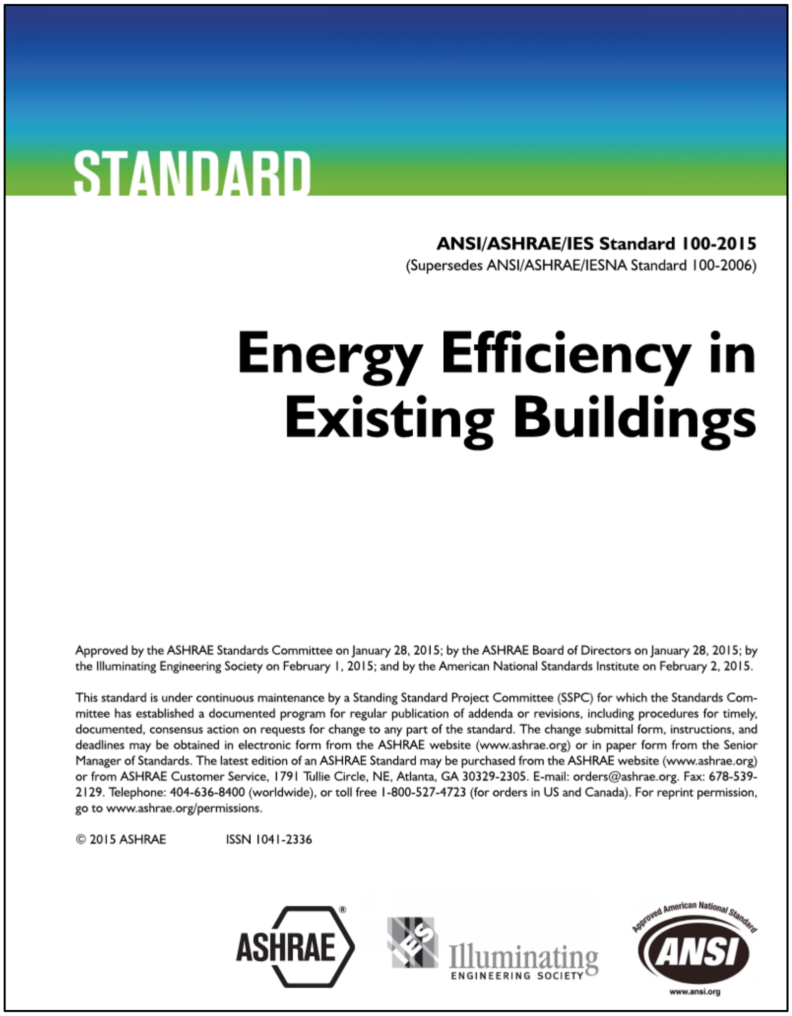
RDH BUILDING SCIENCE

White Paper: Review of Potential Energy Efficiency Standards for Existing Buildings In BC

Project 8777.006



STANDARD

ANSI/ASHRAE/IES Standard 100-2015
(Supersedes ANSI/ASHRAE/IESNA Standard 100-2006)

Energy Efficiency in Existing Buildings

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Appendices

1 Glossary of Acronyms

AHJ	Authority Having Jurisdiction
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BC	British Columbia
BCBC	British Columbia Building Code
BOMA	Building Owners and Managers Association
BOMA BESt	Building Owners and Managers Association – Building Environmental Standards
BSSB	Building and Safety Standards Branch
CARIP	Climate Action Revenue Incentive Program
CBECS	Commercial Buildings Energy Consumption Survey
CEEP	Community Energy and Emissions Plan
CELP	Community Energy Leadership Program
CEM	Community Energy Manager
CIB	Carbon Investment Branch
CMHC	Canada Mortgage and Housing Corporation
DCC	Development Cost Charges
DHW	Domestic Hot Water
DPA	Development Permit Area
ECAD	Energy Conservation Audit & Disclosure Ordinance (Austin)
ECM	Energy Conservation Measure
EUI	Energy Use Intensity
GHG	Greenhouse Gas
HVAC	Heating, Ventilating and Air Conditioning
ICC	Incremental Capital Cost
IECC	International Energy Conservation Code
LEED	Leadership in Energy and Environmental Design
LPD	Lighting Power Density
MURB	Multi-Unit Residential Building
NECB	National Energy Code of Canada for Buildings
NPV	Net Present Value
NRCan	Natural Resources Canada

NYC	New York City
OBC	Ontario Building Code
OCP	Official Community Plan
RECS	Residential Energy Consumption Survey
RGS	Regional Growth Strategy
SCP	Sustainable Communities Program
SEBC	Seattle Existing Building Code
SWH	Service Water Heating
VBBL	Vancouver Building By-Law

2 Executive Summary

This White Paper explores opportunities to develop new energy efficiency standards for existing buildings in BC through the application of third-party, model standards and codes. The objective is to improve the energy efficiency of existing buildings at the time of construction and thereby reduce energy consumption and greenhouse gas emissions. The application of energy efficiency standards to existing buildings also has the potential to contribute to a range of non-energy co-benefits, such as enhanced community economic development, resilience to climate change, and improved air quality and health.

Implementation options are presented that align with the objectives of the *Building Act* and with the competency of building officials who enforce the code. The options also promote consistency and innovation within the building regulatory system.

This work has been sponsored by FortisBC and BC Hydro. It was developed in close consultation with a steering committee comprised of the Building and Safety Standards Branch and the Ministry of Energy and Mines. This document is not intended to serve as a regulatory proposal, but rather it provides background information and an analysis of key options to inform discussion with key influencers and stakeholders.

2.1 Methodology

The White Paper represents a synthesis of the following stages of research undertaken by the study team:

1. Review and evaluation of a set of 15 existing energy efficiency standards and codes against a set of evaluation criteria defined by the Steering Committee, in order to select a short-list of codes for additional analysis.
2. Conduct market research and provide an overview of the existing regulatory framework to serve as a baseline for recommendations. The regulatory framework review involved identification of relevant acts, regulations, codes, and standards. Market research included: an assessment of the current level of permit applications in the province, and a survey and interviews with ten local authorities to evaluate their experience applying related codes and standard.
3. Perform technical and economic analyses of three short-listed standards, in which the potential impact across BC for all BC Building Code (BCBC) and Vancouver Building Bylaw (VBBL) triggered construction works was evaluated.
4. Assess the non-energy co-benefits that could be realized through application of new energy efficiency requirements. The existing base of activity, which could be leveraged to launch a new code, was also reviewed.
5. Develop conclusions and recommendations on applying codes and standards to existing buildings.

2.2 Results

2.2.1 Review of Standards

Fifteen standards were reviewed and assessed for their applicability to form the basis of new energy efficiency requirements for existing buildings within the BC Building Code. A set of three codes were short-listed, including:

- → ASHRAE 90.1-2010, as it is currently regulated under the BCBC and VBBL and includes provisions for existing building alterations.
- → NECB-2015, recently published, with the likelihood of being amended to enable application to existing buildings.
- → ASHRAE 100-2015, as it was written for the specific purpose of improving energy efficiency in existing buildings.

2.2.2 Market and Policy Research

Existing Regulatory Framework

The existing regulatory framework for developing a new energy efficiency code for existing buildings includes the following: the Building Act, Energy Efficiency Act, Vancouver Charter, Safety Standards Act, BC Building Code, Vancouver Building Bylaw and Energy Efficiency Standards Regulation.

Market Research

Market research was conducted by evaluating market-wide building permit data and through a survey of ten building officials from a diverse set of municipalities across the province. The key conclusions drawn were:

- → There is the potential to influence approximately 7,000 building permits per year, representing about 10% of the BC Building stock annually. However, it is expected that only a proportion of those permits are related to energy—the others are assumed not to affect major energy systems such as lighting, heating, ventilation, and air conditioning, service water, power, and building envelope. As such, a more realistic impact would be 3-4% of the building stock affected each year.
- → Approximately 81% of annual permits are for small projects across the building stock, with an average permit value of $44,000. These are only conducive to minor energy upgrades, with 85% affecting lighting systems through tenant improvements and 25% affecting service water heating (some overlapping with lighting).
- → Nearly 29% of annual permit value is for office building upgrades, followed by retail (trade and service) at 21%, small projects at 20%, and multi-unit residential and hotel/restaurant each at 11% of total permit value.

Energy standards are only actively enforced by two of the ten municipalities interviewed. As such, universal application of the ASHRAE 90.1 standards, currently referenced in BC regulations, may lead to incremental energy savings

2.2.3 Technical and Economic Assessment

The technical and economic analysis for each code scenario has been determined for province-wide implementation. Table 2.1 provides a summary for economic and energy analysis for a single year of each code scenario implemented in 2016. Table 2.2 provides the cumulative annual savings for each code scenario over the period from 2016-2020 or 2016-2025.

TABLE 2.1 ANNUAL COST AND SAVINGS FOR A SINGLE YEAR OF IMPLEMENTATION FOR EACH CODE SCENARIO (WITH MULTIPLE YEARS OF BENEFITS)

	ASHRAE 90.1-2010	NECB 2015	ASHRAE 100-2015	ASHRAE 90.1-2010 & ASHRAE 100-2015[1]
Applicable Permits	All	All	Excl. Small Projects	ALL
incremental capital Cost	$55 million (4%)	$50 million (4%)	$81 million (7%)	$112 million (8%)
Net present value	$15 million	$12 million	$76 million	$83 million
Electricity Savings	63 GWh/yr	54 GWh/yr	62 GWh/yr	98 GWh/yr
NG Savings	0.7 GWh/yr (2,500 GJ)	2.1 GWh/YR (7,600 GJ)	69 GWh/yr (248,000 GJ)	64 GWh/yr (230,000 GJ)
GHG Savings	765 t/yr	914 t/yr	13,060 t/yr	12,500 t/yr

TABLE 2.2 CUMULATIVE ANNUAL ENERGY SAVINGS FOR EACH CODE SCENARIO

		ASHRAE 90.1-2010	NECB 2015	ASHRAE 100-2015	ASHRAE 90.1-2010 & ASHRAE 100-2015[2]
Cumulative Annual Electricity Savings	in 2020	930 GWh/yr	800 GWh/yr	915 GWh/yr	1,450 GWh/yr
	in 2025	3,400 GWh/yr	2,900 GWh/yr	3,300 GWh/yr	5,225 GWh/yr
Cumulative Annual Natural Gas Savings	in 2020	11 GWh/yr (40,000 GJ/yr)	30 GWh/hr (108,000 GJ/yr)	1,000 GWh/yr (3,600,000 GJ/yr)	950 GWh/yr (3,420,000 gj/yr)
	in 2025	40 GWh/yr (144,000 GJ/yr)	110 GWh/yr (396,000 GJ/yr)	3,700 GWh/yr (13,320,000 GJ/yr)	3,400 GWh/yr (12,240,000 GJ/yr)
Cumulative Annual GHG Savings	in 2020	0.01 Mt/yr	0.01 Mt/yr	0.19 Mt/yr	0.19 Mt/yr
	in 2025	0.04 Mt/yr	0.05 Mt/yr	0.70 Mt/yr	0.67 Mt/yr

The ASHRAE 100-2015 analysis (column 3) was applied only to permits for larger construction projects to which a whole-building energy efficiency standard would be applicable. The analysis combining ASHRAE 90.1-2010 and ASHRAE 100-2015 (column 4) assumes that ASHRAE 100-2015 applies to all large permits and ASHRAE 90.1-2010 applies to all small projects. This results in a reduction in natural gas (and thus GHG) savings due to the prevalence of lighting upgrades associated with the small projects, causing increases in space heating requirements and natural gas consumption. Applying 90.1-2010 to small projects in conjunction with ASHRAE 100-2015 to large permits results in substantial electricity savings beyond implementation of either standard in isolation.

[1] The ASHRAE 90.1-2010 & ASHRAE 100-2015 analysis combines the use of the two standards by applying ASHRAE 90.1-2010 to all Small Projects and ASHRAE 100-2015 to all other permits.
[2] Ibid

2.2.4 Non-Energy Co-Benefits and Complementary Initiatives

There are a range of non-energy co-benefits that can be realized through enhancements to the energy efficiency of existing building stock. Some of these co-benefits include:

→ Climate change mitigation associated with reduced energy demand.

→ Improved resilience associated with reduced dependence on energy infrastructure and reduced vulnerability of building stock through weatherization improvements.

→ Increased affordability due to reduced energy costs and job creation.

→ Community economic development through a range of indirect and induced economic benefits, such as improved business competitiveness, higher property values, and job creation.

→ Improved health and comfort for building occupants through reduced noise, comfortable indoor temperatures, and, in cases when ventilation systems are renewed, improved indoor air quality.

→ Increased predictability of outcomes associated with energy efficiency improvements, facilitating more accurate demand forecasting by governments.

A range of complementary initiatives have begun to pave the way for the successful roll-out of new energy efficiency revisions to the building code, including:

→ Existing Provincial legislation and supporting tools developed to support local government climate action, such as the Climate Action Charter, the Local Government Green Communities Statutes Amendment Act, other enabling regulations, and funding and incentives.

→ Funding and incentive programs offered by utilities and private entities such as BC Hydro, Fortis BC, CMHC, and BOMA.

2.3 Recommendations

The recommendations for an energy code for existing buildings combines both a component/system based standard (ASHRAE 90.1-2010) and whole building standard (ASHRAE 100-2015) in order to apply to a range of permit sizes and provide potential flexibility for compliance. The two options include a tiered approach to allow for phased implementation needed to overcome barriers to compliance. Table 2.3 highlights the cumulative annual savings of the two recommended implementation options. It is assumed that the Tiers indicated apply to all relevant permits from the indicated date of implementation.

Option 1

→ Tier 1 (2017-2021)

  → ASHRAE 90.1-2010 applies to all energy related permits.

→ Tier 2 (2022-2030)

  → ASHRAE 90.1-2010 applies to all energy related permits for Small Projects.

  → ASHRAE 90.1-2010 applies to 90% of energy related permits and ASHRAE 100-2015 applies to the remaining 10% of energy related permits for all other segments.

Option 1 essentially represents an extension of the current regulatory environment in British Columbia, with an expansion of flexibility in the Tier 2 implementation (2022). Currently, the BC Building Code mandates ASHRAE 90.1-2010 compliance for construction and change of occupancy in existing buildings. However, there are considerable barriers preventing its implementation and thus, it shouldn't be assumed that those savings are being achieved. Compliance with the BC Building Code is limited, as evidenced by the fact that only 3 out of 10 surveyed municipalities routinely enforce it. This White Paper considers an alternative approach (Option 2 below) that would expand the savings and financial benefits. Option 1b is presented as an alternate that utilizes mandatory retro-commissioning of building systems for large renovations.

Option 1b

- → Tier 1 (2017-2021)
  - → ASHRAE 90.1-2010 applies to all energy related permits.
- → Tier 2 (2022-2030)
  - → ASHRAE 90.1-2010 applies to all energy related permits for all projects.
  - → Retro-commissioning is required as a component of all large projects

Option 2

- → Tier 1 (2017-2021)
  - → ASHRAE 90.1-2010 applies to all energy related permits.
- → Tier 2 (2022-2026)
  - → ASHRAE 90.1-2010 applies to all energy related permits for Small Projects.
  - → ASHRAE 100-2015 Alternate EUIs (40th percentile lowest consumption) applies to all energy related permits for all other segments.
- → Tier 3 (2027-2030)
  - → ASHRAE 90.1-2010 applies to all energy related permits for Small Projects.
  - → ASHRAE 100-2015 (25th percentile lowest consumption) applies to all energy related permits for all other segments.

TABLE 2.3 SUMMARY OF CUMULATIVE ANNUAL SAVINGS RESULTING FROM IMPLEMENTATION OF RECOMMENDED POLICY OPTIONS

		OPTION 1	OPTION 1B	OPTION 2
Cumulative Annual Electricity Savings	in 2025	2,800 GWh/yr	2,900 GWh/yr	3,000 GWh/yr
	in 2030	6,400 GWh/yr	7,100 GWh/yr	7,400 GWh/yr
Cumulative Annual Natural Gas Savings	in 2025	77 GWh/yr (277,000 GJ/yr)	215 GWh/yr (775,000 GJ/yr)	470 GWh/yr (2,400,000 GJ/yr)
	in 2030	270 GWh/yr (970,000 GJ/yr)	880 GWh/yr (3,170,000 GJ/yr)	2,200 GWh/yr (7,920,000 GJ/yr)
Cumulative Annual GHG Savings	in 2025	0.04 Mt/yr	0.06 Mt/yr	0.11 Mt/yr
	in 2030	0.11 Mt/yr	0.20 Mt/yr	0.47 Mt/yr
Discounted Cumulative ICC (2017 $)	in 2025	$405 million	$405 million	$483 million
	in 2030	$560 million	$560 million	$764 million
Discounted Cumulative NPV (2017 $)	in 2025	$123 million	$138 million	$234 million
	in 2030	$175 million	$205 million	$439 million

It is noted that future editions of the noted standards (ASHRAE 90.1 and 100) could be referenced in lieu of the ones evaluated in this report, although the analysis is based on the currently available standards. In addition, though the analysis has been performed using ASHRAE 90.1-2010, the potential exists for NECB to be applied instead. Currently, NECB does not apply to building alternations, but a proposal to the Standing Committee for Energy Efficiency in Buildings would expand its scope to include existing buildings, likely for the 2017 amendments to the NECB-2015.

The following trade-offs are highlighted as possible topics for discussion with stakeholders to determine a priority between Options 1 and 2:

→ Option 1 minimizes incremental capital costs to owners – approximately 4%. Option 2 incremental costs average 8% following full implementation and thus, may require companion financial measures such as property-assessed and/or on-bill financing.

→ Option 1 ensures familiarity of industry players with current regulated standards.

→ Option 2 maximizes economic benefits to consumers.

→ Option 2 maximizes flexibility for compliance.

→ Option 2 has moderate needs for preparation by implementing governments, including but not limited to developing a BC-specific table of EUIs for ASHRAE 100[3], new regulations for enforcement actions following the building permit and financing options to address higher incremental capital costs.

→ Both options may require exemptions for certain building types and owners, to be confirmed through consultations.

→ Both options require industry capacity building and training.

→ Both options require companion market transformation incentives and measures to ready the marketplace for Tier 2 and 3.

[3] This BC-specific table of EUIs could be developed using the methodology described in ASHRAE 100-2015 by substituting the US Commercial Building Energy Consumption Survey (CBECS) data with the Canadian-specific NRCan Survey of Commercial and Institutional Energy Use (SCIEU).

3 Introduction

The BC Building Code (BCBC) and Vancouver Building Bylaw (VBBL) are triggered for construction projects involving existing buildings, essentially applying relevant provisions of the associated energy standards (i.e., ASHRAE 90.1-2010 and NECB-2011) to those building systems being affected by renovation, addition, or change in occupancy types of activities. This is in addition to energy efficiency requirements for building components and equipment under both the BC and NRCan *Energy Efficiency Act* legislation, triggered at the time of purchase of energy devices such as windows or boilers.

In the case of the VBBL, an additional set of requirements applies to the whole building, depending on the type of renovation activity, with a significant amount of flexibility on compliance options. However, jurisdictions outside of Vancouver do not have whole building energy efficiency requirements, which represents a lost opportunity for cost-effective energy efficiency improvements in the province.

This White Paper explores opportunities to develop new energy efficiency requirements for existing buildings in a way that aligns with the objectives of the *Building Act,* and in a way that promotes consistency and innovation within the building regulatory system and competency of building officials who enforce the code. It is noted that any energy efficiency standards shall be aligned with all of the objectives of the BC Building Code, namely health, safety, and protection of persons or property, accessibility, energy and water conservation, and greenhouse gas reductions. The objectives other than energy efficiency are not evaluated in this White Paper.

The purpose of this White Paper is to provide technical, economic, and policy analysis on options to achieve incremental energy savings for existing buildings in British Columbia through the application of codes and standards. Options are presented that will improve the energy efficiency of existing buildings, which will reduce energy consumption and greenhouse gas emissions, while also contributing to a series of additional co-benefits. This document is not intended to serve as a regulatory proposal, but rather it seeks to provide the necessary background information and an analysis of key options to inform a discussion with key influencers and stakeholders.

3.1 Context

This work has been sponsored by FortisBC and BC Hydro. It was developed in close consultation with a steering committee comprised of the Building and Safety Standards Branch and the Ministry of Energy and Mines. In 2011, the Building and Safety Standards Branch (BSSB) hosted an “Existing Buildings Project: Energy and Water Efficiency Working Group” and held discussions about a number of options to advance energy efficiency for existing buildings over the course of five meetings with industry stakeholders.

3.2 Report Structure

This White Paper contains the following components:

1. Section 4 includes an overview and selection of a short-list of existing energy standards developed by government accredited standards development

organizations. Section 5 provides a synthesis of market data such as building permits applied for and overall building metrics.

2. Section 6 presents a technical and economic analysis for the application of short-listed standards across BC for all BCBC and VBBL triggered construction works.
3. Section 7 summarizes the complementary benefits that could accrue to local governments and utilities through application of these new energy efficiency requirements.
4. Sections 8 & 9 provide conclusions and recommendations on two paths forward for applying codes and standards to existing buildings.

4 Review of Standards

A review of relevant energy efficiency standards, codes, and regulations from third parties and government jurisdictions was performed to develop a database and framework of potential options to apply in the development of an Energy Code for Existing Buildings in British Columbia. The standards, codes and regulations reviewed include:

- ASHRAE 100-2015
- ASHRAE 90.1-2010
- Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)
- BOMA BESt
- Boston Energy Assessment and Retro-commissioning Requirements (Component of the Building Energy Reporting and Disclosure Regulation)
- City of Atlanta Land Development Code, Part II, Section 8-2002
- City of Berkeley Building Energy Saving Ordinance
- International Energy Conservation Code (IECC) 2015
- LEED for Existing Buildings
- NECB 2015
- NYC Local Law 87 - Audits and Retro-commissioning
- NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces
- Ontario Building Code incl. SB-10 “Energy Efficiency Supplement”
- San Francisco Commercial Buildings Energy Performance Ordinance
- Seattle Existing Building Code
- Title 24 Part 6 - California Energy Code
- VBBL Part 11 - Existing Buildings

A summary and table of information gathered for each standard is provided in Appendix A.

4.1 Selection of Standards for Further Analysis

The project Steering Committee identified a set of evaluation criteria for assessing which of the aforementioned standards and regulatory approaches should be considered for further analysis. The Steering Committee felt that the most ideal standards were those:

- developed by government accredited standards development organizations, and are thus maintained on a routine basis through the work of committees;
- affecting all major building energy systems and capable of reducing electricity and natural gas consumption;
- leading to measurable and predictable outcomes, using performance and/or objectives based approaches;
- aligning with current regulatory triggers under the BC *Building Act* and Vancouver Charter, namely completion of construction and issuance of a permit;
- having the potential for staged implementation, with magnitude of impact commensurate to the type of building permit being applied for; and,

→ providing sufficient flexibility to address differences between building occupancy types, size, geography and type of construction.

A detailed overview of the analysis of the standards is included in Appendix A. The analysis revealed three standards that met all of the criteria listed above and were therefore selected for further analysis (see Section 6):

→ ASHRAE 100-2015, as it was written for the specific purpose of improving energy efficiency in existing buildings.

→ ASHRAE 90.1-2010, as it is currently regulated under the BC Building Code and Vancouver Building Bylaw and includes provisions for existing building alterations.

→ NECB 2015, recently published, with the likelihood of being amended to enable application to existing buildings.

A summary of these three standards is provided below.

ASHRAE 100-2015

ASHRAE Standard 100-2015 Energy Efficiency in Existing Buildings is a standard that "provides criteria that will result in energy efficiency in existing buildings". The standard provides energy use intensity (EUI) targets based on measured data from the existing building stock for 53 building types (residential and non-residential) in each of the ASHRAE Climate Zones. The EUI targets were derived using data from the Commercial Building Energy Consumption Survey (CBECS) 2003 and the Residential Energy Consumption Survey (RECS) that was then extrapolated to 17 DOE climate zones using multipliers developed from modeling by the Oak Ridge National Laboratory. The standard provides requirements for an energy management plan, an operation and maintenance program, and building energy use. Buildings that do not comply with energy efficiency targets are required to engage a professional to perform energy audits and to implement energy conservation measures (ECMs) to improve building performance. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

ASHRAE 90.1-2010

ASHRAE Standard 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings is a standard that provides minimum efficiency requirements for new buildings, additions to existing buildings, new systems and equipment, or alterations to existing buildings. The standard contains both performance and prescriptive compliance paths to achieve the goal of energy efficient buildings. The prescriptive path requires that the building meets all of the minimum efficiency requirements for each building system or component as specified in Sections 5 through 10. The performance path requires that an energy cost budget be developed through energy modeling of a baseline building with the same size and program as the desired building that meets the prescriptive requirements. The design of the desired building is then modelled and must achieve an energy cost budget lower than the baseline.

ASHRAE 90.1-2010 provides design requirements for new buildings and building components to ensure energy efficient operation. Details are provided for all aspects of the building design, maintenance, and operation. The standard is continuously maintained and updated to more stringent energy efficiency requirements. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

ASHRAE 90.1-2010 contains provisions for specific application of the standard for alterations to existing buildings. A number of exemptions exist for application of the standard or sections of the standard. A selection exemptions of particular relevance to existing buildings include:

- → From Section 4.2.1.3 Alterations of Existing Buildings – "a building that has been specifically identified as historically significant by the adopting authority" is exempt.
- → From Section 5.1.3 Envelope Alterations – Exemptions:
  - → replacement of glazing in existing sash and frame provided the U-factor and SHGC will be equal to or lower than before the glass replacement
  - → alterations to roof/ceiling , wall, or floor cavities, which are insulated to full depth with insulation having a minimum nominal value of R-3.0/in.
  - → alterations to walls and floors, where existing structure is without framing cavities and no new framing cavities are created
  - → replacement of a roof membrane where either the roof sheathing or roof insulation is exposed or, if there is existing roof insulation, below the roof deck
  - → replacement of existing fenestration, provided, however, that the area of the replacement fenestration does not exceed 25% of the total fenestration area of an existing building and that the U-factor and SHGC will be equal to or lower than before the fenestration replacement
- → From Section 9.1.2 Lighting Alterations – "Alterations that involve less than 10% of the connected lighting load in a space or area need not comply with these requirements provided that such alterations do not increase the installed LPD."

National Energy Code of Canada for Buildings (NECB 2015)

The 2015 version of the NECB was released in December 2015. The updated version consists of similar compliance structures as the earlier version but includes a number of changes to increase the level of energy efficiency requirements. The scope of the standard includes energy efficiency in the design and construction of new buildings and in additions to existing buildings. It does not cover alterations to existing buildings. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance. Compliance with the NECB can be achieved through a prescriptive path, a trade-off path, or a performance path. The prescriptive path requires that a building meets the minimum energy efficiency requirements set forth in the NECB. The trade-off path allows the design to trade elements within the same "part" of the building to achieve compliance. An example can include allowing more window area by trading for an improved envelope insulation. The performance path requires that the design of the new building be demonstrated to use less energy than an equivalent building built to the prescriptive requirements.

The Standing Committee on Energy Efficiency for Buildings, a volunteer group that provides advice to the Canada Codes Centre, recently approved a strategic direction to amend the NECB to enable its application to existing buildings, either as a 2017 interim update or within the 2020 NECB.

5 Existing Regulatory Framework and Market Research

In developing this White Paper, the study team undertook market and policy research to assess the options available to the Province for enacting energy efficiency requirements for existing buildings at the time of alteration or repair of existing buildings. The key objectives for the market and policy research were to summarize:

→ existing “triggers” in BC, including *Building Act*, *Energy Efficiency Act*, *Vancouver Charter*, and *Safety Standards Act*;

→ current energy code application and permit characteristics from up to 10 local authorities based on internet search and surveys;

→ a matrix of building and construction type, building size, value of permits and other relevant data, as available;

→ typical regulatory procedures for applying energy standards to existing buildings, including administrative frameworks (inspections, letters of assurance, third party certification) and resourcing (permit fees, consultant fees, manufacturer and taxpayer funding, etc.) for aforementioned triggers; and

→ alignment with current and prospective institutions that could administer requirements (with legislative/regulatory changes), including local authority building inspection departments, the BC Safety Authority, professional oversight or others.

5.1 Summary of Legislation, Regulations, Codes and Standards

The following legislation and regulations pertaining to energy efficiency in buildings are in force within British Columbia as of the time of writing this document. The scope of analysis and recommendations within this White Paper are defined by the current legislative framework in BC, assuming that new legislation is not required to achieve the estimated energy savings, nor legislative amendments. In addition, current regulations are noted. It is assumed that regulatory amendments may be required to achieve energy efficiency improvements in existing buildings.

5.1.1 Building Act

The *Building Act* was finalized in 2015 and many provisions entered into force later that year. Further regulatory development is ongoing but full implementation is expected by 2017. As noted earlier, the *Building Act* aims to improve consistency in the building regulatory system and, as such, significant new regulatory powers are provided to the Minister Responsible for Housing. These include, under Part 2 – Building Regulations, Section 3(2)(c):

i. the design of buildings or planning of building activities;

ii. the inspection of buildings or building activities;

iii. the designs, plans, notices, reports or other records relating to an activity referred to in subparagraph (i) or (ii);

iv. the preparation, retention or inspection of records; and

v. any other matter that the minister considers necessary or advisable.

The definition of “building activity” includes, (a) the construction of new buildings, or (b) the alteration, repair or demolition of existing buildings.

This Act is the most comprehensive for potentially setting energy efficiency standards in existing buildings. It broadens the scope of the BC building regulatory system beyond construction, as was the case under the *Local Government Act*. As such, a variety of regulatory triggers could be established. However, for the purposes of this analysis, it is assumed that such standards would only apply at the time of construction, as the costs of achieving higher levels of energy efficiency are potentially minimized when they piggyback on existing construction activities.

5.1.2 BC Building Code

Aligned with the Building Act, the 2012 BC Building Code (with amendments in 2015) applies to a number of construction related activities for buildings, namely (those that are relevant to this project are highlighted in **bold**):

a. the design and construction of a new building;

b. the occupancy of any building;

c. a change in occupancy of any building;

d. an alteration of any building;

e. an addition to any building;

f. the demolition of any building;

g. the reconstruction of any building that has been damaged by fire, earthquake or other cause;

h. the correction of an unsafe condition in or about any building;

i. all parts of any building that are affected by a change in occupancy;

j. the work necessary to ensure safety in parts of a building

  i. that remain after a demolition,

  ii. that are affected by but that are not directly involved in alterations, or

  iii. that are affected by but not directly involved in additions;

k. except as permitted by the British Columbia Fire Code, the installation, replacement, or alteration of materials or equipment regulated by this Code;

l. the work necessary to ensure safety in a relocated building during and after relocation;

m. safety during construction of a building, including protection of the public;

n. the design, installation, extension, alteration, renewal or repair of plumbing systems; and

o. the alteration, rehabilitation, and change of occupancy of heritage buildings.

Energy efficiency requirements are defined in Part 10 of the BCBC and reference either ASHRAE 90.1 (2010) or NECB (2011). These energy standards currently apply to existing buildings at the time of construction or change of occupancy. However, there are three issues that have resulted in the majority of construction activities for existing buildings being exempt:

1. The NECB (2011) technically does not apply to existing buildings, as stated in code language, except for additions to existing buildings.
2. There are numerous exemptions (see Section 4.1) within ASHRAE 90.1 (2010), particularly for the building envelope, although the standard applies extensively to mechanical equipment and lighting system alterations that affect more than 10% of the connected lighting load.
3. The enforcement of energy standards by local authorities appears to be minimal, with some exceptions, as outlined in the next section.

5.1.3 BC Energy Efficiency Act

The BC Energy Efficiency Act applies to products that use energy, or control or affect the use of energy, excluding buildings as a whole but including appliances, equipment, and manufactured building components. While it is not the central legislation considered for this White Paper to achieve comprehensive energy efficiency improvements in existing buildings, the Act is triggered for the manufacture, offer for sale, sale, lease or disposal of such products. Thus, it applies to existing buildings.

5.1.4 Energy Efficiency Standards Regulation

Aligned with the *Energy Efficiency Act*, the regulation provides minimum energy performance standards and labelling that applies to the installation of the following equipment types into existing buildings:

- → Part 2 — Consumer Electronic Products
- → Part 3 — Manufactured Fenestration Products
- → Part 4 — Household Appliances
- → Part 5 — Heating, Ventilation and Air Conditioning Products
- → Part 6 — Water Heaters
- → Part 7 — Lighting Products
- → Part 8 — Electric Motors

Regulated standards are generally enforced at the earliest point of the supply chain within the province of BC, either by manufacturers, distributors, or at the point of construction in a building. These provide a significant opportunity to improve energy efficiency in existing buildings.

5.1.5 Safety Standards Act

The BC Safety Standards act does not include energy efficiency, nor emissions reductions within its objectives or scope. Thus, it is not relevant for this assignment.

5.1.6 Vancouver Building Bylaw

Aligned with the Vancouver Charter, a summary of the relevant excerpts from the Vancouver Building Bylaw (VBBL) is presented in the Appendix. Similar to the BC Building Code, application of the VBBL is defined in section 1.1.1.1 whereby the code applies to any one or more of the following:

→ the design and construction of a new building,

→ the occupancy of any building,

→ a change in occupancy of any building,

→ an alteration of any building.

5.2 Summary of Provincial Permit Statistics

5.2.1 Market Wide Data

Monthly construction statistics were obtained from Statistics Canada Report 64-001-X to understand the level of retrofit and renovation activity in the Province. Each municipality in the Province is required to submit statistics on the number and value of permits taken out, broken down by new construction and renovation. A summary of activity in BC is presented in Figure 5.1. Based on these data, there were roughly 6,000 permits taken out every year for existing buildings for the period of 2008 to 2015, with a total value of approximately 1.2 billion dollars per year.

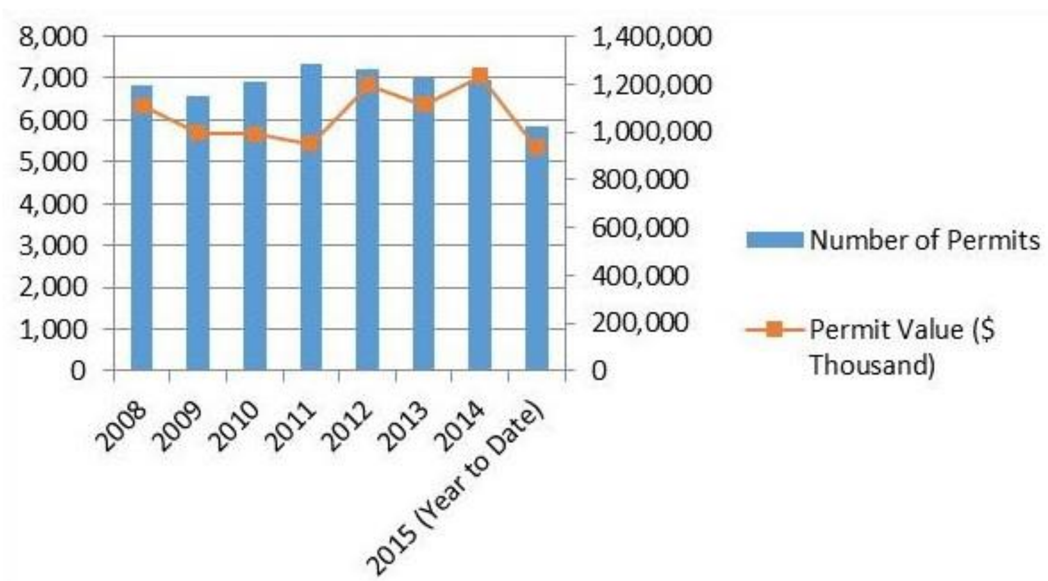

Figure 5.1 Alteration Permits in BC (Number and Value), 2008 to 2015

The sectors used to allocate permits consist of:

→ Hotel, Restaurant – consists of permits for buildings such as hotels, motels, restaurants, bars, etc.

→ Laboratory – consists of permits for buildings such as medical laboratories, research centers, etc.

→ MURB – consists of permits for buildings such as apartment buildings, duplexes, triplexes, condominiums, etc.

→ Office Building – consists of permits for buildings such as office buildings, medical offices, banks, etc.

→ Recreation – consists of permits for buildings such as theatres, sports complexes, arenas, swimming pools, golf clubs, camping facilities, etc.

→ Service Stations – consists of permits for buildings such as vehicle garages, car dealerships, gas stations, repair facilities, etc.

→ Small Projects – consists of permits for all segments with a value less than $250,000

→ Trade and Service – consists of permits for buildings such as retail and wholesale outlets, shopping centers, lumber yards, department stores, etc.

→ Warehouse – consists of permits for buildings such as storage buildings, industrial malls, locker rentals, refrigerated storage terminals, etc.

Table 5.1 and Figure 5.2 provide segmented renovation activity in BC. Small projects account for the majority of renovation activity. The average value of these permits was $44,000 per permit. The breakdown of permit activity by average value of permits shows that Offices, Trade and Service, and Small Projects make up the largest areas of renovation activity.

TABLE 5.1 BREAKDOWN OF RENOVATION PERMITS BY SEGMENT, 2014

SEGMENT	NUMBER OF PERMITS	PERMIT VALUE ($ THOUSAND)	AVERAGE VALUE PER PERMIT
Hotel, Restaurant	156	$135,424	$868,103
Laboratory	3	$1,470	$490,000
MURB	513	$135,885	$264,883
Office Building	273	$355,799	$1,303,293
Recreation	49	$54,946	$1,121,347
Service Stations	19	$11,156	$587,158
Small Project	5,643	$248,060	$43,959
Trade and Service	223	$252,567	$1,132,587
Warehouse	56	$38,101	$680,375
Total	6,935	$1,233,408	$177,853

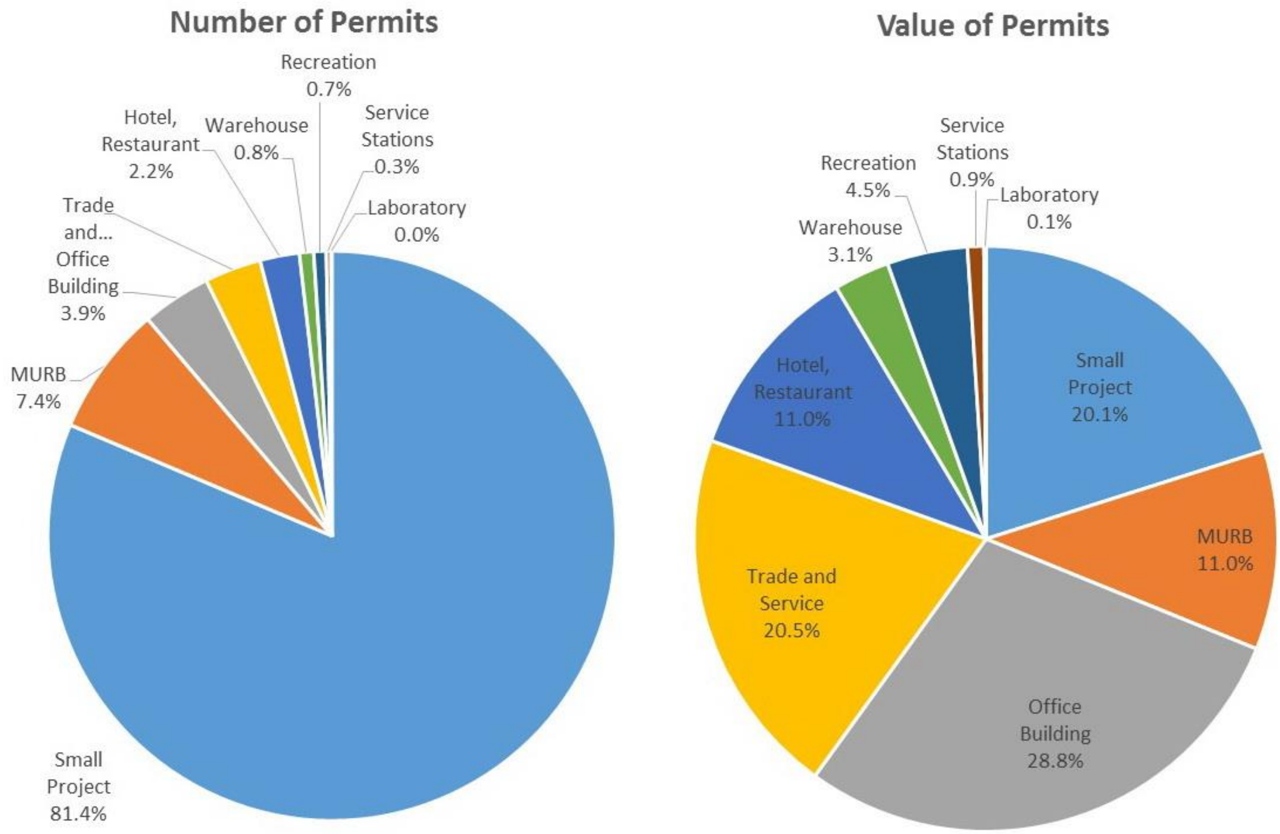

Figure 5.2: Percentage of renovation activity in each segment by number of permits (left) and value of permits (right)

5.2.2 Local Authority Perspectives

A survey was developed and delivered to all authorities having jurisdiction (AHJs) to enforce the BC Building Code via the Building Officials Association of BC. The survey form presented in Appendix B was emailed to every AHJ in the province. After three weeks, only one partially completed form had been submitted. Therefore, team members conducted structured telephone interviews to a number of AHJs to gain insight into the perspective of local authorities. It was found that building inspectors were highly interested in this analysis and were very willing to share their thoughts through a less formal interview process.

Effort was made to provide a regional balance as well as to solicit input from municipalities of different sizes. Jurisdictions who participated in the telephone survey included the following:

1. City of Campbell River
2. City of Coquitlam
3. City of Kamloops
4. City of Langford
5. City of North Vancouver
6. City of Penticton

7. City of Prince George
8. City of Surrey
9. City of Vancouver
10. City of Victoria

Summary of Survey Responses

The telephone interviews included a series of standard questions, the responses to which are summarised below.

Application of energy efficiency requirements in Part 10 of the BC Building Code to permits for existing buildings (ASHRAE 90.1-2010 and NECB-2011):

→ Most jurisdictions stated that they generally applied the energy efficiency requirements for ASHRAE 90.1 to existing buildings; however, there was significant latitude in interpreting the requirements for existing buildings. Three of the AHJs stated that the current BCBC does not provide local authorities an enforceable mandate to regulate renovations of existing buildings for energy efficiency. Two AHJs stated that all part 3 renovations require a registered professional, and that compliance with the Building Code was the responsibility of the engineer or architect of record. One AHJ requires submission of an energy checklist for all building permit applications for existing buildings.

  In summary:

  → Three out of ten do not enforce energy standards for existing buildings

  → Seven out of ten have various levels of enforcement of energy standards for existing buildings

  → Two out of seven require a professional and submission of a letter of assurance
  (Schedule B)

  → One out of seven require completion of a checklist (Vancouver)

Proportion of commercial renovations in jurisdiction occurring without a permit, including tenant alterations:

→ AHJs estimated a range of 0-50% of alteration activity is occurring without a permit. It was noted; however, that the projects that proceed without a permit were thought to be small in scope including minor tenant improvements where opportunities for energy efficiency were generally considered to be small.

Keeping of statistics on the permits issued related to existing buildings:

→ All AHJs confirmed that the number and value of permits are collected and submitted to Statistics Canada as a legal requirement. However, AHJs don't collect additional data such as the specific energy efficiency improvements.

Understanding what type of renovation activity is occurring:

- AHJs highlighted that much of the renovation activity is related to tenant improvements. Much less activity related to building enclosure renovations was recorded. HVAC equipment replacement was noted as being of moderate activity. AHJs noted that opportunities for energy efficiency were present in only about 30% of the alteration permits, the majority of which are related to lighting upgrades. There was significant diversity in the responses as newer municipalities like Langford had very little activity with energy efficiency opportunities whereas, in the City of Vancouver, the survey respondent noted that most renovation activity had the potential for improvements.

Mechanisms to consistently apply the energy code to existing buildings:

- There was a general consensus that flexibility was needed in the mechanism to apply the energy code to existing buildings. Of the options identified, use of a trigger to require improvements for alterations over a certain value was endorsed. Furthermore, three of the AHJs (excluding Vancouver) generally supported the approach that has been adopted by the City of Vancouver. It was noted by two AHJs that there was significant negotiation involved in regulation of existing building alterations, with life safety systems generally taking highest priority when budgets are constrained. It was also noted the current wording of the code is clear that buildings cannot perform worse, but nothing states that they must perform better.[4]

Merits of preparing a White Paper on options to implement an energy code for existing buildings:

- All jurisdictions but one expressed moderate to strong support for implementing an energy code for existing building. AHJs were evenly divided between supporting the development of a new code or providing guidelines and greater clarity to use the existing requirements of ASHRAE 90.1.

City of Vancouver Survey and Interview

An in-depth interview and a survey including additional questions to address the unique implications of the Vancouver Charter and the VBBL were conducted with the City of Vancouver during a face-to-face meeting. The most relevant highlights are noted below:

- The City enforces all energy standards for application in existing buildings, including Part 3 (large) and Part 9 (floor area under 600m^2 per floor) buildings.
- The City has detailed records pertaining to energy standards collected via a checklist as an administrative requirement, filled in by the professionals of record.[5]
- Based on the survey and interview results, it is estimated (with some overlapping, and thus totals adding up to more than 100%) that:
  - 85% of permits are for minor renovations (single space);
  - 11% are for change of occupancy classifications;
  - 2% are for major renovations; and

[4] 1.1.1.5 Application to Existing Buildings states that Where a building is altered, rehabilitated, renovated, or repaired, or there is a change in occupancy, the level of life safety and building performance shall not be decreased below a level that already exists

[5] http://vancouver.ca/home-property-development/large-building-energy-requirements-forms-checklists.aspx

    - 4% are for reconstructions.
- The estimated proportion of permits to building types are:
    - 5% light industrial;
    - 40% retail;
    - 40% office; and
    - 15% multi-unit residential.
- The estimated proportion of permits that apply to major energy systems are estimated (with some overlapping for single permits) at:
    - 5% building enclosure;
    - 85% lighting systems;
    - 25% service water heating; and
    - 15% HVAC systems and motors.

5.3 Administrative Considerations

Further research is required on administrative conditions pertaining to an energy code for existing buildings, namely around alignment with current and prospective institutions (with legislative/regulatory changes) that could administer requirements, including local authority building inspection departments, the BC Safety Authority, professional oversight or others.

6 Analysis of Policy Options

ASHRAE 100-2015, ASHRAE 90.1-2010, and NECB 2011 were chosen for detailed analysis to evaluate their potential for use in the development an Energy Code for Existing Buildings. The methodology and results of the analysis are provided below.

6.1 Methodology

The analysis methodology consisted of estimating the energy and economic impact of applying either ASHRAE 100-2015, ASHRAE 90.1-2010, or NECB 2015 to specific building retrofits in specific building types. The number of permits (and thus applicable buildings and types) was also estimated to extrapolate potential province-wide impacts. A flowchart of the methodology is provided in Figure 6.1 followed by a detailed explanation of each step.

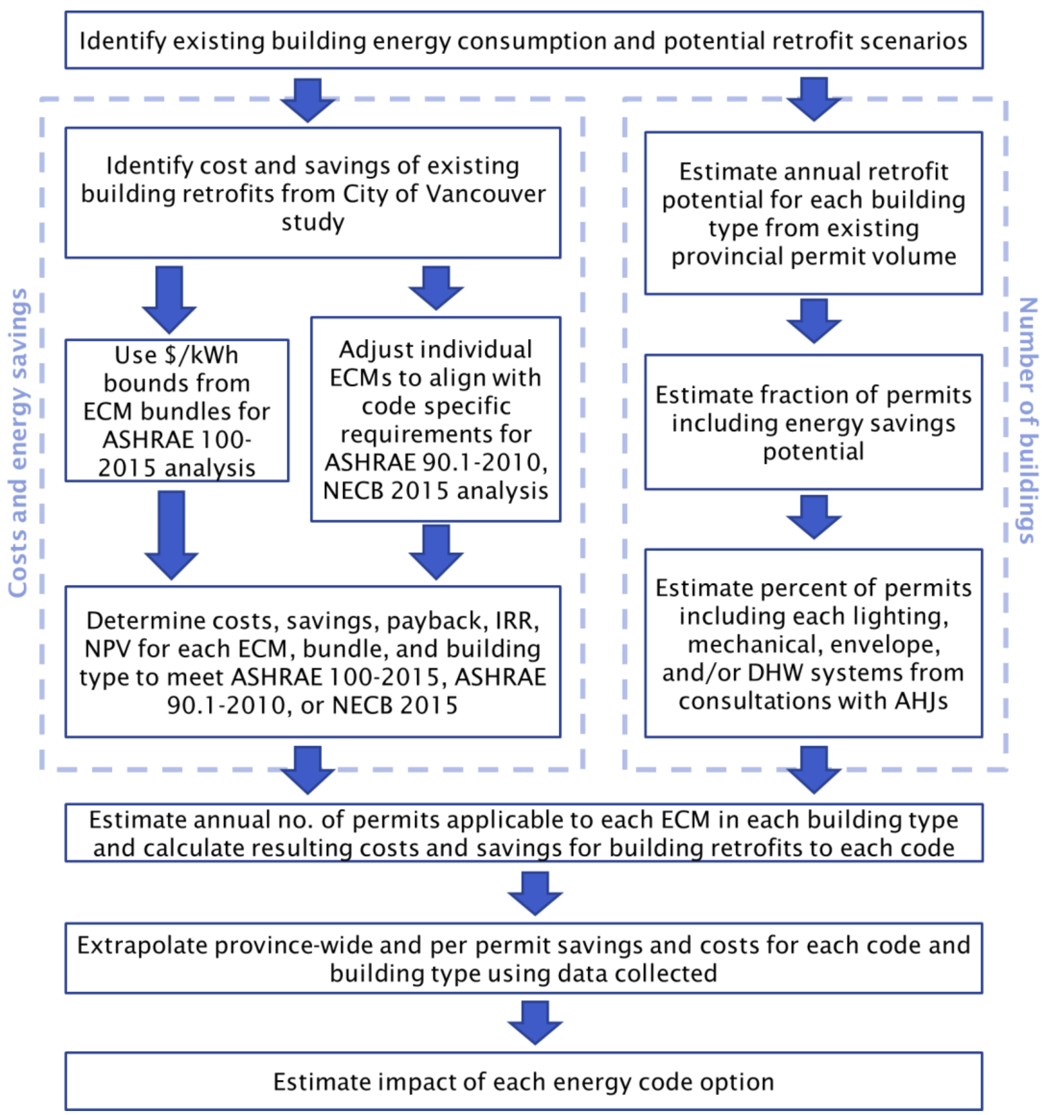

Figure 6.1: Flowchart of analysis methodology

6.1.1 Estimated Number of Buildings Impacted

The potential number of buildings impacted can be estimated using a bottom-up approach by investigating a permit sample from 10 municipalities. As noted in Section 5.2.1, there are approximately 7,000 permits for alterations in buildings in BC per year between 2008 and 2014. The degree to which these permits have an energy related component varied by jurisdiction. In municipalities with a newer building stock (e.g., City of Langford), it was observed that the renovation permits involved tenant improvements (or small projects) with little or no energy impacts, whereas in municipalities with older buildings (e.g., City of Vancouver) the observation was made that a significant portion of retrofits had an energy component. Based on the survey of 10 jurisdictions and responses from interviews with AHJs, discussed in Section 5.2.2, it is estimated that 30% of renovations province-wide (approximately 2,100 renovations per year) have energy related impacts, due to the alternation or renewal of equipment, systems and/or building components that use energy or affect the use of energy.

Alternatively, the potential number of buildings impacted can also be estimated using a top-down approach based on the National Survey of Commercial Buildings from 2009, which includes approximately 73,000 commercial buildings in BC (Table 6.1). Based on the permit statistics summarised in the previous paragraph, one would conclude a retrofit rate of 3% of the total building stock per year that has the potential for improving energy efficiency (approximately 2,100 retrofits). This however results in typical service life of major equipment and building components of 30 years which exceeds typical design service lives of 20 years for boilers, 18 years for cooling equipment, and 10 to 15 years for lighting.[6] On the other hand, major building enclosure components such as windows, cladding and roofs have a longer service life.[7] This suggests that there is a trend of deferring maintenance on building equipment which has resulted in the potential for a significant number of retrofits to replace older, less efficient equipment. Data specific to BC was not identified to support this hypothesis; however, the national statistical analysis supports the notion of a large and untapped potential for retrofit of existing buildings.

[6] ASHRAE Owning and Operating Cost Database. http://xp20.ashrae.org/publicdatabase/

[7] Albrice, D. and Lee, T-S 2014, "The capital load of building enclosure system relative to other systems and its impact on total cost of ownership of condominium buildings in British Columbia" International Conference on Building Envelope Systems and Technologies, Aachen, Germany.

TABLE 6.1 NUMBER OF BUILDINGS FLOOR SPACE BY SEGMENT IN BC[8]

SEGMENT	BUILDINGS	FLOOR SPACE (MILLION M^2)
Office Building (Non-Medical)	9,718	31
Medical Office Building	1,692	3.6
Elementary & Secondary School	3,014	16.9
Nursing & Residential Care	1,252	3.1
Warehouse	2,911	13.1
Hotel & Motel	1,775	7.1
Hospital	136	1.4
Food Retail	5,453	5
Non-Food Retail	10,126	27
Other	25,404	47.9
MURB	11,250	54
Total	72,731	210

6.1.2 Estimating Energy Savings

The results of a previous study produced for the City of Vancouver in 2011 was used as the basis for determining incremental capital cost (ICC) and energy savings for building types representative of typical permits in BC.[9] The City of Vancouver study focuses on the existing building stock in Vancouver and it has been assumed that the results can be extrapolated across the province without correction. The building types analyzed and basic building information is provided in Table 6.1. The baseline EUI is based on data of actual building energy use within the province of BC prepared for a BC Hydro study. The existing building stock today is likely to vary from that modeled in the 2011 study which may impact the savings calculations. This is not anticipated to be a significant source of uncertainty due to the anticipated slow turnover of existing building systems in the years since the original study.

The MURB segment of the building stock was analyzed by assuming a split between four different building types; MURB (Large – Electric), MURB (Small – Electric), MURB (Large – Hydronic), and MURB (Small – Hydronic). These archetypes represent MURBs of two distinct sizes and both electric baseboard heating and hydronic heating (baseboards, radiators, or radiant panels) with gas boilers. The relative proportion of small to large MURBs (35% Large, 65% Small) was determined by comparing the building size distribution in the City of Vancouver using BC Assessment data. The proportion of MURBs with electric baseboard heating and hydronic heating (62%:38%) was determined from 2010 BC Hydro Residential End Use Study.

[8] "Survey of Commercial and Institutional Energy Use – Buildings 2009", Natural Resources Canada, https://oee.nrcan.gc.ca/publications/statistics/scieu09/scieu_e.pdf
[9] "Green Retrofit Report" Prepared by Omicron AEC Ltd. and Light House Sustainable Building Center for the City of Vancouver. 2011.

TABLE 6.2 SUMMARY BUILDING ARCHETYPES AREA AND EUI

BUILDING TYPE	BUILDING AREA (M^2)	BASELINE EUI (KWH/M^2)	ASHRAE 100-2015 (KWH/M^2)[10]
Small Project	300[11]	N/A	N/A
Office	3,717	313	149
MURB (Large - electric)	7,900	212	136
MURB (Small – electric)	2,509	176	136
MURB (Large - hydronic)	7,900	212	136
MURB (Small – hydronic)	2,509	176	136
Retail	558	457	95
Restaurant	581	1,415	493

Modeling and costing data was used to determine potential savings from system-specific ECMs (ASHRAE 90.1-2010 and NECB 2015) or ECM bundles (ASHRAE 100-2015). The results for each ECM used for extrapolation of potential savings for application of different standards are shown in Appendix C.

→ For ASHRAE 90.1-2010 and NECB 2015 the energy efficiency requirements (such as LPD, assembly R-Value, equipment efficiency, etc.) were compared to the modeled values. The energy savings and incremental costs used in this analysis were adjusted proportionally where the modelled ECM did not align with ASHRAE 90.1-2010 or NECB 2015. For example, the results for office LPD were modeled for improvement from 3.5 to 1.2W/ft^2 but ASHRAE 90.1-2010 requires an LPD of 0.9 W/ft^2. Therefore, the modeled cost and energy savings were increased by 13% to account for the difference in energy efficiency requirement prior to use in this analysis. The incremental costs for each ECM used was assumed to vary by +/-20% to create a range of possible cost outcomes.

→ For ASHRAE 100-2015 the cost per kWh was calculated for each building type based on the ECM bundles. The lower bound of cost ($/kWh) was taken from the least costly bundle for each building type in the report for the City of Vancouver.[12] The upper bound was assumed to be double the costliest bundle to account for cost premiums associated with achieving large savings beyond the limits investigated in previous studies. It was assumed that the EUI target for ASHRAE 100-2015 could be met entirely for the costs determined as the upper or lower bounds. Additionally, ASHRAE 100-2015 could require additional transaction costs to be incurred for implementation due to the added timeline associated with calculating building EUI prior to implementation of ECMs and the testing and verification process associated with compliance.

A financial analysis was performed for whole building compliance with ASHRAE 100-2015 and for each ECM representing potential for ASHRAE 90.1-2010 or NECB 2015 compliance routes based on system type involved in the potential retrofit for each building. The costs and energy savings are all assumed to occur at the time of replacement and/or construction and represent incremental costs and energy savings above replacement of

[10] The target EUI for compliance with ASHRAE 100-2015 is based on Climate Zone 4C
[11] The building area associated with Small Projects has been assumed to be 300m2 to align with BCBC thresholds.
[12] "Green Retrofit Report" Prepared by Omicron AEC Ltd. and Light House Sustainable Building Center for the City of Vancouver. 2011.

the existing equipment with standard replacement products. An exception is for lighting systems, in which case, the costs represent the full cost of replacement. All of the costing assumptions are stated in the aforementioned City of Vancouver study, prepared by Omicron.

A discount rate of 6% (real 2015 dollars) was assumed for the implementation of each measure. The value of energy savings was determined using applicable rates for each building type as described in Table 6.3 Electricity rates have been assumed to increase following the BC Hydro 10-yr plan with nominal increases of 4%, 3.5% and 3% (including inflation) in 2016, 2017 and 2018 respectively.[13] Natural gas prices were assumed to increase at a rate of 2% per year (including inflation).

TABLE 6.3 SUMMARY OF UTILITY RATES

BUILDING TYPE	ELECTRICITY SERVICE (BC HYDRO)	NATURAL GAS SERVICE (FORTIS BC)
Office	Large General Service	Rate 2
MURB (Large - electric)	Residential Rates	Rate 3
MURB (Small - electric)	Residential Rates	Rate 2
MURB (Large - hydronic)	Residential Rates	Rate 3
MURB (Small - hydronic)	Residential Rates	Rate 2
Retail Small	Medium General Service	Rate 2
Restaurant	Medium General Service	Rate 3
Tenant Improvement	Large General Service	Rate 2

The energy savings, incremental cost, and lifecycle economic analysis results for each ECM (or high and low value bundles as applied to ASHRAE 100-2015) were used to determine the potential impact of an energy code for existing buildings. The value of the potential impacts province-wide were estimated by extrapolating out the number of energy related permits per building type and the percentage of permits applicable to each system type as determined in Section 5. The breakdown of the percent of permits applying to each system type is shown in Table 6.4. The sum of each row can exceed 100% as permits may apply to multiple systems. All lighting upgrades in MURBs are assumed to be captured in the category of Small Projects permits.

[13] https://news.gov.bc.ca/stories/10-year-plan

TABLE 6.4 SUMMARY OF PERMIT BREAKDOWN

BUILDING TYPE	TOTAL NUMBER OF PERMITS	LIGHTING	MECHANICAL	ENVELOPE	DHW
Small Projects	1,693	85%	15%	5%	25%
Office	82	85%	15%	5%	25%
MURB (Large - electric)	33	0%	45%	5%	50%
MURB (Small - electric)	62	0%	45%	5%	50%
MURB (Large - hydronic)	20	0%	45%	5%	50%
MURB (Small - hydronic)	38	0%	45%	5%	50%
Retail	67	85%	15%	5%	25%
Restaurant	47	85%	15%	5%	25%

6.2 Energy and Financial Impacts

The results of the financial analysis for whole building or ECM specific outcomes applicable to permits relating to ASHRAE 100-2015 (Table 12), ASHRAE 90.1-2010 (Table 13) and NECB 2015 (Table 14) are provided in Appendix C.

6.2.1 Number of Buildings Impacted

The following analysis of the annual number of buildings estimated to be affected by an energy code for existing buildings aligns most closely with the bottom-up approach. This method was selected as the main approach for the White Paper as it utilizes known permit data as a bound on the potential number of buildings impacted (Table 6.5). The number of energy related permits for each building type was calculated by multiplying the total number of permits by 30% to reflect estimates provided by AHJs in the interviews and survey conducted for this research. It is estimated that 2,082 permits per year would be subject to the proposed energy code for existing buildings under ASHRAE 90.1-2010 and NECB 2015. A lesser amount would be subject to the new code under ASHRAE 100-2015, given that it is a whole building energy standard, and would therefore not be applicable to the Small Projects segment.

TABLE 6.5 SUMMARY OF TOTAL AND ENERGY RELATED PERMITS BY SEGMENT[14]

SEGMENT	TOTAL NUMBER OF PERMITS	NUMBER OF ENERGY RELATED PERMITS
Small Project	5,643	1,693
MURB	513	154
Office	273	82
Trade and Service	223	67
Hotel, Restaurant	156	47
Warehouse	56	17
Recreation	49	15
Service Stations	19	6
Laboratory	3	1
Total	6,935	2,082

Based on the total number of permits versus the BC building stock in the previous tables, a rough conclusion could be drawn that BC buildings apply for a permit every 10 years on average. However, energy related permits only come up every 30 years on average. Applying a 30-year typical life span to building systems implies a 3% renovation rate on the stock of 72,731 commercial buildings, resulting in an estimated renovation population of 2,400 buildings per year. This top-down estimate is consistent with the bottom-up estimate of 2,082 from above.

By analyzing the potential impacts of energy codes being applied to permits for the top five segments (by number of permits) we are able to capture the vast majority of permit activity in the province (98% by number, 95% by value). The segments to be analyzed in this whitepaper include:

- → Small projects (includes all segments)
- → Offices
- → MURBs (including Large – electric, Small – electric, Large – hydronic, Small – hydronic)
- → Trade and Service (Retail)
- → Hotel, Restaurant

6.2.2 Incremental Capital Costs (ICC)

The incremental cost of permits with energy efficiency related work was calculated from data in Appendix C and the methodology outlined above. The results are presented in Table 6.6. Applying ASHRAE 100-2015 would increase the value of permits by approximately 7%[15]. Applying ASHRAE 90.1-2010 or NECB 2015 would increase the value of permits by 4%. The largest financial impact of ASHRAE 90.1-2010 and NECB 2015 is expected to be for Small Projects with an increase of 13% and 9% above the existing costs.

[14] Definitions of segments are provided in Section 5.2.1
[15] Note that the analysis for ASHRAE 100-2015 excludes permits for Small projects.

TABLE 6.6 SUMMARY OF ANNUAL INCREMENTAL COSTS TO IMPLEMENT ENERGY CODES ON EXISTING BUILDING PERMITS

SEGMENT		SMALL PROJECT	OFFICE BUILDING	MURB	TRADE AND SERVICE	HOTEL, RESTAURANT	TOTAL
TOTAL Number of Permits		5,643	273	513	223	156	6,808
Number of Energy Related Permits		1,693	82	154	67	47	2,043
Permit Value ($ Thousand)	Existing Permits	$248,060	$355,799	$135,885	$252,567	$135,424	$1,233,408
	Increment for ASHRAE 100-2015	N/A	$45,765 (13%)	$17,816 (13%)	$11,523 (5%)	$5,813 (4%)	$80,916 (7%)
	Increment for ASHRAE 90.1-2010	$31,065 (13%)	$17,401 (5%)	$1,798 (1%)	$1,980 (1%)	$2,412 (2%)	$54,656 (4%)
	Increment for NECB 2015	$22,933 (9%)	$20,148 (6%)	$1,828 (1%)	$2,131 (1%)	$2,397 (2%)	$49,547 (4%)
Average Value per Permit	Existing Permits	$43,959	$1,303,293	$264,883	$1,132,587	$868,103	$177,853
	Increment for ASHRAE 100-2015	N/A	$558,108 (43%)	$115,686 (44%)	$171,982 (15%)	$123,683 (14%)	$269,866[16] (36%)
	Increment for ASHRAE 90.1-2010	$18,349 (42%)	$212,211 (16%)	$11,539 (5%)	$29,549 (3%)	$51,315 (6%)	$26,801 (15%)
	Increment for NECB 2015	$13,546 (31%)	$245,709 (19%)	$11,868 (5%)	$31,813 (3%)	$50,995 (6%)	$24,198 (14%)

6.2.3 Annual Energy and GHG Savings

The annual energy savings and GHG reductions per permit are shown in Figure 6.2 through Figure 6.4 for ASHRAE 100-2015, ASHRAE 90.1-2010, and NECB 2015, respectively. Applying ASHRAE 100-2015 as an energy code for existing buildings has the potential for greater savings per permit due to the requirement for a reduction in whole building energy use.

Applying ASHRAE 100-2015 results in a GHG reduction of between 12 and 84 t/yr depending on the building type. The greatest reduction is expected for Restaurants due to the significant potential reduction in natural gas requirements. The GHG savings per permit using ASHRAE 90.1-2010 (Figure 6.3) is expected to range between an increase of 1.26 t/yr and decrease of 8.35 t/yr. The GHG savings per permit using NECB 2015 (Figure 6.4) is expected to range between an increase of 1.42 and decrease of 8.42 t/yr. The increases in GHG emissions are a result of the high percentage of permits (85%) containing lighting upgrades and the resultant increase in space heating load, provided by natural gas.

The application of ASHRAE 90.1-2010 or NECB 2015 to small projects (such as tenant improvements and lighting upgrades) results in a small savings on a per permit basis as

[16] Ibid

presented in Figure 6.3 and Figure 6.4. This however represents a significant potential for energy savings when implemented province-wide, as this segment represents 81% of the number of permits. The province-wide estimation for electricity savings for ASHRAE 90.1-2010 or NECB 2015 for small projects is 36 GWh/yr or 25 GWh/yr, respectively. Due to the prevalence of lighting upgrades, this results in an increase in space heating requirements and thus natural gas consumption of 4.9 GWh/yr or 3.8 GWh/yr, respectively, and a corresponding increase in GHG emissions of 522t/yr or 429t/yr, respectively.

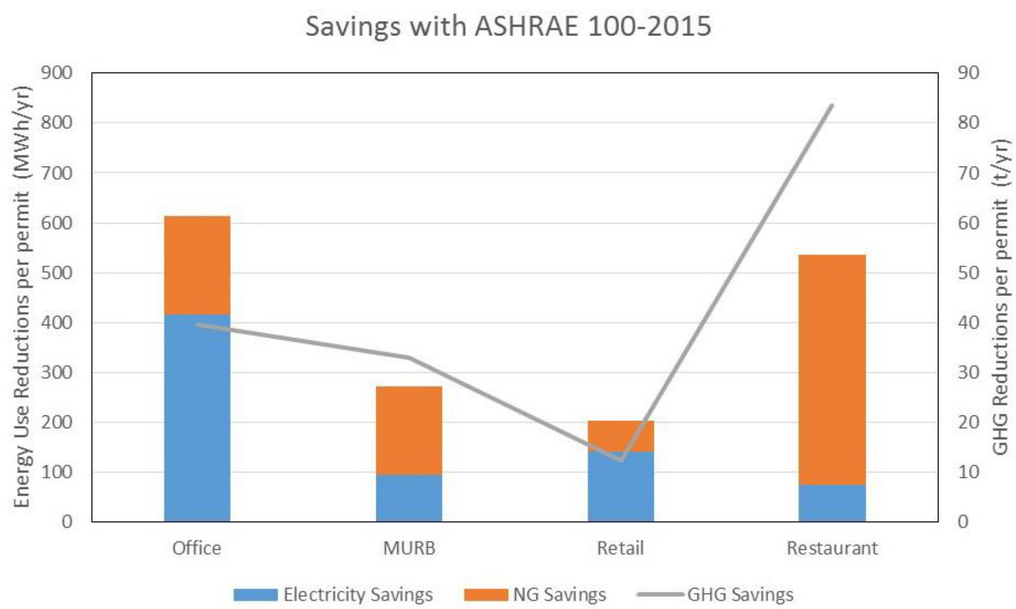

Figure 6.2: Annual Savings with ASHRAE 100-2015 as an Energy Code for Existing Buildings

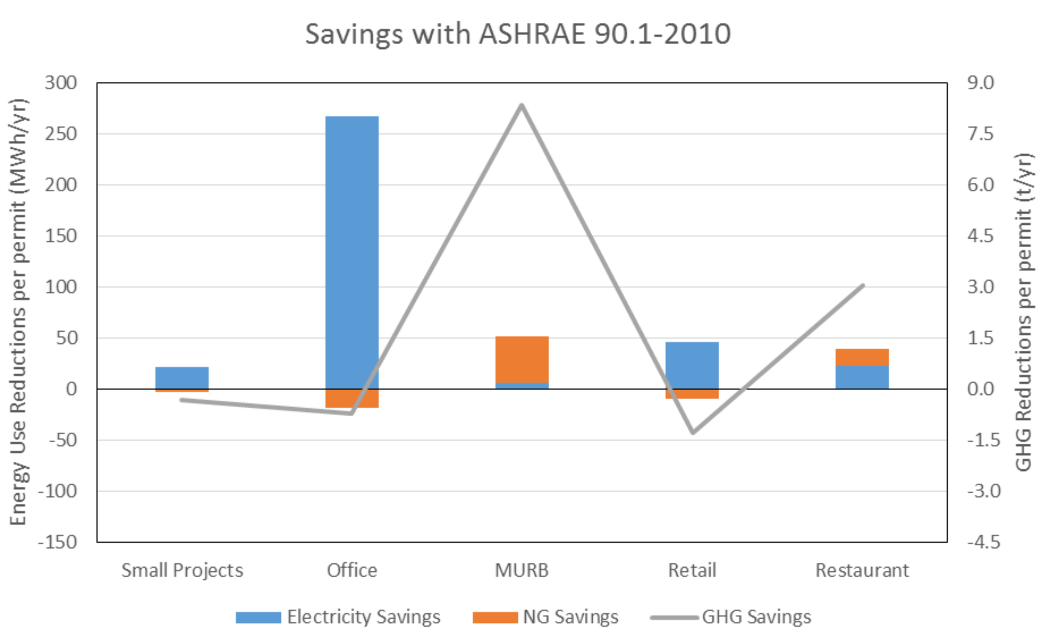

Figure 6.3 Annual Savings with ASHRAE 90.1-2010 as an Energy Code for Existing Buildings

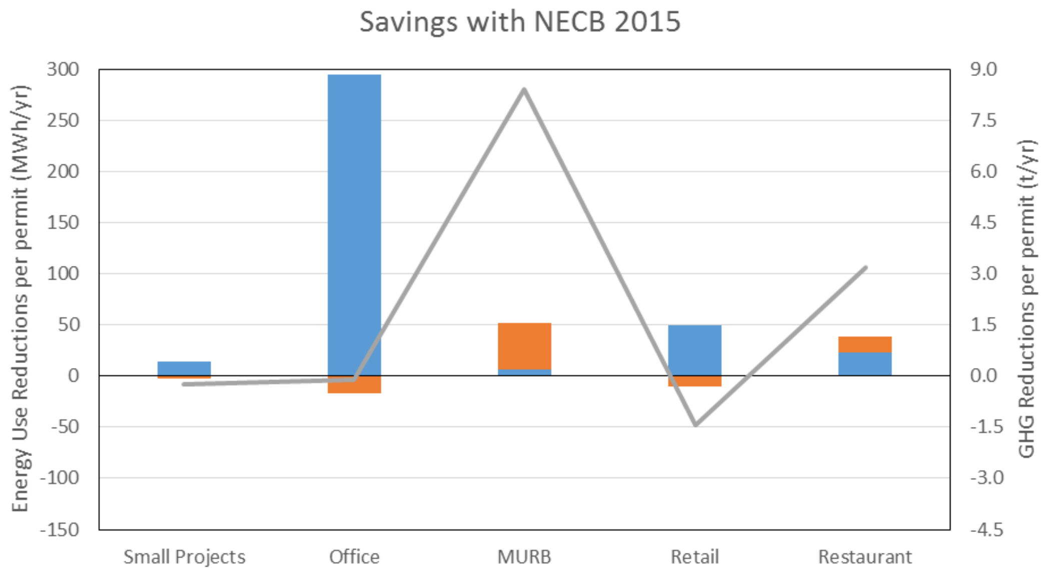

Figure 6.4: Annual Savings with NECB 2015 as an Energy Code for Existing Buildings

The province-wide, cumulative annual energy savings from implementing energy codes for existing buildings in BC are shown in Figure 6.5 for the year 2025. A 1% reduction on savings has been assumed for each year after the retrofit to capture a reduction in the persistence of energy efficiency improvements.[17]

The total savings is largest for ASHRAE 100-2015 due to the significant energy efficiency improvements required for compliance. The estimated cumulative annual reduction in energy use is 6,987 GWh/yr in the year 2025. Of that reduction 47% is electricity (3,299 GWh/yr) and 53% is natural gas (3,688 GWh/yr).

Annual greenhouse gas emission reductions are estimated at 697,000 tonnes in the year 2025 and 193,000 tonnes in 2020, assuming the standard is applied to relevant permits starting in 2016. It is noted that full implementation is not realistic in short order, and an revised estimate with staged implementation is outlined in Chapter 9.

A lower cumulative annual energy savings is expected for the implementation of ASHRAE 90.1-2010 or NECB 2015, due to the reduced scope of implementation (single system rather than whole building). These codes; however, would be applicable to a larger number of permits, including small permits, and have a more targeted focus on the systems involved in the construction.

[17] The relaxation factor reduces the energy savings from each scenario by 1% per year after the implementation. For example, if an ECM saves 100kWh/m2 when implemented it is assumed that during the first year after implementation it saves the building owner 100kWh/m2. In the second year that savings is reduced to 99kWh/m2.

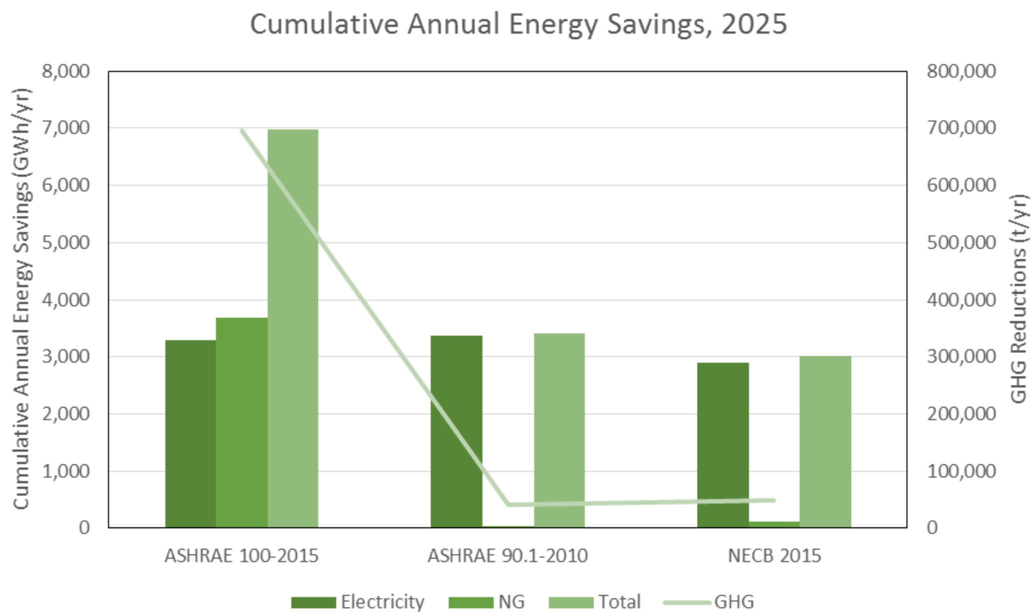

Figure 6.5: Cumulative Annual Energy Savings in 2025 from Implementing Energy Codes for Existing Buildings

6.2.4 Net Present Value (NPV)

The Net Present Value (NPV) per permit is shown in Figure 6.6 through Figure 6.7 for each building type for ASHRAE 100-2015, ASHRAE 90.1-2010, and NECB 2015.

The NPV is positive for all building types over the range of anticipated costs for ASHRAE 100-2015 except for the Worst Case scenario analysis of office buildings. The largest NPV for the average cost scenarios was found for Restaurants due to the large energy savings. The NPV per permit is lower for ASHRAE 90.1-2010 and NECB 2015 and contains a mixture of positive and negative results. Offices, MURB, and Retail buildings are positive for all scenarios. Restaurants have a negative NPV for all scenarios. Small Projects have a positive NPV for Best Case and Average scenarios but negative NPV for Worst Case scenarios.

The total province-wide NPV, accounting for all building types, is positive for each of the three codes analyzed when the average scenario values are used. The resulting province-wide NPV was found to be $76 million, $15 million, and $12 million for ASHRAE 100-2015, ASHRAE 90.1-2010, and NECB 2015, respectively.

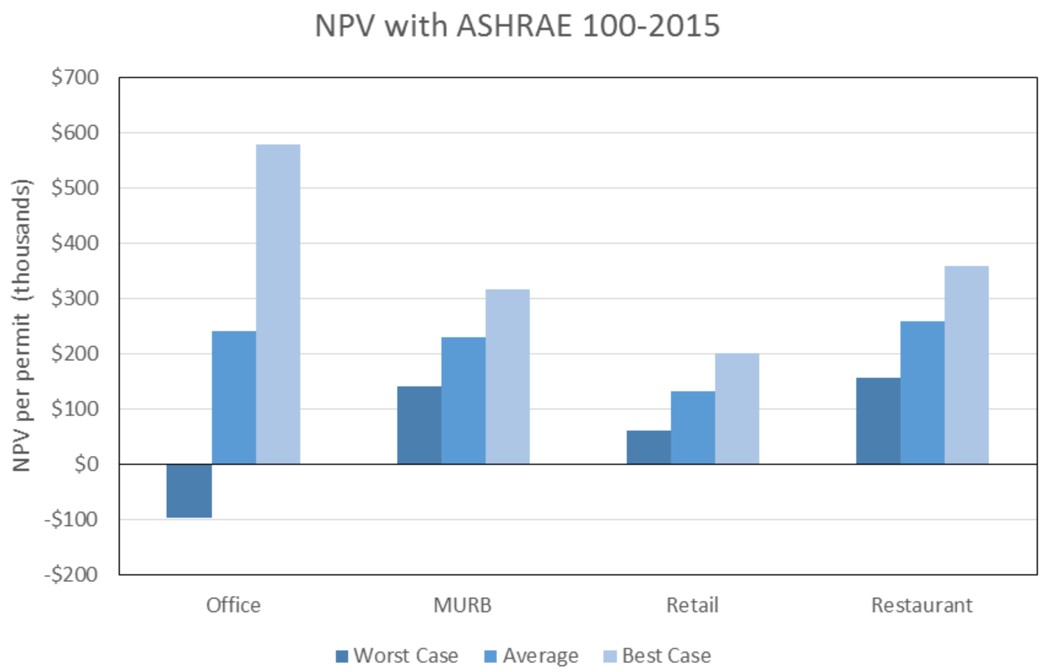

Figure 6.6: Net Present Value Per Permit Issued for Applying ASHRAE 100-2015 as an Energy Code for Existing Buildings

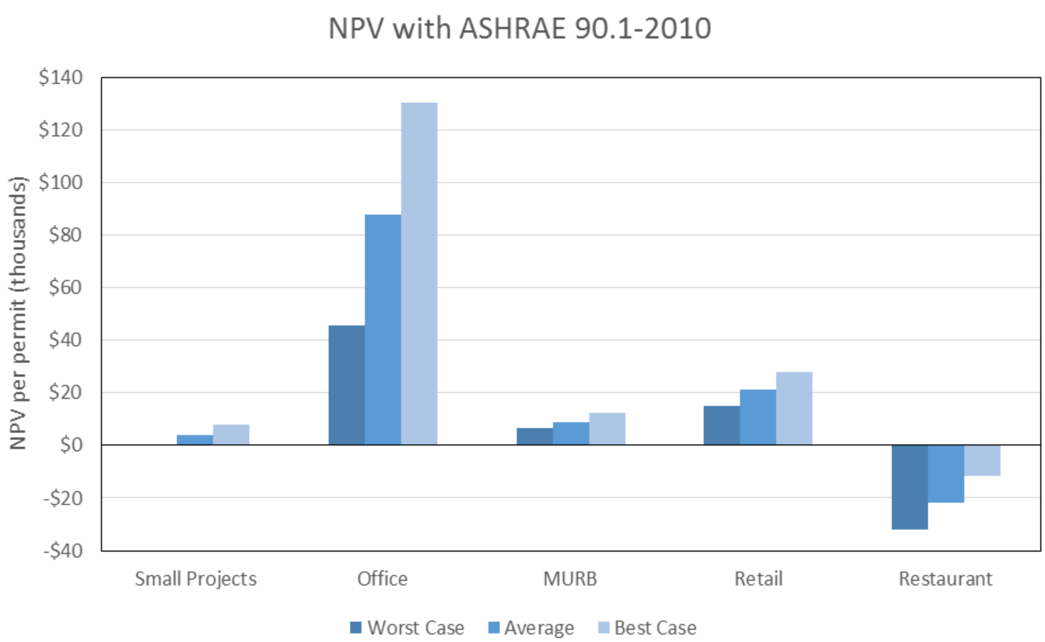

Figure 6.7: Net Present Value Per Permit Issued for Applying ASHRAE 90.1- as an Energy Code for Existing Buildings

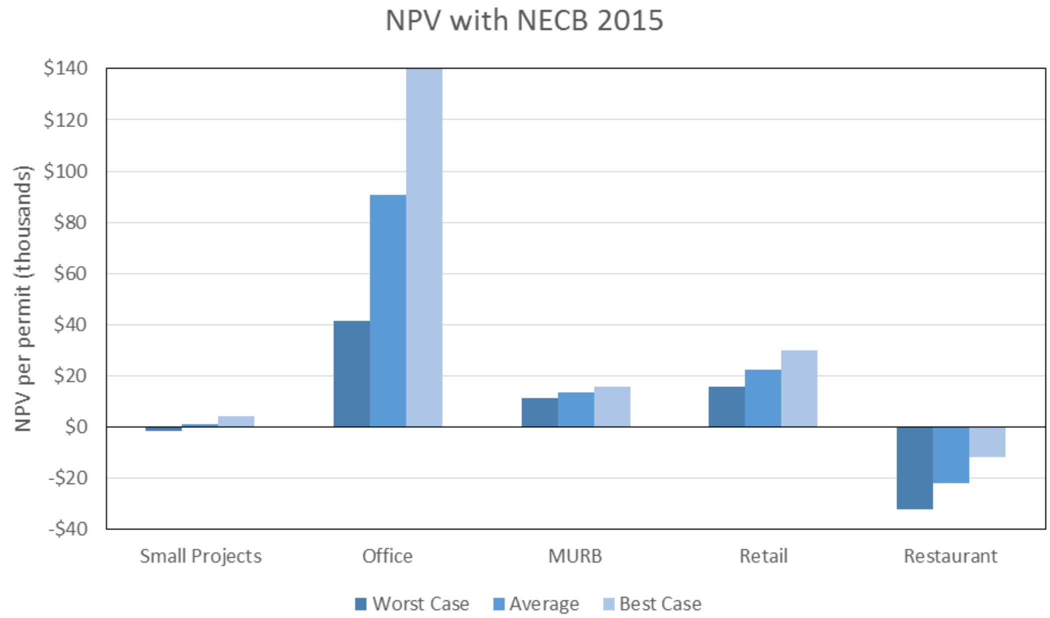

Figure 6.8: Net Present Value Per Permit Issued for Applying NECB 2015 as an Energy Code for Existing Buildings

6.2.5 Sensitivity Analysis

A sensitivity analysis was performed on the province-wide NPV results for implementation of each code. The analysis included sensitivity to changes in incremental capital costs (Figure 6.9) and energy benefits (Figure 6.10). The energy benefit analysis accounts for either changes in the price of energy supply or the amount of energy savings. The zero NPV intercept has been determined for each code and presented in the figures. This indicates the percentage change required for the Average cost scenario to move from a positive NPV to the breakeven point. ASHRAE 100-2015 has a positive NPV for increases in ICC up to 94% or decreases in energy benefits down to -48.5%. ASHRAE 90.1-2010 and NECB 2015 have a positive NPV over smaller ranges of analysis. ASHRAE 90.1-2010 has positive NPV for increases in ICC up to 27.7% or decreases in energy benefits to -22%. NECB 2015 has similar trends with positive NPV for increases in ICC up to 24% or decreases in energy benefits to -19.6%.

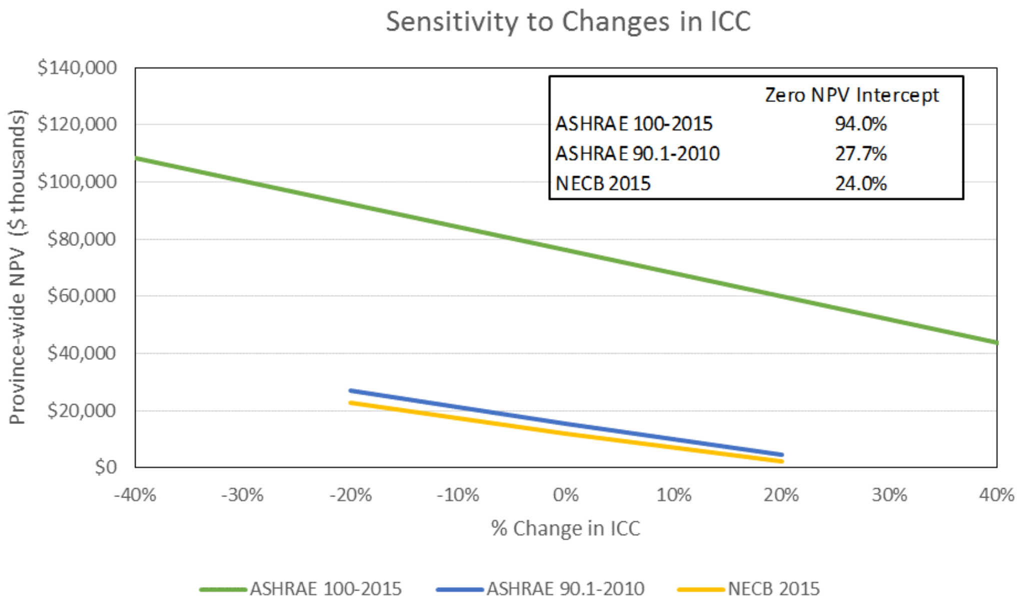

Figure 6.9: Sensitivity of Province-wide NPV to Changes in Incremental Capital Costs

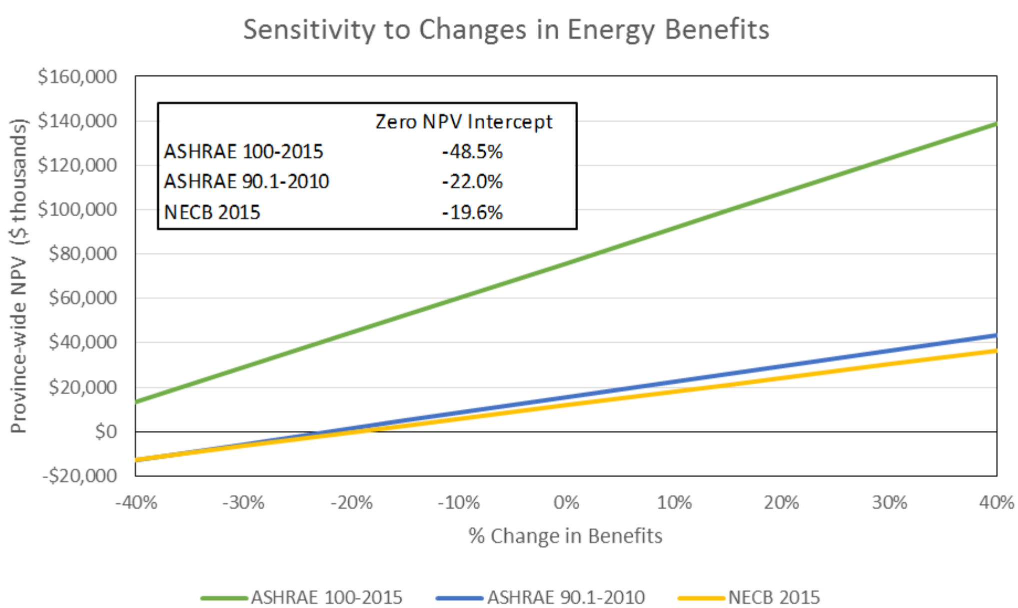

Figure 6.10: Sensitivity of Province-wide NPV to Changes in Energy Benefits

7 Non-Energy Co-Benefits and Complementary Initiatives

7.1 Co-Benefits

There are a range of non-energy co-benefits that can be realized through enhancements to the energy efficiency of existing building stock. Some of these co-benefits include:

Local governments in BC have become leaders in energy management and climate change action. They developed the first Community Energy Plans in the country in the mid-1990s and still lead the way in energy planning. By 2015, there were twice as many Community Energy and Emissions Plans in place in BC as there were in all other Canadian provinces combined. The adoption of an energy efficiency code for existing buildings could help maintain BC's leadership position in this area.

→ **Climate change mitigation**: This paper has demonstrated the GHG emission reduction potential associated with adopting an energy efficiency code for existing buildings. This co-benefit could be considered one of the primary drivers for enhancing the energy efficiency of existing building stock, given that it will directly support a range of stakeholders in meeting their GHG emission reduction goals and targets, including those that have been legislated by the Provincial government (see Section 7.2.1

→ **Improved resilience:** Energy efficiency improvements can reduce the need for energy infrastructure, and thereby reduce a region's level of exposure to extreme weather events and other causes of supply disruptions. In addition, weatherization improvements increase a building envelope's resilience to the elements, thereby decreasing the vulnerability of a building and its occupants to extreme weather events, the risk of which may increase with climate change.

→ **Increased affordability**: Reducing the energy demand of existing buildings will directly reduce heating and cooling costs for building owners and/or occupants. Additionally, an energy code for existing buildings could circumvent the split incentive associated with energy efficiency improvements, in which landlords are presently dis-incentivized to undertake energy retrofits because the return on investment (direct energy savings) do not accrue to them, but rather to the building's tenants. Mandatory energy efficiency improvements could therefore improve the affordability of rental accommodation, which will be beneficial to low-income families and renters.

→ **Community economic development**: An energy efficiency code could create a range of spin-off economic benefits, including the improved business competitiveness associated with reduced energy costs, and higher property values. It could also contribute to the creation of the jobs required to implement energy efficiency improvements. A recent report prepared by the International Energy Association suggests that every EUR 1 million invested in energy efficiency measures in the European Union could yield 8 to 27 job years in job creation benefits.[18]

[18] International Energy Agency. (2014). Capturing the Multiple Benefits of Energy Efficiency. Retrieved from: https://www.iea.org/publications/freepublications/publication/Captur_the_MultiplBenef_ofEnergyEficiency.pdf

→ **Improved health and comfort**: Energy efficiency improvements can reduce noise, help to maintain a comfortable indoor temperature and improve indoor air quality. An evaluation of the impact of health improvements that could be achieved through an aggressive energy efficiency program in the EU found that potential savings could be EUR 190 billion annually.[19] Some studies have also suggested that when health and wellness benefits are incorporated into benefit-cost ratios, health-related benefits can account for up to 75% of the benefits.[20] Increases in affordability can also serve to increase the level of comfort of occupants and to decreased fuel poverty for building occupants that could previously not afford to heat their homes to appropriate levels.[21]

→ **Improved local air quality**: The reduction in fuel combustion can contribute to improved local air quality impacts in some communities as a result of reduced nitrous oxide emissions.

→ **Increased predictability of outcomes**: Developing an outcome based code, rather than piecemeal prescriptive requirements will serve to increase the predictability of energy efficiency retrofit initiatives. This will be beneficial to local governments who are setting energy efficiency and GHG emission reduction targets in that they will be better able to forecast energy consumption levels and GHG emissions.

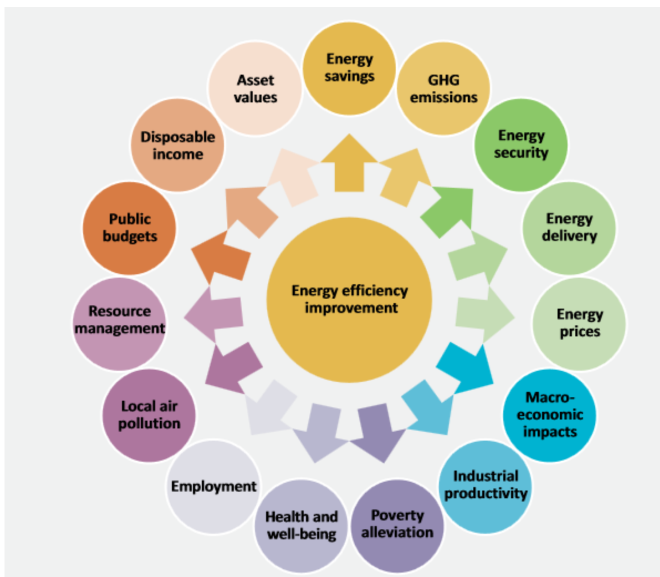

Figure 7.1: Sensitivity of Province-wide NPV to Changes in Energy Benefits
Source: International Energy Agency. (2014). Capturing the Multiple Benefits of Energy Efficiency.

7.2 Complementary Initiatives

A range of complementary initiatives have begun to pave the way for successful roll-out of a new energy efficiency code for existing buildings. The following initiatives and programs can be leveraged to ease the implementation of a new code.

[19] Ibid.
[20] Ibid.
[21] A study conducted in England and Wales found linkages between poor housing and poverty to low indoor temperatures and cold-related deaths, in the order of 40,000 excess deaths. (Heffener, G and N. Campbell. (2011). Results of the Dublin Workshop, 27-28 January 2011: Evaluating the co-benefits of low-income energy-efficiency programmes. International Energy Association. Retrieved from: https://www.iea.org/publications/freepublications/publication/low_income_energy_efficiency.pdf)

7.2.1 Provincial Climate Change Legislation & Supporting Tools

Requirements for Targets, Policies and Actions

In 2008, the Province of BC passed the Green Communities Statutes Amendment Act (Bill 27), which requires local governments to set GHG emission targets, policies, and actions in their Official Community Plans (OCPs) and Regional Growth Strategies (RGSs). The Province also created the Climate Action Charter in 2007 as a mechanism to engage local governments in contributing towards provincial GHG emission reduction goals and targets. In signing this voluntary Charter, 181 of 190 local governments have now committed to the Charter goals. These goals include working towards carbon neutral corporate operations and creating more energy efficient communities. An energy efficiency code for existing buildings could serve as an important tool for local governments working towards meeting these commitments.

Enabling Legislation

The Province has developed legislation aimed at expanding the authority of local governments to undertake energy efficiency improvement within their communities. For example:

→ The Green Communities Statutes Amendment Act empowers local governments to create Development Permit Areas (DPAs) for new developments and rehabilitation projects that contain specific objectives and guidelines for GHG emission reduction, and energy and water conservation. It also empowers local governments to waive or reduce development cost charges (DCCs) for projects that reduce GHG emissions.

→ Section 226 of BC's Community Charter provides local governments the authority to exempt environmental revitalizations from the municipal portion of property value taxes.[22]

Funding and Incentives

The Province has established funding and incentive programs to encourage investments in energy efficiency. For example:

→ The Community Energy Leadership Program (CELP) was established in 2015 to support retrofits of community owned buildings.[23]

→ The Climate Action Revenue Incentive Program (CARIP) was created as a conditional grant program for local governments that have signed on to the Climate Action Charter, equivalent to 100% of their carbon tax costs.[24]

→ An exemption from the Provincial Sales Tax has been provided for the purchase of insulation for residential application.[25]

→ The BC Government Carbon Investment Branch (CIB) is seeking bids for emission reductions through a competitive process for a program of activities or individual building projects that reduce emissions by 5,000 tonnes.[26]

[22] http://www.cscd.gov.bc.ca/lgd/gov_structure/community_charter/finance/permissive_exemptions.htm
[23] http://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/community-energy-systems/community-energy-leadership-program
[24] http://www.cscd.gov.bc.ca/LGD/greencommunities/carip.htm
[25] http://www.sbr.gov.bc.ca/documents_library/bulletins/pst_203.pdf
[26] http://www2.gov.bc.ca/gov/topic.page?id=0382DA98FD3445059EF23CE209B66FE4

7.2.2 Utility and Private Sector Initiatives

Incentives and capacity building programs are available from utilities and the private sector that will help promote market transformation to accelerate the uptake of energy efficiency improvements for existing buildings. An overview of these initiatives is included in Table 7.1.

TABLE 7.1 GOVERNMENT, UTILITY AND PRIVATE SECTOR DSM PROGRAMS

PROGRAM	DESCRIPTION
BOMA BESt	An environmental sustainability and energy management certification program for existing buildings that requires certification with an independent verification service provider every three years. Program participants are required to track and report their energy use intensity (EUI) and fuel mix. There are now about 220 buildings registered in BC.
BC Hydro Sustainable Communities Program (SCP)	The SCP has funded more than 45 Community Energy and Emissions Plans (CEEP) and 26 Community Energy Manager (CEM) positions with local governments, and an implementation offer began in 2014 to fund community-based energy efficiency and conservation implementation projects[27]
BC Hydro Power Smart Partners Program[28]	Provides energy study funding, co-funding for an energy manager, and other incentives for energy upgrades.
FortisBC Commercial Custom Design Program – Retrofit[29]	Funds 50% of energy study up to $25,000. Capital incentive funding (incremental cost minus 1yr gas cost). Implementation bonus up to $25,000. Minimum energy savings of 1,200 GJ/yr.
Business Energy Saving Incentives[30]	Incentives provide up to 75% of the incremental cost of equipment upgrades.
FortisBC Equipment Incentives[31]	Provides incentives for purchase of water heaters, boilers, pre-rinse spray valves and other equipment that meet pre-defined standards.
CMHC Mortgage Insurance Refund[32]	Provides 10% refund on CMHC Mortgage Loan Insurance for residential spaces in buildings that achieve a 5% improvement, compared to current BC Building Code standards. (Incentive is valued at 0.036% of the loan equalling $1,080 on a $300k mortgage.).
Climate Investment Branch[33]	Request for Emission Offsets (RFEO) in alignment with the Emission Offset Regulation. The Ministry of Environment commissioned an in-depth study on emission offsets for buildings. A new RFEO will be released in 2016.

[27] QUEST. (2015, JULY). National Report on Policies Supporting Community Energy Plan Implementation. http://gettingtoimplementation.ca/wp-content/uploads/2015/07/National-Report-on-Policies-Supporting-CEP-Implementation-July2015.pdf
[28] https://www.bchydro.com/powersmart/business/programs/partners.html
[29] http://www.fortisbc.com/Rebates/RebatesOffers/CommercialCustomDesignProgramRetrofit/Pages/default.aspx
[30] https://www.bchydro.com/powersmart/business/programs/express.html
[31] http://www.fortisbc.com/Rebates/RebatesOffers/Pages/default.aspx?type=business
[32] http://www.cmhc-schl.gc.ca/en/co/moloin/moloin_008.cfm
[33] http://www2.gov.bc.ca/gov/content/environment/climate-change/stakeholder-support/selling-offsets

8 Technical Conclusions

This paper presents results of three stages of technical, economic, and policy analysis on options to achieve incremental energy savings for existing buildings through codes and standards. The key conclusions drawn from each stage are noted below.

Stage 1 – Literature review of standards

Section 4 and Appendix A highlight a number of energy efficiency standards developed by government accredited standards development organizations and regulations in a number of cities that apply to existing buildings, not including reporting of energy benchmarking information, which is outside of the scope of this research. Based on a number of criteria, the following three standards were identified as the best candidates for future research.

- → ASHRAE 90.1-2010, as it is currently regulated under the BC Building Code and Vancouver Building Bylaw and includes provisions for existing building alterations.
- → NECB 2015, recently published, with the likelihood of being amended to enable application to existing buildings.
- → ASHRAE 100-2015, as it was written for the specific purpose of improving energy efficiency in existing buildings.

Stage 2 – Market research

Section 5 outlined results of market-wide building permit data and a survey of ten building officials from a diverse set of municipalities across the province. The key conclusions drawn were:

- → There is the potential to influence approximately 7,000 building permits per year, representing about 10% of the BC Building stock annually. However, it is expected that only a proportion of those permits are related to energy—the others are assumed not to affect major energy systems such as lighting, heating, ventilation and air conditioning, service water, power, and building envelope. As such, a more realistic impact would be 3-4% of the building stock affected each year.
- → Approximately 81% of annual permits are for small projects across the building stock, with an average permit value of $44,000. These are only conducive to minor energy upgrades, with 85% affecting lighting systems through tenant improvements and 25% service water heating (some overlapping with lighting).
- → Nearly 29% of annual permit value is for office building upgrades, followed by retail (trade and service) at 21%, small projects at 20% and multi-unit residential and hotel/restaurant each at 11% of total permit value.
- → Energy standards are only actively enforced by two of the ten municipalities interviewed. As such, universal application of the ASHRAE 90.1 standards currently referenced in BC regulations may lead to incremental energy savings.

Stage 3 – Technical and economic assessment

The technical and economic analysis for each code scenario has been determined for province-wide implementation. Table 8.1 provides a summary for economic and energy analysis for a single year of each code scenario implemented in 2016.

TABLE 8.1: ANNUAL COST AND SAVINGS FOR A SINGLE YEAR OF IMPLEMENTATION FOR EACH CODE SCENARIO

	ASHRAE 90.1-2010	NECB 2015	ASHRAE 100-2015	ASHRAE 90.1-2010 & ASHRAE 100-2015
Applicable Permits	All	All	Excl. Small Projects	ALL
incremental capital Cost	$55 million (4%)	$50 million (4%)	$81 million (7%)	$112 million (8%)
Net present value	$15 million	$12 million	$76 million	$83 million
Electricity Savings	63 GWh/yr	54 GWh/yr	62 GWh/yr	98 GWh/yr
NG Savings	0.7 GWh/yr (2,500 GJ/yr)	2.1 GWh/yr (7,600 GJ/yr)	69 GWh/yr (248,000 GJ/yr)	64 GWh/yr (230,000 GJ/yr)
GHG Savings	765 t/yr	914 t/yr	13 kt/yr	12.5 kt/yr

It is noted that natural gas savings are negative for “small projects” under both NECB-2015 and ASHRAE 90.1-2010 due to the preponderance of lighting improvements that increase space heating needs during winter months and shoulder seasons. This results in increased natural gas consumption of 8 and 9 GWh/yr across ~1,400 permits per year under NECB-2015 and ASHRAE 90.1-2010, respectively, versus the 4 GWh of gas savings for service water heating upgrades across ~400 permits per year. Greenhouse gas emissions will increase for small projects. The figures in Table 8.1 include large projects as well, resulting in a net reduction in natural gas consumption and GHG emissions. The ASHRAE 100-2015 analysis was applied only to large permits to which a whole-building energy efficiency standard would be applicable. The analysis combining ASHRAE 90.1-2010 and ASHRAE 100-2015 assumes that ASHRAE 100-2015 applies to all large permits and ASHRAE 90.1-2010 applies to all small projects. This results in a reduction in natural gas (and thus GHG) savings due to the aforementioned prevalence of lighting upgrades associated with the small projects causing increases in space heating requirements from natural gas. Applying 90.1-2010 to small projects in conjunction with ASHRAE 100-2015 to large permits results in substantial electricity savings beyond implementation of either standard in isolation.

Table 8.2 provides the cumulative annual savings for each code scenario over the period from 2016-2020 or 2016-2025. The results illustrate a potential GHG reduction of nearly 0.7 megatonnes in 2025 assuming that ASHRAE 100-2015 is implemented for energy related permits, except small projects, starting in 2016. Natural gas savings can be maximized under that same scenario with 13.3 million gigajoules per year in 2025. Electricity saving can be maximized under a hybrid of ASHRAE 90.1-2010 for small projects and ASHRAE 100-2015 for large projects, saving 5,200 GWh/yr in 2025. Chapter 9 outlines the potential benefits under realistic implementation scenarios, given current policy development and regulatory cycles in BC.

TABLE 8.2: CUMULATIVE ANNUAL ENERGY SAVINGS FOR EACH CODE SCENARIO

		ASHRAE 90.1-2010	NECB 2015	ASHRAE 100-2015	ASHRAE 90.1-2010 & ASHRAE 100-2015[34]
Cumulative Annual Electricity Savings	in 2020	930 GWh/yr	800 GWh/yr	915 GWh/yr	1,450 GWh/yr
	in 2025	3,400 GWh/yr	2,900 GWh/yr	3,300 GWh/yr	5,225 GWh/yr
Cumulative Annual Natural Gas Savings	in 2020	11 GWh/yr (40,000 GJ/yr)	30 GWh/hr (108,000 GJ/yr)	1,000 GWh/yr (3,600,000 GJ/yr)	950 GWh/yr (3,420,000 GJ/yr)
	in 2025	40 GWh/yr (144,000 GJ/yr)	110 GWh/yr (396,000 GJ/yr)	3,700 GWh/yr (13,320,000 GJ/yr)	3,400 GWh/yr (12,240,000 GJ/yr)
Cumulative Annual GHG Savings	in 2020	0.01 Mt/yr	0.01 Mt/yr	0.19 Mt/yr	0.19 Mt/yr
	in 2025	0.04 Mt/yr	0.05 Mt/yr	0.70 Mt/yr	0.67 Mt/yr

Stage 4 – Non-energy benefits and complementary initiatives assessment

There are a range of non-energy co-benefits that can be realized through enhancements to the energy efficiency of existing building stock. Some of these co-benefits include:

- → Climate change mitigation associated with reduced energy demand.
- → Improved resilience associated with reduced dependence on energy infrastructure and reduced vulnerability of building stock through weatherization improvements.
- → Increased affordability due to reduced energy costs and job creation.
- → Community economic development through a range of spin-off economic benefits, such as improved business competitiveness, higher property values, and job creation.
- → Improved health and comfort for building occupants through reduced noised, comfortable indoor temperatures and improved indoor air quality.
- → Increased predictability of outcomes associated with energy efficiency improvements, facilitating more accurate demand forecasting by governments.

A range of complementary initiatives have begun to pave the way for successful roll-out of new energy efficiency revisions to the building code, including:

- → Existing Provincial legislation and supporting tools developed to support local government climate action, such as the Climate Action Charter, the Local Govern Green Communities Statutes Amendment Act, other enabling regulations and funding and incentives.
- → Funding and incentive programs offered by utilities and private entities such as BC Hydro, Fortis BC, CMHC and BOMA.

[34] The ASHRAE 90.1-2010 & ASHRAE 100-2015 analysis combines the use of the two standards by applying ASHRAE 90.1-2010 to all Small Projects and ASHRAE 100-2015 to all other permits.

9 Policy Conclusions and Recommendations

This White Paper has highlighted a number of opportunities to improve energy efficiency in existing buildings through the application of an energy code. The analysis presented in the paper was based on a combination of technical, market, and economic research. Conclusions in Chapter 8 were drawn on the technical and economic potential for energy savings and emission reductions associated with three distinctive standards and a fourth hybrid approach, assuming immediate implementation. This chapter outlines further hybrid approaches with implementation dates that reflect current code development cycles. It also includes a discussion on current market barriers and potential solutions that could be topics for stakeholder consultation.

9.1 Policy Options

Two mutually exclusive policy options have been identified; the first is closely aligned with the current legislative context, while the second requires a change of legislation and/or regulations:

1. **Option 1**: Expanding upon existing momentum in the modernization of the BC building regulatory system by ensuring consistent, province-wide enforcement of the BC Building Code (BCBC) to existing buildings, along with ongoing revisions to the Energy Efficiency Act. An option 1b includes the addition of a retro-commissioning provision for large permits.
2. **Option 2**: Broadening the scope beyond current BCBC referenced standards in a manner that achieves the highest economic returns for society, with substantial energy efficiency and emission reduction outcomes.

The context for implementation of these options would be under the Climate Leadership Plan, with two or three tiers of implementation starting in 2017. The options are described below, along with the pros and cons of each. Both options include combines both a system-based standard (ASHRAE 90.1-2010) and whole-building standard (ASHRAE 100-2015) in order to apply to a range of permit sizes and provide potential flexibility for compliance. The two options include a tiered approach to allow for phased implementation needed to overcome barriers to compliance. The analysis has been performed using ASHRAE 90.1-2010, the potential exists for NECB to be applied instead. Currently, NECB does not apply to building alternations, but a proposal to the Standing Committee for Energy Efficiency in Buildings would expand its scope to include existing buildings, likely for the 2017 amendments to the NECB 2015.

9.1.1 Option 1

For Tier 1, this option includes the following components, with a prospective implementation date of 2017 or 2018:

→ Establish Building Act regulation to ensure consistent enforcement of the BC Building Code (BCBC) energy standards to existing buildings, generally applying only to the building systems being retrofitted through permitted activities.

- Enforce ASHRAE 90.1 alteration standards and exemptions for all building permit applications.
  - It is noted that this option will largely exclude building envelope measures that have significant natural gas and GHG reduction potential, due to exemptions under ASHRAE 90.1. Furthermore, lighting systems with less than 10% retrofit are exempt.
- Establish additional exemptions for building types through new regulatory language and/or legally binding administrative procedures.
- Update the BCBC to the latest technical standards, when available, such as ASHRAE 90.1 (2016) and/or NECB (2017), should it be expanded in scope to include building alterations.
- Implement Energy Efficiency Act standards that reflect the best already regulated in North America (not analyzed separately, but providing an alternative regulatory framework to achieve savings and reinforcing BCBC standards with third-party verification and labelling).

For Tier 2, with an implementation date as late as 2022, the following additional components are recommended:

- Continued updating of the BCBC and Energy Efficiency Act to reference the most up-to-date standards.
- In Option 1b, retro-commissioning would be required for buildings seeking a “large permit”, as per the definition for Option 2 below.
- In order to provide flexibility to building owners, an Alternative Solution could be designated whereby a whole building standard such as ASHRAE 100 is complied with, in lieu of ASHRAE 90.1 or NECB. The 40th percentile lowest consumption EUI targets could be referenced.
  - Capacity building surrounding Energy Management Plans and Energy Audits may be required. This component; however, is similar to re-commissioning that was supported by the Continuous Optimization Program.
  - A BC specific table of energy use intensity targets could be developed, rather than using the 25th and 40th lowest consumption percentile for the United States.
  - Compliance with ASHRAE 100 could require significant activity prior to permit application and approval, as illustrated in Figure 9.1 below. Without a new legislative framework to enable post-retrofit enforcement actions, full compliance would be required at time of permit.

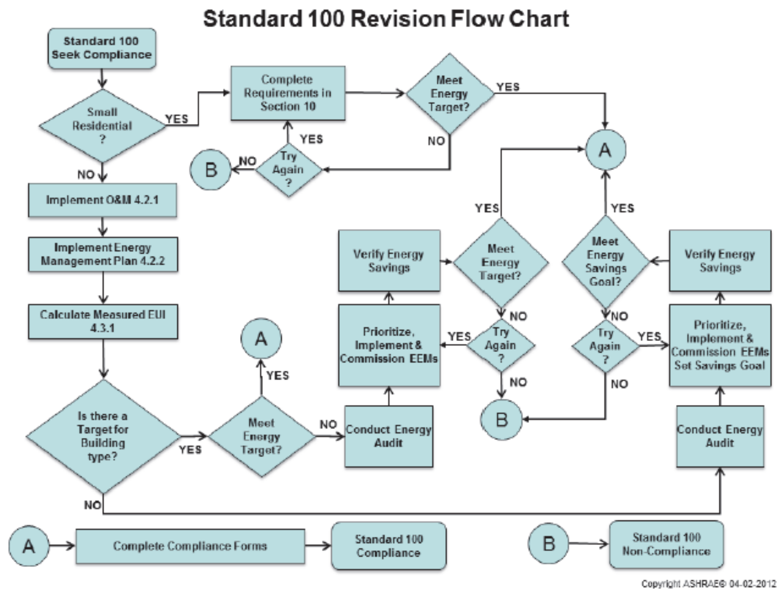

Figure 9.1: ASHRAE 100-2015 Revision Flow Chart

A Tier 3 stage could be developed with a 2027 target date that references the latest standard(s) (NECB and/or ASHRAE 90.1) and references the ASHRAE 100 EUI table for the 25th percentile of lowest energy consumption buildings.

Option 1 essentially represents an extension of the current regulatory environment in British Columbia, with an expansion of flexibility in the Tier 2 implementation (2022). Currently, the BC Building Code mandates ASHRAE 90.1-2010 compliance for construction and change of occupancy in existing buildings. However, there are considerable barriers preventing its implementation and thus, it shouldn't be assumed that those savings are being achieved. Compliance with the BC Building Code is limited, as evidenced by the fact that only 3 out of 10 surveyed municipalities routinely enforce it. This White Paper considers an alternative approach (Option 2 below) that would expand the savings and financial benefits.

Option 1 Pros:

- Works within the current legislative framework.
- Extends current practice in leading municipalities (representing approximately 30% of the surveyed building inspectors) to the entire province.
- References technical standards that are updated by Standards Development Organizations (SDOs) and are familiar to BC industry players.
- Minimizes incremental capital costs (4% on average).
- In Tier 2, provides flexibility for high performance buildings with EUIs lower than ASHRAE 100 (BC adapted) targets, and/or comprehensive retrofits that enable optimization of energy efficiency upgrades rather than following the component specific approaches outlined in ASHRAE 90.1 and NECB. It is noted that the ASHRAE 100 energy audit procedure ($3,000-$10,000) is lower in cost than the performance paths of the existing BCBC standards ($10,000-$25,000).

Option 1 Cons:

- → Does not maximize financial benefits to consumers, greenhouse gas emissions.
- → Provides limited flexibility for compliance options (need to follow ASHRAE 90.1 prescriptive requirements).
- → In Tier 2, the ASHRAE 100 alternative compliance path is impractical without a new legislative framework that would enable enforcement actions up to five years following the retrofit. As such, it is unlikely to be followed, except for cases of high performance buildings owned and managed by leading organizations that already have benchmarking, audits, and energy management plans in place.

9.1.2 Option 2

This option includes three tiers of implementation starting in 2017/2018 with subsequent code revision dates (e.g., 2022 and 2027). It includes several aspects of Option 1, but focuses on whole-building energy performance for larger projects, starting at the Tier 2 implementation date.

Tier 1 (2017):

- → Enforce ASHRAE 90.1 (or NECB) for all permits.
- → In addition, mandate an ASHRAE 100 energy audit (section for large permits) triggered by one of the following three conditions:
  1. Permit greater than $250,000, as aligned with the Stats Canada category;
  2. Buildings with a gross floor area more than 50,000 ft^2 of (aligned with benchmarking policy threshold floor size in many jurisdictions); or,
  3. "Major" permit types, as defined by regulation, similar to VBBL menu triggers.
- → Full compliance with ASHRAE 100 at the time of building permit as an Alternative Solution instead of 90.1, NECB, and the energy audit. See additional notes on this Alternative Solution in Option 1, Tier 2 above.
- → Ongoing Energy Efficiency Act regulatory amendments.

Tier 2 (2022)

- → Enforce ASHRAE 90.1 (or NECB) for small permits that are triggered by one of the following three conditions:
  1. Permit value less than $250,000, as aligned with the Stats Canada category;
  2. Buildings with a gross floor area less than 50,000 ft^2; or,
  3. "Minor" permit types, as defined by regulation, similar to VBBL menu triggers.
- → Mandate ASHRAE 100 compliance for large permits, other than those noted in the four points above:
  - → Compliance with ASHRAE 100 EUIs that represent the 40^{th} percentile of lowest energy consumption, currently referenced in Normative Annex A based on energy performance of US buildings. This would be required at the time of building permit, requiring significant work in advance.

→ Alternatively, it would be possible to develop a BC specific EUI table that assigns the 40th percentile lowest consumption values for BC or Canadian market conditions utilizing the NRCan Survey for Commercial and Institutional Energy Use (SCIEU) in place of the US-specific Commercial Building Energy Consumption Survey (CBECS) and following the same procedure used to develop the current table in ASHRAE 100-2015.

→ In line with ASHRAE 100 flowchart (Figure 9.1), enable a second compliance path that includes operations and maintenance, an Energy Management Plan, energy audits, energy efficiency measures (with five-year payback or less), and verification with one year of energy data.

→ New legislation and/or regulations under the Building Act are required to provide for enforcement actions following the building permit, as the ASHRAE 100 process can take up to three years. See Figure 9.2: ASHRAE 100-2015 Timeline. The new regulations would enable jurisdictions to withhold a performance bond related to achieving ASHRAE 100 requirements in the months following the completion of the building permit, and/or to mandate additional remedial action on energy efficiency. This requires an in-depth discussion with stakeholders.

→ Applicable to ASHRAE 100, it may be appropriate to establish a financing option for owners that are unable to cover incremental capital costs. Current legislation under the Clean Energy Act enables on-bill financing provided by energy utilities, subject to new regulations. Other jurisdictions use property-assessed financing, provided by local governments or designated investors.

INFORMATIVE ANNEX B
TIMELINE

Compliance shall be deemed to be valid for the number of years indicated in the table below, beginning with the date of the signature on Form A in Normative Annex C.

For buildings with energy targets, Table B-1, "Compliance Timeline for Buildings with Energy Targets," shall apply. For buildings that do not have energy targets, Table B-2, "Compliance Timeline for Buildings without Energy Targets," shall apply.

TABLE B-1 Compliance Timeline for Buildings with Energy Targets

Event	Time Frame	Reference
Step 1—Determine (a) the building's measured energy-use intensity and (b) the building's energy target.	Time 0	Section 4.3.1
Step 2—If building's measured EUI is equal to or less than its energy target, go to Step 9. If the building's measured EUI is greater than its energy target, continue to Step 3.	Time 0	Sections 4.3.1.1 and 4.3.1.2
Step 3—Carry out an energy audit.	0 to 4 months	Sections 4.3.1.2 and 8.2.2
Step 4—Identify a package of EEMs and, assuming their implementation, calculate an adjusted EUI for the building that is equal to or lower than its energy target.	2 to 6 months	Section 8.2.2
Step 5—Implement the selected package of EEMs.	3 months to 1 year	Sections 8.2.2 and 9.1.1.1
Step 6—Apply for conditional compliance	At completion of step 5.	Section 4.3.1.2 a
Step 7—Measure the building's energy use for 12 months and determine its post-EEM energy-use intensity.	12 to 15 months after completion of step 5.	Section 4.3.1
Step 8—If the building's measured EUI is equal to or less than its energy target, go to Step 9. If the building's measured EUI is greater than its energy target, return to Step 4, identify additional EEMs, and calculate a new adjusted EUI that is equal to or lower than the building's energy target.	12 to 15 months after completion of step 5.	
Step 9—Apply for compliance with Standard 100.	12 to 15 months after completion of step 5.	Section 4.3.1.3 and Form A

A building which achieves compliance shall remain compliant for a period of five years from the date of validation.

Figure 9.2: ASHRAE 100-2015 Timeline

Tier 3 (2027):

→ All of the Tier 2 provisions above, referencing the latest standards, with the following modification:

  → For Tier 3, compliance with ASHRAE 100 EUIs that represent the 25th percentile lowest energy consumption.

Option 2 Pros:

  → Maximizes energy savings, emissions reductions and consumer financial benefits.

  → References technical standards that are updated by Standards Development Organizations (SDOs) and are familiar to BC industry players.

  → Provides significant flexibility for building owners for compliance.

Option 2 Cons:

  → Higher incremental capital costs (7%).

  → Potentially requires new legislation to enable post-occupancy permit enforcement actions.

9.2 Energy Saving Benefits

Table 9.1 highlights the cumulative annual savings of the two options identified in Section 9.1 in the years 2025 and 2030. The numbers vary slightly from those comparable approaches presented in Section 6.2.3 due to delayed implementation dates. The method assumes that the code requirements of each Tier are included in all applicable (energy related) permits starting from the implementation year indicated. The discounted ICC and NPV presented in this table utilize the base values calculated in Section 6 and were not corrected for fluctuations in utility prices or construction costs associated with market maturation in future years. The ICC and NPV are presented as cumulative discounted values determined using a 6% discount rate applied to the cost over the number of years between 2017 and the implementation year of the retrofit (i.e., for retrofits occurring in 2027 the ICC has been discounted by a factor of (1.06)^-10=0.56). This methodology aligns with the discounted value of money utilized in the original NPV analysis to discount savings from energy efficiency.

TABLE 9.1 SUMMARY OF CUMULATIVE ANNUAL SAVINGS RESULTING FROM IMPLEMENTATION OF RECOMMENDED POLICY OPTIONS

		OPTION 1	OPTION 1B	OPTION 2
Cumulative Annual Electricity Savings	in 2025	2,800 GWh/yr	2,900 GWh/yr	3,000 GWh/yr
	in 2030	6,400 GWh/yr	7,100 GWh/yr	7,400 GWh/yr
Cumulative Annual Natural Gas Savings	in 2025	77 GWh/yr (277,000 GJ/yr)	215 GWh/yr (775,000 GJ/yr)	470 GWh/yr (2,400,000 GJ/yr)
	in 2030	270 GWh/yr (970,000 GJ/yr)	880 GWh/yr (3,170,000 GJ/yr)	2,200 GWh/yr (7,920,000 GJ/yr)
Cumulative Annual GHG Savings	in 2025	0.04 Mt/yr	0.06 Mt/yr	0.11 Mt/yr
	in 2030	0.11 Mt/yr	0.20 Mt/yr	0.47 Mt/yr
Discounted Cumulative ICC (2017 $)	in 2025	$405 million	$405 million	$483 million
	in 2030	$560 million	$560 million	$764 million
Discounted Cumulative npv (2017 $)	in 2025	$123 million	$138 million	$234 million
	in 2030	$175 million	$205 million	$439 million

The calculations to determine savings under each Option assume the following:

Option 1

- Tier 1 (2017-2021)
  - ASHRAE 90.1-2010 applies to all energy related permits.
- Tier 2 (2022-2030)
  - ASHRAE 90.1-2010 applies to all energy related permits for Small Projects.
  - ASHRAE 90.1-2010 applies to 90% of energy related permits and ASHRAE 100-2015 applies to the remaining 10% of energy related permits for all other segments.

Option 1b

- Tier 1 (2017-2021)
  - ASHRAE 90.1-2010 applies to all energy related permits.
- Tier 2 (2022-2030)
  - ASHRAE 90.1-2010 applies to all energy related permits for all projects.
  - Retro-commissioning is required as a component of all large projects

Option 2

- Tier 1 (2017-2021)
  - ASHRAE 90.1-2010 applies to all energy related permits.
- Tier 2 (2022-2026)
  - ASHRAE 90.1-2010 applies to all energy related permits for Small Projects.

  - → ASHRAE 100-2015 Alternate EUIs (40th percentile lowest consumption) applies to all energy related permits for all other segments.

- → Tier 3 (2027-2030)
  - → ASHRAE 90.1-2010 applies to all energy related permits for Small Projects.
  - → ASHRAE 100-2015 (25th percentile lowest consumption) applies to all energy related permits for all other segments.

It is noted that future editions of the noted standards (ASHRAE 90.1 and 100), or other standards (NECB), could be referenced in lieu of the ones evaluated in this report, although the analysis is based on the currently available standards.

9.3 Costs

Incremental capital costs and net economic benefits (net present value) were presented in Table 8.1: Annual Cost and Savings for a Single Year of Implementation for Each Code Scenario. The incremental capital costs of the options provided in this chapter, over and above common practices for building renewals, are represented by columns 1 (ASHRAE 90.1-2010) and 4 (hybrid) in the table, following full implementation in 2022 (Option 1, Tier 2) and 2027 (Option 2, Tier 3):

- → Option 1 – $55 million per year; 4% of total permit value
- → Option 2 - $112 million per year; 8% of total permit value

It is noted that calculation of net present value in this chapter is challenging due to the delayed implementation date and the need to extend benefits to 30 years to be consistent with previous chapters, through to 2057. It is not advisable to estimate energy rates to that year and thus, a simplified conclusion is provided that the proposed options are cost-effective under conditions from 2016 to 2045. Furthermore, the sensitivity analyses performed in Section 6.2.5 illustrate that the individual standards continue to be cost-effective with capital cost increases of up to 94% and reduced energy bill of 49%.

9.4 Policy Trade-offs

In addition to the pros and cons for each of Options 1 and 2 noted in Section 9.1, the following trade-offs are highlighted as possible topics for discussion with stakeholders to determine a priority between them:

- → Option 1 minimizes incremental capital costs to owners – approximately 4%. Option 2 incremental costs average 8% following full implementation and thus, may require companion financial measures such as property-assessed and/or on-bill financing.
- → Option 1 ensures familiarity of industry players with current regulated standards.
- → Option 2 maximizes economic benefits to consumers.
- → Option 2 maximizes flexibility for compliance.
- → Option 2 has moderate needs for preparation by implementing governments, including but not limited to developing a BC-specific table of EUIs for ASHRAE 100, new regulations for enforcement actions following the building permit and financing options to address higher incremental capital costs.

→ Both options may require exemptions for certain building types and owners, to be confirmed through consultations.

→ Both options require industry capacity building and training.

→ Both options require companion market transformation incentives and measures to ready the marketplace for Tier 2 and 3.

9.5 Recommendations

The following actions are recommended to facilitate consideration for provincial policy.

TABLE 9.2 SUMMARY OF CUMULATIVE ANNUAL SAVINGS RESULTING FROM IMPLEMENTATION

YEAR	STAGE	OPTION 1 ACTIONS	OPTION 2 ACTIONS
2016	Policy Analysis and Stakeholder Engagement	Review ASHRAE 90.1-2016 and compare with NECB-2015. Prepare policy proposals for 2017 and complete consultations.	Prepare policy proposals for 2017 and complete consultations. Develop training on ASHRAE 100 flexibility provisions (audits).
2017	Development of Regulatory Roadmap	Tier 1 Target Date Checklist to track compliance approach. Review NECB-2017.	Tier 1 Target Date Checklist to track compliance approach. Confirm ASHRAE 100 EUI table.
2018-2020	Voluntary Market Transformation Programs	Promote use of ASHRAE 100 as flexibility measure. Review ASHRAE 90.1-2019. Review NECB-2020.	Provide incentives for owners to seek full ASHRAE 100 compliance at 40th percentile lowest consumption EUI. Review ASHRAE 100-2018.
2021	Voluntary Market Transformation Programs	Prepare policy proposals and conduct consultations. Develop training for new standards. Confirm ASHRAE 100 EUI table. Provide training on ASHRAE 100 flexibility provisions.	Prepare policy proposals and conduct consultations. Develop training for new standards and full EUI requirements under ASHRAE 100 (40^{th} percentile lowest consumption EUI).
2022	Comprehensive Standards	<u>Tier 2 Target Date</u> Incentives for ASHRAE 100 flexibility provision.	<u>Tier 2 Target Date</u> Incentives for ASHRAE 100 25^{th} percentile lowest consumption EUIs.
2027 (or earlier)	Deep Energy Retrofits	<u>Tier 3 Target Date</u>	<u>Tier 3 Target Date</u>

Yours truly,

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Appendix A

Summary of Energy Efficiency Policy Review

ASHRAE 100-2015

ASHRAE Standard 100-2015 Energy Efficiency in Existing Buildings is a standard that "provides criteria that will result in energy efficiency in existing buildings". The standard provides Energy Use Intensity (EUI) targets based on measured data from the existing building stock for 53 building types (residential and non-residential) in each of the ASHRAE Climate Zones. The EUI targets were derived using data from the Commercial Building Energy Consumption Survey (CBECS) 2003 and the Residential Energy Consumption Survey (RECS) that was then extrapolated to 17 DOE climate zones using multipliers developed from modeling by the Oak Ridge National Laboratory. The standard provides requirements for an Energy Management Plan, an Operation and Maintenance Program, and Building Energy Use. Buildings that do not comply with energy efficiency targets are required to engage a professional to perform Energy Audits and to implement Energy Conservation Measures (ECMs) to improve building performance. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

ASHRAE 90.1-2010

ASHRAE Standard 90.1-2010 Energy Standard for Buildings Except Low-Rise Residential Buildings is a standard that provides minimum efficiency requirements for new buildings, additions to existing buildings, new systems and equipment, or alterations to existing buildings. The standard contains both performance and prescriptive compliance paths to achieve the goal of energy efficient buildings. The prescriptive path requires that the building meets all of the minimum efficiency requirements for each building system or component as specified in Sections 5 through 10. The performance path requires that an energy cost budget be developed through energy modeling of a baseline building with the same size and program as the desired building that meets the prescriptive requirements. The design of the desired building is then modelled and must achieve an energy cost budget lower than the baseline.

ASHRAE 90.1-2010 provides design requirements for new buildings and building components to ensure energy efficient operation. Details are provided for all aspects of the building design, maintenance, and operation. The standard is continuously maintained and updated to more stringent energy efficiency requirements. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)

As part of the Austin ECAD, energy audits are required for MURBS older than ten years. If the MURB energy use is >150% of the average in Austin (determined from energy benchmarking) the owner is required to implement EEMs to reduce the energy use by 20%. The ordinance applies to buildings over 10,000ft^2 and is based on measured whole building utility data. Potential for alignment with the Building Act exists at time of construction or change of occupancy/use.

BOMA BESt

BOMA BESt is a national building certification program designed to assess environmental performance and management of existing commercial buildings. The program provides a framework to critically assess six key areas of environmental performance and management in six areas; energy, water, waste reduction and site, emissions and effluents, indoor environment, and environmental management system. The process uses 14 BESt Practices as minimums for certification and an online questionnaire to determine higher levels of achievement (bronze, silver, gold, platinum). Certification can commence after 12 months of operation and recertification is required every three years. Potential for alignment with the Building Act exists at time of construction of change of occupancy/use. Follow-up activities are not aligned with legislation, including the three-year recertification timeframe.

Boston Energy Assessment and Retro-commissioning Requirements (within the Building Energy Reporting and Disclosure Regulation)

The City of Boston's Building Energy Reporting and Disclosure Regulation requires energy benchmarking, reporting, and investments in energy efficiency upgrades unless specified performance-based exemption levels are achieved. Performance targets are based on Energy Star Certification, LEED-EBOM, or measured data. This standard is not aligned with current BC regulations under the Building Act that are focused on construction or change of occupancy/use.

City of Atlanta Land Development Code, Part II, Section 8-2002

The City of Atlanta requires energy benchmarking and reporting. Energy and water audits of base building systems within ten years of benchmarking disclosure are required unless exemptions are met. Exemption is provided if: (1) The property has received an Energy Star certification from EPA for at least two of the three years preceding the due date of the audit report, (2) there is no EPA Energy Star rating for the building and a registered design professional submits documentation that the property's energy performance is 25 or more percentage points better than the average building of its type, (3) the property has improved its EPA Energy Star score by 15 points, or (4) the property has achieved or maintained the most recent LEED certification for at least two of the three years preceding the due date for the audit report. This standard is not aligned with current BC regulations under the Building Act that are focused on construction or change of occupancy/use.

City of Berkeley Building Energy Saving Ordinance

The City of Berkeley requires energy benchmarking and reporting. As part of the above noted ordinance an energy assessment must be performed and the results provided to a buyer or lessee. Exemptions exist if: (1) Building Energy Score or Green Building Rating can demonstrate a reasonable level of efficiency, (2) a building completes an energy improvement project with a verified minimum improvement, or (3) a new building or extensive renovation is completed within ten years of the reporting deadline. This standard is not aligned with current BC regulations under the Building Act that are focused on construction or change of occupancy/use.

International Energy Conservation Code (IECC) 2015

The IECC 2015 provides minimum efficiency requirements for new buildings, additions to existing buildings, new systems and equipment, or alterations to existing buildings. The standard contains both prescriptive compliance and a Total Building Performance (Section C407) paths to achieve the goal of energy efficient buildings. ASHRAE 90.1 is referenced as an alternative compliance path within the body of Chapter 4 Commercial Energy Efficiency.

LEED for Existing Buildings Operation and Maintenance (LEED-EBOM)

LEED-EBOM is a set of performance standards for certifying the operation and maintenance of existing commercial or institutional buildings and high-rise residential buildings. The certification checklist provides credits from the following categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in operation, and regional priority. The Energy and Atmosphere Prerequisite 2 Minimum Efficiency Performance requires an Energy Star Score of at least 69 or demonstrated efficiency of 19% better than typical buildings of similar type. Buildings must recertify every five years. There is potential to align these standards with the Building Act at the time of construction or with the change of occupancy/use. The five-year recertification timeframe is not aligned with legislation.

National Energy Code of Canada for Buildings (NECB 2011)

The NECB 2011 establishes minimum efficiency requirements for buildings. The scope of the standard includes energy efficiency in the design and construction of new buildings and in additions to existing buildings. It does not cover alterations to existing buildings. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance. Compliance with the NECB 2011 can be achieved through a prescriptive path, a trade-off path, or a performance path. The prescriptive path requires that building meet the minimum energy efficiency requirements set forth in the NECB. The trade-off path allows the design to trade elements within the same "part" of the building to achieve compliance. An example can include allowing more window area by trading for an improved envelope insulation. The performance path requires that the design of the new building be demonstrated to use less energy than an equivalent building built to the prescriptive requirements.

NECB 2015

The 2015 version of the NECB was released in December 2015. The updated version consists of similar compliance structures as the earlier version but includes a number of changes to increase the level of energy efficiency requirements. The scope of the standard includes energy efficiency in the design and construction of new buildings and in additions to existing buildings. It does not cover alterations to existing buildings. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance. Compliance with the NECB can be achieved through a prescriptive path, a trade-off path, or a performance path. The prescriptive path requires that building meet the minimum energy efficiency requirements set forth in the NECB. The trade-off path allows the design to trade elements within the same "part" of the building to achieve compliance. An example can include allowing more window area by trading for an improved envelope insulation. The performance path requires that the design of the new building be demonstrated to use less energy than an equivalent building built to the prescriptive requirements.

The Standing Committee on Energy Efficiency for Buildings, a volunteer group that provides advice to the Canada Codes Centre, recently approved a strategic direction to amend the NECB to enable its application to existing buildings either as a 2017 interim update or within the 2020 NECB.

NYC Local Law 87 - Audits and Retro-commissioning

NYC LL87 requires energy audits and retro-commissioning of all properties over 50,000ft^2 every ten years as part of the Greener, Greater Buildings Plan (GGBP). The energy audit is required to be as stringent as an ASHRAE Level 2 audit. The regulation does not target a specific level of energy efficiency and does not require EEMs to be implemented but rather applies to all covered buildings. Potential for alignment with Building Act exists at time of construction of change of occupancy/use. Follow-up activities are not aligned with legislation, including ten-year recertification timeframe.

NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces

NYC LL88 requires large non-residential buildings to upgrade lighting to meet current NYC Energy Conservation Code standards and to install electricity sub-meters for each large non-residential tenant space and provide monthly spaces by 2025. Upgrades must meet the Energy Conservation Code enforced at the time of upgrade. This regulation is not aligned with Building Act legislation and it does align with proposed Energy and Water Efficiency Act legislation (2012) for energy systems.

Ontario Building Code including SB-10 “Energy Efficiency Supplement”

The Ontario Building Code provides minimum requirements for new buildings, change of occupancy (Part 10), and renovations to existing buildings (Part 11). The code is applies to “design and construction of the extensions and those parts of the that are subject to material alteration or repair” and does not apply to the whole building in the case of renovations. The supplement SB-10 provides energy efficiency requirements and is referenced in the main body of the code in Part 12 Resource Conservation and Environmental Integrity. The supplement contains both performance and prescriptive compliance paths to achieve the goal of energy efficient buildings. ASHRAE 90.1is referenced within the supplement.

San Francisco Commercial Buildings Energy Performance Ordinance

The San Francisco Commercial Buildings Energy Performance Ordinance requires energy audits to be performed every five years for non-residential buildings larger than 10,000ft^2. ASHRAE Level 1 audits are required for buildings 10,000-49,999ft^2. ASHRAE Level 2 audits are required for buildings larger than 50,000ft^2. Potential for alignment with Building Act exists at time of construction or change of occupancy/use. Follow-up activities are not aligned with legislation, including five-year recertification timeframe.

Seattle Existing Building Code (2012 SEBC)

The Seattle Existing Building Code contains a list of special requirements for buildings which undergo substantial alterations. The extent of the improvements required is based on the size and scope of work and the relative hazard that exists. The code includes requirements for the entire building to comply with Section C101.4.7 of the 2012 Seattle Energy Code. Several compliance paths are available, as detailed in Section C101.4.7.3 of the Seattle Energy Code including: full compliance with prescriptive requirements, envelope thermal performance within 20 percent of code, total building performance within 15 percent of code, and operating energy consumption within 20 percent of code.

Title 24 Part 6 - California Energy Code

The California Energy Code establishes minimum energy efficiency requirements for buildings. The 2013 Building Energy Efficiency Standards focus on several key areas to improve the energy efficiency of newly constructed buildings and additions and alterations to existing buildings, and includes requirements that will enable both demand reductions during critical peak periods and future solar electric and thermal system installations. The regulation provides performance and prescriptive requirements for residential and non-residential buildings. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

VBBL Part 11 - Existing Buildings

Part 11 of the VBBL establishes minimum energy efficiency requirements for existing buildings. When work is carried out on an existing building the building must be upgraded to an "acceptable level". The acceptable level is based on "Project Types and Categories of Work". The flow chart to be used is based on the project type and work category. The flowcharts indicate the Energy Efficiency Upgrade Level required (E1 to E6). Energy Efficiency Upgrade Levels (one or more requirements in L1-L6) are described in Appendix A: Table A-11.2.1.2.C and the acceptable solutions for these levels are indicated in Appendix A: Table A-11.2.1.2.D. The designer can choose between a number of acceptable solutions that apply to either specific systems—envelope, HVAC (heating, ventilation and air conditioning), SWH (solar water heating), lighting—or whole building elements. A flexibility provision includes compliance with BOMA BESt in lieu of meeting menu standards. The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

	ASHRAE 100-2015	ASHRAE 90.1-2010	Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)	BOMA BESt	Boston Energy Assessment and Retro-commissioning Requirements	City of Atlanta Land Development Code, Part II, Section 8-2002	City of Berkeley Building Energy Saving Ordinance	International Energy Conservation Code (IECC) 2015	LEED for Existing Buildings	NECB 2011	NYC Local Law 87 - Audits and Retro-commissioning	NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces	Ontario Building Code and SB-10	San Francisco Commercial Buildings Energy Performance Ordinance	Seattle Existing Building Code	Title 24 Part 6 - California Energy Code	VBBL Part 11 - Existing Buildings
Type of Standard (Performance; Prescriptive)?	Both	Both	Performance	Both	Both	Not a standard	Not a standard	Prescriptive	Prescriptive	Both	Prescriptive	Prescriptive	Both	Not a standard	Both	Both	Prescriptive, with performance components (e.g., lighting power density), as required
Scope of Standard: Type of Buildings (Commercial, MURB, Industrial, etc.)?	All	Residential; non-residential; industrial	MURB	Commercial: Office Open Air Retail Light Industrial Shopping Centres MURBs Health Care Facilities	Phased roll-out based on building type and size. May 15, 2014: Nonresidential buildings 50,000 square feet and greater May 15, 2015: Residential buildings 50 Units/50,000 square feet and greater May 15, 2016: Nonresidential buildings 35,000-49,999 square feet May 15, 2017: Residential buildings 35 Units/35,000-49 Units/49,999 square feet	Residential; non-residential	October 1, 2018: All commercial buildings 15,000 SF or larger perform an energy assessment every 5 years October 1, 2019: All commercial buildings 5,000 SF- 14,999 SF perform an energy assessment every 8 years October 1, 2020: All commercial buildings less than 5,000 SF perform an energy assessment every 10 years	Commercial and MURB	Commercial; MURB	Residential; non-residential; industrial	All properties over 50,000sq ft	Non-residential	Commercial and Residential with exemptions	Non-residential	Commercial	All	Residential (other than 1 and 2 family residential); non-residential
Scope of Standard: System (s) (Whole building, specific systems)?	Residential and non-residential with specific targets for each building type	Building systems being added: Envelope, HVAC, SWH, Power, Lighting, Other	Whole building; existing buildings	Whole building; existing buildings	See cell to above	Whole building; existing buildings	Whole building	Building systems being added: Envelope, HVAC, SWH, Power, Lighting, Other.	Whole building; existing buildings	Building systems being added: Envelope, HVAC, SWH, Power, Lighting, Other	Base building systems which include: envelope, HVAC, conveying systems, DHW, and electrical and lighting	Lighting systems and electricity sub-metering	Building systems being added o extended: Envelope, HVAC, SWH, Power, Lighting, Other.	Non-residential buildings	Whole building and/or specific systems	Residential and non-residential with prescriptive and performance based using an energy budget	Project Area or Whole Building depending on the project

	ASHRAE 100-2015	ASHRAE 90.1-2010	Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)	BOMA BESt	Boston Energy Assessment and Retro-commissioning Requirements	City of Atlanta Land Development Code, Part II, Section 8-2002	City of Berkeley Building Energy Saving Ordinance	International Energy Conservation Code (IECC) 2015	LEED for Existing Buildings	NECB 2011	NYC Local Law 87 - Audits and Retro-commissioning	NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces	Ontario Building Code and SB-10	San Francisco Commercial Buildings Energy Performance Ordinance	Seattle Existing Building Code	Title 24 Part 6 - California Energy Code	VBBL Part 11 - Existing Buildings
Size requirement for the building (minimum, maximum)?	>5,000 sq ft	Components of the standard are based on specific system sizes which are indirectly tied to the size of the building (ie HRV requirements based on HVAC airflow)	>10,000sq ft	None	See cell to above	25,0000 sq ft as of June 2016	See above	Components of the standard are based on specific system sizes which are indirectly tied to the size of the building (ie HRV requirements based on HVAC airflow).	>1,000 sq ft	None	A single building on a single lot over 50,000sq ft or 2 or more buildings on a single lot that combined are more than 100,000sq ft	A single building on a single lot over 50,000sq ft or 2 or more buildings on a single lot that combined are more than 100,000sq ft One or more submeter is required for tenant space 10,000sq ft or larger; or for each floor >10,000sq ft let by two or more different people	Exemptions for building size	10,000sq ft	Any	All non residential, regardless of size; large residential	No
Compliance Demonstration:	Measured site energy; normalized through a formula provided in the standard	Design data	Measured site energy	Checklist and third party verification	Owner delivers summary of assessment to the Commission including all EEMs with Simple Payback of <10 years.	Measured site energy	Measured site energy	Design data	Checklist and verification by a third party	Design data	Measured site energy	Retrofit documentation	Construction documents	Owner must submit a Confirmation of Energy Audit	Construction documents	Prescriptive or performance based using an energy budget method	Construction documents
Performance Benchmark? (Does the standard kick-in at a certain performance level?)	Lowest 25th percentile energy consumption is the target based on 2003 U.S. Commercial Building Energy Consumption Survey (CBECS) and 2005 Residential Energy Consumption Survey (RECS) data. Newer and/or Canadian data may alter benchmarks.	None	150% of typical MURB energy use in the city	A minimum number of requirements must be met for certification; additional credits allow for higher level certifications to be achieved	The relevant component of the regulation is required unless the exemptions are met (exemptions are indicated below)	Energy Star Score of 75	None	None	A minimum number of credits are required for certification. Additional credits allow for higher level certifications to be achieved. EA Prerequisite 2 requires an Energy Star Score of at least 69 or demonstrated efficiency of 19% better than typical buildings of similar type.	None	No specific energy efficiency threshold is indicated as required; all buildings are required to perform the audits and retrocommissioning	Not based on efficiency but just a requirement	None	Not required.	None	Covers all new and retrofit conditions	No performance benchmark but a requirement for any project
Appropriate trigger for compliance with standard? (Annually?, During retrofit construction?, Change of occupancy/use?)	Any	Construction	Time based	Certification can commence at any time after 12 months of operation and recurs every 3 years	Time based	Time based	Time of sale	Construction	Anytime or after renovation	Construction	Specified role out year based on tax block number starting in 2013	Lighting upgrade and monitoring upgrade must be performed once before 2025	Construction	Time based	Alterations	Whenever a building permit is taken out	Section 11.2.1.1.1) an alteration to an existing building shall trigger upgrading of the existing building to meet the following objectives; c) the building shall be upgraded to an acceptable level of fire, life and health safety, structural safety, non-structural safety, accessibility for persons with disabilities, and energy efficiency

	ASHRAE 100-2015	ASHRAE 90.1-2010	Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)	BOMA BESt	Boston Energy Assessment and Retro-commissioning Requirements	City of Atlanta Land Development Code, Part II, Section 8-2002	City of Berkeley Building Energy Saving Ordinance	International Energy Conservation Code (IECC) 2015	LEED for Existing Buildings	NECB 2011	NYC Local Law 87 - Audits and Retro-commissioning	NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces	Ontario Building Code and SB-10	San Francisco Commercial Buildings Energy Performance Ordinance	Seattle Existing Building Code	Title 24 Part 6 - California Energy Code	VBBL Part 11 - Existing Buildings
Duration of Compliance?	Annex A indicates that compliance is valid for 5 years after initial compliance certificate	At time of construction	10 years, if upgrades implemented	Certification is valid for 3 years	Annual benchmarking reporting and Energy Assessment or Action within 5 years of the trigger and every 5 years thereafter	Annual.	Duration of ownership	At time of construction	Must recertify at least once every 5 years	At time of construction	10 years		At time of construction	5 years	At time of alteration	At time of construction	The specific alternative acceptable solutions (ie the upgrades) can only be used once in a 5 year period.
Continuous Improvement? (Comparison to other buildings? Based on energy efficiency metrics?, Action required to reduce energy use?, etc.)	The EUI targets are based on comparison with top 25% performers of existing buildings using CBECS data. As existing buildings become more efficient the target self-ratchets to be more stringent. The standard is updated by ASHRAE on a routine basis. The most recent version is 2015. The previous version was 2006. As of the 2015 edition, ASHRAE has assigned Standard 100 to the continuous maintenance cycle, which will be updated every 3 years.	Standard becomes more stringent with subsequent iterations to ensure new buildings become more efficient. The standard is updated every three years consistently.	Required to reduce energy use by 20% will self-ratchet with the building stock performance and result in increasingly stringent requirements.	No quantitative guarantee of continuous improvement is specified in the certification process but the requirement for an energy assessment providing cost effective EEM recommendations and the requirement for an Energy Management Plan could lead to continuous improvements.	Compliance paths are based on continuously meeting Energy Star Certification or LEED EBOM Silver which in theory will result in energy efficiency improvements. The Energy Action Path requires a 15% energy reduction over 5 years or alternative paths that would theoretically result in energy savings.	Requirement to receive energy audit unless the building is Energy Star Certified would promote energy efficiency upgrades though none are specifically required.	No quantitative guarantee but improvements could be driven by market demand for energy efficient buildings at time of sale.	Standard becomes more stringent with subsequent iterations to ensure new buildings become more efficient. The standard is updated every three years consistently.	EA Prerequisite 2: Minimum Efficiency Performance requires an Energy Star Score of at least 69 or demonstrated efficiency of 19% better than typical buildings of similar type. This requires that all buildings seeking certification need to be high performers relative to similar buildings. As the building stock energy efficiency increases the efficiency of those buildings qualifying for LEED EBOM will necessarily increase as well.	Code becomes more stringent with subsequent iterations to ensure new buildings become more efficient.	Retrocommissioning will (in theory) reduce energy consumption. The energy audit does not require that the owner improve energy efficiency but provides information on potential cost savings interventions. City-owned buildings must implement EEMs identified in the energy audit to have a simple payback <7yrs.	One time energy efficiency upgrade ensured by reliance on energy conservation code.	Continuous code updates on cycle	No quantitative guarantee. Improvements would result if owner's chose retro-commissioning alternative to energy audit or if they implement EEMs identified in the audit.	Continuous improvement to the Seattle Energy Code.	No requirement for continuous improvement. The standards are updated on a scheduled basis by the California Energy Commission (CEC) every 3 years.	Energy upgrades to be in compliance with ASHRAE 90.1-2010 will result in efficiency improvements compared to most existing buildings. Section 11.2.1.1.f) indicates that the "...building performance shall not be decreased below the existing level." Potential for City to revise the standards over time; referencing new ASHRAE 90.1 provisions. Requires standards development and regulatory consultations.
Professional Roles and Certification (Energy Audit Professional, Energy Modeller, Engineer, Architect, etc.)?	"Qualified person"; energy manager; energy auditor	Engineers; architects; modeller	Further research required		Energy assessment to be performed by a qualified energy professional	Energy audit to performed by a qualified energy professional	Energy audit to be performed by a qualified energy professional	Engineers Architects Modeller	Engineers; architects; LEED consultants	Engineers; architects; modeller	Qualified energy audit or retro-commissioning team	Registered design professional, licensed master, or special electrician must certify the submetering	Engineers Architects	Qualified energy auditor	Design professionals	Division 3 of the Business and Professions Code to accept responsibility for the system design, construction or installation in the applicable classification for the scope of work identified on the Certificate of Acceptance, or shall be signed by their authorized representative.	Design professionals

	ASHRAE 100-2015	ASHRAE 90.1-2010	Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)	BOMA BESt	Boston Energy Assessment and Retro-commissioning Requirements	City of Atlanta Land Development Code, Part II, Section 8-2002	City of Berkeley Building Energy Saving Ordinance	International Energy Conservation Code (IECC) 2015	LEED for Existing Buildings	NECB 2011	NYC Local Law 87 - Audits and Retro-commissioning	NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces	Ontario Building Code and SB-10	San Francisco Commercial Buildings Energy Performance Ordinance	Seattle Existing Building Code	Title 24 Part 6 - California Energy Code	VBBL Part 11 - Existing Buildings
Compliance Verification Procedures	Qualified person to determine EUI and whether the target is met; after implementation of EEMs to reduce consumption, the energy manager submits EUI to AHJ based on 12 months of data	Construction documents, worksheets, and calculation review	Further research required	Checklist and third party verifier site visit; certification issued	Owner submits summary or report to commission	Further research required	Further research required	Construction documents, worksheets, and calculation review	Checklist and verification by a third party	Compliance demonstrated through construction documents designing systems to the required provisions of the code	A qualified professional is required to submit certification forms	Further research required	Perit documents	Further research required	Permit documents	A Certificate of Compliance described in Section 10-103 shall be signed by the person in charge of the building design, who is eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design (*responsible person*); and submitted in accordance with Sections 10-103(a)1 and 10-103(a)2 to certify conformance with Part 6	Letter of assurance by professional; official certification documentation for BOMA BESt if that alternative path is chosen in lieu of the alternative acceptable solutions
Compliance Disclosure (Website?, Posted in building?, Certified third party verification, etc)?	None	None	Results of audits to be posted in buildings and provided to prospective tenants.	List of buildings and certification level is available on the BOMA BESt website	Energy Benchmarking information is disclosed on a public website	Further research required	Energy audit report provided to buyer or lessee	None	LEED Rating is disclosed within the building	None	Not directly from this Local Law but it is required for LL84 for Benchmarking	Third party submittal of verification	None	No. Building owners are required to submit a Confirmation of Energy Audit but not disclose the information	None	The person(s) responsible for the Certificate(s) of Compliance shall submit the Certificate(s) for registration and retention to a data registry approved by the Commission; the submittals to the approved data registry shall be made electronically in accordance with the specifications in Reference Joint Appendix JA7	BOMA BESt (Path 1) may be substituted as the solution for Design Level E2 and BOMA BESt (Path 2) may be substituted as the solution for Design Levels E3, E4 or E5. BOMA BESt requires disclosure on a public website.

	ASHRAE 100-2015	ASHRAE 90.1-2010	Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)	BOMA BESt	Boston Energy Assessment and Retro-commissioning Requirements	City of Atlanta Land Development Code, Part II, Section 8-2002	City of Berkeley Building Energy Saving Ordinance	International Energy Conservation Code (IECC) 2015	LEED for Existing Buildings	NECB 2011	NYC Local Law 87 - Audits and Retro-commissioning	NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces	Ontario Building Code and SB-10	San Francisco Commercial Buildings Energy Performance Ordinance	Seattle Existing Building Code	Title 24 Part 6 - California Energy Code	VBBL Part 11 - Existing Buildings
Compatibility with other building code objectives (health, safety, protection, etc.)?	In theory, the application of the standard should align with broader objectives, as it encompasses a whole building approach to energy. The standard provides flexibility to enable Authority Having Jurisdiction discretion on its application.	The standard provides flexibility to enable Authority Having Jurisdiction discretion on its application.	Further research required	Certification criteria regarding indoor environment overlaps with health aspects of the building code objectives	Further research required	Further research required	Further research required	The standard provides flexibility to enable Authority Having Jurisdiction discretion on its application.	Further research required	Code to be used in conjunction with NBC. The standard provides flexibility to enable Authority Having Jurisdiction discretion on its application.	Further research required	Further research required	Yes	Further research required	Further research required	Title 24 requires the Energy Commission to adopt, implement, and periodically update energy efficiency standards for both residential and nonresidential buildings. The Standards must be cost effective based on the life cycle of the building, must include performance and prescriptive compliance approaches, and must be periodically updated to account for technological improvements in efficiency technology. The standard provides flexibility to enable Authority Having Jurisdiction discretion on its application.	The standard provides flexibility to enable Authority Having Jurisdiction discretion on its application. Similar procedure as that for other VBBL objectives such as Fire & Life Safety, Structural
Referencing other standards (reference to ASHRAE 90.1, ASHRAE Guideline 0)?	ASHRAE 90.1 for equipment efficiency during upgrade. ASHRAE Procedures For Commercial Building Energy Audits	Numerous standards referenced as summarised in Section 12	Further research required	ASHRAE Handbook; HVAC Applications; ASHRAE Procedures For Commercial Building Energy Audits	ASHRAE Procedures For Commercial Building Energy Audits	Further research required	Further research required	Relies on ASHRAE 90.1 as a compliance path	ASHRAE Procedures For Commercial Building Energy Audits; ASHRAE 62.1-200	Used in conjunction with the National Building Code and local codes, and bylaws. Calculation methods reference: ASHRAE Handbooks, Standards and Guidelines, HRAI Digest, Hydronics Institute Manuals, and TSO 13790-Energy performance of buildings-Calculation of energy use for space heating and cooling An extensive list of Standards is provided in Table 1.3.1.2	References Procedures For Commercial Building Energy Audits Energy audit must meet ASHRAE Level 2 audit requirements	Section 805 of NYC Energy Conservation Code (meets requirements for new systems)	References ASHRAE 90.1 and NECB	References ASHRAE Procedures For Commercial Building Energy Audits ASHRAE Level II Audit: Buildings 50,000 square feet and greater ASHRAE Level I Audit: Buildings 10,000-49,999 square feet	ASHRAE 90.1 ASHRAE Handbooks ASHRAE 62.1 Various other ANSI/ASHRAE Standards	Other energy standards for newly constructed buildings, additions, alterations, and repairs to existing buildings may be adopted by local jurisdictions, provided the Energy Commission finds that the standards will require buildings to be designed to consume no more energy than permitted by Title 24, Part 6.	The Alternative Acceptable Solution Options reference specific sections of ASHRAE 90.1-2010 to address building sections such as envelope, HVAC, SHW, Lighting

	ASHRAE 100-2015	ASHRAE 90.1-2010	Austin Energy Conservation Audit & Disclosure Ordinance (ECAD)	BOMA BESt	Boston Energy Assessment and Retro-commissioning Requirements	City of Atlanta Land Development Code, Part II, Section 8-2002	City of Berkeley Building Energy Saving Ordinance	International Energy Conservation Code (IECC) 2015	LEED for Existing Buildings	NECB 2011	NYC Local Law 87 - Audits and Retro-commissioning	NYC Local Law 88 - Lighting Upgrades and Sub-metering in Tenant Spaces	Ontario Building Code and SB-10	San Francisco Commercial Buildings Energy Performance Ordinance	Seattle Existing Building Code	Title 24 Part 6 - California Energy Code	VBBL Part 11 - Existing Buildings
Exemptions to the code/standard?	No EEMs need be implemented if they will compromise historical integrity. Buildings smaller than 5000ft2 do not need an Energy Manager or an Energy Management Plan.	**Section 4.2.1.3 Alterations of Existing Buildings** "Exemptions: a. A building that has been specifically designated as historically significant by the adopting authority or is listed in The National Registry of Historic Places or has been determined to be eligible for listing by the US Secretary of the Interior need not comply with these requirements." Where it is impractical.	Yes Exemptions to audit if certain upgrades have been performed through Austin Energy's rebate program in last 10 years		Buildings are not required to perform the Energy Audit or Action if they meet one of the following criteria: 1) EPA Energy Star Certified in 3 of last 5 years 2) LEED EBOM Silver with 15 points in Energy and Atmosphere within the last 5 years 3)Building generates amount of energy equal to that consumed on site annually 4) Building uses renewable electricity or fuels such that it generates no net GHG annually 5) Building Energy Star Score increased by 15 points in last 5 years 6) In development 7) Building included in institutional master plan of institution that has reduced energy or GHG by 15% in last 5 years 8) Building to be demolished within 6 months 9) Fully vacant for 5 years	Audit not required if: (1) The property has received an Energy Star certification from EPA for at least two of the three years preceding the due date of the audit report. (2) There is no EPA Energy Star rating for the building and a registered design professional submits documentation that the property's energy performance is 25 or more percentage points better than the average building of its type. (3) The property has improved its EPA Energy Star score by 15 points (4) The property has achieved or maintained the most recent LEED certification for at least two of the three years preceding the due date for the audit report.	1) Building Energy Score or Green Building Rating can demonstrate a reasonable level of efficiency 2) A building completes an energy improvement project with a verified minimum improvement 3) New building or Extensive Renovation is completed within ten years of the reporting deadline	Historic buildings and select system requirements based on size of alteration or building performance.		Systems can be exempted from meeting the requirements of the code if it can be shown that it is impractical to do so.	A number of exemptions exist including if: 1) The building is an EPA ENERGY STAR-labeled building for two of the three years prior to filing. 2) The building has been certified in LEED® for Existing Buildings Operations and Maintenance within four years prior to filing. 3) The building has been documented by a registered design professional as an ENERGY STAR or LEED certification equivalent.	If lighting is in compliance with July 1,2010 NYC Energy Conservation Code Dwelling units classified in occupancy group R-2 (Residential - Apartments) and R-3 (Single Family) Spaces classified in occupancy group A-3 (Assembly - other) that is within a house of worship	Numerous exemptions to energy performance including, but not limited to, heritage buildings, temporary structures, and space conditioning setpoints.	Energy audits are not required for: 1) New construction – buildings constructed less than five years prior to the date the energy audit is due 2) ENERGY STAR – buildings that have received the ENERGY STAR label for at least three of the five years preceding the due date for the energy audit 3) LEED – buildings that have been certified under the LEED for Existing Buildings rating system within five years prior to the due date for the energy audit 4) Financial distress – as determined by falling under a specific situation 5) Unoccupied buildings – buildings with less than one full-time occupant in the previous 12-month period	Exceptions exist for landmark buildings, unreinforced masonry buildings, and recently-constructed buildings, as well as situations deemed by the code official to be "impractical."	The Commission may exempt any building from any provision of Part 6 if it finds that: 1) Substantial funds had been expended in good faith on planning, designing, architecture, or engineering of the building before the adoption date of the provision. 2) Compliance with the requirements of the provision would be impossible without both substantial delays and substantial increases in costs of construction above the reasonable costs of the measures required to comply with the provision.	Not required if upgrades to the building are considered voluntary.
Alignment with Legislation (Building Act, Safety Standards Act and/or EE Act)	The standard is compatible with the triggers provided under the Building Act for an initial review of building performance. The 5-year expiration may not align with the same trigger, but could be the basis of an exemption within that timeframe.	The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.	Potential for alignment with Building Act, at time of construction or change of occupancy/use. Follow-up activities not aligned with legislation, including 10 program exemption timeframe.	Potential for alignment with Building Act, at time or construction of change of occupancy/use. Follow-up activities not aligned with legislation, including 3 year recertification timeframe.	Not aligned with current BC legislation due to time based trigger, not necessarily at time of construction or change of occupancy/use.	Not aligned with current BC legislation due to time based trigger, not necessarily at time of construction of change of occupancy/use.	Not aligned with current BC legislation due to time based trigger, not necessarily at time of construction of change of occupancy/use.	The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.	Potential for alignment with Building Act, at time of construction of change of occupancy/use. Follow-up activities not aligned with legislation, including 5 year recertification timeframe.	The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.	Potential for alignment with Building Act, at time of construction or change of occupancy/use. Follow-up activities not aligned with legislation, including 10 year recertification timeframe,	Not aligned with Building Act legislation. Aligned with proposed Energy and Water Efficiency Act legislation (2012) for energy systems.		Potential for alignment with Building Act, at time of construction or change of occupancy/use. Follow-up activities not aligned with legislation, including 5 year recertification timeframe.	Further research required	The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.	The standard is compatible with the triggers provided under the Building Act for an initial review of building performance.

Appendix B

Local Authority Survey

RDH BUILDING SCIENCE

3795 Carey Road #500
Victoria, BC V8Z 6T8

Survey of Building Retrofit Permits in your Jurisdiction

RDH Building Science Inc. is conducting research on behalf of BC Hydro and FortisBC on options to increase the energy efficiency of existing buildings at the time of alteration, addition, reconstruction, rehabilitation or change in occupancy, including tenant alterations.

The scope of this study is all existing Part 3 buildings (including multi-unit residential buildings), as well as non-residential Part 9 buildings. See the attached workplan with more details about the project.

We are contacting a number of Authorities Having Jurisdictions throughout British Columbia to understand the level and type of retrofit activity in your community.

We request you take 10+ minutes to answer the following questions.

Name: ____

Jurisdiction: ____

Position: ____

Do you apply the energy efficiency requirements in Part 10 of the BC Building Code to permits for existing buildings (ASHRAE 90.1-2010 and NECB-2011)?

→ Yes, for Part 3 buildings only (all occupancy types)

→ Yes, for both Part 3 and Part 9 non-residential buildings

→ No

If yes, please describe the administrative approach, or provide a weblink to the procedure:

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What proportion of commercial renovation in your jurisdiction do you estimate is occurring without a permit, including tenant alterations? ________ (percent)

Do you keep statistics on the permits issued in your community related to existing buildings?

→ Yes

→ No

Please circle points below to reflect the statistics you collect:

→ Number of buildings affected

→ Type of construction (Part 3/Part 9)

→ Square footage

→ $ value of permit / retrofit activity

→ Type of occupancy

→ Other, please specify: ____

Is this information public, and are you able to share the information for the last two to five years? Please provide files or web link: ____________________________________

If not, please provide a summary of statistics in the table below. Feel free to alter the descriptions in column A with a comment in column D to reflect your jurisdiction stats.

Type of Building Occupancy	**% of permits for existing buildings (Part 3)**	**% of permits for existing blds (Part 9, non-residential)**	**Comments**
Community			
College/ University			
Food Retail			
Health Care			
Hotel			
Light industrial			
Non-food Retail (shopping centre)			
Non-food Retail (open air and strip mall)			
Office (medium & large)			
Office (small)			

Type of Building Occupancy	**% of permits for existing buildings (Part 3)**	**% of permits for existing blds (Part 9, non-residential)**	**Comments**
Restaurant			
School			
Multi-unit residential building (mid-rise)			
Multi-unit residential building (mid-rise)			

We are interested in understanding what type of renovation activity that is occurring in your jurisdiction. Please characterise this in the following table.

Type of retrofit	% of permits for existing buildings (Part 3)	% of permits for existing blds (Part 9, non-residential)	Comments
Building envelope repair			
Window/Fenestration replacement			
Other building envelope component upgrade			
HVAC equipment replacement			
HVAC system upgrade			
Service Water Heating equipment (boiler)			
Service Water Heating system upgrade (plumbing)			
Power systems			
Lighting system upgrades			
Other (please specify)			

While the BC Building Code energy provisions apply to existing buildings, it is believed that the enforcement by jurisdictions is variable across the Province. As such, this project aims to identify mechanisms to consistently apply the energy code to existing buildings. Should you have the time to review the attached workplan, we would appreciate your comments on this project to prepare a White Paper on options to implement an energy code for existing buildings.

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Thank you for your assistance. Please email your responses to Andrew Pape-Salmon at apapesalmon@rdh.com by December 11, 2015.

Appendix C

Economic Analysis Results

Table 12: Economic Analysis Results for ASHRAE 100-2015

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVERAGE	BEST CASE	AVE	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
Office	ASHRAE 100	EEM-100	112	0.05	0.19	165	10.63	$59	$241	$150	$155	$65	-$26
MURB (Large-electric)	ASHRAE 100	EEM-100	29	0.01	0.17	76	8.69	$9	$66	$37	$93	$65	$37
MURB (Small-electric)	ASHRAE 100	EEM-100	10	0.00	0.11	41	5.52	$3	$26	$14	$41	$30	$19
MURB (Large - hydronic)	ASHRAE 100	EEM-100	29	0.01	0.17	76	8.69	$7	$51	$29	$95	$73	$51
MURB (Small - hydronic)	ASHRAE 100	EEM-100	7	0.00	0.12	41	6.05	$3	$23	$13	$34	$24	$14
Retail	ASHRAE 100	EEM-100	254	0.12	0.39	362	22.09	$183	$434	$308	$363	$237	$111
Restaurant	ASHRAE 100	EEM-100	129	0.06	2.85	922	144.02	$39	$388	$213	$619	$445	$270

Table 13: Economic Analysis Results for ASHRAE 90.1-2010

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
Small Projects	ASHRAE 90.1-2010 - Lighting	EEM-90.1-L	75	0.02	(0.08)	53	(3.18)	$56	$83	$69	$24	$8	-$6

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
Small Projects	ASHRAE 90.1-2010 - Mechanical	EEM-90.1-M	49	0.01	0.01	51	0.82	$10	$15	$13	$27	$24	$22
Small Projects	ASHRAE 90.1-2010 - DHW	ECM-90.1-DHW	0	0.00	0.12	35	6.22	$1	$1	$1	$8	$8	$8
Office	ASHRAE 90.1-2010 - LPD from 3.5W/ft2 to 0.9 W/ft2	EEM-90.1-L1	84	0.03	(0.03)	74	(0.86)	$48	$71	$59	$45	$33	$21
Office	ASHRAE 90.1-2010 - Lighting Controls Upgrade	EEM-90.1-L2	30	0.00	(0.02)	24	(0.82)	$3	$5	$4	$14	$14	$13
Office	ASHRAE 90.1-2010 - Replace RTU with high efficiency model	EEM-90.1-M1	8	0.02	0.01	11	0.47	$6	$9	$7	$11	$10	$8
Office	ASHRAE 90.1-2010 - Air heat recovery and DCV	EEM-90.1-M2	0	0.00	0.00	0	0.01	$1	$2	$2	-$1	-$2	-$2
Office	ASHRAE 90.1-2010 - Upgrade to mid-efficiency boiler (72% Baseline to 80%)	EEM-90.1-M3	0	0.00	0.05	15	2.72	$3	$4	$3	$2	$2	$1
Office	ASHRAE 90.1-2010 - Upgrade walls to R16 and roof to R24	EEM-90.1-E1	(0)	0.00	0.02	6	1.13	$94	$140	$117	-$91	-$115	-$138
Office	ASHRAE 90.1-2010 - Upgrade glazing to U-0.38, SHGC=0.29	EEM-90.1-E2	16	0.01	0.25	85	12.52	$101	$152	$127	-$42	-$67	-$92
Office	ASHRAE 90.1-2010 - retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.03	8	1.36	$0	$0	$0	$2	$2	$1

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
MURB (Large-electric)	ASHRAE 90.1-2010 - Replace RTU with high efficiency model	EEM-90.1-M1	0	0.00	0.02	7	1.12	$4	$6	$5	-$1	-$2	-$3
MURB (Large-electric)	ASHRAE 90.1-2010 - Add programmable thermostats	EEM-90.1-M2	8	0.01	0.00	8	0.08	$3	$4	$4	$12	$11	$10
MURB (Large-electric)	ASHRAE 90.1-2010 - Upgrade roof to R21	EEM-90.1-E1	1	0.00	(0.01)	(3)	(0.57)	$3	$5	$4	-$3	-$4	-$5
MURB (Large-electric)	ASHRAE 90.1-2010 - Upgrade glazing to U-0.4, SHGC=0.29	EEM-90.1-E2	23	0.01	(0.01)	19	(0.42)	$189	$283	$236	-$140	-$187	-$235
MURB (Large-electric)	ASHRAE 90.1-2010 - Retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.03	8	1.37	$0	$1	$1	$1	$1	$1
MURB (Small-electric)	ASHRAE 90.1-2010 - LPD from	EEM-90.1-L1	0	0.00	0.00	0	0.00	$0	$0	$0	$0	$0	$0
MURB (Small-electric)	ASHRAE 90.1-2010 - Replace RTU with high efficiency model	EEM-90.1-M1	0	0.00	0.07	19	3.45	$6	$9	$8	$2	$0	-$1
MURB (Small-electric)	ASHRAE 90.1-2010 - Add programmable thermostats	EEM-90.1-M2	7	(0.03)	0.00	7	0.07	$2	$4	$3	-$8	-$9	-$9
MURB (Small-electric)	ASHRAE 90.1-2010 - Upgrade wall to R16	EEM-90.1-E1	8	0.00	0.00	8	0.08	$6	$9	$7	$12	$10	$9
MURB (Small-electric)	ASHRAE 90.1-2010 - Upgrade glazing to U-0.4, SHGC=0.29	EEM-90.1-E2	25	0.01	0.00	25	0.25	$79	$119	$99	-$20	-$40	-$60

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
MURB (Small-electric)	ASHRAE 90.1-2010 - Retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.00	0	0.00	$1	$2	$1	-$1	-$1	-$2
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Replace RTU with high efficiency model	EEM-90.1-M1	0	0.00	0.02	7	1.19	$4	$6	$5	-$2	-$3	-$4
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Add programmable thermostats	EEM-90.1-M2	1	0.00	0.06	19	3.25	$3	$4	$4	$2	$1	$1
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Replace boiler (80% baseline to 80% inc, no change)	EEM-90.1-M3	0	0.00	0.00	0	0.00	$0	$0	$0	$0	$0	$0
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Upgrade roof	EEM-90.1-E1	0	0.00	0.00	1	0.22	$2	$3	$2	-$1	-$2	-$2
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Upgrade glazing to U-0.4, SHGC=0.29	EEM-90.1-E2	0	0.00	0.03	7	1.26	$189	$283	$236	-$187	-$234	-$281
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.12	33	5.86	$1	$2	$2	$9	$9	$8
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Replace RTU with high efficiency model	EEM-90.1-M1	0	0.00	0.07	19	3.45	$6	$9	$8	$2	$0	-$1
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Add programmable thermostats	EEM-90.1-M2	0	0.00	0.04	13	2.20	$2	$4	$3	$1	$1	$0

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Replace boiler (80% baseline to 80% inc, no change)	EEM-90.1-M3	0	0.00	0.00	0	0.00	$0	$0	$0	$0	$0	$0
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Upgrade wall to R16	EEM-90.1-E1	0	0.00	0.05	15	2.65	$6	$9	$7	$2	$1	-$1
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Upgrade glazing to U-0.4, SHGC=0.29	EEM-90.1-E2	1	0.00	0.16	46	8.22	$81	$121	$101	-$69	-$89	-$109
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.14	40	7.19	$1	$2	$1	$20	$13	$12
Retail	ASHRAE 90.1-2010 - LPD from 3.5W/ft2 to 1.4 W/ft2	EEM-90.1-L1	95	0.02	(0.11)	64	(4.60)	$43	$65	$54	$59	$45	$34
Retail	ASHRAE 90.1-2010 - Replace RTU with high efficiency model, add heat recovery and DCV	EEM-90.1-M1	6	0.01	0.18	55	8.85	$15	$23	$19	$20	$23	$19
Retail	ASHRAE 90.1-2010 - Upgrade walls to R16 and roof to R18	EEM-90.1-E1	(1)	0.00	0.04	11	2.14	$74	$110	$92	-$70	-$87	-$106
Retail	ASHRAE 90.1-2010 - Upgrade glazing to U-0.32, SHGC=0.46	EEM-90.1-E2	1	0.00	0.05	16	2.61	$33	$49	$41	-$20	-$35	-$43

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M^2	KW/M^2	GJ/M^2	KWH/ M^2	KG/M^2/YR	\$/M^2	\$/M^2	\$/M^2	\$/M^2	\$/M^2	\$/M^2
Retail	ASHRAE 90.1-2010 - retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.02	5	0.90	$0	$0	$0	$1	$1	$1
Restaurant	ASHRAE 90.1-2010 - LPD from 2.5W/ft2 to 0.9 W/ft2	EEM-90.1-L1	46	0.01	(0.09)	20	(4.09)	$76	$114	$95	-$34	-$53	-$72
Restaurant	ASHRAE 90.1-2010 - Replace RTU with high efficiency model and add DCV	EEM-90.1-M1	8	0.01	0.20	65	10.33	$23	$35	$29	$9	$3	-$3
Restaurant	ASHRAE 90.1-2010 - Upgrade walls to R12 and roof to R16	EEM-90.1-E1	2	0.00	0.09	27	4.45	$57	$86	$71	-$41	-$56	-$70
Restaurant	ASHRAE 90.1-2010 - Upgrade glazing to U-0.32, SHGC=0.46	EEM-90.1-E2	0	0.00	0.06	17	3.10	$288	$432	$360	-$279	-$351	-$423
Restaurant	ASHRAE 90.1-2010 - Retrofit to low flow fixtures	EEM-90.1-DHW	0	0.00	0.55	153	27.46	$1	$1	$1	$37	$37	$37

Table 14: Economic Analysis Results for NECB 2015

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M^2	KW/M^2	GJ/M^2	KWH/M^2	KG/M^2/YR	\$/M^2	\$/M^2	\$/M^2	\$/M^2	\$/M^2	\$/M^2
Small Projects	NECB 2015 - Lighting	EEM-NECB-L	49	0.01	(0.07)	30	(2.97)	$41	$61	$51	$10	-$2	-$12
Small Projects	NECB 2015 - Mechanical	EEM-NECB-M	49	0.01	0.01	51	0.82	$10	$15	$13	$27	$24	$22
Small Projects	NECB 2015 - DHW	ECM-NECB-DHW	0	0.00	0.12	35	6.22	$1	$1	$1	$8	$8	$8
Office	NECB 2015 - LPD from 3.5W/ft2 to 0.82 W/ft2	EEM-NECB-L1	92	0.04	(0.03)	83	(0.71)	$55	$83	$69	$49	$35	$21
Office	NECB 2015 - Lighting Controls Upgrade	EEM-NECB-L2	30	0.00	(0.02)	24	(0.82)	$3	$5	$4	$14	$13	$13
Office	NECB 2015 - Replace RTU with high efficiency model	EEM-NECB-M1	8	0.02	0.01	11	0.47	$6	$9	$7	$11	$10	$8
Office	NECB 2015 - Air heat recovery and DCV	EEM-NECB-M2	0	0.00	0.00	0	0.01	$1	$2	$2	-$1	-$2	-$2
Office	NECB 2015 - Upgrade to mid-efficiency boiler (72% Baseline to 83%)	EEM-NECB-M3	0	0.00	0.07	19	3.41	$3	$4	$3	$4	$3	$2
Office	NECB 2015 - Upgrade walls to R18 and roof to R25	EEM-NECB-E1	(0)	0.00	0.03	7	1.31	$108	$163	$136	-$106	-$133	-$160
Office	NECB 2015 - Upgrade glazing to U-0.42, SHGC=0.29	EEM-NECB-E2	15	0.01	0.23	79	11.65	$94	$141	$118	-$39	-$62	-$86

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
Office	NECB 2015 - retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.03	8	1.36	$0	$0	$0	$2	$2	$1
MURB (Large-electric)	NECB 2015 - Replace RTU with high efficiency model	EEM-NECB-M1	0	0.00	0.02	7	1.12	$4	$6	$5	-$1	-$2	-$3
MURB (Large-electric)	NECB 2015 - Add programmable thermostats	EEM-NECB-M2	8	0.01	0.00	8	0.08	$3	$4	$4	$12	$11	$10
MURB (Large-electric)	NECB 2015 - Upgrade roof to R21	EEM-NECB-E1	1	0.00	(0.01)	(3)	(0.70)	$4	$6	$5	-$4	-$5	-$6
MURB (Large-electric)	NECB 2015 - Upgrade glazing to U-0.4, SHGC=0.29	EEM-NECB-E2	22	0.01	(0.01)	19	(0.41)	$182	$274	$228	-$136	-$181	-$227
MURB (Large-electric)	NECB 2015 - Retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.03	8	1.37	$0	$1	$1	$1	$1	$1
MURB (Small-electric)	NECB 2015 - LPD from	EEM-NECB-L1	0	0.00	0.00	0	0.00	$0	$0	$0	$0	$0	$0
MURB (Small-electric)	NECB 2015 - Replace RTU with high efficiency model	EEM-NECB-M1	0	0.00	0.07	19	3.45	$6	$9	$8	$2	$0	-$1
MURB (Small-electric)	NECB 2015 - Add programmable thermostats	EEM-NECB-M2	7	(0.03)	0.00	7	0.07	$2	$4	$3	-$8	-$9	-$9
MURB (Small-electric)	NECB 2015 - Upgrade wall to R18	EEM-NECB-E1	10	0.00	0.00	10	0.10	$7	$11	$9	$14	$12	$11

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
MURB (Small-electric)	NECB 2015 - Upgrade glazing to U-0.42, SHGC=0.29	EEM-NECB-E2	24	0.01	0.00	24	0.24	$78	$117	$98	-$27	-$47	-$66
MURB (Small-electric)	NECB 2015 - Retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.00	0	0.00	$1	$2	$1	-$1	-$1	-$2
MURB (Large-hydronic)	NECB 2015 - Replace RTU with high efficiency model	EEM-NECB-M1	0	0.00	0.02	7	1.19	$4	$6	$5	-$3	-$4	-$5
MURB (Large-hydronic)	NECB 2015 - Add programmable thermostats	EEM-NECB-M2	1	0.00	0.06	19	3.25	$3	$4	$4	$5	$4	$3
MURB (Large-hydronic)	ASHRAE 90.1-2010 - Replace boiler (80% baseline to 85% inc, no change)	EEM-NECB-M3	0	0.00	0.01	3	0.53	$1	$1	$1	$1	$1	$0
MURB (Large-hydronic)	NECB 2015 - Upgrade wall to R18	EEM-NECB-E1	0	0.00	0.01	1	0.27	$2	$3	$3	-$2	-$2	-$3
MURB (Large-hydronic)	NECB 2015 - Upgrade glazing to U-0.42, SHGC=0.29	EEM-NECB-E2	0	0.00	0.02	7	1.22	$182	$274	$228	-$179	-$225	-$270
MURB (Large-hydronic)	NECB 2015 - Retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.12	33	5.86	$1	$2	$2	$14	$14	$13
MURB (Small-hydronic)	NECB 2015 - Replace RTU with high efficiency model	EEM-NECB-M1	0	0.00	0.07	19	3.45	$6	$9	$8	-$1	-$2	-$4

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
MURB (Small-hydronic)	NECB 2015 - Add programmable thermostats	EEM-NECB-M2	0	0.00	0.04	13	2.20	$2	$4	$3	$3	$3	$2
MURB (Small-hydronic)	ASHRAE 90.1-2010 - Replace boiler (80% baseline to 85% inc, no change)	EEM-NECB-M3	0	0.00	0.01	2	0.38	$1	$1	$1	-$3	-$4	-$4
MURB (Small-hydronic)	NECB 2015 - Upgrade wall to R18	EEM-NECB-E1	0	0.00	0.06	18	3.24	$7	$11	$9	-$3	-$4	-$6
MURB (Small-hydronic)	NECB 2015 - Upgrade glazing to U-0.42, SHGC=0.29	EEM-NECB-E2	1	0.00	0.16	45	7.95	$78	$117	$98	-$54	-$73	-$93
MURB (Small-hydronic)	NECB 2015 - Retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.14	40	7.19	$1	$2	$1	$20	$19	$19
Retail	NECB 2015 - LPD from 3.5W/ft2 to 1.25 W/ft2	EEM-NECB-L1	103	0.03	(0.12)	69	(4.95)	$47	$70	$58	$63	$48	$36
Retail	NECB 2015 - Replace RTU with high efficiency model, add heat recovery and DCV	EEM-NECB-M1	6	0.01	0.18	55	8.85	$15	$23	$19	$20	$23	$19
Retail	NECB 2015 - Upgrade walls to R18 and roof to R25	EEM-NECB-E1	(2)	0.00	0.05	12	2.52	$83	$124	$104	-$79	-$98	-$119
Retail	NECB 2015 - Upgrade glazing to U-0.32, SHGC=0.46	EEM-NECB-E2	1	0.00	0.04	13	2.22	$28	$42	$35	-$17	-$29	-$36

ARCHETYPE	ECM NAME	ECM CODE	SAVINGS					INCREMENTAL COST			NPV		
			ELEC EUI	ELEC DEMAND	NG EUI	TOTAL EUI	ANNUAL GHG REDUCTIONS	BEST CASE	WORST CASE	AVG	BEST CASE	AVG	WORST CASE
			KWH/M²	KW/M²	GJ/M²	KWH/M²	KG/M²/YR	$/M²	$/M²	$/M²	$/M²	$/M²	$/M²
Retail	NECB 2015 - retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.02	5	0.90	$0	$0	$0	$1	$1	$1
Restaurant	NECB 2015 - LPD from 2.5W/ft2 to 0.95 W/ft2	EEM-NECB-L1	44	0.01	(0.09)	20	(3.96)	$74	$110	$92	-$33	-$51	-$70
Restaurant	NECB 2015 - Replace RTU with high efficiency model and add DCV	EEM-NECB-M1	8	0.01	0.20	65	10.33	$23	$35	$29	$9	$3	-$3
Restaurant	NECB 2015 - Upgrade walls to R18 and roof to R25	EEM-NECB-E1	4	0.00	0.15	45	7.55	$94	$141	$118	-$68	-$92	-$115
Restaurant	NECB 2015 - Upgrade glazing to U-0.32, SHGC=0.46	EEM-NECB-E2	0	0.00	0.05	15	2.63	$245	$367	$306	-$237	-$298	-$360
Restaurant	NECB 2015 - Retrofit to low flow fixtures	EEM-NECB-DHW	0	0.00	0.55	153	27.46	$1	$1	$1	$37	$37	$37