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2011 National Energy Code for Buildings: Archetype Building Analysis for Newfoundland and Labrador

Final Report

Prepared for: Government of Newfoundland and Labrador
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Executive Summary

In its 2007 Energy Plan, the Government of Newfoundland and Labrador set energy efficiency at the heart of the province's energy policy. Recognizing that energy efficiency is fundamental to long-term economic growth and environmental sustainability, the provincial government committed to developing a detailed plan for energy conservation and efficiency, including priorities and targets. In 2011, the provincial government released *Moving Forward: Energy Efficiency Action Plan*. The Action Plan set out the province's vision and goals alongside 40 commitments for action. It also reaffirmed the provincial government's commitment to pursue the Conference of New England Governors and Eastern Canadian Premiers target of reducing energy consumption by 20 per cent by 2020 from business-as-usual projections. In the Action Plan, the provincial government committed to "examine the case for adopting new national energy codes for buildings in Newfoundland and Labrador in collaboration with key stakeholders" given the release of the National Energy Code for Buildings (NECB) in 2011.

In order to better understand the NECB in the context of buildings typical of the province, and the potential opportunities and challenges associated with it for Newfoundland and Labrador, the provincial government commissioned this study. It is intended as a foundational piece to understand the issues and develop the evidence base to inform future discussions with interested stakeholders and decision-makers on the case for adopting the NECB in the province.

The NECB details minimum energy performance requirements for new buildings and new additions for five building elements: (1) the building envelope; (2) lighting systems; (3) heating, ventilation, and air-conditioning (HVAC) systems and equipment; (4) service water heating systems; and (5) electrical systems and motors. Previous work to date in the province focused on comparing energy performance and cost benefit analysis for the NECB against seven large buildings designed to meet LEED (Leadership in Energy & Environmental Design) Silver requirements. That work found that buildings built to LEED standards generally exceed the level of energy efficiency required by the NECB.

The main identified gap from this work related to smaller private sector commercial buildings typical of new construction in the province. In most cases, these new buildings are not built to LEED Silver requirements. To address this, Caneta Research Inc. was contracted to assess the energy performance and cost-benefit analysis for five archetype buildings for NECB Climate Zone 6 (which includes about 60% of the province's population), and to consult with local stakeholders to determine an appropriate baseline for the analyses.

Building Archetypes and Current Building Practice

Five building types were selected to reflect private sector construction in the province; office, multi-unit residential (MURB), box retail store, full service restaurant and warehouse. Table ES-1 below provides a brief description of the archetype buildings used in the energy modelling and life cycle costing analysis.

Table ES-1: Outline of Proposed Building Archetypes

Archetype	Construction	Floorspace above ground	Stories above ground
Warehouse	Metal	2,000 m^2	1
Multi-unit residential building (MURB)	Wood	2,000 m^2	2
Office building	Mass	1,500 m^2	2
Box retail store	Mass	1,000 m^2	1
Full service restaurant	Wood	620 m^2	1

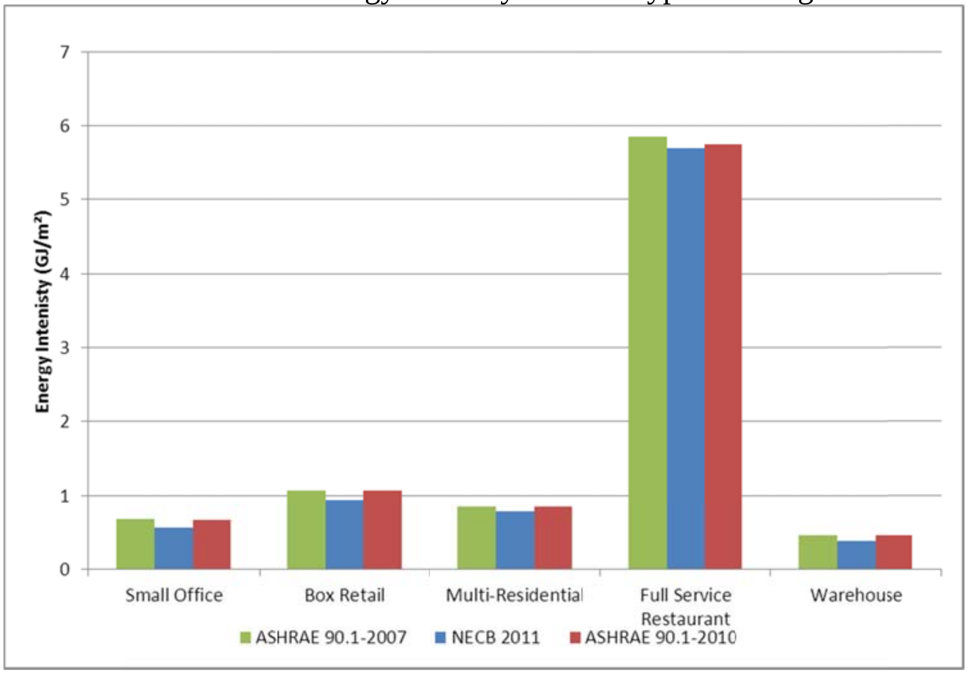
To ensure the archetype buildings used in this study and the baseline energy efficiency requirements properly reflect current practice in the province, consultations were performed with local stakeholders. These consultations included architects, mechanical and electrical engineers, developers and government officials active in Newfoundland and Labrador construction industry. Stakeholder feedback indicated current building practice was more advanced than ASHRAE 90.1-2007. Insulation levels, lighting power densities and HVAC equipment efficiency were generally better than the values required by ASHRAE 90.1-2007 and often approaching ASHRAE 90.1-2010 or NECB 2011 values. Based on these findings and to ensure a conservative approach to the analysis, ASHRAE 90.1-2007 is taken to be current building practice (i.e., the baseline for the analysis in this study), in order to reflect buildings designed with the most basic features in the Newfoundland and Labrador market. It is expected that most buildings would meet ASHRAE 90.1-2007 requirements.

Energy Performance Analysis

Energy models of the archetype buildings were developed for the current practice, NECB 2011 and ASHRAE 90.1-2010 energy efficiency requirements. ASHRAE 90.1-2010 was included in the analysis for comparison purposes because it is considered to be an intermediate step between the current building practice (i.e., the baseline) and NECB 2011.

The modeling showed that energy use ranged between 0.46 and 1.07 GJ/m^2 for four of the five archetypes, but 5.85 GJ/m^2 for the remaining archetype building (i.e., the restaurant) (see Table ES-2). This is because energy use in restaurants, unlike other buildings in this study, is driven by large scale kitchen activities (i.e., equipment/process loads and outside air heating). This difference means that total baseline energy consumption in the restaurant (3,628 GJ on an annual basis) is at least 2.1 times higher than for each of the other four archetypes buildings (ranging from about 919 to 1,689 GJ), despite the fact that the restaurant is the smallest building among the five archetypes.

Table ES-2: Energy Intensity of Archetype Buildings



Heating represents the largest energy use in all buildings except the full service restaurant where heating is the third largest energy consumer. Heating also represents the largest energy savings for all buildings except the full service restaurant.

The key findings for the NECB 2011 analysis (Tables ES-3 to ES-5) relative to the baseline include:

- Energy savings varied between 2.7 percent (restaurant) and 16.7 percent (office building).
- In terms of actual energy reduction, energy savings varied between 96.7 gigajoules (GJ) (restaurant) and 168.8 GJ (office building)
- In terms of annual energy costs, savings ranged between $3,062 (restaurant) and $6,478 (office building).

The key findings for the ASHRAE 90.1-2010 analysis relative to the baseline include:

- Energy savings varied between 0.5 percent (box retail store) and 1.8 percent (restaurant).
- In terms of actual energy reduction, energy savings varied between 5.0 gigajoules (GJ) (box retail store) and 66.7 GJ (restaurant)
- In terms of annual energy costs, savings ranged between $87 (box retail store) and $2,090 (restaurant).

Table ES-3: Percent Energy Savings Relative to Current Practice (ASHRAE 90.1-2007)

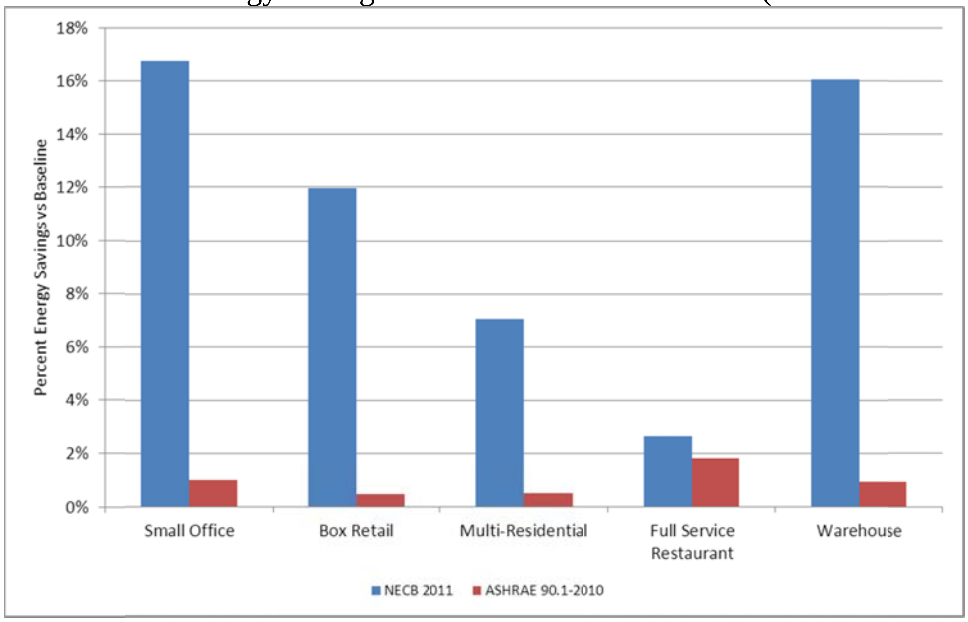


Table ES-4: Annual Energy Savings Relative to Current Practice (ASHRAE 90.1-2007)

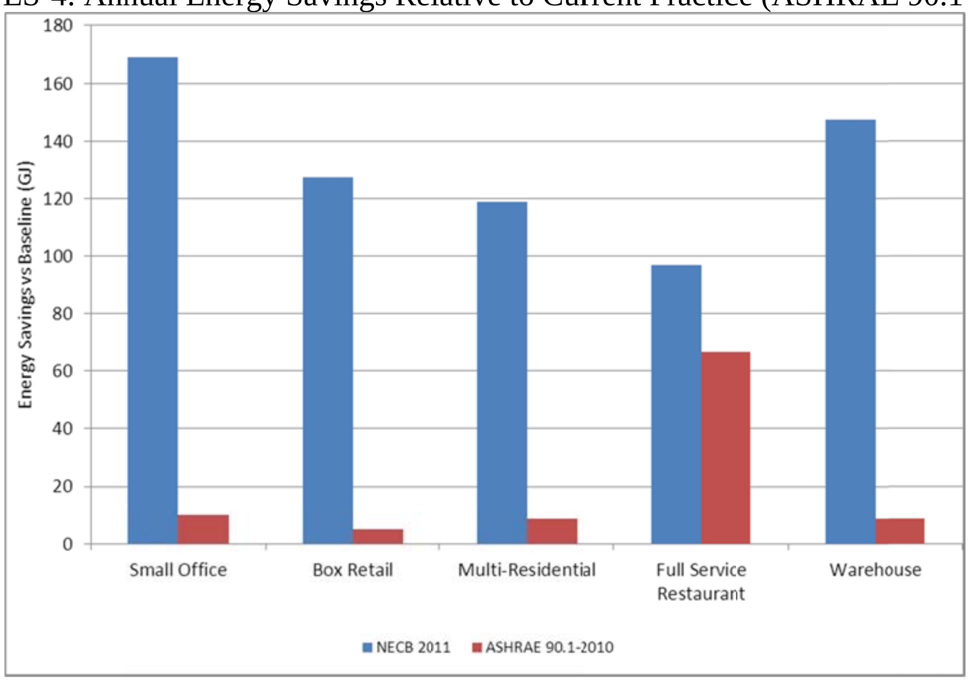
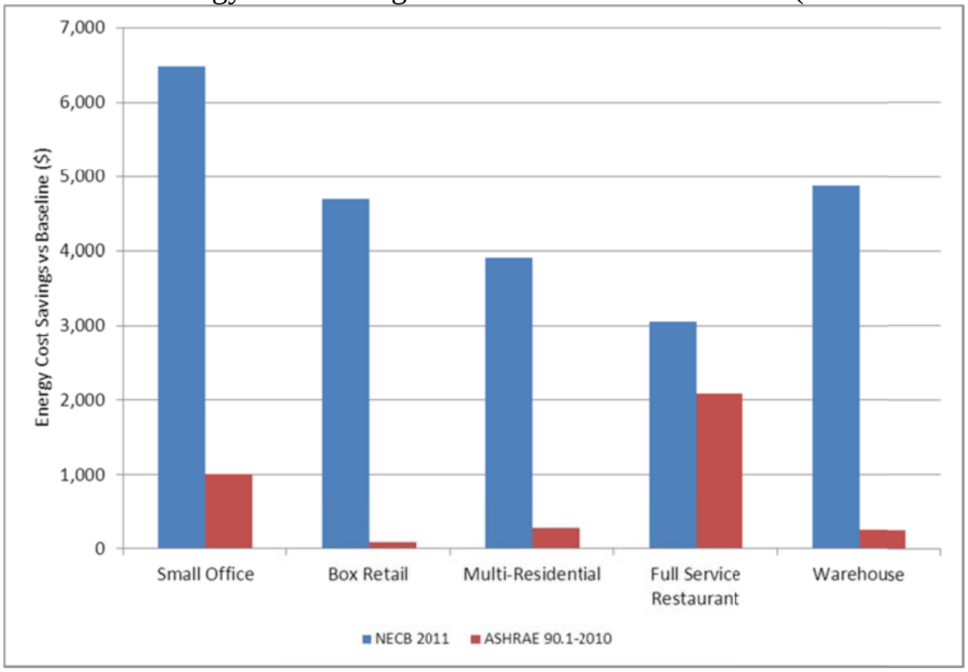


Table ES-5: Annual Energy Cost Savings Relative to Current Practice (ASHRAE 90.1-2007)



Energy savings for NECB 2011 was primarily heating savings for all but the full service restaurant, and was primarily lighting for ASHRAE 90.1-2010. This is because ASHRAE 90.1-2010 had the same envelope requirements as current practice, so heating savings were minimal.

Lifecycle Costing Analysis

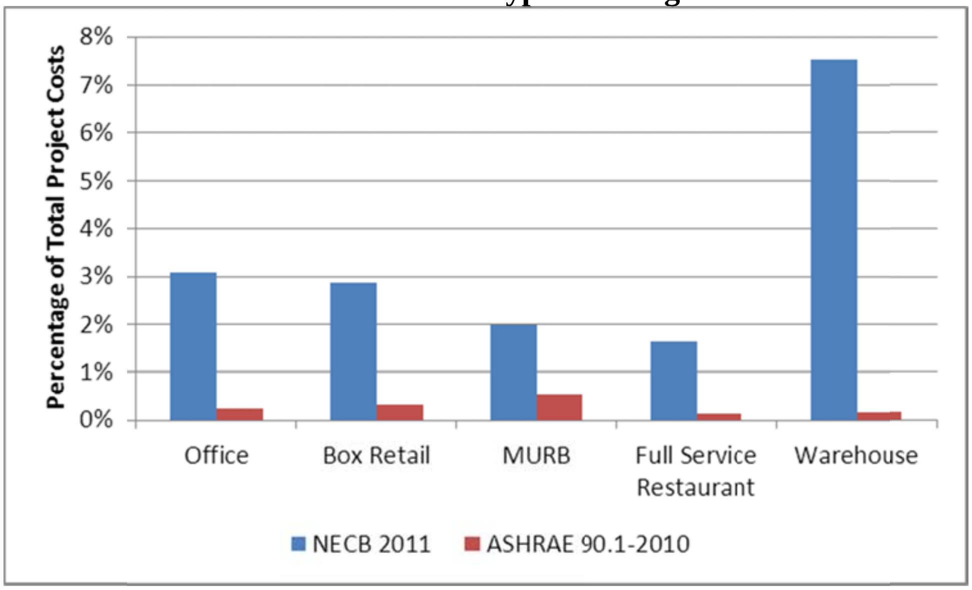
Lifecycle costing analysis is often used to evaluate decision-making in the purchase or construction of new assets, such as buildings, and can be used to compare costs for similar asset types based on different inputs to the purchase or construction process, such as energy performance requirements. Lifecycle costing also allows for consideration of costs which occur after an asset has been purchased or constructed, such as maintenance and operational costs. Alternatively, the analysis would focus on the up-front capital costs that would be incurred (see Table ES-6), which does not to take account of the longer-term costs of operating and maintaining an asset. Lifecycle costing is summarized below using payback periods, internal rates of return and change in net present value (Tables ES-7 to ES-9).

Most incremental capital costs for NECB 2011 were incurred to meet increased thermal resistance requirements of envelope components (wall, roof and window), followed by reduced lighting energy power requirements. Envelope upgrades represent over 75 percent of the NECB 2011 incremental costs for all of the archetypes.

The ASHRAE 90.1-2010 incremental capital costs are dominated by technological improvements to lighting systems to reduced lighting power density. The lighting power density requirements of ASHRAE 90.1-2010 are the same as NECB 2011, but ASHRAE 90.1-2010 does not include any envelope improvements over the ASHRAE 90.1-2007 baseline.

The NECB 2011 incremental up-front costs represent 1.6 to 3.1 percent of the total construction costs with the exception of the warehouse, which were 7.5 percent of the total construction costs (Table ES-6). The ASHRAE-90.1-2010 incremental costs represent 0.1 to 0.5 percent of the total construction costs.

Table ES-6: Incremental Capital Costs as a Percentage of Total Construction Costs for Archetype Buildings



A payback period refers to the period of time required to recover up-front funds expended in an investment, or to reach the break-even point. For example, a $1000 investment which returned $500 per year, ignoring inflation, would have a two-year payback period. The payback period calculated in this study accounts for time value of money by discounting the cash inflows of the project. The payback period for the NECB 2011, including inflation, was greater than 10 years for three of the five archetypes, but less than 25 years for four of the five archetypes (Table ES-7).

For ASHRAE 90.1-2010, the payback period was less than 10 years for two of the five archetypes but greater than 25 years for two other archetypes.

The internal rate of return, also known as the effective interest rate, measures the profitability of an investment. The term *internal* refers to the fact that it does not incorporate external factors such as inflation. It is used to evaluate the desirability of an investment or project. An investment is considered acceptable if its internal rate of return is greater than the minimum acceptable rate of return. Put another way, the higher a project's internal rate of return, the more desirable it is to undertake the investment or project and, assuming all investments and projects require the same amount of up-front investment, the project with the highest internal rate of return would be considered to be undertaken first.

For the NECB 2011, the internal rates of return were less than 10 percent for two of the five archetypes and greater than 15 percent for two of the five archetypes (Table ES-8).

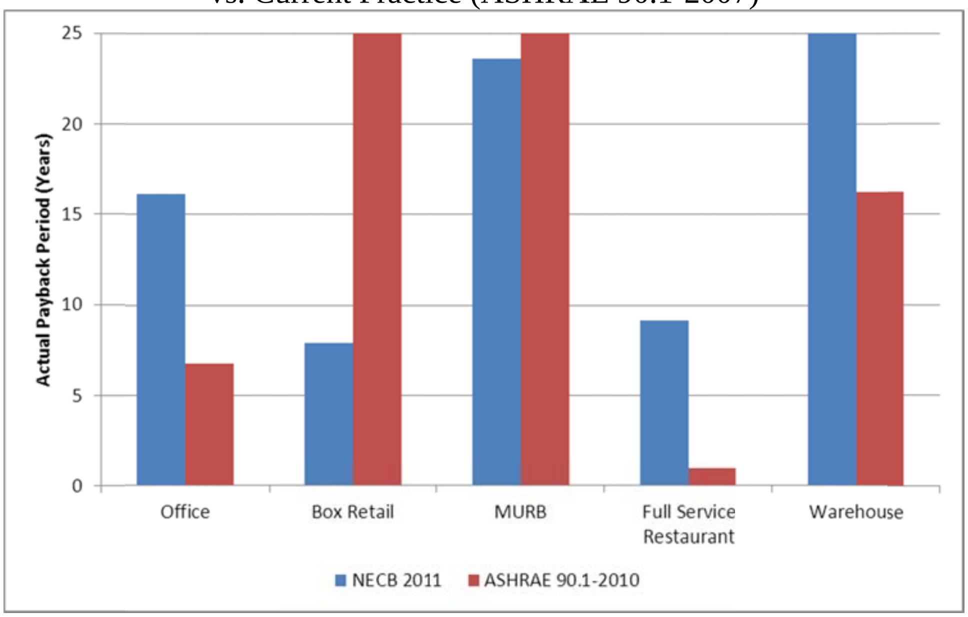
For ASHRAE 90.1-2010, the internal rate of return was negative for two of the five archetypes. Conversely, it was greater than 15 percent for another two of the five archetypes.

The net present value (NPV) is the current value of the building, combining up-front capital construction costs and energy costs incurred over an initial 25-year period, accounting for inflation and interest. The change in NPV measures, on a percentage basis, the incremental change in a building's NPV between the baseline and each of NECB 2011 and ASHRAE 90.1-2010. A positive change in NPV means that a building owner is better off, over the long term, by constructing to NECB 2011 or ASHRAE 90.1.2010 rather than the baseline.

For the NECB 2011, the change in NPV was positive for four of the five archetype buildings, and was greater than 0.9 percent for three of these four archetype buildings (Table ES-9).

For ASHRAE 90.1-2010, the change in NPV was positive for three of the five archetype buildings, and was greater than 0.4 percent for two of the three archetype buildings with a positive change in NPV.

Table ES-7: Actual Payback Period[1] of NECB 2011 and ASHRAE 90.1-2010 vs. Current Practice (ASHRAE 90.1-2007)



[1] Actual payback period (or discounted payback period) accounts for time value of money by discounting the cash inflows of the project. Note: Paybacks have been capped at 25 years in figure.

Table ES-8: Internal Rate of Return of NECB 2011 and ASHRAE 90.1-2010 vs. Current Practice (ASHRAE 90.1-2007)

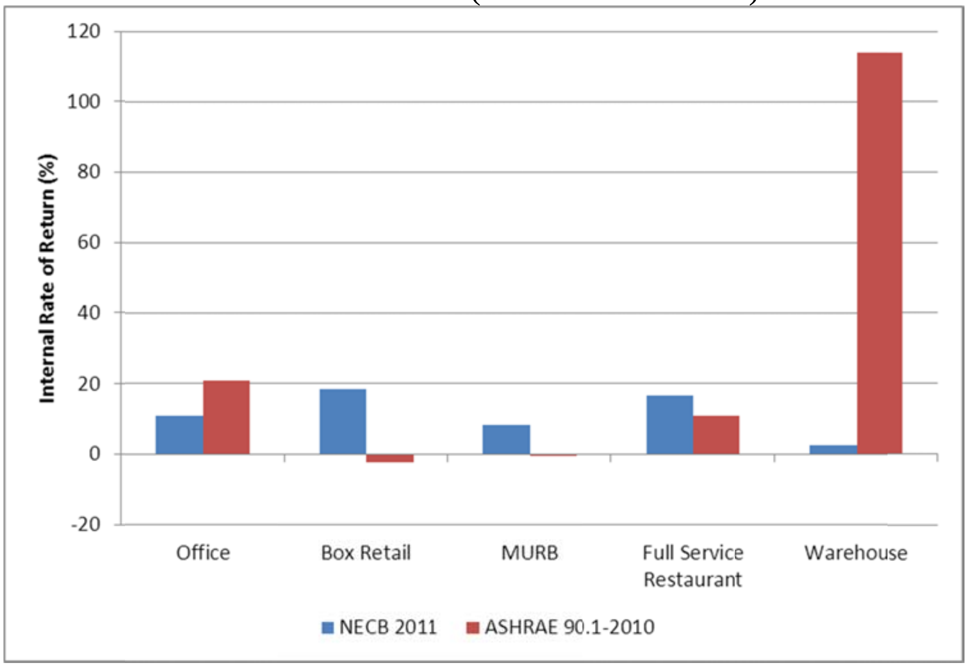
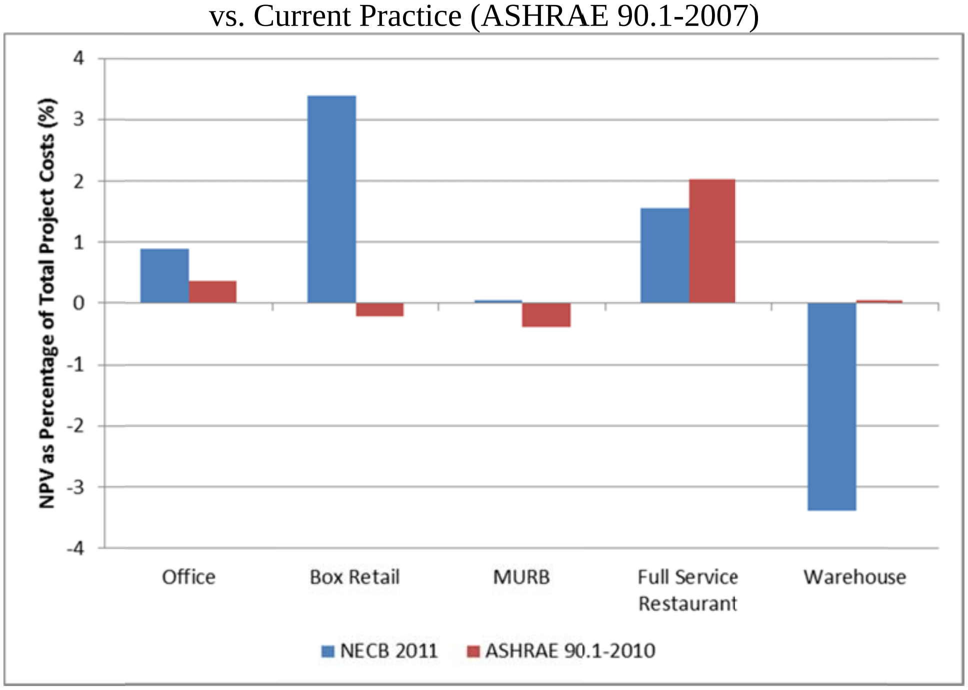


Table ES-9: Change in Net Present Value of NECB 2011 and ASHRAE 90.1-2010 vs. Current Practice (ASHRAE 90.1-2007)



Constructability Issues

The most significant constructability issue identified with NECB 2011 was achieving the wall U-value requirements for Climate Zone 6. NECB 2011 requires above grade walls to have a U-value of no greater than 0.247 W/m² °C which is a highly stringent requirement relative to ASHRAE 90.1-2007. For example, for wood framing, the NECB wall requirements are approximately 17 percent more stringent than ASHRAE 90.1-2007 and ASHRAE 90.1-2010. Similarly, for steel framing, the requirements are approximately 47 percent more stringent, and for concrete block walls the requirements are approximately 84 percent more stringent.

In Climate Zone 6, steel framed walls have the most challenges in meeting this requirement as can be seen through the relatively high incremental capital costs of the warehouse (the warehouse is the only archetype with steel framed construction). In the steel framed wall construction, the inner layer of batt insulation is bridged by the steel studs. The outer layer of continuous polystyrene insulation is also bridged by metal z-girts which are required for the installation of the exterior cladding. Although the concrete block wall (mass wall) represented the largest difference between NECB 2011 and ASHRAE 90.1-2007, the brick ties between the concrete block and the brick cladding resulted in relatively minimal thermal bridging and consequently did not have the same difficulty meeting the NECB 2011 requirements as the steel framed walls.

A second constructability issues relates to window design. NECB 2011 requires an overall window U-value of 2.2 W/m² °C (0.387 Btu/hr/ft² °F). The overall U-value includes the effects of thermal bridging through the framing. This requirement is achievable with double glazed windows with low-e argon and framing with aluminum framing with a good thermal break. Windows with vinyl frames should be able to achieve this requirement. However, standard curtainwall framing or designs with a significant amount of framing will have difficulty achieving the NECB 2011 requirement with double glazing and may have to consider triple glazed windows. This problem can be avoided by specifying curtainwall framing with better thermal breaks and designing the glass with less framing. This constructability issue was outside the analysis for the five archetype buildings in this study.

Conclusions

The decision as to which building code or standard is required for new building construction in Newfoundland and Labrador will come down to trade-offs among policy objectives, particularly as to whether the province wishes to establish a minimum standard relatively close to current baseline building practices and then slowly evolve the building energy efficiency, or whether it wishes to make a significant step forward in the near term. In this context, a summary of the key findings of this study are as follows:

- In Climate Zone 6, neither NECB 2011 nor ASHRAE 90.1-2010 demonstrate cost effectiveness in all building archetypes. The internal rate of return, or the key metric for determining whether it is desirable to pursue an investment or project, varies from 2.6 to 18.4 percent for the NECB 2011 and between -2.2 to 114 percent for ASHRAE 90.1-2010. However, overall both codes demonstrate improved energy performance.

- ASHRAE 90.1-2010 allows for the introduction of energy efficiency requirements with minimal disruption from a cost perspective to building owners (no more than a 0.5 percent increase in up-front building costs). Requirements can then be improved with future iterations of ASHRAE 90.1 (for example, ASHRAE 90.1-2013). The downside to this decision is that initial improvements in energy performance will be limited.

- NECB 2011 offers a more significant increase in energy savings. The downside is that there will be higher incremental up-front capital costs to building owners, ranging from 1.6 to 7.5 percent. The architectural industry will need to modify current wall construction details, as some current wall construction designs in the local market will not be able to attain NECB 2011's stringent requirements.

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1. Introduction

A building's overall energy efficiency is determined by how well it is designed, constructed, maintained, and operated. The benefits of an energy efficient building extend beyond operating cost reductions and may include improved occupant comfort (which is proven to result in more productive occupants and fewer absentee days), reduced greenhouse gas emissions and reduced local air pollutants. In addition energy exports are an important pillar of economic activity and employment in Newfoundland and Labrador.

In its 2007 Energy Plan, the Government of Newfoundland and Labrador set energy efficiency at the heart of the province's energy policy. Recognizing that energy efficiency is fundamental to long-term economic growth and environmental sustainability, provincial government committed to developing a detailed plan for energy conservation and efficiency, including priorities and targets. In 2011, provincial government released *Moving Forward: Energy Efficiency Action Plan*. The Action Plan set out the province's vision and goals alongside 40 commitments for action. It also reaffirmed provincial government's commitment to pursue the Conference of New England Governors and Eastern Canadian Premiers target of reducing energy consumption by 20 per cent by 2020 from business-as-usual projections. In the Action Plan, provincial government committed to "examine the case for adopting new national energy codes for buildings in Newfoundland and Labrador in collaboration with key stakeholders" given the release of the National Energy Code for Buildings (NECB) in 2011.

In order to better understand the NECB in the context of buildings typical of the province, and the potential opportunities and challenges associated with it for Newfoundland and Labrador, the provincial government commissioned this study. It is intended as a foundational piece to understand the issues and develop the evidence base to inform future discussions with interested stakeholders and decision-makers on the case for adopting the NECB in the province.

The NECB details minimum energy performance requirements for new buildings and new additions for five building elements: (1) the building envelope; (2) lighting systems; (3) heating, ventilation, and air-conditioning (HVAC) systems and equipment; (4) service water heating systems; and (5) electrical systems and motors.

Previous work to date in the province focused on comparing energy performance and cost benefit analysis for the NECB against seven large buildings designed to meet LEED (Leadership in Energy & Environmental Design) Silver requirements. That work found that buildings built to LEED standards generally exceed the level of energy efficiency required by the NECB. Additionally, the cost-benefits analysis showed that these buildings were, generally, less expensive to construct and operate compared to NECB.

The main identified gap from this work related to smaller private sector commercial buildings typical of new construction in the province. In most cases, these new buildings are not built to LEED Silver requirements. To address this, Caneta Research Inc. was contracted to assess the energy performance and complete a lifecycle cost analysis for five archetype buildings for NECB Zone 6 (which includes about 60% of the province's population), and to consult with local stakeholders to determine an appropriate baseline for the analyses.

Outline of Proposed Building Archetypes

Archetype	Construction	Floorspace above ground	Stories above ground
Warehouse	Metal	2,000 m^2	1
Multi-unit residential building (MURB)	Wood	2,000 m^2	2
Office building	Mass	1,500 m^2	2
Box retail store	Mass	1,000 m^2	1
Full service restaurant	Wood	620 m^2	1

The analysis includes an assessment against current baseline building practices for both the NECB as well as ASHRAE 90.1 (2010). ASHRAE 90.1-2010 was included in the analysis for comparison purposes because it is an intermediate design between the current practice baseline and NECB 2011. The key differences between current practice, NECB 2011 and ASHRAE 90.1-2010 are described in Section 3.3.

2. Design of Archetype Buildings

2.1 Archetype Building Design

Five building archetypes have been chosen to be representative of buildings being constructed in the province outside of the government sector. These archetype buildings will be used for the energy and lifecycle costing analysis of the NECB 2011 in the province. These buildings include an office, multi-residential, box retail store, full service restaurant and warehouse.

The archetype buildings parameters such as that were based on modified versions of the U.S. DOE's archetype buildings used for code analysis throughout North America. Some adjustments to total building size and number of stories were adjusted to better reflect the Newfoundland and Labrador market. Tables 1 to 5 summarize the generic characteristics of the archetype buildings. These characteristics are independent of the energy efficiency code being evaluated and include features such as building size, aspect ratio, window-to-wall ratio, occupant density, schedules, HVAC system type, etc.

Based on the local stakeholder feedback, there were no concerns regarding the generic characteristics of the archetype buildings (See Section B.2). The general consensus was that they are reasonable reflections of private sector construction in the province.

Most archetype analysis done for other jurisdictions has been done using larger archetype buildings than the ones used in this study. Small buildings offer particular challenges to obtain energy efficiency savings. The envelopes of smaller buildings tend to have a larger impact on energy consumption than it does for larger buildings. Small buildings also have low outside air requirements and rarely require heat recovery under either the NECB 2011 or ASHRAE 90.1. Space heating in this study was assumed to be entirely electric resistance to reflect design practices in the province. An electrically heated building has no potential for heating efficiency improvements as electric heating is already 100 percent efficient. All of the electricity consumed by a resistance heater comes out as heat. Fuel burning equipment that uses oil or propane can lose approximately 20% of their heat when the hot combustion gases are exhausted. However, higher efficiency equipment is available that captures heat from the combustion gases before they are exhausted, improving the efficiency of the equipment above code levels.

Table 1: Office Generic Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	1,500 m² (16,150 ft²)
	No. of Stories	2
	Aspect Ratio	1.5
	DOE archetype	Medium office
	No. occupants	81
	Building Occupancy	Weekdays: 16 hours/day Weekend: unoccupied
Architectural	Construction	Concrete block wall with concrete slab roof
	External Door Configurations	Glass 2 entrances

	Wall Height	8.0 m (26.2 ft)
	Wall-to-Roof Ratio	0.60
	Percent Glazing	33
HVAC	HVAC Zones	Core zone with four perimeter zones on each floor
	System	Single VAV with DX Cooling and electric heating coil serving multiple zones.
	Supply air temperature	12.8 °C (55 °F) reset for warmest zone for code requirements
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	2 l/s/m² (cfm/ft²)
	Economizer	As required by code
	Zone Heating	Electric baseboards
	Fan control	VFD
	Return air path	Plenum
	Outside air	810 l/s (10.0 l/s/person) 1,716 cfm (21.2 cfm/person)
	HVAC Operation	Unoccupied: Outside air dampers closed, fans off
	Temperature setpoints	Clg: 24 °C (75.2 °F)/setback: 26.7°C (80.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	10.8 W/m² (1 W/ft²)
	Lighting and equipment schedules	5% installed lighting power during unoccupied periods 5% installed lighting power during unoccupied periods
Utility Rates	Electricity rate	Demand: posted Newfoundland Power Energy: Based on Levelized rate

Table 2: Warehouse Generic Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	Total bldg.: 2,000 m² (21500 ft²) Office area: 100 m² (1,060 ft²)
	No. of Stories	1
	Aspect Ratio	2.2
	DOE archetype	Warehouse
	No. occupants	Office: 3 Warehouse: 0
	Building Occupancy	Weekdays: 16 hours/day Weekend: 9 hours/day
Architectural	Construction	Steel frame walls with metal deck roof
	External Door Configurations	2 glass entrances in office Multiple truck bays in warehouse
	Wall Height	8.5 m (27.9 ft)
	Wall-to-Roof Ratio	0.82
	Percent Glazing	1
HVAC	HVAC Zones	1 office zone and two warehouse zones
	System	Office: Packaged single zone with SX clg/electric heating Warehouse: Electric unit heaters/No cooling
	Supply air temperature	Office: 12.8 °C (55 °F) reset for warmest zone for code requirements Warehouse: 43.3 °C (110 °F)
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	Office: none Warehouse: none
	Zone Heating	-
	Fan control	Constant
	Return air path	Office: Plenum Warehouse: n/a
	Outside air	Office: 50 l/s (106 cfm) Warehouse: none
	HVAC Operation	Unoccupied: Outside air dampers closed, fans cycle to maintain setpoint
	Temperature setpoints	Office Clg: 24 °C (75.2 °F)/setback: 30.0°C (86.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F) Warehouse: Htg: 15.6 °C (60.1 °F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	2.2 W/m² (0.2 W/ft²)
	Ltg & equip. schedules	10% installed lighting pwr during unocc. periods 10% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	Demand: posted Newfoundland Power Energy: Based on Levelized rate

Table 3: MURB Generic Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	2000 m² (21500 ft²)
	No. of Stories	2
	Aspect Ratio	2.7
	DOE archetype	Mid-rise MURB
	No. occupants	51
	Building Occupancy	Continuous
Architectural	Construction	Wood framed wall with wood framed attic roof
	External Door Configurations	Glass, 1 entrance
	Wall Height	3.05 m (10.0 ft)
	Wall-to-Roof Ratio	0.87
	Percent Glazing	15
HVAC	HVAC Zones	1 corridor zone and 6 apartment perimeter zones per floor
	System	Corridor pressurization with electric heating Apartments: Electric resistance/DX split system
	Supply air temperature	Corridor Press: 26 °C (79 °F) htg only
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	None
	Zone Heating	Electric baseboards
	Fan control	Constant
	Return air path	N/A: Suite exhausted locally through w/rs
	Outside air	670 l/s (1,430 cfm)
	HVAC Operation	Continuous
	Temperature setpoints	Clg: 24 °C (75.2 °F) Htg: 21 °C (69.8 °F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	5.4 W/m² (0.5 W/ft²)
	Lighting and equipment schedules	0% installed lighting power during unoccupied periods 20% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	Demand: posted Newfoundland Power Energy: Based on Levelized rate

Table 4: Box Retail Generic Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	1000 m² (10750 ft²)
	No. of Stories	1
	Aspect Ratio	1.3
	DOE archetype	Stand-alone retail
	No. occupants	141
	Building Occupancy	All days: 15 hours/day
Architectural	Construction	Concrete block wall with concrete slab roof
	External Door Configurations	Glass, 1 entrance
	Wall Height	6.1 m (20.0 ft)
	Wall-to-Roof Ratio	0.78
	Percent Glazing	7
HVAC	HVAC Zones	Separate zone for backspace, core retail, front retail & cash
	System	Packaged single zone/constant volume DX cooling and electric heating
	Supply air temperature	12.8 °C (55 °F) reset for warmest zone for code requirements
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	As required by code
	Zone Heating	-
	Fan control	Constant
	Return air path	Return duct
	Outside air	1,370 l/s (2,900 cfm)
	HVAC Operation	Unoccupied: Outside air dampers closed, fans cycle to maintain temperature
	Temperature setpoints	Clg: 24 °C (75.2 °F)/setback: 30.0°C (80.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	5.2 W/m² (0.48 W/ft²)
	Lighting and equipment schedules	5% installed lighting power during unoccupied periods 20% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	Demand: posted Newfoundland Power Energy: Based on Levelized rate

Table 5: Full Service Restaurant Generic Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	620 m² (6665 ft²)
	No. of Stories	1
	Aspect Ratio	1.0
	DOE archetype	Full service restaurant
	No. occupants	330
	Building Occupancy	Weekdays: 19 hours/day Weekends: 18 hours/day
Architectural	Construction	Wood framed wall with wood framed attic roof
	External Door Configurations	Glass, 1 entrance
	Wall Height	3.05 m (10.0 ft)
	Wall-to-Roof Ratio	0.49
	Percent Glazing	18
HVAC	HVAC Zones	One zone for kitchen and one for customer seating
	System	Kitchen: Packaged single zone/const. volume DX cooling and electric heating Seating: Packaged single zone/constant volume DX cooling and electric heating
	Supply air temperature	12.8 °C (55 °F) reset for warmest zone for code requirements
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	As required by code
	Zone Heating	Electric baseboard
	Fan control	Constant
	Return air path	Return duct
	Outside air	2,730 l/s (5,785 cfm)
	HVAC Operation	Unoccupied: Outside air dampers closed, fans cycle to maintain temperature
	Temperature setpoints	Clg: 24 °C (75.2 °F)/setback: 30.0°C (80.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	473 W/m² (44W/ft²)
	Lighting and equipment schedules	5% installed lighting power during unoccupied periods 20% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	Demand: posted Newfoundland Power Energy: Based on Levelized rate

2.2 Current Practice Energy Efficiency Parameters

Tables 6 (covering non-residential buildings excluding multi-unit residential buildings) and 7 (covering multi-unit residential buildings) summarize the average current practice based on the stakeholder consultations and ASHRAE 90.1-2007. The stakeholder feedback indicates that the average current practice meets, and in some instances exceeds, ASHRAE 90.1-2007 requirements.

For example, insulation levels, lighting power densities and HVAC equipment efficiency were noted by stakeholders as being generally better than the values required by ASHRAE 90.1-2007 and often approached ASHRAE 90.1-2010 or NECB 2011 values. The mechanical and electrical requirements are largely driven by equipment regulated and sold throughout North America and by the availability of high performance mechanical and electrical equipment driven by other markets.

Based on these findings and to ensure a conservative approach to the analysis ASHRAE 90.1-2007 was used to represent the current practice baseline in order to reflect buildings designed in the Newfoundland and Labrador market. It is expected that most buildings would meet ASHRAE 90.1-2007 requirements.

See Section B.4 for more detailed discussion on the stakeholder survey.

Table 6: Current Practice and ASHRAE 90.1-2007 Energy Efficiency Values–Non Residential

Item	ASHRAE 90.1-2007				Consensus stakeholder feedback			
Exterior Walls (ft²·°F/Btuh)								
Wall Type	Mass	Metal	Steel	Other	Mass	Metal	Steel	Other
	12.5	8.8	15.6	19.6	19.5	19.6	21.9	
Roof (ft²·°F/Btuh)								
	20.8				34.0			
Exposed Floor (ft²·°F/Btuh)								
Steel Framed	26.3				33.5			
Wood Framed	30.3				33.5			
Glazing								
Max. Glazing Allowed by Prescriptive Path **(1)**	40%				40%			
Window U-value (Btu/h/(ft² °F))	CurtainWall/ Storefront		Entrance Door	All Other	CurtainWall/ Storefront		Entrance Door	All Other
	0.45		0.80	0.55				
Window SHGC								
	0.40				0.4			
Swinging Doors (Btu/h/(ft²·°F))								
Fully Glazed U-Value	Same as "Other" Requirement for Glazing							
Opaque Door - Uvalue	0.7				0.7			
Underground Wall and Roof (ft²·°F/Btuh)								
	Wall only R-7.5				13.8			
Floors-on-Ground (ft²·°F/Btuh)								
	R-15 for 24"				R-20 for 24"			
LIGHTING								
Interior Lighting (W/ft²)	Office: 1.0 Warehouse: 0.8 Box Retail: 1.5 Full Service Restaurant: 1.6				Office: .8 Warehouse: .8 Box Retail: 1.1 Full Service Restaurant: .9			
Interior Lighting Control	Occupancy Sensors in specified spaces **(2)** Otherwise manual				Yes			
Daylighting Control	N/A							
HVAC								
Economizer	Required if cooling capacity ≥ 135,000 Btu/h				Required if clg > 54,000			
Fan Power Limit (includes supply, return, and exhaust fans) (CV: Constant Volume) (VV: Variable Volume)	HP <= 1.5 hp/1000 CFM (for VV systems) HP <= 1.1 hp/1000 CFM (for CV systems)				to ASHRAE 90.1-2010			
VAV Fan Control	VSD on individual fan motors > 10 hp				VSD motors > 10HP			
Cooling Supply T Control	Zone Reset on multi-zone systems				Zone reset			
Demand Control Ventilation	None				none			
AHU Air to Air heat recovery	50% effectiveness if: The OA ratio is 70% or greater and the supply air capacity is ≥ 5000 cfm				to ASHRAE 90.1-2010			
DX Cooling Efficiency <65 kBtu/h: >65, < 135kBtu/h: >135, < 240kBtu/h: >240, < 760kBtu/h:	13.0 SEER 11.2 EER 11.0 EER 10.0 EER				to ASHRAE 90.1-2010			
Electric Power								
Motor Efficiency	Premium				Premium			

Table 7: Current Practice and ASHRAE 90.1-2007 Energy Efficiency Values–Multi-Residential

Item	ASHRAE 90.1-2007				Consensus stakeholder feedback			
Exterior Walls (ft²·°F/Btuh)								
Wall Type	Mass	Metal	Steel	Other	Mass	Metal	Steel	Other
	14.1	17.5	15.6	19.6	**24.7**	**25.8**	**25.2**	
Roof (ft²·°F/Btuh)								
	20.8				**35.5**			
Exposed Floor (ft²·°F/Btuh)								
Steel Framed	31.2				**33.1**			
Wood Framed	30.3				**32.7**			
Glazing								
Max. Glazing Allowed by Prescriptive Path **(1)**	40%							
Window U-value (Btu/h/(ft²·°F))	CurtainWall/ Storefront		Entrance Door	All Other	CurtainWall/ Storefront		Entrance Door	All Other
	0.45		0.80	0.55	**0.45**		**0.80**	**0.55**
Window SHGC								
	0.40				**<0.4**			
Swinging Doors (Btu/h/(ft²·°F))								
Fully Glazed U-Value	Same as "Other" Requirement for Glazing							
Opaque Door - Uvalue	0.7				**0.6**			
Underground Wall and Roof (ft²·°F/Btuh)								
	Wall only R-7.5				**20.0**			
Floors-on-Ground (ft²·°F/Btuh)								
	R-20 for 48"				**20 for 48"**			
LIGHTING								
Interior Lighting (W/ft²)	0.700				**0.600**			
Interior Lighting Control	Manual				**Manual**			
Daylighting Control	N/A							
Interior Lighting Control	-							
HVAC								
HVAC System	DX MUA unit with electric heat, Through the wall unit in suites with electric baseboard				**DX MUA unit with electric heat, Through the wall unit in suites**			
Economizer	None				**None**			
Fan Power Limit	Constant volume = HP <= CFM*0.0011				**BHP=cfm(0.00094)**			
Fan Control	Constant				**Constant**			
Cooling Supply T Control	No reset							
Humidification	N/A							
Demand Control Ventilation	None				**None**			
AHU Air to Air heat recovery	None				**None**			
MUA unit DX efficiency (EER)	11.0				**ASHRAE 90.1-2010**			
Through the wall A/C unit	SEER 12				**SEER 12/EER 10.37**			
Electric Power								
Motor Efficiency	Premium				**Premium**			

2.3 NECB 2011 and ASHRAE 90.1-2010 Energy Efficiency Parameters

Tables 8 (covering non-residential buildings excluding multi-unit residential buildings) and 9 (covering multi-unit residential buildings) compare the primary energy efficiency requirements of ASHRAE 90.1-2007 (representing current practice), NECB 2011 and ASHRAE 90.1-2010.

The key differences between ASHRAE 90.1-2010 and ASHRAE 90.1-2007 for Climate Zone 6 (covering 60 percent of the province's population) are:

- Reduced lighting power density allowances
- Lower minimum threshold for requirement for heat recovery (does not impact buildings in this study)

The key differences between NECB 2011 and ASHRAE 90.1-2007 for Climate Zone 6 are:

- Significantly improved thermal performance of envelope components (walls, roof, windows, etc.)
- Reduced lighting power density allowances (same as ASHRAE 90.1-2010)
- Lower airflow threshold for requirement of economizers
- Higher minimum threshold for the requirement for heat recovery (does not impact buildings in this study)

Table 8: ASHRAE 90.1-2007, NECB 2011 and ASHRAE 90.1-2010 Energy Efficiency Values (Non Residential)

Item	ASHRAE 90.1-2007				NECB 2011	ASHRAE 90.1-2010			
Exterior Walls ($ft^2 \cdot °F/Btuh$)									
Wall Type	Mass	Metal	Steel	Other	All	Mass	Metal	Steel	Other
	25%	0%	75%	0%	23.0	25%	0%	75%	0%
Roof ($ft^2 \cdot °F/Btuh$)	12.5	8.8	15.6	19.6		12.5	14.5	15.6	19.6
Exposed Floor ($ft^2 \cdot °F/Btuh$)	20.8				31.0	20.8			
Steel Framed									
Wood Framed	15.6				31.0	15.6			
Glazing									
Max. Glazing Allowed by Prescriptive Path	40%				40%	40%			
Window U-value (Btu/h/($ft^2 \cdot °F$))	CurtainWall/ Storefront		Entrance Door	All Other	All	CurtainWall/ Storefront		Entrance Door	All Other
	0.45		0.80	0.55	0.387	0.45		0.80	0.55
Window SHGC									
	0.40				No Requirement	0.40			
Swinging Doors (Btu/h/($ft^2 \cdot °F$))									
Fully Glazed U-Value	Same as "Other" Requirement for				0.476	See under Glazing			
Opaque Door - Uvalue	0.7				0.387	0.7			
Underground Wall and Roof ($ft^2 \cdot °F/Btuh$)									
	Wall only R-7.5				20.0	Wall only: R-7.5			
Floors-on-Ground ($ft^2 \cdot °F/Btuh$)									
	10 (Min 24 in. vertical)				7.5 (Min 1.2m from Perimeter)	10 (Min 24 in. vertical)			
LIGHTING									
Interior Lighting (W/ft^2)	Office: 1.0 Warehouse: 0.8 Box Retail: 1.5 Full Service Restaurant: 1.6				Office: 0.90 Warehouse: 0.66 Box Retail: 1.40 Full Service Restaurant: 0.89	Office: 0.90 Warehouse: 0.66 Box Retail: 1.40 Full Service Restaurant: 0.89			
Interior Lighting Control	Occupancy Sensors in specified spaces				Occupancy Sensors in specified spaces	Occupancy Sensors in specified spaces			
Daylighting Control	No Requirement				Daylight sensors required when primary sidelighted area in enclosed space is > 1000 ft^2.	Daylight sensors required when primary sidelighted area in enclosed space is > 250 ft^2.			
HVAC									
HVAC System	VAV with DX cooling and electric reheat				VAV with DX cooling and electric reheat	VAV with DX cooling and electric reheat			
Economizer	Required if cooling capacity ≥ 135,000				Required if air handler has mechanical	Required if cooling capacity ≥ 54,000			
Fan Power Limit	HP <= 1.5 hp/1000 CFM (for VV systems) HP <= 1.1 hp/1000 CFM (for CV systems)				HP <= 1.67 hp/1000 CFM (for VV systems) HP <= 1.01 hp/1000 CFM (for CV systems)	HP <= 1.5 hp/1000 CFM (for VV systems) HP <= 1.1 hp/1000 CFM (for CV systems)			
Fan Control	VSD on individual fan motors > 10 hp				VSD on individual fan motors > 10 hp	VSD on individual fan motors > 10 hp			
Cooling Supply T Control	Zone Reset				Zone Reset	Zone Reset			
Humidification	N/A				N/A	N/A			
Demand Control Ventilation	None				None	None			
AHU Air to Air heat recovery	50% effectiveness if: The OA ratio is 70% or greater and the supply air capacity is ≥ 5000 cfm				50% effectiveness if the system exhaust flow is > 7178 cfm	50% effectiveness when 30%< %OA< 40% and ≥5500 cfm SA 40%< %OA< 50% and ≥4500 cfm SA 50%< %OA< 60% and ≥3500 cfm SA 60%< %OA< 70% and ≥2000 cfm SA 70%< %OA< 80% and ≥1000 cfm SA or %OA≥80%			
MUA unit DX efficiency (EER)	13.0 SEER 11.2 EER 11.0 EER 10.0 EER				15 SEER for SS & 14 SEER for SP 11.2 EER 11.0 EER 10.0 EER	13.0 SEER 11.2 EER 11.0 EER 10.0 EER			
Electric Power									
Motor Efficiency	Premium				Premium	Premium			

Table 9: ASHRAE 90.1-2007, NECB 2011 and ASHRAE 90.1-2010 Energy Efficiency Values (Multi-Residential)

Item	ASHRAE 90.1-2007				NECB 2011	ASHRAE 90.1-2010			
Exterior Walls (ft^2·°F/Btuh)									
Wall Type	Mass	Metal	Steel	Other	All	Mass	Metal	Steel	Other
	100%	0%	0%	0%	23.0	100%	0%	0%	0%
	14.1	17.5	15.6	19.6		14.1	14.5	15.6	19.6
Roof (ft^2·°F/Btuh)									
	20.8				31.0	20.8			
Exposed Floor (ft^2·°F/Btuh)									
	17.5				31.0	17.5			
Glazing									
Glazing Percent	29%				29%	29%			
Window U-value (Btu/h/(ft^2·°F))	CurtainWall/ Storefront		Entrance Door	All Other	All	CurtainWall/ Storefront		Entrance Door	All Other
	0.45		0.80	0.55	0.387	0.45		0.80	0.55
Window SHGC									
	0.40				No Requirement	0.40			
Swinging Doors									
Fully Glazed U-Value	Same as "Other" Requirement for Glazing				0.476	See under Glazing			
Opaque Door - Uvalue	0.7				0.387	0.5			
Underground Wall and Roof (ft^2·°F/Btuh)									
	Wall only R-7.5				20.0	Wall only: R-7.5			
Floors-on-Ground (ft^2·°F/Btuh)									
	15 (Min 24 in. vertical)				7.5 (Min 1.2m from Perimeter)	15 (Min 24 in. vertical)			
Leakage Rates									
Envelope L/s/m^2	No Requirement				No Requirement	No Requirement			
LIGHTING									
Interior Lighting (W/ft^2)	0.700				0.604	0.600			
Interior Lighting Control	Manual				Manual	Manual			
Daylighting Control	N/A				No Requirement	No Requirement			
Interior Lighting Control	-				No Requirement	Occupancy Sensor			
HVAC									
HVAC System	DX MUA unit with electric heat, PAC in suites with electric baseboard				DX MUA unit with electric heat, PAC in suites with electric baseboard	DX MUA unit with electric heat, PAC in suites with electric baseboard			
Economizer	None				None	None			
Fan Power Limit	Constant volume = HP <= CFM*0.0011				Power input = 1.6 W/(L/s)	bhp = CFM * (0.00094)			
Fan Control	Constant				Constant	Constant			
Cooling Supply T Control	Constant				Constant	Constant			
Heating Supply T Control	Constant				Constant	Constant			
Humidification	N/A				N/A	N/A			
Demand Control Ventilation	None				None	None			
AHU Air to Air heat recovery	None				No HRV on MURB due to local exhaust and climate zone	No Requirement			
MUA unit DX efficiency (EER)	11.0				< 65 kBtu/h: 15 SEER ≥65,< 135 kBtu/h: 11.0 EER, 11.2 IEER ≥135,< 240 kBtu/h: 10.8 EER, 11.0 IEER	< 65 kBtu/h: 13 SEER ≥65,<135 kBtu/h: 11.0 EER, 11.2 IEER ≥135,< 240 kBtu/h: 10.8 EER, 11.0 IEER			
PAC	10.37 EER				10.37 EER	10.37 EER			
SERVICE WATER HEATING									
Type	Electric				Electric	Electric			
Electric Power									
Motor Efficiency	Premium				Premium	Premium			

3. Energy Assessment of NECB 2011 and ASHRAE 90.1-2010 Versus Current Practice

3.1 Development of Energy Models

The archetype buildings were created in the eQuest energy simulation software (version 3.64). The files were created based on the building descriptions outlined in Tables 1-5 of this report. The current practice, NECB 2011 and ASHRAE 90.1-2010 energy efficiency parameters are outlined in Tables 8 and 9. The files were simulated using hourly weather data for St. John's, Newfoundland and Labrador.

Fan power was estimated using G3.1.2.9 of ASHRAE 90.1-2007 and capped using the BHP/cfm limitations of NECB 2011 and the Energy Cost Budget section of ASHRAE 90.1-2007 and 2010. Because unit heaters are not a baseline system type defined by ASHRAE, the fan power of the unit heater in the warehouse was set to 0.000241 kW/cfm based on Caneta's energy modelling experience on design projects.

Figures 1-5 illustrate the 3D representation the archetypes in eQuest. Note: In the 3D representations, light grey represents walls, dark grey represents roofs, blue represents windows or glass doors, and greenish-brown represents opaque doors.

Figure 1: Architectural Representation of Office Archetype from eQuest Energy Model

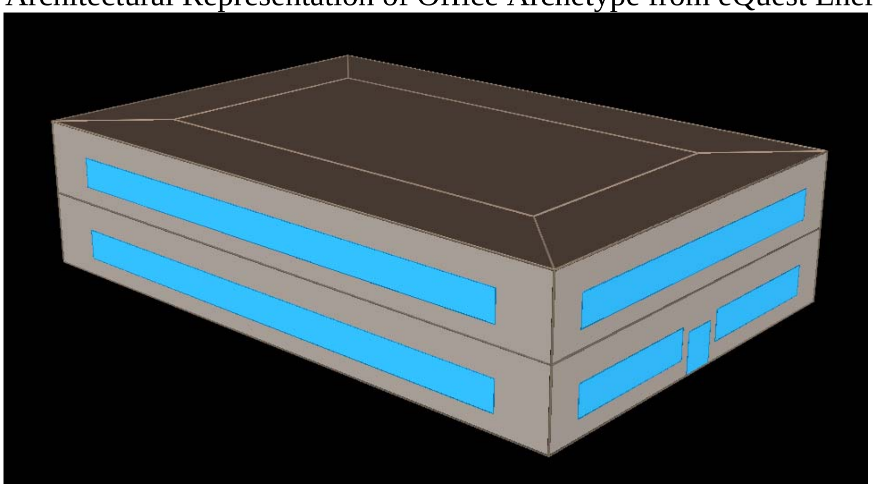


Figure 2: Architectural Representation of Warehouse from eQuest Energy Model

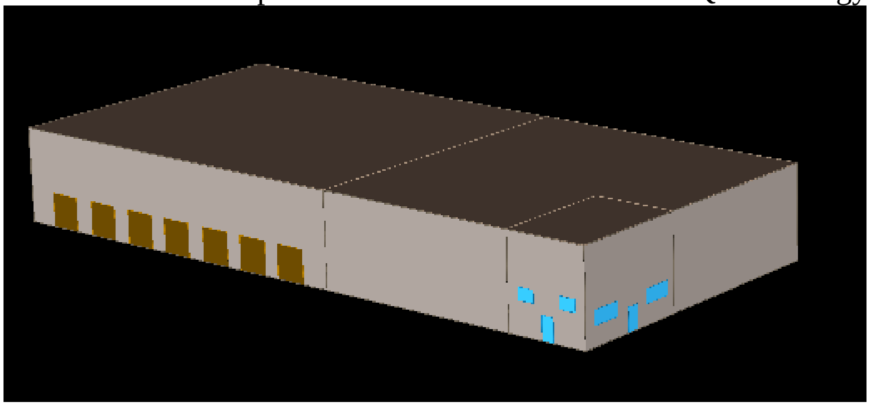


Figure 3: Architectural Representation of Multi-Residential Archetype from eQuest Energy Model

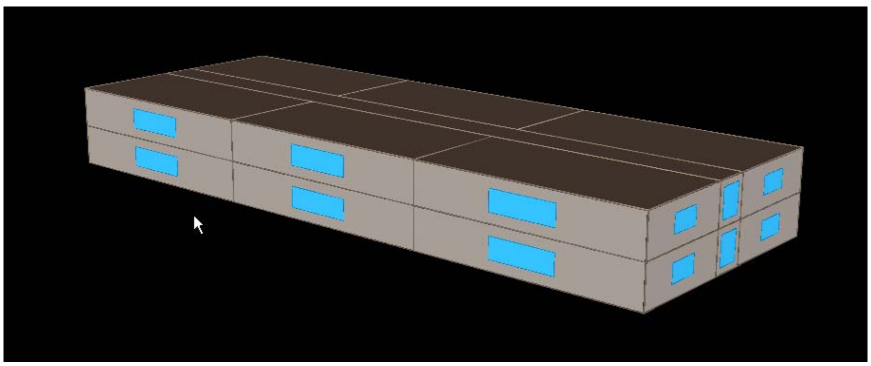


Figure 4: Architectural Representation of Box Store Retail Archetype from eQuest Energy Model

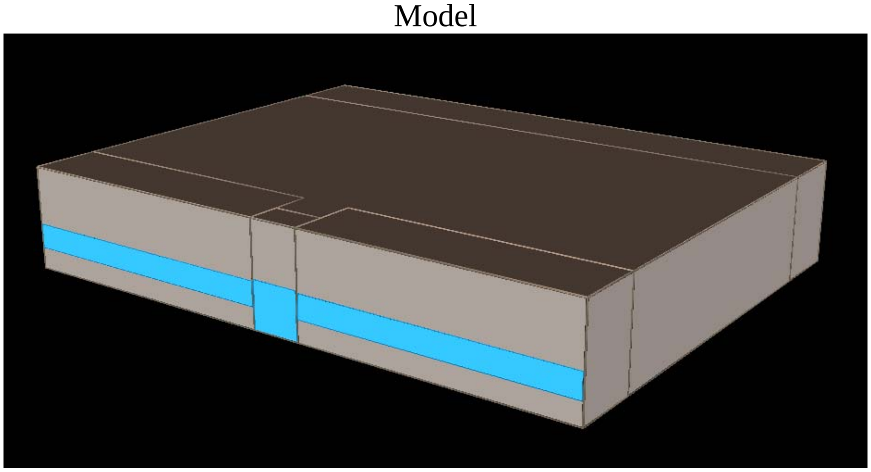
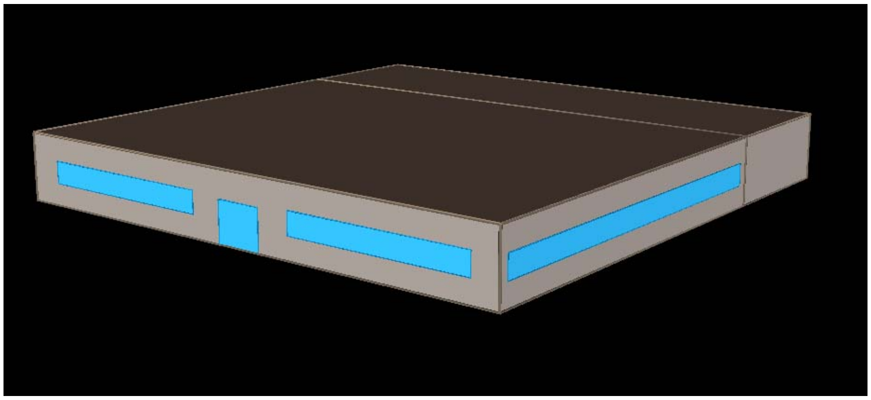


Figure 5: Architectural Representation of Full Service Restaurant Archetype from eQuest Energy Model



3.2 Utility Rates

The electrical utility rates ($/kWh) are based on the Newfoundland and Labrador levelized rate of 14.52 cents per kWh. The levelized rate was converted to a present day rate using the 25 year assumed inflation rates from the generation of the levelized rate.

Demand charges were also applied based on Newfoundland Power's rate 2.3 (General Service 110 kVA (100 kW) - 1000 kVA). The demand rate is of $7.54 per kVA of billing demand from December through March and $5.04 per kVA in all other months.

The monthly meter charges were ignored since they are the same for all cases.

3.3 Results of Energy Analysis

A summary of the percent energy savings, annual energy savings and annual energy cost savings is provided in Figures 6, 7 and 8. The office and warehouse have the largest percent energy savings and the office has the largest annual energy cost savings of the 5 archetypes when designed to NECB 2011. The full service restaurant has the highest percent savings and highest annual cost savings when designed to ASHRAE 90.1-2010.

The full service restaurant has the lowest percent energy savings when design to NECB 2011due to the large equipment and process energy use and outside air loads. However, the annual energy and annual energy cost savings was comparable with the box retail and multi-residential archetypes.

Percentage energy savings varied between 2.7 and 16.7 percent and annual energy savings varied between $3,062 and $6,478 for the NECB 2011 when compared to current practice (ASHRAE 90.1-2007).

Figure 6: Percent Energy Savings Relative to Current Practice (ASHRAE 90.1-2007)

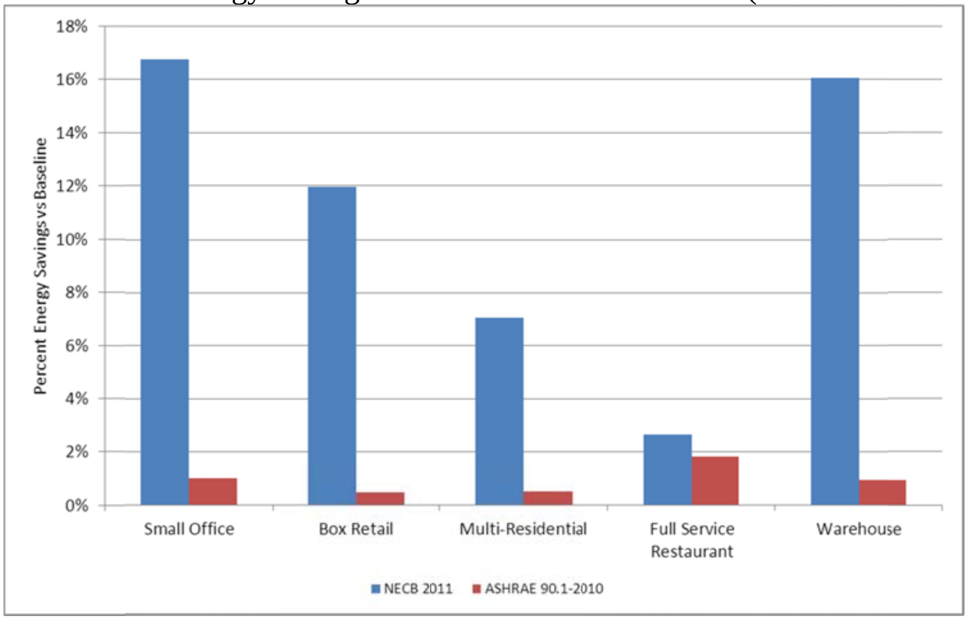


Figure 7: Annual Energy Savings Relative to Current Practice (ASHRAE 90.1-2007)

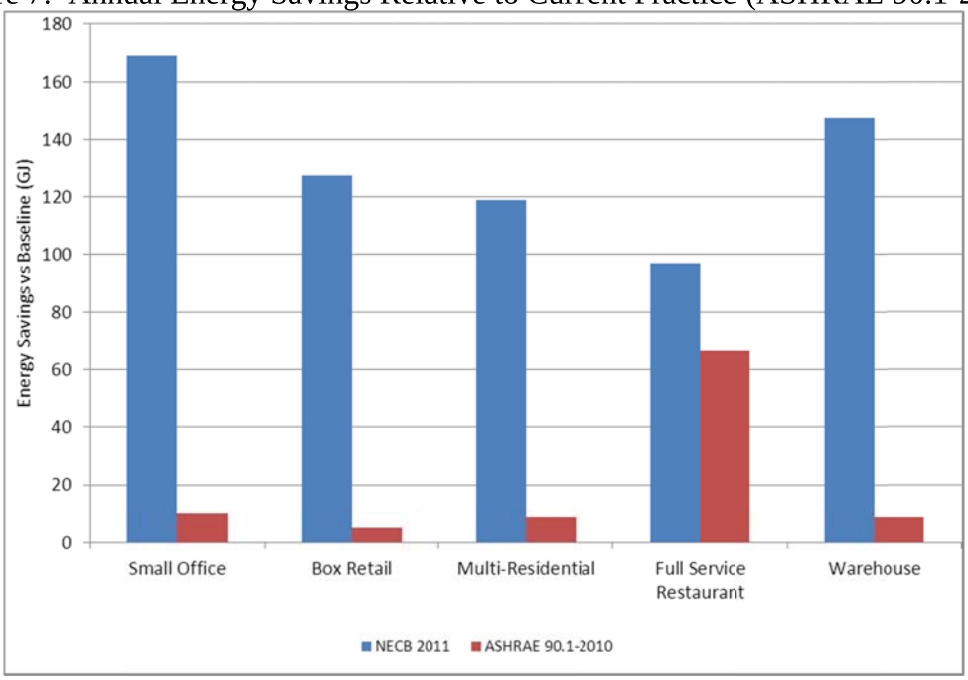
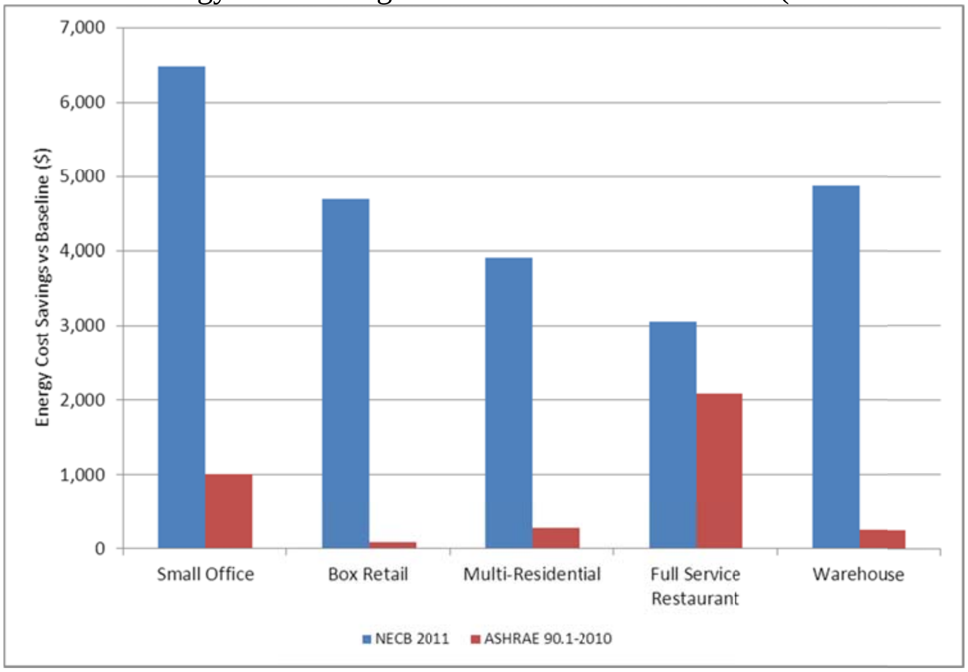


Figure 8: Annual Energy Cost Savings Relative to Current Practice (ASHRAE 90.1-2007)



Detailed results of the energy analysis are reported in Tables 10 to 14 and Figures 9 to 13 for each of the five archetypes buildings.

Heating represents the largest energy use in all buildings except the restaurant where heating is the third largest energy consumer, behind equipment and process energy and service hot water. Heating also represents the largest energy savings for the NECB 2011 design for all archetypes except the restaurant. The heating savings represent 64-91 percent of the total NECB 2011 energy savings for the archetypes other than the restaurant.

The NECB 2011 design for the office building, box retail and warehouse had the highest percent energy savings versus the current practice (ASHRAE 90.1-2007). In all these cases, the envelope heating load was a significant portion of the annual energy consumption and was not overshadowed by the outside air heating requirements of the building as was the case in the full service restaurant and multi-residential archetypes. The envelope requirements of the NECB 2011 are significantly more stringent than ASHRAE 90.1-2007 as illustrated in Tables 8 and 9. When the envelope loads are significant they can result in a significant improvement in energy consumption.

The energy savings of ASHRAE 90.1-2010 over the current practice represented by ASHRAE 90.1-2007 was significantly smaller than NECB 2011. The most significant difference between ASHRAE 90.1-2007 and 2010 was the lower lighting power allowance for ASHRAE 90.1-2010. The envelope requirements are the same between ASHRAE 90.1-2007 and 2010 and there are minimal changes in HVAC requirements.

3.3.1 Office Building

The energy model results of the office building are given in Table 10 and Figure 9. Heating is the largest end use in the office building, representing 40 percent of the total energy use in the ASHRAE 90.1-2007/current practice design.

The NECB 2011 design has an energy savings of 16.7 percent relative to ASHRAE 90.1-2007. The energy savings is primarily heating savings along with some lighting savings. The NECB 2011 represents a significant increase in envelope requirements over ASHRAE 90.1-2007 resulting in significant reductions in heating requirements.

The ASHRAE 90.1-2010 design has an energy savings of 1.0 percent relative to ASHRAE 90.1-2007 with the savings being almost entirely due to a reduction in lighting requirements. Heating increases slightly due to the reduction in internal loads from the improved lighting. The envelope requirements are the same between ASHRAE 90.1-2007 and 2010 and there are minimal changes in HVAC requirements. The higher energy cost savings (2.6 percent) is due to higher demand savings.

3.3.2 Box Retail Store

The energy model results of the box retail building are given in Table 11 and Figure 10. Heating is the largest end use in the box retail building representing 51 percent of the total energy use in the ASHRAE 90.1-2007/current practice design.

The NECB 2011 design has an energy savings of 12.0 percent relative to ASHRAE 90.1-2007. The energy savings is largely heating savings along with some lighting and fan energy savings. The NECB 2011 represents a significant increase in envelope requirements over ASHRAE 90.1-2007 resulting in significant reductions in heating requirements.

The ASHRAE 90.1-2010 design has an energy savings of 0.5 percent relative to ASHRAE 90.1-2007 with the savings due to a reduction in lighting requirements. Heating increases slightly due to the reduction in internal loads. The envelope requirements are the same between ASHRAE 90.1-2007 and 2010 and there are minimal changes in HVAC requirements.

3.3.3 Multi-Unit Residential Building (MURB)

The energy model results of the MURB are given in Table 12 and Figure 11. Heating is the largest end use representing 52 percent of the total energy use in the ASHRAE 90.1-2007/current practice design.

The NECB 2011 design has an energy savings of 7.0 percent relative to ASHRAE 90.1-2007. The energy savings is due to heating and lighting savings. The NECB 2011 percent energy savings is lower than the office, box retail and the warehouse. The MURB system has a significant heating load for outside air. There are minimal improvements in HVAC systems between ASHRAE 90.1-2007 and NECB 2011 for the MURB and consequently, no reduction in the make-up air heating energy. The envelope heating load is a less significant portion of the heating energy for the MURB.

The ASHRAE 90.1-2010 design has an energy savings of 0.5 percent relative to ASHRAE 90.1-2007 with the savings due to a reduction in lighting requirements and minor cooling efficiency improvements. Heating increased slightly due to the reduction in internal loads. The envelope requirements are the same between ASHRAE 90.1-2007 and 2010 and there are minimal changes in heating requirements.

3.3.4 Full Service Restaurant

The energy model results of the full service restaurant are given in Table 13 and Figure 12. Equipment and process is the largest end use representing 62.0 percent of the total energy use in the ASHRAE 90.1-2007/current practice design. Heating only represents 10.0 percent of the total energy use.

The NECB 2011 design has an energy savings of 2.7 percent relative to ASHRAE 90.1-2007. The energy savings is due to lighting and fan energy savings. The NECB 2011 percent energy savings is lower than all other building types. The full service restaurant system has a large heating load for outside air. There are minimal improvements in HVAC systems between ASHRAE 90.1-2007 and NECB 2011 for the restaurant building and consequently, no improvement to the make-up air heating. Air-to-air heat recovery is not required by any of the 3 codes, either due to the fact it is kitchen exhaust or energy content of the exhaust. Due to the large equipment/process loads and outside air heating, the envelope heating load is a relatively small portion of the heating energy for the full service restaurant.

The ASHRAE 90.1-2010 design has an energy savings of 1.8 percent relative to ASHRAE 90.1-2007 with the savings due to a reduction in lighting and fan energy. Heating increased due to the reduction in internal loads. The envelope requirements are the same between ASHRAE 90.1-2007 and 2010 and there are minimal changes in HVAC requirements.

3.3.5 Warehouse

The energy model results of the warehouse are given in Table 14 and Figure 13. Heating is by far the largest end use in the warehouse, representing 72.6 percent of the total energy use in the ASHRAE 90.1-2007/current practice design.

The NECB 2011 design has an energy savings of 16.0 percent relative to ASHRAE 90.1-2007. The energy savings is due to heating savings along with lighting savings. The NECB 2011 represents a significant increase in envelope requirements over ASHRAE 90.1-2007 resulting in significant reductions in heating requirements and since the heating load is dominated by envelope losses in the warehouse, this translates into a significant percent energy savings.

The ASHRAE 90.1-2010 design has an energy savings of 0.9 percent relative to ASHRAE 90.1-2007 with the savings being almost entirely due to a reduction in lighting requirements. Heating increased due to the reduction in internal loads. The envelope requirements are the same between ASHRAE 90.1-2007 and 2010 and there are minimal changes in HVAC requirements.

Table 10: Energy Simulation Results – Office Building

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	400	246	408
Space Cooling	20	24	19
Domestic Hot Water	49	49	49
Interior Lighting	186	167	167
Equip./Appliances	276	276	276
Fans	79	79	81
Total	**1,008**	**840**	**998**
GJ/m²	**0.67**	**0.56**	**0.67**
ELECTRICITY			
Metered Peak Demand (kW)	151	131	148
Metered Consumption (kWh)	280,133	233,237	277,339
ENERGY CHARGES ($)			
Electric (Consumption)	28,887	24,051	28,599
Electric (Demand)	9,875	8,233	9,153
Total	*38,762*	*32,284*	*37,752*
ANNUAL SAVINGS ($)	0	6,478	1,010
($/m²)	0.00	4.32	0.67
SAVINGS (%)			
Energy Consumption	0.00	16.7%	1.0%
Energy Charges	0.00	16.7%	2.6%

Figure 9: Annual Energy Comparison – Office Building

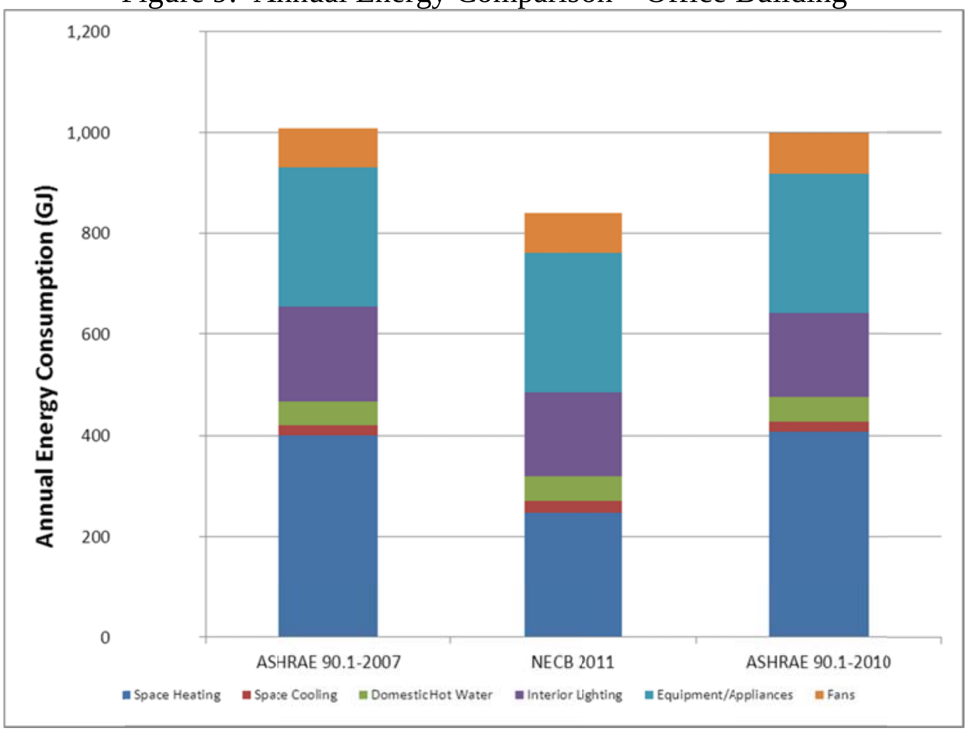


Table 11: Energy Simulation Results – Box Retail Store

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	543	462	552
Space Cooling	11	11	10
Domestic Hot Water	55	55	55
Interior Lighting	215	200	200
Equip./Appliances	87	87	87
Fans	155	123	156
Total	**1,065**	**938**	**1,060**
GJ/m²	**1.07**	**0.94**	**1.06**
ELECTRICITY			
Metered Peak Demand (kW)	161	147	163
Metered Consumption (kWh)	295,836	260,469	294,460
ENERGY CHARGES ($)			
Electric (Consumption)	30,506	26,859	30,364
Electric (Demand)	9,442	8,388	9,497
Total	*39,948*	*35,247*	*39,861*
ANNUAL SAVINGS ($)	0	4,701	87
($/m²)	0.00	4.70	0.09
SAVINGS (%)			
Energy Consumption	0.00	12.0%	0.5%
Energy Charges	0.00	11.8%	0.2%

Figure 10: Annual Energy Comparison – Box Retail Store

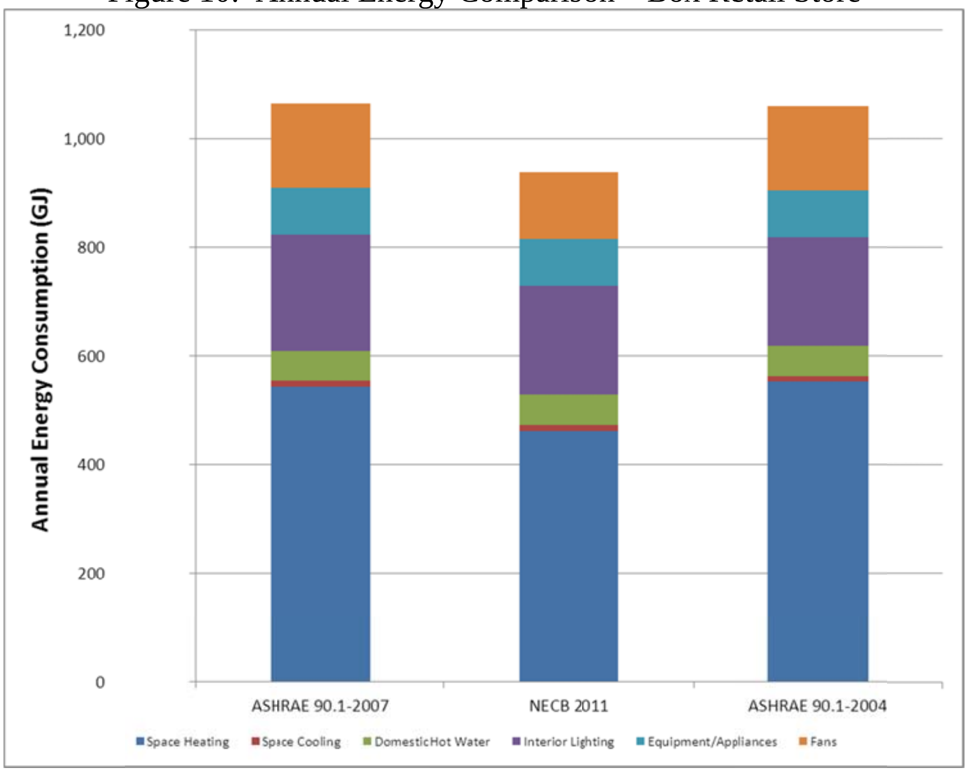


Table 12: Energy Simulation Results – MURB

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	881	780	898
Space Cooling	17	18	15
Domestic Hot Water	352	352	352
Interior Lighting	156	135	135
Equip./Appliances	223	223	223
Fans	59	62	58
Total	**1,689**	**1,570**	**1,680**
GJ/m²	**0.84**	**0.78**	**0.84**
ELECTRICITY			
Metered Peak Demand (kW)	134	124	134
Metered Consumption (kWh)	469,079	436,045	466,673
ENERGY CHARGES ($)			
Electric (Consumption)	48,371	44,965	48,123
Electric (Demand)	7,207	6,699	7,169
Total	*55,578*	*51,664*	*55,292*
ANNUAL SAVINGS ($)	0	3,914	286
($/m²)	0.00	1.96	0.14
SAVINGS (%)			
Energy Consumption	0.00	7.0%	0.5%
Energy Charges	0.00	7.0%	0.5%

Figure 11: Annual Energy Comparison – MURB

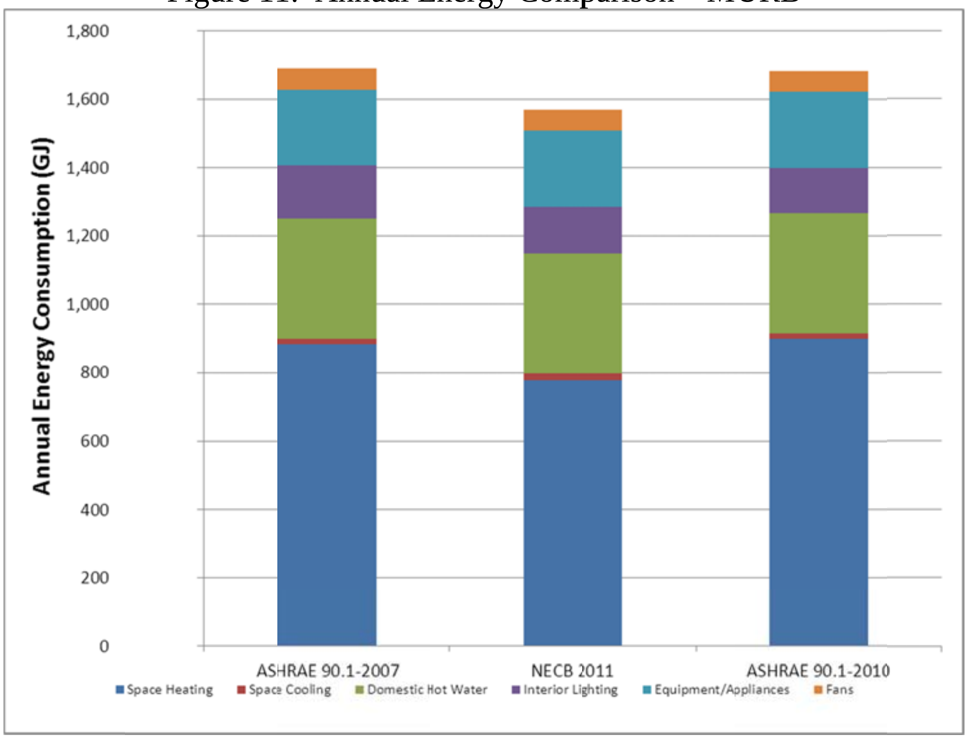


Table 13: Energy Simulation Results – Full Service Restaurant

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	369	391	434
Space Cooling	54	57	49
Domestic Hot Water	427	427	428
Interior Lighting	248	138	138
Equip./Appliances	2,249	2,249	2,249
Fans	281	270	265
Total	**3,628**	**3,532**	**3,562**
GJ/m²	**5.85**	**5.70**	**5.74**
ELECTRICITY			
Metered Peak Demand (kW)	235	230	234
Metered Consumption (kWh)	1,007,906	981,040	989,373
ENERGY CHARGES ($)			
Electric (Consumption)	103,935	101,164	102,023
Electric (Demand)	14,583	14,292	14,405
Total	*118,518*	*115,456*	*116,428*
ANNUAL SAVINGS ($)	0	3,062	2,090
($/m²)	0.00	4.94	3.37
SAVINGS (%)			
Energy Consumption	0.00	2.7%	1.8%
Energy Charges	0.00	2.6%	1.8%

Figure 12: Annual Energy Comparison – Full Service Restaurant

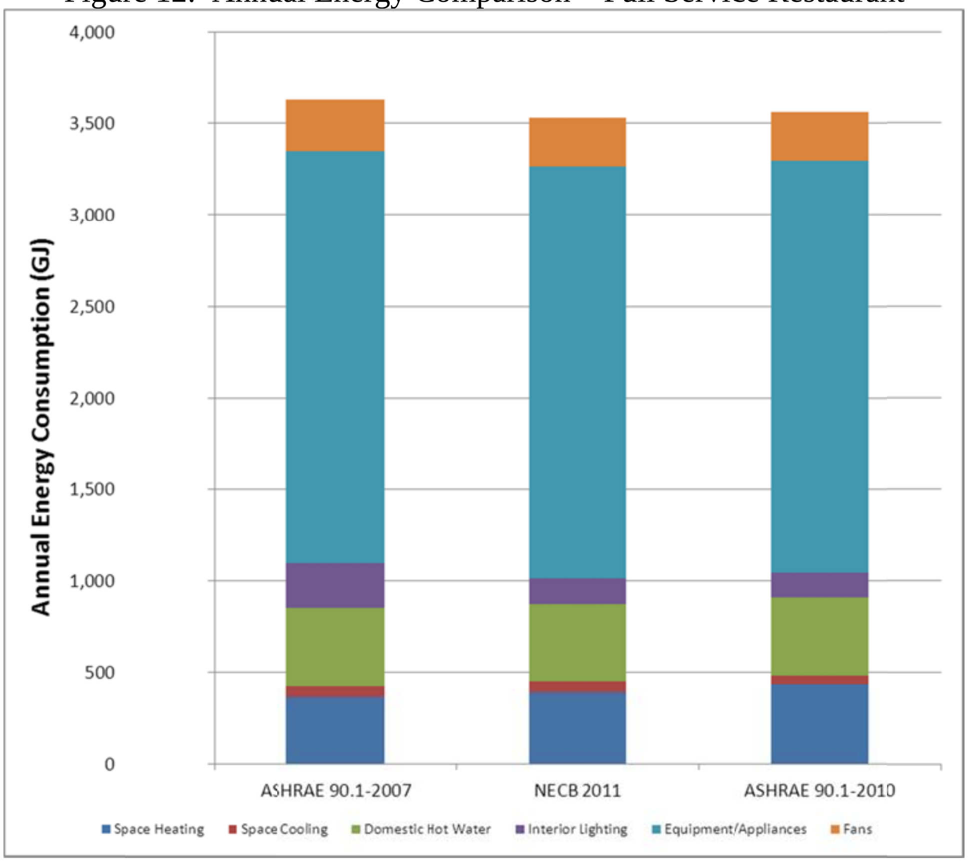
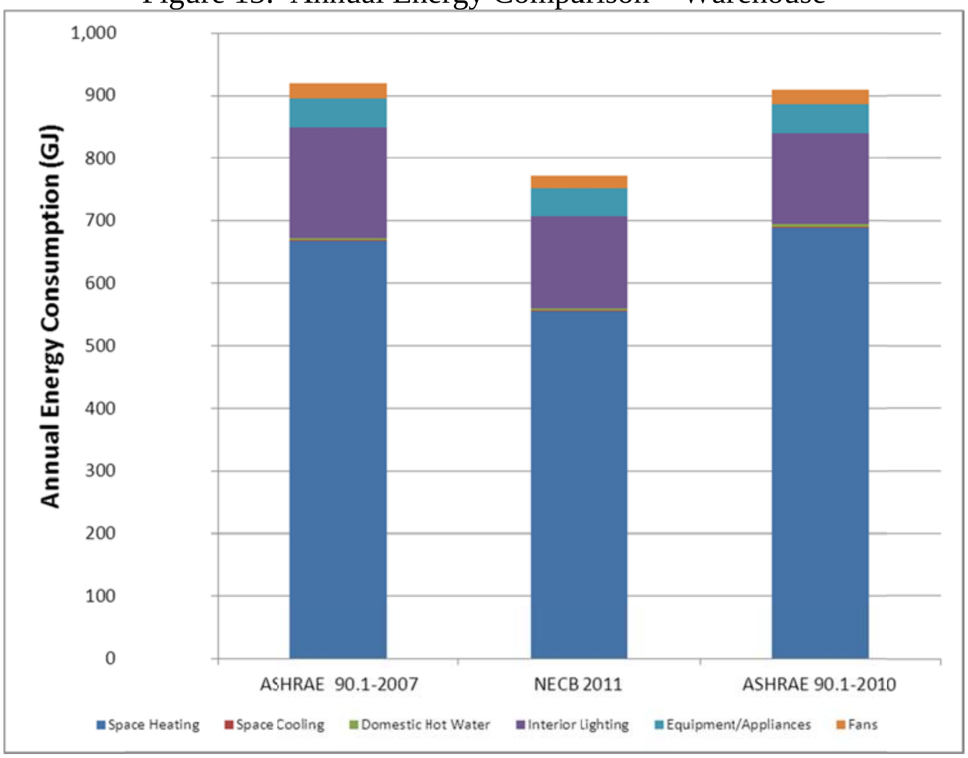


Table 14: Energy Simulation Results – Warehouse

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	668	554	689
Space Cooling	1	1	1
Domestic Hot Water	4	4	4
Interior Lighting	177	147	147
Equip./Appliances	45	45	45
Fans	24	20	24
Total	**919**	**772**	**911**
GJ/m²	**0.46**	**0.39**	**0.46**
ELECTRICITY			
Metered Peak Demand (kW)	102.0	88.1	102.1
Metered Consumption (kWh)	255,349	214,407	252,962
ENERGY CHARGES ($)			
Electric (Consumption)	26,332	22,109	26,085
Electric (Demand)	5,195	4,538	5,187
Total	*31,527*	*26,647*	*31,272*
ANNUAL SAVINGS ($)	0	4,880	254
($/m²)	0.00	2.44	0.13
SAVINGS (%)			
Energy Consumption	0.00	16.0%	0.9%
Energy Charges	0.00	15.5%	0.8%

Figure 13: Annual Energy Comparison – Warehouse



4. Cost Benefit Analysis

4.1 Incremental Capital Costs

The incremental capital costs were determined for NECB 2011 and ASHRAE 90.1-2010 relative to current practice. The incremental costing included; differences in the prescriptive requirements for envelope (walls, roof, floor, and windows), lighting, HVAC equipment sizing, and HVAC cooling efficiency. Since the archetypes were all electrically heated, heating efficiency was not a consideration.

The size of the installed HVAC equipment varied for the different energy efficiency levels, due to the impact envelope and lighting improvement has on a building's heating and cooling loads.

Costing of small DX split system air conditioners were based on previous work by Caneta [1]. Other mechanical costs were based on RS Means Mechanical Cost Data [2].

Because of the stringent envelope requirements of the NECB and the difficulty in meeting the overall wall assembly R-value requirements when accounting for thermal bridging of structural components through the insulation layers, a study for BC Hydro [3] was used to determine the wall constructions for the current practice and NECB 2011. See Appendix C for a more detailed description of the wall construction assumptions. The BC Hydro study [3] also provided costing information in $/ft² for the various wall and roof constructions. These cost estimates were used for wall and roof costing in this study along with the RS Means city cost indices.

Perimeter slab on grade insulation costing was based on RS Means Building Construction Cost Data [4].

Costing for windows was based on a study for the Canadian Code Centre at National Research Council Canada [4] in support of the NECB 2011 development.

Lighting upgrade costs were based on the assumption that reducing the installed lighting power density is achieved by upgrading the lighting technology while maintaining the same number of light fixtures. The lighting technologies for the current practice were assumed to be T8 fluorescents for tube lighting, compact fluorescent for globe lighting[1], and metal halide for high bay lighting. The upgraded lighting technologies were assumed to be T5 fluorescents for tube lighting, LED lamps for globe lighting, and T5HO lamps for high bay lighting. The lighting costs for the different technologies were from RS Means Green Building Cost Data [6].

[1] Unlike most of the other building types, there has not been a significant decrease in the installed lighting power allowance in restaurants when comparing ASHRAE 90.1-1989 to ASHRAE 90.1-2007 (current practice). Therefore, it was assumed that the current practice in restaurants is to use incandescent bulbs for globe lighting, as it would have been when ASHRAE 90.1-1989 was current.

RS Means city cost indices were obtained from RS Means Construction Cost Data [4] were used to adjust costs to reflect local St. John's, Newfoundland and Labrador costs. Inflation adjustments were applied where data was more than 1 year old.

For the NECB 2011, the dominant incremental costs were envelope improvements, followed by reduced lighting power. Envelope upgrades represent over 75 percent of the NECB 2011 incremental costs in the case of all of the archetypes.

The NECB 2011 incremental capital costs of the warehouse were substantially higher than the other archetypes. The warehouse archetype is the only archetype with steel framed walls and metal deck roofing. Due to the thermal bridging of steel framed wall, this wall construction represented the most challenging to meet the NECB 2011 thermal resistance requirements. The cost of increasing the insulation value of steel framed wall was significantly higher than other wall constructions. In addition, the warehouse roof construction was the only archetype with a steel deck roof. There is a cost premium to insulating a steel deck roof to NECB 2011 requirements relative to a concrete deck or attic roof.

The ASHRAE 90.1-2010 incremental capital costs are dominated by reduced lighting power through technological improvements. The envelope is the same between current practice and ASHRAE 90.1-2010.

For the energy analysis, the HVAC airflows, cooling capacity and heating capacity were all auto-sized by the eQuest software. This allowed the impact of envelope and internal loads from lighting to be accounted for in the HVAC costing. In most archetypes, there is a reduction in size of the HVAC equipment. The reduced HVAC capacities result in a reduction in incremental costs relative to the current practice baseline. This is not due to a change in equipment efficiency, but rather a reduction in capacities and airflows due to either improved envelope or reduced internal loads from lighting power.

Table 15: Incremental Capital Cost Estimates by Component

	Office		MURB		Box Retail Store		Warehouse		Full Service Restaurant	
Building Component	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**
MUA System	$0	$0	$36	$44	$0	$0	$0	$0	$0	$0
Re-circulation AHU	$1,068	-$901	$0	$0	-$5,167	$118	$78	-$41	-$1,187	-$2,456
Zone Terminal Equipment	$1,690	-$1,425	-$1,020	-$396	-$14,956	$351	-$1,199	-$192	$0	$0
Exterior Wall	$13,447	$0	$6,820	-$1	$16,212	$0	$48,740	$0	$2,316	$0
Windows	$23,635	$0	$10,882	$10	$3,065	$0	$1,676	$0	$2,376	$0
Roof	$19,657	$0	$20,485	$0	$26,179	-$1	$67,015	$0	$12,705	$0
Perimeter Floor Insulation	$994	$0	$714	$0	$1,133	$0	$1,714	$0	$885	$0
Lighting Cost	$7,875	$7,875	$13,702	$14,273	$2,813	$2,813	$2,926	$2,926	$4,343	$4,343
Total Incremental Capital Costs	**$68,366**	**$5,549**	**$51,620**	**$13,930**	**$29,278**	**$3,281**	**$120,950**	**$2,693**	**$21,439**	**$1,886**

4.2 Total Building Capital Cost Estimates

In order to gauge the impact of the incremental costs on the total construction project, estimates of the total construction costs were made. Using square foot costs from RS Means [3] and using the RS Means city cost indices for St. John's, an estimate of the total project costs was developed for each archetype building. These costs may be higher for other regions of the province, depending on local transportation costs. Table 16 illustrates the total construction costs for the archetype buildings and the incremental costs for NECB 2011 and ASHRAE 90.1-2010 cases as a percentage of the total costs.

Table 16: Total Construction Costs for Archetype Buildings

Building Archetype	Total Costruction Costs per Area [1]		Estimated Project Costs	Incremental Capital Costs			
				NECB 2011		ASHRAE 90.1-2010	
				Incremental Costs	Percentage of Total Project Costs	Incremental Costs ($)	Percentage of Total Project Costs
	($/ft²)	($/m²)	($)	($)	(%)	($)	(%)
Office	137	1,476	$2,214,158	$68,366	3.1	$5,549	0.3
Box Retail	95	1,023	$1,021,986	$29,278	2.9	$3,281	0.3
MURB	121	1,297	$2,591,049	$51,620	2.0	$13,930	0.5
Full Service Restaurant	195	2,103	$1,302,220	$21,439	1.6	$1,886	0.1
Warehouse	75	805	$1,608,365	$120,950	7.5	$2,693	0.2

[1] Includes location adjustment factor for St. John's, Newfoundland and Labrador

The total building costs in Table 16 include all construction costs but do not include design fees or land costs. In the case of the full service restaurant, they also include equipment costs, which is in part the reason why the full service restaurant has the highest total construction costs per area.

The NECB 2011 incremental costs represent 1.6 to 3.1 percent of the total construction costs with the exception of the warehouse, which were 7.5 percent of the total construction costs. As discussed in the previous section, the large incremental envelope costs for the NECB 2011 warehouse were due to the steel framed wall construction and the cost of bringing steel framed construction up to NECB 2011 requirements of R-23.0 (RSI-4.05 m^2 °C/W). The warehouse is also has the lowest total construction costs for the base case at $75/ft^2.

The ASHRAE-90.1-2010 incremental costs represent 0.1 to 0.5 percent of the total construction costs.

4.3 Life Cycle Cost Analysis

Lifecycle costing analysis is often used to evaluate decision-making in the purchase or construction of new assets, such as buildings, and can be used to compare costs for similar asset types based on different inputs to the purchase or construction process, such as energy performance requirements. Lifecycle costing also allows for consideration of costs which occur after an asset has been purchased or constructed, such as maintenance and operational costs. Alternatively, the analysis would focus on the up-front capital costs that would be incurred that fail to take account of the longer-term costs of operating and maintaining an asset.

Lifecycle costing is summarized below using payback periods, internal rates of return and change in net present value. A payback period refers to the period of time required to recover up-front funds expended in an investment, or to reach the break-even point. For example, a $1000 investment which returned $500 per year, ignoring inflation, would have a two-year payback period. The payback period calculated in this study accounts for time value of money by discounting the cash inflows of the project.

The internal rate of return, also known as the effective interest rate, measures the profitability of an investment. The term *internal* refers to the fact that it does not incorporate external factors such as inflation. It is used to evaluate the desirability of an investment or project. An investment is considered acceptable if its internal rate of return is greater than the minimum acceptable rate of return. Put another way, the higher a project's internal rate of return, the more desirable it is to undertake the investment or project and, assuming all investments and projects require the same amount of up-front investment, the project with the highest internal rate of return would be considered to be undertaken first.

The net present value (NPV) is the current value of the building, combining up-front capital construction costs and energy costs incurred over an initial 25-year period, accounting for inflation and interest. The change in NPV measures, on a percentage basis, the incremental change in a building’s NPV between the baseline and each of NECB 2011 and ASHRAE 90.1-2010. A positive change in NPV means that a building owner is better off by constructing to NECB or ASHRAE 90.1.2010 rather than the baseline.

The energy cost savings determined in Section 4.3 and the incremental capital costs determined in Section 5.1 were used to perform lifecycle costing on the NECB 2011 and ASHRAE 90.1-2010 requirements relative to current practice.

The lifecycle analysis was done for a period of 25 years (2015 – 2039) with a real discount rate of 8 percent. The electricity and demand costs were assumed to escalate at 3.78 percent for the first year and 2.65 percent for the remaining years of the analysis. These escalation rates yields the equivalent of the levelized cost discussed in Section 4.2.

The results of the lifecycle analysis are summarized below in Table 17.

For the NECB 2011 archetypes, the payback periods were under 25 years with the exception of the warehouse. The internal rates of return were 2.6 to 18.4 percent. The warehouse was the lowest case at 2.6 percent. Excluding the warehouse, the rates of return for the remaining four archetypes were over 8.3 percent. Last, for the change in net present value (NPV), one archetype showed a negative change, and the range for the remaining four archetypes ranged from 0.1percent to 3.4percent.

The relatively weak performance of the warehouse in the NECB 2011 analysis was due to the high incremental costs for the envelope. As discussed in Section 5.1, the warehouse is the only archetype with steel frame construction. Due to the thermal bridging of the metal framing, this wall construction represented the most challenging to meet the NECB 2011 thermal resistance requirements. In addition, the warehouse roof construction was the only archetype with a steel deck roof. There is a cost premium to insulating a steel deck roof to NECB 2011 requirements relative to a concrete deck or attic roof.

For the ASHRAE 90.1-2010 archetypes, the office, warehouse and full service restaurant had payback periods of 6.8, 16.2 and 1.0 years respectively with internal rates of return of 10.8 to 114 percent. The MURB and box retail archetypes had payback periods of greater than 25 years and negative internal rates of return. Last, for the change in net present value (NPV), two archetypes showed a negative change, and the range for the remaining three archetypes ranged from 0.05percent to 2.0percent.

The ASHRAE 90.1-2010 cases were entirely about lighting upgrades relative to current practice. The incremental costs were relatively inexpensive and resulted in higher levels of energy savings

Table 17: Results of Life Cycle Cost Analysis

Building	Scenario (2007,NECB,2010)	Annual Electricity Savings $	Incremental Capital Cost $	Actual Payback (years)	IRR	Change in NPV (%)
Office	Current Practice					
	NECB	$6,478	$68,366	16.1	10.8	0.9
	90.1-2010	$1,010	$5,549	6.8	20.7	0.4
Multi-Residential	Current Practice					
	NECB	$3,914	$51,620	23.6	8.3	0.1
	90.1-2010	$286	$13,930	> 25	-2.2	-0.4
Box Retail	Current Practice					
	NECB	$4,701	$29,278	7.9	18.4	3.4
	90.1-2010	$87	$3,281	> 25	-0.5	-0.2
Warehouse	Current Practice					
	NECB	$4,879	$120,950	> 25	2.6	-3.4
	90.1-2010	$254	$2,693	16.2	10.8	0.0
Full Service Restaurant	Current Practice					
	NECB	$3,061	$21,439	9.1	16.5	1.5
	90.1-2010	$2,089	$1,886	1.0	114.0	2.0

5. Constructability Issues

5.1 Wall Construction

The key constructability issue identified with NECB 2011 was achieving the wall U-value requirements of for Climate Zone 6. NECB 2011 requires all above grade walls to have a U-value of 0.247 W/m² °C less. This equates to an overall assembly R-value of RSI-4.05 m² °C/W or R-23.0 ft² °F/(btu/hr) or higher. This is a stringent requirement that is challenging for walls where the structural members penetrate the insulation layers and cause thermal bridging, reducing the effectiveness of the insulation, reducing the overall thermal resistance of the wall assembly. Unlike ASHRAE 90.1-2007 or 2010, is applied universally to all construction types.

For wood framing, the NECB wall requirements are approximately 17 percent more stringent than ASHRAE 90.1-2007 and ASHRAE 90.1-2010. Similarly, for steel framing, the requirements are approximately 47 percent more stringent, and for concrete block walls the requirements are approximately 84 percent more stringent. See Appendix C for a more detailed description of the wall construction assumptions. .

The steel framed wall had the most challenges in meeting the RSI 4.05 (R-23) requirement due to the significant thermal bridging through the layer of batt insulation. A second layer of polystyrene, bridged by z-girts required for the installation of the exterior cladding. Although the concrete block wall (mass wall) represented the largest difference between NECB 2011 and ASHRAE 90.1-2007, the brick ties between the concrete block and the brick cladding resulted in minimal thermal bridging and consequently did not have excessive difficulty meeting the NECB 2011 requirements.

The cost of achieving the NECB 2011 wall assembly requirements was incorporated into the incremental capital cost analysis done in Section 5.1.

5.2 Window U-values

NECB 2011 requires an overall window U-value of 2.2 W/m² °C (0.387 Btu/hr/ft² °F). The overall U-value includes the effects of thermal bridging through the framing. This requirement is achievable with double glazed windows with low-e argon and framing with aluminum framing with a good thermal break. Windows with vinyl frames should be able to achieve this requirement.

However, standard curtainwall framing or designs with a significant amount of framing will have difficulty achieving the NECB 2011 requirement with double glazing and may have to consider triple glazed windows. However, this problem can be avoided by specifying curtainwall framing with better thermal breaks and designing the glass with less framing. This study did not include archetype buildings with curtainwall framing.

6. Conclusions

The decision as to which building code or standard is required for new building construction in Newfoundland and Labrador will come down to trade-offs among policy objectives, particularly as to whether the province wishes to establish a minimum standard relatively close to current baseline building practices and then slowly evolve the building energy efficiency, or whether it wishes to make a significant step forward in the near term. In this context, a summary of the key findings of this study are as follows:

- In Climate Zone 6, neither NECB 2011 nor ASHRAE 90.1-2010 demonstrate cost effectiveness in all building archetypes. The internal rate of return, or the key metric for determining whether it is desirable to pursue an investment or project, varies from 2.6 to 18.4 percent for the NECB 2011 and between -2.2 to 114 percent for ASHRAE 90.1-2010. However, overall both codes demonstrate improved energy performance.

- ASHRAE 90.1-2010 allows for the introduction of energy efficiency requirements with minimal disruption from a cost perspective to building owners (no more than a 0.5 percent increase in up-front building costs). Requirements can then be improved with future iterations of ASHRAE 90.1 (for example, ASHRAE 90.1-2013). The downside to this decision is that initial improvements in energy performance will be limited.

- NECB 2011 offers a more significant increase in energy savings. The downside is that there will be higher incremental up-front capital costs to building owners, ranging from 1.6 to 7.5 percent. The architectural industry will need to modify current wall construction details, as some current wall construction designs in the local market will not be able to attain NECB 2011's stringent requirements.

7. References

[1] Caneta Research Inc., *Market Analysis for Update to Central Air Conditioner and Heat Pump Requirements under the Energy Efficiency Regulations*. Natural Resources Canada. February, 2013.

[2] RS Means, *RS Means Mechanical Cost Data – 2014. 2014*

[3] BC Hydro Power Smart, *Building Envelope Thermal Bridging Guide*. 2014.

[4] RS Means, *RS Means Building Construction Cost Data – 2012. 2012*

[5] RBS Consulting Engineers – for National Research Council Canada Canadian Code Centre, Cost Implication Analysis of National Energy Code for Buildings Proposed Part 3 Changes. April 9, 2010.
http://www.chba.ca/uploads/TRC/Webinar/NECB%20Part%203%20Cost%20Analysis%20Report%20final.pdf

[6] RS Means, *RS Means Green Building Cost Data – 2011. 2011*

Appendix A: Stakeholder Survey

Current Practice Energy Criteria Survey

Caneta Research Inc. and AMEC Foster Wheeler are undertaking stakeholder consultations of current design practices in Newfoundland and Labrador on behalf of the Office of Climate Change & Energy Efficiency of the Government of Newfoundland and Labrador to establish what energy criteria are typically being used in small commercial and multi-residential buildings in the province. The study will be used to determine the impact of requiring NECB 2011 for new building construction in the province. Your feedback will be included, anonymously, in a final report to the Province.

These consultations are the first step in the adoption of energy efficiency requirements for new buildings. The provincial government intends to conduct further consultations with stakeholders and the findings of the current consultation will inform the future stakeholder consultations.

On the first page of the attached questionnaire are some general questions to get an understanding of your recent building design experience and your exposure to energy efficient design.

On pages 2 to 6 are descriptions of 5 buildings which we expect to be representative of buildings being constructed in the province outside of the government sector. We will be using these "archetype" buildings for our analysis of the NECB 2011. These buildings include an office, multi-residential, retail, restaurant and warehouse. Please review these details about each of the 5 buildings and indicate if any items that do not reflect your recent design experience.

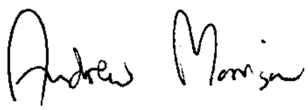
On page 7 and 8 of the questionnaire, there are two tables summarizing the energy criteria of ASHRAE 90.1-2007 as an approximation of current practice in the province. If you feel that the value defined in the column headed ASHRAE 90.1-2007 is typical of current practice write "agree" in the current practice column. If you disagree, an additional column has been provided on each table to allow you to enter new values that you feel are more typical of current design practice than the ones we have proposed. If a specific requirement is outside of your design experience, please indicate "unknown". Feel free to add any additional comments or clarifications you may wish to provide. The tables include non-residential buildings (offices, retail, restaurant and warehouse) and multi-residential buildings (excluding single family).

It is important that you report "typical" energy criteria based on your design project experience. In other words, report the energy criteria that you are currently seeing applied to most new buildings.

Finally, a table has been provided summarizing the energy criteria of NECB 2011. Please review these energy requirements of the NECB 2011 and indicate any concerns you may have regarding the constructability of these requirements. In other words, will any of these requirements result in unreasonable costs and burdens on new construction projects. If you have any concerns please explain in further details why this requirement cannot be implemented cost effectively in the Newfoundland and Labrador market.

You have already been contacted by AMEC–Foster Wheeler to determine your interest in participating in this study. They will be following up with you shortly to discuss this survey with you in more detail.

Thanks for your assistance in this study aimed at improving the efficiency of Newfoundland and Labrador buildings.



Andrew Morrison
Principal, Caneta Research Inc.

General Questions

Completed by: ______________________________________

Company: ______________________________________

Phone: ______________________________________

1) What design projects have you been working on in the last 5 years?

Types of buildings (office, retail, multi-residential, etc.)

Size of buildings

Typical HVAC systems

2) Have you used an energy code(s) on a recent design project. If so, which one(s) (MNECB-1997, ASHRAE 90.1-2004, ASHRAE 90.1-2007, ASHRAE 90.1-2010, NECB 2011)?

3) What percentage of your recent projects have been designed to LEED or been evaluated for LEED energy credits?

Office Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	1,500 m² (16,150 ft²)
	No. of Stories	2
	Aspect Ratio	1.5
	DOE archetype	Medium office
	No. occupants	81
	Building Occupancy	Weekdays: 16 hours/day Weekend: unoccupied
Architectural	Construction	Concrete block wall with concrete slab roof
	External Door Configurations	Glass 2 entrances
	Wall Height	4.0 m (13.1 ft)
	Wall-to-Roof Ratio	0.60
	Percent Glazing	33
HVAC	HVAC Zones	Core zone with four perimeter zones on each floor
	System	Single VAV with DX Cooling and electric heating coil serving multiple zones.
	Supply air temperature	12.8 °C (55 °F) reset for warmest zone for code requirements
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	2 l/s/m² (cfm/ft²)
	Economizer	As required by code
	Zone Heating	Electric baseboards
	Fan control	VFD
	Return air path	Plenum
	Outside air	810 l/s (10.0 l/s/person) 1,716 cfm (21.2 cfm/person)
	HVAC Operation	Unoccupied: Outside air dampers closed, fans off
	Temperature setpoints	Clg: 24 °C (75.2 °F)/setback: 26.7°C (80.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	10.8 W/m² (1 W/ft²)
	Lighting and equipment schedules	5% installed lighting power during unoccupied periods 5% installed lighting power during unoccupied periods
Utility Rates	Electricity rate	St. John’s electricity

Warehouse Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	Total bldg.: 2,000 m² (21500 ft²) Office area: 100 m² (1,060 ft²)
	No. of Stories	1
	Aspect Ratio	2.2
	DOE archetype	Warehouse
	No. occupants	Office: 3 Warehouse: 0
	Building Occupancy	Weekdays: 16 hours/day Weekend: 9 hours/day
Architectural	Construction	Steel frame walls with metal deck roof
	External Door Configurations	2 glass entrances in office Multiple truck bays in warehouse
	Wall Height	8.5 m (27.9 ft)
	Wall-to-Roof Ratio	0.82
	Percent Glazing	1
HVAC	HVAC Zones	1 office zone and two warehouse zones
	System	Office: Packaged single zone with SX clg/electric heating Warehouse: Electric unit heaters/No cooling
	Supply air temperature	Office: 12.8 °C (55 °F) reset for warmest zone for code requirements Warehouse: 43.3 °C (110 °F)
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	Office: none Warehouse: none
	Zone Heating	-
	Fan control	Constant
	Return air path	Office: Plenum Warehouse: n/a
	Outside air	Office: 50 l/s (106 cfm) Warehouse: none
	HVAC Operation	Unoccupied: Outside air dampers closed, fans cycle to maintain setpoint
	Temperature setpoints	Office Clg: 24 °C (75.2 °F)/setback: 30.0°C (86.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F) Warehouse: Htg: 15.6 °C (60.1 °F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	2.2 W/m² (0.2 W/ft²)
	Ltg & equip. schedules	10% installed lighting power during unoccupied periods 10% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	St. John’s electricity

MURB Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	2000 m² (21500 ft²)
	No. of Stories	2
	Aspect Ratio	2.7
	DOE archetype	Mid-rise MURB
	No. occupants	51
	Building Occupancy	Continuous
Architectural	Construction	Wood framed wall with wood framed attic roof
	External Door Configurations	Glass, 1 entrance
	Wall Height	3.05 m (10.0 ft)
	Wall-to-Roof Ratio	0.87
	Percent Glazing	15
HVAC	HVAC Zones	1 corridor zone and 6 apartment perimeter zones per floor
	System	Corridor pressurization with electric heating Apartments: Electric resistance/DX split system
	Supply air temperature	Corridor Press: 26 °C (79 °F) htg only
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	None
	Zone Heating	Electric baseboards
	Fan control	Constant
	Return air path	N/A: Suite exhausted locally through w/rs
	Outside air	670 l/s (1,430 cfm)
	HVAC Operation	Continuous
	Temperature setpoints	Clg: 24 °C (75.2 °F) Htg: 21 °C (69.8 °F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	5.4 W/m² (0.5 W/ft²)
	Lighting and equipment schedules	0% installed lighting power during unoccupied periods 20% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	St. John's electricity

Box Retail Archetype Characteristics

Category	Archetype Characteristic	Description of Detail
General	Size of building	1000 m² (10750 ft²)
	No. of Stories	1
	Aspect Ratio	1.3
	DOE archetype	Stand-alone retail
	No. occupants	141
	Building Occupancy	All days: 15 hours/day
Architectural	Construction	Concrete block wall with concrete slab roof
	External Door Configurations	Glass, 1 entrance
	Wall Height	6.1 m (20.0 ft)
	Wall-to-Roof Ratio	0.82
	Percent Glazing	7
HVAC	HVAC Zones	Separate zone for backspace, core retail, front retail & cash
	System	Packaged single zone/constant volume DX cooling and electric heating
	Supply air temperature	12.8 °C (55 °F) reset for warmest zone for code requirements
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	As required by code
	Zone Heating	-
	Fan control	Constant
	Return air path	Return duct
	Outside air	1,370 l/s (2,900 cfm)
	HVAC Operation	Unoccupied: Outside air dampers closed, fans cycle to maintain temperature
	Temperature setpoints	Clg: 24 °C (75.2 °F)/setback: 30.0°C (80.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	5.2 W/m² (0.48 W/ft²)
	Lighting and equipment schedules	5% installed lighting power during unoccupied periods 20% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	St. John's electricity

Full Service Restaurant Archetype Characteristics

Category	**Archetype Characteristic**	**Description of Detail**
General	Size of building	620 m² (6665 ft²)
	No. of Stories	1
	Aspect Ratio	1.0
	DOE archetype	Full service restaurant
	No. occupants	330
	Building Occupancy	Weekdays: 19 hours/day Weekends: 18 hours/day
Architectural	Construction	Wood framed wall with wood framed attic roof
	External Door Configurations	Glass, 1 entrance
	Wall Height	3.05 m (10.0 ft)
	Wall-to-Roof Ratio	0.49
	Percent Glazing	18
HVAC	HVAC Zones	One zone for kitchen and one for customer seating
	System	Kitchen: Packaged single zone/const. volume DX cooling and electric heating Seating: Packaged single zone/constant volume DX cooling and electric heating
	Supply air temperature	12.8 °C (55 °F) reset for warmest zone for code requirements
	Max supply flow rate (l/s)	Sized to meet cooling load
	Min supply flow rate (l/s)	-
	Economizer	As required by code
	Zone Heating	Electric baseboard
	Fan control	Constant
	Return air path	Return duct
	Outside air	2,730 l/s (5,785 cfm)
	HVAC Operation	Unoccupied: Outside air dampers closed, fans cycle to maintain temperature
	Temperature setpoints	Clg: 24 °C (75.2 °F)/setback: 30.0°C (80.0°F) Htg: 21 °C (69.8 °F)/setback: 15.6°C (60.1°F)
SHW	SHW Heating	Electric
	Fixture flow rates	Faucets: 8.3 l/min (2.2 gpm)
	SHW temp setpoint	60 °C (140°F)
Electrical	Equipment loads	473 W/m² (44W/ft²)
	Lighting and equipment schedules	5% installed lighting power during unoccupied periods 20% installed equipment power during unoccupied periods
Utility Rates	Electricity rate	St. John's electricity

Energy Criteria: Non- Residential

Item	ASHRAE 90.1-2007				Current Practice			
Exterior Walls ($ft^2 \cdot °F/Btuh$) (1)								
Wall Type	Mass	Metal	Steel	Other	Mass	Metal	Steel	Other
	12.5	8.8	15.6	19.6				
Roof ($ft^2 \cdot °F/Btuh$) (1)								
	20.8							
Exposed Floor ($ft^2 \cdot °F/Btuh$) (1)								
Steel Framed	26.3							
Wood Framed	30.3							
Glazing								
Max. Glazing Allowed by Prescriptive Path (2)	40%							
Window U-value (Btu/h/($ft^2 \cdot °F$)) (3)	CurtainWall/ Storefront		Entrance Door	All Other	CurtainWall/ Storefront		Entrance Door	All Other
	0.45		0.80	0.55				
Window SHGC								
	0.40							
Swinging Doors (Btu/h/($ft^2 \cdot °F$))								
Fully Glazed U-Value	Same as "Other" Requirement for Glazing							
Opaque Door - Uvalue	0.7							
Underground Wall and Roof ($ft^2 \cdot °F/Btuh$) (1)								
	Wall only R-7.5							
Floors-on-Ground ($ft^2 \cdot °F/Btuh$) (1)								
	R-15 for 24"							
LIGHTING								
Interior Lighting (W/ft^2)	Office: 1.0 Warehouse: 0.8 Box Retail: 1.5 Full Service Restaurant: 1.6				Office: Warehouse: Box Retail: Full Service Restaurant:			
Interior Lighting Control	Occupancy Sensors in specified spaces (4) Otherwise manual							
Daylighting Control	N/A							
HVAC								
Economizer	Required if cooling capacity ≥ 135,000 Btu/h							
Fan Power Limit (includes supply, return, and exhaust fans) (CV: Constant Volume) (VV: Variable Volume)	HP <= 1.5 hp/1000 CFM (for VV systems) HP <= 1.1 hp/1000 CFM (for CV systems)							
VAV Fan Control	VSD on individual fan motors > 10 hp							
Cooling Supply T Control	Zone Reset on multi-zone systems							
Demand Control Ventilation	None							
AHU Air to Air heat recovery	50% effectiveness if: The OA ratio is 70% or greater and the supply air capacity is ≥ 5000 cfm							
DX Cooling Efficiency <65 kBtu/h: >65, < 135kBtu/h: >135, < 240kBtu/h: >240, < 760kBtu/h:	 13.0 SEER 11.2 EER 11.0 EER 10.0 EER							
Electric Power								
Motor Efficiency	Premium							

(1) R-values of exterior walls, roofs and floors are overall R-values of the assemblies and include effects of framing.
(2) If building exceeds 40% glazing, will have to show compliance using envelope trade-off calculations or energy modelling
(3) Window U-values are overall U-values and include effects of framing.
(4) Occupancy sensors required in 1) Classrooms (excluding shop, labs, preschool through 12th grade) 2) Conference/meeting Rooms 4) Employee Lunch and break rooms.

Energy Criteria: Multi-Residential (Excluding Single Family)

Item	ASHRAE 90.1-2007				Current Practice			
Exterior Walls (ft^2·°F/Btuh) (1)								
Wall Type	Mass	Metal	Steel	Other	Mass	Metal	Steel	Other
	14.1	17.5	15.6	19.6				
Roof (ft^2·°F/Btuh) (1)								
	20.8							
Exposed Floor (ft^2·°F/Btuh) (1)								
Steel Framed	31.2							
Wood Framed	30.3							
Glazing								
Max. Glazing Allowed by Prescriptive Path (2)	40%							
Window U-value (Btu/h/(ft^2·°F)) (3)	CurtainWall/ Storefront		Entrance Door	All Other	CurtainWall/ Storefront		Entrance Door	All Other
	0.45		0.80	0.55				
Window SHGC								
	0.40							
Swinging Doors (Btu/h/(ft^2·°F))								
Fully Glazed U-Value	Same as "Other" Requirement for Glazing							
Opaque Door - Uvalue	0.7							
Underground Wall and Roof (ft^2·°F/Btuh) (1)								
	Wall only R-7.5							
Floors-on-Ground (ft^2·°F/Btuh) (1)								
	R-20 for 48"							
LIGHTING								
Interior Lighting (W/ft^2)	0.700							
Interior Lighting Control	Manual							
Daylighting Control	N/A							
Interior Lighting Control	-							
HVAC								
HVAC System	DX MUA unit with electric heat, Through the wall unit in suites with electric baseboard							
Economizer	None							
Fan Power Limit	Constant volume = HP <= CFM*0.0011							
Fan Control	Constant							
Cooling Supply T Control	No reset							
Humidification	N/A							
Demand Control Ventilation	None							
AHU Air to Air heat recovery	None							
MUA unit DX efficiency (EER)	11.0							
Through the wall A/C unit	SEER 12							
Electric Power								
Motor Efficiency	Premium				Premium			

(1) R-values of exterior walls, roofs and floors are overall R-values of the assemblies and include effects of framing.
(2) If building exceeds 40% glazing, will have to show compliance using envelope trade-off calculations or energy modelling
(3) Window U-values are overall U-values and include effects of framing.

Energy Criteria for Constructability Issues: NECB 2011

Item	NECB 2011
Exterior Walls (ft²·°F/Btuh) (1)	
Wall Type	All
	23.0
Roof (ft²·°F/Btuh) (1)	
	31.0
Exposed Floor (ft²·°F/Btuh) (1)	
	31.0
Glazing	
Max. Glazing Allowed by Prescriptive Path (2)	34%
Window U-value (Btu/h/(ft²·°F)) (3)	All
	0.387
Window SHGC	
	No Requirement
Swinging Doors (Btu/h/(ft²·°F))	
Fully Glazed U-Value	0.476
Opaque Door - Uvalue	0.387
Underground Wall and Roof (ft²·°F/Btuh) (1)	
	20.0
Floors-on-Ground (ft²·°F/Btuh) (1)	
	7.5 (horizontal a min. of 1.2m from Perimeter)
LIGHTING	
Interior Lighting (W/ft²) Whole building	Office: 0.90 Warehouse: 0.66 Box Retail: 1.40 Full Service Restaurant: 0.89
Interior Lighting Control	Occupancy Sensors in specified spaces (4) Otherwise manual
Daylighting Control	Spaces with > 100 m² daylit area from windows or > 400 m² of daylit area under skylights require daylight control

(1) R-values of exterior walls, roofs and floors are overall R-values of the assemblies and include effects of framing.
(2) If building exceeds 34% glazing, will have to show compliance using envelope trade-off calculations or energy modelling
(3) Window U-values are overall U-values and include effects of framing.
(4) Occupancy sensors required in; Classrooms, lecture halls, Conference/meeting and training rooms, Employee Lunch and break rooms, Storage rooms < 100m², Copy/printer rooms, Office spaces < 25m², washrooms and Locker rooms.

Energy Criteria for Constructability Issues: NECB 2011 (Continued)

Item	NECB 2011
HVAC	
Economizer	Required if air handler has mechanical cooling **and** air-handling capacity > 1500 L/s (3180 cfm) **or** air-handler cooling capacity > 68,000 Btu/h
Fan Power Limit (includes supply, return, and exhaust fans) (CV: Constant Volume) (VV: Variable Volume)	HP <= 1.67 hp/1000 CFM (for VV systems) HP <= 1.01 hp/1000 CFM (for CV systems)
VAV Fan Control	VSD on individual fan motors > 10 hp
Cooling Supply T Control	Zone Reset
Demand Control Ventilation	None
AHU Air to Air heat recovery	50% effectiveness if the system exhaust flow is > 7178 cfm
Warm Air Furnace Heating Efficiency (Oil) ≤ 225 MBH > 225 MBH	Et ≥ 84.5% Et ≥81.3%
Duct Furnaces and Unit Heaters (Oil)	Et ≥ 81.0%
DX Cooling Efficiency <65 MBH: >65, < 135MBH: >135, < 240MBH: >240, < 760MBH:	Split System: SEER 15 Single-Packaged: SEER 14 electric htg: EER = 11.2/other htg: 11.0 electric htg: EER = 10.0/other htg: 9.8 electric htg: EER = 9.7/other htg: 9.5
Hot and Chilled Water Pumps	Where control valves modulate as a function of load, pump (> 10 HP) must be capable of variable flow down to 50% of installed capacity unless flow rate required for proper function of plant equipment. VFD pumps or riding curve are acceptable.
Boiler Heating Efficiency (Oil)	< 300 MBH: AFUE ≥ 84.7% 300 MBH - 2,500 MBH: Et ≥ 83.4% > 2,500 Ec ≥ 85.8%
Chiller Cooling Efficiency	Positive Displacement < 75 tons: COP ≥ 4.51 75 - 150 tons: COP ≥ 4.54 150-300 tons: COP ≥ 5.17 > 300 tons: COP ≥ 5.67 Centrifugal < 300 tons: COP ≥ 5.55 300 - 600 tons: COP ≥ 6.1
Electric Power	
Motor Efficiency	Premium

Appendix B: Stakeholder Consultations

B.1 Participating Stakeholders

A mix of local design professionals (architects, mechanical engineers and electrical engineers), government officials and private sector developers were contacted to obtain their feedback on the applicability of the geometric descriptions of the archetype buildings, and the current practice energy efficiency design which was initially assumed to be reflected by ASHRAE 90.1-2007. In addition, the stakeholders were questioned regarding their concerns about constructability issues surrounding the requirements of NECB 2011.

In total, responses from 14 local stakeholders were obtained during the stakeholder survey. The stakeholders included:

- 5 architects
- 2 mechanical engineers
- 3 electrical engineers
- 3 government officials (municipal code enforcement and project managers)
- 1 developer representative

Stakeholder experience included a broad range of commercial and multi-residential building types. All but one of the stakeholders were familiar with at least one energy code (MNECB 1997, ASHRAE 90.1-2007, ASHRAE 90.1-2010 or NECB 2011). Six stakeholders were familiar with NECB 2011.

Stakeholders were provided with a detailed 12 page survey which included general questions about the participant's knowledge of energy efficiency standards and green building programs such as LEED, and the sectors and sizes of building projects in which they were involved. The survey also included detailed geometric, occupancy and HVAC system parameters of the five archetype buildings, proposed current practice energy efficiency parameters with space for the stakeholders to mark up their understanding of current practice. NECB 2011 energy efficiency requirements were also provided to give the stakeholders an opportunity to voice any concerns regarding the constructability of the standard. The stakeholders were later contacted by a local member of the project team to schedule a face-to-face meeting. The local team member met with all local stakeholders to walk through the survey with the stakeholder and clarify any questions.

B.2 Geometric Details of Archetype Buildings

The detailed geometric, occupancy and HVAC system type descriptions of the 5 archetype buildings were initially based on modified versions of the U.S. DOE archetype buildings. Stakeholders were asked to comment on the geometric, occupancy and HVAC system type descriptions of the archetype buildings and indicate if any of the parameters did not represent the buildings currently being constructed by the private sector in the province. Feedback from the stakeholders was used to update the archetype buildings to better reflect current practice.

The initial details of the archetype buildings given to the local stakeholders can be seen in the survey form provided in Appendix A.

B.3 Current Practice Energy Efficiency Requirements

Initial energy efficiency parameters assumed to represent current practice such as insulation levels, lighting levels, and equipment efficiencies were taken as the ASHRAE 90.1-2007 energy efficiency requirements.

Summaries of the current practice/ASHRAE 90.1-2007 energy efficiency parameters were provided to the local stakeholders for commercial buildings and multi-residential buildings.

The initial energy efficiency parameters given to the local stakeholders can be seen in the survey form provided in Appendix A.

B.4 Stakeholder Responses

The local stakeholders had limited comments on the geometric, occupancy and HVAC system descriptions of the five archetype buildings. The general consensus was that these were reasonable representations of private sector building in the province.

Comments on the current practice energy efficiency requirements were varied with most indicating that current practice is better than the ASHRAE 90.1-2007 initially proposed as current practice. For example, insulation levels were found to be at the level of ASHRAE 90.1-2010 or NECB 2011.

The insulation levels put forward by the architectural stakeholders are approaching the values of NECB 2011. The mechanical and electrical current practices are also approaching ASHRAE 90.1-2010 and NECB 2011 levels. These requirements are largely driven by equipment regulated and sold throughout North America. The availability of high performance mechanical and electrical equipment is driven by other markets.

There were minimal comments from the architects regarding window performance. The impression given was that they relied on manufacturers for the window performance.

B.5 Key Messages from Stakeholder Consultations

In addition to specific questions on the current practice questionnaire, the consultations elicited additional information on the stakeholder's familiarity with energy codes and their thoughts regarding implementation of energy efficiency requirements in the Province.

- The proposed building archetypes are considered representative of private sector buildings in Newfoundland and Labrador.
- Current building practice in the province is equal or better than the proposed baseline of ASHRAE 90.1-2007.
- There is a general awareness of the impending increase in electricity prices in the province, which in turn has created an awareness of building energy efficiency and driven energy efficiency practices.
- The design professionals were receptive to new energy efficiency requirements, since they felt it would force all design professionals to improve the energy efficiency of their designs and force clients and developers to provide the funds necessary for energy efficiency features.
- Seven of the 10 design professionals that responded to the consultation request had a working knowledge of either NECB 2011 or ASHRAE 90.1–2010 and in many cases these standards were used in their day-to-day design practice. The engineers were generally more familiar with these two standards than the architects.
- There has been a significant exposure to LEED design strategies through government projects. Although a limited number of projects have been LEED certified in the province, the design strategies used for the LEED projects have impacted their design techniques on other private sector projects.
- Architects frequently rely on the mechanical and electrical engineers to develop their energy efficiency strategies.

Concerns raised by stakeholders

- Smaller private sector projects may only include base building components, with tenant fit-ups being implemented by other design professionals with no interest in energy efficiency.
- The stringent energy efficiency requirements of NECB, in particular regarding the envelope, will require the use of energy modelling in many cases. Energy modelling allows the design to show compliance by comparing the whole building energy consumption with the same building designed to NECB 2011 requirements. This effectively allows the design to trade-off between envelope, HVAC or lighting systems to meet the energy efficiency requirements.
- Thermal bridging is often ignored by design teams. This would apply to both the prescriptive path and the building energy performance path (energy modelling).

Appendix C: Wall Construction Assumptions/Analysis

In September 2014, BC Hydro released a guide related to the construction of wall assemblies. The guide recognizes that building envelope thermal performance is a critical consideration for reducing space heating loads and will be an important factor to achieve lower energy consumption in buildings. In this context, BC Hydro found that the thermal performance of the building envelope can be greatly affected by *thermal bridging*. Thermal bridges are localized areas of high heat flow through walls, roofs and other insulated envelope components. It is caused by highly conductive elements (steel framing, z-girts, floor slabs, etc.) that penetrate the thermal insulation or misaligned thermal insulation. This allows heat flow to bypass the insulating layer and reduces the effectiveness of the insulation.

The impact of thermal bridging can be significant to building energy use. The previous approach to reducing space heating loads in buildings was to introduce progressively higher levels of thermal insulation and more stringent glazing performance requirements. The effects of thermal bridging were assumed to be negligible if the cross-sectional areas of these conductive components were small relative to the rest of the building envelope (or they were not considered due to the difficulty in assessing the impact). The NECB 2011 stringent envelope requirements require a more detailed analysis of the impacts of thermal bridging. BC Hydro notes that thermal bridging can result in an underestimation of between 20 and 70 percent of the total heat flow through walls.

More specifically in the local market, the wall U-value requirements of NECB 2011 for Climate Zone 6 are 0.247 W/m² °C or RSI-4.05 m² °C/W (R-23.0). This is a stringent requirement relative to ASHRAE 90.1-2007 and 90.1-2010 that, unlike ASHRAE 90.1-2007 or 2010, is applied universally to all construction types.

The NECB 2011 requirement of RSI 4.05 is a value for the overall assembly and includes effects such as thermal bridging of framing through the envelope and the insulating value of wall components such as plywood sheathing, gypsum board, etc.

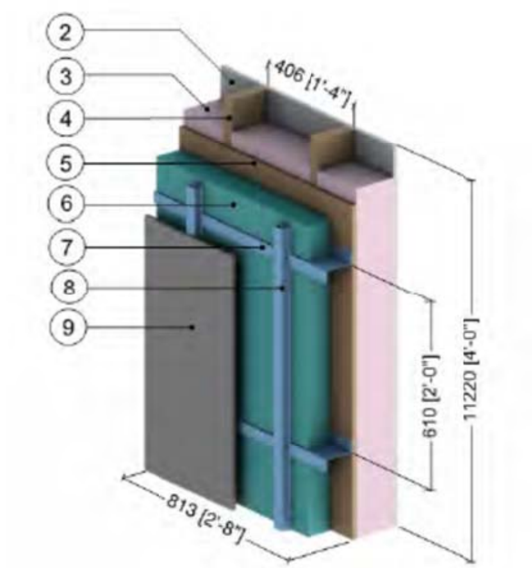
The five archetype buildings being evaluated are represented by three different wall constructions considered to reflect common practice, including wood framed (multi-residential, and restaurant), concrete block (office and retail), and steel framing (warehouse). In order to get a reasonable estimate of the cost implication of the NECB 2011 construction requirement a wall construction was identified for each of the three wall constructions that met the RSI 4.05 (R-23.0) requirement. Examples of acceptable wall assemblies are outlined below.

The steel framed wall was the most challenging to meet the RSI 4.05 requirement due to the significant thermal bridging through the layer of batt insulation. It was not possible to meet the requirement for the steel framed assembly with 6” of mineral fibre between the z-girts supporting the exterior cladding. This was the maximum z-girt thickness proposed in the BC Hydro study. The mineral fibre was replaced by 6” of polystyrene to achieve R23.

Wood Framing
Applicable archetype buildings: Restaurant and MURBs

ASHRAE 90.1-2007 and 2010 requirements: R19.6 (RSI 3.45)
NECB 2011 requirements: R23 (RSI 4.05)

Proposed wall construction for NECB 2011 requirement
2x6 Wood stud framing with mineral batt insulation, horizontal z-girts supporting fibre cement board with 1" (R-5) polystyrene insulation.



ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film (right side)[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Fiberglass Batt Insulation	5 1/2" (140)	0.29 (0.042)	R-19 (3.3 RSI)	0.9 (14)	0.17 (710)
4	2x6 Wood Stud (16" o.c.)	5 1/2" (140)	0.69 (0.10)	-	31 (500)	0.45 (1880)
5	Exterior Wood Sheathing	1/2" (13)	0.69 (0.10)	R-0.7 (0.13 RSI)	31 (500)	0.45 (1880)
6	Exterior Insulation	Varies	-	R-5 (0.88 RSI) to R-15 (2.64 RSI)	1.8 (28)	0.29 (1220)
7	Horizontal Z-Girt with 1 1/2" Flange	18 gauge	430 (62)	-	489 (7830)	0.12 (500)
8	Steel Furring Hat Track (16" o.c.)	18 gauge	430 (62)	-	489 (7830)	0.12 (500)
9	Fiber Cement Board Cladding with 3/4" (19mm) vented airspace incorporated into exterior heat transfer coefficient					
10	Exterior Film (left side)[1]	-	-	R-0.7 (0.12 RSI)	-	-

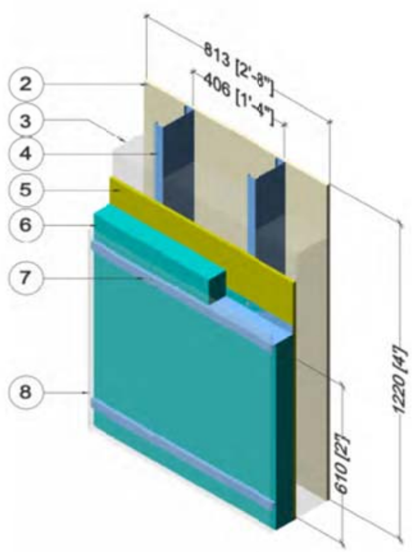
[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Steel Framing
Applicable archetype buildings: Warehouse

ASHRAE 90.1-2007 and 2010 requirements: R15.6 (RSI 2.75)
NECB 2011 requirements: R23 (RSI 4.05)

Proposed wall construction for NECB 2011 requirement
3 5/8” x 1 5/8” Steel Stud (16” o.c.) with mineral batt insulation, horizontal z-girts supporting metal cladding with 6” (R-30) polystyrene insulation.

Notes:
The steel framing wall appears to have difficulty achieving the R-23 requirement of NECB 2011 walls. It cannot be met with 6” of mineral fibre between the z-girts supporting the exterior cladding. This was the maximum z-girt thickness proposed in the BC Hydro study. To address this, the mineral fibre was replaced by 6” of polystyrene to achieve R23.



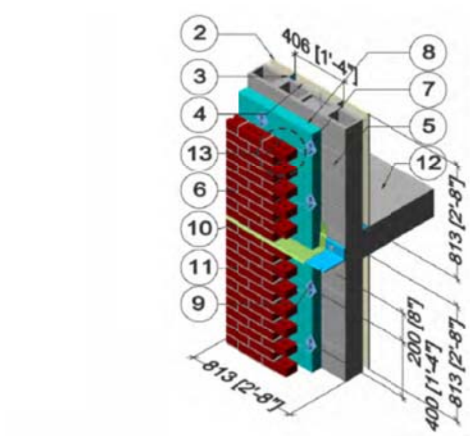
ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	3 5/8" x 1 5/8" Steel Studs	18 gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Exterior Insulation	Varies	-	R5 to R25 (0.88 to 4.4 RSI)	1.8 (28)	0.29 (1220)
7	Horizontal Z-Girts w/ 1 1/2" Flange	18 gauge	430 (62)	-	489 (7830)	0.12 (500)
8	Metal cladding with 1/2" (13mm) vented air space is incorporated into exterior heat transfer coefficient					
9	Exterior Film[1]	-	-	R-0.7 (0.12 RSI)	-	-

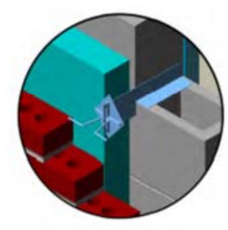
[1] Value selected from table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation

Concrete Block Walls
Applicable archetype buildings: Offices and retail

ASHRAE 90.1-2007 and 2010 requirements: R12.5 (RSI 2.20)
NECB 2011 requirements: R23 (RSI 4.05)

Proposed wall construction for NECB 2011 requirement
Concrete block with brick ties, with 1" air space, 5" polystyrene insulation (R-25), brick cladding and 1-5/8" steel studs supporting interior gypsum finish.





Brick Tie Detail

ID	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film[1]	-	-	R-0.6 (0.11 RSI) to R-0.9 (0.16 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	1 5/8" Steel Studs with Metal Tracks	20 gauge	430 (62)	-	489 (7830)	0.12 (500)
4	Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
5	Standard Concrete Block	7 5/8" (190)	3.5 (0.5)	-	119 (1900)	0.19 (800)
6	Cement Mortar	-	3.5 (0.5)	-	113 (1800)	0.12 (500)
7	Masonry Ties @ 16" (406) o.c.	14 gauge	347 (50)	-	489 (7830)	0.12 (500)
8	Insulation	Varies	-	R-5 (0.88 RSI) to R-25 (4.4 RSI)	1.8 (28)	0.29 (1220)

CANETA
RESEARCH INC.

2011 National Energy Code for Buildings: Archetype Building Analysis for Newfoundland and Labrador

Climate Zone 8 Analysis

Prepared for: Government of Newfoundland and Labrador
Government Purchasing Agency
30 Strawberry Marsh Road, St. John's, NL
A1B 4R4

Attention: Gerald Crane
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Prepared by: Caneta Research Inc.
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September 29, 2015

Table of Contents

1. Introduction

As a follow-up to the report prepared March 31, 2015, Caneta has been asked to extend the energy and life-cycle costing analysis to locations in Northern Labrador, which is NECB 2011 Climate Zone 8. This will provide a indication of the economics in colder and more remote areas in the province. The original study looked at the life cycle costing of buildings in Climate Zone 6.

The Climate Zone 6 energy efficiency requirements of the current practice (ASHRAE 90.1-2007), NECB 2011 and ASHRAE 90.1-2010 were maintained for this update to simplify the analysis and provide for comparison with the results of the earlier study.

The weather file was changed from St. John's to Schefferville, QC. There were no DOE weather files for Climate Zone 8 in the province of Newfoundland and Labrador. Schefferville, QC is in Climate zone 8 and at the border on Quebec and Newfoundland and Labrador. The table shows the comparison of heating degree days (HDD) for Schefferville, QC and towns located in Northern Labrador. The heating degree days of both Labrador City and Twin Falls are within a 10% of those for Schefferville, QC.

Heating Degree Days (Base 18°C) Comparison of Climate Zone 8 Locations

Location	HDD_{18}
Schefferville, QC	8550
Labrador City	7710
Twin Falls	7790

Note: Heating Degree Days taken from supporting document for draft of NBC 2010 (NBC-13774_-_Temperature_Data_Table_C-2_2010.xlsx)

Two utility rate structures were evaluated in this analysis for Climate Zone 8. Newfoundland and Labrador Hydro - General Service Diesel over 10 kW (Rate No. 2.2D) and Newfoundland and Labrador Hydro - General Service 10-100 kW (Rate No. 2.2L).

2. Annual Energy Comparison

The annual energy consumption of the 5 archetypes in Climate Zone 8 are summarized below. Two tables are provided for each archetype, one with General Service rates and the second with General Service Diesel rates. Energy consumption is the same for each rate structure, however, energy costs differ.

Table 1a: Energy Simulation Results – Office Building in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2L (General Service 10-100 kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	832	578	843
Space Cooling	7	8	6
Domestic Hot Water	56	56	56
Interior Lighting	186	167	167
Equip./Appliances	276	276	276
Fans	82	81	83
Total	**1,438**	**1,166**	**1,432**
GJ/m²	**0.96**	**0.78**	**0.95**
ELECTRICITY			
Metered Peak Demand (kW)	180	160	172
Metered Consumption (kWh)	399,465	323,772	397,670
ENERGY CHARGES ($)			
Electric (Consumption)	9,719	7,877	9,675
Electric (Demand)	4,007	3,193	3,859
Total	*13,726*	*11,070*	*13,534*
ANNUAL SAVINGS ($)	0	2,656	192
($/m²)	0.00	1.77	0.13
SAVINGS (%)			
Energy Consumption	0.00	18.9%	0.4%
Energy Charges	0.00	19.4%	1.4%

Table 1b: Energy Simulation Results – Office Building in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2D (General Service Diesel > 10kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	832	578	843
Space Cooling	7	8	6
Domestic Hot Water	56	56	56
Interior Lighting	186	167	167
Equip./Appliances	276	276	276
Fans	82	81	83
Total	**1,438**	**1,166**	**1,432**
GJ/m²	**0.96**	**0.78**	**0.95**
ELECTRICITY			
Metered Peak Demand (kW)	180	160	172
Metered Consumption (kWh)	399,465	323,772	397,670
ENERGY CHARGES ($)			
Electric (Consumption)	62,912	50,991	62,629
Electric (Demand)	22,585	17,997	21,749
Total	*85,497*	*68,988*	*84,378*
ANNUAL SAVINGS ($)	0	16,509	1,119
($/m²)	0.00	11.01	0.75
SAVINGS (%)			
Energy Consumption	0.00	18.9%	0.4%
Energy Charges	0.00	19.3%	1.3%

Figure 1: Annual Energy Comparison – Office Building in Climate Zone 8

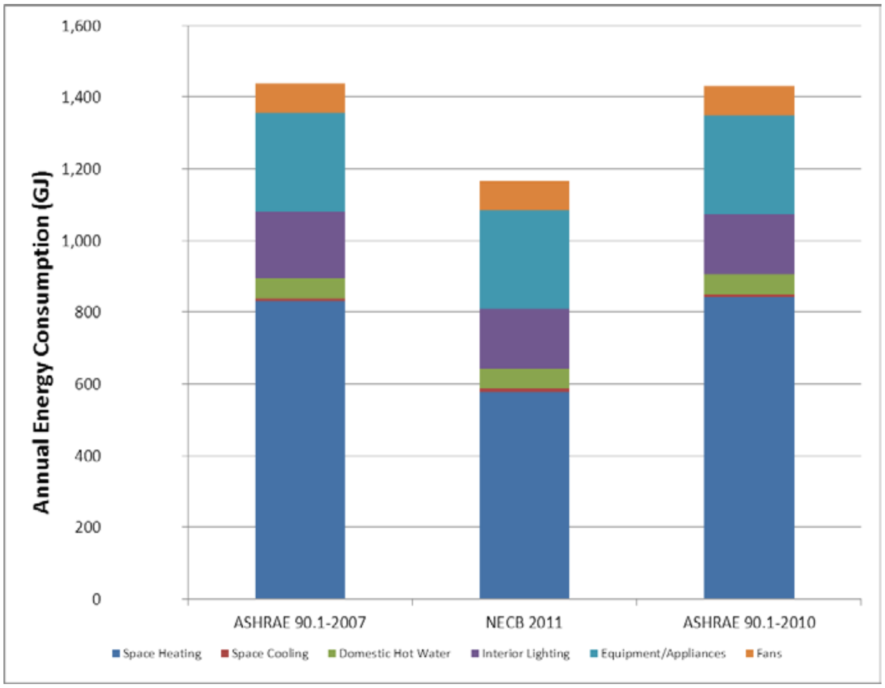


Table 2a: Energy Simulation Results – Box Retail in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2L (General Service 10-100 kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	950	816	960
Space Cooling	5	5	4
Domestic Hot Water	63	63	63
Interior Lighting	215	200	200
Equip./Appliances	87	87	87
Fans	241	192	242
Total	**1,560**	**1,363**	**1,557**
GJ/m²	**1.56**	**1.36**	**1.56**
ELECTRICITY			
Metered Peak Demand (kW)	219	196	216
Metered Consumption (kWh)	433,449	378,514	432,497
ENERGY CHARGES ($)			
Electric (Consumption)	10,546	9,209	10,523
Electric (Demand)	4,492	3,990	4,502
Total	*15,038*	*13,199*	*15,025*
ANNUAL SAVINGS ($)	0	1,839	13
($/m²)	0.00	1.84	0.01
SAVINGS (%)			
Energy Consumption	0.00	12.7%	0.2%
Energy Charges	0.00	12.2%	0.1%

Table 2b: Energy Simulation Results – Box Retail in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2D (General Service Diesel > 10kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	950	816	960
Space Cooling	5	5	4
Domestic Hot Water	63	63	63
Interior Lighting	215	200	200
Equip./Appliances	87	87	87
Fans	241	192	242
Total	**1,560**	**1,363**	**1,557**
GJ/m²	**1.56**	**1.36**	**1.56**
ELECTRICITY			
Metered Peak Demand (kW)	219	196	216
Metered Consumption (kWh)	433,449	378,514	432,497
ENERGY CHARGES ($)			
Electric (Consumption)	68,264	59,612	68,114
Electric (Demand)	25,318	22,489	25,374
Total	*93,582*	*82,101*	*93,488*
ANNUAL SAVINGS ($)	0	11,481	94
($/m²)	0.00	11.48	0.09
SAVINGS (%)			
Energy Consumption	0.00	12.7%	0.2%
Energy Charges	0.00	12.3%	0.1%

Figure 2: Annual Energy Comparison – Box Retail Store in Climate Zone 8

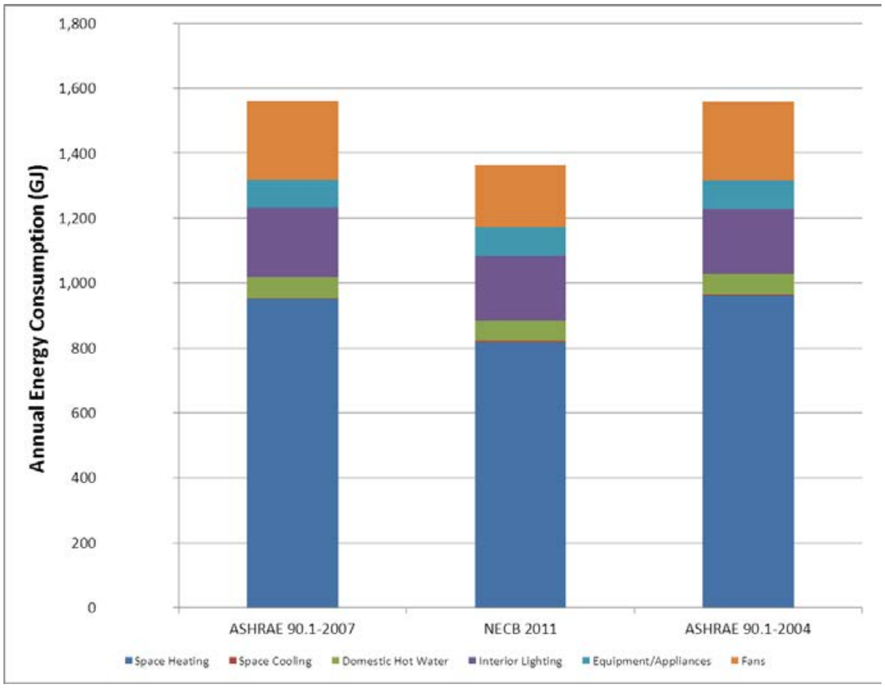


Table 3a: Energy Simulation Results – Multi-Residential in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2L (General Service 10-100 kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	1,555	1,396	1,573
Space Cooling	5	5	4
Domestic Hot Water	430	430	430
Interior Lighting	156	135	135
Equip./Appliances	223	223	223
Fans	43	44	42
Total	**2,413**	**2,234**	**2,408**
GJ/m²	**1.21**	**1.12**	**1.20**
ELECTRICITY			
Metered Peak Demand (kW)	196	183	196
Metered Consumption (kWh)	670,155	620,424	668,840
ENERGY CHARGES ($)			
Electric (Consumption)	16,305	15,095	16,273
Electric (Demand)	3,367	3,119	3,365
Total	*19,672*	*18,214*	*19,638*
ANNUAL SAVINGS ($)	0	1,458	34
($/m²)	0.00	0.73	0.02
SAVINGS (%)			
Energy Consumption	0.00	7.4%	0.2%
Energy Charges	0.00	7.4%	0.2%

Table 3b: Energy Simulation Results – Multi-Residential in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2D (General Service Diesel > 10kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	1,555	1,396	1,573
Space Cooling	5	5	4
Domestic Hot Water	430	430	430
Interior Lighting	156	135	135
Equip./Appliances	223	223	223
Fans	43	44	42
Total	**2,413**	**2,234**	**2,408**
GJ/m²	**1.21**	**1.12**	**1.20**
ELECTRICITY			
Metered Peak Demand (kW)	196	183	196
Metered Consumption (kWh)	670,155	620,424	668,840
ENERGY CHARGES ($)			
Electric (Consumption)	105,543	97,710	105,336
Electric (Demand)	18,980	17,577	18,967
Total	*124,523*	*115,287*	*124,303*
ANNUAL SAVINGS ($)	0	9,236	220
($/m²)	0.00	4.62	0.11
SAVINGS (%)			
Energy Consumption	0.00	7.4%	0.2%
Energy Charges	0.00	7.4%	0.2%

Figure 3: Annual Energy Comparison – Multi-Residential in Climate Zone 8

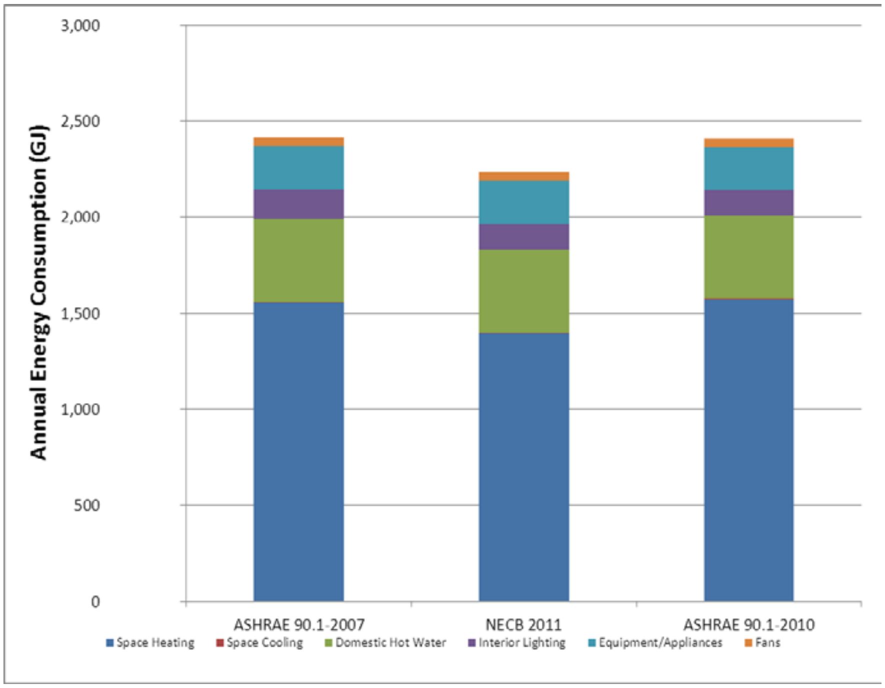


Table 4a: Energy Simulation Results – Full Service Restaurant in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2L (General Service 10-100 kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	1,025	1,038	1,110
Space Cooling	22	24	20
Domestic Hot Water	497	497	497
Interior Lighting	248	138	138
Equip./Appliances	2,249	2,249	2,249
Fans	271	260	256
Total	**4,312**	**4,206**	**4,270**
GJ/m²	**6.95**	**6.78**	**6.89**
ELECTRICITY			
Metered Peak Demand (kW)	311	307	312
Metered Consumption (kWh)	1,197,797	1,168,220	1,186,137
ENERGY CHARGES ($)			
Electric (Consumption)	29,142	28,423	28,859
Electric (Demand)	6,032	5,927	5,997
Total	*35,174*	*34,350*	*34,856*
ANNUAL SAVINGS ($)	0	824	318
($/m²)	0.00	1.33	0.51
SAVINGS (%)			
Energy Consumption	0.00	2.5%	1.0%
Energy Charges	0.00	2.3%	0.9%

Table 4b: Energy Simulation Results – Full Service Restaurant in Climate Zone 8 Newfoundland and Labrador Hydro Rate 2.2D (General Service Diesel > 10kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	1,025	1,038	1,110
Space Cooling	22	24	20
Domestic Hot Water	497	497	497
Interior Lighting	248	138	138
Equip./Appliances	2,249	2,249	2,249
Fans	271	260	256
Total	**4,312**	**4,206**	**4,270**
GJ/m²	**6.95**	**6.78**	**6.89**
ELECTRICITY			
Metered Peak Demand (kW)	311	307	312
Metered Consumption (kWh)	1,197,797	1,168,220	1,186,137
ENERGY CHARGES ($)			
Electric (Consumption)	188,640	183,982	186,804
Electric (Demand)	34,000	33,406	33,799
Total	*222,640*	*217,388*	*220,603*
ANNUAL SAVINGS ($)	0	5,252	2,037
($/m²)	0.00	8.47	3.29
SAVINGS (%)			
Energy Consumption	0.00	2.5%	1.0%
Energy Charges	0.00	2.4%	0.9%

Figure 4: Annual Energy Comparison – Full Service Restaurant in Climate Zone 8

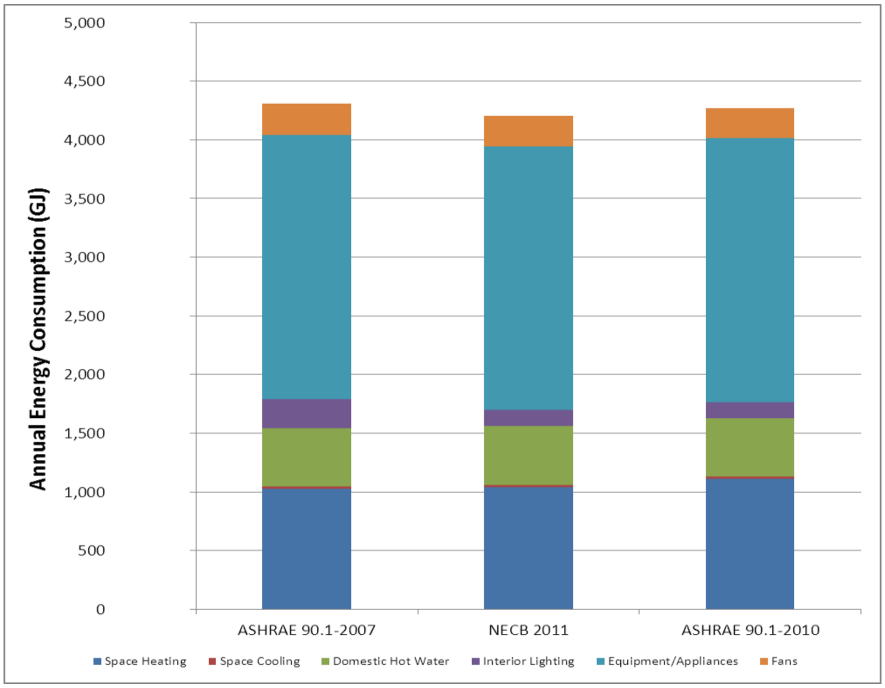


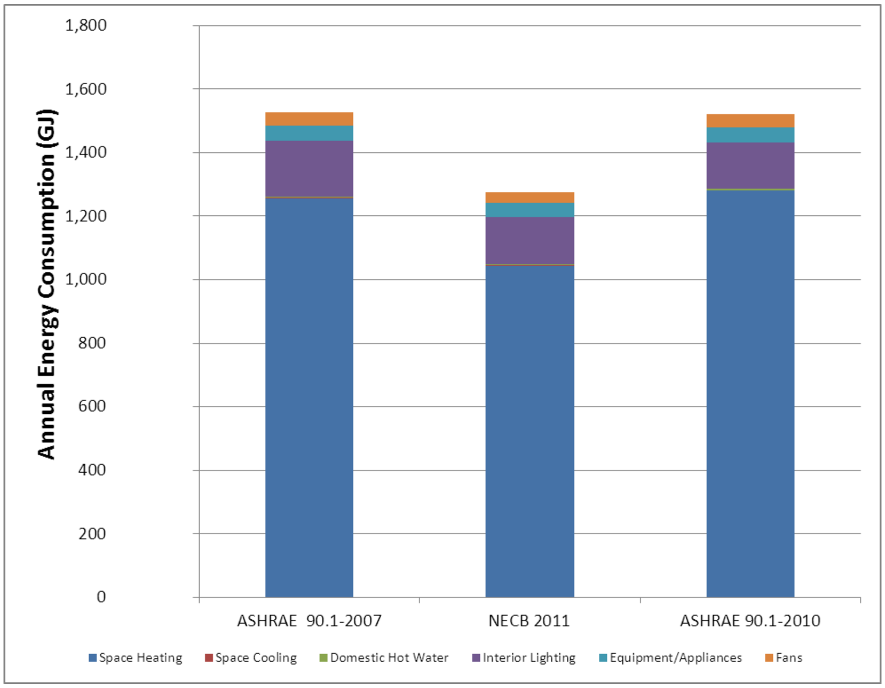
Table 5a: Energy Simulation Results – Warehouse in Climate Zone 8
Newfoundland and Labrador Hydro Rate 2.2L (General Service 10-100 kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	1,256	1,043	1,280
Space Cooling	1	1	1
Domestic Hot Water	4	4	4
Interior Lighting	177	147	147
Equip./Appliances	45	45	45
Fans	42	35	43
Total	**1,526**	**1,276**	**1,521**
GJ/m²	**0.76**	**0.64**	**0.76**
ELECTRICITY			
Metered Peak Demand (kW)	145.3	126.4	145.4
Metered Consumption (kWh)	423,916	354,506	422,447
ENERGY CHARGES ($)			
Electric (Consumption)	10,314	8,625	10,278
Electric (Demand)	2,482	2,149	2,484
Total	*12,796*	*10,774*	*12,762*
ANNUAL SAVINGS ($)	0	2,022	34
($/m²)	0.00	1.01	0.02
SAVINGS (%)			
Energy Consumption	0.00	16.4%	0.3%
Energy Charges	0.00	15.8%	0.3%

Table 5b: Energy Simulation Results – Warehouse in Climate Zone 8
Newfoundland and Labrador Hydro Rate 2.2D (General Service Diesel > 10kW)

DESCRIPTION	Current Practice (ASHRAE 90.1-2007)	NECB 2011	ASHRAE 90.1 2010
ENERGY USED (GJ)			
Space Heating	1,256	1,043	1,280
Space Cooling	1	1	1
Domestic Hot Water	4	4	4
Interior Lighting	177	147	147
Equip./Appliances	45	45	45
Fans	42	35	43
Total	**1,526**	**1,276**	**1,521**
GJ/m²	**0.76**	**0.64**	**0.76**
ELECTRICITY			
Metered Peak Demand (kW)	145.3	126.4	145.4
Metered Consumption (kWh)	423,916	354,506	422,447
ENERGY CHARGES ($)			
Electric (Consumption)	66,763	55,831	66,531
Electric (Demand)	13,989	12,114	14,001
Total	*80,752*	*67,945*	*80,532*
ANNUAL SAVINGS ($)	0	12,807	220
($/m²)	0.00	6.40	0.11
SAVINGS (%)			
Energy Consumption	0.00	16.4%	0.3%
Energy Charges	0.00	15.9%	0.3%

Figure 5: Annual Energy Comparison – Warehouse in Climate Zone 8



3. Capital Costs

The capital costs have been adjusted to reflect the shipping costs of equipment and materials to the more remote communities of Northern Labrador. An additional 50% was added to the capital cost estimates for St. John's calculated in the March 31, 2015 study.

Table 6: Incremental Capital Cost Estimates by Component for Climate Zone 8

	Office		MURB		Box Retail Store		Warehouse		Full Service Restaurant	
Building Component	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**	**NECB**	**90.1-2010**
MUA System	$0	$0	$54	$66	$0	$0	$0	$0	$0	$0
Re-circulation AHU	$1,603	-$1,351	$0	$0	-$7,750	$178	$117	-$61	-$1,780	-$3,685
Zone Terminal Equipment	$2,536	-$2,138	-$1,530	-$594	-$22,434	$527	-$1,799	-$288	$0	$0
Exterior Wall	$20,170	$0	$10,229	-$1	$24,318	$0	$73,110	$0	$3,474	$0
Windows	$35,452	$0	$16,323	$15	$4,597	$0	$2,515	$0	$3,564	$0
Roof	$29,485	$0	$30,728	$0	$39,268	-$2	$100,523	$0	$19,058	$0
Perimeter Floor Insulation	$1,491	$0	$1,071	$0	$1,700	$0	$2,571	$0	$1,327	$0
Lighting Cost	$11,813	$11,813	$20,553	$21,410	$4,219	$4,219	$4,389	$4,389	$6,514	$6,514
Total Incremental Capital Costs	**$102,550**	**$8,324**	**$77,430**	**$20,895**	**$43,917**	**$4,921**	**$181,426**	**$4,040**	**$32,158**	**$2,829**

Table 7: Total Construction Costs for Archetype Buildings in Climate Zone 8

Building Archetype	Total Costruction Costs per Area [1]		Estimated Project Costs	Incremental Capital Costs			
				NECB 2011		ASHRAE 90.1-2010	
				Incremental Costs	Percentage of Total Project Costs	Incremental Costs ($)	Percentage of Total Project Costs
	($/ft²)	($/m²)	($)	($)	(%)	($)	(%)
Office	206	2,215	$3,321,238	$102,550	3.1	$8,324	0.3
Box Retail	143	1,535	$1,532,980	$43,917	2.9	$4,921	0.3
MURB	181	1,946	$3,886,574	$77,430	2.0	$20,895	0.5
Full Service Restaurant	293	3,154	$1,953,330	$32,158	1.6	$2,829	0.1
Warehouse	112	1,208	$2,412,547	$181,426	7.5	$4,040	0.2

4. Life Cycle Costing

Table 8a: Results of Life Cycle Cost Analysis for Climate Zone 8
Newfoundland and Labrador Hydro Rate 2.2L (General Service 10-100 kW)

Building	Scenario (2007,NECB,2010)	Annual Electricity Savings $	Incremental Capital Cost $	Actual Payback (years)	IRR	Change in NPV (%)
Office	Current Practice					
	NECB	$2,656	$102,550	> 25	-0.6	-3.0
	90.1-2010	$192	$8,324	> 25	-1.4	-0.3
Multi-Residential	Current Practice					
	NECB	$1,458	$77,430	> 25	-2.7	-2.2
	90.1-2010	$34	$20,895	> 25	-14.9	-0.8
Box Retail	Current Practice					
	NECB	$1,839	$43,917	> 25	2.9	-1.9
	90.1-2010	$13	$4,921	> 25	-12.7	-0.5
Warehouse	Current Practice					
	NECB	$2,022	$181,426	> 25	-5.8	-9.6
	90.1-2010	$34	$4,040	> 25	-7.3	-0.2
Full Service Restaurant	Current Practice					
	NECB	$825	$32,158	> 25	-0.7	-1.6
	90.1-2010	$319	$2,829	12.5	13.0	0.1

Table 8b: Results of Life Cycle Cost Analysis for Climate Zone 8
Newfoundland and Labrador Hydro Rate 2.2D (General Service Diesel > 10kW)

Building	Scenario (2007,NECB,2010)	Annual Electricity Savings $	Incremental Capital Cost $	Actual Payback (years)	IRR	Change in NPV (%)
Office	Current Practice					
	NECB	$16,509	$102,550	7.9	18.4	5.5
	90.1-2010	$1,119	$8,324	9.9	15.5	0.3
Multi-Residential	Current Practice					
	NECB	$9,235	$77,430	11.6	13.8	1.9
	90.1-2010	$220	$20,895	> 25	-6.1	-0.7
Box Retail	Current Practice					
	NECB	$11,481	$43,917	4.5	28.9	11.0
	90.1-2010	$94	$4,921	> 25	-2.6	-0.4
Warehouse	Current Practice					
	NECB	$12,806	$181,426	> 25	7.6	-0.5
	90.1-2010	$219	$4,040	> 25	5.1	-0.1
Full Service Restaurant	Current Practice					
	NECB	$5,252	$32,158	7.7	18.7	3.0
	90.1-2010	$2,037	$2,829	1.5	75.1	1.9