ENERGY

STEP CODE

BUILDING BEYOND THE STANDARD

2018 Metrics Research
Full Report Update

2018

A report prepared for BC Housing and the Energy Step Code Council.
With the support of Natural Resources Canada and Remi Charron.

BC HOUSING

Morrison Hershfield

e3ecogroup.com

INTEGRAL GROUP

This page left blank for printing
Version – 2018-09-18 (2018 Update)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 The BC Energy Step Code

The BC Energy Step Code (the "Step Code") is an amendment to the BC Building Code (BCBC) that provides a performance-based path intended to support a market transformation from current energy efficiency requirements to net-zero energy ready buildings by 2032. The Province has committed to taking these incremental steps as a part of its overarching commitments to improving energy efficiency in the built environment.

The path to net-zero energy-ready buildings is set out through a series of increasingly stringent requirements for energy use, thermal energy demand, and airtightness. The performance requirements that have been set were the result of a lengthy consensus-building process among several key stakeholders from across the province and supported by energy modelling and analysis. The process of establishing the Step Code took a period of approximately two years through the efforts of the Energy Efficiency Working Group and the BC Energy Step Code Council and is still ongoing.

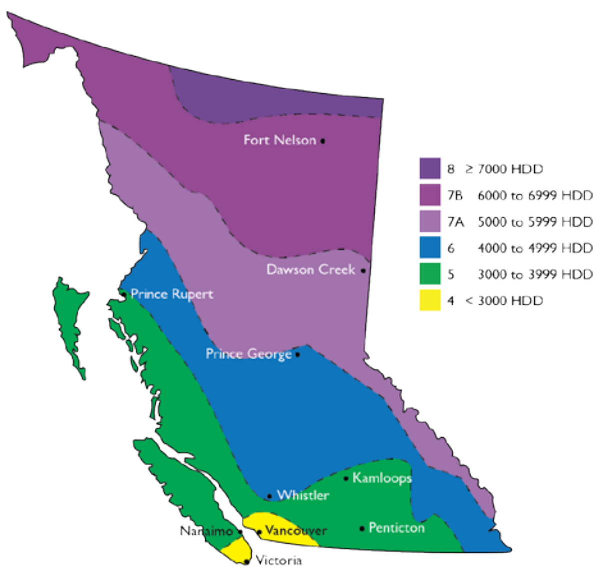


Figure 1: British Columbia Climate Zones, based on heating degree days (HDD).

One of the central purposes of the Step Code is to provide province-wide consistency and predictability in local government building energy and emissions policies and bylaws. As of December 15, 2017, local governments regulated by the BC Building Act and Community Charter (i.e. all but Vancouver) that wish to require higher energy efficiency standards may only reference the Step Code. The Step Code applies to any new construction of Part 9 residential buildings province-wide, with different performance requirements set for Climate Zones 4, 5, 6, 7a, 7b, and 8 (see Figure 1). The Step Code also applies to Part 3 multi-unit residential and large commercial buildings (Group D & E) throughout the province. As a technical regulation, it is an optional compliance pathway for local governments, who can elect to adopt higher or lower Steps. Builders can also voluntarily comply with the Step Code in lieu of 9.36 or the National Energy Code for Buildings (NECB)/ASHRAE.

1.2 Study Purpose and Scope

This study explores and anticipates the implications of the Step Code in terms of its impact on the design and construction sector. More specifically, the study was designed to:

- Identify potential design solutions and other technical responses to the Step Code (e.g. design and construction practices);
- Anticipate implementation impacts of the proposed metrics and targets, including both benefits and outcomes relative to building size, climate zone, greenhouse gas (GHG) emissions, peak electrical demand, first and operating costs, and lifecycle GHG abatement costs; and
- Identify any modifications to the Step Code necessary to ensure that it effectively and efficiently achieves the desired outcomes, while mitigating negative impacts.

In covering the above, the report identifies both areas in which effectiveness and efficiency may be improved using regulatory changes, as well as opportunities for local governments to better implement the Step Code in the absence of such regulatory changes. In scoping the project, a set of ten multipart research questions was developed, to be answered by the consultant team via a combination of research, energy modelling, and cost and sensitivity analyses. The consultant team used these questions alongside the guiding objectives above to select specific methods, identify databases to be developed, guide the analysis of modelling results, and evaluate any anticipated implementation impacts and challenges.

1.3 Oversight Committee and Consultant Team Members

This project was led by BC Housing, in collaboration with and with funding and/or in-kind support from the following individuals and institutions:

- Wilma Leung, BC Housing (Project Lead)
- Gary Hamer, BC Hydro
- Zachary May, BC Building and Safety Standards Branch
- Patrick Enright, City of Vancouver, and
- Alex Ferguson, Natural Resources Canada

All analysis was conducted by the following consultant team members:

- Integral Group (Consultant Team Lead)
- Morrison Hershfield
- E3 Eco Group

All work received input from Oversight Committee members and Dr. Remi Charron, an energy modeller with specific expertise in applications relevant to the project. Results also received input from expert stakeholders representing local governments, utilities, and construction-related community and industry associations across British Columbia.

1.4 The 2018 Update

This report represents an updated version of an original report released in 2017 – the Energy Step Code 2017 Metrics Research Report. The report has been revised based on proposed updated performance targets for both Part 3 and Part 9 buildings.

The proposed update sees the Part 3 performance targets extended across the province to enable jurisdictions beyond Climate Zone 4 to use or reference the Step Code. Additionally, separate targets were created under residential occupancies for Hotels and Motels and under commercial occupancies for Commercial Offices. These targets were developed to more equitably account for specific characteristics of these sub-occupancies. The proposed Part 3 building performance targets are summarized in Section 2.2.1.

The proposed updates to the Part 9 performance targets aim to improve equity across building archetypes and climate zones, as well as to enable net-zero energy-ready building construction throughout the province. The proposed updates do not change the fundamental intent of Step Code, but instead ensure that energy savings will more closely align with the initial goal of establishing 10%, 20%, 40% energy savings for Steps 2, 3, and 4 respectively. The proposed Part 9 building performance targets are summarized in Section 2.3.2.

Performance target updates primarily impact the results given in Section 3 and in the Appendices in Section 8.

Table 1: BC Step Code Metrics Research Questions & Methods

1	• What existing and proposed building archetypes will combine to establish a reasonable collection of building archetypes to be used in the modelling and analyses necessary to adequately explore and answer each of the research questions in this project? Why is this adequate?
	• How would builders achieve the performance targets established in the Step Code for each of the building types, climate zones, building and dwelling sizes, and common construction styles?
2	• How do the proposed intensity metrics impact small and large buildings, and dwelling units?
	• What is the typical window to wall ratio that is required to achieve the targets established in the Step Code? What impact may building and dwelling size make?
3	• What outcomes (GHG emissions, building energy use and peak demand, and envelope construction) are the proposed targets in the Step Code likely to achieve?
	• Are the outcomes equitable across climate zones, building types and dwelling sizes?
	• What options are there to address any undesirable outcomes and what difference would these options make?
4	• What are the anticipated first and operating costs, and life-cycle cost per abated tonne of carbon, from the implementation of these metrics and targets across climate zones, building types and dwelling sizes?
	• What conventional archetypes should or should not be used to evaluate the practical and financial impacts of the Step Code? Are unique archetypes required for different building sizes, levels of performance, or climate zones? Are certain archetypes subject to 'performance ceilings' whereby they cannot attain Step 4 or Step 5 performance levels? If so, why?
5	• Would the proposed Part 9 metrics and targets in Step 2 risk resulting, in some cases, in a building envelope less than the BCBC 2012 prescriptive requirements shown in the Illustrated Guide on Energy Efficiency Requirements for Houses in B.C.?
	• Would the proposed Part 9 metrics and targets in Step 3 and Step 4 risk resulting, in some cases, in a building envelope less than that shown in the Illustrated Guide for R22+ Effective Walls in Wood-Frame Construction in B.C.?
6	• How do the metrics used in the Step Code align with existing energy benchmarking and reporting programs, such as Energy Star Portfolio Manager and the EnerGuide Rating System (ERS)?
7	• What standards or requirements referenced in the Building Code, particularly ventilation standards, need to be reviewed and/or modified to ensure that they are serving the Step Code appropriately?
8	• What are the potential risks or unintended outcomes associated with the Step Code targets?
	• Is there a risk of overheating due to solar heat gain and does the Step Code provide adequate measures to avoid overheating? Under what conditions is overheating a risk?
9	• Are the Step Code metrics effective in gauging building energy use, peak demand and GHG impact, when renewables, waste energy, district energy and other energy sources are being used, or when there are electric vehicle charging requirements? If not, what options are there to improve effectiveness?
10	• Are the proposed metrics and targets for Part 9 residential buildings applicable and effective for Part 9 non-residential buildings? Are there occupancy types that will have particular difficulty with these metrics and targets?
	• Are the proposed metrics and targets for Part 3 buildings applicable and effective for Part 9 non-residential buildings? Are there occupancy types that will have particular difficulty with these metrics and targets?

2 ENERGY MODELLING AND COSTING

2.1 Building Energy Modelling

The Step Code is a performance-based framework, which by definition is a flexible approach to compliance. A key challenge in researching compliance with performance-based codes is that there is a vast number of potential solutions to compliance. Identifying one, two, or even a dozen paths to compliance does not adequately address market variations in construction that may be impacted by the proposed Step Code. As such, a much larger set of potential outcomes must be explored.

To overcome this challenge, a large-scale parametric analysis (or "options analysis") was conducted, a process that allows for the analysis of hundreds of thousands of design possibilities for each building archetype to gain deeper insight into compliance with the Step Code. The large dataset can be analyzed using various techniques to identify opportunities with the lowest incremental capital costs, best life cycle opportunities, emission reduction potential, design constraints, market segment challenges, and impacts on other potential building outcomes not currently measured by the Step Code. This parametric analysis was key to answering many of the research questions posed by this study, including those related to potential building costs and the testing of different design strategies. Specifics on the approach and software used to model the building archetypes explored in this study are provided in more detail in the sections below. Note that all GHG savings noted in the document are operational carbon emissions, and do not include any embodied carbon metrics.

2.2 Modelling Part 3 Buildings

2.2.1 Part 3 Archetypes

The archetypes selected for this study were initially defined by the Step Code framework, which defines Total Energy Use Intensity (TEUI) and Thermal Energy Demand Intensity (TEDI) performance requirements for Part 3 buildings (see Table 2). One base building per category was modelled, except for Multi-Unit Residential Buildings (MURBs) where both a wood frame mid-rise and high-rise scenario were modelled. The base building attributes were developed in consultation with the Oversight Committee and based on project experience by both the Committee and the consultant team. In total, five archetypes were modelled with the following characteristics (see Figure 2 through Figure 3 for examples of each):

Archetype	Details
• Low-Rise MURB	Variable characteristics to represent the range of MURBs in the marketplace (see Section 2.2.3 for more detail), 90% suites, 10% common area
• High-Rise MURB	Variable characteristics to represent the range of MURBs in the marketplace (see Section 2.2.3 for more detail), 90% suites, 10% common area
• Hotel	Market, 9,520 m^2, 10 storeys, 500 people
• Commercial Office*	Market, 18,200m^2, 10 storeys, 790 people, 155 parking spaces
• Retail (big box)	Market, 4,500m^2, 1 storey, 150 people

**The Commercial Office archetype was used in analysis for both the Commercial Office and Other Commercial performance targets*

Additional details on the Part 3 archetypes are included in Appendix 8.1.

For Part 3 multifamily residential occupancies, one amorphous archetype was developed for this study in lieu of defining many, discrete residential archetypes. This single archetype was programmed with the ability to modify key characteristics and performance drivers to reflect the province's different residential market segments. The key program characteristics were selected based on their potential impact with the absolute metrics in the Step Code and include design attributes not typically included within the list of energy efficiency measures. These include:

- Shape;
- Occupancy density (to mimic variations in suite size);
- Combustible (wood frame) vs. non-combustible (concrete) construction; and
- Process loads.

Details on the individual attributes used in residential modelling are provided in Section 2.2.3. These aspects were studied for the residential archetype only, not the hotel archetype, although the influence of variations will be similar.

2.2.2 Part 3 Performance Targets

Table 2: Proposed Step Code Targets - Part 3 Buildings

	Energy Modelling & Airtightness Testing	Thermal Energy Demand Intensity Target (kWh/m²/yr)	Total Energy Use Intensity Target (kWh/m²/yr)	Estimated Annual Energy Savings (over BCBC Baseline)	Estimated Cost Impact (% Increase in Construction Costs)
Multifamily Residential (Group C)					
Step 1 Enhanced Compliance	Required	No target	No target	Up to 20%	0-2%
Step 2	Required	45	130	Up to 40%	2-5%
Step 3	Required	30	120	Up to 50%	5-10%
Step 4	Required	15	100	Up to 60%	Insufficient data
Hotels and Motels					
Step 1 Enhanced Compliance	Required	No target	No target	N/A	N/A
Step 2	Required	30	170	N/A	N/A
Step 3	Required	20	140	N/A	N/A
Step 4	Required	15	120	N/A	N/A
Commercial Office					
Step 1 Enhanced Compliance	Required	No target	No target	N/A	N/A
Step 2	Required	30	130	N/A	N/A
Step 3	Required	20	100	N/A	N/A
Other Commercial (Group D & E)					
Step 1 Enhanced Compliance	Required	No target	No target	N/A	N/A
Step 2	Required	30	170	N/A	N/A
Step 3	Required	20	120	N/A	N/A

Figure 2: Example of a Low-Rise MURB
(Source: Cor)

Figure 3: Example of a High-Rise MURB
(Source: KPF)

Figure 6: Example of a Retail Building
(Source: REA)

Figure 4: Example of a Commercial Office Building
(Source: MGA)

Figure 5 Example of a Hotel
(Source: MH)

2.2.3 Modelled Program Variations

This section presents details on select program variations that were used in modelling Step Code compliance for Part 3 buildings. A full summary of variations is presented in Table 3.

Table 3: Summary of Program Variations for Part 3 Buildings

Program Variation	Options
Shape / Massing	VFAR (MURB only), values ranging from 0.4 to 1.2
Occupancy Density	o Three values were modelled in MURB as surrogates for suite size ▪ High – 25.2m²/p (ex. 25m² SRO/studio, 50 m² 1 bed, 75m² 2 bed) ▪ Mid – 28.8m²/p (ex. 29m² SRO/studio, 58m² 1 bed, 87m² 2 bed) ▪ Low – 40.4m²/p (ex. 40m² SRO/studio, 80m² 1 bed, 121m² 2 bed) o Two values were modelled in Commercial Office to represent the typical value *and* double the typical value to represent denser offices, such as call centers); ▪ Default – 20m²/p, 7.5 W/m² plug load ▪ Double – 10m²/p, 15 W/m² plug load o Two values were modelled for Retail Buildings to represent and big box store, and a mall ▪ Big Box – 100% Retail ▪ Mall – 40% Retail, 30% Warehouse, 20% Concourse, 5% Dining, 5% Food Prep
Ventilation Standards	62-2001 or 62.1-2010 (MURB only)
Process Loads	In the form of IT/data loads at 1, 2.2 and 11 W/m² for Commercial and Office only Energy Source for Laundry and DHW Load in Hotels
Construction Type	Wood frame and Concrete

Building Shape and Massing

A building's vertical surface area to floor area ratio (VFAR) is a significant influential factor on the heating energy use of a building, especially when the TEDI target is normalized for floor area. This metric is similar to a more common metric of surface area to volume ratio. However, in the BC context for MURB buildings, most heat loss occurs in the vertical surface areas. This is because walls and windows have significantly higher U-values than roofs, and floors are typically over below-grade parkades with lower temperature differences. As such, VFAR has a more direct relationship with TEDI than surface area to volume ratio and has been used as the primary shape metric.

Most building codes render the VFAR metric compliance-neutral, by using a reference building with the same geometry as the proposed building. However, absolute TEUI and TEDI targets can shift the focus towards optimizing a building's form factor to improve performance. The VFAR for a sample of high- and low-rise MURB projects in British Columbia and across Canada was calculated and found that most projects fall within the range of 0.5 to 0.65 VFAR. Floor plate size and level of articulation were found to be the principal factors affecting VFAR, assuming floor-to-floor heights are consistent.

Table 4 shows the VFAR for a selection of building shapes and floor plate sizes. Very small or narrow buildings will have elevated VFAR and will likely require improved envelope systems to compensate for high vertical surface area. A single family detached home typically has a VFAR between 1.2 and 1.5.

Table 4: VFAR for Example Building Shapes and Floor Plate Sizes

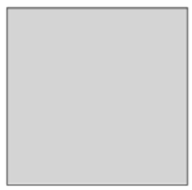
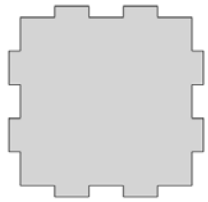
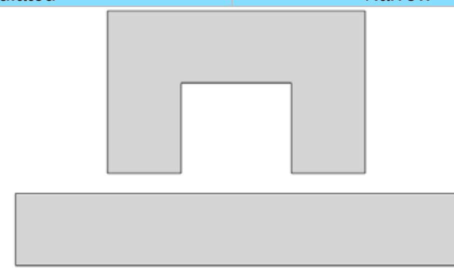
Floor Plate Size	Building Shapes		
	Sqare	Articulated	Narrow
			
600m^2	0.49 VFAR	0.59 VFAR	0.7 VFAR
400m^2	0.6 VFAR	0.72 VFAR	0.86 VFAR

Figure 7 demonstrates the impact of VFAR on a building's TEUI and TEDI. Except for VFAR, the design parameters are identical and represent solutions that would comply with Step 2 for buildings with 0.6 VFAR. Doubling VFAR, from 0.5 to 1, more than doubles TEDI. The absolute change in TEDI is larger in Climate Zone 7 than 4, however the percentage increase in TEDI is largest for Climate Zone 4 because the wall and window heat loss is proportionally greater to other heating loads such as ventilation and infiltration. The impact on building energy use is similar for both Climate Zone 4 and 7, with a 40% increase in TEUI with VFAR 1 vs. VFAR 0.5. Assuming a VFAR of 0.6 as typical, 20% TEDI savings and 7% TEUI savings are possible by reducing VFAR to 0.5, which can be achieved by designing with less articulation, more compact or square shapes, or larger floorplates. All solutions presented elsewhere in this report for Part 3 MURB assumes a VFAR of 0.6 unless otherwise noted.

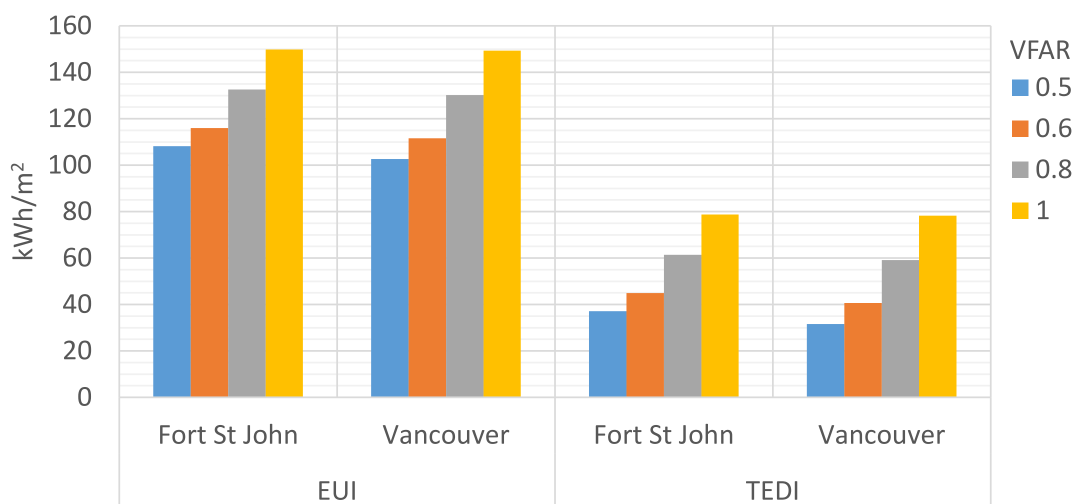


Figure 7: Impact of VFAR on MURB TEUI and TEDI

Figure 8 shows the impact of window-to-wall ratio (WWR) on a MURB's TEUI and TEDI. For other building parameters, the solutions used are those required to comply with Step 2 at 40% WWR in Climate Zone 4 and 20% WWR in Zone 7. The effect of WWR in Climate Zone 7 appears smaller than in Climate Zone 4 because the Climate Zone 7 solution includes higher performance glazing, which mitigates the impact of higher glazing ratios. For reference, the NECB prescriptive path requires a maximum WWR for a location based on local heating degree days, which varies from 40% in Climate Zones 4 and 5 down to 20% in Climate Zone 8.

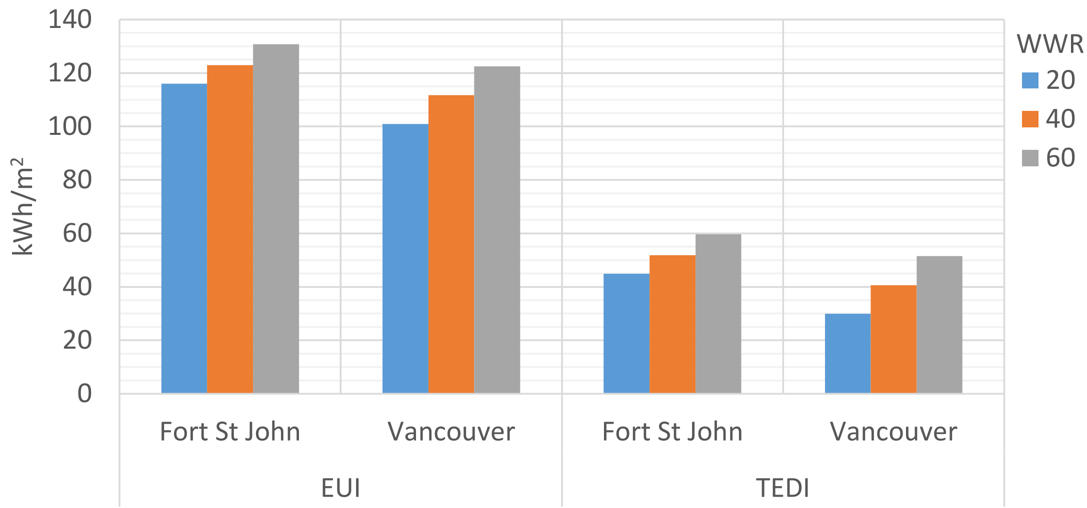


Figure 8: Impact of WWR on MURB TEUI and TEDI

Occupancy Density and Process Loads

MURB occupancy density typically falls within the range of 25 to 30m^2/person, with lower densities found in very large, normally luxury apartments. A value of 25m^2/person is a very high occupancy case representing a 75m^2 (800ft^2) two bedroom, a 50m^2 (540ft^2) one bedroom, or a 25m^2 (270ft^2) bachelor apartment. While some MURBs may have a selection of suites at high density, typically buildings will also have some lower density suites available.

While higher occupancy densities do produce more internal heat gains, the ventilation air requirement also increases, which produces a small net effect on TEDI, as shown in Figure 9. The principal impact of higher occupancy density is increased domestic hot water heating energy, on TEUI, which can be mitigated by purchasing low flow fixtures and installing drain water heat recovery. Depending on the energy efficiency of other building components, DHW can make up 12% to 40% of total energy use, meaning a 50% increase in occupancy can produce a 6% to 20% increase in TEUI. For buildings that are otherwise energy efficient, occupancy density will have a larger impact on energy use.

In comparison, Hotels have higher occupancy density, lower ventilation rates per suite, higher DHW demand per occupant, and higher process loads from laundry and commercial kitchens compared to typical residential buildings. As noted above, these factors result in lower TEDI and higher TEUI values compared to other residential buildings. However, at the high-performance end, TEDI improvements are limited by exhaust rates for commercial kitchens and laundry, where heat cannot be recovered.

For Commercial Office buildings, the difference between the default and double occupancy case is primarily due to increased plug load affecting total energy use. TEDI is slightly decreased at double occupancy, as increase occupant heat gain and plug load counteracts increased ventilation requirements. The doubled plug loads in office spaces increases overall TEUI by around 25%, shown in Figure 10. This increase typically has little effect on a buildings ability to meet Step 2 of the code, but Step 3 may require additional energy savings measures. Incorporating additional process loads, such as IT loads, has a similar effect. It should be noted that modelled occupancy in commercial buildings is standardized by the Step Code through its reference to the City of Vancouver's Energy Modelling Guidelines[1]. The increased occupancy and plug load scenarios are intended to show the actual operating impact of atypical occupancies in commercial buildings. These buildings will not be impacted with respect to compliance, as modelled inputs will need to align with the City of Vancouver's Energy Modelling Guidelines.

[1] Section 10.2.3.4 states: "…for buildings and major occupancies conforming to the requirements of any of Steps 1 to 4, energy modelling shall conform to a) the applicable requirements of Part 8 of the NECB, and (See Appendix A.) b) the City of Vancouver Energy Modelling Guidelines."

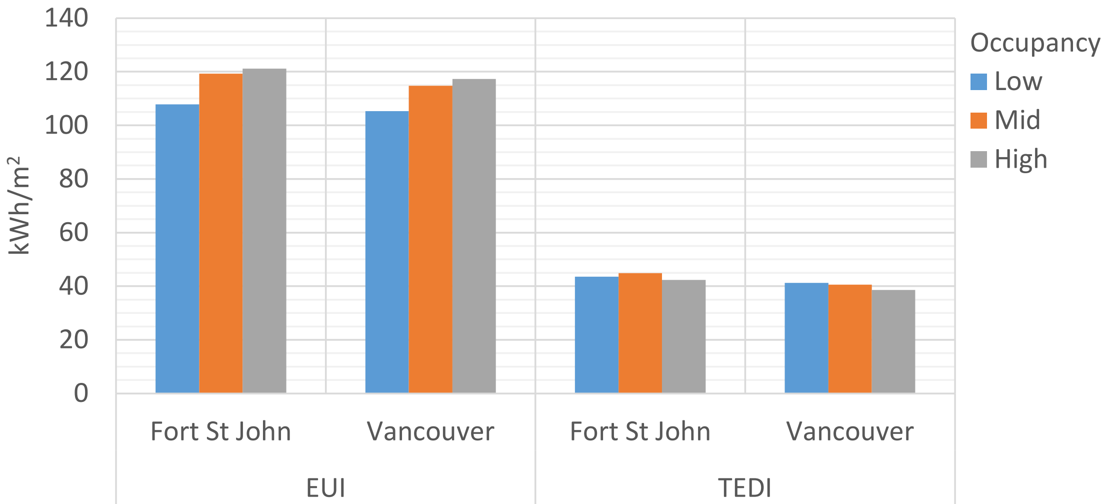


Figure 9: Impact of Occupancy Density on MURB TEUI and TEDI

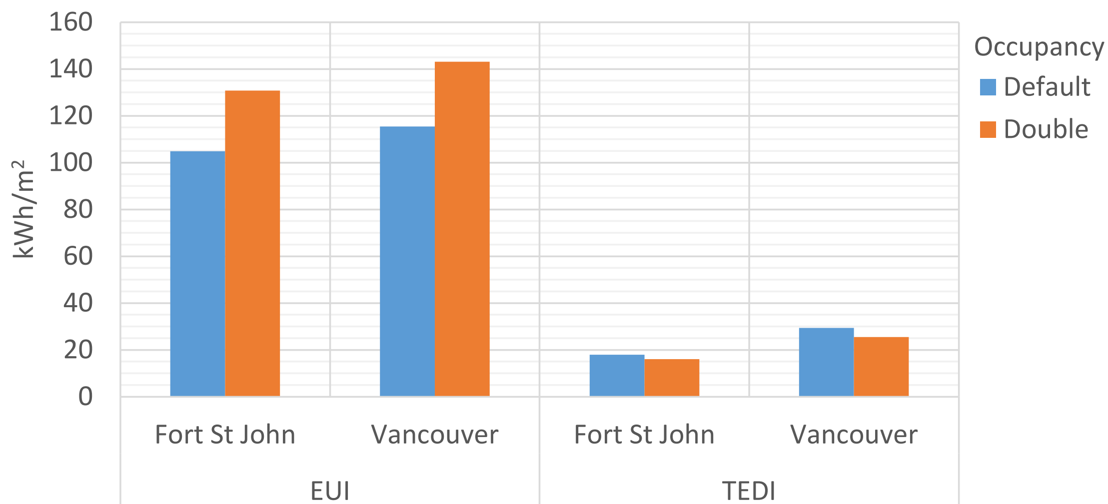


Figure 10: Impact of Occupancy Density on Commercial Office TEUI and TEDI

For Retail buildings, a big box, ground floor or strip retail typically have higher plug and lighting power densities and ventilation requirements than a mall with mixed-space use. In warmer climates, the internal heat gains reduce TEDI for the big box store-type retail, but in colder climates, the cold ventilation air negates the internal heat gain benefit making it more in line with the mall occupancy scenario, shown in Figure 11. The mall has a higher domestic hot water load, due to the presence of food services, however due to lighting and plug loads, big box stores have significantly higher TEUI, which will have the most impact on achieving Step 3.

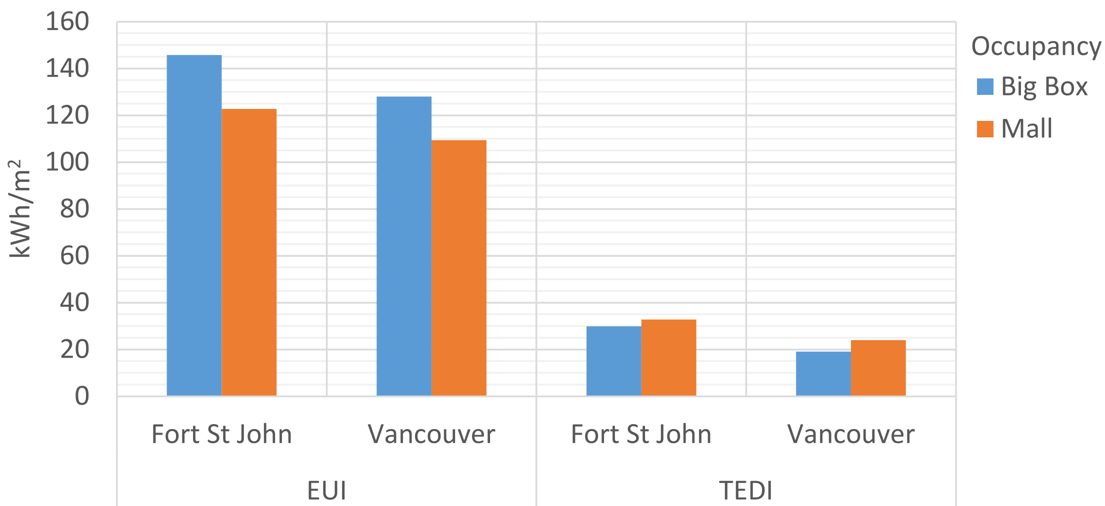


Figure 11: Impact of Occupancy Density on Retail TEUI and TEDI

Construction Type

In general, method of construction does not significantly change the physics of building behaviour. For example, an effective R10 wood-framed wall will have a similar level of performance as an effective R10 concrete wall (except for impacts on thermal mass, which have been shown to be insignificant for residential building types in the BC climate[2]). However, the method of construction has two primary impacts within this analysis that have been considered: cost and performance.

With respect to *cost*, wood frame construction has a lower base construction cost, which impacts the % incremental capital cost numbers presented within the report. Wood frame construction also typically has less thermal bridging than concrete construction and therefore the premiums to achieve higher effective R-values are lower than concrete construction. With respect to *performance*, wood frame construction can achieve higher effective R-values within known methods of construction. A high of R40 effective wall performance was included for wood frame construction versus a high of an effective R20 wall for concrete construction.

All results presented in subsequent sections have held building shape, occupancy density and process loads constant. Costing results are provided for both types of construction (MURB only) throughout.

2.2.4 Modelling with EnergyPlus – Pathfinder

The analysis of Part 3 buildings was conducted using EnergyPlus v8.6, the primary simulation engine used for whole building energy modeling. EnergyPlus is a free, open-source, and cross-platform simulation program, whose development is funded by the U.S. Department of Energy's Building Technologies Office. EnergyPlus is compliant software for energy code compliance throughout North America and used extensively in both industry and research. All energy models were developed in compliance with the City of Vancouver's Energy Modelling Guidelines, which are directly referenced in the BCBC.

[2] See BC Hydro's Building Envelope Thermal Bridging Guide, 2016

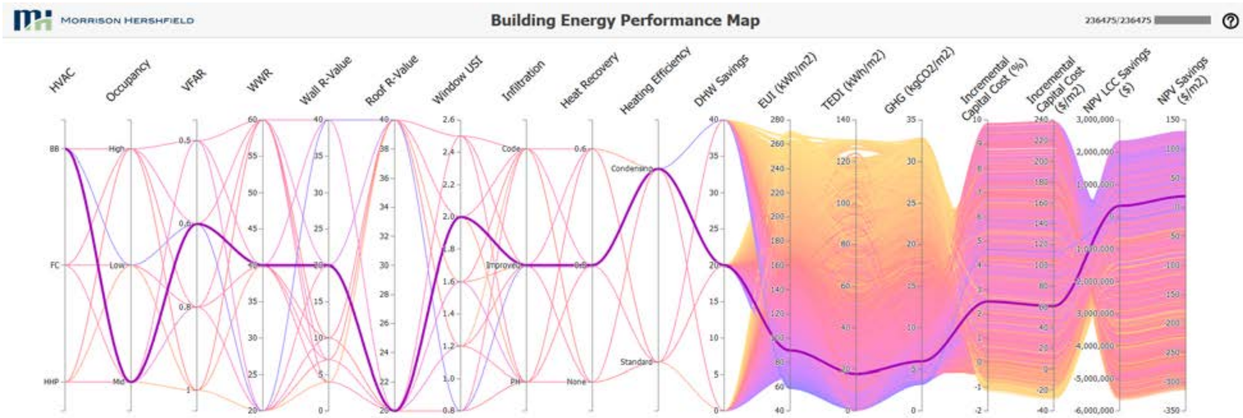


Figure 12: Screenshot of the Building PathFinder Tool

The primary technique used to analyze the data was through an interactive data visualization tool developed at Morrison Hershfield called Building PathFinder ("PathFinder"). PathFinder allows the analysis of the large data sets generated by parametric analysis, with the purpose of identifying the relationships between different design parameters and their various outcomes (e.g. energy, economic and environmental). It also allows the optimization of design options based on preferred outcomes (e.g. lowest first cost) and the identification of design constraints under the imposition of fixed requirements (e.g. Step Code performance limits). The PathFinder tool was used in a workshop setting with the Step Code Working Group to better articulate the methodology and communicate some of the main findings of the project.

2.2.5 Part 3 Energy Conservation Measures

Modelled parameters were chosen carefully to feed the dataset the necessary information to adequately answer the research questions posed in this study. While the parameters assessed are dependent on building type, general ECMs used in Part 3 modelling are presented in Table 5.

Table 5: ECM Options and Design Constraints used in Part 3 Modelling

Component	Options
Climate Zones	Vancouver (CZ4), Kamloops (CZ5), Prince George (CZ6), Fort St. John (CZ7a), Whitehorse (CZ7b), Yellowknife (CZ8)
Envelope performance	o Wall R values, R-4, 7, 10, 20, 40 o Roof R values, R-20, 30, 40 o Window U values, USI-2.5, 2, 1.6, 1.2, 0.8 o Air leakage (BCBC, "Improved" and Passive House)
Window to Wall Ratio (WWR)	o 20%,40%,60% MURB o 20%, 50% Hotel o 30%,50%,70% Office o 5%, 20%, 40% Retail
HVAC	o System: Baseboards, fan coils and DOAS, VAV, RTUs o Heating Efficiency, Standard or Condensing o Primary Fuel Source: electric baseboards, standard or condensing gas boilers and coils, air-source heat pump options
Lighting Efficiency	0%, 25%, 50% (Commercial Office and Retail only) 0%,20%,40% (Hotel)

2.3 Modelling Part 9 Buildings

2.3.1 Part 9 Archetypes

The archetypes selected for this study have been defined by the Step Code framework, which defines targets for Airtightness, Mechanical Energy Use Intensity (MEUI) and Thermal Energy Demand Intensity (TEDI) for Part 9 residential buildings (see Table 6 to Table 11).

Six archetypes were modelled for Part 9 buildings, which together represent the widest possible range of potential performance outcomes. These archetypes were selected based on BC Housing research that identified the most common types of Part 9 residential buildings found across the province and refined in consultation and deliberation with the Oversight Committee. Archetypes were selected to assess the impact of Step Code targets on the size and complexity of different housing forms, and are detailed below (see Figure 13 through Figure 18 for examples of each archetype):

Archetype	Details
• MURB (10 units)	Market, 1,654m^2, 1,780ft^2/unit, 3 storeys over underground parkade
• Row House (6 units)	Market, 957m^2, 1,720ft^2/unit, 3 storeys over underground parkade
• Quadplex	Market, 513m^2, 1,382ft^2/unit, 3 storeys over underground parkade
• Large SFD*	Market, 511m^2, 5,500ft^2, 2 storeys with basement
• Medium SFD*	Market, 237m^2, 2,551ft^2, 2 storeys with basement
• Small SFD*	Market, 102m^2, 1,098ft^2, single storey on heated crawlspace

*SFD - *single family dwelling*

It should be noted that while a Duplex archetype was not modelled, results pertaining to the Quadplex archetype are generally applicable to Duplex housing types as well. The Small SFD archetype was also modelled with a Slab on Grade option to evaluate the impact of a more efficient architecture on Small SFD performance and costs. Additional details on the Part 9 archetypes are included in Appendix 8.2.

2.3.2 Part 9 Performance Targets

Table 6: Step Structure and Requirements for Part 9 – Climate Zone 4

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	Comply with BCBC 9.36.5 OR ERS v15 ref. house (MEUI of 80 kWh/m²/yr is likely, but not required)	Report on TEDI (TEDI 50 kWh/m²/yr is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 60 kWh/m²/yr	TEDI – 35 kWhm²/yr
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 50 kWh/m²/yr	TEDI – 30 kWh/m²/yr
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 40 kWh/ m²/yr	TEDI – 20 kWh/m²/yr
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 25 kWh/m²/yr (no ERS option)	TEDI – 15 kWh/m²/yr

Table 7: Step Structure and Requirements for Part 9 – Climate Zone 5

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	Comply with BCBC 9.36.5 OR ERS v15 ref. house (MEUI of 100 kWh/ m²/yr is likely, but not required)	Report on TEDI (TEDI 65 kWh/m²/yr is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 70 kWh/ m²/yr	TEDI – 45 kWh/ m²/yr
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 65 kWh/ m²/yr	TEDI – 40 kWh/ m²/yr
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 50 kWh/ m²/yr	TEDI – 30 kWh/ m²/yr
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 30 kWh/ m²/yr (no ERS option)	TEDI – 20 kWh/ m²/yr

Table 8: Step Structure and Targets for Part 9 – Climate Zones 6

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	Comply with BCBC 9.36.5 OR ERS v15 ref. house (MEUI of 115 $kWh/m^2/yr$ is likely, but not required)	Report on TEDI (TEDI 75 $kWh/m^2/yr$ is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 85 $kWh/m^2/yr$	TEDI – 60 $kWh/m^2/yr$
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 75 $kWh/m^2/yr$	TEDI – 50 $kWh/m^2/yr$
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 55 $kWh/m^2/yr$	TEDI – 40 $kWh/m^2/yr$
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 40 $kWh/m^2/yr$ (no ERS option)	TEDI – 25 $kWh/m^2/yr$

Table 9: Step Structure and Targets for Part 9 – Climate Zones 7a

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	Comply with BCBC 9.36.5 OR ERS v15 ref. house (MEUI of 115 $kWh/m^2/yr$ is likely, but not required)	Report on TEDI (TEDI 75 $kWh/m^2/yr$ is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 110 $kWh/m^2/yr$	TEDI – 80 $kWh/m^2/yr$
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 95 $kWh/m^2/yr$	TEDI – 70 $kWh/m^2/yr$
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 70 $kWh/m^2/yr$	TEDI – 55 $kWh/m^2/yr$
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 55 $kWh/m^2/yr$ (no ERS option)	TEDI – 35 $kWh/m^2/yr$

Table 10: Step Structure and Targets for Part 9 – Climate Zones 7b

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	Comply with BCBC 9.36.5 OR ERS v15 ref. house (MEUI of 115 $kWh/m^2/yr$ is likely, but not required)	Report on TEDI (TEDI 75 $kWh/m^2/yr$ is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 130 $kWh/m^2/yr$	TEDI – 100 $kWh/m^2/yr$
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 115 $kWh/m^2/yr$	TEDI – 90 $kWh/m^2/yr$
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 85 $kWh/m^2/yr$	TEDI – 65 $kWh/m^2/yr$
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 65 $kWh/m^2/yr$ (no ERS option)	TEDI – 50 $kWh/m^2/yr$

Table 11: Step Structure and Targets for Part 9 – Climate Zones 8

Step Level	Energy Modelling	Airtightness	Equipment and Systems	Envelope
Step 1 Enhanced Compliance (BC Building Code Performance)	Required	No target	Comply with BCBC 9.36.5 OR ERS v15 ref. house (MEUI of 115 $kWh/m^2/yr$ is likely, but not required)	Report on TEDI (TEDI 75 $kWh/m^2/yr$ is likely, but not required)
Step 2 10% Beyond Code	Required	3.0 ACH_{50}	10% better than ERS v15 ref. house OR MEUI – 150 $kWh/m^2/yr$	TEDI – 120 $kWh/m^2/yr$
Step 3 20% Beyond Code	Required	2.5 ACH_{50}	20% better than ERS v15 ref. house OR MEUI – 130 $kWh/m^2/yr$	TEDI – 105 $kWh/m^2/yr$
Step 4 40% Beyond Code	Required	1.5 ACH_{50}	40% better than ERS v15 ref. house OR MEUI – 100 $kWh/m^2/yr$	TEDI – 80 $kWh/m^2/yr$
Step 5: 50%+ Beyond Code	Required	1.0 ACH_{50}	MEUI – 75 $kWh/m^2/yr$ (no ERS option)	TEDI – 60 $kWh/m^2/yr$

2.3.3 MEUI Adjustments

MEUI targets are based on a per unit floor area, but some mechanical systems are modelled the same regardless of home size (e.g. domestic hot water consumption). This disproportionately burdens smaller homes, which typically are both more affordable and consume less total energy. This burden was highlighted by the significant cost premiums seen in the original Metrics report for the Small SFD archetype[3]. As a result, the MEUI targets defined above have been adjusted for small houses to provide an increased energy intensity budget for these properties. The additional MEUI allowance is defined in Table 12 below.

Table 12: Additional MEUI Allowance for Small Houses

Step Level	Additional MEUI (kWh/m²/yr)				
	≤ 50 m² (538 ft²)	≤ 75 m² (807 ft²)	≤ 120 m² (1,292 ft²)*	≤ 165 m² (1,776 ft²)	≤ 210 m² (2,260 ft²)
1	85	65	35	15	5
2	75	60	30	15	5
3	70	50	25	13	3
4	50	40	20	8	0
5	40	30	15	5	0

**Applies to modelled results for Small SFD archetype, which is modelled at 102 m²*

Cooling needs are increasing with the warming climate, and homes risk overheating without the option of air conditioning. Cooling loads are included within MEUI limits, which creates a disincentive to provide cooling, even if it is necessary for occupant health and comfort. MEUI targets have therefore also been adjusted for buildings that include cooling in their design. The additional MEUI allowance is defined in Table 13 below and applies to all steps. This additional allowance applies to all modelled results that have cooling loads and is scaled to provide larger adjustments for smaller buildings.

Table 13: Additional MEUI Allowance for Designs with Cooling

Building Size	Additional MEUI (kWh/m²/yr)
≤ 50 m² (538 ft²)	35
≤ 75 m² (807 ft²)	28
≤ 120 m² (1,292 ft²)*	18
≤ 165 m² (1,776 ft²)	10
≤ 210 m² (2,260 ft²)	8
> 210 m² (2,260 ft²)**	5

**Applies to modelled results for Small SFD archetype with cooling.*
***Applies to modelled results for all other Part 9 archetypes with cooling.*

[3] See the Energy Step Code 2017 Metrics Research – Full Report

Figure 13: Example of a 6-Unit Row House
(Source: House Plans)

Figure 14: Example of a 10-Unit MURB
(Source: blue host)

Figure 15: Example of a Quadplex
(Source: Core Development)

Figure 16: Example of a Large SFD
(Source: bm2dev)

Figure 17: Example of a Medium SFD
(*Source: realspace*)

Figure 18: Example of a Small SFD
(Source: Smallworks)

2.3.4 Modelling in H2000/HTAP

The six base building archetypes were modelled using Version 11.3 of Natural Resources Canada (NRCan)'s HOT2000 program, an energy simulation and design tool used for low-rise residential buildings. Each archetype was designed with various combinations of the energy conservation measures (ECM), which resulted in nearly 54 million possible modelling combinations for each archetype. Each archetype was further modelled across BC's six climate zones using the HOT2000 weather file locations listed below:

- Climate Zone 4: Vancouver – 2,825 HDD
- Climate Zone 5: Summerland – 3,350 HDD
- Climate Zone 6: Cranbrook – 4,400 HDD
- Climate Zone 7a: Fort St John – 5,750 HDD
- Climate Zone 7b: Fort Nelson – 6,710 HDD
- Climate Zone 8: Uranium City, SK[4] – 7,500 HDD

Given the quantity of possible ECM combinations, as well as the significant number of climate zones, the need for a secondary form of analysis was identified. Developed by NRCan in 2010, the Housing Technology Assessment Platform (HTAP) was used to examine the costs and benefits of increasing energy efficiency in residential buildings, allowing for an estimate of the energy impact of implementing various ECMs. HTAP expanded the capabilities of HOT2000 by incorporating:

- Batch processing and optimization capabilities that automate the task of evaluating different combinations of ECMs, housing archetypes and locations; and
- High performance computing resources that shorten the time required to evaluate hundreds-of-thousands of different home designs.

For this study, one of HTAP's most useful innovations is the ability to automate home design variations that apply different ECM combinations. HTAP automates configuring, dispatching, and collecting the results from HOT2000 energy simulation runs using an objective function that factors in capital and operating costs. Based on the objective function value for a set of ECMs, HTAP automatically selects more design variants with the aim to improve the objective function. HTAP can optimize for a range of criteria, including upgrade costs, utility bills, energy use, and home ownership affordability. Traditionally done manually by energy advisors, this HTAP process greatly increased the variety of Step Code-related design options that could be explored.[5]

2.3.5 Part 9 Energy Conservation Measures

For each archetype, between 10,000 and 20,000 combinations of ECM's were evaluated for each climate zone to identify those that could meet the Step Code's performance thresholds. For all archetypes, baseload values for *occupancy*, *appliance/lighting loads* and *hot water consumption* were assumed to be the same as those stipulated in Version 15 of the EnerGuide Rating System. Some archetypes were also modelled with different ventilation rates and dominant window orientations (discussed below). Altogether, 60,000 to 240,000 separate HOT2000 evaluations were modelled, representing different ECM combinations for each archetype.

[4] Uranium City, SK was selected because no climate files for Climate Zone 8 are available for BC in HOT2000.
[5] HTAP's automation capabilities are provided in part by third-party optimization tool GenOpt: https://simulationresearch.lbl.gov/GO/.

Table 14: ECM Options used in Part 9 Energy Modelling

Component	Options	# of choices
Airtightness ACH	3.5 ACH, 2.5 ACH, 1.5 ACH, 1.0 ACH, 0.6 ACH	5
Wall R-Value	R16, R18, R22, R24, R30, R40, R50, R60	8
Under-slab R-Value	R0, R11, R15, R20	4
Foundation Wall R-Value	R11, R17, R20, R25	4
Exposed Floor R-Value	R27, R29, R35, R40	4
Ceiling/Roof R-Value	R40, R50, R60, R70, R80, R100	6
Window Option & U-Value	Double (1.8), double (1.6), double (1.4), high gain triple (1.2), low gain triple (1.2), triple (1.0), high performance triple (0.8)	7
Domestic Hot Water (DHW) System	Electric tank, gas tank, 2 x gas tankless, heat pump (electric)	5
Drain Water Heat Recovery	None, 30%, 42%, 55% (recovery efficiencies)	4
Space Heating	Gas 92% & 95% AFUE, gas combo, Cold Climate ASHP (electric), Baseboard (electric)	5
Ventilation Heat Recovery	None, 60%, 70%, 75% & 84% SRE	5
Total Number of Possible Combinations		53,760,000

Note: All values in the table are effective R-values.

It should be noted that under the direction of BC Housing, limitations were set for select types of ECMs when modelling different archetypes in different climate zones. Specifically, limitations were set on airtightness levels, window USI, ventilation heat recovery, drain water heat recovery and space heating (MURB archetype only) to generate more realistic building outcomes. For example, it is unlikely that drain water heat recovery would be used in buildings of less than two storeys, and as such these possibilities were excluded from the model. Limitations that were placed on the Part 9 ECMs that were modelled in this study are detailed in Appendix 8.3.

Although not treated as ECMs, it should also be noted that the orientation of a building and the proportion of glazing on each façade affects the quantity of solar gains available to offset a portion of heating loads. These differences will in turn affect the ability of an archetype to meet specific Step Code requirements, in terms of both the MEUI and TEDI values. To provide clarity on the distribution of windows assumed in this study, Table 15 presents a summary of the distribution of the windows on each façade for each of the six Part 9 archetypes. The impact of window orientation on building performance is discussed in the results (see Section 3.2.5).

Table 15: Distribution of Windows in Modelled Archetypes

Archetype	Percent of Window Area Facing Each Direction			
	South	North	East	West
Small SFD	22.5%	22.5%	22.5%	32.5%
Medium SFD	45.3%	13.8%	18.0%	22.8%
	22.8%	22.8%	22.5%	31.8%
Large SFD	24.4%	26.9%	24.4%	24.4%
Quadplex	18.1%	14.1%	39.7%	28.2%
	28.2%	39.7%	18.1%	14.1%
	39.7%	28.2%	14.1%	18.1%
6-Unit Row House	38.0%	48.3%	6.9%	6.9%
10-Unit MURB	49.5%	10.4%	10.4%	29.7%

2.3.6 Limitations

A few limitations of the Part 9 analysis should be noted. First, the analysis presented here is limited to the archetypes that were studied. As such, the difficulty or ease with which other archetypes (e.g. sixplex, larger MURB) can reach different levels of the Step Code is unknown. For example, a house that has an area spread out over two storeys and a basement may have less difficulty achieving higher levels of performance compared to a single storey, slab-on grade house with a larger area of exposed envelope per unit area of living space.

Second, the modelling approach involves the application of different combinations of ECM to a single base building design for each archetype. More specifically, results are derived by taking a code compliant home and increasing its performance by adding different combinations of ECMs. While this is a traditional, rational and effective method to equitably compare between interventions, it is also limited in its ability to achieve higher performance levels. This is because the approach normalizes any efficiency gains derived from the use of passive design measures, which can provide a major source of savings in TEUI-based frameworks

It should also be noted that this methodology may approximate how a builder and designer go about optimizing a building at Steps 2, 3 and 4 in milder climates, and where the services of an Energy Advisor are engaged to provide guidance on energy saving strategies. However, it may not be the most cost-effective approach for colder climates or for reaching higher tiers of the Step Code. Designers targeting higher levels of performance will likely pursue a more thoughtful and site-specific design strategy that maximizes passive design strategies before pursuing more costly or complicated ECMs.

Finally, time and computing power limited the total number of ECM combinations that could be evaluated. Recall that the set of ECMs in Table 14 can be combined into 54 million different variations. Even with the HTAP evaluation running for 12 to 24 hours, only 10,000 to 20,000 HOT2000 evaluations could be run, representing only 0.00025% to 0.0005% of the possible combinations for each archetype in each climate location. As such, there could be some ECM combinations that would have achieved higher performance than those found in the simulation, although this is mitigated to some degree through HTAP optimizing for an objective function (as described above). To ensure that the most energy efficient design combination was modelled for each case, one simulation was carried out for each archetype and climate that included the most energy efficient options of each ECM category.

2.4 Costing

2.4.1 Context

One of the research questions and a major overarching goal of this report is to explore the costing impacts of applying various steps of the Step Code to different steps archetypes across multiple climate zones in BC. These investigations aim to understand if the costs of implementing the Step Code vary across archetypes and climate and if these costs are significant enough to impact affordability. It should be noted that BCBC is currently structured such that the code becomes more stringent in colder climate zones, which has cost implications even in the absence of more stringent levels of the Step Code. However, although past studies commissioned by the City of Vancouver[6] projected modest increases in construction costs resulting from adopting higher building energy performance requirements, the higher requirements have proven to have no demonstrable impact on cost.

Figure 19 shows changes in construction costs for MURB, SFD and Commercial Office buildings in Vancouver between 2007 and 2017, and notes where in 2009 and 2014 new energy codes were adopted. The graph shows that the cost impact of increasing energy requirements may in fact be lower than other factors that affect construction cost. In two cases, construction costs actually decreased substantially within a year of adopting new requirements that were expected to add costs.

[6] Building Energy Code Update Study - City of Vancouver (2012). Prepared by BTY Group and Stantec Consulting Ltd

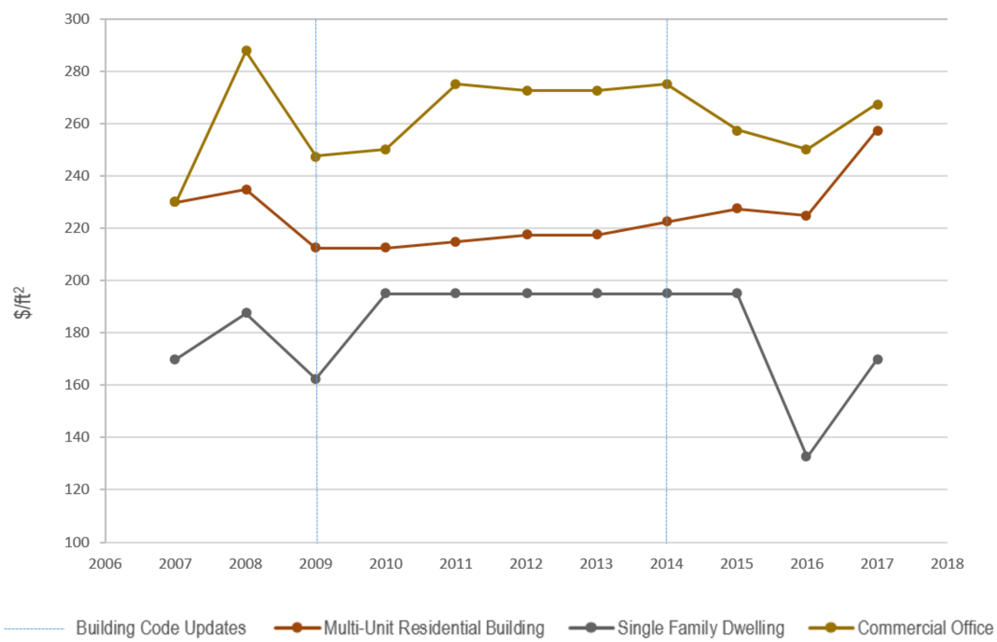


Figure 19: Changes in Construction Costs in Vancouver, 2009-2017

Finally, it should be noted that while the analysis produced comprehensive results for Part 9 buildings across all climate zones and for Part 3 across Climate Zones 4 to 7a, models were run only for Part 3 Low-Rise MURB and Hotels in Climate Zones 7b and 8. This is because there are currently no weather files in the national data base for cities in BC in these climate zones, as there are very few municipalities in these regions, and they are extremely small in terms of both population and scale of development. For example, there are three municipalities in Zone 7b and one municipality in Zone 8. The combined population of both Climate Zone 7b and 8 is approximately 4,000 people, 3,900 of which live in Fort Nelson in Zone 7b. As such, the economic, energy saving and greenhouse gas implications of applying the Step Code for Part 3 buildings in these regions are limited. However, for the sake of comprehensiveness the residential archetypes were modelled in Climate Zones 7b and 8 using climate data from comparable locations in the Yukon and the Northwest Territories respectively as a proxy to capture these population centres.

2.4.2 Part 3 Costing Information Sources

Costing sources for Part 3 buildings were derived from two major sources. *Base construction costs* were developed by the consultant team by sourcing multiple projects across the different archetypes (see Table 16). These costs were vetted extensively by industry members during the City of Vancouver's Zero Emissions buildings consultation process and over the course of 2016-2017. *Base construction costs* were sourced from the 2016 Altus Canadian Construction Guide.

Table 16: Base Construction Costs for Part 3 Buildings

Part 3 Archetype	Cost per square meter ($/m^2)	Cost per square foot ($/ft^2)	Description
High Rise MURB	3,035	282	See Section 2.2.1
Low Rise MURB	3,422	225	See Section 2.2.1
Hotel	2,960	275	9,520 m^2, 10 storeys, 500 people
Office	2,874	267	18,200m^2, 10 storeys, 155 parking spaces
Retail	1,722	160	4,500m^2, 1 storey, 150 people

2.4.3 Part 9 Costing Information Sources

Base construction costs for Part 9 archetypes were sourced from the 2017 Altus Construction Guide, with input from the Province. They are outlined in Table 17.

Table 17: Base Construction Costs for Part 9 Buildings

Part 9 Archetype	Cost per square meter ($/m²)	Cost per square foot ($/ft²)	Description
10-Unit MURB	2,422	225	Three storey apartment building on underground parking garage
6-Unit Row House	1,749	163	Three storeys on slab on grade; garage on ground floor
Quadplex	1,857	173	3 storeys, on underground parkade
Large House	1,938	180	2 storeys on basement
Medium House	2,045	190	2 storeys on basement
Small House	2,314	215	1 storey on 4ft crawlspace

Costing sources for the ECMs modelled for Part 9 buildings were derived by leveraging the work that NRCan put into its costing calculator tool used for the Local Energy Efficiency Partnership (LEEP) program. NRCan has collected costing data for many upgrades, based on dollar figures provided by quantity surveyors. Those figures have been used and evaluated by LEEP Builder participants in the Lower Mainland, Okanagan and Northern BC.

Material costs and labour costs of Part 9 ECMs were provided on a per square foot of assembly basis, allowing the overall costs to be calculated by entering the area of building assemblies specific to the archetype under evaluation. Using a spreadsheet tool, the total cost of different upgrade scenarios for each of the building archetypes could then be calculated. Those costs were in turn entered into the HTAP software, which produced variations of the HOT2000 energy models, along with their associated cost increments. These costs went through an additional vetting process by comparing them with project experiences from staff at E3 - EcoGroup[7]. Where costs were deemed out of date, they were compared against input from local suppliers and builders to assess if any changes or adjustments were necessary to more accurately represent present day (2017) costs. Examples where this occurred included certain efficiency levels of HRVs and the cost of different types of rigid foam insulation.

2.4.4 Regional Costs

Building construction costs vary across the province according to a range of factors, including labour and materials availability and local economies of scale. To reflect this range, *ECM and base costs* were adjusted by climate zone.

For Part 9 buildings, costs were adjusted using factors obtained from BC Housing, which were in turn created to reflect their own project and budgeting experience. For Part 3 buildings, base and incremental capital costs were multiplied by location factors according to the Altus Construction Guide. Table 18 presents the location factors used for both Part 3 and Part 9 buildings.

Table 18: Regional Cost Multipliers for Part 3 and Part 9 Buildings

Climate Zone	Multiplier over CZ4		
	Part 9 – All	Part 3 – MURB, Hotel	Part 3 – Office/Retail
4	1	1	1
5	1.073	1.073	0.95
6	1.126	1.126	1.15
7a	1.502	1.502	1.15
7b	1.502	1.502	1.502
8	1.502	1.502	N/A

[7] E3 – EcoGroup is a building consultancy that provides energy modelling and energy advisor services.

2.4.5 Costing Assumptions

All steps within the Step Code were optimized for both lowest cost and for the highest Net Present Value (NPV) to assess both capital costs and long-term cost effectiveness. Cost calculations were all base-lined against the minimum code requirements for a given climate zone.

NPV calculations apply a real discount rate of 3% and assume a time horizon of 20 years to represent a consistent lifespan of major component units associated with the analysis. This means that all ECMs are assumed to last a minimum of 20 years, and any residual or remaining value that any ECM may have beyond a 20-year lifespan is not accounted for. For example, while wall systems are expected to last far beyond 20 years, this analysis only accounts for overall costs through the initial impact on the overall capital costs of the building. The implications of this assumption are twofold:

1) If an ECM lasts less than 20 years, the additional investment required to replace it is not captured. If an ECM fails before the 20-year period is over, it would have a downward effect on NPV.
2) Conversely, ECMs that last beyond the 20-year time horizon continue to provide value to the building owner; for example, by decreasing annual energy costs that are not fully reflected in the 20-year NPV. Adjusting the NPV to account for the ongoing value of these ECMS would create a more positive result.

Effectively, the 20-year time horizon functions like a weighted average for building components. This approach, while not detailed in its methodology, does provide a level playing field by which to assess the relative cost effectiveness of the thousands of buildings within this study. For example, while exterior cladding may have a projected lifespan of up to 50 years[8], HVAC system components may have to be replaced after as little as 10 to 15 years[9].

As some utility and other government programs typically use a more conservative rate of 6% to 7%, a sensitivity analysis was conducted on Medium SFD NPV results and associated carbon abatement costs, to determine the impact of a range of discount rates between 3% and 7%. The results are presented in Section 3.2.3. It's important to note that the base case 3% discount rate partially offsets the fact that all costs in the report are presented in today's (2017) costs. For example, the costing results presented in this report do not reflect the inevitable declines in the costs of certain technologies (e.g. HRVs) that are achieved through economies of scale and market maturity. As such, while the low discount rate has an upward effect on NPV results, the overestimation of future ECM costs has a downward effect.

Other assumptions are noted below:

- Projected energy price estimates were based on a review of BC Hydro and Fortis BC rate projections and include the carbon tax, which is assumed to increase to \$50/tCO_2e in 2022; see Appendix 8.4 for details.
- The GHG intensity of electricity was assumed to be 0.0000107 tonnes/kWh, as per the 2016/2017 BC Best Practices Methodology for Quantifying GHG Emissions.
- The GHG intensity of natural gas was assumed to be 0.000180 tonnes/kWh, as per the 2016/2017 BC Best Practices Methodology for Quantifying GHG Emissions.[10]

Finally, Part 9 costs calculated for all Steps include estimates for the Energy Advisor services and blower door tests that are required to comply with the Step Code. Cost estimates were sourced from local practitioners who provided estimates for Climate Zone 4. These were adjusted for colder climate zones using the regional cost multipliers noted above. These cost assumptions for Part 9 services are presented in Table 19 and Table 20. Part 3 costs also include costs for airtightness testing, based on a baseline cost of \$25,000 for testing at Step 1. Part 3 airtightness testing costs assume one test and some additional consulting based on industry experience in the province's Lower Mainland. The

[8] http://www.rdh.com/long-buildings-last/
[9] As outlined by ASHRAE, see http://www.culluminc.com/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf
[10] http://www2.gov.bc.ca/assets/gov/environment/climate-change/cng/methodology/2016-17-pso-methodology.pdf

actual costs of air-tightness testing will vary depending on location, size and complexity of the building, as well as how well-planned and coordinated the testing is.

Table 19: Cost Estimates for Part 9 Energy Advisor Services (CZ4)

Part 9 Archetype	Energy Advisor Costs				
	Step 1	Step 2	Step 3	Step 4	Step 5
10-Unit MURB	$1,200	$1,360	$1,920	$3,200	$4,800
6-Unit Row House	$1,200	$1,360	$1,920	$3,200	$4,800
Quadplex	$1,000	$1,133	$1,600	$2,667	$4,000
Large House	$750	$850	$1,200	$2,000	$3,000
Medium House	$500	$850	$1,200	$2,000	$3,000
Small House	$400	$680	$960	$1,600	$2,400

Table 20: Cost Estimates for Part 9 Blower Door Tests (CZ4)

Part 9 Archetype	Blower Door Costs (All Steps)	Assumptions
10-Unit MURB	$3,050	Mid Construction, Thermal Bypass, Check and Blower, Fan Test
6-Unit Row House	$1,450	Mid Construction, Thermal Bypass, Check and Blower, Fan Test
Quadplex	$1,250	Mid Construction, Thermal Bypass, Check and Blower, Fan Test
Large House	$800	Mid Construction, Thermal Bypass, Check and Blower, Fan Test, 450, Final Blower Fan Test, 350
Medium House	$600	Mid Construction, Thermal Bypass, Check and Blower, Fan Test, 350, Final Blower Fan Test
Small House	$600	Mid Construction, Thermal Bypass, Check and Blower, Fan Test, 350

3 RESULTS

This section presents the results of the costing analysis, as well as additional analysis required to answer some of the key research questions posed by the study.

The study sought to optimize results for each of the three metrics – capital costs, net present value (NPV), and costs per tonne of carbon abated. However, it should be noted that optimizing these three metrics separately will yield in results that are sub-optimal for the other two. For example, when ECMs are optimized for NPV, an increase in GHG emissions tends to be a common outcome. Of course, it should be borne in mind that, as with any performance-based framework, there are multiple possible outcomes that can be used to meet the targets, and that these represent only one possibility. The full set of results have been made available to BC Housing for any additional analysis.

3.1 Part 3 Buildings

As outlined in Section 2.4.2 above, all costs for this analysis were baselined off the Part 3 prescriptive code requirements for each climate zone. Optimized costs for incremental capital costs, cost per tonne of carbon abated, and NPV are shown in Table 21, Table 22 and Table 23, respectively. The full results of the Part 3 costing analysis are summarized in Appendices 8.5 to 8.7.

3.1.1 Incremental Capital Cost

Incremental Capital Cost refers to the cost premium associated with going to a higher step within the Step Code framework and includes both materials and labour. It does not include any savings that might be realized from lower operating costs, or the likely reductions in the capital costs of mechanical equipment due to the use of better building envelopes. It also does not include potential for increases in design costs – while these may be initially higher, changes to the market will see these increases disappear over time. Incremental capital costs are typically used by the building industry as they are seen to have the biggest impact on consumer choice and affordability.

Table 21 shows the results of the incremental capital cost analysis. All building types across all climate zones studied could achieve all levels of the Step Code for less than 4%, with two exceptions: Low-Rise MURB in Climate Zones 7a for Step 4, and Retail buildings in Climate Zone 7a for Steps 2 and 3. High-rise MURB could not meet Step 4 in Climate Zone 7a within the set parameters. However, this was considered acceptable due to the limited presence of this building form in the north. Low-rise MURBs could not meet Step 4 in CZ 7b or Step 3 in CZ 8. Projects in these regions will need further innovations in building performance to meet higher steps. Alternately, the Province can consider setting specific performance targets for all climate zones. Hotels could not meet Step 4 in Climate Zone 7a, nor Step 3 in Climate Zone 7b, and no step target was achieved in Climate Zone 8. Lower glazing ratios are required for Hotels to meet Step 4 in most climate zones, and to meet any steps in colder climates. Hotels without pools and commercial kitchens will achieve higher steps more easily. Technology to recover heat from more exhaust sources will be necessary in Hotels, especially in Climates Zones 7 and 8. Here again, the Province should consider developing specific performance targets for Hotels in Climate Zone 5 and above. This will apply the Step Code more equitably across the province and enable buildings in colder climates to achieve higher steps.

In general, incremental capital costs do not increase significantly in higher climate zones due to the increase in baseline code requirements. Higher climate zones already require higher performance envelope characteristics, as well as the use of heat recovery on ventilation air as per NECB 2011 (referenced by BCBC). As such, base costs in higher climate zones already included many of the energy efficiency measures required to meet the different step levels.

At higher step levels, especially in higher climate zones, the use of high-performance windows typically drives any increases in incremental capital costs. As the climate gets colder and the TEDI requirement becomes more difficult to achieve, the use of higher performance windows is necessary, which can come at a significant cost premium. It is also important to note that in these colder climates, window-to-wall ratio is significantly lower than in other climates, but consistent with the NECB's prescriptive pathway. The cost optimized results for MURBs in Climate Zones 6 and 7a, for example, have a window-to-wall ratio of 20%.

It should also be noted that Retail buildings appear to have the highest incremental capital costs, though it is comparable to other building types on the basis of absolute $/m^2. Lower base construction costs for Retail buildings inflate the premium substantially.

In summary, in Climate Zones 4-6 (where 95% of BC's population resides), all buildings modelled were able to achieve Step 4 for less than a 3% incremental capital cost and achieve Step 3 for less than 2.4%. Hotels had slightly higher TEUI than the performance target for Step 3 in CZ 7b, but capital costs for that solution were also less than 2.4%. In comparison, incremental capital costs for Commercial Office buildings were correlated to their choice of mechanical system, and not to the achievement of the different levels of the Step Code. In all cases, except Step 3 with VAV systems, these costs were less than 3%. It is important to note that in Climate Zones 4, the achievement of Step 3 (the highest step for Commercial Office) could be achieved for less than a 1% cost premium for most cases. For MURB, these costs are substantially lower than what was originally anticipated (see Table 2).

Table 21: Lowest Incremental Capital Costs (% change) – Part 3 Buildings

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
High-Rise MURB *Electric BB Mid Occupancy 0.6 VFAR 62-2001*	1	0.0%	0.0%	0.0%	0.0%	--	--
	2	0.4%	1.0%	1.3%	2.0%	--	--
	3	0.8%	2.3%	1.8%	2.3%	--	--
	4	2.4%	3.2%	2.7%	2.7%*	--	--
Low-Rise MURB *Electric BB Mid Occupancy 0.6 VFAR 62-2001*	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	2	0.5%	0.5%	0.4%	1.4%	2.7%	3.3%
	3	0.6%	2.2%	1.0%	1.6%	3.3%	3.3%*
	4	2.6%	3.3%	2.2%	4.1%	--	--
Hotel *50% WWR Common Area Fan Coils Heat Pump DHW Electric Laundry Load*	1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	2	-0.2%	-0.1%	1.1%	0.7%	0.9%	1.9%*
	3	0.0%	1.2%	2.3%	2.2%	2.3%*	--
	4	1.2%	2.1%	2.8%	2.7%*	--	--
Commercial Office *No IT Load Default Occupancy with ASHP*	1	0.0%	0.0%	0.0%	0.0%	--	--
	2	-0.2%	-0.1%	0.4%	1.6%	--	--
	3	0.0%	0.2%	1.4%	1.8%	--	--
Other Commercial *No IT Load Default Occupancy with ASHP*	1	0.0%	0.0%	0.0%	0.0%	--	--
	2	-0.2%	-0.1%	0.4%	1.6%	--	--
	3	0.0%	0.2%	1.4%	1.8%	--	--
Retail *Big Box with FC*	1	0.0%	0.0%	0.0%	0.0%	--	--
	2	0.8%	1.3%	2.8%	4.6%	--	--
	3	2.0%	3.7%	5.5%	6.6%	--	--

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

3.1.2 Net Present Value & Carbon Abatement Costs

Net Present Value (NPV) is a measurement commonly used in the financial industry as a method of calculating potential profit or loss over time. It is calculated by subtracting the present value of the initial costs from the present value of any savings or revenues over time. It is often used as a method of comparing capital investments over time. In the case of this analysis, the total costs of the upgraded ECM package and the total savings from utility bills over time were assessed in comparison to the code baseline. A positive NPV indicates that savings outweigh any incurred costs over time, whereas a negative NPV indicates that any incremental costs could not be recovered in operational savings. The cost of abated carbon was calculated using the NPV analysis to ascertain the total cost of abated carbon once all costs and savings were applied over a 20-year time horizon. As noted in Section 2.4.5, a 3% real discount rate was assumed.

Table 22 shows the results for costs per tonne of carbon abated, while Table 23 shows the results of the NPV analysis. While overall cost premiums were low, NPV and costs per tonne of carbon abated results were mixed and range from positive to negative values. It is important to remember that these cost metrics are based on a comparison to a BCBC compliant building with one set of fixed characteristics that do not necessarily reflect typical market practice. For example, the code allows for different compliance mechanisms that can lead to very different solutions and resulting energy, energy cost and GHG use for equally code compliant buildings. Therefore, a fixed energy use intensity, energy cost, and GHG emissions for a "code compliant" building does not really exist. It is a key limitation to the code and a major impetus for moving to the target-based approach presented in the Step Code. Further, it is very difficult to achieve positive NPV results in British Columbia. This is because the province has some of the lowest energy costs in North America, so any savings achieved are also small, making the recovery of any incremental costs very challenging.

One of the major indicators of NPV and GHG outcomes is fuel source, on which the code provides no explicit direction. However, the starting point for base costs (i.e. gas-based heating vs. electric-based heating) will be highly sensitive to the final NPV and GHG outcomes, as a result of the disparity in costs and GHG emissions between fuel sources in BC.

Overall, NPV and costs per tonne of carbon abated numbers should be interpreted carefully. The main takeaway from these metrics is that even the most unfavourable NPV numbers are small relative to the overall cost of building and operating a building, and do not exceed 2%. Two notable exceptions are an increase of up to 5% in total costs over a 20-year period for Low-Rise MURB in Climate Zone 7b, and a 3% increase in total costs for Retail buildings to meet Step 3 in Climate Zones 6 and 7a. In terms of cost per tonne of carbon abated, carbon savings are often also associated with NPV savings, especially in Climate Zone 4. As such, most optimized carbon abatement costs indicate that Part 3 building can reduce GHG emissions while also reducing the total cost of building ownership. In colder climate zones, the cost of abated carbon can be up to 10 to 15 times the current carbon tax in BC, at $30/tonne.

While overall cost premiums were low, NPV results were mixed. In most cases, MURB and Hotel NPVs were positive for lower steps and climate zones, Retail NPV's were negative, and Commercial Office and other Commercial numbers were dependent on heating fuel type.

Table 22: Lowest Carbon Abatement Costs ($/tonne$CO_2$e) – Part 3 Buildings

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
High-Rise MURB *Electric BB* *Mid Occupancy* *0.6 VFAR* *62-2001*	1	--	--	--	--	--	--
	2	-332.1	0.7	-370.6	470.3	--	--
	3	-499.5	144.6	-509.4	314.8	--	--
	4	27.4	158.8	-240.5	368.4*	--	--
Low-Rise MURB *Electric BB* *Mid Occupancy* *0.6 VFAR* *62-2001*	1	--	--	--	--	--	--
	2	-731.6	-528.3	-1374.3	-1.7	193.1	12.2
	3	-897.5	-17.0	-1441.3	-250.3	151.5	123.7*
	4	-144.9	18.0	-1005.6	464.0	--	--
Hotel *50% WWR* *Common Area Fan Coils* *Heat Pump DHW* *Electric Laundry Load*	1	--	--	--	--	--	--
	2	-92.9	-90.4	3.1	-6.6	-16.1	64.9*
	3	-67.6	-14.1	60.6	93.0	56.0*	--
	4	-35.0	-19.1	51.5	121.6*	--	--
Commercial Office *No IT Load* *Default Occupancy with ASHP*	1	--	--	--	--	--	--
	2	-156.7	-98.4	-30.8	112.6	--	--
	3	-135.1	-65.9	116.0	141.9	--	--
Other Commercial *No IT Load* *Default Occupancy with ASHP*	1	--	--	--	--	--	--
	2	-156.7	-98.4	-30.8	112.6	--	--
	3	-135.1	-65.9	116.0	141.9	--	--
Retail *Big Box with FC*	1	--	--	--	--	--	--
	2	-225.3	-71.8	109.6	90.5	--	--
	3	-119.2	-15.0	161.0	107.8	--	--

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Table 23: Highest Net Present Value ($/m²) – Part 3 Buildings

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ
High-Rise MURB *Electric BB Mid Occupancy 0.6 VFAR 62-2001*	1	--	--	--	--	--	--
	2	15.1	-0.1	18.6	-44.6	--	--
	3	21.0	-14.0	24.0	-30.2	--	--
	4	-2.7	-16.1	15.5	-28.9*	--	--
Low-Rise MURB *Electric BB Mid Occupancy 0.6 VFAR 62-2001*	1	--	--	--	--	--	--
	2	27.5	20.8	51.9	0.1	-20.0	-1.3
	3	33.5	1.3	57.3	14.6	-16.1	-13.1*
	4	10.8	-1.8	47.0	-47.5	--	--
Hotel *50% WWR Common Area Fan Coils Heat Pump DHW Electric Laundry Load*	1	--	--	--	--	--	--
	2	34.4	35.8	-1.4	2.7	6.7	-33.9*
	3	30.9	6.9	-32.7	-44.8	-27.4*	--
	4	16.1	9.5	-27.9	-58.6*	--	--
Commercial Office *No IT Load Default Occupancy with ASHP*	1	--	--	--	--	--	--
	2	25.8	16.2	6.0	-26.7	--	--
	3	22.3	10.7	-22.7	-33.7	--	--
Commercial *No IT Load Default Occupancy with ASHP*	1	--	--	--	--	--	--
	2	25.8	16.2	6.0	-26.7	--	--
	3	22.3	10.7	-22.7	-33.7	--	--
Retail *Big Box with FC*	1	--	--	--	--	--	--
	2	16.9	9.4	-24.3	-32.3	--	--
	3	12.6	-2.5	-43.1	-42.7	--	--

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Table 24: Highest Net Present Value ($/unit*) – Part 3 MURB

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
High-Rise MURB *Electric BB Mid Occupancy 0.6 VFAR 62-2001*	1	--	--	--	--	--	--
	2	1027	-7	1265	-3033	--	--
	3	1428	-952	1632	-2054	--	--
	4	-184	-1095	1054	-1965	--	--
Low-Rise MURB *Electric BB Mid Occupancy 0.6 VFAR 62-2001*	1	--	--	--	--	--	--
	2	1870	1414	3529	7	-1360	-88.4
	3	2278	88	3896	993	-1095	--
	4	734	-122	3196	-3230	--	--

**Assumes 68m² units*

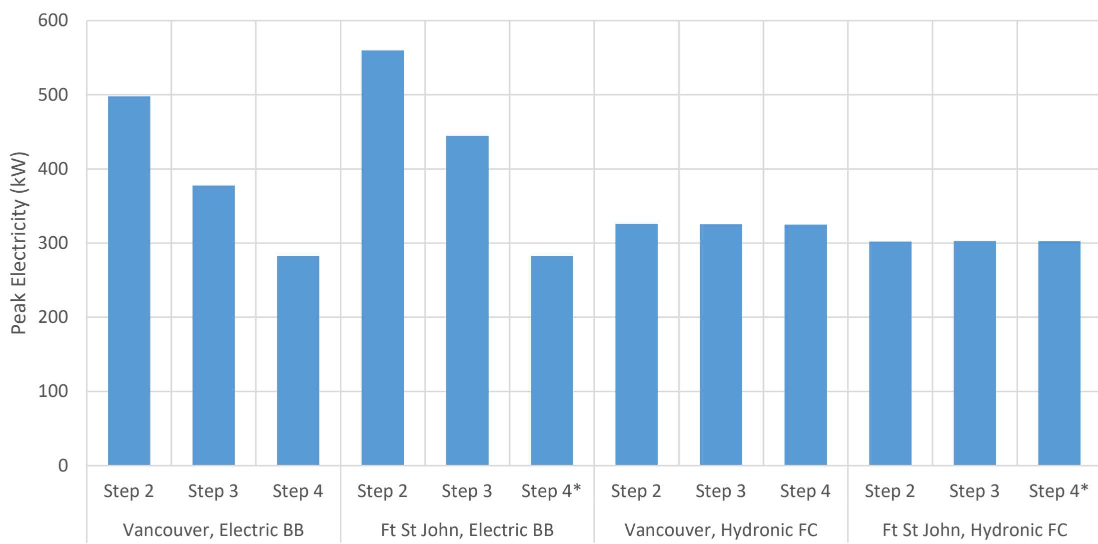
3.1.3 Appropriateness of Metrics and Targets

Peak Load and GHGs

In this section, the effectiveness of current Step Code metrics and performance requirements are explored with regard to their ability to gauge reductions in energy use, peak demand, and GHG emissions. From the results of the analysis, some interesting findings can be discerned.

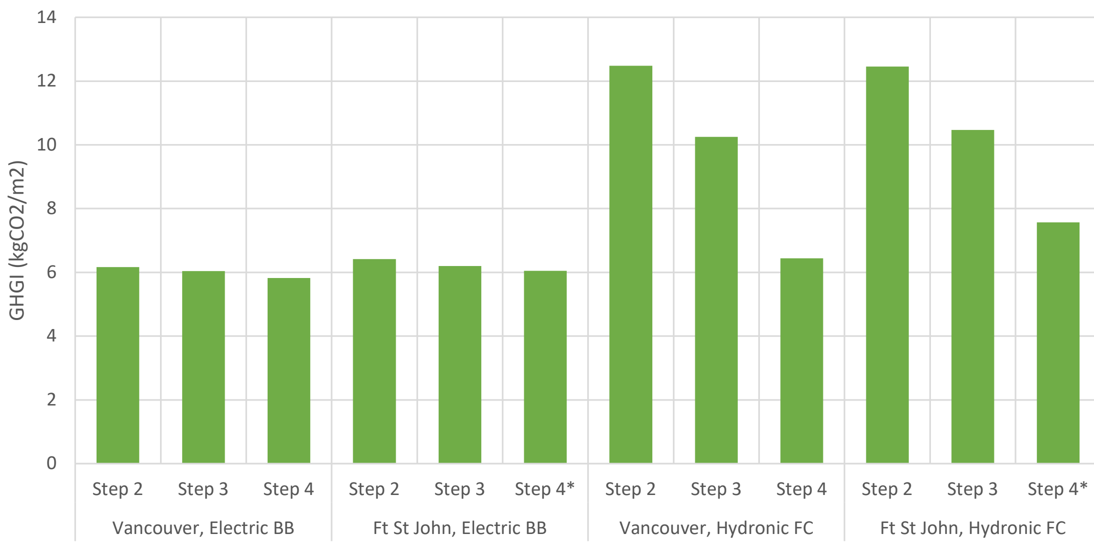
First, designing a Part 3 MURB to meet the TEUI and TEDI performance requirements for higher steps of the Step Code does result in lower peak electricity and GHG intensity (GHGI) outcomes, as shown in Figure 20. Large reductions are seen for peak electricity when heating is provided by electric baseboards, and for GHGI when heating is provided by natural gas (i.e. the hydronic fan coil case). This is expected since the Step Code primarily drives down heating energy use; electrically heated buildings will have reductions in electrical peak demand, while gas-heated buildings will have reductions in GHGs since gas is more carbon intensive than electricity. When heat is provided by electric baseboards, peak electricity use can be reduced by 40% in Vancouver and by 60% in Fort St. John by reaching Step 4 instead of Step 2. For buildings with hydronic fan coils where heating is provided by a gas-fired hot water boiler, GHGI can be reduced by approximately 50% in both climates. Only slight reductions in peak electricity and GHGI are achieved for buildings heated by natural gas and electricity, respectively, assuming there is no fuel switching for any other building systems.

At Steps 2 and 3, gas-heated scenarios naturally have lower peak electricity demand and higher GHGI than the electric baseboards scenarios. At Step 4, however, the more stringent TEDI performance requirement reduces heating demand sufficiently that the peak electricity demand of the electric baseboard scenarios is lower than the hydronic fan coil scenarios. This is due to the peak in the hydronic fan coil scenario changing from a winter peak to a summer peak as the TEDI performance requirement gets lower (the hydronic fan coil scenarios include cooling, while the electric baseboard scenarios do not). The Step 4 GHGI result for both HVAC systems and across all climates zones is similar, as the bulk of the GHGI is attributed to domestic hot water heating with additional use by the corridor make-up air unit gas-fired coil for both electric baseboards and hydronic fan coil scenarios.



**Represents the most feasible scenario which approaches, but does not meet the performance requirements*

Figure 20: Step Code Peak Electricity Outcomes for MURB in Climate Zones 4 & 7



**Represents the most feasible scenario which approaches, but does not meet the performance requirements*

Figure 21: Step Code GHGI Outcomes for MURB in Climate Zones 4 and 7

Variations in Mechanical Systems

The measures taken for MURB using electric baseboards (BB) and hydronic fan coils served by a gas boiler (FC) to meet the Step Code in Climate Zones 4 and 7 are summarized in Table 25. The base building is a High Rise MURB with 0.6 VFAR and the mid-density occupancy scenario. Switching from electric baseboards to fan coils reduces pressure on the TEDI performance requirement in exchange for higher energy use. This is attributed to the higher electricity use and corresponding internal heat gains from additional fans and pumps – as fans run continuously, waste heat is dumped into the space, lowering heating coil demand and thus the building's TEDI. In general, this means that capital may be required to be spent on other energy saving measures such as domestic hot water use reduction, rather than further envelope improvements.

For Commercial Office and Retail buildings, TEUI and TEDI are largely impacted by mechanical system choice. Notably, moving away from conventional air-based systems that combine heating, cooling and ventilation to hydronic systems that separate ventilation functions from heating and cooling can improve both metrics. The current Step Code performance limits will not generally push projects to a specific fuel source. Meeting the TEDI requirements generally leads to complying with TEUI performance requirements with conventional gas-based or electric heating sources unless the buildings have significant internal loads, at which point heat pump systems may be required. That is, buildings with non-typical occupancy use or process loads can still comply with the Step Code using higher efficiency mechanical systems.

For each of the steps, solutions are given for the progression of mechanical system interventions, beginning with conventional air-based systems (VAV), hydronic systems with dedicated outdoor air delivery with gas-based heating, and hydronic systems with dedicated outdoor air delivery with heat pump-based heating. Results show that moving to hydronic systems takes pressure off the building envelope to meet the TEDI, primarily due to elimination of reheat energy for VAV systems. The heat pump solution takes pressure off electrical load reductions, such as lighting and plug loads. A selection of recommended high NPV solutions is shown in Table 26, with full tables of solutions available in Appendix 8.

Variations in Window to Wall Ratio

Table 27 to Table 29 below show the recommended solutions for warm and cold climates at a range of glazing ratios, optimized for NPV. The typical MURB WWR is 40% in Climate Zones 4 and 5, and 20% in Zones 6 and 7. The typical office WWR is 50% (unless a lower value is required to meet performance requirements), and the retail typical WWR is 20%.

Recommended measures are typically similar for different glazing ratios, with some improvements in window performance and heat recovery efficiency required for some scenarios. If high performance glazing is required, the incremental capital cost for glazing increases with WWR due to the larger glazing area, which can significantly impact ICC and NPV, even when overall energy use remains relatively constant. High glazing ratios typically do not prevent higher steps from being achieved in any climate. However, choosing to design with low glazing ratios can be beneficial in terms of economic outcomes. While lower WWR may be undesirable for select building types in select markets, there are other opportunities to meet performance requirements using a different combination of ECMs that permit a higher WWR (e.g. 50%). Hotels with a high glazing ratio just missed Step 4 targets in Climate Zones 5 and 6 and missed many steps for Climates Zones above 6. In these cases, a lower glazing ratio was selected, with the added benefit of lowering incremental costs, as high performance opaque walls can be less costly than high performance windows.

3.1.4 Applying Part 3 Targets to Part 9 Non-Residential Buildings

Part 9 Non-residential buildings differ from Part 3 Non-residential buildings primarily due to building size leading to higher vertical surface to floor area ratios. Since the proposed solutions for Part 3 Commercial/Retail buildings are typically selected to meet the TEDI restriction, and are less limited by TEUI restrictions, the elevated VFAR of small commercial buildings will directly impact the building envelope performance and ventilation heat recovery efficiency required to meet the Part 3 performance requirements. The impact may be reduced by design measures such as lower window-to-wall ratios, and the use of combustible construction, which reduces thermal bridging and allows for higher opaque wall performance at lower cost than the equivalent non-combustible construction. Buildings with high process loads and associated internal heat gain will be less impacted by VFAR. Based on the analysis for increased WWR (which also causes increased envelope heat loss) in Commercial/Retail buildings, Step 2 and Step 3 performance requirements are achievable in all climate zones for Part 9 Non-Residential Buildings.

Table 25: Step Code Solutions for MURBs with Alternate HVAC Systems

Scenario			Measures								Outcome							
Climate	Step	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Savings	TEUI (kWh/m²)	TEDI (kWh/m²)	ncrementa Capital Cos (%)	ncrementa Capital Cos ($/m²)	NPV LCC Savings ($)	NPV LLC Savings ($/m²)	COC ($/tonCO₂e)
CZ4	2	BB	40%	10	20	2.5	Code	60%	Condensing	20%	111.7	40.6	0.4%	11.8	$266,000	14.8	-222.9
		FC									128.4	33.8	0.4%	12.4	-$669,000	-37.2	204.6
	3	BB	40%	10	20	2.5	Improved	80%	Condensing	20%	100.8	29.7	0.8%	24.9	$371,000	20.6	-299.5
		FC						60%		40%	116.7	28.8	0.6%	18.5	-$673,000	-37.4	165.1
	4	BB	40%	10	20	1.6	PH	80%	Condensing	20%	85.8	14.8	2.4%	74.3	-$55,000	-3.0	41.6
		FC								40%	98.8	9.8	2.6%	78.0	-$1,664,000	-92.4	305.8
CZ7	2	BB	20%	20	40	1.2	Code	60%	Condensing	20%	116.0	44.9	2.0%	92.5	-$817,000	-45.4	638.2
		FC			20	1.6		80%		40%	130.0	39.8	2.3%	104.3	-$669,000	-109.6	481.4
	3	BB	20%	20	20	0.8	Improved	60%	Condensing	20%	100.3	29.2	2.3%	104.6	-$544,000	-30.2	401.5
		FC			40	1.2				40%	119.8	29.8	2.3%	102.7	-$1,864,000	-103.5	386.8
	4*	BB	20%	20	40	0.8	PH	80%	Condensing	20%	88.7	17.6	2.7%	123.3	-$520,000	-28.9	368.4
		FC								40%	106.5	15.3	2.8%	128.9	-$2,289,000	-127.2	390.6

**Measures and outcomes represent the most feasible scenario that approaches, but does not meet the performance requirements*

Table 26: Step Code Solutions for Retail Buildings with Alternate HVAC Systems

Scenario			Measures						Outcome							
Climate	Step	HVAC	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m^2)	TEDI (kWh/m^2)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m^2)	NPV LCC Savings ($)	NPV LLC Savings ($/m^2)	COC ($/tonCO$_2$e)
CZ4 Retail *Big Box Cond. Boiler 20% WWR*	2	RTU	10	20	2.5	Code	60%	0	139.9	15.4	0.9	13.2	-$40,085	-8.9	105.3
		FC	10	20	2.5	Code	60%	0	128.1	19.1	0.8	12.1	$17,461	3.9	-39.9
		ASHP	7	20	2.5	Code	60%	0	114.7	22.4	0.8	12.1	$18,885	4.2	-24.8
	3	RTU	10	20	2.5	Improved	60%	25	118.0	15.6	2.1	31.3	-$5,105	-1.1	12.8
		FC	10	20	2.5	Improved	60%	25	106.3	18.6	2.0	30.1	$49,472	11.0	-106.0
		ASHP	10	20	2.5	Improved	60%	0	114.1	13.9	1.2	17.6	-$2,812	-0.6	3.7
CZ6 Retail *Big Box Cond. Boiler 20% WWR*	2	RTU	20	20	2.5	Code	80%	0	158.5	27.1	2.6	43.7	-$154,696	-34.4	173.9
		FC	10	20	0.8	Code	80%	0	142.5	29.8	2.8	47.8	-$109,493	-24.3	109.6
		ASHP	10	20	0.8	Code	80%	0	120.0	29.8	2.8	47.8	-$82,608	-18.3	57.5
	3	RTU	20	40	2	Improved	80%	25	118.3	16.8	6.0	102.3	-$260,657	-57.9	221.8
		FC	10	40	0.8	Improved	80%	25	111.9	19.0	5.5	93.9	-$193,981	-43.1	161.0
		ASHP	20	20	1.2	Improved	80%	0	118.6	19.8	3.9	67.5	-$163,200	-36.3	113.5

Table 27: Step Code Solutions for High Rise MURB with Varying WWR

Scenario			Measures								Outcome					
Archetype	Step	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Savings	TEUI (kWh/m²)	TEDI (kWh/m²)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m²)	NPV LCC Savings ($)	NPV LLC Savings ($/m²)	COC ($/tonCO₂e)
CZ4 High-Rise MURB *Mid Occupancy 0.6 VFAR Electric BB*	2	20	10	20	2.5	Code	60%	Condensing	40%	94.2	29.9	0.7	21.2	$499,236	27.7	-295.5
		40	10	20	2.5	Code	60%	Condensing	40%	104.9	40.6	0.5	15.2	$272,282	15.1	-166.0
		60	20	20	2.5	Code	80%	Condensing	40%	105.0	40.7	1.1	32.6	-$42,676	-2.4	26.0
	3	20	10	20	2.5	Improved	60%	Condensing	40%	89.1	24.8	0.8	24.0	$610,212	33.9	-356.6
		40	10	20	2.5	Improved	80%	Condensing	40%	94.0	29.7	0.9	28.4	$377,269	21.0	-223.8
		60	10	40	2	Improved	80%	Condensing	40%	94.2	29.9	2.5	77.1	-$505,055	-28.1	299.0
	4	20	20	20	2.5	PH	60%	Condensing	40%	77.4	13.1	1.7	51.4	$477,326	26.5	-268.4
		40	10	20	1.6	PH	80%	Condensing	40%	79.1	14.8	2.6	77.8	-$48,294	-2.7	27.4
		60	10	20	1.2	PH	80%	Condensing	40%	76.3	12.0	3.7	113.8	-$611,882	-34.0	342.7
CZ7 High-Rise MURB *Mid Occupancy 0.6 VFAR Electric BB*	2	20	20	40	0.8	Code	60%	Condensing	20%	110.3	39.2	2.2	101.5	-$802,763	-44.6	612.0
		40	20	40	0.8	Code	60%	Condensing	20%	112.4	41.3	3.1	141.7	-$1,590,596	-88.4	1216.8
		60	20	40	0.8	Code	60%	Condensing	20%	115.5	44.4	4.0	181.9	-$2,411,886	-134.0	1862.6
	3	20	20	40	0.8	Improved	60%	Condensing	20%	99.7	28.6	2.3	105.7	-$543,752	-30.2	400.5
		40	20	20	0.8	Improved	80%	Condensing	20%	97.2	26.1	3.5	160.3	-$1,452,773	-80.7	1057.9
		60	20	20	0.8	Improved	80%	Condensing	20%	100.5	29.4	4.4	200.5	-$2,276,701	-126.5	1675.1
	4*	20	20	40	0.8	PH	80%	Condensing	20%	88.7	17.6	2.7	123.3	-$519,845	-28.9	368.4
		40	20	40	0.8	PH	80%	Condensing	20%	91.4	20.3	3.6	163.5	-$1,328,322	-73.8	949.3
		60	20	40	0.8	PH	80%	Condensing	20%	94.6	23.5	4.5	203.7	-$2,151,292	-119.5	1553.8

Table 28: Step Code Solutions for Commercial Offices with Varying WWR

Scenario		Measures							Outcome						
Climate	Step	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m^2)	TEDI (kWh/m^2)	Incremental Capital Cost (%)	Incremental Capital Cost ($\$/m^2$)	NPV LCC Savings ($)	NPV LLC Savings ($\$/m^2$)	COC ($\$/tonCO_2e$)
CZ4 Office *Default Occupancy No IT Load Hydronic FC*	2	30	10	20	2.5	Code	None	0	110.8	26.0	-0.1	-2.4	$445,671	24.5	-367.1
		50	10	20	2.5	Code	None	0	115.4	29.4	-0.2	-5.8	$458,761	25.2	-471.9
		70	10	20	2.5	Code	60%	0	112.9	21.1	-0.2	-5.1	$378,593	20.8	-247.1
	3	30	10	20	2.5	Improved	60%	0	99.9	11.2	0.1	3.1	$362,084	19.9	-162.1
		50	10	20	2.5	Improved	60%	0	104.8	14.7	0.0	-0.3	$370,345	20.3	-186.8
		70	10	20	2.5	Improved	60%	0	110.0	18.1	-0.1	-3.7	$371,792	20.4	-214.1
CZ7 Office *Default Occupancy No IT Load Hydronic FC*	2	30	20	20	1.2	Code	60%	0	112.2	29.3	1.0	34.4	-$165,172	-9.1	57.5
		50	20	40	1.2	Code	60%	0	115.0	29.7	1.6	51.9	-$539,435	-29.6	190.5
		70	10	20	0.8	Code	60%	0	118.5	28.5	2.3	77.0	-$1,086,924	-59.7	375.0
	3	30	20	20	0.8	Improved	60%	0	102.7	19.0	1.3	41.9	-$249,129	-13.7	69.4
		50	20	20	0.8	Improved	60%	0	106.4	19.4	1.8	60.8	-$668,208	-36.7	188.3
		70	20	40	0.8	Improved	60%	0	109.5	18.6	2.5	82.3	-$1,137,770	-62.5	317.0

Table 29: Step Code Solutions for Retail Buildings with Varying WWR

Scenario		Measures							Outcome						
Climate	Step	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m^2)	TEDI (kWh/m^2)	Incremental Capital Cost (%)	Incremental Capital Cost ($\$/m^2$)	NPV LCC Savings ($)	NPV LLC Savings ($\$/m^2$)	COC ($\$/tonCO_2e$)
CZ4 Retail *Big Box Condensing Boiler Hydronic FC*	2	5	10	20	2	Code	60%	50	93.8	29.9	2.9	42.5	$100,281	22.3	-339.3
		20	10	20	2.5	Code	80%	50	93.7	25.8	3.0	44.8	$75,900	16.9	-210.0
		40	10	20	2.5	Code	80%	50	100.6	29.6	2.8	41.2	$69,207	15.4	-235.6
	3	5	10	20	2.5	Improved	80%	50	82.7	16.2	3.6	53.1	$61,948	13.8	-117.1
		20	10	20	2.5	Improved	80%	50	88.0	19.1	3.4	50.3	$56,832	12.6	-119.2
		40	20	20	2.5	Improved	80%	50	91.7	19.9	4.0	59.7	-$2,132	-0.5	4.6
CZ7 Retail *Big Box Condensing Boiler Hydronic FC*	2	5	20	40	2	Improved	80%	25	117.9	29.6	5.2	89.5	-$69,561	-15.5	43.0
		20	20	40	1.2	Improved	80%	25	121.9	29.9	6.0	101.9	-$145,545	-32.3	90.5
		40	20	40	0.8	Improved	60%	0	144.8	29.2	5.9	100.7	-$263,790	-58.6	165.2
	3	5	20	40	0.8	PH	80%	25	110.0	19.5	5.8	99.0	-$107,373	-23.9	60.0
		20	20	40	0.8	PH	80%	25	114.8	19.7	6.6	112.4	-$192,084	-42.7	107.8
		40*	20	40	0.8	PH	80%	25	122.3	20.6	7.6	130.3	-$309,149	-68.7	175.7

**Measures and outcomes represent the most feasible scenario that approaches, but does not meet the performance requirements*

3.1.5 District Energy and Waste Heat

It is also important to clarify the implications of the Step Code performance requirements for the use of district energy and waste heat systems. Due to the ‘envelope first’ and fuel-neutral approach taken in the Step Code, the focus is on reducing the amount of heating required by the building by constructing an energy efficient envelope. Consequently, the heating system does not significantly impact a project’s ability to meet the requirements. That is, regardless of whether the heat is sourced from district energy or a conventional gas-fired boiler, it would still be possible for the project to demonstrate energy performance of the building in a step-wise manner by addressing the envelope and equipment efficiencies. As it is defined in the Step Code, Thermal Energy Demand Intensity (TEDI) is a measure of the annual heating energy required by the building and is not influenced by the source of heat. Therefore, connecting to a district energy system will have no impact on this metric.

However, connecting to a district energy system does impact Total Energy Use Intensity (TEUI) as TEUI is influenced by, among other things, heating system efficiency. According to the Version 2.0 of City of Vancouver’s Energy Modelling Guidelines (which is referenced in the Step Code as the guidelines modelling must conform to), district heating can be modelled one of two ways:

- Delivered to site with 100% efficiency;
- Including the total district energy system with system efficiency defined by utility.

Depending on the modelling option selected and the characteristics of the district energy system, the district energy system has the potential to offer TEUI savings over on-site systems. For example, energy use for an on-site gas-fired boiler might be higher for the same heating load, due to the efficiency losses. Similarly, the TEUI for a building using district energy may be equivalent to one using an electric resistance heater (e.g. electric baseboard). Conversely, heat pumps and other high efficiency site equipment will likely offer a significant advantage to TEUI over district energy.

To allow flexibility for district energy systems within the Zero Emissions Building Plan, the City of Vancouver has relaxed the TEDI performance requirement for buildings connected to neighbourhood renewable energy systems (district energy)[11]. However, this relaxation is only permitted for systems that meet the City of Vancouver’s GHGI performance requirement. The ensures the city can meet their carbon emission targets even with higher heating loads. The City of Vancouver encourages connection to low carbon district energy systems as these can also lower GHG emissions for existing buildings that connect. Therefore, incentivizing district energy can lead to an overall net reduction in community GHG emissions.

The Energy Step Code Council is considering a clarification that TEUI relaxations of up to 20% may be granted where a building is connected to a district energy system. However, a relaxation in TEUI requirements for district energy-connected buildings does not ensure GHG reductions without an accompanying GHGI performance requirement. Given this, and the relative affordability of achieving a broad spectrum of Step Code performance requirements, such a relaxation is not recommended. Alternatively, local governments may decide to relax the step requirements in district energy zones. For example, outside of a district energy zone, buildings could be required to meet Step 4, while within a district energy zone, buildings could be required to achieve only Step 2. This could be combined with a local government GHGI metric to ensure emissions reductions. Although not required to be reported under the Step Code, local governments could require compliance with a GHGI metric under the BC Climate Action Charter[12] to encourage the use of low-carbon district energy. District energy emissions factors are something that modellers can easily obtain at little to no extra effort.

Low-carbon district energy utilities are a significant shared infrastructure investment by the local government which provide measurable GHG benefits. In addition to the relaxation of the TEUI metric, a relaxation of the TEDI metric (as

---

[11] Note: The City of Vancouver Zero Emissions Building Plan (2016) does not include performance targets for TEUI.

[12] https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/local-governments/planning-land-use/bc_climate_action_charter.pdf

seen in Vancouver) may also be warranted to improve the economics of district energy connections (i.e. a building with very little heating load does not make a good district energy customer).

Similar to district energy, waste heat sources do not impact TEDI, as TEDI is measured as the heating requirement of the building, regardless of its source. However, waste heat sources that reduce energy consumption at the utility meters can reduce TEUI. This means that passive design strategies cannot be compromised regardless of heat source. However, leveraging available waste heat can reduce TEUI. Examples of waste heat sources include heat recovered from space conditioning (e.g. heat pump systems that can take the heat from cooling parts of the building and using it to heat other parts of the building) and waste heat generated from processes (e.g. cogeneration, industrial, etc.).

3.1.6 Adapting to the Warming Climate

As the climate warms, passive cooling techniques, such as building orientation, offer significant potential to reduce building overheating. Mechanical space cooling equipment will also contribute to maintaining comfortable living spaces. Mechanical space cooling systems do not impact TEDI, but can result in a modest increase of the building TEUI. Warming temperatures in the future could increase TEUI in buildings with a cooling-dominant energy use (e.g. buildings with large computer servers). Employing passive cooling techniques allows enables optimizing mechanical space cooling equipment size, especially since the cooling losses are mitigated through the building of an airtight building. This is further discussed in Section 6.1.1.

In addition to a warming climate, climate change is expected to increase storm activity and consequently the frequency and severity of power failures. Analysis undertaken to support the Toronto's Zero Emissions Buildings Framework[13] found that higher performing MURBs were more habitable during power failures. This was because the building was able to stay at a comfortable temperature for longer without mechanical systems. This improved resilience was a primary benefit in the winter months in Climate Zone 6 and above.

3.2 Part 9 Buildings

As outlined in Section 2.4.3 above, all costs were baselined using Part 9 prescriptive code requirements for each climate zone. Base building and ECM costs were also factored up for each climate zone, based on regional cost multipliers provided by BC Housing (as summarized in Section 2.4.4). The following pages provide a summary of results using the updated performance targets that have been optimized to: minimize incremental capital costs (Table 30), maximize NPV (Table 31), and minimize carbon abatement costs (Table 32). These results were generated through the H2000/HTAP process outlined in Section 2.3.4. Due to the larger impact that absolute performance metrics have on smaller buildings (especially smaller homes), a wider variety of archetypes was run for this building category than for Part 3.

Summary results are presented in Table 30, Table 31, and Table 32, while the full results of the Part 9 costing analysis are summarized in Appendices 8.8 to 8.10. For definitions and discussion of lowest incremental cost, net present value, and cost of carbon abatement, please see Section 2.4. In interpreting the Part 9 results, it is important to bear in mind several key issues. First, Section 2.3.6 discussed the limitations to the modelling approach taken in this study (i.e. adding combinations of ECMs to a base, code-compliant building), that would not necessarily produce the best or most cost effective solutions at higher levels of the Step Code and/or in colder climates. It is also important to recall that certain ECMs have been excluded from the Part 9 analysis for select archetypes and climate zones (see Appendix 8.3).

[13] Provident, Morrison Hershfield, & Integral Group (2017), City of Toronto Zero Emissions Buildings Framework Prepared for City Planning Division, City of Toronto https://www.toronto.ca/wp-content/uploads/2017/11/9875-Zero-Emissions-Buildings-Framework-Report.pdf

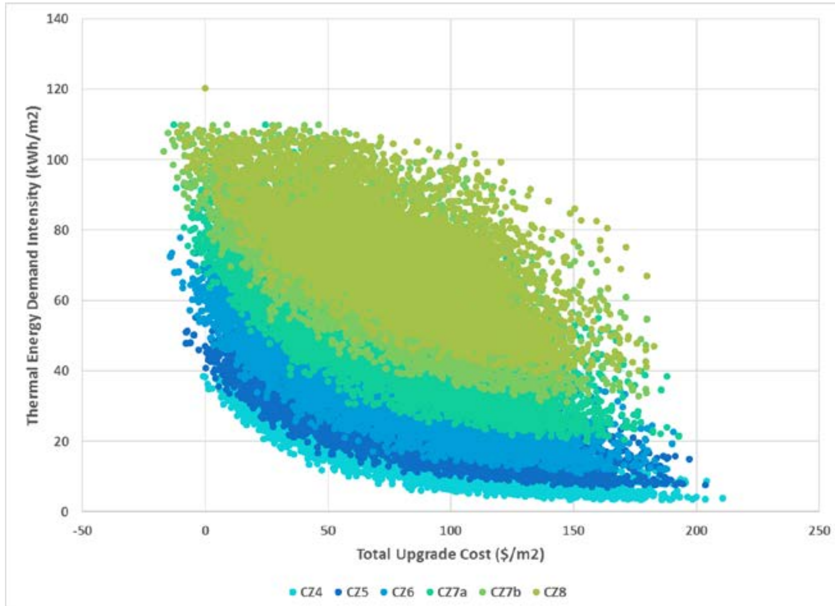


Figure 22: Sample Scatterplot Output Optimized Capital Costs for TEDI in Medium SFD Archetypes

3.2.1 Incremental Capital Costs

As shown in Table 30, incremental capital cost (ICC) results are generally modest, as most steps can be achieved for less than a 2% ICC. The full results, including ECM combinations, are summarized in Appendix 8.8.

The lowest ICC results are seen for the MURB archetype, which can reach Step 5 for less than a 2% ICC in all climate zones. The Row House and Medium SFD archetypes can reach Step 4 for under 2% ICC in all climate zones, and Step 5 for under 4%. The Large SFD archetype can also reach Step 4 for under a 2% ICC for all climate zones (except for Climate Zone 4 at 2.4%), and Step 5 for under 5%.

Results for the Quadplex were slightly higher, but still fell under a 2% ICC for scenarios up to and including Step 3. For Step 4, the Quadplex ICC ranges from 1.5% (Climate Zone 4) and 3.2% (Climate Zone 7a). Incremental capital costs for the Quadplex archetype landed above 5% to reach Step 5 for all climate zones, ranging from 6.0% for Climate Zone 4 and 7.4% for Climate Zone 7b.

The Small SFD archetype has the highest ICC results. Up to Step 3 can be reached for under 3% for all climate zones. Step 4 results range from 2.4% for Climate Zone 5 to 5.2% for Climate Zone 7b. For Step 5, the ICC results range from 7.6% for Climate Zone 5 to 13.1% for Climate Zone 7b. The Small SFD – Slab on Grade variation achieved the energy steps for lower ICC versus the conventional Small SFD. For the Slab on Grade option, up to Step 4 can be reached for under 5%. Step 5 ranges from 6.0% (Climate Zone 4) in to 8.5% (Climate Zone 8).

Table 30: Lowest First Costs (% change) – Part 9 Buildings

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
10 Unit MURB	1	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
	2	0.5%	0.5%	0.6%	0.6%	0.5%	0.7%
	3	0.8%	0.6%	0.4%	0.5%	0.2%	0.2%
	4	0.8%	0.6%	0.4%	0.5%	0.2%	0.2%
	5	1.9%	1.7%	1.2%	1.0%	1.0%	1.2%
6 Unit Row House	1	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
	2	0.4%	0.5%	-0.1%	0.4%	0.4%	0.2%
	3	0.6%	0.5%	0.5%	0.3%	0.0%	0.2%
	4	1.8%	1.6%	1.4%	1.5%	1.4%	1.0%
	5	3.4%	3.3%	2.5%	2.5%	2.7%	2.6%
Quadplex	1	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%
	2	0.6%	0.3%	0.2%	0.5%	0.2%	0.2%
	3	0.7%	1.1%	1.2%	1.9%	1.7%	1.8%
	4	1.5%	2.7%	2.7%	3.2%	3.1%	3.0%
	5	6.0%	6.7%	6.3%	7.4%	7.4%	7.3%
Large SFD	1	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
	2	1.2%	0.4%	-0.1%	-0.2%	0.2%	1.2%
	3	1.3%	0.6%	0.4%	0.4%	0.4%	0.3%
	4	2.4%	1.7%	1.3%	0.9%	0.9%	0.5%
	5	4.2%	3.7%	4.1%	4.6%	3.6%	3.5%
Medium SFD	1	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%
	2	0.4%	0.2%	0.0%	-0.2%	-0.2%	-0.1%
	3	0.9%	0.4%	0.7%	0.8%	0.4%	0.0%
	4	1.8%	1.4%	1.4%	1.7%	1.5%	1.1%
	5	3.6%	3.3%	3.9%	3.4%	3.8%	3.5%
Small SFD	1	0.4%	0.4%	0.5%	0.6%	0.6%	0.6%
	2	1.5%	0.5%	0.4%	0.9%	0.8%	4.4%
	3	1.6%	1.2%	1.6%	1.5%	2.6%	2.7%
	4	3.4%	2.4%	4.4%	4.2%	5.2%	4.9%
	5	8.7%	7.6%	10.8%	11.8%	13.1%	12.3%
Small SFD – Slab on Grade	1	0.4%	0.4%	0.5%	0.6%	0.6%	0.6%
	2	0.3%	0.4%	0.6%	1.0%	1.2%	0.9%
	3	0.8%	0.7%	1.2%	1.8%	2.1%	2.1%
	4	2.2%	2.1%	2.9%	4.2%	4.6%	4.3%
	5	6.0%	6.4%	7.3%	8.1%	8.5%	8.5%

As indicated in the Appendix, results of the Part 9 investigation show that when optimizing for capital costs, envelope values in Climate Zones 7a and below are frequently in the range of R16 to R18 (with the exception of Step 5 for most archetypes). These envelope values are roughly equivalent to current building code values. The explanation for this trend is that the requirements for air tightness improve envelope performance sufficiently enough to meet the thermal demand requirements without extra insulation.

3.2.2 Net Present Value & Carbon Abatement Costs

With regards to NPV, results are mixed. In general, larger buildings are found to have higher and often positive NPVs, decreasing as building area decreases and becoming primarily negative for SFDs. For example, achieving Step 4 for 10-Unit MURBs in all Climate Zones yields NPVs between \$61/m^2 and \$306/m^2, whereas the same step for the Medium SFD yields NPVs between -\$43/m^2 and -\$28/m^2. Note that positive values indicate a net financial gain over 20 years (i.e. energy cost savings outweigh incremental capital costs over 20 years).

Given that carbon abatement costs are based on the NPVs, the same pattern follows as for the NPVs. The reason for this pattern is that smaller buildings use and spend less on energy, and the reduction in annual energy spending is not enough to offset the increase in capital costs. Even a small increase in capital costs may outweigh the small decreases in energy costs. The results are summarized in Table 31 and Table 32, with associated ECM solutions and other data found in Appendices 8.9 and 8.10.

The full set of optimized NPV outcomes indicates a significant shift to using high insulation values when optimizing the results for long term savings (i.e. via NPV). There is also a tendency for archetypes to shift to natural gas-based heating and domestic hot water appliances, away from or instead of electric systems, due to their lower operating costs. As such, it is important to note that in some cases (particularly for Steps 1 to 3), optimizing for NPV can lead to higher GHG outcomes than what would occur in a code-compliant building using the prescriptive methodology, or if buildings had been optimized for another objective, such as GHG reductions.

In assessing the NPV and carbon abatement cost, the same cautions expressed in Section 3.1.2 apply here. Outcomes and their relative performance are partly dependent on fuel choice and in many cases, particularly for smaller buildings, initial investments cannot be recovered via lower energy costs. As noted previously, all ECM costs are based on current prices that will likely decrease as market maturity forces further drive down equipment and installation costs. Furthermore, an analysis of the *optimized* carbon abatement cost unfortunately does not yield actionable results for all archetypes. This occurs because low cost interventions that have only minor impacts on GHGs can nevertheless yield attractive carbon abatement costs, and become the optimized results found through this process, despite achieving a very small GHG reduction. As a result, optimized carbon abatement costs do not correlate well to overall greenhouse gas reductions, and the resulting solutions can obscure other ECM combinations that may achieve deeper GHG reductions at still modest costs. An approach that should be considered for future studies is to compare the carbon abatement potential for different suites of ECMs and explore the relative differences between them in terms of cost-effectiveness and impacts on GHG reductions. Alternatively, new and likely valuable optimized results could be generated by requiring solutions to achieve a certain level of GHG reductions.

A similar comment can be made about the NPV results. The summary tables in this section present results that have been optimized for each of the three primary financial outcomes: lowest incremental capital costs, highest NPV, and lowest carbon abatement costs. When optimizing for one, the others may be higher or lower than desired. As such, the lowest incremental capital costs solutions may appear to have poor NPV results, and vice versa for the optimized NPV results.

Table 31: Highest Net Present Value ($/m²) – Part 9 Buildings

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
10 Unit MURB	1	-$3	-$3	-$3	-$5	-$5	-$5
	2	$52	$53	$122	$185	$244	$264
	3	$49	$81	$125	$186	$252	$306
	4	$49	$81	$125	$186	$252	$306
	5	$31	$59	$110	$168	$231	$286
6 Unit Row House	1	-$3	-$3	-$3	-$5	-$5	-$5
	2	-$5	-$7	$6	$3	$7	$20
	3	-$7	-$7	$0	$2	$14	$20
	4	-$25	-$17	-$17	-$13	-$5	$6
	5	-$54	-$58	-$39	-$46	-$44	-$36
Quadplex	1	-$4	-$5	-$5	-$8	-$8	-$8
	2	$46	$71	$99	$161	$193	$238
	3	$33	$54	$74	$122	$153	$196
	4	-$8	$20	$46	$98	$128	$186
	5	-$65	-$62	-$23	-$16	-$65	-$32
Large SFD	1	-$3	-$3	-$4	-$6	-$6	-$6
	2	-$12	$1	$6	$11	-$177	-$227
	3	-$23	-$12	-$6	-$7	-$7	-$22
	4	-$35	-$19	-$6	-$23	-$9	$4
	5	-$67	-$55	-$60	-$102	-$75	-$56
Medium SFD	1	-$5	-$5	-$6	-$9	-$9	-$9
	2	-$11	-$6	-$2	-$5	-$2	-$186
	3	-$17	-$12	-$8	-$15	-$6	-$28
	4	-$33	-$28	-$32	-$43	-$37	-$33
	5	-$71	-$83	-$75	-$95	-$98	-$87
Small SFD	1	-$10	-$11	-$12	-$19	-$19	-$19
	2	-$24	-$5	-$12	-$31	-$194	-$310
	3	-$34	-$23	-$32	-$30	-$103	-$158
	4	-$87	-$69	-$92	-$99	-$136	-$107
	5	-$192	-$180	-$254	-$428	-$512	-$463
Small SFD – Slab on Grade	1	-$10	-$11	-$12	-$19	-$19	-$19
	2	-$25	-$23	-$25	-$47	-$50	-$46
	3	-$31	-$34	-$35	-$70	-$74	-$86
	4	-$61	-$56	-$85	-$137	-$147	-$136
	5	-$147	-$162	-$171	-$267	-$276	-$269

While the optimized cost of carbon abatement data presented in this report may not be useful on its own, this report does provide recommendations and guidance to local governments and the Province on how to optimize the Step Code for both GHG outcomes and limited impacts on affordability (see Section 6). The inclusion of a Greenhouse Gas Intensity (GHGI) metric similar to the Vancouver Zero Emissions Buildings Policy (see Section 6.4.3) is one approach that could be taken. Such a GHGI metric could be optimized to ensure that as steps increase, a predictable reduction in GHG outcomes could follow. This is not the case under the existing Step Code, as some cost-optimized outcomes had higher GHG emissions than the baseline code archetypes. Furthermore, additional analysis can be run on the Part 9 modelling outcomes, offering the Province the opportunity to explore and pose additional research questions that can provide new and valuable insights (see Section 7.2 for some examples).

Table 32: Lowest Carbon Abatement Costs ($/tonne$CO_2$e) – Part 9 Buildings

Note: Calculation based on NPV (20 year) divided by change in CO_2e emissions over 20-year period. Negative values indicate a decrease in GHGs with a positive NPV, with very large negative values representing cases with very low GHG reductions.

Archetype	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
10 Unit MURB	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	-$4,815	-$6,773	-$7,002	-$6,991	-$7,523	-$7,476
	3	-$5,831	-$6,894	-$7,463	-$7,901	-$8,608	-$8,682
	4	-$5,831	-$6,894	-$7,463	-$7,901	-$8,608	-$8,682
	5	-$91,532	-$247,163	-$250,004	-$7,038	-$7,062	-$7,321
6 Unit Row House	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	$306	$107	-$304	-$43	-$69	-$136
	3	$146	$107	-$0	-$21	-$134	-$136
	4	$273	$189	$120	$71	$22	-$24
	5	$314	$296	$185	$161	$138	$102
Quadplex	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	-$298,005	-$195,467	-$1,586	-$2,484	-$2,037	-$2,531
	3	-$708	-$4,480	-$1,267	-$911	-$666	-$1,239
	4	$135	-$933	-$504,539	-$53,851	-$39,353	-$3,093
	5	$489	$497	$339	$393	$396	$191
Large SFD	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	$185	-$13	-$122	-$147	$415	$429
	3	$236	$138	$70	$54	$54	$108
	4	$286	$152	$46	$112	$49	-$19
	5	$414	$340	$314	$395	$286	$186
Medium SFD	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	$201	$159	$57	$58	$25	$399
	3	$232	$166	$112	$143	$59	$142
	4	$290	$254	$212	$199	$165	$141
	5	$365	$352	$327	$335	$311	$244
Small SFD	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	$317	$69	$112	$231	$352	$498
	3	$348	$195	$178	$146	$359	$350
	4	$457	$368	$364	$346	$400	$282
	5	$639	$522	$647	$790	$785	$680
Small SFD – Slab on Grade	1	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs	No change in GHGs
	2	$291	$235	$192	$255	$235	$194
	3	$266	$264	$217	$318	$315	$322
	4	$306	$298	$304	$390	$371	$339
	5	$442	$443	$429	$517	$469	$434

It should also be noted that unit size and unit density are critical variables to affordable solutions that meet the Step Code in residential construction. The size and number of units constructed in a given building have a significant impact on a building's achievement of the MEUI performance requirements. This is because energy use from domestic hot water, lighting and appliances is assumed to remain constant regardless of size, and when sizes of units are small, energy use intensity is spread over a smaller floor area, which results in higher values. This can be seen most prominently in the Small SFD and Quadplex archetypes. On the other hand, spreading heat loss from occupants and appliances across a smaller unit can have a beneficial impact to TEDI, though this is somewhat counterbalanced by the higher building envelope to floor area ratio.

3.2.3 Sensitivity Analysis on NPV Discount Rate

A sensitivity analysis was performed to determine the impact of assuming different discount rates for the NPV analysis. The base case assumes 3%, but some utility and government program analyses can use higher rates such as 6% to 7%, which reduces the value of future cost relative to upfront costs. Using the Medium SFD, optimum NPVs were calculated for discount rates from 3% to 7%. A comparison of NPV results and associated carbon abatement costs is provided in Table 33.

Table 33: Comparison of Optimized NPVs and Associated Carbon Abatement Costs for Discount Rate Sensitivity Analysis on Medium SFD

CZ	Step	NPV per m² (20-year) Discount Rate					Range	Associated Carbon Abatement Cost ($/tCO2e) Discount Rate					Range
		3%	4%	5%	6%	7%		3%	4%	5%	6%	7%	
4	1	-$5	-$5	-$5	-$5	-$5	-	No change in GHGs					-
	2	-$11	-$11	-$12	-$13	-$13	$2	$221	$49	$248	$259	$269	$49
	3	-$17	-$19	-$20	-$20	-$21	$4	$232	$50	$260	$272	$282	$50
	4	-$33	-$34	-$36	-$37	-$38	$6	$290	$50	$318	$330	$340	$50
	5	-$71	-$72	-$73	-$74	-$75	$4	$393	$22	$405	$410	$414	$22
5	1	-$5	-$5	-$5	-$5	-$5	-	No change in GHGs					-
	2	-$6	-$7	-$7	-$8	-$8	$2	$159	$48	$187	$198	$208	$48
	3	-$12	-$13	-$14	-$15	-$15	$3	$203	$54	$233	$246	$257	$54
	4	-$28	-$30	-$31	-$32	-$33	$5	$254	$50	$282	$294	$304	$50
	5	-$83	-$86	-$88	-$88	-$87	$5	$479	$183	$507	$330	$325	$183
6	1	-$6	-$6	-$6	-$6	-$6	-	No change in GHGs					-
	2	-$2	-$3	-$3	-$4	-$4	$2	$57	$48	$84	$95	$105	$48
	3	-$8	-$9	-$10	-$11	-$12	$4	$112	$49	$140	$151	$161	$49
	4	-$32	-$34	-$36	-$38	-$39	$7	$223	$51	$252	$264	$275	$51
	5	-$75	-$78	-$81	-$83	-$85	$10	$376	$48	$403	$415	$424	$48
7a	1	-$9	-$9	-$9	-$9	-$9	-	No change in GHGs					-
	2	-$5	-$6	-$7	-$8	-$8	$3	$58	$87	$124	$135	$145	$87
	3	-$15	-$16	-$17	-$19	-$20	$5	$143	$50	$171	$183	$193	$50
	4	-$43	-$46	-$49	-$52	-$54	$11	$199	$50	$228	$239	$249	$50
	5	-$95	-$98	-$102	-$105	-$107	$13	$372	$50	$400	$412	$422	$50
7b	1	-$9	-$9	-$9	-$9	-$9	-	No change in GHGs					-
	2	-$2	-$4	-$5	-$6	-$7	$4	$25	$50	$53	$65	$75	$50
	3	-$6	-$8	-$9	-$11	-$12	$6	$59	$55	$90	$102	$114	$55
	4	-$37	-$40	-$43	-$46	-$48	$12	$165	$51	$194	$206	$216	$51
	5	-$98	-$101	-$103	-$105	-$107	$9	$311	$29	$327	$334	$340	$29
8	1	-$9	-$9	-$9	-$9	-$9	-	No change in GHGs					-
	2	-$186	-$168	-$153	-$139	-$127	$59	$410	$131	$336	$306	$280	$131
	3	-$28	-$31	-$34	-$36	-$38	$10	$142	$50	$170	$181	$191	$50
	4	-$33	-$37	-$40	-$42	-$45	$11	$141	$47	$168	$179	$189	$47
	5	-$87	-$90	-$93	-$96	-$98	$11	$244	$31	$262	$269	$275	$31

The results indicate a wider spread in resulting NPVs at higher steps and colder climate zones. The largest spread is for Step 2 in Climate Zone 8 at $59/m^2, equal to $14,057 total, or approximately 2% of base case Medium SFD capital costs in Climate Zone 8. While this is relatively small compared to total capital costs, this change could outweigh energy cost savings for smaller buildings. Changing the discount rate may change a positive NPV to negative for some cases.

3.2.4 Achieving Higher Building Performance in Colder Climates

There are a number of key takeaways that should be noted for the achievement of the Step Code in colder climates.

First, it is challenging to achieve higher levels of the Step Code (i.e. Steps 4 and 5) in the coldest climate zones. In these areas of the province, R-values of 40 and above will likely be necessary in both above- and below-grade walls for several of the smaller building archetypes, particularly for Small SFD and Quadplex buildings. However, MURBs and Row Houses will likely be able to achieve Steps 4 and 5 with lower R-values. For the other archetypes, the thermal performance of certain building envelope components become something of a limiting factor. For example, window U-values of 0.80 or lower would considerably help to achieve TEDI thresholds. Doors also present a limitation – particularly in multi-unit buildings such as Row Houses, which can have 2-3 doors per unit. As doors have lower overall thermal performance, the higher the number of doors, the more difficulty designers may encounter in achieving TEDI thresholds.

Second, airtightness becomes increasingly important for larger buildings in colder climates – indeed, even small improvements in airtightness in these archetypes and situations yield significant improvements in TEDI for lower costs than other upgrades. Airtightness values of less than 1.0 ACH_{50} will help to cost-effectively reach the TEDI targets. Finally, cold-climate air source heat pumps become a viable choice in mechanical systems.

3.2.5 Window to Wall Ratios

An analysis of the impact of window-to-wall ratios (WWR) on the achievement of Step Code performance requirements was not conducted using the results of this study, as the tool used (i.e. HOT2000) does not allow for a sensitivity analysis on this particular building feature. However, other recent studies point to numerous conclusions that can be drawn on this issue. For example, work conducted by Alex Ferguson on window selection found that adding window area only reduces energy use in gas-heated and electric baseboard homes when the primary façade faces south. Increased TEUI was found in homes equipped with heat pumps, as well as homes with added glass in cases where the rear facade faced north, east or west[14]. Where wall R-values are increased beyond R-18, energy savings associated with added glass diminished further. The author concluded that increasing WWR may provide some modest benefits in homes that are optimally oriented, but that in instances where orientation cannot be controlled (e.g. in subdivisions), net energy savings may be negative more often than positive. This impact changes when exploring for TEDI, where an increased WWR would instead have positive results. However, the overall impact on TEUI, utility bills, and occupant comfort would likely be negative. These findings are supported by an analysis by Gary Proskiw on Identifying Affordable Net Zero Energy Housing Solutions[15].

3.2.6 Equity and Affordability

One of the central research questions of this project centred on determining how equitable the Step Code performance requirements were for various steps and archetypes. In other words, do the Step Code performance requirements adversely impact certain build types in certain climate zones, and do these impacts make affordability potentially worse for home buyers with limited budgets in northern communities?

The results show that the 10-Unit MURB archetype achieves the most "equitable" results of any of the building archetypes analyzed (i.e. the most affordable regardless of climate zone and archetype). For the 10-Unit MURB, all

[14] Ferguson A (n.d). Window Selection Guide. CanmetENERGY, NRCan.

[15] Proskiw G (2010). Identifying Affordable Net Zero Energy Housing Solutions. Prepared for Alex Ferguson, Sustainable Building and Communities, CanmetENERGY, NRCan.

steps in all climate zones can be achieved for a less than 2% increase in the incremental capital costs. The Row House, Large SFD, and Medium SFD archetypes also show equitable results, as all are able to reach Step 4 for less than 2% across all climate zones (except Large SFD in Climate Zone 4 – 2.4%). For these four archetypes in colder climate zones (7a, 7b and 8), incremental capital costs remain approximately equivalent to, or lower than, results for those in warmer climate zones. These findings indicate that Step Code performance requirements do not unfairly burden buildings in regions with colder climates.

Small SFDs and Quadplex buildings are more problematic in terms of equity, but overall do not present a major discrepancy in incremental capital costs between climate zones. However, these archetypes do typically see upward trending costs to achieve the Step Code in colder climate zones. For example, to achieve Step 5 for the Small SFD, incremental costs range from 7.6% for Climate Zone 5, to 13.1% for Climate Zone 7b. This pattern is repeated for most of the lower steps as well. Incremental costs vary less between climate zones for the Small SFD – Slab on Grade option but do still show an increasing trend in colder climate zones. The Slab-on-Grade option can however achieve nearly all steps for less than 5%, except for Step 5.

3.2.7 Unintentionally Increasing GHG Emissions

One of the goals of this study is to identify potential unintended outcomes associated with the current Step Code metrics. In this regard, the analysis indicates that Part 9 buildings subject to the Step Code can achieve Steps 3, 4, and 5 while increasing GHG emissions, rather than decreasing (and thereby contributing to the Province's GHG reduction targets). Table 34 below summarizes select examples of such instances for the achievement of Step 3 or above across all climate zones. While these examples were taken from Highest NPV results, a similar outcome can be observed in the lowest incremental capital costs results. In all cases, this increase in GHGs is attributable to a fuel switch from electricity to natural gas for space heating and/or domestic hot water. Though the example table only includes the 10-Unit MURB archetype, results indicate that GHG emissions will also increase in the Quadplex archetype when fuel is switched from electricity to natural gas. As such, implementing the Step Code can result in an increase in GHG emissions in some buildings, even where those buildings achieve the stringent energy efficiency requirements of higher steps. A means of mitigating this issue is the addition of a GHG intensity (GHGI) target, as discussed above and in Section 6.5.

Table 34: Examples of Results in which Achieving Higher Steps Increases GHG Emissions

Archetype	Climate Zone	Step	DHW System	Space Heating System	Change in GHGs from BCBC (%)
10 Unit MURB	4	3	Combination	Combination	+49%
10 Unit MURB	5	4	Combination	Combination	+74%
10 Unit MURB	6	5	Combination	Combination	+44%
10 Unit MURB	7a	3	Combination	Combination	+147%
10 Unit MURB	7b	4	Combination	Combination	+165%
10 Unit MURB	8	5	Combination	Combination	+108%

3.2.8 Appropriateness of Part 9 Targets for MURBs

Another key goal of this study is to explore whether there was any inherent advantage or disadvantage to modelling MURBs in HOT2000 versus an ASHRAE compliant model. As part of the original 2017 Metrics Research Report, low-rise MURBs were modelled both using Energy Plus and HOT2000 to attempt to discern the difference between modelling programs, and how the Part 9 and Part 3 performance requirements impacted similar buildings. It is important to note that this comparison is imperfect, as the archetypes are not identical, and because steps and performance metrics also vary between the Part 9 and Part 3 frameworks. With those qualifiers noted, the results for the costing derived from the use of HOT2000 (Part 9) were lower. For example, achieving Steps 3 or 4 for the 10-Unit MURB in

Climate Zone 4 using HOT2000 yielded an incremental cost of 0.8%. The range for achieving Steps 3 and 4 in Climate Zone 4 using Energy Plus varied between 0.6% and 2.6%. It is important to note, however, that in both cases the results for this archetype were some of the most affordable and cost-effective, regardless of the energy modelling tool or the framework applied. Most results in both cases had an incremental capital cost less than 1%. This analysis was not replicated for the updated performance targets, but the results remain relevant for this 2018 update.

3.2.9 Typical Energy Conservation Measures

Finally, modelled results were analyzed to identify the most common ECMs used to achieve the various Step Code levels for each archetype. Results from the lowest ten incremental capital costs were used to generate an analysis of each specific ECM, which is presented and discussed in Figure 23 through Figure 33 below. These figures summarize results across all Part 9 building archetypes and climate zones. Detailed tables for each building archetype across all climate zones are given in Appendix 8.11.

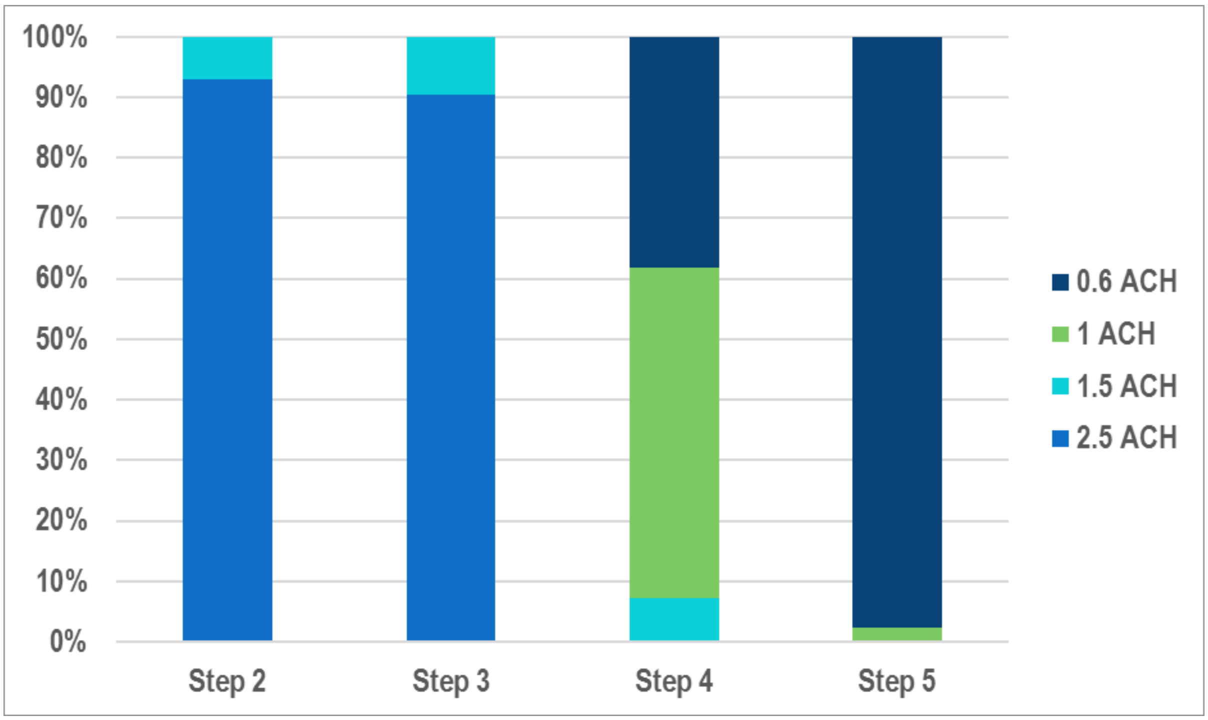


Figure 23: Typical Airtightness Values across all Archetypes and Climate Zones

Figure 23 clearly shows an increase in airtightness levels with each step of the Step Code. Projects built to Step 2 can be expected to have airtightness levels of 2.5 ACH_{50}, while projects built to Step 5 can be expected to almost exclusively have levels of 0.6 ACH_{50}.

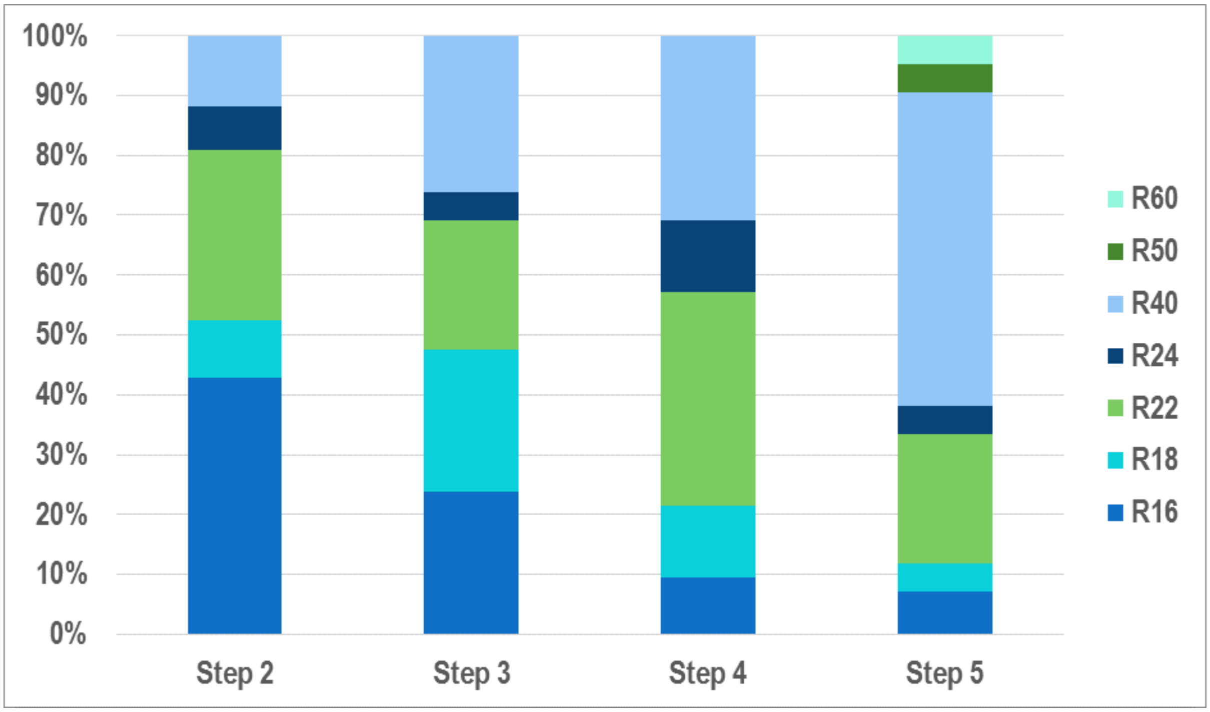


Figure 24: Typical Wall R-Values across all Archetypes and Climate Zones

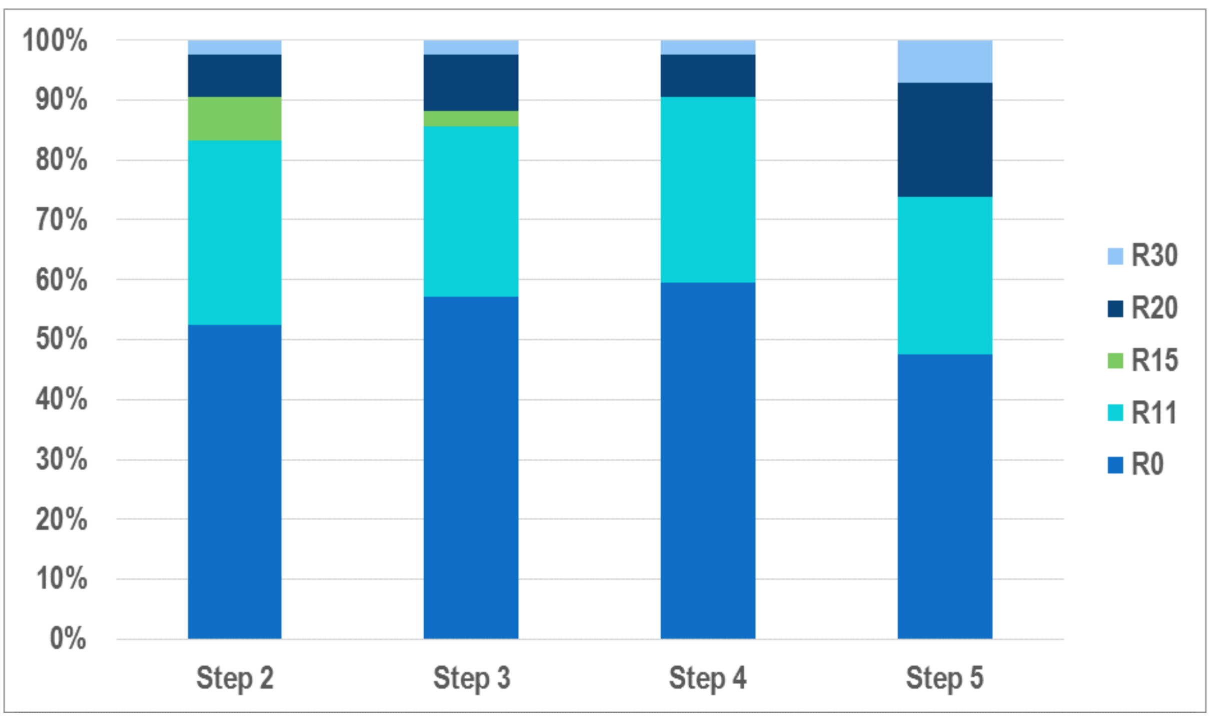


Figure 25: Typical Underslab R-Values across all Archetypes and Climate Zones

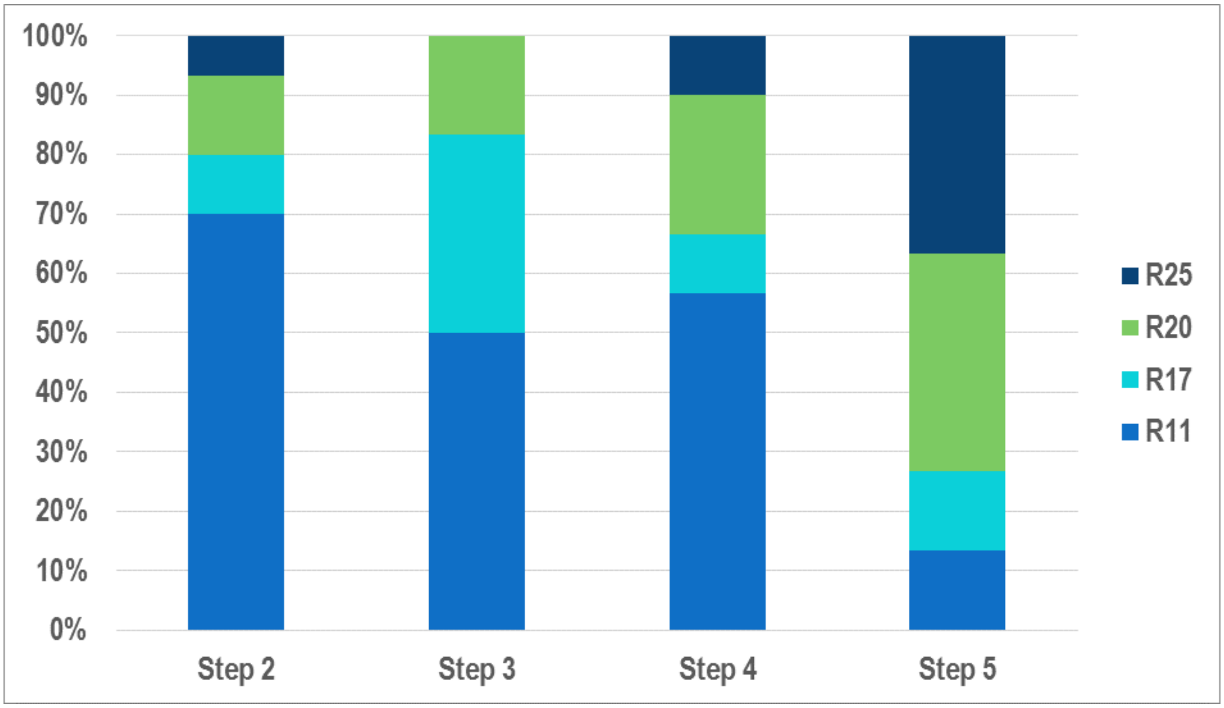


Figure 26: Typical Foundation R-Values across all Archetypes and Climate Zones

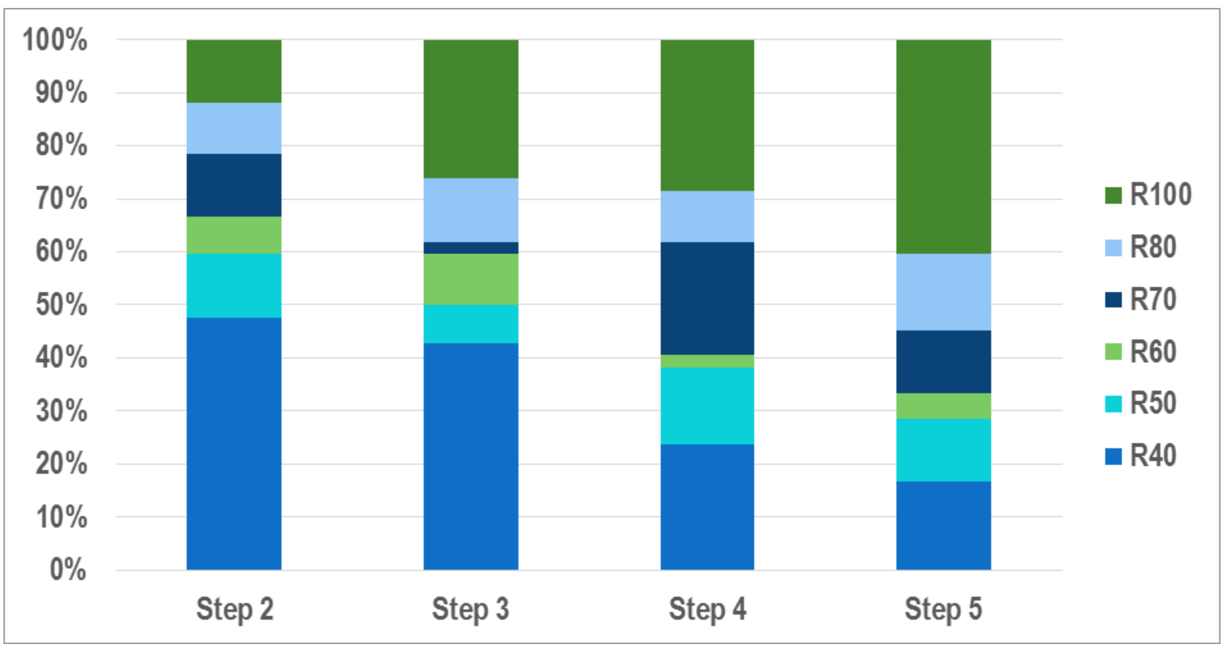


Figure 27: Typical Ceiling / Roof R-Values across all Archetypes and Climate Zones

Figure 24 through Figure 27 all show a likely increase in wall, underslab, foundation, and ceiling/roof R-values, respectively, from Step 2 to Step 5. However, these figures also show that a broad range of values are suitable for meeting the performance targets associated with higher steps. This indicates that projects built to higher levels of the Step Code will have flexibility in their approach to insulation in the building envelope.

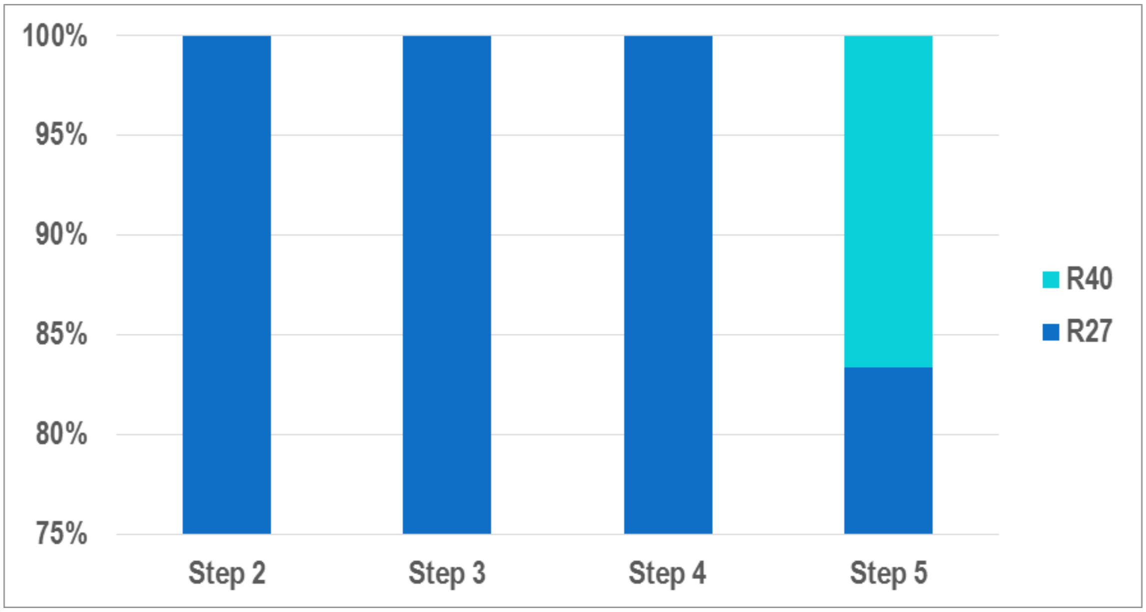


Figure 28: Typical Exposed Floor R-Values across all Archetypes and Climate Zones

Conversely, Figure 28 shows that an exposed floor R-value of 27 is the most frequent level of insulation used to meet the Step Code. Projects built to the Step Code can therefore expect to require a minimum exposed floor insulation value of R27, but may occasionally need to apply R40 for Step 5.

Figure 29 shows increasing requirements with increasing steps. Projects built to Step 2 can expect to use double-glazed windows; projects seeking Step 5 will not reach performance targets without using triple-glazed windows.

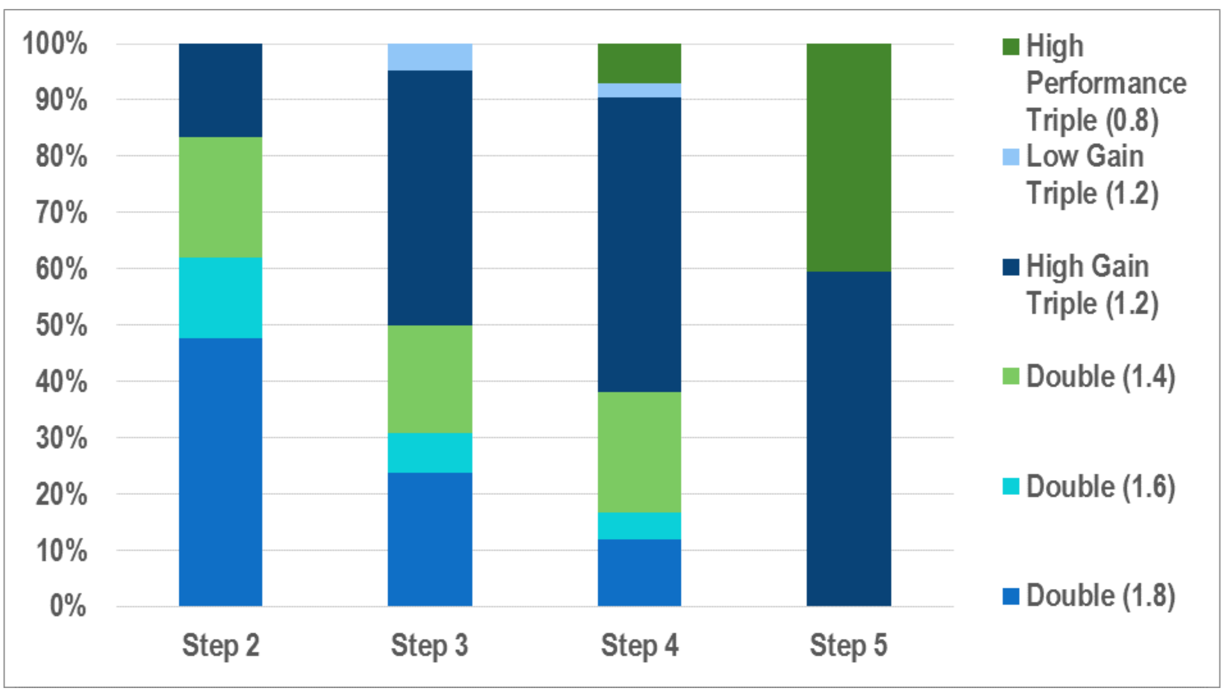


Figure 29: Typical Window Options & U-Values across all Archetypes and Climate Zones

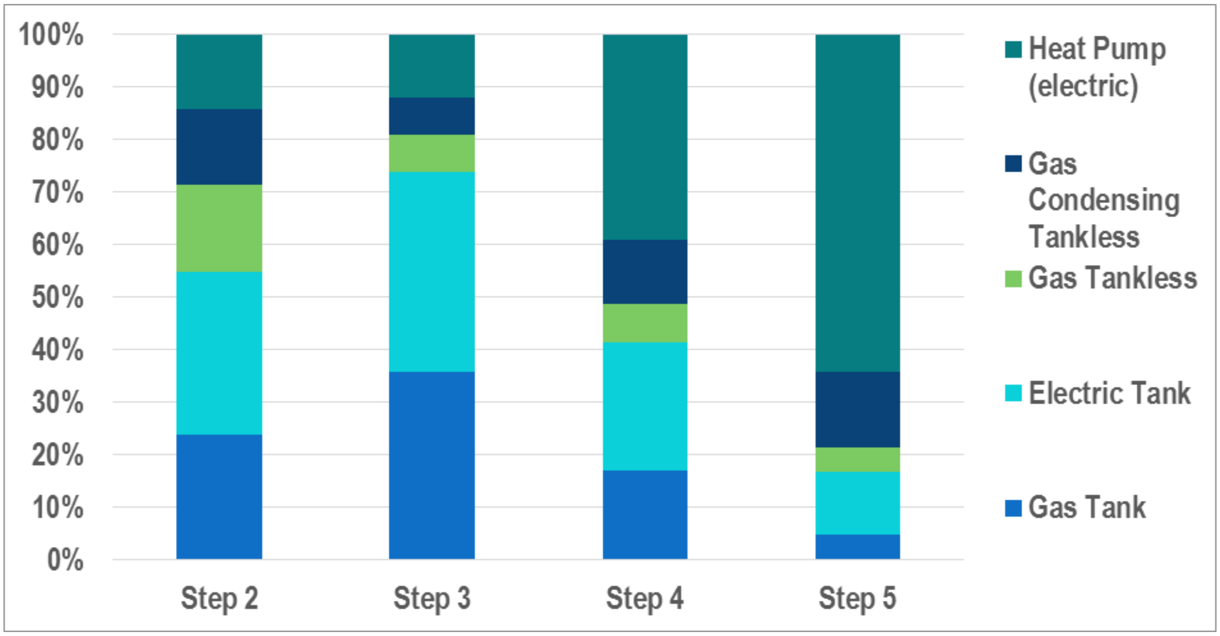


Figure 30: Typical Domestic Hot Water Systems across all Archetypes and Climate Zones

With respect to DHW system solutions, Figure 30 shows a broad range of possible DHW system types for use in achieving all steps of the Step Code. This indicates that projects will have flexibility in their choice of domestic hot water system. Step 5, however, predominantly requires the use of an electric heat pump. This will have a positive impact on reducing GHG emissions. Figure 31 shows that drainwater heat recovery is typically not needed to achieve any level of the Step Code, indicating that in many cases, drainwater heat recovery need not be prioritized when building to the Step Code.

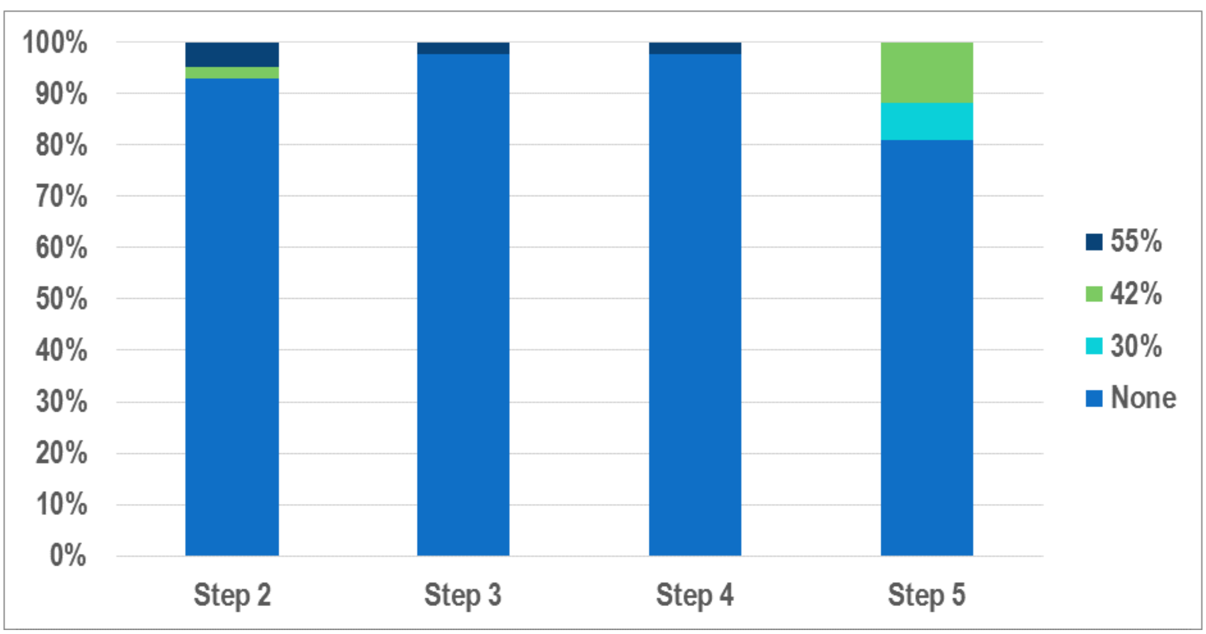


Figure 31: Typical Drainwater Heat Recovery Efficiency across all Archetypes and Climate Zones

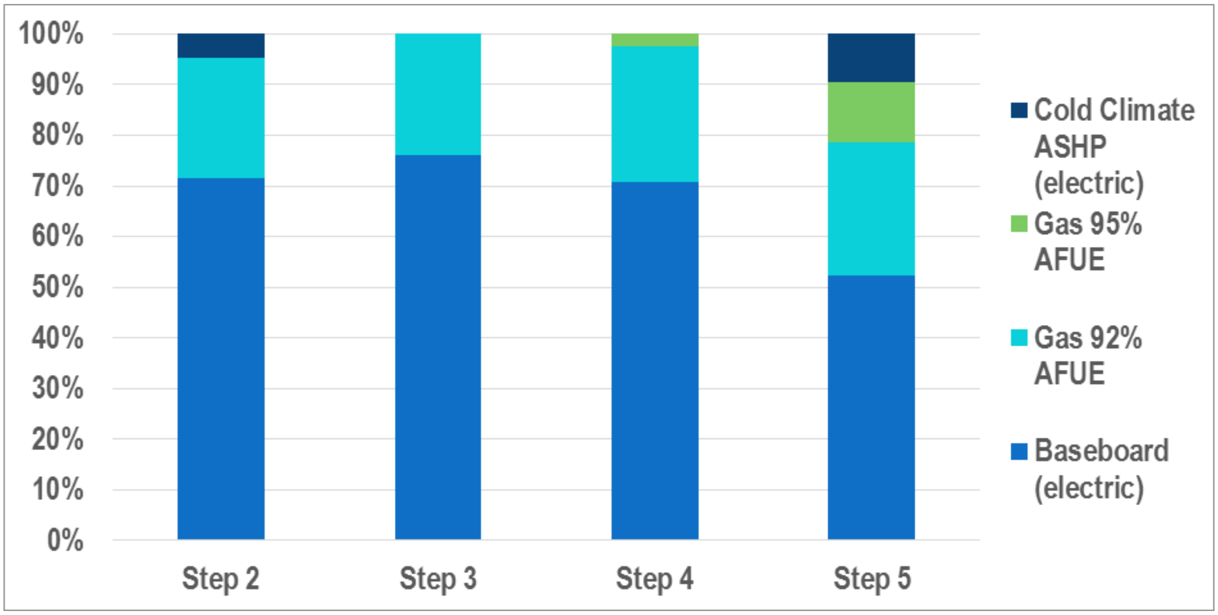


Figure 32: Typical Space Heating Systems across all Archetypes and Climate Zones

With respect to HVAC systems, Figure 32 shows that electric baseboard heaters are predominantly the most cost-effective solution for space heating for all steps. However, the range of potential systems that meet the Step Code indicate that there is flexibility in the selection of space heating systems. As discussed in Section 3.2.7 above, selecting a natural gas-based system will likely result in increased emissions over the baseline BC Building Code. Similarly, Figure 33 shows increasing percentages of ventilation heat recovery with higher steps of the Step Code, but with broad variation in value. As with many of the other ECMs described above, projects built to the Step Code will have flexibility in their approach to ventilation heat recovery.

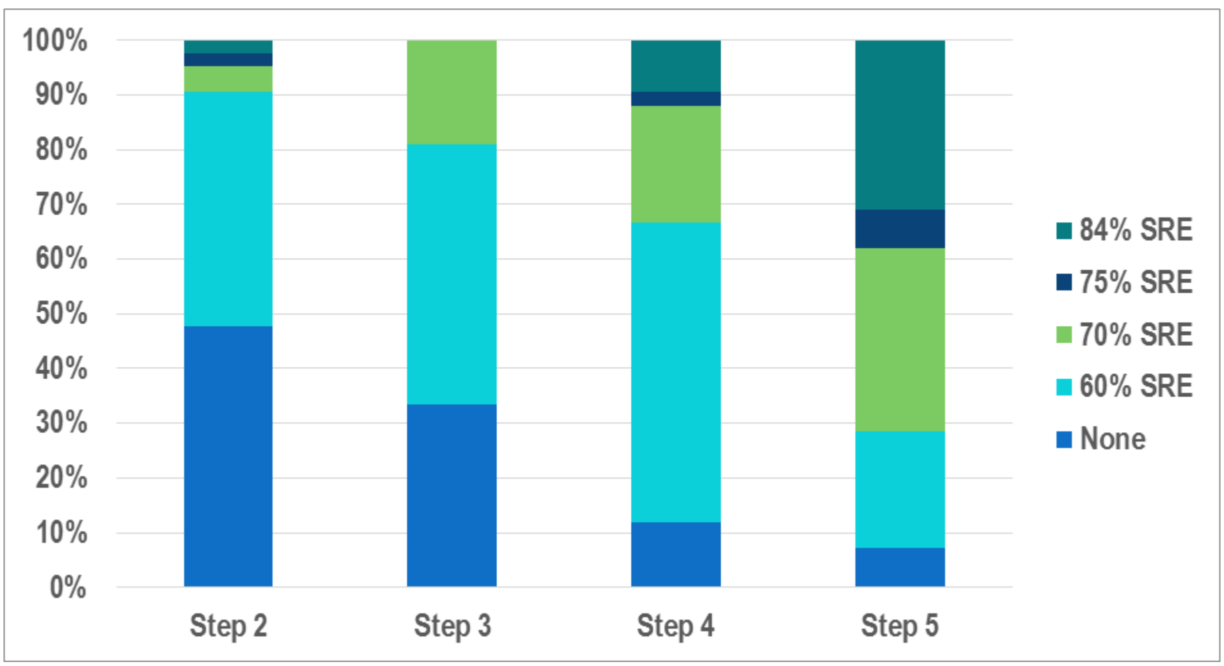


Figure 33: Typical Ventilation Heat Recovery across all Archetypes and Climate Zones

4 THE IMPACT OF CLIMATE AND SIZE ON PART 9 REQUIREMENTS

4.1 Climate Zone

A key objective of this study was to investigate the impacts of Step Code performance requirements on the affordability and constructability of key Part 9 building types across climate zones. The need to address concerns around affordability was already built into the original Part 9 performance requirements developed for the Step Code. Targets were normalized for climate zone using a sample of HOT2000 files based on completed projects, and then adapted to represent 10%, 20%, and 40% improvements over the base code's compliance path for whole building energy use for each climate zone. For Step 5, an option was given to achieve Passive House levels of performance (using Passive House modelling software), which were not normalized for climate, but were instead held constant across climate zones. The results of this exercise were used by the Province of BC to determine the original climate-adjusted set of Mechanical Energy Use Intensity (MEUI), Peak Thermal Load (PTL), and Thermal Energy Use Intensity (TEDI) metrics used in the original 2017 Metrics Research study.

The original 2017 Metrics Research Report, indicated higher costs were associated with achieving the Step Code in colder climate zones for Part 9 buildings. While it is important to note that this is *also* the case for the building code[16] , the Step Code is targeting comparable levels of effort across climate zones. As noted in Section 1.4, this is the primary rationale for why the performance requirements have been adjusted. These changes are designed to produce results that minimize affordability impacts of the Step Code in northern climates, but that are still effective in reducing energy and carbon emissions.

Equipment and Systems targets were adjusted by shifting the MEUI targets across all climate zones to provide more comparable requirements throughout the province. As described in Section 2.3.3, MEUI was further adjusted for designs with cooling to remove the disincentive to provide cooling when necessary.

Envelope targets were adjusted by shifting the TEDI targets across all climate zones to provide more comparable requirements throughout the province. While the original Envelope targets offered an option of meeting either a Peak Thermal Load target or a TEDI target, Peak Thermal Load has been removed to simplify compliance and to remove a loophole that potentially allowed lower performance than the base BC Building Code for larger homes in warmer climates.

4.2 Building Size

A second key component of this research was to determine whether Step Code performance requirements should be adjusted according to dwelling size. Interest in this aspect of the research is partially founded in findings from other markets that have used performance-based frameworks with energy intensity metrics. This research has demonstrated that these frameworks can be more difficult for smaller buildings to achieve. This can especially be the case in residential buildings, where major energy consumers in the home are not dependent on size. For example, housing units almost always have a kitchen and laundry facility, regardless of the home's size.

The original analysis of Part 9 buildings presented in the original 2017 Metrics Research Report indicated a much greater challenge for smaller homes to achieve Step Code values than larger homes, in that cost premiums were higher in smaller dwellings when compared to larger homes. Moreover, it should also be noted that there were select cases in which the results of parametric analysis were not able to yield any solutions that met the Step Code performance requirements using the ECMs provided in smaller homes. To improve equity for smaller buildings, MEUI was adjusted as described in Section 2.3.3. This additional MEUI allowance for small buildings has improved the Small SFD results compared to the original study resulting in significant incremental capital costs reductions.

[16] Due to the higher stringency and higher cost multiplier associated with the base building code

4.3 Incremental Costs Comparison

The incremental capital costs for the original and updated Part 9 performance metrics are compared by building archetype in Figure 34 through Figure 40 below. The comparison clearly indicates improved equity across climate zones and building size with the updated performance targets. Items marked with a question mark (?) in the figures below indicate scenarios where the parametric analysis did not yield any solutions that met the Step Code performance.

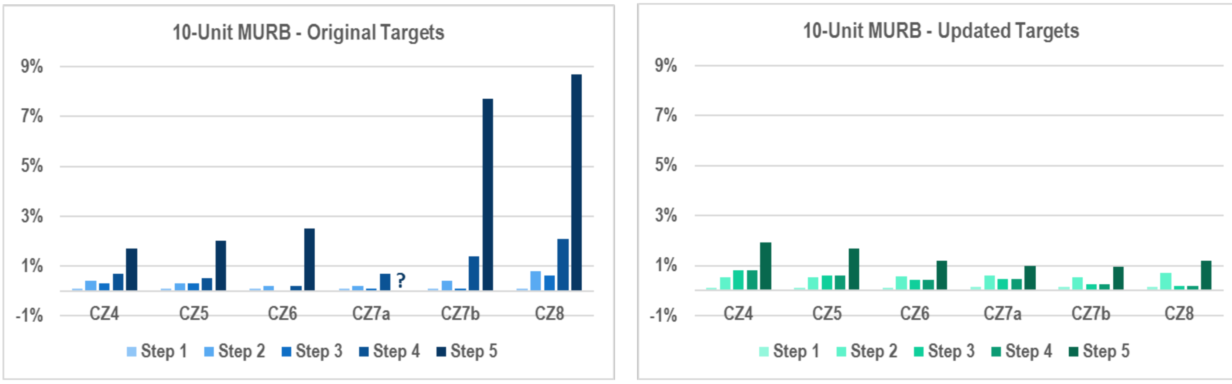


Figure 34: MURB Incremental Costs - Original vs Updated Targets

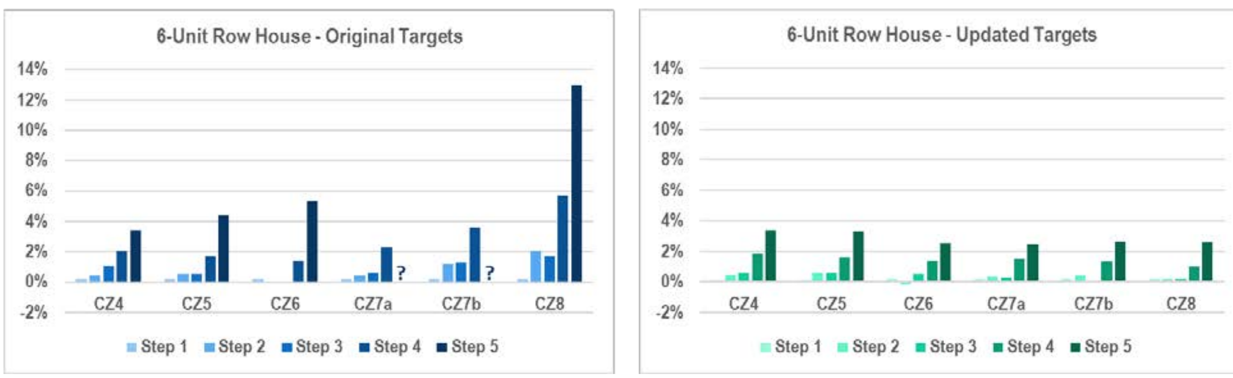


Figure 35: Row House Incremental Costs - Original vs Updated Targets

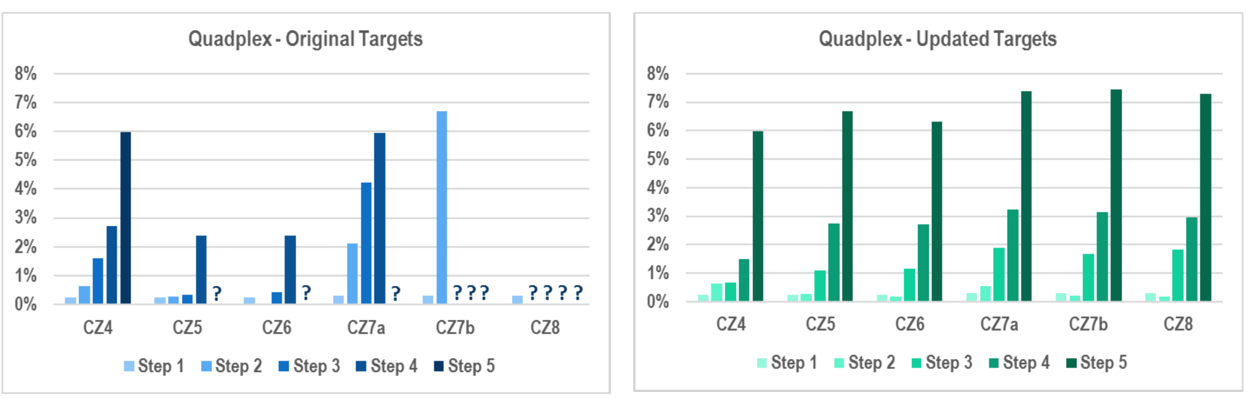


Figure 36: Quadplex Incremental Costs - Original vs Updated Targets[17]

[17] Quadplex Original Target results are for updated modelling using 8-hour ventilation, see Section 5.2.2

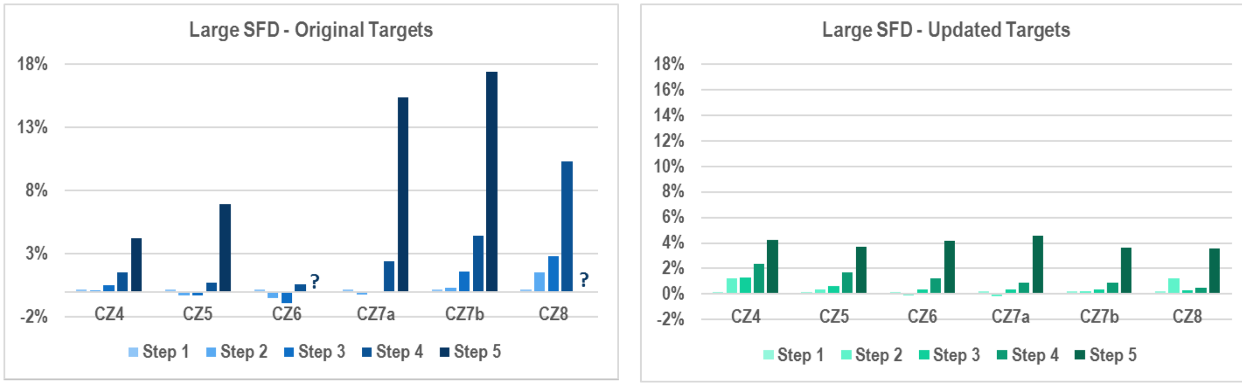


Figure 37: Large SFD Incremental Costs - Original vs Updated Targets

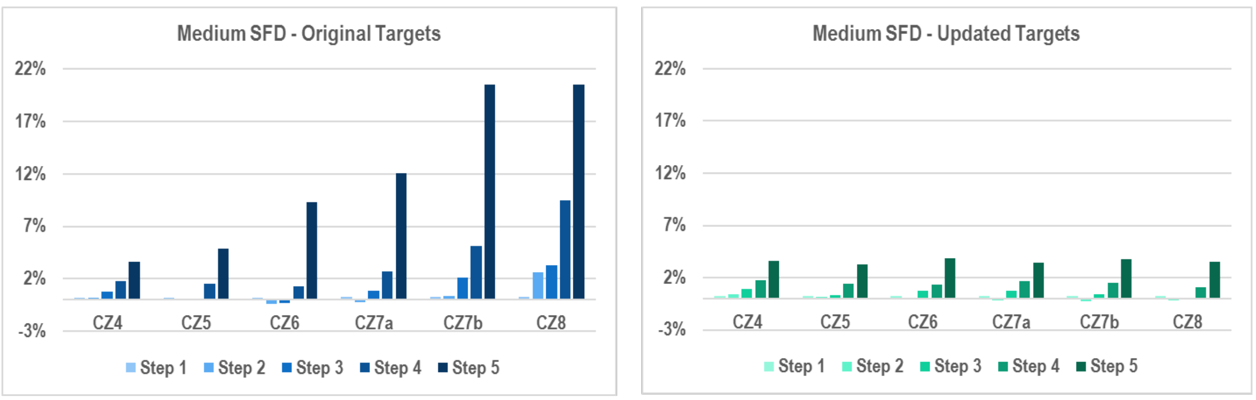


Figure 38: Medium SFD Incremental Costs - Original vs Updated Targets

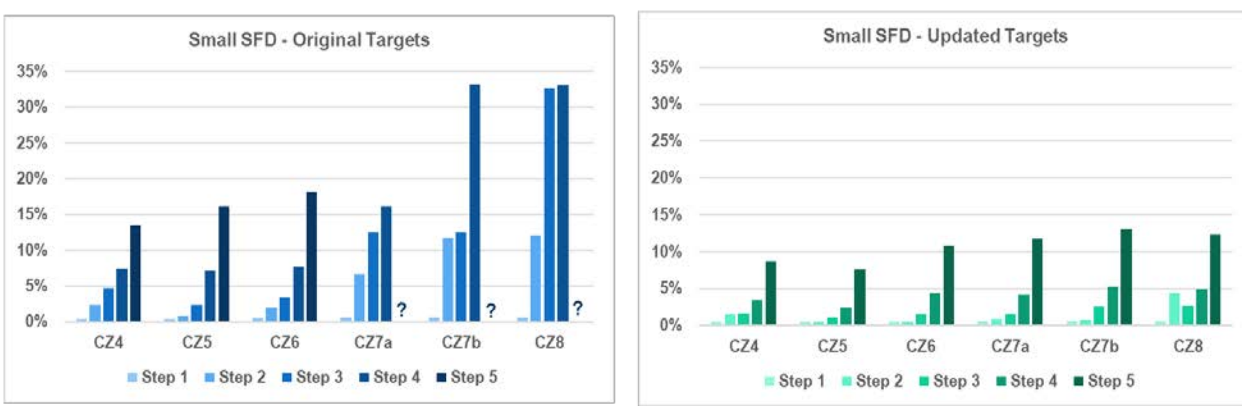


Figure 39: Small SFD Incremental Costs - Original vs Updated Targets

Figure 40: Small SFD Slab on Grade Incremental Costs - Original vs Updated Targets[18]

[18] Small SFD Slab on Grade Original Target results were generated by applying the original targets to the newly modelled Small SFD Slab on Grade results

5 THE STEP CODE—BUILDING POLICY INTERFACE

This section explores the interface between the Step Code and BC Building Code (BCBC). This intersection is important to explore to identify any potential conflicts or contradictions between the two codes, as well as to identify opportunities to provide further guidance or changes to ensure their harmony. Issues covered in this section include an exploration of ventilations requirements for both Part 3 and Part 9 buildings, as well as minimum R-value requirements under the BCBC.

5.1 Part 9 R-Values

Two research questions outlined by this study pertain to the intersection of the Step Code with BCBC requirements. First, to explore the potential for the Step Code to allow using wall assemblies with lower R-values than the BC Building Code's prescriptive requirements to construct Part 9 buildings. Secondly, it is important to determine whether performance steps can be achieved using R-values less than R-22 effective (i.e. the minimum value set out by the Vancouver Building By-law). Such questions are of interest principally due to a stated principle raised during the Step Code development process to encourage the use of passive design over mechanical solutions. It was deemed important to ensure that wherever possible, savings should be derived primarily from the building envelope. As lower R-values place greater reliance on buildings' mechanical systems to provide indoor heating and cooling, it is important to identify where lower R-values might be permitted.

With respect to the first question, the analysis shows that it is possible to achieve the Step Code in Part 9 buildings with lower wall R-values and/or higher window U-values than those prescribed in BC Building Code in climate zones 5 and above. These results are presented in Table 35. These numbers are based on the solutions optimized for incremental capital costs. Wall solutions varied according to the inclusion or exclusion of an HRV as a part of the total ECMs used to achieve performance requirements, as per Section 9.36 of the BCBC. It should be noted that while these findings are based on a small set of optimized results, they likely indicate that many more instances exist in which the Step Code can be achieved using wall and window assemblies that fall below what is prescribed by the BCBC.

Based on a review of optimized solutions for incremental capital costs, it was also determined that buildings across several climate zones may be constructed using walls that fall below an R22 effective level of performance to achieve Steps 2, 3, 4, and even 5 (one example MURB in climate zone 6). While this is an important finding, it is also important to bear in mind that such results can also be achieved under the current Building Code's performance pathway, as the purpose of the performance pathway itself is to allow for a multitude of solutions that allow builders to optimize to their needs.

Table 35: Part 9 R-Values that fall below BCBC Prescriptions when Optmizing for Incremental Captial Costs

Archetype	Climate Zone	Step 2 (Windows)	Step 2 (Walls)	Step 3 (Windows)	Step 3 (Walls)	Step 4 (Windows)	Step 4 (Walls)	Step 5 (Walls)
10-Unit MURB	4							
	5		R-16					
	6	1.8		1.8		1.8		R-16
	7a	1.8		1.8		1.8		
	7b	1.8		1.8		1.8		
	8	1.6		1.8		1.8		
6-Unit Row House	4							
	5						R-16	
	6	1.8	R-16	1.8	R-16			
	7a	1.8	R-16	1.8	R-16		R-16	
	7b			1.8			R-16	
	8	1.8		1.8			R-16	
Quadplex	4							
	5							
	6	1.8						
	7a							
	7b							
	8							
Large SFD	4							
	5				R-16			
	6	1.8						
	7a							
	7b							
	8	1.8						
Medium SFD	4							
	5		R-16		R-16			
	6	1.8	R-16		R-16		R-16	
	7a	1.8			R-16			
	7b	1.8			R-16	1.6		
	8	1.8		1.6				
Small SFD	4							
	5		R-16					
	6				R-16			
	7a							
	7b							
	8	1.8						
Small SFD – Slab on Grade	4							
	5		R-16					
	6		R-16					
	7a							
	7b							
	8							

While they do not explicitly address this issue, local governments may also wish to consider developing zoning policies that allow for wall thickness exclusions or floor area ratio relaxations for better performing walls. This practice has already been implemented in the Cities of Vancouver and New Westminster to effectively remove the incentive for builders to construct thinner walls as a way of increasing total saleable floor area.

5.2 Ventilation Requirements

Two issues related to the implementation of the Step Code that were evaluated in this report are relevant to ventilation. The first considers the design of ventilation systems in Part 3 buildings, while the second relates to how Part 9 buildings are modelled within the EnerGuide Rating System. Both are presented in the sections below.

5.2.1 The Impact of Different Ventilation Standards on Part 3 Step Code Targets

For Part 3 buildings, the BCBC requires compliance with ASHRAE 62-2001, excluding Addendum n. Addendum n of ASHRAE 62-2001 introduced a substantially different methodology to calculating outdoor air requirements in buildings, recognizing that ventilation rates could be lowered in buildings if the air was delivered efficiently. ASHRAE 62-2004 Addendum h, however, changed the outdoor air requirements for residential dwelling units, primarily from having exhaust driven requirements to being treated like any other commercial type space with both a ventilation rate for people and for floor area. This change led to higher ventilation rates in larger suites, where the overall outdoor air requirements are driven by the floor area. The National Building Code (NBC), and the provinces that predominantly base their code on the NBC, have maintained their reference to ASHRAE 62-2001, excluding Addendum n, avoiding the major changes implemented by ASHRAE 62 over subsequent years.

A comparison was done to a more recent version of ASHRAE 62.1-2010, which is referenced by other jurisdictions (e.g. Ontario), as well as LEED v4. Figure 41 shows the design ventilation rate for different sizes of two-bedroom suites with three occupants according to ASHRAE 62-2001 and 62.1-2010. For very small suites, the two codes produce similar ventilation rates. At more typical floor areas for two-bedroom suites, the 2010 version of the code requires up to 46% more outdoor air than the 2001 version. The ASHRAE 62-2001 results are used for all other sections of this report.

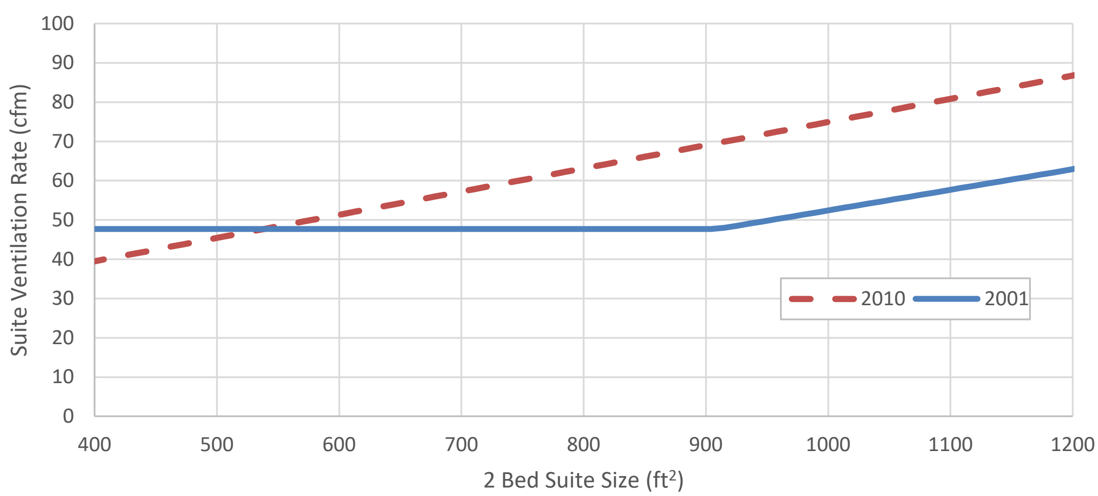


Figure 41: Two Bedroom Suite Ventilation Rates for ASHRAE 62.1-2001 and 2010

The energy implications of higher ventilation rates are affected by several factors, including climate zone, the use of heat recovery ventilation, and the magnitude of other building loads.

Figure 42 shows the impacts of different ventilation code versions on TEUI and TEDI for the recommended solutions for meeting Step 2 of the Step Code for each climate zone. All solutions include 60% efficient heat recovery ventilation and pertain to low occupancy densities. The results show an increase of over 40% in ventilation rates between 2001 and 2010 versions of ASHRAE 62. This change is most pronounced in Fort St. John (Climate Zone 7a), resulting in a 9 kWh/m^2 increase in TEUI, and an 8 kWh/m^2 increase in TEDI – an increase similar in magnitude to one step of the Step Code. In Vancouver (Climate Zone 4), the milder climate reduces the influence of ventilation rates and shifting from 2001 to 2010 versions of the code increases TEUI by 5 kWh/m^2, and TEDI by 4 kWh/m^2.

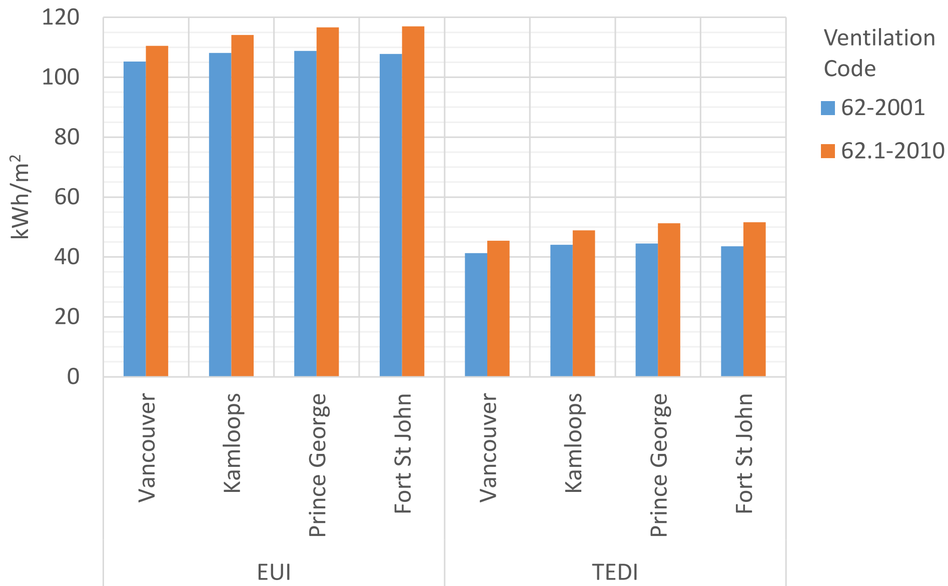


Figure 42: Impact of Ventilation Code on MURB TEUI and TEDI

Another important ventilation implication for MURB is the practice of corridor pressurization. This involves supplying corridors with substantially more air than what is required by code to pressurize the corridor to overcome stack effect forces and to minimize odour transmission between suites and the corridors. As it is difficult to design a corridor pressurization system that utilizes heat recovered air, this approach can significantly impact the TEDI and subsequently, the TEUI. The expectation is that over time, as buildings get more air tight and designers use new ways to manage stack effect and odours, the practice of corridor pressurization will be eliminated. All targets presented in this report are in line with the City of Vancouver's Energy Modelling Guidelines, which give an allowance of up to 9.4 L/s/suite (20 cfm/suite) of corridor pressurization at no penalty to the TEDI or TEUI.

For Commercial and Retail buildings, outdoor air requirements are typically lower in ASHRAE 62-1-2010 compared to ASHRAE 62-2001. As such, there is no risk to complying with the performance requirements for non-residential facilities due to ventilation.

5.2.2 The Impact of Ventilation Assumptions on Part 9 Modelling Results

With respect to Part 9 buildings, the Building and Safety Standards Branch Information Bulletin No. B14-05 issued in September 17, 2014, states that "*to satisfy the exhaust requirements of a principal ventilation system, every dwelling unit needs to have one fan that exhausts air continuously (24hr/day) at the minimum exhaust rates outlined in Table 9.32.3.5*." [19] However, the Building and Safety Standards Branch allows the use of the EnerGuide Rating System to demonstrate compliance with energy performance requirements of the BCBC, which assumes that the principal ventilation system operates for only 8 hours a day. This presents a challenge, in that there can be significant implications for both the MEUI and TEDI in using an assumption for either 24-hour or 8-hour ventilation.

In order to investigate the impact of this discrepancy, the original 2017 Metrics Research study modelled the 10-Unit MURB and the Large SFD archetypes in HTAP twice: once with continuous (24-hour) ventilation and once with intermittent ventilation set at 8 hours per day. Permutations with the same or very similar ECM combinations were modelled under both 8 hr and 24 hr ventilation modes. Permutations from multiple climate zones (Zones 4, 5 and 8 for

[19] http://www.housing.gov.bc.ca/building/B14-05_9%2032%20_Ventilation.pdf

the Large SFD, and all zones except 7b for the MURB archetype) were included, as well as those that achieved multiple steps of the Step Code.

The outcomes of this exploration can be found in Appendix 8.12, and remain relevant for this 2018 update. The sample of results where all ECMs are identical, but ventilation rates are different, indicates that assuming 24-hour ventilation rather than 8-hour for the Large SFD increases MEUI and TEDI by an average of 8% and 7%, respectively. The difference in MEUIs ranges from 3% to 15% and difference in TEDIs from 0% to 16%, across all climate zones. The impact of different ventilation assumptions is greater and more varied for the MURB. Based on the selected samples, shifting from 8-hour to 24-hour ventilation increases the MURB's average MEUI and TEDI by 15% and 10%, respectively, with ranges of 9% to 21% and 0% to 20%, respectively.

Overall, these results demonstrate that the ventilation assumptions applied in modelling buildings can have a significant impact on energy performance, and thus what step a building achieves. As such, there is a need for clarity in the regulation and guidelines for compliance to both the BCBC and the Step Code issued to Energy Advisors who model ventilation to ensure consistent results.

It should be noted that costing analyses for Part 9 buildings assumed an 8-hour ventilation rate for all six building archetypes. However, the original 2017 Metrics Research Report, used a 24-hour rate for the Quadplex archetype. Original study results have been updated for the Quadplex to instead use an 8-hour ventilation rate. Comparisons shown throughout this report referencing the original study use these 8-hour ventilation Quadplex results and as such are slightly different from what was reported in the 2017 Metrics Research Report.

6 DESIGN AND INDUSTRY IMPACTS

A final component of this study is to identify the potential risks that may be posed as a result of the implementation of the Step Code, as well as any conflicts with existing tools or regulations. The sections below, implications for overheating and thermal comfort, fire safety, and building durability are explored first, followed by a summary of the alignment of the Step Code with two existing building energy performance tools (Energy Star® Portfolio Manager and EnerGuide) and the City of Vancouver's Zero Emissions Building Plan.

6.1 Risk of Overheating

6.1.1 Part 3

The City of Vancouver commissioned a study that assessed the impacts of the City's Zero Emissions Building Plan (ZEBP) on overheating in typical suites using passive cooling[20]. The study uses energy modeling to assess the risk of overheating for MURB with no active cooling systems to compare the risk of overheating between conventional practice and buildings complying with the ZEBP. It was found that current typical practice could cause up to 1000 overheated hours per year for the modelled, worst-case suites (i.e. southwest facing). The updated ZEBP that encourages improved envelopes (roughly equivalent to Step 3 of the Step Code) increases the number of overheated hours by an additional 100 - 1300 overheated hours per year, depending on suite type. It is reasonable to assume that implementing the Step Code could have similar impacts. For buildings with no active cooling, overheating can be mitigated using typical approaches, such as properly sized windows for adequate natural ventilation, reduced solar heat gain coefficient on windows, and external overhangs in the form of balconies or sunshades. When these typical measures are applied, the maximum temperature experienced in a suite has been shown to be under 30°C for Vancouver.

The Vancouver study also investigated a number of passive cooling strategies to mitigate this overheating and compared the costs of those strategies with the cost premium of adding mechanical cooling. Several design strategies were identified that allow the suites to reduce overheating to below 200 hours per year. Natural ventilation through larger operable windows, and shading provide savings without adding a cost premium to current typical practice. Other solutions, such as reducing solar heat gain through carefully selected window coatings, cost no more than installing a mechanical cooling system. Warmer climates in BC outside of Vancouver typically use mechanical cooling, and if not mechanically cooled, may require additional measures to limit overheating than what was studied for the City of Vancouver. Mechanical cooling is also becoming more common in new construction projects in Climate Zone 4. Passive cooling techniques will help to lower TEUI for the buildings with mechanical cooling. Balancing mechanical and passive cooling options should be addressed on a project by project basis as indicated in the energy modelling guidelines.

6.1.2 Part 9

The same risks of designing homes that could have thermal comfort problems related to overheating that were outlined for Part 3 buildings apply to Part 9 buildings. Caution should be taken to ensure that buildings with highly heat-retentive envelopes and high solar gain glazing do not overheat, even in colder climates. This is particularly the case with the Small SFD, where overheating presented a potential problem at higher levels of the Step Code in Climate Zones 4, 5 and 6, and various levels in Climate Zones 7a, 7b and 8. As discussed in Section 2.3.3, the MEUI allowance has been adjusted to accommodate buildings designed with cooling systems. This additional allowance aims to mitigate the overheating risk in buildings built to the higher levels of the Step Code.

One key issue to note is that HOT2000 is not well suited to diagnosing overheating as a potential issue. An experienced energy modeller may realize from looking at the heating requirements of the home and derive that the home has the potential for over-heating. However, explorations into the development of a robust methodology to address this concern

[20]Morrison Hershfield (2017), Passive Cooling Measures for Multi-Unit Residential Buildings, Prepared for City of Vancouver. https://vancouver.ca/files/cov/passive-cooling-measures-for-murbs.pdf

is necessary. One methodology that could be explored is the approach used in developing the CHBA Net-Zero label. Absent of this, designers should be encouraged to moderate solar gain and consider mechanical cooling where appropriate in buildings targeting Steps 4 and 5. This can be done through design with solar shading devices, window selection and placement and natural ventilation strategies, or through the selection of mechanical solutions such as heat pumps. The ability to also provide cooling is an advantage of heat pumps versus other heating system options.

6.2 Fire Safety

Proposed design solutions associated with both lowest cost premiums and highest NPV for each building archetype were reviewed to assess any additional risk to fire safety.[21] Results of this review indicated that that none of the solutions proposed increase either the risk of fire or the ability of occupants to exit the building in an emergency.

However, it is important for building designers to continue to conform to provincial, and where applicable, municipal requirements vis-à-vis fire safety. This includes the need to provide egress to allow occupants to exit the building during an evacuation, as well as the use of non-combustible insulation materials.

6.3 Building Durability

All proposed solutions and wall assemblies likely to be employed as a result of pursuing Part 3 Step Code performance requirements were reviewed by Morrison Hershfield's Building Science Division. They found that while poor design or construction is always a risk, the proposed thresholds presented no more of a risk than current construction practices. It is also important to note that the building envelope professional review and sign off requirements for Part 3 will still be in effect to ensure that building durability will not be compromised.

While there are no requirements for professional review and sign off on building envelope performance for Part 9 buildings, an understanding of building science is increasingly critical with the implementation of the Step Code. As members of the construction industry are required to build increasingly thicker walls and more airtight homes, there is less margin for error with regards to possible moisture issues. This risk can be mitigated by placing insulation on the exterior of the envelope and outside the vapour barrier, but this is not a standard practice across the industry. As a result, more training and resources in correct design and installation for the achievement of airtight corners and windows will be required to support industry as higher steps are broadly implemented.

6.4 Industry Alignment

6.4.1 Energy Star® Portfolio Manager

Energy Star® Portfolio Manager is an interactive, web-based tool used to measure and track energy and water consumption in Part 3 buildings. It has become a widely used tool in energy benchmarking, reporting and disclosure policies across North America, and has been noted as the primary tool to calculate energy and emissions for compliance with the Canada Green Building Council's recently released Zero Carbon Building Standard.

In its current form, Energy Star® Portfolio Manager allows for a calculation of TEUI, but does not allow for the calculation of TEDI. Further, it should be noted that the final calculation of TEUI within Portfolio Manager should not be expected to correlate with modelled results, as the energy modelling guidelines cited by the Step Code require the use of select normalized inputs. While this is important to ensure the comparability between energy models during Step Code compliance checks, it means that any TEUI values in these energy models will not be predictive of actual energy use, and therefore are unlikely to align with reported outcomes in Portfolio Manager. As such, it will be important to make this discrepancy clear in any guidance provided to assist buildings required to comply with the Step Code.

[21] Fire safety reviews were conducted by Integral Group's Fire Protection Engineering Group

6.4.2 EnerGuide Rating System

EnerGuide is the Government of Canada's energy performance rating and labelling program for homes (as well as other energy-using products). The EnerGuide rating system does not explicitly collect or track any of the metrics currently used in the Step Code framework; however, its expanded reports do provide the necessary outputs needed to calculate Thermal Energy Demand Intensity (TEDI), and Mechanical Energy Use Intensity (MEUI). Efforts are currently underway to allow the software to automatically produce a performance path compliance report by pulling the metrics important to the Step Code directly out of a HOT2000 v11.3 XML file. Such an effort would assist in the harmonization between the Step Code and the use of the EnerGuide system, and support consistency within the industry.

6.4.3 The City of Vancouver's Zero Emission Building Plan

Released in 2016, the City of Vancouver's Zero Emissions Building Plan (ZEBP) is Vancouver's step code for Part 3 buildings. The ZEBP differentiates between high and low-rise MURB and provides separate sets of Step Code performance requirements for each building type. In addition to energy use and thermal energy demand intensity performance requirements, the ZEBP also includes thresholds for Greenhouse Gas Intensity (GHGI). In general, the GHGI requirement for ZEBP drives a fuel switch to various degrees depending on the building type and timeline. The discussion below focuses on the TEUI and TEDI differences only.

Table 36 provides a comparison of the City of Vancouver's performance requirements with those outlined in the Step Code. It can be noted that the City of Vancouver's requirements for High-Rise MURB are similar to those established in the Step Code, but start at a higher baseline equivalent to one step higher. The differentiation between the two sets of performance requirements for Low-Rise MURB accounts for the assumption that low-rise buildings will be of wood-frame construction, in which higher levels of envelope performance are possible with minimal incremental cost, and thermal bridging is typically less severe. Wood-frame, or combustible construction, also more easily allows for the installation of higher performance windows with vinyl or fibreglass frames. As such, there is an incentive to use wood-frame construction to meet the low-rise requirements. Low-Rise concrete/steel buildings will be somewhat challenged to meet the City of Vancouver's Low-Rise targets, requiring the use of better-performing materials over what is typical. The comparisons below only consider the TEUI and TEDI requirements between the BC Step Code and the City of Vancouver Zero Emissions Building Plan targets. The GHG targets, which are only applicable to the City of Vancouver requirements are not considered in the comparison.

Table 36: Step Code vs. Vancouver Building Bylaw (VBBL) Performance Requirements

Building	BC Step Code			City of Vancouver (Without a Low-Carbon District Energy System)		
	Step	TEUI (kWh/m²/yr)	TEDI (kWh/m²/yr)	TEUI (kWh/m²/yr)	TEDI (kWh/m²/yr)	COV Rezoning Date
High-Rise MURB	1	Current Code		Current VBBL		VBBL
	2	130	45	120	32	2016 Rezoning
	3	120	30	100	18	2020 Rezoning*
	4	100	15	90	10	2025 Rezoning*
Low-Rise MURB	1	Current Code		110	25	VBBL
	2	130	45	100	15	2016 Rezoning
	3	120	30	Not Yet Defined		N/A
	4	100	15	Not Yet Defined		N/A
Hotel	1	Current Code		Current VBBL		VBBL
	2	170	30	170	25	2016 Rezoning
	3	140	20	Not Yet Defined		N/A
	4	120	15	Not Yet Defined		N/A
Commercial Office	1	Current Code		Current VBBL		VBBL
	2	130	30	100	27	2016 Rezoning
	3	100	20	100	21	2020 Rezoning*
Other Commercial	1	Current Code		Current VBBL		VBBL
	2	170	30	100	27	2016 Rezoning
	3	120	20	100	21	2020 Rezoning*
Retail	1	Current Code		Current VBBL		VBBL
	2	170	30	170	21	2016 Rezoning
	3	120	20	Not Yet Defined		N/A

**Speculative*

High-Rise MURB

Table 37 summarizes the low-cost solutions for typical High-Rise MURB to meet both the Step Code and City of Vancouver performance requirements. Incremental capital costs for the Step Code thresholds range between 0.4% and 3.2%, while the City of Vancouver's targets result in a range between 1.4% and 3.5%. Most steps require less than a 1% additional incremental capital cost to meet the more stringent City of Vancouver's thresholds over the Step Code performance requirements. The additional cost is usually attributed to improved window performance and heat recovery efficiency. Notably, in Climate Zone 7, the City of Vancouver's requirements cannot be met for Steps 2 and 3 without accelerating the timeline for air infiltration improvements, and Step 4 is not feasible within the parameters modelled. However, it should be noted that high-rise, non-combustible MURB are rare building forms in the north.

Alignment between the Step Code and City of Vancouver's requirements appears possible, where the City of Vancouver could align with Step 3 for the future 2020 VBBL requirements and Step 4 for the future 2020 rezoning requirements. Although the City of Vancouver has indicated a potentially more stringent target in 2025 than Step 4, the improvements are small and could likely be dealt with through the GHGI requirement.

Low-Rise MURB

Table 38 summarizes the lowest cost solutions for typical low-rise, wood-frame MURB that meet Step 2 of the Step Code and the City of Vancouver's 2016 rezoning target. For wood frame buildings, R-40 effective wall assemblies are feasible for relatively low absolute incremental capital costs. However, the lower base buildings costs for low-rise buildings can inflate the incremental capital cost as a percentage of the base building cost. Due to the feasibility of R-40 effective wall performance for wood stud assemblies vs. steel stud assemblies, the City of Vancouver 2016 Rezoning and Step Code Step 4 for Climate Zone 7a is attainable for low-rise buildings, as long as Passive House level air tightness standards are met. The more stringent performance requirement is not achievable in Climate Zone 7b due to TEDI limitations, although this may be addressed by designing for a low VFAR.

Step 2 performance requirements lead to the use of low-rise MURB measures that are similar to current practice, though with the addition of heat recovery ventilation. Aside from Climate Zones 7a and 7b, they also allow for a lower overall glazing performance than current prescriptive code requirements, which is not typical in the market. In general, the Step Code and City of Vancouver performance requirements for low-rise MURB can align in the future. The 2020 VBBL could align with Step 4 of the Step Code.

Hotels

Table 39 summarizes the lowest cost solutions that meet Step 2 of the Step Code and the City of Vancouver's 2016 rezoning target. As the TEUI targets are the same, and high efficiency heat recovery is required in most climate zones, the lower TEDI target for the City of Vancouver results in slightly improved envelope solutions. In Climate Zone 4, only a marginal improvement in wall performance is required. In higher climate zones, more substantial envelope improvements are required to meet a lower TEDI target, resulting in an increase in capital cost up to 0.6%. Neither the City of Vancouver nor BC Step Code Step 2 Target can be met in Climate Zone 8.

Commercial / Retail Buildings

Lowest costs solutions for Commercial Offices and Other Commercial that meet Steps 2 and 3 are presented in Table 41 and Table 42 respectively. Solutions for big box Retail buildings that meet Step 2 are presented in Table 40. For Commercial Office buildings, the Step Code's and City of Vancouver's TEDI performance requirements are similar, while the City of Vancouver's TEUI threshold is comparatively very low. Office buildings with default occupancy densities and no additional (i.e. Information Technology, or IT) loads can meet the City of Vancouver's requirements using lighting savings and some additional envelope improvements, or else a move to more efficient HVAC plants such as air-source heat pumps. However, buildings with very high IT loads will not meet the City of Vancouver's TEUI performance requirement within the parameters modeled. As such, it is recommended that high process loads and their associated internal gains be allowed to be captured within the TEDI calculation, but that they can be excluded from TEUI calculations. To do so would further require separate metering to segregate any loads not included in the TEUI calculation.

It should also be noted that commercial office buildings with high occupancy will require higher efficiency HVAC plants. Buildings in Climate Zone 5 that have warmer summers and high occupancy also may be unable to meet the City of Vancouver's TEUI performance requirement without additional interventions that were not within the parameters modeled (e.g. renewable energy).

Finally, the City of Vancouver's framework currently only defines performance requirements for Step 2 for Retail buildings. The Step 2 TEUI threshold is the same for both codes, while the City of Vancouver's TEDI threshold is the same as BCBC's Step 3. Since Retail buildings solutions with typical internal loads are well below the TEUI threshold at Step 2, City of Vancouver solutions need only focus on envelope improvements to reduce TEDI. HVAC system efficiency and lighting savings are not necessary.

Table 37: Step Code Low-cost Solutions for High-Rise MURB – Step Code vs. City of Vancouver (CoV) Targets

Scenario			Measures								Outcomes						
Climate	Step	Targets	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m²)	TEDI (kWh/m²)	Inc. Cap. Cost (%)	Inc. Cost ($/m²)	NPV ($)	NPV ($/m²)	COC ($/t$CO_2$e)
CZ4	2	BCBC	40	10	20	2.5	Code	60%	Condensing	20%	111.7	40.6	6.2%	0.4	$265,815	11.8	14.8
		CoV				2		80%			98.6	27.6	6.0%	1.9	-$162,638	58.2	-9.0
	3	BCBC	40	10	20	2.5	Improved	80%	Condensing	20%	100.8	29.7	6.0%	0.8	$370,803	24.9	20.6
		CoV				1.6					88.4	17.4	5.9%	2.4	-$111,005	72.9	-6.2
	4	BCBC	40	10	20	1.6	PH	80%	Condensing	20%	85.8	14.8	5.8%	2.4	-$54,760	74.3	-3.0
		CoV				1.2					80.7	9.7	5.7%	2.8	-$116,244	86.3	-6.5
CZ5	2	BCBC	40	20	20	2.5	Code	60%	Condensing	20%	114.9	43.8	6.3%	1.0	-$3,094	33.6	-0.2
		CoV		10		1.6		80%			102.6	31.6	6.1%	2.3	-$372,192	75.3	-20.7
	3	BCBC	40	10	20	1.6	Improved	80%	Condensing	20%	97.2	26.1	6.0%	2.4	-$254,325	78.3	-14.1
		CoV		20		1.2		60%			89.0	18.0	5.9%	3.1	-$413,993	100.9	-23.0
	4	BCBC	40	10	20	0.8	PH	80%	Condensing	20%	82.5	11.5	5.8%	3.2	-$292,175	105.5	-16.2
		CoV		20				60%			80.8	9.8	5.8%	3.5	-$418,544	115.3	-23.3
CZ6	2	BCBC	20	20	20	2.5	Code	60%	Condensing	20%	111.6	40.5	6.3%	1.3	$311,748	45.4	17.3
		CoV		10		0.8		80%			99.5	28.4	6.2%	2.1	$203,258	72.3	11.3
	3	BCBC	20	20	20	2.5	Improved	80%	Condensing	20%	99.3	28.2	6.2%	1.8	$429,605	60.2	23.9
		CoV				0.8		60%			88.7	17.6	6.0%	2.6	$230,370	89.1	12.8
	4	BCBC	20	20	40	0.8	PH	60%	Condensing	20%	85.7	14.7	5.9%	2.7	$279,667	91.5	15.5
		CoV						80%			80.8	9.8	5.9%	3.0	$220,799	103.1	12.3
CZ7a	2	BCBC	20	20	40	1.2	Code	60%	Condensing	20%	116.0	44.9	6.4%	2.0	-$816,552	92.5	-45.4
		CoV*				0.8		80%			104.0	32.8	6.2%	2.6	-$883,310	117.1	-49.1
	3	BCBC	20	20	20	0.8	Improved	60%	Condensing	20%	100.3	29.2	6.2%	2.3	-$544,081	104.6	-30.2
		CoV*			40			80%			94.0	22.9	6.1%	2.7	-$647,440	121.3	-36.0
	4	BCBC*	20	20	40	0.8	PH	80%	Condensing	20%	88.7	17.6	6.0%	2.7	-$519,845	123.3	-28.9
		CoV*									88.7	17.6	6.0%	2.7	-$519,845	123.3	-28.9

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Table 38: Step Code Lowest Cost Solutions for Part 3 Low-Rise MURB, BCBC vs. CoV Targets

Scenario			Measures									Outcomes						
Climate	Step	Targets	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m²)	TEDI (kWh/m²)	Inc. Cap. Cost (%)	Inc. Cost ($/m²)	NPV ($)	NPV ($/m²)	COC ($/tCO₂e)
CZ4	2	BCBC	40	20	20	2.5	Code	60%	Condensing	20%	104.4	33.4	0.5%	11.8	$489,000	27.2	-398.2
		CoV			40	1.2					85.7	14.7	3.1%	75.5	-$78,000	-4.3	58.5
CZ5	2	BCBC	40	20	20	2.5	Code	60%	Condensing	20%	114.9	43.8	0.5%	12.7	$373,000	20.7	-306.8
		CoV				0.8		80%			83.5	12.5	3.9%	101.0	-$248,000	-13.8	178.9
CZ6	2	BCBC	20	20	20	2.5	Code	60%	Condensing	20%	111.6	40.5	0.4%	12.0	$914,000	50.8	-704.0
		CoV		40		1.2		80%			85.3	14.2	4.1%	111.4	-$68,000	-3.8	46.6
CZ7a	2	BCBC	20	20	40	1.2	Code	60%	Condensing	20%	116.0	44.9	1.4%	52.1	-$89,000	-4.9	69.6
		CoV		40	20	0.8	PH	80%			84.2	13.1	4.1%	149.5	-$855,000	-47.5	590.4
CZ7b	2	BC Step	20	40	40	0.8	Code	60%	Condensing	40%	124.0	43.8	2.7%	9.8	-$79,284	-22.0	217.1
		CoV*					PH	80%			101.3	21.1	3.5%	12.9	-$49,700	-13.8	128.3
CZ8	2	BC Step	20	40	20	0.8	PH	80%	Condensing	20%	129.2	42.2	3.3%	12.2	-$19,435	-5.4	65.3
		CoV*			40					40%	118.3	38.0	3.5%	12.9	-$4,770	-1.3	12.2

Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements

Table 39: Step Code Lowest Cost Solutions for Hotels, BCBC vs. CoV Targets

Scenario			Measures									Outcomes						
Climate	Step	Targets	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infil.	Vent. Heat Recovery (%)	Lighting Savings (%)	Plant	DHW Loads Savings	TEUI (kWh/m²)	TEDI (kWh/m²)	Inc. Cap. Cost	Inc. Cost $/m²	NPV	NPV $/m²	COC $/tCO₂e
CZ4	2	BCBC	50	5	20	2.5	Code	60%	0%	Boiler/Chiller	20%	164.0	28.0	-0.2%	-5.7	$287,489	30.2	-86.4
		CoV		10								158.3	22.9	-0.2%	-5.4	$307,656	32.3	-87.5
CZ5	2	BCBC	50	10	20	2.5	Code	90%	0%	Boiler/Chiller	20%	166.7	28.2	-0.1%	-1.9	$319,964	33.6	-84.9
		CoV		20	40							162.5	24.7	0.2%	6.9	$255,146	26.8	-65.4
CZ6	2	BCBC	50	10	20	1.6	Code	90%	0%	Boiler/Chiller	20%	165.0	29.2	1.1%	37.8	-$34,904	-3.7	8.1
		CoV				1.2						161.0	24.2	1.4%	48.3	-$129,984	-13.7	28.8
CZ7A	2	BCBC	20	15	40	1.6	Code	90%	0%	Boiler/Chiller	20%	167.6	29.6	1.9%	84.1	-$512,973	-53.9	128.9
		CoV		20		0.8						162.4	24.5	2.3%	103.5	-$680,073	-71.4	162.8
CZ7B	2	BC Step	20	15	40	1.2	Code	90%	0%	Boiler/Chiller	20%	166.6	30.0	2.3%	79.7	-$453,098	-47.6	107.0
		CoV*		30								166.6	30.0	2.3%	79.7	-$453,098	-47.6	107.0

Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements

Table 40: Step Code Lowest Cost Solutions for Big Box Retail, BCBC vs. CoV Targets

Scenario			Measures								Outcomes						
Climate	Step	Targets	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m^2)	TEDI (kWh/m^2)	Inc. Cap. Cost (%)	Inc. Cost ($\$/m^2$)	NPV ($)	NPV ($\$/m^2$)	COC ($\$/tCO_2e$)
CZ4	2	BCBC	FC	20	10	20	2.5	Code	60%	0	128.1	19.1	0.8%	12.1	$17,461	3.9	-39.9
		CoV	ASHP								113.3	19.1	0.8%	12.1	$6,098	1.4	-7.0
CZ5	2	BCBC	FC	20	10	20	2.5	Code	80%	0	147.0	26.7	1.3%	18.8	$2,650	0.6	-4.5
		CoV	ASHP				0.8				123.1	20.2	2.8%	39.5	-$75,288	-16.7	66.1
CZ6	2	BCBC	FC	20	10	20	0.8	Code	80%	0	142.5	29.8	2.8%	47.8	-$109,493	-24.3	109.6
		CoV	ASHP			40	0.8				119.5	20.3	4.3%	73.1	-$214,167	-47.6	138.4
CZ7a	2	BCBC	FC	20	20	40	2	Improved	80%	0	145.8	29.9	4.6%	79.1	-$168,901	-37.5	106.7
		CoV*	ASHP				0.8	PH	60%		124.7	20.9	5.2%	89.2	-$193,198	-42.9	95.2

**Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Table 41: Step Code Lowest Cost Solutions for Commercial Office, BCBC vs. CoV Targets

Scenario			Measures								Outcomes						
Climate	Step	Targets	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m^2)	TEDI (kWh/m^2)	Inc. Cap. Cost (%)	Inc. Cost ($\$/m^2$)	NPV ($)	NPV ($\$/m^2$)	COC ($\$/tCO_2e$)
CZ4	2	BCBC	FC	50	10	20	2.5	Code	None	0%	115.4	29.4	-0.2%	-5.8	$458,761	25.2	-471.9
		CoV	ASHP						60%		92.9	17.7	-0.1%	-1.7	$416,036	22.8	-138.6
	3	BCBC	FC	50	10	20	2.5	Improved	60%	25%	95.6	16.7	0.4%	12.2	$369,423	20.3	-195.6
		CoV	ASHP							0%	92.2	14.7	0.0%	-0.3	$405,984	22.3	-135.1
CZ5	2	BCBC	FC	50	10	20	2.5	Code	60%	0%	117.8	24.9	-0.1%	-1.6	$254,225	14.0	-195.0
		CoV	ASHP								99.0	24.9	-0.1%	-1.6	$288,523	15.8	-98.0
	3	BCBC	FC	50	20	20	2.5	Improved	80%	50%	93.4	19.5	1.3%	36.2	$6,920	0.4	-3.9
		CoV	ASHP		10	40			60%	0%	97.7	20.3	0.1%	1.8	$254,689	14.0	-86.3
CZ6	2	BCBC	FC	50	20	20	2.5	Code	80%	0%	116.2	28.7	0.4%	12.0	$6,354	0.3	-3.6
		CoV	ASHP				2		60%		90.9	26.0	1.0%	33.7	-$239,793	-13.2	67.3
	3	BCBC	FC	50	20	20	1.2	Improved	60%	0%	98.9	14.3	1.7%	55.0	-$617,810	-33.9	220.8
		CoV	ASHP		10	40	1.6				90.0	20.9	1.3%	41.6	-$364,254	-20.0	102.2
CZ7a	2	BCBC	FC	50	20	40	1.2	Code	60%	0%	115.0	29.7	1.6%	51.9	-$539,435	-29.6	190.5
		CoV*	ASHP			20	0.8				96.7	25.8	1.8%	59.2	-$614,469	-33.7	142.3
	3	BCBC	FC	50	20	40	0.8	Improved	60%	25%	95.8	19.4	2.4%	77.7	-$750,287	-41.2	208.8
		CoV*	ASHP			20				0%	95.4	19.4	1.8%	60.8	-$613,765	-33.7	141.9

**Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Table 42: Step Code Lowest Cost Solutions for Other Commercial, BCBC vs. CoV Targets

Scenario			Measures								Outcomes						
Climate	Step	Targets	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	EUI (kWh/m²)	TEDI (kWh/m²)	Inc. Cap. Cost (%)	Inc. Cost ($/m²)	NPV ($)	NPV ($/m²)	COC ($/tCO$_2$e)
CZ4	2	BCBC	FC	50	10	20	2.5	Code	None	0	115.4	29.4	-0.2%	-5.8	$458,761	25.2	-471.9
		CoV	ASHP						60%		92.9	17.7	-0.1%	-1.7	$416,036	22.8	-138.6
	3	BCBC	FC	50	10	20	2.5	Improved	60%	0	104.8	14.7	0.0%	-0.3	$370,345	20.3	-186.8
		CoV	ASHP								92.2	14.7	0.0%	-0.3	$405,984	22.3	-135.1
CZ5	2	BCBC	FC	50	10	20	2.5	Code	60%	0	117.8	24.9	-0.1%	-1.6	$254,225	14.0	-195.0
		CoV	ASHP								99.0	24.9	-0.1%	-1.6	$288,523	15.8	-98.0
	3	BCBC	FC	50	20	20	2.5	Improved	60%	0	111.1	18.5	0.2%	5.9	$166,445	9.1	-94.9
		CoV	ASHP		10	40					97.7	20.3	0.1%	1.8	$254,689	14.0	-86.3
CZ6	2	BCBC	FC	50	20	20	2.5	Code	80%	0	116.2	28.7	0.4%	12.0	$6,354	0.3	-3.6
		CoV	ASHP				2		60%		90.9	26.0	1.0%	33.7	-$239,793	-13.2	67.3
	3	BCBC	FC	50	20	20	1.6	Improved	60%	0	102.4	18.6	1.4%	45.1	-$450,493	-24.7	180.0
		CoV	ASHP		10	40					90.0	20.9	1.3%	41.6	-$364,254	-20.0	102.2
CZ7A	2	BCBC	FC	50	20	40	1.2	Code	60%	0	115.0	29.7	1.6%	51.9	-$539,435	-29.6	190.5
		CoV*	ASHP			20	0.8				96.7	25.8	1.8%	59.2	-$614,469	-33.7	142.3
	3	BCBC	FC	50	20	20	0.8	Improved	60%	0	106.4	19.4	1.8%	60.8	-$668,208	-36.7	188.3
		CoV*	ASHP								95.4	19.4	1.8%	60.8	-$613,765	-33.7	141.9

**Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Overall, the performance requirements are very similar in terms of costs and outcomes. When the High-Rise MURB archetype (the most impacted by cost by the Step Code) was tested against the Vancouver performance requirements, the increase in capital costs was less than 1% in all cases but one. Energy and greenhouse gas savings were also greater when the COV framework was applied. Given these outcomes, the building industry may be willing to accept slightly higher costs for the sake of province-wide consistency. Given the relatively low costs, local governments may appreciate the ability to be more aggressive and aligned with a program that is already in operation.

6.5 Greenhouse Gas Emissions Reductions

One of the objective of this report is to identify any possible unforeseen impacts to adopting the Step Code that could be identified using the data generated by this project. One issue that local governments should examine is the level of GHG reductions being delivered by each step of the Step Code. In some cases, particularly at lower steps, achieving the Step Code does not yield GHG emissions reductions, or results in only small reductions. GHG emissions are not significantly reduced until Step 3. As discussed in Section 3.2.7, the parametric analysis revealed that it was even possible to have higher GHG emissions than a BCBC building by adopting Steps 3, 4, and even 5. This outcome is counter to the primary interests of the local governments who are interested in adopting the Step Code and counter to the Province's own climate policy.

The primary issue driving GHG increases is fuel choice. Where buildings shift away from electricity and toward natural gas, GHG emissions will increase if overall energy use reductions are not significant enough. This is particularly true for BCBC base buildings assumed to rely primarily on electricity. In the present analysis, this is the case for the MURB and Quadplex base buildings. As can be seen in Table 43, where space heating and DHW systems shift to a natural gas dependence, even higher steps can result in significant GHG increases.

Table 43: Examples of Increasing GHG Emissions while Achieving Higher Steps

Archetype	Climate Zone	Step Achieved	DHW System	Space Heating System	Change in GHGs from BCBC (%)
10 Unit MURB	4	3	Combination	Combination	+49%
	4	4	Combination	Combination	+49%
Quadplex	4	3	Base DHW	Gas Furnace	+47%
10 Unit MURB	5	3	Combination	Combination	+74%
	5	4	Combination	Combination	+74%
Quadplex	5	3	Base DHW	Gas Furnace	+68%
10 Unit MURB	6	3	Combination	Combination	+112%
	6	4	Combination	Combination	+112%
	6	5	Combination	Combination	+44%
Quadplex	6	3	Base DHW	Gas Furnace	+90%
	6	4	Heat Pump (electric)	Gas Furnace	+5%
10 Unit MURB	7a	3	Combination	Combination	+147%
	7a	4	Combination	Combination	+147%
	7a	5	Combination	Combination	+69%
Quadplex	7a	3	Base DHW	Gas Furnace	+123%
	7a	4	Base DHW	Gas Furnace	+69%
10 Unit MURB	7b	3	Combination	Combination	+165%
	7b	4	Combination	Combination	+165%
	7b	5	Combination	Combination	+92%
Quadplex	7b	3	Base DHW	Gas Furnace	+152%
	7b	4	Base DHW	Gas Furnace	+90%
10 Unit MURB	8	3	Combination	Combination	+177%
	8	4	Combination	Combination	+177%
	8	5	Combination	Combination	+108%
Quadplex	8	3	Base DHW	Gas Furnace	+172%
	8	4	Base DHW	Gas Furnace	+106%

To address this issue, it is recommended that the Province explore requirements around fuel selection and/or explore the adoption of a GHG Intensity (GHGI) target for the Step Code that would result in predictable GHG emissions reductions. The authors of this report acknowledge that this may require an amendment to the BC Building Code to add GHG reductions as an objective, but that this would be consistent with the current draft of the BC Climate Action Plan. A GHGI metric may be able to be applied with little or no extra cost over what has been already contemplated. In the absence of clear direction on GHGI, there is also a risk that local governments may adopt differing GHG targets to ensure GHG savings. Such a trend would be counter to one of the central reasons for the Step Code's existence: to increase energy code alignment across the province.

7 SUMMARY AND RECOMMENDATIONS

7.1 Implementation Recommendations for Local Governments

Based on the analysis presented in this report, several recommendations have been made for the Province and local governments to consider for the implementation or ongoing development of the Step Code. It should also be noted that these results are a theoretical analysis of feasibility and affordability of the Step Code performance targets. The challenge is now to build capacity across the Province to actually achieve what is theoretically possible.

7.1.1 Targets for Part 3 Buildings

The performance requirements were developed for Climate Zone 4, but can affordably be applied to Climate Zones 4, 5, 6, and 7a. These targets can also be met in Climate Zones 7b and 8, though only lower steps are achievable within the parameters analyzed. In spite of this, the Province should consider developing specific performance targets for Climate Zone 5 and above. This will apply the Step Code more equitably across the province and enable buildings in colder climates to achieve higher steps. In future iterations or updates, the Province may wish to consider adding a specific Low-Rise MURB (6 storeys) building classification that would allow for targets that better reflect the economics of this building type. It is acknowledged that this issue could also be dealt with at the local government level in implementation.

7.1.2 Greenhouse Gas Intensity Targets

Further to the above, it is also recommended that the Province explore the adoption of the City of Vancouver's GHGI targets into the Step Code. While this may require an amendment to the BC Building Code, several municipalities have expressed a desire to explicitly target GHG emissions reductions. Without such a target, this study has shown that GHG emissions can increase even at the highest steps of the Step Code. This is inconsistent with the BC Climate Action Plan and diminishes the Step Code's ability to show climate leadership.

7.1.3 Application of the Step Code on Different Building Types

One Part 9 archetype was disproportionately *advantaged* in hitting the Step Code performance requirements: Low-Rise MURB. When applying the Step Code to this building type, local governments may want to consider applying Step 4 as the base code. The cost premium to reach Step 4 is less than 1% of total construction costs in all climate zones for Low-Rise MURBs when modelled with HOT2000. This is a similar, or even lower cost impact, than what has been legislated in past building code updates. Note that this strategy of defining building types that do not exist in the BC Building Code, such as Low-Rise MURB or "Large" SFD, may require alternate implementation policies that are executed through zoning and land-use regulations. Additionally, Step 4 is considered a higher step and as such implementation must comply with Provincial requirements for a 12-month transition period.

Two archetypes of those tested that were disproportionately *disadvantaged* by the Step Code performance requirements were Small SFD (including Laneway Homes) and the Quadplex. Duplexes will likely have similar results to the Quadplex typology. For these typologies, local governments are advised to consider targeting lower levels of the Step Code (Steps 2 and 3) in Climate Zones 6 and lower. In colder Climate Zones (7 and above), local governments may still wish to limit Step Code implementation to lower steps initially and re-evaluate in 2 years.

Overall, except for the building types and locations noted above, most local governments in the province can target Step 3 for both Part 3 and Part 9 buildings as an aggressive but affordable base code. The projected impacts on cost are lower than the typical yearly variations in construction rates observed over the past ten years and are unlikely to impact housing affordability based on the data available. Adopting Step 2 in Climate Zones 4, 5, and 6 may in fact prove disadvantageous, as the costs of going to Step 3 are marginal when compared to Step 2. There is furthermore lower risk of buildings with emissions higher than the typical building code levels at Step 3, which is a possible and even likely outcome at Step 2.

With regards to incentives, targeting incentives at Step 5 in Part 9 and Step 4 in Part 3 is likely where the greatest benefits will be realized. These are the steps most impacted by cost, and therefore potentially most likely to adversely impact affordability.

7.2 Future Research Directions

While this study has answered several questions as to the impact of the Step Code, several areas of further inquiry could still be pursued. In addition to the recommendation of using the existing dataset to test the application of the Vancouver ZEBP targets province-wide, some key possible directions for further research are outlined below.

Achieving Net-Zero Energy-Ready Buildings
Further exploration into methods for lowering EUIs to ensure that net-zero energy-ready levels of performance can be achieved should be conducted. Currently, the Step 4 TEUI performance requirement of 100 kWh/m^2/year for Multifamily Residential Part 3 buildings is intended to achieve a 'net-zero energy-ready' level of performance; however, lower performance requirements may be more effective in achieving the desired outcome without any additional impacts on cost.

Ventilation Rates
More detailed analysis is required to quantify the impact of modelling a house with 24-hour ventilation compared to 8 hr/day intermittent ventilation. The impact is more substantial in colder climates and with homes without heat recovery ventilation. When moving to Step 5, there is less of an impact in terms of energy use; however, it can make the difference in whether a building meets the MEUI and TEDI requirements.

Window WWR and Orientation
Several archetypes were modelled in the original 2017 Metrics Research Report by varying the distribution of windows on the different façade orientations. A short analysis quantifying the results of these cases would provide useful input.

Cost Impact and Incentive Analysis
More analysis on the monthly cost impact to a homeowner (financing + energy) for different utility rate increases, incentive programs, cost assumptions, etc., would be useful. Given that the same base house was modelled for all climate zones, it would be of interest to look at the net-monthly cost of the different steps from the same base building (Zone 4 code levels). This would provide a better comparison of the cost burden placed on homeowners in colder climate zones.

Analysis of Costs of Fuel Switching to Electricity and Achieving Deep GHG Reductions
The findings indicate that fuel choice has a significant impact on GHG emissions reductions. Considering the need to significantly reduce GHGs from buildings to achieve the Province's GHG reduction target, an important follow-up analysis would involve focusing more specifically on the relationship between fuel switching and GHG reductions, and its implications for upfront capital costs, annual fuel costs, and the Step Code's MEUI and TEDI requirements. The existing dataset should be very valuable in this regard, and allow the Province to investigate items of interest, such as the energy efficiency improvements required to offset increased costs from switching to electricity.

GHG Impact Assessments for Different Provinces
Given the low GHG emissions of the BC electrical grid, simple fuel switching can lead to a low upfront cost and $/tCO2e rate. It would be of interest to assess what the $/tCO2e of savings would be using the electricity GHG emissions intensities from different provinces.

Cooling Load Impact
Acknowledging that HOT2000 is not the best tool to model cooling, it would still be interesting to examine the cooling load implication of achieving the different steps. Hourly software could be used to model some archetype buildings to get a better understanding of the cooling load as well as the overheating potential of buildings if cooling is not included.

Software Tool Impact
The code allows the use of any ASHRAE 140 validated tool to be used for code compliance. It would be of interest to assess a few other tools to see how the results compare to HOT2000, or indeed if any other tools exist that can meet all modelling requirements outlined by 9.36.5.

LEEP Type Plotting for Individual Measures
The analysis to date has looked at overall design and combinations of measures. Further analysis can be done to examine the effectiveness of individual measures. An example would be the type of graphs produced for the LEEP workshops that highlight individual measures in different plots.

8 APPENDICES

8.1 Part 3 Archetype Summaries

Characteristic	High Rise MURB
Weather	Vancouver CWEC, Kamloops CWEC, Prince George CWEC, Fort St John CWEC
Software	EnergyPlus v8.6
Climate Zone	4,5,6,7A
Building Area	18,000 m^2 plus 2,330 (varies with occupancy) m2 parking
Operating Hours	NECB Schedule G occupancy, lighting and plug loads for suites. Corridor and parking lighting always on.
Occupancy	Options: High – 25.2 m^2/p Mid – 28.8 m^2/p Low – 40.4 m^2/p
Plug & Process Loads	5 W/m^2 Suites 1 W/m^2 Corridor 5 kW elevator load 150 W/suite Suite exhaust fans, 2 h/day 3.7 L/s/m^2, 0.5W/cfm Parking exhaust fans, 4 h/day
Outdoor Air	Per ASHRAE 62.1-2001 Suites: maximum of 7.5 L/s/person or 0.35 ACH Corridors: 0.25 L/s/m^2
Infiltration	0.25 L/s/m^2 Exterior Area, Code DOE-2 Coefficients Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-4 to R-40
Roof R-Value	Options: R-20 to R-40
Window U-Value	Options: USI-2.5 to USI-0.8
Window SHGC	0.4
Window Area %	Options: 60% to 20%
Lighting	5 W/m^2 Suites 7.1 W/m^2 Corridors 2 W/m^2 Parking
HVAC Systems	Options: Electric Baseboards with Suite HRV and Corridor MUA Suite Fan Coils with Suite Ventilators and Corridor MUA Suite Hybrid Heat Pump with Suite HRV and Corridor MUA
Baseline Building HVAC Systems	NECB Baseline building with Electric Baseboards for BB MURBS with Hydronic Baseboards and Gas-fired boilers for FC and HHP MURBS
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through Suite HRV with heat recovery, or though Corridor MUA without heat recovery. Fan coil/hybrid heat pump fans run continuously.

Characteristic	High Rise MURB
Heat Recovery	Options: 0% to 80% Suite ERV efficiency, Electric Preheat Coil to -5°C
Fans	1.0 W/cfm ERVs, Corridor MUA 0.2 W/cfm Fan Coils, continuous
Cooling	Options Boiler Plant: Water-cooled Screw Chiller, COP 5.2 ASHP Plant: ASHP, COP 3.15
Heating	Options Boiler Plant or Corridor MUA Gas Coil: Standard, 83% eff. or Condensing, 92% eff. ASHP Plant: ASHP, COP 4.15, condensing or electric boiler top-up
Pumps	72 ft head, variable speed HW, DHW, ChW, and CndW
DHW	1.6 L/s/p, 370 W/person Suites Same as Heating Plant, with top up boiler for supply temperature Options: Up to 40% load savings

Characteristic	Office
Weather	Vancouver CWEC, Kamloops CWEC, Prince George CWEC, Fort St John CWEC
Software	EnergyPlus v8.6
Climate Zone	4,5,6,7A
Building Area	18,209 m^2 plus 4,550 m2 parking in Zones 4 and 5
Operating Hours	NECB Schedule A occupancy, lighting and plug loads. Parking lighting always on.
Occupancy	20 m^2/person Office 10 m^2/person Lobby 3.33 m^2/person Reception 2 m^2/person Conference Options: Double Occupancy – 10 m^2/person Office
Plug & Process Loads	7.5 W/m^2 Office 1 W/m^2 Conference, Reception, Lobby, Storage 3.5 kW elevator load 12 kW general exhaust fans, 2 h/day 17.8 kW Parking exhaust fans, 4 h/day Options: Double Occupancy – 15 W/m^2 Office It Loading – None, 2.2 W/m2, or 11 W/m2 average continuous load (None, 4 kW/floor peak, 20 kW/floor peak)
Outdoor Air	Per ASHRAE 62.1-2001 2.5 L/s/person and 0.3 to 0.6 L/s/m^2 Overall Ventilation Effectiveness 0.56 for VAV systems, 1 for DOAS systems

Characteristic	Office
Infiltration	0.25 L/s/m² Exterior Area, Code DOE-2 Coefficients Options: 0.1 L/s/m² Exterior Area, Improved 0.01 L/s/m² Exterior Area, Passive house
Wall R-Value	Options: R-4 to R-40
Roof R-Value	Options: R-20 to R-40
Window U-Value	Options: USI-2.5 to USI-0.8
Window SHGC	0.4
Window Area %	Options: 70% to 40%
Lighting	11.9 W/m² Office 13.2 W/m² Conference 7.1 W/m² Corridors 7.9 W/m² Reception 9.7 W/m² Lobby 6.8 W/m² Storage 2 W/m² Parking 3 kW Exterior Lights Options: Up to 50% reduction in lighting
HVAC Systems	Options: Hydronic VAV Hydronic Fan Coils and DOAS
Baseline Building HVAC Systems	NECB Baseline building with Hydronic VAV
Supply and Ventilation Air	Ventilation air supplied directly to zones through DOAS or VAV system. Fan coil fans cycle to meet heating and cooling loads.
Heat Recovery	Options: Up to 80% Heat Recovery efficiency, Electric Preheat Coil to -5°C
Fans	VAV Fans: 1 W/cfm, VFD Curve DOAS: 1 W/cfm Fan Coils: 0.3 W/cfm
Cooling	Options Boiler Plant: Water-cooled Centrifugal Chiller, COP 5.2 ASHP Plant: ASHP, COP 3.15
Heating	Options Boiler Plant: Condensing Boiler, 96% eff. ASHP Plant: ASHP, COP 4.15, condensing boiler top-up
Pumps	72 ft head, variable speed HW, DHW, ChW Secondary, and CndW 72 ft head, constant speed ChW Primary
DHW	90 W/person Office 45 W/person Conference Same as Heating Plant, with top up boiler for supply temperature Options: Up to 40% load savings

Characteristic	Retail
Weather	Vancouver CWEC, Kamloops CWEC, Prince George CWEC, Fort St John CWEC
Software	EnergyPlus v8.6
Climate Zone	4,5,6,7A
Building Area	4,502 m^2
Operating Hours	NECB Schedule C and B occupancy, lighting and plug loads.
Occupancy	30 m^2/person Options: Big-Box – 100% Retail Space Mall – 40% Retail, 30% Warehouse, 20% Concourse, 5% Dining, 5% Food Prep
Plug & Process Loads	2.5 W/m^2 Retail 1 W/m^2 Warehouse, Dining, Concourse 10 W/m^2 Food Prep
Outdoor Air	Per ASHRAE 62.1-2001 3.8 to 5 L/s/person and 0.3 to 0.9 L/s/m^2 Ventilation Effectiveness 0.8 for Unitary, and 1 for DOAS
Infiltration	0.25 L/s/m^2 Exterior Area, Code DOE-2 Coefficients Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-4 to R-40
Roof R-Value	Options: R-20 to R-40
Window U-Value	Options: USI-2.5 to USI-0.8
Window SHGC	0.4
Window Area %	5% to 40%
Lighting	18.1 W/m^2 Retail 10.2 W/m^2 Warehouse 7 W/m^2 Dining 11.8 W/m^2 Concourse 10.7 W/m^2 Food Prep Options: Up to 50% reduction in lighting
HVAC Systems	Options: Unitary Gas Roof-top Units Hydronic Fan Coils and DOAS
Baseline Building HVAC Systems	NECB Baseline building with Unitary Gas Roof-top Units
Supply and Ventilation Air	Ventilation air supplied directly to zones through DOAS or Unitary system. Fan coil fans cycle to meet heating and cooling loads.
Heat Recovery	Options: Up to 80% Heat Recovery efficiency, Electric Preheat Coil to -5°C
Fans	Unitary: 1 W/cfm DOAS: 1 W/cfm Fan Coils: 0.5 W/cfm

Characteristic	Retail
Cooling	Options Unitary: DX Cooling, COP 3.8 Boiler: Water-cooled Centrifugal Chiller, COP 5.2 ASHP Plant: ASHP, COP 3.15
Heating	Options Unitary: Gas Coil, 70% eff. Boiler Plant: Condensing Boiler, 96% eff. ASHP Plant: ASHP, COP 4.15, condensing or electric boiler top-up
Pumps	72 ft head, variable speed HW, DHW, ChW Secondary, and CndW 72 ft head, constant speed ChW Primary
DHW	40 W/person Retail 65 W/person Warehouse 120 W/person Dining, Food Prep 30 W/person Concourse Same as Heating Plant, with top up boiler for supply temperature

Characteristic	Hotel
Weather	Vancouver CWEC, Kamloops CWEC, Prince George CWEC, Fort St John CWEC, Whitehorse CWEC, Yellowknife CWEC
Software	EnergyPlus v8.5
Climate Zone	4,5,6,7A, 7B, 8
Building Area	9,520 m^2 plus 6,600 m2 parking
Operating Hours	NECB Schedule F occupancy, lighting and plug loads for suites. NECB Schedule H occupancy, lighting and plug loads for Lobby and Corridors. NECB Schedule B occupancy, lighting and plug loads for Kitchen, Laundry, Pool, Fitness. NECB Schedule C occupancy, lighting and plug loads for Conference. NECB Schedule E occupancy, lighting and plug loads for Storage. Parking lighting always on.
Occupancy	Default values from the NECB Appendix A were used: Suites – 25 m^2/p Laundry – 20 m^2/p Kitchen, Lobby – 10 m^2/p Conference, Fitness, Pool – 5 m^2/p Corridor, Storage – 100 m^2/p

Characteristic	Hotel
Plug & Process Loads	Default values from the NECB Appendix A were used: 10 W/m^2 Kitchen 2.5 W/m^2 Suites, Lobby 1 W/m^2 Conference, Fitness, Laundry, Storage, Corridor, Pool Plus Process Loads: 25.9 kW Parkade Exhaust Fans, 4 h/day 6 kW Elevators 1 kW Pool Pumps Pool Latent Load of 1.6 kW Pool Water Heating Load of 6.1 kW, assuming 5% make-up water/week Laundry Load (Variable: Electric or Natural Gas): 29.75 kW average continuous load Kitchen and Laundry Exhaust modelled 6 h/day, included in MUA
Outdoor Air	Per ASHRAE 62.1-2010 2.5 to 10 L/s/person and 0.3 to 2.4 L/s/m^2 3.5 L/s/m^2 Kitchen Exhaust and 5 L/s/m^2 Laundry Exhaust
Infiltration	0.25 L/s/m^2 Exterior Wall Area, Code DOE-2 Coefficients Options: 0.1 L/s/m^2 Exterior Area, Improved 0.01 L/s/m^2 Exterior Area, Passive house
Wall R-Value	Options: R-5 to R-30
Roof R-Value	Options: R-20 to R-40
Window U-Value	Options: USI-2.5 to USI-0.8
Window SHGC	Options: SHGC 0.2 to 0.4
Window Area %	50%
Lighting	11.9 W/m^2 Suites 11.4 W/m^2 Lobby 13.2 W/m^2 Conference 7.8 W/m^2 Fitness, Pool 6.8 W/m^2 Storage 10.7 W/m^2 Kitchen 10.2 W/m^2 Laundry 7.1 W/m^2 Corridors 2 W/m^2 Parking Options: 0-40% lighting power savings in all spaces 2kW Exterior Lighting, Atmospheric Clock

Characteristic	Hotel
HVAC Systems	Suites: HRVs and Fan Coils Suite Corridors, Kitchen, and Laundry: Gas-fired MUA Pool: Dectron Unit, DX-Coil heat recovery from condenser to reheat air Options: VAV System: serving remaining common areas Fan Coils and DOAS: serving remaining common areas
Baseline Building HVAC Systems	NECB Baseline building with Fan Coils and Unit Ventilators in suites (50% HR in CZ 7+) Packaged Unitary Roof-top Units with HW baseboards in common areas
Supply and Ventilation Air	Constant ventilation air supplied directly to zones through Suite HRV with heat recovery, or though Corridor MUA without heat recovery. Suite Fan coil fans cycle for heating/cooling. Common systems (except kitchen, laundry and pool) use demand control ventilation
Heat Recovery	No HR in Kitchen, Laundry, Suite Corridors, or Pool Options: 0% to 80% Suite ERV, and common area HR efficiency, Electric Preheat Coil to -5°C
Fans	Options: Non-ECM Fans: 1.0 W/cfm ERVs, MUA, VAV 0.3 W/cfm Fan Coils, cycling ECM Fans: 0.5 W/cfm ERVs, MUA, VAV 0.2 W/cfm Fan Coils, cycling
Cooling	Options Boiler Plant: Water-cooled Centrifugal Chiller, COP 5.2 ASHP Plant: ASHP, COP 3.15
Heating	Options Boiler Plant: Condensing Boiler, 96% eff. ASHP Plant: ASHP, COP 4.15, condensing boiler top-up
Pumps	72 ft head, variable speed HW, DHW, and CndW, constant primary/variable secondary ChW
DHW	600 W/person Suites 300 W/person Storage 120 W/person Kitchen 90 W/person Fitness, Pool 45 W/person Conference 30 W/person Lobby Same as Heating Plant, with top up condensing boiler for supply temperature Options: Up to 40% load savings

8.2 Part 9 Archetype Summaries

Archetype	Storeys	Total Floor Area (ft^2)	Total Floor Area (m^2)	Floor Heights (ft)	Window Area (ft^2)	Gross Wall Area (sq ft) incl floor headers and above grade foundation walls	WWR	Space Heating	Domestic Hot Water Heating	Ventilation
10 unit MURB	3 storeys, on underground parkade	17800	1654	9/9/9/9	2500	9858	0.25	Electric baseboard heat	Electric hot water storage tank, 40 gallon, 0.82EF (per unit)	Fans without heat recovery, Section 9.32 ventilation rate
6 unit Row House	3 storeys, on slab on grade (ground level mainly garage space)	10300	957	8/8/8	1750	10900	0.16	PSC furnace, 92% AFUE	Gas storage tank, 50 gallon, power vented - 0.67 EF	Fans without heat recovery, Section 9.32 ventilation rate
Quadplex	3 storeys, on underground parkade	5526	513	8/8/8/8	825	5572	0.15	Electric baseboard heat	Electric hot water storage tank, 40 gallon, 0.82EF (per unit)	Fans without heat recovery, Section 9.32 ventilation rate
Large SFD	2 storeys, on full basement	5500	511	7.74/8/8	718	5446	0.13	Natural gas forced air furnace, 92%AFUE	Natural gas hot water storage tank, 40 gallon, 0.67EF	Fans without heat recovery, Section 9.32 ventilation rate
Medium SFD	2 storeys, on full basement	2550	237	7.74/8/8	333	2518	0.13	Natural gas forced air furnace, 92%AFUE	Natural gas hot water storage tank, 40 gallon, 0.67EF	Fans without heat recovery, Section 9.32 ventilation rate
Small SFD	1 storey, on 3ft crawlspace	1100	102	3/8	144	1530	0.09	Natural gas forced air furnace, 92%AFUE	Natural gas hot water storage tank, 40 gallon, 0.67EF	Fans without heat recovery, Section 9.32 ventilation rate

Climate Zone	HDD	Weather file	Above Grade Wall RSI	Below Grade Wall RSI	Floor Slab RSI (assume slab insulated)	Floors Above Unheated Space RSI	Ceiling under Attic RSI	Flat Roof RSI	Window and Doors USI	Window and Doors RSI	Airtightness
4	up to 3000	Vancouver (2825 HDD)	2.78	1.99	1.96	4.67	6.91	4.67	1.80	0.56	3.5ACH@50Pa
5	3000-3999	Summerland (3350 HDD)	3.08	2.98	1.96	4.67	8.67	4.67	1.80	0.56	3.5ACH@50Pa
6	4000-4999	Cranbrook (4400 HDD)	3.08	2.98	1.96	4.67	8.67	4.67	1.60	0.63	3.5ACH@50Pa
7A	5000-5999	Fort St. John (5750 HDD)	3.08	3.46	1.96	5.02	10.43	5.02	1.60	0.63	3.5ACH@50Pa
7B	6000-6999	Fort Nelson (6710 HDD)	3.85	3.46	1.96	5.02	10.43	5.02	1.40	0.71	3.5ACH@50Pa
8	7000+	No HOT2000 selection for BC (Uranium City, Saskatchewan: 7500HDD)	3.85	3.97	1.96	5.02	10.43	5.02	1.40	0.71	3.5ACH@50Pa

Archetype	No. Units	No. Occupants	Base Load (kWh/day per Unit)					Hot Water per Unit (L/day)	Dryer use per unit (cfm)	Ventilation per unit (cfm)	Ventilation time (min/day)
			Electrical Appliances	Lighting	Other Electric	Avg. Exterior Use	Totals				
10 unit MURB	10	20	5.2	1.7	4.4	0.4	11.7	125			
6 unit Row House	6	12	5.2	1.7	4.4	0.4	11.7	125	80	45	480
Quadplex	4	12	6.3	2.6	9.7	0.9	19.5	188	80	45	480

8.3 Part 9 ECM Limitations used in Costing Analysis

As shown in the tables below, the airtightness level limitations were set at a minimum of 1.0 air change per hour at 50 Pascals pressure differential (ACH_{50}). However, the modelled results were also analyzed with an airtightness level limitation of 2.5 ACH_{50}. The results for this case are summarized in Appendix 8.13.

10 Unit MURB

ECM limitations for CZ4 to CZ8					
	Airtightness	Window USI	Space Heating	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	no furnace-based systems	must be under 75%	--
2	must be over 1.0	must be over 1.0	no furnace-based systems	must be under 75%	--
3	--	--	no furnace-based systems	--	--
4	--	--	no furnace-based systems	--	--
5	--	--	no furnace-based systems	--	--

6 Unit Row House

ECM limitations for CZ4 to CZ8				
	Airtightness	Window USI	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
2	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
3	--	must be over 1.0	must be under 75%	--
4	--	--	--	--
5	--	--	--	--

Quadplex

ECM limitations for CZ4 to CZ8				
	Airtightness	Window USI	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
2	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
3	must be over 1.0	must be over 1.0	must be under 75%	--
4	--	--	--	--
5	--	--	--	--

Large SFD

ECM limitations for CZ4 to CZ8				
	Airtightness	Window USI	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
2	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
3	must be over 1.0	must be over 1.0	must be under 75%	--
4	--	--	--	--
5	--	--	--	--

Medium SFD

ECM limitations for CZ4 to CZ8				
	Airtightness	Window USI	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
2	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
3	must be over 1.0	must be over 1.0	must be under 75%	--
4	--	--	--	--
5	--	--	--	--

Small SFD & Small SFD – Slab on Grade

ECM limitations for CZ4				
	Airtightness	Window USI	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
2	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
3	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
4	--	--	--	cannot have any
5	--	--	--	cannot have any
ECM limitations for CZ5 to CZ8				
	Airtightness	Window USI	Ventilation Heat Recovery	Drain Water Heat Recovery
1	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
2	must be over 1.0	must be over 1.0	must be under 75%	cannot have any
3	must be over 1.0	must be over 1.0	must be under 75%	--
4	--	--	--	--
5	--	--	--	--

8.4 Energy Price Escalation Estimates

Part 3 Buildings

Electricity	Rate	F2018	F2019	F2020	F2021	F2022	F2023	F2024	F2025	F2026	F2027	F2028	F2029	F2030	F2031	F2032	F2033	F2034	F2035	F2036	F2037	F2038
Consumption > 240,000 kWh/yr	Base Energy ($/kWh)	$ 0.055	$ 0.057	$ 0.058	$ 0.060	$ 0.061	$ 0.063	$ 0.064	$ 0.066	$ 0.067	$ 0.068	$ 0.070	$ 0.071	$ 0.073	$ 0.074	$ 0.075	$ 0.077	$ 0.079	$ 0.080	$ 0.082	$ 0.083	$ 0.085
	Rate Rider ($/kWh)	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004
	GST ($/kWh)	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.003	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004	$ 0.004
	Total ($/kWh)	$ 0.061	$ 0.063	$ 0.064	$ 0.066	$ 0.067	$ 0.069	$ 0.071	$ 0.072	$ 0.074	$ 0.075	$ 0.077	$ 0.078	$ 0.080	$ 0.082	$ 0.083	$ 0.085	$ 0.087	$ 0.088	$ 0.090	$ 0.092	$ 0.094
Natural Gas	Rate	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Consumption > 2000 GJ/yr	Cost of NG delivery (commercial – 2017)	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997	$ 2.997
	Cost of NG Storage & Transport	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684	$ 0.684
	Cost of NG Midstream commodity (commercial – 2017)	$ 2.306	$ 2.306	$ 2.370	$ 2.370	$ 2.434	$ 2.434	$ 2.498	$ 2.498	$ 2.523	$ 2.549	$ 2.574	$ 2.600	$ 2.626	$ 2.652	$ 2.679	$ 2.705	$ 2.733	$ 2.760	$ 2.787	$ 2.815	$ 2.843
	Cost of NG carbon tax (commercial – 2017)	$ 1.493	$ 1.493	$ 1.493	$ 1.493	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488
	Muncipal Operating Charge (3.09% of amounts)	$ 0.185	$ 0.185	$ 0.187	$ 0.187	$ 0.189	$ 0.189	$ 0.191	$ 0.191	$ 0.192	$ 0.192	$ 0.193	$ 0.194	$ 0.195	$ 0.196	$ 0.197	$ 0.197	$ 0.198	$ 0.199	$ 0.200	$ 0.201	$ 0.202
	Clean Energy Levy	$ 0.024	$ 0.024	$ 0.024	$ 0.024	$ 0.024	$ 0.024	$ 0.025	$ 0.025	$ 0.025	$ 0.025	$ 0.025	$ 0.025	$ 0.025	$ 0.025	$ 0.025	$ 0.026	$ 0.026	$ 0.026	$ 0.026	$ 0.026	$ 0.026
	GST	$ 0.299	$ 0.299	$ 0.303	$ 0.303	$ 0.306	$ 0.306	$ 0.309	$ 0.309	$ 0.310	$ 0.311	$ 0.313	$ 0.314	$ 0.315	$ 0.317	$ 0.318	$ 0.319	$ 0.321	$ 0.322	$ 0.323	$ 0.325	$ 0.326
	PST	$ 0.419	$ 0.419	$ 0.424	$ 0.424	$ 0.428	$ 0.428	$ 0.433	$ 0.433	$ 0.434	$ 0.436	$ 0.438	$ 0.440	$ 0.441	$ 0.443	$ 0.445	$ 0.447	$ 0.449	$ 0.451	$ 0.453	$ 0.455	$ 0.457
	Total $/GJ	$ 8.407	$ 8.407	$ 8.481	$ 8.481	$ 9.550	$ 9.550	$ 9.624	$ 9.624	$ 9.653	$ 9.682	$ 9.712	$ 9.741	$ 9.771	$ 9.802	$ 9.832	$ 9.863	$ 9.894	$ 9.926	$ 9.958	$ 9.990	$ 10.022

Part 9 Buildings

Electricity	Rate	F2018	F2019	F2020	F2021	F2022	F2023	F2024	F2025	F2026	F2027	F2028	F2029	F2030	F2031	F2032	F2033	F2034	F2035	F2036	F2037	F2038
Residential TIER 1 (Energy Only)	Base Energy ($/kWh)	$ 0.086	$ 0.088	$ 0.091	$ 0.093	$ 0.095	$ 0.098	$ 0.101	$ 0.103	$ 0.105	$ 0.107	$ 0.109	$ 0.111	$ 0.113	$ 0.115	$ 0.118	$ 0.120	$ 0.123	$ 0.125	$ 0.127	$ 0.130	$ 0.132
First 8,100 kWh/yr	Rate Rider ($/kWh)	$ 0.004	$ 0.004	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.007
	GST ($/kWh)	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.005	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.006	$ 0.007	$ 0.007	$ 0.007	$ 0.007
	Total ($/kWh)	$ 0.095	$ 0.097	$ 0.100	$ 0.103	$ 0.105	$ 0.108	$ 0.111	$ 0.113	$ 0.115	$ 0.118	$ 0.120	$ 0.122	$ 0.125	$ 0.127	$ 0.130	$ 0.132	$ 0.135	$ 0.138	$ 0.141	$ 0.143	$ 0.146
Electricity	Rate	F2018	F2019	F2020	F2021	F2022	F2023	F2024	F2025	F2026	F2027	F2028	F2029	F2030	F2031	F2032	F2033	F2034	F2035	F2036	F2037	F2038
Residential TIER 2 (Energy Only)	Base Energy ($/kWh)	$ 0.129	$ 0.133	$ 0.136	$ 0.140	$ 0.143	$ 0.147	$ 0.151	$ 0.154	$ 0.157	$ 0.160	$ 0.163	$ 0.166	$ 0.170	$ 0.173	$ 0.177	$ 0.180	$ 0.184	$ 0.187	$ 0.191	$ 0.195	$ 0.199
All energy above 8,100 kWh/yr	Rate Rider ($/kWh)	$ 0.006	$ 0.007	$ 0.007	$ 0.007	$ 0.007	$ 0.007	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.009	$ 0.009	$ 0.009	$ 0.009	$ 0.009	$ 0.010	$ 0.010	$ 0.010
	GST ($/kWh)	$ 0.007	$ 0.007	$ 0.007	$ 0.007	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.008	$ 0.009	$ 0.009	$ 0.009	$ 0.009	$ 0.009	$ 0.009	$ 0.010	$ 0.010	$ 0.010	$ 0.010	$ 0.010
	Total ($/kWh)	$ 0.142	$ 0.146	$ 0.150	$ 0.154	$ 0.158	$ 0.162	$ 0.166	$ 0.169	$ 0.173	$ 0.176	$ 0.180	$ 0.183	$ 0.187	$ 0.191	$ 0.195	$ 0.199	$ 0.203	$ 0.207	$ 0.211	$ 0.215	$ 0.219
Natural Gas	Rate	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Residential Rate (Rate 1) - Mainland	Cost of NG delivery (commercial – 2017)	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299	$ 4.299
	Cost of NG Storage & Transport	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811	$ 0.811
	Cost of NG Midstream commodity (commercial – 2017)	$ 2.306	$ 2.306	$ 2.370	$ 2.370	$ 2.434	$ 2.434	$ 2.498	$ 2.498	$ 2.523	$ 2.549	$ 2.574	$ 2.600	$ 2.626	$ 2.652	$ 2.679	$ 2.705	$ 2.733	$ 2.760	$ 2.787	$ 2.815	$ 2.843
	Cost of NG carbon tax (commercial – 2017)	$ 1.493	$ 1.493	$ 1.493	$ 1.493	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488	$ 2.488
	Clean Energy Levy	$ 0.030	$ 0.030	$ 0.030	$ 0.030	$ 0.030	$ 0.030	$ 0.030	$ 0.030	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.031	$ 0.032	$ 0.032	$ 0.032
	GST	$ 0.371	$ 0.371	$ 0.374	$ 0.374	$ 0.377	$ 0.377	$ 0.380	$ 0.380	$ 0.382	$ 0.383	$ 0.384	$ 0.385	$ 0.387	$ 0.388	$ 0.389	$ 0.391	$ 0.392	$ 0.393	$ 0.395	$ 0.396	$ 0.398
	PST	$ 0.519	$ 0.519	$ 0.524	$ 0.524	$ 0.528	$ 0.528	$ 0.533	$ 0.533	$ 0.534	$ 0.536	$ 0.538	$ 0.540	$ 0.542	$ 0.543	$ 0.545	$ 0.547	$ 0.549	$ 0.551	$ 0.553	$ 0.555	$ 0.557
	Total $/GJ	$ 9.828	$ 9.828	$ 9.900	$ 9.900	$ 10.967	$ 10.967	$ 11.039	$ 11.039	$ 11.067	$ 11.096	$ 11.124	$ 11.153	$ 11.183	$ 11.212	$ 11.242	$ 11.272	$ 11.302	$ 11.333	$ 11.364	$ 11.395	$ 11.426

8.5 Part 3 – Lowest Incremental Capital Costs

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate	Step	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	COC ($/tonCO2e)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
High Rise MURB Electric BB Mid Occupancy 0.6 VFAR 62-2001	4	1									138.7	48.8	9.5	45.7	93.0											
		2	40	10	20	2.5	Code	60	Standard	20	114.7	40.6	6.7	31.4	83.3	498	0.4	11.6	239065	13.3	-242.0	9.5	17.3	12.4	29.0	8.6
		3	40	10	20	2.5	Improved	80	Standard	20	103.8	29.7	6.6	31.4	72.4	378	0.8	24.7	344091	19.1	-333.0	8.4	25.1	21.9	30.3	10.4
		4	40	10	20	1.6	PH	80	Standard	20	88.8	14.8	6.4	31.1	57.8	283	2.4	74.1	-81132	-4.5	72.8	7.0	35.9	34.9	32.7	19.7
	5	1									145.9	56.0	9.6	46.2	99.7											
		2	40	20	20	2.5	Code	60	Standard	20	118.0	43.8	6.8	31.8	86.2	678	1.0	33.3	-29600	-1.6	29.3	9.7	19.1	14.9	29.1	19.5
		3	40	20	40	2	Improved	60	Standard	20	104.0	29.9	6.7	31.7	72.4	476	2.3	75.7	-357709	-19.9	332.6	8.4	28.7	26.4	31.0	25.0
		4	40	20	40	1.2	PH	60	Standard	20	88.9	14.8	6.4	31.3	57.6	347	3.2	102.9	-379974	-21.1	327.6	7.0	39.1	38.7	33.4	23.2
	6	1									159.6	69.5	9.9	47.0	112.5											
		2	20	20	20	2.5	Code	60	Standard	20	114.8	40.5	6.9	32.5	82.2	501	1.3	45.1	284947	15.8	-262.2	9.4	28.1	26.0	30.4	13.7
		3	20	20	20	2.5	Improved	80	Standard	20	102.5	28.2	6.8	32.4	70.0	431	1.8	59.9	402894	22.4	-353.0	8.2	35.8	35.1	31.9	13.4
		4	20	20	40	0.8	PH	60	Standard	20	88.9	14.7	6.5	31.8	57.1	282	2.7	91.2	253598	14.1	-205.3	7.0	44.3	44.9	34.5	16.0
	7A	1									155.3	65.1	10.0	47.5	107.8											
		2	20	20	40	1.2	Code	60	Standard	20	119.2	44.9	7.0	32.7	86.5	560	2.0	92.1	-841637	-46.8	789.3	9.8	23.2	20.0	29.7	37.5
		3	20	20	20	0.8	Improved	60	Standard	20	103.5	29.2	6.8	32.5	71.0	445	2.3	104.2	-568932	-31.6	497.5	8.3	33.4	32.1	31.9	26.5
		4*	20	20	40	0.8	PH	80	Standard	20	91.8	17.6	6.6	32.3	59.5	283	2.7	122.9	-544522	-30.3	453.5	7.2	40.9	41.0	33.5	24.5

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Low Rise MURB Electric BB Mid Occupancy 0.6 VFAR (except 0.5 CZ 8 Step 3) 62-2001	4	1									138.7	48.8	9.5	45.7	93.0											
		2	40	20	20	2.5	Code	60	Standard	20	107.5	33.4	6.6	31.3	76.2	463	0.5	11.6	462783	25.7	-451.4	8.8	22.5	18.7	30.1	5.7
		3	40	20	20	2.5	Improved	60	Standard	20	102.5	28.4	6.6	31.3	71.2	369	0.6	14.3	569094	31.6	-544.1	8.3	26.1	23.0	30.7	5.8
		4	40	20	20	2	PH	80	Standard	20	87.9	13.9	6.4	31.0	56.9	272	2.6	62.1	162332	9.0	-144.9	6.9	36.6	35.7	32.8	16.1
	5	1									145.9	56.0	9.6	46.2	99.7											
		2	40	20	20	2.5	Code	60	Standard	20	118.0	43.8	6.8	31.8	86.2	678	0.5	12.4	346629	19.3	-343.6	9.7	19.1	14.9	29.1	7.2
		3	40	20	40	2	Improved	60	Standard	20	104.0	29.9	6.7	31.7	72.4	476	2.2	57.9	-38134	-2.1	35.5	8.4	28.7	26.4	31.0	19.2
		4	40	20	40	1.2	PH	60	Standard	20	88.9	14.8	6.4	31.3	57.6	347	3.3	85.2	-60399	-3.4	52.1	7.0	39.1	38.7	33.4	19.2
	6	1									159.6	69.5	9.9	47.0	112.5											
		2	20	20	20	2.5	Code	60	Standard	20	114.8	40.5	6.9	32.5	82.2	501	0.4	11.7	887538	49.3	-816.6	9.4	28.1	26.0	30.4	3.5
		3	20	20	20	2.5	Improved	80	Standard	20	102.5	28.2	6.8	32.4	70.0	431	1.0	26.4	1005486	55.9	-881.0	8.2	35.8	35.1	31.9	5.9
		4	20	20	40	0.8	PH	60	Standard	20	88.9	14.7	6.5	31.8	57.1	282	2.2	61.0	796737	44.3	-644.8	7.0	44.3	44.9	34.5	10.7
	7A	1									155.3	65.1	10.0	47.5	107.8											
		2	20	20	40	1.2	Code	60	Standard	20	119.2	44.9	7.0	32.7	86.5	560	1.4	51.7	-114145	-6.3	107.0	9.8	23.2	20.0	29.7	21.1
		3	20	20	20	0.8	Improved	60	Standard	20	103.5	29.2	6.8	32.5	71.0	445	1.6	59.4	237866	13.2	-208.0	8.3	33.4	32.1	31.9	15.1
		4	20	40	20	0.8	PH	80	Standard	20	87.3	13.1	6.5	32.0	55.3	222	4.1	149.1	-879749	-48.9	709.1	6.8	43.8	44.3	34.6	27.5
	7B	1									184.5	79.7	10.5	48.4	136.1											
		2	20	40	40	0.8	Code	60	Condensing	40	124.0	43.8	5.4	23.1	100.9	97	2.7	9.8	-79284	-22.0	217.1	11.5	32.8	26.3	48.5	2.4
		3	20	40	40	0.8	Improved	80	Condensing	20	113.3	26.4	6.4	29.6	83.7	81	3.3	11.8	-59151	-16.4	202.3	10.0	38.6	35.5	38.8	2.1
	8	1									204.9	99.8	11.0	50.1	154.9											
		2	20	40	20	0.8	PH	80	Condensing	20	129.2	42.2	6.8	31.1	98.1	66	3.3	12.2	-19435	-5.4	65.3	11.4	36.9	35.5	37.7	1.9
		3*	20	40	40	0.8	PH	80	Condensing	40	115.2	34.9	5.4	24.0	91.2	55	3.3	11.9	-47090	-13.1	123.7	10.6	40.3	35.1	49.3	2.1

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics									Energy and Emissions Outcomes					Costing Outcomes									
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	Plant	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Hotel Common Area Fan Coils Heat Pump DHW Electric Laundry Load	4	1										244.2	26.9	25.8	132.8	111.4										
		2	50	5	20	2.5	Code	60	0	Boiler/Chiller	20	164.0	28.0	8.3	37.5	126.5	-0.2	-5.7	287489	30.2	-86.4	9.3	32.9	17.3	67.7	0.0
		3	50	15	20	2.5	Improved	60	0	GSHP	20	138.2	19.2	3.0	8.5	129.7	0.0	1.0	274477	28.8	-63.2	8.6	43.4	23.3	88.4	0.4
		4	20	20	40	2.5	PH	60	20	GSHP	40	119.7	14.2	2.8	8.5	111.2	1.2	35.5	153385	16.1	-35.0	7.4	51.0	33.9	89.2	9.3
	5	1										261.3	35.8	28.0	144.5	116.9										
		2	50	10	20	2.5	Code	90	0	Boiler/Chiller	20	166.7	28.2	8.2	36.7	130.0	-0.1	-1.9	319964	33.6	-84.9	9.5	36.2	20.5	70.7	0.0
		3	50	15	20	2	Improved	90	0	GSHP	40	139.7	19.6	3.3	10.2	129.5	1.2	33.6	66129	6.9	-14.1	8.6	46.5	27.5	88.2	10.8
		4	20	30	20	2.5	PH	90	40	GSHP	40	116.4	14.1	3.1	10.4	106.0	2.1	58.5	90387	9.5	-19.1	7.1	55.4	40.1	89.0	12.9
	6	1										272.2	47.4	30.8	159.9	112.3										
		2	50	10	20	1.6	Code	90	0	Boiler/Chiller	20	165.0	29.2	8.1	36.3	128.7	1.1	37.8	-34904	-3.7	8.1	9.4	39.4	22.4	73.6	12.1
		3	50	10	40	0.8	Improved	90	20	GSHP	20	139.1	19.8	3.9	13.5	125.7	2.3	78.7	-326049	-34.2	63.6	8.5	48.9	29.8	87.4	19.0
		4	20	30	40	0.8	PH	90	40	GSHP	40	119.6	11.3	3.7	13.6	106.0	2.8	95.5	-265877	-27.9	51.5	7.2	56.1	40.2	88.1	17.0
	7A	1										265.2	43.4	28.3	145.9	119.3										
		2	20	15	40	1.6	Code	90	0	Boiler/Chiller	20	166.6	29.7	8.1	36.1	130.5	0.7	32.4	22274	2.3	-5.8	9.5	37.2	21.7	71.3	8.2
		3	20	30	40	1.2	PH	90	20	GSHP	40	136.4	19.0	4.2	15.7	120.7	2.2	96.8	-426123	-44.8	93.0	8.2	48.6	32.0	85.0	16.6
		4*	20	30	40	0.8	PH	90	40	GSHP	40	127.6	18.5	4.2	15.9	111.7	2.7	121.1	-558244	-58.6	121.6	7.7	51.9	36.7	85.3	18.1
	7B	1										270.5	49.3	29.3	151.3	119.2										
		2	20	15	40	1.2	Code	90	0	Boiler/Chiller	20	169.9	29.9	8.4	37.8	132.1	0.9	29.0	49557	5.2	-12.5	9.7	37.2	21.4	71.2	9.6
		3*	20	30	40	0.8	PH	90	20	GSHP	40	141.1	19.9	4.8	18.7	122.4	2.3	78.4	-261350	-27.4	56.0	8.5	47.8	31.3	83.6	17.7
	8	1										295.6	70.7	32.0	165.4	130.2										
		2*	20	30	40	0.8	PH	90	20	GSHP	40	159.6	35.4	6.0	24.1	135.5	1.9	85.9	-322407	-33.9	64.9	9.5	46.0	29.6	81.4	14.4

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Office No IT Load Default Occupancy	4	1									141.4	35.1	11.9	59.5	81.9											
		2	VAV	50	10	20	2.5	Code	60	0	120.5	18.7	7.2	33.8	86.7	420	0.1	1.6	57424	3.2	-33.5	6.6	14.8	6.8	39.5	3.3
			FC	50	10	20	2.5	Code	None	0	115.4	29.4	9.2	45.8	69.7	452	-0.2	-5.8	458761	25.2	-471.9	5.9	18.4	17.0	22.4	0.0
			ASHP	50	10	20	2.5	Code	None	0	93.9	29.4	3.7	15.2	78.8	460	-0.2	-5.8	469931	25.8	-156.7	5.5	33.6	22.0	69.2	0.0
		3	VAV	50	20	20	2.5	Improved	60	50	97.7	18.6	7.0	34.0	63.8	297	1.2	34.5	-52837	-2.9	29.5	5.1	30.9	27.5	41.3	17.7
			FC	50	10	20	2.5	Improved	60	25	95.6	16.7	6.7	32.6	63.0	392	0.4	12.2	369423	20.3	-195.6	5.0	32.4	28.8	43.6	6.0
			ASHP	50	10	20	2.5	Improved	60	0	92.2	14.7	3.7	15.2	77.0	465	0.0	-0.3	405984	22.3	-135.1	5.4	34.8	23.6	69.3	0.0
	5	1									141.3	36.0	11.8	59.0	82.3											
		2	VAV	50	10	40	2.5	Code	60	0	129.5	27.4	8.4	39.9	89.5	477	0.1	3.6	-79498	-4.4	63.4	7.0	8.4	1.7	29.1	31.4
			FC	50	10	20	2.5	Code	60	0	117.8	24.9	8.2	39.9	77.9	515	-0.1	-1.6	254225	14.0	-195.0	6.2	16.6	12.3	30.3	0.0
			ASHP	50	10	20	2.5	Code	60	0	99.0	24.9	3.7	15.2	83.9	590	-0.1	-1.6	288523	15.8	-98.0	5.8	29.9	17.5	68.5	0.0
		3	VAV	50	20	40	2	Improved	80	50	99.0	15.5	6.0	28.4	70.7	329	2.6	71.0	-819824	-45.0	388.8	5.4	29.9	23.8	49.0	44.5
			FC	50	20	20	2.5	Improved	80	50	93.4	19.5	7.0	34.2	59.2	381	1.3	36.2	6920	0.4	-3.9	4.8	33.9	31.6	40.9	17.0
			ASHP	50	20	20	2.5	Improved	60	0	97.0	18.5	3.7	15.2	81.9	582	0.2	5.9	194612	10.7	-65.9	5.7	31.3	19.3	68.6	4.5
	6	1									144.5	47.1	13.4	68.0	76.5											
		2	VAV	50	20	40	2.5	Code	80	0	127.6	30.0	8.2	39.0	88.7	417	0.7	24.6	-494660	-27.2	259.9	6.9	11.6	1.5	39.0	100.0
			FC	50	20	20	2.5	Code	80	0	116.2	28.7	8.5	41.6	74.5	438	0.4	12.0	6354	0.3	-3.6	6.0	19.6	13.3	36.5	11.3
			ASHP	50	20	20	2.5	Code	80	0	93.0	28.7	3.7	15.2	77.9	456	0.4	12.0	109418	6.0	-30.8	5.5	35.6	21.8	72.7	6.9
		3	VAV	50	20	20	1.2	Improved	80	50	94.4	18.9	5.8	27.6	66.8	295	3.1	101.7	-1348055	-74.0	488.8	5.1	34.7	26.6	56.5	47.7
			FC	50	20	20	1.2	Improved	60	0	98.9	14.3	5.7	26.7	72.3	474	1.7	55.0	-617810	-33.9	220.8	5.4	31.5	21.9	57.3	31.2
			ASHP	50	20	20	1.6	Improved	60	0	89.3	18.6	3.6	15.2	74.2	472	1.4	45.1	-413784	-22.7	116.0	5.2	38.2	25.2	73.0	22.3
	7A	1									161.9	63.3	15.6	79.2	82.7											
		2	VAV	50	20	40	0.8	Improved	80	25	116.7	29.6	5.7	25.4	91.3	377	2.9	95.7	-1531638	-84.1	426.4	6.6	27.9	14.1	63.4	76.2
			FC	50	20	40	1.2	Code	60	0	115.0	29.7	7.8	37.5	77.6	514	1.6	51.9	-539435	-29.6	190.5	6.1	28.9	20.8	50.0	28.2
			ASHP	50	20	40	1.2	Code	60	0	97.0	29.7	3.7	15.2	81.8	515	1.6	51.9	-486397	-26.7	112.6	5.7	40.1	26.0	76.2	22.5
		3	VAV *	50	20	40	0.8	PH	80	50	103.2	26.7	5.3	24.2	79.0	312	3.4	111.6	-1550500	-85.2	416.5	5.8	36.3	24.8	65.7	50.6
			FC	50	20	40	0.8	Improved	60	25	95.8	19.4	5.7	26.7	69.1	461	2.4	77.7	-750287	-41.2	208.8	5.2	40.8	32.0	63.4	27.3
			ASHP	50	20	20	0.8	Improved	60	0	95.4	19.4	3.7	15.2	80.2	540	1.8	60.8	-613765	-33.7	141.9	5.6	41.1	27.4	76.3	25.0

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Office 2.2 W/m2 IT Load Double Occupancy	4	1									154.3	20.8	10.3	49.3	105.0											
		2	FC	50	10	20	2.5	Code	60	50	127.8	17.1	8.3	39.4	88.4	466	0.8	23.8	-16392	-0.9	22.3	6.9	17.2	16.6	19.7	17.4
		3*	FC	50	20	40	0.8	Improved	60	50	116.1	1.9	5.4	23.5	92.6	510	3.0	85.3	-1108808	-60.9	621.7	6.6	24.7	19.2	47.7	53.9
	5	1									170.6	26.7	11.6	56.1	114.4											
		2*	FC	50	20	40	2	Code	60	50	130.5	16.6	8.0	37.5	93.1	534	2.0	55.3	-423237	-23.2	315.1	7.1	23.5	21.4	31.7	30.0
		3*	FC	50	20	40	0.8	Improved	60	50	121.5	4.9	5.7	25.4	96.1	556	3.0	81.0	-868748	-47.7	404.8	6.9	28.8	23.3	50.6	40.4
	6	1									162.5	35.3	12.3	60.4	102.1											
		2	FC	50	20	20	2	Code	60	50	128.0	25.7	9.2	44.6	83.4	461	1.9	62.9	-640494	-35.2	564.0	6.7	21.2	20.0	25.4	32.6
		3*	FC	50	20	40	0.8	Improved	60	50	114.0	9.2	6.0	27.4	86.6	505	2.9	96.6	-1196323	-65.7	524.3	6.4	29.8	23.8	51.0	42.0
	7A	1									181.7	52.2	14.7	72.9	108.8											
		2	FC	50	20	40	0.8	Code	60	50	129.9	24.6	8.0	37.6	92.3	544	2.8	91.0	-1054219	-57.9	431.2	7.1	28.5	23.3	45.7	37.0
		3*	FC	50	20	40	0.8	Improved	60	50	124.4	18.5	6.8	31.2	93.1	546	2.8	92.6	-1054965	-57.9	367.5	6.9	31.6	24.8	53.7	35.4

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Commercial No IT Load Default Occupancy	4	1									141.4	35.1	11.9	59.5	81.9											
		2	VAV	50	10	20	2.5	Code	60	0	120.5	18.7	7.2	33.8	86.7	420	0.1	1.6	57424	3.2	-33.5	6.6	14.8	6.8	39.5	3.3
			FC	50	10	20	2.5	Code	None	0	115.4	29.4	9.2	45.8	69.7	452	-0.2	-5.8	458761	25.2	-471.9	5.9	18.4	17.0	22.4	0.0
			ASHP	50	10	20	2.5	Code	None	0	93.9	29.4	3.7	15.2	78.8	460	-0.2	-5.8	469931	25.8	-156.7	5.5	33.6	22.0	69.2	0.0
		3	VAV	50	10	20	2.5	Improved	60	0	117.3	16.0	6.6	30.6	86.6	418	0.1	3.0	56881	3.1	-29.6	6.5	17.1	8.2	44.4	5.1
			FC	50	10	20	2.5	Improved	60	0	104.8	14.7	6.5	30.5	74.3	456	0.0	-0.3	370345	20.3	-186.8	5.7	25.9	19.4	45.7	0.0
			ASHP	50	10	20	2.5	Improved	60	0	92.2	14.7	3.7	15.2	77.0	465	0.0	-0.3	405984	22.3	-135.1	5.4	34.8	23.6	69.3	0.0
	5	1									141.3	36.0	11.8	59.0	82.3											
		2	VAV	50	10	20	2.5	Code	60	0	131.0	28.4	8.6	41.3	89.6	474	0.1	1.5	-54112	-3.0	46.7	7.0	7.3	1.0	26.9	22.5
			FC	50	10	20	2.5	Code	60	0	117.8	24.9	8.2	39.9	77.9	515	-0.1	-1.6	254225	14.0	-195.0	6.2	16.6	12.3	30.3	0.0
			ASHP	50	10	20	2.5	Code	60	0	99.0	24.9	3.7	15.2	83.9	590	-0.1	-1.6	288523	15.8	-98.0	5.8	29.9	17.5	68.5	0.0
		3	VAV	50	20	20	2.5	Improved	80	25	114.3	18.6	6.8	31.6	82.7	394	1.2	32.6	-399852	-22.0	217.0	6.3	19.1	11.5	42.8	42.1
			FC	50	20	20	2.5	Improved	60	0	111.1	18.5	7.0	33.2	77.9	511	0.2	5.9	166445	9.1	-94.9	6.0	21.4	15.1	40.8	5.8
			ASHP	50	20	20	2.5	Improved	60	0	97.0	18.5	3.7	15.2	81.9	582	0.2	5.9	194612	10.7	-65.9	5.7	31.3	19.3	68.6	4.5
	6	1									144.5	47.1	13.4	68.0	76.5											
		2	VAV	50	20	40	2.5	Code	80	0	127.6	30.0	8.2	39.0	88.7	417	0.7	24.6	-494660	-27.2	259.9	6.9	11.6	1.5	39.0	100.0
			FC	50	20	20	2.5	Code	80	0	116.2	28.7	8.5	41.6	74.5	438	0.4	12.0	6354	0.3	-3.6	6.0	19.6	13.3	36.5	11.3
			ASHP	50	20	20	2.5	Code	80	0	93.0	28.7	3.7	15.2	77.9	456	0.4	12.0	109418	6.0	-30.8	5.5	35.6	21.8	72.7	6.9
		3	VAV	50	20	40	1.2	Improved	60	0	113.1	19.8	6.3	28.9	84.2	423	1.9	61.3	-993617	-54.6	381.7	6.3	21.7	10.0	53.3	76.2
			FC	50	20	20	1.6	Improved	60	0	102.4	18.6	6.5	31.1	71.3	461	1.4	45.1	-450493	-24.7	180.0	5.5	29.1	20.9	51.2	26.9
			ASHP	50	20	20	1.6	Improved	60	0	89.3	18.6	3.6	15.2	74.2	472	1.4	45.1	-413784	-22.7	116.0	5.2	38.2	25.2	73.0	22.3
	7A	1									161.9	63.3	15.6	79.2	82.7											
		2	VAV	50	20	40	0.8	Improved	80	25	116.7	29.6	5.7	25.4	91.3	377	2.9	95.7	-1531638	-84.1	426.4	6.6	27.9	14.1	63.4	76.2
			FC	50	20	40	1.2	Code	60	0	115.0	29.7	7.8	37.5	77.6	514	1.6	51.9	-539435	-29.6	190.5	6.1	28.9	20.8	50.0	28.2
			ASHP	50	20	40	1.2	Code	60	0	97.0	29.7	3.7	15.2	81.8	515	1.6	51.9	-486397	-26.7	112.6	5.7	40.1	26.0	76.2	22.5
		3	VAV*	30	20	40	0.8	PH	80	50	105.9	26.0	4.9	21.4	84.5	279	2.8	92.7	-1302735	-71.5	335.4	6.1	34.6	21.4	68.5	48.9
			FC	50	20	20	0.8	Improved	60	0	106.4	19.4	5.8	26.7	79.7	525	1.8	60.8	-668208	-36.7	188.3	5.9	34.3	23.3	62.6	29.5
			ASHP	50	20	20	0.8	Improved	60	0	95.4	19.4	3.7	15.2	80.2	540	1.8	60.8	-613765	-33.7	141.9	5.6	41.1	27.4	76.3	25.0

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Commercial 2.2 W/m2 IT Load Double Occupancy	4	1									154.3	20.8	10.3	49.3	105.0											
		2	FC	50	10	20	2.5	Code	None	0	156.1	25.4	10.1	48.1	108.0	598	-0.2	-5.8	40814	2.2	-591.3	8.4	-1.2	-1.9	1.8	100.0
		3	FC	50	20	20	2	Improved	60	50	120.0	8.7	6.7	30.7	89.3	477	2.0	57.4	-583106	-32.0	442.7	6.7	22.2	19.1	35.2	36.5
	5	1									170.6	26.7	11.6	56.1	114.4											
		2	FC	50	4	20	2.5	Code	60	0	168.4	28.6	10.6	50.0	118.4	675	0.0	-1.2	-28089	-1.5	71.4	9.1	1.2	-0.8	9.3	100.0
		3	FC	30	20	40	1.6	Improved	60	50	119.6	8.0	6.3	28.5	91.1	488	2.1	57.4	-355177	-19.5	181.9	6.7	29.8	25.8	46.1	25.9
	6	1									162.5	35.3	12.3	60.4	102.1											
		2	FC	50	10	40	2.5	Code	60	0	152.1	29.4	10.1	48.5	103.6	576	0.0	1.1	26000	1.4	-32.8	8.1	6.4	3.2	17.7	3.6
		3	FC	50	20	40	1.6	Improved	60	50	119.9	17.1	7.5	35.7	84.2	476	2.3	76.9	-846922	-46.5	487.8	6.5	26.2	22.7	38.8	35.2
	7A	1									181.7	52.2	14.7	72.9	108.8											
		2	FC	50	20	20	1.2	Code	60	0	153.8	28.4	8.9	41.5	112.2	657	1.5	49.9	-759744	-41.7	361.6	8.5	15.4	8.1	39.3	58.5
		3	FC	30	20	40	1.2	PH	60	50	119.2	17.5	6.6	30.2	89.0	476	2.1	69.3	-535497	-29.4	181.0	6.6	34.4	28.0	55.3	23.4

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Retail Big Box	4	1									159.8	30.4	11.0	52.9	107.0											
		2	RTU	20	10	20	2.5	Code	60	0	139.9	15.4	6.1	25.9	113.9	154	0.9	13.2	-40085	-8.9	105.3	8.1	12.1	5.3	41.1	29.1
			FC	20	10	20	2.5	Code	60	0	128.1	19.1	5.4	23.1	105.0	149	0.8	12.1	17461	3.9	-39.9	7.4	19.5	13.0	47.3	10.8
			ASHP	20	10	20	2.5	Code	60	0	113.4	19.1	1.8	3.2	110.2	159	0.8	12.1	25765	5.7	-33.7	7.2	28.7	16.2	82.5	8.7
		3	RTU	20	10	20	2.5	Improved	60	25	118.0	15.6	5.9	26.2	91.8	126	2.1	31.3	-5105	-1.1	12.8	6.7	25.8	21.8	43.0	16.8
			FC	20	10	20	2.5	Improved	60	25	106.3	18.6	5.1	22.6	83.7	123	2.0	30.1	49472	11.0	-106.0	6.1	33.2	29.2	50.4	12.1
			ASHP	20	10	20	2.5	Improved	60	0	114.1	13.9	1.8	3.2	110.9	161	1.2	17.6	-2812	-0.6	3.7	7.2	28.3	15.7	82.4	13.1
	5	1									188.0	39.1	14.0	68.5	119.4											
		2	RTU	20	10	20	2.5	Code	60	0	168.8	26.3	8.7	39.2	129.7	182	0.9	12.6	-50524	-11.2	120.6	9.5	9.8	3.3	34.9	39.3
			FC	20	10	20	2.5	Code	80	0	147.0	26.7	6.7	29.3	117.7	165	1.3	18.8	2650	0.6	-4.5	8.4	21.5	14.1	49.6	13.5
			ASHP	20	10	20	2.5	Code	80	0	124.5	26.7	1.9	3.2	121.3	193	1.3	18.8	30628	6.8	-29.8	7.9	33.5	19.9	85.6	9.6
		3	RTU	20	10	20	0.8	Improved	80	50	111.5	18.7	6.1	27.9	83.6	119	5.1	71.5	-51985	-11.5	79.7	6.2	40.5	36.8	54.4	19.8
			FC	20	20	20	2.5	Improved	80	25	116.0	19.5	5.1	21.7	94.2	132	3.7	52.4	-11170	-2.5	15.0	6.7	38.0	31.8	62.0	16.8
			ASHP	20	20	20	2.5	Improved	80	25	99.8	19.5	1.7	3.2	96.7	154	3.7	52.4	9719	2.2	-9.2	6.3	46.7	36.0	87.6	14.8
	6	1									203.3	54.9	18.5	93.4	109.9											
		2	RTU	20	10	20	1.6	Code	80	0	163.0	28.5	8.3	37.6	125.4	158	2.5	43.0	-168408	-37.4	197.3	9.2	19.5	7.9	53.2	54.5
			FC	20	10	20	0.8	Code	80	0	142.5	29.8	6.7	29.7	112.9	152	2.8	47.8	-109493	-24.3	109.6	8.1	29.6	18.4	62.2	26.1
			ASHP	20	10	20	0.8	Code	80	0	120.0	29.8	1.9	3.2	116.9	159	2.8	47.8	-82608	-18.3	57.5	7.6	40.7	23.9	89.5	20.0
		3	RTU	20	20	40	2	Improved	80	25	118.3	16.8	4.8	19.9	98.4	119	6.0	102.3	-260657	-57.9	221.8	6.9	41.6	30.7	73.2	33.4
			FC	20	10	40	0.8	Improved	80	25	111.9	19.0	4.4	18.5	93.4	119	5.5	93.9	-193981	-43.1	161.0	6.5	44.8	34.3	75.1	27.4
			ASHP	20	20	20	1.2	Improved	80	0	118.6	19.8	1.9	3.2	115.4	159	3.9	67.5	-163200	-36.3	113.5	7.5	41.5	24.9	89.6	27.2
	7A	1									245.1	69.1	23.9	121.9	123.2											
		2	RTU	20	20	40	2	Improved	80	0	157.7	30.0	6.3	26.1	131.6	158	4.8	82.7	-238093	-52.9	155.9	9.2	35.4	21.1	73.0	33.6
			FC	20	20	40	2	Improved	80	0	145.8	29.9	5.7	23.3	122.5	150	4.6	79.1	-168901	-37.5	106.7	8.6	40.3	26.8	75.7	25.3
			ASHP	20	20	40	2	Improved	80	0	126.9	29.9	2.0	3.2	123.7	158	4.6	79.1	-138878	-30.8	72.5	8.0	48.1	31.4	91.6	21.6
		3	RTU*	20	20	40	0.8	PH	80	25	122.0	21.1	3.6	13.1	108.8	129	6.8	116.0	-244197	-54.2	138.3	7.4	50.1	36.9	84.4	26.8
			FC	20	20	40	0.8	PH	80	25	114.8	19.7	3.5	12.6	102.2	123	6.6	112.4	-192084	-42.7	107.8	6.9	53.0	40.7	85.1	23.6
			ASHP	20	20	40	0.8	PH	80	25	103.4	19.7	1.7	3.2	100.2	131	6.6	112.4	-164793	-36.6	84.9	6.5	57.7	44.3	92.7	21.7

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

8.6 Part 3 – Highest NPV

Scenario			Archetype Characteristics								Energy and Emissions Outcomes															
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
High Rise MURB Electric BB Mid Occupancy 0.6 VFAR 62-2001	4	1									138.7	48.8	9.5	45.7	93.0											
		2	40	10	20	2.5	Code	60	Condensing	40	104.9	40.6	4.9	21.6	83.3	498	0.5	15.2	272282	15.1	-166.0	9.2	24.3	15.2	48.1	9.3
		3	40	10	20	2.5	Improved	80	Condensing	40	94.0	29.7	4.8	21.6	72.4	378	0.9	28.4	377269	21.0	-223.8	8.1	32.2	24.7	49.4	10.6
		4	40	10	20	1.6	PH	80	Condensing	40	79.1	14.8	4.6	21.3	57.8	283	2.6	77.8	-48294	-2.7	27.4	6.7	43.0	37.6	51.7	19.1
	5	1									145.9	56.0	9.6	46.2	99.7											
		2	40	20	20	2.5	Code	60	Condensing	40	108.2	43.8	5.0	22.0	86.2	678	1.1	37.3	-1149	-0.1	0.7	9.4	25.9	17.5	47.9	18.6
		3	40	10	20	1.6	Improved	80	Condensing	40	90.4	26.1	4.8	21.8	68.6	462	2.5	82.0	-252380	-14.0	144.6	7.8	38.0	32.1	50.3	22.3
		4	40	10	20	0.8	PH	80	Condensing	40	75.8	11.5	4.6	21.4	54.3	337	3.4	109.2	-290230	-16.1	158.8	6.4	48.1	44.0	52.6	21.7
	6	1									159.6	69.5	9.9	47.0	112.5											
		2	20	20	40	2.5	Code	80	Condensing	20	103.7	32.6	6.2	29.3	74.4	474	1.7	57.9	334447	18.6	-250.8	8.5	35.0	32.6	37.3	14.0
		3	20	20	40	2.5	Improved	80	Condensing	20	98.7	27.6	6.2	29.3	69.5	425	1.8	61.0	432254	24.0	-319.0	8.1	38.1	36.3	37.9	13.3
		4	20	20	40	0.8	PH	60	Condensing	20	85.7	14.7	5.9	28.7	57.1	282	2.7	91.5	279667	15.5	-193.8	6.9	46.3	45.7	40.3	15.8
	7A	1									155.3	65.1	10.0	47.5	107.8											
		2	20	20	40	0.8	Code	60	Condensing	20	110.3	39.2	6.3	29.4	81.0	512	2.2	101.5	-802763	-44.6	612.0	9.2	28.9	25.1	36.6	33.0
		3	20	20	40	0.8	Improved	60	Condensing	20	99.7	28.6	6.2	29.3	70.4	439	2.3	105.7	-543752	-30.2	400.5	8.2	35.8	33.4	37.8	25.9
		4*	20	20	40	0.8	PH	80	Condensing	20	88.7	17.6	6.0	29.1	59.5	283	2.7	123.3	-519845	-28.9	368.4	7.1	42.9	41.7	39.3	24.1

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Low Rise MURB Electric BB Mid Occupancy 0.6 VFAR 62-2001	4	1									138.7	48.8	9.5	45.7	93.0											
		2	40	20	20	2.5	Code	60	Condensing	40	97.7	33.4	4.8	21.5	76.2	463	0.6	15.2	495860	27.5	-295.7	8.5	29.5	21.4	49.2	6.6
		3	40	20	20	2.5	Improved	60	Condensing	40	92.7	28.4	4.8	21.5	71.2	369	0.7	18.0	602157	33.5	-354.8	8.0	33.1	25.8	49.8	6.5
		4	40	20	20	2	PH	80	Condensing	40	78.2	13.9	4.6	21.3	56.9	272	2.7	65.8	195132	10.8	-110.2	6.7	43.6	38.4	51.9	15.9
	5	1									145.9	56.0	9.6	46.2	99.7											
		2	40	20	20	2.5	Code	60	Condensing	40	108.2	43.8	5.0	22.0	86.2	678	0.6	16.4	375080	20.8	-225.4	9.4	25.9	17.5	47.9	8.2
		3	40	20	20	2	Improved	80	Condensing	40	89.0	24.7	4.8	21.8	67.2	446	2.7	69.1	24064	1.3	-13.7	7.6	39.0	33.3	50.5	18.1
		4	40	20	40	1.2	PH	60	Condensing	40	79.1	14.8	4.6	21.5	57.6	347	3.4	89.2	-32514	-1.8	18.0	6.7	45.8	41.3	52.2	18.9
	6	1									159.6	69.5	9.9	47.0	112.5											
		2	20	20	20	2.5	Code	80	Condensing	20	104.2	33.1	6.2	29.3	74.9	479	0.9	23.6	933748	51.9	-701.5	8.6	34.7	32.2	37.2	5.8
		3	20	20	20	2.5	Improved	80	Condensing	20	99.3	28.2	6.2	29.3	70.0	431	1.0	26.7	1032197	57.3	-763.1	8.1	37.8	35.9	37.8	5.9
		4	20	20	20	1.2	PH	80	Condensing	20	84.6	13.5	5.9	28.7	55.9	296	2.3	62.1	845870	47.0	-585.9	6.8	47.0	46.6	40.3	10.5
	7A	1									155.3	65.1	10.0	47.5	107.8											
		2	20	20	20	0.8	Code	60	Condensing	20	111.0	39.9	6.3	29.4	81.7	517	1.5	55.6	2205	0.1	-1.7	9.2	28.5	24.6	36.5	18.4
		3	20	20	20	0.8	Improved	60	Condensing	20	100.3	29.2	6.2	29.3	71.0	445	1.6	59.8	262717	14.6	-193.9	8.2	35.4	32.9	37.8	14.8
		4	20	40	20	0.8	PH	80	Condensing	20	84.2	13.1	5.9	28.8	55.3	222	4.1	149.5	-855422	-47.5	590.4	6.7	45.8	45.1	40.4	27.1
	7B	1									184.5	79.7	10.5	48.4	136.1											
		2	20	40	40	0.8	Code	80	Condensing	40	116.9	36.7	5.3	23.0	93.9	96	3.0	10.8	-71870	-20.0	193.1	10.8	36.7	30.6	49.4	2.3
		3	20	40	40	0.8	Improved	80	Condensing	40	106.6	26.4	5.2	22.9	83.7	81	3.3	12.2	-57858	-16.1	151.5	9.8	42.2	36.8	50.7	2.1
	8	1									204.9	99.8	11.0	50.1	154.9											
		2	20	40	40	0.8	PH	80	Condensing	40	118.3	38.0	5.5	24.4	93.9	61	3.5	12.9	-4770	-1.3	12.2	10.8	42.3	38.9	49.4	1.9
		3*	20	40	40	0.8	PH	80	Condensing	40	115.2	34.9	5.4	24.0	91.2	55	3.3	11.9	-47090	-13.1	123.7	10.6	40.3	35.1	49.3	2.1

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics									Energy and Emissions Outcomes					Costing Outcomes									
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	Plant	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Hotel Common Area Fan Coils Heat Pump DHW Electric Laundry Load	4	1										244.2	26.9	25.8	132.8	111.4										
		2	50	10	20	2.5	Code	60	0	Boiler/Chiller	40	153.6	22.9	7.3	32.1	121.4	-0.1	-1.9	327344	34.4	-92.9	8.8	37.1	21.6	71.8	0.0
		3	50	15	20	2.5	Improved	60	0	GSHP	40	133.5	19.2	2.9	8.5	125.0	0.2	4.5	294164	30.9	-67.6	8.3	45.3	26.0	88.6	1.6
		4	20	20	40	2.5	PH	60	20	GSHP	40	119.7	14.2	2.8	8.5	111.2	1.2	35.5	153385	16.1	-35.0	7.4	51.0	33.9	89.2	9.3
	5	1										261.3	35.8	28.0	144.5	116.9										
		2	50	10	20	2.5	Code	90	0	Boiler/Chiller	40	161.9	28.2	8.2	36.7	125.2	0.1	1.4	341317	35.8	-90.4	9.2	38.0	23.1	70.8	0.5
		3	50	15	20	2	Improved	90	0	GSHP	40	139.7	19.6	3.3	10.2	129.5	1.2	33.6	66129	6.9	-14.1	8.6	46.5	27.5	88.2	10.8
		4	20	30	20	2.5	PH	90	40	GSHP	40	116.4	14.1	3.1	10.4	106.0	2.1	58.5	90387	9.5	-19.1	7.1	55.4	40.1	89.0	12.9
	6	1										272.2	47.4	30.8	159.9	112.3										
		2	50	20	40	2	Code	90	0	Boiler/Chiller	40	159.8	29.6	8.1	36.6	123.1	1.2	41.9	-13254	-1.4	3.1	9.0	41.3	25.3	73.6	11.9
		3	50	10	40	0.8	Improved	90	20	GSHP	40	134.4	19.8	3.8	13.5	120.9	2.4	82.8	-311360	-32.7	60.6	8.2	50.6	32.3	87.6	18.4
		4	20	30	40	0.8	PH	90	40	GSHP	40	119.6	11.3	3.7	13.6	106.0	2.8	95.5	-265877	-27.9	51.5	7.2	56.1	40.2	88.1	17.0
	7A	1										265.2	43.4	28.3	145.9	119.3										
		2	20	15	40	1.6	Code	90	0	Boiler/Chiller	40	161.9	29.7	8.1	36.1	125.7	0.8	37.6	25233	2.7	-6.6	9.2	38.9	24.2	71.5	8.5
		3	20	30	40	1.2	PH	90	20	GSHP	40	136.4	19.0	4.2	15.7	120.7	2.2	96.8	-426123	-44.8	93.0	8.2	48.6	32.0	85.0	16.6
		4*	20	30	40	0.8	PH	90	40	GSHP	40	127.6	18.5	4.2	15.9	111.7	2.7	121.1	-558244	-58.6	121.6	7.7	51.9	36.7	85.3	18.1
	7B	1										270.5	49.3	29.3	151.3	119.2										
		2	20	15	40	1.2	Code	90	0	Boiler/Chiller	40	165.2	29.9	8.4	37.8	127.4	1.0	33.0	64246	6.7	-16.1	9.4	38.9	23.9	71.4	9.8
		3*	20	30	40	0.8	PH	90	20	GSHP	40	141.1	19.9	4.8	18.7	122.4	2.3	78.4	-261350	-27.4	56.0	8.5	47.8	31.3	83.6	17.7
	8	1										295.6	70.7	32.0	165.4	130.2										
		2*	20	30	40	0.8	PH	90	20	GSHP	40	159.6	35.4	6.0	24.1	135.5	1.9	85.9	-322407	-33.9	64.9	9.5	46.0	29.6	81.4	14.4

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Office No IT Load Default Occupancy	4	1									141.4	35.1	11.9	59.5	81.9											
		2	VAV	50	10	20	2.5	Code	60	25	111.1	21.2	7.5	36.1	74.9	357	0.5	14.1	63640	3.5	-39.8	5.9	21.4	16.4	36.9	12.1
			FC	50	10	20	2.5	Code	None	0	115.4	29.4	9.2	45.8	69.7	452	-0.2	-5.8	458761	25.2	-471.9	5.9	18.4	17.0	22.4	0.0
			ASHP	50	10	20	2.5	Code	None	0	93.9	29.4	3.7	15.2	78.8	460	-0.2	-5.8	469931	25.8	-156.7	5.5	33.6	22.0	69.2	0.0
		3	VAV	50	20	20	2.5	Improved	60	50	97.7	18.6	7.0	34.0	63.8	297	1.2	34.5	-52837	-2.9	29.5	5.1	30.9	27.5	41.3	17.7
			FC	50	10	20	2.5	Improved	60	25	95.6	16.7	6.7	32.6	63.0	392	0.4	12.2	369423	20.3	-195.6	5.0	32.4	28.8	43.6	6.0
			ASHP	50	10	20	2.5	Improved	60	0	92.2	14.7	3.7	15.2	77.0	465	0.0	-0.3	405984	22.3	-135.1	5.4	34.8	23.6	69.3	0.0
	5	1									141.3	36.0	11.8	59.0	82.3											
		2	VAV	50	10	40	2.5	Code	60	0	129.5	27.4	8.4	39.9	89.5	477	0.1	3.6	-79498	-4.4	63.4	7.0	8.4	1.7	29.1	31.4
			FC	50	10	20	2.5	Code	60	50	100.0	29.5	8.9	44.7	55.3	381	0.8	22.2	269461	14.8	-251.5	4.9	29.3	30.7	24.9	10.8
			ASHP	50	10	20	2.5	Code	60	50	78.5	29.5	3.5	15.2	63.3	445	0.8	22.2	294604	16.2	-97.3	4.5	44.5	36.1	70.4	9.1
		3	VAV	50	10	40	1.2	Improved	60	50	99.6	19.1	6.7	32.2	67.4	338	2.5	69.4	-747703	-41.1	401.1	5.3	29.5	25.1	43.3	41.1
			FC	50	20	20	2.5	Improved	80	50	93.4	19.5	7.0	34.2	59.2	381	1.3	36.2	6920	0.4	-3.9	4.8	33.9	31.6	40.9	17.0
			ASHP	50	20	20	2.5	Improved	60	0	97.0	18.5	3.7	15.2	81.9	582	0.2	5.9	194612	10.7	-65.9	5.7	31.3	19.3	68.6	4.5
	6	1									144.5	47.1	13.4	68.0	76.5											
		2	VAV	50	20	40	2.5	Code	80	0	127.6	30.0	8.2	39.0	88.7	417	0.7	24.6	-494660	-27.2	259.9	6.9	11.6	1.5	39.0	100.0
			FC	50	20	20	2.5	Code	80	0	116.2	28.7	8.5	41.6	74.5	438	0.4	12.0	6354	0.3	-3.6	6.0	19.6	13.3	36.5	11.3
			ASHP	50	20	20	2.5	Code	80	0	93.0	28.7	3.7	15.2	77.9	456	0.4	12.0	109418	6.0	-30.8	5.5	35.6	21.8	72.7	6.9
		3	VAV	50	20	20	1.2	Improved	80	50	94.4	18.9	5.8	27.6	66.8	295	3.1	101.7	-1348055	-74.0	488.8	5.1	34.7	26.6	56.5	47.7
			FC	50	20	40	1.6	Improved	60	25	92.8	19.3	6.6	31.9	61.0	398	1.9	62.0	-542906	-29.8	217.6	4.9	35.7	30.1	51.1	25.7
			ASHP	50	20	20	1.6	Improved	60	0	89.3	18.6	3.6	15.2	74.2	472	1.4	45.1	-413784	-22.7	116.0	5.2	38.2	25.2	73.0	22.3
	7A	1									161.9	63.3	15.6	79.2	82.7											
		2	VAV	50	20	40	0.8	Improved	80	50	105.4	29.0	5.9	27.2	78.2	313	3.3	110.0	-1527410	-83.9	434.0	5.8	34.9	24.3	62.1	51.1
			FC	50	20	40	1.2	Code	60	0	115.0	29.7	7.8	37.5	77.6	514	1.6	51.9	-539435	-29.6	190.5	6.1	28.9	20.8	50.0	28.2
			ASHP	50	20	40	1.2	Code	60	0	97.0	29.7	3.7	15.2	81.8	515	1.6	51.9	-486397	-26.7	112.6	5.7	40.1	26.0	76.2	22.5
		3	VAV *	50	20	40	0.8	PH	80	50	103.2	26.7	5.3	24.2	79.0	312	3.4	111.6	-1550500	-85.2	416.5	5.8	36.3	24.8	65.7	50.6
			FC	50	20	40	0.8	Improved	60	25	95.8	19.4	5.7	26.7	69.1	461	2.4	77.7	-750287	-41.2	208.8	5.2	40.8	32.0	63.4	27.3
			ASHP	50	20	20	0.8	Improved	60	0	95.4	19.4	3.7	15.2	80.2	540	1.8	60.8	-613765	-33.7	141.9	5.6	41.1	27.4	76.3	25.0

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Office 2.2 W/m2 IT Load Double Occupancy	4	1									154.3	20.8	10.3	49.3	105.0											
		2	FC	50	10	20	2.5	Code	60	50	127.8	17.1	8.3	39.4	88.4	466	0.8	23.8	-16392	-0.9	22.3	6.9	17.2	16.6	19.7	17.4
		3*	FC	50	20	40	0.8	Improved	60	50	116.1	1.9	5.4	23.5	92.6	510	3.0	85.3	-1108808	-60.9	621.7	6.6	24.7	19.2	47.7	53.9
	5	1									170.6	26.7	11.6	56.1	114.4											
		2*	FC	50	20	40	2	Code	60	50	130.5	16.6	8.0	37.5	93.1	534	2.0	55.3	-423237	-23.2	315.1	7.1	23.5	21.4	31.7	30.0
		3*	FC	50	20	40	0.8	Improved	60	50	121.5	4.9	5.7	25.4	96.1	556	3.0	81.0	-868748	-47.7	404.8	6.9	28.8	23.3	50.6	40.4
	6	1									162.5	35.3	12.3	60.4	102.1											
		2	FC	50	20	20	2	Code	60	50	128.0	25.7	9.2	44.6	83.4	461	1.9	62.9	-640494	-35.2	564.0	6.7	21.2	20.0	25.4	32.6
		3*	FC	50	20	40	0.8	Improved	60	50	114.0	9.2	6.0	27.4	86.6	505	2.9	96.6	-1196323	-65.7	524.3	6.4	29.8	23.8	51.0	42.0
	7A	1									181.7	52.2	14.7	72.9	108.8											
		2	FC	50	20	40	0.8	Code	60	50	129.9	24.6	8.0	37.6	92.3	544	2.8	91.0	-1054219	-57.9	431.2	7.1	28.5	23.3	45.7	37.0
		3*	FC	50	20	40	0.8	Improved	60	50	124.4	18.5	6.8	31.2	93.1	546	2.8	92.6	-1054965	-57.9	367.5	6.9	31.6	24.8	53.7	35.4

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Commercial No IT Load Default Occupancy	4	1									141.4	35.1	11.9	59.5	81.9											
		2	VAV	50	10	20	2.5	Code	60	25	111.1	21.2	7.5	36.1	74.9	357	0.5	14.1	63640	3.5	-39.8	5.9	21.4	16.4	36.9	12.1
			FC	50	10	20	2.5	Code	None	0	115.4	29.4	9.2	45.8	69.7	452	-0.2	-5.8	458761	25.2	-471.9	5.9	18.4	17.0	22.4	0.0
			ASHP	50	10	20	2.5	Code	None	0	93.9	29.4	3.7	15.2	78.8	460	-0.2	-5.8	469931	25.8	-156.7	5.5	33.6	22.0	69.2	0.0
		3	VAV	50	10	20	2.5	Improved	60	25	108.1	18.4	7.0	33.4	74.7	356	0.5	15.5	63190	3.5	-35.4	5.8	23.5	17.8	41.2	12.3
			FC	50	10	20	2.5	Improved	60	0	104.8	14.7	6.5	30.5	74.3	456	0.0	-0.3	370345	20.3	-186.8	5.7	25.9	19.4	45.7	0.0
			ASHP	50	10	20	2.5	Improved	60	0	92.2	14.7	3.7	15.2	77.0	465	0.0	-0.3	405984	22.3	-135.1	5.4	34.8	23.6	69.3	0.0
	5	1									141.3	36.0	11.8	59.0	82.3											
		2	VAV	50	10	20	2.5	Code	60	0	131.0	28.4	8.6	41.3	89.6	474	0.1	1.5	-54112	-3.0	46.7	7.0	7.3	1.0	26.9	22.5
			FC	50	10	20	2.5	Code	60	50	100.0	29.5	8.9	44.7	55.3	381	0.8	22.2	269461	14.8	-251.5	4.9	29.3	30.7	24.9	10.8
			ASHP	50	10	20	2.5	Code	60	50	78.5	29.5	3.5	15.2	63.3	445	0.8	22.2	294604	16.2	-97.3	4.5	44.5	36.1	70.4	9.1
		3	VAV	50	20	40	2.5	Improved	80	50	102.7	19.2	6.8	32.5	70.3	331	1.7	46.6	-396034	-21.7	216.0	5.5	27.3	22.4	42.6	31.0
			FC	50	20	20	2.5	Improved	60	0	111.1	18.5	7.0	33.2	77.9	511	0.2	5.9	166445	9.1	-94.9	6.0	21.4	15.1	40.8	5.8
			ASHP	50	20	20	2.5	Improved	60	0	97.0	18.5	3.7	15.2	81.9	582	0.2	5.9	194612	10.7	-65.9	5.7	31.3	19.3	68.6	4.5
	6	1									144.5	47.1	13.4	68.0	76.5											
		2	VAV	50	20	40	2.5	Code	80	0	127.6	30.0	8.2	39.0	88.7	417	0.7	24.6	-494660	-27.2	259.9	6.9	11.6	1.5	39.0	100.0
			FC	50	20	20	2.5	Code	80	0	116.2	28.7	8.5	41.6	74.5	438	0.4	12.0	6354	0.3	-3.6	6.0	19.6	13.3	36.5	11.3
			ASHP	50	20	20	2.5	Code	80	0	93.0	28.7	3.7	15.2	77.9	456	0.4	12.0	109418	6.0	-30.8	5.5	35.6	21.8	72.7	6.9
		3	VAV	50	20	40	1.2	Improved	60	0	113.1	19.8	6.3	28.9	84.2	423	1.9	61.3	-993617	-54.6	381.7	6.3	21.7	10.0	53.3	76.2
			FC	50	20	20	1.6	Improved	60	0	102.4	18.6	6.5	31.1	71.3	461	1.4	45.1	-450493	-24.7	180.0	5.5	29.1	20.9	51.2	26.9
			ASHP	50	20	20	1.6	Improved	60	0	89.3	18.6	3.6	15.2	74.2	472	1.4	45.1	-413784	-22.7	116.0	5.2	38.2	25.2	73.0	22.3
	7A	1									161.9	63.3	15.6	79.2	82.7											
		2	VAV	50	20	40	0.8	Improved	80	50	105.4	29.0	5.9	27.2	78.2	313	3.3	110.0	-1527410	-83.9	434.0	5.8	34.9	24.3	62.1	51.1
			FC	50	20	40	1.2	Code	60	0	115.0	29.7	7.8	37.5	77.6	514	1.6	51.9	-539435	-29.6	190.5	6.1	28.9	20.8	50.0	28.2
			ASHP	50	20	40	1.2	Code	60	0	97.0	29.7	3.7	15.2	81.8	515	1.6	51.9	-486397	-26.7	112.6	5.7	40.1	26.0	76.2	22.5
		3	VAV*	30	20	40	0.8	PH	80	50	105.9	26.0	4.9	21.4	84.5	279	2.8	92.7	-1302735	-71.5	335.4	6.1	34.6	21.4	68.5	48.9
			FC	50	20	20	0.8	Improved	60	0	106.4	19.4	5.8	26.7	79.7	525	1.8	60.8	-668208	-36.7	188.3	5.9	34.3	23.3	62.6	29.5
			ASHP	50	20	20	0.8	Improved	60	0	95.4	19.4	3.7	15.2	80.2	540	1.8	60.8	-613765	-33.7	141.9	5.6	41.1	27.4	76.3	25.0

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Commercial 2.2 W/m2 IT Load Double Occupancy	4	1									154.3	20.8	10.3	49.3	105.0											
		2	FC	50	10	20	2.5	Code	None	25	146.1	27.6	10.4	50.3	95.7	532	0.2	6.7	58344	3.2	1768.0	7.7	5.3	6.8	-0.9	11.9
		3	FC	50	20	20	2	Improved	60	50	120.0	8.7	6.7	30.7	89.3	477	2.0	57.4	-583106	-32.0	442.7	6.7	22.2	19.1	35.2	36.5
	5	1									170.6	26.7	11.6	56.1	114.4											
		2	FC	50	10	20	2.5	Code	60	50	138.5	24.5	9.5	45.7	92.8	531	0.8	22.6	118279	6.5	-150.2	7.3	18.8	18.9	18.6	13.9
		3	FC	30	20	40	1.6	Improved	60	50	119.6	8.0	6.3	28.5	91.1	488	2.1	57.4	-355177	-19.5	181.9	6.7	29.8	25.8	46.1	25.9
	6	1									162.5	35.3	12.3	60.4	102.1											
		2	FC	50	10	40	2.5	Code	60	0	152.1	29.4	10.1	48.5	103.6	576	0.0	1.1	26000	1.4	-32.8	8.1	6.4	3.2	17.7	3.6
		3	FC	50	20	40	1.6	Improved	60	50	119.9	17.1	7.5	35.7	84.2	476	2.3	76.9	-846922	-46.5	487.8	6.5	26.2	22.7	38.8	35.2
	7A	1									181.7	52.2	14.7	72.9	108.8											
		2	FC	50	20	20	1.2	Code	60	0	153.8	28.4	8.9	41.5	112.2	657	1.5	49.9	-759744	-41.7	361.6	8.5	15.4	8.1	39.3	58.5
		3	FC	30	20	40	1.2	PH	60	50	119.2	17.5	6.6	30.2	89.0	476	2.1	69.3	-535497	-29.4	181.0	6.6	34.4	28.0	55.3	23.4

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Retail Big Box	4	1									159.8	30.4	11.0	52.9	107.0											
		2	RTU	20	10	20	2.5	Code	80	50	105.7	22.1	7.4	35.9	69.8	97	3.2	47.9	18932	4.2	-73.3	5.6	33.5	34.8	27.9	16.1
			FC	20	10	20	2.5	Code	80	50	93.7	25.8	6.3	30.1	63.6	96	3.0	44.8	75900	16.9	-210.0	5.0	41.1	41.6	39.0	12.6
			ASHP	20	10	20	2.5	Code	80	50	72.8	25.8	1.4	3.2	69.7	100	3.0	44.8	92791	20.6	-115.4	4.6	54.2	46.6	86.8	11.2
		3	RTU	20	10	20	2.5	Improved	80	50	96.8	15.6	5.7	26.4	70.5	98	3.6	53.4	7519	1.7	-18.0	5.3	39.1	37.7	45.0	16.6
			FC	20	10	20	2.5	Improved	80	50	88.0	19.1	5.0	23.1	64.9	96	3.4	50.3	56832	12.6	-119.2	4.9	44.7	43.1	51.5	13.7
			ASHP	20	10	20	2.5	Improved	80	50	71.9	19.1	1.3	3.2	68.7	101	3.4	50.3	72617	16.1	-90.2	4.5	54.8	47.3	86.9	12.4
	5	1									188.0	39.1	14.0	68.5	119.4											
		2	RTU	20	20	20	2.5	Code	80	50	124.3	28.8	8.8	42.9	81.4	117	4.4	61.9	-24667	-5.5	61.1	6.5	33.6	33.6	33.7	18.8
			FC	20	10	40	2.5	Code	80	50	103.3	29.6	6.8	32.3	71.0	104	4.5	63.4	42496	9.4	-71.8	5.5	44.8	43.6	49.3	14.8
			ASHP	20	10	40	2.5	Code	80	50	80.5	29.6	1.4	3.2	77.4	119	4.5	63.4	61759	13.7	-57.7	5.1	57.0	48.6	89.2	13.3
		3	RTU	20	10	40	2.5	Improved	80	50	106.3	17.5	5.7	26.1	80.2	110	5.1	71.6	-31815	-7.1	46.4	5.9	43.2	39.6	57.2	18.4
			FC	20	20	20	2.5	Improved	80	25	116.0	19.5	5.1	21.7	94.2	132	3.7	52.4	-11170	-2.5	15.0	6.7	38.0	31.8	62.0	16.8
			ASHP	20	20	20	2.5	Improved	80	25	99.8	19.5	1.7	3.2	96.7	154	3.7	52.4	9719	2.2	-9.2	6.3	46.7	36.0	87.6	14.8
	6	1									203.3	54.9	18.5	93.4	109.9											
		2	RTU	20	10	40	2.5	Code	80	25	138.7	29.2	8.3	38.7	99.9	123	3.9	66.0	-139281	-30.9	161.8	7.6	31.5	23.9	53.6	27.6
			FC	20	10	20	0.8	Code	80	0	142.5	29.8	6.7	29.7	112.9	152	2.8	47.8	-109493	-24.3	109.6	8.1	29.6	18.4	62.2	26.1
			ASHP	20	10	20	0.8	Code	80	0	120.0	29.8	1.9	3.2	116.9	159	2.8	47.8	-82608	-18.3	57.5	7.6	40.7	23.9	89.5	20.0
		3	RTU	20	20	40	1.2	Improved	80	50	97.8	18.5	5.0	22.8	75.1	92	7.3	125.1	-245073	-54.4	212.9	5.5	51.7	44.8	71.7	28.0
			FC	20	10	40	0.8	Improved	80	25	111.9	19.0	4.4	18.5	93.4	119	5.5	93.9	-193981	-43.1	161.0	6.5	44.8	34.3	75.1	27.4
			ASHP	20	20	20	1.2	Improved	80	0	118.6	19.8	1.9	3.2	115.4	159	3.9	67.5	-163200	-36.3	113.5	7.5	41.5	24.9	89.6	27.2
	7A	1									245.1	69.1	23.9	121.9	123.2											
		2	RTU	20	20	40	1.2	Improved	80	25	133.5	28.8	6.0	26.3	107.2	129	6.2	105.4	-211953	-47.1	136.9	7.7	45.4	34.4	74.0	26.2
			FC	20	20	40	1.2	Improved	80	25	121.9	29.9	5.4	23.2	98.7	123	6.0	101.9	-145545	-32.3	90.5	7.0	50.1	39.9	76.9	21.9
			ASHP	20	20	40	1.2	Improved	80	25	104.1	29.9	1.7	3.2	100.9	128	6.0	101.9	-120964	-26.9	62.4	6.6	57.4	43.9	92.7	19.9
		3	RTU*	20	20	40	0.8	PH	80	25	122.0	21.1	3.6	13.1	108.8	129	6.8	116.0	-244197	-54.2	138.3	7.4	50.1	36.9	84.4	26.8
			FC	20	20	40	0.8	PH	80	25	114.8	19.7	3.5	12.6	102.2	123	6.6	112.4	-192084	-42.7	107.8	6.9	53.0	40.7	85.1	23.6
			ASHP	20	20	40	0.8	PH	80	25	103.4	19.7	1.7	3.2	100.2	131	6.6	112.4	-164793	-36.6	84.9	6.5	57.7	44.3	92.7	21.7

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

8.7 Part 3 – Lowest Carbon Abatement Costs

Scenario			Archetype Characteristics								Energy and Emissions Outcomes																
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
High Rise MURB Electric BB Mid Occupancy 0.6 VFAR 62-2001	4	1									138.7	48.8	9.5	45.7	93.0											
		2	40	10	20	2.5	Code	60	Standard	0	122.2	40.6	8.1	38.9	83.3	498	0.4	11.6	163253	9.1	-332.1	9.7	11.9	10.3	14.4	10.4
		3	40	10	20	2.5	Improved	80	Standard	0	111.3	29.7	8.0	38.9	72.4	378	0.8	24.7	268280	14.9	-499.5	8.7	19.7	19.9	15.7	11.5
		4	40	10	20	1.6	PH	80	Condensing	40	79.1	14.8	4.6	21.3	57.8	283	2.6	77.8	-48294	-2.7	27.4	6.7	43.0	37.6	51.7	19.1
	5	1									145.9	56.0	9.6	46.2	99.7											
		2	40	20	20	2.5	Code	60	Condensing	40	108.2	43.8	5.0	22.0	86.2	678	1.1	37.3	-1149	-0.1	0.7	9.4	25.9	17.5	47.9	18.6
		3	40	10	20	1.6	Improved	80	Condensing	40	90.4	26.1	4.8	21.8	68.6	462	2.5	82.0	-252380	-14.0	144.6	7.8	38.0	32.1	50.3	22.3
		4	40	10	20	0.8	PH	80	Condensing	40	75.8	11.5	4.6	21.4	54.3	337	3.4	109.2	-290230	-16.1	158.8	6.4	48.1	44.0	52.6	21.7
	6	1									159.6	69.5	9.9	47.0	112.5											
		2	20	20	40	2.5	Code	80	Standard	0	114.3	32.6	8.2	39.9	74.4	474	1.7	57.6	231892	12.9	-370.6	8.9	28.4	30.1	17.5	15.1
		3	20	20	40	2.5	Improved	80	Standard	0	109.4	27.6	8.1	39.9	69.5	425	1.8	60.7	329732	18.3	-509.4	8.4	31.5	33.8	18.1	14.2
		4	20	20	40	0.8	PH	60	Standard	0	96.3	14.7	7.9	39.2	57.1	282	2.7	91.2	177786	9.9	-240.5	7.2	39.7	43.2	20.7	16.6
	7A	1									155.3	65.1	10.0	47.5	107.8											
		2	20	20	40	0.8	Code	60	Condensing	40	103.6	39.2	5.1	22.6	81.0	512	2.3	106.7	-827385	-46.0	470.3	9.0	33.3	26.8	49.0	32.5
		3	20	20	40	0.8	Improved	60	Condensing	40	92.9	28.6	5.0	22.6	70.4	439	2.4	110.9	-568374	-31.6	314.8	8.0	40.2	35.0	50.3	25.8
		4*	20	20	40	0.8	PH	80	Condensing	20	88.7	17.6	6.0	29.1	59.5	283	2.7	123.3	-519845	-28.9	368.4	7.1	42.9	41.7	39.3	24.1

Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Heating Efficiency	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Low Rise MURB Electric BB Mid Occupancy 0.6 VFAR 62-2001	4	1									138.7	48.8	9.5	45.7	93.0											
		2	40	20	20	2.5	Code	60	Standard	0	115.0	33.4	8.0	38.7	76.2	463	0.5	11.6	386971	21.5	-731.6	9.0	17.1	16.6	15.5	6.5
		3	40	20	20	2.5	Improved	60	Standard	0	110.0	28.4	7.9	38.7	71.2	369	0.6	14.3	493283	27.4	-897.5	8.5	20.7	20.9	16.1	6.3
		4	40	20	20	2	PH	80	Standard	20	87.9	13.9	6.4	31.0	56.9	272	2.6	62.1	162332	9.0	-144.9	6.9	36.6	35.7	32.8	16.1
	5	1									145.9	56.0	9.6	46.2	99.7											
		2	40	20	20	2.5	Code	60	Standard	0	125.5	43.8	8.2	39.3	86.2	678	0.5	12.4	270818	15.0	-528.3	10.0	14.0	13.0	14.8	8.3
		3	40	20	20	2	Improved	80	Condensing	20	95.7	24.7	6.0	28.5	67.2	446	2.5	65.4	22119	1.2	-17.0	7.8	34.4	31.5	37.6	18.1
		4	40	20	40	1.2	PH	60	Condensing	40	79.1	14.8	4.6	21.5	57.6	347	3.4	89.2	-32514	-1.8	18.0	6.7	45.8	41.3	52.2	18.9
	6	1									159.6	69.5	9.9	47.0	112.5											
		2	20	20	20	2.5	Code	60	Standard	0	122.2	40.5	8.3	40.0	82.2	501	0.4	11.7	811727	45.1	-1374.3	9.6	23.4	24.2	16.5	3.8
		3	20	20	20	2.5	Improved	80	Standard	0	109.9	28.2	8.1	39.9	70.0	431	1.0	26.4	929674	51.6	-1441.3	8.5	31.1	33.4	18.0	6.2
		4	20	20	20	1.2	PH	80	Standard	0	95.2	13.5	7.9	39.3	55.9	296	2.3	61.8	743926	41.3	-1005.6	7.1	40.4	44.0	20.7	11.1
	7A	1									155.3	65.1	10.0	47.5	107.8											
		2	20	20	20	0.8	Code	60	Condensing	20	111.0	39.9	6.3	29.4	81.7	517	1.5	55.6	2205	0.1	-1.7	9.2	28.5	24.6	36.5	18.4
		3	20	20	20	0.8	Improved	60	Standard	0	110.9	29.2	8.2	39.9	71.0	445	1.6	59.4	162054	9.0	-250.3	8.5	28.6	30.2	18.0	16.0
		4	20	40	20	0.8	PH	80	Condensing	40	77.4	13.1	4.7	22.1	55.3	222	4.3	154.7	-880044	-48.9	464.0	6.5	50.1	46.7	52.9	27.0
	7B	1									184.5	79.7	10.5	48.4	136.1											
		2	20	40	40	0.8	Code	80	Condensing	40	116.9	36.7	5.3	23.0	93.9	96	3.0	10.8	-71870	-20.0	193.1	10.8	36.7	30.6	49.4	2.3
		3	20	40	40	0.8	Improved	80	Condensing	40	106.6	26.4	5.2	22.9	83.7	81	3.3	12.2	-57858	-16.1	151.5	9.8	42.2	36.8	50.7	2.1
	8	1									204.9	99.8	11.0	50.1	154.9											
		2	20	40	40	0.8	PH	80	Condensing	40	118.3	38.0	5.5	24.4	93.9	61	3.5	12.9	-4770	-1.3	12.2	10.8	42.3	38.9	49.4	1.9
		3*	20	40	40	0.8	PH	80	Condensing	40	115.2	34.9	5.4	24.0	91.2	55	3.3	11.9	-47090	-13.1	123.7	10.6	40.3	35.1	49.3	2.1

Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements

Scenario			Archetype Characteristics									Energy and Emissions Outcomes					Costing Outcomes									
Archetype	Climate Zone	Step Achieved	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	Plant	DHW Loads Savings	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Hotel Common Area Fan Coils Heat Pump DHW Electric Laundry Load	4	1										244.2	26.9	25.8	132.8	111.4										
		2	50	10	20	2.5	Code	60	0	Boiler/Chiller	40	153.6	22.9	7.3	32.1	121.4	-0.1	-1.9	327344	34.4	-92.9	8.8	37.1	21.6	71.8	0.0
		3	50	15	20	2.5	Improved	60	0	GSHP	40	133.5	19.2	2.9	8.5	125.0	0.2	4.5	294164	30.9	-67.6	8.3	45.3	26.0	88.6	1.6
		4	20	20	40	2.5	PH	60	20	GSHP	40	119.7	14.2	2.8	8.5	111.2	1.2	35.5	153385	16.1	-35.0	7.4	51.0	33.9	89.2	9.3
	5	1										261.3	35.8	28.0	144.5	116.9										
		2	50	10	20	2.5	Code	90	0	Boiler/Chiller	40	161.9	28.2	8.2	36.7	125.2	0.1	1.4	341317	35.8	-90.4	9.2	38.0	23.1	70.8	0.5
		3	50	15	20	2	Improved	90	0	GSHP	40	139.7	19.6	3.3	10.2	129.5	1.2	33.6	66129	6.9	-14.1	8.6	46.5	27.5	88.2	10.8
		4	20	30	20	2.5	PH	90	40	GSHP	40	116.4	14.1	3.1	10.4	106.0	2.1	58.5	90387	9.5	-19.1	7.1	55.4	40.1	89.0	12.9
	6	1										272.2	47.4	30.8	159.9	112.3										
		2	50	20	40	2	Code	90	0	Boiler/Chiller	40	159.8	29.6	8.1	36.6	123.1	1.2	41.9	-13254	-1.4	3.1	9.0	41.3	25.3	73.6	11.9
		3	50	10	40	0.8	Improved	90	20	GSHP	40	134.4	19.8	3.8	13.5	120.9	2.4	82.8	-311360	-32.7	60.6	8.2	50.6	32.3	87.6	18.4
		4	20	30	40	0.8	PH	90	40	GSHP	40	119.6	11.3	3.7	13.6	106.0	2.8	95.5	-265877	-27.9	51.5	7.2	56.1	40.2	88.1	17.0
	7A	1										265.2	43.4	28.3	145.9	119.3										
		2	20	15	40	1.6	Code	90	0	Boiler/Chiller	40	161.9	29.7	8.1	36.1	125.7	0.8	37.6	25233	2.7	-6.6	9.2	38.9	24.2	71.5	8.5
		3	20	30	40	1.2	PH	90	20	GSHP	40	136.4	19.0	4.2	15.7	120.7	2.2	96.8	-426123	-44.8	93.0	8.2	48.6	32.0	85.0	16.6
		4*	20	30	40	0.8	PH	90	40	GSHP	40	127.6	18.5	4.2	15.9	111.7	2.7	121.1	-558244	-58.6	121.6	7.7	51.9	36.7	85.3	18.1
	7B	1										270.5	49.3	29.3	151.3	119.2										
		2	20	15	40	1.2	Code	90	0	Boiler/Chiller	40	165.2	29.9	8.4	37.8	127.4	1.0	33.0	64246	6.7	-16.1	9.4	38.9	23.9	71.4	9.8
		3*	20	30	40	0.8	PH	90	20	GSHP	40	141.1	19.9	4.8	18.7	122.4	2.3	78.4	-261350	-27.4	56.0	8.5	47.8	31.3	83.6	17.7
	8	1										295.6	70.7	32.0	165.4	130.2										
		2*	20	30	40	0.8	PH	90	20	GSHP	40	159.6	35.4	6.0	24.1	135.5	1.9	85.9	-322407	-33.9	64.9	9.5	46.0	29.6	81.4	14.4

Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Office No IT Load Default Occupancy	4	1									141.4	35.1	11.9	59.5	81.9											
		2	VAV	50	10	20	2.5	Code	60	25	111.1	21.2	7.5	36.1	74.9	357	0.5	14.1	63640	3.5	-39.8	5.9	21.4	16.4	36.9	12.1
			FC	50	10	20	2.5	Code	None	0	115.4	29.4	9.2	45.8	69.7	452	-0.2	-5.8	458761	25.2	-471.9	5.9	18.4	17.0	22.4	0.0
			ASHP	50	10	20	2.5	Code	None	0	93.9	29.4	3.7	15.2	78.8	460	-0.2	-5.8	469931	25.8	-156.7	5.5	33.6	22.0	69.2	0.0
		3	VAV	50	20	20	2.5	Improved	60	50	97.7	18.6	7.0	34.0	63.8	297	1.2	34.5	-52837	-2.9	29.5	5.1	30.9	27.5	41.3	17.7
			FC	50	10	20	2.5	Improved	60	50	86.4	18.7	7.0	34.6	51.7	327	0.9	24.7	367534	20.2	-204.8	4.4	38.9	38.1	41.4	9.2
			ASHP	50	10	20	2.5	Improved	60	0	92.2	14.7	3.7	15.2	77.0	465	0.0	-0.3	405984	22.3	-135.1	5.4	34.8	23.6	69.3	0.0
	5	1									141.3	36.0	11.8	59.0	82.3											
		2	VAV	50	10	40	2.5	Code	60	0	129.5	27.4	8.4	39.9	89.5	477	0.1	3.6	-79498	-4.4	63.4	7.0	8.4	1.7	29.1	31.4
			FC	50	10	20	2.5	Code	60	50	100.0	29.5	8.9	44.7	55.3	381	0.8	22.2	269461	14.8	-251.5	4.9	29.3	30.7	24.9	10.8
			ASHP	50	10	20	2.5	Code	60	25	88.7	27.1	3.6	15.2	73.5	517	0.4	10.3	293788	16.1	-98.4	5.2	37.3	26.9	69.4	5.7
		3	VAV	50	20	40	2	Improved	80	50	99.0	15.5	6.0	28.4	70.7	329	2.6	71.0	-819824	-45.0	388.8	5.4	29.9	23.8	49.0	44.5
			FC	50	20	20	2.5	Improved	80	50	93.4	19.5	7.0	34.2	59.2	381	1.3	36.2	6920	0.4	-3.9	4.8	33.9	31.6	40.9	17.0
			ASHP	50	20	20	2.5	Improved	60	0	97.0	18.5	3.7	15.2	81.9	582	0.2	5.9	194612	10.7	-65.9	5.7	31.3	19.3	68.6	4.5
	6	1									144.5	47.1	13.4	68.0	76.5											
		2	VAV	50	20	40	2.5	Code	80	0	127.6	30.0	8.2	39.0	88.7	417	0.7	24.6	-494660	-27.2	259.9	6.9	11.6	1.5	39.0	100.0
			FC	50	20	20	2.5	Code	80	0	116.2	28.7	8.5	41.6	74.5	438	0.4	12.0	6354	0.3	-3.6	6.0	19.6	13.3	36.5	11.3
			ASHP	50	20	20	2.5	Code	80	0	93.0	28.7	3.7	15.2	77.9	456	0.4	12.0	109418	6.0	-30.8	5.5	35.6	21.8	72.7	6.9
		3	VAV	50	20	20	1.2	Improved	80	50	94.4	18.9	5.8	27.6	66.8	295	3.1	101.7	-1348055	-74.0	488.8	5.1	34.7	26.6	56.5	47.7
			FC	50	20	40	1.6	Improved	60	25	92.8	19.3	6.6	31.9	61.0	398	1.9	62.0	-542906	-29.8	217.6	4.9	35.7	30.1	51.1	25.7
			ASHP	50	20	20	1.6	Improved	60	0	89.3	18.6	3.6	15.2	74.2	472	1.4	45.1	-413784	-22.7	116.0	5.2	38.2	25.2	73.0	22.3
	7A	1									161.9	63.3	15.6	79.2	82.7											
		2	VAV	50	20	40	0.8	Improved	80	25	116.7	29.6	5.7	25.4	91.3	377	2.9	95.7	-1531638	-84.1	426.4	6.6	27.9	14.1	63.4	76.2
			FC	50	20	40	1.2	Code	60	0	115.0	29.7	7.8	37.5	77.6	514	1.6	51.9	-539435	-29.6	190.5	6.1	28.9	20.8	50.0	28.2
			ASHP	50	20	40	1.2	Code	60	0	97.0	29.7	3.7	15.2	81.8	515	1.6	51.9	-486397	-26.7	112.6	5.7	40.1	26.0	76.2	22.5
		3	VAV *	50	20	40	0.8	PH	80	50	103.2	26.7	5.3	24.2	79.0	312	3.4	111.6	-1550500	-85.2	416.5	5.8	36.3	24.8	65.7	50.6
			FC	50	20	40	0.8	Improved	60	25	95.8	19.4	5.7	26.7	69.1	461	2.4	77.7	-750287	-41.2	208.8	5.2	40.8	32.0	63.4	27.3
			ASHP	50	20	20	0.8	Improved	60	0	95.4	19.4	3.7	15.2	80.2	540	1.8	60.8	-613765	-33.7	141.9	5.6	41.1	27.4	76.3	25.0

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Office 2.2 W/m2 IT Load Double Occupancy	4	1									154.3	20.8	10.3	49.3	105.0											
		2	FC	50	10	20	2.5	Code	60	50	127.8	17.1	8.3	39.4	88.4	466	0.8	23.8	-16392	-0.9	22.3	6.9	17.2	16.6	19.7	17.4
		3*	FC	50	20	40	0.8	Improved	60	50	116.1	1.9	5.4	23.5	92.6	510	3.0	85.3	-1108808	-60.9	621.7	6.6	24.7	19.2	47.7	53.9
	5	1									170.6	26.7	11.6	56.1	114.4											
		2*	FC	50	20	40	2	Code	60	50	130.5	16.6	8.0	37.5	93.1	534	2.0	55.3	-423237	-23.2	315.1	7.1	23.5	21.4	31.7	30.0
		3*	FC	50	20	40	0.8	Improved	60	50	121.5	4.9	5.7	25.4	96.1	556	3.0	81.0	-868748	-47.7	404.8	6.9	28.8	23.3	50.6	40.4
	6	1									162.5	35.3	12.3	60.4	102.1											
		2	FC	50	20	40	1.2	Code	60	25	127.7	13.8	7.0	32.2	95.5	551	2.1	70.8	-950300	-52.2	494.6	7.1	21.4	15.3	42.9	47.9
		3*	FC	50	20	40	0.8	Improved	60	50	114.0	9.2	6.0	27.4	86.6	505	2.9	96.6	-1196323	-65.7	524.3	6.4	29.8	23.8	51.0	42.0
	7A	1									181.7	52.2	14.7	72.9	108.8											
		2	FC	50	20	40	0.8	Code	60	50	129.9	24.6	8.0	37.6	92.3	544	2.8	91.0	-1054219	-57.9	431.2	7.1	28.5	23.3	45.7	37.0
		3*	FC	50	20	40	0.8	Improved	60	50	124.4	18.5	6.8	31.2	93.1	546	2.8	92.6	-1054965	-57.9	367.5	6.9	31.6	24.8	53.7	35.4

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Commercial No IT Load Default Occupancy	4	1									141.4	35.1	11.9	59.5	81.9											
		2	VAV	50	7	20	2.5	Code	60	25	112.6	23.2	7.9	38.2	74.4	359	0.5	14.1	60334	3.3	-41.3	5.9	20.4	16.0	33.7	12.4
			FC	50	10	20	2.5	Code	None	0	115.4	29.4	9.2	45.8	69.7	452	-0.2	-5.8	458761	25.2	-471.9	5.9	18.4	17.0	22.4	0.0
			ASHP	50	10	20	2.5	Code	None	0	93.9	29.4	3.7	15.2	78.8	460	-0.2	-5.8	469931	25.8	-156.7	5.5	33.6	22.0	69.2	0.0
		3	VAV	50	10	20	2.5	Improved	60	25	108.1	18.4	7.0	33.4	74.7	356	0.5	15.5	63190	3.5	-35.4	5.8	23.5	17.8	41.2	12.3
			FC	50	10	20	2.5	Improved	60	50	86.4	18.7	7.0	34.6	51.7	327	0.9	24.7	367534	20.2	-204.8	4.4	38.9	38.1	41.4	9.2
			ASHP	50	10	20	2.5	Improved	60	0	92.2	14.7	3.7	15.2	77.0	465	0.0	-0.3	405984	22.3	-135.1	5.4	34.8	23.6	69.3	0.0
	5	1									141.3	36.0	11.8	59.0	82.3											
		2	VAV	50	10	20	2.5	Code	60	0	131.0	28.4	8.6	41.3	89.6	474	0.1	1.5	-54112	-3.0	46.7	7.0	7.3	1.0	26.9	22.5
			FC	50	10	20	2.5	Code	60	50	100.0	29.5	8.9	44.7	55.3	381	0.8	22.2	269461	14.8	-251.5	4.9	29.3	30.7	24.9	10.8
			ASHP	50	10	20	2.5	Code	60	25	88.7	27.1	3.6	15.2	73.5	517	0.4	10.3	293788	16.1	-98.4	5.2	37.3	26.9	69.4	5.7
		3	VAV	50	20	40	2.5	Improved	80	50	102.7	19.2	6.8	32.5	70.3	331	1.7	46.6	-396034	-21.7	216.0	5.5	27.3	22.4	42.6	31.0
			FC	50	20	20	2.5	Improved	60	0	111.1	18.5	7.0	33.2	77.9	511	0.2	5.9	166445	9.1	-94.9	6.0	21.4	15.1	40.8	5.8
			ASHP	50	20	20	2.5	Improved	60	0	97.0	18.5	3.7	15.2	81.9	582	0.2	5.9	194612	10.7	-65.9	5.7	31.3	19.3	68.6	4.5
	6	1									144.5	47.1	13.4	68.0	76.5											
		2	VAV	50	20	40	2.5	Code	80	0	127.6	30.0	8.2	39.0	88.7	417	0.7	24.6	-494660	-27.2	259.9	6.9	11.6	1.5	39.0	100.0
			FC	50	20	20	2.5	Code	80	0	116.2	28.7	8.5	41.6	74.5	438	0.4	12.0	6354	0.3	-3.6	6.0	19.6	13.3	36.5	11.3
			ASHP	50	20	20	2.5	Code	80	0	93.0	28.7	3.7	15.2	77.9	456	0.4	12.0	109418	6.0	-30.8	5.5	35.6	21.8	72.7	6.9
		3	VAV	50	20	40	1.2	Improved	60	0	113.1	19.8	6.3	28.9	84.2	423	1.9	61.3	-993617	-54.6	381.7	6.3	21.7	10.0	53.3	76.2
			FC	50	20	20	1.6	Improved	60	0	102.4	18.6	6.5	31.1	71.3	461	1.4	45.1	-450493	-24.7	180.0	5.5	29.1	20.9	51.2	26.9
			ASHP	50	20	20	1.6	Improved	60	0	89.3	18.6	3.6	15.2	74.2	472	1.4	45.1	-413784	-22.7	116.0	5.2	38.2	25.2	73.0	22.3
	7A	1									161.9	63.3	15.6	79.2	82.7											
		2	VAV	30	20	40	0.8	Improved	80	50	108.6	27.7	5.6	25.1	83.5	279	2.8	91.1	-1279722	-70.3	351.2	6.1	32.9	20.7	64.3	49.5
			FC	50	20	40	1.2	Code	60	0	115.0	29.7	7.8	37.5	77.6	514	1.6	51.9	-539435	-29.6	190.5	6.1	28.9	20.8	50.0	28.2
			ASHP	50	20	40	1.2	Code	60	0	97.0	29.7	3.7	15.2	81.8	515	1.6	51.9	-486397	-26.7	112.6	5.7	40.1	26.0	76.2	22.5
		3	VAV*	30	20	40	0.8	PH	80	50	105.9	26.0	4.9	21.4	84.5	279	2.8	92.7	-1302735	-71.5	335.4	6.1	34.6	21.4	68.5	48.9
			FC	50	20	20	0.8	Improved	60	0	106.4	19.4	5.8	26.7	79.7	525	1.8	60.8	-668208	-36.7	188.3	5.9	34.3	23.3	62.6	29.5
			ASHP	50	20	20	0.8	Improved	60	0	95.4	19.4	3.7	15.2	80.2	540	1.8	60.8	-613765	-33.7	141.9	5.6	41.1	27.4	76.3	25.0

** Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Commercial 2.2 W/m2 IT Load Double Occupancy	4	1									154.3	20.8	10.3	49.3	105.0											
		2	FC	50	10	40	2.5	Code	None	25	145.2	26.8	10.2	49.5	95.7	532	0.3	8.9	25026	1.4	-1124.1	7.6	5.9	7.1	0.6	15.1
		3	FC	50	20	20	2	Improved	60	50	120.0	8.7	6.7	30.7	89.3	477	2.0	57.4	-583106	-32.0	442.7	6.7	22.2	19.1	35.2	36.5
	5	1									170.6	26.7	11.6	56.1	114.4											
		2	FC	50	7	20	2.5	Code	60	50	141.1	26.9	9.9	48.2	92.9	534	0.8	22.6	97740	5.4	-157.3	7.4	17.3	17.9	14.7	14.6
		3	FC	30	20	40	1.6	Improved	60	50	119.6	8.0	6.3	28.5	91.1	488	2.1	57.4	-355177	-19.5	181.9	6.7	29.8	25.8	46.1	25.9
	6	1									162.5	35.3	12.3	60.4	102.1											
		2	FC	50	10	40	2.5	Code	60	0	152.1	29.4	10.1	48.5	103.6	576	0.0	1.1	26000	1.4	-32.8	8.1	6.4	3.2	17.7	3.6
		3	FC	50	20	40	1.6	Improved	60	50	119.9	17.1	7.5	35.7	84.2	476	2.3	76.9	-846922	-46.5	487.8	6.5	26.2	22.7	38.8	35.2
	7A	1									181.7	52.2	14.7	72.9	108.8											
		2	FC	50	20	40	1.2	Code	60	0	152.1	26.8	8.6	39.9	112.2	658	1.6	52.4	-793413	-43.6	358.9	8.4	16.3	8.6	41.3	57.5
		3	FC	30	20	40	1.2	PH	60	50	119.2	17.5	6.6	30.2	89.0	476	2.1	69.3	-535497	-29.4	181.0	6.6	34.4	28.0	55.3	23.4

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

Scenario			Archetype Characteristics								Energy and Emissions Outcomes						Costing Outcomes									
Archetype	Climate Zone	Step Achieved	HVAC	WWR	Wall R-Value (effective)	Roof R-Value (effective)	Window USI-Value	Infiltration	Vent. Heat Recovery (%)	Lighting Savings (%)	TEUI (kWh/m2)	TEDI (kWh/m2)	GHGI (kgCO2e/m2)	Natural Gas Consumption (kWh/m2)	Electricity Consumption (kWh/m2)	Peak Electricity (kW)	Incremental Capital Cost (%)	Incremental Capital Cost ($/m2)	NPV LCC Savings ($)	NPV LLC Savings ($/m2)	Carbon Abatement Cost ($/tonCO2)	Energy Cost ($/m2)	Energy Savings (%)	Cost Savings (%)	GHG Savings (%)	Simple Payback (Years)
Retail Big Box	4	1									159.8	30.4	11.0	52.9	107.0											
		2	RTU	20	10	20	2.5	Code	80	50	105.7	22.1	7.4	35.9	69.8	97	3.2	47.9	18932	4.2	-73.3	5.6	33.5	34.8	27.9	16.1
			FC	20	7	20	2.5	Code	80	50	97.7	29.3	6.9	33.7	63.9	98	3.0	44.8	67714	15.0	-225.3	5.1	38.6	40.0	32.5	13.1
			ASHP	20	10	20	2.5	Code	80	50	72.8	25.8	1.4	3.2	69.7	100	3.0	44.8	92791	20.6	-115.4	4.6	54.2	46.6	86.8	11.2
		3	RTU	20	10	20	2.5	Improved	80	50	96.8	15.6	5.7	26.4	70.5	98	3.6	53.4	7519	1.7	-18.0	5.3	39.1	37.7	45.0	16.6
			FC	20	10	20	2.5	Improved	80	50	88.0	19.1	5.0	23.1	64.9	96	3.4	50.3	56832	12.6	-119.2	4.9	44.7	43.1	51.5	13.7
			ASHP	20	10	20	2.5	Improved	80	50	71.9	19.1	1.3	3.2	68.7	101	3.4	50.3	72617	16.1	-90.2	4.5	54.8	47.3	86.9	12.4
	5	1									188.0	39.1	14.0	68.5	119.4											
		2	RTU	20	10	20	2.5	Code	80	25	145.6	25.3	8.2	37.7	107.8	151	2.4	33.6	-27348	-6.1	58.9	8.1	22.2	17.9	38.7	19.1
			FC	20	10	40	2.5	Code	80	50	103.3	29.6	6.8	32.3	71.0	104	4.5	63.4	42496	9.4	-71.8	5.5	44.8	43.6	49.3	14.8
			ASHP	20	10	40	2.5	Code	80	50	80.5	29.6	1.4	3.2	77.4	119	4.5	63.4	61759	13.7	-57.7	5.1	57.0	48.6	89.2	13.3
		3	RTU	20	10	40	2.5	Improved	80	50	106.3	17.5	5.7	26.1	80.2	110	5.1	71.6	-31815	-7.1	46.4	5.9	43.2	39.6	57.2	18.4
			FC	20	20	20	2.5	Improved	80	25	116.0	19.5	5.1	21.7	94.2	132	3.7	52.4	-11170	-2.5	15.0	6.7	38.0	31.8	62.0	16.8
			ASHP	20	20	20	2.5	Improved	80	25	99.8	19.5	1.7	3.2	96.7	154	3.7	52.4	9719	2.2	-9.2	6.3	46.7	36.0	87.6	14.8
	6	1									203.3	54.9	18.5	93.4	109.9											
		2	RTU	20	10	40	2.5	Code	80	25	138.7	29.2	8.3	38.7	99.9	123	3.9	66.0	-139281	-30.9	161.8	7.6	31.5	23.9	53.6	27.6
			FC	20	10	20	0.8	Code	80	0	142.5	29.8	6.7	29.7	112.9	152	2.8	47.8	-109493	-24.3	109.6	8.1	29.6	18.4	62.2	26.1
			ASHP	20	10	20	0.8	Code	80	0	120.0	29.8	1.9	3.2	116.9	159	2.8	47.8	-82608	-18.3	57.5	7.6	40.7	23.9	89.5	20.0
		3	RTU	20	20	40	1.2	Improved	80	50	97.8	18.5	5.0	22.8	75.1	92	7.3	125.1	-245073	-54.4	212.9	5.5	51.7	44.8	71.7	28.0
			FC	20	10	40	0.8	Improved	80	25	111.9	19.0	4.4	18.5	93.4	119	5.5	93.9	-193981	-43.1	161.0	6.5	44.8	34.3	75.1	27.4
			ASHP	20	20	20	1.2	Improved	80	0	118.6	19.8	1.9	3.2	115.4	159	3.9	67.5	-163200	-36.3	113.5	7.5	41.5	24.9	89.6	27.2
	7A	1									245.1	69.1	23.9	121.9	123.2											
		2	RTU	20	20	40	1.2	Improved	80	25	133.5	28.8	6.0	26.3	107.2	129	6.2	105.4	-211953	-47.1	136.9	7.7	45.4	34.4	74.0	26.2
			FC	20	20	40	1.2	Improved	80	25	121.9	29.9	5.4	23.2	98.7	123	6.0	101.9	-145545	-32.3	90.5	7.0	50.1	39.9	76.9	21.9
			ASHP	20	20	40	1.2	Improved	80	25	104.1	29.9	1.7	3.2	100.9	128	6.0	101.9	-120964	-26.9	62.4	6.6	57.4	43.9	92.7	19.9
		3	RTU*	20	20	40	0.8	PH	80	25	122.0	21.1	3.6	13.1	108.8	129	6.8	116.0	-244197	-54.2	138.3	7.4	50.1	36.9	84.4	26.8
			FC	20	20	40	0.8	PH	80	25	114.8	19.7	3.5	12.6	102.2	123	6.6	112.4	-192084	-42.7	107.8	6.9	53.0	40.7	85.1	23.6
			ASHP	20	20	40	0.8	PH	80	25	103.4	19.7	1.7	3.2	100.2	131	6.6	112.4	-164793	-36.6	84.9	6.5	57.7	44.3	92.7	21.7

* *Measures and outcomes represent the most feasible scenario which approaches, but does not meet the performance requirements*

8.8 Part 9 – Lowest Incremental Capital Costs

Note: Negative carbon abatement costs occur when a building has lower GHG emissions and a positive NPV, meaning investing in GHG reductions is profitable.

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
10 unit MURB	4	BCBC	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.0%	n/a	$2,422	-
		1	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.1%	egative NPV but no GHG reducti	$2,424	-$3
		2	27.0%	1.5	16	17	20	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	60%	66	40	21	19	108,996	0	1.6	0.5%	-$70	$2,435	$4
		3	27.0%	0.6	16	11	15	27	40	LG-avg-Double	1.8	BaseDHW	30%	elec-baseboard	60%	64	38	17	16	77,486	103	6.3	0.8%	-$5,249	$2,441	$37
		4	27.0%	0.6	16	11	15	27	40	LG-avg-Double	1.8	BaseDHW	30%	elec-baseboard	60%	64	38	17	16	77,486	103	6.3	0.8%	-$5,249	$2,441	$37
		5	27.0%	0.6	16	17	0	27	40	HG-avg-Triple	1.2	HPHotWater	0%	elec-baseboard	60%	47	22	11	14	78,371	0	1.2	1.9%	-$272	$2,469	$19
	5	BCBC	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.0%	n/a	$2,599	-
		1	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.1%	egative NPV but no GHG reducti	$2,602	-$3
		2	27.0%	1.5	16	17	15	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	77	51	29	25	98,303	104	6.6	0.5%	-$6,773	$2,613	$45
		3	27.0%	1.0	18	11	15	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	70	45	26	22	116,401	0	1.7	0.6%	-$382	$2,614	$25
		4	27.0%	1.0	18	11	15	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	70	45	26	22	116,401	0	1.7	0.6%	-$382	$2,614	$25
		5	27.0%	0.6	22	20	11	27	50	MG-HP-Double	1.4	HPHotWater	0%	elec-baseboard	70%	56	30	19	19	92,246	0	1.4	1.7%	-$493	$2,643	$35
	6	BCBC	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.0%	n/a	$2,727	-
		1	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.1%	egative NPV but no GHG reducti	$2,730	-$3
		2	27.0%	1.5	18	20	0	40	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	89	63	41	33	117,678	108	7.1	0.6%	-$7,002	$2,742	$58
		3	27.0%	0.6	18	20	0	27	50	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	78	52	33	27	129,130	0	1.9	0.4%	-$753	$2,739	$54
		4	27.0%	0.6	18	20	0	27	50	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	78	52	33	27	129,130	0	1.9	0.4%	-$753	$2,739	$54
		5	27.0%	0.6	16	11	20	27	50	HG-avg-Triple	1.2	ElectricStorage	0%	elec-baseboard	60%	65	39	19	24	107,041	0	1.6	1.2%	-$900	$2,760	$68
	7a	BCBC	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.0%	n/a	$3,638	-
		1	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	18	25	0	35	100	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	60%	106	81	60	40	176,090	0	2.6	0.6%	-$641	$3,659	$50
		3	27.0%	0.6	22	11	15	29	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	96	70	46	31	125,859	117	7.7	0.5%	-$7,718	$3,655	$121
		4	27.0%	0.6	22	11	15	29	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	96	70	46	31	125,859	117	7.7	0.5%	-$7,718	$3,655	$121
		5	27.0%	0.6	18	11	0	27	40	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	60%	81	55	31	29	101,210	117	7.3	1.0%	-$7,038	$3,674	$141
	7b	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	124	100	9.7	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	257,707	119	9.7	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	24	17	11	35	100	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	126	101	76	43	175,997	119	8.5	0.5%	-$7,523	$3,657	$109
		3	27.0%	0.6	22	11	11	27	50	LG-avg-Double	1.8	ElectricStorage	30%	elec-baseboard	70%	109	83	62	34	180,051	0	2.6	0.2%	-$1,451	$3,647	$124
		4	27.0%	0.6	22	11	11	27	50	LG-avg-Double	1.8	ElectricStorage	30%	elec-baseboard	70%	109	83	62	34	180,051	0	2.6	0.2%	-$1,451	$3,647	$124
		5	27.0%	0.6	18	25	11	27	50	HG-avg-Triple	1.2	ElectricStorage	0%	elec-baseboard	70%	90	64	43	31	148,493	0	2.2	1.0%	-$1,623	$3,672	$148
	8	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	30	20	20	27	100	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	60%	134	108	84	45	188,439	121	8.8	0.7%	-$7,476	$3,664	$145
		3	27.0%	0.6	18	17	20	29	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	126	100	75	37	174,354	121	8.6	0.2%	-$8,542	$3,644	$187
		4	27.0%	0.6	18	17	20	29	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	126	100	75	37	174,354	121	8.6	0.2%	-$8,542	$3,644	$187
		5	27.0%	0.6	22	20	15	27	50	HG-avg-Triple	1.2	BaseDHW	30%	elec-baseboard	70%	100	74	50	31	131,965	120	7.9	1.2%	-$7,125	$3,681	$217

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
6 unit Row House	4	BCBC	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.0%	n/a	$1,749	-
		1	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.2%	egative NPV but no GHG reducti	$1,752	-$3
		2	22.2%	2.5	16	NA	0	27	50	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	0%	95	58	26	24	44,833	203	10.8	0.4%	$306	$1,757	-$5
		3	22.2%	1.0	16	NA	0	29	40	LG-avg-Double	1.8	ElectricStorage	0%	basefurnace	0%	87	50	23	21	66,675	95	5.7	0.6%	$397	$1,759	-$46
		4	22.2%	0.6	16	NA	11	27	50	MG-i89-Double	1.6	ElectricStorage	0%	basefurnace	70%	76	38	12	18	66,474	53	3.6	1.8%	$381	$1,781	-$61
		5	22.2%	0.6	16	NA	11	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	62	23	10	17	54,091	42	2.9	3.4%	$314	$1,808	-$54
	5	BCBC	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.0%	n/a	$1,877	-
		1	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.2%	egative NPV but no GHG reducti	$1,880	-$3
		2	22.2%	1.5	18	NA	0	27	40	LG-avg-Double	1.8	ElectricStorage	0%	basefurnace	0%	98	61	33	28	66,870	136	7.8	0.5%	$427	$1,887	-$52
		3	22.2%	1.5	18	NA	0	27	40	LG-avg-Double	1.8	ElectricStorage	0%	basefurnace	0%	98	61	33	28	66,870	136	7.8	0.5%	$427	$1,887	-$52
		4	22.2%	0.6	16	NA	0	27	80	MG-i89-Double	1.6	HPHotWater	0%	basefurnace	0%	83	45	30	24	54,474	122	6.9	1.6%	$252	$1,907	-$35
		5	22.2%	0.6	24	NA	0	27	40	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	68	29	15	20	54,195	64	4.0	3.3%	$296	$1,939	-$58
	6	BCBC	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.0%	n/a	$1,970	-
		1	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.2%	egative NPV but no GHG reducti	$1,973	-$3
		2	22.2%	1.5	16	NA	0	27	40	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	120	84	51	38	45,311	296	15.4	-0.1%	-$304	$1,967	$6
		3	22.2%	0.6	16	NA	0	27	40	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	70%	111	74	39	33	45,087	262	13.7	0.5%	-$0	$1,979	$0
		4	22.2%	0.6	18	NA	0	27	40	MG-i89-Double	1.6	HPHotWater	0%	basefurnace	70%	92	55	37	31	55,040	155	8.5	1.4%	$168	$1,997	-$27
		5	22.2%	0.6	18	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	78	40	24	27	54,783	100	5.8	2.5%	$185	$2,019	-$39
	7a	BCBC	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.0%	n/a	$2,627	-
		1	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	1.5	16	NA	11	27	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	70%	135	100	63	44	45,544	353	18.3	0.4%	-$43	$2,637	$3
		3	22.2%	0.6	16	NA	0	27	40	LG-avg-Double	1.8	HPHotWater	0%	basefurnace	60%	125	90	68	41	56,463	277	14.6	0.3%	$67	$2,634	-$10
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	0%	102	66	46	35	56,045	190	10.3	1.5%	$121	$2,667	-$28
		5	22.2%	0.6	22	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	89	52	35	31	55,823	142	7.9	2.5%	$161	$2,693	-$46
	7b	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	1.5	24	NA	0	27	50	MG-HP-Double	1.4	GasInst_Low	0%	basefurnace	0%	149	115	73	44	45,735	407	21.0	0.4%	-$69	$2,637	$7
		3	22.2%	0.6	18	NA	0	27	50	LG-avg-Double	1.8	HPHotWater	0%	basefurnace	60%	141	107	83	42	56,966	337	17.6	0.0%	$4	$2,627	-$1
		4	22.2%	0.6	16	NA	0	27	100	HG-avg-Triple	1.2	ElectricStorage	0%	basefurnace	70%	117	81	48	35	70,504	195	10.7	1.4%	$161	$2,663	-$49
		5	22.2%	0.6	24	NA	11	27	50	HG-avg-Triple	1.2	HPHotWater	30%	basefurnace	70%	102	65	46	33	56,086	188	10.2	2.7%	$143	$2,697	-$45
	8	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	156	123	80	42	45,860	434	22.3	0.2%	-$136	$2,633	$20
		3	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	156	123	80	42	45,860	434	22.3	0.2%	-$136	$2,633	$20
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	0%	134	100	77	40	57,010	310	16.3	1.0%	$37	$2,654	-$10
		5	22.2%	0.6	22	NA	11	27	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	111	74	54	34	56,577	220	11.8	2.6%	$102	$2,696	-$36

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Quadplex	4	BCBC	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.0%	n/a	$1,857	-
		1	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.2%	egative NPV but no GHG reducti	$1,861	-$4
		2	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	117	62	27	29	42,381	64	3.8	0.6%	-$944	$1,868	$8
		3	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	0%	112	56	27	29	57,288	0	0.8	0.7%	$388	$1,869	-$48
		4	17.3%	1.0	22	11	0	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	0%	104	48	19	24	53,202	0	0.8	1.5%	$340	$1,885	-$43
		5	17.3%	0.6	22	20	0	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	80	25	12	20	41,218	0	0.6	6.0%	$489	$1,968	-$65
	5	BCBC	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.0%	n/a	$1,992	-
		1	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.2%	egative NPV but no GHG reducti	$1,997	-$5
		2	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	132	76	41	39	49,736	64	3.9	0.3%	-$1,133	$1,998	$9
		3	17.3%	2.5	18	20	0	27	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	120	65	36	37	61,796	0	0.9	1.1%	$386	$2,014	-$49
		4	17.3%	0.6	22	11	11	27	40	MG-HP-Double	1.4	HPHotWater	0%	elec-baseboard	0%	98	43	30	29	50,401	0	0.7	2.7%	$178	$2,047	-$24
		5	17.3%	0.6	40	20	0	27	40	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	85	30	17	24	43,659	0	0.6	6.7%	$502	$2,126	-$68
	6	BCBC	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.0%	n/a	$2,091	-
		1	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.3%	egative NPV but no GHG reducti	$2,096	-$5
		2	17.3%	2.5	22	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	148	92	56	50	57,173	67	4.2	0.2%	-$1,434	$2,095	$12
		3	17.3%	2.5	22	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	139	84	47	48	52,754	67	4.1	1.2%	-$1,267	$2,115	$13
		4	17.3%	0.6	22	20	0	27	100	MG-HP-Double	1.4	HPHotWater	0%	elec-baseboard	0%	109	53	40	36	55,825	0	0.8	2.7%	$93	$2,147	-$13
		5	17.3%	0.6	40	20	0	27	40	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	94	38	25	31	48,180	0	0.7	6.3%	$346	$2,223	-$50
	7a	BCBC	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.0%	n/a	$2,789	-
		1	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	173	117	78	62	68,651	72	4.6	0.5%	-$2,484	$2,804	$30
		3	17.3%	2.5	30	20	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	60%	165	109	70	58	64,506	72	4.6	1.9%	-$911	$2,842	$13
		4	17.3%	0.6	40	20	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	139	83	44	41	51,126	72	4.4	3.2%	-$1,959	$2,879	$44
		5	17.3%	0.6	40	20	11	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	105	49	35	34	53,871	0	0.8	7.4%	$393	$2,995	-$63
	7b	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	20	0	27	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	188	133	99	64	96,651	0	1.4	0.2%	$292	$2,795	-$42
		3	17.3%	2.5	40	20	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	185	129	89	61	74,476	74	4.8	1.7%	-$489	$2,835	$6
		4	17.3%	0.6	40	20	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	0%	153	98	58	40	58,241	74	4.5	3.1%	-$2,107	$2,876	$48
		5	17.3%	0.6	40	20	0	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	119	64	49	36	61,352	0	0.9	7.4%	$396	$2,996	-$65
	8	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	11	27	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	208	153	119	69	107,023	0	1.6	0.2%	$250	$2,794	-$37
		3	17.3%	2.5	40	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	201	145	105	64	82,350	75	4.9	1.8%	-$1,239	$2,840	$19
		4	17.3%	0.6	40	11	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	0%	165	110	69	43	64,053	75	4.7	3.0%	-$3,093	$2,872	$80
		5	17.3%	0.6	40	20	0	40	70	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	130	75	60	38	66,981	0	1.0	7.3%	$191	$2,992	-$32

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Large SFD	4	BCBC	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.0%	n/a	$1,938	-
		1	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.2%	egative NPV but no GHG reducti	$1,941	-$3
		2	14.6%	1.5	18	11	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	63	49	34	22	7,523	89	4.6	1.2%	$187	$1,961	-$12
		3	14.6%	1.5	16	11	0	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	50	36	27	20	25,419	0	0.4	1.3%	$332	$1,963	-$76
		4	14.6%	0.6	24	17	0	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	70%	42	28	20	16	17,418	14	0.9	2.4%	$293	$1,984	-$60
		5	14.6%	0.6	40	17	20	NA	50	HG-avg-Triple	1.2	ElectricStorage	42%	baseboard	70%	37	23	15	14	18,835	0	0.3	4.2%	$428	$2,020	-$99
	5	BCBC	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.0%	n/a	$2,079	-
		1	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.2%	egative NPV but no GHG reducti	$2,082	-$3
		2	14.6%	1.5	22	11	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	60%	76	63	45	27	7,885	112	5.7	0.4%	-$13	$2,086	$1
		3	14.6%	1.5	16	11	0	NA	50	HG-avg-Triple	1.2	ElectricStorage	30%	baseboard	0%	61	47	39	28	31,086	0	0.5	0.6%	$345	$2,092	-$87
		4	14.6%	0.6	24	11	0	NA	40	HG-avg-Triple	1.2	BaseDHW	42%	baseboard	70%	52	38	27	22	21,474	19	1.2	1.7%	$301	$2,115	-$67
		5	14.6%	0.6	40	17	11	NA	100	HG-avg-Triple	1.2	BaseDHW	30%	baseboard	75%	44	30	19	18	17,085	19	1.2	3.7%	$386	$2,156	-$86
	6	BCBC	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.0%	n/a	$2,182	-
		1	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.2%	egative NPV but no GHG reducti	$2,185	-$4
		2	14.6%	1.5	30	11	0	NA	40	LG-avg-Double	1.8	ElectricStorage	0%	baseboard	70%	82	68	59	35	41,726	0	0.6	-0.1%	$386	$2,180	-$117
		3	14.6%	1.5	18	11	0	NA	60	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	0%	72	58	49	35	32,725	14	1.2	0.4%	$306	$2,189	-$85
		4	14.6%	1.5	24	11	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	60%	62	48	39	30	27,613	14	1.1	1.3%	$280	$2,209	-$79
		5	14.6%	0.6	40	20	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	42%	basefurnace	84%	51	37	25	22	11,612	52	2.8	4.1%	$333	$2,272	-$72
	7a	BCBC	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.0%	n/a	$2,910	-
		1	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	1.5	22	11	0	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	baseboard	60%	97	83	73	41	44,892	16	1.5	-0.2%	$302	$2,905	-$115
		3	14.6%	1.5	22	11	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	90	76	63	41	39,587	23	1.7	0.4%	$285	$2,920	-$106
		4	14.6%	0.6	24	11	0	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	80	66	53	34	34,531	23	1.6	0.9%	$258	$2,937	-$97
		5	14.6%	0.6	40	25	0	NA	100	HG-i89-Triple-B	0.8	BaseDHW	0%	baseboard	60%	62	48	35	27	25,196	23	1.5	4.6%	$411	$3,044	-$156
	7b	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	2.5	18	11	20	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	60%	121	107	96	51	56,588	19	1.8	0.2%	$415	$2,916	-$177
		3	14.6%	1.5	22	17	0	NA	50	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	60%	102	88	77	41	46,698	19	1.6	0.4%	$304	$2,921	-$131
		4	14.6%	0.6	22	20	0	NA	70	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	75%	88	74	64	35	45,087	0	0.7	0.9%	$283	$2,936	-$133
		5	14.6%	0.6	40	17	0	NA	70	HG-i89-Triple-B	0.8	GasInst_Low	0%	baseboard	75%	75	61	50	29	32,892	19	1.4	3.6%	$354	$3,015	-$155
	8	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	1.5	40	20	20	NA	40	LG-avg-Double	1.8	HPHotWater	0%	baseboard	0%	126	112	107	46	64,311	0	0.9	1.2%	$429	$2,945	-$227
		3	14.6%	1.5	22	17	0	NA	40	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	60%	115	101	91	44	53,949	17	1.6	0.3%	$306	$2,920	-$154
		4	14.6%	0.6	22	11	0	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	103	89	79	38	52,838	0	0.8	0.5%	$275	$2,924	-$148
		5	14.6%	0.6	40	20	11	NA	100	HG-HP-Triple	1	GasInstantaneous	0%	baseboard	84%	81	67	57	30	36,836	17	1.4	3.5%	$313	$3,013	-$161

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Medium SFD	4	BCBC	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.0%	n/a	$2,045	-
		1	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.2%	egative NPV but no GHG reducti	$2,050	-$5
		2	14.7%	2.5	16	25	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	baseboard	0%	87	57	33	27	15,057	20	1.2	0.4%	$430	$2,053	-$63
		3	14.7%	2.5	16	11	11	NA	50	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	60%	74	44	26	24	17,613	0	0.3	0.9%	$386	$2,064	-$88
		4	14.7%	1.0	18	17	0	NA	50	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	0%	68	38	19	21	11,723	16	1.0	1.8%	$312	$2,082	-$53
		5	14.7%	0.6	24	20	11	NA	40	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	70%	53	23	14	17	12,445	0	0.2	3.6%	$370	$2,119	-$87
	5	BCBC	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.0%	n/a	$2,194	-
		1	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.2%	egative NPV but no GHG reducti	$2,200	-$5
		2	14.7%	2.5	16	11	0	NA	50	LG-avg-Double	1.8	GasInstantaneous	0%	baseboard	70%	91	61	44	32	17,751	14	0.9	0.2%	$379	$2,198	-$78
		3	14.7%	1.5	16	11	11	NA	50	LG-avg-Double	1.8	ElectricStorage	0%	baseboard	60%	86	56	38	29	20,418	0	0.3	0.4%	$393	$2,202	-$102
		4	14.7%	1.5	18	11	11	NA	60	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	0%	75	45	27	28	17,835	0	0.3	1.4%	$370	$2,226	-$97
		5	14.7%	0.6	22	17	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	75%	58	28	20	22	13,834	0	0.2	3.3%	$352	$2,266	-$94
	6	BCBC	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.0%	n/a	$2,303	-
		1	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.2%	egative NPV but no GHG reducti	$2,308	-$6
		2	14.7%	1.5	16	11	11	NA	50	LG-avg-Double	1.8	ElectricStorage	0%	baseboard	60%	103	73	54	39	24,419	0	0.4	0.0%	$407	$2,302	-$128
		3	14.7%	1.5	16	20	0	NA	40	MG-i89-Double	1.6	ElectricStorage	0%	basefurnace	70%	103	73	47	37	11,859	46	2.4	0.7%	$277	$2,319	-$38
		4	14.7%	0.6	16	11	0	NA	80	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	83	53	34	32	19,696	0	0.3	1.4%	$337	$2,334	-$108
		5	14.7%	0.6	40	25	11	NA	80	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	66	36	17	24	15,723	0	0.2	3.9%	$377	$2,392	-$122
	7a	BCBC	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.0%	n/a	$3,072	-
		1	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	18	17	0	NA	40	LG-avg-Double	1.8	ElectricStorage	0%	baseboard	60%	126	96	76	47	29,975	0	0.4	-0.2%	$392	$3,065	-$164
		3	14.7%	1.5	16	17	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	117	87	59	46	21,335	23	1.4	0.8%	$346	$3,096	-$115
		4	14.7%	1.0	24	25	0	NA	100	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	75%	99	69	48	35	23,419	0	0.3	1.7%	$351	$3,123	-$149
		5	14.7%	0.6	40	17	0	NA	70	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	70%	84	54	31	29	14,668	18	1.1	3.4%	$335	$3,177	-$120
	7b	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	18	11	11	NA	40	LG-avg-Double	1.8	GasInstantaneous	0%	baseboard	60%	147	117	97	50	30,280	16	1.3	-0.2%	$402	$3,065	-$167
		3	14.7%	1.5	16	17	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	139	108	80	49	26,308	23	1.5	0.4%	$375	$3,084	-$147
		4	14.7%	0.6	24	20	0	NA	100	MG-i89-Double	1.6	GasInstantaneous	0%	baseboard	75%	113	83	63	36	22,252	16	1.1	1.5%	$313	$3,119	-$133
		5	14.7%	0.6	40	17	20	NA	50	HG-avg-Triple	1.2	ElectricStorage	30%	baseboard	70%	95	65	45	32	22,418	0	0.3	3.8%	$390	$3,188	-$193
	8	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	18	25	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	baseboard	70%	165	135	106	53	32,503	23	1.6	-0.1%	$410	$3,067	-$186
		3	14.7%	1.5	22	11	0	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	baseboard	0%	152	122	101	52	31,391	17	1.3	0.0%	$358	$3,071	-$173
		4	14.7%	0.6	18	11	0	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	128	98	76	42	30,336	0	0.4	1.1%	$331	$3,105	-$184
		5	14.7%	0.6	40	11	11	NA	70	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	75%	99	69	58	34	23,363	0	0.3	3.5%	$322	$3,179	-$182

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	1.5	16	11	11	NA	50	LG-avg-Double	1.8	BaseDHW	0%	baseboard	70%	155	84	28	45	10,167	20	1.1	1.5%	$472	$2,349	-$73
		3	12.2%	1.5	16	11	11	NA	60	MG-HP-Double	1.4	ElectricStorage	0%	basefurnace	0%	147	78	29	48	11,435	13	0.8	1.6%	$444	$2,352	-$97
		4	12.2%	0.6	16	11	11	NA	80	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	129	60	18	41	13,196	0	0.2	3.4%	$478	$2,393	-$163
		5	12.2%	0.6	18	11	20	NA	70	HG-avg-Triple	1.2	ElectricStorage	0%	CCASHP-ecm	84%	125	55	14	37	12,720	0	0.2	8.7%	$798	$2,515	-$273
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	1.5	16	11	11	NA	60	MG-HP-Double	1.4	ElectricStorage	0%	basefurnace	0%	164	94	44	60	11,463	19	1.1	0.5%	$342	$2,496	-$73
		3	12.2%	1.5	18	11	11	NA	40	HG-avg-Triple	1.2	ElectricStorage	30%	basefurnace	0%	156	86	39	59	11,191	17	1.0	1.2%	$340	$2,512	-$80
		4	12.2%	1.5	18	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	70%	139	69	27	50	14,168	0	0.2	2.4%	$406	$2,543	-$159
		5	12.2%	0.6	40	11	11	NA	100	HG-i89-Triple-B	0.8	HPHotWater	0%	baseboard	75%	108	38	19	42	11,029	0	0.2	7.6%	$522	$2,673	-$210
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	18	11	11	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	0%	188	117	59	81	13,279	21	1.2	0.4%	$374	$2,617	-$106
		3	12.2%	1.5	16	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	160	90	46	67	16,307	0	0.2	1.6%	$375	$2,646	-$179
		4	12.2%	1.0	22	11	11	NA	60	HG-i89-Triple-B	0.8	GasInstantaneous	0%	baseboard	84%	146	76	35	59	10,834	14	0.9	4.4%	$386	$2,720	-$136
		5	12.2%	0.6	40	25	30	NA	100	HG-i89-Triple-B	0.8	HPHotWater	30%	basefurnace	70%	118	48	24	45	9,072	11	0.7	10.8%	$647	$2,889	-$254
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	22	11	11	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	baseboard	60%	195	124	79	79	15,335	16	1.0	0.9%	$301	$3,506	-$144
		3	12.2%	1.5	18	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	70%	185	115	67	77	18,835	0	0.3	1.5%	$367	$3,528	-$229
		4	12.2%	0.6	30	11	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	75%	176	106	51	65	7,404	38	2.0	4.2%	$346	$3,622	-$99
		5	12.2%	0.6	40	25	30	NA	70	HG-HP-Triple	1	ElectricStorage	0%	CCASHP-ecm	75%	153	83	34	53	15,557	0	0.2	11.8%	$793	$3,885	-$503
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	18	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	214	144	95	83	21,807	0	0.3	0.8%	$370	$3,503	-$264
		3	12.2%	2.5	40	11	11	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	0%	224	153	89	91	16,418	23	1.4	2.6%	$450	$3,567	-$227
		4	12.2%	0.6	40	11	11	NA	70	HG-i89-Triple-B	0.8	GasInst_Low	0%	baseboard	70%	184	113	59	66	13,362	19	1.1	5.2%	$423	$3,658	-$233
		5	12.2%	0.6	60	11	20	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	30%	CCASHP-ecm	84%	167	96	47	60	17,014	0	0.3	13.1%	$785	$3,931	-$570
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	40	25	20	NA	70	LG-avg-Double	1.8	GasInst_Low	0%	baseboard	60%	231	160	106	81	18,113	19	1.2	4.4%	$498	$3,628	-$310
		3	12.2%	1.5	40	11	11	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	70%	219	148	94	80	16,890	19	1.2	2.7%	$350	$3,569	-$219
		4	12.2%	0.6	40	11	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	70%	202	132	71	68	7,451	47	2.5	4.9%	$282	$3,647	-$107
		5	12.2%	0.6	40	25	30	NA	100	HG-avg-Triple	1.2	GasInstantaneous	42%	CCASHP-ecm	84%	173	103	60	58	13,556	15	0.9	12.3%	$680	$3,904	-$463

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD - Slab on Grade	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	16	N/A	11	NA	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	0%	145	75	33	38	14,781	0	0.2	0.3%	$390	$2,321	-$131
		3	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	139	70	28	37	14,203	0	0.2	0.8%	$381	$2,333	-$129
		4	12.2%	1.0	18	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	130	61	19	30	13,288	0	0.2	2.2%	$401	$2,364	-$137
		5	12.2%	1.0	22	N/A	20	NA	40	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	103	33	14	26	10,520	0	0.2	6.0%	$445	$2,453	-$155
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	154	84	42	47	15,659	0	0.2	0.4%	$378	$2,492	-$147
		3	12.2%	2.5	18	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	151	81	39	46	15,403	0	0.2	0.7%	$379	$2,500	-$148
		4	12.2%	0.6	18	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	140	71	29	37	14,306	0	0.2	2.1%	$397	$2,536	-$156
		5	12.2%	1.0	22	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	108	38	19	30	11,028	0	0.2	6.4%	$443	$2,641	-$178
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	170	100	56	55	17,295	0	0.3	0.6%	$377	$2,621	-$179
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	160	91	47	50	16,349	0	0.2	1.2%	$357	$2,636	-$171
		4	12.2%	0.6	22	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	146	76	32	40	14,865	0	0.2	2.9%	$367	$2,681	-$177
		5	12.2%	1.0	40	N/A	11	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	114	45	25	35	11,658	0	0.2	7.3%	$429	$2,796	-$211
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	193	123	76	62	19,698	0	0.3	1.0%	$377	$3,511	-$235
		3	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	185	115	67	57	18,838	0	0.3	1.8%	$386	$3,540	-$241
		4	12.2%	1.0	22	N/A	11	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	0%	elec-baseboard	60%	161	92	44	47	16,485	0	0.2	4.2%	$419	$3,623	-$264
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	0%	elec-baseboard	84%	139	70	22	34	14,232	0	0.2	8.1%	$536	$3,758	-$342
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	20	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	216	146	98	66	22,048	0	0.3	1.2%	$401	$3,519	-$286
		3	12.2%	2.5	22	N/A	20	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	206	136	87	61	20,987	0	0.3	2.1%	$402	$3,547	-$287
		4	12.2%	1.0	40	N/A	20	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	175	105	57	46	17,870	0	0.3	4.6%	$411	$3,637	-$297
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	142	72	50	39	14,450	0	0.2	8.5%	$469	$3,771	-$344
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	18	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	239	169	120	70	24,363	0	0.4	0.9%	$403	$3,509	-$319
		3	12.2%	2.5	22	N/A	20	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	222	152	103	64	22,644	0	0.3	2.1%	$394	$3,547	-$314
		4	12.2%	0.6	40	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	188	118	69	47	19,181	0	0.3	4.3%	$374	$3,624	-$302
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	152	82	60	40	15,499	0	0.2	8.5%	$434	$3,771	-$356

8.9 Part 9 – Highest NPV

Note: Negative carbon abatement costs occur when a building has lower GHG emissions and a positive NPV, meaning investing in GHG reductions is profitable.

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
10 unit MURB	4	BCBC	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.0%	n/a	$2,422	-
		1	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.1%	egative NPV but no GHG reducti	$2,424	-$3
		2	27.0%	1.5	18	20	11	27	60	LG-avg-Double	1.8	Combo	0%	ComboHeatA	0%	73	47	26	18	50,284	255	13.5	1.4%	ositive NPV but no GHG reductio	$2,455	$52
		3	27.0%	0.6	18	25	20	27	40	LG-avg-Double	1.8	Combo	0%	ComboHeatA	60%	62	36	16	16	50,154	190	10.2	1.7%	ositive NPV but no GHG reductio	$2,464	$49
		4	27.0%	0.6	18	25	20	27	40	LG-avg-Double	1.8	Combo	0%	ComboHeatA	60%	62	36	16	16	50,154	190	10.2	1.7%	ositive NPV but no GHG reductio	$2,464	$49
		5	27.0%	0.6	50	20	20	27	70	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	70%	50	24	2	11	53,948	104	6.0	2.6%	-$2,896	$2,485	$31
	5	BCBC	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.0%	n/a	$2,599	-
		1	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.1%	egative NPV but no GHG reducti	$2,602	-$3
		2	27.0%	2.5	24	25	11	27	100	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	60%	66	41	20	25	50,190	216	11.5	2.7%	ositive NPV but no GHG reductio	$2,670	$53
		3	27.0%	0.6	16	11	0	27	50	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	70	44	23	20	50,239	235	12.5	1.6%	ositive NPV but no GHG reductio	$2,640	$81
		4	27.0%	0.6	16	11	0	27	50	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	70	44	23	20	50,239	235	12.5	1.6%	ositive NPV but no GHG reductio	$2,640	$81
		5	27.0%	0.6	22	11	15	35	100	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	70%	56	30	8	15	63,298	104	6.1	2.1%	-$4,541	$2,654	$59
	6	BCBC	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.0%	n/a	$2,727	-
		1	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.1%	egative NPV but no GHG reducti	$2,730	-$3
		2	27.0%	1.5	18	20	11	27	40	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	91	65	42	34	50,426	362	18.8	1.2%	ositive NPV but no GHG reductio	$2,760	$122
		3	27.0%	0.6	16	20	0	27	50	LG-avg-Double	1.8	Combo	0%	ComboHeatA	60%	84	58	35	27	50,364	318	16.6	1.2%	ositive NPV but no GHG reductio	$2,761	$125
		4	27.0%	0.6	16	20	0	27	50	LG-avg-Double	1.8	Combo	0%	ComboHeatA	60%	84	58	35	27	50,364	318	16.6	1.2%	ositive NPV but no GHG reductio	$2,761	$125
		5	27.0%	0.6	16	17	0	27	40	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	66	40	18	24	50,168	211	11.2	2.2%	ositive NPV but no GHG reductio	$2,786	$110
	7a	BCBC	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.0%	n/a	$3,638	-
		1	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	16	17	11	27	40	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	115	89	64	43	50,569	505	25.9	0.9%	ositive NPV but no GHG reductio	$3,672	$185
		3	27.0%	0.6	16	11	0	27	40	LG-avg-Double	1.8	Combo	30%	ComboHeatA	60%	103	77	53	34	50,481	431	22.2	1.1%	ositive NPV but no GHG reductio	$3,678	$186
		4	27.0%	0.6	16	11	0	27	40	LG-avg-Double	1.8	Combo	30%	ComboHeatA	60%	103	77	53	34	50,481	431	22.2	1.1%	ositive NPV but no GHG reductio	$3,678	$186
		5	27.0%	0.6	16	11	20	27	40	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	79	53	30	29	50,256	290	15.2	2.0%	ositive NPV but no GHG reductio	$3,710	$168
	7b	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	124	100	9.7	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	257,707	119	9.7	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	18	17	11	27	70	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	133	107	81	45	50,658	611	31.2	0.9%	ositive NPV but no GHG reductio	$3,671	$244
		3	27.0%	0.6	18	20	0	27	60	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	115	89	64	35	50,539	503	25.8	1.0%	ositive NPV but no GHG reductio	$3,674	$252
		4	27.0%	0.6	18	20	0	27	60	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	115	89	64	35	50,539	503	25.8	1.0%	ositive NPV but no GHG reductio	$3,674	$252
		5	27.0%	0.6	22	25	15	27	40	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	91	65	41	30	50,340	360	18.7	2.0%	ositive NPV but no GHG reductio	$3,709	$231
	8	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	40	11	0	40	100	LG-avg-Double	1.8	Combo	0%	ComboHeatA	70%	134	108	81	43	50,640	614	31.4	2.1%	ositive NPV but no GHG reductio	$3,714	$264
		3	27.0%	0.6	22	25	15	27	60	LG-avg-Double	1.8	Combo	0%	ComboHeatA	60%	125	99	73	35	50,592	564	28.9	1.1%	ositive NPV but no GHG reductio	$3,676	$306
		4	27.0%	0.6	22	25	15	27	60	LG-avg-Double	1.8	Combo	0%	ComboHeatA	60%	125	99	73	35	50,592	564	28.9	1.1%	ositive NPV but no GHG reductio	$3,676	$306
		5	27.0%	0.6	22	11	11	27	80	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	60%	101	75	50	30	50,396	419	21.6	2.0%	ositive NPV but no GHG reductio	$3,711	$286

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
6 unit Row House	4	BCBC	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.0%	n/a	$1,749	-
		1	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.2%	egative NPV but no GHG reducti	$1,752	-$3
		2	22.2%	2.5	16	NA	0	27	50	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	0%	95	58	26	24	44,833	203	10.8	0.4%	$306	$1,757	-$5
		3	22.2%	0.6	16	NA	0	27	40	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	87	50	22	20	44,752	173	9.3	0.8%	$146	$1,764	-$7
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	0%	77	39	10	18	44,519	136	7.4	2.3%	$305	$1,789	-$25
		5	22.2%	0.6	16	NA	11	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	62	23	10	17	54,091	42	2.9	3.4%	$314	$1,808	-$54
	5	BCBC	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.0%	n/a	$1,877	-
		1	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.2%	egative NPV but no GHG reducti	$1,880	-$3
		2	22.2%	0.6	18	NA	0	27	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	94	57	29	25	44,888	200	10.6	0.9%	$107	$1,894	-$7
		3	22.2%	0.6	18	NA	0	27	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	94	57	29	25	44,888	200	10.6	0.9%	$107	$1,894	-$7
		4	22.2%	0.6	18	NA	0	27	40	MG-i89-Double	1.6	GasInstantaneous	0%	basefurnace	60%	87	50	22	24	44,759	174	9.3	1.7%	$189	$1,908	-$17
		5	22.2%	0.6	24	NA	0	27	40	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	68	29	15	20	54,195	64	4.0	3.3%	$296	$1,939	-$58
	6	BCBC	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.0%	n/a	$1,970	-
		1	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.2%	egative NPV but no GHG reducti	$1,973	-$3
		2	22.2%	1.5	16	NA	0	27	40	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	120	84	51	38	45,311	296	15.4	-0.1%	-$304	$1,967	$6
		3	22.2%	0.6	16	NA	0	27	40	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	70%	111	74	39	33	45,087	262	13.7	0.5%	-$0	$1,979	$0
		4	22.2%	0.6	22	NA	0	27	40	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	0%	88	51	22	27	44,751	177	9.5	2.1%	$120	$2,010	-$17
		5	22.2%	0.6	18	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	78	40	24	27	54,783	100	5.8	2.5%	$185	$2,019	-$39
	7a	BCBC	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.0%	n/a	$2,627	-
		1	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	1.5	16	NA	11	27	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	70%	135	100	63	44	45,544	353	18.3	0.4%	-$43	$2,637	$3
		3	22.2%	0.6	16	NA	0	29	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	60%	129	94	58	39	45,450	332	17.2	0.5%	-$21	$2,641	$2
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	60%	108	72	35	35	45,010	252	13.2	1.6%	$71	$2,670	-$13
		5	22.2%	0.6	22	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	89	52	35	31	55,823	142	7.9	2.5%	$161	$2,693	-$46
	7b	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	1.5	24	NA	0	27	50	MG-HP-Double	1.4	GasInst_Low	0%	basefurnace	0%	149	115	73	44	45,735	407	21.0	0.4%	-$69	$2,637	$7
		3	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	145	110	69	40	45,657	390	20.1	0.2%	-$126	$2,633	$14
		4	22.2%	0.6	16	NA	11	27	40	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	120	84	50	37	45,289	297	15.5	1.5%	$22	$2,668	-$5
		5	22.2%	0.6	22	NA	11	27	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	75%	99	63	44	32	56,213	179	9.7	2.7%	$138	$2,698	-$44
	8	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	156	123	80	42	45,860	434	22.3	0.2%	-$136	$2,633	$20
		3	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	156	123	80	42	45,860	434	22.3	0.2%	-$136	$2,633	$20
		4	22.2%	0.6	22	NA	0	27	50	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	0%	133	98	61	36	45,501	344	17.8	1.3%	-$24	$2,662	$6
		5	22.2%	0.6	22	NA	11	27	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	111	74	54	34	56,577	220	11.8	2.6%	$102	$2,696	-$36

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Quadplex	4	BCBC	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.0%	n/a	$1,857	-
		1	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.2%	egative NPV but no GHG reducti	$1,861	-$4
		2	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	gas-furnace-ecm	0%	121	66	27	29	28,743	120	6.4	1.3%	ositive NPV but no GHG reductio	$1,882	$46
		3	17.3%	2.5	18	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	116	60	22	28	28,733	111	5.9	2.2%	ositive NPV but no GHG reductio	$1,897	$33
		4	17.3%	0.6	22	11	11	27	40	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	0%	91	36	20	23	35,179	42	2.6	3.8%	$138	$1,927	-$8
		5	17.3%	0.6	22	20	0	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	80	25	12	20	41,218	0	0.6	6.0%	$489	$1,968	-$65
	5	BCBC	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.0%	n/a	$1,992	-
		1	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.2%	egative NPV but no GHG reducti	$1,997	-$5
		2	17.3%	2.5	18	20	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	gas-furnace-ecm	0%	136	81	40	39	28,774	148	7.8	1.2%	ositive NPV but no GHG reductio	$2,016	$71
		3	17.3%	2.5	22	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	127	71	32	36	28,756	131	7.0	2.3%	ositive NPV but no GHG reductio	$2,038	$54
		4	17.3%	0.6	22	11	11	27	40	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	0%	102	46	30	29	35,202	62	3.6	3.5%	-$933	$2,061	$20
		5	17.3%	0.6	40	11	0	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	60%	85	30	15	22	35,169	31	2.1	8.0%	$763	$2,152	-$62
	6	BCBC	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.0%	n/a	$2,091	-
		1	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.3%	egative NPV but no GHG reducti	$2,096	-$5
		2	17.3%	2.5	18	11	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	152	97	53	51	28,799	178	9.3	1.2%	ositive NPV but no GHG reductio	$2,116	$99
		3	17.3%	2.5	30	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	60%	142	86	44	46	28,781	159	8.3	2.7%	ositive NPV but no GHG reductio	$2,147	$74
		4	17.3%	0.6	30	11	0	27	70	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	0%	113	58	39	36	35,503	82	4.6	3.6%	ositive NPV but no GHG reductio	$2,166	$46
		5	17.3%	0.6	40	20	0	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	0%	95	40	23	30	35,467	49	3.0	7.4%	$403	$2,244	-$23
	7a	BCBC	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.0%	n/a	$2,789	-
		1	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	183	127	78	62	28,873	235	12.1	1.3%	ositive NPV but no GHG reductio	$2,824	$161
		3	17.3%	2.5	40	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	171	115	67	57	28,847	212	11.0	2.9%	ositive NPV but no GHG reductio	$2,870	$122
		4	17.3%	0.6	40	20	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	0%	142	87	42	38	28,793	159	8.4	4.4%	ositive NPV but no GHG reductio	$2,910	$98
		5	17.3%	0.6	40	20	11	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	60%	110	54	35	34	36,064	73	4.2	8.1%	$537	$3,015	-$16
	7b	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	206	151	99	65	28,941	277	14.2	1.0%	ositive NPV but no GHG reductio	$2,815	$193
		3	17.3%	2.5	40	20	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	191	136	86	60	28,906	250	12.9	2.7%	ositive NPV but no GHG reductio	$2,865	$153
		4	17.3%	0.6	40	20	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	60%	157	101	55	39	28,835	186	9.7	4.3%	ositive NPV but no GHG reductio	$2,909	$128
		5	17.3%	0.6	40	20	0	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	119	64	49	36	61,352	0	0.9	7.4%	$396	$2,996	-$65
	8	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	227	172	118	69	29,003	316	16.2	1.0%	ositive NPV but no GHG reductio	$2,815	$238
		3	17.3%	2.5	40	11	0	27	70	LG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	0%	209	154	102	61	28,961	283	14.5	2.8%	ositive NPV but no GHG reductio	$2,867	$196
		4	17.3%	0.6	40	11	0	27	70	LG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	60%	171	115	67	42	28,873	212	11.0	4.0%	ositive NPV but no GHG reductio	$2,901	$186
		5	17.3%	0.6	40	20	0	40	70	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	130	75	60	38	66,981	0	1.0	7.3%	$191	$2,992	-$32

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Large SFD	4	BCBC	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.0%	n/a	$1,938	-
		1	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.2%	egative NPV but no GHG reducti	$1,941	-$3
		2	14.6%	1.5	18	11	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	gas-furnace-ecm	0%	63	49	34	22	7,523	89	4.6	1.2%	$187	$1,961	-$12
		3	14.6%	1.5	24	20	0	NA	40	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	60%	58	44	28	19	7,721	78	4.0	1.9%	$269	$1,975	-$23
		4	14.6%	0.6	24	11	0	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	75%	47	33	19	17	7,488	60	3.1	2.9%	$286	$1,993	-$35
		5	14.6%	0.6	40	25	0	NA	70	HG-avg-Triple	1.2	GasInstantaneous	42%	basefurnace	60%	38	24	14	14	7,590	43	2.2	4.8%	$435	$2,031	-$67
	5	BCBC	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.0%	n/a	$2,079	-
		1	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.2%	egative NPV but no GHG reducti	$2,082	-$3
		2	14.6%	1.5	22	11	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	60%	76	63	45	27	7,885	112	5.7	0.4%	-$13	$2,086	$1
		3	14.6%	1.5	22	11	0	NA	60	MG-HP-Double	1.4	GasInst_Low	42%	basefurnace	60%	65	51	37	26	7,815	92	4.7	1.3%	$138	$2,105	-$12
		4	14.6%	0.6	24	11	0	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	0%	59	45	29	23	7,736	81	4.2	1.8%	$173	$2,116	-$19
		5	14.6%	0.6	40	17	0	NA	70	HG-avg-Triple	1.2	GasInstantaneous	30%	gas-furnace-ecm	84%	44	30	20	18	7,490	53	2.8	4.0%	$340	$2,162	-$55
	6	BCBC	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.0%	n/a	$2,182	-
		1	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.2%	egative NPV but no GHG reducti	$2,185	-$4
		2	14.6%	1.5	16	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	gas-furnace-ecm	60%	90	76	59	36	7,588	138	7.0	0.2%	-$122	$2,186	$6
		3	14.6%	1.5	16	17	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	60%	81	68	48	35	7,917	121	6.2	0.9%	$70	$2,202	-$6
		4	14.6%	1.0	22	11	0	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	69	55	40	30	7,840	98	5.0	1.3%	$46	$2,210	-$6
		5	14.6%	0.6	40	25	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	0%	gas-furnace-ecm	70%	52	38	25	22	7,502	68	3.5	4.2%	$314	$2,274	-$60
	7a	BCBC	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.0%	n/a	$2,910	-
		1	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	1.5	18	11	0	NA	70	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	115	101	79	43	8,221	182	9.2	0.1%	-$147	$2,912	$11
		3	14.6%	1.5	24	11	0	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	0%	101	87	64	41	8,076	157	8.0	1.0%	$54	$2,939	-$7
		4	14.6%	0.6	22	11	0	NA	60	HG-avg-Triple	1.2	Combo	30%	ComboHeatA	84%	81	67	54	34	8,079	119	6.1	1.9%	$112	$2,967	-$23
		5	14.6%	0.6	60	17	11	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	84%	67	53	35	26	7,794	96	4.9	5.0%	$411	$3,054	-$102
	7b	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	2.5	18	11	20	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	60%	121	107	96	51	56,588	19	1.8	0.2%	$415	$2,916	-$177
		3	14.6%	1.5	24	20	0	NA	100	MG-HP-Double	1.4	GasInstantaneous	0%	basefurnace	60%	116	102	82	41	8,255	185	9.3	1.0%	$54	$2,940	-$7
		4	14.6%	0.6	24	17	0	NA	60	HG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	70%	99	85	65	35	7,640	154	7.8	1.5%	$49	$2,954	-$9
		5	14.6%	0.6	50	17	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	75%	78	64	49	28	7,596	116	5.9	4.2%	$286	$3,032	-$75
	8	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	1.5	40	20	20	NA	40	LG-avg-Double	1.8	HPHotWater	0%	baseboard	0%	126	112	107	46	64,311	0	0.9	1.2%	$429	$2,945	-$227
		3	14.6%	1.5	40	11	11	NA	40	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	115	101	80	40	8,242	182	9.2	2.0%	$108	$2,968	-$22
		4	14.6%	0.6	22	11	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	75%	110	96	78	37	7,696	176	8.9	1.2%	-$19	$2,946	$4
		5	14.6%	0.6	40	25	11	NA	70	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	75%	88	74	60	31	8,139	133	6.7	3.7%	$186	$3,018	-$56

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Medium SFD	4	BCBC	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.0%	n/a	$2,045	-
		1	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.2%	egative NPV but no GHG reducti	$2,050	-$5
		2	14.7%	2.5	16	11	0	NA	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	60%	85	55	33	25	7,494	46	2.4	0.9%	$221	$2,064	-$11
		3	14.7%	1.5	18	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	77	47	24	22	7,453	39	2.1	1.5%	$232	$2,075	-$17
		4	14.7%	1.0	18	11	0	NA	70	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	60%	67	37	17	20	7,422	31	1.6	2.5%	$290	$2,097	-$33
		5	14.7%	0.6	22	25	0	NA	40	HG-avg-Triple	1.2	HPHotWater	0%	gas-furnace-ecm	84%	55	25	14	17	9,142	14	0.8	4.1%	$393	$2,130	-$71
	5	BCBC	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.0%	n/a	$2,194	-
		1	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.2%	egative NPV but no GHG reducti	$2,200	-$5
		2	14.7%	2.5	16	11	0	NA	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	60%	98	68	44	32	7,544	56	2.9	0.6%	$159	$2,207	-$6
		3	14.7%	1.5	18	11	0	NA	40	LG-avg-Double	1.8	GasInstantaneous	0%	gas-furnace-ecm	60%	91	61	40	30	7,383	51	2.7	1.0%	$203	$2,217	-$12
		4	14.7%	1.0	18	11	0	NA	70	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	60%	78	48	24	25	7,455	39	2.1	2.1%	$254	$2,241	-$28
		5	14.7%	0.6	40	25	0	NA	70	HG-avg-Triple	1.2	GasInstantaneous	42%	basefurnace	60%	60	30	12	18	7,401	24	1.3	5.1%	$479	$2,307	-$83
	6	BCBC	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.0%	n/a	$2,303	-
		1	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.2%	egative NPV but no GHG reducti	$2,308	-$6
		2	14.7%	1.5	18	17	0	NA	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	114	84	58	40	7,606	70	3.6	0.4%	$57	$2,311	-$2
		3	14.7%	1.5	18	11	0	NA	70	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	104	74	46	36	7,555	62	3.2	0.9%	$112	$2,324	-$8
		4	14.7%	0.6	16	25	0	NA	40	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	70%	84	54	33	31	7,376	46	2.4	2.5%	$223	$2,360	-$32
		5	14.7%	0.6	40	11	11	NA	50	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	75%	69	39	19	24	7,546	32	1.7	4.7%	$376	$2,411	-$75
	7a	BCBC	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.0%	n/a	$3,072	-
		1	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	18	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	131	101	68	44	7,657	84	4.3	0.7%	$58	$3,092	-$5
		3	14.7%	1.5	22	20	0	NA	40	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	60%	128	98	61	43	7,625	82	4.2	1.0%	$143	$3,104	-$15
		4	14.7%	0.6	22	17	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	96	66	40	33	7,529	55	2.8	2.6%	$199	$3,151	-$43
		5	14.7%	0.6	40	20	20	NA	60	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	85	55	30	29	7,488	46	2.4	4.5%	$372	$3,209	-$95
	7b	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	22	20	0	NA	40	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	60%	150	120	81	47	7,717	100	5.1	0.6%	$25	$3,089	-$2
		3	14.7%	1.5	18	17	0	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	gas-furnace-ecm	60%	144	114	86	47	7,459	97	4.9	0.8%	$59	$3,098	-$6
		4	14.7%	0.6	22	20	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	60%	111	81	55	36	7,421	68	3.5	2.5%	$165	$3,148	-$37
		5	14.7%	0.6	40	20	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	95	65	48	32	9,692	46	2.4	4.2%	$311	$3,202	-$98
	8	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	18	25	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	baseboard	70%	165	135	106	53	32,503	23	1.6	-0.1%	$410	$3,067	-$186
		3	14.7%	1.5	22	17	0	NA	50	HG-avg-Triple	1.2	GasInstantaneous	42%	basefurnace	60%	139	109	80	45	7,718	91	4.7	2.0%	$142	$3,134	-$28
		4	14.7%	0.6	22	11	0	NA	40	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	130	100	73	40	7,927	82	4.2	2.3%	$141	$3,143	-$33
		5	14.7%	0.6	40	25	0	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	104	74	56	33	9,767	53	2.8	4.1%	$244	$3,197	-$87

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	16	11	11	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	basefurnace	0%	151	81	34	49	7,368	29	1.5	1.6%	$317	$2,351	-$24
		3	12.2%	2.5	18	11	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	basefurnace	60%	145	75	29	45	7,358	27	1.4	2.2%	$350	$2,364	-$34
		4	12.2%	0.6	30	11	11	NA	70	MG-HP-Double	1.4	GasInstantaneous	0%	basefurnace	60%	130	61	17	38	7,334	22	1.2	4.8%	$590	$2,425	-$87
		5	12.2%	0.6	40	11	11	NA	100	HG-i89-Triple-B	0.8	HPHotWater	0%	basefurnace	70%	104	34	12	33	9,086	5	0.4	8.8%	$639	$2,518	-$192
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	22	11	11	NA	40	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	0%	168	99	45	60	7,388	35	1.9	0.6%	$69	$2,499	-$5
		3	12.2%	2.5	18	11	11	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	70%	159	89	36	55	7,372	32	1.7	1.6%	$227	$2,523	-$23
		4	12.2%	0.6	16	11	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	55%	basefurnace	75%	138	68	28	48	7,356	24	1.3	4.0%	$397	$2,581	-$69
		5	12.2%	0.6	40	11	11	NA	100	HG-i89-Triple-B	0.8	HPHotWater	55%	basefurnace	60%	111	41	20	43	8,897	9	0.6	8.1%	$558	$2,684	-$180
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	1.5	22	11	11	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	60%	196	127	57	70	7,412	45	2.4	0.9%	$209	$2,628	-$12
		3	12.2%	1.5	22	11	11	NA	60	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	60%	163	93	42	64	7,383	33	1.8	2.4%	$178	$2,668	-$32
		4	12.2%	0.6	24	11	11	NA	60	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	151	81	36	58	7,581	28	1.5	4.9%	$408	$2,732	-$92
		5	12.2%	0.6	40	25	30	NA	100	HG-i89-Triple-B	0.8	HPHotWater	30%	basefurnace	70%	118	48	24	45	9,072	11	0.7	10.8%	$647	$2,889	-$254
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	16	11	11	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	60%	219	149	72	82	7,446	54	2.8	1.5%	$231	$3,529	-$31
		3	12.2%	1.5	22	11	11	NA	50	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	60%	198	128	68	77	7,438	46	2.4	1.9%	$146	$3,541	-$30
		4	12.2%	0.6	30	11	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	75%	176	106	51	65	7,404	38	2.0	4.2%	$346	$3,622	-$99
		5	12.2%	0.6	50	11	11	NA	100	HG-i89-Triple-B	0.8	GasInst_Low	0%	CCASHP-ecm	84%	156	86	32	57	10,775	18	1.1	12.3%	$918	$3,903	-$428
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	22	17	11	NA	70	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	225	154	90	85	16,529	23	1.4	1.6%	$385	$3,531	-$194
		3	12.2%	1.5	40	11	20	NA	100	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	60%	203	133	68	71	7,441	48	2.5	4.3%	$359	$3,627	-$103
		4	12.2%	0.6	40	17	11	NA	80	HG-avg-Triple	1.2	GasInst_Low	55%	basefurnace	75%	188	118	62	66	7,428	42	2.2	5.6%	$400	$3,669	-$136
		5	12.2%	0.6	50	25	30	NA	100	HG-avg-Triple	1.2	GasInstantaneous	42%	CCASHP-ecm	84%	162	92	47	54	12,523	14	0.9	14.1%	$857	$3,965	-$512
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	40	25	20	NA	70	LG-avg-Double	1.8	GasInst_Low	0%	baseboard	60%	231	160	106	81	18,113	19	1.2	4.4%	$498	$3,628	-$310
		3	12.2%	1.5	40	25	20	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	211	141	80	72	7,468	51	2.6	6.2%	$456	$3,693	-$158
		4	12.2%	0.6	40	11	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	70%	202	132	71	68	7,451	47	2.5	4.9%	$282	$3,647	-$107
		5	12.2%	0.6	40	25	30	NA	100	HG-avg-Triple	1.2	GasInstantaneous	42%	CCASHP-ecm	84%	173	103	60	58	13,556	15	0.9	12.3%	$680	$3,904	-$463

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD - Slab on Grade	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	18	N/A	11	NA	40	LG-avg-Double	1.8	GasInstantaneous	0%	gas-furnace-ecm	0%	147	78	33	37	7,310	28	1.5	1.7%	$293	$2,354	-$25
		3	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	143	73	30	37	7,309	26	1.4	2.1%	$306	$2,363	-$31
		4	12.2%	1.0	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	129	59	17	28	7,305	21	1.2	3.8%	$402	$2,401	-$61
		5	12.2%	1.0	22	N/A	20	NA	40	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	60%	106	36	14	26	9,067	6	0.4	6.8%	$505	$2,472	-$147
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	159	89	44	47	7,315	32	1.7	1.6%	$235	$2,524	-$23
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	151	81	37	44	7,313	29	1.6	2.3%	$264	$2,539	-$34
		4	12.2%	1.0	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	140	71	27	35	7,309	25	1.4	3.4%	$341	$2,568	-$56
		5	12.2%	1.0	22	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	60%	111	41	19	30	9,069	8	0.5	7.2%	$495	$2,662	-$162
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	175	105	56	57	7,321	38	2.0	1.9%	$192	$2,654	-$25
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	166	97	49	50	7,319	35	1.8	2.5%	$217	$2,670	-$35
		4	12.2%	0.6	22	N/A	20	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	145	76	30	39	7,312	27	1.5	4.8%	$357	$2,731	-$85
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	GasInstantaneous	0%	elec-baseboard	60%	123	54	13	31	8,590	14	0.8	7.9%	$476	$2,811	-$171
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	203	133	78	62	7,338	48	2.5	2.3%	$255	$3,556	-$47
		3	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	194	124	70	57	7,335	45	2.3	3.1%	$318	$3,584	-$70
		4	12.2%	1.0	22	N/A	11	NA	80	HG-i89-Triple-B	0.8	GasInstantaneous	0%	gas-furnace-ecm	60%	167	97	46	47	7,323	35	1.9	5.5%	$435	$3,667	-$137
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	GasInstantaneous	0%	elec-baseboard	84%	139	69	24	34	9,703	16	0.9	8.6%	$541	$3,773	-$267
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	222	152	96	63	7,355	55	2.9	2.5%	$235	$3,564	-$50
		3	12.2%	2.5	22	N/A	20	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	216	146	90	61	7,350	53	2.8	3.3%	$315	$3,592	-$74
		4	12.2%	0.6	22	N/A	20	NA	80	HG-i89-Triple-B	0.8	GasInstantaneous	0%	gas-furnace-ecm	60%	181	111	58	47	7,334	40	2.1	6.0%	$405	$3,685	-$147
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	84%	147	77	50	39	9,405	20	1.1	9.3%	$502	$3,800	-$276
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	240	170	111	66	7,367	62	3.2	2.5%	$194	$3,564	-$46
		3	12.2%	2.5	40	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	232	162	103	63	7,364	59	3.0	3.8%	$322	$3,609	-$86
		4	12.2%	1.0	40	N/A	20	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	194	124	69	48	7,345	45	2.4	5.9%	$339	$3,681	-$136
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	84%	159	89	60	40	9,449	24	1.4	9.3%	$451	$3,800	-$269

8.10 Part 9 – Lowest Carbon Abatement Costs

Note: Negative carbon abatement costs occur when a building has lower GHG emissions and a positive NPV, meaning investing in GHG reductions is profitable.

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
10 unit MURB	4	BCBC	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.0%	n/a	$2,422	-
		1	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.1%	egative NPV but no GHG reducti	$2,424	-$3
		2	27.0%	1.5	18	17	15	35	40	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	70	44	22	18	86,478	104	6.5	0.8%	-$4,815	$2,441	$23
		3	27.0%	0.6	18	11	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	75%	62	36	14	15	73,016	104	6.3	#N/A	-$5,831	$2,444	$42
		4	27.0%	0.6	18	11	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	75%	62	36	14	15	73,016	104	6.3	0.9%	-$5,831	$2,444	$42
		5	27.0%	0.6	60	11	15	35	40	MG-i89-Double	1.6	Combo	55%	ComboHeatA	84%	51	25	5	12	50,011	123	6.8	3.7%	-$91,532	$2,512	$8
	5	BCBC	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.0%	n/a	$2,599	-
		1	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.1%	egative NPV but no GHG reducti	$2,602	-$3
		2	27.0%	1.5	16	17	15	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	77	51	29	25	98,303	104	6.6	0.5%	-$6,773	$2,613	$45
		3	27.0%	0.6	16	17	0	27	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	72	46	24	20	89,635	104	6.5	#N/A	-$6,894	$2,615	$57
		4	27.0%	0.6	16	17	0	27	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	72	46	24	20	89,635	104	6.5	0.6%	-$6,894	$2,615	$57
		5	27.0%	0.6	24	17	11	29	100	HG-i89-Triple-B	0.8	Combo	0%	ComboHeatA	75%	52	26	6	15	50,019	129	7.2	4.5%	-$247,163	$2,716	$15
	6	BCBC	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.0%	n/a	$2,727	-
		1	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.1%	egative NPV but no GHG reducti	$2,730	-$3
		2	27.0%	1.5	18	20	0	40	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	89	63	41	33	117,678	108	7.1	0.6%	-$7,002	$2,742	$58
		3	27.0%	0.6	22	25	11	27	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	80	54	32	26	102,075	108	6.9	#N/A	-$7,463	$2,742	$83
		4	27.0%	0.6	22	25	11	27	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	80	54	32	26	102,075	108	6.9	0.6%	-$7,463	$2,742	$83
		5	27.0%	0.6	60	17	0	40	70	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	84%	54	28	8	18	50,029	142	7.8	3.9%	-$250,004	$2,833	$70
	7a	BCBC	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.0%	n/a	$3,638	-
		1	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	30	20	0	27	40	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	60%	103	77	54	40	138,333	117	7.9	0.7%	-$6,991	$3,662	$94
		3	27.0%	0.6	24	17	11	27	50	LG-avg-Double	1.8	GasInst_Low	0%	elec-baseboard	70%	94	68	44	31	121,939	119	7.7	#N/A	-$7,901	$3,663	$120
		4	27.0%	0.6	24	17	11	27	50	LG-avg-Double	1.8	GasInst_Low	0%	elec-baseboard	70%	94	68	44	31	121,939	119	7.7	0.7%	-$7,901	$3,663	$120
		5	27.0%	0.6	18	11	0	27	40	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	60%	81	55	31	29	101,210	117	7.3	1.0%	-$7,038	$3,674	$141
	7b	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	124	100	9.7	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	257,707	119	9.7	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	24	17	11	35	100	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	126	101	76	43	175,997	119	8.5	0.5%	-$7,523	$3,657	$109
		3	27.0%	0.6	24	17	11	27	50	LG-avg-Double	1.8	GasInst_Low	0%	elec-baseboard	70%	110	85	60	33	148,913	122	8.3	#N/A	-$8,608	$3,653	$155
		4	27.0%	0.6	24	17	11	27	50	LG-avg-Double	1.8	GasInst_Low	0%	elec-baseboard	70%	110	85	60	33	148,913	122	8.3	0.4%	-$8,608	$3,653	$155
		5	27.0%	0.6	22	20	0	29	50	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	75%	89	63	39	29	113,633	119	7.6	1.2%	-$7,062	$3,683	$181
	8	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	1.5	30	20	20	27	100	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	60%	134	108	84	45	188,439	121	8.8	0.7%	-$7,476	$3,664	$145
		3	27.0%	0.6	24	17	11	27	50	LG-avg-Double	1.8	GasInst_Low	0%	elec-baseboard	70%	121	95	70	35	165,619	124	8.6	#N/A	-$8,682	$3,653	$192
		4	27.0%	0.6	24	17	11	27	50	LG-avg-Double	1.8	GasInst_Low	0%	elec-baseboard	70%	121	95	70	35	165,619	124	8.6	0.4%	-$8,682	$3,653	$192
		5	27.0%	0.6	24	11	20	27	70	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	75%	96	71	46	30	125,786	121	7.9	1.3%	-$7,321	$3,684	$224

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
6 unit Row House	4	BCBC	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.0%	n/a	$1,749	-
		1	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.2%	egative NPV but no GHG reducti	$1,752	-$3
		2	22.2%	2.5	16	NA	0	27	50	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	0%	95	58	26	24	44,833	203	10.8	0.4%	$306	$1,757	-$5
		3	22.2%	0.6	16	NA	0	27	40	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	87	50	22	20	44,752	173	9.3	0.8%	$146	$1,764	-$7
		4	22.2%	0.6	16	NA	11	27	40	MG-HP-Double	1.4	HPHotWater	0%	basefurnace	0%	72	34	20	19	54,281	82	4.9	2.0%	$273	$1,784	-$36
		5	22.2%	0.6	16	NA	11	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	62	23	10	17	54,091	42	2.9	3.4%	$314	$1,808	-$54
	5	BCBC	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.0%	n/a	$1,877	-
		1	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.2%	egative NPV but no GHG reducti	$1,880	-$3
		2	22.2%	0.6	18	NA	0	27	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	94	57	29	25	44,888	200	10.6	0.9%	$107	$1,894	-$7
		3	22.2%	0.6	18	NA	0	27	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	94	57	29	25	44,888	200	10.6	0.9%	$107	$1,894	-$7
		4	22.2%	0.6	18	NA	0	27	40	MG-i89-Double	1.6	GasInstantaneous	0%	basefurnace	60%	87	50	22	24	44,759	174	9.3	1.7%	$189	$1,908	-$17
		5	22.2%	0.6	24	NA	0	27	40	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	68	29	15	20	54,195	64	4.0	3.3%	$296	$1,939	-$58
	6	BCBC	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.0%	n/a	$1,970	-
		1	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.2%	egative NPV but no GHG reducti	$1,973	-$3
		2	22.2%	1.5	16	NA	0	27	40	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	120	84	51	38	45,311	296	15.4	-0.1%	-$304	$1,967	$6
		3	22.2%	0.6	16	NA	0	27	40	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	70%	111	74	39	33	45,087	262	13.7	0.5%	-$0	$1,979	$0
		4	22.2%	0.6	22	NA	0	27	40	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	0%	88	51	22	27	44,751	177	9.5	2.1%	$120	$2,010	-$17
		5	22.2%	0.6	18	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	78	40	24	27	54,783	100	5.8	2.5%	$185	$2,019	-$39
	7a	BCBC	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.0%	n/a	$2,627	-
		1	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	1.5	16	NA	11	27	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	70%	135	100	63	44	45,544	353	18.3	0.4%	-$43	$2,637	$3
		3	22.2%	0.6	16	NA	0	29	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	60%	129	94	58	39	45,450	332	17.2	0.5%	-$21	$2,641	$2
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	60%	108	72	35	35	45,010	252	13.2	1.6%	$71	$2,670	-$13
		5	22.2%	0.6	22	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	89	52	35	31	55,823	142	7.9	2.5%	$161	$2,693	-$46
	7b	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	1.5	24	NA	0	27	50	MG-HP-Double	1.4	GasInst_Low	0%	basefurnace	0%	149	115	73	44	45,735	407	21.0	0.4%	-$69	$2,637	$7
		3	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInstantaneous	30%	basefurnace	0%	148	114	77	40	45,799	403	20.8	0.1%	-$134	$2,631	$14
		4	22.2%	0.6	16	NA	11	27	40	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	120	84	50	37	45,289	297	15.5	1.5%	$22	$2,668	-$5
		5	22.2%	0.6	22	NA	11	27	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	75%	99	63	44	32	56,213	179	9.7	2.7%	$138	$2,698	-$44
	8	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	156	123	80	42	45,860	434	22.3	0.2%	-$136	$2,633	$20
		3	22.2%	0.6	18	NA	11	27	70	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	60%	156	123	80	42	45,860	434	22.3	0.2%	-$136	$2,633	$20
		4	22.2%	0.6	22	NA	0	27	50	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	0%	133	98	61	36	45,501	344	17.8	1.3%	-$24	$2,662	$6
		5	22.2%	0.6	22	NA	11	27	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	111	74	54	34	56,577	220	11.8	2.6%	$102	$2,696	-$36

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Quadplex	4	BCBC	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.0%	n/a	$1,857	-
		1	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.2%	egative NPV but no GHG reducti	$1,861	-$4
		2	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	HPHotWater	0%	gas-furnace-ecm	0%	107	51	34	29	35,208	71	4.0	2.0%	-$298,005	$1,893	$17
		3	17.3%	2.5	22	11	0	27	70	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	114	58	23	27	40,608	64	3.8	1.2%	-$708	$1,879	$6
		4	17.3%	0.6	22	20	0	27	40	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	0%	91	35	19	22	35,178	41	2.6	3.8%	$135	$1,928	-$8
		5	17.3%	0.6	22	20	0	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	80	25	12	20	41,218	0	0.6	6.0%	$489	$1,968	-$65
	5	BCBC	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.0%	n/a	$1,992	-
		1	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.2%	egative NPV but no GHG reducti	$1,997	-$5
		2	17.3%	2.5	22	11	0	27	40	MG-HP-Double	1.4	ElectricStorage	0%	gas-furnace-ecm	0%	123	67	34	36	43,531	70	4.1	1.9%	-$195,467	$2,030	$6
		3	17.3%	2.5	30	11	11	40	70	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	60%	108	52	35	34	35,213	72	4.1	4.2%	-$4,480	$2,075	$2
		4	17.3%	0.6	22	11	11	27	40	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	0%	102	46	30	29	35,202	62	3.6	3.5%	-$933	$2,061	$20
		5	17.3%	0.6	40	11	0	27	70	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	85	29	16	23	43,442	0	0.6	6.7%	$497	$2,126	-$68
	6	BCBC	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.0%	n/a	$2,091	-
		1	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.3%	egative NPV but no GHG reducti	$2,096	-$5
		2	17.3%	2.5	22	11	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	141	86	49	49	53,865	67	4.1	0.8%	-$1,586	$2,107	$16
		3	17.3%	2.5	22	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	139	84	47	48	52,754	67	4.1	1.2%	-$1,267	$2,115	$13
		4	17.3%	0.6	30	11	11	27	70	MG-HP-Double	1.4	HPHotWater	0%	gas-furnace-ecm	60%	111	56	37	35	35,498	78	4.4	4.2%	-$504,539	$2,179	$34
		5	17.3%	0.6	40	11	0	27	70	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	93	38	24	30	47,875	0	0.7	6.3%	$339	$2,223	-$49
	7a	BCBC	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.0%	n/a	$2,789	-
		1	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	173	117	78	62	68,651	72	4.6	0.5%	-$2,484	$2,804	$30
		3	17.3%	2.5	30	20	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	60%	165	109	70	58	64,506	72	4.6	1.9%	-$911	$2,842	$13
		4	17.3%	1.0	40	20	11	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	gas-furnace-ecm	0%	118	62	42	39	36,080	88	4.9	6.9%	-$53,851	$2,981	$12
		5	17.3%	0.6	40	20	11	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	105	49	35	34	53,871	0	0.8	7.4%	$393	$2,995	-$63
	7b	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	195	139	99	65	79,457	74	4.8	0.2%	-$2,037	$2,795	$21
		3	17.3%	2.5	40	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	184	128	88	61	73,825	74	4.8	1.7%	-$666	$2,836	$9
		4	17.3%	0.6	40	20	0	40	100	HG-i89-Triple-B	0.8	ElectricStorage	0%	gas-furnace-ecm	60%	137	82	43	36	45,808	89	5.1	6.7%	-$39,353	$2,976	$6
		5	17.3%	0.6	40	20	0	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	119	64	49	36	61,352	0	0.9	7.4%	$396	$2,996	-$65
	8	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	214	159	118	69	89,176	75	5.0	0.2%	-$2,531	$2,795	$29
		3	17.3%	2.5	40	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	201	145	105	64	82,350	75	4.9	1.8%	-$1,239	$2,840	$19
		4	17.3%	0.6	40	11	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	0%	165	110	69	43	64,053	75	4.7	3.0%	-$3,093	$2,872	$80
		5	17.3%	0.6	40	20	0	40	70	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	130	75	60	38	66,981	0	1.0	7.3%	$191	$2,992	-$32

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Large SFD	4	BCBC	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.0%	n/a	$1,938	-
		1	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.2%	egative NPV but no GHG reducti	$1,941	-$3
		2	14.6%	1.5	18	17	0	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	gas-furnace-ecm	60%	58	44	32	20	7,521	79	4.1	1.5%	$185	$1,968	-$15
		3	14.6%	1.5	18	17	0	NA	60	HG-avg-Triple	1.2	GasInst_Low	0%	gas-furnace-ecm	0%	53	39	27	20	7,506	71	3.6	2.1%	$236	$1,978	-$23
		4	14.6%	0.6	24	11	0	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	75%	47	33	19	17	7,488	60	3.1	2.9%	$286	$1,993	-$35
		5	14.6%	0.6	40	17	0	NA	70	HG-avg-Triple	1.2	ElectricStorage	42%	gas-furnace-ecm	70%	39	25	15	14	11,232	31	1.7	4.4%	$414	$2,022	-$73
	5	BCBC	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.0%	n/a	$2,079	-
		1	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.2%	egative NPV but no GHG reducti	$2,082	-$3
		2	14.6%	1.5	22	11	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	60%	76	63	45	27	7,885	112	5.7	0.4%	-$13	$2,086	$1
		3	14.6%	1.5	22	11	0	NA	60	MG-HP-Double	1.4	GasInst_Low	42%	basefurnace	60%	65	51	37	26	7,815	92	4.7	1.3%	$138	$2,105	-$12
		4	14.6%	0.6	22	11	0	NA	40	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	54	40	29	22	7,846	70	3.6	2.0%	$152	$2,120	-$20
		5	14.6%	0.6	40	17	0	NA	70	HG-avg-Triple	1.2	GasInstantaneous	30%	gas-furnace-ecm	84%	44	30	20	18	7,490	53	2.8	4.0%	$340	$2,162	-$55
	6	BCBC	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.0%	n/a	$2,182	-
		1	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.2%	egative NPV but no GHG reducti	$2,185	-$4
		2	14.6%	1.5	16	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	gas-furnace-ecm	60%	90	76	59	36	7,588	138	7.0	0.2%	-$122	$2,186	$6
		3	14.6%	1.5	16	17	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	60%	81	68	48	35	7,917	121	6.2	0.9%	$70	$2,202	-$6
		4	14.6%	1.0	22	11	0	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	69	55	40	30	7,840	98	5.0	1.3%	$46	$2,210	-$6
		5	14.6%	0.6	40	25	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	0%	gas-furnace-ecm	70%	52	38	25	22	7,502	68	3.5	4.2%	$314	$2,274	-$60
	7a	BCBC	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.0%	n/a	$2,910	-
		1	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	1.5	18	11	0	NA	70	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	115	101	79	43	8,221	182	9.2	0.1%	-$147	$2,912	$11
		3	14.6%	1.5	24	11	0	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	0%	101	87	64	41	8,076	157	8.0	1.0%	$54	$2,939	-$7
		4	14.6%	0.6	22	11	0	NA	60	HG-avg-Triple	1.2	Combo	30%	ComboHeatA	84%	81	67	54	34	8,079	119	6.1	1.9%	$112	$2,967	-$23
		5	14.6%	0.6	50	25	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	0%	gas-furnace-ecm	75%	63	49	34	26	7,536	90	4.6	5.1%	$395	$3,058	-$103
	7b	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	2.5	18	11	20	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	60%	121	107	96	51	56,588	19	1.8	0.2%	$415	$2,916	-$177
		3	14.6%	1.5	24	20	0	NA	100	MG-HP-Double	1.4	GasInstantaneous	0%	basefurnace	60%	116	102	82	41	8,255	185	9.3	1.0%	$54	$2,940	-$7
		4	14.6%	0.6	24	17	0	NA	60	HG-avg-Triple	1.2	BaseDHW	0%	gas-furnace-ecm	70%	99	85	65	35	7,640	154	7.8	1.5%	$49	$2,954	-$9
		5	14.6%	0.6	50	17	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	75%	78	64	49	28	7,596	116	5.9	4.2%	$286	$3,032	-$75
	8	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	1.5	40	20	20	NA	40	LG-avg-Double	1.8	HPHotWater	0%	baseboard	0%	126	112	107	46	64,311	0	0.9	1.2%	$429	$2,945	-$227
		3	14.6%	1.5	40	11	11	NA	40	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	115	101	80	40	8,242	182	9.2	2.0%	$108	$2,968	-$22
		4	14.6%	0.6	22	11	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	75%	110	96	78	37	7,696	176	8.9	1.2%	-$19	$2,946	$4
		5	14.6%	0.6	40	25	11	NA	70	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	75%	88	74	60	31	8,139	133	6.7	3.7%	$186	$3,018	-$56

Scenario			Archetype Characteristics												Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Medium SFD	4	BCBC	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.0%	n/a	$2,045	-
		1	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.2%	egative NPV but no GHG reducti	$2,050	-$5
		2	14.7%	2.5	16	11	0	NA	50	MG-i89-Double	1.6	GasInstantaneous	0%	basefurnace	0%	84	54	32	26	7,488	45	2.3	1.0%	$201	$2,065	-$11
		3	14.7%	1.5	18	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	77	47	24	22	7,453	39	2.1	1.5%	$232	$2,075	-$17
		4	14.7%	1.0	18	11	0	NA	70	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	60%	67	37	17	20	7,422	31	1.6	2.5%	$290	$2,097	-$33
		5	14.7%	0.6	22	17	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	75%	52	22	13	17	12,307	0	0.2	3.6%	$365	$2,119	-$86
	5	BCBC	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.0%	n/a	$2,194	-
		1	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.2%	egative NPV but no GHG reducti	$2,200	-$5
		2	14.7%	2.5	16	11	0	NA	60	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	60%	98	68	44	32	7,544	56	2.9	0.6%	$159	$2,207	-$6
		3	14.7%	1.5	18	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	88	58	33	28	7,494	48	2.5	1.1%	$166	$2,219	-$12
		4	14.7%	1.0	18	11	0	NA	70	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	60%	78	48	24	25	7,455	39	2.1	2.1%	$254	$2,241	-$28
		5	14.7%	0.6	22	17	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	75%	58	28	20	22	13,834	0	0.2	3.3%	$352	$2,266	-$94
	6	BCBC	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.0%	n/a	$2,303	-
		1	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.2%	egative NPV but no GHG reducti	$2,308	-$6
		2	14.7%	1.5	18	17	0	NA	50	LG-avg-Double	1.8	GasInstantaneous	0%	basefurnace	0%	114	84	58	40	7,606	70	3.6	0.4%	$57	$2,311	-$2
		3	14.7%	1.5	18	11	0	NA	70	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	104	74	46	36	7,555	62	3.2	0.9%	$112	$2,324	-$8
		4	14.7%	1.0	22	11	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	75%	80	50	29	29	7,373	42	2.2	2.6%	$212	$2,364	-$33
		5	14.7%	0.6	40	25	0	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	64	33	21	24	9,325	21	1.2	4.5%	$327	$2,406	-$80
	7a	BCBC	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.0%	n/a	$3,072	-
		1	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	18	11	0	NA	60	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	60%	131	101	68	44	7,657	84	4.3	0.7%	$58	$3,092	-$5
		3	14.7%	1.5	22	20	0	NA	40	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	60%	128	98	61	43	7,625	82	4.2	1.0%	$143	$3,104	-$15
		4	14.7%	0.6	22	17	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	70%	96	66	40	33	7,529	55	2.8	2.6%	$199	$3,151	-$43
		5	14.7%	0.6	40	17	0	NA	70	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	70%	84	54	31	29	14,668	18	1.1	3.4%	$335	$3,177	-$120
	7b	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	22	20	0	NA	40	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	60%	150	120	81	47	7,717	100	5.1	0.6%	$25	$3,089	-$2
		3	14.7%	1.5	18	17	0	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	gas-furnace-ecm	60%	144	114	86	47	7,459	97	4.9	0.8%	$59	$3,098	-$6
		4	14.7%	0.6	22	20	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	gas-furnace-ecm	60%	111	81	55	36	7,421	68	3.5	2.5%	$165	$3,148	-$37
		5	14.7%	0.6	40	20	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	95	65	48	32	9,692	46	2.4	4.2%	$311	$3,202	-$98
	8	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	1.5	22	20	11	NA	40	LG-avg-Double	1.8	GasInstantaneous	0%	baseboard	0%	160	129	109	54	33,086	17	1.3	0.0%	$399	$3,072	-$192
		3	14.7%	1.5	22	17	0	NA	50	HG-avg-Triple	1.2	GasInstantaneous	42%	basefurnace	60%	139	109	80	45	7,718	91	4.7	2.0%	$142	$3,134	-$28
		4	14.7%	0.6	22	11	0	NA	40	HG-avg-Triple	1.2	Combo	0%	ComboHeatA	70%	130	100	73	40	7,927	82	4.2	2.3%	$141	$3,143	-$33
		5	14.7%	0.6	40	25	0	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	104	74	56	33	9,767	53	2.8	4.1%	$244	$3,197	-$87

Scenario			Archetype Characteristics												Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	16	11	11	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	basefurnace	0%	151	81	34	49	7,368	29	1.5	1.6%	$317	$2,351	-$24
		3	12.2%	2.5	18	11	11	NA	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	124	54	29	43	9,120	13	0.8	3.4%	$348	$2,394	-$80
		4	12.2%	0.6	22	11	20	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	0%	129	59	20	42	9,306	14	0.8	4.0%	$457	$2,407	-$100
		5	12.2%	0.6	40	11	11	NA	100	HG-i89-Triple-B	0.8	HPHotWater	0%	basefurnace	70%	104	34	12	33	9,086	5	0.4	8.8%	$639	$2,518	-$192
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	22	11	11	NA	40	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	0%	168	99	45	60	7,388	35	1.9	0.6%	$69	$2,499	-$5
		3	12.2%	2.5	18	11	11	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	60%	153	83	36	55	7,372	30	1.6	1.8%	$195	$2,528	-$24
		4	12.2%	0.6	22	11	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	70%	118	48	29	47	12,057	0	0.2	4.1%	$368	$2,584	-$147
		5	12.2%	0.6	40	11	11	NA	100	HG-i89-Triple-B	0.8	HPHotWater	0%	baseboard	75%	108	38	19	42	11,029	0	0.2	7.6%	$522	$2,673	-$210
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	18	11	11	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	60%	176	106	55	71	7,408	38	2.0	1.4%	$112	$2,642	-$15
		3	12.2%	1.5	22	11	11	NA	60	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	60%	163	93	42	64	7,383	33	1.8	2.4%	$178	$2,668	-$32
		4	12.2%	1.5	40	11	11	NA	70	HG-avg-Triple	1.2	HPHotWater	42%	basefurnace	70%	135	65	39	59	9,057	17	1.0	5.4%	$364	$2,746	-$121
		5	12.2%	0.6	40	25	30	NA	100	HG-i89-Triple-B	0.8	HPHotWater	30%	basefurnace	70%	118	48	24	45	9,072	11	0.7	10.8%	$647	$2,889	-$254
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	16	11	11	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	basefurnace	60%	219	149	72	82	7,446	54	2.8	1.5%	$231	$3,529	-$31
		3	12.2%	1.5	22	11	11	NA	50	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	60%	198	128	68	77	7,438	46	2.4	1.9%	$146	$3,541	-$30
		4	12.2%	0.6	30	11	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	75%	176	106	51	65	7,404	38	2.0	4.2%	$346	$3,622	-$99
		5	12.2%	1.0	40	25	30	NA	100	HG-avg-Triple	1.2	ElectricStorage	30%	CCASHP-ecm	84%	149	80	34	53	15,234	0	0.2	12.0%	$790	$3,892	-$502
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	24	11	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	60%	211	140	94	84	16,862	16	1.1	1.8%	$352	$3,539	-$200
		3	12.2%	1.5	40	11	20	NA	100	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	60%	203	133	68	71	7,441	48	2.5	4.3%	$359	$3,627	-$103
		4	12.2%	0.6	40	17	11	NA	80	HG-avg-Triple	1.2	GasInst_Low	55%	basefurnace	75%	188	118	62	66	7,428	42	2.2	5.6%	$400	$3,669	-$136
		5	12.2%	0.6	60	11	20	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	30%	CCASHP-ecm	84%	167	96	47	60	17,014	0	0.3	13.1%	$785	$3,931	-$570
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	1.5	40	25	20	NA	70	LG-avg-Double	1.8	GasInst_Low	0%	baseboard	60%	231	160	106	81	18,113	19	1.2	4.4%	$498	$3,628	-$310
		3	12.2%	1.5	40	11	11	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	70%	219	148	94	80	16,890	19	1.2	2.7%	$350	$3,569	-$219
		4	12.2%	0.6	40	11	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	70%	202	132	71	68	7,451	47	2.5	4.9%	$282	$3,647	-$107
		5	12.2%	0.6	40	25	30	NA	100	HG-avg-Triple	1.2	GasInstantaneous	42%	CCASHP-ecm	84%	173	103	60	58	13,556	15	0.9	12.3%	$680	$3,904	-$463

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Archetype	CZ	Step Achieved	WWR	Airtightness (ACH@50kPa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD - Slab on Grade	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	16	N/A	11	NA	40	LG-avg-Double	1.8	GasInstantaneous	0%	elec-baseboard	60%	139	69	31	34	10,420	14	0.8	1.2%	$291	$2,342	-$63
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	elec-baseboard	60%	128	59	20	30	9,303	14	0.8	2.2%	$266	$2,366	-$58
		4	12.2%	1.0	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	elec-baseboard	60%	126	56	17	28	9,026	14	0.8	2.9%	$306	$2,382	-$67
		5	12.2%	1.0	22	N/A	11	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	103	33	14	25	10,460	0	0.2	6.0%	$442	$2,454	-$154
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	159	89	44	47	7,315	32	1.7	1.6%	$235	$2,524	-$23
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	151	81	37	44	7,313	29	1.6	2.3%	$264	$2,539	-$34
		4	12.2%	1.0	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	elec-baseboard	60%	136	66	27	35	10,062	14	0.8	2.6%	$298	$2,547	-$81
		5	12.2%	1.0	22	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	108	38	19	30	11,028	0	0.2	6.4%	$443	$2,641	-$178
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	0%	175	105	56	57	7,321	38	2.0	1.9%	$192	$2,654	-$25
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	166	97	49	50	7,319	35	1.8	2.5%	$217	$2,670	-$35
		4	12.2%	0.6	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	elec-baseboard	60%	145	75	34	40	10,773	14	0.9	3.3%	$304	$2,692	-$107
		5	12.2%	1.0	40	N/A	11	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	114	45	25	35	11,658	0	0.2	7.3%	$429	$2,796	-$211
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	203	133	78	62	7,338	48	2.5	2.3%	$255	$3,556	-$47
		3	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	194	124	70	57	7,335	45	2.3	3.1%	$318	$3,584	-$70
		4	12.2%	1.0	22	N/A	11	NA	80	HG-i89-Triple-B	0.8	GasInstantaneous	0%	elec-baseboard	60%	161	91	46	47	11,992	16	1.0	4.7%	$390	$3,638	-$190
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	125	55	33	36	12,709	0	0.2	8.9%	$517	$3,787	-$332
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	222	152	96	63	7,355	55	2.9	2.5%	$235	$3,564	-$50
		3	12.2%	2.5	22	N/A	20	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	216	146	90	61	7,350	53	2.8	3.3%	$315	$3,592	-$74
		4	12.2%	0.6	40	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	elec-baseboard	60%	177	107	61	45	13,495	16	1.0	4.7%	$371	$3,639	-$214
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	142	72	50	39	14,450	0	0.2	8.5%	$469	$3,771	-$344
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	240	170	111	66	7,367	62	3.2	2.5%	$194	$3,564	-$46
		3	12.2%	2.5	40	N/A	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	232	162	103	63	7,364	59	3.0	3.8%	$322	$3,609	-$86
		4	12.2%	1.0	40	N/A	20	NA	80	MG-HP-Double	1.4	GasInstantaneous	0%	gas-furnace-ecm	60%	194	124	69	48	7,345	45	2.4	5.9%	$339	$3,681	-$136
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	152	82	60	40	15,499	0	0.2	8.5%	$434	$3,771	-$356

8.11 Part 9 – Typical Energy Conservation Measures

Summary tables for each building archetype are given below. The tables show the most frequent energy conservation measure (ECM) used in the results with the ten lowest incremental capital costs. The tables show results for both the original performance targets from 2017 and the updated targets summarized in Sections 2.3.2 and 2.3.3 above. Cells are highlighted where the most frequent ECM has changed with the updated targets.

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
10 Unit MURB	CZ4	2	Original (2017)	1.5 ACH	R16	R0	R11	R27	R100	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R30	R25	R27	R50	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	0.6 ACH	R16	R20	R11	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R16	R30	R17	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R16	R0	R20	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R16	R30	R11	R27	R50	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	0.6 ACH	R16	R11	R25	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		5	Updated (2018)	0.6 ACH	R16	R30	R25	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
	CZ5	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R16	R0	R11	R27	R40	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		3	Original (2017)	0.6 ACH	R16	R11	R17	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R18	R15	R17	R27	R40	Double (1.6)	Gas Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R16	R0	R11	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R18	R11	R11	R27	R40	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
		5	Original (2017)	0.6 ACH	R18	R0	R17	R27	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		5	Updated (2018)	0.6 ACH	R22	R0	R20	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
	CZ6	2	Original (2017)	2.5 ACH	R16	R0	R20	R29	R100	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R15	R11	R27	R40	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		3	Original (2017)	0.6 ACH	R18	R0	R17	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R16	R0	R20	R27	R60	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	0.6 ACH	R18	R0	R20	R27	R50	Double (1.8)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	0.6 ACH	R50	R0	R11	R27	R60	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		5	Updated (2018)	0.6 ACH	R18	R0	R17	R27	R50	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	70% SRE
	CZ7a	2	Original (2017)	2.5 ACH	R22	R11	R11	R27	R40	Double (1.8)	Heat Pump (electric)	55%	Baseboard (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R22	R11	R11	R27	R50	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	0.6 ACH	R22	R0	R20	R27	R60	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R22	R20	R17	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	70% SRE
		4	Original (2017)	0.6 ACH	R22	R0	R11	R27	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R22	R0	R11	R27	R70	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R22	R0	R17	R27	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
	CZ7b	2	Original (2017)	1.5 ACH	R24	R20	R11	R27	R50	Double (1.6)	Gas Tank	None	Baseboard (electric)	70% SRE
		2	Updated (2018)	2.5 ACH	R22	R15	R20	R27	R100	High Gain Triple (1.2)	Gas Tank	42%	Baseboard (electric)	60% SRE
		3	Original (2017)	0.6 ACH	R24	R11	R11	R27	R70	Double (1.8)	Electric Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R16	R20	R20	R27	R60	Double (1.8)	Electric Tank	None	Baseboard (electric)	70% SRE
		4	Original (2017)	0.6 ACH	R22	R20	R11	R27	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		4	Updated (2018)	0.6 ACH	R22	R20	R11	R27	R50	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R22	R0	R20	R27	R50	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	70% SRE
	CZ8	2	Original (2017)	1.5 ACH	R30	R11	R25	R27	R100	High Gain Triple (1.2)	Gas Tank	55%	Baseboard (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R40	R0	R20	R27	R60	High Gain Triple (1.2)	Gas Tank	55%	Baseboard (electric)	75% SRE
		3	Original (2017)	0.6 ACH	R22	R11	R25	R27	R60	Double (1.8)	Electric Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R40	R0	R20	R27	R60	High Gain Triple (1.2)	Gas Tank	55%	Baseboard (electric)	70% SRE
		4	Original (2017)	0.6 ACH	R60	R15	R25	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		4	Updated (2018)	0.6 ACH	R22	R20	R25	R27	R50	Double (1.8)	Gas Tank	None	Baseboard (electric)	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R22	R20	R25	R27	R60	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	70% SRE

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
6 Unit Row House	CZ4	2	Original (2017)	2.5 ACH	R16	R0	N/A	R27	R40	Double (1.8)	Electric Tank	None	Gas 92% AFUE	None
		2	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R40	Double (1.8)	Electric Tank	None	Gas 92% AFUE	None
		3	Original (2017)	0.6 ACH	R16	R0	N/A	R27	R50	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	None
		3	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R40	Double (1.8)	Electric Tank	None	Gas 92% AFUE	None
		4	Original (2017)	0.6 ACH	R16	R0	N/A	R27	R40	Double (1.6)	Heat Pump (electric)	None	Gas 92% AFUE	None
		4	Updated (2018)	1.5 ACH	R16	R0	N/A	R27	R40	Double (1.6)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		5	Original (2017)	0.6 ACH	R16	R0	N/A	R27	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		5	Updated (2018)	0.6 ACH	R16	R0	N/A	R27	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
	CZ5	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R40	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		3	Original (2017)	0.6 ACH	R18	R0	N/A	R27	R40	Double (1.8)	Gas Condensing Tankless	None	Gas 92% AFUE	None
		3	Updated (2018)	2.5 ACH	R18	R0	N/A	R27	R40	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		4	Original (2017)	0.6 ACH	R16	R0	N/A	R27	R40	Double (1.6)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		4	Updated (2018)	1 ACH	R18	R0	N/A	R27	R40	Double (1.6)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		5	Original (2017)	0.6 ACH	R24	R11	N/A	R27	R70	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		5	Updated (2018)	0.6 ACH	R18	R11	N/A	R27	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
	CZ6	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R40	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		3	Original (2017)	1.5 ACH	R16	R0	N/A	R27	R40	Double (1.8)	Electric Tank	None	Gas 92% AFUE	None
		3	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R40	Double (1.6)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		4	Original (2017)	0.6 ACH	R16	R0	N/A	R27	R40	Double (1.6)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		4	Updated (2018)	0.6 ACH	R16	R0	N/A	R27	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		5	Original (2017)	0.6 ACH	R60	R11	N/A	R27	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		5	Updated (2018)	0.6 ACH	R16	R0	N/A	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
	CZ7a	2	Original (2017)	1.5 ACH	R24	R11	N/A	R27	R50	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	None
		2	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R50	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	None
		3	Original (2017)	0.6 ACH	R16	R0	N/A	R27	R50	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		3	Updated (2018)	2.5 ACH	R16	R0	N/A	R27	R50	Double (1.8)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		4	Original (2017)	0.6 ACH	R22	R0	N/A	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		4	Updated (2018)	1 ACH	R18	R0	N/A	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R22	R0	N/A	R27	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
	CZ7b	2	Original (2017)	1.5 ACH	R22	R0	N/A	R27	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 95% AFUE	60% SRE
		2	Updated (2018)	2.5 ACH	R18	R0	N/A	R27	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	None
		3	Original (2017)	0.6 ACH	R22	R0	N/A	R27	R70	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		3	Updated (2018)	2.5 ACH	R22	R0	N/A	R27	R60	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		4	Original (2017)	0.6 ACH	R50	R11	N/A	R27	R70	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		4	Updated (2018)	1 ACH	R22	R0	N/A	R27	R70	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R22	R11	N/A	R27	R70	High Gain Triple (1.2)	Heat Pump (electric)	42%	Gas 92% AFUE	70% SRE
	CZ8	2	Original (2017)	1.5 ACH	R22	R0	N/A	R27	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 95% AFUE	70% SRE
		2	Updated (2018)	2.5 ACH	R40	R0	N/A	R27	R80	Double (1.4)	Electric Tank	55%	Gas 92% AFUE	84% SRE
		3	Original (2017)	0.6 ACH	R22	R0	N/A	R27	R60	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		3	Updated (2018)	2.5 ACH	R22	R0	N/A	R27	R80	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		4	Original (2017)	0.6 ACH	R50	R11	N/A	R27	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Cold Climate ASHP (electric)	84% SRE
		4	Updated (2018)	1 ACH	R22	R0	N/A	R27	R70	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R22	R11	N/A	R27	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
Quadplex	CZ4	2	Original (2017)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R22	R0	R11	R27	R40	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R22	R0	R11	R27	R40	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	None
		4	Updated (2018)	1 ACH	R22	R0	R11	R27	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	None
		5	Original (2017)	0.6 ACH	R22	R0	R20	R27	R70	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		5	Updated (2018)	0.6 ACH	R22	R0	R20	R27	R70	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	None
	CZ5	2	Original (2017)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R22	R0	R11	R27	R40	Double (1.4)	Gas Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R22	R0	R11	R27	R40	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	None
		4	Updated (2018)	1 ACH	R22	R0	R20	R27	R70	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	None
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R20	R27	R70	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	None
	CZ6	2	Original (2017)	2.5 ACH	R18	R0	R11	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R22	R0	R11	R27	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R22	R0	R11	R27	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R22	R0	R20	R27	R100	Double (1.4)	Gas Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R22	R0	R11	R27	R70	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	None
		4	Updated (2018)	1 ACH	R22	R0	R20	R27	R100	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	None
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R11	R27	R40	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	None
	CZ7a	2	Original (2017)	2.5 ACH	R40	R0	R11	R27	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R22	R0	R11	R27	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R40	R11	R20	R40	R100	Low Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R40	R0	R20	R27	R70	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R40	R0	R11	R27	R70	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		4	Updated (2018)	1 ACH	R40	R0	R20	R27	R100	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	None
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R20	R40	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
	CZ7b	2	Original (2017)	2.5 ACH	R40	R0	R20	R27	R100	Low Gain Triple (1.2)	Heat Pump (electric)	None	Cold Climate ASHP (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R22	R0	R11	R27	R70	Double (1.4)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	2.5 ACH	R40	R0	R11	R27	R100	Low Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	None
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	1 ACH	R40	R0	R11	R27	R70	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R20	R40	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
	CZ8	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R22	R0	R11	R27	R70	Double (1.4)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	2.5 ACH	R40	R0	R20	R27	R100	Low Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	None
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	1 ACH	R40	R0	R20	R27	R100	Low Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R20	R40	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
Large SFD	CZ4	2	Original (2017)	1.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Gas Condensing Tankless	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R0	R17	N/A	R50	Double (1.4)	Gas Tank	None	Gas 92% AFUE	60% SRE
		3	Original (2017)	1.5 ACH	R16	R0	R11	N/A	R40	Double (1.6)	Heat Pump (electric)	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R18	R0	R17	N/A	R100	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R16	R0	R11	N/A	R40	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R40	R0	R11	N/A	R100	High Gain Triple (1.2)	Gas Tank	None	Gas 92% AFUE	84% SRE
		5	Original (2017)	0.6 ACH	R40	R0	R25	N/A	R100	High Gain Triple (1.2)	Electric Tank	42%	Gas 95% AFUE	70% SRE
		5	Updated (2018)	0.6 ACH	R40	R0	R17	N/A	R100	High Gain Triple (1.2)	Electric Tank	42%	Gas 95% AFUE	70% SRE
	CZ5	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.6)	Gas Tankless	None	Gas 92% AFUE	60% SRE
		3	Original (2017)	1.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R24	R0	R11	N/A	R50	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R18	R0	R11	N/A	R40	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	None
		4	Updated (2018)	1.5 ACH	R24	R0	R11	N/A	R40	High Gain Triple (1.2)	Gas Tank	None	Gas 95% AFUE	84% SRE
		5	Original (2017)	0.6 ACH	R60	R20	R25	N/A	R100	High Performance Triple (0.8)	Electric Tank	42%	Gas 95% AFUE	84% SRE
		5	Updated (2018)	0.6 ACH	R40	R0	R25	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	30%	Gas 95% AFUE	75% SRE
	CZ6	2	Original (2017)	2.5 ACH	R16	R0	R11	N/A	R50	Double (1.8)	Gas Tank	None	Gas 92% AFUE	60% SRE
		2	Updated (2018)	2.5 ACH	R22	R0	R11	N/A	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	1.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R18	R0	R11	N/A	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R18	R0	R11	N/A	R40	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R24	R0	R11	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Gas 92% AFUE	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R20	N/A	R70	High Gain Triple (1.2)	Electric Tank	None	Gas 92% AFUE	84% SRE
	CZ7a	2	Original (2017)	1.5 ACH	R18	R0	R17	N/A	R40	Double (1.6)	Gas Tank	None	Baseboard (electric)	70% SRE
		2	Updated (2018)	2.5 ACH	R24	R0	R11	N/A	R100	Double (1.6)	Gas Tankless	None	Baseboard (electric)	70% SRE
		3	Original (2017)	1.5 ACH	R16	R0	R11	N/A	R100	Double (1.8)	Gas Condensing Tankless	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R40	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tank	None	Gas 92% AFUE	60% SRE
		4	Original (2017)	0.6 ACH	R22	R0	R17	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Cold Climate ASHP (electric)	75% SRE
		4	Updated (2018)	0.6 ACH	R22	R0	R20	N/A	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R20	N/A	R100	High Gain Triple (1.2)	Gas Tankless	None	Gas 95% AFUE	84% SRE
	CZ7b	2	Original (2017)	1.5 ACH	R22	R0	R11	N/A	R50	High Gain Triple (1.2)	Gas Tankless	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R24	R15	R17	N/A	R40	Double (1.8)	Gas Tankless	None	Cold Climate ASHP (electric)	None
		3	Original (2017)	1.5 ACH	R22	R0	R25	N/A	R40	High Gain Triple (1.2)	Gas Tankless	55%	Cold Climate ASHP (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R40	R0	R17	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R40	R0	R20	N/A	R50	High Gain Triple (1.2)	Heat Pump (electric)	55%	Cold Climate ASHP (electric)	75% SRE
		4	Updated (2018)	0.6 ACH	R40	R0	R20	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	84% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R50	R11	R20	N/A	R70	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	75% SRE
	CZ8	2	Original (2017)	1.5 ACH	R40	R11	R25	N/A	R40	High Gain Triple (1.2)	Gas Condensing Tankless	None	Cold Climate ASHP (electric)	None
		2	Updated (2018)	2.5 ACH	R40	R0	R20	N/A	R100	Double (1.6)	Gas Condensing Tankless	None	Baseboard (electric)	None
		3	Original (2017)	1.5 ACH	R50	R0	R17	N/A	R50	High Gain Triple (1.2)	Electric Tank	42%	Cold Climate ASHP (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R40	R0	R17	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	None
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	1 ACH	R22	R0	R11	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R20	N/A	R100	High Gain Triple (1.2)	Gas Tankless	None	Baseboard (electric)	75% SRE

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
Medium SFD	CZ4	2	Original (2017)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Gas Condensing Tankless	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Gas Condensing Tankless	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R18	R0	R20	N/A	R40	Double (1.6)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.6)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R16	R0	R11	N/A	R40	Double (1.6)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
		4	Updated (2018)	1 ACH	R16	R0	R17	N/A	R70	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		5	Original (2017)	0.6 ACH	R24	R0	R11	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		5	Updated (2018)	0.6 ACH	R24	R0	R11	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
	CZ5	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Gas Condensing Tankless	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R16	R0	R11	N/A	R50	Double (1.8)	Gas Tank	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R16	R11	R11	N/A	R40	Double (1.8)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R22	R0	R11	N/A	R40	Double (1.6)	Heat Pump (electric)	None	Baseboard (electric)	None
		4	Updated (2018)	1 ACH	R24	R0	R25	N/A	R60	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		5	Original (2017)	0.6 ACH	R40	R0	R25	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	70% SRE
		5	Updated (2018)	0.6 ACH	R24	R0	R25	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	42%	Gas 92% AFUE	70% SRE
	CZ6	2	Original (2017)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Gas Tankless	None	Gas 92% AFUE	None
		2	Updated (2018)	2.5 ACH	R16	R11	R11	N/A	R70	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R18	R11	R17	N/A	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R18	R0	R17	N/A	R40	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R16	R0	R11	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
		4	Updated (2018)	1.5 ACH	R24	R0	R11	N/A	R100	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	0.6 ACH	R60	R15	R25	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	42%	Gas 95% AFUE	84% SRE
		5	Updated (2018)	0.6 ACH	R40	R0	R25	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
	CZ7a	2	Original (2017)	1.5 ACH	R18	R0	R17	N/A	R40	Double (1.8)	Gas Tankless	None	Baseboard (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R16	R0	R11	N/A	R40	Double (1.8)	Gas Tankless	None	Baseboard (electric)	60% SRE
		3	Original (2017)	1.5 ACH	R18	R11	R11	N/A	R50	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	70% SRE
		3	Updated (2018)	2.5 ACH	R18	R0	R17	N/A	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	70% SRE
		4	Original (2017)	0.6 ACH	R40	R11	R20	N/A	R60	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R22	R0	R17	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	75% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R17	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	70% SRE
	CZ7b	2	Original (2017)	1.5 ACH	R40	R11	R17	N/A	R40	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R18	R11	R17	N/A	R40	Double (1.6)	Gas Tankless	None	Baseboard (electric)	60% SRE
		3	Original (2017)	1.5 ACH	R40	R0	R11	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
		3	Updated (2018)	2.5 ACH	R18	R0	R17	N/A	R40	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R50	R15	R17	N/A	R100	Triple (1.0)	Heat Pump (electric)	42%	Baseboard (electric)	75% SRE
		4	Updated (2018)	0.6 ACH	R40	R11	R17	N/A	R70	High Gain Triple (1.2)	Gas Tankless	None	Baseboard (electric)	84% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R25	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	30%	Baseboard (electric)	70% SRE
	CZ8	2	Original (2017)	1.5 ACH	R40	R11	R25	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Gas 92% AFUE	60% SRE
		2	Updated (2018)	2.5 ACH	R22	R20	R20	N/A	R40	Double (1.6)	Gas Tank	None	Baseboard (electric)	None
		3	Original (2017)	1.5 ACH	R60	R11	R17	N/A	R70	High Gain Triple (1.2)	Gas Tankless	42%	Gas 92% AFUE	70% SRE
		3	Updated (2018)	2.5 ACH	R40	R0	R17	N/A	R40	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	None
		4	Original (2017)	0.6 ACH	R60	R11	R25	N/A	R70	High Performance Triple (0.8)	Heat Pump (electric)	55%	Cold Climate ASHP (electric)	70% SRE
		4	Updated (2018)	1 ACH	R40	R0	R25	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R0	R25	N/A	R60	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	70% SRE

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
Small SFD	CZ4	2	Original (2017)	2.5 ACH	R16	R11	R11	N/A	R60	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
		2	Updated (2018)	2.5 ACH	R16	R11	R11	N/A	R60	Double (1.8)	Gas Condensing Tankless	None	Gas 92% AFUE	60% SRE
		3	Original (2017)	2.5 ACH	R40	R20	R11	N/A	R40	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	None
		3	Updated (2018)	2.5 ACH	R16	R20	R11	N/A	R60	High Gain Triple (1.2)	Gas Condensing Tankless	None	Gas 92% AFUE	None
		4	Original (2017)	0.6 ACH	R40	R11	R11	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Gas 92% AFUE	84% SRE
		4	Updated (2018)	0.6 ACH	R24	R11	R11	N/A	R50	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R11	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Gas 92% AFUE	84% SRE
	CZ5	2	Original (2017)	2.5 ACH	R18	R11	R11	N/A	R40	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R11	R11	N/A	R60	Double (1.6)	Gas Tankless	None	Gas 92% AFUE	None
		3	Original (2017)	1.5 ACH	R18	R11	R11	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	70% SRE
		3	Updated (2018)	2.5 ACH	R18	R11	R11	N/A	R50	High Gain Triple (1.2)	Electric Tank	None	Gas 92% AFUE	60% SRE
		4	Original (2017)	0.6 ACH	R40	R11	R11	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	0.6 ACH	R18	R11	R11	N/A	R100	High Gain Triple (1.2)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R11	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Gas 92% AFUE	60% SRE
	CZ6	2	Original (2017)	1.5 ACH	R18	R11	R11	N/A	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R16	R11	R11	N/A	R70	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	1.5 ACH	R40	R11	R11	N/A	R100	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	1.5 ACH	R24	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R40	R30	R11	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	0.6 ACH	R40	R11	R11	N/A	R70	High Gain Triple (1.2)	Gas Combo	None	Gas Combo	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R11	R25	N/A	R100	High Performance Triple (0.8)	Heat Pump (electric)	30%	Cold Climate ASHP (electric)	70% SRE
	CZ7a	2	Original (2017)	1.5 ACH	R50	R30	R17	N/A	R50	High Gain Triple (1.2)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		2	Updated (2018)	1.5 ACH	R24	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	1.5 ACH	R22	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tankless	None	Gas 92% AFUE	60% SRE
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	0.6 ACH	R40	R11	R11	N/A	R70	High Gain Triple (1.2)	Gas Tankless	None	Gas 92% AFUE	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R50	R30	R25	N/A	R100	High Performance Triple (0.8)	Electric Tank	None	Cold Climate ASHP (electric)	84% SRE
	CZ7b	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	1.5 ACH	R40	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	None	Baseboard (electric)	60% SRE
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	1.5 ACH	R40	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tankless	None	Baseboard (electric)	60% SRE
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	0.6 ACH	R40	R11	R11	N/A	R100	High Performance Triple (0.8)	Gas Condensing Tankless	55%	Gas 92% AFUE	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R60	R20	R25	N/A	R100	High Performance Triple (0.8)	Gas Condensing Tankless	42%	Cold Climate ASHP (electric)	84% SRE
	CZ8	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	1.5 ACH	R40	R20	R25	N/A	R70	Double (1.8)	Gas Tankless	None	Cold Climate ASHP (electric)	60% SRE
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	1.5 ACH	R40	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tankless	None	Baseboard (electric)	70% SRE
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	0.6 ACH	R40	R11	R11	N/A	R100	High Gain Triple (1.2)	Gas Tankless	None	Gas 92% AFUE	70% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R60	R30	R25	N/A	R100	High Gain Triple (1.2)	Gas Condensing Tankless	42%	Cold Climate ASHP (electric)	84% SRE

Scenario				Most Common Energy Conservation Measures - Top 10 Lowest Incremental Costs										
Archetype	Climate Zone	Step Achieved	Performance Targets Version	Airtightness (ACH @ 50Pa)	Wall R-Value (effective)	Underslab R-Value (effective)	Foundation Wall R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling/Roof R-Value (effective)	Window Option & U-Value	Domestic Hot Water System	Drainwater Heat Recovery Efficiency	Space Heating System	Ventilation Heat Recovery
Small SFD - Slab on Grade	CZ4	2	Original (2017)	2.5 ACH	R16	R11	N/A	N/A	R40	Double (1.8)	Heat Pump (electric)	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R11	N/A	N/A	R40	Double (1.8)	Gas Condensing Tankless	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R22	R20	N/A	N/A	R80	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R16	R11	N/A	N/A	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		4	Original (2017)	1 ACH	R22	R20	N/A	N/A	R80	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R22	R11	N/A	N/A	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		5	Updated (2018)	1 ACH	R22	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
	CZ5	2	Original (2017)	2.5 ACH	R16	R11	N/A	N/A	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		2	Updated (2018)	2.5 ACH	R16	R11	N/A	N/A	R40	Double (1.8)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R22	R11	N/A	N/A	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R16	R11	N/A	N/A	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R22	R20	N/A	N/A	R80	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	1 ACH	R22	R11	N/A	N/A	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
	CZ6	2	Original (2017)	2.5 ACH	R18	R11	N/A	N/A	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R22	R11	N/A	N/A	R40	Double (1.4)	Electric Tank	None	Baseboard (electric)	None
		3	Original (2017)	2.5 ACH	R22	R11	N/A	N/A	R80	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		3	Updated (2018)	2.5 ACH	R22	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R22	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		4	Updated (2018)	0.6 ACH	R22	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
	CZ7a	2	Original (2017)	2.5 ACH	R40	R20	N/A	N/A	R80	Double (1.4)	Heat Pump (electric)	None	Baseboard (electric)	60% SRE
		2	Updated (2018)	2.5 ACH	R22	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	2.5 ACH	R22	R20	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
		4	Updated (2018)	1 ACH	R22	R20	N/A	N/A	R80	High Performance Triple (0.8)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Baseboard (electric)	84% SRE
	CZ7b	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R22	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	2.5 ACH	R22	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	0.6 ACH	R40	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Gas 95% AFUE	84% SRE
	CZ8	2	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		2	Updated (2018)	2.5 ACH	R22	R20	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		3	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		3	Updated (2018)	2.5 ACH	R40	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		4	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		4	Updated (2018)	0.6 ACH	R40	R11	N/A	N/A	R80	Double (1.4)	Electric Tank	None	Baseboard (electric)	60% SRE
		5	Original (2017)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		5	Updated (2018)	0.6 ACH	R40	R20	N/A	N/A	R80	High Performance Triple (0.8)	Heat Pump (electric)	None	Gas 95% AFUE	84% SRE

8.12 Impact of 8hr vs. 24hr Ventilations Rates on Part 9 Buildings

10 Unit MURB

CZ	Vent. Modelled	WWR	Airtightness ACH	Foundation R-Value	Underslab R-Value	Floor R-Value	Wall R-Value	Roof R-Value	Window USI	Space Heating	DHW System	Vent. Heat Recovery (%)	Drainwater Heat Recovery (%)	MEUI (kWh/m2)	TEDI (kWh/m2)	Annual Elec. (kWh)	Annual NG (m3)	Annual GHGs (t)	Step Achieved
4	24 hrs	0.2	3.5	11	0	27	16	40	1.8	Elec. BB	NG 67%	None	None	60	39	113,670	2,787	7.0	1
4	8 hrs	0.2	3.5	11	0	27	16	40	1.8	Elec. BB	NG 67%	None	None	51	32	98,190	2,787	6.8	1
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*18%*	*20%*	*16%*	*0%*	*3%*	
5	24 hrs	0.2	0.6	16	15	27	30	80	1.6	Elec. BB	HP COP2.3	84	55	26	16	85,281	-	1.3	4
5	8 hrs	0.2	0.6	16	15	27	30	80	1.6	Elec. BB	HP COP2.3	84	55	23	16	80,517	-	1.2	4
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*13%*	*0%*	*6%*	*0%*	*6%*	
5	24 hrs	0.2	1.5	25	11	27	30	80	0.8	Elec. BB	NG 80% Tankless	84	55	29	10	66,575	2,321	5.4	4
5	8 hrs	0.2	1.5	25	11	27	30	80	0.8	Elec. BB	NG 80% Tankless	84	55	26	10	61,713	2,321	5.3	4
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*11%*	*1%*	*8%*	*0%*	*1%*	
6	24 hrs	0.2	0.6	25	20	29	24	100	1	Elec. BB	NG 67%	70	55	31	12	70,056	2,381	5.6	4
6	8 hrs	0.2	0.6	25	20	29	24	100	1	Elec. BB	NG 67%	70	55	27	11	62,874	2,382	5.5	4
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*16%*	*14%*	*11%*	*0%*	*2%*	
7b	24 hrs	0.2	0.6	20	20	40	40	100	1.2	NG ECM Furnace 95%	NG 80% Tankless	84	55	50	30	49,996	7,346	14.8	4
7b	8 hrs	0.2	0.6	20	20	40	40	100	1.2	NG ECM Furnace 95%	NG 80% Tankless	84	55	46	29	45,249	7,116	14.2	4
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*9%*	*5%*	*10%*	*3%*	*4%*	
8	24 hrs	0.2	1	20	20	40	40	100	1.2	NG ECM Furnace 95%	HP COP2.3	84	55	65	55	59,895	8,744	17.6	3
8	8 hrs	0.2	1	20	20	40	40	100	1.2	NG ECM Furnace 95%	HP COP2.3	84	55	79	65	42,609	10,433	20.5	2
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*-17%*	*-16%*	*41%*	*-16%*	*-14%*	
8	24 hrs	0.2	1.5	16	11	29	30	70	1.8	Elec. BB	HP COP2.3	84	55	99	89	207,350	-	3.0	1
8	8 hrs	0.2	1.5	20	11	29	30	70	1.8	Elec. BB	HP COP2.3	84	55	114	101	209,618	-	3.1	1
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*-13%*	*-12%*	*-1%*	*0%*	*-1%*	
													average % difference of sample	14%	8%	10%	1%	3%	
													maximum	18%	20%	16%	3%	6%	
													minimum	9%	0%	6%	0%	1%	

Large SFD

CZ	Vent. Modelled	WWR	Airtightness ACH	Foundation R-Value	Underslab R-Value	Floor R-Value	Wall R-Value	Roof R-Value	Window USI	Space Heating	DHW System	Vent. Heat Recovery (%)	Drainwater Heat Recovery (%)	MEUI (kWh/m2)	TEDI (kWh/m2)	Annual Elec. (kWh)	Annual NG (m3)	Annual GHGs (t)	Step Achieved
4	24 hrs	0.2	1	11	20	n/a	30	60	1.8	NG PSC Furnace 92%	NG 80% Tankless	None	55	57	48	8,331	2,707	5.3	1
4	8 hrs	0.2	1	11	20	n/a	30	60	1.8	NG PSC Furnace 92%	NG 80% Tankless	None	55	50	42	7,739	2,388	4.7	2
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*15%*	*16%*	*8%*	*13%*	*13%*	
4	24 hrs	0.2	0.6	25	15	n/a	16	80	1.2	CCASHP COP2.0	NG 67%	60	42	27	15	16,010	497	1.2	4
4	8 hrs	0.2	0.6	25	15	n/a	16	80	1.2	CCASHP COP2.0	NG 67%	60	42	25	14	14,987	497	1.2	4
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*8%*	*6%*	*7%*	*0%*	*1%*	
5	24 hrs	0.2	2.5	16	11	n/a	24	60	1.6	CCASHP COP2.0	HP COP2.3	60	55	36	29	25,532	-	0.4	3
5	8 hrs	0.2	2.5	17	11	n/a	24	60	1.6	CCASHP COP2.0	HP COP2.3	60	55	35	29	24,928	-	0.4	3
	Modelled ECMs are very similar												*% diff. btw 24 and 8 hr ventilation*	*3%*	*0%*	*2%*	*0%*	*2%*	
5	24 hrs	0.2	1	25	20	n/a	24	50	1.4	CCASHP COP2.0	HP COP2.3	84	42	29	22	22,143	-	0.3	4
5	8 hrs	0.2	1	25	20	n/a	24	50	1.4	CCASHP COP2.0	HP COP2.3	84	42	28	22	21,387	-	0.3	4
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*5%*	*1%*	*4%*	*0%*	*4%*	
8	24 hrs	0.2	1.5	20	11	n/a	40	70	1.6	NG PSC Furnace 92%	HP COP2.3	None	None	127	121	11,144	5,865	11.4	1
8	8 hrs	0.2	1.5	20	11	n/a	40	70	1.6	NG PSC Furnace 92%	HP COP2.3	None	None	111	106	10,446	5,148	10.0	1
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*14%*	*14%*	*7%*	*14%*	*14%*	
8	24 hrs	0.2	1	25	20	n/a	40	100	0.8	NG PSC Furnace 92%	NG 80% Tankless	84	55	78	68	8,544	3,737	7.3	2
8	8 hrs	0.2	1	25	20	n/a	40	100	0.8	NG PSC Furnace 92%	NG 80% Tankless	84	55	75	66	7,959	3,641	7.1	2
	Modelled ECMs are identical												*% diff. btw 24 and 8 hr ventilation*	*4%*	*3%*	*7%*	*3%*	*3%*	
													average % difference of sample	8%	7%	6%	5%	6%	
													maximum	15%	16%	8%	14%	14%	
													minimum	3%	0%	2%	0%	1%	

8.13 Part 9 – Lowest Incremental Capital Costs – Air Tightness Limitation of Minimum 2.5 ACH_{50}

As mentioned in Appendix 8.3, the modelled results were also analyzed with airtightness level limitations of a minimum of 2.5 air change per hour at 50 Pascals pressure differential (ACH_{50}) (versus the 1.0 ACH_{50} applied to the main analysis). These limitations only apply to the steps outlined in the tables in Appendix 8.3.

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
10 unit MURB	4	BCBC	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.0%	n/a	$2,422	-
		1	27.0%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	86	60	39	26	113,670	104	6.9	0.1%	egative NPV but no GHG reducti	$2,424	-$3
		2	27.0%	2.5	16	17	11	29	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	71	46	24	22	89,483	104	6.5	0.8%	-$4,433	$2,441	$19
		3	27.0%	0.6	16	11	15	27	40	LG-avg-Double	1.8	BaseDHW	30%	elec-baseboard	60%	64	38	17	16	77,486	103	6.3	0.8%	-$5,249	$2,441	$37
		4	27.0%	0.6	16	11	15	27	40	LG-avg-Double	1.8	BaseDHW	30%	elec-baseboard	60%	64	38	17	16	77,486	103	6.3	0.8%	-$5,249	$2,441	$37
		5	27.0%	0.6	16	17	0	27	40	HG-avg-Triple	1.2	HPHotWater	0%	elec-baseboard	60%	47	22	11	14	78,371	0	1.2	1.9%	-$272	$2,469	$19
	5	BCBC	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.0%	n/a	$2,599	-
		1	27.0%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	100	74	52	35	136,114	104	7.2	0.1%	egative NPV but no GHG reducti	$2,602	-$3
		2	27.0%	2.5	16	20	0	29	100	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	87	61	39	29	114,645	104	6.9	0.8%	-$3,505	$2,619	$13
		3	27.0%	1.0	18	11	15	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	70	45	26	22	116,401	0	1.7	0.6%	-$382	$2,614	$25
		4	27.0%	1.0	18	11	15	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	70	45	26	22	116,401	0	1.7	0.6%	-$382	$2,614	$25
		5	27.0%	0.6	22	20	11	27	50	MG-HP-Double	1.4	HPHotWater	0%	elec-baseboard	70%	56	30	19	19	92,246	0	1.4	1.7%	-$493	$2,643	$35
	6	BCBC	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.0%	n/a	$2,727	-
		1	27.0%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	118	92	70	49	164,518	108	7.8	0.1%	egative NPV but no GHG reducti	$2,730	-$3
		2	27.0%	2.5	16	20	15	27	50	MG-i89-Double	1.6	HPHotWater	0%	elec-baseboard	70%	88	62	51	41	145,932	0	2.1	0.9%	-$234	$2,751	$16
		3	27.0%	0.6	18	20	0	27	50	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	78	52	33	27	129,130	0	1.9	0.4%	-$753	$2,739	$54
		4	27.0%	0.6	18	20	0	27	50	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	70%	78	52	33	27	129,130	0	1.9	0.4%	-$753	$2,739	$54
		5	27.0%	0.6	16	11	20	27	50	HG-avg-Triple	1.2	ElectricStorage	0%	elec-baseboard	60%	65	39	19	24	107,041	0	1.6	1.2%	-$900	$2,760	$68
	7a	BCBC	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.0%	n/a	$3,638	-
		1	27.0%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	149	123	100	63	214,243	117	9.0	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	2.5	16	20	11	27	40	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	70%	107	81	57	50	143,858	117	8.0	0.8%	-$6,414	$3,668	$80
		3	27.0%	0.6	22	11	15	29	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	96	70	46	31	125,859	117	7.7	0.5%	-$7,718	$3,655	$121
		4	27.0%	0.6	22	11	15	29	60	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	60%	96	70	46	31	125,859	117	7.7	0.5%	-$7,718	$3,655	$121
		5	27.0%	0.6	18	11	0	27	40	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	60%	81	55	31	29	101,210	117	7.3	1.0%	-$7,038	$3,674	$141
	7b	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	124	100	9.7	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	176	150	126	68	257,707	119	9.7	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	2.5	16	17	15	27	40	HG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	70%	132	106	82	55	184,978	119	8.7	0.6%	-$7,238	$3,658	$94
		3	27.0%	0.6	22	11	11	27	50	LG-avg-Double	1.8	ElectricStorage	30%	elec-baseboard	70%	109	83	62	34	180,051	0	2.6	0.2%	-$1,451	$3,647	$124
		4	27.0%	0.6	22	11	11	27	50	LG-avg-Double	1.8	ElectricStorage	30%	elec-baseboard	70%	109	83	62	34	180,051	0	2.6	0.2%	-$1,451	$3,647	$124
		5	27.0%	0.6	18	25	11	27	50	HG-avg-Triple	1.2	ElectricStorage	30%	elec-baseboard	70%	90	64	43	31	148,493	0	2.2	1.0%	-$1,623	$3,672	$148
	8	BCBC	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.0%	n/a	$3,638	-
		1	27.0%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	200	174	150	73	297,846	121	10.4	0.1%	egative NPV but no GHG reducti	$3,643	-$5
		2	27.0%	0.6	18	17	20	29	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	126	100	75	37	174,354	121	8.6	0.2%	-$8,542	$3,644	$187
		3	27.0%	0.6	18	17	20	29	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	126	100	75	37	174,354	121	8.6	0.2%	-$8,542	$3,644	$187
		4	27.0%	0.6	18	17	20	29	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	70%	126	100	75	37	174,354	121	8.6	0.2%	-$8,542	$3,644	$187
		5	27.0%	0.6	22	20	15	27	50	HG-avg-Triple	1.2	BaseDHW	30%	elec-baseboard	70%	100	74	50	31	131,965	120	7.9	1.2%	-$7,125	$3,681	$217

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
6 unit Row House	4	BCBC	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.0%	n/a	$1,749	-
		1	22.2%	3.5	16	NA	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	63	30	26	44,913	219	11.6	0.2%	egative NPV but no GHG reducti	$1,752	-$3
		2	22.2%	2.5	16	NA	0	27	50	LG-avg-Double	1.8	GasInst_Low	0%	basefurnace	0%	95	58	26	24	44,833	203	10.8	0.4%	$306	$1,757	-$5
		3	22.2%	2.5	16	NA	0	27	40	MG-i89-Double	1.6	ElectricStorage	30%	basefurnace	0%	87	50	23	23	66,412	94	5.7	0.8%	$418	$1,763	-$49
		4	22.2%	0.6	16	NA	11	27	50	MG-i89-Double	1.6	ElectricStorage	0%	basefurnace	70%	76	38	12	18	66,474	53	3.6	1.8%	$381	$1,781	-$61
		5	22.2%	0.6	16	NA	11	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	62	23	10	17	54,091	42	2.9	3.4%	$314	$1,808	-$54
	5	BCBC	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.0%	n/a	$1,877	-
		1	22.2%	3.5	18	NA	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	111	75	42	34	45,131	264	13.8	0.2%	egative NPV but no GHG reducti	$1,880	-$3
		2	22.2%	2.5	16	NA	11	27	40	LG-avg-Double	1.8	HPHotWater	0%	basefurnace	60%	94	57	40	31	54,667	163	8.9	1.0%	$300	$1,895	-$29
		3	22.2%	2.5	16	NA	11	27	40	LG-avg-Double	1.8	HPHotWater	0%	basefurnace	60%	94	57	40	31	54,667	163	8.9	1.0%	$300	$1,895	-$29
		4	22.2%	0.6	16	NA	0	27	80	MG-i89-Double	1.6	HPHotWater	0%	basefurnace	0%	83	45	30	24	54,474	122	6.9	1.6%	$252	$1,907	-$35
		5	22.2%	0.6	24	NA	0	27	40	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	68	29	15	20	54,195	64	4.0	3.3%	$296	$1,939	-$58
	6	BCBC	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.0%	n/a	$1,970	-
		1	22.2%	3.5	18	NA	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	90	53	45	45,351	317	16.5	0.2%	egative NPV but no GHG reducti	$1,973	-$3
		2	22.2%	2.5	16	NA	11	27	50	LG-avg-Double	1.8	HPHotWater	0%	basefurnace	70%	111	75	55	41	55,377	227	12.1	0.7%	$281	$1,982	-$24
		3	22.2%	2.5	16	NA	0	27	70	MG-HP-Double	1.4	GasInstantaneous	30%	basefurnace	70%	108	72	40	40	45,106	252	13.2	1.5%	$276	$1,998	-$18
		4	22.2%	0.6	18	NA	0	27	40	MG-i89-Double	1.6	HPHotWater	0%	basefurnace	70%	92	55	37	31	55,040	155	8.5	1.4%	$168	$1,997	-$27
		5	22.2%	0.6	18	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	78	40	24	27	54,783	100	5.8	2.5%	$185	$2,019	-$39
	7a	BCBC	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.0%	n/a	$2,627	-
		1	22.2%	3.5	18	NA	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	155	122	79	56	45,848	431	22.2	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	2.5	18	NA	0	40	70	LG-avg-Double	1.8	HPHotWater	0%	basefurnace	70%	137	102	78	49	56,657	319	16.8	0.9%	$306	$2,650	-$33
		3	22.2%	2.5	18	NA	0	27	50	LG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	127	92	69	45	56,488	284	15.0	1.5%	$305	$2,667	-$44
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	0%	102	66	46	35	56,045	190	10.3	1.5%	$121	$2,667	-$28
		5	22.2%	0.6	22	NA	0	27	60	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	89	52	35	31	55,823	142	7.9	2.5%	$161	$2,693	-$46
	7b	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	143	98	59	46,207	506	25.9	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	2.5	16	NA	11	27	40	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	137	103	79	51	56,877	322	16.9	1.1%	$151	$2,656	-$27
		3	22.2%	2.5	16	NA	11	27	40	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	60%	137	103	79	51	56,877	322	16.9	1.1%	$151	$2,656	-$27
		4	22.2%	0.6	16	NA	0	27	100	HG-avg-Triple	1.2	ElectricStorage	0%	basefurnace	70%	117	81	48	35	70,504	195	10.7	1.4%	$161	$2,663	-$49
		5	22.2%	0.6	24	NA	11	27	50	HG-avg-Triple	1.2	HPHotWater	30%	basefurnace	70%	102	65	46	33	56,086	188	10.2	2.7%	$143	$2,697	-$45
	8	BCBC	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.0%	n/a	$2,627	-
		1	22.2%	3.5	22	NA	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	196	164	117	63	46,566	582	29.7	0.2%	egative NPV but no GHG reducti	$2,632	-$5
		2	22.2%	2.5	18	NA	20	27	80	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	60%	156	122	79	50	45,843	433	22.3	1.6%	$111	$2,670	-$17
		3	22.2%	2.5	18	NA	20	27	80	HG-avg-Triple	1.2	GasInst_Low	0%	basefurnace	60%	156	122	79	50	45,843	433	22.3	1.6%	$111	$2,670	-$17
		4	22.2%	0.6	16	NA	0	27	50	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	0%	134	100	77	40	57,010	310	16.3	1.0%	$37	$2,654	-$10
		5	22.2%	0.6	22	NA	11	27	100	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	111	74	54	34	56,577	220	11.8	2.6%	$102	$2,696	-$36

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Quadplex	4	BCBC	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.0%	n/a	$1,857	-
		1	17.3%	3.5	16	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	126	71	34	32	45,989	68	4.0	0.2%	egative NPV but no GHG reducti	$1,861	-$4
		2	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	117	62	27	29	42,381	64	3.8	0.6%	-$944	$1,868	$8
		3	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	0%	112	56	27	29	57,288	0	0.8	0.7%	$388	$1,869	-$48
		4	17.3%	1.0	22	11	0	27	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	0%	104	48	19	24	53,202	0	0.8	1.5%	$340	$1,885	-$43
		5	17.3%	0.6	22	20	0	27	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	80	25	12	20	41,218	0	0.6	6.0%	$489	$1,968	-$65
	5	BCBC	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.0%	n/a	$1,992	-
		1	17.3%	3.5	18	17	0	27	50	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	138	83	46	42	52,341	68	4.1	0.2%	egative NPV but no GHG reducti	$1,997	-$5
		2	17.3%	2.5	18	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	132	76	41	39	49,736	64	3.9	0.3%	-$1,133	$1,998	$9
		3	17.3%	2.5	18	20	0	27	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	120	65	36	37	61,796	0	0.9	1.1%	$386	$2,014	-$49
		4	17.3%	0.6	22	11	11	27	40	MG-HP-Double	1.4	HPHotWater	0%	elec-baseboard	0%	98	43	30	29	50,401	0	0.7	2.7%	$178	$2,047	-$24
		5	17.3%	0.6	40	20	0	27	40	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	85	30	17	24	43,659	0	0.6	6.7%	$502	$2,126	-$68
	6	BCBC	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.0%	n/a	$2,091	-
		1	17.3%	3.5	18	17	0	27	50	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	155	100	61	55	60,051	70	4.4	0.3%	egative NPV but no GHG reducti	$2,096	-$5
		2	17.3%	2.5	22	11	0	27	40	LG-avg-Double	1.8	BaseDHW	0%	elec-baseboard	0%	148	92	56	50	57,173	67	4.2	0.2%	-$1,434	$2,095	$12
		3	17.3%	2.5	22	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	139	84	47	48	52,754	67	4.1	1.2%	-$1,267	$2,115	$13
		4	17.3%	0.6	22	20	0	27	100	MG-HP-Double	1.4	HPHotWater	0%	elec-baseboard	0%	109	53	40	36	55,825	0	0.8	2.7%	$93	$2,147	-$13
		5	17.3%	0.6	40	20	0	27	40	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	0%	94	38	25	31	48,180	0	0.7	6.3%	$346	$2,223	-$50
	7a	BCBC	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.0%	n/a	$2,789	-
		1	17.3%	3.5	18	20	0	29	60	MG-i89-Double	1.6	BaseDHW	0%	elec-baseboard	0%	192	136	95	71	77,383	76	4.9	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	173	117	78	62	68,651	72	4.6	0.5%	-$2,484	$2,804	$30
		3	17.3%	2.5	30	20	0	27	70	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	60%	165	109	70	58	64,506	72	4.6	1.9%	-$911	$2,842	$13
		4	17.3%	0.6	40	20	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	139	83	44	41	51,126	72	4.4	3.2%	-$1,959	$2,879	$44
		5	17.3%	0.6	40	20	11	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	105	49	35	34	53,871	0	0.8	7.4%	$393	$2,995	-$63
	7b	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	207	151	109	73	84,720	78	5.1	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	20	0	27	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	188	133	99	64	96,651	0	1.4	0.2%	$292	$2,795	-$42
		3	17.3%	2.5	40	20	0	27	40	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	185	129	89	61	74,476	74	4.8	1.7%	-$489	$2,835	$6
		4	17.3%	0.6	40	20	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	0%	153	98	58	40	58,241	74	4.5	3.1%	-$2,107	$2,876	$48
		5	17.3%	0.6	40	20	0	40	100	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	119	64	49	36	61,352	0	0.9	7.4%	$396	$2,996	-$65
	8	BCBC	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.0%	n/a	$2,789	-
		1	17.3%	3.5	22	20	0	29	60	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	229	174	131	78	95,945	79	5.3	0.3%	egative NPV but no GHG reducti	$2,797	-$8
		2	17.3%	2.5	22	11	11	27	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	208	153	119	69	107,023	0	1.6	0.2%	$250	$2,794	-$37
		3	17.3%	2.5	40	11	0	27	100	MG-HP-Double	1.4	BaseDHW	0%	elec-baseboard	0%	201	145	105	64	82,350	75	4.9	1.8%	-$1,239	$2,840	$19
		4	17.3%	0.6	40	11	0	27	100	LG-avg-Triple	1.2	BaseDHW	0%	elec-baseboard	0%	165	110	69	43	64,053	75	4.7	3.0%	-$3,093	$2,872	$80
		5	17.3%	0.6	40	20	0	40	70	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	130	75	60	38	66,981	0	1.0	7.3%	$191	$2,992	-$32

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Large SFD	4	BCBC	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.0%	n/a	$1,938	-
		1	14.6%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	82	68	49	27	7,927	122	6.2	0.2%	egative NPV but no GHG reducti	$1,941	-$3
		2	14.6%	2.5	16	17	0	NA	50	MG-HP-Double	1.4	GasInst_Low	0%	basefurnace	70%	64	50	35	23	7,790	89	4.6	1.3%	$237	$1,963	-$15
		3	14.6%	2.5	22	17	0	NA	100	MG-HP-Double	1.4	BaseDHW	30%	baseboard	60%	54	40	29	21	22,252	19	1.3	1.8%	$387	$1,972	-$74
		4	14.6%	0.6	24	17	0	NA	50	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	70%	42	28	20	16	17,418	14	0.9	2.4%	$293	$1,984	-$60
		5	14.6%	0.6	40	17	20	NA	50	HG-avg-Triple	1.2	ElectricStorage	42%	baseboard	70%	37	23	15	14	18,835	0	0.3	4.2%	$428	$2,020	-$99
	5	BCBC	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.0%	n/a	$2,079	-
		1	14.6%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	90	76	56	34	7,998	136	6.9	0.2%	egative NPV but no GHG reducti	$2,082	-$3
		2	14.6%	2.5	16	20	0	NA	70	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	70%	67	53	44	29	34,197	0	0.5	0.4%	$393	$2,088	-$99
		3	14.6%	2.5	24	11	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	70%	60	45	34	27	24,752	20	1.4	1.1%	$327	$2,102	-$71
		4	14.6%	0.6	24	11	0	NA	40	HG-avg-Triple	1.2	BaseDHW	42%	baseboard	70%	52	38	27	22	21,474	19	1.2	1.7%	$301	$2,115	-$67
		5	14.6%	0.6	40	17	11	NA	100	HG-avg-Triple	1.2	BaseDHW	30%	baseboard	75%	44	30	19	18	17,085	19	1.2	3.7%	$386	$2,156	-$86
	6	BCBC	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.0%	n/a	$2,182	-
		1	14.6%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	105	91	69	44	8,122	165	8.3	0.2%	egative NPV but no GHG reducti	$2,185	-$4
		2	14.6%	2.5	30	11	0	NA	100	MG-i89-Double	1.6	GasInstantaneous	0%	baseboard	0%	80	66	57	37	36,753	14	1.3	0.5%	$392	$2,192	-$109
		3	14.6%	2.5	24	11	0	NA	40	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	73	59	47	36	31,308	21	1.5	0.7%	$331	$2,198	-$88
		4	14.6%	1.5	24	11	0	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	60%	62	48	39	30	27,613	14	1.1	1.3%	$280	$2,209	-$79
		5	14.6%	0.6	40	20	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	42%	basefurnace	84%	51	37	25	22	11,612	52	2.8	4.1%	$333	$2,272	-$72
	7a	BCBC	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.0%	n/a	$2,910	-
		1	14.6%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	137	123	95	55	8,383	222	11.2	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	2.5	18	11	20	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	0%	103	89	78	49	47,532	18	1.6	0.5%	$398	$2,925	-$150
		3	14.6%	2.5	22	17	0	NA	70	HG-avg-Triple	1.2	HPHotWater	0%	basefurnace	70%	97	83	68	43	10,204	143	7.3	1.5%	$173	$2,953	-$27
		4	14.6%	0.6	24	11	0	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	80	66	53	34	34,531	23	1.6	0.9%	$258	$2,937	-$97
		5	14.6%	0.6	40	25	0	NA	100	HG-i89-Triple-B	0.8	BaseDHW	0%	baseboard	60%	62	48	35	27	25,196	23	1.5	4.6%	$411	$3,044	-$156
	7b	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	153	139	110	58	8,535	251	12.7	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	2.5	18	11	20	NA	40	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	60%	121	107	96	51	56,588	19	1.8	0.2%	$415	$2,916	-$177
		3	14.6%	2.5	40	17	15	NA	100	MG-HP-Double	1.4	BaseDHW	0%	baseboard	0%	114	99	86	46	51,449	23	1.9	1.7%	$462	$2,958	-$194
		4	14.6%	0.6	22	20	0	NA	70	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	75%	88	74	64	35	45,087	0	0.7	0.9%	$283	$2,936	-$133
		5	14.6%	0.6	40	17	0	NA	70	HG-i89-Triple-B	0.8	GasInst_Low	0%	baseboard	75%	75	61	50	29	32,892	19	1.4	3.6%	$354	$3,015	-$155
	8	BCBC	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.0%	n/a	$2,910	-
		1	14.6%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	173	159	128	61	8,711	288	14.5	0.2%	egative NPV but no GHG reducti	$2,916	-$6
		2	14.6%	2.5	40	17	0	NA	100	MG-i89-Double	1.6	GasInstantaneous	55%	baseboard	60%	120	106	97	47	57,255	14	1.5	1.5%	$405	$2,955	-$205
		3	14.6%	2.5	40	17	0	NA	100	MG-i89-Double	1.6	GasInstantaneous	55%	baseboard	60%	120	106	97	47	57,255	14	1.5	1.5%	$405	$2,955	-$205
		4	14.6%	0.6	22	11	0	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	103	89	79	38	52,838	0	0.8	0.5%	$275	$2,924	-$148
		5	14.6%	0.6	40	20	11	NA	100	HG-HP-Triple	1	GasInstantaneous	0%	baseboard	84%	81	67	57	30	36,836	17	1.4	3.5%	$313	$3,013	-$161

Scenario			Archetype Characteristics												Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Medium SFD	4	BCBC	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.0%	n/a	$2,045	-
		1	14.7%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	99	69	38	29	7,517	57	3.0	0.2%	egative NPV but no GHG reducti	$2,050	-$5
		2	14.7%	2.5	16	25	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	baseboard	0%	87	57	33	27	15,057	20	1.2	0.4%	$430	$2,053	-$63
		3	14.7%	2.5	16	11	11	NA	50	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	60%	74	44	26	24	17,613	0	0.3	0.9%	$386	$2,064	-$88
		4	14.7%	1.0	18	17	0	NA	50	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	0%	68	38	19	21	11,723	16	1.0	1.8%	$312	$2,082	-$53
		5	14.7%	0.6	24	20	11	NA	40	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	70%	53	23	14	17	12,445	0	0.2	3.6%	$370	$2,119	-$87
	5	BCBC	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.0%	n/a	$2,194	-
		1	14.7%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	109	78	47	37	7,556	66	3.4	0.2%	egative NPV but no GHG reducti	$2,200	-$5
		2	14.7%	2.5	16	11	0	NA	50	LG-avg-Double	1.8	GasInstantaneous	0%	baseboard	70%	91	61	44	32	17,751	14	0.9	0.2%	$379	$2,198	-$78
		3	14.7%	2.5	16	20	0	NA	40	MG-i89-Double	1.6	BaseDHW	0%	baseboard	70%	91	61	36	31	15,918	20	1.2	0.6%	$396	$2,207	-$72
		4	14.7%	1.5	18	11	11	NA	60	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	0%	75	45	27	28	17,835	0	0.3	1.4%	$370	$2,226	-$97
		5	14.7%	0.6	22	17	11	NA	100	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	75%	58	28	20	22	13,834	0	0.2	3.3%	$352	$2,266	-$94
	6	BCBC	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.0%	n/a	$2,303	-
		1	14.7%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	125	95	60	48	7,617	79	4.1	0.2%	egative NPV but no GHG reducti	$2,308	-$6
		2	14.7%	2.5	16	17	11	NA	40	MG-i89-Double	1.6	BaseDHW	0%	baseboard	0%	113	83	58	46	20,974	21	1.4	0.1%	$470	$2,306	-$108
		3	14.7%	2.5	16	11	15	NA	40	HG-avg-Triple	1.2	GasInstantaneous	0%	baseboard	0%	96	65	48	42	18,613	14	1.0	1.0%	$375	$2,326	-$97
		4	14.7%	0.6	16	11	0	NA	80	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	83	53	34	32	19,696	0	0.3	1.4%	$337	$2,334	-$108
		5	14.7%	0.6	40	25	11	NA	80	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	66	36	17	24	15,723	0	0.2	3.9%	$377	$2,392	-$122
	7a	BCBC	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.0%	n/a	$3,072	-
		1	14.7%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	156	126	86	59	7,738	106	5.4	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	2.5	16	17	0	NA	100	MG-HP-Double	1.4	GasInstantaneous	0%	baseboard	70%	122	92	72	49	24,446	16	1.2	0.7%	$393	$3,092	-$141
		3	14.7%	2.5	18	17	11	NA	50	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	70%	111	81	60	47	26,363	0	0.4	1.2%	$394	$3,107	-$166
		4	14.7%	1.0	24	25	0	NA	100	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	75%	99	69	48	35	23,419	0	0.3	1.7%	$351	$3,123	-$149
		5	14.7%	0.6	40	17	0	NA	70	HG-avg-Triple	1.2	GasInst_Low	0%	baseboard	70%	84	54	31	29	14,668	18	1.1	3.4%	$335	$3,177	-$120
	7b	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	175	145	103	62	7,817	122	6.2	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	2.5	16	20	0	NA	70	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	70%	147	117	96	53	34,808	0	0.5	-0.2%	$432	$3,066	-$207
		3	14.7%	2.5	18	17	11	NA	50	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	70%	133	103	82	51	31,503	0	0.5	0.8%	$413	$3,095	-$199
		4	14.7%	0.6	24	20	0	NA	100	MG-i89-Double	1.6	GasInstantaneous	0%	baseboard	75%	113	83	63	36	22,252	16	1.1	1.5%	$313	$3,119	-$133
		5	14.7%	0.6	40	17	20	NA	50	HG-avg-Triple	1.2	ElectricStorage	30%	baseboard	70%	95	65	45	32	22,418	0	0.3	3.8%	$390	$3,188	-$193
	8	BCBC	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.0%	n/a	$3,072	-
		1	14.7%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	195	165	120	66	7,901	139	7.0	0.3%	egative NPV but no GHG reducti	$3,081	-$9
		2	14.7%	2.5	22	20	20	NA	100	MG-i89-Double	1.6	GasInst_Low	0%	baseboard	0%	159	129	105	56	32,253	19	1.4	0.7%	$439	$3,094	-$207
		3	14.7%	2.5	16	17	11	NA	70	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	70%	159	129	100	56	31,141	23	1.6	0.9%	$443	$3,098	-$202
		4	14.7%	0.6	18	11	0	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	128	98	76	42	30,336	0	0.4	1.1%	$331	$3,105	-$184
		5	14.7%	0.6	40	11	11	NA	70	HG-avg-Triple	1.2	HPHotWater	0%	baseboard	75%	99	69	58	34	23,363	0	0.3	3.5%	$322	$3,179	-$182

Scenario			Archetype Characteristics												Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	16	11	11	NA	60	MG-i89-Double	1.6	GasInstantaneous	0%	basefurnace	0%	151	81	34	49	7,368	29	1.5	1.6%	$317	$2,351	-$24
		3	12.2%	2.5	18	11	11	NA	40	MG-HP-Double	1.4	GasInstantaneous	0%	basefurnace	60%	145	75	29	45	7,358	27	1.4	2.2%	$350	$2,364	-$34
		4	12.2%	0.6	16	11	11	NA	80	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	129	60	18	41	13,196	0	0.2	3.4%	$478	$2,393	-$163
		5	12.2%	0.6	18	11	20	NA	70	HG-avg-Triple	1.2	ElectricStorage	0%	CCASHP-ecm	84%	125	55	14	37	12,720	0	0.2	8.7%	$798	$2,515	-$273
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	22	11	11	NA	40	MG-i89-Double	1.6	GasInst_Low	0%	basefurnace	0%	168	99	45	60	7,388	35	1.9	0.6%	$69	$2,499	-$5
		3	12.2%	2.5	16	11	11	NA	60	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	60%	161	90	34	57	10,779	20	1.2	1.3%	$366	$2,514	-$76
		4	12.2%	1.5	18	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	70%	139	69	27	50	14,168	0	0.2	2.4%	$406	$2,543	-$159
		5	12.2%	0.6	40	11	11	NA	100	HG-i89-Triple-B	0.8	HPHotWater	0%	baseboard	75%	108	38	19	42	11,029	0	0.2	7.6%	$522	$2,673	-$210
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	18	11	11	NA	50	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	0%	188	117	59	81	13,279	21	1.2	0.4%	$374	$2,617	-$106
		3	12.2%	2.5	18	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	55%	basefurnace	70%	164	94	47	67	11,150	20	1.2	2.3%	$338	$2,666	-$100
		4	12.2%	1.0	22	11	11	NA	60	HG-i89-Triple-B	0.8	GasInstantaneous	0%	baseboard	84%	146	76	35	59	10,834	14	0.9	4.4%	$386	$2,720	-$136
		5	12.2%	0.6	40	25	30	NA	100	HG-i89-Triple-B	0.8	HPHotWater	30%	basefurnace	70%	118	48	24	45	9,072	11	0.7	10.8%	$647	$2,889	-$254
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	18	11	11	NA	100	HG-avg-Triple	1.2	ElectricStorage	0%	baseboard	60%	193	123	75	83	19,696	0	0.3	1.0%	$378	$3,512	-$235
		3	12.2%	2.5	22	17	11	NA	70	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	70%	203	132	69	83	14,307	22	1.3	2.1%	$408	$3,549	-$170
		4	12.2%	0.6	30	11	11	NA	100	HG-avg-Triple	1.2	GasInstantaneous	0%	basefurnace	75%	176	106	51	65	7,404	38	2.0	4.2%	$346	$3,622	-$99
		5	12.2%	0.6	40	25	30	NA	70	HG-HP-Triple	1	ElectricStorage	0%	CCASHP-ecm	75%	153	83	34	53	15,557	0	0.2	11.8%	$793	$3,885	-$503
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	40	11	11	NA	50	MG-i89-Double	1.6	ElectricStorage	0%	baseboard	60%	216	147	98	84	22,057	0	0.3	1.5%	$415	$3,528	-$295
		3	12.2%	2.5	40	11	11	NA	100	HG-avg-Triple	1.2	BaseDHW	0%	baseboard	0%	224	153	89	91	16,418	23	1.4	2.6%	$450	$3,567	-$227
		4	12.2%	0.6	40	11	11	NA	70	HG-i89-Triple-B	0.8	GasInst_Low	0%	baseboard	70%	184	113	59	66	13,362	19	1.1	5.2%	$423	$3,658	-$233
		5	12.2%	0.6	60	11	20	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	30%	CCASHP-ecm	84%	167	96	47	60	17,014	0	0.3	13.1%	$785	$3,931	-$570
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	40	17	11	NA	70	HG-avg-Triple	1.2	BaseDHW	55%	CCASHP-ecm	60%	225	155	99	88	17,314	20	1.3	7.4%	$643	$3,732	-$395
		3	12.2%	2.5	40	17	11	NA	70	HG-avg-Triple	1.2	BaseDHW	55%	CCASHP-ecm	60%	225	155	99	88	17,314	20	1.3	7.4%	$643	$3,732	-$395
		4	12.2%	0.6	40	11	11	NA	100	HG-avg-Triple	1.2	GasInst_Low	42%	basefurnace	70%	202	132	71	68	7,451	47	2.5	4.9%	$282	$3,647	-$107
		5	12.2%	0.6	40	25	30	NA	100	HG-avg-Triple	1.2	GasInstantaneous	42%	CCASHP-ecm	84%	173	103	60	58	13,556	15	0.9	12.3%	$680	$3,904	-$463

Scenario			Archetype Characteristics													Energy and Emissions Outcomes							Costing Outcomes			
Arch.	CZ	Step Achieved	WWR	Airtightness (ACH@50Pa)	Wall R-Value (effective)	Foundation Wall R-Value (effective)	Underslab R-Value (effective)	Exposed Floor R-Value (effective)	Ceiling / Roof R-Value (effective)	Window Option	Window U-Value	DHW System	Drainwater Heat Recovery (%)	Space Heating System	Vent. Heat Recovery (%)	TEUI (kWh/m2)	MEUI (kWh/m2)	TEDI (kWh/m2)	PTL (W/m2)	Electricity Consumption (kWh)	Natural Gas Consumption (GJ)	Annual GHG Emissions (tCO2e)	Incremental Capital Cost (%)	Carbon Abatement Cost ($/tCO2e)	Building with ECMs Cost per m2 ($/m2)	NPV per m2 (20-year)
Small SFD - Slab on Grade	4	BCBC	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.0%	n/a	$2,314	-
		1	12.2%	3.5	16	11	0	NA	40	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	172	102	37	57	7,373	37	1.9	0.4%	egative NPV but no GHG reducti	$2,324	-$10
		2	12.2%	2.5	16	N/A	11	NA	40	LG-avg-Double	1.8	ElectricStorage	0%	elec-baseboard	0%	145	75	33	38	14,781	0	0.2	0.3%	$390	$2,321	-$131
		3	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	139	70	28	37	14,203	0	0.2	0.8%	$381	$2,333	-$129
		4	12.2%	1.0	18	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	130	61	19	30	13,288	0	0.2	2.2%	$401	$2,364	-$137
		5	12.2%	1.0	22	N/A	20	NA	40	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	103	33	14	26	10,520	0	0.2	6.0%	$445	$2,453	-$155
	5	BCBC	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.0%	n/a	$2,483	-
		1	12.2%	3.5	18	17	0	NA	50	LG-avg-Double	1.8	BaseDHW	0%	basefurnace	0%	187	118	51	70	7,400	42	2.2	0.4%	egative NPV but no GHG reducti	$2,494	-$11
		2	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	154	84	42	47	15,659	0	0.2	0.4%	$378	$2,492	-$147
		3	12.2%	2.5	18	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	0%	151	81	39	46	15,403	0	0.2	0.7%	$379	$2,500	-$148
		4	12.2%	0.6	18	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	140	71	29	37	14,306	0	0.2	2.1%	$397	$2,536	-$156
		5	12.2%	1.0	22	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	108	38	19	30	11,028	0	0.2	6.4%	$443	$2,641	-$178
	6	BCBC	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.0%	n/a	$2,606	-
		1	12.2%	3.5	18	17	0	NA	50	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	213	143	71	89	7,439	51	2.7	0.5%	egative NPV but no GHG reducti	$2,618	-$12
		2	12.2%	2.5	16	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	170	100	56	55	17,295	0	0.3	0.6%	$377	$2,621	-$179
		3	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	160	91	47	50	16,349	0	0.2	1.2%	$357	$2,636	-$171
		4	12.2%	0.6	22	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	146	76	32	40	14,865	0	0.2	2.9%	$367	$2,681	-$177
		5	12.2%	1.0	40	N/A	11	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	60%	114	45	25	35	11,658	0	0.2	7.3%	$429	$2,796	-$211
	7a	BCBC	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.0%	n/a	$3,476	-
		1	12.2%	3.5	18	20	0	NA	60	MG-i89-Double	1.6	BaseDHW	0%	basefurnace	0%	256	187	104	105	7,507	67	3.5	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	11	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	193	123	76	62	19,698	0	0.3	1.0%	$377	$3,511	-$235
		3	12.2%	2.5	22	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	185	115	67	57	18,838	0	0.3	1.8%	$386	$3,540	-$241
		4	12.2%	1.0	22	N/A	11	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	0%	elec-baseboard	60%	161	92	44	47	16,485	0	0.2	4.2%	$419	$3,623	-$264
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	ElectricStorage	0%	elec-baseboard	84%	139	70	22	34	14,232	0	0.2	8.1%	$536	$3,758	-$342
	7b	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	283	214	128	110	7,557	77	4.0	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	22	N/A	20	NA	40	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	216	146	98	66	22,048	0	0.3	1.2%	$401	$3,519	-$286
		3	12.2%	2.5	22	N/A	20	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	206	136	87	61	20,987	0	0.3	2.1%	$402	$3,547	-$287
		4	12.2%	1.0	40	N/A	20	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	175	105	57	46	17,870	0	0.3	4.6%	$411	$3,637	-$297
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	142	72	50	39	14,450	0	0.2	8.5%	$469	$3,771	-$344
	8	BCBC	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.0%	n/a	$3,476	-
		1	12.2%	3.5	22	20	0	NA	60	MG-HP-Double	1.4	BaseDHW	0%	basefurnace	0%	309	239	150	115	7,602	86	4.4	0.6%	egative NPV but no GHG reducti	$3,495	-$19
		2	12.2%	2.5	18	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	239	169	120	70	24,363	0	0.4	0.9%	$403	$3,509	-$319
		3	12.2%	2.5	22	N/A	20	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	222	152	103	64	22,644	0	0.3	2.1%	$394	$3,547	-$314
		4	12.2%	0.6	40	N/A	11	NA	80	MG-HP-Double	1.4	ElectricStorage	0%	elec-baseboard	60%	188	118	69	47	19,181	0	0.3	4.3%	$374	$3,624	-$302
		5	12.2%	0.6	40	N/A	20	NA	80	HG-i89-Triple-B	0.8	HPHotWater	0%	elec-baseboard	84%	152	82	60	40	15,499	0	0.2	8.5%	$434	$3,771	-$356

8.14 Terms and Acronyms

AHJ - Authority Having Jurisdiction

COV - City of Vancouver

ECM - Energy Conservation Measures

GHGI - Greenhouse Gas Intensity

NBC - National Building Code

HDD - Heating degree days

HOT2000 - An energy simulation and design tool used for low-rise residential buildings

HTAP - Housing Technology Assessment Platform

LEEP - Local Energy Efficiency Partnership

MURB – Multi-Unit Residential Building

NECB - National Energy Code of Canada for Buildings

NPV - Net Present Value

NRC - The National Research Council

NRCan - Natural Resources Canada

PHIUS - Passive House Institute of the United States

PTL - Peak Thermal Load

SFD - Single Family Dwelling

TEDI - Thermal Energy Demand Intensity

TEUI - Total Energy Use Intensity

VFAR - Vertical surface area to floor area ratio

WWR - Window-to-wall ratio

ZEBP - City of Vancouver Zero Emissions Building Plan

More information:

energystepcode.ca
bchousing.org