, relying on extruded polystyrene or other rigid combustible insulation. These systems present challenges in terms of fire safety, lifecycle and durability. The research will examine options for more robust, cost-effective, and noncombustible solutions.

Thermal Bridging: Envelope renewal projects in Canada apply new systems on flat building faces, but do not address balconies and other projections. As a result, these unprotected projections become thermal bridges, causing heat transfer and reducing GHG savings, but more critically creating interior cold surfaces where condensation and mould forms. Our research will examine international best practice that has adapted to isolate all thermal bridges through a number of innovative approaches.

Ventilation: Old high-rises are not air-tight, highly inefficient and have a high degree of seasonal swings in interior temperature and comfort. The introduction of modernized ventilation systems into towers is complex and expensive. A review of international best practice, outlining simple and cost-effective approaches to streamline this conversion, is required to support healthy indoor environments in retrofitted buildings.

Gap Analysis

This gap analysis identified barriers and opportunities for addressing three persistent technical retrofit challenges in addressing the energy performance and resident comfort goals of Canada's aging high-rise housing stock: addressing thermal bridging; upgrading ventilation systems; and cost-effective and non-combustible building envelopes. The analysis is limited to the challenges around how to implement specific retrofits in multi-unit residential buildings (MURBs) and considers both the technical issues (different technologies, materials, etc.) as well as policy gaps (building code updates, incenting development of local technology, etc.)

The gap analysis is further broken down into key elements within each category. A fourth category regarding overall industry readiness and training is also provided. These elements are outlined below:

1. **Technical Challenges:**

   Building Envelope
   - Cladding
   - Windows
   - External Moveable Shading

   Ventilation (HVAC)
   - Energy Recovery Units
   - Heating and Cooling
   - Fresh Air Supply
   - Natural Ventilation

   Thermal Bridging
   - Balconies
   - Other Penetrations
   - Typical Conditions

2. **Overall Industry and Trade Readiness**
   - Training, Means and Methods

This gap analysis is informed by CUG+R's body of retrofit analysis, including the report "Standards for Healthy, Safe, and Resilient Housing Retrofit"; the jurisdictional scan found in the

next section of the report; as well as the expertise of project partners Transsolar and JMV Consulting.

Building Envelope

Why is the building envelope important?

The building envelope is the primary source of heat loss and heat gain (in the summer). It can be a carrier for moisture, draft and noise. Without a good envelope damage to the building's structure is likely, as is energy loss. Importantly poor envelope performance contributes to uncomfortable conditions for residents (overheating, damp) and health risks through mould.

Subcategories include **cladding**, **windows**, **external movable shading**.

What is the gap?

- In aging high-rise apartment housing, envelopes are typically poorly designed; poorly performing; and in the process of deteriorating.
- Most of these existing existing buildings have little or no insulation, single glazed or old double glazed aluminium windows and no way to control solar gains. The result is that buildings use up to 10 times more heat than best in class construction, have high cooling loads; have health risks due to mould; and still aren't comfortable.

Cladding

Why is cladding important?

Wrapping existing buildings in insulation to reduce heat loss is essential. On an uninsulated building as much as 35% of heat loss is through the wall system. Without good cladding options, it is difficult to address this massive heat loss. Existing high-rise housing with poorly performing envelopes are well suited to be modernized through a process of 'over-cladding'; applying a new layer of insulation and weather protection on top of the existing exterior wall system - which in most cases consist of exposed masonry.

What is the gap?

- While the Canadian market has a variety of high performance cladding systems, 'over-cladding' is a relatively new process and products are limited, particularly in the high-performance, lower-cost category.
- The standard cost - effective approach is to use of EIFs, a polystyrene based stucco application which poses challenges in terms of flammability, is not recyclable and has high GHG emissions in production and disposal.
- Non flammable higher-performance systems are several orders of magnitude more expensive in the Canadian market and require custom assemblies made of several components.

- There is a limited set of options for cladding developed fully supplied by insulation provider, with typical assemblies requiring several products and the cladding contractor carrying performance risk; increasing costs, and requiring the coordination of several trades on site, as well as prolonging the schedule for installation.
- Requirement for a rainscreen in the Canadian market-place limits use of several off the shelf European products typically used in retrofit applications that meet performance, ease of installation and cost criteria.

What are some solutions?

- Advance Local Manufacturers: Rockwool insulation, available in Canada, presents a low-carbon and non-flammable approach to over-cladding. Following the Grenfell tragedy in London UK, use of rockwell is becoming mandatory in emerging British buildings codes. While rockwool is available in Canada, it is only as an insulation product, not a complete cladding system. Local industry could be advanced to provide a full systems.
- Import best practice off-the-shelf solutions: Throughout Europe, rockwool insulation suppliers have developed several options for off-the-shelf complete cladding options complete with installation details for retrofit providing clear guidance for accommodating window, door and roof tie-ins, mechanical penetrations and other typical conditions. These products provide over-cladding options at lower risk to contractors and lower costs to owners. There is an opportunity to expand these products to the Canadian market-place.
- Prefabrication: The use of 3D scanning and BIM technology provides the opportunity to customize prefabrication for the creation of panel systems for rapid erection. Such systems are currently cost-prohibitive in the Canadian marketplace but have found to be effective internationally, such as the Netherlands where a full supply chain has been developed, enabling cost competitiveness and efficiency.

Windows

Why are windows important?

Light, fresh air and warmth from the sun are some of the benefits from windows. But with poor quality windows, uncontrolled leakage, condensation and mould can develop. Additionally, overheating due to poor control of glazing properties, and inability to open fully can occur. Finally, in the winter time, poor windows act as cold radiators sometimes getting frost on the inside of the window and losing significant amounts of heat. Windows are a key part of a building's envelope that, when failing, increase heating and cooling costs and increase discomfort.

What is the gap?

- Supported by policy, such as the BC Step Code, Canadian manufacturers are beginning to provide high performance fiberglass punch windows comparable to EU standards, with one line Passive House certified. However, products remain cost prohibitive with respect to typical low-performing windows, and supply is limited to smaller companies located in the west coast.
- While development has occurred for punch windows, curtainwall windows with high performance are unavailable in the local market.
- Aluminium insulated window options are currently not produced in Canada and importing products from the EU is currently cost prohibitive.
- Air barrier connection for windows not a common detail, presenting risk for discontinuity of the full envelope system.
- Windows are designed for new build application, not retrofit, presenting challenges for installation in existing (and often damaged) window openings.

What are some solutions?

- Support Product Development through Standards and Incentives: The BC Step Code has been effective is broadening the window market in the west coast. A similar approach could be achieved across Canada.
- Update Codes for New Products: Canadian high-performance windows are currently only available in fiberglass frames, yet while their use is supported in the most recent version of the BC Building Code, most Provincial codes have not been updated to allow their use. Code should be updated.
- Streamline Importation of High Performance Products: The EU and developing markets are producing an array of high-performance windows suitable for retrofit. Streamlining the process for CSA approval could create a more competitive local market in light of CETA.

External Moveable Shading (roller shades or venetian blinds):

Why are external movable shading / blinds important?

Managing solar gains and eliminating the need for cooling or drastically reducing it is a key opportunity to addressing climate change. In Ontario the peak electrical demand occurs not in winter when it is coldest but on the hottest days of summer when all air conditioning units are being used. External moveable shading in conjunction with a good building envelope can reduce the impact of solar gains by 90% and in most cases eliminate the demand for air conditioning. They are a relatively low cost component for achieving low-energy and indoor comfort.

What is the gap?

- While external movable shading / blinds is a common off the shelf product in the EU, it is unknown and unavailable in Canada.

- Unfamiliarity with their use and installation means that contractors place a price premium for their import and installation – as much as ten times the cost as in Europe – and most will not provide a warranty.

What are some solutions?

- Demonstrations: As these products are largely unknown in Canada, targeted demonstration could show their efficacy in mitigating heat gain and achieving indoor comfort.
- Codes and Standards: External shading and blinds have been optimizing as a means of addressing heat-load and indoor comfort requirements of various European codes. As Canadian codes evolve to include more stringent demands, these components will be in higher demand.
- Partnerships: Creating Canadian partnerships with established EU firms could provide knowledge transfer and accelerate product development in the local market.

Ventilation (HVAC)

HVAC:

Why is HVAC Important?

Getting fresh air, cooling and heating is how one survives in a building and makes it liveable. Highly efficient mechanical and passive equipment to support ventilation, heating and cooling is essential in achieving a low-energy and comfortable building. Once a good envelope is in place HVAC is the next major energy consumer for a building. Currently most HVAC systems in aging high-rise residential towers are poorly designed, provide inadequate fresh air to individual units, and lack heating / cooling controls. In older systems, adequate fresh air in units are often achieved through leaky building envelopes. Once the envelope is improved and made air-tight, ventilation systems must be upgraded to ensure resident health and optimum performance.

Subcategories include **Energy Recovery Units**, **Heating and Cooling**,**Ventilation Air Supply and Natural Ventilation.**

What is the gap?

- Currently, existing HVAC systems in aging residential highrise rely on central systems. Retrofitting these systems to meet current health and comfort expectations is challenging, requiring significant intervention within occupied spaces, are capital intensive and provide little financial pay-back.
- A solution is the provision of unitized systems – where HVAC systems are provided in each suite rather than through central systems. However, unitized heating and ventilator units, heat pump or other systems that are designed for retrofit, sized for smaller units, high-performance and cost effective currently lacking in the current market.
- Ductwork within suites associated with both central and unitized systems adds cost and disruption into occupied units that prevent uptake.

Energy Recovery Units (ERUs):

Why are ERU's important?

Without heat recovery 100% of the heat and moisture of the air is lost when exhausted. ERU's capture sensible (air temperature) and latent (moisture) energy to reduce heating / cooling and humidification / dehumidification requirements.

What's the gap?

Whereas these components are common in Europe, there are limited products available in the Canadian market design for high performance and suitable for retrofit. Of these, only two are certified for use in passive house projects: SWEGON for large central

applications and Zehnder units for unitized applications. Use of Heat wheels in a residential environment seem to be rare.

What are some solutions?

- Create awareness and cost effectiveness in residential market
- Encourage expansion of product line of already established European suppliers

Heating and Cooling:

Why is heating and cooling important?

Without conditioning of the spaces they either get too hot or too cold. Poor dimensioning or lack of control can lead to overconsumption and/or lack of comfort in the space.

What's the gap?

Lack of small scale technology to provide unit by unit heating and cooling that is right sized, affordable and easy to control (most 2 – 4 times too big). Also need for central heating / cooling loop makes this more expensive for a retrofit.

What are some solutions?

- Centralized heating and cooling through the air with a reheat coil in the unit. No significant cooling potential.
- Hydronic units supplying local heating and cooling to centralized air with a central hydronic loop providing cold or hot water.
- Hydronic heating and cooling with decentralized ventilation unit. Heating and cooling source still centralized.
- Note hydronic heating and cooling can be built into the ventilation system but more realistically may be a fan coil or a gravity wall.

Ventilation air supply:

Why is fresh air important?

Getting fresh air into each suite is essential for health, reducing odour transmission, and comfort.

What is the gap?

Most high-rise buildings built before the 1990s do not have adequate mechanical ventilation within suites. Systems design in decades past use a strategy of pressurizing the corridors, pushing the air under the doors. This leads to uneven air distribution. Odors, sounds from the corridors, potential for pests to travel under the doors, the undercut being covered and thus no fresh air reaching the unit at all. Uneven distribution in the unit. Often short circuited. This strategy does not adequately services unit nor meet current base standards.

What are some solutions?

- Decentralized ventilation approach – install new individual units to each suite – ie Zehnder ComforAir 160 complete with Heat Recovery into bathroom ceiling with ducting to outer wall and rooms.
- Centralized ventilation approach with new ducting and air tightness testing – Use existing supply and exhaust ducting (if in good shape otherwise replace or clean but use shaft space), to supply air to each floor and add new ducting to each suite. Add heat recovery and determine why to do return air so that air streams can cross (for maximum heat recovery)
- New 'for retrofit' easy install ducting systems as used in the UK, but as yet unavailable in Canada.
- Use of ductless systems common in the EU, just entering Canadian market and not standard practice.
- Pre-fabricated retrofit ducting and ERV systems, used in Austria, untested in Canadian context.
- Semi-centralized approach – install one unit per floor in an accessible location to provide air floor by floor (removes stack effect and makes access for filter changes + maintenance easier than in fully decentralized approach)

Natural Ventilation

Why is Natural Ventilation important?

Opening windows connects us to the outside. It is proven to improve health, provide comfort and also if properly connected to the ventilation system reduce fan energy, heating and cooling simply by bringing in fresh outside air.

What is the Gap?

Most units have operable windows but the total opening width is typically limited to 4" (due to balustrade height restriction) Typically this is not enough area to bring meaningful cooling and ventilation into the space. Natural ventilation in retrofits is key to providing cooling and fresh air when cooking among other situations. Importantly, air changes from natural ventilation is not calculated in many North American HVAC codes and standards, yet is core to EU codes. As a result provision for natural ventilation in building design is less common.

What are some solutions?

- Advance codes and standards to accept and encourage natural ventilation.
- Design windows to open through use of guards, juliette balconies etc to remove fall risk
- Test use of 'trickle vents' - windows with built in flow of natural air movement. Common in Europe this approach is rare in Canada and can be imported and tested.
- Create awareness of positive livability and health outcomes of access to natural ventilation through demonstration

Thermal Bridging

Why is thermal bridging important? Typical building designs lead to significant thermal bridges (changes in the building envelope) that lead to a reduction in the thermal performance of the building envelope by 20 – 50%. Thermal bridging represent breaks in insulation, where the internal environment is directly exposed to the exterior via conductive materials without an insulation layer. The following outlines common areas of bridging where solutions are required.

Balconies

Why are balconies important for thermal bridging?

Typical existing balconies are an extension of the concrete slab lacking insulation; acting like radiators to the outside. Without addressing these when improving the building envelope significant heat loss can occur but more importantly they can dramatically increase the risk of mould and condensation at building interiors due to the presence of cold interior surfaces in winter.

What is the Gap?

Ready made solutions to address existing balconies are unavailable in the Canadian market.

What are some solutions:

- Several approaches to addressing balconies exist, including:
    - Full enclosure (make them part of the building and usable space)
    - Make them into a wintergarden but insulate around the edges
    - Remove and replace (replace with thermally broken balconies or structurally separate ones)
    - Wrap – fully wrap with insulation (requiring a bespoke solutions on a project by project basis)
    - Removal
- Balcony enclosure systems and new thermally broken balconies are typical solutions in Europe, with various manufacturers provided off-the-shelf solutions. Demonstrations, product importation and technical partnerships will benefit the Canadian market.

Other Penetrations

Why are other penetrations important?

Most existing buildings have an uncontrolled number of penetrations through the building envelope: gas lines, rain water drainage, gutters, electrical cables, direct vents, etc. These each contribute to heat loss, condensation and mould risk and make the future building envelope more expensive.

What is the gap? Most penetrations are not treated or thought about and doing so can make the retrofit more expensive and slower.

What are some solutions?

- Better details – this takes time and iterative thermal modelling but can achieve it.
- Better products – fiberglass instead of steel for structural ties, special EIFS attachment pieces rather than screws, armatherm and thermal isolators for difficult connections.
- Limit penetrations and changes as much as possible

Typical Conditions:

Why are typical conditions important?

Because they are repeated. Wall to floor slab connections, wall to inner wall connections can increase energy consumption by as much as 5 – 10% of the total building energy consumption. Developing a great detail is essential.

What is the gap? Because thermal bridges have been ignored for so long, little experience on developing better details, materials are more expensive and are not standard for each project. Even standard conditions – floor to wall, roof to wall, window to wall, etc are not standard and developing a high performance detail takes time, expertise and sometimes special products

What are some solutions?

- Develop standard solutions for retrofits.
- Provide access to better products

Overall Industry and Trade-Readiness: Training, Means and Methods

Why is training, means and methods important?

High performance buildings are only as good as they are built and operated. Without quality building or operation most buildings fall short of their aspirational goals. Additionally, lack of training and awareness of building techniques often results in price jumps that reflect a desire to mitigate risk but are not reflective of the materials or effort to do.

What is the gap?

A lack of trained tradespeople in high performance air tight construction techniques. Construction quality lags, costs rise and it is difficult even to attract bidders.

What are some solutions?

- Provide increased training opportunities and training ambassadors for builders. (similar to BC Housing's train the trainer program to help prepare builders for the step code)
- Support colleges and universities to develop high performance building labs / spaces that offer ongoing training for tradespeople, architects and engineers (BCIT High Performance Building Lab as an example)
- Provide publicly-sponsored design assist / review (ie Union Gas Savings by Design) – could also envision to do this for builders. Ie Lab in a box to the construction site.

Jurisdictional Scan and Case Studies

While widespread deep retrofits are in their nascency in a Canadian context, other jurisdictions have been accelerating retrofits for decades. A jurisdictional scan can help to uncover successes and areas of learning, as well as point to solutions which might be adapted for the Canadian market.

Using a combination of interviews, field investigation and technical analysis, three jurisdictions have been outlined here: Germany, the United Kingdom and British Columbia, Canada. The scans identify technical and policy solutions addressing the deep-retrofits of residential high-rise buildings in general, and solutions for thermal bridging; upgrading ventilation systems; and cost-effective and non-combustible building envelopes specifically. To illustrate technical approaches to retrofit in each jurisdiction, a case study of a local retrofit project is featured for each.

- **Germany**
    - Case Study: Güterstraße 30, Pforzheim, Germany
- **United Kingdom**
    - Case Study: Five Tower Blocks, Oxford, United Kingdom
- **British Columbia, Canada**
    - Case Study: Case Study: Grandview Terrace, East Vancouver, British Columbia

Case Study Engagement:

United Kingdom: CUG+R engaged members of the Oxford City Council over several conference calls to understand the council's experience retrofitting five tower blocks. In particular, Rockwool cladding was used to meet new performance and safety standards in the United Kingdom following the Grenfell tragedy.

Germany: Members of the CUG+R research team conducted a site visit of Güterstraße 30 building in Pforzheim, Germany. Güterstraße 30 was one of 15 projects funded by the German federal Zukunft Haus (Future House) fund to pilot net zero construction and renovation. The end result was a Passive House certified project. The retrofit project mainly dealt with improving mechanical systems and upgrading the building envelope, with some in-suite construction required. Prefabrication played a considerable role in ensuring the fastest construction possible.

British Columbia: CUG+R has held several conversations with the City of Vancouver, BC Housing as well as New City Contracting, the primary contractor for the Grandview Terrace Retrofit. Retrofitting a series of aging higrises (8 storeys), duplexes and townhomes owned by BC Housing provides a solid case study to review the BC Step Code Program.

Germany

Policy Context:

Beginning in the 1970s, Germany introduced an energy code, prescribing base standards for new construction. This energy code has been updated regularly, 'stepping' toward more stringent performance expectations, and providing forward guidance on future requirements of the code. Beginning in the 1990s, the code included requirements for substantial renovations to existing buildings.

In parallel, the Kreditanstalt für Wiederaufbau (KfW) Bank, a federal corporation integrated with the commercial banking system, provided targeted loans and grants for energy projects which met Federal performance criteria. As a result of these tools, over the past decades the construction industry as a whole has regularly surpassed Federal targets – there being a positive incentive for doing so through access to KfW funds.

Despite building codes being implemented at the municipal level, federal targets and funding mechanisms have helped to drive the transformation of the German construction industry toward the delivery of expert green construction, including trades, manufacturers, consultants and building owners. It has also made Germany a world leader in exporting green construction products.

National Energy Targets:

The current German federal energy code is the EnEV 2014, with the EnEV 2019 coming into effect for all buildings in 2021. The EnEV 2019 aligns with the latest EU carbon reduction targets, and prescribes a maximum of 50 kWh/m2 of energy use for heating, cooling and hot water for all buildings. Surpassing this target results in applicability for grants and favourable loans through the KfW.

KfW Financing:

- Loan periods are 20 years, and longer terms are being considered. The current interest rate of the loans is 0.75% for a ten-year term (refinanced at ten years), or 1.5% fixed for a twenty-year period;
- Performance-based granting of 12% - 27.5% of the loan value is available to projects that achieve various levels of energy performance beyond the baseline. A grant, or 'repayment subsidy' is achieved through the reduction of the loan duration. For example,

a 12% repayment subsidy will result in the loan period being reduced from 20 years to 17.
- KfW programs are delivered through commercial banks, with KfW establishing project criteria and underwriting loans;
- The KfW does not monitor building operations, but rather performs audits to ensure that buildings are constructed or retrofitted as specified to achieve energy performance levels;
- Each year the KfW randomly audits several thousand projects to ensure they are built as specified;
- The KfW provides financing to tens of thousands of projects at a given time. Since 2006, it has enabled the reduction of over 7 megatonnes of GHGs, as well as creating over 390,000 jobs on an annual basis.

Case Study: Güterstraße 30, Pforzheim, Germany

Market Transformation Phase: Late Majority (Best in class in a mature retrofit market)

Owner: Pforzheimer Bau und Grund

Building Characteristics:
- Size (floors or sq ft): 10 storeys
- Number and type of units: 21,291 sq ft / 17 units
- Type of organization (private, non-profit, social housing, etc): municipal public housing provider
- Passive House certified project

Retrofit Scope:

Güterstraße 30 was one of 15 projects funded by the German federal *Zukunft Haus* (Future House) fund to pilot net zero construction and renovation. The end result was a Passive House certified project. The retrofit project mainly dealt with improving mechanical systems and upgrading the building envelope, with some in-suite construction required. Work included:
- Overcladding
- New windows
- Building out and extending the facade, adding balconies
- Adding a new floor of penthouses to help subsidize the project
- Ice storage in basement for energy recovery
- Work conducted with residents in place, and while keeping rents affordable for sitting tenants

Key Learnings:

- The project was funded through various German green finance vehicles including the KfW Bank, prodiving performance based favourable lending and grants.
- While the project is a landmark in Pforzheim, and one of only several Passive House retrofits in the EU, products availability and trade readiness was not felt to be a problem by the project team due to a mature low-energy construction market.
- The full envelope system was enhanced, with new windows, insulation and exterior cladding. Windows were designed to be installed outboard of window frames to allow for ease of installation and to ensure continuity of the air-barrier independent of the rough opening of the former windows. This also minimized need for entry into units for window install.
- Existing balconies were removed, and new, more generously sized and thermally broken balconies were installed in their place as part of the comprehensive envelope system.
- A central ventilation system was replaced with unitized ERVs in each suite, with minimal ductwork, minimizing construction disruption in units and cost.
- A precast cladding system was installed atop rockwool insulation, placed outboard of the original facade.
- The largest disruption occurred at the existing facade for window removal where adjacent components of the facade containing asbestos were fully removed. This required careful protection of units and living spaces.
- Significant components of new construction were prefabricated off site, reducing on-site construction, such as window systems and façade panels. The owner also deliberately did not include in-suite interior work to avoid increasing disruptions, attempted to strike a balance of what is reasonable to do and what is not reasonable to do with residents in place.
- The project integrated renewables to offset energy usage for near net zero status, including a rare application in retrofit construction of an ice storage system integrated into the precast facade. The engineering team suggested this was done to enhance the ‘landmark’ aspect of the project and may not have been necessary from a performance perspective.

United Kingdom

Policy Context
The UK Code for Sustainable Homes was a key mechanism in the advancement of British green industry. This framework was enacted in 2007, as part of a strategy to reduce carbon emissions. From 2008-2015, the code was mandatory in many jurisdictions, building a culture of higher-performance construction, with a focus not only on emissions but also on health, waste, ecology, and other resilience factors. During this time, there was tangible growth in the knowledge, products and skills required to grow the market. Since 2015, the code has been superseded by Building Regulations and a number of certification programs.

A number of other measures contribute to the market environment in the UK: the Decent Homes Standard (2006), prescribes base standards for existing affordable housing, addressing air quality, ventilation, damp, state of repair, base amenity and comfort. As of 2016, landlords cannot refuse requests from tenants to make improvements for energy efficiency, with buildings rated E energy class or lower illegal to rent out.

The combination of these programs and regulations have resulted in considerable activity in tower block refurbishment throughout the UK.

Case Study: Five Tower Blocks, Oxford, United Kingdom

Market Transformation Phase: Early Majority (Higher performance in an emerging retrofit market)

Owner: Oxford City
Building Characteristics: Five “tower blocks”: Evenlode and Windrush towers in Blackbird Leys, Hockmore Tower in Cowley, Plowman Tower in Northway and Foresters Towers in Wood Farm

- Number and type of units: ~340 units
- Type of organization (private, non-profit, social housing, etc): Public social housing (though roughly 54 units were purchased by tenants through rent-to-buy programs)
- Length of project/construction: 2016 to 2018

Retrofit Scope:
The range of repairs across all five of the city’s tower blocks will include:

- Works to the communal structure of the blocks

- Over-cladding and additional insulation (non-combustible insulation, fire breaks within the cladding system)
- Replacement of windows & New heating and ventilation system
- Upgrading communal electrical and fire safety systems and refurbishment of elevators
- Updates include post-Grenfell Code Requirements
- Works will also be carried out to improve the grounds, car parks, fencing, landscaping, and front entrances.

Key Learnings:

- Retrofits occurred with residents in place.
- The envelope was enclosed with rockwool insulation with a mixture of stucco and panel sheathing systems.
- Existing balconies were enclosed to form a 'winter garden', where the primary insulation plane is within the inner building face; windows facing balconies are replaced; the balcony upturn and soffit is insulated and clad; and balconies enclosed with operable windows using a purpose built system.
- Building ventilation was upgraded through in-suite HRVs, using rapid install 'snap' in place ductwork (a system as yet unavailable in Canada). This system eliminates the need for sheet metal and drywall work for ventilation ducts.
- Individual thermostatic controls were introduced in each suite.
- The buildings introduced a sprinkler system, face mounted to ceilings with a covered with a tamper guard. This system eliminates the need for drywall work.
- Contractor Selection: Residents participated in the selection of contractor (based on track record with similar projects)
    - Residents were invited to visit previous similar projects and speak to residents there
- Builder was contractually required to provide a "high degree of customer care" and opted to provide a resident liaison on-site to meet this criteria.
    - This strategy allowed the contractor to mitigate lost time due to access refusal. Although in some cases, worst case scenarios resulted in legal measures to allow suite access.
- Clear relationship established between builder and council
    - Regular check-ins between constructor and landlord re: tenant issues.
    - Builder not responsible for issues which were the legal responsibility of the landlord, but many items only escalated to landlord once vetted by constructor tenant liaison.

Additional Learnings – Impact of Grenfell Tragedy:

Following the Grenfell tragedy buildings regulations have been rapidly evolving in the UK. Selected changes include:

- Various forms of insulation and cladding systems have been banned from use in high-rise buildings. Importantly EPS type insulation, in common usage in Canada, is now non-compliant in the UK.
- All high-rise buildings to be sprinklered, with annual maintenance required. (Currently most high-rise residential buildings in Canada do not have sprinkler systems).
- All suites to be compartmentalized with firestops between all vertical and horizontal risers (common practice in Canada).
- Replacement of all suite doors to new standard and upgrade fire doors.
- Upgraded Fire Alarm System standards.

In the case of the Oxford Towers explored above, an aluminum rainscreen cladding system used atop non-flammable rockwool insulation was de-mounted and replaced. While the insulation material was not flammable (as was the case at Grenfell), the Aluminum panel system can ignite if exposed to high temperatures. Currently over 200 high-rise buildings are in the process of ‘re-cladding’ to adhere to new codes. A £200 million pound fund has been established by the government to aid in fire compliance and ‘re-cladding’ in private buildings across the UK.

British Columbia, Canada

Policy Context

In 2017, British Columbia introduced the **BC Energy Step Code** – a provincial energy performance regulation that all new buildings will be built for net-zero-readiness by 2032. It provides forward guidance on the process by which base codes will increase requirements in a graduated, or 'stepped' manner toward net zero. To enable market readiness, the legislation allows individual municipalities to require and incentives performance beyond the current in-force base building code. Though the Step Code does not yet include retrofit construction projects, the code has generally upskilled the construction industry and created the market and expertise to carry out high performance retrofits. This process has accelerated energy requirements throughout the Province - for instance all public buildings in the City of Vancouver are now to be built to the Passive House Standard, with classes of private buildings to follow well ahead of base code timelines. Investments in municipal building departments to advanced literacy of understanding and approving low-energy projects, making possible 'fast track' and lower fee approval paths for projects that surpass base code.

A recent 'Lessons Learned' report summarizing success in the initial roll out of the BC Step Code outlines the following:

1. Importance of shared leadership for achieving the target – Inclusion of construction associations, building stakeholders, municipalities and building consultants in design, launch and roll out of legislation;
2. Setting a target and working backwards – setting Net-Zero ready by 2032 and clearly showing a path to get there;
3. Identifying and tackling pain points – cost was identified as a perceived risk, true costs were assessed and incentives provided to aid in closing gaps;
4. An 'easy on-ramp' approach – the first level of the code only requires proof current targets are met using the existing building code with an energy advisor, creating literacy for energy design and reporting;
5. Enabling innovation in local governments – municipalities with more capacity were engaged as trailblazers allowing for a staged adoption of the code while still building industry know-how, case studies, product availability.

As a result of the BC Step Code, BC has developed Canada largest number of complete and in-process low-energy buildings, as well as a supply chain to support them (such as windows, ventilator units and trained trades) unknown in the rest of Canada, if not North America.

Case Study: Grandview Terrace, East Vancouver, British Columbia

Market Transformation Phase: Early Adopter (Demonstration of comprehensive retrofit in an unfamiliar market)

Name of Project: Grandview Terrace
Owner: BC Housing - Directly Managed
Building Characteristics

- Size (floor area): 13,199 m^2
- Number and type of units: 154 Units
  Housing Types:
  - High Rise Apartment (8 storeys) x 2
  - Duplexes (attached to high rise towers, 2 storeys) x 2 connected
  - Townhouses (3 storeys) x 6 separate buildings
- Type of organization (private, non-profit, social housing, etc): Public social Housing
- Length of construction: Construction began in June 2019, and is expected to be completed by October 31st, 2019

Retrofit Scope:

- **Building Envelope Remediation (BER):** The building envelope was replaced and is now constructed of: The existing CMU structural Wall, Insulated aluminum panels on the towers, and Hardie Board exterior wall finish on the duplexes and townhomes, Weatherstripping and air sealing of the buildings, Upgraded wall cavity insulation for all buildings, with exterior insulation added in most locations, Installation of energy efficient low heat gain windows on all buildings
- **Upgraded Heating System:** New low temperature heating radiators were installed throughout all six buildings.
- **Roof Replacement:** Full roof replacement with additional insulation
- **Ventilation:** Replaced existing make-up Air unit with condensing unit prior to the current project Central air conditioning unit replacement . All bathroom and range hood fans were replaced. The new range hood fans exhaust to the exterior
- **Plumbing:** A full re-pipe of the buildings was also included in the project.
- **Electrical:** Existing natural gas generator was replaced with a diesel fuel generator, and was relocated from the mechanical room to the exterior. Energy efficient lighting upgrades. Common area lighting controls were installed
- **Landscaping:** Aged and deteriorating landscaping elements were replaced and rejuvenated, along with some grading improvements.

Key Learnings:

- The project achieved a comprehensive and systems based retrofit with residents in place, among the first of its kind in Canada.
- Performance levels surpassed base codes through BC Housing leadership and commitment to energy performance goals.
- The construction process used a sophisticated process to manage residents in place, whereby the contractor staffed parallel superintendent positions, one charged exclusively with tenant communication, and project schedule development based on tenant needs.

Summary Table (Gap Analysis & Case Studies)

Case Study	Market Transformation Phase		Envelope	
BC Housing Grandview Terrace	**Phase**	**Notes**	**Component**	**Strategy**
Canada	Early Adopter (Demonstration of comprehensive retrofit in an unfamiliar market)	Mid-Performance Range	Windows	**Double glazed**
			Shading	N/A
			Cladding	**New exterior over-cladding: rockwool with hardyboard sheathing**
Oxford City Council Towers	**Phase**	**Notes**	**Component**	**Strategy**
United Kingdom	Early Majority (Higher performance in an emerging retrofit market)	High-Performance Range	Windows	**Double glazed, higher performance and retrofit ready**
			Shading	N/A
			Cladding	**New exterior over-cladding: rockwool and metal panel cladding**
Pforzeim Bau und Grund Tower	**Phase**	**Notes**	**Component**	**Strategy**
Germany	Late Majority (Best in Class in a mature retrofit market)	Peak-Performance	Windows	**Triple glazed, designed for retrofit exterior face application**
			Shading	**Exterior operables shades**
			Cladding	**New exterior over-cladding: rockwool and precast concrete cladding**

Availability in Canadian Marke of Product / Approach:
Commonly Available
Challenging to Implement
Unavailable

Case Study	Ventilation		Thermal Bridging	
BC Housing Grandview Terrace	**Component**	**Notes**	**Component**	**Notes**
Canada	Heating	**Hydronic, existing system**	Balconies	N/A
	Fresh Air	**Central system replacement with air condition and dehumidification**	Typ. Details	**Commitment to air tightness, mid performance mandate**
	Natural Ventilation	N/A	Other Penetrations	**Commitment to air tightness, mid performance mandate**
	Heat Recovery	N/A		
Oxford City Council Towers	Component	Notes	Component	Notes
United Kingdom	Heating	**Hydronic, Updated Low-Energy System**	Balconies	**Enclosed with wintergarden glazed assembly**
	Fresh Air	**Retrofit specific unitized HERV systems with 'snap' ductwork for easy install**	Typ. Details	**Commitment to air tightness, high performance mandate**
	Natural Ventilation	**Operable Windows**	Other Penetrations	**Commitment to air tightness, high performance mandate**
	Heat Recovery	**Contained in in-suite units**		
Pforzeim Bau und Grund Tower	Component	Notes	Component	Notes
Germany	Heating	**Hydronic, Updated Low-Energy System**	Balconies	**Replaced, thermally broken new assembly**
	Fresh Air	**In-suite HERVs, minimal ductwork, Passive House Certified**	Typ. Details	**PH House Certified**
	Natural Ventilation	**Operable Windows / trickle vents**	Other Penetrations	**PH House Certified**
	Heat Recovery	**Contained in in-suite units, Passive House Certified**		

Availability in Canadian Marke of Product / Approach:
Commonly Available
Challenging to Implement
Unavailable

Case Study	Residents In-Situ		Regulation	
BC Housing Grandview Terrace	**Occupancy During Construction**	**Notes**	**Context**	**Notes**
Canada	**Residents in Place**	**Sophisticated staging, scheduling and communication plan lead by constructor superintendent in consultation with BC Housing. Model scaling to other complex renovation projects.**	Code	**BC Step Code**
			Funding	**Provincial Low-Carbon Funds / BC Housing**
Oxford City Council Towers	**Occupancy During Construction**	**Notes**	**Context**	**Notes**
United Kingdom	**Residents in Place**	**Council mandated and resident endorsed 'customer care' directive for selected contractor, ensuring minimal tenant disruption and inclusion in key decision making through contractor 'tenant liaison' and weekly meetings between council, tenants and contractor.**	Code	Code for Sustainable Homes / Decent Homes Standard
			Funding	Oxford Council (Supported by Government Carbon Reduction Funds)
Pforzeim Bau und Grund Tower	**Occupancy During Construction**	**Notes**	**Context**	**Notes**
Germany	**Residents in Place**	**Interior works minimized and per-fabrication used to minimize construction duration and disruption. Housing company highly involved in day to day construction to minimize tenant disruption.**	Code	EnEv 2019
			Funding	KfW

Availability in Canadian Marke of Product / Approach:
Commonly Available
Challenging to Implement
Unavailable

Industry Engagement & Recommendation Development

Market Transformation Workshop with NAIMA Canada

In September, CUG+R hosted a Market Transformation Workshop with NAIMA Canada, a key member of the Advisory Group. The workshop was designed to discuss, brainstorm and identify: the state of the Canadian retrofit market, trade readiness, market transformation through products, market transformation through means and methods as well as identifying opportunities for further engagement with industry partners and manufacturers. Key learnings included:

- Confirmed market gaps in Canadian retrofit industry
    - Envelope/Cladding
    - Thermal Bridging & Balconies
    - Ventilation (HVAC)
- Training programs are for profit and currently “knowledge hoarding”
- Codes and Regulations are the best way to move the market
- It is important toIdentify industry/manufactures who can champion new technology and techniques
- Partnering with manufacturers for demonstration projects is key

The workshop agenda can be found in Appendix D.

Stakeholder Workshops

Using the gap analysis and case studies, the research team identified five themes that reflect the Canadian issues around market transformation, product importation and industry training. Essentially, after identifying the items missing in Canada within the *Building Envelope, Thermal Bridging* and *Ventilation* areas and comparing it to other international jurisdictions that are more advanced, it became clear that wider discussion was needed with industry stakeholders.

As a result, two half-day workshops - one in Toronto, ON and one in Vancouver, BC - were held in late 2019 and early 2020. A set of industry experts from British Columbia and Ontario, who have experience with high performance energy retrofit projects were invited. In total, nearly 30

stakeholders attended and included housing authorities, engineering and design firms, municipal government divisions and environmental non-profits. In particular, British Columbia highlighted their experience with the StepCode and demonstrated the ways in which it has played a role in transforming the market on the west coast.

The five themes and workshop topics were:

1. What's Missing: Products & Supply Chain
2. How To Do It Better: Contractor Scope and Capacity in Executing Complex Retrofits
3. Putting Residents First: Means and Methods to Minimize Disruption
4. Inducing Demand and Supporting Delivery: Supporting Industry Growth
5. Establishing a Baseline: Performance Standards & Enforcement

These five themes were used to design the workshop agenda, devoting time for each theme area, discussing related issues as well as developing specific recommendations. A consolidated summary of the two workshops responses is below, organized by the five theme areas. All recommendations stemming from the workshops are included in the Recommendations Section. The workshop agenda can be found in Appendix D.

TOPIC 1: What's Missing: Products & Supply Chain
This subject area explored the following themes:

- What products are available elsewhere, but are missing in our market?
- What barriers are there to importing them to our market?
- What products already available in our market could be adapted for use in retrofit?
- What are the key supply chain areas where innovation is required?
- Are there products in BC that were developed in response to the leaky condo crisis whose use could be expanded nationally?

Summary of Industry Input:
There are a wide range of products -- from windows to mechanical system components -- that are geared to high-performance retrofits but are not readily available in Canada. Industry partners have indicated that challenges associated with imports are due to several reasons, including: costly and confusing product certification, warranties, installation and training, and insufficient economies of scale. Further, contractors and sub-trades often increase the cost of unfamiliar or non-standard products and assemblies by 15%-20% in an attempt to mitigate their risk.

Market Gaps / Missing Products: Industry partners engaged noted the difficulty in securing the following products in a cost-effective manner for Canadian high-performance retrofits. It was noted that many of these products would also be applicable for new-build high-performance housing.

- Heating, Ventilation, Air Conditioning and Plumbing Equipment:
    - HRVs, ERVs, Heat Pumps, Kitchen Vent HRVs:
        - Combo HRV / heat pump module is unavailable in Canadian markets
        - Heat pumps with low global-warming potential (GWP) coolants
        - More competitive global-warming potential (GWP) refrigerants
        - Larger heat pumps that can provide full loads in various Canadian climate zones
        - HRVs/ERVs sized for use in existing apartments; designed to fit in the closet or within available ceiling space
        - Retrofit ventilation systems, including modular ducting solutions design to minimize disruptions within units
        - Decentralized HRVs/ERVs with simpler maintenance requirements
    - All-in-one "magic box" (i.e. combination space heating, hot water heating and ventilation unit) - not yet available in Canada
    - Retrofit revenue-grade metering systems for individual suites including on HVAC units, water usage and electrical usage. HVAC/plumbing
- Opaque and Transparent Envelope Components:
    - Glazing Systems:
        - Limited high-performance glazing systems available with extremely high

cost premiums
        - Low heat transfer coefficient insulated glazing units (IGUs) not available in Canada
        - Barriers to securing CSA certifications can be a barrier to import
    - Overcladding:
        - Thicker insulation products not commonly available in market, or available at a significant cost and risk premium
        - Importing is “psychological barrier for insulation manufacturers”; with insufficient demand perceived
    - Insulated or Low-Conductivity Connections
        - Low-conductivity cladding support systems, thermally-broken balcony connections, thermally-broken roof anchors -- all rarely used and therefore priced at significant premiums

The Import Challenge:

- Imported products are often missing critical local information (ability to accommodate Canadian hardware requirements, software protocols, or typical local installation procedures, etc.)
- CSA testing and certification is complex, expensive, and often not worthwhile on a project-by-project basis - economies of scale are required
    - Fans, building scale heat pumps, ventilators
    - “Murky road for testing”
- Warranties, certified installation, and training for operators is challenging
- Simplified approval procedure for importing foreign products (European product “CE” equivalencies / reciprocity)
- Insufficient volume can deter potential importers
- Pipeline for communication of product gaps is required in order to communicate needs clearly and to the correct players internationally
- Federal and provincial agencies and authorities need to play a more active role
    - Industry Canada has a role to play in consolidating gaps, and facilitating testing, certification, and other approvals, while assisting with risk mitigation
- Difficulty partnering with European providers
    - Concerns over “taking opportunity away from Canadian business”
- Procurement is a challenge (sole sourcing, procurement regulations)
    - Very difficult to use IPD (Integrated Product Delivery) on publicly-procured projects
- Consultants and Owners can be risk averse to specifying new products and assemblies
    - Support must be provided by manufacturers for early adopters (operations and maintenance, warranties, certified installation, etc.)
    - New products must be easily integrated into owner operations and maintenance
    - Clear project charters help to structure ordered decision-making, especially for

early adopters where there are fewer example projects from which to learn

Increased Costs:

- "Luxury and efficiency have basically been bundled together"
    - High efficiency components must be competitively priced to encourage use
    - Demand drives price; prices go down when regulation is increased which is the most effective driver of demand (BC Step Code is prime example)
- When a product is not available locally, there are often project delays and costs
- Labour costs are a major contributor to cost premiums (15% - 20%)
    - Need to create comfort and familiarity with new products and systems among sub-trades
        - Trades training (on the job/site)
        - Create certifications that tradespeople can acquire: 'retrofit experts' or 'high-performance building experts'
    - Labour supply: labour premiums on high-performance jobs are also related to overall shortages in tradespeople
        - Encouraging people to join the trades is critical in already-overheated markets

TOPIC 2: How To Do It Better: Contractor Scope and Capacity in Executing Complex Retrofits

This subject area explored the following themes:

- What size and type of contracting outfits are best suited for retrofit?
- What training would enhance trade readiness?
- Where are current gaps in means and methods, and how can we fill them?
- What has BC done well? What worked and what hasn't in the recladding projects following the leaky condo crisis?

Summary of Industry Input:

Across the project continuum, Canadian engineers and architects, contractors, trades and government all require training, education and awareness around high-performance retrofit design and construction. The perceived risk associated with unknowns specific to retrofits can lead to price escalation in the 15-20% range. Shortages of contractors and skilled tradespeople experienced in high-performance retrofits contribute to these escalations. Compounding these issues, industry representatives indicated that project delivery and procurement as well as the bidding processes for public projects make it difficult to use new products and designs or import products.

Training, Education and Awareness:

- Setting training targets is a starting point but is no guarantee for new program development
    - Adapting curricula takes time and may not be completed quickly enough to meet Canada's carbon reduction or housing targets
- Industry-wide training improvements are most effective when triggered by regulation
    - Following insulation requirements changing in the Building Code, insulation manufacturers brought on in-house building scientists to assist their trades with installation
- Training should be accompanied by education and awareness
    - "We keep selling Fords, like no one has heard of a Ferrari"
    - Returns on investment of individual measures are typically not enough to build a business case, but coupled with averted capital repairs and resilience-planning, owners and decision makers are beginning to see the need for holistic retrofits
- Training is required to normalize a broad spectrum of relatively simple retrofit concepts
    - Air tightness testing, retrofit envelope assemblies, ventilation retrofit and commissioning approaches could all benefit from trades/owners/architects and engineers understanding the 'big picture' of how holistic retrofits change the building as a whole
- Structure training as an opportunity to leverage trades' expertise to tackle new problems
    - "You already know how to do this, you know how to work quickly and effectively, we need that attitude to tackle new climate change challenges"

- Training strategy must be distributed from new apprentices in the classroom all the way to highly-experienced trades in the field
    - Training can be delivered on site, on a project-specific basis, related to a specific product or technology, or more holistically delivered through structured curricula
    - Recommendation to provide adult certificate programs on specific skills
- Trades training for high-performance outcomes is already normalized in the commercial/institutional building sectors
    - Bringing this level of rigour to the residential sector is simply a matter of changing perceptions and expectations
    - Communication strategy is required to demonstrate that growth of relatively sophisticated contracting outfits into the residential sector is a major business opportunity
- “Retaining knowledge” is hard from project to project
    - Case studies, training programs, certifications, and manufacturing-led training can help
    - Convey to trades that they are getting paid to learn: will be first in line for the next project
    - Convey that there will be more demand/projects coming down the pipeline
- Step codes such as the Toronto Green Standard (TGS) are not being communicated loudly enough
    - Previous increase in TGS took industry by surprise; industry needs ample time to prepare for the future increase in these codes through training and up-skilling in anticipation of future demand
    - All players having line of sight on step code increases will change market rapidly
- Role of federal government in funding/infrastructure for trades training nation-wide
    - Apprenticeship program is formalized and turning out a decent ‘product’
    - Compared to European model, which builds more ‘stature’, bias in Canada still undervalues the trades (some Provinces/Territories are ahead on changing this bias)

Project Delivery:

- Delivery method has an impact on quality of outcomes
    - Design-bid-build is most commonly used
    - Potential to de-risk by engaging design and contractor teams together (Integrated Project Delivery or similar) to bring contractor into the decision-making process
    - Bring trades and contractors into the design process and have their input in the problem-solving process
        - Rocky Mountain Institute (RMI) is incorporating IPD into all pilots - DOE funding required them to be private and make economic sense
- People still working in silos
    - Strong project managers help to foresee and avert perceived or actual risk

    - Contractor must anticipate sub-trade risk aversion and work to mitigate
    - Delivery means from feasibility and assessment all the way through to completion
- Public projects struggle with procurement where there are limited products on the market which can meet the specifications

TOPIC 3: Putting Residents First: Means and Methods to Minimize Disruption
This subject area explored the following themes:

- How can resident disruption be minimized during retrofit construction projects?
- What is the role of the contractor in mitigating disruption?
- What is the role of design in mitigating disruption?
- How can residents be engaged participants in the process?

Summary of Industry Input:
Retrofit construction projects can be extremely disruptive, confusing and create a sense of insecurity. Retrofits in occupied buildings require a different approach than typical new builds that considers sequencing, communication and maximizing preparation off-site. In Canada, these types of procedures are not yet well understood.

Unhappy tenants can result in delays, cost overruns and a dissatisfied community that can negate project objectives. Strategies including prefabrication and modular systems, design strategies, installation means and methods that reduce unit entry, tenant engagement and protocols, and contractor anticipation of challenges can help to make projects run more smoothly, with better outcomes and perceptions of success for all parties.

Project Planning - Tenant Communications & Engagement

- Community events and communications provide big-picture context to residents, and an opportunity to build relationships up front and ensure design works for tenants
    - Tenants are more tolerant of retrofit when they know what the goal is, and have an understanding of the schedule and how it will affect them
- Effective engagement and communication requires time and resources, and must be built into project budgets
    - Funding requirements to allocate budgets to engagements will be critical, given that capital dollars are typically already tightly stretched
- Information should be delivered in a number of formats
    - A combination of signage, lobby information panel, elevator notices, suite-by-suite notifications, information sessions, and regular email/phone updates may be required
    - Identification of informed individuals is crucial
        - Owner's operations and maintenance staff on site should be as informed

as possible; misinformation can be cause of frustration
        - Tenants can become informal liaisons to others if they understand and are invested in the outcomes of the process
- Tenant Steering Committees can be useful
    - Small group of motivated and informed tenants
    - Can provide day-to-day knowledge of repeat failures which can inform project assumptions
    - Can help to disseminate vision / end results to other tenants (tour similar renovated buildings)
    - Can help to identify friction points during construction before they become larger problems impacting progress
    - Can provide feedback to improve next retrofit after construction
- Respite spaces (on-site or in neighbourhood) should be created for tenants who cannot remain in their units while work is taking place
    - Swing-space units may be required for more extensive work which requires overnight displacement from units
        - This requires owners to keep units unoccupied upon turnover for years/months in advance of the project
- Strategies required by owner:
    - Communicating best practices and getting buy-in
    - Setting expectations with tenants to get ahead of friction points
    - How to manage those who will never buy-in
    - How to make tenants partners in the project
- Unsophisticated owners will need to upskill their operations teams
    - Social Housing sector may be leader in this respect

Construction - Tenant Communications & Engagement

- Construction schedules
    - Working hours anticipated in the construction schedule must be adjusted to suit tenant requirements
    - Being permitted entry to suites is critical to maintaining the construction schedule
    - Sequencing plans must be designed to minimize the number of access points to unit - in some projects where this is uncoordinated, contractors were required to enter units up to 26 times.
- RFPs should include a required Tenant Liaison role on the contractor's team
    - Responsibilities may include: pre-construction tenant needs audit; scheduling and contingencies to ensure no labourer down-time; communications, problem-solving, and escalating to owner as required
    - Ensures that someone with daily tenant interaction is always on site; has tenant best interests in mind
    - Developing plan with owner for tenants refusing entry

    - Unable to access planned unit? Have backup unit or another way to use workers elsewhere without wasting day(s) of work.
    - Role was piloted at BC Housing's Grandview Terrace with extremely promising results
    - Addition of this role to construction teams will have a cost impact
- Trades should be trained in protocols for entering suites, in accordance with a security plan
- Temporary internal partitions may need to be built into means and methods budgets for more invasive works in occupied suites
- Involving contractors during design can have a number of benefits for early adopter projects:
    - How to address unknowns inherent in retrofits
    - How to choose a project delivery method which suits the project conditions
    - How to capture contractor input and realistic costing at design phase

Prefabrication and Modular Systems

- Cost-effective prefabricated panelized solutions are nearly non-existent in Canada (ie: Energiesprong assemblies) due to high costs associated with equipment for fabrication; lack of sophistication of most fabrication facilities.
- Opportunity for retrofit panel solutions to join forces with tall wood panel solutions -- which also needs hanging panels and rapid construction.
- Modular HVAC and plumbing retrofit systems are also critical
    - Packaged "ready-to-install" mechanical equipment
        - Water heating
        - Space heating
        - Ventilation
    - Modular, fast, and safe approaches to riser replacements are needed
        - Challenging to complete quickly and without noise/dust/service disruptions, but widely required throughout aging building

TOPIC 4: Inducing Demand and Supporting Delivery: Supporting Industry Growth
This subject area explored the following themes:

- Which local/national industry leads can innovate to fill gaps in the retrofit industry?
- How can European or other international products best make their way to our market?
- What technical partnerships can help drive up local capacity through training and support?
- How have the Step Code and Vancouver Building Code been effective in driving demand?

Summary of Industry Input:
For industry participants, inducing demand and supporting the delivery of high-performance energy retrofits comes down to (a) early adopters being incented through funding and other supports, and later (b) industry changes being solidified through mandatory minimums regulated by codes. Varying types of building owners will be willing to participate in phases (a) and (b). Since these types of retrofits in today's market are generally not able to generate a short- to medium-term return on investment, owners must be supported through government funding and financing.

Overall Industry Growth

- Social housing sector is poised to lead as early adopter; with more government support can de-risk solutions for larger-scale implementation through regulation
- In BC, supply chain has improved dramatically since adoption of Step Code - push nationally to launch green industry investment
- Different strategies needed for different markets / archetypes
- Stepwise replacement needs to be mapped as an option for owners and unit holders
- Measuring improvements to productivity and cost decreases with increased demand will be critical to mapping market growth at all scales
- Small municipalities can travel to larger cities to learn / use standards
- Need to communicate future resilience demands / needs of building
    - What will it be like in your building in summer/winter without power?
    - How important are operational ventilations systems in wildfire season?
    - Where will tenants be housed if the building is evacuated due to a system failure?

Public Funding as Industry Catalyst – the National Housing Strategy:

- National Housing Strategy Repair and Renewal Funding a game changer ($5Billion and 240,000 unit over ten years). To advance uptake and industry stimulation, the program could:
    - Communicate to broader industry impact of funding to promote investment to address current industry gaps;
    - Support for demonstrations that push gaps will advance industry;

    - Partner with other Ministries and programs to provide support beyond project cost support to broader industry stimulation such as:
        - Trade and industry training;
        - Product development (see Topic 2);
            - By Canadian firms
            - With EU Partners
            - Through product importation and testing
    - Calibration of funding requirements that both expand participation while increasingly performance targets will push industry;
- Funding and incentives provided by NHS, coupled with a Step Code approach (see Topic 4) can drive long term change toward 2030 / 2050 goals.
- As projet's develop, rapid feedback required to avoid 'innovation' or policy misfires
- Challenges with public funding can include:
    - High construction costs that put pressure on budgets
    - Incentives and other funding that are not stackable
    - Deadlines for dollars to be spent are often in conflict with good integrated design principles - can lead to out-of-sequence, expensive approaches to construction.
    - Cost of performance requirements is often not commensurate with operating revenues; pro forma often does not work
    - Owners need more case studies and a clear evidence base to inform decision making
        - Cost actuals should be used to inform performance standards
    - Lack of industry development subsidies can mean that industry will go elsewhere
        - Lead innovators should be incented to keep/create Canadian offices

Private Owner Investment Challenge: Funding retrofits with long-term returns on investment

- Green retrofits do not provide an ROI;
- Return on investment must account for cost of future operational and capital repairs, generally covered by increases to rent profiles, placing pressure on affordability
- Affordability concerns
    - Above guideline increases to rent profiles are causing 'renovictions' in private housing where other debt recovery mechanisms are not available
    - Low-rise MURBs typically have more affordable rent and they are being knocked down and replaced with towers with less affordability
- **Potential Solutions Include:**
    - Compliance: Introduction of Step Code for existing buildings (See Topic 4)
    - Requirement to development depreciation reports / reserve fund studies that include roadmap to 2030/2050 performance plans;
    - Adopt rental replacement protection control such as those of the City of Toronto across the country to preserve existing rental housing
    - Provide direct and indirect funding such as tax Incentives and other tools to support private sector investment in retrofit, that do not impact rents

- To ensure affordability in private housing, subsidy programs must keep pace with real estate price, market rental and construction cost increases

TOPIC 5: Establishing a Baseline: Performance Standards & Enforcement
This subject area explored the following themes:

- What is a 'model' level of retrofit to set as the objective for the National Housing Strategy, balancing uptake and performance? Is 25% reduction in GHG emissions enough?
- How can we leverage demonstrations to push the market?
- Beyond building codes, what are other public levers to drive change? How can the BC Step Code be a model for other parts of the country?

Summary of Industry Input:
Building codes play a pivotal role in moving the market toward high-performance. Improvements that are not required by building codes are the first to go when budgets become constrained. At a larger scale, codes are not subject to political changes, and are therefore seen by industry as stable catalysts for market demand. While high-performance codes for new buildings, chiefly the BC Step Code, are catalysing industry development for new builds, no such code for existing buildings is in force. Accordingly, industry participants suggested many ways that standards and codes can contribute to improving the high performance retrofit landscape.

Impact of Standards and Codes:

- Funding programs can help to set stepped targets through required performance criteria
- Funding programs can create projects, lessons learned, and initial industry development.
- Targets coupled with regulation change are required in the long term, in addition to incentives:
    - Codes are not subject to political changes, and are therefore seen by industry as stable catalysts for market demand.
    - Programs can run out of money or be cancelled, leaving actors across the industry who have invested in high performance preparedness disillusioned, out of work, etc. As a result, incentives alone do not drive long term investments.
    - "Code drives capacity" and provides a secure framework from which industry can invest.
- Codes should reflect Canadian carbon reduction goals, ie: 2030, 2050.
    - Step codes allow industry and designers and municipalities to get on board
    - Smaller communities do not have the same capacity as major centres, and will be looking to cities such as Toronto and Vancouver to lead on municipal standards
- New build learnings and industry readiness will help to support the retrofit projects and vice versa
- Industry should be provided with forward-guidance on upcoming requirements
    - Step codes create 'forward' guidance, allowing decision makers to understand current and future requirements.
    - Step codes paired with incentives for surpassing base code (achieving "next

step") have been successful in BC and Germany in catalyzing market change
    - Operational savings can be projected through smoother and more predictable performance targets

Public Funding Performance Standards

- 25% reduction in GHG emissions is not high enough
    - A higher relative reduction will encourage more integrated retrofit approaches
    - 75%+ GHG emission reductions will be required to see real impacts on mould and other moisture-related deterioration, thermal performance, comfort and climate resilience
    - Owners should be encouraged to switch fuel to cleaner energy sources
    - Carbon targets should be expanded to capture health and resilience measures, including ventilation modernization or upgrades
- Enabling or urgent capital repair/asset management costs are typically more expensive than the energy efficiency work and must be incorporated into projects
    - Seismic upgrades are seldom integrated into retrofits; this is a missed opportunity
    - Capital repair typically makes up the majority of the retrofit cost
        - BC Housing beginning a study on the areas of overlap
- Accessibility requirements can be challenging to fit into projects
    - Requires that tenants be vacated from their units while partitions, risers, fixtures and millwork are reconfigured
    - Depending on building configuration, can require reductions to overall number of units to accommodate required clearances and transfer spaces
    - CSA accessibility standards have to be met alongside local requirements (ie: municipal barrier free standards), sometimes resulting in conflicting requirements
    - Other accessibility standards (ie: Rick Hansen Ranking) may be more appropriate for retrofits
- Studies by various owners to complete accessibility requirements have averaged ~$100K/unit, which is difficult to justify next to their internal $150K/unit for tearing down and rebuilding
- Minimum or standard tenant engagement requirements could be added to performance standard

Areas Requiring Change:

- Envelope-first approach is critical and will help to avoid locking in poor performance down the road
- Once building retrofits reach Passive House or Net-Zero, there is not much more to do toward carbon and resilience targets
- Failing systems or distributions often have no GHG impact, but are still critical to building resilience. Few standards to get this done
    - Plumbing/electrical systems upgrades
- Requirements with resilience/comfort impacts are rarely solidified into code, and typically remain voluntary standards

    - Emergency back-up power for long-term power outages
    - Ventilation system upgrades to mitigate odour transfer, deliver fresh air, and avoid mould
    - You can make a high performance building that is unpleasant to live in
- Metrics from other jurisdictions which could be considered in Canada
    - Minimum surface temperatures on interior surfaces of walls (enforceable, whereas Canadian codes indicate that condensation should be avoided, but not how)
    - Operative thermal comfort
    - Wellbeing and health standards in housing
- Codes have largely moved to performance-based, but at times, prescriptive requirements can be effective in ensuring specific adherence where useful

Recommendations & Analysis

Building Retrofit Theory of Change

Advancing the building sector toward deep retrofits requires system-wide movement, ranging from supportive financing to industry upskilling to regulatory change. The Theory of Change framework – a widespread methodology used by many sectors – is here applied to the low-energy retrofit industry. This framework can be used to illustrate how behaviours and norms can evolve over time, and what actions will be required to catalyze this movement. By setting outputs for each stage, the Theory of Change can be evaluated and refined to reflect which levers are working and which are not.

The framework includes strategies for bringing best practice to the following market segments:

1. Early Adopters
2. Early Majority
3. Late Majority
4. Stragglers

The most common barriers limiting the uptake of deep retrofits are:

- Risk avoidance by owners;
- Absence of regulatory requirements to undertake retrofits;
- Lack of return on investment on most deep retrofit measures, especially those tied to greenhouse gas emission reductions;
- Expensive retrofit design solutions due to lack of off-the-shelf products.

Further gaps in product availability are outlined in the summary chart on pages 36-38.

There are significant gaps that need to be addressed to move market accessibility from early adopters, who are primarily ideologically-driven (ie: those who choose to undertake deep retrofits as a result of an organizational mandate), to the early and late majority adopters whose participation is influenced by the broader market and regulatory framework, where participation presents little to no friction.

Being an early adopter in the buildings sector has little reward, compared to being second or third. Breaking new ground is expensive, comes with high risk due to uncertainty, takes more time, and can have limited impact on demand in jurisdictions with low vacancy rates.

A working framework to explore the theory of change model can be found below. By addressing gaps, the market can move into a more demand-driven economy where retrofits are both incentivized and regulated. Refinement of this draft framework will be ongoing during the next phase of the project.

High Rise Retrofit Innovation Adoption Model

	Early Adopters	Addressing Gaps
Outputs	Successful Pilots and Demonstrations addressing identified gaps; Best Practice Case Studies; Technical Papers; Industry guidelines	NHS and related programs provide potential for this; output should be coordinated with Provincial and municipal programs; target industry associations and trades training; and align with common goals and benchmarks
Risk Management approach	Bring international expertise into local teams; work to implement testing outcomes from other jurisdictions locally (ie, manage risk through ensuring proof of concept); outline known market gaps and work to address prior to execution; provide large project budget contingencies to address risk profile	Provide low-energy retrofit training to trades; Develop incentives and gap funding tied to identified industry gaps for multiple projects; Increased training for professionals (designers + engineers); Incentives to product development (le BC supporting window PH certification)
Regulation	No supporting regulation. Some alternative compliance flexibility (ie fiberglass windows)	Development of a model step code for retrofits; Housing retrofit funding tied to clear performance outcomes, tied to goals of model code; Develop clear alternative compliance standard approaches (fiberglass windows, AAVs, operable windows)
Demand Driver	Specific innovative client or government program	Retrofit goals / targets stated by government; Education / sharing between owners, industry to push demand; Code timelines and objectives communicated
Product Availability	Most products available but not locally produced. Little experience with existing products	Technical partnerships made between European and Canadian manufacturers + sellers (ie RAICO in BC); Areas for local advancement identified and promoted through targeted research aligned to code objectives

	Early Majority	Addressing Gaps
Outputs	Successful financially secure retrofits implement, using mature and stable set of funding tools; Multiple example projects of different types and sectors (Social housing; private not for profits; market housing	Retrofit finance available from multiple sources
Risk Management approach	Growing industry experience with complex retrofit, contractor and sub trade have like project experience and training; Budgets and schedules aligned to past project experience, trade pricing of 'unknown' risk significantly reduced	Robust trades training to meet new standard part of college and other training Standard certification available to become a retrofit 'expert' (modeller, designer, building scientist, tradesperson, etc) Costs lower due to availability of materials and increased experience
Regulation	Step code implemented and in-force with clear incentives available to 'beat code'; Industry standards for products enhanced to improve base performance (ie windows) Codes updated to accept low-energy retrofit products and practices to limit need for alternative compliance	Ramping Step Code to higher performance levels; Provide timeline for compliance, training period and potential financial incentives to retrofit sooner rather than later.
Demand Driver	Broad industry and owner awareness; meeting future code requirements and growing ease of engaging in retrofits pushes demand; Full public sector compliance targeted – initial pilots of private sector emerging	Building certification systems; resident awareness regarding healthy and low-energy housing; tax incentives for low-energy retrofit compliance; tax penalties for non-participation after set date
Product Availability	Canadian products expanding quality and growing number of international products available. Targeted training ensures builders have experience with most products.	Local businesses are thriving and producing the products and materials needed. Innovation and competition drives product availability and prices.

	Late Majority	Stragglers
Outputs	Most existing buildings are retrofitted	Last buildings are retrofitted or receive exemptions.
Risk Management approach	Investment done to meet code. Use of existing materials and all standard approaches. Hiring of firms that have completed similar work.	No major risks to be avoided.
Regulation	Regulation on retrofits active. Requires upgrading before penalties applied	Regulation requires retrofits to Low-energy standard, non-compliance causes issues with selling, renting, etc.
Demand Driver	All building owners and occupants demanding better spaces.	Retrofitted high-rise are standard and moving into a non-energy efficient building is not considered a good option.
Product Availability	All products needed to do retrofit are commercially available. Innovations continue to be developed.	Products to quickly and efficiently do a retrofit are available.

Recommendations

Following from the local gap analysis, jurisdictional scans and case study review, and industry engagements across Ontario and British Columbia, the following recommendations have been developed in support of advancing the retrofit industry in Canada:

1. **What's Missing: Products & Supply Chain**
   - Encourage Canadian manufacturers to compete to address enhanced performance goals through new product development (ie: higher performance windows; low-cost cladding assemblies; balcony enclosure window systems);
   - Streamline process and provide funding to support the certification of international off-the-shelf retrofit solutions (ventilation solutions for retrofit; retrofit-ready ductwork etc);
   - Encourage technical partnerships between proven international manufacturers and capable Canadian partners to fill product gaps (external roller blinds; trickle vents; structural thermal breaks);
   - Provide targeted research and development funding for products and assemblies required to fill market gaps;
   - Establish centralized repository of product and technology gaps, and establish concierge service at federal level to streamline CSA testing and certification for international manufacturers ready to fill those gap areas, as well as support for international-Canadian manufacturing partnerships;
   - Support and develop demonstration centres for proof-of-concept, product testing and cross-industry education and training.

2. **How To Do It Better: Contractor Scope and Capacity in Executing Complex Retrofits**
   - Provide financial project support to encourage early adopter demonstrations that tackle identified market gaps with potential to scale;
   - Provide specialized training and certification for retrofit and high-performance builders to allow them to distinguish themselves in the market;
   - Support colleges and universities to develop high-performance building labs that offer ongoing training for tradespeople, architects and engineers;
   - Communicate growth areas by quantifying the size of the low carbon market and by working with Provinces and Territories to attract labour market toward the skilled trades.

3. **Putting Residents First: Means and Methods to Minimize Disruption**
   - Provide guidance documents and other knowledge dissemination to owners undertaking retrofits with residents in place;
   - Build requirements for tenant engagement and mitigation of disruption to sitting tenants into retrofit program eligibility criteria, and assign budgets to these activities;

- Develop model RFP language for a tenant liaison role on construction teams to ensure that contractors plan for interacting with sitting residents through their sequencing plans, construction schedules, and daily operations.

4. **Inducing Demand and Supporting Delivery: Supporting Industry Growth**
   - Allow publicly-supported carbon-reduction-driven retrofits to be bundled with capital repairs to encourage more holistic projects, incorporating GHG emission reduction targets of 60%+, resilience and wellbeing improvements, and accessibility upgrades retooled to mitigate negative impacts on sitting tenants;
   - Provide clear technical and best practice guidelines for retrofits for owners, contractors, and design professionals, including guidance on phased retrofit approaches to avoid 'locking in' carbon;
   - Support cross-Canada high-performance building forums and networks whose mandate is to: compile evidence base for early-adopter outcomes through central database; advise on targets and incentive/regulatory frameworks to meet targets; identify barriers and opportunities nation-wide;
   - Create demonstration centres as knowledge-dissemination hubs for information, training, product and methodology showrooms, and other supports for high-performance new-builds and retrofits;
   - Provide publicly-funded design assist and review services for complex retrofits;
   - Incent early adoption country-wide by requiring publicly-owned asset retrofits to meet the highest targets.

5. **Establishing a Baseline: Performance Standards & Enforcement**
   - Pilot market advancement through incentive programs, but use targets and step codes to realize wide-scale industry advancement;
   - Develop a federal model step code, like those implemented in Germany and British Columbia, providing a trajectory and guidance on future code requirements to spur industry readiness, and work with Provinces and Territories to plan for their adoption;
   - Disseminate knowledge and require training to encourage step code readiness, allowing industry to up-skill and decision-makers to plan on that basis;
   - Incentivize participation in projects that 'beat' base code;
   - Require owners of rental MURB buildings to develop 'decarbonization' plans to meet 2030/2050 targets, encouraging stepped but 'stackable' retrofits.

Government Roles & Recommendations

Government Role
This body of research has identified opportunities to catalyze the Canadian retrofit market, and make recommendations which could be driven by a number of government bodies:

CMHC:
With its target of repair and renewal of 240,000 units across the country, CMHC has a unique opportunity to facilitate communication, provide supports for early adopters, and assist owners undertaking retrofits through guidance, review, and data-collection.

- **Communicate growth areas** by quantifying the size of the low carbon market and by working with Provinces and Territories to attract labour market toward the skilled trades.
- Support and develop **demonstration centres** for proof-of-concept, product testing and cross-industry education and training.
- Provide financial project support to **encourage early adopter demonstrations** that tackle identified market gaps with potential to scale;
- Provide **guidance documents and other knowledge dissemination** to owners undertaking retrofits with residents in place;
- Build **requirements for tenant engagement and mitigation of disruption** to sitting tenants into retrofit program eligibility criteria, and assign budgets to these activities;
- Allow publicly-supported carbon-reduction-driven **retrofits to be bundled with capital repairs** to encourage more holistic projects, incorporating GHG emission reduction targets of 60%+, resilience and wellbeing improvements, and accessibility upgrades retooled to mitigate negative impacts on sitting tenants;
- Provide clear **technical and best practice guidelines** for retrofits for owners, contractors, and design professionals, including guidance on phased retrofit approaches to avoid ‘locking in’ carbon;
- Support **cross-Canada high-performance building forums and networks** whose mandate is to: compile evidence base for early-adopter outcomes through central database; advise on targets and incentive/regulatory frameworks to meet targets; identify barriers and opportunities nation-wide;
- Provide publicly-funded **design assist and review services** for complex retrofits;
- Incent early adoption country-wide by requiring **publicly-owned asset retrofits to meet the highest targets**;
- Require owners of rental MURB buildings to **develop ‘decarbonization’ plans to meet 2030/2050 targets**, encouraging stepped but ‘stackable’ retrofits.

Innovation, Science and Economic Development Canada, NRCan and NRC:
These ministries and agencies have an opportunity to catalyze tremendous economic growth through the decarbonization of the building sector, stimulating labour markets, international trade, and supporting the growth of robust Canadian knowledge networks.

- **Encourage Canadian manufacturers to compete** to address enhanced performance goals through new product development (ie: higher performance windows; low-cost cladding assemblies; balcony enclosure window systems);
- Streamline process and provide funding to **support the certification of international off-the-shelf retrofit solutions** (ventilation solutions for retrofit; retrofit-ready ductwork etc);
- Encourage **technical partnerships** between proven international manufacturers and capable Canadian partners to fill product gaps (external roller blinds; trickle vents; structural thermal breaks);
- Provide targeted **research and development funding for products and assemblies** required to fill market gaps;
- Establish **centralized repository of product and technology gaps**, and **establish concierge service** at federal level to streamline CSA testing and certification for international manufacturers ready to fill those gap areas, as well as support for international-Canadian manufacturing partnerships;
- Support and **develop demonstration centres** for proof-of-concept, product testing and cross-industry education and training.
- Provide **specialized training and certification for retrofit and high-performance builders** to allow them to distinguish themselves in the market;
- Support colleges and universities to develop **high-performance building labs** that offer ongoing training for tradespeople, architects and engineers;
- **Communicate growth areas** by quantifying the size of the low carbon market and by working with Provinces and Territories to attract labour market toward the skilled trades.
- Provide clear **technical and best practice guidelines** for retrofits for owners, contractors, and design professionals, including guidance on phased retrofit approaches to avoid ‘locking in’ carbon;
- Support **cross-Canada high-performance building forums and networks** whose mandate is to: compile evidence base for early-adopter outcomes through central database; advise on targets and incentive/regulatory frameworks to meet targets; identify barriers and opportunities nation-wide;
- Create **demonstration centres as knowledge-dissemination hubs** for information, training, product and methodology showrooms, and other supports for high-performance new-builds and retrofits.

NRCan, NRC and the Canadian Commission on Building and Fire Codes:
These agencies and ministries have an opportunity to catalyze industry shifts through introduction of model national step codes and overseeing their implementation throughout the country.

- Support **cross-Canada high-performance building forums and networks** whose mandate is to: compile evidence base for early-adopter outcomes through central database; advise on targets and incentive/regulatory frameworks to meet targets; identify barriers and opportunities nation-wide;
- Create **demonstration centres as knowledge-dissemination hubs** for information, training, product and methodology showrooms, and other supports for high-performance new-builds and retrofits;
- Develop a **federal model step code**, like those implemented in Germany and British Columbia, providing a trajectory and guidance on future code requirements to spur industry readiness, and work with Provinces and Territories to **plan for their adoption**;
- Disseminate knowledge and require training to **encourage step code readiness**, allowing industry to up-skill and decision-makers to plan on that basis.

Next Steps

This research project, “Advancing Building Retrofits”, is the first phase in a broader project to assist key stakeholders in meeting Canada’s retrofit objectives. Recommended future phases of this work are as follows:

1. **Engagements:** Presenting project findings to CMHC and relevant federal stakeholders;
2. **Solutions Framework:** Advancing gap analysis to create a “solutions framework” that identifies specific product categories as well as specific Canadian and European partners for industry advancement;
3. **Solutions Demonstration Project:** Working with Canadian and European partners to design and build demonstration unit(s) that address identified critical gaps:
    a. Ventilation
    b. Cladding & Envelope
    c. Balconies
4. **Best Practice Forum:** Launch cross-Canada ‘Advancing Retrofits’ Forum with industry partners.

Appendices

Appendix A: Advisory Group List

Advisory Group Member	**Area of Expertise**	**Contact**
Pembina Institute	Low-carbon building policy	Tom-Pierre Frappé-Sénéclauze, Director, Buildings and Urban Solutions
The Atmospheric Fund	Low-carbon building policy and retrofit implementation	Bryan Purcell, Vice President, Policy and Programs
Zero Energy Buildings Lab, BCIT	Trades training to support high-performance building techniques	Alexandre Hebert, Manager
United Way	Housing policy	Alex Dow, Director of Neighbourhood Initiatives
Wellesley Institute	Housing policy	Greg Suttor, Senior Researcher
Canadian Federation of Apartment Associations	Retrofit implementation	John Dickie, President
NAIMA Canada	Construction industry implementation	Jay Nordenstrom, Director
Transsolar	Industry implementation	Helmut Meyer, Principal
City of Toronto, City Manager's Office	Housing policy	Amy Buitenhuis, Resilience Lead

Appendix B: Advisory Group Terms of Reference

Tower Renewal Research 2019 - 2020

Advisory Group Terms of Reference - Advancing Building Retrofits

CUG+R's Research Advisory Group will provide review and input toward the "Advancing Building Retrofits" CMHC-funded research project. Primarily through teleconferencing, the Advisory Group will review, comment, improve and clarify CUG+R's research on identifying retrofit product gaps in three main areas: (1) thermal bridging (2) ventilation and HVAC systems and (3) building envelopes and cladding.

Time Commitment
The time commitment required of this Advisory Group will be periodic teleconference calls over the span of 9 months.

Included CUG+R Research Projects:

1. *Advancing Building Retrofits (February '19 - November '19)*

Advancing Building Retrofits

Identifying retrofit product gaps: Our research seeks to identify and scale cost-effective Canadian solutions to three persistent technical retrofit challenges: addressing thermal bridging; upgrading ventilation systems; and cost-effective and non-combustible building envelopes. The research is confined to the challenges around how to implement specific retrofits in multi-unit residential buildings (MURBs) and will consider both the technical solutions (different technologies, materials, etc.) as well as policy solutions (building code updates, incenting development of local technology, etc.)

Methodology:

- Conduct a gap analysis, using the results of CUG+R's "Standards for Healthy, Safe, and Resilient Housing Retrofit" report, to identify barriers to addressing thermal bridging, ventilation and building envelopes in tower retrofits.
- A jurisdictional scan of two European and one North American jurisdictions will identify technical and policy solutions that address identified barriers. Jurisdictional scans will include evaluating government policies, programs and legislation to understand the role that different levels of government play when encouraging or requiring retrofits. Scans will also include evaluating local industry's technology, design and material use.
- A set of draft technical and policy recommendations will be refined and developed into a final report.

- Advisory Group input at each research stage

Output(s):

- Develop a Final Report with technical and policy recommendations for all levels of government

Appendix C: Key Stakeholders Engaged

Individual	Organization
Bill MacKinnon	BC Housing
Margaret Herd	Park Properties
Geoff Grist	Brook Restoration
Sean Botham	CityHousing Hamilton
Christopher Mahase	Retrofit NY (NYSERDA)
Valesa Faria	City of Toronto Housing Secretariat
Edward Buset, Chris Maslovich, Sharon Pitamber	New City Contracting
George Benson	Vancouver Economic Commission
Monte Paulsen, Marine Sanchez	RDH Building Science
Alexandre Hebert	BCIT
Andrew MacDonald	Nexii
Jordy Fisher	FRESCo Building Efficiency
Christian Cianfrone	ZebX
Ben Mills	HiH Energy
Hamid Samani	Prism Engineering
Marie-France Venneri, Mike Reimer, Reza Mousakhani	AME Consulting Group
Shaun	475 High Performance Building Supply
Abigail Moriah	New Commons Development
Amy Buitenhuis	City Of Toronto, City Manager's Office
Bryan Purcell	Toronto Atmospheric Fund
Cara Sloat	Reinbold Engineering
Jenny McMinn	Urban Equation
Mike Hillcoat	Entuitive
Nadia Lawrence	City of Toronto, Affordable Housing Office
Eric Legault	Owens Corning Corp.

Marlon Thompson	CertainTeed
Gina Allegro	Johns Manville
Gary Romes	Knauf Insulation
Mark Bromily	Rockwool

Appendix D: Industry Workshop Agendas

Market Transformation Workshop – NAIMA Canada
Workshop Agenda

1. Introductions and Project Overview
2. Market Transformation Workshop:
    a. Market Transformation through Products and Assemblies:
        i. Cladding Market Transformation
            ii. Rockwool vs. EPS
            iii. Canadian product gaps (ie: mineral wool assemblies such as Rockwool UK)
            iv. Opportunities
    b. Engaging Industry: Manufacturer Associations and Constructor Groups
            i. Windows & doors
            ii. Ventilation systems
            iii. Builder associations
    c. Market Transformation through Means and Methods:
        i. Building with Residents in Place Solutions Lab progress to date
        ii. Trade readiness and training
3. Drivers of Change
        i. Increasing Demand
        ii. Incentives / Regulation
        iii. R&D (Cheaper / Faster)
4. Dissemination: Training module
        i. Audience
        ii. Dissemination and use
5. Next Steps

TOWER RENEWAL PARTNERSHIP

CENTRE FOR URBAN GROWTH AND RENEWAL
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Tower Renewal Workshop: Advancing Deep Retrofits in Occupied Buildings Meeting Agenda (Toronto and Vancouver Workshops)

Welcome and Introductions (10 min)		
Context Setting: The Retrofit Ecosystem – Gaps and Opportunities in the Canadian Context Presentation (15 min)		
Introduction: Advancing Deep Retrofits in Canadian Multi-Unit Housing	**A Growing Public Interest in Housing Retrofit:** Canada's National Housing Strategy is supporting the retrofit of 240,000 units of housing over the next ten years, with the aim of engaging in retrofits for climate resilience, tenant comfort and health. As funds flow to undertake this work, this research project examines market readiness in ensuring retrofits are a success, ie: cost-effective, holistically-performative and minimally-disruptive. This workshop will examine the current state of the retrofit market, and discuss recommendations to expand industry readiness related to product supply chain; trade readiness; performance criteria and more.	Graeme Stewart
Context: The Delivery Challenge	**Challenge Brief Review:** The Challenge Brief circulated to to participants will be reviewed, outlining Gap Analysis and Solutions Development to date. Key topics will include: ● The Problem ● Research Questions ● Findings so far	Josh Vanwyck / Ya'el Santopinto
Expanding Capacity and Reducing Risk in Complex Retrofits in Canada - Discussion (2.5 Hour)		
Topic 1: What's Missing Products & Supply Chain	● What products are available elsewhere, yet missing in our market? ● How can we best bring them here? ● What available products could be refined for use in retrofit? ● What are the key areas where innovation is required?	Group

	● Are there products in BC that were developed for the leaky condo crisis or other that could be shared nationally?	
Topic 2: How To Do It Better Contractor Scope and Capacity in Executing Complex Retrofits	● What size and type of contracting outfits are best suited for retrofit? ● What training would enhance trade readiness? ● Where are current gaps in means and methods and how can we fill them? ● What has BC done well? What worked and what hasn't in the recladding projects post leaky condo?	Group
Topic 3: Putting Residents First Means and Methods to Minimize Disruption	● How can resident disruption be minimized? ● What is the role of the contractor in mitigating disruption? ● What is the role of design in mitigating disruption? ● How can residents be engaged participants in the process? ● What has BC done well? What worked and what hasn't in the recladding projects post leaky condo?	Group
Topic 4: Establishing a Baseline Performance Standards & Enforcement	● What is a 'model' level of retrofit to set as the objective for the National Housing Strategy, balancing uptake and performance? Is 25% reduction in GHG emissions enough? ● How can we leverage demonstrations to push the market? ● Beyond building codes, what are other public levers to drive change? How can the BC Step Code be a model for other parts of the country?	Group
Topic 5: Inducing Demand and Supporting Delivery Supporting Industry Growth	● Which local/national industry leads can innovate to fill gaps on required products? ● How can EU or other international products best make their way to our market? ● What technical partnerships can help drive up local capacity through training and support? ● What has worked with the Step Code and Vancouver Building Codes pushing higher performance?	Group
Conclusion: Wrap Up and Next Steps		