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Scaling deep retrofits in social housing:

Insights, challenges, and roadmap foundations for Eastern Ontario

envirocentre | Retrofit Accelerator

Supported by funding from Natural Resources Canada's Greener Neighbourhoods Pilot Program, the objective of EnviroCentre's Retrofit Accelerator is to increase the uptake of deep energy retrofits in social housing buildings in eastern Ontario. The project helps housing providers plan, build the right financing strategy and deliver deep energy retrofits across their building portfolios to save energy, money and emissions. Designed with a tenant-centred lens, the Retrofit Accelerator supports organizations in renewing aging buildings, improving resident well-being, and maximizing long-term capital investment.

To learn more, please visit our website at www.envirocentre.ca or connect with us @EnviroCentre on social media.

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TABLE OF CONTENTS

1. Introduction

In Eastern Ontario, like other parts of the country, many people living in social housing struggle with expensive energy bills and homes that do not provide adequate comfort or efficiency (Kantamneni et al., 2025; Laidman, 2024; McIlroy et al., 2024).

As Canada pursues its legislated commitment to achieve net-zero greenhouse gas (GHG) emissions by 2050, the importance of transforming the residential building sector, including social housing, has never been greater. Deep retrofits, which deliver comprehensive upgrades to homes to achieve reductions in energy consumption and emissions, are increasingly recognized by policymakers as cornerstones of both climate mitigation and social equity strategies(CUSP, 2019; Government of Ontario, 2024)

However, the path to large-scale implementation of deep retrofits in social housing is complex. Literature consistently points to persistent barriers, including funding constraints, regulatory misalignments, workforce shortages, and the need to ensure equitable access for vulnerable populations. At the same time, there is a growing body of evidence highlighting the wide-ranging co-benefits of retrofits, from improved occupant health and comfort to enhanced resilience and economic opportunity for communities.

This literature review synthesizes current research, policy analyses, and case studies to inform the development of comprehensive retrofit pathways for social housing in Eastern Ontario, supporting the achievement of Canada's net-zero GHG target by 2050. It explores national climate priorities, regulatory frameworks, financial mechanisms, workforce capacity, equity considerations, and the broader benefits of deep retrofits. By examining experiences and lessons from other regions, the review identifies actionable insights and critical factors that influence retrofit adoption, with an emphasis on models that promote both climate mitigation and social equity.

Designed to provide an evidence-based foundation for strategic planning and decision-making, this review offers guidance for policymakers, industry stakeholders, social housing providers, and researchers working in the retrofit space. By highlighting persistent challenges, opportunities, and cross-cutting themes, it aims to support the design of effective, equitable, and scalable retrofit strategies that deliver meaningful benefits to communities while advancing low-carbon goals. This synthesis contributes to a growing body of knowledge essential for shaping the future of social housing retrofits in Eastern Ontario and beyond.

To further support practitioners, policymakers, and industry partners, this review includes annotated bibliographies that provide concise summaries and critical commentary on key sources, enabling readers to quickly assess the relevance and contributions of foundational research and policy documents.

Through a thematic approach to the literature, each section is structured around a central research question.

Theme 1 **Canada's goals:**	**How do Canada's national climate policies and energy transition strategies prioritize deep retrofits in social housing, particularly for vulnerable populations, and what are the key challenges in aligning these efforts with Canada's 2030 and 2050 climate goals?** The section situates retrofits within Canada's climate goals and explores how national and international precedents inform local strategy.
Theme 2 **Governmental role:**	**What are the regulatory and policy responsibilities across different levels of government in Canada for enabling deep retrofits, and where are coordination gaps or misalignments that limit implementation?** This theme analyses the responsibilities and interactions of governments in Canada in enabling retrofits. It identifies coordination gaps, regulatory barriers, and opportunities to align policy frameworks for greater impact.
Theme 3 **Scaling retrofits:**	**What financial incentives, policy drivers, and market mechanisms are most effective for making deep retrofits viable for social housing providers, and how can these be adapted to different regional conditions?** Examining available funding, tools, and mechanisms that make deep retrofits viable for social housing providers, this section assesses disparities, gaps, and international best practices to inform scalable solutions.
Theme 4 **Workforce capacity:**	**What are the current workforce and supplier capacity gaps in Eastern Ontario for implementing deep retrofits in social housing, and what strategies can be employed to address these gaps and ensure a scalable supply chain?** This section identifies gaps and explores strategies for capacity-building and regional economic development.

Theme 5 **Equity in scaling:**	**How can deep retrofits in social housing be scaled equitably to address the unique needs of vulnerable populations, including Indigenous communities, and what policy changes are necessary to ensure equitable access to these benefits?** We examine who benefits from retrofit programs, with a focus on barriers. The section proposes principles for equitable program design and policy changes to ensure inclusive access.
Theme 6 **Non-energy benefits:**	**What are the non-energy benefits of deep retrofits in social housing, such as improved health and economic outcomes, and how can these benefits be quantified and communicated to support the business case for large-scale retrofitting initiatives?** This section considers how the benefits of retrofits extend beyond energy savings and how they can be quantified and communicated to strengthen the case for investment and tenant-centred design.
Theme 7 **Case studies:**	**What lessons can be learned from successful case studies of deep retrofit programs in Canada and internationally that can inform the development of a scalable and effective retrofit roadmap for social housing in Eastern Ontario?** Drawing on Canadian and international examples of effective retrofit programs, this section distils lessons and approaches that can be adapted to the Eastern Ontario context.

We then synthesize findings across thematic sections, highlighting tensions, points of alignment, and recurring challenges. We examine areas where the literature converges or diverges and assess overall readiness for implementation. We also identify areas where evidence is lacking or where further research, innovation, or demonstration projects are needed to advance deep retrofits in social housing.

Finally, we summarize key findings and present actionable insights for practitioners, policymakers, and industry stakeholders. We outline the next steps and recommendations for roadmap development.

2. Key definitions

Key definitions clarify foundational concepts as they appear in literature today.

It is worth noting that while we found generalized concepts, there are no agreed-upon cohesive definitions of these concepts, and we will explore them further throughout the review.

Energy poverty lacks a clear and consistent definition both in Canada and worldwide. Kantamneni, Gaede, and Haley (2025), along with Tozer et al. (2024), highlight that this lack of a formal definition makes it harder to identify affected households, who may also be considered as experiencing core housing need, and impedes efforts to track progress in reducing energy poverty.

Energy poverty is generally defined as a condition where households face significant challenges in adequately meeting their essential home energy needs, such as heating, cooling, lighting, and powering their homes (Kantamneni et al., 2025; Martin et al., 2024; Shwashreh et al., 2024).

This struggle often stems from a combination of factors, including low incomes, high energy prices, and energy-inefficient housing (e.g., poor insulation or leaky windows) (Kantamneni et al., 2025; Kantamneni & Haley, 2022). As a result, households experiencing energy poverty may spend a disproportionately high percentage of their income on energy costs (Canada Electricity Advisory Council, 2024; Gaede & Nippard, 2023; Martin et al., 2024). While there is no single, universally accepted definition, some operational thresholds (e.g., 6% of after-tax income) are commonly used in practice, albeit inconsistently across programs and jurisdictions. (Kantamneni & Haley, 2022; Task Force for Housing and Climate, 2024). In the UK, it is sometimes defined as spending over 10% of gross salary on essential fuel (Shwashreh et al., 2024).

The consequences of energy poverty can be severe, leading to inadequate energy services, social exclusion, and forcing households to choose between keeping utilities on and affording other basic necessities like food, medical care, or prescriptions (Gaede & Nippard, 2023; ICAST, 2016; Shwashreh et al., 2024). It also has detrimental effects on physical and mental health (Kantamneni et al., 2025).

While energy poverty affects various income groups, it disproportionately impacts low-income households, Indigenous and remote communities, seniors, renters, and rural communities (Berkouwer & Dean, 2021; International Energy Agency, 2024; McIlroy et al., 2024; Natural Resources Canada, 2022). Canada currently lacks a single, nationally recognized definition and standardized metrics for energy poverty, which complicates efforts to identify and target vulnerable households effectively (Canada Electricity Advisory Council, 2024; Kantamneni et al., 2025; Martin et al., 2024).

Affordable housing

The literature consistently demonstrates that there is no single, universally accepted definition of affordable housing in Canada or internationally. In the Canadian context, the Canada Mortgage and Housing Corporation (CMHC) and the National Housing Strategy (NHS) adopt the definition of “core housing need,” where housing is deemed “affordable” if it costs less than 30% of a household’s before-tax income (Government of Canada, 2018) This shelter-cost-to-income ratio is widely referenced in federal, provincial, and municipal policy in Canada, including Ontario’s Second Action Plan under the NHS, and is used to determine eligibility for various affordable and social housing programs (Government of Ontario, 2024; Social Housing Services Corporation, 2008). In policy and program contexts, this term encompasses multiple

forms, including social and community housing provided by public, non-profit, or co-operative organizations. Special attention is given to the housing needs of vulnerable and marginalized groups, notably low-income households, seniors, people with disabilities, newcomers, and Indigenous Peoples (Social Housing Services Corporation, 2008).

For Indigenous communities, both on and off reserve, affordable housing definitions must recognize specific cultural, geographic, and governance needs, often determined through community-led or distinctions-based approaches (Nasarre-Aznar et al., 2021; Natural Resources Canada, 2022; Task Force for Housing and Climate, 2024).

However, while the 30% benchmark is prevalent in policy and programming, it may not fully capture the complexity of housing needs, particularly for lower-income households. Additional criteria, such as adequacy, suitability, and accessibility, reflecting the multi-dimensional nature of affordability, are often not considered (Westerhoff & Fisher, 2023; McIlroy et al., 2024). Furthermore, rising energy costs and the need for deep retrofits have prompted a growing recognition that affordability must also encompass energy expenditures, as energy poverty can significantly impact overall housing affordability (Kantamneni & Haley, 2022; Millyard, 2023).

From a global perspective, policies related to housing and social well-being are informed by international comparisons and commitments. Canadian policy can be informed by research on housing program delivery in other countries like Denmark, England, and Sweden (Glicker et al., 2024; Vérin & Poirier, 2024). Successful housing policy approaches in places like Austria are notably referenced research (Nasarre-Aznar et al., 2021). Broader international commitments related to human rights, sustainable development, and climate action also provide a backdrop against which domestic housing policies are developed and assessed (Canadian Sustainable Jobs Act Bill C-50, 2024; Government of Canada, 2016, 2020; Net-Zero Advisory Body, 2024).

European literature similarly notes the absence of a pan-European standard for affordable housing. Many European jurisdictions use a threshold of 30–40% of disposable income for housing costs, while also emphasizing housing quality and access to essential services (Valentová et al., 2019). While a single global definition of "affordable housing" is not explicitly provided in these sources, the concept of ensuring adequate and accessible housing is a common and central theme, particularly for vulnerable populations, which aligns with international human rights frameworks and objectives.

In summary, the literature indicates that affordable housing is most commonly defined by a shelter-cost-to-income ratio (typically 30% in Canada), but that effective definitions are context-dependent and multi-faceted, encompassing considerations of quality, suitability, and energy costs. Canadian and European sources highlight the need for flexible, locally-relevant definitions to address the diverse needs of low and moderate-income households and effectively guide policy and program delivery.

Vulnerable populations

The concept of “vulnerable populations” in the context of housing, energy, and climate initiatives is defined and discussed across several key Canadian policy and research documents. The literature consistently identifies specific groups and the particular challenges they face, with each source contributing unique insights:

- **Low-income households:** Multiple sources, including the NHS (Government of Canada, 2018) and Efficiency for All (Kantamneni & Haley, 2022) explicitly define low-income households as a primary vulnerable group. These households are more likely to experience housing insecurity, energy poverty, and barriers to accessing retrofit programs (McIlroy et al., 2024; Millyard & Kolb, 2025).
- **Indigenous Peoples:** The vulnerability of Indigenous Peoples, especially in remote and Northern communities, is highlighted in both the NHS (Government of Canada, 2018) and technical market assessments (The Atmospheric Fund, 2024). These sources emphasize the intersection of systemic barriers, infrastructure deficits, and the need for culturally appropriate, self-determined solutions (Liberty Multimedia Inc., 2024).
- **Seniors and people with disabilities:** The NHS (Government of Canada, 2018) and the Ontario Action Plan (Government of Ontario, 2024) both identify seniors and people with disabilities as vulnerable due to fixed incomes, health challenges, and higher rates of social isolation. These groups are at increased risk of poor housing conditions and face barriers to accessing energy efficiency programs.
- **Women, children, and survivors of violence:** Women and children fleeing violence are specifically named as vulnerable in the NHS (Government of Canada, 2018) and targeted by specific benefits such as the Canada-Ontario Housing Benefit (Government of Ontario, 2024). These sources note the compounding risks of housing insecurity and energy poverty for survivors of gender-based violence.
- **Racialized groups and newcomers:** Racialized populations, including Black Canadians and recent immigrants, are recognized as facing discrimination and systemic barriers in the housing and energy sectors (Millyard & Kolb, 2025). These groups are more likely to experience core housing needs and have less access to affordable, energy-efficient housing.
- **Renters, tenants, and social housing residents:** Several sources, including Better Buildings for All (McIlroy et al., 2024) and Retrofitting Canada's Homes Progress Report #2 (Millyard & Kolb, 2025), highlight renters and social housing residents as vulnerable due to limited control over building upgrades, higher rates of energy poverty, and risk of "renovictions."
- **Rural and remote communities:** The challenges faced by rural and remote communities, such as higher energy costs and limited access to retrofit programs, are discussed in market assessments and energy poverty reviews (Kantamneni, 2024b; The Atmospheric Fund, 2024).

Drawing on sources, vulnerable populations in the Canadian context are defined as groups who, due to factors such as low-income, Indigenous identity, age, disability, newcomer or racialized status, tenancy, or geographic isolation, are at heightened risk of housing insecurity, energy poverty, and negative impacts from climate change. The literature emphasizes the need for targeted, inclusive, and culturally sensitive policy responses to address the specific barriers faced by these populations (Government of Canada, 2018; Kantamneni et al., 2024; McIlroy et al., 2024; Millyard & Kolb, 2025).

Deep retrofits

The sources reviewed show that "deep retrofits" are a critical but evolving concept in the context of building decarbonization and climate policy, with no single, universally accepted definition. Most sources agree that substantial reductions in building energy consumption characterize deep retrofits, but the quantitative thresholds and specific criteria vary.

For example, Glicker et al. (2024) report that a common threshold is achieving at least a 50% reduction in energy use compared to pre-retrofit levels, with some jurisdictions like the European Union and Argentina setting the bar at 60% or more. This source also highlights that definitions are shaped by regional policy frameworks, citing Belgium-Flanders' use of an EPC level A (100 kWh/m^2/year), France's Bâtiment Basse Consommation (BBC) label (80 kWh/m^2/year), and Ireland's requirement for a Building Energy Rating (BER) - A rating with a primary energy use of 0 to 25 kWh/m^2/yr.

A fundamental objective is to virtually eliminate greenhouse gas (GHG) emissions from buildings and contribute significantly to achieving net-zero economy objectives, preparing the building stock for decarbonization (Glicker et al., 2024; Haley & Torrie, 2021; Natural Resources Canada, 2022). GHG reductions from deep retrofits are noted as being more than double those from average retrofits and often target 80% emissions savings (McIlroy et al., 2024; Natural Resources Canada, 2022).

Millyard and Kolb (2025) emphasize that, in the Canadian context, deep retrofits are essential for achieving national climate mitigation goals. However, they note that programs such as the Canada Greener Homes Grant often fall short of the >50% savings target, with average savings of only 17–21%.

Calder (2020) and The Atmospheric Fund (2024) both underscore that deep retrofits go beyond energy savings alone. These sources describe deep retrofits as comprehensive interventions that eliminate direct fossil fuel use and prepare buildings for zero-carbon operation, typically through a systems-thinking approach that integrates improvements to the building envelope, electrification of heating and cooling, and the addition of renewables.

Overall, the sources show that deep retrofits are explicitly distinguished from less comprehensive approaches such as shallow or single-measure retrofits. They are also recognized for delivering co-benefits, including improved occupant comfort, resilience, health, and skilled job creation (Calder, 2020a; Millyard & Kolb, 2025). Because definitions of deep retrofits vary across jurisdictions and programs, the absence of a clear and explicit definition complicates policy design, benchmarking, and evaluation, and risks misalignment between stated climate objectives and delivered outcomes (Glicker et al., 2024; Haley & Torrie, 2021; Natural Resources Canada, 2022).

Annotated references

Kantamneni, A., Gaede, J., & Haley, B. (2025). *Making Net-Zero Retrofits Work for Energy-Poor Households*. Efficiency Canada, Carleton University, Ottawa, ON. Retrieved from https://www.efficiencycanada.org

This report by Kantamneni, Gaede, and Haley explores the intersection of energy poverty, energy efficiency, and net-zero retrofits in Canada. It highlights the challenges of energy-poor households, including financial barriers, fragmented policies, and workforce shortages, while emphasizing the risks of exclusion and unintended consequences in retrofitting programs. The authors propose actionable recommendations, including no-cost retrofits, flexible financing, renter protections, and workforce training, to ensure equitable access to energy-efficient upgrades. The report also advocates establishing a national definition of energy poverty, setting reduction targets, and creating a centralized advisory hub to track progress. Grounded in evidence and practitioner insights, this comprehensive study provides a roadmap for aligning climate goals with social equity. It is a valuable resource for policymakers, researchers, and advocates working toward a sustainable and inclusive energy transition.

City of Peterborough (2024). *Community Housing Strategic Plan, Report CSSS24-006*. Retrieved from https://pub-peterborough.escribemeetings.com/Meeting.aspx?Id=d95bdb66-e06a-47cb-b3a5-7161027f2e66&Agenda=Agenda&lang=English&Item=20&Tab=attachments

This comprehensive report, prepared by the City of Peterborough, outlines the first phase of the Community Housing Strategic Plan study. It provides an in-depth analysis of the current state of affordable housing in Peterborough, including demographic trends, housing metrics, and challenges such as the expiration of operating agreements and mortgages for community housing providers. The report highlights the need for strategic priorities, including improving system performance, enhancing operational efficiency, leveraging the current housing portfolio, and increasing housing supply. It also emphasizes the importance of partnerships, financial planning, and best practices for negotiating new operating agreements to ensure the sustainability of affordable housing. The document serves as a valuable resource for policymakers, housing providers, and other stakeholders working to address housing challenges in Peterborough.

McIlroy, Jessica, Betsy Agar, and Emma Harris. *Better Buildings for All: Relieving Energy Poverty through Deep Retrofits*. The Pembina Institute, 2024.

This report analyzes how deep retrofits can reduce energy poverty and advance climate goals for low-income Canadians, particularly those in social housing. Defining energy poverty as spending more than 6% of income on energy, the authors estimate that 8% of households are affected and detail the benefits of retrofits, such as lower bills, improved comfort, and greater resilience to extreme weather. The report identifies barriers to program uptake-including administrative complexity, insufficient funding, and renoviction risk-and recommends $2.8 billion in annual public investment to provide zero-cost, fully funded retrofits, delivered through simplified, locally administered programs. While it offers robust policy analysis and actionable recommendations, the report notes the challenge of protecting tenants from displacement during retrofits but does not fully resolve it.

Canadian Urban Sustainability Practitioners (CUSP). (2019, October). Energy poverty in Canada: A CUSP backgrounder. Retrieved from https://www.cuspnetwork.ca

This backgrounder by the Canadian Urban Sustainability Practitioners (CUSP) provides an in-depth analysis of energy poverty in Canada, defined as households spending more than 6% of their after-tax income on home energy needs. The report highlights key trends, including the prevalence of energy poverty in Atlantic Canada, its impact on both urban and rural households, and the role of housing characteristics and income levels in shaping energy cost burdens. It emphasizes the need for equitable clean energy program design to address barriers faced by low- and moderate-income households, which are disproportionately affected by energy poverty. The document also introduces the Energy Poverty and Equity Explorer, a mapping tool developed under the Local Energy Access Programs (LEAP) project to guide cities in designing inclusive clean energy programs. This resource is valuable for policymakers, researchers, and sustainability practitioners working to address energy poverty and promote equitable climate action.

Government of Canada (2024). *Bill C-19: Canadian Net-Zero Emissions Accountability Act*. Retrieved from http://laws-lois.justice.gc.ca

This document outlines Canada's commitment to net-zero greenhouse gas emissions by 2050. It establishes a framework for setting national emissions-reduction targets, establishing milestone years, and developing emissions-reduction plans. The Act emphasizes transparency, accountability, and public participation, incorporates Indigenous knowledge, and aligns with international climate agreements, including the Paris Agreement. It also mandates progress and assessment reports, the establishment of an advisory body, and collaboration with provinces and other stakeholders. This resource is essential for understanding Canada's legislative approach to climate change mitigation and its alignment with global climate goals

Tozer, L., Baggio, G., Kantamneni, A., & MacRae, H. (2024). *Equity-Based Energy Retrofits to Address Energy Poverty in Canada*. Energy Policy. https://doi.org/10.1016/j.enpol.2024.114341

This research explores how deep retrofits can be designed and scaled to address energy poverty among vulnerable populations, focusing on equitable outcomes. The authors analyze policy frameworks and case studies across Canada, highlighting that traditional retrofit programs often fail to reach those most in need, including low-income households and Indigenous communities, due to barriers such as upfront costs, limited access to financing, and inadequate program design. The study advocates for an equity-based approach that centres marginalized groups' unique needs and lived experiences, recommending policies that provide targeted funding, community-driven program development, and culturally relevant solutions for Indigenous communities. The article concludes that governments must implement comprehensive policy changes to ensure equitable access to retrofit benefits, including dedicated funding streams, collaboration with community organizations, and mechanisms for ongoing evaluation and adaptation, ensuring that deep retrofits effectively reduce energy poverty and promote social equity across Canada.

Martin, N., Bowie, D., Fakhoury, R., & Kabbara, M. (2024). *Household Energy Affordability in a Net-Zero Future*. The Transition Accelerator. Retrieved from www.electrifyingcanada.ca

This report, authored by experts at The Transition Accelerator, explores the implications of Canada's transition to a net-zero economy by 2050, with a focus on household energy affordability. It examines how electrification, through technologies like electric vehicles and heat pumps, can reduce energy costs for most households while highlighting challenges for vulnerable groups, such

as lower-income households and those in regions with high electricity rates. The report emphasizes the need for proactive policies to ensure equitable benefits, including energy efficiency measures, alternative technologies, and strategies to mitigate rising electricity costs. It also underscores the importance of collaboration between provincial and federal governments to achieve affordable electrification nationwide. This comprehensive analysis provides valuable insights for policymakers, researchers, and stakeholders involved in Canada's energy transition.

Shwashreh, L., Taki, A., & Kagioglou, M. (2024). *Retrofit Strategies for Alleviating Fuel Poverty and Improving Subjective Well-being in the UK's Social Housing*. Buildings, *14*(316). https://doi.org/10.3390/buildings14020316

This article explores retrofit strategies for social housing in Leicester, UK, with a focus on alleviating fuel poverty and improving subjective well-being. The authors employ a mixed-methods approach, including surveys, interviews, and simulations, to assess energy efficiency and indoor comfort. Key findings highlight the transformative potential of comprehensive retrofits, such as insulation upgrades and renewable energy integration, to reduce energy costs and enhance residents' quality of life. The study also emphasizes the importance of resident engagement and proposes a checklist for future retrofit projects. This research is valuable for policymakers and architects aiming to address fuel poverty and promote sustainability in social housing.

Kantamneni, A., & Haley, B. (2022). *Efficiency for All: A Review of Provincial/Territorial Low-Income Energy Efficiency Programs with Lessons for Federal Policy in Canada*. Efficiency Canada, Carleton University. https://www.efficiencycanada.org

This report provides a comprehensive analysis of energy efficiency programs targeting low-income households across Canada. It highlights the importance of addressing energy poverty through tailored efficiency measures, emphasizing the role of such programs in reducing greenhouse gas emissions and achieving net-zero goals. The authors review existing provincial and territorial programs, identifying strengths such as participant outreach and institutional learning, while also addressing gaps such as insufficient depth of energy savings, limited fuel-switching options, and barriers related to non-energy upgrades. The report advocates for a federal strategy that complements provincial efforts, focusing on results, stable funding, and supportive systems to ensure equitable access to energy efficiency benefits. This research underscores the urgency of expanding low-income energy efficiency initiatives to meet Canada's climate and social equity objectives.

Canada Electricity Advisory Council (2024). *A Blueprint for Success: Canada Electricity Advisory Council Final Report*. Natural Resources Canada. https://www.nrcan.gc.ca

This report provides a detailed roadmap for Canada's electricity transition to achieve net-zero emissions by 2050. It emphasizes four cornerstones: speed, affordability, reliability, and Indigenous participation. The document includes recommendations for aligning policies, enabling infrastructure development, supporting the transition, and promoting energy efficiency. It highlights the importance of regional cooperation, Indigenous economic reconciliation, and addressing energy poverty. The report is valuable for policymakers, industry stakeholders, and researchers interested in sustainable energy systems and climate action. It also offers insights into the challenges and

opportunities of decarbonizing Canada's electricity sector while ensuring inclusivity and affordability.

Task Force for Housing & Climate (2024). *Blueprint for More and Better Housing: How Federal, Provincial, and Municipal Governments Can Ensure We Build 5.8 million Homes That Are Affordable, Low-Carbon, and Resilient*. Retrieved from www.housingandclimate.ca

This report focuses on addressing Canada's housing crisis by constructing 5.8 million new homes by 2030 that are affordable, climate-resilient, and low-carbon. It provides a comprehensive strategy focused on legalizing density, reforming building codes, accelerating innovation in construction, and improving multi-level government coordination. A distinctive feature of this report is its emphasis on Indigenous-led housing initiatives and the integration of international best practices related to housing emissions and infrastructure. The blueprint is primarily designed for housing policymakers, planners, and researchers aiming to expand the supply of sustainable, accessible housing while reducing associated emissions.

ICAST (2016). *Multifamily Green Rehabilitation Resource Guide*. International Centre for Appropriate and Sustainable Technology. Retrieved from www.ICASTusa.org

This resource guide, developed by ICAST, provides a comprehensive overview of strategies for implementing green rehabilitation in multifamily affordable housing (MFAH) properties. It addresses market barriers, solutions, and best practices, including planning, design, project management, financing, reporting, and tenant behaviour change. The guide is particularly useful for service providers, property owners, and managers seeking to enhance sustainability and affordability in MFAH properties. It includes case studies, industry certifications, and tools like the EPA's Portfolio Manager to track energy savings. The document emphasizes ICAST's one-stop-shop model, which integrates all aspects of green rehab under one contract to overcome common challenges in the sector.

Berkouwer, S., & Dean, J. (2021). *Barriers to Energy Efficiency Adoption in Low-Income Communities*. Kleinman Centre for Energy Policy. Retrieved from https://kleinmanenergy.upenn.edu

This document explores barriers to adopting energy-efficient technologies in low-income communities. It highlights the financial, environmental, and health benefits of energy efficiency, such as reduced charcoal consumption, lower greenhouse gas emissions, and improved indoor air quality. Despite these benefits, adoption remains low due to credit constraints and affordability issues. The authors argue that subsidies or targeted financing may be more effective than carbon taxes in promoting energy efficiency in low-income settings, given the regressive nature of such taxes and prevalent financial market frictions. The research underscores the importance of tailored policies to address unique challenges in low-income contexts.

International Energy Agency (2024). *World Energy Outlook 2024*. Paris: International Energy Agency. Retrieved from https://www.iea.org/weo

This document provides a detailed analysis of global energy trends, policies, and projections up to 2050. It examines energy demand, supply, emissions, and investment across sectors and regions under three main scenarios: the Stated Policies Scenario (STEPS), the Announced Pledges Scenario (APS), and the Net Zero Emissions by 2050 Scenario (NZE). The report highlights the growing role of

renewables, electrification, energy efficiency, and critical minerals in achieving climate goals, while addressing challenges such as LNG oversupply, electricity demand growth, and the pace of clean energy deployment. It also explores regional dynamics, such as bioenergy potential in Latin America and strategies for reducing coal emissions in Southeast Asia. This document is vital for policymakers, researchers, and industry stakeholders, offering insights into clean energy transitions, investment trends, and the geopolitical risks shaping the global energy landscape.

Natural Resources Canada (2022, July). *Canada Green Buildings Strategy: Discussion Paper*. https://natural-resources.canada.ca/energy-efficiency/building-energy-efficiency/canada-green-buildings-strategy-transforming-canada-s-buildings-sector-net-zero-resilient-future

This discussion paper, published by Natural Resources Canada in July 2022, outlines the Canada Green Buildings Strategy to achieve net-zero emissions and climate-resilient buildings by 2050. It provides a comprehensive overview of the built environment's current emissions profile, challenges, and opportunities for transformation. The document identifies six strategic themes, including government leadership, policy mandates, investment facilitation, workforce development, technological innovation, and data transparency. It emphasizes collaboration among federal, provincial, territorial, and Indigenous governments, as well as private-sector stakeholders, to drive market transformation. The paper also highlights the importance of affordability, equity, and inclusion in achieving its goals. It serves as a foundational framework for engaging stakeholders and guiding future actions to decarbonize Canada's building sector.

Government of Canada (2018). *Canada's National Housing Strategy: A Place to Call Home*. Retrieved from https://placetocallhome.ca

The document outlines a 10-year, $40-billion plan to address housing challenges across Canada. It includes key initiatives such as the National Housing Co-Investment Fund, the Canada Housing Benefit, and community housing programs, focusing on reducing chronic homelessness, creating or repairing housing units, and prioritizing vulnerable populations, including women, Indigenous peoples, seniors, and people with disabilities. Positive aspects include its human rights-based approach, integration of Gender-Based Analysis Plus (GBA+), and the $241 million allocated for evidence-based research. However, the strategy's success relies on effective implementation and collaboration among stakeholders, and it acknowledges gaps in knowledge, particularly regarding housing needs in Northern communities and among racialized women, which require further research. Overall, the strategy is ambitious and inclusive but demands ongoing evaluation and adjustments to meet its goals.

Government of Ontario. (2022). *Ontario's Second Action Plan Under the National Housing Strategy (2022–25)*. Retrieved from https://www.ontario.ca/document/ontarios-second-action-plan-under-national-housing-strategy-2022-25

This document outlines Ontario's strategic approach to addressing housing challenges and homelessness under the National Housing Strategy (NHS) for the years 2022–2025. It provides a detailed overview of initiatives such as the Canada-Ontario Community Housing Initiative (COCHI), Ontario Priorities Housing Initiative (OPHI), and Canada-Ontario Housing Benefit (COHB), which aim to increase affordable housing supply, preserve existing housing stock, and provide rental assistance to vulnerable populations. The plan highlights Ontario's efforts to tackle affordability,

supply shortages, and supportive housing needs, while addressing homelessness through streamlined programs like the Homelessness Prevention Program (HPP). It also emphasizes collaboration with Indigenous Program Administrators and local Service Managers to ensure community-specific solutions. The document includes measurable targets, funding allocations, and reporting mechanisms to track progress and align with NHS principles.

Social Housing Services Corporation. (2008). *Ontario Social Housing Primer*. Toronto, ON: Author. Retrieved from www.shscorp.ca

This document provides a comprehensive overview of social housing in Ontario, including its history, legislative framework, costs, programs, and providers. It outlines the roles of various organizations, such as Local Housing Corporations, non-profit housing providers, and co-operative housing, and discusses funding mechanisms and challenges associated with social housing. The primer also highlights the transition of administrative responsibilities from provincial to municipal governments under the Social Housing Reform Act (SHRA). Additionally, it describes sector organizations like the Social Housing Services Corporation (SHSC) and Ontario Non-Profit Housing Association (ONPHA), which support housing providers and service managers. This resource is valuable for understanding Ontario's structure, challenges, and administration of social housing.

Nasarre-Aznar, S., Lambea-Llop, N., Ftáčnik, M., & Rasnača, L. (2021). *Concrete Actions for Social and Affordable Housing in the EU*. Foundation for European Progressive Studies. ISBN: 978-2-930769-50-9.

The report identifies key challenges in social and affordable housing across Europe (EU), including housing unaffordability, urbanization, shortages of social rental housing, housing deprivation, and homelessness. It highlights successful practices such as Austria's Limited Profit Housing Associations, the Netherlands' Energiesprong project for energy-efficient housing, and Spain's Habitat 3 Foundation for social housing management. However, challenges such as insufficient data, financialization, and incoherent policies persist, underscoring the need for robust data collection, interdisciplinary collaboration, and territorial cohesion policies. The report includes complementary studies that underscore similar issues, including overcrowding, poor housing quality, and regional disparities, while advocating for innovative solutions like housing guarantee programs and energy-efficient renovations. Research gaps remain in areas such as the impact of financialization on housing markets, eviction prevention measures, and the long-term effects of homelessness, highlighting the need for coordinated action at the local, national, and EU levels to ensure access to sustainable, inclusive, and affordable housing.

Westerhoff, L., & Fisher, J. (2023). *Low-Income and Social Housing Electrification Roadmap*. Introba Consulting Ltd. Retrieved from www.introba.com

This roadmap aims to decarbonize affordable housing in British Columbia by 2030 through electrification, preserving affordability, and preventing displacement. It highlights benefits like improved air quality, reduced utility bills, life-saving cooling systems, and barriers such as high costs, limited industry capacity, and regulatory challenges. Key strategies include setting decarbonization targets, streamlining incentives, embedding tenant protections, and expanding industry capacity. Identified gaps include limited data on low-income market rentals, technology availability, and challenges in rural areas. The roadmap emphasizes collaboration, funding, and

alignment with broader climate and housing policies to achieve equitable electrification for vulnerable populations.

House of Commons of Canada. (2024). *Bill C-50: Canadian Sustainable Jobs Act*. Retrieved from https://www.ourcommons.ca

Bill C-50, titled the Canadian Sustainable Jobs Act, establishes a framework to promote economic growth, create sustainable jobs, and support workers and communities in Canada's transition to a net-zero economy. The Act outlines accountability, transparency, and engagement measures, including creating a Sustainable Jobs Partnership Council to provide independent advice, the establishment of a Sustainable Jobs Secretariat to coordinate implementation, and the requirement for periodic Sustainable Jobs Action Plans and progress reports. It emphasizes inclusivity, equity, and collaboration with stakeholders such as Indigenous peoples, trade unions, and provincial governments. The Act also mandates a review every ten years to ensure its effectiveness in achieving its goals.

Government of Canada. (2016). *Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy*. Retrieved from https://www.canada.ca/en/services/environment/conservation/sustainability/pan-canadian-framework.html

The *Pan-Canadian Framework on Clean Growth and Climate Change* outlines Canada's comprehensive strategy to address climate change while fostering economic growth. Developed collaboratively by federal, provincial, and territorial governments, the framework is built on four pillars: pricing carbon pollution, complementary measures to reduce emissions, adaptation and climate resilience, and clean technology innovation. It emphasizes the importance of transitioning to a low-carbon economy through renewable energy, energy efficiency, sustainable transportation, and industrial innovation. The framework also highlights the need for collaboration with Indigenous Peoples, respect for their Traditional Knowledge, and support for vulnerable communities, including northern and coastal regions. It sets ambitious targets to reduce greenhouse gas emissions by 30% below 2005 levels by 2030, aligning with Canada's commitments under the Paris Agreement. The document provides a roadmap for achieving these goals through federal investments, provincial and territorial actions, and international partnerships.

Government of Canada. (2020). *A Healthy Environment and a Healthy Economy: Canada's Strengthened Climate Plan to Create Jobs and Support People, Communities, and the Planet*. Environment and Climate Change Canada. Retrieved from https://www.canada.ca

This document outlines Canada's strengthened climate plan to address climate change while fostering economic growth and job creation. It details strategies across various sectors, including energy efficiency in homes and buildings, clean transportation, industrial decarbonization, nature-based solutions, and Indigenous climate leadership. The plan emphasizes collaboration with provinces, territories, Indigenous communities, and international partners to achieve net-zero emissions by 2050. It also highlights the importance of carbon pricing, clean fuel standards, and investments in clean technology. The resource is valuable for understanding Canada's approach to integrating environmental sustainability with economic resilience, making it relevant for policymakers, researchers, and environmental advocates.

Net-Zero Advisory Body. (2024, September). *Climate's Bottom Line: Carbon Budgeting and Canada's 2035 target*. Retrieved from www.nzab2050.ca

The report provides comprehensive advice to the Canadian government on setting a 2035 greenhouse gas (GHG) emissions reduction target. It emphasizes the importance of developing a national carbon budget, adopting an emissions reduction target of 50% to 55% below 2005 levels, and addressing Canada's excess emissions. The report highlights Canada's role in global climate efforts, the urgency of accelerating emissions reductions, and the need for transparent governance mechanisms. It explores fairness-based and target-based carbon budget approaches, recommending a target-based approach due to feasibility concerns. The report also underscores the importance of international climate finance and negative emissions technologies to address excess emissions. This document serves as a critical roadmap for Canada's climate policy, aligning with the Paris Agreement and the Canadian Net-Zero Emissions Accountability Act.

Millyard, K. (2023, November). *Retrofitting Canada's Homes: Progress Report #1*. Green Communities Canada. https://greencommunitiescanada.org/retrofitting-canadas-homes-progress-report-1

This report provides a critical assessment of the Canada Greener Homes Grant (CGHG) program, launched in 2021 to accelerate residential energy retrofit in general, nationwide. While the program increased retrofit activity nearly fourfold and supported over 600,000 projects, it fell short of national climate goals: average energy savings rose only modestly (from 17% to 21%), with deep retrofits (>50% energy savings) achieved in just a small fraction of cases. The report identifies key barriers, including insufficient grant amounts, a focus on single measures like heat pumps at the expense of essential building envelope upgrades, and significant "hassle costs" and expertise gaps for homeowners. The CGHG model is found to be particularly inaccessible for low-income and First Nations households, who require full-cost incentives. Drawing on international best practices, the reports recommend reorienting national retrofit programs toward deep retrofits, raising grant and loan limits, introducing performance-based incentives, and funding expert support services such as energy coaches. They also stress the need for expanded training for energy advisors and phasing out fossil fuel equipment in new construction to align with Canada's net-zero 2050 target.

Glicker, J., Lee, L. Y., Cheikh, N., & Gérard, F. (2024). Deep Retrofit Models: A Global Perspective. Report of the Energy Efficiency in Buildings Task Group under the Energy Efficiency Hub. European Commission.

Glicker et al. (2024) provide a global analysis of deep retrofit (DR) models based on surveys and workshops from countries including Argentina, Brazil, China, the EU, Germany, Korea, and Saudi Arabia. The report highlights significant variation in DR definitions and ambitions due to national policies, climate, building stock, and regulations. Despite deep retrofits' potential to achieve over 50% energy savings and decarbonize buildings, barriers such as limited policy ambition, high upfront costs, financing gaps, labour shortages, and low awareness remain. The authors recommend harmonizing policies, setting clear targets, expanding financing, investing in workforce training, and launching support programmes like One-Stop Shops to accelerate DR adoption and meet climate goals.

Vérin, A., & Poirier, M. (2024). *Building Heating Decarbonization – Jurisdictional Scan*. Building Decarbonization Alliance. Version 2.0.

This report provides a comprehensive overview of policies and initiatives aimed at decarbonizing building heating systems across Canada, the United States, and Europe. It highlights regulatory frameworks, energy performance standards, and fossil fuel phase-out strategies at federal, provincial, and municipal levels. The document also includes international examples and emphasizes the importance of collaboration among governments to achieve net-zero emissions. It serves as a valuable resource for policymakers, researchers, and advocates working on building decarbonization and climate action.

Valentová, M., Karásek, J., & Knápek, J. (2018). *Ex-post Evaluation of Energy Efficiency Programs: Case study of Czech Green Investment Scheme*. WIREs Energy and Environment, 8(2). https://doi.org/10.1002/wene.323

This study post-evaluates the Czech Green Savings Program (2009–2012), a residential energy efficiency initiative funded through the Green Investment Scheme (GIS). Analyzing 206 measures across 124 projects via on-site inspections and interviews, the authors identify a 25% gap between projections and actual CO_2 emission reductions. Discrepancies stem from methodological limitations in standardized calculations (e.g., overlooking real-world energy use patterns) and behavioural factors such as altered heating practices, occupancy changes, and increased reliance on secondary heat sources like fireplaces post-retrofit. While participants reported high satisfaction with subsidized upgrades and benefits like cost savings and improved comfort, challenges included mould due to inadequate ventilation and coordination difficulties in multi-apartment buildings. The study underscores the necessity of integrating post evaluations into program design to refine energy-saving assumptions, improve monitoring systems, and account for occupant behaviour. It also highlights the role of subsidies in accelerating sustainable technologies and stresses the need for calculation methods that better align theoretical models with real-world outcomes.

Millyard, K., & Kolb, J. (2025). *Retrofitting Canada's Homes: Progress Report #2*. Green Communities Canada. Retrieved from https://greencommunitiescanada.org

This report published by Green Communities Canada, provides a comprehensive analysis of Canada's home energy retrofit initiatives, focusing on the rise and fall of the Canada Greener Homes Grant (CGHG) and its impact on greenhouse gas emissions, energy savings, and economic stimulation. It highlights the challenges of retrofitting Canada's 12 million homes to meet net-zero targets by 2050. It offers recommendations for future programs, including larger grants, performance incentives, and professional support for homeowners. The report also emphasizes the importance of deep retrofits and the role of heat pumps and solar photovoltaic (PV) systems in achieving significant energy savings. It is a critical resource for policymakers, industry stakeholders, and environmental advocates aiming to advance sustainable housing solutions in Canada.

Calder, D. (2020). *The Case for Deep Retrofits: Improved Business Case Evaluation and Financing Options for Deep Retrofits in Multi-unit Residential Buildings*. The Atmospheric Fund. Retrieved from https://taf.ca

This report examines the need for deep retrofits in multi-unit residential buildings to meet Canada's net-zero carbon emissions goal by 2050. It highlights retrofits' financial, social, and environmental benefits, while addressing barriers such as long payback periods and lack of awareness. The report emphasizes Life Cycle Cost Analysis (LCCA) and modern financing models as solutions, offering

actionable recommendations for governments, utilities, and property owners to scale up retrofits and support climate goals.

The Atmospheric Fund. (2024). *Prefabricated Overcladding Solutions for Deep Retrofits: Market Assessment and Procurement*. Toronto, ON: The Atmospheric Fund.

The report provides a comprehensive analysis of prefabricated overcladding solutions for deep retrofits in multi-unit residential buildings (MURBs) within the Greater Toronto and Hamilton Area (GTHA). It highlights the urgent need for innovative retrofit solutions to reduce carbon emissions in the building sector, which accounts for a significant portion of Canada's greenhouse gas emissions. The report outlines the benefits of prefabricated overcladding systems, such as improved energy efficiency, reduced construction waste, and minimized disruption to building occupants. However, it also identifies barriers to widespread adoption, including limited market demand, insufficient manufacturing capacity, and challenges with integrating these systems into existing building structures. The report proposes actionable recommendations, such as focusing on social housing as a catalyst market, developing a Request for Supplier Qualifications (RFSQ) process, commissioning design exercises, and creating a national knowledge-sharing platform. The document also details the procurement approach, evaluation criteria, and results of the RFSQ process, which prequalified three systems for future retrofit projects. This resource serves as a valuable guide for stakeholders, including housing providers, manufacturers, and policymakers, to advance the adoption of prefabricated overcladding systems and accelerate Canada's transition to net-zero emissions by 2050.

Haley, B., & Torrie, R. (2021). *Canada's Climate Retrofit Mission: Why the Climate Emergency Demands an Innovation-Oriented Policy for Building Retrofits*. Efficiency Canada. https://efficiencycanada.org

This 2021 report by Haley and Torrie outlines a strategy called the "Mass Climate Retrofit Mission" aimed at transforming Canada's existing building stock to address the climate emergency. The authors argue that current fragmented market and policy efforts are insufficient for achieving the scale and pace of retrofits needed. They quantify the potential for deep energy savings and fossil fuel elimination, highlighting how comprehensive retrofits could significantly cut greenhouse gas emissions and make more clean electricity available for other uses. The report calls for a mission-oriented policy approach that encourages innovation, draws on successful international models like Energiesprong, and coordinates public efforts through a national retrofit leader and local teams to pilot and scale effective solutions, targeting major progress by 2035.

3. Thematic literature review sections

3.1 Canada's climate and energy transition priorities

How do Canada's national climate policies and energy transition strategies prioritize deep retrofits in social housing, particularly for vulnerable populations, and what are the key challenges in aligning these efforts with Canada's 2030 and 2050 climate goals?

Canada's national climate policies explicitly prioritize deep retrofits as a critical strategy to decarbonize the building sector and address the energy needs of vulnerable populations, particularly in social housing. These priorities are anchored by the federal commitment to achieve net-zero greenhouse gas (GHG) emissions by 2050, with an interim target of a 40% reduction below 2005 levels by 2030 (Canadian Energy Regulator (CER), 2023).

Canada acknowledges that the building sector is a significant source of national greenhouse gas emissions, accounting for up to 18% of total emissions when electricity use is considered (Natural Resources Canada, 2022). However, building emissions increased by 8.8% between 2005 and 2022 rather than declining. This upward trend highlights that current efforts are insufficient and underscores the need for transformative action. Deep retrofits, which aim for at least 50% energy savings and major GHG reductions through improvements such as building envelope upgrades and the electrification of heating systems, are seen as a critical solution to reverse this trajectory (Harland et al., 2024; Millyard & Kolb, 2025).

Equity and inclusion are central to Canada's energy transition strategies. National frameworks like the Canada Green Buildings Strategy (CGBS) and the NHS explicitly focus on integrating equity, diversity, and inclusion by supporting low-income households and Indigenous communities with targeted funding, no-cost retrofits, and Indigenous-led approaches (Canadian Energy Regulator (CER), 2023; Martin et al., 2024). Vulnerable groups, including low-income Canadians, renters, seniors, and Indigenous Peoples, face disproportionate burdens from climate change and housing unaffordability, underscoring the necessity for specialized retrofit programs (Government of Canada, 2018; Harland et al., 2024). Theme 3.5 Equity in Scaling Deep Retrofits will discuss this in detail. Notably, the Canada Greener Homes Affordability Program (CGHAP), first launched through a delivery agreement in Manitoba and designed for expansion through provincial and territorial partners, reflects a federal shift toward no-cost, direct-install retrofit delivery models that explicitly include tenants and lower-income households (Kantamneni et al., 2025; Kantamneni & Haley, 2022; Millyard, 2023).

However, aligning these priorities with Canada's 2030 and 2050 climate goals faces several key challenges:

Pace and scale	The current retrofit rate is insufficient, with projections indicating it would take over a century to retrofit homes at the current pace (Millyard & Kolb, 2025). Deep decarbonization requires unprecedented speed and scale (Haley & Torrie, 2021).

Cost and upfront investment	Deep retrofits require significant upfront capital, creating a barrier, especially for low-income homeowners and social housing providers (Edalatnia et al., 2023). Renters face a related challenge: where tenants pay the utilities, landlords often lack the incentive or resources to invest in retrofits, while tenants bear the costs and impacts. This is known as the split-incentive barrier. No-cost retrofit programs for vulnerable groups remain limited and underfunded, restricting access for renters and low-income households (Canada Electricity Advisory Council, 2024; Harland et al., 2024; Millyard, 2023).
Program design and accessibility	Incentive programs like the Canada Greener Homes Grant inadequately serve low-income and Indigenous communities, who require tailored approaches such as full incentives and accessible technical and financial support (Edalatnia et al., 2023; Millyard, 2023).
Coordination and jurisdictional complexity	Multiple government levels share responsibility for energy and housing policies, but a lack of alignment and coordination hinders effective scaling. Clearer, harmonized policies that leverage provincial and territorial expertise are needed (Government of Canada, 2020; Harland et al., 2024).
Regulatory and governance frameworks	Provincial energy utility regulations do not consistently align with Federal net-zero objectives, slowing the transition of building energy systems (Canada Electricity Advisory Council, 2024).
Data gaps and equity integration	Inconsistent data collection and unclear definitions - such as those for “affordable housing” and “energy poverty” - limit effective policy development and program monitoring. While equity, meaning fair access to affordable, energy-efficient housing for low-income, Indigenous, and marginalized groups, is frequently cited as a priority at all levels of government, it is not yet fully embedded in policy and program design.

> Ongoing partnerships, especially with Indigenous communities, are essential to achieve these equity goals (Government of Canada, 2020; Martin et al., 2024; Task Force for Housing and Climate, 2024).

Across the sources reviewed, deep retrofits and equity-oriented support for vulnerable populations are consistently framed as priorities within Canada's climate and energy transition policy landscape, including for social housing contexts. At the same time, the literature documents multiple barriers that limit implementation and scaling, notably constraints on financing and up-front investment, program design and accessibility issues, jurisdictional coordination challenges, and uneven integration of equity considerations into delivery. Taken together, these factors contribute to an observed gap between stated policy ambition and implementation capacity, with consequences for alignment with Canada's 2030 and 2050 goals.

Annotated references

Edalatnia, S., & Das, R. R. (2023). *A Toolkit for Affordability-Driven Home Energy Efficiency Retrofits Through Local Improvement Charge Programs: Literature Review*. Prepared for Canada Mortgage and Housing Corporation. Volta Research Inc

This literature review analyzes the Canadian Local Improvement Charge (LIC) and Property Assessed Clean Energy (PACE) programs as mechanisms for financing energy-efficiency retrofits in residential and social housing. It identifies persistent barriers-including high upfront costs, administrative complexity, restrictive eligibility criteria, and the requirement for mortgage lender approvals that limit participation, particularly among low- and moderate-income households. Motivators such as financial savings, improved comfort, and environmental benefits are highlighted, with recommendations to streamline processes, remove policy barriers, adopt flexible qualifying criteria, and implement "one-stop-shop" service models. The review also emphasizes the importance of targeted outreach, transparent communication, community partnerships, ongoing contractor training, and independent evaluation to enhance program accessibility and impact, ultimately supporting the equitable scaling of deep retrofits in social housing.

Canada Energy Regulator. (2023). *Energy Future 2023: Energy Supply and Demand Projections to 2050*. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2023/results/

This report presents scenario-based projections for Canada's energy future, centering on pathways to achieve net-zero greenhouse gas emissions by 2050. It uses quantitative analysis informed by consultations across governments, industry, and academia to illustrate the scale of transformation required. The report projects that total emissions will decline sharply under net-zero scenarios, contrasting with modest reductions under current policies. Key to this transformation is the deep decarbonization of sectors like buildings, which historically relied on fossil fuels for heating. Achieving projected emissions reductions in buildings depends on significant energy efficiency improvements and fuel switching to low-carbon alternatives. This source highlights the critical role

of sectoral shifts in energy use and emissions reductions, framing the building sector as essential for meeting Canada's broader climate goals.

Harland, K., Gibson, S., Dion, J., Gajudhur, N., & Mifflin, K. (2024). *Heat Exchange: How Today's Policies will Drive or Delay Canada's Transition to Clean, Reliable Heat for Buildings*. Canadian Climate Institute. https://climateinstitute.ca/reports/building-heat/

This report by the Canadian Climate Institute explores the implications of Canada's transition to clean building heat systems in alignment with net-zero goals by 2050. It provides a detailed analysis of the current trajectory of building heat, limitations of existing policies, and opportunities for policy-driven change. The authors emphasize the need for electrification, energy efficiency, and the gradual contraction of gas networks to achieve cost-effective decarbonization. Recommendations include provincial leadership, regulatory reforms, and equity-focused policies to ensure affordability and reliability during the transition. This resource is valuable for policymakers, researchers, and stakeholders involved in climate action and energy system planning.

3.2 Canada's regulatory framework: The role of government in scaling retrofits

What are the regulatory and policy responsibilities across different levels of government in Canada for enabling deep retrofits, and where are coordination gaps or misalignments that limit implementation?

The literature consistently highlights the necessity of deep retrofits in Canada's building sector to achieve national greenhouse gas (GHG) reduction targets. Decarbonizing the building stock is widely recognized as a critical strategy for meeting climate commitments and addressing energy poverty (Calder, 2020b; Glicker et al., 2024; Haley & Torrie, 2021; Kantamneni & Haley, 2022; McIlroy et al., 2024; The Atmospheric Fund, 2024; Zhang, 2023).

Canada's regulatory approach to deep retrofits involves a layered system of responsibilities across federal, provincial, and municipal governments, each playing distinct but sometimes overlapping roles in standards, funding, and program delivery (Kantamneni & Haley, 2022; Vérin & Poirier, 2024).

- **Federal government**: The federal government has a legislated commitment to achieve net-zero GHG emissions by 2050 through the *Canadian Net-Zero Emissions Accountability Act*. It has the authority to set national standards, develop decarbonization regulations and frameworks, support innovation, and administer programs like the Canada Greener Homes Program for equity and energy poverty reduction (Government of Canada, 2020; Task Force for Housing and Climate, 2024). The federal government can use its levers to set new energy-efficiency standards for heating equipment and other key technologies. It also works to develop increasingly stringent model building codes, aiming for provinces and territories to adopt a "net-zero energy ready" model building code by 2030 (Government of Canada, 2016).
- **Provincial and territorial governments:** These governments hold significant primary authority, especially concerning energy and building codes. They have the ability to align these codes with net-zero objectives, drawing on regional expertise in ways that can drive meaningful progress (Natural Resources Canada, 2024). They can pass laws to regulate emissions, set energy efficiency standards, or phase out fossil fuel heating systems (Vérin & Poirier, 2024). For instance, British Columbia adopted the Zero Carbon Step Code to limit GHG emissions for new constructions (Vérin & Poirier, 2024). Provinces are primarily responsible for adopting increasingly stringent model building codes (Government of Canada, 2016).
- **Municipal governments:** Municipalities focus on local implementation, planning, and specific incentives. Through bylaws, they can set standards for new construction and renovations, including the type of heating systems allowed. They are often at the forefront of implementing decarbonization initiatives(Vérin & Poirier, 2024). Tools such as Property Assessed Clean Energy (PACE) or Local Improvement Charge (LIC) financing are emerging supports but vary widely in availability and scale (Edalatnia et al., 2023; Vérin & Poirier, 2024).

Sources note that coordination gaps between these levels result in policy fragmentation, duplicative permitting, and inefficient incentives. These misalignments impede a unified national retrofit strategy and slow the transition to decarbonization (Canada Electricity Advisory Council, 2024; Task Force for Housing and Climate, 2024).

The primary constraint noted in the sources is the lack of policy consistency, clarity, and alignment across federal, provincial/territorial, and municipal governments (Canada Electricity Advisory Council, 2024). This creates significant uncertainty and slows investment. No single order of government controls all the policy levers affecting housing and the supporting infrastructure, requiring their coordination (Task Force for

Housing and Climate, 2024). Furthermore, municipal authority to impose stringent environmental standards, such as fossil fuel prohibitions, is frequently limited and subject to provincial jurisdiction and alignment (Harland et al., 2024). This lack of coherent, multi-level legislation results in disjointed programs that fail to achieve maximum impact (Harland et al., 2024).

Governments at all levels have fallen short of establishing the foundational systems and data infrastructure required to efficiently execute and scale a nationwide deep retrofit mission. This includes a crucial lack of standardized data on energy poverty and standard definitions across jurisdictions (Kantamneni et al., 2025). For example, Canada lacks a consistent, government-backed national definition for "affordability" or "energy poverty," hindering the ability of policy makers (federal, provincial, and municipal) to target vulnerable households and track progress accurately (Kantamneni et al., 2025; Task Force for Housing and Climate, 2024). Recent national syntheses of low-income energy efficiency programming further reinforce these findings, emphasizing the need for a coordinated federal framework that aligns definitions, data, and funding mechanisms across provinces and territories to support equitable, deep retrofit delivery (Gaede et al., 2026).

Furthermore, governments, particularly provincial and federal, must enhance collaboration to develop regional workforce plans to address the current and predicted shortage of skilled labour and professionals (engineers, trades, auditors) (Blue & Agar, 2024; Natural Resources Canada, 2022).

The key issue noted surrounding unstable funding mechanisms for deep retrofits across government levels is the pervasive lack of long-term, stable financial commitment, which creates "boom-bust dynamics" that disrupt energy efficiency supply chains, erode public and investor confidence, and inhibit the necessary scale-up of the retrofit market (Glicker et al., 2024; Kantamneni et al., 2025; Kantamneni & Haley, 2022). This instability is compounded by misaligned and inflexible program design, as funding, particularly federal grants for affordable housing, is often subject to strict "use it or lose it" spending requirements or annual cycles, forcing municipal and local administrators to cancel projects, lose capital funding, or prioritize shallow upgrades over the deeper retrofits required for net-zero goals (Government of Ontario, 2024; Kantamneni & Haley, 2022; Office of the Auditor General of Ontario, 2017).

Comparative international analysis shows that Europe's more comprehensive policies, driven by EU directives, and the U.S. Weatherization Assistance Program's intergovernmental coordination offer valuable lessons for Canada in harmonizing policy, boosting funding, and improving program design (International Energy Agency, 2024; Nasarre-Aznar et al., 2021).

Canada's multi-level governance framework has the potential to support the large-scale deployment of deep retrofits, but the literature highlights persistent challenges related to fragmented responsibilities, policy misalignment, and unstable funding. While Canadian governments have examined international approaches to retrofit delivery, the literature suggests that stronger coordination across levels of government, through aligned objectives, streamlined regulatory processes, and long-term, collaborative funding mechanisms, particularly for social housing and vulnerable populations, is critical to scaling progress. International best practices reinforce these findings by illustrating how integrated governance and financing arrangements can accelerate retrofit outcomes, rather than serving as standalone models for replication.

Annotated references

Gaede, J., Nippard, A., & Turner, K. (2026). *The 2025 Energy Efficiency Programs Report*. Efficiency Canada, Carleton University, Ottawa, ON. Retrieved from https://www.efficiencycanada.org

This report, authored by James Gaede, Alyssa Nippard, and Katharine Turner, provides a comprehensive overview of energy efficiency programs and demand-side management (DSM) initiatives across Canada for 2024 and 2025. It includes detailed benchmarking of utility DSM portfolio performance, jurisdictional scans of demand flexibility initiatives, and equity-oriented programs targeting marginalized communities. The report highlights trends in program spending, energy savings, and capacity-building efforts, emphasizing the growing focus on equity outcomes and demand flexibility. It also identifies gaps in service and barriers to accessibility for underserved populations, such as low-income households and Indigenous communities, while discussing funding sources and program developments. The report serves as a valuable resource for policymakers, energy efficiency advocates, and utility program administrators.

Blue, R., & Agar, B. (2024). *Deep Retrofit Supply Chain Analysis: Scaling capacity to decarbonize Canadian residential buildings*. The Pembina Institute. Retrieved from https://www.pembina.org

This report provides an in-depth analysis of the supply chain challenges and opportunities for scaling deep retrofits in Canadian residential buildings to support decarbonization efforts. It examines barriers such as high costs, lack of skilled labour, and limited awareness of low-carbon technologies, while also identifying supports needed, including financial incentives, training programs, and policy reforms. The report incorporates survey data, jurisdictional scans, and expert insights to propose actionable recommendations for enhancing the capacity of the retrofit supply chain. It serves as a valuable resource for policymakers, industry stakeholders, and organizations aiming to advance Canada's clean energy transition.

Office of the Auditor General of Ontario. (2017). *Social and Affordable Housing: Value-for-Money Audit Report*.

This comprehensive audit report by the Office of the Auditor General of Ontario evaluates the Ministry of Housing's effectiveness in overseeing and coordinating social and affordable housing programs in Ontario. The report highlights systemic issues, including the growing demand for affordable housing, lengthy wait times, and the lack of a provincial strategy to address housing needs. It provides detailed observations on challenges such as insufficient funding, inadequate housing stock, and the expiration of housing provider contracts. The report also offers recommendations to improve housing program delivery, prioritize applicants based on need, and support tenants transitioning out of social housing. This document is a critical resource for policymakers, housing advocates, and researchers interested in understanding and addressing Ontario's housing crisis.

Zhang, H. (2023). *Life Cycle Costing Analysis of Deep Energy Retrofits of a Mid-Rise Building to Understand the Impact of Energy Conservation Measures*. School of Engineering, Faculty of Applied Science, The University of British Columbia.

This report analyses the life-cycle costs, energy savings, and greenhouse gas impacts of 11 deep energy retrofit measures for a representative mid-rise multi-unit residential building in British Columbia, using EnergyPlus modelling. Two base cases, electricity-heated and natural gas-heated, are assessed to compare energy, cost, and emissions outcomes under Canadian conditions. The findings show that low-cost operational measures such as temperature setbacks, lighting upgrades, and improved airtightness provide the strongest life cycle cost performance, while capital-intensive

measures including window replacement, air source heat pumps, and solar photovoltaics are generally not cost-effective without incentives. The study provides useful comparative evidence for prioritizing retrofit strategies in existing mid-rise residential buildings, particularly where emissions reduction objectives must be balanced against economic constraints.

3.3 Scaling retrofits: Financial incentives, market mechanisms, and policy drivers

What financial incentives, policy drivers, and market mechanisms are most effective for making deep retrofits viable for social housing providers, and how can these be adapted to different regional conditions?

FINANCIAL INCENTIVES

The literature consistently identifies financial incentives as critical to overcoming the high upfront costs that impede deep retrofits in social housing. Direct public funding through grants and forgivable loans is the most effective financial incentive for enabling deep retrofits in this sector (McIlroy et al., 2024; Millyard, 2023). These targeted funds alleviate financial barriers and enable providers to undertake comprehensive energy-saving measures rather than superficial upgrades. Several sources emphasize the importance of funding models explicitly dedicated to deep retrofits, with targets of >50% energy savings and large GHG reductions, rather than just general energy efficiency. Enabling more strategic investments aligns directly with greater energy and GHG savings (Canada Electricity Advisory Council, 2024; Kantamneni et al., 2025).

In contrast, while important, low-interest loans and tax incentives are generally considered less effective for social housing providers, unless carefully tailored to their financial circumstances (Calder, 2020a; Glicker et al., 2024). Furthermore, non-profit social housing organizations often struggle to secure loans from traditional banks due to limited capital and higher perceived risks, creating a significant barrier to financing deep retrofits(ICAST, 2016). Tax incentives often provide delayed or indirect returns, which may be less attractive or accessible to non-profit organizations. This highlights a key trade-off: while loans improve capital leverage, they do not fully solve the barrier posed by limited financial capacity and risk aversion (Kantamneni et al., 2025; Task Force for Housing and Climate, 2024).

Pioneering financing models, such as 'Energy Savings Insurance' and 'Energy as a Service (EaaS),' are gaining attention in recent studies for their potential to reduce upfront financial burdens while shifting investment risks away from social housing providers (Edalatnia et al., 2023). These models operate primarily at the project or provider level and are therefore best understood as complementary financing and risk-transfer tools, rather than market-level mechanisms for scaling retrofits. Importantly, the literature underscores the necessity of incorporating non-energy benefits and pre-retrofit repairs, such as addressing mould or structural issues, into financial support programs to ensure the viability and durability of retrofits in aging and vulnerable housing stock (McIlroy et al., 2024; The Atmospheric Fund, 2024).

MARKET MECHANISMS

Among market mechanisms, aggregation or bundling of multiple social housing retrofit projects into larger portfolios stands out as one of the most effective strategies for reducing transaction costs and attracting investors to deep retrofits (Haley & Torrie, 2021; Westerhoff & Fisher, 2023). By grouping projects, providers can achieve economies of scale that lower per-unit costs and present more consistent, standardized investment opportunities. Standardization is essential here; retrofit projects need to exhibit similar characteristics and predictable performance so they can be pooled effectively, increasing investor confidence and enabling securitization or other financing structures (Natural Resources Canada, 2022).

Property Assessed Clean Energy (PACE) financing, while not the best option for social housing for a variety of reasons, still offers a new model that can reduce upfront costs and improve access to capital by enabling loan repayments through property tax assessments, making investments more manageable and transferable (Edalatnia et al., 2023; Kennedy et al., 2020). However, while PACE programs have proven effective in

encouraging energy retrofits in private residential and commercial sectors, their application to social housing providers remains limited due to gaps in provincial legislation and the lack of explicit inclusion of non-profit or social housing within most municipal PACE programs (Edalatnia et al., 2023; Kennedy et al., 2020). As a result, social housing providers face restricted access to this promising mechanism despite its potential to alleviate financial barriers.

Additionally, emerging market models such as the Energiesprong approach provide transformative market-level solutions by integrating prefabricated building components, supply chain coordination, and large-scale bundling of retrofit projects to drive down costs and accelerate (Haley & Torrie, 2021; The Atmospheric Fund, 2024). While Energiesprong remains untested at scale in North America, it exemplifies how pioneering delivery methods can complement financial mechanisms to overcome systemic challenges in social housing retrofits.

Lastly, loan guarantees and credit enhancements offered by governments and utilities play a critical role in de-risking investments, fostering the availability of long-term, low-cost capital necessary for social housing providers that are often risk-averse or capital-constrained (Calder, 2020a). Sources conclude that together, these mass market mechanisms, supported by standardization and credit enhancements, form the most promising pathway to mobilize the substantial private and institutional investment required to scale deep retrofits across the social housing sector.

POLICY DRIVERS

The literature identifies a clear, nationally consistent yet regionally adaptable policy framework as the most effective foundation for making deep retrofits viable in social housing (Glicker et al., 2024). Establishing unambiguous definitions and standards for what constitutes a deep retrofit would enable social housing providers and funding bodies to benchmark progress and align investments toward meaningful energy and emissions reductions.

Coupled with this, setting ambitious national retrofit targets can create strong market signals that drive confidence among investors, developers, and housing providers, focusing efforts on deep rather than incremental upgrades (Haley & Torrie, 2021). These targets act as a catalyst for mobilizing resources and encouraging long-term planning necessary for capital-intensive deep retrofits.

The literature frames the most effective policy approach as mission-oriented, in which achieving net-zero emissions represents the overarching societal objective and mass deployment of deep retrofits is defined as the primary means of delivering that outcome. In this framing, deep retrofits are not treated as isolated projects, but as a coordinated national undertaking requiring alignment across policy, finance, regulation, and market actors. Such an approach necessitates coordination across all levels of government, federal, provincial/territorial, and municipal, each leveraging its distinct authorities and capacities. Municipal governments, in particular, play a critical role through their control over building codes, land use, and permitting processes, which directly shape retrofit feasibility and pace (Kantamneni et al., 2025; McIlroy et al., 2024) Successful mission-oriented frameworks also emphasize cross-sector collaboration to overcome market fragmentation, create economies of scale, and enable replication of effective retrofit models across diverse regional contexts (Haley & Torrie, 2021).

Finally, embedding robust technical assistance, financing guidance, and project management support into policy programs is essential to lower capacity barriers within social housing providers, enabling them to

navigate complex retrofit processes effectively and accelerate deployment (Natural Resources Canada, 2022; Westerhoff & Fisher, 2023).

ADAPTING TO REGIONAL VARIABILITY

The literature underscores that regional conditions materially influence both the feasibility and effectiveness of financial and policy instruments. Climatic differences, regional building typologies, local labour markets, and socioeconomic factors necessitate flexible program designs to prioritize context-specific retrofit measures (ICAST, 2016; Westerhoff & Fisher, 2023). For example, colder regions may require more intensive building envelope upgrades, while areas with older building stocks might prioritize structural repairs with energy retrofits (Shwashreh et al., 2024) .

Several authors advocate for place-based strategies that initially focus on replicable solutions tailored to predominant building types within regions, allowing for targeted investment and scalability (Shwashreh et al., 2024). Recognizing financial disparities among social housing providers and tailoring funding models accordingly is repeatedly emphasized, especially for Indigenous and remote communities facing distinct barriers and data gaps (Liberty Multimedia Inc., 2024). Effective adaptation also requires strong intergovernmental collaboration to harmonize local mandates and resources (McIlroy et al., 2024; Westerhoff & Fisher, 2023).

INTEGRATING BROADER SOCIAL AND ENVIRONMENTAL GOALS

Finally, the literature recognizes that to be truly viable and equitable, deep retrofit programs must integrate broader social and environmental benefits beyond energy savings. Reducing energy poverty through lower utility bills addresses a critical social equity issue, particularly for vulnerable populations in social housing (Kantamneni & Haley, 2024; Millyard, 2023). Enhanced housing quality through improved thermal comfort and indoor air quality contributes to health and well-being outcomes (Haley & Torrie, 2021; Kantamneni et al., 2025).

Moreover, sources say that aligning retrofit investments with the replacement cycles of aging housing components can improve long-term cost-effectiveness and build resilience (BC Housing, 2024). Programs should incorporate safeguards to prevent displacement or rent increases post-retrofit, protecting tenants from unintended negative consequences (Glicker et al., 2024; TWC Inc, 2016). Recognizing these co-benefits reinforces the multi-dimensional value of deep retrofits and supports their prioritization within social housing policy agendas.

The literature indicates that the viability and scaling of deep retrofits in social housing depend on an integrated approach that combines tailored financial incentives, innovative market mechanisms, and robust policy frameworks. Across studies, these approaches are consistently framed as requiring regional adaptability and alignment with broader social equity and environmental objectives. Taken together, this body of work suggests that, while promising models and mechanisms exist, overcoming persistent financial, technical, and institutional barriers requires coordinated, long-term commitment across all levels of government and industry stakeholders

Annotated references

Kennedy, M., Frappé-Sénéclauze, T.P., & Agar, B. (2020). *Property Assessed Clean Energy In Canada: Design Considerations For PACE Programs And Enabling Legislation*. The Pembina Institute. Retrieved from https://www.pembina.org

This report by Kennedy, Frappé-Sénéclauze, and Agar (2020) provides a comprehensive analysis of Property Assessed Clean Energy (PACE) programs in Canada, emphasizing their potential to support the country's clean energy transition. It examines the current state of PACE legislation across Canadian provinces, highlights successful examples from the U.S., and offers detailed recommendations for enabling legislation and program design. The authors advocate that provincial governments adopt PACE-enabling legislation and that national harmonization be pursued to maximize the effectiveness of PACE programs. The report also addresses challenges such as primary lien status, savings-to-investment ratios, and consumer protection measures, offering solutions to mitigate risks and enhance program accessibility. This resource is valuable for policymakers, municipalities, and stakeholders interested in advancing energy efficiency and sustainability initiatives.

Liberty Multimedia Inc. (2024). *A Blueprint for Sustainable Housing Development: Paddle Prairie Metis Settlement*. Liberty Multimedia Inc.

This document is a comprehensive guide for addressing housing challenges within the Paddle Prairie Metis Settlement (PPMS). It outlines strategies for sustainable housing development, including retrofitting, new construction, and infrastructure enhancement, while emphasizing cultural sensitivity and community engagement. The blueprint leverages government funding opportunities, such as the Canada Greener Affordable Homes Program and Rapid Housing Initiative, to improve living standards and promote long-term sustainability. It also details governance structures, application processes, and monitoring frameworks to ensure transparency and accountability. The report is significant for its focus on empowering the Settlement, preserving Métis cultural heritage, and setting a precedent for Indigenous housing initiatives across Canada.

TWC Inc (2016, March). *Building New Affordable Housing Through Leveraging in the Greater Toronto–Hamilton Area: Challenges and Opportunities.* Draft Report.

This report explores the potential for leveraging existing social housing assets to address the affordable housing shortage in the Greater Toronto–Hamilton Area (GTHA). It provides a detailed analysis of the challenges and opportunities associated with the expiration of operating agreements for social housing providers, particularly those developed under federal housing programs. The report highlights financial, physical, and governance conditions necessary for leveraging, examines municipal incentives, and offers case studies of successful projects. Recommendations are provided for non-profit housing organizations, financial institutions, municipalities, and senior governments to maximize the creation of new affordable housing. This resource is valuable for policymakers, housing providers, and researchers interested in novel strategies to address housing affordability.

BC Housing (2024.). *Low Carbon Solutions for Multi-Unit Residential Buildings*. Prepared in collaboration with Evoke Buildings Engineering Inc. and Building Enclosure Labs Inc., BC Housing.

This source, a report on Low Carbon Solutions for Multi-Unit Residential Buildings (MURBs), presents a detailed life cycle assessment (LCA) methodology and key findings for reducing operational and embodied carbon emissions in the building sector. The document emphasizes that, especially in jurisdictions with a low-carbon electricity grid like British Columbia, embodied carbon is becoming as significant as operational emissions and outlines existing knowledge gaps regarding optimization strategies. Ultimately, the report provides crucial guidance to the industry and policymakers, arguing that efforts must focus on reducing material quantities by design and promoting durable building systems to achieve deeper carbon reductions across a building's entire lifecycle.

3.4 Workforce and supplier capacity for deep retrofits

What are the current workforce capacity and supply chain capacity gaps in Eastern Ontario for implementing deep retrofits in social housing, and what strategies are recommended to address these gaps and ensure a scalable supply chain retrofit industry?

CURRENT REALITY

National and provincial literature consistently identifies substantial workforce and supplier capacity gaps that directly constrain Eastern Ontario's ability to deliver deep retrofits in social housing(Westerhoff & Fisher, 2023). The evidence indicates that while retrofit activity is expected to increase significantly across the province, the labour market is already under strain (Natural Resources Canada, 2022). BuildForce Canada projects that Ontario's residential construction sector will require an additional 65,490 workers between 2023 and 2032. Most of the growth is concentrated in the GTA, but a 22 per cent workforce expansion provincially is projected. Within this broader provincial context, employment levels in Eastern Ontario's residential construction and retrofit sector are expected to return to 2021 levels by 2032 as retrofit activity accelerates (BuildForce Canada, 2024). However, the literature clarifies that this projected recovery does not resolve ongoing shortages in specialized trades essential to deep retrofit delivery, particularly in heating, refrigeration, and air conditioning. Ontario will require approximately 4,200 additional HVAC mechanics, nearly quadruple from the 2022 workforce, to meet retrofit and heat pump installation needs (BuildForce Canada, 2024). Employers in the HVAC and electrical trades continue to face challenges filling installation, supervisory, and technical roles due to a shortage of qualified candidates (ECO Canada, 2019).

- 22% workforce expansion in Ontario- but **only a 1%** change in Eastern Ontario with **399% increase** in Eastern Ontario for HVAC

The literature provides several provincial-level projections that, while not specifically disaggregated for Eastern Ontario, offer meaningful insight into anticipated regional demand pressures for deep retrofit labour. Residential construction employment in Eastern Ontario was previously projected to decline by nearly 10% from 2021 peak levels due to rising interest rates and slowing population growth. Accelerating green building activity is now expected to offset this decline and return employment to 2021 record highs by 2032. Even though total residential construction employment in Eastern Ontario is only projected to change by 1% overall, the demand for trades essential to deep retrofits is projected to surge exponentially. Specifically, the demand for refrigeration and air conditioning mechanics in Eastern Ontario is forecast to increase by 399% by 2032 (BuildForce Canada, 2024). Local labour market planning for the Eastern Workforce Innovation Board (EWIB) area confirms that residential electricians and HVAC technicians are among the top 10 most in-demand skilled trades in the region (EWIB, 2025).

Skills-related gaps compound these labour shortages across Canada and within Eastern Ontario. Only 34 per cent of workers in the energy-efficiency workforce possess post-secondary credentials, far below the Canadian average of 70 per cent across all sectors (ECO Canada, 2019). The literature notes that this gap matters because specialized retrofit work increasingly requires technical proficiency, certification, and advanced problem-solving capacity (Glicker et al., 2024; Kantamneni et al., 2025). In addition, the underrepresentation of women and Indigenous Peoples in retrofit-related trades presents a structural constraint in regions such as Eastern Ontario, where Indigenous and equity-seeking populations form a meaningful share of the broader labour force. These disparities illustrate that labour capacity gaps are multidimensional, encompassing not only shortages of qualified tradespeople but also demographic and credential-related imbalances that limit the sector's ability to scale effectively(ECO Canada, 2024; EWIB, 2025).

NATIONAL POLICY DIRECTIONS RELEVANT TO WORKFORCE & SUPPLY CHAIN CAPACITY

Across the national policy landscape, the literature highlights several initiatives expected to shape workforce and supplier capacity for deep retrofits, even though these initiatives are not accompanied by region-specific forecasting. The federal government's commitment to adopt a net-zero energy-ready model building code by 2030 is positioned as a major instrument for elevating expectations for material performance and construction practices (Canadian Energy Regulator (CER), 2023; Government of Canada, 2020; Task Force for Housing and Climate, 2024). Standardized code requirements are also identified as a mechanism to support supply chain optimization, particularly by generating more predictable market conditions for manufacturers of high-performance retrofit material(Canada Electricity Advisory Council, 2024; Natural Resources Canada, 2022)s. Federal agencies and international partners, including ECO Canada and the International Energy Agency, emphasize the importance of such standards for improving affordability, accelerating electrification, and harmonizing supplier expectations across jurisdictions (Canada Electricity Advisory Council, 2024; Gordon et al., 2023; Haley & Torrie, 2021). These national-level signals are expected to influence the structure of labour and material markets in Eastern Ontario by increasing demand for skilled trades and specialized low-carbon technologies (BuildForce Canada, 2024; Government of Canada, 2020).

FEDERAL TECHNOLOGY AND SUPPLY-CHAIN INITIATIVES

Federal research programs also play an important role in shaping future supplier capacity. The Prefabricated Exterior Energy Retrofit (PEER) initiative, led by CanmetENERGY, is explicitly designed to stimulate market development for prefabricated over-cladding systems tailored to mid and high-rise retrofits(Haley & Torrie, 2021). Likewise, procurement strategies, such as Requests for Supplier Qualifications (RFSQs) are cited as tools for aggregating demand signals and encouraging industry participation in manufacturing retrofit-specific components (Haley & Torrie, 2021; Westerhoff & Fisher, 2023). However, the literature underscores a persistent challenge: market demand for manufactured retrofit solutions has not yet been demonstrated at a scale sufficient to justify large-scale investment. As a result, manufacturers remain hesitant to expand production capacity, despite ongoing federal efforts to accelerate technology commercialization (Canadian Home Builders Association, 2024; Haley & Torrie, 2021). These gaps are particularly relevant to Eastern Ontario, where the feasibility of scaling deep retrofits depends heavily on predictable access to specialized materials (Blue & Agar, 2024; Haley & Torrie, 2021; Natural Resources Canada, 2022).

INTERNATIONAL PRECEDENTS AND THEIR INFLUENCE ON CANADA

International organizations such as the International Energy Agency emphasize harmonizing energy-performance standards and establishing clear pathways toward electrification (Canada Electricity Advisory Council, 2024; Canadian Energy Regulator (CER), 2023; Glicker et al., 2024). These international precedents reinforce the importance of standardized building codes and strong procurement frameworks, areas where Canada's policies are already moving toward alignment. Although the literature does not provide explicit projections for how these global policy directions will influence Eastern Ontario, it is clear that Canada's alignment with international standards is expected to increase domestic demand for skilled retrofit labour and high-performance materials (BuildForce Canada, 2024; Government of Canada, 2020). This is particularly relevant for Eastern Ontario's older housing stock, where deep retrofits require coordinated upgrades across mechanical, envelope, and electrical systems (EWIB, 2025; Westerhoff & Fisher, 2023).

LOCALIZED POLICY DRIVERS AND REGIONAL CONDITIONS

While federal policy frameworks provide broad direction, Eastern Ontario's retrofit economy is shaped by conditions documented at the regional and municipal levels (BuildForce Canada, 2024). The literature

identifies persistent shortages of HVAC, electrical, and other specialized retrofit trades in Eastern Ontario. Also noted is limited access to affordable, locally sourced retrofit materials, defined here as building envelope components, mechanical systems, and prefabricated assemblies specifically designed or adapted for installation in existing buildings, rather than standard materials intended for new construction (Haley & Torrie, 2021). These constraints reflect the technical and logistical demands of retrofitting an ageing and varied existing building stock, where compatibility with existing structures and systems is critical (BuildForce Canada, 2024; McIlroy et al., 2024; Westerhoff & Fisher, 2023). These shortages are compounded by demographic pressures, interregional labour competition, and dependence on suppliers outside the region. As a result, the literature commonly frames the scaling of deep retrofits as contingent on a dual strategy: sustained investment in workforce development, particularly the recruitment of underrepresented groups, and coordinated supplier strategies that can stabilize costs, support prefabrication innovation, and reduce reliance on non-regional manufacturing. Despite the needs identified in the literature, further evaluation is acknowledged as necessary to determine which local strategies will be most effective and scalable across Eastern Ontario's diverse housing portfolio (EWIB, 2025; Natural Resources Canada, 2022; Westerhoff & Fisher, 2023).

SYNTHESIS OF WORKFORCE AND SUPPLIER BARRIERS

Taken together, the literature portrays a workforce and supplier ecosystem that is simultaneously undergoing rapid transformation and facing significant structural constraints. Eastern Ontario's retrofit economy remains constrained by shortages of specialized retrofit trades, most notably HVAC and electrical workers, as well as limited supply chain readiness for the materials required to support large-scale electrification and deep energy retrofits. These constraints persist even as federal and provincial policies create strong signals for market transformation. At the same time, the literature indicates insufficient evaluation of emerging workforce and supplier initiatives to assess their potential for scalability in Eastern Ontario. As deep retrofit activity accelerates, these gaps, including the limited availability of retrofit-ready components and a shortage of tradespeople with the necessary technical expertise, pose substantive barriers to meeting decarbonization timelines.

Annotated references

BuildForce Canada. (2024). *Building a Greener Future: Estimating the Impact on Construction Labour Demands from Transitioning Buildings in Canada Away from Fossil Fuels*. https://buildforce.ca

> "Building a Greener Future" outlines Canada's national strategy to decarbonize the buildings sector as part of the country's commitment to achieving net-zero greenhouse gas emissions by 2050. The document emphasizes accelerating deep retrofits for existing structures, ensuring new construction meets high-efficiency and low-carbon standards, and fostering innovation in building technologies and workforce skills. It highlights these actions' economic, social, and environmental benefits, including job creation, improved energy affordability, and greater climate resilience, particularly for vulnerable and underserved communities. The strategy also underscores the importance of collaboration among governments, industry, and financial institutions to overcome implementation challenges and build a sustainable, equitable future.

ECO Canada. (2024). *Energy Efficiency Employment in Canada*. https://eco.ca/

This comprehensive report by ECO Canada, funded by Natural Resources Canada, provides an in-depth analysis of the energy efficiency workforce in Canada as of 2023. It highlights key findings, including the growth of the energy efficiency sector, employment distribution across industries, and challenges such as hiring difficulties and workforce diversity. The report also examines the economic contributions of energy efficiency activities, projecting an 8% employment growth in the sector for 2024. It emphasizes the importance of addressing labour shortages and enhancing workforce training to support Canada's transition to a low-carbon economy. This resource is valuable for policymakers, educators, and industry stakeholders aiming to understand and develop the energy efficiency workforce.

Gordon, M. (2023). *A Sustainable Jobs Blueprint, Part I: Governance Recommendations to Support Canada's Clean Energy Workforce and Economy*. The Pembina Institute. https://www.pembina.org

This report, authored by Megan Gordon and published by the Pembina Institute in collaboration with the Canadian Labour Congress, provides a comprehensive framework for sustainable jobs planning in Canada. It emphasizes the importance of governance structures to support workers and communities while transitioning to a net-zero economy. The document outlines enabling factors, governance criteria, and actionable recommendations, including legislative amendments, workforce development strategies, and regional collaboration mechanisms. It also highlights the role of social dialogue and the need for decent job standards in emerging industries. The report is informed by extensive research, expert consultations, and worker interviews, making it a valuable resource for policymakers, labour organizations, and stakeholders involved in climate and economic transition planning.

Eastern Workforce Innovation Board. (2025). *Local Labour Market Planning Report 2024/25* https://www.workforcedev.ca/llmp-reports/

This report by the Eastern Workforce Innovation Board (EWIB), covering Frontenac, Leeds and Grenville, and Loyalist Township, provides a comprehensive analysis of the local labour market, integrating quantitative data from various sources (e.g., Statistics Canada, Immigration, Refugees and Citizenship Canada) with qualitative insights from 152 community stakeholders. Published in February 2025, the report highlights persistent labour shortages in key sectors such as healthcare, education, construction, and hospitality/tourism, which are intensified by an aging workforce leading to significant retirements and low birth rates, alongside social issues like mental illness, addiction, homelessness, and infrastructure challenges, including a lack of affordable housing and childcare. Despite these hurdles, the report forecasts overall employment growth of 5.8% by 2029 across all occupational categories and most industry sectors within the EWIB region, with projected increases in areas like Health care and social assistance, public administration, Accommodation and food services, and Trades, transport and equipment operators, and related occupations.

Canadian Home Builders' Association. (2024). *Sector Transition Strategy: Solutions to the Barriers Preventing Canada from Building 5.8 million Homes*. https://www.chba.ca/2024/02/08/chba-releases-strategy-for-building-5-8-million-homes/

The document outlines the Canadian Home Builders' Association (CHBA) Sector Transition Strategy, which addresses Canada's housing crisis stemming from a chronic undersupply of market-rate housing. To meet the federal government's goal of building 5.8 million homes over the next decade,

the strategy emphasizes the need for systemic changes in financial systems, policies, labour, and productivity. It advocates for increased adoption of factory-built construction methods, such as modular and panelized systems, to enhance efficiency, reduce costs, and address labour shortages. The document highlights barriers to this transition, including high capital investment, regulatory challenges, and transportation restrictions, and proposes government support through financial incentives, tax credits, and targeted programming to de-risk investments and accelerate the shift. The strategy aims to close Canada's housing supply gap, improve affordability, and prepare the housing industry for future growth.

3.5 Equity in scaling deep retrofits

How can deep retrofits in social housing be scaled equitably to address the unique needs of vulnerable populations, including Indigenous communities, and what policy changes are necessary to ensure equitable access to these benefits?

Scaling deep retrofits in Eastern Ontario requires technical and financial solutions and a critical examination of equity and systemic barriers. Literature on deep retrofits highlights that marginalized groups, particularly Indigenous Peoples and low-income households, face disproportionate challenges in accessing and benefiting from retrofit programs. Addressing these inequities is essential to ensure that retrofit initiatives do not perpetuate or exacerbate existing disparities and that all communities can participate in and benefit from the transition to a low-carbon future. This adds another layer of complexity to scaling deep retrofits in social housing.

SYSTEMIC AND FINANCIAL BARRIERS

Systemic inequities, including exclusion during policy and program development, influence who benefits from retrofit initiatives. Vulnerable populations in Ontario, especially Indigenous Peoples, are more likely to face energy poverty (Wale et al., 2023), where households struggle to afford basic energy needs, causing hardship. Without targeted, equity-focused efforts, these groups will bear an unfair share of costs and risks(Wale et al., 2023).

Financial barriers remain a major obstacle to implementing and benefiting from programs. The upfront costs of deep retrofits are often prohibitive for low-income households, and most current programs do not offer upgrades at no cost (McIlroy et al., 2024; Tozer et al., 2024b). Rebates for low-income households typically cover only a portion of the expenses – usually 60% to a maximum of 90% – but full coverage is often necessary for these vulnerable households to enable participation (McIlroy et al., 2024).

Additionally, the per-household funding amounts are frequently too small to address broader needs, raising questions about the adequacy of resources (Kantamneni et al., 2024). Achieving a financial return on investment solely through energy cost savings has historically proven challenging, limiting the attractiveness and feasibility of deep retrofits for those most in need (Kantamneni et al., 2024; Tozer et al., 2024b).

PROGRAM DESIGN AND IMPLEMENTATION LIMITATIONS

Many retrofit programs in Canada focus narrowly on energy efficiency, often overlooking broader health, housing, and equity needs that can impact access to energy-efficiency supports. (Kantamneni et al., 2024). Homes in the poorest condition or requiring major repairs are frequently unable to participate, despite being occupied by those most in need (Kantamneni & Haley, 2024; McIlroy et al., 2024). Cost-effectiveness standards prioritize utility-wide savings over household affordability, incentivizing shallow retrofits and leaving out the most vulnerable (Kantamneni et al., 2024; Tozer et al., 2024b). Complex application processes and inconsistent policy innovations further limit participation by low-income households. Additionally, traditional program evaluations often fail to capture benefits beyond energy savings, such as improved health or housing stability (Kantamneni et al., 2024).

In the Canadian context, programs such as the Canada Greener Homes Affordability Program (CGHAP) represent a partial response to these equity and design limitations by offering no-cost energy upgrades to low-income households and explicitly recognizing that affordability is a prerequisite for participation (Kantamneni et al., 2025; Millyard & Kolb, 2025; Natural Resources Canada, 2022). CGHAP's delivery model

addresses several barriers identified in the literature, including limited household financial capacity and the need for simplified, turnkey access to programs (Millyard & Kolb, 2025). However, its current scope and funding levels constrain its ability to support deep retrofits, address extensive pre-retrofit repair needs, or be systematically applied across social housing portfolios and Indigenous communities (Kantamneni et al., 2025; Kantamneni & Haley, 2022; Millyard & Kolb, 2025; Natural Resources Canada, 2022). As a result, while CGHAP illustrates the direction of travel toward more equitable retrofit programming, the literature suggests that substantially expanded funding, broader eligibility, and closer integration with social housing and Indigenous housing frameworks would be required for such programs to meaningfully support equitable scaling of deep retrofits (Canada Electricity Advisory Council, 2024; Kantamneni et al., 2025; Kantamneni & Haley, 2022; Millyard & Kolb, 2025).

SOCIO-CULTURAL AND HOUSEHOLD-LEVEL BARRIERS

Multiple, overlapping vulnerabilities, including age, health, employment, caregiving, immigration status, and issues like hoarding, overcrowding, and substandard living conditions, make it especially difficult for some households to undertake retrofits (Kantamneni et al., 2024; Tozer et al., 2024b). Language barriers and a lack of accessible information further exclude newcomers and minority groups (Tozer et al., 2024b). Furthermore, competing daily priorities, distrust of program administrators, and fears of displacement or “renoviction” deter participation (Kantamneni et al., 2024; Tozer et al., 2024b). Households may also fear uncovering unaffordable problems during retrofits, which may add to their reluctance to participate (McIlroy et al., 2024; Wale et al., 2023).

BUILT ENVIRONMENT AND HOUSING CONDITION BARRIERS

Poor housing quality, specifically the necessity for major pre-retrofit repairs or remediation of issues like mould, asbestos, electrical problems, or structural deficiencies, creates a significant barrier that frequently disqualifies or renders homes ineligible for energy retrofit programs. This challenge is particularly acute for older homes, especially within low-income and Indigenous communities, where the need for such foundational repairs is often prevalent. (Kantamneni et al., 2024). Many of these homes are in Indigenous communities, and urgent repairs necessarily take precedence over energy upgrades (Wale et al., 2023)Minimum health, safety, and structural standards required for retrofit program eligibility or code compliance can therefore increase long-term costs for these communities, as critical repairs must be addressed, often without dedicated funding, before energy upgrades can proceed. Rental properties and multi-unit residential buildings face additional barriers due to split incentives between owners and tenants, more complex decision-making structures, higher upfront and coordination costs, and program designs that are often poorly suited to multi-unit or affordable housing contexts (Wale et al., 2023). The feasibility and cost of retrofits vary widely by region and building type, complicating equitable delivery (Tozer et al., 2024b; Wale et al., 2023).

POLICY, GOVERNANCE, AND DATA CHALLENGES

Addressing energy poverty is considered a necessary component of Canada's net-zero transition to ensure fairness and prevent existing inequalities from worsening (Gaede & Nippard, 2023; Kantamneni et al., 2025). However, the absence of a unified definition of energy poverty complicates targeted policy development. Measuring energy poverty requires nuanced, multi-indicator approaches that account for systemic inequalities and lived experience, but there is ongoing debate about the best methods to attaining more complete data (Kantamneni, 2024c). Energy poverty is often marginalized within broader policy frameworks,

and administrative silos hinder coordinated action (Kantamneni, 2024c). The lack of granular demographic data and underdeveloped evidence from lived experiences further undermines efforts to target and evaluate programs accurately, with respect to energy poverty (Kantamneni et al., 2024; Tozer et al., 2024b)). Translating high-level commitments into decisive, cross-sectoral action remains challenging (Tozer et al., 2024b).

INDIGENOUS-SPECIFIC POLICY AND CULTURAL BARRIERS

While both social housing and Indigenous housing initiatives share the common goal of providing affordable, safe, and adequate housing for vulnerable populations, the approach to Indigenous housing recognizes distinct needs and a legacy of systemic issues. (Martin et al., 2024; Natural Resources Canada, 2022). For example, Ontario's housing plan works with Indigenous Program Administrators (IPAs) to deliver specific services for off-reserve Indigenous peoples, including funding, construction, and home repair, explicitly targeted to Indigenous households (Government of Ontario, 2024). This highlights a tailored, distinctions-based approach rather than inclusion under a broad "social housing" umbrella.

Indigenous communities face unique policy and cultural barriers. Western approaches to housing and deep retrofits often fail to reflect Indigenous values, traditions, and living arrangements, and standardized program designs may not align with community priorities (Gaede & Nippard, 2023; Indigenous Climate Action, 2019). Short project timelines and limited funding frequently exclude Indigenous communities from meaningful participation (Wale et al., 2023). Historical exclusion from decision-making and distrust of large utility companies, rooted in colonialism and unequal power relations, are significant obstacles (Laboucan-Massimo et al., 2023; Wale et al., 2023). Despite these barriers, Indigenous leadership in clean energy is growing, with many renewable energy projects involving Indigenous participation operating or planned in Canada, including Ontario (Laboucan-Massimo et al., 2023). However, fair pricing, ownership opportunities, and community control remain critical issues (Canada Electricity Advisory Council, 2024).

PRINCIPLES FOR EQUITABLE SCALING

Equitable deep retrofits must move beyond demographic labels (oversimplifying as vulnerable households) and instead recognize the complex interplay between energy poverty, housing conditions, and health (Kantamneni et al., 2024). A vulnerability-based approach with an equity lens considers factors such as age, health, employment, and cultural background, ensuring interventions are holistic and responsive to community realities (Bouzarovski et al., 2021; Kantamneni, 2024a).

For Indigenous communities, solutions must be developed with, by, and for Indigenous Peoples, respecting their right to self-determination and integrating traditional knowledge, cultural values, and community priorities (Laboucan-Massimo et al., 2023; Martin et al., 2024; Wale et al., 2023).

The literature consistently demonstrates that programs should address not only energy efficiency but also health hazards (e.g., mould, asbestos), housing suitability, and climate resilience. Notably, concepts such as "Healthy Energy Homes" emphasize the intersection of well-being, cultural identity, and sustainability (Wale et al., 2024; Tozer et al., 2024).

The literature indicates that scaling deep retrofits in social housing is shaped by a combination of systemic, financial, programmatic, socio-cultural, and housing condition factors, which disproportionately affect vulnerable populations, including Indigenous communities. Studies identify energy poverty, high upfront costs, and program eligibility criteria as key constraints on participation, while other work highlights

mismatches between standardized retrofit approaches and Indigenous cultural contexts. Research further suggests that retrofit initiatives that do not account for the interrelated dynamics of energy affordability, housing quality, and health outcomes tend to have limited reach among households with the greatest need. Overall, the literature highlights the importance of approaches that are responsive to local housing conditions and community contexts when scaling deep retrofits in social housing.

Annotated references

Wale, J., Shallard, M., Scholten, I., & Bonnetrouge, C. (2024). *Beyond Sustainability: The Power of Indigenous Healthy Energy Homes*. Canadian Climate Institute. https://climateinstitute.ca/publications/beyond-sustainability-the-power-of-indigenous-healthy-energy-homes/

The report explores how deep retrofits and new construction of "Healthy Energy Homes" in Indigenous communities can be scaled equitably to address the unique needs of vulnerable populations. The report positions Healthy Energy Homes, energy-efficient, climate-resilient, and culturally aligned housing, as a critical policy approach to improving Indigenous health outcomes, reducing energy poverty, and supporting climate adaptation. Drawing on data, community dialogue, and Indigenous leadership, the report demonstrates that current housing conditions contribute to poor health for Indigenous Peoples and that energy-efficient retrofits can deliver multiple, "nested" benefits: improved physical and mental health, lower household costs, reduced emissions, and progress toward reconciliation by aligning with Indigenous worldviews. The authors argue that unlocking these benefits at scale requires a new, national approach led by and in partnership with Indigenous communities, with policy changes focused on dedicated funding, culturally relevant program design, and holistic, community-driven solutions rather than one-size-fits-all standards. The report recommends removing barriers to financing, increasing government investment, and embedding Indigenous knowledge and leadership in retrofit and housing policy to ensure equitable access to healthy, energy-efficient homes for all Indigenous Peoples.

Kantamneni, A., & Haley, B. (2024). *Climate and Affordability in Budget 2024*. Efficiency Canada, Carleton University. https://www.efficiencycanada.org

Kantamneni and Haley's (2024) report, Climate and Affordability in Budget 2024, published by Efficiency Canada, examines how federal budget measures can advance both climate action and affordability, particularly through energy efficiency programs that benefit vulnerable populations. The authors highlight that millions of Canadians face rising energy costs and energy poverty, and they argue that scaling up deep retrofit programs in social housing is essential for addressing these challenges equitably. The report emphasizes the need for targeted investments and policy reforms to ensure that retrofit initiatives reach low-income and marginalized groups, including Indigenous communities, who often experience the highest energy burdens and live in less efficient housing. Kantamneni and Haley advocate for policy changes such as increased funding for deep retrofits, streamlined access to programs, and the removal of barriers that prevent vulnerable households from participating in energy efficiency upgrades. The report concludes that a just transition to a net-zero future requires federal leadership to prioritize equity in program design and implementation, ensuring that the benefits of climate action and improved affordability are accessible to all Canadians, especially those most at risk of being left behind.

Kantamneni, A. 2024. *Energy Poverty, Housing and Vulnerability in Canada*. Efficiency Canada, Carleton University, Ottawa, ON.

Kantamneni's 2024 report examines the critical intersection of energy poverty and housing vulnerability, revealing that nearly two million Canadian households face significant financial strain due to high energy costs and inadequate housing conditions. The report identifies vulnerable groups, including seniors, renters, newcomers, single-parent families, and Indigenous communities, as being disproportionately affected, with challenges such as difficulty keeping homes warm or cool exacerbating health and housing instability. Kantamneni argues that there is no one-size-fits-all solution and emphasizes the need for tailored, equity-focused policies, recommending that the federal government define energy poverty, establish clear metrics, and set national guidelines to support and align local and provincial retrofit and assistance programs. The report highlights that in partnership with provinces and territories, federal leadership is essential to elevate and coordinate deep retrofit programs and energy affordability initiatives. This ensures that all vulnerable populations, including Indigenous communities, can benefit from improved energy efficiency and resilient housing.

Kantamneni, A. 2024. *Efficiency Canada Energy Poverty Data Map: User Guide*. Efficiency Canada, Carleton University, Ottawa, ON.

Kantamneni's 2024 report introduces an interactive mapping tool designed to visualize the geographic distribution of energy poverty and related vulnerabilities across Canada, enabling users to explore key indicators such as energy costs, sociodemographic factors, and housing conditions at various scales. The guide explains how energy poverty compounds existing vulnerabilities, particularly for groups at greater risk of negative health and housing outcomes. It demonstrates how the map can help policymakers, researchers, and advocates identify critical areas for intervention and support. By providing clear data and visualizations, the user guide supports efforts to target energy-efficiency improvements to those most in need, highlighting that advancing energy efficiency can improve affordability, health, and resilience for vulnerable Canadians experiencing high energy cost burdens.

Laboucan-Massimo, M., Rickerby-Nishi, F., Demeris, N., & Shafazand, S. (2023). *Just Transition Guide: Indigenous-led Pathways Toward Equitable Climate Solutions and Resiliency in the Climate Crisis*. Sacred Earth Solar and Indigenous Climate Action.

The *Just Transition Guide* by Laboucan-Massimo et al. (2023) provides a comprehensive framework for Indigenous-led climate solutions and energy sovereignty in the face of the climate crisis. The guide emphasizes the importance of Indigenous knowledge, cultural revitalization, and self-determination in achieving a Just Transition from fossil fuels to renewable energy. It includes case studies of successful Indigenous renewable energy projects, explores challenges such as greenwashing and systemic barriers, and offers policy recommendations to support equitable energy transitions. The resource is a valuable tool for policymakers, Indigenous communities, and advocates seeking to implement sustainable and culturally aligned climate solutions.

Bowie-Edwards, A., Jodoin, S., Cree, I., Goodleaf-Labelle, K., Chiblow, J., & Deranger, E. (2023). *Indigenous Rights and Sovereignty in National Climate Policies: A Systematic Analysis*. Indigenous Climate Action.

The report published by Indigenous Climate Action systematically examines the extent to which national climate policies recognize and uphold Indigenous rights and sovereignty. The report analyzes participating member states' climate commitments under the Paris Agreement and domestic adaptation policies across four key areas: Indigenous participation, protection of Indigenous knowledge systems, realization of Indigenous rights, and restoration of Indigenous jurisdiction over land. Findings reveal that Indigenous Peoples participated in the design of only a minority of climate policies, highlighting widespread exclusion and a failure to ensure free, prior, and informed consent (FPIC). The report critiques the tendency of states to reference Indigenous engagement without providing substantive mechanisms for participation or respecting rights to self-determination and decision-making. It concludes that the lack of meaningful inclusion increases the risk of climate policies violating Indigenous rights and undermines equitable climate action. The authors recommend policy changes to guarantee the rights to self-determination, participation, FPIC, protection of traditional knowledge, jurisdiction over lands, and access to health, food, water, and adequate living standards, emphasizing that climate justice requires moving from symbolic recognition to substantive processes that uphold Indigenous sovereignty in climate policy.

Bouzarovski, S., Thomson, H., & Cornelis, M. (2021). *Confronting Energy Poverty in Europe: A Research and Policy Agenda*. Energies, 14(4), 858. https://doi.org/10.3390/en14040858

This paper outlines a comprehensive framework for addressing energy poverty in Europe, emphasizing the need for targeted and equitable policy interventions to meet the diverse needs of vulnerable populations. The authors highlight significant regional differences in energy poverty levels and stress that effective scaling of deep retrofits in social housing requires context-specific approaches that account for local conditions, social inequalities, and housing stock characteristics. The paper advocates for coordinated policy measures beyond technical upgrades, including meaningful public consultation, intersectional research, and integrating health, social equity, and resource access into retrofit programs. It calls for policy changes such as establishing robust monitoring frameworks, tailored financial support, and removing regulatory barriers to ensure that the benefits of energy efficiency reach marginalized and at-risk groups, thereby promoting a just and inclusive energy transition across Europe.

Indigenous Climate Action. (2023). *Decolonizing Climate Policy in Canada: Report from Phase 2 | Part 1*. Indigenous Climate Action. Retrieved from https://www.indigenousclimateaction.com/publications

This report critically examines Canadian climate policy through an Indigenous lens, emphasizing the need to decolonize climate action by centring Indigenous rights, knowledge, and leadership. Drawing on extensive community engagement and dialogue, the report documents how current climate policies often perpetuate colonial structures and exclude Indigenous Peoples from meaningful participation and decision-making. It highlights Indigenous communities' unique needs and priorities, such as the importance of land stewardship, cultural continuity, and self-determination. It argues that effective climate solutions must be rooted in Indigenous worldviews and governance systems. The report calls for policy changes that ensure free, prior, and informed consent (FPIC), support Indigenous-led climate initiatives, and embed Indigenous knowledge throughout all climate planning and implementation levels. By advocating for a shift from tokenistic inclusion to genuine partnership and power-sharing, the report provides a framework for scaling

equitable climate action, such as deep retrofits in housing, by ensuring Indigenous communities have the authority, resources, and respect necessary to access and benefit from climate solutions.

3.6 Non-energy benefits of deep retrofits

What are the non-energy benefits of deep retrofits in social housing, such as improved health and economic outcomes, and how can these benefits be quantified and communicated to support the business case for large-scale retrofitting initiatives?

Deep retrofits, often defined by >50% energy and >80% GHG reductions, can include comprehensive upgrades to building envelopes, systems, and equipment (McIlroy et al., 2024) and are increasingly recognized for their potential to deliver a wide array of non-energy benefits (NEBs) as well (McIlroy et al., 2024). In the context of social housing, particularly within Indigenous and low-income communities, these NEBs are diverse and significant, encompassing improvements in health, economic well-being, social cohesion, and community resilience (Kantamneni et al., 2024).

A consistent finding across the literature is the strong link between improved housing conditions and better health outcomes. Poorly insulated, inefficient homes are associated with a range of health challenges, including respiratory illnesses, allergies, and mental health stressors (Wale et al., 2023) By improving thermal comfort, indoor air quality, and reducing exposure to mould and toxins, deep retrofits can mitigate these risks (Wale et al., 2023). Enhanced housing conditions foster physical health and emotional and spiritual well-being, particularly when retrofits are designed to address the lived experiences of energy poverty (McIlroy et al., 2024; Wale et al., 2023). Additionally, increased resilience to extreme weather events, such as heat waves and cold snaps, further protects vulnerable populations (Tozer et al., 2024a).

The economic impacts of deep retrofits extend well beyond reduced utility bills (Dunsky Energy Consulting, 2021). Lower energy costs directly alleviate financial stress and free up household income for other essential needs, such as food and healthcare(Tozer et al., 2024a). This is particularly crucial in communities where residents face difficult trade-offs between basic necessities (Raidin et al., 2024; Tozer et al., 2024a; Wale et al., 2023). At the community and societal level, deep retrofits can stimulate job creation, support local economies, and contribute to GDP growth. For example, large-scale retrofit programs have been projected to generate thousands of long-term jobs and billions in economic activity (Dunsky Energy Consulting, 2021). Reduced building operations and maintenance costs, as well as avoided healthcare expenditures due to improved occupant health, further strengthen the economic case (McIlroy et al., 2024; Tozer et al., 2024b; Wale et al., 2023).

Beyond individual households, NEBs encompass broader social and cultural gains. Deep retrofits can enhance community pride, foster a sense of empowerment over energy decisions, and support capacity building and skill development. Projects that align with the cultural values of Indigenous communities, for instance, can support energy sovereignty and further reconciliation goals (Laboucan-Massimo et al., 2023; Wale et al., 2023). Addressing energy poverty is also framed as a matter of social justice, with retrofits as a tool to redress systemic marginalization and exclusion (Tozer et al., 2024b).

Deep retrofits support broader environmental goals, including reductions in emissions and climate adaptation. Investments in resilient, efficient housing reduce the risk and costs associated with extreme weather events and align with national frameworks for clean growth and climate change (Government of Canada, 2020).

The literature underscores the importance and complexity of quantifying NEBs to capture the full value of deep retrofits. Recent studies have employed both quantitative and qualitative methods, including participant surveys and sector-level analyses, to estimate the value of benefits such as reduced financial

stress, improved thermal comfort, better indoor air quality, and an enhanced sense of agency and influence over their living environment (Dunsky Energy Consulting, 2021)

A key finding is that, in many cases, the value participants assign to NEBs exceeds the direct energy cost savings. For example, the public health value of avoided air pollution, reduced illness and mortality, and improved well-being can be substantial (Dunsky Energy Consulting, 2021; McIlroy et al., 2024). However, several challenges remain:

- **Data limitations:** Limited data availability hinders tracking NEBs across diverse demographics and building types, especially for health-related outcomes (Tozer et al., 2024b).
- **Attribution and valuation:** Isolating the impact of retrofits from other factors and assigning monetary values to qualitative benefits (such as social inclusion or community pride) is methodologically complex (Dunsky Energy Consulting, 2021; Laboucan-Massimo et al., 2023).
- **Standardization:** There is a lack of standardized metrics and frameworks for consistently assessing and reporting NEBs, complicating cross-program comparisons (Laboucan-Massimo et al., 2023).
- **Longitudinal tracking:** Many NEBs accrue over time, requiring long-term studies to capture their full impact(Dunsky Energy Consulting, 2021).

To address these challenges, the literature points to several practical approaches such as tracking thermal comfort improvements may involve continuously monitoring indoor temperature and humidity. At the same time, self-reported surveys about respiratory health, absenteeism, or other relevant indicators can measure changes in health outcomes. Economic and maintenance outcomes are often assessed through utility bills and operational cost records. Many studies emphasize the importance of using mixed methods, combining quantitative measures with qualitative interviews, to capture the full range of lived experiences and social benefits (Dunsky Energy Consulting, 2021; Tozer et al., 2024b; Wale et al., 2023).

Despite these challenges, emerging methodologies demonstrate that robust quantification is possible and essential for comprehensive program evaluation (Tozer et al., 2024b).

For policymakers and industry experts, NEBs represent a critical lever in building the business case for large-scale retrofit initiatives. Traditional cost-benefit analyses focused solely on energy savings may underestimate the true value of retrofits, particularly in contexts where financial returns are marginal (Dunsky Energy Consulting, 2021)

By incorporating NEBs, the business case is significantly strengthened in several ways:

- **Demonstrating broader value:** Quantified NEBs highlight benefits that resonate with stakeholders, such as improved health, economic stability, and community resilience, often surpassing the value of energy savings (Wale et al., 2023).
- **Informing program design and targeting:** Understanding NEBs enables more effective program design and marketing, allowing for tailored messaging that emphasizes real-world impacts on households and communities (Dunsky Energy Consulting, 2021)
- **Justifying public investment:** Presenting the potential for job creation, GDP growth, and avoided costs (e.g., healthcare, disaster recovery) supports arguments for public funding and policy support (McIlroy et al., 2024).

- **Prioritizing social outcomes:** NEBs allow for a more holistic evaluation of retrofit programs, ensuring that social benefits are recognized and prioritized, even where energy savings alone may not justify investment (Dunsky Energy Consulting, 2021; Tozer et al., 2024b)
- **Enabling cross-sectoral collaboration:** Recognizing the interconnectedness of energy, health, housing, and social policy encourages integrated approaches and unlocks new funding and partnership opportunities (Wale et al., 2023)
- **Addressing energy justice:** Framing retrofits to address energy poverty and systemic injustice provides a compelling narrative for policy action and public support (McIlroy et al., 2024; Tozer et al., 2024b)

In summary, the literature supports integrating and quantifying NEBs are essential for articulating the whole value proposition of deep retrofits (Dunsky Energy Consulting, 2021). Moving beyond narrow energy metrics, policymakers and industry leaders can design, fund, and implement retrofit programs that deliver lasting benefits for individuals, communities, and society (Dunsky Energy Consulting, 2021; Tozer et al., 2024b). By clearly documenting improvements, not only in energy performance but in resident comfort, health outcomes, and reduced costs, practitioners can build a more compelling business case for investment and better engage stakeholders, funders, and policymakers (Dunsky Energy Consulting, 2021; Tozer et al., 2024b; Wale et al., 2023).

Annotated references

Dunsky Energy Consulting. (2021, July). *Non-Energy Benefits Study: Phase II - Quantified Benefits and Qualitative Insights*. Prepared for Independent Electricity System Operator (IESO).

Dunsky Energy Consulting's 2021 report systematically assesses the non-energy benefits (NEBs) of energy-efficiency projects, including deep retrofits in social housing, by quantifying and qualifying improvements such as reduced financial stress, enhanced thermal comfort, improved indoor air quality, and decreased building operations and maintenance costs. The study identifies these NEBs as significant contributors to improved health and economic outcomes for residents, noting that participant NEBs can sometimes exceed the value of direct energy savings. To quantify these benefits, Dunsky employed participant surveys using relative scaling (comparing NEBs to annual electricity bill savings) and willingness-to-pay methods, integrating the results with program tracking data to assign monetary values to specific NEBs. The study further demonstrates how these quantified NEBs can be incorporated into cost-effectiveness testing and program evaluation, providing actionable insights for program design, marketing, and policy, and strengthening the business case for large-scale retrofitting by capturing the broader social value beyond energy savings.

3.7 Case studies: Successful pathways to deep retrofits at scale

What lessons can be learned from successful case studies of deep retrofit programs in Canada and internationally that can inform the development of a scalable and effective retrofit roadmap for social housing in Eastern Ontario?

Deep retrofit case studies from across Canada reveal that successful scaling is not achieved through technical solutions alone, but by integrating financial, social, and operational strategies tailored to local contexts. The Paddle Prairie Métis Settlement(Liberty Multimedia Inc., 2024), Climative's virtual assessment initiative(Huang & Morton, 2023), Walnut Court's phased upgrades(Furlong, 2019), and City Housing Hamilton's heat pump pilot (The Atmospheric Fund, 2022) each demonstrates unique pathways and pitfalls toward scalable deep retrofits. Notably, these projects often share features with Eastern Ontario's social housing context, such as diverse building ages, limited capital, and high needs among marginalized populations.

A consistent lesson is the transformative impact of targeted funding and policy alignment. Federal and provincial grants, especially those prioritizing underserved or Indigenous communities, act as catalysts for deep retrofits that might otherwise be financially out of reach (Liberty Multimedia Inc., 2024). However, (Huang & Morton, 2023; Kantamneni et al., 2025). Projects like Paddle Prairie and City Housing Hamilton show that aligning retrofit measures with community priorities, such as accessibility, cultural values, and occupant comfort, builds trust and ensures long-term success. This approach is particularly relevant for Eastern Ontario, where social housing providers must balance ambitious energy goals with residents' diverse needs and backgrounds (McIlroy et al., 2024). The reliance on multi-level government grants mirrors funding realities for many Eastern Ontario providers, suggesting that coordination and flexibility in program design are critical.

Technological solutions are not without challenges (Natural Resources Canada, 2022). The City Housing Hamilton heat pump pilot underscores the importance of robust planning, system sizing, and ongoing commissioning(The Atmospheric Fund, 2022). Issues such as oversizing heat pumps, leading to inefficiencies like short cycling (Millyard & Kolb, 2025) highlight the need for careful calibration and continued resident engagement through feedback loops. These experiences point to the necessity of continuous monitoring, skilled local labour, and strong quality assurance protocols, which are pressing issues for social housing providers in Eastern Ontario managing a wide range of building types and resident populations.

Incremental and context-sensitive approaches, as demonstrated by Walnut Court's phased upgrades, also offer a practical model for scaling (Furlong, 2019). Rather than solely relying on comprehensive, one-time overhauls, phased or targeted upgrades, prioritizing envelope improvements, passive solar gains, and mechanical system optimization can deliver substantial energy savings, especially in older or partially upgraded stock (Glicker et al., 2024). This incremental model may be more financially and operationally viable for housing providers in Eastern Ontario, who often manage portfolios of buildings with varying conditions and retrofit readiness.

Common barriers persist, including high upfront costs, fragmented funding, logistical complexity, and the need for skilled labour. However, these case studies collectively suggest that integrated program design, combining flexible funding, digital innovation, community engagement, and technical rigour, can overcome

these obstacles. Understanding how these elements have worked in similar Canadian contexts provides valuable direction for policymakers and industry partners in Eastern Ontario, emphasizing the importance of local adaptation, capacity building, and operational excellence.

Annotated references

Huang, T., & Morton, W. (2023). *Scaling net-zero retrofits: Accelerating Net-Zero Retrofits with Virtual Home Energy Assessments*. Climative.ai. Retrieved from https://climative.ai

This report by Huang and Morton (2023) explores the urgent need to accelerate retrofitting efforts in North America to achieve net-zero emissions by 2050. It highlights the limitations of traditional on-site home energy assessments, such as high costs, slow scalability, and accessibility challenges, and advocates for virtual home energy assessments as a solution. The authors detail three types of virtual assessments, no-touch mass market, survey-based, and remote assessments, and introduce Climative's AI-powered platform, which integrates these methods to create a comprehensive digital twin of residential buildings. The report emphasizes the benefits of virtual assessments, including faster evaluations, improved homeowner engagement, and data-driven decision-making for stakeholders. It also discusses use cases for governments, financial institutions, and real estate professionals, showcasing how virtual assessments can drive climate action, program design, and compliance with emissions reporting standards.

Furlong, G. (2019). *A Near-net Zero Retrofit Case Study: Walnut Court*. EnviroCentre.

This case study details a near-net-zero retrofit of a row townhouse at 110 Walnut Court in Ottawa, originally built in 1981 with above-code insulation (R32 ceilings, R20 walls, R10 foundation). Prior to the retrofit, the home already featured some efficiency upgrades, including a mid-efficiency gas furnace, a standard water heater, a heat recovery ventilator (HRV), and air sealing. The retrofit further enhanced the building envelope and mechanical systems through additional air sealing, fireplace removal to reduce infiltration, attic air sealing, upgrading the back basement clerestory, and installing a new HRV. These targeted measures were selected to maximize energy savings, leveraging the unit's advantageous design as a middle unit with limited exposed wall area and a south-southwest orientation for passive solar gain. Notably, the project was undertaken without external grant funding, demonstrating the feasibility of phased, homeowner-driven improvements as resources allow. These upgrades led to lower energy consumption, reduced greenhouse gas emissions, and enhanced occupant comfort, while also reducing energy bills. The Walnut Court case highlights that even homes with a relatively efficient starting point can achieve near-net zero performance through incremental, cost-effective retrofits. Key lessons include the importance of prioritizing envelope and air sealing, leveraging passive solar design, and considering building orientation and unit type. This approach offers a practical, replicable pathway for scaling deep retrofits in older attached housing stock.

The Atmospheric Fund. (2022). *Lessons from a Heat Pump Retrofit at CityHousing Hamilton: A TAF Case Study*. Retrieved from https://taf.ca

This pilot project, a collaboration between The Atmospheric Fund (TAF) and CityHousing Hamilton, evaluated the performance of a heat recovery, variable refrigerant flow (VRF) air source heat pump

(ASHP) system in a three-storey, 40-unit multi-family residential building. The system was installed in three suites – including one for a resident with reduced mobility – to assess its ability to deliver efficient space heating and cooling under Ontario's climate conditions. The retrofit was part of TAF's Retrofit Accelerator program, with the broader CityHousing Hamilton initiative supported by $10 million from Natural Resources Canada's Greener Neighbourhoods Pilot Program, $14.3 million from CMHC, and $2.6 million from CityHousing Hamilton. The heat pump system successfully maintained comfortable indoor temperatures year-round, improving resident satisfaction and resilience to extreme heat. However, energy savings were less than anticipated due to system oversizing, which led to short-cycling and increased electricity use compared to pre-retrofit electric baseboards. The project underscores the importance of proper system sizing, continuous monitoring, and resident feedback in achieving both energy and comfort goals. Lessons from this pilot highlight the need for comprehensive planning and quality assurance in scaling heat pump retrofits within multi-family and social housing contexts.

4. Cross-cutting insights and patterns

The literature on scaling deep retrofits in Canadian social housing reveals several overarching themes and recurring patterns. Achieving Canada's net-zero targets by 2050 cannot be attained without transformational change in the building sector, with deep retrofits positioned as absolutely essential for bridging the emissions gap. Multiple studies indicate that standard or incremental energy upgrades are insufficient; deep retrofits are a necessary, non-optional pathway for achieving the substantial building-level emissions reductions required for net-zero. Without a large-scale, deep transformation of the existing housing stock, including the social and affordable housing sector, Canada risks falling short of its climate commitments.

Crucially, this transition must be grounded in equity and affordability principles, as the impacts of energy poverty and climate vulnerability fall hardest on marginalized populations: low-income households, Indigenous Peoples, seniors, people with disabilities, renters, racialized groups, newcomers, and those in rural or remote areas.

Deep retrofits deliver significant non-energy benefits, such as improved health, enhanced thermal comfort, increased resilience to extreme weather, economic stimulus through job creation, and progress toward social equity and reconciliation objectives. The literature increasingly stresses the importance of quantifying and valuing these co-benefits to create a comprehensive business case for deep retrofits in the social housing sector.

The regulatory environment is marked by a complex, multi-level governance structure involving federal, provincial, and municipal governments, each with distinct yet sometimes overlapping roles. Literature widely agrees that effective scaling demands greater policy and program alignment across these tiers, as the lack of coordination is a persistent barrier.

Financial levers are pivotal; strong public funding, innovative financing, and enduring incentives are necessary to accelerate uptake, especially in the social housing sector, where costs cannot be passed to residents. Programs are most effective when paired with aggregation and standardization strategies to drive down costs. However, significant workforce and supplier capacity gaps persist, especially in specialized trades and materials, underscoring the need for incentives and targeted training and recruitment, particularly from underrepresented groups.

Case studies highlight that successful large-scale retrofits require holistic planning, multi-level funding, advanced financing, equitable design, community engagement, and integration of technical solutions with social and cultural needs. The literature also identifies several tensions and points of alignment: for example, the ambitious pace required to meet net-zero targets contrasts sharply with the current slow rate of retrofitting, and while deep retrofits can advance both climate action and social equity, traditional cost-effectiveness standards (i.e., relying on simple payback or lowest first-cost approaches) may inadvertently exclude the most vulnerable households.

While technical strategies for deep retrofits are well-established and the value of multi-level governance is widely recognized, the literature shows that key areas still require further development. These include stable and adequate financing mechanisms, more accessible and equitable program design, improved regulatory alignment, workforce development, and enhanced data collection and monitoring, especially post retrofit to validate actual outcomes and demonstrate that benefits are reaching vulnerable populations.

5. Gaps and opportunities

Despite growing momentum, the literature identifies several persistent gaps that limit the effectiveness and scalability of deep retrofits in social housing.

There is a lack of granular data on housing needs, energy use, and retrofit feasibility for specific vulnerable populations and multi-faceted building types across Canada's diverse regions. This lack of detailed, locally relevant data makes it challenging to design retrofit programs that truly meet the needs of different groups and housing types. As a result, interventions may not target those who need them most, resources may be misallocated, and retrofit measures may be less effective or even unsuitable for specific communities or building types. This data gap is widely recognized in the literature as a key reason some vulnerable populations remain underserved and programs struggle to achieve equity and scale. The low-income rental sector, in particular, lacks detailed analysis and effective strategies to address the split-incentive barrier between landlords and tenants.

There is also limited comprehensive evidence on the long-term impacts and effectiveness of financing mechanisms within the Canadian context, such as Property Assessed Clean Energy (PACE), on-bill financing, and market models like Energiesprong and Energy as a Service. Because of this, decision-makers and providers may not have the confidence to scale up or adapt these models, and promising approaches may struggle to gain traction without clear, localized evidence of success.

Methodologies for quantifying and valuing non-energy benefits, especially health, social, and resilience outcomes, are inconsistent and underdeveloped. This matters because robust accounting of non-energy benefits, such as improved health, resilience, comfort, and community well-being, helps to strengthen the business case for deep retrofits. Where these benefits are undervalued or unmeasured, projects that deliver significant social impacts may not be prioritized for funding or may be excluded under traditional cost-effectiveness standards. A more nuanced understanding of intersectional vulnerability is needed, as multiple factors such as age, health, income, language, and race, can compound barriers to accessing retrofit programs.

Specific data and tailored strategies for Indigenous communities remain insufficient, particularly regarding housing conditions, integration of traditional knowledge, and overcoming systemic barriers to self-determined housing and energy solutions.

The literature frequently identifies workforce and supplier capacity constraints as barriers to scaling deep energy retrofits, particularly in relation to specialized trades and materials; however, there is limited consistency in how these shortages are defined, measured, and evidenced across studies. Much of the existing work relies on qualitative assessments, stakeholder perceptions, or high-level projections, with relatively little empirical analysis linking workforce and supply constraints to retrofit delivery outcomes in social housing contexts. In addition, the literature provides limited examination of how these capacity constraints vary by region, housing type, or retrofit depth, making it difficult to assess their implications for large-scale implementation. Relatedly, while studies acknowledge structural factors such as housing financialization and tenant displacement risks during retrofits, there remains a lack of integrated evidence on how these dynamics affect affordability, feasibility, and equity outcomes in social and affordable housing.

While the literature frequently references workforce training and recruitment initiatives, including programs targeting marginalized and underrepresented communities, there is limited empirical evidence assessing the scale, effectiveness, or durability of these efforts in addressing workforce and supplier capacity constraints

for deep energy retrofits. Existing studies tend to describe training initiatives at the programmatic or policy level, with little systematic analysis of outcomes, labour retention, or the alignment between training pathways and the specialized skills required for high-performance retrofits in social housing. As a result, the literature provides limited insight into whether and how such initiatives materially contribute to scaling deep retrofits across different regional and housing contexts.

In parallel, the literature identifies broader structural factors, including housing financialization, affordability pressures, and tenant displacement risks, as relevant to the feasibility of deep retrofits in social and affordable housing. However, there is a lack of integrated analysis examining how these dynamics interact with workforce capacity constraints, retrofit delivery timelines, and tenant stability during implementation. Existing research typically treats labour capacity, financial conditions, and tenant impacts as discrete issues, leaving gaps in the understanding of how their interactions shape retrofit feasibility and equity outcomes in practice.

To address these gaps, the literature points to several opportunities for further research, innovation, and demonstration projects. Research priorities include developing standardized definitions and metrics for energy poverty and deep retrofits that reflect geographic and demographic variation, conducting regional typology studies to identify optimal retrofit solutions, and undertaking longitudinal studies to track the full range of non-energy benefits and their monetary value over time. There is also a need for policy and regulatory research to resolve landlord–tenant split incentives, address provincial inconsistencies, and advance Indigenous-led housing and energy solutions that integrate traditional knowledge and support self-determination.

Innovation opportunities include the development and scaling of financing models accessible to non-profit social housing providers and low-income households, such as performance-based incentives and Energy as a Service. Technological innovations like virtual or AI-powered assessment tools could streamline retrofit processes and reduce costs. Standardized, replicable retrofit packages and prefabricated solutions offer potential for achieving economies of scale, while innovation in supply chain development for low-carbon materials and technologies, particularly through domestic manufacturing, could address current capacity gaps.

Demonstration projects are needed to pilot no-cost or fully funded deep retrofits targeting vulnerable populations and specific building types, including necessary pre-retrofit repairs. Aggregated or bundled retrofit projects could attract larger investment and reduce transaction costs, while "one-stop-shop" service models could provide integrated technical, financial, and social support for housing providers and residents. Demonstrations of electrification strategies combined with deep envelope upgrades, as well as Indigenous-led projects that reflect cultural appropriateness and self-determination, are also identified as critical next steps for advancing the field.

6. Conclusion and next steps

Canada's pursuit of net-zero emissions by 2050 demands accelerated, transformative action in the social housing sector. This literature review demonstrates that scaling deep retrofits is both a climate imperative and a pivotal lever for advancing social equity and energy justice. The evidence assembled here confirms that deep retrofits in social housing can address energy poverty, improve health, and foster resilient communities. These benefits extend well beyond energy savings alone.

Despite the clear benefits associated with social housing, deep retrofits, significant obstacles persist. High upfront costs, fragmented funding streams, program complexity, workforce shortages, and regulatory misalignments continue to limit the pace and scope of retrofit efforts, especially for the most vulnerable populations. Yet the literature also offers clear pathways forward, highlighting models and policies that have delivered measurable results and underscoring the necessity of coordinated, equity-driven strategies.

This literature review, as part of the research process, can now move from evidence into action. The findings within this review will help paint the picture of the state of social housing in Eastern Ontario and inform the prioritization of further investigative work as we develop a comprehensive, regionally specific pathway for scaling deep retrofits in Eastern Ontario's social housing.

Our immediate next steps will be to use the findings of this review to identify and address the key remaining gaps and develop a regionally tailored roadmap for retrofitting social housing stock. This roadmap will be informed by a qualitative practitioner engagement process structured around the same themes explored in this review: Canada's Climate and Energy Transition Priorities; Canada's Regulatory Framework; Financial Incentives, Market Mechanisms, and Policy Drivers; Workforce and Supplier Capacity for Green Retrofits; Equity in Scaling Retrofits; and Non-Energy Benefits of Deep Energy Retrofits.

Through stakeholder interviews, we will validate the key barriers, opportunities, and priority actions identified in the literature review, and assess their relevance, feasibility, and priority from a practitioner perspective. This process will bring to light implementation challenges we may have overlooked and highlight where additional support or coordination is needed to accelerate deep retrofits across Eastern Ontario.

By grounding our strategy in evidence and focusing on implementation, we will build the roadmap for Eastern Ontario to lead the way toward safe, healthy, and climate-resilient homes for all who need them most, and to Canada's net-zero future.