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**Summary of the
Scientometric Study and
Stakeholder Engagement on
Resilient Residential Retrofit Theme
under National Research Council's
Climate Resilient Built Environment Initiative
May 2024**

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EXECUTIVE SUMMARY

The National Research Council of Canada (NRC) is contributing to the Government of Canada's climate resilience efforts by providing guidance, tools and standards, which contribute to long-lasting infrastructure and buildings, including retrofits and upgrades, to help communities build resilience, reduce disaster risks and conserve costs over the long term. This will ensure that both new and existing structures continue to support the health, safety and prosperity of Canadians in current and future climates.

Since 2021, the NRC's Climate Resilient Built Environment Initiative (CRBE) has been undertaking research to support climate resilient buildings and infrastructure. Under this initiative, a new theme of research work under the title Resilient Residential Retrofit, or R³, was launched in April 2023. This theme is focused on developing national guidelines, tools, and technologies to enhance the climate resilience of existing residential buildings (all type of buildings, anywhere people live) against climate change and extreme weather through retrofit. Efforts under this theme will be completed over five years, ending in March 2028.

This report presents the results of the following foundational studies and stakeholder engagement activities undertaken between April 2023 and December 2023 to shape the R³ theme:

- A scientometric study to detect and categorizes the international research domains in the field of resilient residential retrofit, as they pertain to resistance to weather events including the impacts of climate change and natural disasters
- A comprehensive questionnaire on the current landscape and gaps for residential resilience, completed by 68 expert stakeholders
- Two stakeholder workshops, held in October and December 2023, with about 130 participants

The scientometric study and comprehensive questionnaire were used to design the workshops. The first workshop explored critical issues and knowledge gaps. Based on the results of the first workshop, the R³ team developed a roadmap for enabling adaptation retrofits. This roadmap was used as the organizing structure for the second workshop, in which participants focussed on need for coordinated, collaborative approaches and barriers to adopting new information and guidance. The results of these activities informed the selection and refinement of specific research projects under the R³ theme. Research efforts are now underway on retrofits to address risks to existing residential buildings from flooding, permafrost thaw, extreme heat, wildfires and wildfire smoke, and other hazards.

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1. INTRODUCTION

Under the Climate Resilient Built Environment (CRBE) Initiative, the Construction Research Centre has launched a new theme on Resilient Residential Retrofit (R³) in April 2023, which will be completed in March 2028. The R³ theme is designed to address the critical issue of climate resilience in existing residential buildings through retrofitting strategies and provide research insights that will enable Canada's residential sector to become more resilient to climatic events.

The core objectives of the R³ theme can be summarized as follows:

- **Generate Science-Based Guidance:** This objective revolves around bridging knowledge gaps pertaining to the adaptation of residential buildings to the challenges posed by climate change and extreme weather events. Emphasis is placed on safeguarding vulnerable populations. The insights gleaned from this endeavor are expected to inform robust strategies and best practices for retrofitting residential structures, thereby enhancing their resilience to climate-related adversities.
- **Support Evidence-Based Decision-Making:** The R³ theme aims to foster collaboration between the public sector and industry stakeholders. By aligning knowledge and best practices, this collaborative effort seeks to ensure that decisions regarding residential building retrofits are firmly grounded in the latest research and expert insights.
- **Advance Near-Market-Ready Technical Solutions:** An essential facet of the R³ theme involves de-risking and facilitating the adoption of technical solutions that are on the verge of entering the market. These solutions are instrumental in furthering the goals of climate change adaptation and resilience for residential buildings.

To inform and guide the development of R³ roadmap and key priorities, a scientometric study was completed. In addition, a series of consultation events including a consultation questionnaire and two virtual workshops were conducted involving a diverse group of stakeholders and experts. The consultation questionnaire was meticulously designed to gather invaluable input and feedback from stakeholders. This information served as the cornerstone for shaping the structure and focus areas of the two virtual workshops. The workshops were strategically crafted to delve into critical issues and knowledge gaps identified during this stakeholder consultation process. This collective effort, scientometric study and consultation events, contributed significantly to the development of a roadmap for R³ in order to enable this theme to provide guidelines, tools, and cutting-edge technologies aimed at augmenting the climate resilience of residential buildings through retrofitting. The overarching objective of this report is to offer a summary of both scientometric study as well as consultation results. Through this report, we aim to provide an insight into the valuable information we gathered during the first year of R³ theme, which are instrumental in driving progress in the coming years.

2. SCIENTOMETRIC STUDY

This scientometric study was conducted to detect and categorizes the international research domains in the field of resilient residential retrofit, as they pertain to resistance to weather events including the impacts of climate change and natural disasters. The study analyzes the research trends and related advances in the understanding of resilient retrofit for residential purposes from 2012 to the present. It also identifies the top research organizations and collaboration networks in the field. It is not a critical evaluation of the methods or theories being reviewed, but rather reports on trends in the literature based on an analysis of the metadata associated with the bibliographic references. A high-level summary of the scientometric study findings is summarized in this section of the report.

The research trends analysis shows that emerging research interests in resilient residential retrofit include, but are not limited to, nature-based solutions, energy efficiency and thermal comfort. Close to half of the publications mention urban context and more than a third mention costs. Building envelope is the most frequently discussed housing component. Even though energy retrofit was outside of the scope of this study and not specifically searched, energy concerns still permeated the publications dataset with 40% of the publications mentioning the word “energy”. Indeed, even without planning residential retrofit for energy efficiency, energy consumption or backup power will most likely be part of the planning process of a retrofit for overheating or prolonged power outage, for example. The R³ research field is led in volume by the USA, followed by China and the UK. The leading organization in the publications, albeit only with 1.5% of the dataset, is the University of London who, like the UK as a whole, has a research focus on indoor thermal challenges like overheating. The patent landscape is largely led by China. Concerns about water, roofing, urban settings, houses and interior walls each account for about a half of the patent dataset. The top topics also all relates either to tackling issues or to housing.

Similar to the challenges it is tackling, resilient residential retrofit research is multifold. There is effectively no “one size fits all” when it comes to resilient residential retrofit and the “best” solution will depend on several factors such as the type of housing, its location and the occupants’ preferences and financial means. Resilient retrofit can hardly cover all the climate risks at once and, even though thorough and holistic planning is recommended, chances are that the implementation will be incremental at best. Research about wildfire resilience showed the weight of the occupants’ perception of risk and financial means in the decision process. Bottom-up community-based measures are vital in post-disaster reconstruction as well as to overcome limits to climate resilience. Community engagement can be eased through education and awareness. Nonetheless, the urge from occupants to upgrade existing homes will likely come in reaction to an exposition to risk, hence the role of governmental entities in providing sound policies and incentives to protect their populations, especially those most vulnerable.

The present study provides insights about areas where the NRC could have the most impact to improve Canadians’ lives and housing situation impacted by climate change. Deep-dives on one specific climatic event, house component or challenge could provide more precise research trends and technologies. A more comprehensive report on the scientometric study will be published in a separate report.

3. STAKEHOLDER CONSULTATION

In the context of the stakeholder consultation, a comprehensive questionnaire was meticulously designed to gather invaluable input and feedback from stakeholders. This information served as the cornerstone for shaping the structure and focus areas of forthcoming workshops that happened in Fall 2023. The overarching objective of this section of the report is to offer a summary of the consultation results.

Question 1: As an interested party, which one of the following categories best describes the current focus of your work? Select one choice please.

There was a total of 68 respondents that participated in the consultation out of 120 invitations that were sent out. The categories of respondents are presented in Table 3.

Table 3- Participants' category

Stakeholder Category	Respondent %	# Respondent
Government	38.24%	27
Builders/Renovators	20.59%	14
Academia	14.71%	10
Research entity	8.82%	6
Standards development	7.35%	5
Industry association	2.94%	2
Advocacy groups	2.94%	2
Housing agencies	2.94%	2
Insurance/Finance	1.47%	1
	Answered	68

Question 2: What are the most common concerns related to climate hazards you have, and that you hear about from your clients and colleagues? In other words, which climate risks do you consider to be the most relevant in your area? Select as many choices as you see fit.

The results (Figure 30) suggest that extreme heat followed by flooding were considered the most relevant climate risks of the voters. Wildfires were considered the third most relevant climate hazard. The top three voted climate hazards were followed by extreme wind and then hail and ice storms. In addition to the common climate hazards listed above, respondents provided insights into other climate risks that are of concern. These include:

- Seismic Risks: Concerns about earthquakes and their potential impact on residential buildings.
- Drought Conditions: Extended periods of drought, which can lead to water shortages and affect the livability of residential areas.
- Lack of Potable Water Supply: Linked to drought conditions and or aftermath of forest fires, the availability of safe drinking water during and after climate-related events.
- Smoke and Poor Air Quality: The presence of wildfire smoke and poor air quality, particularly concerning for health and well-being.

- Energy Security and Infrastructure: Resilience of energy infrastructure during or after climate events.
- Permafrost Degradation: The thawing of permafrost, which can impact food sources and result in the introduction of invasive species.
- Urban/Pluvial Floods: Specific types of floods defined in standards like CSA Z800, with a focus on urban and pluvial flooding.
- Humidity Levels: The effects of extreme humidity on residential buildings and comfort.

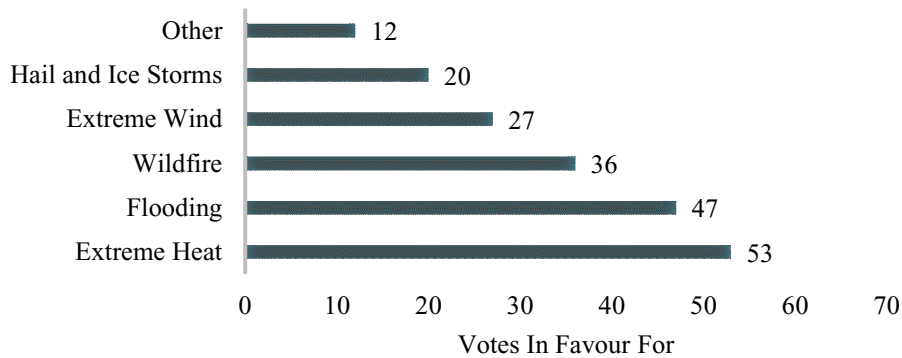


Figure 30- Most common climate hazards

Question 3: In your experience, which of the following issues is currently the most important concern in residential renovation/retrofit? Please rank the following elements (with 1 being the most important and 5 being the least important).

Affordability was the respondents first vote, followed by energy efficiency and climate resiliency (Figure 31). In addition, Energy Efficiency was clearly the top second choice followed by climate resilience, and affordability. In general, energy efficiency, affordability and climate resiliency received the most rankings followed by carbon emission and accessibility.

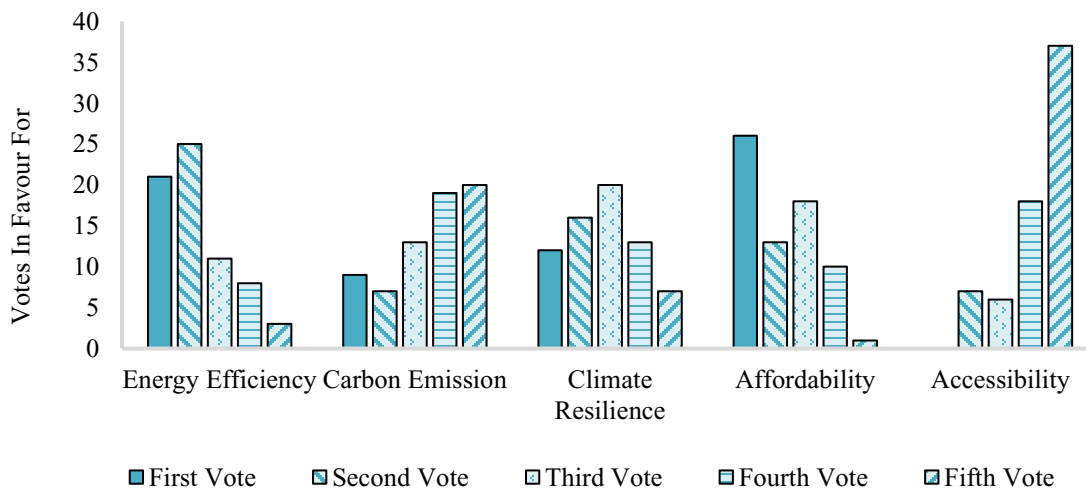


Figure 31- most important concern in residential renovation/retrofit

Question 4: What are the three key factors that influence decision making and the implementation of climate resilient residential retrofits?

A significant majority of respondents considered the cost versus benefit analysis or ROI as the most influential factor in decision-making for climate-resilient residential retrofits (Figure 32). This was followed closely by cost as the second most influential factor. Knowledge about climate risks and compliance with regulations or bylaws tied for third place in influencing decision-making.

Other factors that respondents considered important, although not included in the original list, include previous climate-related damages, insurance requirements, awareness of local climate risks and housing vulnerabilities, and the imperative to avoid future damage. Building literacy and knowledge about potential solutions were also mentioned, highlighting the need for education and awareness-building among homeowners and stakeholders. Additionally, considering the product service life is essential for long-term effectiveness.

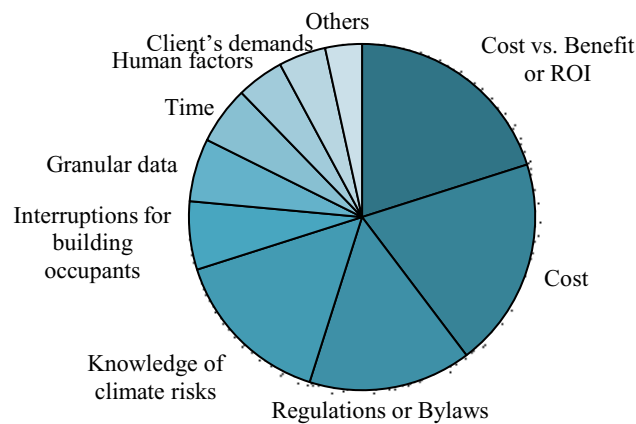


Figure 32- Key factors for implementation of climate resilient residential retrofits

Question 5: What are the three key barriers that prevent or impede the implementation of climate resilient retrofit measures?

The results suggest that cost, overwhelmingly, is the most significant barrier identified by respondents preventing the implementation of climate resilient retrofit measures (Figure 33). The second most popular selection was knowledge about the climate risk preventing or impeding the implementation of climate resilient retrofit measures. Interestingly, the third key barrier to implementation was shared among three different factors: time, interruptions for building occupants, and human (behavioral) barriers.

Additional barriers mentioned by respondents under the "other" category included, as below:

- Inability (e.g., renters without support from owners)
- Capacity of trades, coordinating retrofit work when tradespeople are already oversubscribed
- Labour pool

- Contractor knowledge on new requirements and implementation
- The building sector is forcing the standards to be non-mandatory
- Not a priority because things are working fine, no emergency
- Building literacy - homeowners don't have the trust and knowledge about what can be done

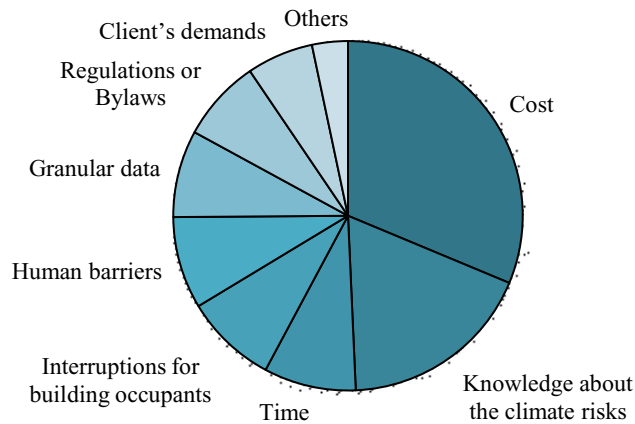


Figure 33- Key barriers for implementation of climate resilient residential retrofits

Question 6: Have you worked on or been involved with retrofit of residential building to increase climate resiliency? If yes, what was the nature/type of the retrofit and which retrofit practices (renovation, alteration, addition, replacement, etc.) did you use?

45.59% of respondents (31 out of 68) have been involved in residential building retrofits for climate resilience:

- Flood Prevention Measures:
 - Alterations to buildings
 - Addition of sump pumps, battery backups, improved gutter and downspouts
 - Changes to building design or construction techniques
 - Alterations to property to mitigate flood risks such as lot-level water management
 - Community level involvement in retrofit initiatives through municipal-level incentive programs
- Energy Retrofits: Retrofit projects aimed at achieving energy savings
 - Upgrades to windows, insulation, heat pumps, HVAC
 - Participation in building to higher standards such as NetZero, PACE Program Participation (Property Assessed Clean Energy programs designed for deep energy retrofits)
- Wildfires
 - Wildfire Smoke: Addition of portable air cleaners
 - Building Envelope Improvements
- Overheating
 - Retrofit projects focusing on overheating, taking into consideration energy efficiency and cooling measures.

- Installation of air conditioning and operable windows.
- High Winds
 - Use of materials rated for higher wind resistance
- General Research or Renovations
 - Analysis, Research, and Training Development: Several respondents mentioned their involvement in research, analysis, and the development of training programs related to retrofitting for climate resilience. This suggests a commitment to advancing knowledge and expertise in this field.
 - Risk Assessment: Some respondents focused on risk assessment and the identification of options to reduce risk for clients.

Question 7: What decision-making tools (data portals, guidance document, standards, Codes, software, etc.), if any, do you currently use to identify the need for incorporating climate resilience in residential retrofits?

The responses indicated a diverse set of decision-making tools and resources, as below:

- Standards and Guides
 - Building Codes and Standards: to guide their decision-making regarding climate resilience in retrofit projects (such as CSA S478)
 - Guidance and best practices documents: Use guidance documents and reports to inform their retrofit decisions
- Tools and Data
 - Climate Data and Portals: such as ClimateData.ca and proprietary portals like CatIQ and JBA's flood map portal, are used to assess climate-related hazards, historical records, and flood risk.
 - Energy Simulation and Modeling Software: (e.g., EnergyPlus, Wufi) to assess the energy efficiency and thermal performance of retrofits, which indirectly impacts climate resilience.
 - Tools for Specific Hazards: specialized tools for assessing specific hazards, such as wildfire risk assessment tools and permafrost thawing standards.
 - Cost-Benefit Analysis and Insurance and Loss Data
- Studies and Consultation
 - Expert Consultations: Discussions with peers, experts from organizations like Intact Centre, and engineers play a role in decision-making.
 - Research and Academic Sources: Participants leverage research findings and academic publications to inform their retrofit decisions.
 - Community and First Nation Input
- Initiatives
 - Public Resources: Respondents mention various public resources, including government strategies like the Greening Government Strategy and federal sustainable development strategies, as guiding their retrofit decisions.

Question 8: What tools do you need in your practice that are not currently available which could help increase incorporating climate resilience in residential retrofits?

Here are some key themes and specific needs mentioned by participants:

- Financial Incentives, Grants and Funding
 - Government financial incentives at both municipal and federal levels
 - Tools to improve access to grants
 - Funding for staff training and software upgrades is seen as important.
 - Investment in code acceleration, training, and collaborative data collection to support the growth of the industry and the ability to address retrofits effectively.
- Education and Guidance
 - Tools, literature and sources to educate clients and builders about climate-resilient retrofit options. (To enhance public awareness)
 - Checklist that offers upgrade options for review with clients, especially those that renovators can easily communicate,
 - Provide science-based advice on resilience
 - Dissemination of freely available information to the public, such as infographics
 - Access to qualified individuals who can assess climate risks.
 - Guidance specific to geographical areas on climate resilience measures
 - Resources and guidance on interpreting flood data
- Data
 - Accessible and organized public information on hazards like hail, high wind, wildfire, and urban flood is crucial.
 - Studies and maps identifying climate risk factors throughout Canada
 - A regionalized map providing climate information and recommended materials for specific areas
 - Predictive data for environmental design loads
- Analysis tools for
 - Comprehensive life-cycle assessments, carbon impact assessments
 - Cost-benefit analysis and the comparison of climate change risks relative to each other (Ability to assess multi-hazard risk)
 - Computer modeling of different materials to optimize energy efficiency.
 - Simplified decision support tools: need for easy-to-use, quick, and understandable tools that provide results without extensive research
 - Assessing the integrated health impacts of climate extremes on occupants.
- Less Restrictive Building Codes: It was suggested that less restrictive building codes may facilitate climate-resilient retrofits.

Question 9: Which research focus do you see as the most important to support resilient residential retrofit? Please rank the following items (with 1 being the most important and 5 being the least important).

It appears that the respondents first vote was on “how to prioritize the most critical risks in a given location” followed closely by “how to best integrate resilience, adaptation and mitigation measures”. The second vote was split between “how to prioritize the most critical risk in a given location” and “how to better understand the compound climate risks”. The third choice was close for two options but was led by “how to better understand the compound climate risks”. The most popular last choice was “how to avoid the risks of mal adaptation”. The results are shown in Figure 34.

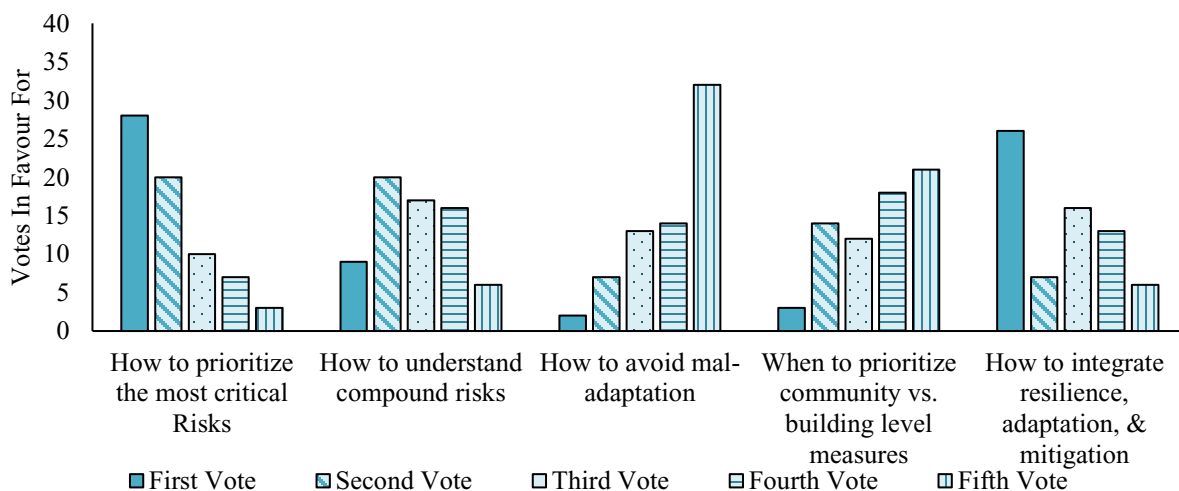


Figure 34- Most important research focus to support resilient residential retrofit

Question 10: Are there any other research focus areas that you believe are critical that have not been mentioned in the previous question? Please explain.

Here is an analysis of the suggested research focus areas:

- Economic Analysis
 1. Economic Opportunity of Resilient Retrofits: Resilient retrofits represent a potentially transformative economic opportunity when the focus is on the economic aspects & benefits of retrofits.
 2. Financial Modeling, long-term business case and Insurance Integration: The importance of financial modeling to demonstrate the risks of inaction and the benefits of taking action (long-term business case for avoided damage costs resulting from resilient retrofits). Respondents also noted the need for integrating and collaborating with the insurance industry into understanding the risks and benefits of adaptation and stabilizing the risks.
 3. Cost-Benefit Analysis: Cost-benefit analysis was mentioned multiple times, highlighting the importance of assessing the financial implications of resilient retrofits, including both investment costs and potential savings.

4. Co-Benefits of Resilience Measures: Quantifying the co-benefits of resilience measures over the asset's life cycle was highlighted as a research focus.
- Education, Guidance and Community Engagement
 1. Community Engagement and Human Behavior: Consider the importance of building relationships with communities to increase acceptance of innovative concepts. Respondents also noted the role of social and human factors in resilience, emphasizing the need for engagement and understanding human emotions and behaviors.
 2. Empowering Vulnerable Populations and Unique Needs: Research questions should be tailored to specific groups, including Indigenous communities, renters, new Canadians, and those with disabilities. It was suggested that research that benefits and understands their specific needs and barriers is required. Also, understand how the research can benefit the resilience of health facilities, particularly long-term care facilities.
 3. Occupant Behavior and Education: The importance of occupant behavior and education during extreme conditions and calculating the co-benefits of resilience retrofits was mentioned.
 - Data
 1. Data Quality and Health Impact: The need for correct and effective data to inform actions related to climate resilience. This includes considering health data and its influence on well-being, especially in the context of extreme heat.
 2. Continual Updating of Climate Data: The need for continually updated climate data to provide predictive loads, highlighting the importance of using up-to-date information for design and planning.
 - Holistic Analysis
 1. Carbon Reduction and Energy Efficiency: The need to evaluate retrofit scenarios for carbon reduction and energy efficiency, especially in areas without natural gas.
 2. Trade-offs Between Energy Efficiency and Resilience: Exploring trade-offs between energy efficiency and resilience, such as infiltration and overheating, was suggested as a research area.
 3. Research into Service life: Explore life cycle analysis for retrofit measures.
 4. Risk Assessment Methodologies and Vulnerability: The development of risk assessment methodologies and the understanding of vulnerability were suggested as important research areas.
 5. Equal Importance of Issues: Ranking certain issues might not capture the fact that many of these challenges are equally important and should be addressed simultaneously.
 6. Importance of Resilient Retrofits: The need to address multiple critical issues, including GHG emissions reductions, climate adaptation, human health, job creation, economic development, affordability.
 - Adapted Construction Practices
 1. Building Materials and Techniques: An opportunity to explore alternative building materials and construction techniques, such as transitioning from wooden framing to metal/steel.
 2. Adaptive Capacity and Design: The need for adaptive capacity and design adaptation is highlighted, particularly concerning codes and standards for new and retrofit infrastructure.

- Coordinated Leadership
 1. Coordination and Collaboration between Government and Insurance Agencies: Working together with all stakeholders and experts in the field.
 2. Leadership and Innovation for Canada: Developing technologies and systems for energy efficiency and climate change adaptation in the building industry, particularly for existing buildings.
 3. Regulation: The development of regulations may be needed to ensure meaningful engagement in resilient retrofits, especially when voluntary behavior by building owners falls short.
 4. Diverse Advisory Board: Include diverse advisory board members, including those from vulnerable groups, to ensure that the research empowers a wide range of stakeholders.
 5. Regulations and Standards: Suggestions were made regarding the need for industry standards to evaluate and identify climate risk, as well as the importance of future regulations related to resilience measures.

Question 11: Please mention any existing Canadian initiatives or programs (federal, provincial, municipal and corporate) that you have used, or of which you are aware, to help Canadians adapt their residence to the effects of climate change.

- CaGBC (Canada Green Building Council): The CaGBC is known for its focus on green building practices. It plays a crucial role in promoting sustainable and resilient building design and construction.
- Ontario Green Investment Fund: This fund likely supports projects and initiatives aimed at environmental sustainability and resilience within the province of Ontario.
- Novoclimat: Novoclimat is a program in Quebec aimed at encouraging energy-efficient and environmentally sustainable residential construction. It can indirectly contribute to climate resilience through energy-efficient designs.
- Canada Greener Homes Grant/Loan: This program, managed through Natural Resources Canada, provides incentives for homeowners to undertake energy-efficient and climate-resilient retrofits in their homes.
- Better Homes Ottawa: This initiative likely focuses on improving residential properties in Ottawa with a particular emphasis on energy efficiency and potentially climate resilience.
- CMHC Green Home: The Canada Mortgage and Housing Corporation (CMHC) offers programs that support green and energy-efficient home improvements, which can also enhance climate resilience.
- Health Canada's Indoor Heat Health Guidance: This initiative aims to provide guidance on safe indoor temperatures for various population groups, which can be crucial for addressing health impacts related to extreme heat events.
- FM Global Benefit for Climate Adaptation: FM Global, an insurance company, provides benefits to insureds for climate adaptation measures. This can help incentivize businesses to invest in resilience.
- Lyton Region's Wildfire Resiliency Codes: Mentioned as a positive development in British Columbia, this initiative focuses on changing municipal codes to enhance wildfire resilience, particularly in regions prone to wildfires.

- Clean Foundation's Resilient Retrofit Program: Clean Foundation, in collaboration with municipalities like HRM (Halifax Regional Municipality) and New Glasgow, offers programs related to resilient retrofitting and flood preparedness.
- Intact Centre: The Intact Centre conducts research related to climate resilience and provides valuable insights and tools for homeowners, businesses, and municipalities.
- Partners for Action (P4A): Partners for Action is involved in flood resilience efforts and provides resources, including checklists and mailers, to help communities and individuals.
- Federation of Canadian Municipalities Programs: FCM supports municipal initiatives related to climate resilience, including the PACE (Property Assessed Clean Energy) programs that allow funding for resilience measures.
- Red Cross Programs: The Red Cross collaborates with partners on various programs and initiatives related to climate resilience, including checklists and mailers for flood resilience.
- Windsor Backflow Valve Subsidy Program: This program in Windsor focuses on preventing sewer backup, which can be a resilience measure in flood-prone areas.
- ICCA (Insurance Bureau of Canada) Home Flood Protection Assessment: offers assessments to homeowners to help protect against flooding.
- FireSmart Home Partners Program: FireSmart is an initiative that focuses on wildfire resilience. The Home Partners Program likely supports homeowners in wildfire-prone areas.
- National Adaptation Strategy: Building Resilient Communities and a Strong Economy: This strategy likely outlines Canada's national approach to climate adaptation, with a focus on community resilience and economic strength.

Question 12: Please mention any existing international initiatives or programs (provide country name) of which you are aware, that are focused on supporting the adaptation of residential buildings to the effects of climate change.

- Switzerland & Sweden: Switzerland and Sweden have multiple initiatives and programs related to climate resilience and energy efficiency in residential buildings. These countries are known for their efforts to promote sustainable construction practices.
- United States (Green Building Council): The U.S. Green Building Council (USGBC) is known for its LEED (Leadership in Energy and Environmental Design) certification system, which includes criteria for climate resilience and sustainability in residential and commercial buildings.
- Germany (Passive House Institute): Germany's Passive House Institute promotes the Passive House standard, which emphasizes ultra-energy-efficient building design, including aspects related to climate resilience.
- World Health Organization (WHO): The WHO collaborates with various countries, including Canada, to identify best practices for protecting health from extreme indoor temperatures, which often involves considerations related to the built environment.
- UK Health Security Agency: explores programming to identify safe indoor temperatures for UK populations, likely including measures related to the built environment.

- HazardAware (USA): HazardAware is a tool in the United States that rates risk and recommends resilience measures, which can be valuable for homeowners and communities.
- Amsterdam Rainproof (Netherlands): focused on managing rainfall and flood risks in urban areas, which may include residential adaptation measures.
- IEA Annex 80 and Annex 86: These International Energy Agency (IEA) annexes focus on energy-efficient indoor air quality management in residential buildings, which is relevant to climate resilience.
- EU Climate Adaptation Policy (European Union): The European Union has a climate adaptation policy that includes sector-specific policies for buildings. These policies likely promote climate resilience in residential construction.
- Boston Flood Adaptation Guidelines (USA): Boston has developed flood adaptation guidelines and retrofit code mandates to enhance resilience in buildings. Similar initiatives may exist in other U.S. cities.
- California Programs (USA): California has programs related to earthquake retrofitting and labeling of buildings, which can contribute to building resilience against seismic events.
- FEMA (USA) and Insurance Institute for Business & Home Safety (USA): FEMA and the Insurance Institute for Business & Home Safety (IBHS) in the United States focus on disaster resilience, including residential adaptation measures.
- FloodRe (UK): FloodRe is a UK initiative aimed at providing affordable flood insurance, which can incentivize homeowners to invest in flood resilience measures.
- Carbon Leadership Forum's CARE Tool (USA): The Carbon Leadership Forum offers the CARE tool, which helps assess carbon emissions in building construction, contributing to climate resilience efforts.
- National Institute of Standards and Technology (NIST) (USA): NIST funds programs related to community resilience planning and risk assessment, including efforts to address climate change impacts on buildings.

These international initiatives cover a wide range of aspects, including energy efficiency, disaster resilience, indoor air quality, and adaptation to extreme temperatures and weather events. Researchers, policymakers, and practitioners in Canada can learn from these international experiences to enhance climate resilience in residential buildings domestically.

4. WORKSHOP 1

The first workshop, held October 20, 2023, was strategically crafted to delve into critical issues and knowledge gaps identified during this stakeholder consultation process. The workshop started with an overview presentation of the consultation survey's outcomes and identified knowledge gaps. The three critical identified knowledge gaps were the topic of the breakout discussions in the workshop:

- Identifying and prioritizing climate risks for a given location and looking into their intersections; what do we need to know in order to undertake a retrofit?
- Cost-benefit analysis of retrofit and return on investment; how do we make retrofits happen?
- Integrating energy efficiency, emission reductions, and climate resiliency; how do we enable holistic approaches?

These knowledge gaps were discussed during two separate breakout discussions and were further explored using a post-workshop feedback platform (FacPro). Inspired by the conversations in the workshop, we drafted a step-by-step roadmap for climate adaptation retrofits (will be discussed in more details in Section 5.1). The summary of the key takeaways from the discussions in workshop 1 are organized based on the steps shown in Figure 35 and will be presented in Section 4.1. The phases of the roadmap are as follows:

- **Hazard and exposure mapping:** A tool that is publicly accessible and postal-code-based which will help with risk assessment, home inspection and retrofit planning.
- **Building Assessment and Vulnerability Identification:** Use of GIS maps with vulnerability indices to assess climate action priorities. Considerations include degree of exposure, consequences of climate events and vulnerability of occupants; balance between protecting the home and protecting the community; and use of archetypes of the most common housing with regional considerations.
- **Identification of Adaptation Measures:** Centralized and simplified access to recommended adaptation measures; use of a standard assessment approach that accounts for common hazards.
- **Evaluate Adaptation Measures:** Understand the costs and benefits associated with resilient retrofit; impact of the insurance sector and how insurance companies perceive and value resilience; energy efficiency and GHG emissions; integration of nature-based solutions in retrofits. Durability of building materials is an important factor.
- **Implementation of Adaptation Measures:** Pilot studies to gain practical insights; feasibility studies; identify and promote champion builders.
- **Knowledge Dissemination:** Effective education and messaging tailored to regions and audiences to motivate behaviour change; demonstrate the investment case; create connections between effectiveness and local relevance.

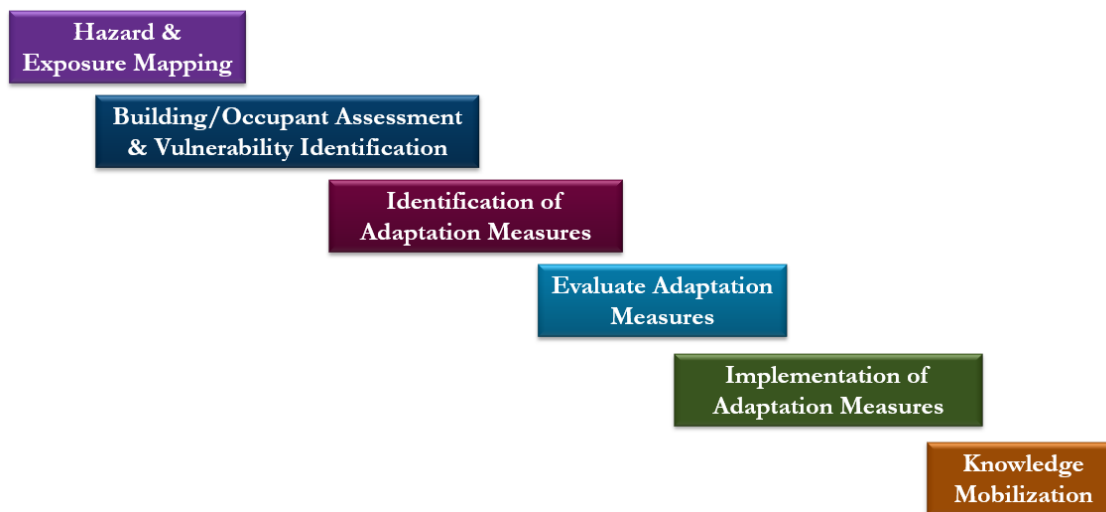


Figure 35 Proposed R³ roadmap to enable climate adaptation retrofits

4.1. Summary of the Breakout Discussions

4.1.1. Hazard and Exposure Mapping

- Access to current climate and climate change focused mapping for risk assessment (national mapping on flood, wildfire and extreme heat risk), is necessary to inform prioritization.
- Need for Automated Risk Assessment by Postal Code: an easily accessible climate risk assessment tool where you enter a postal code, and a high-level assessment of regional climate hazards and their associated risks are generated. There are various different hazard and risk maps that don't talk to each other. Creating this tool can help home inspection professionals with risk assessment and let them focus on recommending risk mitigation/retrofit actions. BC is looking at compiling some of this information as part of new requirements for resilient public sector buildings.
- Precise Risk Mapping: Accurately mapping risks on a granular level enables targeted and effective resilient retrofit planning. Mapping will also help determine areas where climate change will render properties unlivable in the long run.
- There is a need for making climate data and risk mapping available, along with clearly defining the assumptions made while developing the data and maps, to increase consumer protection and transparency. Followed by continued enhancement of data quality. Information should be presented in an understandable format. Data should be connected to an action matrix that describes how an individual might intervene at a site and community scale to reduce risk.

4.1.2. Building/Occupant Assessment and Vulnerability Identification

- There is a need for a tool to assess whether some retrofits actually need to be completed and what the risks/impact of not doing upgrades would be. The tool could potentially rank/assess risks from low risk to high risk.

- The use of GIS maps with vulnerability indices is a way to assess the priority of climate actions using demographics. A good example is the one developed by City of Toronto on Heat Vulnerabilities, available at <https://www.toronto.ca/legdocs/mmis/2011/hl/bgrd/backgroundfile-39468.pdf>.
- Need for adaptable strategies that account for multiple climate risks. Appropriate adaptation measures could therefore be tailored to geographic location. Prioritization of climate resilience actions should consider, for example:
 - Degree of exposure to climate event,
 - Consequences of impacts (may vary depending type of buildings, remote locations, etc.),
 - Vulnerability of occupants (e.g., senior residents, underserved communities).
- Considering social, demographics and economic factors for assessing vulnerabilities as they may have different values and objectives for vulnerability.
 - Balance between protecting the home and protecting the community in the economics. Dollar loss per household vs number of people affected within a community.
 - Equity of the construction – Is it a risk of losing the equity of failure of the structure?
- Equity is a concern, with the burden primarily on individuals. Collective action and government support for resilient initiatives are needed.
- Use archetypes of the most common housing to illustrate relevant retrofit options perhaps with regional considerations, before getting down to the individual home level for tailored solutions. Need action at the broader scope beyond owners of single-family homes, e.g., actions by multi-unit residential buildings, the additional risks to those living in high rises (i.e., failure of elevators and other systems in power outages). Governments and system operators have a role to play, as some hazards are better addressed at the community, watershed, or other systemic scale.
- Leveraging vulnerability mapping tools for priority hazards. Such as Montreal and Quebec have had climate hazard vulnerability mapping tools and index since 2015 (updated in 2022) on main priority hazards: social, territorial, environmental, and physical vulnerability to climate hazards.
- Home energy advisors for retrofits: Practitioners are noticing the need for retrofits to address climate change-related risks like regular seasonal flooding, but they don't know what to offer as solutions or where to point the homeowner to get funding supports for retrofits like backflow valves or sump pumps. There is a need to integrate and improve this existing retrofit process through training, education, communication.

4.1.3. Identification of Adaptation Measures

- Consider a standard assessment approach that accounts for hazards that commonly occur simultaneously: overheating and wildfire smoke, overheating and power outages, high wind and rain, freezing rain and power outages, others? (i.e., You can't rely on operable windows when there is smoke, you can't rely on AC during a power outage, wind may cause little damage to a roof but the following rain can cause damage).
- To facilitate the adoption of resilient retrofit measures, a comprehensive list of adaptation measures should be compiled.
- Having centralized and simplified access to information on recommended adaptation actions and related rebates from various government levels is crucial.

4.1.4. Evaluate Adaptation Measures

- Understanding/Identifying the cost and benefit associated with resilient retrofit is critical. The benefits could be tangible short-term returns such as energy savings, health/brain health, long-term business case for avoided damage and maintenance costs as well as increased property value. What are the risks/costs of inaction?
- Cost-benefit analysis plays a pivotal role in prioritization, enabling the evaluation of retrofit costs and benefits. Situations where the cost for the adaptation measure is reasonable in comparison to potential losses should be given priority. If some measures are low to no cost, they should likely be implemented even though the likelihood or consequence is lower relative to other risks that have high-cost mitigation measures.
- Cost and Benefit Assessment for Different Building Types for financing and decision making: To effectively promote resilient retrofit, it's crucial to differentiate between Part 4 and Part 9 buildings.
- Shifting Focus from cost recovery to Value: Rather than solely focusing on cost recovery, emphasize the valuation aspect of resilient retrofit such as personal value or community value. This shift in perspective can highlight the importance of property value retention, insurability, and community value enhancement. Recognizing the economic benefits of resilient retrofit is essential. Retrofitting for resilience generates local jobs and contributes to societal well-being.
- Consistent Framework for Cost-Benefit Analysis: To streamline the process of evaluating the cost and benefit of resilient retrofit, a consistent framework for conducting cost-benefit analyses is needed. This framework would provide a standardized method for assessing the value of resilience measures.
- Impact of the Insurance Sector: The insurance industry plays a pivotal role in influencing cost-benefit analyses for resilient retrofit projects. It's essential to consider how insurance companies perceive and value resilience measures. Can insurance providers be incentivized to support and reward resilient retrofit initiatives? Could there be a resiliency checklist that the insurance industry would accept?
- Energy Efficiency Synergies: Energy efficiency and resilience are intertwined. Integrating resilience questions into the energy efficiency conversation can lead to more holistic solutions that address both energy and resilience needs.
- Carbon emissions scenarios should be considered in retrofits. On embodied carbon, there is the potential to improve durability by reducing the frequency of replacement (e.g., replace roofs less often by choosing a longer lasting option).
- Integrate the use of Nature-based Solutions in retrofits, considering the building and surrounding property lands to enhance energy efficiency, carbon sequestration and climate resilience. For example, trees and green roofs can help reduce extreme heat impacts on buildings and occupants, while also reducing the wider Urban Heat Island Effect.
- Incorporating local best practices and legal/regulatory compliance into prioritization: Local best practices should be incorporated to account for the unique characteristics of the location, community vulnerability, and adaptive capacity. Compliance with legal and regulatory requirements is paramount, especially in high-risk scenarios, ensuring alignment with local building codes and regulations. The feasibility of implementing risk mitigation measures and retrofit strategies must also be evaluated.

Acknowledging public perception and community priorities is crucial, as they can significantly influence overall prioritization.

4.1.5. Implementation of Adaptation Measures

- Cost-benefit studies alone cannot lead to implementation. Piloting these solutions is essential to gain practical insights into their effectiveness and potential challenges. To encourage retrofits, practical examples and pilot programs to demonstrate the feasibility and benefits of resilient retrofit are needed. Concrete success stories can inspire others to take action. Identifying and promoting champion builders who have successfully implemented resilient retrofit projects can serve as powerful examples for others in the industry such as builders and renovators. These champions can inspire and encourage more renovators and builders to embrace resilience.
- Transition from general guidance tools to lot-level assessments for tailored strategies and homeowner packages for stakeholders to understand how to become resilient.

4.1.6. Knowledge dissemination

- **Effective Education and Messaging:** Educating various stakeholder groups (such as homeowners, insurers and professionals) about the benefits of resilient retrofit (including its impact on insurance) is critical. However, it's equally important to tailor the information to suit the specific needs and perspectives of different audiences. Using accessible language, engaging communication methods, and practical ways of presenting information can prevent information overload and foster greater understanding. The reason that it is important to engage home owners is that the person who owns the asset has the most motivation for completing the retrofit. There are many instances where the occupant is not the owner, and it makes a difference who is paying the bills. You are more likely to do an energy efficiency upgrade if you are the one paying the electricity bill, and if you will be responsible for repairs you are more likely to make protective upgrades. On the other hand, home owner is not the only element and there are other factors in the decision-making process such as condo boards restrictions, insurance coverage requirements, bylaws or other requirements. A homeowner may not be able to make changes due to these external forces.
- **Demonstrating the Investment Case:** Making a compelling case for resilient retrofit can be challenging. There is a need to explore ways to present the investment in resilience to stakeholders, emphasizing the broader societal benefits and long-term cost savings. Point of sale labeling with resilience and risk information is a priority.
- **Creating a connection between effectiveness and local relevance is essential.** Need to have very locally applicable information to support action, like Calgary's Climate Smart Home Guide, that creates the connection to effectiveness and local relevance.
- **Motivating Behavior Change:** Motivating behavior change among property owners and stakeholders goes beyond cost considerations. To encourage resilient retrofit adoption, an understand of what people value most should be made to align retrofit initiatives with those values.

4.2. Review of the Recently Launched NRC Projects under R³

A concise overview of eight recently launched research projects under R³ was provided and a high-level summary is mentioned here.

- Role of Balconies in Resilient MURBs Retrofit: A Survey of the Canadian Context
 - Objective: Assess environmental and behavioral performance.
- Performance of Residential Balconies in Changing Climates
 - Objective: Address risks, review evaluation procedures, identify knowledge gaps, and develop modeling and testing frameworks.
- Resilient Residential Retrofit – Flooding
 - Objective: Identify existing technology and knowledge gaps to support the adoption of flood protection retrofits.
- Resilient and Sustainable Retrofit Solutions to Mitigate Overheating
 - Objective: Identify and assess promising technologies, barriers using calibrated building simulations, and field test selected technologies to reduce risks.
- Retrofits to Improve Resilience of Residential Buildings to Overheating Stress and Wildfire Exposure
 - Objective: Identify efficient interventions, collect indoor environment quality data, assess occupant health impacts, and conduct cost-benefit analyses.
- Evaluation of Indoor Overheating Risk Mitigation Strategies in Social Housing
 - Objective: Assess overheating events, develop data-driven forecasting tools, and evaluate retrofit scenarios using calibrated simulations.
- Technical Solutions for Climate Resilient Requirements for Retrofit of Residential Roofing with Asphalt Shingles
 - Objective: Develop evaluation protocols and update guidelines for climate-resilient roofing retrofit.
- Development and Cost-Benefit Analysis of Residential Building Envelope Retrofit Packages to Mitigate Climate Change Impacts
 - Objective: Develop a database of climate adaptation measures for envelope retrofits, identify high-risk municipalities, and analyze adoption costs and performance of archetypes.

5. WORKSHOP 2

Workshop 2 which was held on December 01, 2023, was a follow-on event from Workshop 1 (held on October 20, 2023) and built on the results of that previous session. The second Workshop was an opportunity to consolidate the feedback and focus on the NRC's role in residential resilience. The workshop started with an overview of the R³ process and summarized the results of Workshop 1. Based on those results, the R³ team¹ developed a roadmap for enabling adaptation retrofits which was used as the organizing structure for Workshop 2. The phases of the roadmap are as follows and will be explained in more detail in Section 5.1:

- I. Hazard and exposure mapping
- II. Building Assessment and Vulnerability Identification
- III. Identification of Adaptation Measures
- IV. Evaluate Adaptation Measures
- V. Implementation of Adaptation Measures
- VI. Knowledge Dissemination

5.1. Roadmap

Based on the information gathered from our initial consultation and first workshop session, along with our initial review of current literature, we have identified several common themes or needs. The identified themes or needs include, a need to organize and coordinate the fragmented work being completed in parallel, a desire to identify gaps in information and or any barriers in the way of creating a resilient retrofit guide and, that current information can be sometimes hard to find, follow and connect. As such, R³ is proposing a roadmap to resilient residential retrofits as seen in Figure 36.

The proposed roadmap is to help organize work and gathering information being completed in parallel across the industry and ultimately lead to enabling adaptation retrofits. The output of the R³ is to develop an adaptation pathway or resilient retrofit methodology that an individual or professional planning a resilient retrofit can follow. The roadmap is broken into 6 sections which were inspired and built from our previous stakeholder engagements and have been approved by several internal and external experts.

The first step on hazard and exposure mapping is to identify areas of the country that are currently at risk or may experience risk in the future due to a changing climate. The objective of this section is to develop current and future climate hazard design loads in which vulnerability can be assessed against.

The intent of the second step is to help gather information on what vulnerability means to both buildings and their occupants. Research will be conducted to help identify how some buildings may be inherently more vulnerable than others to future climate loads due to parameters such as but not limited to their age, construction practices, source of energy, or their management. Similarly, an understanding of what vulnerability means to building occupants will also need to be developed. The objective of this section is

¹ The credit goes to Travis Moore and Alex Hayes for their enormous contributions to developing the roadmap.

to develop a weighting or evaluating system which can be used to assign a level of risk to a building and or occupant based on their vulnerability and probability of the hazard occurring.

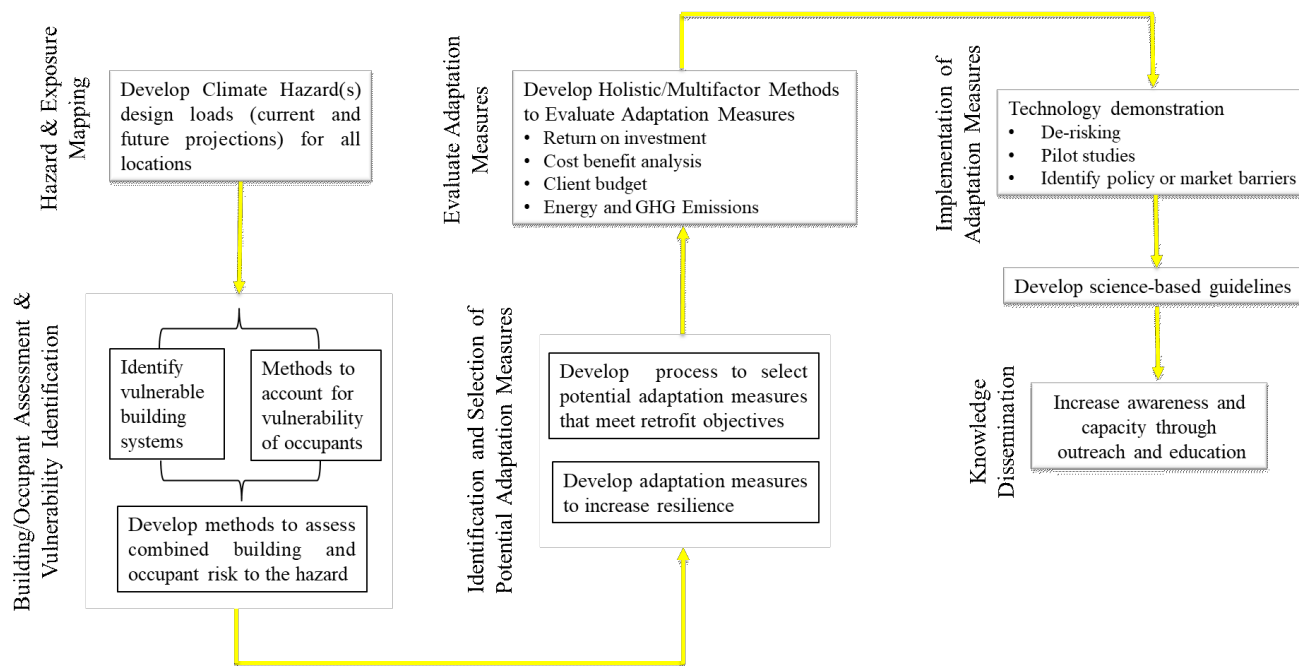


Figure 36- Proposed roadmap to Enabling Adaptation Retrofits

(note: this is an iterative process (loop) and you can always go back to the previous step, if needed)

The third step gathers information on the recommended practices and adaptation measures that could be used to decrease vulnerability of buildings and their occupants to the risks associated with climate hazards. These recommended practices and adaptation measures will be used as inputs for a process which when developed would suggest possible strategies to decrease the vulnerability for specific buildings and occupants.

Once more adaptation measures have been proposed and identified, a holistic/multifactor method to evaluate the adaptation measures against additional societal considerations may be required. These additional parameters could include but are not limited to cost benefit analysis, the budget of the client, and the Energy and GHG Emissions associated with the retrofit. The objective of step four is the development of a holistic/multifactor method to evaluate the adaptation measures.

In the ideal case, it is envisioned that select adaptation measures would be validated through pilot studies to de-risk the technology and identify any policy or market barriers that may limit their uptake. Finding from these studies would aide in the development of science-based guidelines. These guidelines could provide information to outreach and educational groups which in turn could increase the awareness and uptake of resilient measures.

As stated before, the objective of the proposed roadmap is to organize work and gathering information being completed in parallel across the industry. Using the gained knowledge and developed tools, the program would like to develop a resilient retrofit methodology, which an individual or professional planning resilient retrofit(s) could follow, a draft of which can be seen in Figure 37. The envisioned methodology would allow an individual or professional to learn about current and future climate hazards and their expected design loads based on location. From there, the unique characteristics of both the building and occupant could be accounted for as inputs to assess vulnerability against. The process could then be used iteratively to identify adaptation measures that meet the specific building/occupant needs.

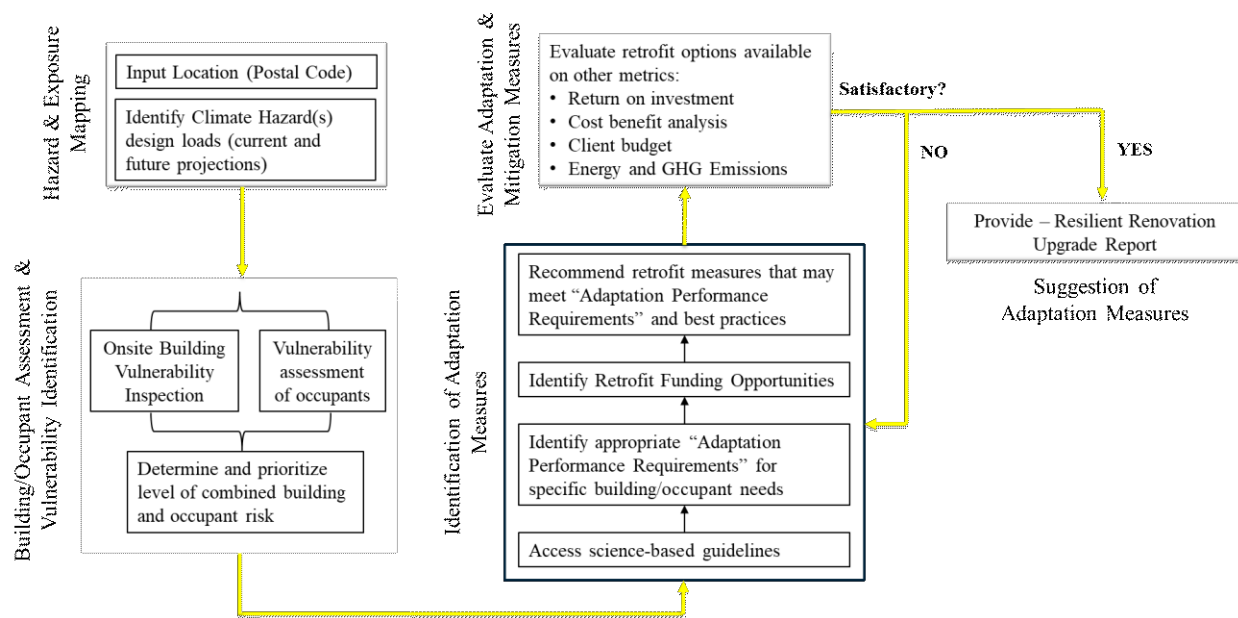


Figure 37- Proposed Resilient Retrofit Methodology

5.2. Mapping Existing Expertise

Participants were led through an exercise to map existing expertise in eight areas relating to the phases of the roadmap. Ideas and comments were captured as virtual Post-It notes on a Mural board and are presented here as bullet points.

I. Hazard and Exposure Mapping

- Public safety will be releasing Canada-wide flood hazard information including flood risk areas for infrastructure risk assessment into a public portal launching Fall 2024.
- Need to ensure that information is used appropriately. Canada-wide information may not be appropriate for site-specific assessments.
- NRCan has collected local flood hazard information from PTs.

- NRCan is working on a home adaptation rating program that will require the exact same information as this project.
- INFC is working on a very similar hazard and exposure mapping project and is working through the exact same data collection questions as your team are through their resilient toolkit project.
- NRCan is working on a Canada-wide wildfire risk model alongside Public Safety.
- Western University has a Northern Tornadoes Project that aims to better detect tornado occurrences throughout Canada.
- Partners for Action at University of Waterloo - Flood Risk Maps.
- PS is working on a “Coordinated Exposure Data Network” project to collect exposure data for Canada
- The Northern Hail Project at Western aims to improve knowledge of damaging hail storms and the detection of hail occurrence across Canada.
- Urban flood: Municipalities have information on vulnerability to sewer surcharge and surface flood
- Focus on beyond-the-building solutions, e.g., green infrastructure, district energy/microgrids with more cost-effective community benefits.

II. Building/Occupant Assessment and Vulnerability Identification

- Public Safety is working with Statistics Canada to develop a government wide social vulnerability layer
- Clean Foundation is completing flood risk assessment pilot of homes in Nova Scotia
- Incredible number of guidelines at Canada-wide and local levels for risk assessment that provide guidance on vulnerability and criticality
- https://bac-quebec.qc.ca/media/6253/designing-the-path-to-climate-compatibility_oct-22.pdf
- Partners for Action at University of Waterloo worked on Social Vulnerability Index (49 socio-economic indicators, Census)
- Developing probabilistic SoVI Can be done with or without stakeholders choosing and weighting variables
- Safety and serviceability of residential building balconies
- Institute of Catastrophic Loss Reduction’s Assessment checklist
- Impact of tiered building codes on overheating resilience in residential buildings
- Tool to convert energy performance model for energy analysis purposes to thermal resilience analysis
- <https://hab.civmin.utoronto.ca/projects/automated-tool-for-evaluating-building-thermal-resilience/>
- Assessment and monitoring of permafrost foundations and superstructure
- Importance of collecting indoor environment data and occupant health information through field study and wearable devices.

III. Identification of Adaptation Measures

- Suggested to be done by building archetype for easy distributed implementation
- Integration of energy efficiency, decarbonization and climate resiliency measures
- Checklists of measures with adaptation/mitigation synergies or conflicts
- Database and guidance resources on resilient retrofit measures

- Have a top-down process of modelling and research to identify all measures and priorities, but also start a bottom-up process to come up with tried, tested and true measures that combine energy, GHG, and resilience. This is especially important for the adaptive measures.
- There are many guidelines on this space from NRC, Canada Standards Associations, Standard- Council Canada, Partners for Actions, Intact Center, Infrastructure Canada, NRCan, Institute of Catastrophic Loss Reduction, etc.
- New/retrofit options for Part 9 buildings - high wind, hail, urban/pluvial flood, WUI fire
- Outreach to Authorities Having Jurisdictions (AHJs) to identify climate impacts on building products across Canada
- Best practices in remediation of permafrost foundations and superstructure such as replacement of wood piles, soils improvement, drainage improvement, sensing and monitoring systems.
- Resilient retrofit strategies: exterior shading systems, solar powered AC, and sky radiative cooling
- Evaluate mitigation measures for overheating and wildfire smoke in the lab, field study and building simulation models. The results will be generalized through data-driven models

IV. Evaluate Adaptation Measures

- Evaluate impact to livability, insurability, sell-ability
- Implication to real estate valuation (by appraisal/lender/realtor)
- Cost-benefit analysis on resilient retrofit packages
- Public Safety and Infrastructure Canada are both working on Return on Investment toolkits
- Ongoing project between Institute of Catastrophic Loss Reduction, Mantle and Standards Council Canada on developing a framework for assessing impact of resilience measures on embodied carbon
- Thinking of affordable retrofit options that are not perfect but are more affordable than an advanced expensive option
- Testing of variables impacting flood damage. ASFQ, INRS & NRC
- Energy simulation and cost estimation for different retrofit strategies
- Cost-benefit analysis of mitigation measures for overheating and wildfire smoke considering energy performance and occupant health

V. Implementation of Adaptation Measures

- Use a science-based Peril matching
- Conduct partnered pilots such as the ones conducted by Institute of Catastrophic Loss Reduction on high wind (Dufferin County)
- Institute of Catastrophic Loss Reduction's Insurers Rebuild Stronger Homes program that demonstrates insurance industry leadership to increase disaster resilience in recovery from a major disaster.
- Resilience Home Retrofit pilot project by Clean Foundation- Turnkey style upgrades for 20 homeowners in Nova Scotia
- Edmonton Power Corporation (EPCOR) basement flood prevention inspection program (site-level assessment of building vulnerability to flood)

- Institute of Catastrophic Loss Reduction and University of Guelph’s basement flood protection lab projects (urban flood hazard evaluation, performance of building systems, backflow protection, foundation drainage systems), available at: <https://www.iclr.org/wp-content/uploads/PDFS/protect-your-home-from-basement-flooding.pdf>
- Pilot project on sensing, monitoring and remediation of permafrost foundation
- Install selected retrofit strategies for demonstration
- Implement intervention strategies for overheating and wildfire smoke to real buildings and monitor the indoor environment and occupant health before and after the intervention

VI. Development of Guides, Codes, Standards

- Publish guide/toolkit/infographics on resilient retrofit measures
- Infrastructure Canada is partnering with NRC and Standards Council of Canada to fund research to inform climate resilient guidance: codes, standards, guidelines, and tools. Guidance developed so far can be found here: <https://www.infrastructure.gc.ca/climate-resilience-climatique/codes-standards-normes-guidances-eng.html>
- Multi-hazard resilience check lists for energy auditors. Lack of integration of energy and flood protection audits and retrofits is causing us to miss important opportunities on more meaningful and comprehensive homeowner engagement on making their homes safer, healthier, lower carbon – and minimizing costs for energy, insurance and potential repairs
- Public Safety has done a comprehensive review of hazard related guidelines and identified a key gap between guidance provided and implementation in policy
- Public Safety is working on guidelines for infrastructure mitigation in flood risk areas that will include risk tolerances
- Existing “Adaptive Home Renovation Manual” by Canadian Home Builders’ Associations
- The context of northern communities and resilience building in areas where housing or infrastructure is far below typical standards needs to be considered.
- Tie into and expand upon existing CSA work in developing climate resilience standards and guidelines
- Better collaboration between standardization system and code system to expedite uptake of new resilience standards
- Ensure home owners have quick and easy access to federal and/or provincial building assessment tools by imputing their address
- Development of the Climate Adaptation Home Rating Program by NRCan
- Guideline and standards for assessment, monitoring and remediation of permafrost foundations
- Developing evaluation criteria (technical guides) for climate resilient building products
- Develop guidelines for property managers/residents and update national/provincial building and energy codes
- Develop guidelines and update codes for relevant systems

VII. Knowledge Dissemination

- Mainstream communication to all professional channels
- Resiliency literacy
- Trades and contractors are essential in capacity building
- Realtor needs to be able to communicate the value of the renovation to future buyer
- Lender needs to value resiliency and track data in connection with Climate Risk Management B-15 reporting
- Ongoing LEEP and Net Zero training sessions for builders and renovators
- Booth at municipality-focused conferences like FCM, ICLEI
- FloodSmartCanada.ca
- Outreach to organizations representing building owners (for large multi-residential audiences)
- Tie into and expand upon existing CSA work in resilience capacity building (e.g., training courses, webinars, workshops, infographics, handbooks, “how to” guides, checklists, fact sheets, videos, etc.)
- Different audiences for large/full building assessment and versus component-level retrofit (deep retro versus just replacing siding)
- Use step-wise infographics with low, medium, higher cost options
- Identify target audiences and co-create resources to help them take one step at a time
- Work with Intact Center for Climate Adaptation to understand step-wise community-based approach to raising awareness, identifying risks, prioritizing applicable actions, step-wise implementation and ongoing maintenance.
- Insurance Advisory Committee (dissemination of information to ICLR member insurers ~90% of Canadian market)
- Behaviour change research and processes, key resources and methods through cbsm.ca
- Integration with existing programs for energy efficiency
- Organize workshops, publish journal articles, stub articles, infographics presentation on conferences presentation sessions in long-term care homes

Funding of Adaptation Measures

- Educate/motivate personal building upgrades done by private capital to improve the value of the asset
- CMHC's Can Greener Affordable Housing Program allows resiliency measures to be eligible in the total project costs for available grants/loans.
- Infrastructure Canada is developing resilience requirements for future funding programs
- Province of Nova Scotia (Department of Environment and Climate Change) funding the Resilience Retrofits pilot project through their Climate Change Plan
- Greener Homes Grant by NRCan
- Reap Green Solutions (Sharmalene is on the Board)
- Municipal basement flood subsidy programs (~35 municipalities across Canada)
- Insurer incentives/direct subsidies for resilience options

5.3. Setting the Stage for Breakout Discussions

Three brief presentations highlighting existing programs and projects set the stage for breakout discussions.

I. Partners for Action (P4A) Database of Resilient Retrofits for Buildings (University of Waterloo)

Sharmalene Mendis-Millard offered an overview of P4A, a research initiative that seeks to empower Canadians to become flood resilient by protecting existing homes and buildings. Working with a Halifax initiative to have all buildings possible retrofitted by 2040, the students addressed two research questions: What retrofits help protect against hazards? and What enables implementation of retrofits? They developed a searchable database of resilient retrofits, enabling initiatives, and funding programs to facilitate the implementation of retrofits.

Question/Answer from participant/speaker:

- Q: Was there any discussion about the constancy of shifting, changing, and disparately available programming resources in your research?
- A: Yes, these databases are best if they are living resources that are continually updated, with the site regularly maintained so that links, funding deadlines, etc. are all kept up to date. Our database includes dates. The database of funding programs accessible to communities, for example, includes application deadlines, including those that have passed. The list then serves as a reference point to update with the next application details, or as an archive of past funding opportunities that could potentially be revived.

II. Clean Foundation's Resilient Retrofit Program, Integrating Energy Efficiency and Climate Resiliency

Charlyne Robertson profiled a pilot project in Nova Scotia that is looking at flood risk. They are working with the cities of Halifax and New Glasgow to identify 10 homes each on which to conduct resilient retrofits. The target is single family homes selected based on social, biophysical and infrastructure factors. The project will conduct an 80-point flood risk assessment for each home and then develop retrofit planning within budget and time constraints. The project is collaborating with the energy team so that the homes are assessed from both perspectives.

Question/comment from participants:

- What would it take to get the Energy Advisors to be also “certified” in flood risk? e.g., courses, etc. Wouldn't that be the ultimate vision?
- This is an exciting project that the Intact Centre would like to help with. The flood risk assessment that energy advisors would need and could integrate into their reports can and needs to be very lean and efficient.

III. Canadian Home Builders' Association (CHBA) Industry Engagement for Climate Resiliency Implementation

Sarah Caron presented engagement and knowledge dissemination and mobilization activities conducted by CHBA. The Association has 8,500 member companies across the construction industry nationally.

Information is shared by local, provincial and national HBAs. Activities include a series of events throughout the year; a webinar series, some open to the public; numerous member newsletters and emails; a magazine; and manuals available publicly. Educational programs include Local Energy Efficiency Partnerships, LEEP workshops delivered across the country and Net Zero Renovations boot camps across the country.

5.4. Breakout Discussions

Participants split into three breakout groups, each addressing a different topic. Ideas were captured as virtual Post-It notes on Mural boards. Below the key takeaways from each breakout discussion are presented as bullet points.

I. Breakout Topic 1: Identification of Adaptation Measures

- Need common definitions to facilitate and enhance communications
- Centralize information for easier access and avoid repetition
- Conduct educational presentations to identify implementation barriers, practicality issues, and gather industry and government departments for better strategic alignment and coordination.
- Consolidate and build consensus for recommended measures.
- Perform market scans and literature reviews to identify potential adaptation measures and products.
- Establish "Resiliency Literacy" across the housing supply chain and promote energy literacy.
- Develop risk assessment tools for non-building science staff and energy advisors. Simplified visuals and calculators that can be easily accessed by public
- Shift the focus of resiliency from cost to profit preservation and identify co-benefits while avoiding maladaptation.
- Align funding solutions with technical interventions and consider financial incentives for homeowners.
- Coordinate with stakeholders to avoid duplication, find efficiencies, and promote program best practices.
- Keep practicality, affordability, accessibility, and longevity in mind throughout the process.

II. Breakout Topic 2: Implementation of Adaptation Measures

- Engage in education and outreach with trades and contractors.
- Create product databases for easy identification of resilient products.
- Work with manufacturers to develop low-risk, low-cost climate resilience solutions.
- Provide financing options for long-term return on investment.
- Train municipal personnel to guide residents on flood risks and responsibilities.
- Incorporate resilience into community development plans and infrastructure funding programs.
- Develop retrofit codes and standards for adoption by municipalities.
- Prioritize community concerns and target regions with known hazards.
- Ensure adaptation measures are user-focused and cost-effective.
- Coordinate grants and funding across government levels and streamline funding mechanisms.
- Prepare for future regulation by integrating resilience options into construction codes.

- Implement effective municipal programs and overcome implementation barriers.
- Provide evidence and tools to support resilience decisions for homeowners.
- Include resilience standards for public sector buildings and promote public education.
- Collaborate with insurance companies and offer incentives for resilience measures.
- Support workforce development for adaptation and resilience measures.
- Integrate resilience with decarbonization efforts and prioritize community-level adaptation.
- Facilitate pilots and demonstrations with funds and technical solutions.
- Establish clear roles and responsibilities among government organizations.
- Focus on meaningful incentives over regulation for effective impact.
- Provide accessible data and information on climate-related risks and resilience measures.
- Encourage collaboration and sharing of best practices among jurisdictions.
- Ensure equitable access to resilience measures and consider long-term evaluation and adaptation.

III. Breakout Topic 3: Knowledge Dissemination and Mobilization

- Outlets such as Net Zero Home Labelling Program by CHBA aim to certify homes designed, modeled, tested, and inspected for resilience.
- Tools and resources, including workshops and guides, are being developed by organizations like NRCan LEEP to aid in resilience and adaptation efforts.
- Recommendations include funding training sessions for industry professionals, creating funding programs for adaptation, and integrating climate-related risks into building codes and requirements.
- Collaboration and knowledge-sharing among stakeholders, including municipalities, industry professionals, and insurance providers, are essential for effective implementation.
- Challenges such as labor availability, cost considerations (affordability), and reaching rental building owners are being addressed through various initiatives and collaborations.
- Build on the existing network of knowledge mobilization
- Use funding programs to influence behaviour
- Develop case studies and mentorship as ways to share knowledge

Overall, the focus is on building capacity, promoting awareness, and implementing practical measures to enhance resilience and adaptation in the built environment.