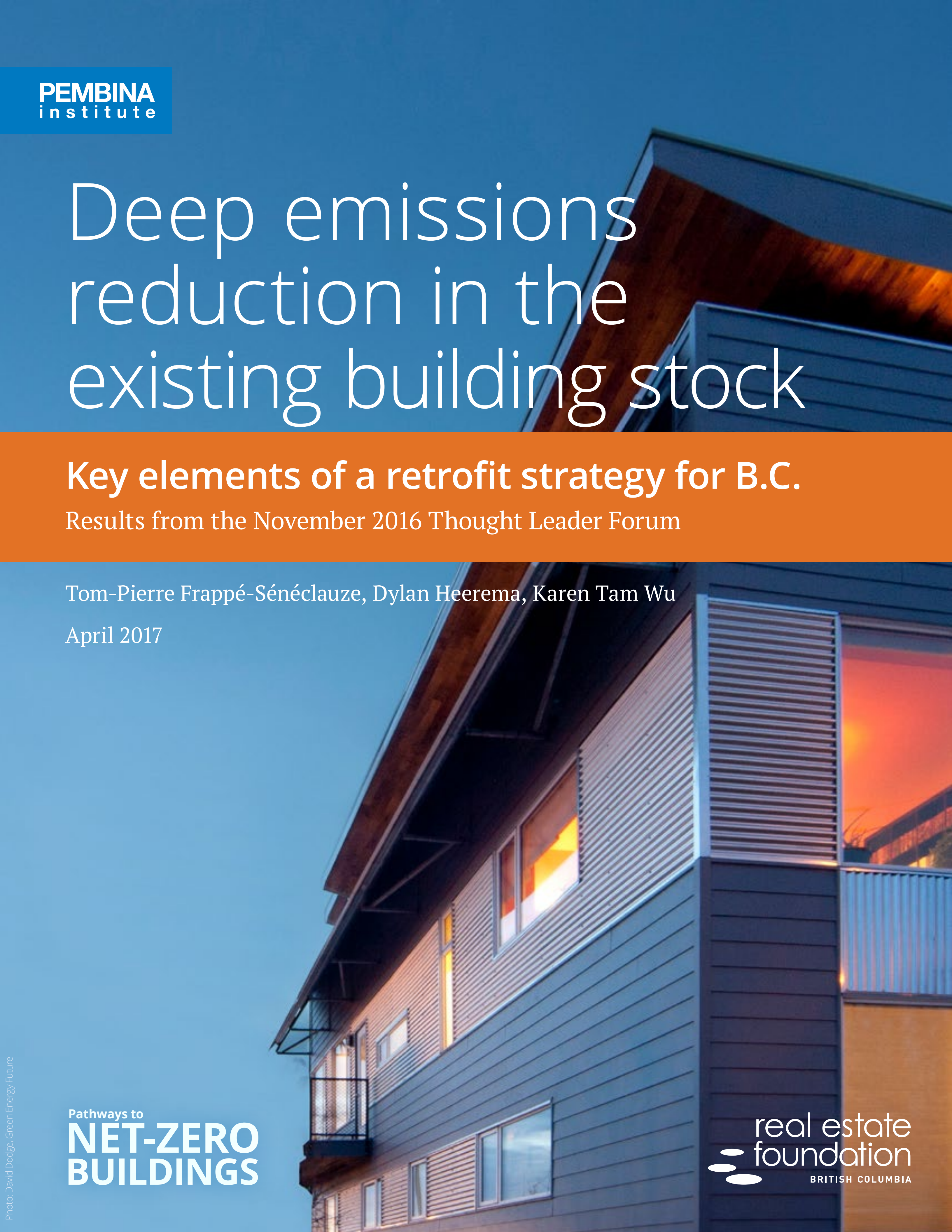

PEMBINA institute

Deep emissions reduction in the existing building stock

Key elements of a retrofit strategy for B.C.

Results from the November 2016 Thought Leader Forum

Tom-Pierre Frappé-Séněclauze, Dylan Heerema, Karen Tam Wu

April 2017

Photo: David Dodge, Green Energy Future

Pathways to NET-ZERO BUILDINGS

real estate foundation BRITISH COLUMBIA

PEMBINA institute

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Pathways to Net-Zero Buildings in B.C.

Tom-Pierre Frappé-Sénéclauze, Dylan Heerema, Karen Tam Wu

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The Pembina Institute is a national non-partisan think tank that advocates for strong, effective policies to support Canada's clean energy transition. We employ multi-faceted and highly collaborative approaches to change. Producing credible, evidence-based research and analysis, we consult directly with organizations to design and implement clean energy solutions, and convene diverse sets of stakeholders to identify and move toward common solutions.

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Deep emissions reduction in the existing building stock

Key elements of a retrofit strategy for B.C.

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Executive summary

The Pembina Institute hosted the Pathways to Net-Zero Thought Leader Forum in November 2016. We brought together over 120 participants from across the building sector to establish recommendations for a national and provincial building retrofit strategy. Over two days, we discussed strategies to accelerate retrofit uptake in one- and two-family homes, multi-unit residential buildings (MURBs), and commercial-institutional buildings.

Given the breadth of topic covered, we did not attempt to reach consensus; the recommendations below do not necessarily represent the views of all participants.

Targets

We propose that the building sector should aim to reduce greenhouse gas emissions from the operation of buildings by **40-50%** below 2007 levels by 2030, and **80-100%** by 2050. In absolute terms, this means on-site emissions and upstream emissions related to electricity generation should be brought down to ~4 $MtCO_2e$ by 2030, and below 1.5 $MtCO_2e$ by 2050.

Modelling shows that measures announced in B.C.'s 2016 Climate Leadership Plan will not be sufficient to meet B.C.'s legislated economy-wide emissions reduction targets (Figure 1). Some of the policies proposed in the Plan, such as the commitment for building codes to require net-zero ready buildings by 2032, will help reduce emissions in the building sector, but they are insufficient to meet the proposed building sector targets (Figure 2). Additional policies are needed to reduce emissions, particularly from existing buildings.

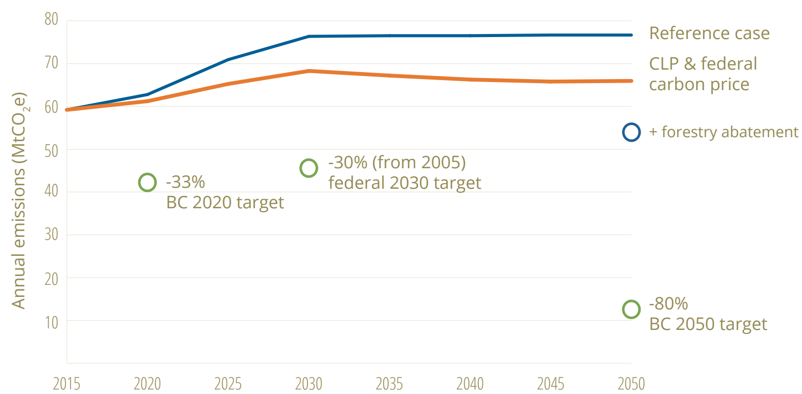


Figure 1. Annual GHG emissions in B.C. under a reference case and a CLP + Federal carbon price case

Pathways

If we are successful in making net-zero ready the norm by 2032, these efficiency gains will contribute roughly a third of the emissions reductions needed (Figure 2b). The rest will have to come from the renovation of existing buildings. This can be achieved by retrofitting 3% of the building stock each year, and also converting half of these buildings from natural gas or oil to non-emitting heat sources such as electricity or low-carbon district energy systems (Figure 2d). This amount (3%) of building stock is equivalent to roughly 30,000 houses per year, 17,000 units of MURBs, and 3 million square metres of commercial/institutional space. Retrofits should reduce energy use sufficiently to protect affordability, and aim to achieve 25% emissions reductions in non-electrified buildings. Overall, an approach that combines both fuel switching and efficiency will achieve 60% emissions reductions across all retrofitted buildings

Past incentives programs have been insufficient in scale and persistence to meet the proposed retrofit targets; the combined ecoENERGY Retrofit and LiveSmart BC residential incentive programs, for example, reached on average 1% of eligible B.C. homes per year and resulted in average emissions reductions of 26% per household (less than half of the depth needed). At their peak, however, these programs showed that the proposed target retrofit and electrification rates were achievable. In the second quarter of 2009, LiveSmart BC incentive programs reached over 2,500 homes per month (3% of eligible stock annually). Between March 2008 and April 2011, over 45,000 households purchased an air source heat pump, resulting in the electrification of up to 2% of eligible households. The challenge will be to mobilize public and private resources to sustain these peak retrofit and electrification rates steadily over the next thirty years.

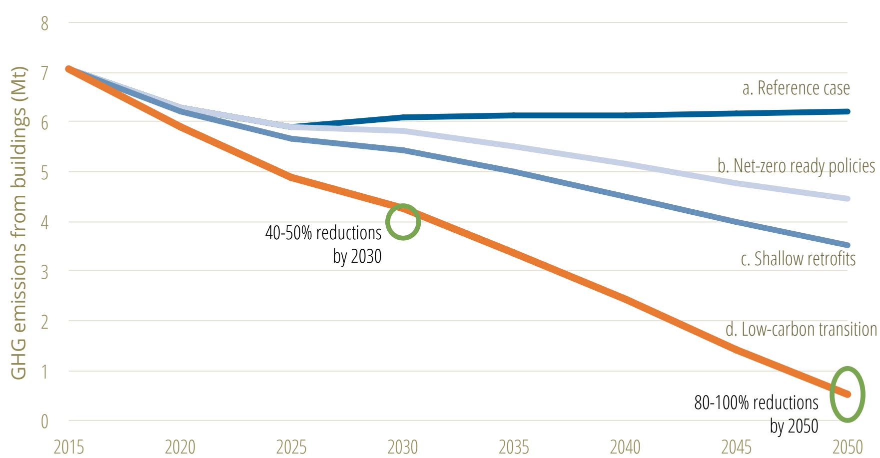


Figure 2. A 'Low-carbon transition' pathway for B.C. buildings that includes new buildings policies, a broad retrofit program, and fuel switching

Building renewal: investment and job creation

Meeting the proposed targets will require an unprecedented public and private investment in the renewal of our buildings. We estimate that meeting the 3% retrofit target in B.C. would require an investment of $750 million to $1 billion per year. This would create up to 5,000 direct jobs in the retrofit industry, another 6000 indirect or induced jobs, and $4-8 billion in GDP growth. Public investments in retrofit incentives and programming often more than pay for themselves through new tax revenues; in Germany, for example, KfW's retrofit grants and loans return $4 to $5 to public coffers per $1 invested by the national bank.

Barriers

Barriers to retrofits are complex and vary by building types (see Section 4.10). Forum participants repeatedly raised four interwoven challenges:

1. Difficulty in making a business case for retrofits on energy savings alone, particularly given's B.C. low energy costs and mild weather.
2. Lack of awareness and knowledge of decision-makers, who may lack time and/or capacity to assess the energy and non-energy benefits of retrofits.
3. Complexity of the retrofit process; in the absence of an integrated home energy performance industry, homeowners and business owners must piece together complex construction projects (e.g. contracting an energy advisor, analyzing the business case, securing financing, finding contractors, comparing quotes, sequencing the work).
4. Lack of capacity and training, specifically: in the construction industry, which is already faced with skills and labour shortages; in the real estate industry, which lacks resources to train owners and operators; and in local governments, which already struggle to keep up with permitting and inspection workloads. Trade certifications and quality control processes are lacking for most energy retrofit procedures. Programs exist, but most are voluntary and are not widely recognized or valued by the public. The repeated introduction and removal of incentives has compounded this capacity issue and has been detrimental to the establishment of a mature retrofit industry. An indicator of this is the rapid decrease in energy advisors after the end of LiveSmart: B.C. went from 188 registered energy advisors in 2011 to 21 as of October 2016.

Solutions and recommendations

Nine strategies were discussed at the forum to address these barriers. These strategies are summarized below. Please refer to the full report for an overview of key points of discussion on these at the forum.

Carbon pricing

Pricing undesired externalities, such as carbon pollution, is the most direct way to incent the market to innovate to meet desired outcomes. Most policy packages that have been shown, through economic modelling, to meet legislated targets include a price on carbon much higher than the one currently set by the federal government. B.C.'s Climate Leadership Team, for example, proposed a $10 per year increase in the carbon tax starting in 2018, rising to $110 per tonne by 2025 (Table 7). This does not mean that it would be impossible to meet the proposed building sector targets under the current price schedule as laid out in B.C.'s Climate Leadership Plan, but it does mean that other subsidies and regulations will need to be ramped up significantly to otherwise encourage efficiency and fuel switching. Recommendation:

- The Government of B.C. should increase the price signal for efficiency and conservation through carbon pricing.

Electrification strategy

In absence of a meaningful price on carbon, other measures must be considered to encourage fuel switching such that roughly half of the 3% of buildings retrofitted each year are fuel switched. An electrification strategy should answer these questions: What policies should be put in place to drive smart electrification? Do local grids have the capacity to meet the added demand, and if not, what upgrades would be necessary? And how would these costs compare with that of creating or extending district energy systems?

Recommendations:

- The Government of B.C. should articulate an electrification and fuel switching strategy to drive reductions in building emissions.
- BC Hydro should, as part of its 2018 IRP, assess the need for upgrades in local distribution systems to meet increased demand from the electrification of buildings.
- The Government of B.C. and BC Hydro should collaborate to accelerate market transformation for heat pump technology including investments in pilot projects, incentives, and training.

Retrofit codes

Given that windows, cladding and heating equipment in a given building will likely only be replaced once between now and 2050, we need to maximize the energy upgrade potential at each replacement if we are to achieve a near-decarbonized building stock by mid-century without redoing work. Retrofit codes, whether enforced at time of renovation or triggered based on performance, provide guidelines for owners on the level of performance expected of their buildings. A predictable retrofit codes schedule would provide clarity and confidence to the retrofit industry, which could then invest to meet the demand more affordably.

Regulations can lead to less-than-optimal solutions if too prescriptive. Performance-based retrofit codes for larger buildings, such as ASHRAE 100, provide both clarity of desired outcomes and the flexibility to select measures such that costs and disruption are minimized and co-benefits are maximized. The current energy code, ASHRAE 90.1-2010, provides a prescriptive path for compliance, which is appropriate for smaller (simpler) buildings. A prescriptive retrofit code tailored to the needs of Canadian homes should also be developed.

Some key necessary conditions for success of retrofit codes raised at the forum include:

1. Building the capacity of local permitting offices, most of which should start with enforcing energy codes for new buildings.
2. A process to address whether a site would be better off redeveloped than refurbished.
3. Low-barrier financing to make compliance possible and non-punitive for cash-strapped owners.
4. Integration of other social objectives deemed essentials for the resiliency of buildings (seismic upgrades, sprinklers, accessibility) into a coherent integrated retrofit code.

Recommendation:

- The Government of B.C. should adopt a schedule of retrofit requirements at time of renovation based on ASHRAE 100 for large buildings and ASHRAE 90.1 for small buildings. Working with local government, it should encourage enforcement of current energy codes at time of retrofits. Working with the federal government, it should investigate whether and how other social priorities — seismic resilience, adaptability, fire protection — could be included in an integrated retrofit code for resilient buildings.

Public financing

There are multiple ways in which publicly-raised capital could be used to accelerate retrofits. Ideas mentioned at the forum included the creation of a long-lasting retrofit program providing loans and grants; capitalization of rotating funds for retrofit investments in public buildings; and various credit-enhancements to encourage private investment in energy efficiency, such as loan-loss reserves, loan guarantees, and interest buy-downs.

Operating these programs and monitoring their success will require dedicated focus and coordination, which would be best served by creating a centralized public financing authority (or 'green bank') focused on energy efficiency and building renewal. The upcoming federal investments in housing are a one-time investment, not a sustainable financing model. Leveraging these funds to create provincial and/or federal green banks would enable the establishment of institutions with capacity to raise capital on an ongoing basis, a necessity if we are to maintain retrofit efforts between now and 2050. Ontario has taken a step in this direction with its proposed 'Green Bank', and B.C. should consider a similar model. The Federal Infrastructure Bank could play this role, but given the distributed nature of building investments and their unique challenges, it would require a dedicated department to aggregate projects and design programs suited for different market segments.

Recommendation:

- The Government of B.C. and/or the federal government should create a public financing authority (or 'green bank') focused on energy efficiency and building renewal. Current federal funds and additional provincial funds should be used to establish this organization, create a sustainable retrofit financing model leveraging public and private financing, and capitalize the first round of programs.

Energy benchmarking and disclosure

For markets to recognize the various benefits of energy upgrades, decision-makers need access to validated and comparable data on building performance. Access to reliable information supports decision-making on investments in energy efficiency. The absence of this information is a fundamental market failure that should be corrected through public policy; just as we label processed foods to support sound dietary decisions, we should label the performance of homes and buildings to support valuation of energy efficiency by the market. Voluntary programs for the assessment of energy performance have existed for several years, but uptake will remain low and limited to high performers until reporting of energy performance data is a requirement.

Recommendations:

- The Government of B.C. should require home energy labelling at time of sale by 2019.
- The Government of B.C. should require energy benchmarking for buildings larger than 50,000 square feet, with mandatory disclosure within three years.

Valuation of non-energy benefits

Given the difficulty in making the business case for retrofit projects on energy cost savings alone, many participants highlighted the importance of fostering a greater understanding, and ultimately valuation, of non-energy benefits. These include decreased maintenance costs, improved comfort, health, productivity, increased resale value, etc.

Measuring health benefits related to energy upgrades could be a strong argument for increased investment, particularly in low-income housing. Symptoms of respiratory and cardiovascular conditions, rheumatism, arthritis and allergies can be reduced through improved ventilation systems and airtightness, both in new construction and in existing buildings.

Recommendations:

- The Government of B.C. should work with the B.C. Assessment and the Appraisal Institute of Canada to identify and collect data needed to consider energy efficiency upgrades in property assessments.
- Governments and utilities should work with media, public personalities, the home performance and development industry, and realtors to amplify messages on non-energy benefits of retrofits.
- Academic institutions should pursue further research and communication on the link between energy upgrades and improved productivity, health, and comfort.

Project aggregation

Instead of tackling each retrofit as a unique project, economies of scale can be obtained by issuing energy services contracts for several buildings with similar characteristics. This aggregation model was piloted by the Dutch *EnergieSprong* program in the social housing sector. This approach allows the creation of contracts of sufficient value to justify investments in research and development; it proposes a paradigm shift from a market where private companies tell building owners what is available for retrofits, to one where owners collectively define criteria for retrofits and private companies innovate to meet this demand.

Recommendation:

- BC Housing should form a multi-stakeholder working group to pilot aggregation of demand in the B.C. social housing sector.

Integrated delivery

The retrofit process can be simplified by the creation of integrated retrofit services, whether delivered by a 'one-stop shop' company acting as project manager, or coordinated by a financing agency with a network of pre-certified contractors. An integrated delivery model would remove barriers to entry by streamlining the process for homeowners. It would also drive deeper retrofits by proposing a sequenced package of measures that can be implemented one at a time, and creating a continuous relationship to see them through over the years.

A steady demand for services needs to be secured before integrated services can be profitably developed. This can be achieved by a combination of strategies such as public financing, regulations, energy labelling, and innovative financing mechanisms. Additionally, governments need to build the capacity of the renovation industry to meet this demand and ensure the quality of installations.

Recommendation:

- The Government of B.C. and the federal government should support the development and implementation of training, certification, and quality assurance programs for trades and professionals in the building sector, considering the specific needs of the construction industry, the real estate industry, and local governments.

Innovative financing mechanisms

With $2.9 billion invested in the last year alone, the success of PACE financing for residential and commercial buildings in California illustrates the potential of pairing a low-barrier financing model with an integrated single point of access providing pre-qualified contractors, quality assurance, and outreach.

Various financing solutions have been proposed to address barriers to private investment in energy upgrades, barriers that include split incentives, hyperbolic discounting of future savings, competition for limited borrowing capacity, and long amortization periods. Three mechanisms were discussed at the forum: on-property-title loans (or PACE), metered energy efficiency, and loans to strata corporations.

These aim to reduce loan rates by attaching loan repayment to bills that are routinely paid (property taxes, utilities), thus reducing default risk. Tying the loan to the property or the meter, rather than the individual, removes split incentives by enabling the transfer of the loan at time of sale, and reduces competition with other possible investments (e.g. new lobby or granite countertops) by providing off-the-ledger lending. Transferability at time of sale makes longer-term loans more acceptable, which reduces the loan repayments to a level where they can be offset by energy cost savings, or integrated with other housing costs without undue burden on homeowners or tenants.

Recommendations:

- The Government of B.C. should work with local governments to create a Local Improvement Charge (LIC) structure to fund energy efficiency, water conservation, climate adaptation and renewable energy upgrades.
- Governments and utilities should be engaged to evaluate and fund a pilot of the Metered Energy Efficiency Transaction Structure in a high-profile commercial building in B.C.
- The federal government should work with provinces, local governments and Canada Mortgage and Housing Corporation to harmonize rules across the country for LIC programs and remove barriers to applicants (e.g. requirement for lender consent).
- The Government of B.C. should require depreciation reports to incorporate energy conservation options provided by energy audit and to provide recommendations for cost-effective measures to be integrated in maintenance plans.
- The Government of B.C. should provide credit enhancement or otherwise remove barriers to encourage strata corporations to borrow funds to cover energy efficiency upgrades.

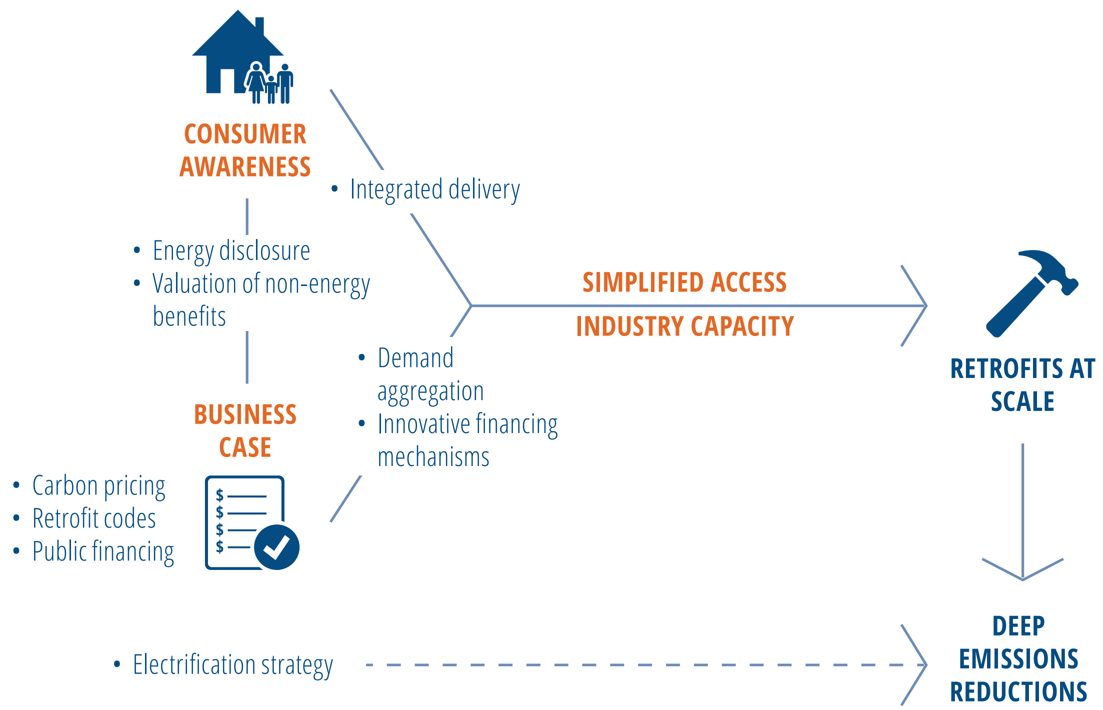


Figure 3. Necessary conditions and systemic interventions for deep retrofits

1. Introduction

On November 28 and 29, 2016, the Pembina Institute, in partnership with TD Bank and the Real Estate Foundation of B.C., hosted a Thought Leader Forum to accelerate policy development and market transformation for high-efficiency buildings. Over two days, 126 participants from 90 organizations with a stake in the building sector (Table 12) discussed the regulatory roadmap to net-zero ready new buildings in B.C., and how to accelerate deep energy retrofits in existing buildings. Most participants were from B.C., with industry and government representation from Ontario, Alberta, the federal government, and from the U.S. (City of Seattle, Rocky Mountain Institute, New Buildings Institute, International Living Futures Institute). The event was run under the Chatham House Rule, meaning conversations and ideas exchanged at the forum can be shared, but not attributed.

This document synthesizes the key outcomes of this discussion, along with the results of research conducted via interviews and literature review before the event. It is not meant as a proceeding of the discussions at the forum, but rather attempts to integrate perspectives shared to outline key elements of a retrofit policy for British Columbia, and, more broadly, for Canada. The Pembina Institute's recommendations are introduced through the document and summarized in Section 5. Some of these proposals were tested directly with participants, others emerged during the course of the discussion. In neither case did we seek to achieve consensus, and these recommendations might not be supported by all participants.

Most of the forum was dedicated to retrofit strategies, and this is also the focus of this report. Perspectives of participants on the recently announced federal and provincial commitments to net-zero ready new construction are summarized in Appendix A.

2. Targets and pathways for deep decarbonization of existing buildings

In order for B.C. and Canada to achieve their climate targets and mid-century decarbonization goals, we must significantly reduce emissions from existing buildings and rapidly evolve construction practices to reach net-zero ready for new buildings. The building sector offers some of the lowest cost, most rapidly achievable GHG reductions opportunities. Investing in the efficiency of our building stock also provides substantial co-benefits: improved economic and employee productivity, green jobs, better health outcomes, and more comfortable spaces to live and work.

2.1 Proposed sectoral targets

While both the Province of B.C. and the federal government have set economy-wide emission targets, neither has defined how much reduction should be expected from each sector of the economy including the building sector. Yet some target is needed to assess appropriate levels of retrofit activity for buildings.

As shown by global abatement costs studies (Figure 15) and energy-economy models of the Canadian economy (Table 6, Appendix B), some of the most cost-effective mitigation opportunities are in the building sector. Few other mitigation strategies have the benefit of returning a cost saving, in addition to decreasing emissions. As discussed in Section 2.3.4, these cost savings multiply the economic benefits of these mitigation investments.

The building sector in B.C. should aim at a **minimum for the economy-wide target of 80% emissions reductions by 2050** (relative to 2007 levels); but given the difficulty in reducing emissions in some sectors of the economy (oil and gas, transportation; see Appendix B) it would be prudent to aim for a near-total decarbonization of building operations by 2050.

To avoid leaving the hard work for the last minute, provincial and federal building strategies should also adopt interim targets for 2030. The B.C. Climate Leadership Team recommended an **interim target of 50% emissions reductions by 2030 for buildings,**[1] and provided economic modelling showing how this target could be achieved through carbon pricing, codes and standards, and equipment regulations (see Table 7 and adjacent discussion for details). For now, we will work with an interim target in the 40% to 50% range for 2030.

Recommendation # 1

Adopt a sectoral target for the building sector to reduce emissions from building operation by 40 to 50% below 2007 levels by 2030, and 80 to 100% below 2007 by 2050

Participant feedback: Strong support[2]

Feedback from forum participants

Thought Leader Forum participants were asked to rate their overall level of confidence that the proposed 2030 and 2050 targets could be met, as well as their support for these targets.

Opinion was divided on B.C.'s capacity to achieve a 50% reduction by 2030, with many participants indicating that the technology and mechanisms exist to make these reductions possible, but that there is a lack of political and social will to do so. Some commented that building owners are less motivated by energy efficiency than some other building features, creating a social barrier. Others insisted that a long-term market signal of government intention to regulate would be required to meet such a target. Surveyed after the forum, 94% of respondents supported the target.[3]

There was more enthusiastic support for the 2050 target, both in the closing survey and in the follow-up survey. Several indicated that technological developments and market transformation will help to achieve this target.[4] Some believed that resistance from a few industry players was likely to slow progress toward the goal.

2.2 Impact of policies announced in the Climate Leadership Plan

To understand the impacts of policies announced in the 2016 Climate Leadership Plan (CLP), the Pembina Institute, the Pacific Institute for Climate Solutions, and Clean Energy Canada commissioned a modelling study by Navius Research Inc. The study shows that policies described in the CLP, assuming their successful implementation, are insufficient to meet the 2020 or 2050 targets: instead of a sharp decrease in total emissions, they barely manage to offset some of the growth expected in the reference case (Figure 4). **Unless more stringent policies are put in place, B.C. will miss its economy-wide 2050 targets by over 40 Mt CO_2e.**[5]

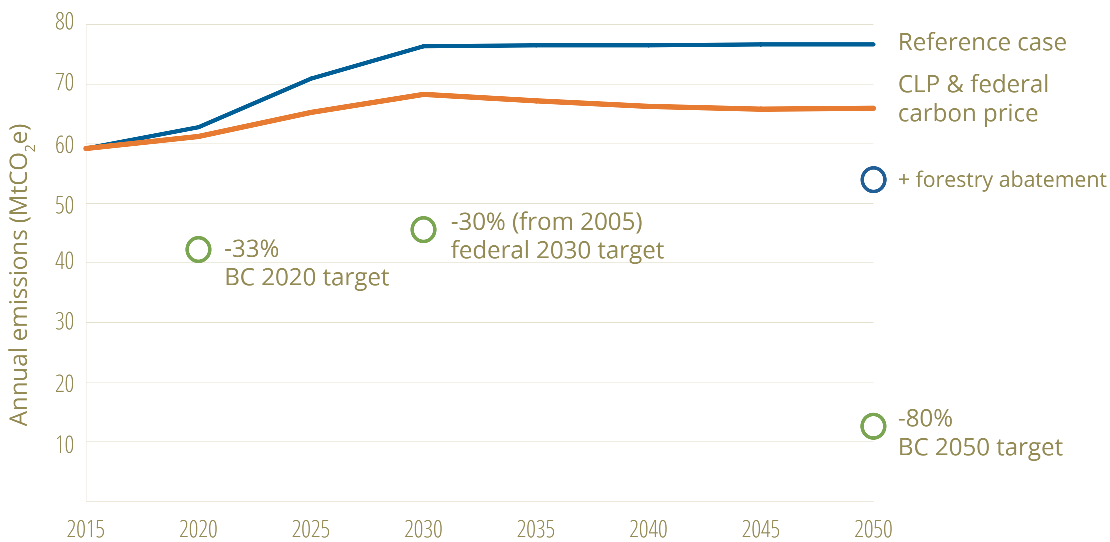


Figure 4. Annual GHG emissions in B.C. under a reference case and a CLP + Federal carbon price case

Source: Navius Research Inc.[6]

CLP policies are also insufficient to drive the building sector towards the proposed target. Modelling results predict little reduction in the residential sector from these policies, though it does predict a rapid decarbonization in commercial buildings driven by a switch to electric heat pumps (Figure 5). Appendix B discusses in more details these results; whether these forecasts pan out will depend to a great extent on the stringency of new regulations for natural gas space and water heating (details not yet announced), and on the future price of gas.

These modelling results do indicate that large emissions reductions can be achieved through stock turnover if old furnaces and boilers are replaced by low-emitting technologies such as high efficiency heat pumps. Overall, however, even with this optimistic transition, the model suggests that the policies proposed in the Climate Leadership Plan (including increased carbon tax) could lead to a 25% reduction in building sector emissions by 2030, and about 50% by 2050. More is needed to meet the proposed targets.

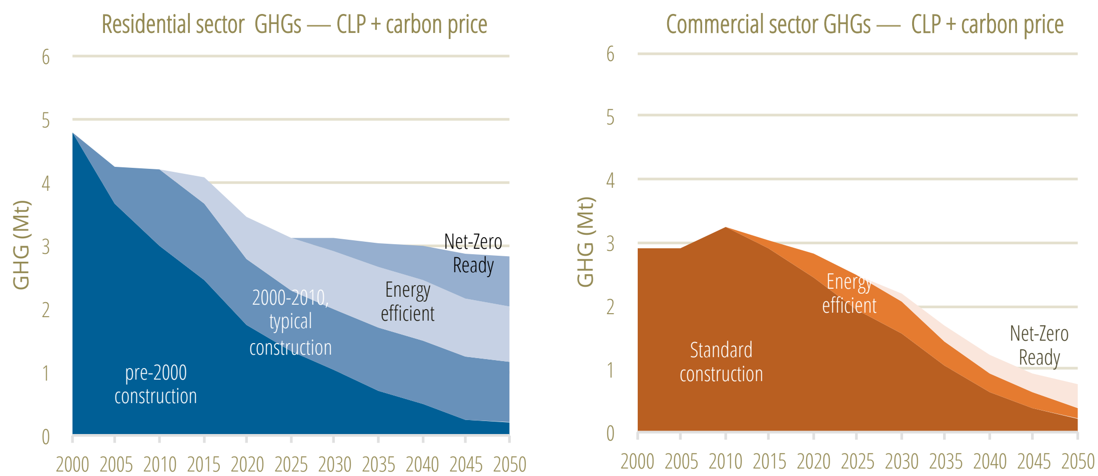


Figure 5. Residential and commercial sector GHG emissions under CLP policies (including the minimum carbon price set by pan-Canadian Framework)

Source: Navius Research Inc. See Table 7 and Figure 16 for modelling assumptions, emissions, and fuel mix in residential and commercial sector under reference scenario and current policies.

2.3 Pathways to meeting targets

The Climate Leadership Team proposed a set of polices that could, according to other modelling done by Navius, meet both economy-wide and building sector targets. They use the same policy levers as those proposed in the CLP — carbon pricing, building codes, and equipment regulations — but at greater stringency. Emissions in existing buildings are reduced by a combination of higher carbon price and stricter equipment standards, which lead to a phase-out of natural gas for space heat and hot water starting around 2025 (see Table 7 for details).

To reduce emissions from new construction, they assume the introduction of a net-zero ready requirement within a decade. Participants of the 2015 Pathways to Net-Zero Thought Leader Forum discussed the feasibility of such a rapid transition; some deemed it possible (particularly people already working in design and construction of high performance buildings), but most thought it would require more time.[7]

Irrespective of one's opinion on the timing of that transition, these policy packages provide a useful indication of the scale and type of intervention needed to meet the targets. Another way to provide such a sense of scale is to estimate the rate and depth of retrofit that would be needed, each year, to meet the 2030 and 2050 targets.

2.3.1 Low-carbon transition: depth and scale

Assuming new constructions shifts to net-zero ready by 2032, what rate and depth of retrofits would be needed each year to achieve the remaining reductions? Figure 6 below shows emissions trajectories for four different scenarios:

a) Reference case: building sector emissions forecast based on currently enacted policies.
b) Net-zero ready policy: business-as-usual emissions minus reductions resulting from a greater penetration of net-zero ready buildings and their requirement in code as of 2032.
c) Shallow retrofits: emissions reductions possible by combining the net-zero ready policy with a retrofit program reaching most of the stock but limited to retrofits that average 15% energy/GHG savings (shallow retrofits).
d) Low-carbon transition: emissions reductions possible by combining the net-zero ready policy with a retrofit program achieving on average 60% GHG reductions through a mix of fuel switching and efficiency.

The **Low-carbon transition scenario** (d) is the only one in this set that meets the proposed targets. The next section discusses how efficiency and fuel switching can be balanced to meet this goal.

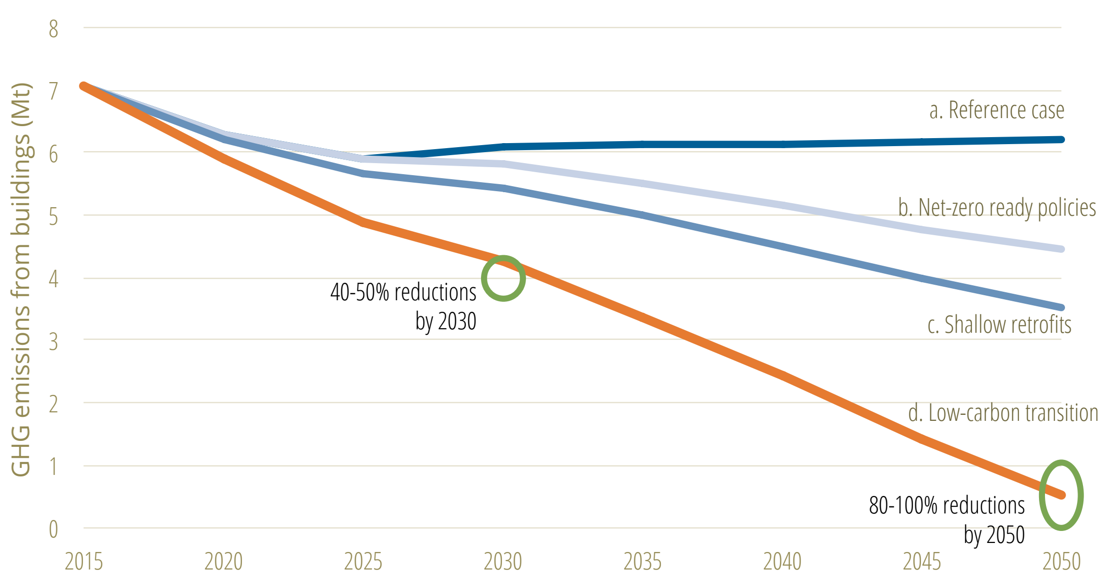


Figure 6. Abatement scenarios for the B.C. building stock

2.3.2 Balancing the role of efficiency and fuel switching

Figure 7 shows comparable emissions trajectory for two "book-end" scenarios for a low-carbon transition, and a hybrid scenario:

- A deep retrofits scenario, whereby 3% of building stock undergoes deep retrofit each year, achieving consistently 60% reductions in emissions.
- A deep electrification scenario, whereby 2% of building stock per year is electrified or otherwise converted to a low-carbon fuel.
- A hybrid scenario, whereby 3% of stock per year undergoes efficiency upgrade leading to GHG savings of 25% and half of these retrofitted buildings are also switched to a low-carbon fuel.

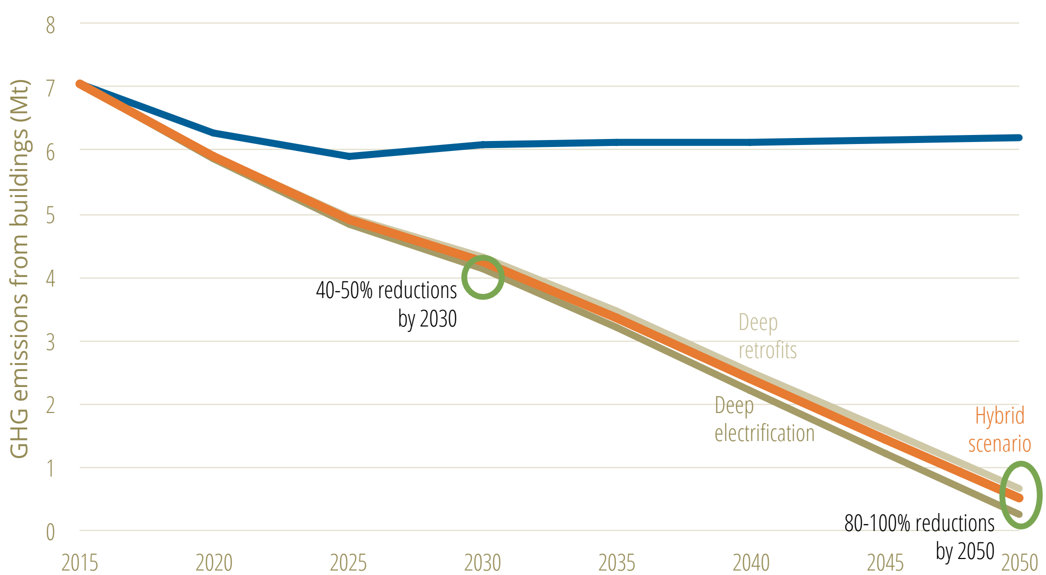


Figure 7. Alternative abatement scenarios

To reduce emissions by 80% to 100% by 2050, all vintage buildings standing by 2050 must have undergone a deep retrofit (>50% energy reductions; see Figure 8 for an description of what deep retrofits typically include) or been converted to a low-carbon energy source. To ensure the 2030 target is also met, this conversion would need to start soon and occur at a pace of about 3% of stock per year. As there have, to this day, been very few examples of deep retrofits in North America (see a list of case studies in Table 11), we are doubtful the industry could ramp up in time to meet the 2030 target through efficiency alone; electrification and fuel switching will need to be a central component of an existing buildings strategy.

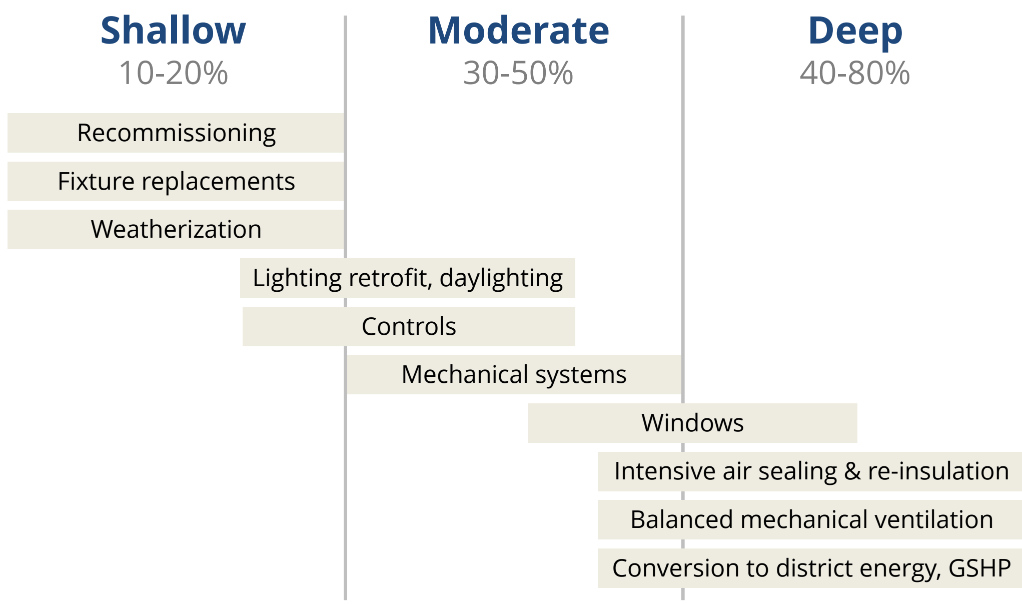


Figure 8. Energy efficiency measures typically incorporated in shallow, moderate, and deep retrofits

Because both the deep retrofit and deep electrification scenarios rely on significant transformations in technology and industry capacity, we recommend an hybrid approach:

Recommendation # 2

Set an objective to retrofit 3% of the building stock each year and to electrify half of these (or otherwise convert to other low-carbon heat source). Retrofits should aim to reduce total energy use sufficiently to protect affordability, and lead to 25% GHG savings in non-electrified buildings (on average).

Participant feedback: Strong support

One could argue that with ready access to low-carbon electricity and plenty of renewable resource options, B.C. might not have to pursue efficiency as vehemently. What constitutes an 'appropriate' level of efficiency improvement before fuel switching depends both on an economic optimization (balancing upfront and operation costs) and on an ethical judgment (generational equity, equity of environmental impacts, access to comfortable homes, etc.)

Efficiency gains are also needed to keep energy costs affordable, given that electricity is currently more expensive per unit of energy than natural gas (about 3 to 1 currently in B.C. for residential rates). For example, a commercial building with a 50/50 split of gas and electric energy use would need to see its total energy use reduced by about 33% to maintain the same total utility costs after electrification. A residential home with gas heating and a 75/25 gas-electric split would need to reduce energy use by 50% to maintain the same total utility costs after electrification.[8] Greater reductions would be needed to return a net benefit, which can be used to repay some of the investment.

These savings could be achieved through a variety of measures, including efficiency gains related to the electrification itself if heat pumps are used. Analysis of actual energy use for a sample of 900 LiveSmart participants whose sole intervention was to replace their natural gas furnace by an air source heat pump showed that despite the higher cost of electricity, these participants saw their energy bill reduced by $16 per year (on average).[9]

2.3.3 Feasibility and comparison with historical levels of retrofits

How does the proposed pathway compare with historical rates of retrofits? Figure 9 summarizes the outcome of seven years of energy efficiency incentives under the LiveSmart BC Efficiency Incentive Program and ecoENERGY Retrofit program, showing number of closing audits for each month, and cumulative penetration rate. Over this seven-year period, the two programs reached a little more than 6% of the eligible housing stock. The rate we are proposing is therefore equivalent to tripling this outcome. The data also shows that at its peak, LiveSmart reached over 2,500 homes per month, which amounts to a 3% penetration rate. Thus, we know that there is, or at least was, enough labour capacity to meet this objective.

Significant electrification also occurred under these programs. Between April 2008 and March 2011, about 8,000 homes took advantage of the heat pump LiveSmart incentives and converted from oil, natural gas, or propane heating to electrical heating.[10] This represents about 0.7% of the approximately 1.2 million households eligible for the program. Survey of utility customers that did NOT participate in LiveSmart suggests that another 35,000 B.C. households installed an air source heat pump during these two years. We do not know what fraction of these systems replaced oil or natural gas heating (vs. supplementing existing systems or displacing electrical baseboards). Assuming, as an upper bound, the ratio to be the same as that of LiveSmart participants, this means that up to 2% of homes were electrified during those two years. Reaching a 1.5% electrification rate for homes therefore seems to be within reach.[11]

Overall, homes retrofitted under LiveSmart reached on average a 26% (modelled) reduction in emissions through energy efficiency and fuel switching.[12] This is significant, but still below the 60% average needed to meet targets. There has not been an detailed study of the impacts of utility incentive programs since the end of LiveSmart, but given the lower levels of incentives and removal of incentives for heat pumps (with the exception of incentives for mini ductless systems to upgrade homes with electric baseboards), the removal of a requirement for energy evaluations, and increasing electricity prices we expect overall retrofit rates and emissions reductions from retrofit programs have decreased.

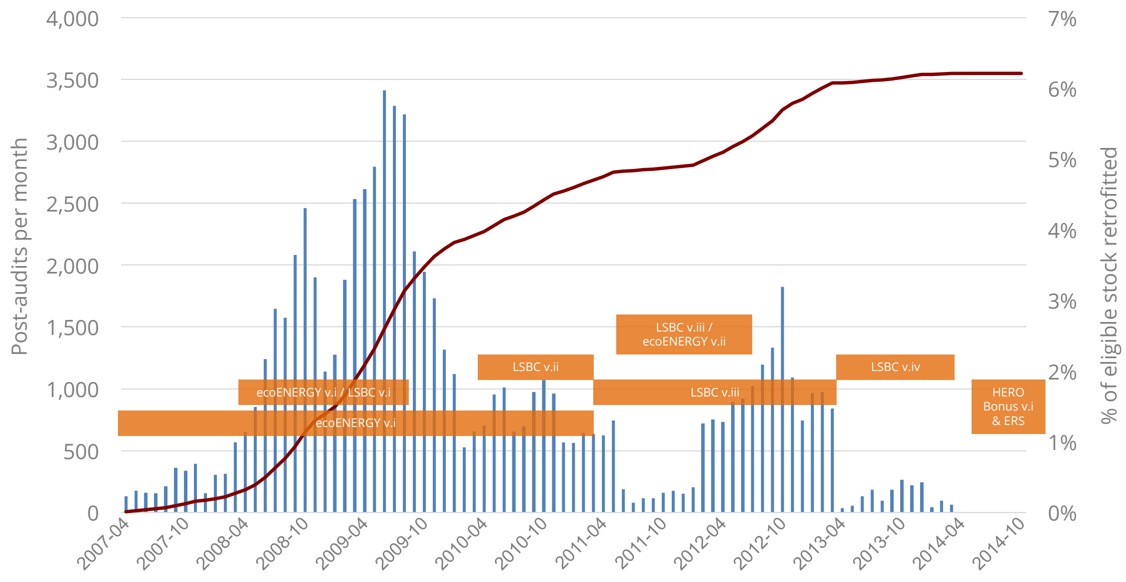


Figure 9. Number of closing EnerGuide audits in B.C. and cumulative percentage of eligible stock reached between 2007 and 2014.

The orange bars identify the duration of different provincial and federal incentive programs.

Data source: NRCan, via Province of B.C., and CityGreen[13]

The objective for one- and two-family homes is therefore to return to the retrofit rates we had at the peak of ecoENERGY and LiveSmart BC, to increase electrification rates further, and to maintain this effort between now and 2050. Maintaining this level of effort will require new models for the resourcing of incentives and/or loans to ensure the longevity of programs (see Section 4.4).

The repeated introduction and removal of incentives has been detrimental to the establishment of a mature retrofit industry. It creates instability in markets, with demand dropping both before the introduction of incentive (as clients await the rebates) and after their withdrawal. This instability discourages investment in training and in the development of new products and services, particularly within companies that have experienced contraction at the end of incentives. A stark example of this is the rapid decrease in energy advisors after the end of LiveSmart BC (Figure 10); B.C. went from 188 registered energy advisors in 2011 to 21 as of October 2016.[14]

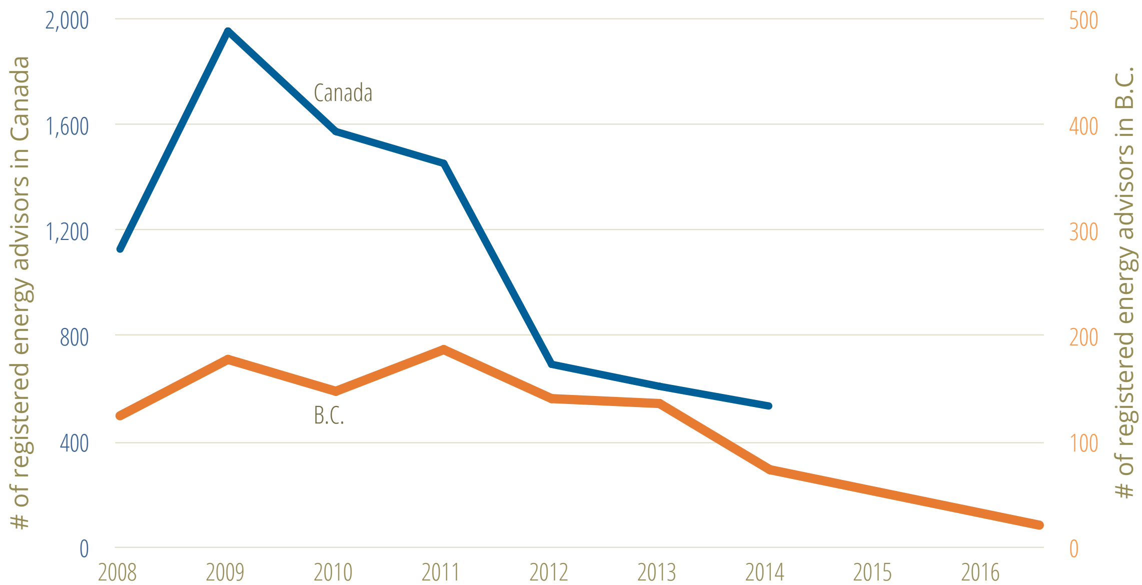


Figure 10. Number of registered energy advisors for existing homes in B.C. and Canada

Data Source: NRCan

We do not have accurate data on current rates of retrofits in the MURB sector and commercial/institutional sector. The main service providers for utility-funded MURB retrofit programs in B.C. estimate that they annually retrofit about 300 buildings per year (~12,000 units), 85-90% of which are limited to the most cost-effective measures (weatherization, lighting, water fixtures; reaching savings of about 10-15%) and 10-15% of which include some equipment replacements (~30 buildings per year, 1000 units; reaching savings of 20-30%), though the number of buildings undergoing deeper retrofits is increasing.[15] This corresponds roughly to a 2.5% penetration rate, so not far from our objective, but not at a sufficient depth. To meet targets, we would need the majority of these interventions to go to moderate levels of retrofits, and half to include a fuel switch.

	Homes	MURBs	ICI
Current stock	1 million	25,000 (575,000 units)	60,000 (100 million m^2)
3%	30,000 per year	800 per year (17,000 units)	1,800 per year (3 million m^2)

Figure 11. Number of buildings that must undergo retrofit in order to achieve a 3% annual retrofit rate.

Source: see references in Table 9

2.3.4 Economic benefits of proposed pathway

Such a retrofit program would create significant economic growth and employment. We estimate that meeting such retrofit rates would require direct investments on the order of $750 million to $1 billion per year and generate from $4 to $8 billion in GDP growth. These investments would in turn sustain around 3,500-5,000 direct jobs in the retrofit industry plus and an additional 4,500-6000 indirect or induced jobs. By way of comparison, around 4,000 direct oil and gas jobs have been lost in Alberta in the past two years.[16]

These are rough estimates based on a range of retrofit costs and published job factors. Appendix D presents the calculation details. A more detailed analysis would be warranted; particularly, estimates of tax revenues from such activity would be useful to contextualize public investment in incentive and/or financing programs.

3. Core challenges

Throughout the forum, four interwoven challenges were repeatedly raised by participants.

3.1 Difficulty in making business case for moderate/deep retrofits

Most retrofits investments are still evaluated primarily on their capacity to generate energy cost savings, rather than on other benefits such as deferred maintenance, improved comfort, increased rental value, market repositioning, climate protection, health, etc. Given B.C.'s low energy costs and mild weather, it can be a challenge to show sufficient energy cost savings to justify deeper retrofits from a energy life cycle cost perspective alone. It is also too common for proposed energy conservation measures to be evaluated solely on the basis of their payback periods, disregarding other metrics such as net present value or internal rate of return, which can help identify longer-term investments that are profitable. This is compounded by other barriers which often defer investment even when the economics are good: uncertainty of realizing the expected savings given new technologies or uncertain occupant response; competition for limited borrowing capacity; division between capital and operational budgets; etc.

3.2 Lack of awareness and knowledge of decision-makers

Owners of buildings are numerous, diverse, and distributed: homeowners, strata corporations, SMEs, non-profit associations, public entities, etc. Only a fraction of the building stock is professionally managed by people with the capacity and time to proactively address asset replacement, operating costs, and improvements for occupants. Even when buildings are professionally managed, knowledge and capacity gaps mean many economic retrofit opportunities are missed.

3.3 Complexity of process

Some energy services companies offer turnkey services for energy efficiency upgrades, but these mostly target large commercial and institutional buildings. Energy advisors and consultants can help identify energy conservation measures and clarify available incentives, but most building owners are left on their own to decide which measures they want to pursue, to secure financing, to identify and retain qualified contractors, to oversee the work, etc. Some local governments, industry associations, and non-profits provide additional support to decision-makers to bridge this gap,[17] but the scale of these programs is limited and they rely on continued funding from utilities or government.

3.4 Industry capacity

The scale of action required to meet proposed sectoral targets will require a significant investment in capacity building for the construction industry, which is faced with skills and labour shortages; the real estate industry, which lacks resources to train owners and operators; and for local governments, which already struggle to keep up with permitting and inspection workloads. Training in high-performance building construction has increased in recent years due to market growth of standards such as Passive House, but still reaches only a fraction of a construction industry dominated by small businesses: 68% of BC’s construction businesses are sole-proprietorships with no employees.[18] Trade certifications and quality control processes are lacking for most energy retrofit procedures; programs exist, but most are voluntary and are not widely recognized or valued by the public.[19]

The Home Performance Stakeholder Council and the B.C. Energy Step Code Council both are in the midst of completing landscape analysis for industry capacity to deliver energy retrofits and high efficiency new construction.

To secure demand for retrofit services at the scale needed to meet targets, economics, public awareness, industry capacity and simplicity of offerings must align. The next chapter summarizes the strategies discussed at the forum to create these conditions. More detailed mapping of barriers and solutions for homes, MURBs, and commercial/institutional buildings is available in Section 4.10.

4. Solutions

To remove the barriers outlined in Section 3, we must find new ways to incent, finance, procure, and regulate building retrofits. Over the course of two days, participants of the *2016 Pathways to Net-Zero Buildings Thought Leader Forum* discussed proposals brought forward by Pembina and guest presenters. Participants also provided their own ideas on how best to accelerate retrofit uptake.

Figure 12 presents the key strategies discussed during the forum. The first four — carbon pricing, electrification strategy, retrofit codes, and public financing — are the most direct public policy levers that can be used to accelerate retrofits. They can have the most impact, and require significant political buy-in. The next five strategies — energy disclosure, valuation of non-energy benefits, integrated delivery, demand aggregation and innovative financing mechanisms — aim to address some of the market failures and barriers discussed in the previous chapter. Governments need to play an active role to create the regulatory and programmatic framework to enable these strategies, but ultimately their successful implementation depends on innovation in both private and public sectors. Each strategy is discussed below.

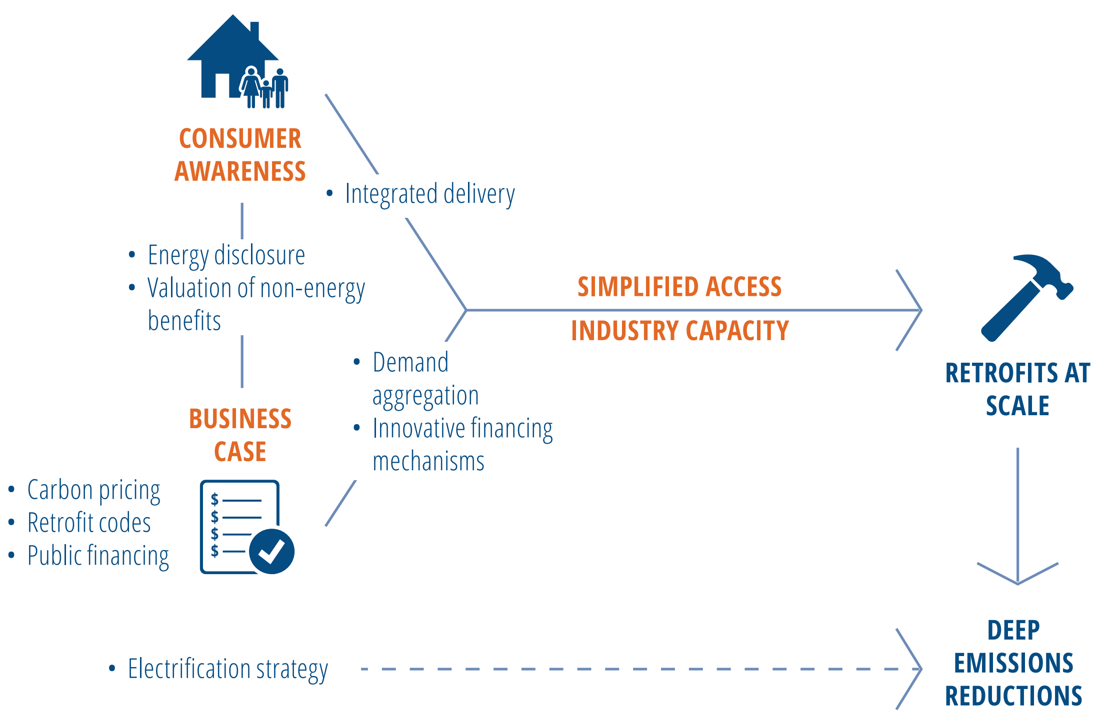


Figure 12. Necessary conditions and systemic interventions for deep retrofits

4.1 Carbon pricing

Most economists agree that setting a price on undesired externalities and letting the market innovate to meet the new conditions is more cost effective than regulatory approaches.[20] B.C.'s Climate Leadership Team, for example, proposed a $10 per year increase in the carbon tax starting in 2018, and reaching a total of $110 per tonne by 2025 (Table 7); significantly higher than current federal proposals ($40/t in 2021 and $50 in 2022, pending review in 2020).

This does not mean that it will be impossible to meet building targets under the current price schedule, but it does mean that programs and regulations will need to be ramped up to fill the gap. Other measures, such as the elimination of fossil fuel subsidies (estimated at $3.3 billion/year nationally; $271 million in B.C. for the Deep Drilling Credit program alone[21]) would help balance the price between natural gas and alternatives.

Various businesses in the building sector have called for increased carbon pricing, for example in the Call for Action on Climate and Energy in the Building Sector, launched by the Urban Development Institute, Architecture Canada, and the Pembina Institute.[22]

Recommendation # 3

The Government of B.C. should increase the price signal for efficiency and conservation through carbon pricing.

Suggested by participants; general participant support untested. Supported by the 100+ signatories of Pembina's Call for Action on Energy and Climate in the Building Sector

4.2 Electrification strategy

As discussed in Section 2.3, switching to low-carbon heating fuels will be necessary to meet interim and mid-century targets. District energy systems can play a role in urban cores, while biomass and renewable natural gas might also be useful for buildings with large process heat loads (e.g. hospitals), but in most cases fuel switching will require electrification of the heating supply.

The exact rate of fuel switching needed depends on how much efficiency gain can be secured in the remaining gas-heated buildings, but overall, an electrification rate of 1%

to 2% of stock per year will likely be necessary (we propose a target of 1.5%). This raises three important questions which an electrification strategy should answer:

First: what will be the impact on the distribution and supply of clean electricity? Which local grids have the capacity to meet the increased demand, and where might upgrades be needed? What are the implications on energy and capacity supply? These questions will likely be raised over the course of the revision of the BC Hydro Integrated Resource Plan, which is starting this year, but political direction will be needed.

Second: what policies will be put in place to drive smart electrification? Modelling shows that the proposed carbon pricing schedule will not be sufficient to trigger broad fuel switching in buildings, at least given today's electricity and natural gas price forecasts (see Appendix C). Other policies will need to fill the gap: removal of fossil fuel subsidies, the return of rebates for heat pumps, the extension of clean fuel standards to buildings (as proposed by the federal government), etc. Efficiency regulations could also be used to require heating equipment to have a performance coefficient greater than one, which would force the market to shift to heat pumps, whether electric or gas powered.

Third: how can we accelerate the development, deployment, and proper installation and maintenance of heat pump technologies? Heat pumps are becoming more common in smaller residential buildings, but larger size applications are still emerging. Large CO_2 heat pumps with the capacity to produce the high temperatures needed to replace conventional boilers and/or furnaces in larger buildings exist, but are not yet common in North American markets.[23] Training and quality assurance processes are also needed to ensure heat pumps are properly installed and maintained.[a] Investment in pilot programs, R&D, and capacity building for installation and maintenance of heat pump systems will be crucial to accelerate market penetration.

[a] This is in fact a problem that runs across all heating system equipment, including natural gas furnaces and boilers. There are no trade requirements for the design and installation of HVAC system in part 9 buildings (only for their connection, which might require a gas fitter or electrician ticket). *HVAC Regulations in B.C.: Research, Analysis and Recommendations into Energy Efficiency Codes and Standards Related to HVAC Systems for New Homes.*

Recommendation # 4

The Government of B.C. should articulate an electrification and fuel switching strategy to drive reductions in building emissions.

Participant feedback: Strong support[24]

Recommendation # 5

BC Hydro should, as part of its 2018 IRP, assess the need for upgrades in local distribution systems to meet increased demand from the electrification of buildings.

Participant feedback: untested

Recommendation # 6

The Government of B.C. and BC Hydro should collaborate to accelerate market transformation for heat pump technology including investments in pilot projects, incentives, and training.

Suggested by some participants; general support untested

4.3 Retrofit codes

Two forms of retrofit requirements were discussed at the forum: retrofit codes applicable at time of renovation, and building energy performance standards, which require retrofit upgrades for low-performing buildings.

Forum participants saw some challenges with the implementation of either form of retrofit code, but nevertheless generally supported government implementing such policies. Surveyed after the forum, 81% of respondents were in favour of retrofit requirements at time of renovation for one- and two-family homes and 90% supported it for larger buildings, while 83% supported a performance-based standard.[25]

Presenters and participants stressed the role of codes and regulations in ensuring that opportunities for energy upgrades are not missed when other work is conducted on buildings. Given that windows, cladding and heating equipment in a given building will likely only be replaced once between now and 2050, it is crucial to maximize the energy upgrade potential at each replacement. This is particularly true for insulation upgrades, which are much cheaper to complete when buildings are being resurfaced. Despite being suggested by professionals and shown to return reasonable paybacks, these opportunities are too often passed up.

Some of the most common challenges with retrofits codes raised by participants included the difficulty of creating regulations for existing buildings given their wide variety and range of conditions. Some saw performance-based standards, such as ASHRAE 100, as a useful way to accommodate this diversity and provide some flexibility (see text box, next page). Others suggested that design guides for the retrofit of some typical envelopes would be a valuable resource. There were concerns that further regulations would drive renovation activity underground, particularly as owners often approach renovations with a set budget in mind, which might not accommodate unplanned requirements.

There is also, as yet, no clear direction on how best to apply a retrofit code to low-rise residential construction. ASHRAE 90.1 is not designed to include such buildings, which are covered under the separate ASHRAE 90.2 standard. The applicability of the ASHRAE 90.2 standard to the B.C. context has not been extensively studied. It is possible that a retrofit code for low-rise residential buildings could be combined with other necessary interventions including fire and seismic code compliance.

Several participants stressed the need to start by enforcing current codes before trying to enforce energy upgrades at time of renovations. Given the large number of renovation permits issued, enforcing retrofit code will require further investment in permitting offices and inspections. Participants were generally favourably impressed with the experience of the City of Vancouver in enforcing energy codes, though some expressed frustration with the complexity of the checklists.

Participants also commented on the fact that alongside emissions reductions were other social objectives that called for upgrades in existing buildings, such as seismic resilience, fire protection, climate adaptation and accessibility. An integrated retrofit code could be created to address several of these objectives. This would increase the complexity of retrofit codes and the cost of compliance, but would ensure a holistic conversation on our social objectives, and on how to finance them. This could also help identify efficiencies (e.g. tackling both seismic and insulation upgrades at time of recladding). Whether it is for an integrated retrofit code or for an energy retrofit code, the establishment of accessible financing options was seen by several participants as a necessary condition to enable adoption and enforcement.

Finally, participants also flagged the need to link retrofit requirements with land use decisions. It might not make sense to require further investments in energy efficiency if the building is likely to be demolished and replaced by a higher density unit. Some exemption clause or process could be created, for homes or buildings in areas zoned for increased density. This might be ultimately more relevant to the application of a building energy performance standard than to retrofit requirements at time of renovations, since one can presume that the building is expected to stand for a while if the owner is investing in major renovations.

Recommendation # 7

The Government of B.C. should adopt a schedule of retrofit requirements at time of renovation based on ASHRAE 100 for large buildings and ASHRAE 90.1 for small buildings. Working with local government, it should encourage enforcement of current energy codes at time of retrofits. Working with the federal government, it should investigate whether and how other social priorities — seismic resilience, adaptability, fire protection — should be integrated in retrofit codes.

Participant feedback: supportive[26]

Retrofit at time of renovation based on ASHRAE 100

RDH proposal:[27]

Beginning in 2017: Enforce AHSRAE 90.1 for all permits except low-rise residential.

Beginning in 2022: Enforce ASHRAE 100 for large permits (>50,000 square feet) and ASHRAE 90.1 for smaller permits. Establish a revised EUI target representing the lowest 40th percentile of energy use.

Beginning in 2027: Enforce ASHRAE 100 and revise the EUI target to the lowest 25th percentile of energy use.

ASHRAE 100 is a standard for existing building retrofits. It provides energy use intensity (EUI) targets based on the measured data from the existing building stock for 53 building types (residential and non-residential) in each of the ASHRAE climate zones. (These targets would need to be adapted to B.C. context before use of the standard). Buildings that can show (e.g. through ENERGY STAR® Portfolio Manager) that they already meet the target EUI are deemed in compliance and require no further action. Otherwise, they must engage a professional to perform energy audits and to implement energy conservation measures to improve building performance, starting with retro-commissioning.

About 7,000 existing buildings go through some permitting process each year in B.C., about a third of which affect energy-related systems. Thus, a policy requiring the upgrade of impacted energy components could reach ~4% of Part 3 buildings in B.C. each year. BC Hydro modelling of the RDH proposal (above) estimate it would result in a 4% GHG reduction in the commercial sector by 2030 and a 10% reduction by 2040; combining these regulatory measures with incentives for fuel switching will be necessary to meet deeper reductions.[28]

Enforcing energy codes in the City of Vancouver[29]

The City of Vancouver is the only jurisdiction in B.C. that is enforcing energy codes beyond letters of assurance. In March 2012, they started by requiring designers of new construction projects to complete an energy checklist with associated support documentation to show how compliance with ASHRAE 90.1 was reached. The energy documentation is reviewed for building permit, then passed on to the inspector, who verifies that installation matches building permit documents. At all stages, there was a learning curve, but the process is now familiar to the vast majority of applicants. Energy reviews now take on average 15–30 minutes of the total application review time (which generally takes two to seven days in total to complete).

In 2015, the City of Vancouver expanded the energy enforcement process to include renovation projects as well, affecting eight to ten times more permits than new construction. Because the 90.1 standard applies to all buildings except low-rise residential, this affects not only professionals but also contractors and trades working on smaller commercial projects not covered by Part 3 of the building code. The City of Vancouver recognized the industry needed education and support systems and so created energy web pages with links to the latest energy requirements, complete with standardized documents and tools, sample checklists, and video tutorials. Intake and review staff have been trained in energy requirements and enforcement and provide valuable resources to applicants at all levels of application. The energy checklists have been modified over the years based on feedback provided by industry. These modifications can happen quickly, without changes to bylaws. Review time for renovations projects was cut from ~45 minutes to ~20 minutes in the first 18 months of enforcement; meanwhile, errors in applications and phone call inquiries have decreased significantly, particularly since the releases of video tutorials in January 2016.

4.4 Public financing

Upgrading B.C. buildings to achieve significant energy savings and carbon reductions will require investments in the order of $750 million to $1 billion per year between now and 2050 (Appendix D). More investment will be needed if we seek to also address upgrades for seismic resilience, climate adaptation, fire protection and accessibility.

Given their high credit ratings, governments have the capacity to secure debt at a much lower rate than the private sector, for example through the issuance of green bonds. This public finance should be used to invest in building renewal, similarly to the way government pays for transit infrastructure or other large capital projects that generate economic activity and improve the productivity of our economy.

There are multiple ways in which publicly raised capital could be used to accelerate retrofits. Ideas raised at the forum included the creation of a long-lasting retrofit program providing loans and grants; capitalization of rotating funds for retrofit investments in public buildings; and various credit-enhancements to encourage private investment in energy efficiency, such as loan-loss reserves, loan guarantees, and interest buy-downs.

One example of a grant and loan program financed through capital markets via bonds guaranteed by the government is the German KfW Development Bank's "energy efficiency renovation" program. This is a public–private partnership where KfW provides low-interest capital and grants, and local retail banks interface with clients/owners. The program is accessible to new and existing buildings in public and private sectors, and the level of grants increase with the depth of the energy efficiency measures.[30]

These public investments do not necessarily have to increase public debt. Particularly when these investments are matched with private investments, the taxation of the increased economic activity can return more dollars than the original investment. KfW's program, for example, was shown to return nearly four times more to the public coffers than it costs; more than five times if reduction in unemployment benefits were included.[31]

To ensure effectiveness and equity — particularly of concern as we consider public investment into private properties — these financing programs will need to be customized to the needs of different ownership models, building types, and socioeconomic segments (some suggestions on innovative financing models are outlined in Section 4.9). Operating these programs and monitoring their success will require dedicated focus and coordination, which would be best served by creating a centralized public financing authority (or ‘green bank’) focused on energy efficiency and building renewal. Ontario has taken a step in this direction, and B.C. should consider a similar model.

The Federal Infrastructure Bank could play this role, but given the distributed nature of building investments, and their unique challenges, a dedicated branch would be needed to aggregate projects and design programs suited for different market segments.

The recent Federal announcement of $11 billion over 11 years for affordable housing will provide a unique opportunity to invest in building renewal, and to ensure that new social housing is built to the highest standard of energy efficiency. However important, these funds are a one-time investment, not a sustainable financing model. Provincial and federal governments should use this window of opportunity to create institutions with capacity to raise capital on an ongoing basis, a necessity if we are to maintain retrofit efforts between now and 2050.

Recommendation # 8

The Government of B.C. and/or the federal government should create a public financing authority (or ‘green bank’) focused on energy efficiency and building renewal. Current federal funds and additional provincial funds should be used to establish this organization, create a sustainable retrofit financing model leveraging public and private financing, and capitalize the first round of programs.

Participant feedback: supportive

4.5 Energy labelling, benchmarking and disclosure

For markets to recognize the various benefits of energy upgrades, decision-makers need access to validated and comparable data on building performance. The absence of this information is a fundamental market failure that should be corrected through public policy, in the same way as food labelling was legislated. Citizens should have access to reliable information to make decisions about their important housing investments. Voluntary programs for the assessment and labelling of energy performance have existed for several years, but uptake will remain low and limited to high performers until such disclosure is required.

4.5.1 Mandatory labelling at point of sale for homes

Forum participants supported requiring the labelling of homes at time of sale, with 88% of survey respondents in favour.[32]

Participants stressed the need to accompanying labels with education and financing for homeowners to improve the score if they deemed it necessary. They also saw realtors as key actors in situating the score within the market, comparing to other homes of similar vintage and price, and linking it to co-benefits. Realtors can also add significant value for their clients (both sellers and buyers) by connecting them to financing and incentive programs, and by raising the possibility of integrating some of the upgrades recommended in the EnerGuide report with pre-sale or move-in renovations.

Broad uptake of labelling will also provide a basis to collect data for the scientific appraisal of energy efficiency features. Currently, appraisals do not reflect the value of energy upgrades; there are indications that investments in energy efficiency increase resale value in other markets,[b] but local data is insufficient to establish this with a rigor sufficient for assessment purposes. A few years of mandatory labelling would fill this data void. Home energy labelling is slated to be mandatory by 2019 in Ontario, a commitment echoed in the Pan-Canadian Framework on Clean Growth and Climate Change.

Recommendation # 9

The Government of B.C. should require home energy labelling at time of sale by 2019.

Participant feedback: strong support

4.5.2 Annual benchmarking and disclosure for larger buildings

Forum participants were nearly unanimously in favour of requiring benchmarking and disclosure for larger buildings.[33] Participants observed that few industries know less about their product and its performance than the building sector.

[b] A study of the resale market in California has shown that homeowners who used PACE loans to finance retrofits and/or PV installs were (on average) able to recover their full investment at resale (i.e. whatever portion of the loan they had repaid at time of sale). This is a much better performance than most other home improvements, which generally only recover about 60% of invested costs. Laurie Goodman and Jun Zhu, "PACE Loans: Does Sale Value Reflect Improvements?" *Journal of Structured Finance* 21 (2016).

Benchmarking and disclosure policies are gaining momentum worldwide, and are already common in the E.U., Australia, and parts of the U.S. There exists a strong regional precedent in the City of Seattle, which has required benchmarking and disclosure for commercial and multi-unit residential buildings larger than 20,000 square feet since 2010.[34] In Canada, Ontario just passed a benchmarking regulation requiring buildings larger than 50,000 square feet to report energy and water use.[35] A National Energy Benchmarking Framework was also developed by the Canada Green Building Council.[36]

The main concern with disclosure was that some building owners may not have the capacity to significantly improve their building's performance, and could be at a disadvantage in the marketplace. Some argued this market differentiation was part of the desired outcomes as it rewarded leaders; others argued this would be unfair to smaller operators with less capacity to invest. Proposed solutions included the provision of financing mechanisms for upgrades, and the creation of a two- to three-year grace period between the introduction of the benchmarking requirement and the requirement to publicly disclosure results.

Other conditions for success included the harmonization of requirements nationally, electronic data transfer protocols, capacity for owners to access aggregated data from all suites without requiring explicit permission from each tenant, and the provision of education and training. Participants suggested that utilities could enable clients to transfer their billing data automatically to any third-party energy management software (i.e. not just Portfolio Manager) using DOE's Green Button protocol. The capacity to move data easily from utilities to apps would enable companies and homeowners to tap into the quickly innovating world of energy management and home automation apps.

Recommendation # 10

The Government of B.C. should require energy benchmarking for buildings larger than 50,000 square feet, with mandatory disclosure within three years.

Participant feedback: near unanimous support

4.6 Valuation of non-energy benefits

Given the difficulty encountered by many forum participants in selling retrofit projects on energy cost savings alone, many participants highlighted the importance of fostering a greater understanding, and ultimately valuation, of non-energy benefits: improved comfort, health, productivity, increased resale value, etc. (Figure 13).

Public agencies and utilities can play a role in education (e.g. Metro Vancouver's RateOurHome.ca, FortisBC and BC Hydro outreach programs, etc.) but some of the more convincing messaging might come from other sources: peers, the media, social validators (e.g. home renovation shows, celebrities) and direct marketing from manufacturers, contractors and realtors.

To properly value non-energy benefits, decision-makers will need to be able to distinguish hype from facts. If energy efficiency is used as a proxy for other benefits, decision-makers will also need validated metrics to distinguish between high performance buildings, minimum code-compliant buildings, and older stock. This role could be played by labelling and benchmarking policies.

Participants also suggested that further research was needed to substantiate claims that energy upgrades in commercial space improves employee productivity. While the idea is commonly raised while pitching upgrades, and sometimes monetized, the link is often considered too uncertain to allow this value to be incorporated into the business evaluation.

Similarly, measuring health benefits related to energy upgrades could be a strong argument for increased investment, particularly in low-income housing. Symptoms of respiratory and cardiovascular conditions, rheumatism, arthritis and allergies can be reduced through improved ventilation systems and airtightness, both in new construction and in existing buildings.[37] Several studies have found that, when monetized, these health benefits could represent up to 75% of the overall value of energy efficiency retrofits.

Recommendation # 11

The Government of B.C. should work with B.C. Assessment and the Appraisal Institute of Canada to identify and collect data needed to consider energy efficiency upgrades in property assessments.

Suggested by participants

Recommendation # 12

Governments and utilities should work with media, public personalities, the home performance and development industry, and realtors to amplify messages on non-energy benefits of retrofits.

Suggested by participants

Recommendation # 13

Academic institutions should pursue further research and communication on the link between energy upgrades and improved productivity, health and comfort.

Suggested by participants

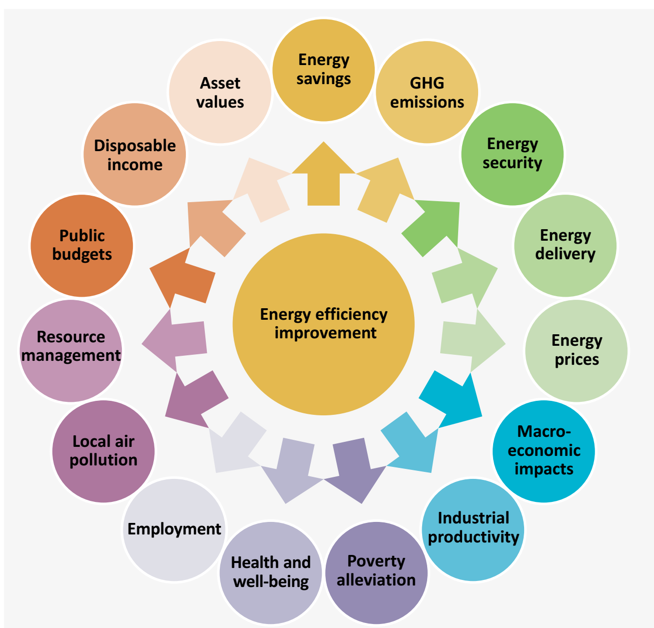


Figure 13. Co-benefits resulting from energy efficiency improvements

Source: International Energy Agency[38]

4.7 Project aggregation

Instead of tackling each retrofit as a unique project, economies of scale can be obtained by issuing energy services contracts for several buildings with similar characteristics. This aggregation model was piloted by the Dutch *EnergieSprong* program in the social housing sector. This approach allows the creation of contracts of sufficient value to justify investments in research and development, both on the technology supply side (how to deliver deep retrofits at low costs) and on the demand side (how to streamline RFPs and uptake processes to reach more housing). It can give rise to new solutions to reduce costs and improve ongoing performance (e.g., preassembled panels, performance warranties, heat/light as a service, etc.). It proposes a paradigm shift from a market where private companies tell building owners what is available for retrofits, to one where owners collectively define criteria for retrofits and private companies innovate to meet this demand.

Social housing projects are an ideal incubator for aggregation for several reasons: a large number of projects can be pooled from a few agencies; public investment is justified given the social benefits of improved living conditions; and cost savings accrue to the investor since energy and maintenance costs are generally covered by public agencies (thus eliminating split incentive barriers).

Forum participants were enthusiastic about the possibility of piloting an *EnergieSprong* program in B.C.; some of the factors they saw as conditions for success were:

1. The need to engage occupants to ensure ongoing performance. This includes designing systems that are as 'fail-safe' as possible, sharing energy costs to provide incentives for conservation, providing real-time feedback on energy, ventilation, and moisture to ensure health and durability.
2. Removing barriers to innovation in non-profit and social housing procurement policies. Pre-qualifying contractors and simplifying RFPs was seen as an opportunity to streamline the process of tendering for retrofit projects and to keep more space open for innovation. One major benefit of an aggregated approach is that a single RFP can be developed that addresses a building archetype rather than a single building, with aspects such as financial and warranty models being identified early on in the process.
3. Keeping an open mind as to what the technical solutions will look like. One of the most notable aspects of the *EnergieSprong* model was the use of exterior custom pre-fabricated panels with solar panels attached, a new technology. However, it is uncertain this approach will be applicable in B.C. given the more

intricate building shapes and low energy costs. The first step of innovation will be in the procurement process; the establishment of new retrofit technologies might require more time.

4. Exploring opportunities to raise capital for retrofits in social housing when ownership of assets is transferred from BC Housing to housing societies.

Recommendation # 14

BC Housing should form a multi-stakeholder working group to pilot aggregation of demand in the B.C. social housing sector.

Participant feedback: strong support

4.8 Integrated delivery

The need for integrated turnkey retrofit services was one of the main strategies discussed in the one- and two-family home stream. Entities that act as a single point of access, or "one-stop shop," fulfill two purposes: they remove barriers to entry by streamlining the process for homeowners, and they create a continuity of relationship that can drive deeper retrofits over time. Energy services companies (ESCOs) provide such turnkey services to larger commercial, institutional and, sometimes, residential buildings, but owners of smaller buildings generally have to put the pieces together on their own.

A one-stop-shop entity could be private or public. It could offer project management services, or maintain a pre-approved list of contractors for auditing, design, and installation services. It could also facilitate applications for incentives, and possibly provide financing. Such an entity could also provide homeowners guidance on prioritizing and sequencing interventions, ensuring that components do not have to be removed or downsized as the result of a future retrofit project.

Renovate America's Home Energy Renovation Opportunity (HERO) program is an example of a single-point-of-contact agency that has provided financing for billions of dollars of projects through PACE (Property Assessed Clean Energy) loans. The HERO program provides financing and contact information for pre-approved contractors, making it very easy for homeowners to get the work done.

Companies in B.C. and Alberta have attempted to offer integrated retrofit services tailored for homeowners, but most have folded because of a lack of demand, or they maintain a nominal presence on the market while sustaining their businesses via other means.[39] This suggests that the success of an integrated delivery entity may be predicated on increased demand for home energy retrofits.

Because a steady demand for services need to be secured before integrated services can be profitably developed, the most immediate way to support the creation of such integrated services companies is to stimulate demand through public financing (section 4.4), regulations (section 4.3), energy labelling (section 4.5), and innovative financing mechanisms (next section). Governments need also to set these structures up for success by investing now in the training and capacity building the renovation sector will need to meet this demand and ensure the quality of installations.

Recommendation # 15

The Government of B.C. and the federal government should support the development and implementation of training, certification, and quality assurance programs for trades and professionals in the building sector, considering the specific needs of the construction industry, the real estate industry, and local governments.

Participant feedback: Strong support

4.9 Innovative financing mechanisms

There are many innovative financing solutions that can address market failures and barriers specific to different segments of the building sector. Three were discussed at the forum: on-property-title loans, metered energy efficiency, and loans to strata corporations. Generally, these financing mechanisms aim to do three things:

- Reduce risk of default (and therefore interest rates) by attaching loan repayment to bills that are routinely paid (property taxes, utilities).
- Remove split-incentive barriers by aligning interests of current and future owners, tenant, owners, etc.
- Provide ‘off-the-ledger’ lending, allowing companies, stratas or individuals with limited borrowing capacity to invest in energy efficiency with little (or no) cash up front.

These primarily address the mechanism by which the loan is repaid, not the original source of the capital (i.e. private or public). As discussed in Section 4.4, public financing could be used at low cost to provide the seed capital for such programs. Once a first generation of loans have been disbursed, and are being repaid, programs can be recapitalized by bundling loans together and selling them to institutional investors as revenue-generating securities. Or they could remain a public asset, with subsequent programs similarly funded through more public borrowing.

4.9.1 On-property-title loans

Property-Assessed Clean Energy (PACE) loans in the U.S. and local improvement charges (LICs) in Canada provide property owners the means to finance energy efficiency and renewable energy projects through a loan tied to their property title and repaid through property tax. Because very few people default on property tax payments, these types of financing arrangements are considered a very secure loan; and because the financing is tied to the title, it is transferable at time of sale and does not affect individual credit limits.

Since its inception in 2009, PACE has provided over $3.4 billion in renewable and energy efficiency loans, funding projects in over 130,000 U.S. homes.[40] PACE is also used by the commercial sector, with over $300 million borrowed across nearly a thousand projects.[41] Demand has increased rapidly since 2015, with over three-quarters of total capital distributed in the last year alone ($2.9 billion). Over half of that investment went to energy efficiency measures, with the rest going to renewable energy and water conservation.[42]

On-title loan programs in Canada are still in early development. Enabling legislation was passed in Ontario and Nova Scotia,[43] and pilot programs run in Toronto and Halifax. A legal opinion obtained by the City of Saanich indicates that local government would have jurisdiction to implement such programs in B.C., but the Ministry of Community, Sport, and Cultural Development has not confirmed this to be the case. Several B.C. local governments have expressed interest in using LICs to fund energy efficiency, and the Union of BC Municipalities passed a resolution to that effect in 2014 and again in 2016.[44]

One of the main design challenges with on-property-title loans is the question of their precedence with the mortgage. That is, in case of default, there is debate over which loan should be repaid first. Consensus in the U.S. is converging towards giving mortgages precedence.[45] In Canada, CMHC has expressed concern with the priority lien status of LIC loans. The City of Toronto pilot required LIC applicants to obtain consent from their mortgage lenders in order to participate in the program. This was an important barrier as only half of applicants obtained consent from their lender.[46]

Forum participants had a mixed response to this strategy. While some saw its potential, many were pessimistic about its chance to succeed given current market conditions for retrofits and generally low interest rates; financing in isolation was not seen as sufficient to drive uptake of retrofits. The ongoing ambiguity regarding whether B.C. local governments have the jurisdiction to use LICs for energy retrofits was also seen as a deterrent. Generally, there was both a sense of great potential, fuelled by the experience in the U.S., and skepticism of a similar uptake in B.C. without clear political support and/or regulation from the province and the federal government. Several saw the presence of a financing model such as LICs as a necessary condition for the establishment of retrofit codes.

The requirement for lender consent for participation was also seen as a considerable deterrent to program uptake. This could be replaced by reducing risk to lenders in other ways. First, LIC-backed financing could be structured such that only the specific payments in arrears are added to a tax lien, rather than the entire financing balance. After a foreclosure, the remaining repayments would be passed on to the new owner of the property, leaving only a small window of payments in arrears to repay. These in turn should easily be covered by the increase in sale price of the foreclosed property resulting from the LIC investments to date.[47]

If this is not sufficient, a local, provincial, or national fund could be set up to act as security, to indemnify a mortgage lender on their losses on missed payments to the LIC loans. Alternatively, screening criteria could also be added to the LIC application to filter out applicants for whom taking on an LIC loan would put their ability to pay their mortgage at risk. A caveat being that these checks should be kept simple.[48] The goal of all these approaches would be to ease the concerns of mortgage lenders and thereby reduce the risk of having the LIC program challenged.

Recommendation # 16

The Government of B.C. should work with local governments to create a LIC structure to fund energy efficiency, water conservation, climate adaptation and renewable energy upgrades.

Participant feedback: supportive

Recommendation # 17

The federal government should work with provinces, local governments and CMHC to harmonize rules across the country for LIC programs and remove barriers to applicants (e.g. requirement for lender consent).

Participant feedback: not tested

4.9.2 Metered Energy Efficiency Transaction Structure (MEETS)

MEETS is a new billing model for commercial buildings that removes split incentives and demonstrates the value of energy efficiency upgrades for owners, utilities, investors, energy efficiency entrepreneurs and tenants.

In the MEETS model, energy upgrades are completed by an ‘energy tenant’, which can be either the building owner or a third-party company. The resulting energy savings are estimated by comparing actual energy use to a dynamic model of how the building would have performed without the upgrades. The utility continues to bill the tenant as if no energy upgrades were conducted, using the modelled baseline to estimate pre-retrofit energy use. The energy tenant sells the metered energy efficiency (the calculated difference between modeled baseline and actual energy use) to the utility provider through a power purchasing agreement at a pre-determined rate. The energy tenant uses some of this revenue to pay the building owner rent for the use of their building.

Thus, the utility continues to bill for the same quantity of energy as before the retrofit and does not lose sales. The building owners realize improvements at no cost, the tenants work in a more comfortable building, and the energy tenant acts as an independent power producer, selling ‘negawatts’ to the utility under a long-term power purchase agreement.

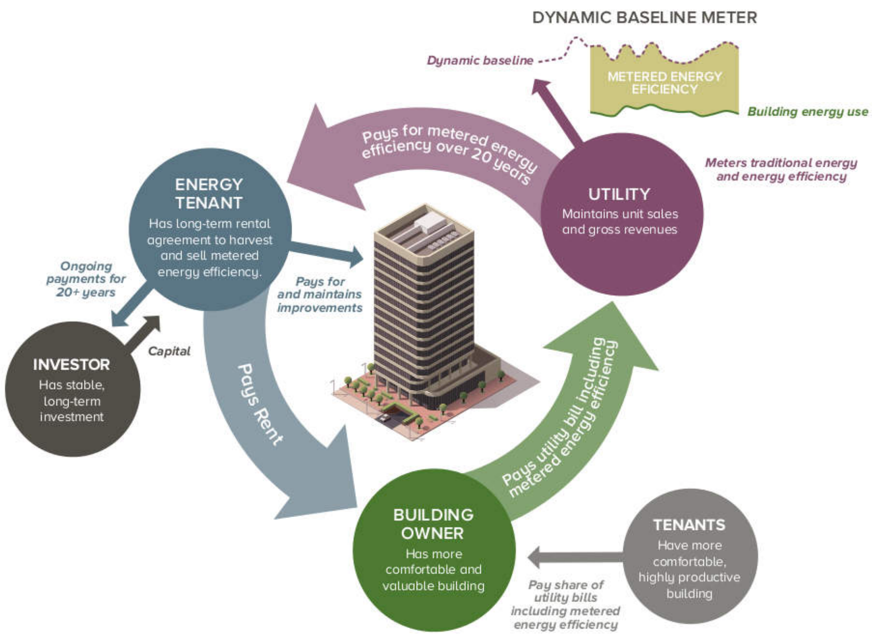


Figure 14. How MEETS works

Source: MEETS coalition[49]

Forum participants were supportive of this strategy, and there was interest in seeing this approach piloted in B.C. Participants were confident that a building could be secured for such a pilot, but less confident that utilities would participate. They suggested the selected buildings should be centrally located and highly visible, but otherwise non-exceptional, in order to make the pilot more transferable. The fact that the energy tenant was financially invested in maintaining the long-term performance of the building was seen as a strong advantage, but participants wondered what the respective roles of energy tenants and property managers were in ensuring maintenance of the systems and the engagement of tenants.

Recommendation # 18

Governments and utilities should be engaged to evaluate and fund a pilot of the Metered Energy Efficiency Transaction Structure in a high-profile commercial building in B.C.

Participant feedback: Strong support

4.9.3 Reserve funds and loans to strata corporations

Several forum participants commented on the difficulty of getting strata corporations to invest in energy efficiency upgrades, even when the paybacks are only a few years. There is frequently a lack of knowledge and capacity on strata councils to assess energy efficiency retrofits. Many condo owners are also cash-strapped and/or see their ownership as short-term investments, deterring them from investing for the long term. Forum participants proposed two strategies to address this barrier: integration of energy efficiency upgrade costs in depreciation reports, and loans to strata corporations.

Depreciation reports prepared for strata corporations in B.C. generally contain cost estimates based on like-for-like component replacement, and do not consider the costs or savings resulting from potential energy efficiency upgrades. They do not always take into account the additional costs to comply with more stringent building codes when major renovations are done. Forum participants suggested that depreciation reports should incorporate a schedule of potential energy efficiency upgrades. Upgrades considered should include early retirement of inefficient components when the potential for energy savings is significant, not just end-of-life replacement. The schedule of upgrades should take into account future regulations and sequencing, to ensure upgrades for a cohesive package. This would ensure that reserve funds are sufficient to incorporate the needed upgrades at time when it is most beneficial to conduct them. At a minimum, the inclusion of the energy efficiency upgrades in the depreciation reports builds awareness among owners and enables discussion on currently under-recognized opportunities.

Recommendation # 19

The Government of B.C. should require depreciation reports to incorporate energy conservation options provided by energy audit and to provide recommendations for cost-effective measures to be integrated in maintenance plans.

Participant feedback: Strong support

Even with more forethought (and funds) set aside for energy efficiency, early failure of building components can leave strata corporations exposed with insufficient reserve to allow them to choose the most energy efficient replacement option. Additionally, other priorities might arise that are deemed preferable. Enhancing the borrowing capacity of strata corporations to pay for energy upgrades would provide a means to bridge the gap.

This idea was previously proposed during the 2015 Thought Leader Forum as a means for developers to pass on some of the additional costs of improved energy performance to strata corporations. The rationale was that this loan, amortized over 20 or 30 years, would be repaid through strata fees. The reduced energy use in common spaces and reduced reserve fund payments associated with higher quality components would offset this increase, avoiding increases to strata fees.

The same rationale would apply for investments in energy upgrades in existing buildings. Unfortunately, strata corporations are limited in their ability to borrow money, due partly to a lack of assets to use as collateral for the loan. Strata councils also typically require a three-quarter majority vote to approve borrowing. Stratas would otherwise be the ideal borrower: they never change address, have no key person risk, and have a stable source of income.

Recommendation # 20

The Government of B.C. should provide credit enhancement or otherwise remove barriers to encourage strata corporations to borrow funds to cover energy efficiency upgrades.

Suggested by participants

4.10 Barriers and solutions by building type

Discussions at the forum were divided into three 'streams' according to building type: one- and two-family homes, MURBs, and commercial/institutional buildings. Some of the barriers and solutions identified for these three building types are shown below.

Table 1. Barriers and solutions in one and two family buildings[50]

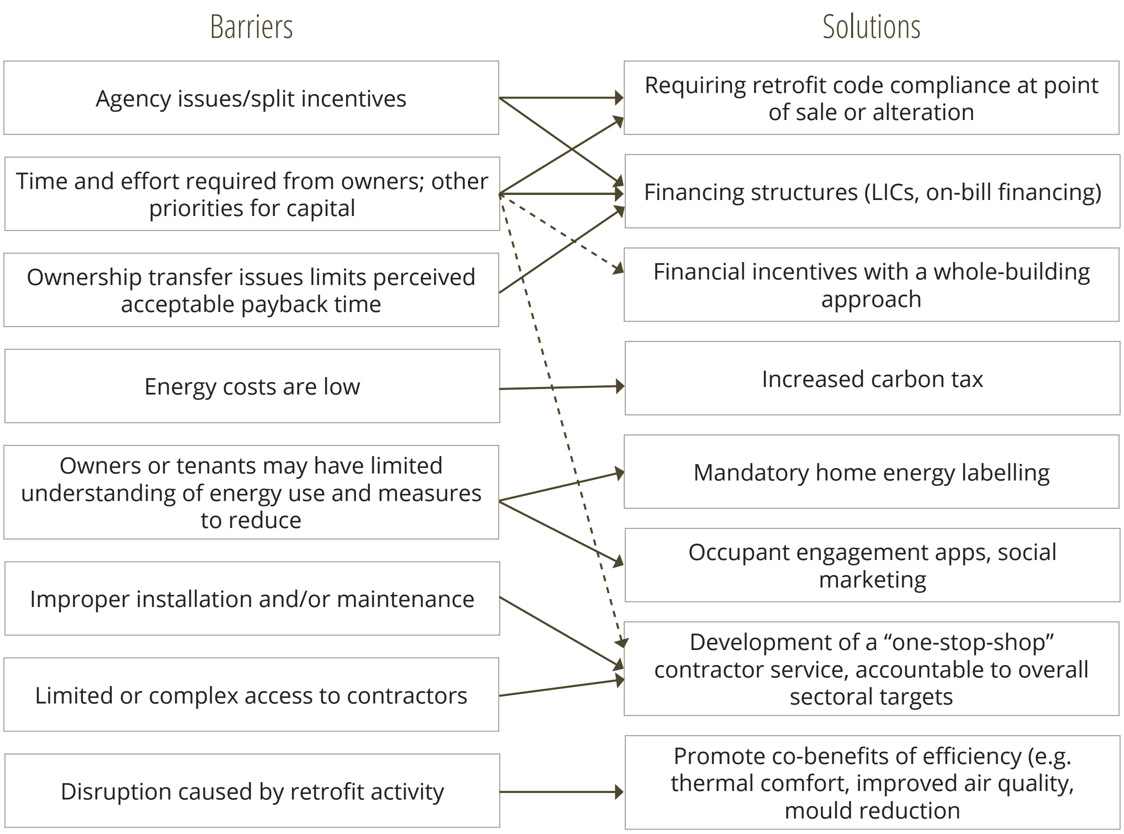


Table 2. Barriers and solutions in multi-unit residential buildings

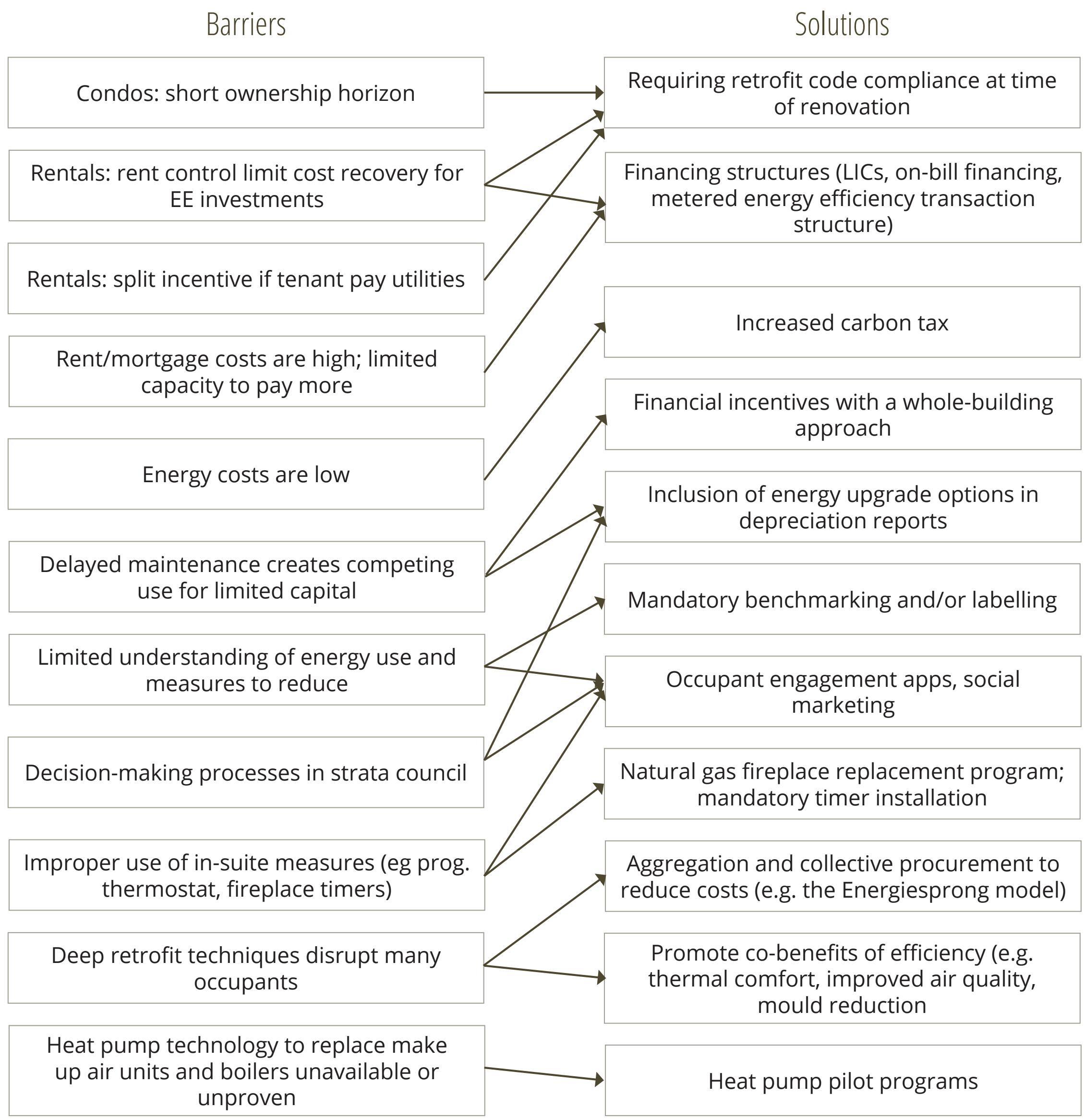
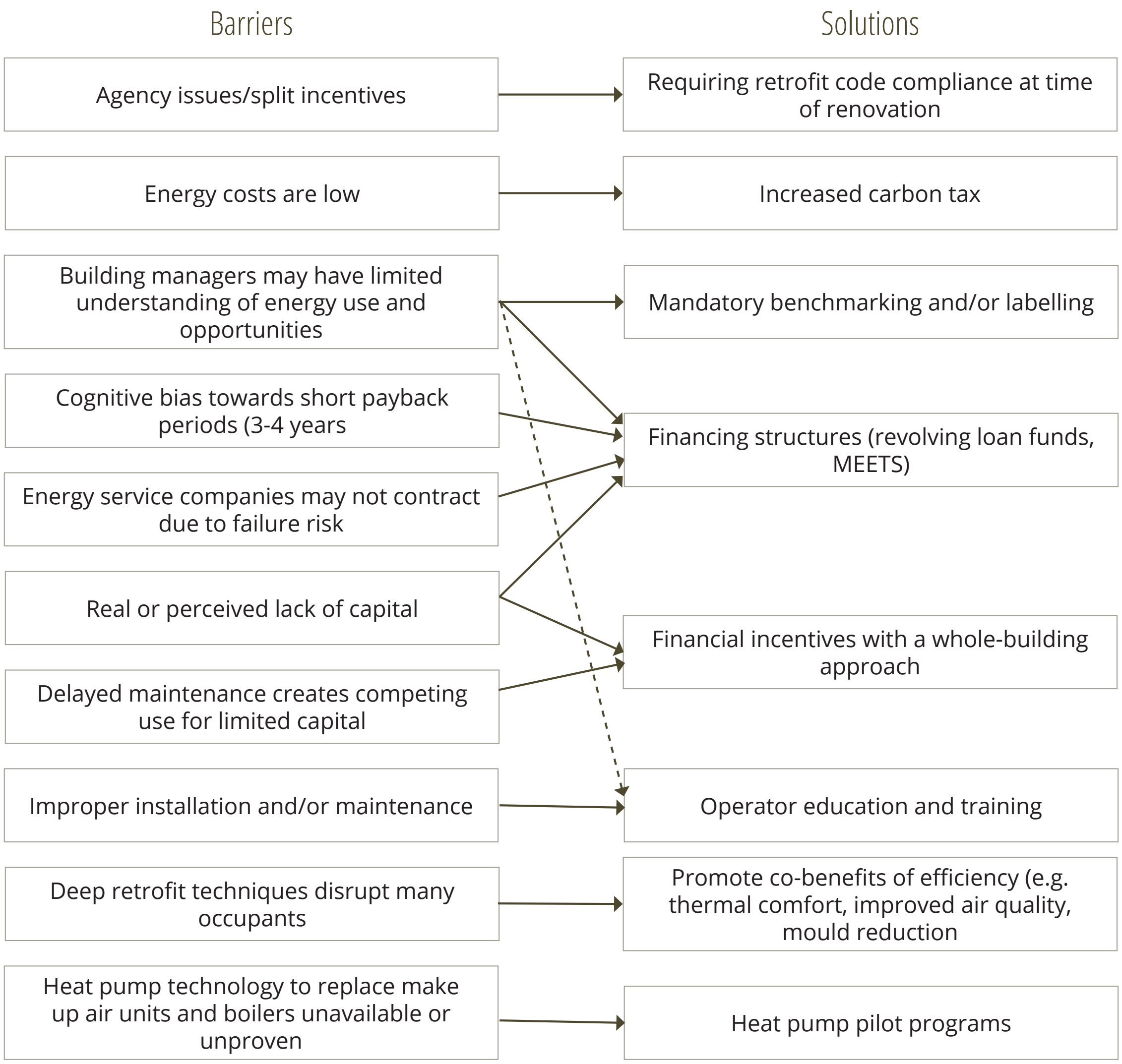


Table 3. Barriers and solutions in commercial and institutional buildings[51]



5. Conclusion

The first session of the forum focused on the pathway to net-zero ready for *new* buildings in B.C.; a year and a half after the 2015 forum — which was dedicated to this topic — participants noted how powerful it was now to have the three levels of government aligned, with a shared goal and the outline of a strategy to get there (0).

This level of clarity is still missing for existing buildings. There are utility programs for retrofits, but in the absence of policy they will not achieve the scale required; economics and market inertia are limiting the growth of the sector. Deciding to invest in renovating our buildings is a political decision: like major infrastructure projects, it calls for public resources (and regulatory powers) to be invested in return for important societal benefits.

The need for a political vision for building renewal was voiced by participants throughout the forum. They called for a long-term vision for the built environment, providing leadership through public investments and direction on the future of regulations. This vision should articulate the benefits in order to mobilize public and industry support, and will provide some clarity for the industry's investors, contractors, manufacturers and suppliers.

The key recommendations that emerged from these two days of dialogue and the preparatory research are recapped below. These recommendations do not necessarily represent the views of all participants.

Table of recommendations

Appendix A. Confirming pathways towards net-zero ready for new buildings in B.C.

At the Thought Leader Forum, representatives from three levels of government presented their visions for the pathway to net-zero energy ready (NZEr) new buildings. Participants were then asked to share their reactions to the proposed pathways through several exercises including a strengths, weaknesses, opportunities, threats (SWOT) analysis and several "human gradient" questions.

A.1 Key elements of NZEr roadmap

Natural Resources Canada's roadmap identified the opportunity to signal clear timelines to a net-zero ready goal, applying more stringent model energy codes, supporting compliance with training and tools, and supporting R&D and demonstration projects to lower construction and technology costs. Since the Thought Leader Forum, the Pan-Canadian Framework on Clean Growth and Climate Change has been released, a document that signals the intention for model building codes to reach net-zero energy ready standards by 2030.

The B.C. government's roadmap to net-zero ready as a code requirement by 2032 was described, with the Energy Step Code as a key enabling tool. The B.C. Building Code is traditionally revised every five years, leaving three code cycles between now and 2032. It has been suggested that the Energy Step Code tiers could inform successive improvements to the baseline code, eventually reaching the highest tier and achieving a net-zero ready requirement by 2032. The importance of public sector leadership and financial incentives were highlighted, but no further details were given.

Finally, the City of Vancouver described key elements of the roadmap to implementing the City's Zero Emissions Building Plan, which will require that all new construction have zero carbon emissions by 2030. The importance of a stepped approach similar to the B.C. Energy Step Code was highlighted, along with planned support for private sector incentives, capacity building, and leading by example by building new public buildings to the Passive House (or equivalent zero emissions) standard.

A.2 SWOT analysis

Table 4. SWOT analysis associated with the net-zero energy ready pathway in B.C.

Strengths	Weaknesses
Common, fixed target with a set date Clear, incremental and predictable long-term goals are being set by governments Defensible, achievable, communicable Demonstrated technology exists; momentum is building in the industry Predictability allows all parties to plan Similar targets have been set in other jurisdictions Performance-based target drives innovation and creativity There is emerging consensus and recognition of the end goal of codes and standards being net-zero energy ready Tools like the Step Code will 'backstop' the market transformation to ensure that all entities are progressing together Themes: Predictability, clear path, momentum	Jargon impedes public understanding; 'Net-zero ready' might not be most inspiring target Benchmarking and labelling are important tools that are currently lacking Consumer awareness/engagement is low Carbon price is not high enough Incentives tied to budget cycles are vulnerable and unpredictable Supply chains for net-zero building components are still nascent Lack of consensus and clear communication around definition of NZEr Not moving fast or far enough to meet climate targets Cost uncertainty – still difficult to get good costing data Themes: Unpredictability, uncertainty, lack of capacity
Opportunities	**Threats**
Support B.C. green businesses and supply chain, encourage private sector capacity for innovation and leadership Increase competitiveness of our economy Address systemic issue and modernize industry Meet / align with municipal and provincial emissions targets Improve indoor air quality and health Further coordination across levels of government Support capacity building and education for contractors and builders Develop and apply a framework for energy benchmarking and disclosure Introduce new financing mechanisms Encourage procurement policies to embrace energy efficiency Learn from other jurisdictions Themes: Coordination, alignment, capacity building	Low energy prices weaken economic case Risk of pushback from developers, builders, etc. Affordability concerns for purchasers First-cost culture does not look at the life cycle cost Inconsistent or non-existent enforcement Broad adoption requires ability and interest that are not currently available across industry Changes in government priority affects consistency and effectiveness Lack of qualified professionals and trades (e.g. energy advisors) outside the Lower Mainland Consumer or government complacency; changes in government Inconsistent occupant behaviour Lack of consumer interest (other priorities) Split incentives Themes: Capacity, costs, complacency

A.3 Areas of agreement and divergence

A.3.1 Feasibility of 2030 target

- Most participants agreed that the technology exists to make net-zero energy ready a code requirement by 2030
- Concerns raised around small builders' ability to meet the target
- There is a need for a more complete and consistent definition of "net-zero ready"
- On a national scale, some provinces are far behind others

A.3.2 Leading by example

- The public sector should lead and inspire confidence through its own building projects
- Mandatory labelling at time of renovation or sale should be considered
- EnerGuide rating could be a data point on B.C. assessments
- Certain classes of buildings (e.g. MURBs for non-profit housing, class A commercial buildings and public sector buildings) can move faster
- Leverage examples from U.S. states (e.g. California, Colorado, Maine, Pennsylvania)
- A B.C. jobs program could build capacity of energy advisors and energy modellers
- Need to demonstrate clearly what the cost premium is for building to net-zero ready
- Implement performance-based regulations

A.3.3 Increasing market demand

- Support was generally strong for incentive programs that provide strong direction and enable buyers to select more efficient buildings
- The private sector should be encouraged to build net-zero ready buildings through financial incentives, fast-tracked approvals or other measures
- Identify and incentivize effective technologies such as heat pumps
- Communicate co-benefits (health, comfort, productivity) as part of the value for buyers
- The recent surge in market uptake of the Passive House standard was seen as a positive step toward increasing market demand
- Tours of successful projects were seen as a good tool to increase demand
- Better communication materials and case studies (including projects costs and performance) were suggested

- Highlight and promote successful case studies
- Implement a pilot project to showcase what a net-zero energy ready code building will look like.

A.3.4 Building capacity

- Challenges with building permits and approvals were identified as a significant barrier
- Processing should be streamlined for "champions" who are proposing net-zero ready buildings
- Internal staff, including plan checkers and inspectors, need to be trained
- Providing education and outreach around net-zero roadmaps (e.g. the Energy Step Code) was seen as a key part of the roadmap
- Concerns were raised around most contractors' awareness of building codes
- Enforcement of code compliance needs to be strengthened
- Best practice (e.g. HPO) guides were identified as important tools, especially for builders
- Provide opportunities for suppliers to showcase their products
- Partner with professional organizations to provide courses, training and resources
- Signal code changes well in advance

A.3.5 Improving commissioning and performance monitoring

- There is a need to ensure that owners/operators are properly trained
- Consider longer commissioning periods
- For incentive programs, include requirements that buildings be commissioned and monitored for performance
- Use performance results to create a benchmarking program, so that projects have quantifiable goals

A.4 Barriers and solutions for new buildings

Table 5. Barriers to energy efficiency in new buildings and policies proposed to address them

Barrier	Description	Public policies addressing barriers
Focus on incremental costs rather than total/future costs	Involved parties are often only interested in the construction budget and may be unwilling or unable to account for future running costs Actors don't have training to analyze a building's life cycle costs and guide improvements Construction companies are rarely involved in paying energy bills; occupants are rarely involved in design	Operational and asset-based benchmarking and disclosure Financing mechanisms Public sector leadership
Insufficient efficiency awareness among consumers, designers and banks	Unpractised buyers unaware of the cost of low energy efficiency Energy advisors not extensively involved in the early design process Banks assess construction costs, are reluctant to fund investments in efficiency that are profitable later on	Operational and asset-based benchmarking and disclosure Public sector leadership
Cost structures and lack of capacity	Specialized, expensive or delayed equipment affect likelihood of efficient construction Some builders unwilling to invest in training	Energy code roadmap Stretch codes Training programs & helpdesk support
Performance gap	Buildings do not meet the level of performance they were designed to meet Many buildings do not comply with minimum energy codes	Commissioning Operational benchmarking Outcome-based codes Compliance and administration
Split incentives, brief occupancy and difficulties marketing efficiency	Total costs may be reduced by efficiency, but the expense is covered by builders and the reward is reaped by owners Many buildings have short occupancy times; occupants won't witness benefits Uncertainty of future profit means cost of efficiency is rarely included in transactions	Financing mechanisms Incentives Benchmarking and disclosure

Energy is invisible	Only status and comfort of using energy is visible As energy costs are only a small part of the budget for many operations, increasing energy prices might reduce this barrier	Carbon pricing Equipment regulation and habitant engagement on plug loads
Building codes set the minimum and maximum standards	New buildings are rarely better than building codes require (particularly in the residential sector), even though they were intended to be a minimum. Building code writing processes are conservative and lean towards the lowest common denominator	Stretch codes Incentives Benchmarking and disclosure

Source: IEA[52]

Appendix B. Abatement costs in building sector compared to other sectors

Figure 15 shows McKinsey's global abatement costs curve, with building-sector related strategies highlighted. The most cost effective mitigation opportunities globally are in the building sector. Few other mitigation strategies have the benefit of returning a cost saving, in addition to decreasing emissions.

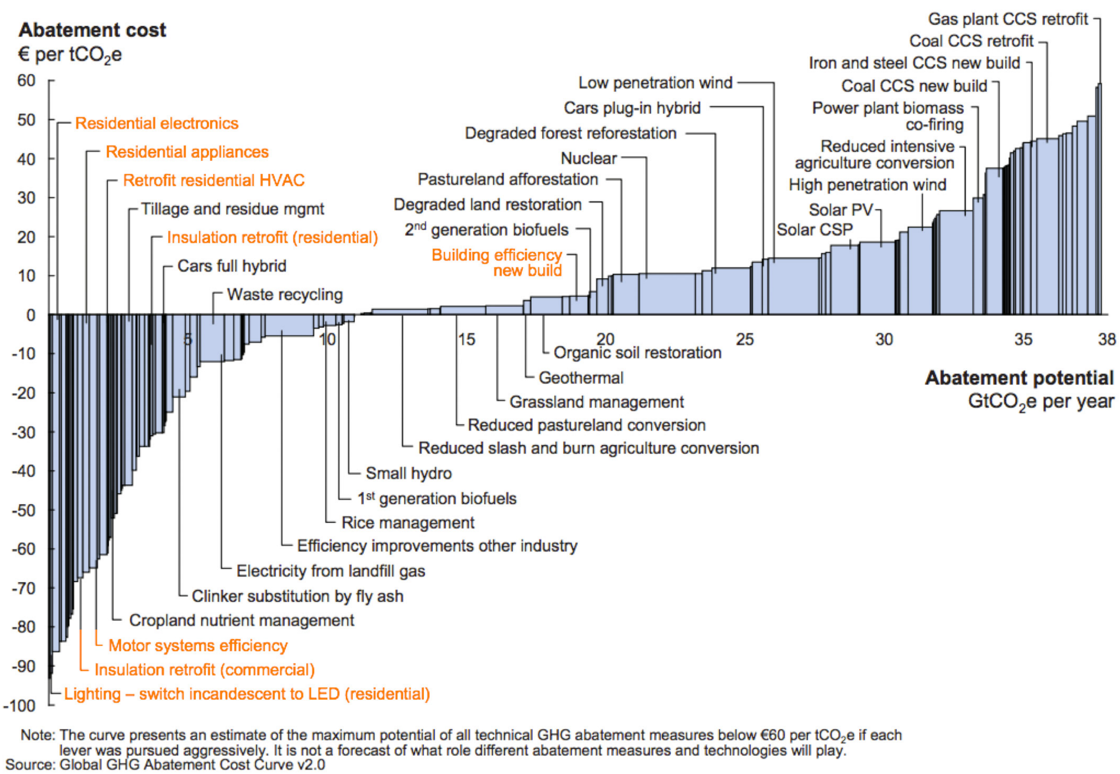


Figure 15. Global cost abatement curve beyond business as usual, with building sector opportunities highlighted

Source: McKinsey & Company[53]

Similar cost-optimization exercises for reductions within Canada have been conducted by various teams of economists. In all cases we could find, the emissions reductions expected in the building sector are greater than the percentage target for economy-wide reductions.

For example, the three modelling studies cited in the federal *Mid-Century Long-Term Low-Greenhouse Gas Development Strategy* resulted in building sector reductions ranging from 76% to 99% by 2050, exceeding their respective economy-wide target by 7% to 24%. Modelling for B.C. conducted by Navius Research for Clean Energy Canada in 2015 shows similar results; the suite of policies proposed to meet an 80% economy-wide reduction target led to building emissions being reduced by 97% by 2050 (see Table 7).

Table 6. Mid-century reductions in building sector for different decarbonization pathway models

Env. & Climate Change Canada	overall: -80% (below 2005)
Stationary sources	-87%
Trottier, current technology scenario	overall: -65% (below 2015)
Residential	- 87%
Commercial	- 76%
Trottier, new technology scenario	overall: -65% (below 2015)
Residential	-89%
Commercial	-88%
Deep Decarbonization Pathways Project	overall: -89% (below 2015)
Residential	-99%
Commercial	-99%
Clean Energy Canada*	overall: -80% (below 2007)
Residential	-97%
Commercial	-94%

* For B.C. only

Source: Government of Canada[54]

What these various modelling exercises show also stands to reason: technology is readily available to reduce demand from buildings today, and the remaining energy needs can be met by the electricity grid, which, if not already low carbon, has the capacity to decarbonize significantly between now and 2050 (generally a necessary condition to meeting targets in all models). Reaching a near decarbonization of transportation systems, or of industrial processes, faces much more fundamental challenges (e.g. storage of energy for transportation, and high-quality energy required by various industrial processes).

Appendix C. Impact of Climate Leadership Plan on building sector emissions

How will the CLP policies and the federal carbon price floor impact emissions from the building sector? Table 7 summarizes policies that will have a material impact on buildings. Other than the carbon price, which affects the entire economy, this includes the requirement for new construction to be net-zero ready by 2032 and the announcement of increased efficiency requirements for gas fireplaces (by 2018), air source heat pumps (by 2018), natural gas space heating equipment (by 2020) and natural gas water heating equipment (by 2025). Figure 16 present the modelled impact of these policies, compared to the reference case, on emissions from and energy use of residential and commercial buildings.

In the reference case, the replacement of older stock by more efficient new buildings roughly balances out the growth demand, and total emissions remain relatively constant. Adding the CLP's new equipment standards and net-zero ready requirements and the federal carbon price does not significantly impact emissions in the residential sector, but it appears to drive a significant emissions reduction in the commercial sector.

According to the modeller, this forecasted decarbonization (shift in energy use) of the commercial sector is driven primarily by an uptake of heat pump technology. In this simulation, heat pumps become much more mainstream HVAC equipment around 2030, competing more effectively with traditional alternatives when equipment must be replaced at end of life. This uptake in heat pump technology is driven primarily by a forecast increase in gas prices (32% between 2015 and 2030, 72% between 2015 and 2050, including the carbon price) and by the introduction in 2020 of stricter regulations on heating equipment, which brings natural gas and heat pump technologies to a more equal footing.[55] The increased competitiveness of heat pumps for commercial HVAC systems then leads to the steady electrification of that sector between now and 2050.

Like all modelling results, these forecasts should be taken with a large grain of salt. This uptake of heat pump technology depends on many factors which might not unfold as modelled, including future gas and electricity prices, the relative capital cost of heat pump technologies compared to more traditional HVAC systems, and some intangible costs related to the risk of adopting a new technology. Competition between the two technologies will also depend on the stringency of the new performance standards for heating equipment, which have not been announced.

The model also assumes there will still be significant emissions from net-zero ready residential stock, which comes as a surprise. Most of the domestic hot water is still assumed to be natural gas heated, and so is a fraction of space heating. Given their low space heating demand, we expect most net-zero ready home will use electricity for space heat. What fraction of net-zero homes will use electricity for domestic hot water as well in order to avoid gas connection costs remains to be seen. Overall, we suspect emissions from net-zero ready houses will be smaller than predicted by the model.

Generally, these results should not be taken as predictions, but rather as illustration of the potential for market shifts toward electrical heating, which could occur if the right market conditions were in place. Overall, CLP policies are expected to reduce emissions by ~30% by 2030, and 50% by 2050, still a far cry from the proposed targets (40-50% by 2030, 80-100% by 2050; Table 7).

Table 7. Policies impacting building sector as modelled in various studies, and estimated resulting emissions reductions[56]

	Existing policies (Reference case)	Additional policies in CLP, plus federal carbon floor price[57]	Additional policies in CLT recommendations[58]	Additional policies in CEC model[59]
Carbon tax	Fixed at \$30t/CO_2e	Rises to \$40/tCO_2e in 2021and \$50/tCO_2e by 2022	Rises to \$40/tCO_2e in 2018 climbs \$10 per year, reaches \$110/tCO_2 in 2025, and continues to climb beyond that.	Rises to \$38/tCO_2e in 2018, climbs \$8 per year, reaches ~\$80/tCO_2 in 2025, and is adjusted for inflation beyond that.
Code for new buildings	Current codes	Net-zero ready building standard for new construction after 2032	Net-zero ready building standard for new construction by 2025 (2016 for public sector*)	Net-zero ready building standard for new construction by 2025 (2020 for public sector*)
Equipment standards	Current provincial and federal standards	Regulations that require more efficient natural gas equipment for furnaces and boilers[60]	Standards that transition the market to high-efficiency electric heating equipment, building components and appliances. **	Standards requiring all new and replacement space and water heating equipment to be non-emitting by 2025
Others	Clean Energy Act – 93% non-emitting sources		Programs (such as on-bill financing) that encourage retrofits*	
Resulting sectoral GHG reductions below 2007 level				
2030	16%	27%	50%	64%
2050	14%	51%	N/A	97%

* policy not included in Navius modelling; impacts not factored in projected reductions

** details of what standards were actually modelled were not publicly released

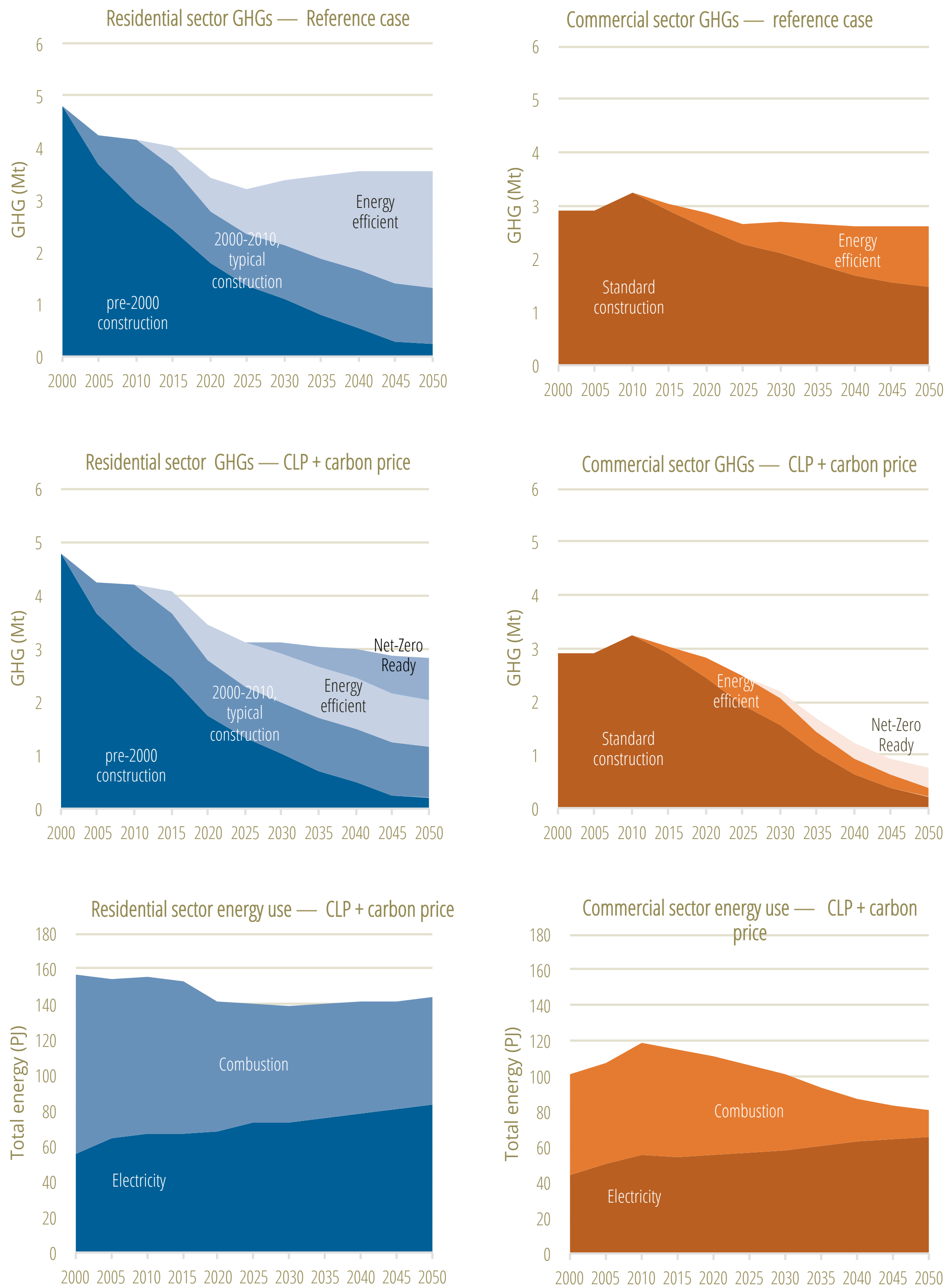


Figure 16. Residential and commercial sector GHG emissions and energy use under reference case and CLP+Federal carbon price scenarios.

Appendix D. Economic benefits and jobs estimate

To estimate total investment required, we used available case studies (see Table 11) to estimate the average cost of achieving energy reductions in the three main market segments. We also estimated the average cost of maintaining a 1.5% electrification rate, assuming it is mostly based on installation of air source and geoexchange heat pumps. From these investment figures, we estimate the direct, indirect, and induced job creation based on multipliers from the Institute for Market Transformation. Induced jobs result from the recirculation in the local economy of energy cost savings; as electrification does not lead to significant operational cost reduction (given the higher cost of fuel) only the investment in other energy efficiency measures was used to infer induced costs. The total economic growth benefits were estimated using GDP multipliers from the Acadia Centre.

Table 8. Costs and benefits of proposed pathway in B.C.

	Homes		MURBs		Institutional & commercial	
	homes	cost/home	units	cost/unit	area	cost/ m^2
Retrofit projects @ 3% annual rate and 25% GHG savings[61]	30,000	~$6,500	17,000	~$5,000	3 million m^2	~$37
Electrification @ 1.5% annual rate[62]	15,000	~$10,000	8500	~$5,000	1.5 million m^2	~$120/$m^2$
Total annual investment per type[63]	**$300-400 million**		**$100-200 million**		**$350-400 million**	

Economic activity and jobs			
	Economic activity	Job multiplier	Jobs
Direct[64]	$750 million - $1 billion	5 jobs/$M	3,750-5,000 direct jobs
Indirect[65]	$750 million - $1 billion	4 jobs/$M	3,200-4,000 indirect jobs
Induced[66]	$400-500 million	4 jobs/$M	1,500-2,000 induced jobs
Overall economic benefits[67]	**$4-8 billion in GDP growth annually**		**8,000-11,000 jobs**

These estimates suggest that such a retrofit program would require direct investments of approximately $700 million - $1 billion per year. This would create between 3500-5000 direct jobs in the retrofit industry, another 4500-6000 indirect and induced jobs, and as much as $4-8 billion in GDP growth. By way of comparison, around 4,000 direct oil and gas jobs have been lost in Alberta in the past two years.[68]

In addition to the utility bill savings and GHG reductions that a comprehensive retrofit program would deliver, there are significant non-energy and non-emissions benefits associated with improving the efficiency and performance of the building stock, which are not accounted for here.

Appendix E. State of the B.C. building stock

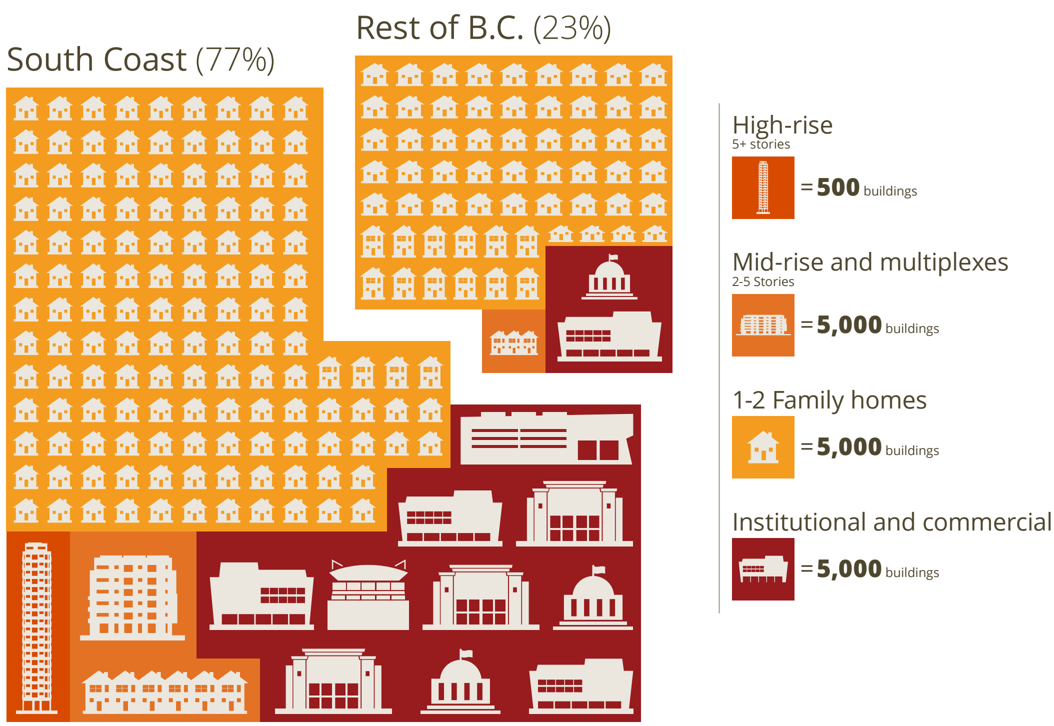


Figure 17. Breakdown of B.C. building stock by type and location.

Shaded area represents the respective proportion of total floor space for the four building types. The number of icons relate to the total number of building (as per legend).

B.C.'s approximately 1 million buildings (376 million m^2) emit 7.2 million tonnes of carbon dioxide equivalent (Mt CO_2e) per year, accounting for 11% of B.C.'s total emissions.[69] One- and two-family dwellings account for half of building GHG emissions and energy use, while institutional and commercial and multi-unit residential (MURB) buildings are responsible for 41% and 10% of emissions, respectively (Figure 19). Emission intensities vary by building type, with institutional and commercial buildings generally having higher emissions per unit of floor area (Figure 18). All three segments contribute significantly to building sector emissions, and strategies for reductions customized to each should be considered.

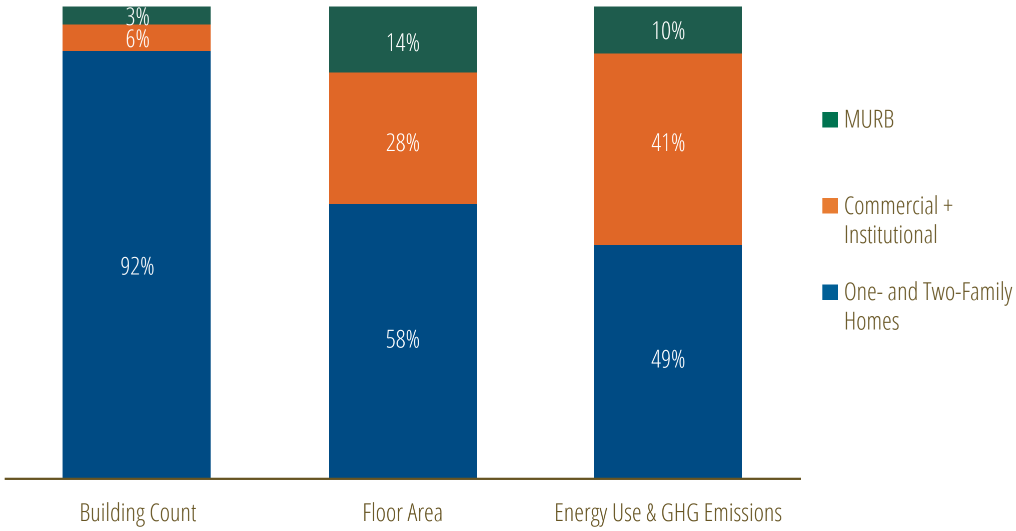


Figure 18. Split of total building, floor area, and energy use between homes, MURBs, and commercial/institutional buildings.

Source: NRCan, Government of B.C.

As B.C.'s electricity is mostly low-carbon and renewable, emissions from the building sector are primarily due to burning fuel for space and water heating (Figure 19). To reduce emissions from buildings, measures should therefore focus on heating loads. However, to protect affordability and reduce environmental impacts associated with new generation projects, strategies to reduce electricity use from appliances, lighting and plug loads should also be encouraged — particularly if electrification of heating is considered.

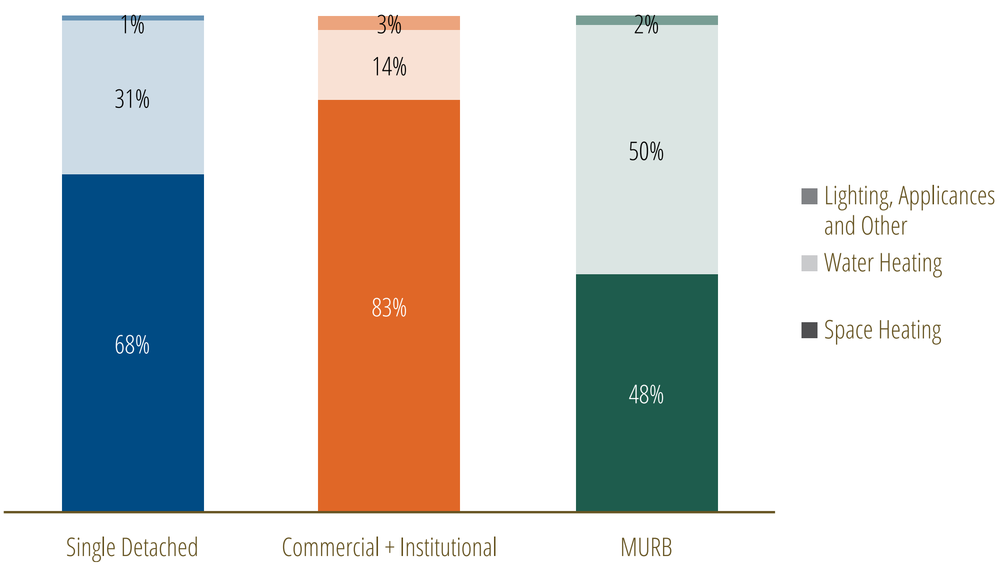


Figure 19. Source of emissions in B.C. buildings

Source: NRCan, Government of B.C.

Most of B.C.'s buildings are located on the South Coast. One- and two-family dwellings constitute 92% of buildings and about half of total floor area in the province (Figure 18). Nearly half of these homes are in the Lower Mainland, a quarter on Vancouver Island and the Sunshine Coast, with the rest distributed across the province. Similarly, 86% of low-rise MURBs, 98% of high-rise MURBs, and 86% of commercial buildings are located on the South Coast (Figure 20). This is also where most new construction is occurring.[70]

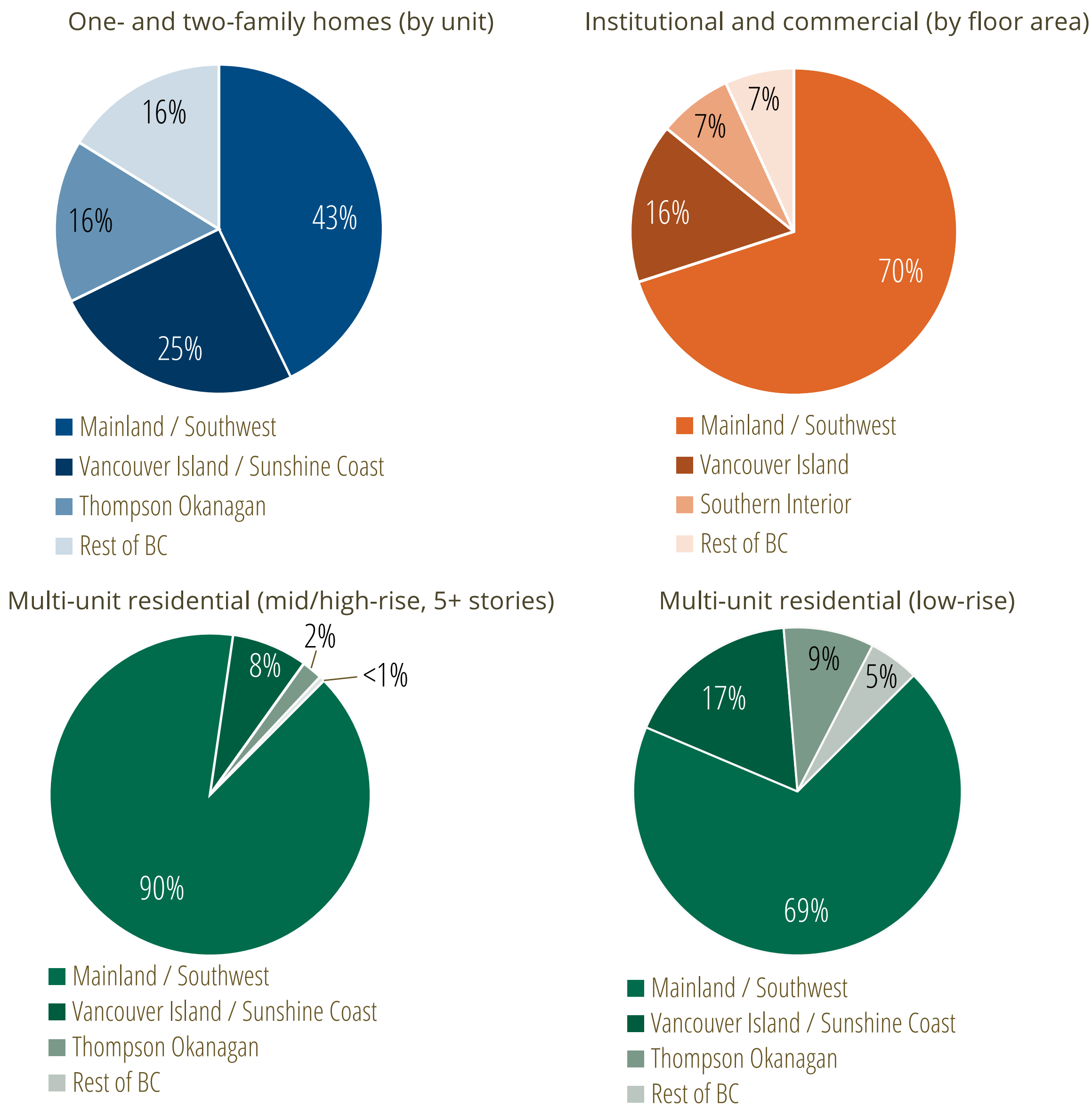


Figure 20. Geographic distribution of different buildings types in B.C.

This concentration suggests that significant gains could be achieved by concentrating retrofit efforts on the South Coast; however, for equity reasons, it is important that other regions also benefit from the economic development opportunities resulting from retrofit investments. In keeping with Canada's Reconciliation commitments, specific energy efficiency programs should also be developed to serve the unique needs of First Nation communities (see textbox below).

Energy efficiency for First Nation communities

Residential retrofits in First Nations communities can provide significant benefits. Common measures like stopping air leakages and drafts, and upgrading windows, doors and appliances (including wood stoves) to higher efficiency products, reduce energy consumption in homes and communities. Yet larger initiatives like fuel switching to clean electricity, replacing insulation, and structural upgrades also have advantages. These initiatives can save money for residents, have quick paybacks, and for remote First Nations communities, can directly offset diesel fuel usage. Diesel fuel generators are extremely inefficient (in the range of 25–30%); every 1 GJ of energy used in a home requires 3–4 GJ of diesel fuel. The rest of the energy is lost as heat and noise. Many communities face load restrictions and cannot build new houses or grow businesses because no new electrical connections are allowed. Adopting energy efficiency solutions can remove this load restriction.

Appendix F. Buildings statistics and retrofit case studies

Table 9. Number of buildings, units, and area for residential and commercial buildings in B.C. in 2011-2012

Sector	# Buildings	# Units	Area (million m^2)	Annual growth
1-2 family homes	**967,100**	**1,076,300**	**208**	**30,000 starts/year**
Single family	814,700	814,700	180	
Duplexes	109,100	218,200	20	
Mobile	43,300	43,400	8	
Multi-unit residential	**26,800**[71]	**575,900**	**37**	**1-2 million m^2**
5+ storey	600	117,700	11	
2-4 storey	9,800	343,500	23	
Row houses and town houses	16,400	114,700	3	
Commercial / institutional	**61,400**	**-**	**105**	**2 million m^2**
TOTAL	1,055,300		350	

Data source: StatsCan,[72] NRCan[73]

Table 10. Retrofit types and costs

Retrofit depth	Shallow	Moderate	Deep
Typical energy conservation measures	Lighting Smart controls HVAC motors and fans Caulking and sealing Optimization	Boiler, furnace, or AHU replacement Steam to hot/low-temp water Heat pumps Drain/waste heat recovery Heat recovery ventilation Roof/cavity insulation	*As above, plus:* Window replacement Wall and foundation reinsulating Shading Envelope replacement Conversion to renewable district energy
Energy savings range[74]	10-20%	30-50%	40-80%
Typical payback period and costs[75]	1-3 year payback Commercial: <$2 / ft^2 MURB: <$2,000 / unit Home: <$5,000	3-6 year payback Commercial: $2-$5 / ft^2 MURB: $2,000-$6,000 / unit Home: $5,000-$50,000	6+ year payback Commercial: $20-$50 / ft^2 MURB: $10,000-$60,000 / unit Home: $100,000-$150,000
Advantages	Short payback Cost-effective Incentivized by current program and policy structure	Attractive balance of energy savings and payback Can be performed with minimal disruption to tenants	Holistic approach optimizes components Large and lasting energy and emissions reductions
Disadvantages	Small energy savings Weakens business case for deeper retrofits in the future Missed synergies between building components	Higher energy reductions difficult to achieve without envelope upgrade May result in oversized mechanical systems compared with a deep envelope retrofit	Complex Longer payback period Disruption to tenants/owners

Table 11. Retrofit case studies

Building/Location	Energy Reduction	Cost
Commercial and Institutional		
Alliance Centre, CO[76]	22%	$3 / ft^2
Joseph Vance, WA	24%	$26 / ft^2
Jawl Properties, Vancouver Island[77]	20-25%	$2/ ft^2
1525 Wilson, VA	35%	$3.5 / ft^2
77 Bloor Street, Toronto[78]	36%	-
Empire State Building, NY	38%	$40 / ft^2
Indianapolis City-County Building, IN	48%	$11 / ft^2
Public building, Vancouver[79]	50%	$1 / ft^2
Johnson Braund, WA	59%	$31 / ft^2
The Aventine, CA	63%	$3.2 / ft^2
Retail Chain, US	45-72%	$6-21 / ft^2
Sunnyvale, CA	~80% (net-zero)	$55 / ft^2
MURBs		
The Belmont, Vancouver[80]	20%	$3,300/unit (energy upgrades) $100,000/unit (total)
TAF TowerWise projects[81]	30-50%	$1200-6000/unit
Castle Square, MA[82]	50-60%	$18,000 / unit (energy upgrades) $42,600 / unit (total)
Freiburg, Germany[83]	78% (Passive House standard)	$173 / ft^2
Energiesprong MURBs, Netherlands[84]	70-80% (net-zero)	$60,000/unit
Homes		
Utica, NY (4 case studies)[85]	60-65%	$100,000 - $145,000
Arlington, MA (duplex)[86]	67% (heating energy only)	$100,000
Energiesprong, Netherlands (row houses)[87]	70-80% (net-zero)	$135,000

Appendix G. Participants and agenda

Table 12. Forum participants

Stakeholder group	# participants	Organizations
Developers, builders, contractors, manufacturers	19	Ledcor Renew, Canadian Home Builders' Association of BC, Greater Vancouver Home Builders' Association, Concert Properties, Habitat Studio & Workshop, Britco LP, Urban Development Institute, Performance Construction, RDC Fine Homes, Centra Windows, NAIMA Canada, EuroLine Windows, BC Insulators, Midtown Heating and Cooling
Architects, engineers, energy modellers, consultants	17	DIALOG, SES Consulting, Integral Group, Stantec, Morrison Hershfield, RDH Building Science, Ecolighten Energy Solutions, Red Door Energy Design, Focal Engineering, E3 Eco Group, Cornerstone Architecture, Prism Engineering, Jawl Properties, Edge Consultants, Stadsrium, FRESCo, McLennan Design
Owners, managers, tenants, utilities, financial inst.	14	Brookfield Global Integrated Solutions*, Vancity, Bentall Kennedy, Building Owners and Managers Association of BC, BC Hydro, FortisBC, BC Housing, BC Non-Profit Housing Association, Vancouver Native Housing Society, Low Tide Properties, Baptist Housing, Greater Victoria Housing Society, Condominium Home Owners Association
Local government	12	Metro Vancouver, North Vancouver, Richmond, Vancouver, Surrey, Burnaby, New Westminster, Victoria, Gibsons, Nelson, Seattle*
Provincial and federal government	13	Natural Resources Canada (Office of Energy Efficiency)*, Government of Alberta (Climate Change and Branch Operations)*, BC Ministry of Natural Gas and Housing (BC Office of Housing and Construction Standards and the Building and Safety Standards Branch), BC Ministry of Energy and Mines (Energy Efficiency Branch), BC Ministry of Environment (BC Climate Action Secretariat), BC Ministry of Community, Sport and Cultural Development
Education, research, advocacy	21	Rocky Mountain Institute*, New Buildings Institute*, The Atmospheric Fund*, MaRS Cleantech*, MEETS Accelerator Coalition*, Canadian Energy Efficiency Alliance*, Canada Green Building Council, UBC, Pacific Institute for Climate Solutions, Passive House Canada, Lighthouse, Real Estate Foundation of BC, BC Community Energy Association, City Green, QUEST Canada, Home Performance Stakeholder Council, BC Advanced Conservation and Efficiency Association
Facilitation team and note takers	30	International Living Futures Institute*, PICS, CAS, Pembina Institute, RAIC, UBC, UNBC
TOTAL	126	90 organizations

* Participants from other Canadian provinces and the U.S.

Table 13. Forum agenda

DAY 1 AM	Pathways to net-zero energy ready (NZEr) for NEW buildings
7:45	Registration & breakfast
8:30	**Opening remarks** Josha MacNab, Pembina Institute Hanne Selby, Board of Governors Real Estate Foundation of B.C.
8:45	**Table Discussion:** Introductions & Objectives
9:10	**Panel: Pathways to NZEr** Patricia Fuller, Director General at NRCan's Office of Energy Efficiency: *Pan-Canadian Framework's vision for buildings in Canada* Jarrett Hutchinson Executive Director, BSSB: *Proposed pathway to net-zero ready for new homes and buildings* Sean Pander, City of Vancouver: *Catalyzing transition to low carbon buildings in Vancouver* Q&A
10:10	Break
10:30	**Table Discussion I:** Reaction to pathway to net-zero ready • Strengths, weaknesses, opportunities and threats of the proposed strategy • How can we catalyze market leapfrogging to high performance?
11:30	**Plenary:** Testing overall level of confidence with proposed approach
12:00	Lunch
PM	Pathways to deep retrofits for EXISTING buildings
1:00 pm	**Presentations** Patricia Fuller, NRCan OEE: *Towards a federal retrofit strategy for existing buildings* Tom-Pierre Frappé-Sénéclauze, Pembina Institute: *Retrofit targets and pathways for deep reductions* **Pecha Kucha:** Transformative ideas for deep retrofits Martha Campbell, RMI: *Realize: pooling MURBs to unlock R&D potential* Jensen Thor, PICS-Sauder: *Why PACE can do more than cheap money* Rob Harmon, MEETS coalition: *Metered Energy Efficiency Transaction System*
2:10	**Breakout Session I**

Strategies for MURB retrofits	**Strategies for one and two family dwelling retrofits**	**Strategies for commercial/institutional retrofits**
Tony Gioventu, CHOA: *Opportunities and challenges in B.C. MURBs* Bryan Purcell, The Atmospheric Fund: *Game-changing heat pump technologies and incentive pilot*	Tracy Cassavant, Lighthouse: *Strategies for retrofit of homes* Scott Kennedy, Passive House Canada: *Sequenced retrofits: how to reach deep reductions, one upgrade at a time*	Dave Ramslie, Integral: *Commercial building roadmap* Duane Jonlin, City of Seattle: *8 strategies for existing building energy use*

3:15	Break		
	(break out continues)	(break out continues)	(break out continues)
4:40	Rapporteurs and closing remarks		
5:00-7:30	Reception at Moxie's Grill and Bar (in the hotel)		

DAY 2 AM — Pathways to deep retrofits for EXISTING buildings (con't)

7:45 Breakfast

8:30 **Opening remarks**

Richard MacIntosh, North American Energy and Sustainability Director, TD account at Brookfield: *Review of day 1 and industry leadership*

Josha MacNab, Pembina Institute: *Structure of day 2*

8:45 **Options for retrofit regulations**

Andrew Pape-Salmon, RDH: *Options for retrofit regulations at time of renovation*

Dave Ramslie, Integral: *Building Energy Performance Standard (BEPS)*

Patrick Ryan, CBO & Kelly Anderson, manager of building permit reviewers, City of Vancouver: *Enforcing energy codes at time of retrofits: Vancouver's learning curve*

Q&A

9:45 **Table Discussion:** Design and phasing of retrofit regulations

- Conditions for success

10:30 Break

10:50 **Breakout Session II**

Innovation for deep retrofits in social housing	LIC financing and one-stop shops	Unlocking investments in energy efficiency
Martha Campbell, RMI: *Key characteristics of supply-side offer*	Vivian Chung, TAF: *Lessons learned from Toronto LIC program*	Tim Mosley, BC Hydro: *BC Hydro's viewpoint on financing*
Andrew Pape-Salmon, RDH & Robert Pennings, Stadsruim*: Local and European solutions to deep MURB retrofit*	Thor Jensen: *Conditions for a successful residential PACE program*	Rob Harmon, MEETS coalition: *Aligning incentives between investors, owners, and utilities*
Ian Cullis, BC-NPHA: *Opportunities in B.C. social housing*		

12:30 Lunch

PM	Moving to Action
1:30	**Plenary:** Report back from breakouts
2:00	**Caucuses:** Testing regulatory proposals: Conditions for success Industry: Operation & management Industry: Development Industry: Design Industry: Construction Industry: Manufacturing and supply-chain Research and education Local governments and utilities Provincial government
2:45	Break
3:00	**Plenary:** Towards a comprehensive retrofit strategy • Test agreement and level of confidence for key elements of a retrofit strategy
3:40	**Closing Remarks** Patricia Fuller, NRCan OEE Jarrett Hutchinson, BSSB Tom Berkhout, MEM
4:00	Adjourn

Appendix H. Further resources

H.1 Regulatory proposals

RDH Engineering. 2016. *Review of Potential Energy Efficiency Standards for Existing Buildings In B.C.* http://www.pembina.org/reports/rdh-existing-buildings-whitepaper-2016.pdf

Sustainability DC. 2014. *Building Energy Performance Standards Task Force.* http://www.sustainabledc.org/wp-content/uploads/2014/12/10-Building-Energy-Performance-Standards.pdf

Pembina Institute. 2015. *Pathways to Net-Zero Buildings in B.C.: Policy Proposal: Getting new Part 3 buildings net-zero ready*. https://www.pembina.org/pub/pathways-to-net-zero-bc-policy-2015

H.2 Energy disclosure

Canadian Green Building Council. 2016. *Energy Benchmarking Disclosure in Canada: A Guide to a Common Framework.* http://www.cagbc.org/cagbcdocs/CaGBC_National_Energy_Benchmarking_Framework_April_2016.pdf

Pembina Institute. 2015. *Home Energy Labelling: Strategic Plan for Labelling of Part 9 Residential Buildings in B.C.* http://www.pembina.org/pub/home-energy-labelling

H.3 Commercial/institutional buildings

Integral Group. 2016. *BC Hydro Part 3 Existing Buildings Road Map*. http://www.pembina.org/reports/bchydro-existing-commercial-roadmap-2016.pdf

H.4 One- and two-family homes

Light House Sustainable Building Centre. 2015. *Towards Net Zero Energy Ready Residential Buildings: Roadmap for British Columbia,* http://www.sustainablebuildingcentre.com/wp-content/uploads/2011/10/BC_Part_9_Roadmap_Final_Report.pdf

Columbia Institute. 2016. *This Green House II: Building Momentum on Green Jobs and Climate Action.* http://www.civicgovernance.ca/green-house-ii-2/

H.5 MURBs

Pape-Salmon, Andrew, Jordan Fisher, Warren Knowles, and Jennifer Sanguinetti. 2011. *Multi-Unit Residential Buildings in B.C.: A Vision for Energy Efficiency.* http://www.rdh.com/wp-content/uploads/2014/04/MURB___Energy_Efficiency.pdf

Endnotes

[1] 50% relative to 2015 levels, ~55% relative to 2007 levels.

[2] As mentioned in the introduction, not all these policy recommendations were tested explicitly at the Forum. Some were included in participant surveys following the forum; for these we provide survey results in the endnotes. Others were tested by show of hands at tables, or by ranking exercise in plenary, or simply came up as suggestions in several table discussions. For these, we provide a subjective appreciation of overall support, based on the feedback captured by note takers. Other recommendations emerged from specific table conversations and were not tested with other participants; we flag these simply as 'suggested by participant(s)'; the level of support for these ideas is unknown.

[3] "B.C. should aim for a 40-50% reduction in greenhouse gases from the building sector by 2030"; of 52 respondents (half of participants; we did not survey the facilitation team) 36 strongly supported, 13 supported, 2 were neutral, one opposed.

[4] "B.C. should aim for a 80-100% reduction in greenhouse gases from the building sector by 2050"; of 52 respondent, 40 strongly supported, 9 supported, 3 were neutral, none opposed.

[5] Navius Research Inc., *Modelling the Impact of the Climate Leadership Plan & Federal Carbon Price on British Columbia's Greenhouse Gas Emissions* (2016). http://www.pembina.org/pub/bc-climate-modelling This study used an energy–economy model (CIMS) to simulate how energy prices, real and perceived technology costs, and government policies are likely to affect B.C.'s GHG emissions from present to 2050. Two scenarios were modelled: a reference case, which includes policies in place before the CLP, and a test case, which includes the policies announced in B.C.'s 2016 CLP and the modest carbon tax resulting from the new federal directive on minimum carbon pricing announced in October 2016 (i.e. from $30 per tonne currently to $40/t by 2021 and $50/t by 2022). This scenario attempted to include policies that were well described in the CLP plus those that still lacked details, making optimistic assumptions when information was missing. The reference case assumes LNG production equivalent to the combined production of all phases of PacificNorthWest, LNG Canada and Woodfibre LNG's projects; projected emissions will decrease significantly if these projects do not materialize.

[6] *Modelling the Impact of the Climate Leadership Plan & Federal Carbon Price.* The CIMS model does not include forest carbon dynamics and net-forest carbon is not part of this analysis. The CLP claimed that improved forest management could reduce emissions by 12 $MtCO_2e$ by 2050; these potential additional emissions reductions are added here for illustrative purposes (blue circle). Even considering these additional strategies, current policies get only a third of the way to B.C.'s 2050 target, leaving a gap of over 40 $MtCO_2e$. They also miss both the provincial 2020 target and the federal 2030 target.

[7] See Tom-Pierre Frappé-Sénéclauze, Karen Tam Wu, *Pathways to Net-Zero Buildings in B.C.: Policy Proposal: Getting new Part 3 buildings net-zero ready* (Pembina Institute, 2015) https://www.pembina.org/pub/pathways-to-net-zero-bc-policy-2015

[8] Given that current rate for electricity is about 3 times that of current natural gas prices (including delivery charges). More generally, if $g is the average price of a delivered unit of energy from gas, $e is the price of a unit of electrical energy, and E/G is the original fuel mix, then maintaining bill neutrality will required overall reductions in energy use of $R = [1 - g/e] / [1 + E/G]$ percent.

[9] Selecting only participants who had a heat pump installed but no other measures ensured that impacts of other efficiency measures are not conflated. BC Hydro, *Evaluation of the LiveSmart BC Efficiency Incentive Program, F2009-F2011*, February 2012: D-6

[10] BC Hydro, *Evaluation of the LiveSmart BC Efficiency Incentive Program, F2009-F2011*, February 2012: 35

[11] 10,590 air-source heat pumps installed by participants + 36,000 estimated installs by non-participants x 59% of heat pump incentive recipients who completely replaced their old heating system x 87% of these whose previous system was oil or natural gas fueled ~ 23,600 fuel switched homes; 2% of 1.2M eligible stock. BC Hydro, *Evaluation of the LiveSmart BC Efficiency Incentive Program, F2009-F2011*, February 2012: D-3

[12] Based on LiveSmart BC data obtained from NRCan via the Province of B.C.

[13] Audit data from NRCan via Province of B.C., summary of program history from CityGreen Solutions. 2015. *City of Vancouver EnerGuide Rating System Existing Homes Data Analysis Report.*

[14] Data from NRCan, provided by CityGreen.

[15] Jordan Fisher, personal communication, October 2016.

[16] Tracy Johnson, "Just how many jobs have been cut in the oilpatch?" *CBC News*, July 6, 2016. http://www.cbc.ca/news/canada/calgary/oil-patch-layoffs-how-many-1.3665250

[17] Nelson and New Westminster's energy coaching programs, BOMA Best, CHOA's proposed energy advisor program, and CityGreen's Municipal Partner Offer, to name a few.

[18] Helen Goodland, Chris Lindberg, and Paul Shorthouse, Construction Innovation Project: Building B.C.'s Vision (2015), 23. https://www.bccassn.com/media/bcca-report-construction-innovation-2016.pdf.

[19] Tom-Pierre Frappé-Sénéclauze, Dave Lovekin, Benjamin Thibault, and Josha MacNab.,*HVAC Regulations in B.C.: Research, Analysis and Recommendations into Energy Efficiency Codes and Standards Related to HVAC Systems for New Homes* (2014). Available upon request to FortisBC.

[20] It is worth noting that some level of regulations will likely be needed regardless of the cost on carbon. There is a fundamental 'split incentive' barrier in the construction and renovation industry, whereby the economic interest of the builder and/or original investor does not always align with that of future owners – i.e. to save construction costs, decisions are made that do not optimize life-cycle costs. Energy codes will still be needed to ensure that buildings are built (and renovated) to be good long term investments. More effective carbon pricing is still beneficial, in that it reduces the pressure on regulations and codes to drive market transformation.

[21] International Institute for Sustainable Development, "Unpacking Canada's Fossil Fuel Subsidies." http://www.iisd.org/faq/unpacking-canadas-fossil-fuel-subsidies/

[22] Royal Architectural Institute of Canada, Urban Development Institute Pacific Region, and Pembina Institute, *Call for action on energy and climate in the building sector* (2015). http://www.pembina.org/pub/buildings-declaration

[23] See for example the deployment of Mycom's EcoCute CO_2 Heat Pump in La Cité Verte in Québec City: http://www.mayekawausa.com/news/news2-06152011.html

[24] TLF survey question 'B.C. should actively drive fuel switching to low carbon sources (electricity, renewable district energy systems, biogas) to reduce emissions from buildings' – 92% in support (of 52 respondents, 48 supported, two were neutral, two opposed)

[25] 'Assuming the top enabling pieces discussed above are in place, do you support adoption of these policies in B.C.? Retrofit code at point of renovation for one and two family homes' (42 supported, 9 neutral, 1 opposed); 'Retrofit code at point of renovation for other buildings' (47 supported, 4 neutral, 1 opposed); Retrofit requirement based on building performance (e.g. Building energy performance standard, or 'air care for buildings') (43 supported, 7 neutral, 2 opposed).

[26] This proposal was presented to participants and during discussion most were supportive of moving towards a retrofit code (see also survey results in previous footnote), though support for the specifics of this proposal was not always tested.

[27] Andrew Pape-Salmon, *White Paper : Review of Potential Energy Efficiency Standards for Existing Buildings In BC*. (2016) Available at http://www.pembina.org/reports/rdh-existing-buildings-whitepaper-2016.pdf

[28] Ibid.

[29] Based on presentation from the Chief Building Official and Manager of Plan Reviewers, and conversations with Greg McCall in March 2017.

[30] KFW, "Energieeffizient Bauen und Sanieren." https://www.kfw.de/inlandsfoerderung/Privatpersonen/index-2.html

[31] KfW Bankengruppe, *Impact on Public Budgets of KfW Promotional Programmes in the Field of 'Energy-Efficient Building and Rehabilitation,'* (2011), 8. http://www.kfw.de/kfw/en/KfW_Group/Research/PDF-Files/STE_Research_Report.pdf

[32] 'Assuming the top enabling pieces discussed above are in place, do you support adoption of these policies in B.C.?: Mandatory labelling at time of sale and/or renovation for homes': 46 supported, 5 neutral, 1 opposed.

[33] During the forum and in a follow-up survey, all but one indicated support.

[34] The definition of "larger buildings" is often suggested as being >50,000 square feet for larger cities with many buildings of this size, or >20,000 square feet for medium size cities. A phased approach is also commonly suggested, with a program initially targeting very large buildings and growing in scope over time. For more context, see Canada Green Building Council, *Energy Benchmarking, Reporting & Disclosure in Canada* (2016). https://www.cagbc.org/cagbcdocs/CaGBC_National_Energy_Benchmarking%20_Framework_April_2016.pdf

[35] Government of Ontario, *Large Building Energy and Water Reporting and Benchmarking*, proposal and decision, Environmental Registry, March 6, 2017. https://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTI3ODY0&statusId=MjAwMjMy

[36] *Energy Benchmarking, Reporting & Disclosure in Canada.*

[37] International Energy Agency, *Capturing the Multiple Benefit of Energy Efficiency* (2014). http://www.iea.org/publications/freepublications/publication/Captur_the_MultiplBenef_ofEnergyEficiency.pdf

[38] *Capturing the Multiple Benefit of Energy Efficiency,* 28.

[39] See for example C-Returns (www.creturns.com), in Alberta, an integrated retrofit company offering audits and project management services, but whose staff work mostly in new construction under the Carbon Buster banner (www.carbonbusters.org/); Godo Stoyke, personal communication, 31 January 2017.

[40] PACENation, "PACE Market Data." http://pacenation.us/pace-market-data/

[41] PACENation, *C-Pace Market Update: Q3 2016*, 2. http://pacenation.us/wp-content/uploads/2017/01/Market-update-Q3-2016.pdf

[42] Residential: 58% EE, 37% RE, 4% water; Commercial: 51% EE, 36% RE, 14% mixed: "PACE Market Data."

[43] Ontario did this by amending the City of Toronto Act (O.Reg. 596/06) and the Municipal Act (O.Reg. 586/06) in 2012. Nova Scotia did this by amending the Halifax Regional Municipality Charter in 2010 and the Municipal Government Act in 2012.

[44] Resolutions B64-2014 (North Cowichan) and B19-2016 (Powell River)

[45] U.S. Federal Housing Administration, *Guidance for Use of FHA Financing on Homes with Existing PACE Liens and Flexible Underwriting through Energy Department's Home Energy Score* (2015). http://portal.hud.gov/hudportal/documents/huddoc?id=FTDO.pdf

[46] Vivian Chung, *Property-Assessed Financing in Canada: Lessons learned from Toronto's LIC program,* presentation at TLF. https://drive.google.com/drive/folders/0B_C2JmpcBJsldzVmQ1FmQ21IYU0 see also Ottwatch.ca, *Document 2: Assessment of the Use of Local Improvement Charges to Finance Home Energy Retrofits in Ottawa*, (2016) 7-8. http://ottwatch.ca/meetings/file/366137

[47] As indicated by data from the U.S., which shows that that properties with PACE bonds see an increase in resale value at least equivalent to the PACE payments completed (ie total value of PACE retrofit minus remaining payments). This should suffice in most cases to cover the few missed payments. See Laurie Goodman and Jun Zhu, "PACE Loans: Does Sale Value Reflect Improvements?" *Journal of Structured Finance* 21 (2016).

[48] Dunsky Energy Consulting, *Local Improvement Charge (LIC) Financing Pilot Program Design for Residential Buildings in Ontario* (2013), 19.

[49] MEETS Accelerator Coalition, "How MEETS works." http://www.meetscoalition.org/how-meets-works/

[50] Sources: stakeholder interviews; McKinsey & Company, *Unlocking Energy Efficiency in the U.S. Economy* (2009). https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/epng/pdfs/unlocking energy efficiency/us_energy_efficiency_exc_summary.ashx ; and Light House, 2015. *Towards Net Zero Energy Ready Residential Buildings*. http://www.sustainablebuildingcentre.com/wp-content/uploads/2011/10/BC_Part_9_Roadmap_Final_Report.pdf

[51] Based on *Unlocking Energy Efficiency in the U.S. Economy* (2009); and Integral Group, *BC Hydro Part 3 Existing Buildings Road Map* (2016). http://www.pembina.org/reports/bchydro-existing-commercial-roadmap-2016.pdf

[52] Adapted from Jens Laustsen, *Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings* (EIA, 2008). http://www.iea.org/g8/2008/Building_Codes.pdf

[53] *Unlocking Energy Efficiency in the U.S. Economy* (2009).

[54] Government of Canada, *Canada's Mid-Century Long-Term Low-Greenhouse Gas Development Strategy* (2016), 85-87 http://unfccc.int/files/focus/long-term_strategies/application/pdf/canadas_mid-century_long-term_strategy.pdf

[55] Another factor worth noting is the model's use of "intangible cost" as a parameter to represent a range of issues typical to non-mainstream technologies: a lack of information, perceived risks in cost and operation, difficulty finding trades to design and install the system or a lack of a competitive market for those services. Once the new market share of a technology gets towards 10%, those costs start declining in the model, which can lead to a feedback where the technology sees more adoption which further reduces the intangible costs. Michael Wolinetz, personal communication, 18 November 2016.

[56] Assumptions for the most recent modelling results ('reference case' and 'CLP+Fed. carbon price') follow the modelling done for Clean Energy Canada in 2015 and reported in Navius Research Inc, *A Plan for Climate Leadership in British Columbia* (2015). This modelling exercise in turn followed the same assumptions as the modelling done by Navius for the Climate Leadership Team. Thus, assumptions (e.g. population growth, projected LNG developments) are the same across the four sets of results presented here, which allows us to compare more directly the impact of the different policy options.

[57] *Modelling the Impact of the Climate Leadership Plan & Federal Carbon Price*.

[58] Climate Leadership Team, *Recommendations to Government* (2015). https://engage.gov.bc.ca/climateleadership/files/2015/11/CLT-recommendations-to-government_Final.pdf

[59] Navius Research, *A Plan for Climate Leadership in British Columbia* (2015).

[60] The CLP announced "increased efficiency requirements for gas fireplaces and air source heat pumps, effective in 2018; and high-efficiency technology requirements for natural gas space and water heating equipment, effective in 2020 and 2025 respectively" (Government of British Columbia, *Climate Leadership Plan* (2016), 36. http://climate.gov.bc.ca/feature/climate-leadership-plan/) but did not provide further clarity on the levels of performance expected. Current B.C. standard for residential gas furnaces is >= 92% AFUE and the national standard is >= 82% AFUE for residential gas boiler. The modellers chose to simulate the impact of the CLP by letting consumers choose furnaces that are either 80% or 90% efficient in the reference case scenario, and by assuming that new gas fired furnaces are at least 90% efficient by 2020 and gas-fired water heaters in homes are EF 84 or more by 2025 in the CLP scenario.

[61] Based on available case studies in Appendix F and historical LiveSmart BC statistics.

[62] Based on a rough estimate of current heat pump prices and installation costs.

[63] A range was provided with an upper bound around 30% greater than that estimated from case studies, in order to account for a steepening supply curve and the complexities of retrofits at large scale.

[64] Institute for Market Transformation and Political Economy Research Institute, *Analysis of Job Creation and Energy Cost Savings from Building Energy Rating and Disclosure Policy* (2012).

[65] Ibid.

[66] Ibid. Induced benefits were not counted for electrification, as this program would not return cost savings to consumers in the same manner as energy efficiency programs.

[67] Acadia Centre, *Energy Efficiency: Engine of Economic Growth in Canada* (2014). These numbers should be considered as maximum benefits.

[68] "Just how many jobs have been cut in the oilpatch?"

[69] NRCan Comprehensive Energy Use Database Tables (CEUD) - Historical Database August 2014. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm; NRCan Survey of Household Energy Use (SHEU) Data Tables - 2011.

[70] B.C. Stats, Building Permits, Housing Starts and Sales. http://www.bcstats.gov.bc.ca/StatisticsBySubject/Economy/BuildingPermitsHousingStartsandSales.aspx

[71] Based on NRCan data, which provides number of dwellings for these categories. Number of buildings inferred assuming an average of 200 units/building for high-rise, 35 for mid-rise, and 7 for attached.

[72] StatsCan, *Housing starts, by province*, CANSIM, table 027-0008. http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/manuf05-eng.htm

[73] NRCan Comprehensive Energy Use Database Tables (CEUD) - Historical Database August 2014. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/trends/comprehensive_tables/list.cfm; NRCan Survey of Household Energy Use (SHEU) Data Tables - 2011. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/sheu/2011/tables.cfm; NRCan Survey of Commercial and Industrial Energy Use (SCIEU) Data Tables - 2009. http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/scieu/2009/tables.cfm; BC Community Energy and Emissions Inventory (CEEI). http://www2.gov.bc.ca/gov/content/environment/climate-change/reports-data/community-energy-emissions-inventory

[74] Based on interviews with local practitioners, range depends on initial performance of the building.

[75] Based on interviews with local practitioners, available case studies and/or costing studies including: Institute for Market Transformation and Political Economy Research Institute, *Analysis of Job Creation and Energy Cost Savings From Building Energy Rating and Disclosure Policy* (2012).

[76] Based on U.S. commercial building case studies from Rocky Mountain Institute, 2012-2015. http://www.rmi.org/retrofit_depot_get_connected_true_retrofit_stories

[77] Based on case studies from Jawl Properties Ltd., 2016.

[78] Based on a case study from Morguard, 2016.

[79] This example utilized extensive heat recovery which is not possible for all buildings.

[80] Andrew Pape-Salmon, *Deep Energy Retrofit of the Belmont.* http://rdh.com/wp-content/uploads/2015/08/Deep-Energy-Retrofit-Vancouver-Andrew-Pape-Salmon.pdf

[81] Bryan Purcell, "TowerWise.ca: Introduction to Tower Retrofits," presentation, Tower Retrofit webinar series, 2011. http://towerwise.ca/wp-content/uploads/2013/05/TowerWise-Intro-to-energy-retrofits-presentation.pdf

[82] Paul Bertram, "Challenges and Opportunities in Deep Envelope Retrofitting," *Kingspan*, November 16, 2015. http://www.kingspanpanels.us/kingspan-news-us/november-2015/challenges-and-opportunities-in-deep-envelope-retrofitting

[83] Baden-Württemberg Klimaschutz und Energieagentur, *Business and Technical Concepts for Deep Energy Retrofits of Public Buildings* (2014). http://bpie.eu/wp-content/uploads/2015/11/Business-and-technical-concepts-for-deep-energy-retrofits-in-public-buildings-IEA-EBC-Annex-61-findings-Rudiger-Lohse-IEA-Annex-61.pdf

[84] Based on interviews with Stadsruim, 2016.

[85] Martin Holladay, "The High Cost of Deep-Energy Retrofits," *Green Building Advisor*, 2012. http://www.greenbuildingadvisor.com/blogs/dept/musings/high-cost-deep-energy-retrofits

[86] Martin LaMonica, "'Deep-energy retrofits' take root in homes," *CNet*, 2010. https://www.cnet.com/news/deep-energy-retrofits-take-root-in-homes/

[87] Based on interviews with Stadsruim, 2016.