Draft Building Carbon Pollution Standards for Part 3 buildings in British Columbia

Technical and financial data tables

Building and Safety Standards Branch

Province of British Columbia

Contents

Preface

The following data tables for Part 3 buildings are designed to isolate and highlight some potential financial and technical implications of a tiered carbon pollution standard for buildings in British Columbia which local governments may opt-in to.

This document is meant to be an initial costing analysis by illustrating whether decarbonizing a hypothetical building is cost effective across climate zones in B.C.

This document should not be considered an exhaustive costing study to meet the carbon pollution steps in your area. This analysis is not representative of all buildings in all situations.

Local governments and the construction industry should conduct more detailed or specific costing analysis which builds on this initial analysis.

The analysis prioritizes the most commonly built archetypes and scenarios; Not all energy Steps, carbon Levels and archetypes were analyzed for all climate zones.

Document format

The following pages contain:

- A proposed table of GHGI targets that could be inserted into the BC Building Code
- An example of how several buildings would meet the levels of the proposed Building Carbon Pollution Standard

Authors and sources

The report was written by the Building and Safety Standards Branch of the Province of British Columbia, using data and analysis from the 2021 update to the BC Energy Step Code Metrics Research Report, written by Evoke Buildings and E3 Eco Group. More examples may be found in the Metrics Research Report. Thanks to Alex Blue, Einar Halbig, Donald Fast, and M'Beth Schoenfeld.

Assumptions

- *Electricity emissions factor: 0.011kg CO2e/kWh as listed currently in the BC Building Code*
- *Natural Gas emissions factor: 0.185kg CO2e/kWh as listed currently in the BC Building Code*
- *Renewable gas emissions factor: 0.001kg CO2e/kWh (converted from 0.29kg CO2e/GJ as described in the BC Best Practices Methodology for Quantifying Greenhouse Gas Emissions and rounded to the nearest thousandth)*
- *Cost of 100% conventional natural gas: $0.042 $/kWh*
- *Cost of 100% RNG blend: $0.066 $/kWh*
- *Cost of BC Hydro residential electricity: $0.094 $/kWh (Step 1) or $0.141 $/kWh (Step 2)*
- *Cost of BC Hydro commercial electricity: $0.068 $/kWh + 12.4 $/kW*
- *Carbon tax rate: $45 in 2021, $50 in 2022, Linear increase to $170 in 2030 Escalate to $300 at final year of 20 year period (linear increase $13/year)*
- *Annual utility costs consider an annual average rate over 20 years, including a 2% per year utility escalation rate and a 3% discount rate.*

Other assumptions:

- *Other costing data, such as panel size or service upgrade charges, are not included in this analysis given the unique nature of those costs to each project.*
- *Electric vehicle (EV) charging is not included in energy models.*
- *Cooling was included in all Part 3 models; MURBs may not be designed with this in all cases, however the operating GHG impact is very small.*
- *Heat pump domestic hot water heaters were not modeled in this study; these are likely to be a common and viable decarbonisation measure but were excluded to reduce modelling runs.*

- *All values throughout this document, as well as potential GHGI targets and compliance paths, use modeled values, which may differ from eventual metered results.*
- *Equipment efficiencies:*
    - *DHW: electric tank (0.82 EF), natural gas tank (0.67 EF), natural gas tankless (0.95 EF), ASHP integrated tank (1.90 EF)*
    - *Space Heating: natural gas furnace (95% AFUE), electric baseboard, Cold Climate ASHP for CZs 6-8 (COPs from NRCan calculator based on NEEP data) with back up heat same as base case if needed, regular heat pump for CZs 4 and 5 (HSPF 7.1/SEER 14.5) with back up heat same as base case if needed*
- *Financial incentives were not included in this analysis as they change frequently*

Approach

Four levels of target

The GHG Levels are set as follows:

- Measure-only: Measuring GHG emissions with on reductions required
- Medium: intended to require decarbonization of one major system (space heating or hot water).
- Low: intended to require both major systems to decarbonize, but still allows for high-carbon fuel backup heating, cooking loads, or similar.
- Zero-carbon Ready: All energy end-uses on a low-carbon energy source.

Intensity targets (GHGI)

The targets are set using an intensity metric, similar to the existing TEUI and TEDI Step Code metrics, which scale by floor area.

Reasoning

Four levels of target

- Each GHG target is set at a level which drives a technology or design choice towards lower carbon energy.

Intensity targets (GHGI)

- Part 3 buildings vary widely in size, and their energy use generally tracks with size (i.e. there is not a substantial portion of fixed loads that stay the same regardless of size).

Table 10.3.1.3.
Greenhouse Gas Emissions
Forming Part of Sentence 10.3.1.3.(1)

GHG Emission Level	**PROPOSAL: Maximum GHGi of the *Building*, Expressed in $kgCO_{2e}/m^2$/year**			
	Residential Major Occupancy		***Business and Personal Service* and *Mercantile Major Occupancies***	
	Hotels and Motels	**Other *Residential Occupancies***	**Offices**	**Other *Business and Personal Service* and *Mercantile Occupancies***
Measure	Measure Only			
medium	9.0	7.0	5.0	6.0
low	4.0	3.0	3.0	3.0
zero carbon ready	2.0	1.8	1.5	2.0

Rationale for Targets

Initial discussion on targets centred around a 6/3/1 set of GHGI targets. This format is generally adhered to, however some changes for individual archetypes have been suggested above to better target the desired level of decarbonization measures, while remaining achievable without requiring renewables such as solar photovoltaics.

Maximum TEUI/TEDI by Step

First, targets are analyzed based on a simple spreadsheet calculation using the existing Step Code TEUI and TEDI targets, combined with domestic hot water usage modeled in the archetype models. Using these existing targets, and assigning heating and DHW to a high-carbon fuel as an initial baseline (and assuming a 95% condensing boiler for heating), and

assuming the rest of the energy use allowable in the TEUI uses a low-carbon fuel given connection to the electrical grid, the following GHGI values (in kgCO2e/m2/year) are seen. This could be considered a "typical worst case" as it uses the maximum allowable TEUI and TEDI for each Step; many projects would be expected to be below those maximums in reality.

The initial targets are set using an allowance based on these maximums, then validated against archetype modelling, described below.

This analysis is summarized below, with levels that would be achieved with each decarbonization measure shown shaded in green.

Target levels

- Each Step and climate zone shows an option to use decarbonization to meet proposed targets at the appropriate decarbonization measures and Steps. In general targets appear to generate the desired outcomes.
- Ability to meet targets does not appear to depend substantially on climate zone but rather on employing effective use of low-carbon fuels. As such and for simplicity, we have proposed a single set of targets for all climate zones.
- Buildings which fully decarbonize would meet the currently proposed zero carbon ready targets. None would meet the initially proposed target of 1 $kgCO_2e/m^2/year$; significant TEUI savings (up to 50% below Step 2 and nearly 40% below Step 4), or use of renewable energy generation such as PV or wind power would be required if a target of 1 was set. This generally holds true in archetype modelling though the office archetype does show some high-efficiency options that would meet a GHGI of 1. All other archetypes do not.
- Office archetype modelling showed several instances of designs with high-carbon backup heating falling into the zero-carbon ready targets, and was therefore reduced to 1.5 rather than matching other archetypes. Other archetypes may show similar outcomes in some cases but may have difficulty meeting 1.5 in colder climate zones and have been left as-is.

Impact of Steps

- This analysis also shows the generalized impact of increasing the Step on decarbonization.
- Targeted decarbonization measures have significantly greater impact on GHG savings, compared with much smaller impact from TEUI/TEDI Steps. When increasing Steps without employing targeted decarbonization measures, the carbon savings range from 12% - 30%. The use of decarbonization measures within the same energy Step is in the range of 76% - 92%.
- While moving to a higher energy Step for a particular project may assist in meeting thresholds where they are close, it is not expected to typically be the major driving factor of decarbonization measures selected or the number of decarbonization measures required.

Relationship between energy efficiency and decarbonization

Legend:
Medium
Low
Zero-Carbon Ready

GHGI (kgCO2e/m2/year)	Climate Zone	Step	DHW + Heat High Carbon Fuel	Heat Decarb	DHW Decarb	Fully Decarb
Office	4 - 7a	2	9.1	3.6	6.9	1.4
		3	6.9	3.2	4.8	1.1
Retail	4	2	7.8	2.3	7.4	1.9
		3	5.5	1.8	5.0	1.3
	5	2	7.8	2.3	7.4	1.9
		3	6.4	1.8	6.0	1.4
	6	2	10.6	2.3	10.1	1.9
		3	7.4	1.9	6.9	1.4
	7a	2	12.6	2.6	12.2	2.1
		3	9.4	2.1	9.0	1.7
Hotel/ Motel	4	2	20.7	15.2	7.4	1.9
		3	18.5	14.8	5.2	1.5
		4	17.4	14.6	4.1	1.3
	5	2	20.7	15.2	7.4	1.9
		3	18.7	14.9	5.4	1.6
		4	17.7	14.7	4.4	1.4
	6	2	20.7	15.2	7.4	1.9
		3	19.5	14.9	6.2	1.6
		4	18.0	14.7	4.7	1.4
	7a	2	21.0	15.2	7.7	1.9
		3	20.1	14.9	6.8	1.7
		4	18.5	14.9	5.3	1.6

GHGI (kgCO2e/m2/year)	Climate Zone	Step	DHW + Heat High Carbon Fuel	Heat Decarb	DHW Decarb	Fully Decarb
Other Residential (Part 3)	4	2	15.4	7.1	9.7	1.4
		3	12.5	7.0	6.8	1.3
		4	9.5	6.8	3.8	1.1
	5	2	15.4	7.1	9.7	1.4
		3	13.4	7.0	7.7	1.3
		4	10.9	6.9	5.2	1.2
	6	2	16.3	7.2	10.6	1.5
		3	13.4	7.0	7.7	1.3
		4	10.9	6.9	5.2	1.2
	7a	2	17.2	7.2	11.6	1.5
		3	14.3	7.0	8.6	1.3
		4	10.9	6.9	5.2	1.2
	7b	2	18.3	7.3	12.6	1.7
		3	16.4	7.2	10.7	1.5
		4	13.5	7.1	7.8	1.4
	8	2	24.1	7.7	18.5	2.0
		3	21.2	7.4	15.5	1.8
		4	18.2	7.2	12.5	1.5

Renewable natural gas analysis

Using renewable natural gas (RNG) can lower the carbon emissions of a building compared to conventional natural gas. However, there is no mechanism available at the time of publishing (August 2022) to ensure low-carbon energy will be used for the life of the building.

As of August 2022, a proposal from FortisBC to introduce RNG at scale is before the BC Utilities Commission (or BCUC), an independent agency of the provincial government responsible for regulating British Columbia's energy utilities. The BCUC has not issued a decision on the proposal yet.

If an agreement existed to use RNG for the life of the building, regardless of a change in owner or ratepayer, that could potentially assure the Authority Having Jurisdiction that the building would reliably meet a Level of the Building Carbon Pollution Standard.

However, to illustrate a potential future state, this document includes an analysis illustrating the potential blend of renewable gas (RNG) required to achieve the same stepped GHGI targets if all-gas equipment were used.

The annual modelled utility cost of RNG assumes an unlimited supply and is based on rates accurate at the time of publishing.

The archetype examples below focus primarily on electrification decarbonization measures; the energy and cost implications for electrification measures are more complex and require significant analysis to understand.

Renewable natural gas (RNG) decarbonization measures are much simpler from an analysis perspective:

- Use of RNG does not require changes to natural gas baseline equipment and therefore do not incur incremental capital costs.
- Utility cost of RNG in the analysis ends up cost neutral with natural gas once escalating carbon taxes over a 20-year period are accounted for (see assumptions above for more detail.)
- Thus, RNG becomes a simple 1:1 substitution for the modeled base case, which is typically natural gas.
- The main issue considered is therefore what blend of RNG, as a percentage of total natural gas, would be sufficient to meet GHG targets? This is shown in the table below.

The percentage of RNG required to meet targets is shown as a range because it will typically depend on the climate zone, with warmer climate zones requiring a lower percentage and colder climate zones requiring a higher percentage. The percentage required will vary with project specifics and design; for example, a design that reduces natural gas heating loads would require a lower percentage of RNG. The below should be considered as a non-exhaustive example only. The below uses Step 2 as a base case.

Archetype	% RNG to meet Medium GHG Target	% RNG to meet Low GHG Target	% RNG to meet Zero-Carbon Ready GHG Target
MURB (high and low rise)	50% - 70%	75% - 85%	90% – 95%
Office	50%	75%	95%
Retail	30% - 60%	75% - 85%	90% – 95%
Hotel	60%	85% - 90%	95% - 97%

Examples of archetypes

The tables below contain examples of modeled greenhouse gas emissions for a particular archetype, location, and set of design measures. The "base case" within the table uses a high-carbon fuel and approximately Step 2 design measures (envelope, heat recovery) to set an initial baseline prior to decarbonization. Decarbonization measures are then applied to heating and domestic hot water, separately and in combination. This is not an exhaustive list of options to meet targets but is meant to demonstrate a few example points, with key metrics including incremental capital cost, utility cost, and the GHG target level achieved.

Targets Achieved

- Each archetype shows at least one fully decarbonized, zero carbon ready option.
- Designs using one decarbonization measure generally meet medium targets, as expected. In some cases a particular measure (either heating or DHW) must be used.
- Designs using high-carbon backup heating fuel generally achieve the Low target, as expected. There are some cases where they meet either Medium or Zero Carbon ready; these targets fall into a narrow range with some overlap.

Cost Impacts

- Costs for decarbonization remain within 2.5% for all archetypes modelled, to reach Zero-carbon Ready.
- The cost difference between decarbonization measures for Climate Zone 7a versus 4 is consistently between 0.2% - 0.3% across all archetypes considered. This is further discussed below but suggests a bookending approach to Part 3 decarbonization cost considerations and modelling is appropriate.

Mixed Use Buildings

Mixed use buildings have not been modeled within these data sheets; it is anticipated that they would follow the procedure outlined in the City of Vancouver Energy Modelling Guidelines

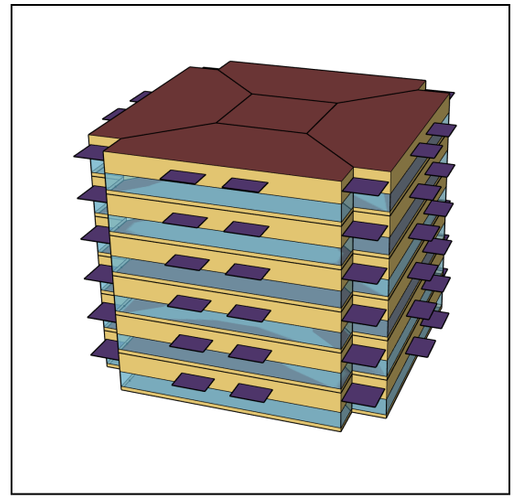
Impact of Steps

A Step 2 base case is shown for all archetypes below. The MURBs and office show analysis for all steps. Due to time constraints, upper Steps have not been analysed for the retail and hotel archetypes. The generalized analysis above demonstrates that archetypes for all climate zones can achieve all targets.

- Achieving a higher Step will reduce annual heating loads (TEDI) as well as overall energy (TEUI). This would lead to carbon reductions, particularly if the heating is supplied by a high-carbon fuel.
- However, efficiency improvements are not a substitute for targeted decarbonization measures. While projects are likely to employ both in combination to some extent, decarbonization measures and targets require over 30% reductions in carbon between levels, and in many cases greater reductions from typical design to even the Medium target. 30% or greater reduction in energy use beyond Step 2 is significant and would require substantial design interventions (this would mean reducing EUI from Step 2 to somewhat below Step 4.) On the other hand, employing the use of targeted decarbonization measures such as RNG or electrification can readily achieve those levels.
- As such, the below archetype analysis focusses on targeted decarbonization measures, including RNG and electrification measures.
- However, significant impacts for a design employing a higher Step would include:
    - Reduced operating costs (via a reduction in load).
    - Potential for reduced equipment size
- The below table provides the average incremental capital cost (ICC), for the 10 lowest ICC options for each archetype, Step, and climate zone, prior to applying any decarbonization measures. This can be considered along with the decarbonization costs in the data tables below.

	Lowest ICC Options for each Step prior to decarbonization						
	Step	CZ4	CZ5	CZ6	CZ7a	CZ7b	CZ8
Hotel	1	0%	0.3%	0.5%	0.1%	0.2%	-4.4%
	2	0.5%	0.8%	1.8%	1.8%	3.3%	5.6%
	3	2.6%	1.3%	3.9%	3.8%	7%	11.4%
	4	N/A	7.3%	9.1%	6.1%	12.1%	N/A
High-rise MURB	1	-0.4%	-0.4%	-0.3%	-0.1%	Not run	Not run
	2	-0.3%	0.3%	0.8%	1.3%	Not run	Not run
	3	0.3%	0.4%	2.6%	4.4%	Not run	Not run
	4	1.8%	2%	10%	12.5%	Not run	Not run
Low-rise MURB	1	-0.4%	-0.4%	-0.3%	-0.2%	0	-0.6
	2	-0.4%	0.2%	0.5%	0.3%	0.7	0.3
	3	0.2%	0.2%	1.2%	1.6%	2.8	1.9
	4	1.1%	1%	3.2%	5.5%	6.8	4
Office	1	-1.9%	-2.3%	-2.4%	-1.8%	Not run	Not run
	2	-2.4%	-2.3%	-2.1%	-0.2%	Not run	Not run
	3	-2.4%	-2.1%	-1.4%	1.3%	Not run	Not run
Retail	1	-8.8%	-10%	-10.5%	-6.4%	Not run	Not run
	2	-9.1%	-9.5%	-9.3%	-6.6%	Not run	Not run
	3	-8.9%	-9.4%	-8.7%	-6%	Not run	Not run

Low-rise multi-unit residential building (MURB) archetype



Base case

- 100% conventional natural gas (to isolate changes and costs related to carbon requirements)
- Vertical surface area to floor area ratio (VFAR): 0.6
- Medium density (approx. 55m^2 average unit size)
- Cooling equipment: Packaged terminal air conditioner (PTAC) units in suites, or fan coils if heating system is FC.

In some cases, energy costs shown for ASHP cases are higher than those shown for electric baseboard cases. Savings are expected due to better heating efficiency in the ASHP case. However, the base model for the ASHP case includes conservative (NECB baseline) fan power which increases utility costs for this case. In design scenarios using improved fan designs utility cost savings would be anticipated.

Step	ECM	Climate Zone 4	Climate Zone 5	Climate Zone 6	Climate Zone 7a	Climate Zone 7b	Climate Zone 8
Base Case: Step 2	Walls	R-7	R-10	R-10	R-10	R-20	R-20
	Roof	R-40	R-40	R-40	R-40	R-40	R-40
	WWR	40%	40%	40%	20%	20%	20%
	Windows	USI 2.0	USI 1.6	USI 1.2	USI 1.2	USI 1.2	USI 1.6
	SHGC	0.3	0.3	0.3	0.3	0.3	0.3
	Infiltration	No savings beyond code	50% savings vs code	50% savings vs code	50% savings vs code	50% savings vs code	50% savings vs code
	HRV	60%	60%	80%	80%	80%	80%
Step 3	Walls	R-10	R-20	R-20	R-20	R-20	R-20
	Roof	R-40	R-40	R-40	R-40	R-40	R-40
	WWR	40%	40%	40%	40%	40%	20%
	Windows	USI 1.6	USI 1.6	USI 1.2	USI 0.8	USI 0.8	USI 1.2
	SHGC	0.3	0.3	0.3	0.3	0.3	0.3
	Infiltration	50% savings vs code	50% savings vs code	50% savings vs code	Passive house level	50% savings vs code	50% savings vs code
	HRV	60%	60%	80%	80%	80%	80%

Step	ECM	Climate Zone 4	Climate Zone 5	Climate Zone 6	Climate Zone 7a	Climate Zone 7b	Climate Zone 8
Step 4	Walls	R-20	R-20	R-20	R-40	R-20	R-20
	Roof	R-40	R-40	R-40	R-40	R-40	R-40
	WWR	40%	40%	20%	20%	20%	20%
	Windows	USI 1.2	USI 1.2	USI 0.8	USI 0.8	USI 0.8	USI 0.8
	SHGC	0.3	0.3	0.3	0.3	0.3	0.3
	Infiltration	50% savings vs code	50% savings vs code	50% savings vs code	Passive house level	Passive house level	Passive house level
	HRV	80%	80%	80%	80%	80%	80%

Low-Rise MURB data tables: Climate Zone 4

	Step 2						Step 3						Step 4					
	None >7 kgCO2e/m2/yr		Medium 7 kgCO2e/m2/yr	Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr	
	A	B			A	B		A	B		A	B		A	B		B	C
Space heating equipment																		
Gas condensing boiler with fan coils	●	●					●	●					●			●		
Electric baseboard			●		●				●		●				●		●	
Air-source heat pump; 30% natural gas backup				●						●				●				●
Air-source heat pump; no natural gas backup						●						●						
Water heating equipment [1]																		
High efficiency gas (95%)	●	●	●				●		●				●	●	●			
Electric resistance				●	●	●		●		●	●	●				●	●	●
Cost and performance data																		
Actual modelled GHGI	12.9	7.8	6.4	2.3	1.3	1.2	9.8	4.7	6.2	2.2	1.2	1.2	7	6.4	6.0	1.9	1.0	1.4
Annual modelled utility cost ($/m^2)	10.2	10.8	9.9	10	10.4	10.8	9.3	9.9	8.5	9.5	9.1	9.3	8.5	8.4	7.3	9.1	7.8	9.1
Total ICC vs. base case ($/m^2)	0	0	-3.4	42.4	-3.4	70.4	0	0	−3.4	42.4	-3.4	70.2	0	42.4	-3.4	0	-3.4	42.4
% ICC vs base case	0.0%	0.0%	-0.1%	1.4%	-0.1%	2.2%	0	0.0%	−0.1%	1.3%	-0.1%	2.2%	0.0%	1.4%	-0.1%	0.0%	-0.1%	1.4%
Net present value	N/A	-12	9.4	-38.4	-0.6	-82.4	Not calculated											

[1] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Low-Rise MURB data tables: Climate Zone 5

	Step 2						Step 3						Step 4					
	None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready	
	>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr	
		A	B		A	B		A	B		A	B		A	B		A	B
Space heating equipment																		
Gas condensing boiler with fan coils	●	●					●	●					●			●	●	
Electric baseboard			●		●				●		●				●			●
Air-source heat pump; 30% natural gas backup				●						●				●				
Air-source heat pump; no natural gas backup						●						●						
Water heating equipment [2]																		
High efficiency gas (95%)	●		●				●		●				●	●	●			
Electric resistance		●		●	●	●		●		●	●	●				●	●	●
Cost and performance data																		
Actual modelled GHGI	11.6	6.6	6.4	2.9	1.3	1.3	10.4	5.4	6.3	2.5	1.2	1.3	8.1	6.8	6.2	3	1.1	1.8
Annual modelled utility cost ($/m^2)	10.5	11.1	9.7	10.5	10.2	10.2	10	10.6	9.1	10.2	9.7	9.9	9.4	9.1	8.1	10	8.7	9.9
Total ICC vs. base case ($/m^2)	0	0	−3.2	40.3	−3.2	66.7	0	0	−3.1	40.3	−3.1	66.8	0	40.3	−3.2	0	−3.2	40.3
% ICC vs base case	0.0%	0.0%	−0.1%	1.3%	−0.1%	2.1%	0	0.0%	−0.1%	1.3%	−0.1%	2.1%	0.0%	1.2%	−0.1%	0.0%	−0.1%	1.2%
Net present value	11.6	6.6	6.4	2.9	1.3	1.3	Not calculated											

[2] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Low-Rise MURB data tables: Climate Zone 6

	Step 2						Step 3						Step 4					
	None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready	
	>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr	
		A	B		A	B		A	B		A	B		A	B		A	B
Space heating equipment																		
Gas condensing boiler with fan coils	●	●					●	●					●			●		
Electric baseboard			●		●				●		●				●		●	
Air-source heat pump; 30% natural gas backup				●						●				●				●
Air-source heat pump; no natural gas backup						●						●						
Water heating equipment [3]																		
High efficiency gas (95%)	●		●				●		●				●	●	●			
Electric resistance		●		●	●	●		●		●	●	●				●	●	●
Cost and performance data																		
Actual modelled GHGI	11	6	6.4	2.7	1.3	1.3	9.5	4.4	6.3	2.2	1.2	1.3	7.6	6.6	6.1	2.5	1.1	1.6
Annual modelled utility cost ($/m^2)	10.5	11.1	9.7	10.6	10.3	10.3	10	10.6	9	10.3	9.6	10.1	8.7	8.6	7.9	9.3	8.5	9.3
Total ICC vs. base case ($/m^2)	0	0	28.3	48.8	28.3	80.8	0	0	28.2	48.7	28.2	80.8	0	48.8	28.3	0	28.3	48.8
% ICC vs base case	0.0%	0.0%	0.9%	1.5%	0.9%	2.5%	0	0.0%	0.9%	1.5%	0.9%	2.5%	0.0%	1.5%	0.8%	0.0%	0.8%	1.5%
Net present value	Not calculated						Not calculated											

[3] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Low-Rise MURB data tables: Climate Zone 7a

	Step 2						Step 3							Step 4				
	None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr			Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr	
		A	B		A	B		A	B	C		A	B		A	B		A	B
Space heating equipment																			
Gas condensing boiler with fan coils	●	●					●			●				All modeled options meet targets	●				
Electric baseboard			●		●				●			●				●		●	
Air-source heat pump; 30% natural gas backup				●				●											●
Air-source heat pump; no natural gas backup						●							●						
Water heating equipment [4]																			
High efficiency gas (95%)	●		●				●	●	●						●	●			
Electric resistance		●		●	●	●				●		●	●					●	●
Cost and performance data																			
Actual modelled GHGI	12.6	7.5	6.5	2.1	1.4	1.4	8.1	6.6	6.3	3.1		1.2	1.4		6.7	6.1		1.1	1.3
Annual modelled utility cost ($/m^2)	11	11.6	10.7	10.9	11.3	10.7	10.6	10.2	9.1	11		9.7	10.9		9.2	8.1		8.6	9.8
Total ICC vs. base case ($/m^2)	0	0	-3.8	48.8	-3.8	80.8	0	48.8	-3.8	0		-3.8	80.8		0	-3.9		-3.9	48.7
% ICC vs base case	0.0%	0.0%	-0.1%	1.5%	-0.1%	2.5%	0.0%	1.5%	-0.1%	0.0%		-0.1%	2.5%		0.0%	-0.1%		-0.1%	1.5%
Net present value	N/A	-12	9.8	-46.8	-2.2	-74.8		Not calculated											

[4] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Low-Rise MURB data tables: Climate Zone 7b

	Step 2						Step 3						Step 4					
	None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready	
	>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr	
		A	B		A	B		A	B		A	B		A	B		A	B
Space heating equipment																		
Gas condensing boiler with fan coils	●	●					●		●				●					
Electric baseboard			●		●			●			●				●		●	
Air-source heat pump; 30% natural gas backup				●						●				●		●		
Air-source heat pump; no natural gas backup						●						●						●
Water heating equipment [5]																		
High efficiency gas (95%)	●		●				●	●					●	●	●			
Electric resistance		●		●	●	●			●	●	●	●				●	●	●
Cost and performance data																		
Actual modelled GHGI	11.5	6.4	6.5	2.9	1.5	1.5	10.3	6.4	5.2	2.6	1.4	1.4	8.4	7	5	2	1.2	1.4
Annual modelled utility cost ($/m^2)	11.3	11.9	10.9	11.6	11.4	11.4	11	10.4	11.6	11.4	11	11.2	10.5	10.3	9.1	11	9.6	10.9
Total ICC vs. base case ($/m^2)	0	0	4.8	63.7	4.8	105.5	0	17.4	0	63.7	17.4	105.5	0	63.7	23	63.7	23	105.5
% ICC vs base case	0.0%	0.0%	0.2%	2.0%	0.2%	3.3%	0.0%	0.5%	0.0%	2.0%	0.5%	3.3%	0.0%	1.9%	0.7%	1.9%	0.7%	3.3%
Net present value	Not calculated						Not calculated											

[5] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Low-Rise MURB data tables: Climate Zone 8

	Step 2						Step 3							Step 4					
	None	Medium		Low	Zero-Carbon Ready		None		Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready	
	>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr		7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr	
		A	B		A	B	A	B	A	B		A	B		A	B		A	B
Space heating equipment																			
Gas condensing boiler with fan coils	●						●	●						●	●				
Electric baseboard		●			●				●			●				●		●	
Air-source heat pump; 30% natural gas backup			●							●							●		
Air-source heat pump; no natural gas backup						●							●						●
Water heating equipment [6]																			
High efficiency gas (95%)	●	●					●		●					●		●			
Electric resistance			●		●	●		●		●		●	●		●		●	●	●
Cost and performance data																			
Actual modelled GHGI	15.1	6.8	4.2		1.7	1.7	13.6	8.5	6.7	3.7		1.7	1.6	9.6	7.5	6.5	2.4	1.5	1.5
Annual modelled utility cost ($/m^2)	13.2	13.1	13.8		13.7	13.8	12.8	13.4	12.5	13.3		13.1	13.3	11.6	11.3	10.8	12.2	11.4	12.2
Total ICC vs. base case ($/m^2)	0	-5	63.7		-5	105.6	0	0	−5	63.7		−5	105.6	0	63.7	−5.0	63.7	−5.0	105.5
% ICC vs base case	0.0%	-0.2%	2.0%		-0.2%	3.3%	0	0	−0.2%	2.0%		−0.2%	3.3%	0	1.9%	−0.20%	1.9%	−0.2%	3.2%
Net present value	N/A	-37	-119.7		-49	-161.6				Not calculated									

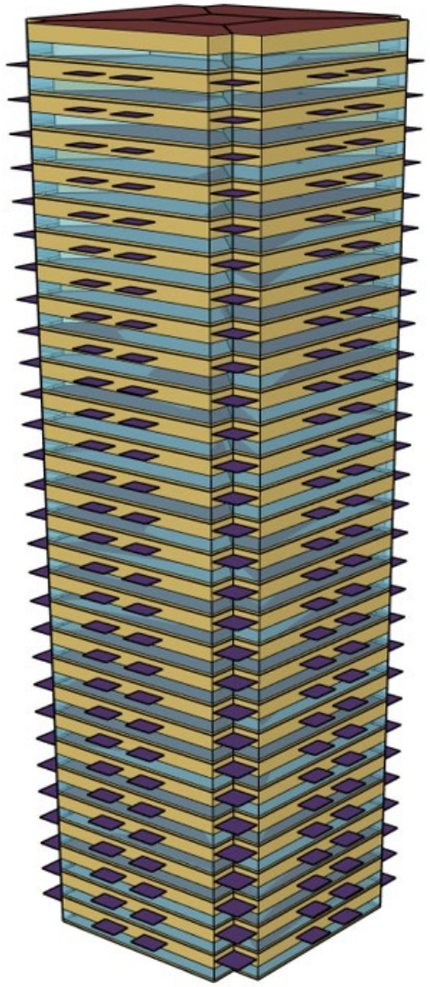
[6] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

High-rise multi-unit residential building (MURB) archetype

Base case

- 100% conventional natural gas (to isolate changes and costs related to carbon requirements)
- Vertical surface area to floor area ratio (VFAR): 0.6
- Medium density (approx. 55m^2 average unit size)
- Cooling equipment: Packaged terminal air conditioner (PTAC) units in suites, or fan coils if heating system is FC

In some cases, energy costs shown for ASHP cases are higher than those shown for electric baseboard cases. Savings are expected due to better heating efficiency in the ASHP case. However, the base model for the ASHP case includes conservative (NECB baseline) fan power which increases utility costs for this case. In design scenarios using improved fan designs utility cost savings would be anticipated.



Step	ECM	Climate Zone 4	Climate Zone 5	Climate Zone 6	Climate Zone 7a	Climate Zone 7b	Climate Zone 8
Base Case: Step 2	Walls	R-7	R-10	R-10	R-10	R-20	R-20
	Roof	R-40	R-40	R-40	R-40	R-40	R-40
	WWR	40%	40%	40%	20%	20%	20%
	Windows	USI 2.0	USI 1.6	USI 1.2	USI 1.2	USI 1.2	USI 1.6
	SHGC	0.3	0.3	0.3	0.3	0.3	0.3
	Infiltration	No savings beyond code	50% savings vs code	50% savings vs code	50% savings vs code	50% savings vs code	50% savings vs code
	HRV	60%	60%	80%	80%	80%	80%
Step 3	Walls	R-10	R-20	R-20	R-20	R-20	R-20
	Roof	R-40	R-40	R-40	R-40	R-40	R-40
	WWR	40%	40%	40%	40%	40%	20%
	Windows	USI 1.6	USI 1.6	USI 1.2	USI 0.8	USI 0.8	USI 1.2
	SHGC	0.3	0.3	0.3	0.3	0.3	0.3
	Infiltration	50% savings vs code	50% savings vs code	50% savings vs code	Passive house level	50% savings vs code	50% savings vs code
	HRV	60%	60%	80%	80%	80%	80%

Step	ECM	Climate Zone 4	Climate Zone 5	Climate Zone 6	Climate Zone 7a	Climate Zone 7b	Climate Zone 8
Step 4	Walls	R-20	R-20	R-20	R-40	R-20	R-20
	Roof	R-40	R-40	R-40	R-40	R-40	R-40
	WWR	40%	40%	20%	20%	20%	20%
	Windows	USI 1.2	USI 1.2	USI 0.8	USI 0.8	USI 0.8	USI 0.8
	SHGC	0.3	0.3	0.3	0.3	0.3	0.3
	Infiltration	50% savings vs code	50% savings vs code	50% savings vs code	Passive house level	Passive house level	Passive house level
	HRV	80%	80%	80%	80%	80%	80%

High-rise MURB data tables: Climate Zone 4

	Step 2							Step 3							Step 4						
	None >7 kgCO2e/m2/yr		Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr			Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr	
	A	B	A	B		A	B		A	B		A	B		A	B	C		A	B
Space heating equipment																					
Gas condensing boiler with fan coils	●	●						●	●							●			●		
Electric baseboard			●			●				●		●						●		●	
Air-source heat pump; 30% natural gas backup				●							●						●				●
Air-source heat pump; no natural gas backup							●						●								
Water heating equipment [7]																					
High efficiency gas (95%)	●		●					●								●	●	●			
Electric resistance		●		●		●	●		●		●	●	●						●	●	●
Cost and performance data																					
Actual modelled GHGI	11.7	7.8	7.8	3.2		1.3	1.2	9.8	4.7	6.2	2.2	1.2	1.2		7	6.4	6.0	1.9	1.0	1.4	
Annual modelled utility cost ($/m^2)	10.2	10.8	10.8	9.9		10.4	9.5	9.3	9.9	8.5	9.5	9.1	9.3		8.5	8.4	7.3	9.1	7.8	9.1	
Total ICC vs. base case ($/m^2)	0	0	0	42		−3	65	0	0	−3.3	42.4	−3.3	70.3		0	42.4	−3.3	0	−3.3	42.4	
% ICC vs base case	0.0%	0.0%	0.0%	1.4%		−0.1%	2.1%	0.0%	0.0%	−0.1%	1.3%	−0.1%	2.2%		0.0%	1.4%	−0.1%	0.0%	−0.1%	1.4%	
Net present value	N/A	−12	−12	−36		−1	−51	Not calculated													

[7] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

High-rise MURB data tables: Climate Zone 5

	Step 2						Step 3						Step 4					
	None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready	
	>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr	
		A	B		A	B		A	B		A	B		A	B		A	B
Space heating equipment																		
Gas condensing boiler with fan coils	●	●					●	●					●			●		
Electric baseboard			●		●				●		●				●		●	
Air-source heat pump; 30% natural gas backup				●						●				●				●
Air-source heat pump; no natural gas backup						●						●						
Water heating equipment [8]																		
High efficiency gas (95%)	●		●				●		●				●	●	●			
Electric resistance		●		●	●	●		●		●	●	●				●	●	●
Cost and performance data																		
Actual modelled GHGI	11.5	6.6	6.4	2.9	1.3	1.3	10.4	5.4	6.3	2.5	1.2	1.3	8.1	6.8	6.2	3	1.1	1.8
Annual modelled utility cost ($/m^2)	10.5	11.1	9.7	10.5	10.2	10.2	10	10.6	9.1	10.2	9.7	9.9	9.4	9.1	8.1	10	8.7	9.9
Total ICC vs. base case ($/m^2)	0	0	−3.2	40.3	−3.2	66.7	0	0	−3.2	40.3	−3.2	66.7	0	40.3	−3.1	0	−3.1	66.8
% ICC vs base case	0.0%	0.0%	−0.1%	1.2%	−0.1%	2.1%	0	0.0%	−0.1%	1.2%	−0.1%	2.1%	0.0%	1.3%	−0.1%	0.0%	−0.1%	2.1%
Net present value	Not calculated						Not calculated											

[8] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

High-rise MURB data tables: Climate Zone 6

	Step 2						Step 3						Step 4					
	None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready		None	Medium		Low	Zero-Carbon Ready	
	>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr		>7 kgCO2e/m2/yr	7 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.8 kgCO2e/m2/yr	
		A	B		A	B		A	B		A	B		A	B		A	B
Space heating equipment																		
Gas condensing boiler with fan coils	●	●					●	●					●			●		
Electric baseboard			●		●				●		●				●		●	
Air-source heat pump; 30% natural gas backup				●						●				●				●
Air-source heat pump; no natural gas backup						●						●						
Water heating equipment [9]																		
High efficiency gas (95%)	●		●				●		●				●	●	●			
Electric resistance		●		●	●	●		●		●	●	●				●	●	●
Cost and performance data																		
Actual modelled GHGI	11	6	6.4	2.7	1.3	1.3	9.5	4.4	6.3	2.2	1.2	1.3	7.6	6.6	6.1	2.5	1.1	1.6
Annual modelled utility cost ($/m^2)	10.5	11.1	9.7	10.6	10.3	10.3	10	10.6	9	10.3	9.6	10.1	8.7	8.6	7.9	9.3	8.5	9.3
Total ICC vs. base case ($/m^2)	0	0	−3.8	48.8	−3.8	80.9	0	0	−3.8	48.8	−3.8	80.8	0	48.8	−3.8	0	−3.8	48.8
% ICC vs base case	0.0%	0.0%	−0.1%	1.5%	−0.1%	2.5%	0	0.0%	−0.1%	1.5%	−0.1%	2.5%	0.0%	1.5%	−0.1%	0.0%	−0.1%	1.5%
Net present value	Not calculated						Not calculated											

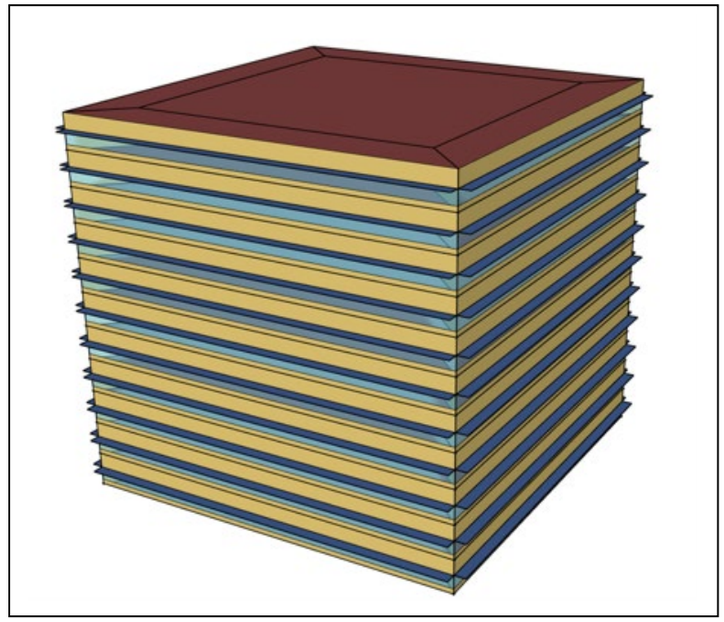
[9] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

High-rise MURB data tables: Climate Zone 7a

	Step 2							Step 3							Step 4					
	None >7 kgCO2e/m2/yr		Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr			Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr		None >7 kgCO2e/m2/yr	Medium 7 kgCO2e/m2/yr		Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 1.8 kgCO2e/m2/yr	
			A	B		A	B		A	B	C		A	B		A	B		A	B
Space heating equipment																				
Gas condensing boiler with fan coils	●	●						●			●				All modeled options meet targets	●				
Electric baseboard			●			●				●			●				●		●	
Air-source heat pump; 30% natural gas backup				●					●											●
Air-source heat pump; no natural gas backup							●							●						
Water heating equipment [10]																				
High efficiency gas (95%)	●		●					●	●	●						●	●			
Electric resistance		●		●		●	●				●		●	●					●	●
Cost and performance data																				
Actual modelled GHGI	12.6	7.5	6.5	3.2		1.4	1.4	8.1	6.6	6.3	3.1		1.2	1.4		6.7	6.1		1.1	1.3
Annual modelled utility cost ($/m^2)	11	11.6	10.7	10.9		11.3	10.7	10.6	10.2	9.1	11		9.7	10.9		9.2	8.1		8.6	9.8
Total ICC vs. base case ($/m^2)	0	0	-3.8	49		-3.8	80.8	0	48.8	-43.6	0		-43.6	80.8		0	-3.8		-3.8	80.8
% ICC vs base case	0.0%	0.0%	-0.1%	1.5%		-0.1%	2.5%	0.0%	2.5%	-0.3%	0.0%		-0.3%	3.5%		0.0%	-0.1%		-0.1%	2.5%
Net present value	N/A	-12	9.8	-47		-2.2	-74.8		Not calculated											

[10] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Office Archetype



Base case

- 25% lighting savings
- 100% conventional natural gas (this will help isolate changes and costs related to carbon requirements)

Base Case	Climate Zone 4	Climate Zone 7a
Step 2	Walls R-7 Roof R-40 WWR 50% Window USI 2.0 SHGC 0.3 Infiltration: No savings beyond code 60% HRV	Walls R-20 Roof R-20 WWR 30% Window USI 1.2 SHGC 0.3 Infiltration: half of code level 80% HRV
Step 3	Walls R-20 Roof R-20 WWR 30% Window USI 1.2 SHGC 0.3 Infiltration: No savings beyond code 80% HRV	Walls R-20 Roof R-20 WWR 30% Window USI 0.8 SHGC 0.3 Infiltration: half of code level 80% HRV

Highlights from analysis

- DHW is fairly low for this archetype; larger focus on space heating.
- DHW heat pumps were not modeled but could be used; GHGI outcomes would typically be similar to electric resistance DHW heating, though the addition of a DHW heat pump in a conditioned space can increase heating loads and may impact overall GHGI depending on space heating fuel source. Project-specific modelling should be used to confirm impacts.

Office data tables, Climate Zone 4

	Step 2					Step 3				
	None	Medium		Low	Zero-Carbon Ready	None	Medium		Low	Zero-Carbon Ready
	>5 kgCO2e/m2/yr	5 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.5 kgCO2e/m2/yr	>5 kgCO2e/m2/yr	5 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.5 kgCO2e/m2/yr
		A	B				A	B		
Space heating equipment										
Gas condensing boiler with fan coils	●	●					●		●	
Air-source heat pump; 30% natural gas backup			●	●		All modeled options meet targets		●		●
Air-source heat pump; no natural gas backup					●					
Water heating equipment [11]										
High efficiency gas (95%)	●		●				●	●		
Electric resistance		●		●	●				●	●
Cost and performance data										
Actual modelled GHGI	6	4.2	4	1.9	0.9		4.3	3.3	2.1	1.2
Annual modelled utility cost ($/m^2)	7.7	7.8	7.3	7.3	7		6.7	6.3	6.5	6.3
Total ICC vs. base case ($/m^2)	0	0	42	42	65		0	85.2	20.5	85.2
% ICC vs base case	0.0%	0.0%	1.4%	1.4%	2.1%		0.0%	2.7%	0.6%	2.7%
Net present value	N/A	-2	-34	-34	-51					

[11] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Office data tables, Climate Zone 7a

	Step 2					Step 3				
	None	Medium		Low	Zero-Carbon Ready	None	Medium		Low	Zero-Carbon Ready
	>5 kgCO2e/m2/yr	5 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.5 kgCO2e/m2/yr	>5 kgCO2e/m2/yr	5 kgCO2e/m2/yr		3 kgCO2e/m2/yr	1.5 kgCO2e/m2/yr
		A	B				A	B		
Space heating equipment										
Gas condensing boiler with fan coils	●	●				All modeled options meet targets	●		●	
Air-source heat pump; 30% natural gas backup			●	●				●		●
Air-source heat pump; no natural gas backup					●					
Water heating equipment [12]										
High efficiency gas (95%)	●		●				●	●		
Electric resistance		●		●	●				●	●
Cost and performance data										
Actual modelled GHGI	5.9	4.1	3.9	1.8	0.8		5.2	3.7	1.6	0.8
Annual modelled utility cost ($/m^2)	8.6	8.6	8.2	8.2	8		8.4	8.1	8.1	7.9
Total ICC vs. base case ($/m^2)	0	0	49	49	75		0	48.7	48.7	74.4
% ICC vs base case	0.0%	0.0%	1.6%	1.6%	2.4%		0.0%	1.6%	1.6%	2.4%
Net present value	N/A	0	-41	-41	-63					

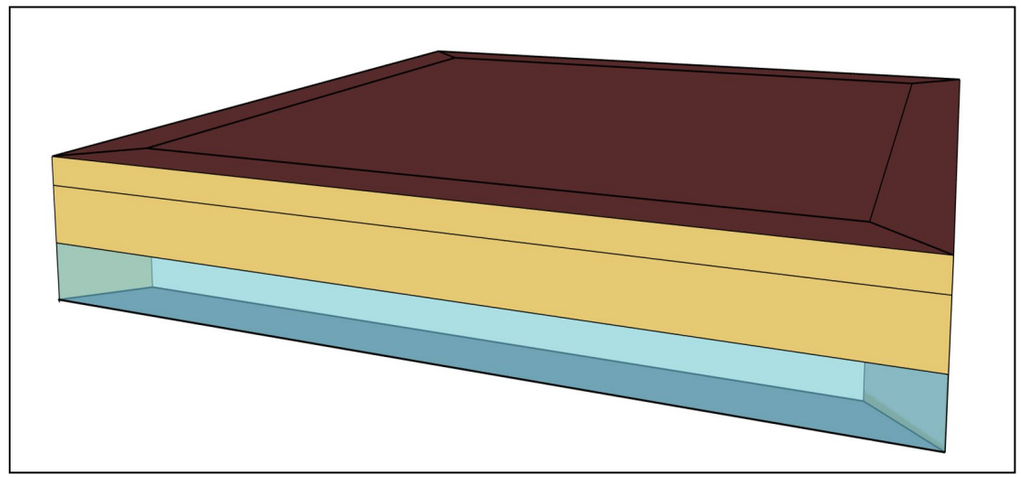
[12] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Retail Archetype

Base case

- 100% conventional natural gas (to isolate changes and costs related to carbon requirements)
- 25% lighting savings vs NECB 2015
- Looking at Mall results rather than big box, as mall has higher GHGI.

Base Case	Climate Zone 4	Climate Zone 7a
Step 2	Walls R-10 Roof R-40 WWR 20% Window USI 2.0 Infiltration: No savings beyond code 60% HRV	Walls R-20 Roof R-40 WWR 20% Window USI 1.6 Infiltration: half of code level 80% HRV



Highlights from analysis

- Due to time constraints, analysis of Step 3 has not been completed, only Step 2. If the envelope were Step 3 (highest step for this building type), annual operational costs would be very similar.
- GHGIs depend on space mix/archetype.
    - GHGIs are higher in malls than in big box stores (used malls in the table, difference on base case fully natural gas is approx. 1.7 GHGI; difference becomes negligible in lowest GHG cases)
- DHW is relatively low for this archetype; larger focus on space heating.
- DHW heat pumps were not modeled but could be used; GHGI outcomes would typically be similar to electric resistance DHW heating, though the addition of a DHW heat pump in a conditioned space can increase heating loads and may impact overall GHGI depending on space heating fuel source. Project-specific modelling should be used to confirm impacts.

Retail data tables

Climate Zone 4

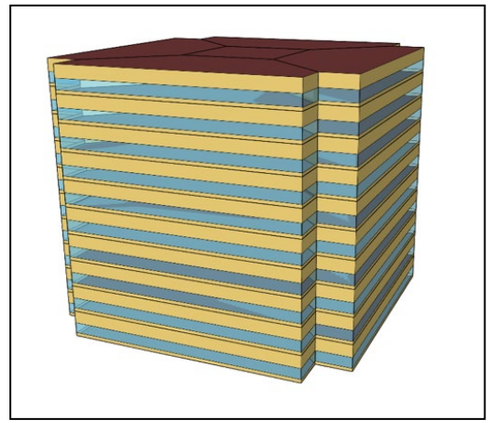
	Step 2			
	None >6 kgCO2e/m2/yr	Medium 6 kgCO2e/m2/yr	Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 2 kgCO2e/m2/yr
Space heating equipment				
Gas condensing boiler with fan coils	●	●		
Air-source heat pump; 10% natural gas backup			●	●
Water heating equipment [14]				
High efficiency gas (95%)	●		●	
Electric resistance		●		●
Cost and performance data				
Actual modelled GHGI	6.6	5.8	2.1	1.3
Annual modelled utility cost ($/m^2)	1.8	1.9	1.9	2
Total ICC vs. base case ($/m^2)	0	0	43	43
% ICC vs base case	0.0%	0.0%	1.2%	1.2%
Net present value	N/A	-2	-45	-47

Climate Zone 7a

	Step 2			
	None >6 kgCO2e/m2/yr	Medium 6 kgCO2e/m2/yr	Low 3 kgCO2e/m2/yr	Zero-Carbon Ready 2 kgCO2e/m2/yr
Space heating equipment				
Gas condensing boiler with fan coils	●	●		
Air-source heat pump; 10% natural gas backup			●	●
Water heating equipment [13]				
High efficiency gas (95%)	●		●	
Electric resistance		●		●
Cost and performance data				
Actual modelled GHGI	7.7	6.9	2.4	1.7
Annual modelled utility cost ($/m^2)	2.4	2.5	2.6	2.7
Total ICC vs. base case ($/m^2)	0	0	48	48
% ICC vs base case	0.0%	0.0%	1.4%	1.4%
Net present value	N/A	-2	-52	-54

[13] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update
[14] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update

Hotel Archetype



Base case

- 100% conventional natural gas (to isolate changes and costs related to carbon requirements)
- 20% lighting savings
- Pool heating fuel source matches the building heating fuel source
- Systems are 4-pipe fan coils with dedicated outdoor air system (DOAS)

Base Case	Climate Zone 4	Climate Zone 7a
Step 2	Walls R-10 Roof R-20 WWR 30% Window USI 2.0 SHGC 0.3 Infiltration: No savings beyond code 60% HRV	Walls R-20 Roof R-40 WWR 30% Window USI 1.2 Infiltration: half of code level 90% HRV

Highlights from analysis

- If the envelope were Step 4, annual operational costs would be approximately 20% lower (varies depending on actual design).
- Due to time constraints, analysis of all Steps has not been completed, only Step 2.
- There is higher laundry use in these archetypes (10%+ of energy use), so laundry energy source affects GHGI.
- DHW heat pumps were not modeled but could be used; GHGI outcomes would typically be similar to electric resistance DHW heating, though the addition of a DHW heat pump in a conditioned space can increase heating loads and may impact overall GHGI depending on space heating fuel source. Project-specific modelling should be used to confirm impacts.

Hotel data tables: Climate Zone 4

	Step 2							
	None >9 kgCO2e/m2/yr				Medium 9 kgCO2e/m2/yr		Low 4 kgCO2e/m2/yr	Zero-Carbon Ready 2 kgCO2e/m2/yr
	A	B	C	D	A	B		
Space heating equipment								
Gas condensing boiler with fan coils	●	●	●		●			
Air-source heat pump; 30% natural gas backup				●		●	●	
Air-source heat pump; no natural gas backup								●
Water heating equipment [15]								
High efficiency gas (95%)	●	●				●		
Electric resistance			●	●	●		●	●
Space heating equipment								
Gas	●	●				●		
Electric			●	●	●		●	●
Cost and performance data								
Actual modelled GHGI	20.5	15.7	12.9	10.9	8.1	8	3.3	1.6
Annual modelled utility cost ($/m^2)	11.8	11.7	12	11.1	11.9	10.8	11	10.6
Total ICC vs. base case ($/m^2)	0	0	0	42	0	42	42	65
% ICC vs base case	0.0%	0.0%	0.0%	1.3%	0.0%	1.3%	1.3%	2.0%
Net present value	N/A	2	-4	-28	-2	-22	-26	-41

Hotel data tables, Climate Zone 7a

	Step 2							
	None >9 kgCO2e/m2/yr				Medium 9 kgCO2e/m2/yr		Low 4 kgCO2e/m2/yr	Zero-Carbon Ready 2 kgCO2e/m2/yr
	A	B	C	D	A	B		
Space heating equipment								
Gas condensing boiler with fan coils	●	●	●		●			
Air-source heat pump; 30% natural gas backup				●		●	●	
Air-source heat pump; no natural gas backup								●
Water heating equipment [16]								
High efficiency gas (95%)	●	●				●		
Electric resistance			●	●	●		●	●
Space heating equipment								
Gas	●	●				●		
Electric			●	●	●		●	●
Cost and performance data								
Actual modelled GHGI	20.8	13.2	16	11	8.4	8.1	3.4	1.6
Annual modelled utility cost ($/m^2)	11.7	11.6	11.9	11.1	11.8	10.8	11	10.6
Total ICC vs. base case ($/m^2)	0	0	0	49	0	49	49	75
% ICC vs base case	0.0%	0.0%	0.0%	1.5%	0.0%	1.5%	1.5%	2.3%
Net present value	N/A	2	-4	-37	-2	-31	-35	-53

[16] Heat pump water heaters were not included in this analysis because they were not included in the modelling completed for the 2021 Metrics Report Update