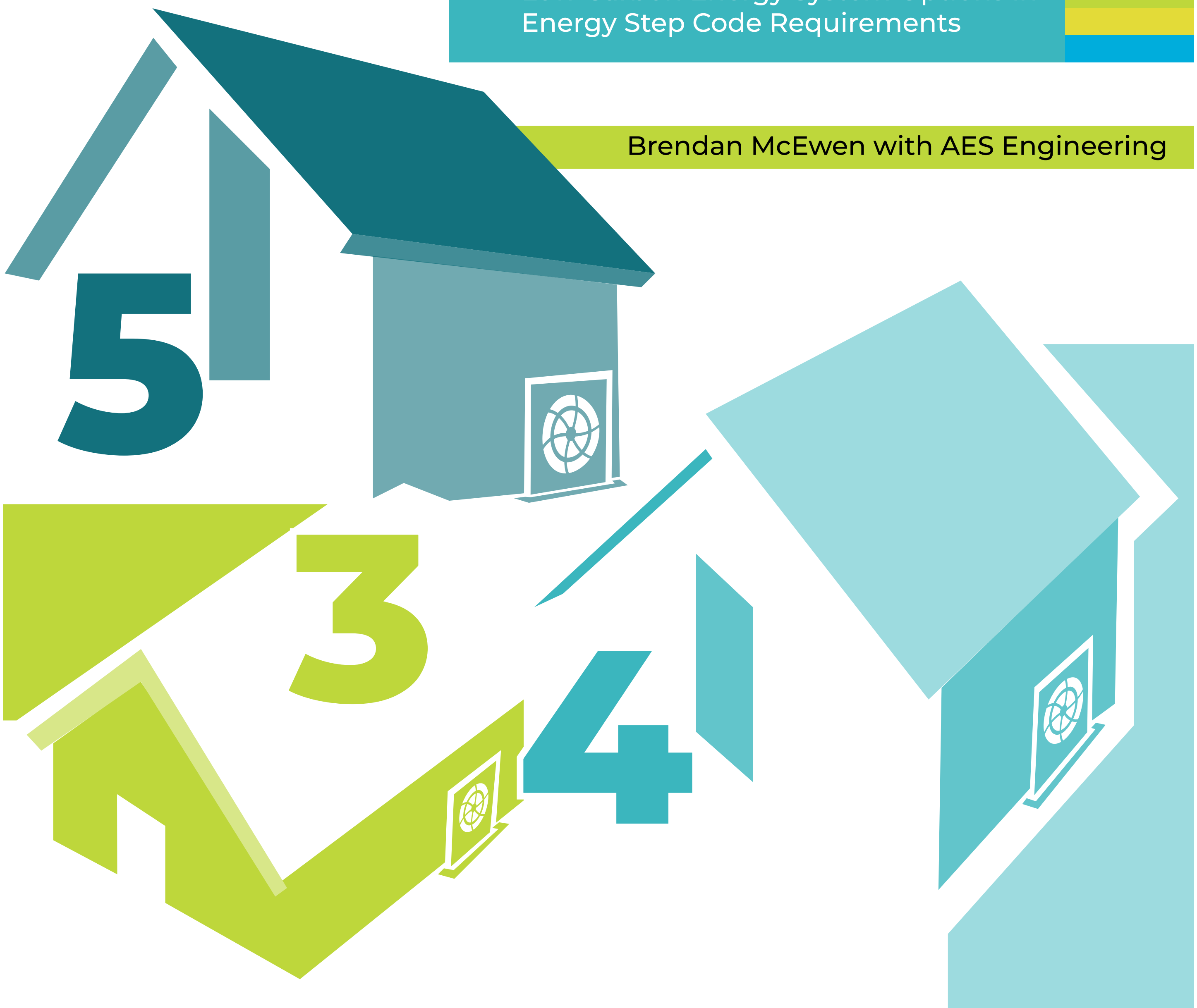
Low Carbon Building Systems in Energy Step Code Requirements

A Best Practice Bulletin & Report on Low Carbon Energy System Options in Energy Step Code Requirements

Brendan McEwen with AES Engineering



About this Document

This resource was prepared for the Energy Step Code Peer Network, a group of BC local governments that coordinate on implementation of the Energy Step Code, with funding from the BC Hydro Sustainable Communities Program.

This resource consists of:

1. A "Best Practice Bulletin" summarizing how local governments can achieve low carbon energy systems as part of Energy Step Code requirements.
2. A more detailed Report, providing guidance on how to structure Low Carbon Energy System Options (LCES Options) in local governments' building bylaws; considerations for how to define what constitutes an LCES; pertinent background information; and model bylaw language.

This work was prepared by Brendan McEwen. Brendan was previously Sustainability Manager at the City of Richmond, where he served for three years as a representative of the Union of BC Municipalities on the Energy Step Code Council and its predecessor the provincial Energy Efficiency Working Group. Brendan now works at AES Engineering. Some of this work was sub-contracted to AES, with Tara Katamay-Smith conducting analysis and co-authoring Appendix C. We also gratefully acknowledge Remi Charron who generously provided updated cost and emissions data from the *BC Housing Energy Step Code Metrics Research*.

Numerous individuals were interviewed as part of this project, including representatives of local governments as well as BC's building industry. The authors gratefully appreciate these individuals sharing their time and expertise. The views expressed in this report and responsibility for its content are the authors', and do not necessarily reflect the views of members of the Energy Step Code Peer Network, BC Hydro, nor anyone interviewed as part of this project.

This resource document does not constitute legal advice. Local governments are expected to seek input from their legal counsel when developing any bylaw or policy amendments.

Best Practice Bulletin – Overview

Summary of Recommendations for Local Governments

This document:

1. Recommends how local governments may structure their Energy Step Code requirements to include carbon emissions performance.

2. Suggests principles for the Energy Step Code Council and Province of BC to consider when developing carbon pollution performance standards for new buildings that local governments can include in building requirements.

It is recommended local governments:

1. **Initiate consultation with their local building and development communities regarding the inclusion of carbon performance in building requirements,** and the importance of the transition to efficient all-electric building systems.

2. **Advocate via the Energy Step Code Council for effective carbon performance requirements local governments may apply to new buildings.** Local governments should be enabled to:

   a. Require all-electric building systems with no gas plumbing to major energy end uses (e.g. space heating, hot water, cooking, etc.). The ability to require all-electric buildings is likely most important for Part 9 buildings, but is also important for Part 3. It is recommended local governments be able to make exemptions for energy end uses at their discretion (e.g. allowing gas for commercial kitchens; etc.).

   b. If the Energy Step Code references greenhouse gas intensity (GHGI), local governments should be able to reference GHGI levels at least as low, and at the same Steps, as leading local governments have currently adopted:

      i. For Part 9 buildings, local governments should be able to apply a GHGI of 3 kg $CO_2e/m^2/yr$ at Step 3 and higher.

      ii. For Part 3 buildings, local governments should be able to apply a GHGI of 3 kg $CO_2e/m^2/yr$ at Step 2 and higher.

iii. If local governments are not enabled to require all-electric building systems, then they should be allowed to apply a GHGI of 1 $kgCO_2e/m^2/yr$ at Step 3 (Part 9 buildings) and Step 2 (Part 3).

Calculation methodologies for GHGI should ensure low carbon building operations in the real world; key issues are identified in this report.

3. **Integrate carbon performance into their Energy Step Code regimes.**

   a. If the Province enables local governments to reference an appropriate carbon performance metric in bylaws in a reasonable timeframe (e.g. announced by April 2021, and effective 2022), adopt such requirements in addition to the Energy Step Code.

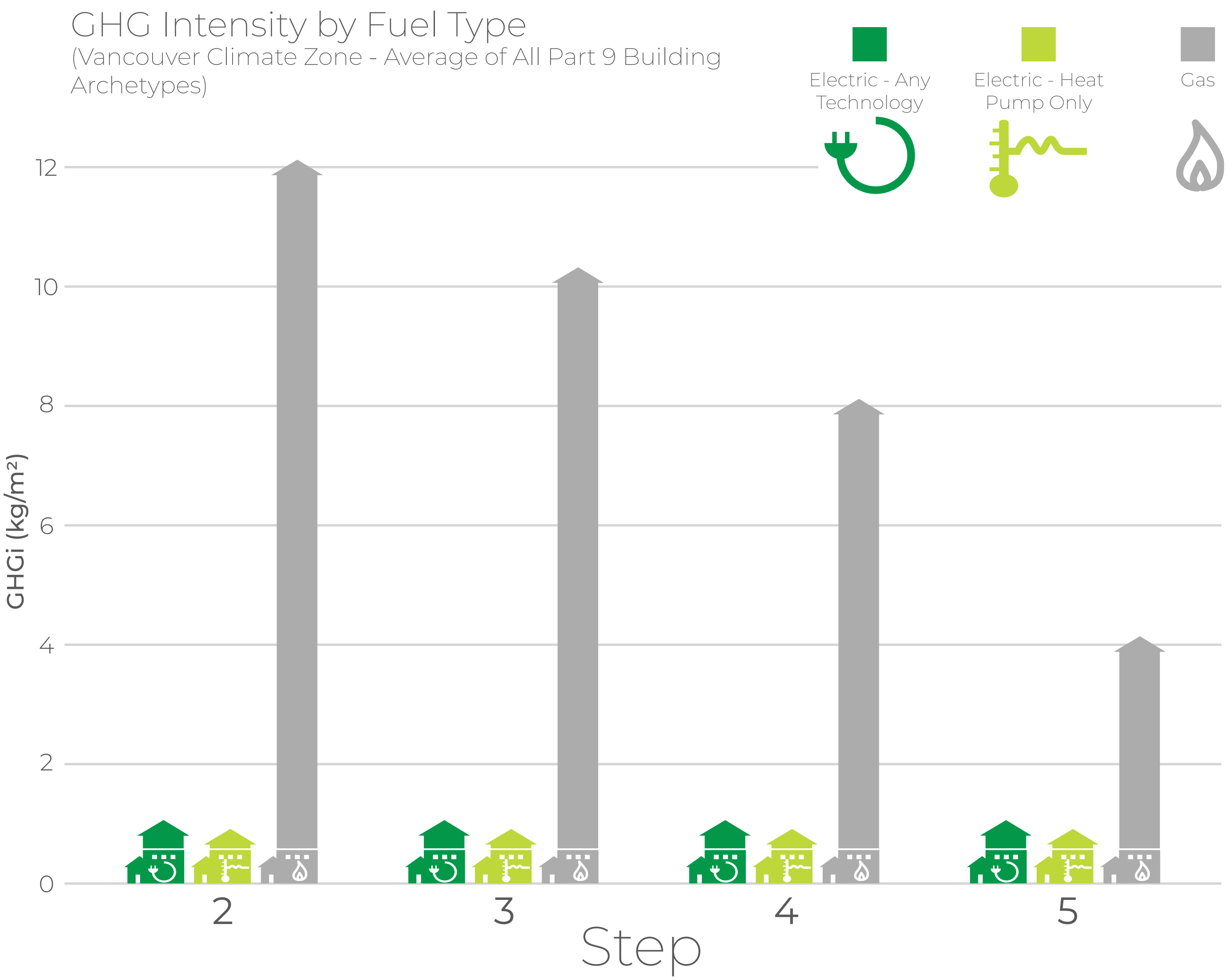
   b. If no appropriate opt-in carbon performance requirement is available, structure Energy Step Code requirements to include a "Low Carbon Energy System Option" (LCES Option), to maximize GHG emissions reductions from new construction.

The need for very low GHG emissions from new buildings

Achieving local, Provincial, Federal, and International climate targets requires transitioning to very low carbon emissions from buildings. Because of buildings' long life and the greater expense associated with retrofitting buildings to be low carbon, it is imperative that, as soon as possible, policymakers require new construction to be (near) zero carbon emissions.

BC local governments can require new construction to achieve a Step of the BC Energy Step Code, which requires progressively more energy efficient construction than the BC Building Code. However, in its current form, the Energy Step Code does not necessarily achieve very low carbon emissions. The key factor determining buildings' GHG emissions is their energy source – The BC Energy Step Code Metrics Research data suggests that buildings that use BC's relatively low carbon electricity electricity for space heating, hot water and other energy end uses are very low emissions, while those supplied by fossil natural gas are higher emissions even at the highest Step of the Energy Step Code (see figure below).

Recognizing the need to achieve very low GHG emissions in new construction, and the limitations of the current Energy Step Code, BC local governments are increasingly structuring their Energy Step Code requirements to encourage new construction to implement low carbon energy systems (LCESs).



GHG intensity by fuel type of the lowest cost option to achieve a given Step of the Energy Step Code for Part 9 buildings. Average of all archetypes in Climate Zone 4. Source: BC Energy Step Code Metrics Research.

How to structure a "Low carbon energy system (LCES) Option" in Energy Step Code requirements

Under the BC Building Act, local governments can not currently outright require LCESs. However, they have structured their Energy Step Code requirements to include options than can encourage their adoption. Under such a structure, local governments specify that new developments must achieve:

A high Step (e.g.) **Step 5**

OR

A lower Step (e.g.) **Step 3** **and a Low carbon energy system**

Such a structure achieves significantly lower emissions from new construction. It provides options for builders and developers, allowing either very energy efficient new construction, or low GHG systems coupled with less stringent (but still reasonable and better than BC Building Code) efficiency levels.

Jurisdictions with LCES Options in their Energy Step Code Requirements

Numerous BC local governments have already implemented an LCES Option in their Energy Step Code requirements, as summarized in the table below.

Local Government	Requirements			Effective Date
			LCES Option	
Part 9 Buildings (Smaller buildings, less than 4 storeys & 600m² in footprint) Step 5 is highest Step; Step 3 is anticipated apprx. performance of 2022 baseline BC Building Code				
D. of West Vancouver	Step 5	OR	Step 3	Mar 2021
City of Vancouver	~Step 5	OR	~Step 4	Jan 2022
City of North Vancouver	Step 5	OR	Step 3	Jul 2021
District of North Vancouver	Step 5	OR	Step 3	Mar 2021
City of Richmond	Step 3	OR	Step 2	In Effect
City of Richmond (proposed)	Step 4	OR	Step 3	Jan 2022
City of Victoria (proposed)	Step 4	OR	Step 3	Jan 2022

Part 3 Buildings – Residential (Larger buildings, 4+ storeys or 600m² footprint) Step 4 is highest Step; Step 2 is anticipated apprx. performance of 2022 baseline BC Building Code				
D. of West Vancouver	Step 4	OR	Step 2	Mar 2021
City of Vancouver – 7 + stories	~Step 3	OR	~Step 2	In effect
City of Vancouver – < 7 stories	~Step 4	OR	~Step 3	In effect
City of Richmond – 7 + stories	Step 3	OR	Step 2	In effect
City of Surrey	Step 3	OR	Step 2	In effect
City of Port Moody	Step 3 Step 4	OR OR	Step 2 Step 3	In effect 2021
City of Burnaby	Step 3	OR	Step 2	In effect
City of New West	Step 3	OR	Step 2	forthcoming
D. of North Vancouver	Step 4	OR	Step 3	2021
City of Victoria (proposed)	Step 3	OR	Step 2	Jan 2022
Part 3 Buildings – Office & Retail Step 3 is highest Step; Step 2 is anticipated apprx. performance of 2022 baseline BC Building Code				
City of Burnaby	Step 3	OR	Step 2	In effect

The Province may provide local governments with authority to directly make carbon performance requirements in bylaw

The Mandate Letter for Attorney General and Minister Responsible for Housing David Eby included direction to "support local governments to set their own carbon pollution performance standards for new buildings" [1].

If the Province were to establish an "opt-in" carbon performance requirement, or integrate carbon performance directly into the Energy Step Code, it could eliminate the need for local governments to establish a LCES Option approach.

Recommended approach

It is recommended local governments integrate carbon performance into their Energy Step Code regimes, by either:

1. Adopting appropriate carbon performance requirements directly into bylaw, if made available by the Province; and/or
2. Establishing a LCES Option in their Energy Step Code requirements.

Local governments are recommended to move expediently to integrate carbon performance into new building requirements, allowing appropriate time for stakeholder consultation. The table below outlines a model timeline for Energy Step Code requirements and associated carbon performance requirements. Local governments can initiate stakeholder consultation based on this timeline.

Model bylaw language for a LCES Option structure to Energy Step Code requirements is included in Appendix D of the accompanying Report to this Bulletin.

Date	If Directly Requiring Carbon Performance	If Using LCES Option Structure		
Part 9				
Residential (Baseline BC Building Code in 2022 anticipated to be ~Step 3)				
2022	Step 4 (or Step 3) and LCES	Step 5	OR	Step 3 with LCES
2026	Step 5 (or Step 4) and LCES	Step 5	OR	Step 4 with LCES

Date	If Directly Requiring Carbon Performance	If Using LCES Option Structure		
Part 3				
Residential < 7 stories (Baseline BC Building Code in 2022 anticipated to be ~Step 2)				
2022	Step 3 and LCES	Step 4	OR	Step 3 with LCES
2026	Step 4 and LCES	Step 4	OR	Step 3 with LCES
Residential 7+ stories (Baseline BC Building Code in 2022 anticipated to be ~Step 2)				
2022	Step 2 (or 3) and LCES	Step 4	OR	Step 2 (or 3) with LCES
2026	Step 3 (or 4) and LCES	Step 4	OR	Step 3 with LCES
Office & Retail (Baseline BC Building Code in 2022 anticipated to be ~Step 2)				
2022	Step 2 (or 3) and LCES	Step 3	OR	Step 2 with LCES
2026	Step 3 and LCES	TBD		

How to define what constitutes a Low carbon energy system (LCES)

There are different options for defining what constitutes an LCES, including:

1. **All-electric buildings with no gas plumbing to major building energy end uses** like space heating, domestic hot water (DHW), cooking and clothes drying. Exceptions can be made for certain end uses for which some end users particularly prefer gas – e.g. for commercial kitchens. This definition has been adopted by multiple cities in the USA.

2. **Greenhouse gas intensity (GHGI).** GHGI is measured in units of kilograms of CO_2 equivalent per metered squared of building area per year (kg $CO_2e/m^2/yr$). GHGI is derived from the energy models used to document compliance with the Energy Step Code. Most BC local governments to date have referenced GHGI in their LCES Options.

3. **Seasonal average coefficient of performance (COP)**. COP is the ratio of useful energy output (e.g. heat energy) to inputs (e.g. electricity, natural gas, or other fuel) over the course of a year. The higher the COP, the more efficient the system. BC local governments that reference this metric have tended to require a COP of greater than 2 (COP>2), which precludes predominant reliance on both natural gas systems as well as electric resistance systems (e.g. baseboards, electric boilers, etc.).

These options are not mutually exclusive and could be combined in different ways.

Recommended LCES Definition – All-Electric Buildings with No Gas Plumbing

It is recommended to define an LCES as an "all-electric buildings systems with no gas plumbing for space heating, domestic hot water heating, cooking and clothes drying" .

This option is recommended because it:

- Is likely to realize the maximum GHG emissions reductions, relative to other LCES definitions.
- Has been referenced by leading USA local governments.
- Supports improved indoor air quality, by avoiding indoor gas combustion.
- Reduces the potential for future conversion to gas space heating or hot water, and/

or the predominant reliance on gas mechanical systems that had been intended to be used for back up heating.

- Supports meeting local governments' climate goals cost effectively. The BC Energy Step Code Metrics Research suggests that electric building systems can be achieved cost effectively. All electric buildings avoid the cost of gas service and plumbing. Local governments could structure their bylaw requirements to allow for use of gas in cases where developments would incur excessive electric utility service extension costs in all-electric buildings, relative to costs that would be incurred if same building were constructed to the Energy Step Code but using gas.

- Can include exemptions in bylaws for certain end uses for which gas is preferred by end users (e.g. commercial kitchens, etc.).

Alternative LCES Definition –Greenhouse Gas Intensity (GHGI) Metric

The Province, Energy Step Code Council, and/or local governments may prefer to use a GHGI metric as part of carbon performance requirements. A GHGI metric:

- Is consistent with BC local government leaders. GHGI is being referenced by most BC local government that have adopted an LCES Option.

- Can achieve low GHG emissions. A GHGI of 3 kg $CO_2e/m^2/yr$ will tend to result in buildings using predominantly electric systems for space heating and DHW (gas can be used for back up and/or peak heating systems). A GHGI of 1 kg $CO_2e/m^2/yr$ will tend to result in all building systems being electric (though with some potential for gas back up).

- Allows gas for cooking and fireplaces. Some builders, developers and occupants desire gas cooking and/or fireplaces. Modeling for the City of Vancouver suggests that a GHGI of 3 kg $CO_2e/m^2/yr$ can allow for such uses. It should be noted that all-electric requirements could include exemptions for such end uses.

- Can allow back up gas systems for peak systems. In some circumstances, this can limit electrical system sizing and associated costs for larger equipment (though gas service and plumbing add costs). It should be noted that all-electric requirements could be structured to include exceptions where electrical system sizing would result in excessive costs.

There are challenges associated with using GHGI. Notably, it is a modeled value, and may not represent how building will operate in practice. For example, HOT2000 (the modeling tool used most often for Part 9 buildings) defaults to assuming if heat pumps are implemented in hybrid systems with gas equipment, heat pumps will serve as the primary source of heating with gas as backup; however, gas systems in these circumstances often wind up used as the primary source of heat, resulting in increased emissions in real world operations. The same issues may occur Part 3 buildings' energy modeling versus real world operations. If GHGI is used, modeling guidelines and tools should be updated to address these issues. For example, the City of Vancouver requires that if any gas mechanical systems are implemented in Part 9 buildings, they must be modeled to serve as the primary source energy for that end use.

Principles for developing "opt-in" carbon performance requirements and/or integrating carbon performance into the Energy Step Code

Below are recommended principles for the Province and the Energy Step Code Council to consider:

1. Consider adopting all electric building requirements (or other GHG performance requirements) directly into the BC Building Code. This will realize the greatest emissions reductions from new construction, and the greatest consistency for the building and development community. Communicate a timeline for integrating GHG performance into the BC Building Code, to provide greater certainty and "direction of travel" for industry.

2. Consider allowing local governments to directly require that new buildings be all-electric with no gas plumbing.

   - Allow local governments to make exceptions for certain end uses (e.g. commercial kitchens).

3. If using GHGI, local governments should be able to reference GHGI levels at least as low, and at the same Steps, as the LCES Options that leading local governments have currently adopted.

   - For Part 9 buildings, local governments should be able to apply a GHGI of 3 kg $CO_2e/m^2/yr$ at Step 3 and higher.

   - For Part 3 buildings, local governments should be able to apply a GHGI of 3 kg $CO_2e/m^2/yr$ at Step 2 and higher.

4. If using GHGI, ensure that the modeling tools and guidelines used to calculate GHGI do not provide "loop holes" whereby modellers may assume that heat pumps provide the majority of space heating, and natural gas equipment provides only backup, when in reality the natural gas equipment may be used as the primary heating source. This will likely involve changes to modeling guidelines, and/or changes to HOT2000 and potentially other modeling software.

5. Consider whether to integrate carbon performance directly into the Energy Step Code, or to provide a separate opt-in requirement. Directly integrating GHGI into the Energy Step Code could create greater consistency.

6. If using GHGI, but not also allowing local governments to directly require new buildings to be all-electric with no gas plumbing, allow local governments to reference a GHGI of 1 kg $CO_2e/m^2/yr$, in addition to 3 kg $CO_2e/m^2/yr$

7. If using GHGI, consider whether to allow for the use of renewable natural gas (RNG) for compliance. As noted in the report, sustainable, cost effective sources of RNG may be limited. The use of limited supplies of RNG should be reserved for sectors that are more difficult to decarbonize than new construction; therefore, the Province and Energy Step Code Council should consider not allowing its use for compliance with GHGI metrics. However, if allowing for use of RNG, ensure that:

    - If buildings are to receive credit for using RNG as part of GHGI calculations, a robust contractual mechanism must be in place to ensure RNG is actually used over the lifetime (e.g. 50+ years) of the building. Contracts should ensure that the delivery of RNG to buildings is transparent to third party observers over the lifetime of the building, and that adherence to this contract is enforceable by the authority having jurisdiction, or some other relevant entity.
    - Local government authorities having jurisdiction are not overly burdened through the enforcement of such mechanisms.

8. Pre-existing local government LCES options should remain in effect until GHG performance requirements in the Building Code or Energy Step Code are effective.

9. Deliberate between local governments, electrical utilities, the development industry, climate action advocates, other interest groups, to develop an appropriate exception clause for local governments to reference as part of their building bylaws' low carbon performance requirements. The intention of such a model exception clause would be to provide flexibility for new developments that would face much higher electric utility service costs (i.e. extension fees) to construct an all-electric (or predominantly electric) low carbon building, versus the same building constructed with use of gas. Most new construction is expected to be able to be all-electric relatively cost-effectively. However, under the structure of current utility tariffs, some developments might face electric service costs that are too high. Local government exceptions clauses would avoid this challenge. The Energy Step Code Council is recommended to develop a consistent exception clause for local governments' consideration.

Low Carbon Energy System Options in Energy Step Code Requirements - Technical Report

Contents

1 Purpose

The purpose of this Report is two-fold:

1. Provide detailed guidance on “Low Carbon Energy System Options” in Energy Step Code requirements – The Province of BC may enable local governments to directly require in bylaw that new construction be low carbon (see below). However, to date, local governments have not been able to directly make requirements for carbon performance.

   Instead, leading local governments have implemented a “Low Carbon Energy System Option” (LCES Option) structure as part of their Energy Step Code requirements. In brief, an LCES Option provides two options for new developments:

   1. Build to a high Step of the Energy Step Code, or
   2. Build to a lower Step, if the development uses low GHG sources of energy (e.g. BC’s low GHG grid electricity) to meet its energy end uses.

   Multiple BC local governments have implemented such an LCES Option structure in their Energy Step Code requirements as part of efforts to reduce GHG emissions from new construction. Other local governments are considering such an approach. This document is intended to support effective implementation of such requirements.

2. Inform the Province’s development of an “opt-in” carbon performance requirement local governments can reference directly in bylaw - It is important to note that it may not be necessary for local governments to structure their Energy Step Code requirements to include an LCES Option, if the Province enables local governments to directly require LCESs in new buildings. At its June 25, 2020 meeting, the Province’s Building and Safety Standards Branch and the Energy Step Code Council agreed to explore options for integrating a greenhouse gas intensity (GHGI) metrics into the Energy Step Code. Likewise, the Mandate Letter for Attorney General and Minister Responsible for Housing David Eby included direction to “support local governments to set their own carbon pollution performance standards for new buildings” [1]. Information in this report can be used in developing carbon pollution performance standards that local governments may reference.

Methodology

The information and recommendations in this document were developed based on a review of BC local governments’ LCES Options structures to Energy Step Code requirements, including those that have been adopted as well as those that are currently being proposed. Literature was reviewed relating to such requirements. Additionally, the author engaged in over two dozen interviews conducted during 2020 with various local government and building industry stakeholders regarding these strategies.

2 About a "Low Carbon Energy Systems Option" in Energy Step Code Requirements

The Structure of LCES Options

To achieve low carbon new construction, several BC local governments have adopted or are considering a LCES Option as part of their Energy Step Code requirements. A LCES Option is structured as follows – Local governments specify that new developments must achieve:

A High Step (e.g. Step 5), *OR*

A Lower Step (e.g. Step 3) and a Low carbon energy system (LCES)

Different jurisdictions have defined what constitutes a LCES in somewhat different ways. The implications of different technical definitions of LCESs are further explored in section 4.

Why Provide a "Low Carbon Energy Systems Option" (LCES Option)

More than 30 BC local governments have declared a Climate Emergency [2]. The building sector accounts for approximately 30-55% of GHG emissions accounted for in BC local government GHG inventories [3]. Multiple BC local governments' climate plans, and other decarbonization strategies, recognize that achieving climate targets will require that all new buildings be (near) zero GHGs from their operations as soon as possible. It is particularly important for equipment providing space heating and domestic hot water (DHW) to be zero emissions, as these are the dominant sources of GHGs in buildings.

BC local governments may make requirements in their Building Bylaws that new construction achieve different Steps of the BC Energy Step Code [4]. However, the Energy Step Code only establishes building efficiency targets, and does not necessarily compel new construction to use low GHG fuel sources for space heating, DHW, or other building systems.

As discussed in the June 2019 report *Implications of the BC Energy Step Code on GHG Emissions* prepared by Integral Group for the BC Building and Safety Standards Branch and the Ministry of Municipal Affairs and Housing, buildings that use BC's relatively low-GHG electricity for all building energy uses have lower emissions than those with gas systems [5]. A building constructed to a higher Step of the Energy Step Code that uses gas for space heating and/or DHW will still be more GHG intensive than a lower Step building using electricity for these loads. Of buildings with gas systems, the highest Step buildings with the greatest efficiency will have the lowest emissions. Figure 1 illustrates these impacts.

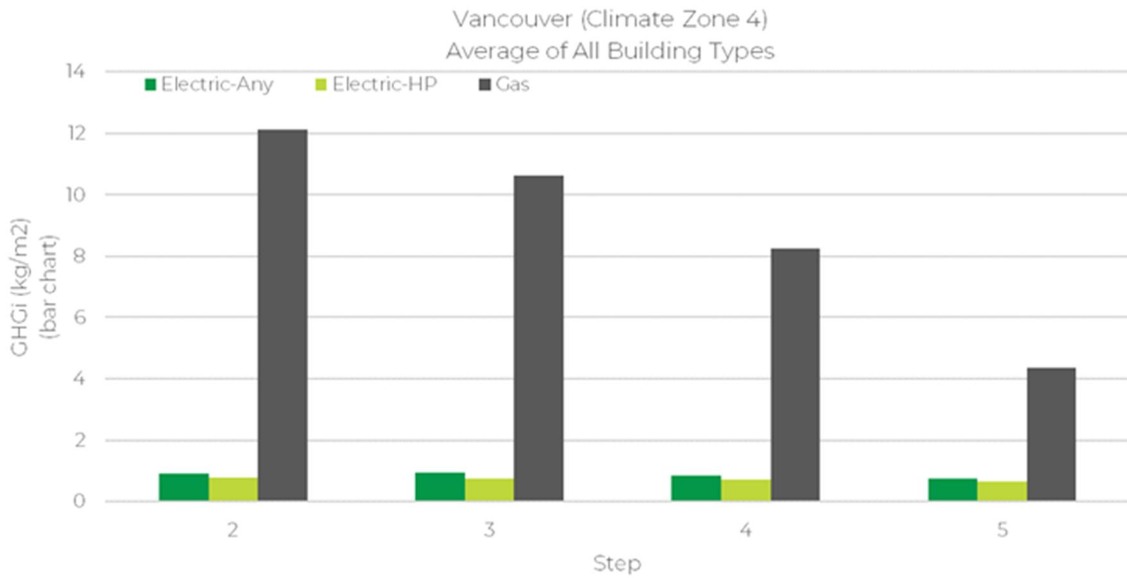


Figure 1: GHG intensity by fuel type of the lowest cost option to achieve a given Step of the Energy Step Code for Part 9 buildings. Average of all archetypes in Climate Zone 4. Source: BC Energy Step Code Metrics Research.

Appendixes A and B of this document summarizes the BC Housing *Energy Step Code Metrics Research* study's results for Part 9 buildings[1], noting GHG intensity and cost premium for buildings using electric and gas appliances for space heating and DHW, for different Climate Zones and building archetypes [6]. Appendix C provides a further discussion of the GHG intensity of different building mechanical systems, and the impacts of electrical grid GHG intensity.

Local Government's Authority to Provide LCES Options

Section 5 of the BC *Building Act* stipulates that only the Province can set technical building requirements; the Act limits local governments' authority to establish building requirements in bylaw [7]. Ministerial Order 157/2017 amended the Building Act General Regulation (B.C. Reg 131/2016), enabling local governments to require a Step of the Energy Step Code [8].

While it is understood that BC local governments bylaws cannot currently require LCESs outright, as this would constitute a technical building requirement under the *Building Act*, several local governments have structured their Energy Step Code bylaw requirements to provide the option to either build to a higher Step, or a lower Step when buildings implement a LCES (see Section 3 below for a summary of LCES Options). Similarly, other local governments have established such options as part of policies applied to new construction at time of rezoning.

The Province and the Energy Step Code Council have published documents that suggest such an LCES option approach is appropriate – The report *BC Energy Step Code: A Best Practices Guide for Local Governments* profiles this approach, suggesting that local governments provide a "relaxation clause", lowering the required Step when a new development implements a City-approved a LCES [9]. Likewise,

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[1] Integral Group's 2019 *Implications of the BC Energy Step Code on GHG Emissions* report include cost and GHG values for both Part 9 and Part 3 buildings. Appendix A of this document includes updated information for Part 9 buildings, reflecting December 2019 changes to the BC Energy Step Code that impacted Part 9 buildings.

the Province of BC's *Provincial Policy: Local Government Implementation of the BC Energy Step Code* notes "When an innovative renewable energy source is being incorporated, local governments are advised to consider lowering the required step of the BC Energy Step Code" [10]. The policy does not define what constitutes "innovative renewable energy sources", but it is certainly reasonable to assume that electric heat pumps and other low GHG mechanical systems match this description.

3 Jurisdictions with LCES Options

The following table summarizes LCES Options in different local governments. In addition to the jurisdictions noted in the table, other local governments are understood to be considering establishing a LCES Option as part of their Energy Step Code requirements. A May 2020 online survey of Energy Step Code Peer Network local governments identified six other local governments that are considering adopting such a structure.

Table 1: Local Government LCES Options.

Local Government	Requirements			Effective Date	Mechanism
			LCES Option		
Part 9 Buildings (Step 5 is highest Step)					
D. of West Vancouver [11]	Step 5	OR	Step 3	Mar 2021	Building Bylaw
City of Vancouver [12]	~Step 5	OR	~Step 4	Jan 2022	Vancouver Building By-Law (requirements vary somewhat from Step Code; CoV is not subject to *Building Act*)
City of North Vancouver [13]	Step 5	OR	Step 3	Jul 2021	Construction Regulation Bylaw.
District of North Vancouver [14]	Step 5	OR	Step 3	Jul 2021	Construction Bylaw
City of Richmond [15]	Step 3 Step 4	OR OR	Step 2 Step 3	In effect Jan 2022	Building Regulation Bylaw Building Regulation Bylaw (proposed)
City of Victoria (proposed) [16]	Step 4	OR	Step 3	Jan 2022	Building and Plumbing Regulation Bylaw amendments in devt.; Council approved framework; lower interim LCES Option pre-2022 (Step 3 *OR* 2 w. LCES).
Part 3 Buildings – Residential (Step 4 is highest Step)					
City of Vancouver – 7+ stories [17] [18]	~Step 3	OR	~Step 2	In effect	Green Building Policy for Rezoning
City of Vancouver – <7 stories [17] [18] [19]	~Step 4	OR	~Step 3	In effect	Green Building Policy for Rezoning; Residential Rental Tenure in C-2 Districts – District Schedule[2]
City of Richmond – 7+ stories [20]	Step 3	OR	Step 2	In effect	Building Regulation Bylaw

[2] The City of Vancouver's proposed amendments to the C2 zoning districts along arterial streets will allow 6 storey residential rental buildings. In addition to other criteria, the District Schedule includes an LCES Option structure, requiring buildings to meet either the Passive House Standard, the Zero Energy standard established by the International Living Future Institute, or greenhouse gas intensity limits and lower energy efficiency requirements.

City of Surrey [21]	Step 3	OR	Step 2	In effect	Building Bylaw
City of Port Moody [22] [23]	Step 3	OR	Step 2	In effect	Corporate Policy – BC Energy Step Code Rezoning Applications Building Bylaw (in effect 2021)
	Step 4	OR	Step 3	2021	Corporate Policy – BC Energy Step Code Rezoning Applications
City of Burnaby [24] [25] [26]	Step 3	OR	Step 2	In effect	Green Building Policy (Part 3 Buildings) for rezoning
City of New West [27]	Step 3	OR	Step 2	forthcoming[3]	Building Bylaw
District of North Vancouver [14]	Step 4	OR	Step 3	Jul 2021	Construction Bylaw
D. of West Vancouver [11]	Step 4	OR	Step 2	Mar 2021	Building Bylaw
City of Victoria (proposed) [16]	Step 3	OR	Step 2	Jan 2022	Building and Plumbing Regulation Bylaw; amendments in devt.
Part 3 Buildings – Business & Personal Services; Retail (Step 3 is highest Step)					
City of Burnaby [24] [25] [26]	Step 3	OR	Step 2	In effect	Green Building Policy (Part 3 Buildings) for rezoning
District of North Vancouver [14]	Step 3	OR	Step 2	Jul 2021	Construction Bylaw

[3] The City of New Westminster's Building Bylaw No. 8125, 2019 includes an LCES Option. However, at the time of this writing, the City's Energy Step Code webpage notes that "the City is not accepting applications under the LCES option until additional policy development is complete" [76].

4 Defining “Low carbon energy systems”

4.1 Different Definitions of Low carbon energy systems

What constitutes a LCES has been defined in different ways. Options include:

1. All-electric buildings with no gas plumbing to major building energy end uses (e.g. space heating, DHW, etc).
2. Greenhouse gas intensity (GHGI).
3. Equipment coefficient of performance (COP) requirements.
4. Prescriptive lists of equipment types.

The sub-sections below provide further description of these options for defining a LCES. The table below summarizes metrics used in the local government bylaws and policies noted in section 3 above as well as select USA cities.

Table 2: Definitions of Low carbon energy systems used by BC local governments.

Local Government	Definition of LCES	
	Part 9	Part 3
California cities (multiple) [28]	All-electric building systems with no gas plumbing.	All-electric building systems with no gas plumbing
City of Seattle (proposed) [29]	N/A	No gas & no electric resistance for space heating; No gas DHW for residential
City of Vancouver	Vancouver Building By-Law (effective Jan 2022) GHGI of 3 kg $CO_2e/m^2/yr$, OR List of acceptable building systems (electric space heating and DHW) [12]	Green Building Policy for Rezonings & Low carbon energy system Policy (effective 2020) *Connection to City-owned district energy system* *Utility-Owned LCES* [17] [18] GHGI of 4.5 kg $CO_2e/m^2/yr$ – <7 storey residential GHGI of 5 kg $CO_2e/m^2/yr$ – 7+ storey residential GHGI of 3 kg $CO_2e/m^2/yr$ – Office *User Owned LCES* [18] GHGI (67% of GHGI values noted above), AND Seasonal average COP >2, AND Minimum maintenance contract provisions. Residential Rental Tenure in C-2 Districts – District Schedule (proposed for 2020) [19] GHGI of 3 kg $CO_2e/m^2/yr$ – <7 storey residential
District of West Vancouver [11]	Building Bylaw (effective Mar 2021) GHGI of 3 kg $CO_2e/m^2/yr$, AND Seasonal average COP >2	Building Bylaw (effective Mar 2021) GHGI of 3 kg $CO_2e/m^2/yr$, AND Seasonal average COP >2
City of North Vancouver [13]	Construction Regulation Bylaw GHGI of 3 kg $CO_2e/m^2/yr$,	N/A – Currently no LCES option
District of North Vancouver	Construction Bylaw GHGI of 3 kg $CO_2e/m^2/yr$	Construction Bylaw GHGI of 3 kg $CO_2e/m^2/yr$
City of Richmond	Building Regulation Bylaw [15] GHGI of 6 kg $CO_2e/m^2/yr$ (currently) GHGI of 3 kg $CO_2e/m^2/yr$ (2022)	Building Regulation Bylaw [20] *Connection to City-owned district energy system* *Onsite LCES (utility or occupant owned)*

		70% of annual heating, cooling, and DHW energy demand from a renewable energy source, as approved by Director of Engineering AND Able to connect to City-owned DE in the future.
City of Victoria [16]	Building and Plumbing Regulation Bylaw (in devt – effective Jan 2022) GHGI of 3 kg $CO_2e/m^2/yr$	Building and Plumbing Regulation Bylaw (in devt – effective 2022) TBD
City of Surrey	N/A – Currently no LCES option	Building Bylaw [21] [30] *Utility-Owned LCES* GHGI of 6 kg $CO_2e/m^2/yr$ – Residential *User Owned LCES* GHGI 4 kg $CO_2e/m^2/yr$, AND Seasonal average COP >2, AND Minimum maintenance contract provisions
City of Port Moody	N/A – Currently no LCES option	Corporate Policy – BC Energy Step Code Rezoning Applications [22] and Building Bylaw [23] [31] GHGI 6 kg $CO_2e/m^2/yr$ AND Seasonal average COP >2, AND administrative requirements to ensure professional management
City of Burnaby	N/A – Currently no LCES option	Green Building Policy for Rezonings & Low carbon energy system Policy [26] [24] [25] *Utility-Owned LCES* GHGI of 6 kg $CO_2e/m^2/yr$ – Residential, Office, and Retail *User Owned LCES* [18] GHGI 4 kg $CO_2e/m^2/yr$, AND Seasonal average COP >2, AND Minimum maintenance contract provisions.
City of New Westminster	N/A – Currently no LCES option	Building Bylaw [27] *Connection to City-owned district energy system* *Onsite LCES (utility or occupant owned)* 70% of annual heating, cooling, and DHW energy demand from a renewable energy source, as approved by the City

All-Electric Buildings with No Gas Connection

As of December 2020, 40 California cities, including San Francisco and San Jose, have required that some or all new construction types (e.g. residential, etc.) be all-electric and not supply gas or other fossil fuel to building energy end uses, or have implemented more stringent energy efficiency requirements for multi-fuel buildings [28]. Likewise, a number of other USA cities are exploring requirements for all-electric buildings, notably Seattle, Bellingham, Massachusetts municipalities, and New York City [29] [32] [33]. Finally, all-electric building requirements have been proposed by stakeholders for California's statewide "Title 24" building energy efficiency standards [34].

The California Statewide Codes & Standards Program[4] has published a definition of an "all-electric building" in its *New Construction Model Reach Code: Electric-Preferred Version 3.0* [35]:

> "An ALL-ELECTRIC BUILDING is a building that uses electricity as the source of energy for all of its space heating, water heating, cooking and clothes drying appliances and has no gas plumbing in the building for these end uses. An All-Electric Building may include solar thermal collectors."

The California Statewide Codes & Standards Program *New Construction Model Reach Code* definition applies to a wide range of building types that would be classified as Part 9 and Part 3 buildings in BC, including single family, low rise residential, high rise residential, hotel/motel, office and retail[5]. This definition has been adopted by many California local governments.

The City of San Francisco has adopted slightly different language, which precludes any gas service to the building [36]:

> "ALL-ELECTRIC BUILDING OR PROJECT: A building or project that uses a permanent supply of electricity as the source of energy for all space conditioning (including heating and cooling), water heating (including pools and spas), cooking appliances, and clothes drying appliances. An All Electric Building or Project may not install natural gas or propane piping systems, fixtures or infrastructure for those purposes in or in connection with the building, structure, or within property lines of the premises, extending from the point of delivery at the gas meter."

Greenhouse gas intensity (GHGI)

GHGI is measured in units of kilograms of CO_2 equivalent per metered squared of building area per year (kg $CO_2e/m^2/yr$). GHGI is derived from the energy models used to document compliance with the Energy Step Code. The process for calculating GHGI is described in the City of Vancouver's Energy Modeling Guidelines (Version 2.0), which are referenced in the Energy Step Code for calculating other compliance metrics (e.g. Thermal Energy Demand Intensity [TEDI]; Total Energy Use Intensity [TEUI]). GHGI is reported as an output on both the "Part 3 Energy Design Report" [37] and the "BC Energy Compliance Report - Performance Path for Part 9 Buildings" [38], which are each used to support compliance with the Energy Step Code. Thus, local governments referencing GHGI in LCES Options can use very similar compliance processes as are used for Energy Step Code compliance.

Most current and proposed LCES options in BC local governments' Energy Step Code requirements reference GHGI. BC Housing includes GHGI metrics in its Design Guidelines and Construction Standards [39].

GHGI is a performance-based metric, providing flexibility with the building technologies and strategies used to comply with GHGI limits. Nevertheless, different GHGI values will tend to drive decarbonization

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[4] This program is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric Company (SDG&E®), Southern California Gas Company, and Southern California Edison Company under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

[5] While this definition does not seem to accommodate district energy as it specifies that electricity serve as the source of energy for all energy end uses, this definition could be augmented by BC local governments with district energy systems to allow for connection to district energy.

of certain building systems. The table below provides some general implications of different GHGI values referenced by local governments.

Table 3: Implications of GHGI levels in BC. (Note: Multiple means of meeting a particular GHGI performance metric exist, and these implications are intended only as a general guide for policy-makers to understand likely implications of GHGI metrics.)

GHGI Level	Implications for Residential Developments
6 kg $CO_2e/m^2/yr$	Space heating tends to be predominantly electric; DHW may remain gas.
3 kg $CO_2e/m^2/yr$	Space heating & DHW tend to be electric (designing back-up gas systems for peak capacity possible); gas fireplaces and cookstoves possible.
1 kg $CO_2e/m^2/yr$	(Nearly) all building systems electric (designing for back-up gas systems may be possible).

GHGI can apply to developments connecting to district energy systems. Vancouver's Energy Modeling Guidelines specify that "the emissions factor of a district energy system shall be provided by the utility (as agreed by the utility and the [authority having jurisdiction])" [40]. Local governments can work with district energy utilities to agree upon appropriate emissions factors representing district energy systems' anticipated life cycle GHG intensity. Local governments with district energy systems currently served predominantly by natural gas, but that intend to transition to low GHG fuels in the future, may consider appropriate emissions factors reflecting systems' lifetime emissions intensity.

Use of a GHGI metric could potentially allow for projects to commit to the use of renewable natural gas (RNG) to comply with carbon performance metrics. However, there are challenges associated with allowing for use of RNG, described in section 4.2 below.

Coefficient of performance (COP) requirements

Seasonal average coefficient of performance (COP) is the ratio of useful energy output (e.g. heat energy) to inputs (e.g. electricity, natural gas, or other fuel) over the course of a year. The higher the COP, the more efficient the system. Gas fired equipment such as furnaces and boilers have COPs of less than 1. Electric resistance equipment such as electric baseboard heaters can have a COP of 1. Electric heat pump systems can have seasonal average COPs of greater than 2.

In addition to GHGI requirements, the Cities of Vancouver, Surrey, Burnaby and Port Moody require seasonal average COPs of greater than 2 (COP>2) in Part 3 buildings for LCESs that are user-owned. These COP>2 requirements ensure that more efficient mechanical systems are implemented, avoiding the potential for predominant reliance on electric resistance for space heating and DHW were only GHGI used; relying predominantly on electric resistance would use greater amounts of electricity and entail higher energy costs[6] for end users at the lower Step allowed under the LCES option.[7] These cities also tend to include maintenance contract provisions to ensure that the mechanical systems implemented in buildings are professionally managed and maintained post occupancy.

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[6] As reflected in the life cycle costing from the *BC Energy Step Code Metrics Research* [42], the energy costs are higher from electric resistance heating; however, heat pumps and gas equipment will typically entail higher operations, maintenance and equipment replacement costs over the life cycle of the building.

[7] These jurisdictions do not include a COP requirement for utility-owned LCESs. A COP requirement is not necessary for developments served by a district- or building-scale utility, as the utility has incentive to optimize equipment's cost, and would therefore likely not implement predominantly electric resistance systems. Likewise, these jurisdictions do not include COP requirements for Part 9 buildings.

The District of West Vancouver includes both GHGI and COP>2 requirements in its definition of LCES for all Part 3 and Part 9 buildings. This effectively requires that new developments predominantly rely on heat pumps for space heating and DHW (electric resistance or gas back-up heat for peak demands can still be accommodated).

The jurisdictions noted above with COP>2 requirements have tended to rely on professional assurance models for compliance, requiring that a qualified engineer provide written verification that the LCES is designed to meet the system seasonal average co-efficient of performance > 2.

Finally, the Federal government and all the Provinces agreed at the 2017 *Energy and Mines Ministers' Conference* to adopt aspirational targets that by 2035, all space heating and water heating technologies for sale in Canada meet an energy performance of more than 100% (i.e. COP >1) [41].

4.2 Implications of LCES Definitions

The table below compares some of the implications of different ways of defining what constitutes an LCES. Further comment on the implications of these different definitions is included in the sub-sections below.

Issue Area	All-Electric	GHGI	COP
Electrification of space heat & DHW	· Necessitates full electrification.	· As GHGI lowers, buildings will tend to increasingly be designed for electric space heat and DHW. · Gas equipment can be designed for backup / peak loads; smaller zones in buildings.	· Seasonal average COP> 2 typically requires electric heat pump to meet most space heating and DHW demand. · Gas or electric resistance may be used for backup / peak loads, smaller zones/loads within buildings, etc.
Electric resistance heating vs. heat pumps for space heat & DHW	· Electric resistance allowed.	· Electric resistance allowed.	· Prevents predominant reliance on electric resistance. · Electric resistance may be used for peak loads, smaller zones/loads within buildings, etc.
Impact on gas equipment and plumbing	· Typically, no gas equipment nor plumbing. · Exemptions can be made for certain end uses (e.g. commercial kitchens; etc.)	· Gas equipment and plumbing allowed.	· Gas equipment and plumbing allowed.
Potential for conversion to gas equipment	· Likely best avoids later conversion to gas equipment	· Some potential for conversion	· Some potential for conversion
Potential for use of gas space heat or DHW equipment modeled as "backup" as primary source of energy	· None. No backup gas equipment.	· Potential for use of "backup" gas equipment as primary source of energy in operations. · GHGI could be defined to specify that if gas equipment is implemented for space heat or DHW, it must be modeled as primary source of energy. The current modeling guidelines and models determining GHGI does not require this, and would need to be changed.	· Potential for use of "backup" gas equipment as primary source of energy in operations.
Use of Renewable Natural Gas	· Does not accommodate use of RNG.	· Could be defined to allow for commitment to use RNG to lower GHGI.	· Use of RNG will not improve COP.

Electrification of space heat & DHW

Electric building systems will achieve lower GHG emissions on BC's relatively low-GHG electrical grid than gas systems. Thus, LCES definitions (e.g. GHGI, COP>2, and all-electric construction) will tend to drive electrification of building systems, particularly space heating and DHW loads that are the predominant source of GHG emissions in most buildings.

The BC Housing *Energy Step Code Metrics Research* conducted analysis of the costs and GHG impacts of achieving different Steps of the Energy Step Code [42]. This analysis was updated to reflect recent changes to BC Energy Step Code for Part 9 buildings. Appendixes A and B of this document summarizes the estimated GHG outcomes, incremental construction cost, and operating costs for different Part 9 building archetypes in different climate zones. Implications for Part 3 buildings are summarized in the *Metric Research* and the 2019 *Implications of the BC Energy Step Code on GHG Emissions* prepared for the Energy Step Code Council and the Province of BC [42] [43].

The Metrics Report data suggests that:

- Gas systems are the most GHG intensive in BC. Gas space heating and DHW will typically result in almost an order of magnitude greater GHG emissions that electric systems, even if buildings are constructed to relatively high Steps.

- Electric resistance and gas systems typically have lower incremental construction costs compared to heat pumps, when new developments do not implement cooling. It is important to note that the Metrics Study assumed that buildings did not implement space cooling.

- The cost premium for heat pumps is significantly less if new developments implement cooling. A study prepared for the City of Richmond by Integral Group concluded that there is little to no cost premium for heat pump space heating systems in new construction that features cooling for the various Part 3 and Part 9 buildings analyzed; the study notes that new construction in the region now commonly features cooling [43]. Cooling will be important to ensuring thermal comfort and resilience in a future warmer climate.

- Heat pumps can realize the lowest utility costs for end users of any space heating or DHW technologies, if they have sufficiently high COPs. At current utility rates, gas heating will realize lower utility costs than heat pumps with low COPs. Electric resistance has the highest utility costs. However, electric resistance may have lower maintenance and replacement costs.

Additionally, electric systems may result in larger electric service requirements and greater extension fees for new developments, which can increase the cost of new development. Less efficient electrical systems will typically be more likely to necessitate larger electrical capacity in new construction.

Electric resistance vs. heat pumps for space heating & DHW

A COP>2 metric is intended to drive buildings to predominantly rely on efficient electric heat pumps. All-electric and GHGI metrics will not on their own compel new developments to use heat pumps; however, designers may elect to implement heat pumps to better meet the needs (financial, thermal comfort, etc.) of end users, and Energy Step Code efficiency metrics (e.g. TEUI, MEUI) will reward buildings for use of more efficient heat pump systems.

Compared to heat pumps, electric resistance space heating and DHW equipment:

- Is less resilient to range of potential future increases in grid GHGI emission. If BC electricity were to become more GHG intensive in the future, for example due to increased imports of more GHG intensive power, the GHG intensity of electric appliances would increase. Because electric resistance is a less efficient use of electricity than heat pumps, their emissions benefits are less resilient to changes in the emissions factor of electricity. This is further explored in Appendix C. However, as documented in Appendix C, it is unlikely that electric resistance used in BC buildings in the foreseeable future will result in greater lifecycle GHG emissions than natural gas equipment.

- May be lower construction cost than heat pumps. Heat pump equipment is typically more expensive than electrical resistance equipment. However, as noted above, if a development implements space cooling, the incremental cost of heat pumps (providing both space heating and cooling) is less substantial.

- Have higher energy costs than heat pumps and natural gas. Electric resistance has substantially higher energy costs than more efficient heat pumps. Likewise, electricity is more expensive than natural gas on a unit basis.

- Often have lower maintenance and replacement costs. Electric resistance is usually relatively simple equipment and often has lower operations and maintenance costs than other systems.

- Typically have greater impact on peak electrical consumption. Electric resistance typically has greater impacts on buildings peak electrical demand, and on the electrical demand of BC's grid. This could impact costs of new development and system costs.

- Are common in residential construction. Electric resistance is commonly used in Part 9 and Part 3 construction in BC for space heating and domestic hot water. Particularly for smaller residences, and smaller spaces within residences, it can be an economical option for occupants and allow for simpler zonal controls. Allowing for electric resistance of these sorts of residential building types will present a less significant departure from current building practices than a COP>2 metric that drives predominant reliance on heat pumps.

All-Electric buildings with no gas plumbing

Buildings constructed to an all-electric building requirement would not allow gas plumbing to serve key building end uses, such as space heating, DHW, cooking and clothes drying (some end uses could be exempted). Reasons to encourage all-electric buildings include:

- Minimizing GHG emissions – All electric construction will tend to have the lowest operational emissions. Moreover, methane, the main constituent of natural gas, is a potent GHG, such that even a fraction of a percent of natural gas leaking in the built environment can contribute meaningfully to community emissions [44] [45] [46] [47]. Reducing gas infrastructure could reduce the risk of methane leaks, including from buildings and utility gas distribution systems.

- Improving indoor health and air quality - Gas cooking and fireplaces have been associated with indoor air pollution and increased risk of adverse health risks such as asthma and other cardio-vascular ailments, relative to electric versions of these appliances [48]. The Canadian Association of Physicians for the Environment have initiated the switchitupbc.ca campaign to encourage households to switch from gas appliances to electric.

- Reducing the potential for future conversion to gas space heating or hot water – A lack of gas connection to space heating and DHW equipment could reduce the likelihood that a building may convert to fully gas systems in future years.

- Eliminating potential for use of gas equipment modeled to be backup systems as the primary source of energy – Likewise, a building with no gas equipment avoids the risk that gas mechanical systems are modeled to provide only backup and/or peak heating, but instead use gas as the primary source of energy during operations. This is an important issue with the current modeling practices and guidelines to calculate GHGI – The modeling tool HOT2000 (commonly used to model compliance of Part 9 buildings with the Energy Step Code) defaults to assuming heat pumps are the primary source of heating if implemented in hybrid system with gas "back up"; in practice, however, interviewees reported that in hybrid systems the gas equipment will often be designed and operated as the primary source of heat. For this reason, the City of Vancouver requires that if any gas mechanical systems are implemented in Part 9 buildings, they must be modeled to serve as the primary source energy for that end use; however, there is nothing in the definition GHGI in the Energy Modeling Guidelines referenced by the BC Energy Step Code to prevent this.

  Likewise, modeling gas systems as backup only to use them as the primary source of energy could be an issue in Part 3 buildings. The City of Vancouver's *Low Carbon Energy System Policy,* and other local government policies, include provisions for user-owned onsite LCESs that "any natural gas fired peak demand heating equipment is sized appropriately and is to augment the primary low-carbon system under peak demand condition". This clause is intended to ensure back up systems are not used as the predominant source of energy in operations.

- Reducing financial risk of under-utilized gas assets and increased gas utility rates – Very low GHG buildings will have limited demand for gas. All else being equal, expanding gas infrastructure in the context of declining overall demand could result in increasing gas utility rates, increasing costs for consumers [49]. Notably, Pacific Gas and Electric, a California electricity and gas utility, has called for the California Energy Commission to adopt all-electric new construction requirements if feasible and cost-effective, noting they wish to avoid investment in under-utilized gas infrastructure [50].

- An all-electric building LCES definition may be more administratively simple, and more resilient to the potential for future changes to assumptions regarding electricity and gas GHG emissions factors, than GHGI. It is possible that as building energy modeling techniques progress, and/or as the mix of electricity generators supplying BC buildings evolves over time, the assumptions regarding the GHG intensity of the electric grid could change; likewise, gas emissions factors could change. These changes would impact the GHGI calculated for individual buildings. In turn, this could impact the viability of different building systems in ways not initially intended by local governments, and could oblige local governments to update their GHGI requirements. An all-electric building definition avoids the potential for such changes, and may therefore be administratively more simple.

However, there are reasons local government may wish to allow for gas connection in certain circumstances:

- Allowing builders to meet buyer demand for gas cooking and fireplaces - Gas cooking and/or fireplaces are valued by many buyers of new residences. Accordingly, some builders and developers have expressed the desire that LCES Options accommodate gas cooking and fireplaces. However, it should be noted electric induction ranges are increasingly viewed as providing high quality cooking performance at least as good as gas ranges, and buyers may be unaware of the health impacts of gas equipment [48]. Electric decorative fireplace options likewise exist.

  All-electric building requirements can include exemptions for certain end uses (e.g. commercial kitchens; outdoor barbeques; residential kitchens; etc.).

- Cases where upgrading electrical service capacity will result in abnormally high cost – Using electricity to meet peak space and DHW heating demands could result in buildings requiring greater electrical capacity and larger electrical systems and services. The structure of BC electrical utilities' tariffs can occasionally result in builders or developers needing to pay significantly higher extension fees (i.e. the cost of new electrical service) for larger electrical services; the structure of electrical tariffs mean that the cost of a larger electrical service can be difficult to predict.

  For these reasons, local governments could consider some form of "safety valve" allowing for exceptions to all-electric building requirements if developments can document significantly higher extension fee costs (e.g. triple the cost, or some other value) for all-electric developments versus the same building with gas connection. The Energy Step Code Council and electrical distribution utilities are recommended to deliberate to determine appropriate model exception clauses to recommend for local government building bylaw amendments. Additionally, demand response strategies and changes in electricity tariff designs to support electrification could help ameliorate these issues; further study of such technologies and utility regulatory approaches to best facilitate building electrification in BC is warranted.

Considerations Regarding Renewable Natural Gas (RNG)

"Renewable natural gas" (RNG) can refer to:

- Bio-methane (e.g. methane derived from manure, energy crops, forestry residues, etc.)
- Landfill gas.
- Synthetic methane (i.e. power to methane).
- Blending "green hydrogen" (H_2 derived from electrolysis of low carbon sources of electricity) or "blue hydrogen" (H_2 derived from electrolysis of low carbon sources of electricity) into the natural gas supply.

All-electric building systems will preclude the use of RNG. GHGI could be defined to allow for the use of RNG. COP will have no bearing on the use of RNG.

The Province and/or local governments may wish to consider allowing use of RNG as a compliance pathway to achieve low carbon new buildings. This would provide more options for builders, allowing for continued use of gas systems in new construction.

However, there are significant challenges with allowing for use of RNG in new construction [51]. Notably:

- Enforcing use of 100% RNG in perpetuity could be challenging. It would be challenging for local government authorities having jurisdiction (AHJs) to ensure that buildings use RNG in perpetuity. Even if proof of some contract or covenant stating RNG would be used in perpetuity were provided to the AHJ, it would be challenging to ensure that these terms were being met over time. Likewise, compelling building owners and stratas to use more expensive RNG might be a political non-starter for local governments. Any effort to allow for RNG credit as part of GHGI calculations must ensure 1) a robust, transparent mechanism to ensure that RNG is actually used in buildings over their lifetime (e.g. 50 years), and 2) enforcement of this mechanism does not overly burden local government AHJs.

- There may not be enough sustainable, cost effective sources of RNG. FortisBC commissioned a *Clean Growth Pathways to 2050* report, comparing an "Electrification Pathway" that entails a 100% transition to electric heat pumps for buildings space heat and DHW (amongst other strategies), and a "Diversified Pathway" involving significant use of RNG [52]. The "Diversified Pathway" contemplates that 136 PJ/yr of RNG would be supplied in 2050, comprising 73% of all natural gas demand (for comparison, 2019 gas system throughput is 200 PJ/yr) [52]. To indicate RNG availability, the *Pathways* report cites a report prepared by Hallbar Consulting for the Province of BC, FortisBC and Pacific Northern Gas Ltd., which estimates 12 PJ/yr of technically achievable RNG supply over the long-term (i.e. by 2035) at costs up to $28/GJ[8] using today's

[8] For comparison, FortisBC's commodity cost of natural gas for residents is $2.84/GJ, effective January 2021.

technologies [53]. The Hallbar study further notes that if technology innovations enable wood feedstocks to produce RNG at $28/GJ or less, the total technical potential increases significantly, to approximately 50 to 90 PJ/yr [53]. It is important to note that the Hallbar study estimates 87%-90% of the available wood feedstock for RNG production to be "Roadside Residue" of logging – e.g. tree tops, branches, and other non-saw log material derived during logging operations [53]; the remainder is mill residues and pulp logs. In other words, even if technology becomes available to enable wood feedstocks for RNG, the vast majority of the potential RNG feedstock the Hallbar study anticipates to be available in BC would be derived from these roadside logging residues.

While it is typically assumed RNG will be very low or zero carbon, and some RNG feedstocks certainly do meet this criteria, RNG derived from logging residues may actually not offer climate benefits at important time scales (e.g. in the next 50+ years) – A 2019 study authored by Canadian Forest Service staff finds that deriving RNG from logging residues that would otherwise have been left on site (i.e. not piled and burned) may take 20 to 75 years to realize any climate benefit relative to fossil natural gas; before this time RNG from logging residue feedstocks results in "carbon debt", contributing more $C0_2e$ in the atmosphere than fossil natural gas [54][9]. Only after sufficient forest regrowth has occurred will any climate benefits be realized. To summarize, the supply of sustainable, cost-effective sources of RNG in BC may be limited.

Likewise, studies prepared in other jurisdictions suggest limited supplies of RNG and challenging economics – the American Gas Federation estimates 5% (low scenario) to 12% (high scenario) of US gas demand could be met through RNG by 2040; Natural Resources Defense Council estimates 3% to 7% [55]. A study prepared for the California Energy Commission evaluates different energy system pathways to achieve GHG emissions reduction targets, and concludes that "building electrification is likely to be a lower-cost, lower-risk long-term strategy compared to RNG" [56].

- Because sustainable, cost-effective RNG feedstocks may be limited, RNG's use should be limited to hard to decarbonize sectors. New buildings are relatively easy to decarbonize. As noted above, it can be relatively cost-effective to implement all-electric new construction (though there may be instances where greater financial challenges arise, due to utility extension fees or other issues). Since sustainable, cost-effective sources of RNG may be limited, it should be reserved for sectors where electrification is more challenging (e.g. some industrial applications, etc.) [56] [55].

[9] As would be expected, the study finds that logging residues that would otherwise be piled and burned onsite will offer immediate climate benefits if diverted to be RNG feedstock. However, the study notes that biomass burning is expected to reduce or even cease in the future due to regulatory and economic drivers.

5 Recommended Local Government Action

If the Province implements an appropriate opt-in mechanism for local governments to require low carbon new construction, local governments are recommended to directly reference that requirement in their Building Bylaws. In the absence of such an appropriate opt-in mechanism, it is recommended that local governments initiate the process of developing LCES Options as part of their Energy Step Code requirements.

Table 4 below outlines recommended structure and timelines for Energy Step Code and LCES. Table 5 outlines options and recommendations for definitions of what constitutes an LCES. It is recommended that local governments engage in stakeholder consultation, then finalize their timeline and definition of LCES.

Appendix D includes model building bylaw amendment language for local government consideration.

Table 4: Recommended Timeline for Energy Step Code Requirements and LCES

Date	If Directly Requiring Carbon Performance	If Using LCES Option Structure		
Part 9				
Residential (Baseline BC Building Code in 2022 anticipated to be ~Step 3)				
2022	Step 4 (or Step 3) and LCES	Step 5	OR	Step 3 with LCES
2026	Step 5 (or Step 4) and LCES	Step 5	OR	Step 4 with LCES
Part 3				
Residential <7 stories (Baseline BC Building Code in 2022 anticipated to be ~Step 2)				
2022	Step 3 and LCES	Step 4	OR	Step 3 with LCES
2026	Step 4 and LCES	Step 4	OR	Step 3 with LCES
Residential 7+ stories (Baseline BC Building Code in 2022 anticipated to be ~Step 2)				
2022	Step 2 (or 3) and LCES	Step 4	OR	Step 2 (or 3) with LCES
2026	Step 3 (or 4) and LCES	Step 4	OR	Step 3 with LCES
Office & Retail (Baseline BC Building Code in 2022 anticipated to be ~Step 2)				
2022	Step 2 (or 3) and LCES	Step 3	OR	Step 2 with LCES
2026	Step 3 and LCES	TBD		

Table 5: Options and Recommendations for Definitions of LCES

Option for LGES Definition	Notes
Part 9	
Option A: All electric building* (*Recommended*)	Matches USA cities
Option B: GHGI of 3 kg $CO_2e/m^2/yr$	Matches CoVan, CoR, CNV, DNV, CoVic
Option C: GHGI of 3 kg $CO_2e/m^2/yr$ & COP>2	Matches DWV
Part 3	
Option A: All electric building* (*Recommended*)	Matches USA cities
Option B: GHGI of 3 kg $CO_2e/m^2/yr$	Matches CoV for residential rental tenure for <7 stories, DNV
Option C: GHGI of 3 kg $CO_2e/m^2/yr$ & COP>2	Matches DWV; similar to CoVan, CoS, CoB & CPM requirements for user-owned LGESs in residential developments.

** LGES definition could also include district energy connection.*

5.1 Rationale for LCES Definition Options

Option A - All-Electric Buildings (Recommended Option)

It is recommended that the Province and/or local governments define a LCES as an all-electric building with no gas plumbing. As discussed in section 4, this definition:

- Is likely to realize the maximum GHG emissions reductions, relative to other LCES definitions. In the context of local governments having declared a climate emergency, immediately moving to building systems that maximize emissions reductions potential is appropriate.
- Supports indoor air quality, by avoiding the potential for gas cooking and fireplaces and the associated risks of air pollutants due indoor combustion and improper ventilation.
- Reduces the potential for future conversion to gas space heating or DHW, which would increase GHG emissions substantially. Likewise, it avoids the potential for buildings to rely on gas equipment that was intended as back-up to meet peak requirements for larger non-peak portions of their heating demand.
- Reduces financial risk of under-utilized or stranded gas assets, both in buildings and at the utility-scale.
- Supports cost-efficacy of local governments' climate goals. A report prepared for the City of Richmond suggests that heat pump systems can be implemented at little to no cost-premium in new residential construction, given that construction increasingly features cooling [43]. All-electric building systems also allow for electric resistance, given there may be circumstances where electric resistance is appropriate.

There are potential challenges to using all-electric buildings as the definition of LCESs, including:

- Stakeholder resistance. Gas utilities may oppose all-electric systems relative to other potential LCES Options, as they would not connect to new customers. Likewise, certain end-user groups are likely to oppose such requirements; for example, gas equipment contractors, restaurant owners and others spoke out against the City of Vancouver's Zero Emissions Building Plan (despite the Plan not applying to restaurant cooking equipment) [57]. Organized opposition to policies restricting gas use in new developments has emerged across North America, including in BC [58].
- Novelty. No local governments in BC, or Canada, have proposed all-electric buildings as options or requirements as part of their building policy.
- Uncertainty regarding all-electric building peak electrical demand and associated electrical costs. In some instances, all-electric buildings could entail significantly higher utility extension fees than the same building with gas equipment. In light of this, local governments could include provisions for exceptions (i.e. a "safety valve") for those cases where extension fees are higher.

Option B - GHGI of 3 kg $CO_2e/m^2/yr$

Alternately, the Province and/or local governments could reference a GHGI of 3 kg $CO_2e/m^2/yr$ as part of requirements. GHGI is:

- Consistent with current BC local government requirements. A GHGI of 3 kg $CO_2e/m^2/yr$ is being reference by all local governments that have implemented or are considering an LCES Option as part of Energy Step Code requirements.
- Achieves low GHG emissions. A GHGI of 3 kg $CO_2e/m^2/yr$ will tend to largely decarbonize space heating and DHW.
- Allows gas for cooking, fireplaces, and/or back up peak heating. Modeling for the City of Vancouver's Part 9 building requirements suggests a GHGI of 3 kg $CO_2e/m^2/yr$ can accommodate gas fireplaces and cooking. Likewise, it could allow for peaking and back-up systems. Gas cooking and fireplaces have been noted by some builders and developers as desired features. Likewise, gas peak systems can limit electrical demands and associated equipment sizing.

If a GHGI metric is used, consideration should be given for how to mitigate the potential for gas mechanical equipment to be modeled as "back up" heating systems, and then be used as a primary source energy in operations. Consider:

- Updating modeling guidelines for Part 9 buildings to specify that if any gas mechanical systems are implemented, they must be modeled to serve as the primary energy source. Consider any necessary updates to modeling software default settings (e.g. HOT2000).
- Provisions and enforcement techniques for Part 3 buildings to ensure that any gas peak heating equipment is sized appropriately to only augment the primary low-carbon system under peak demand conditions.

Option C - GHGI of 3 kg $CO_2e/m^2/yr$ and COP>2

This Option effectively necessitates predominant reliance on heat pumps for buildings using the LCES Option. This Option:

- Typically realizes the greatest energy efficiency.
- May result in lower energy and operating costs than reliance on GHGI alone.
- Ensures the deepest emissions reductions under a range of different future electricity GHG emissions factor scenarios.

However, compelling all developments taking the LCES Option to predominantly rely on heat pumps:

- Could limit some otherwise reasonable electric resistance in some circumstances. For some building types and space heating control strategies (e.g. basement suite; etc.), heat pumps may have relatively greater costs and less efficiency benefits.
- Will represent a greater departure from current building practices than a GHGI alone, as electric resistance is common in many building types.

Thus, using this Option may be most appropriate for jurisdictions like the District of West Vancouver that:

- Are seeking to be climate leaders, and drive market transformation towards greater use of more efficient heat pumps.
- Tend to have larger residential units (e.g. large single family homes) and more valuable real estate.

6 Implementation Considerations

This section notes some implementation considerations for local governments and the Energy Step Code Council.

6.1 Industry Training and Capacity Building

The transition to predominantly or all electric buildings, and particularly widespread use of heat pumps for space heating and DHW, will constitute a rapid change in typical mechanical systems implemented in new construction. Because electricity is more expensive per unit of energy than gas, heat pumps that do not meet expected efficiencies due to improper design and/or installation can result in greater cost relative to improperly implemented gas equipment, as well as comfort, noise and operational deficiencies. For this reason, it is important that heat pumps are designed, installed and operated correctly.

Industry stakeholders broadly expressed faith that the industry can adapt to rapid transition to heat pumps, provided:

1. Energy Step Code and BC Building Code requirements are adequately enforced.
2. Mechanical designers, contractors and trades possess appropriate certifications, and sufficient lead time is provided for training.

Design and installation certifications for heat pumps are being developed by different industry associations, including the Home Performance Stakeholder Council (HPSC) and the Thermal Energy Comfort Association (TECA).

It is recommended the Energy Step Code Council, the Energy Step Code Local Government Peer Network, BC Hydro and other stakeholders engage with appropriate industry associations to ensure that rigorous opportunities for training and industry capacity building are available, and to explore related efforts to support market transformation towards heat pumps.

6.2 Compliance and Enforcement

Part 9 Buildings

Interviewees for this report broadly agreed there are adequate requirements pertaining to installation of mechanical systems in the BC Building Code. However, few local governments actively enforce all relevant components of Part 9 of the Code relating to mechanical systems. For example, section 9.33.5 of the BC Building Code references CSA Group's F280-12 Standard for appropriate sizing of the capacity of heating systems [59]; however, few authorities having jurisdiction (AHJs) check to ensure compliance with F280-12. Industry participants report that F280-12 is rarely complied with, frequently resulting in oversized mechanical systems. While oversized gas systems are inefficient and result in unnecessary GHG emissions, oversized heat pump systems can realize more costly operational challenges. However, many AHJs do not currently have the mandate, resources, or staff knowledge to comprehensive ensure compliance and enforcement of all relevant mechanical provisions in the Code.

It is recommended that Local AHJs, the Energy Step Code Council, the Building Officials Association of BC, trade associations and others increase their collaborations to ensure effective compliance and enforcement regimes.

Part 3 Buildings

Compliance with Energy Step Code, and other BC Building Code requirements, is largely based on a professional assurance model. The city of Vancouver has developed a best practice to support compliance with the energy provisions of the Vancouver Building By-Law and its various policies, requiring that projects complete an Energy Checklist [60]. The Checklist includes fields for modeled building characteristics and energy outputs. Checklists are submitted at building permit application and prior to occupancy. The City of Vancouver conducts reviews of submitted Checklists for plausibility. Industry stakeholders report that Vancouver's regime helps ensure that energy models accurately reflect buildings' actual design and construction.

The Energy Report for the BC Energy Step Code for Part 3 Buildings was recently released [37], and is similar to Vancouver's Energy Checklist. BC local governments can likewise use this tool and similar processes as Vancouver to support compliance with the Energy Step Code and their LCES Options.

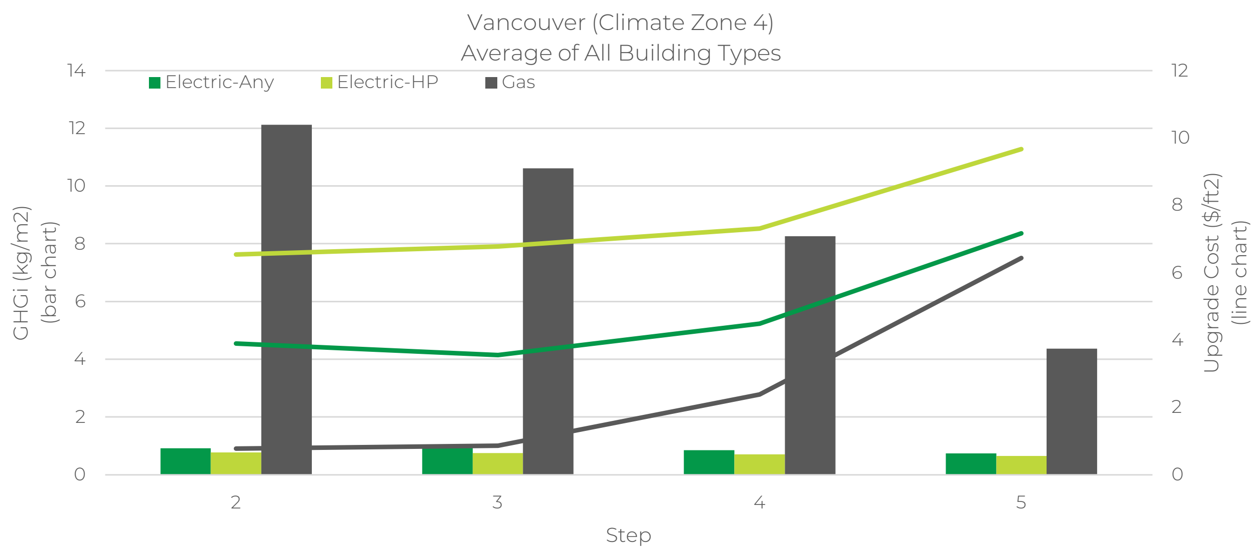
6.3 Building and Development Industry Engagement

It is recommended that local governments proceed expediently to engagement with their local building and development industries. Key topics include:

- What roles local government can play to help ensure industry readiness for widespread implementation of low GHG electric mechanical systems (e.g. heat pumps).
- Whether any additional requirements (e.g. operations and maintenance provisions) should be included to ensure functioning of mechanical equipment. This is most germane to larger Part 3 condominium developments, which have faced issues in the past managing complex central mechanical systems.
- Timelines for LCES Option integration. This includes when lower Steps associated with the LCES Option will be expected to "step up", as well when higher Steps "step up" if local governments do not begin at the highest Step.
- Exceptions (i.e. "safety valve" mechanism) to LCES requirements, in circumstances when utility extension fees will result in unusual and excessive cost.

Appendix A – GHG Emissions and Costs of Energy Step Code Buildings – Part 9

The graphics below summarize GHG emissions and the upgrade cost relative to the "reference house" for different Part 9 building types for different climate zones in BC. Data is derived from the Energy Step Code 2018 Metrics Research, corrected for recent changes to the Energy Step Code for Part 9 buildings.


Vancouver (Climate Zone 4)
Average of All Building Types
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
2
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8
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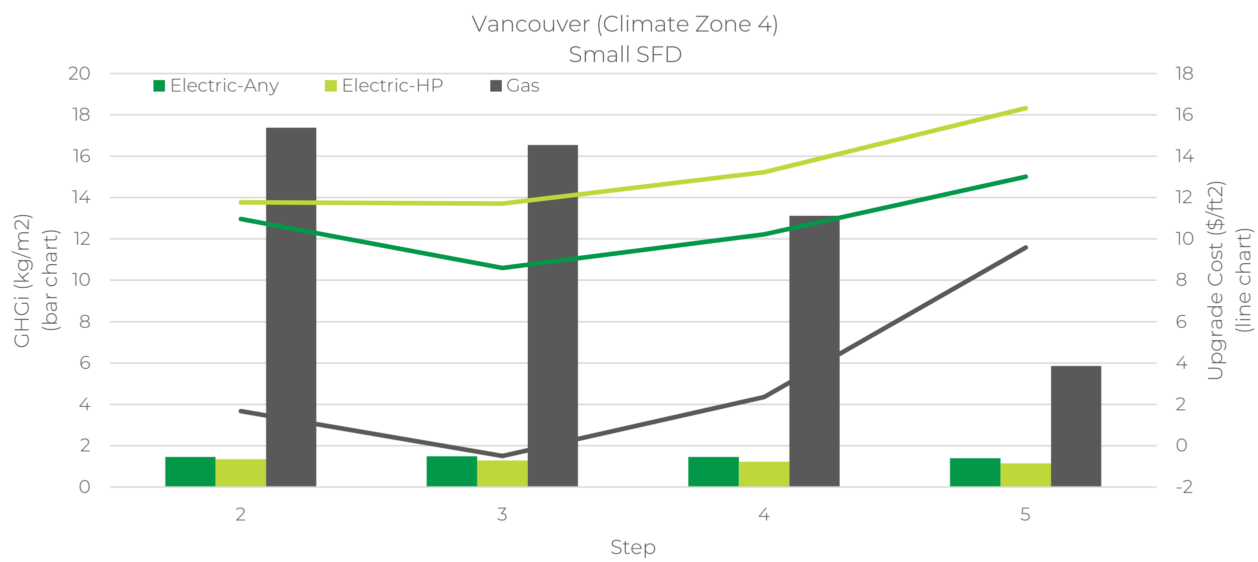
5
Step


Vancouver (Climate Zone 4)
Small SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
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4
6
8
10
12
14
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18
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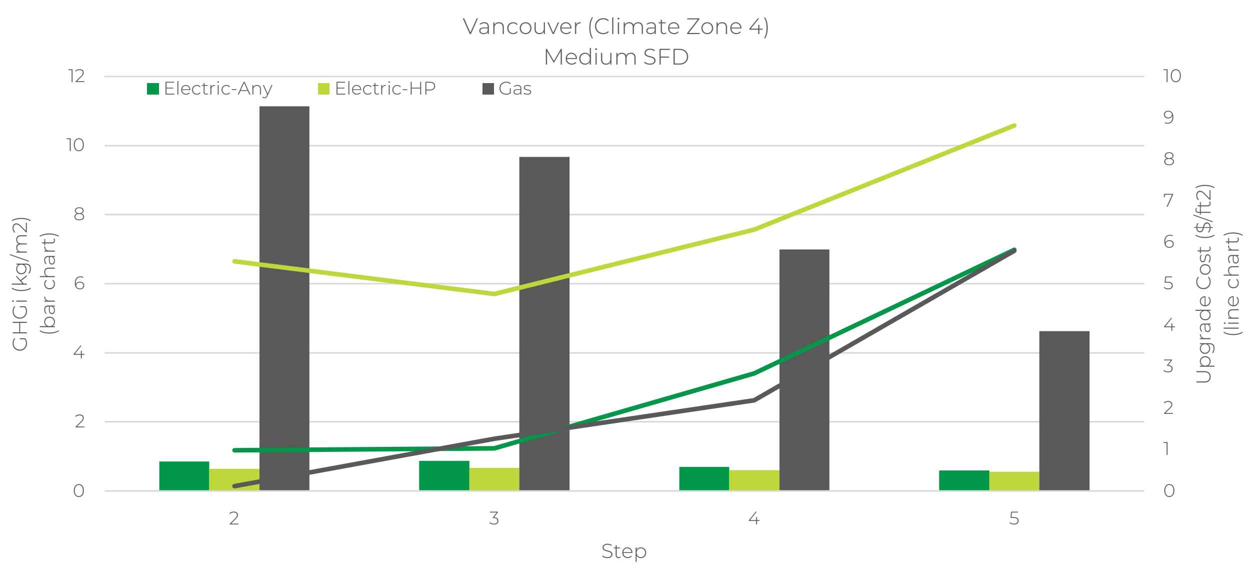
Step


Vancouver (Climate Zone 4)
Medium SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
2
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6
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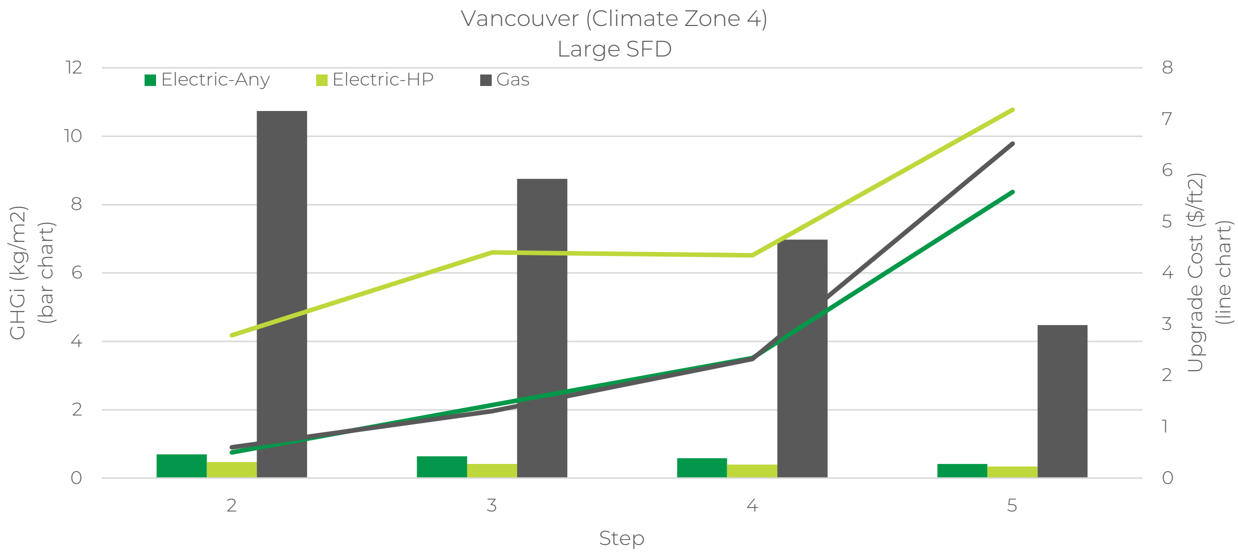
Step


Vancouver (Climate Zone 4)
Large SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
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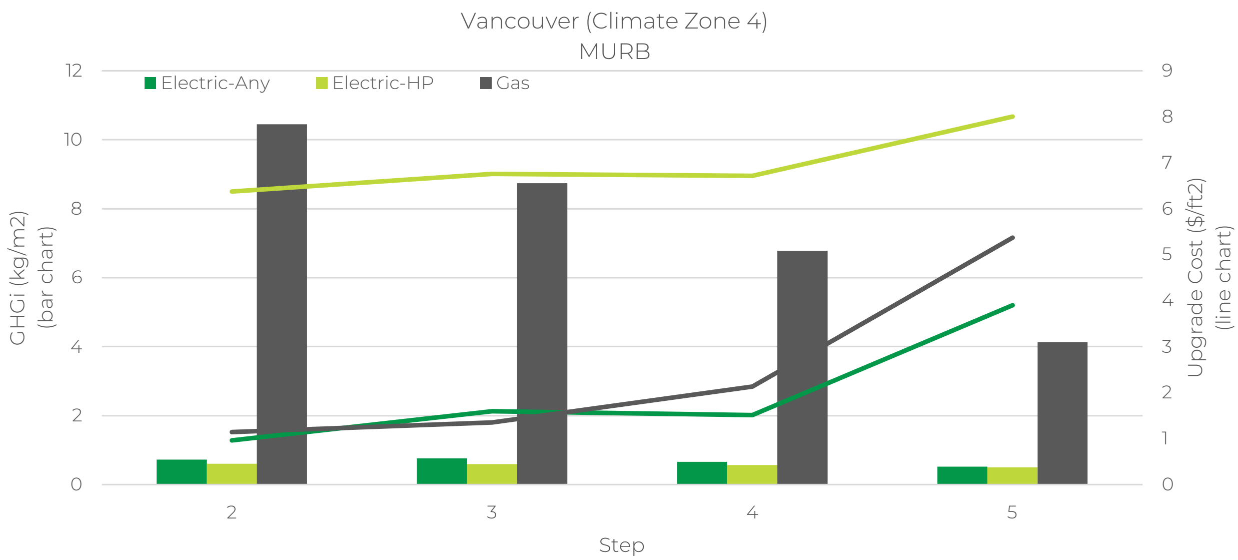
5


Vancouver (Climate Zone 4)
MURB
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
0
2
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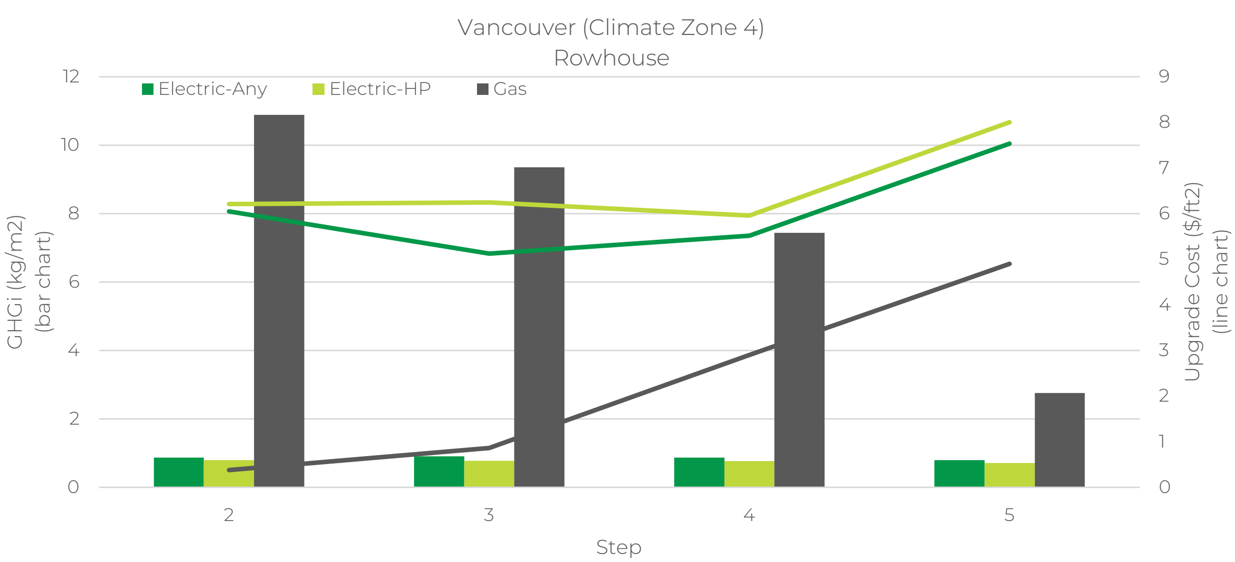
Vancouver (Climate Zone 4)
Rowhouse
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
0
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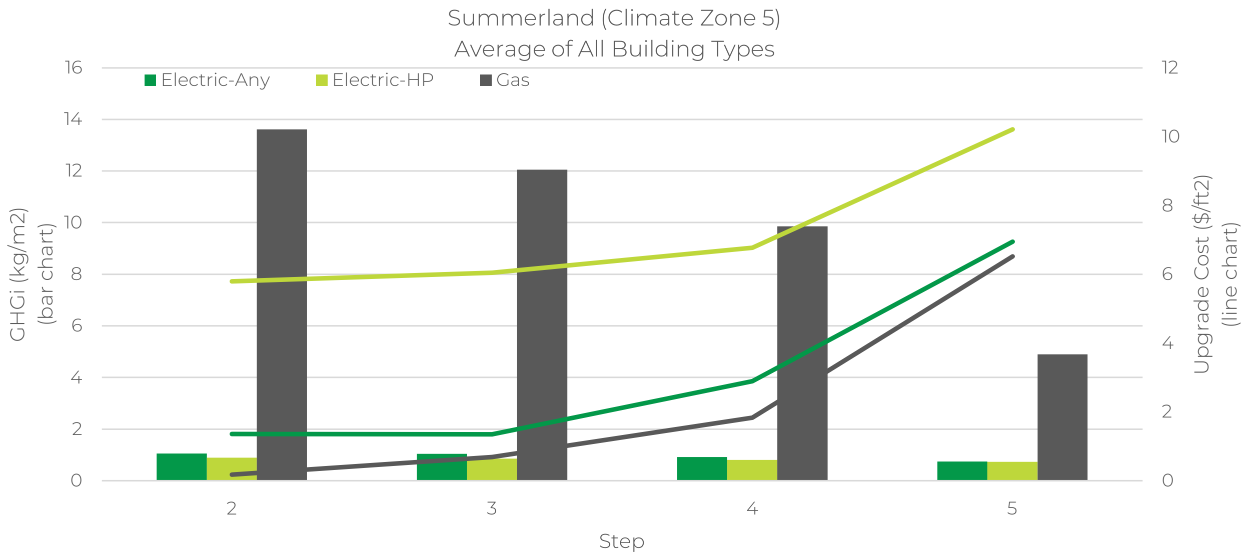
Summerland (Climate Zone 5)
Average of All Building Types
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
16
14
12
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8
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12
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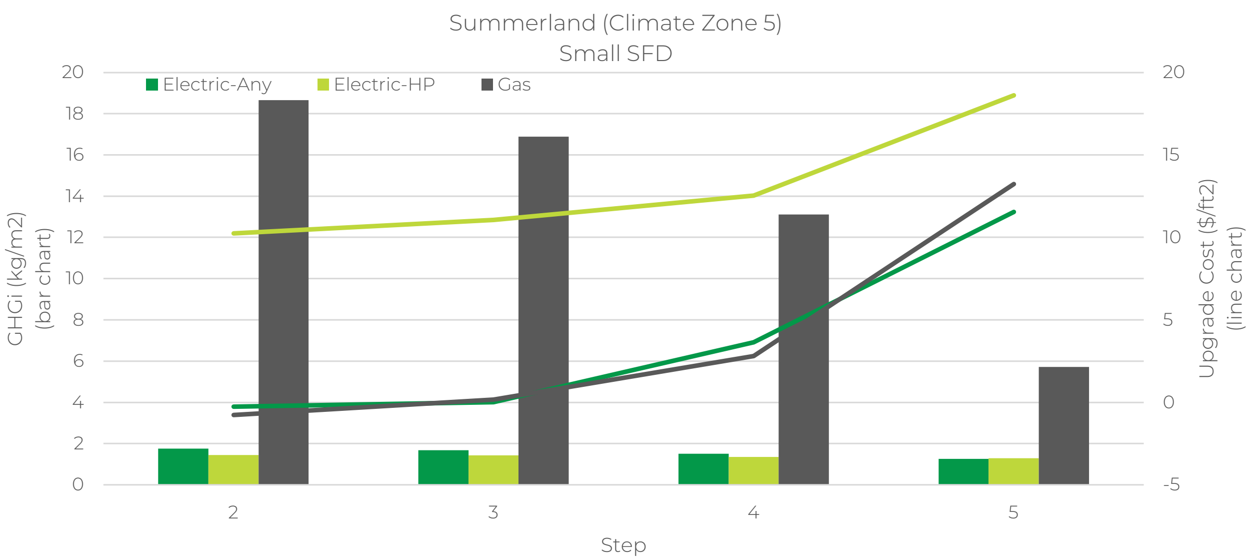
Summerland (Climate Zone 5)
Small SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
20
18
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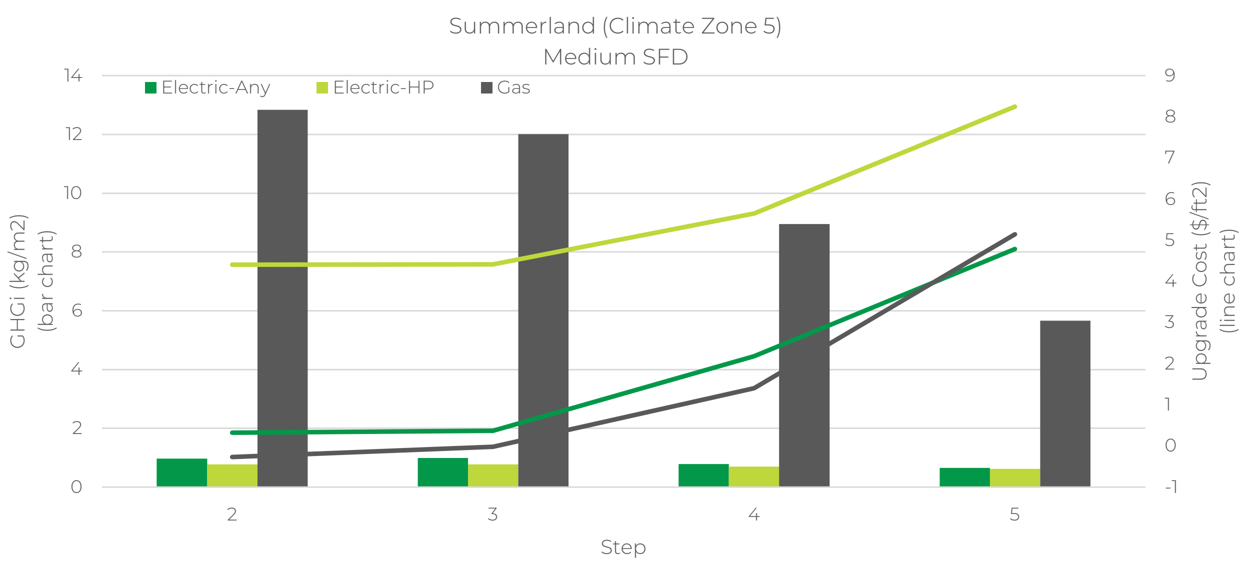
Summerland (Climate Zone 5)
Medium SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
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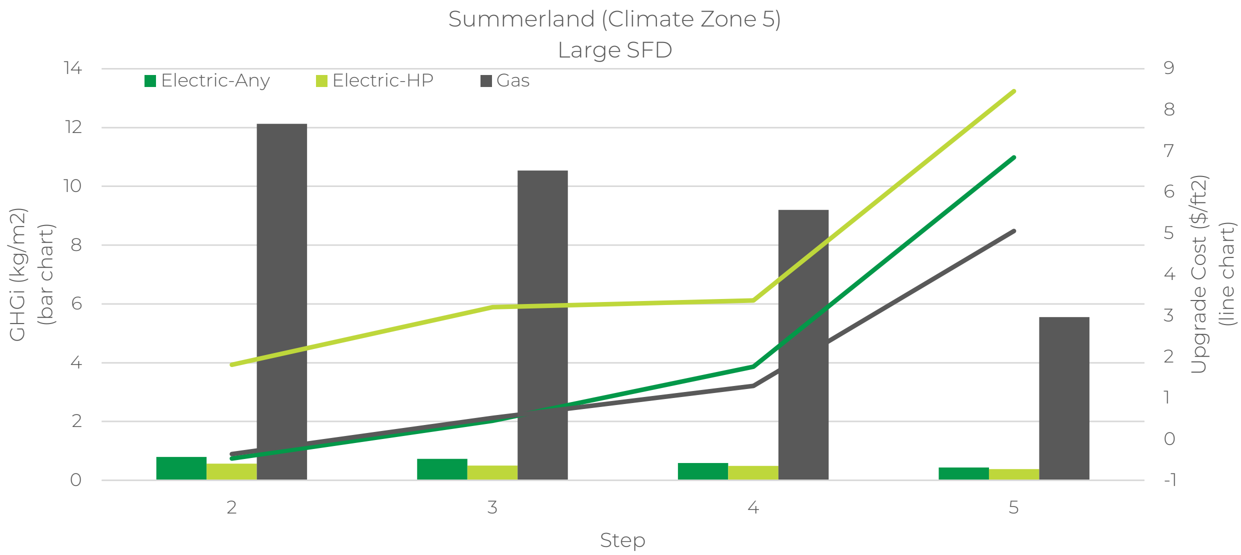
Summerland (Climate Zone 5)
Large SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2) (bar chart)
Upgrade Cost ($/ft2) (line chart)
Step
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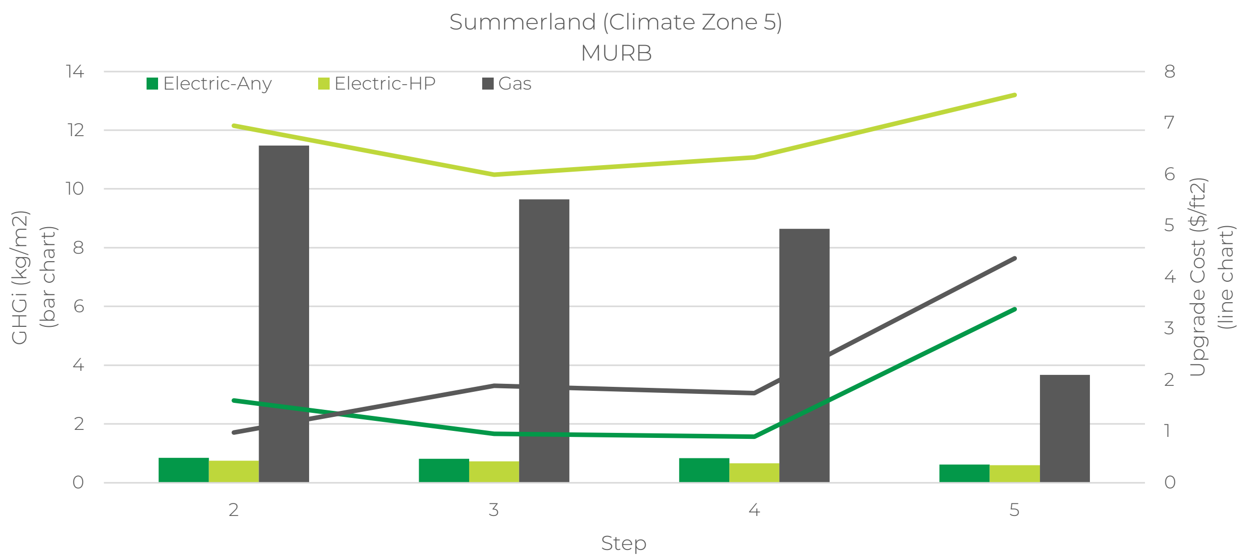
Summerland (Climate Zone 5)
MURB
Electric-Any
Electric-HP
Gas
GHGi (kg/m2) (bar chart)
Upgrade Cost ($/ft2) (line chart)
Step
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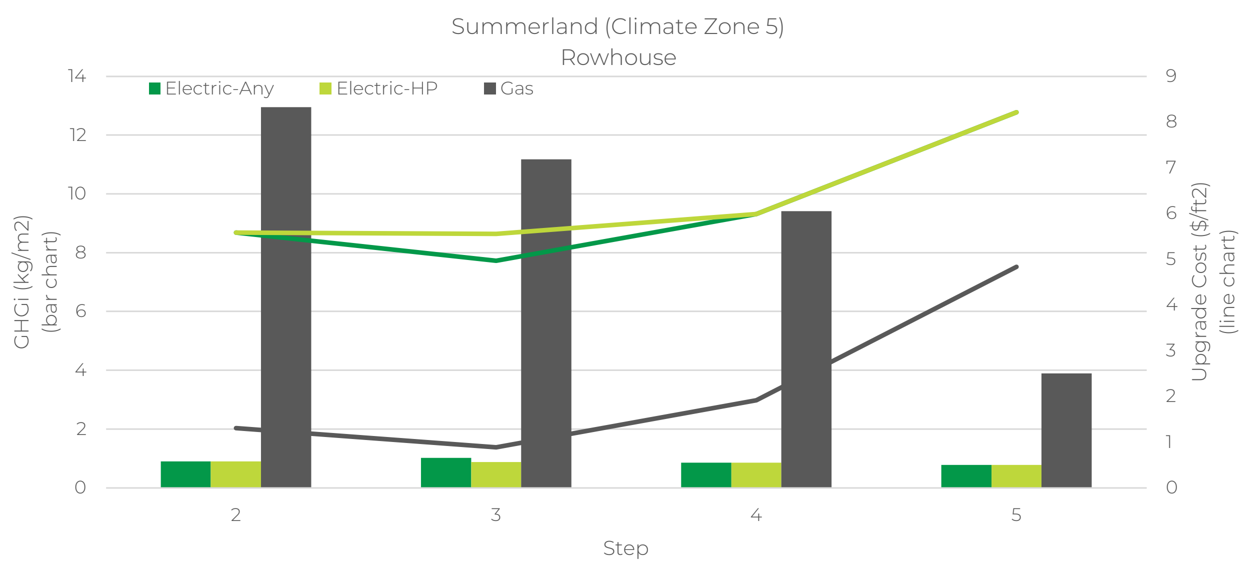
Summerland (Climate Zone 5)
Rowhouse
Electric-Any
Electric-HP
Gas
GHGi (kg/m2) (bar chart)
Upgrade Cost ($/ft2) (line chart)
Step
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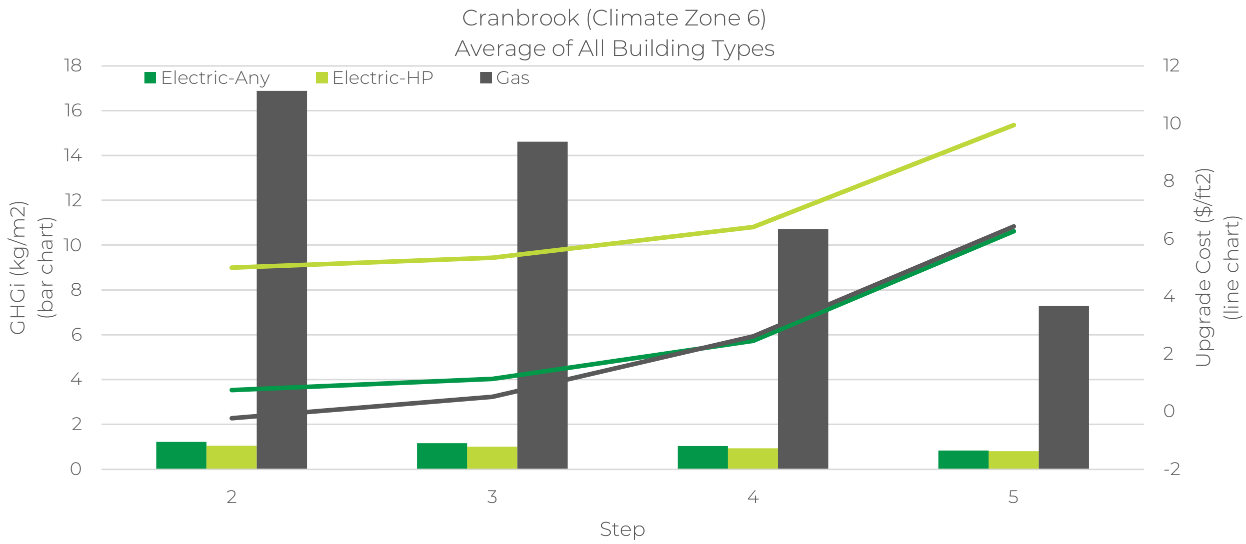
Cranbrook (Climate Zone 6)
Average of All Building Types
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
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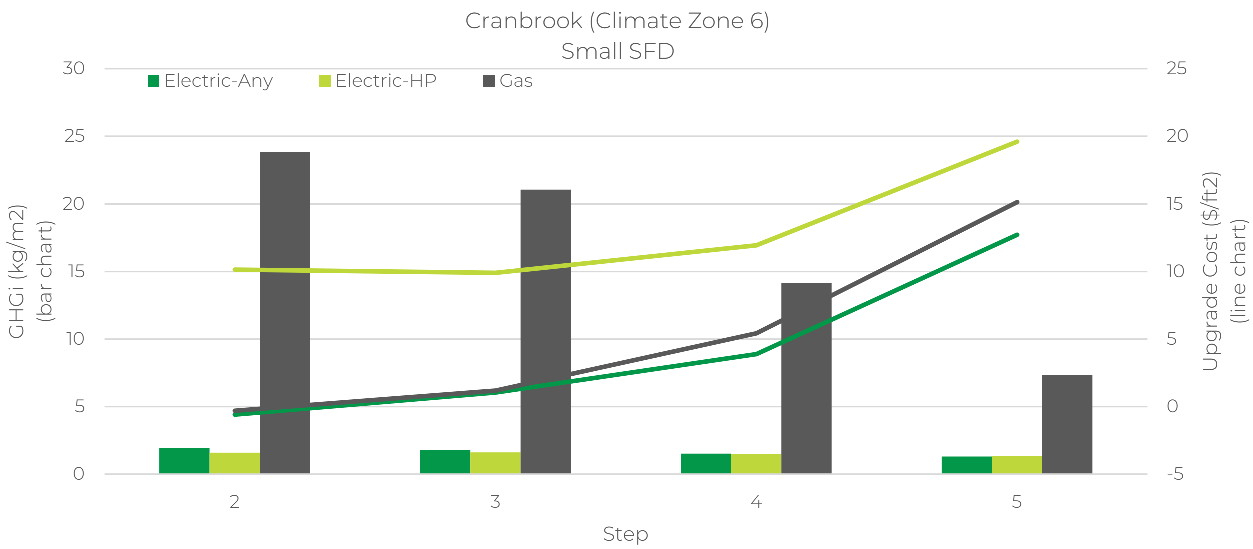
Cranbrook (Climate Zone 6)
Small SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
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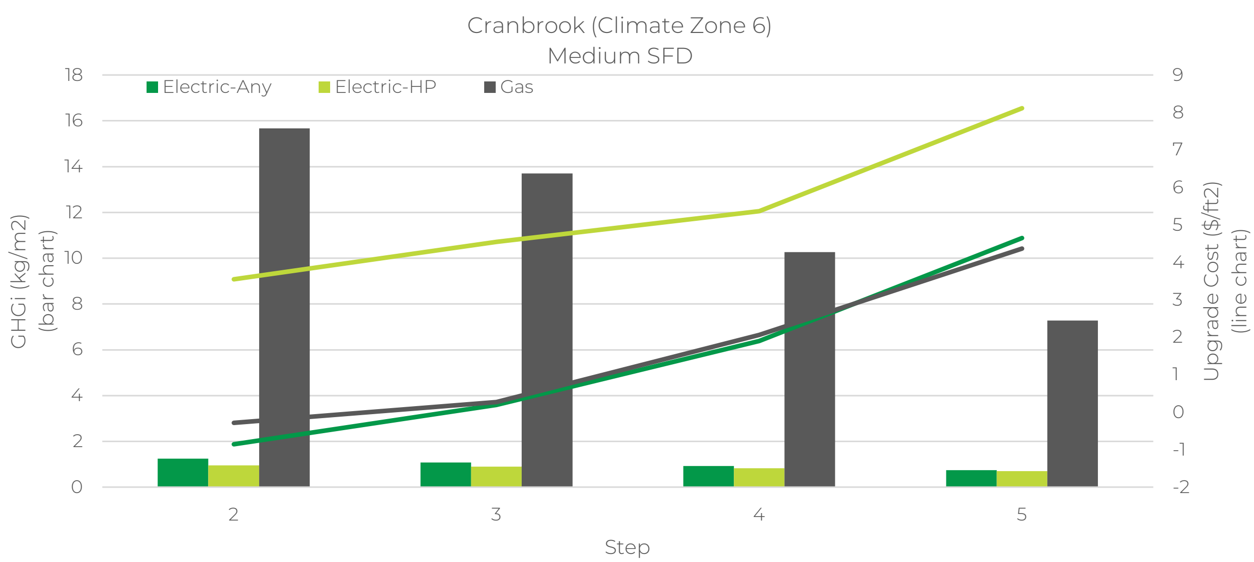
Step


Cranbrook (Climate Zone 6)
Medium SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
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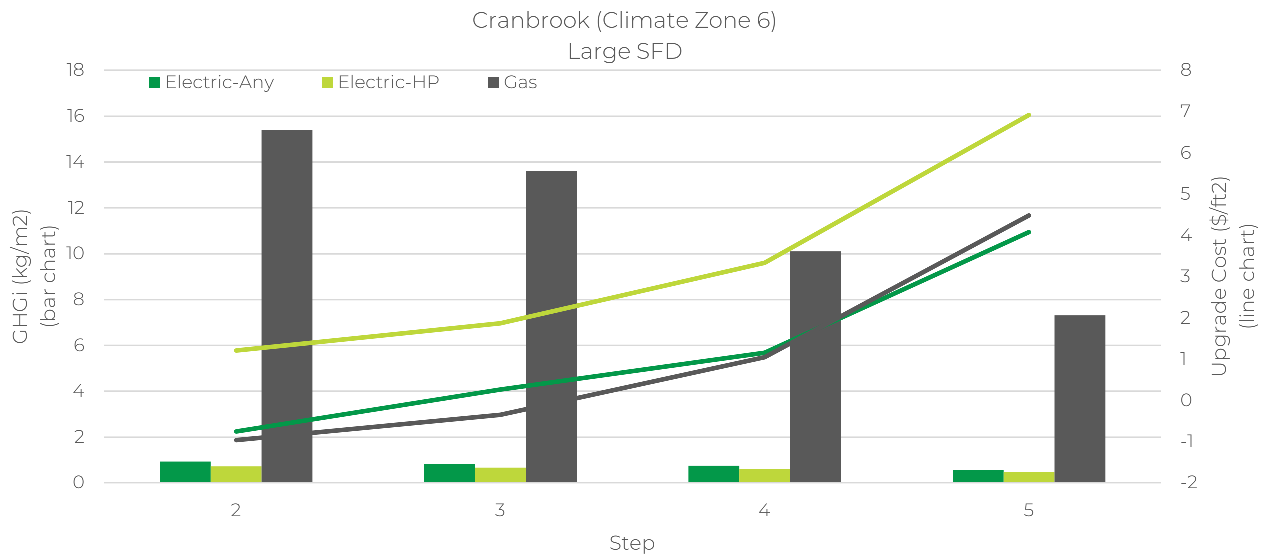
Cranbrook (Climate Zone 6)
Large SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
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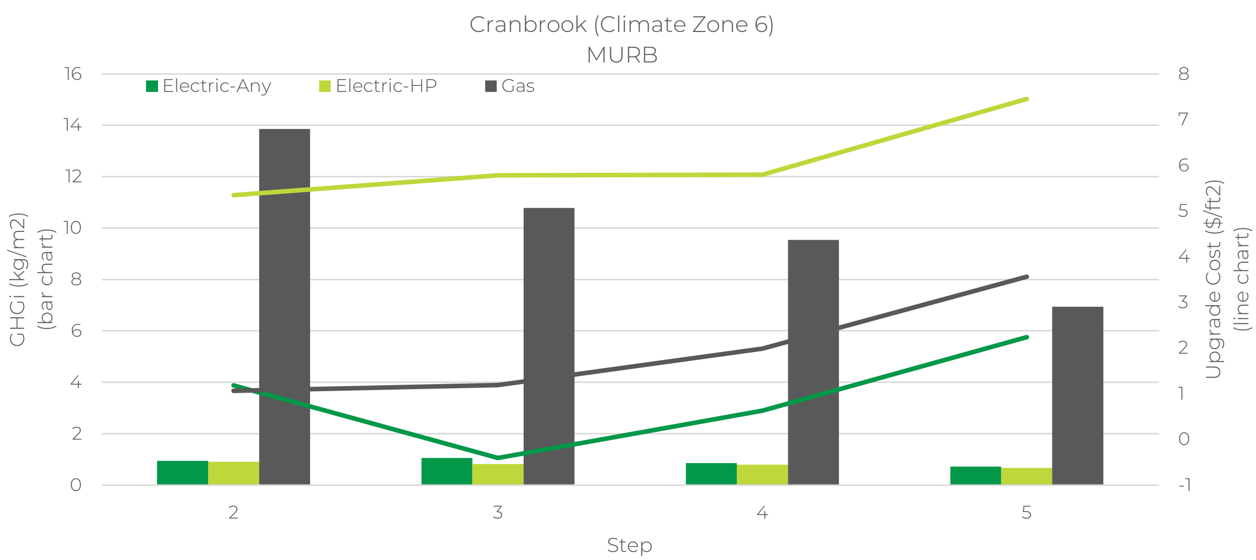
Cranbrook (Climate Zone 6)
MURB
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
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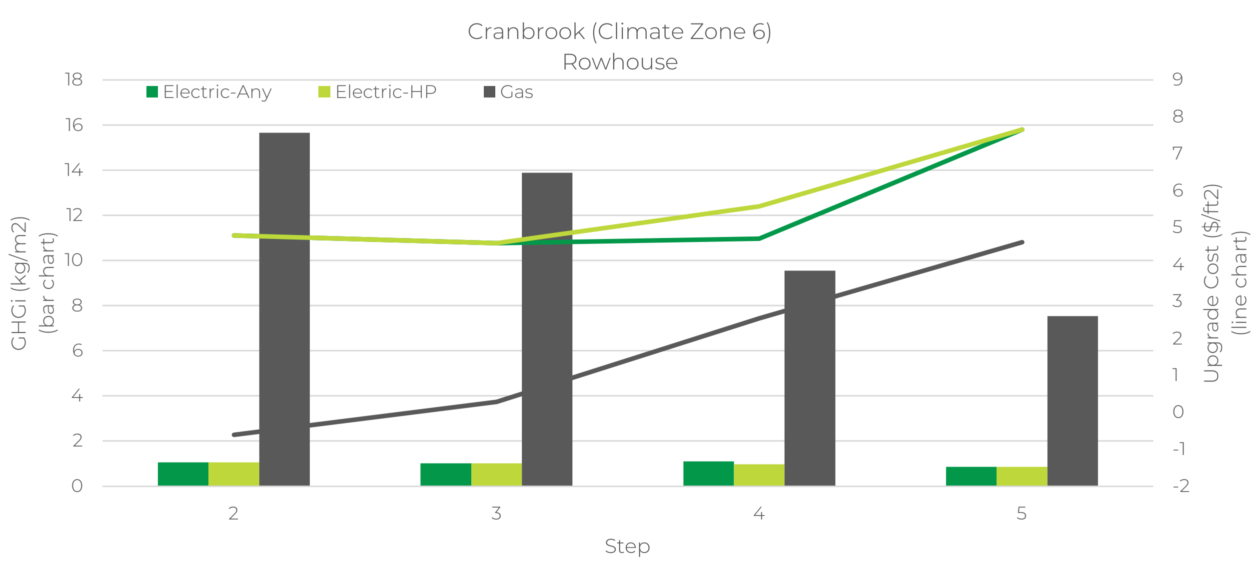
Cranbrook (Climate Zone 6)
Rowhouse
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
Step
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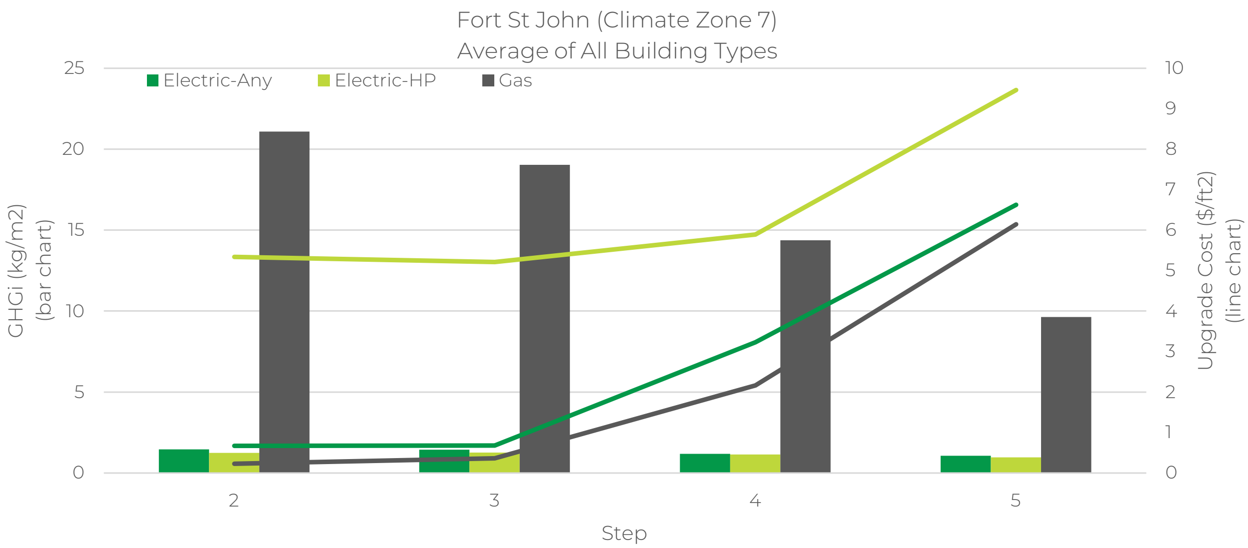
Fort St John (Climate Zone 7)
Average of All Building Types
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
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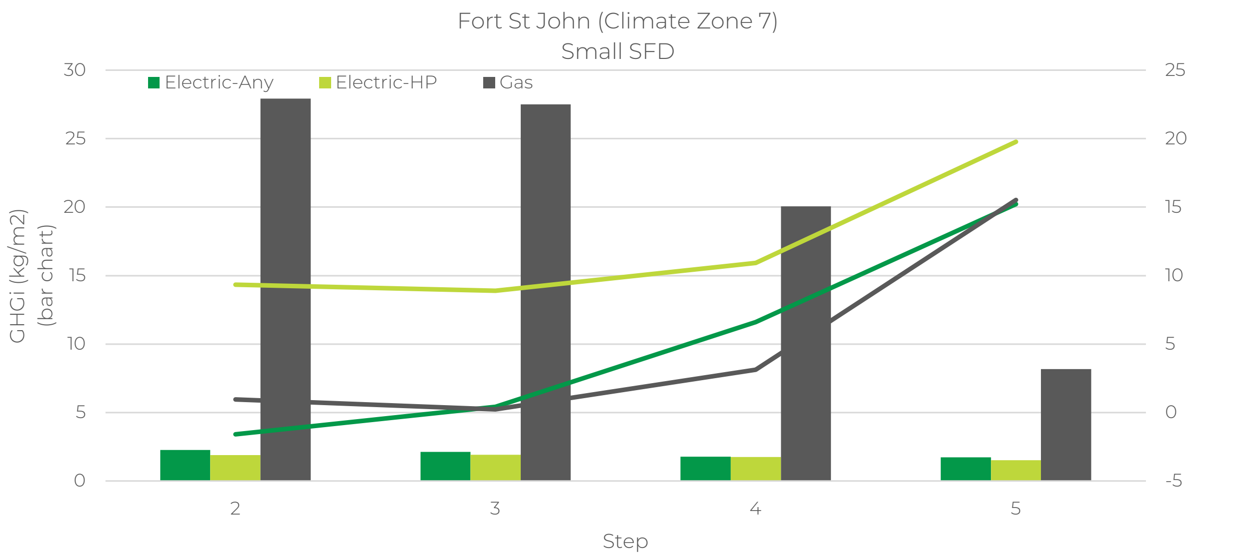
Fort St John (Climate Zone 7)
Small SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
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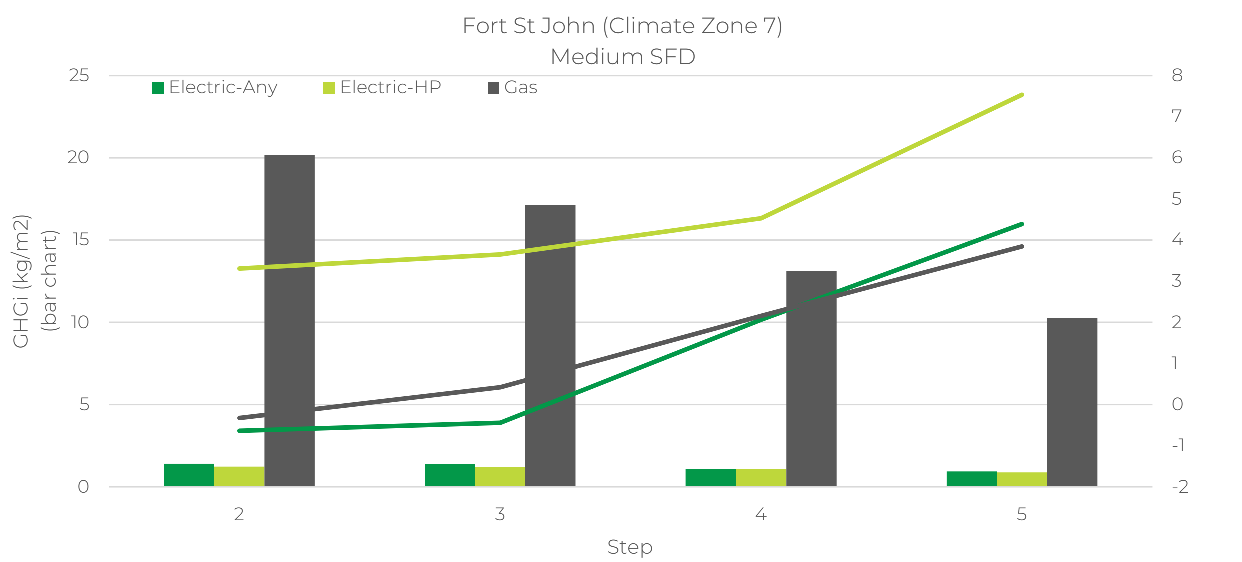
Fort St John (Climate Zone 7)
Medium SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
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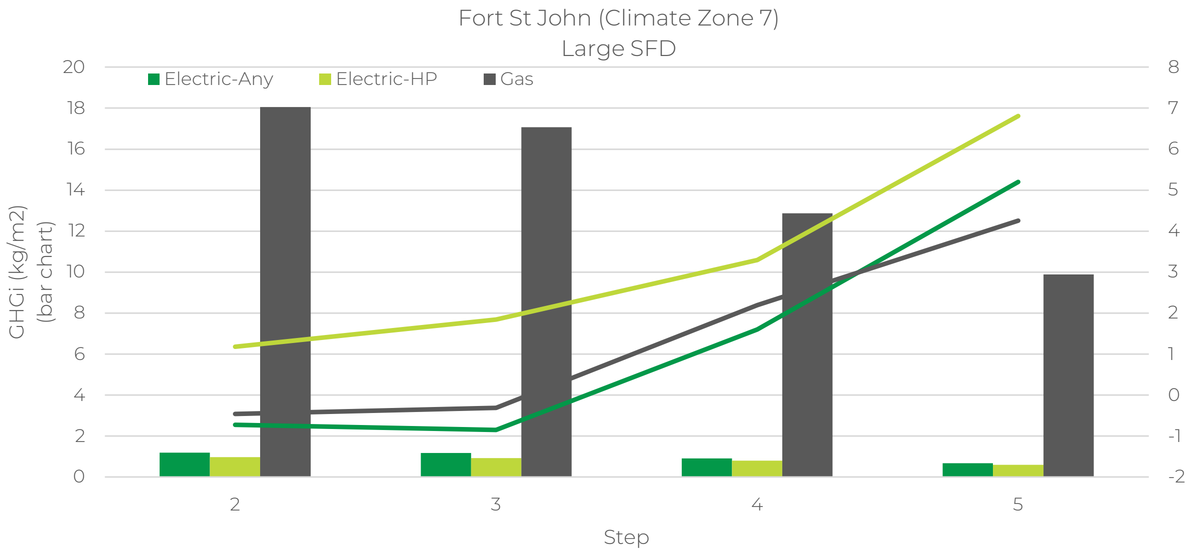
Fort St John (Climate Zone 7)
Large SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2) (bar chart)
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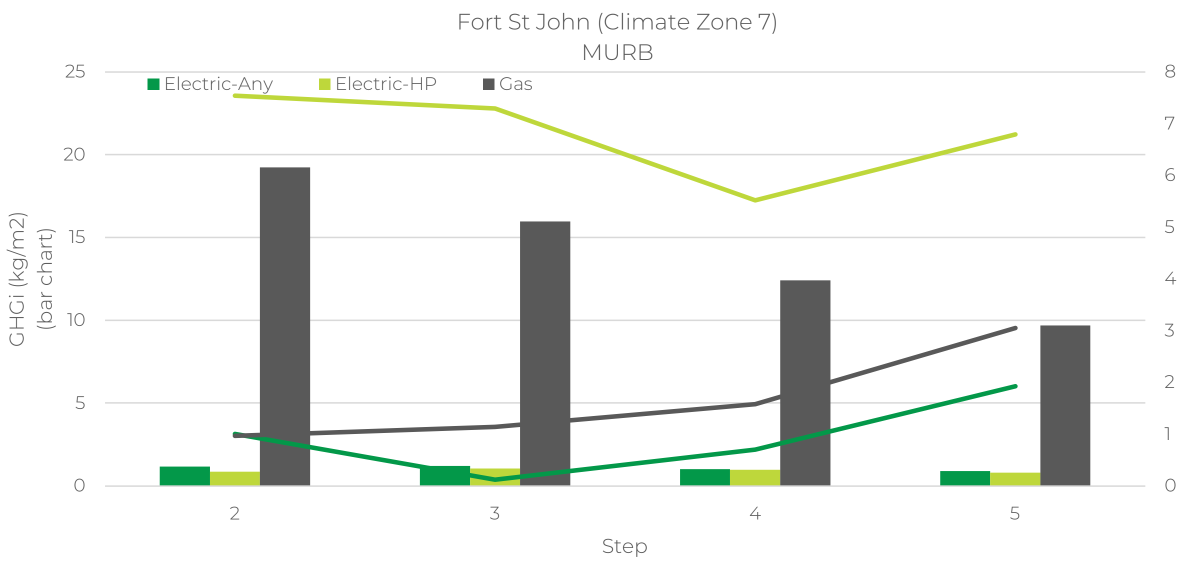
Fort St John (Climate Zone 7)
MURB
Electric-Any
Electric-HP
Gas
GHGi (kg/m2) (bar chart)
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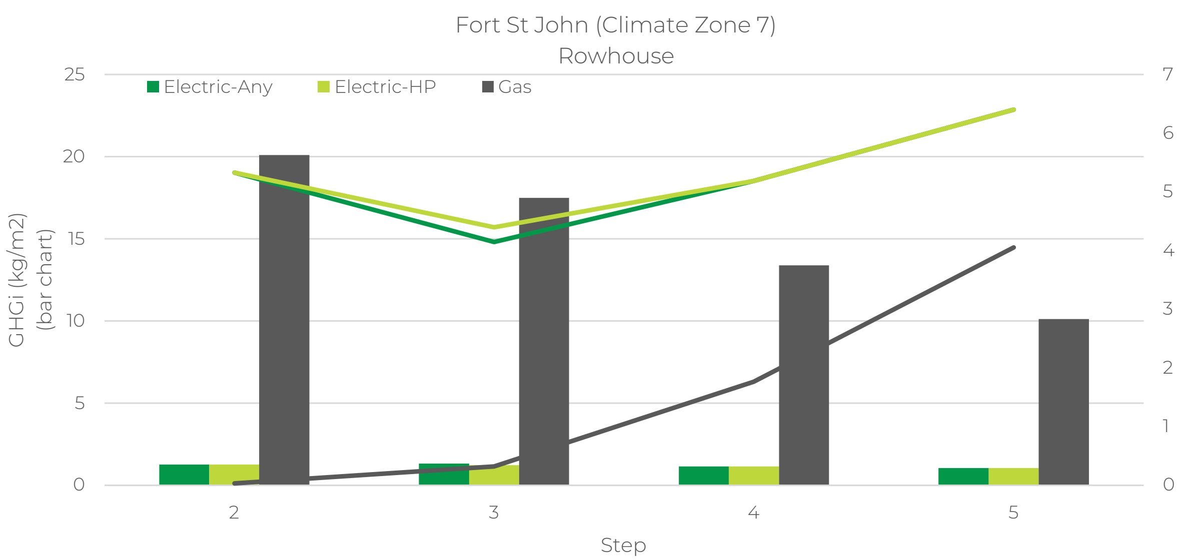
Step


Fort St John (Climate Zone 7)
Rowhouse
Electric-Any
Electric-HP
Gas
GHGi (kg/m2) (bar chart)
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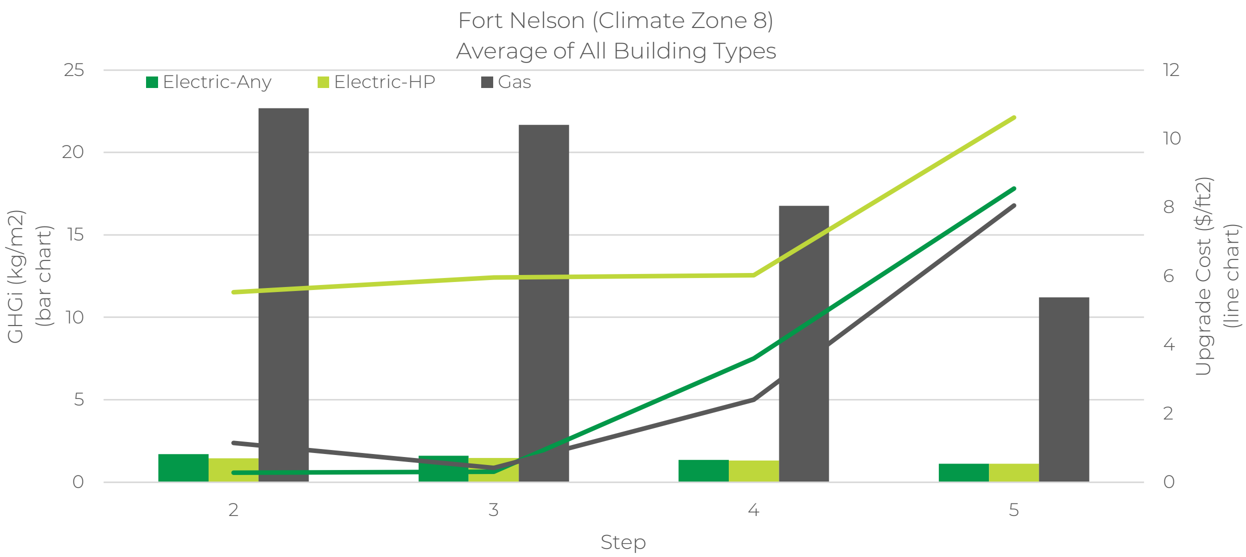
Step


Fort Nelson (Climate Zone 8)
Average of All Building Types
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
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2
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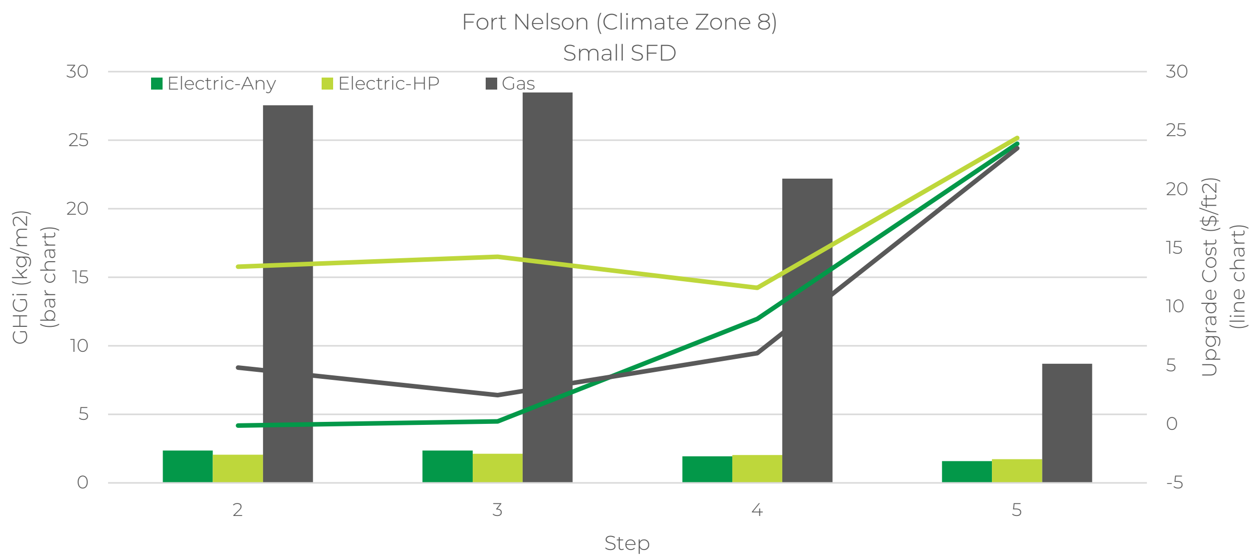
4
5
Step


Fort Nelson (Climate Zone 8)
Small SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
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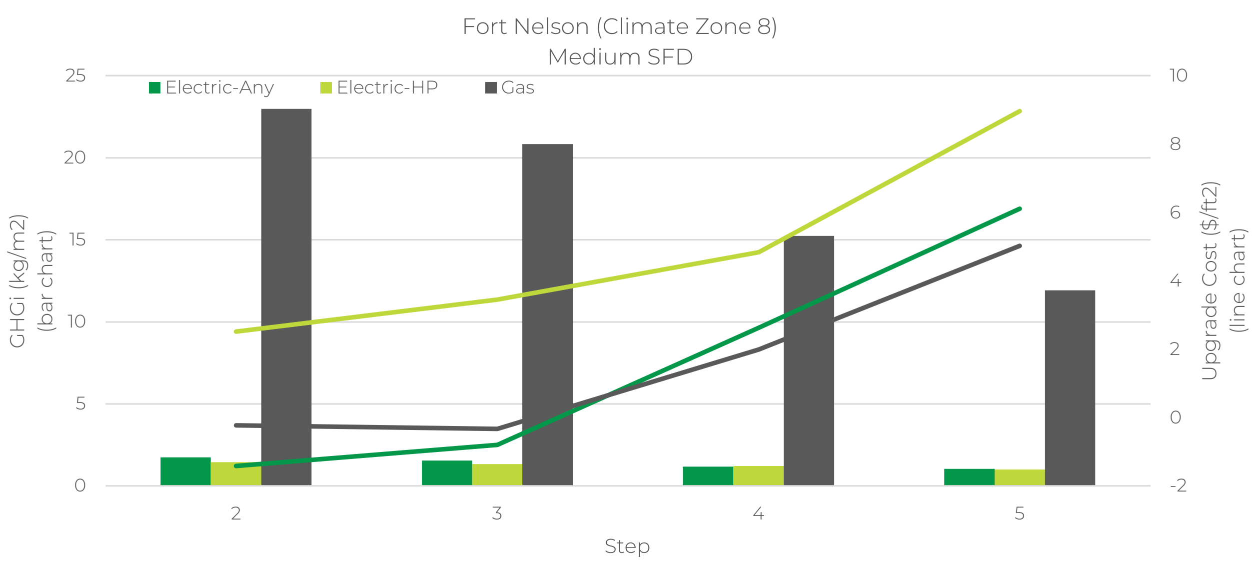
2
3
4
5
Step


Fort Nelson (Climate Zone 8)
Medium SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
25
20
15
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-2
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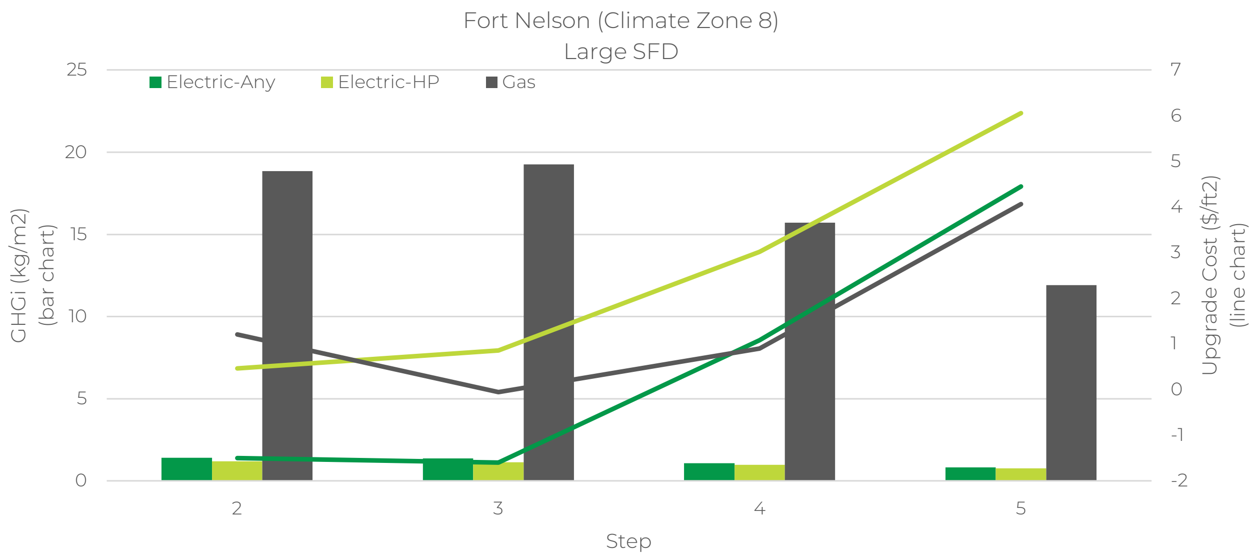
Step


Fort Nelson (Climate Zone 8)
Large SFD
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
5
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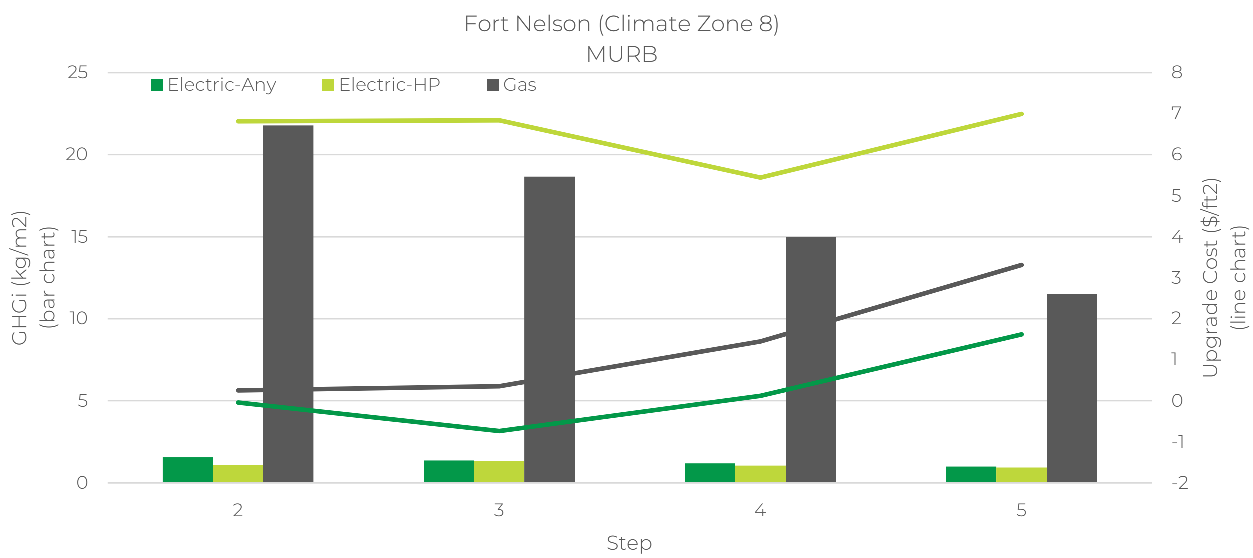
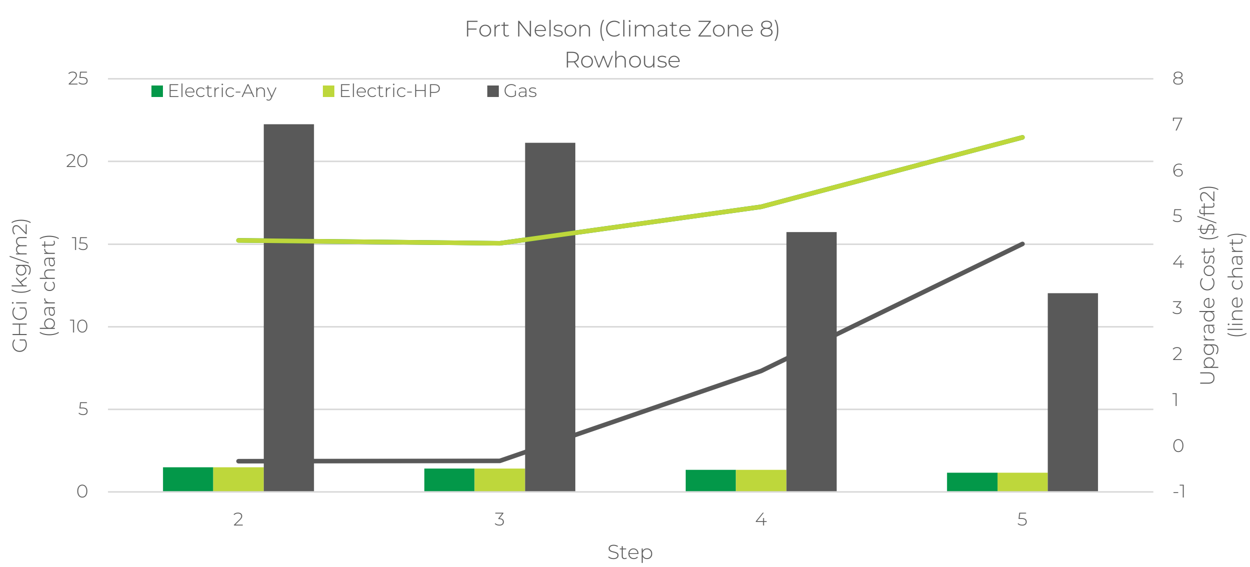
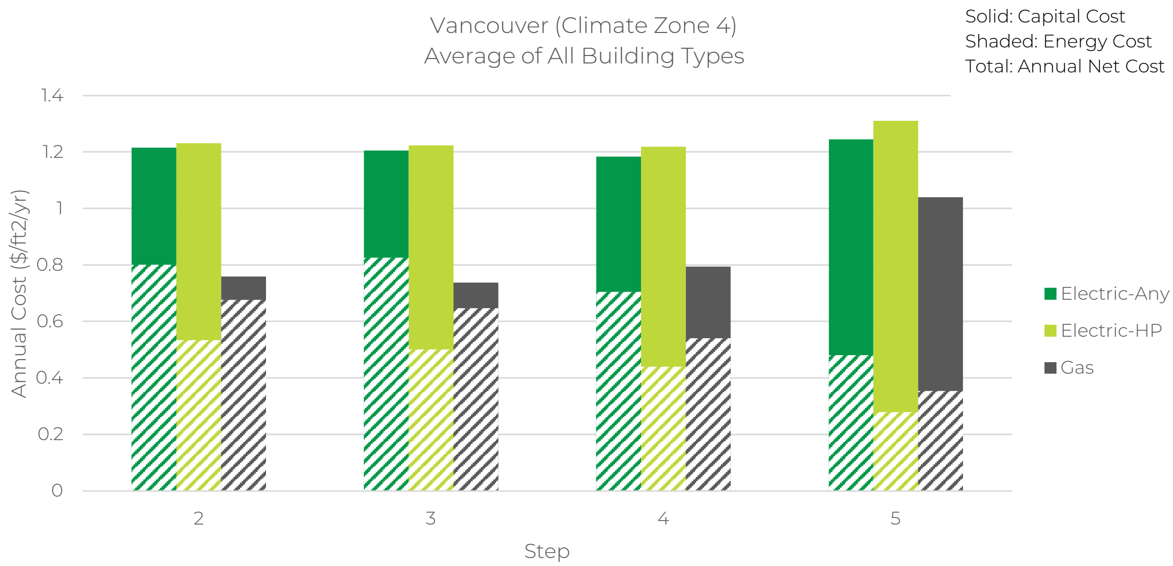
Step

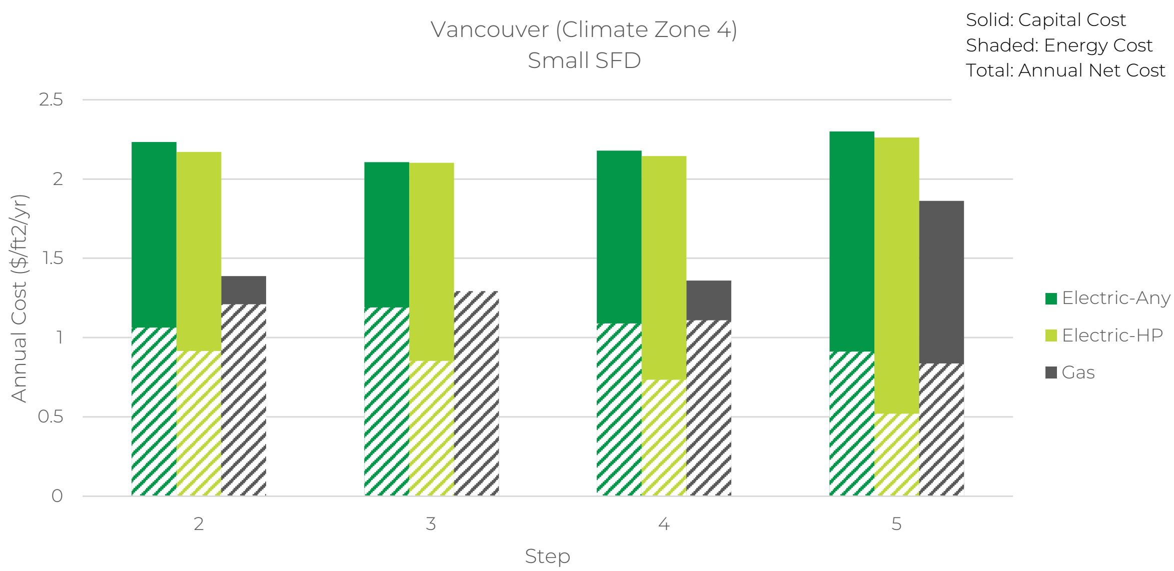

Fort Nelson (Climate Zone 8)
MURB
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
5
10
15
20
25
-2
-1
0
1
2
3
4
5
6
7
8
2
3
4
5
Step

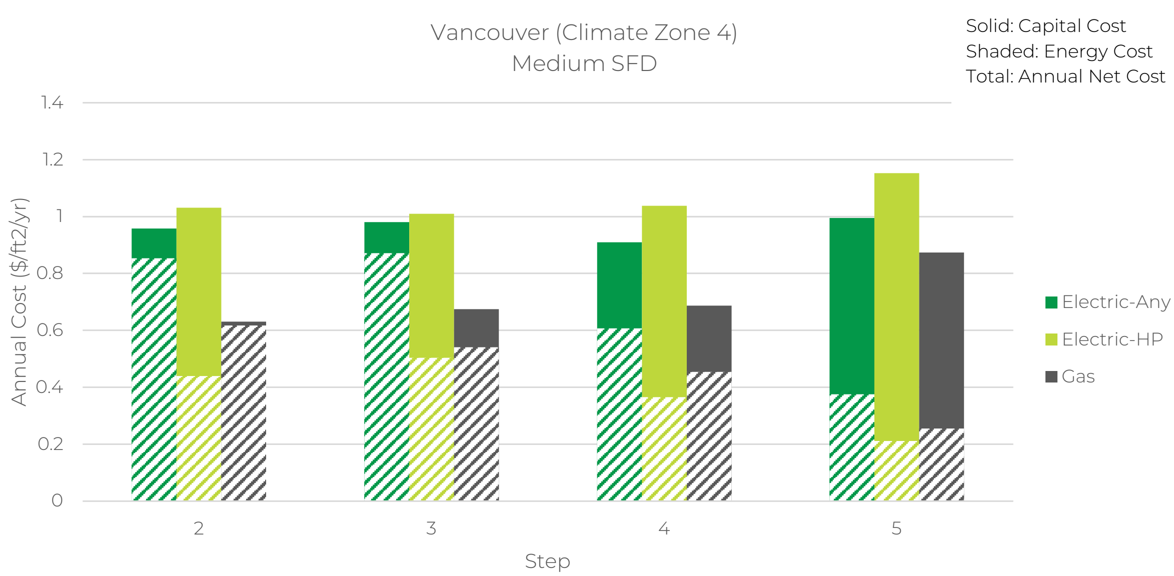

Fort Nelson (Climate Zone 8)
Rowhouse
Electric-Any
Electric-HP
Gas
GHGi (kg/m2)
(bar chart)
Upgrade Cost ($/ft2)
(line chart)
0
5
10
15
20
25
-1
0
1
2
3
4
5
6
7
8
2
3
4
5
Step

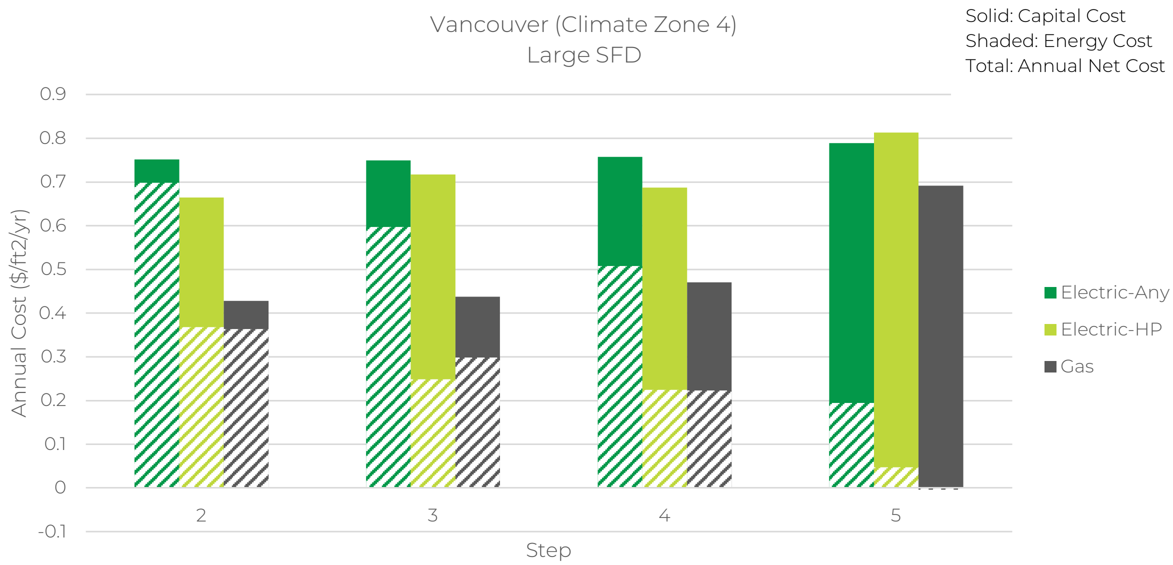
Appendix B – Life Cycle Costs of Energy Step Code Buildings – Part 9

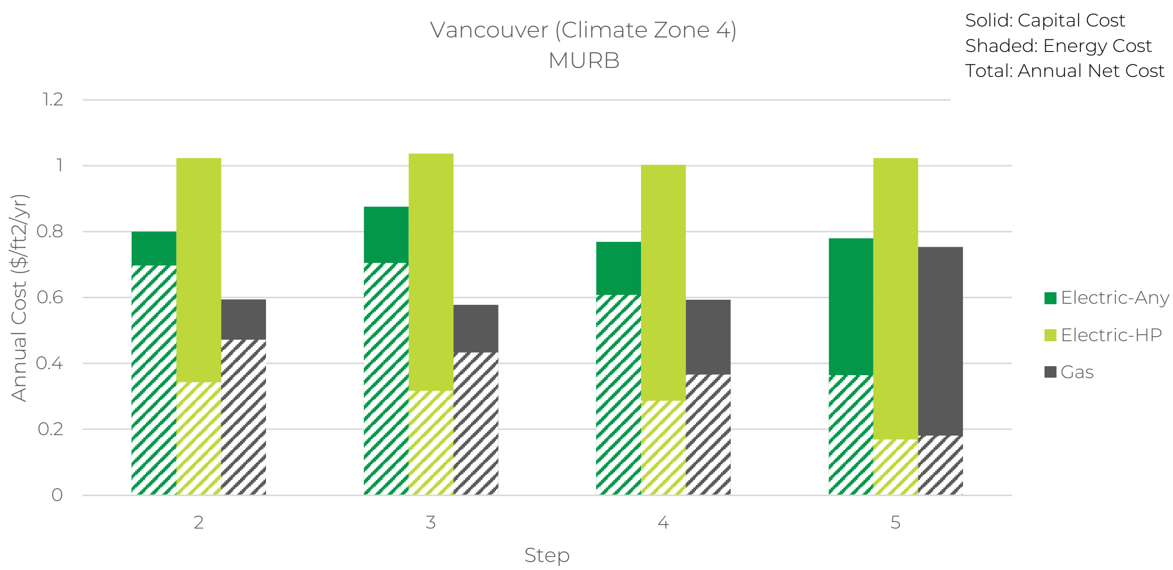
The graphics below summarize annual energy costs and the annualized incremental capital cost relative to the “reference house” for different Part 9 building types for different climate zones in BC. Data is derived from the Energy Step Code 2018 Metrics Research, corrected for recent changes to the Energy Step Code for Part 9 buildings.

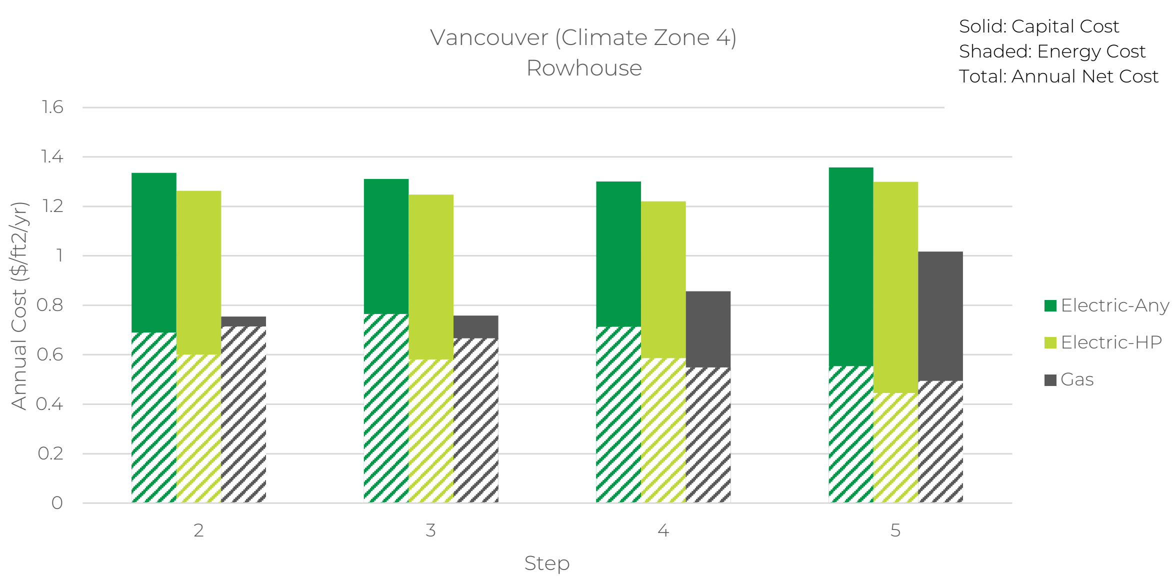

Vancouver (Climate Zone 4)
Average of All Building Types
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Annual Cost ($/ft2/yr)
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

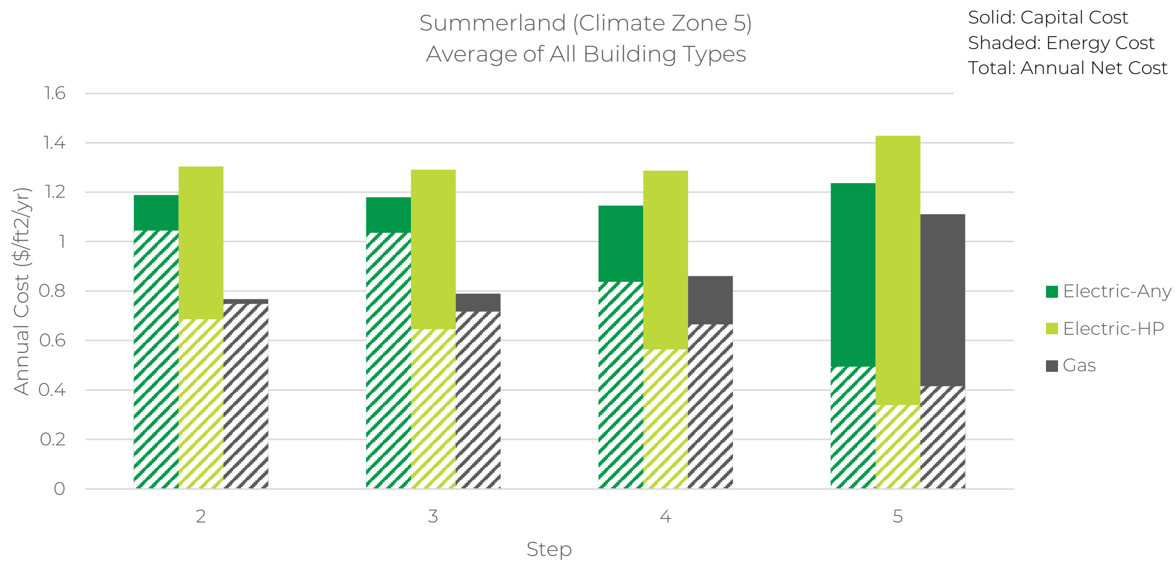

Vancouver (Climate Zone 4)
Small SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
2.5
2
1.5
1
0.5
0
Annual Cost ($/ft2/yr)
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

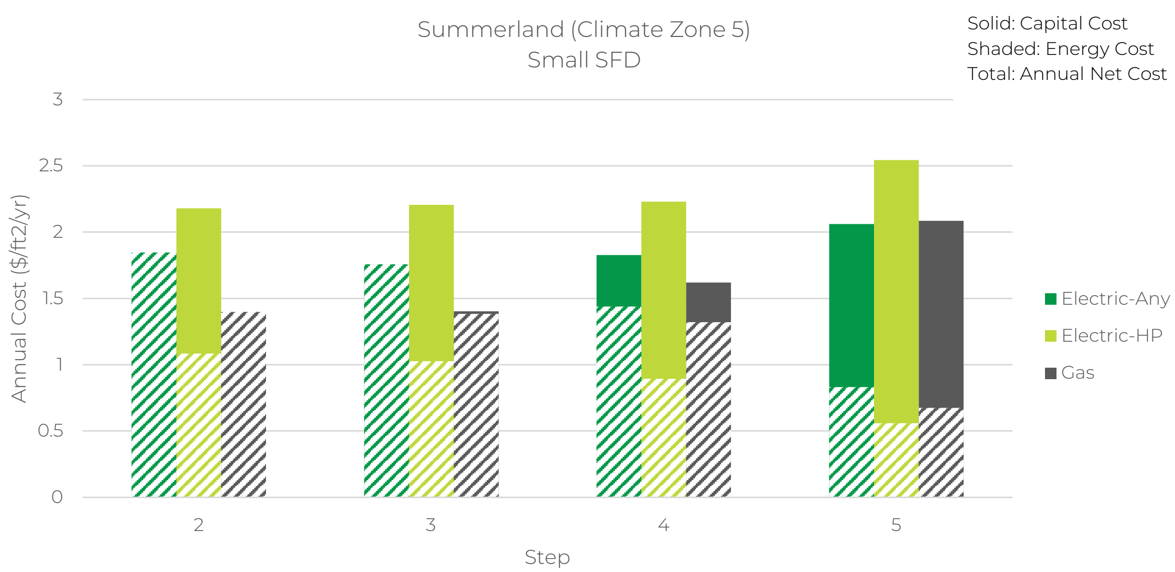

Vancouver (Climate Zone 4)
Medium SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Annual Cost ($/ft2/yr)
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

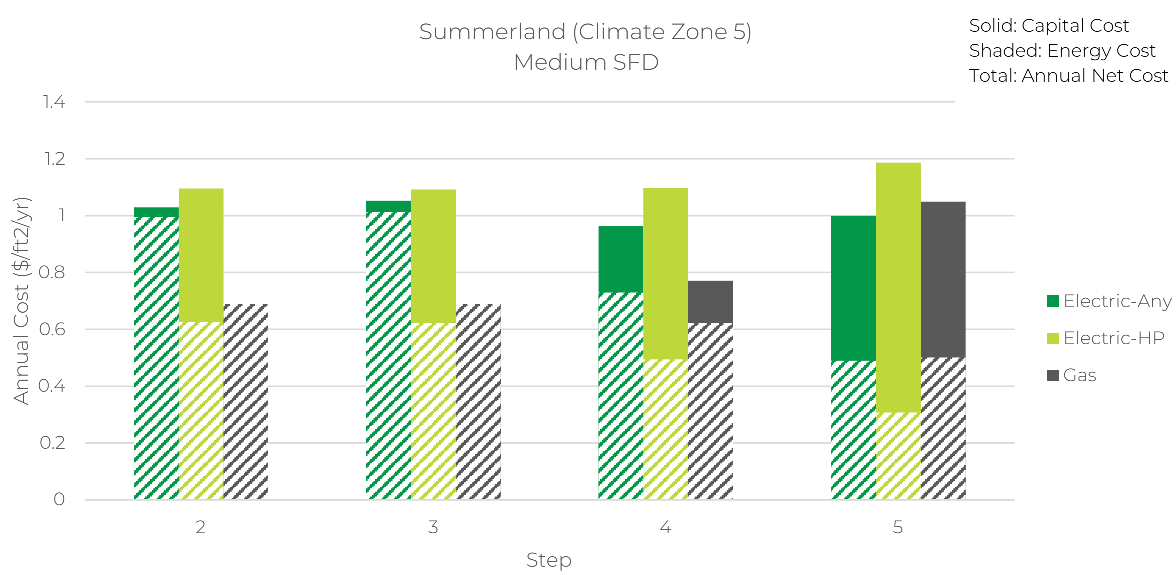

Vancouver (Climate Zone 4)
Large SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

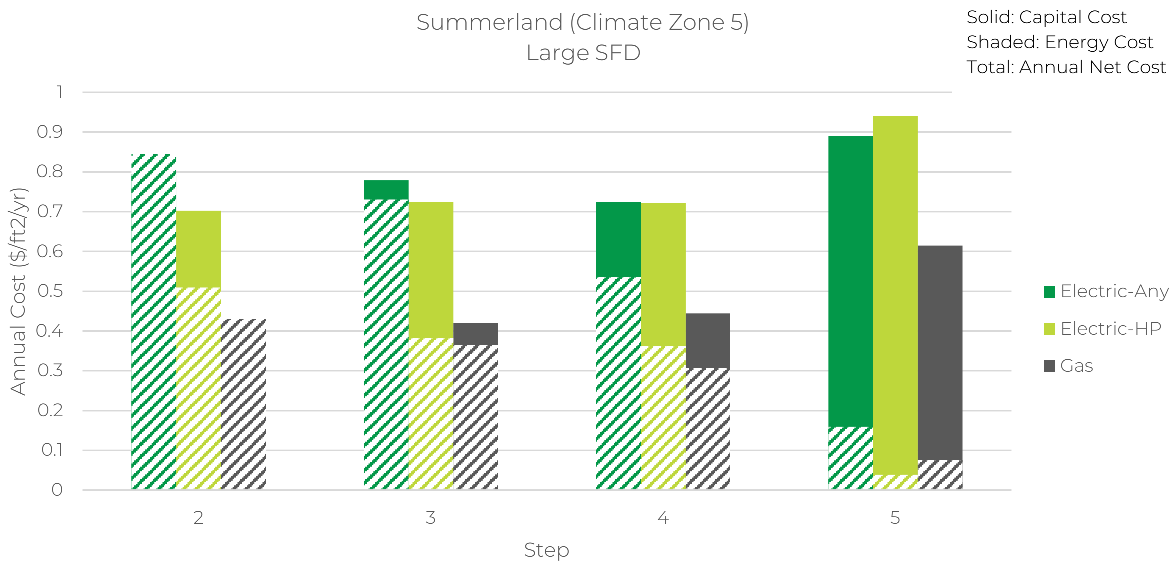

Vancouver (Climate Zone 4)
MURB
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

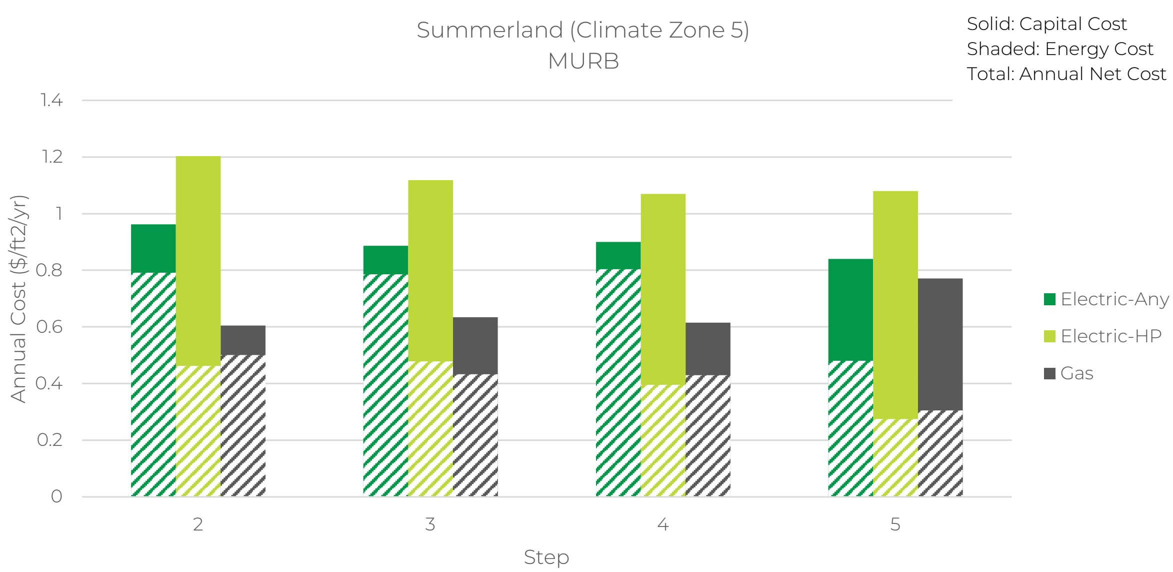

Vancouver (Climate Zone 4)
Rowhouse
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

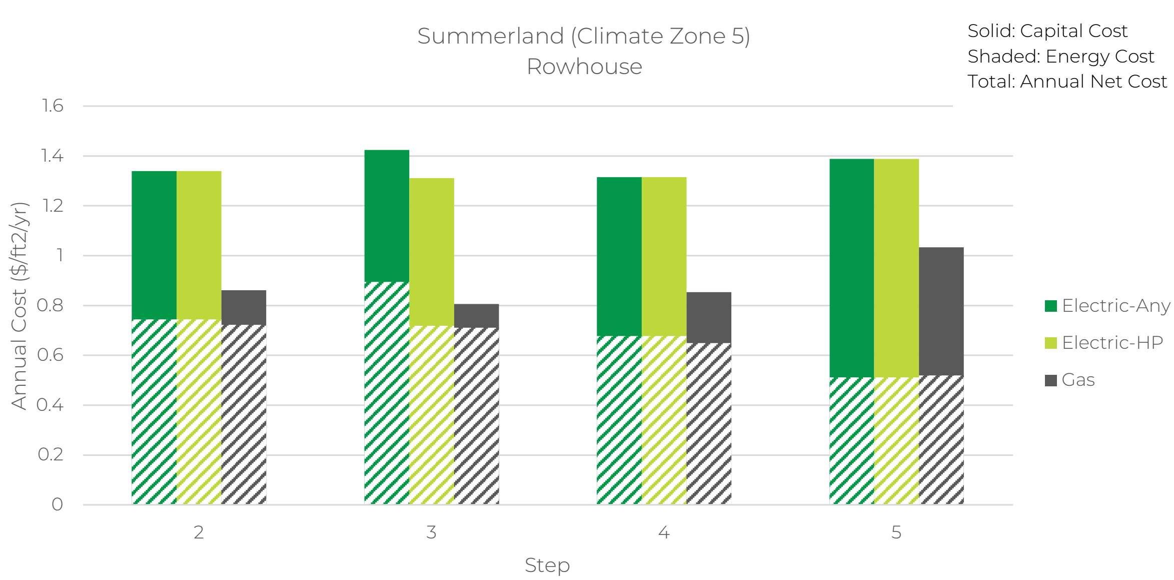

Summerland (Climate Zone 5)
Average of All Building Types
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
Step
Electric-Any
Electric-HP
Gas

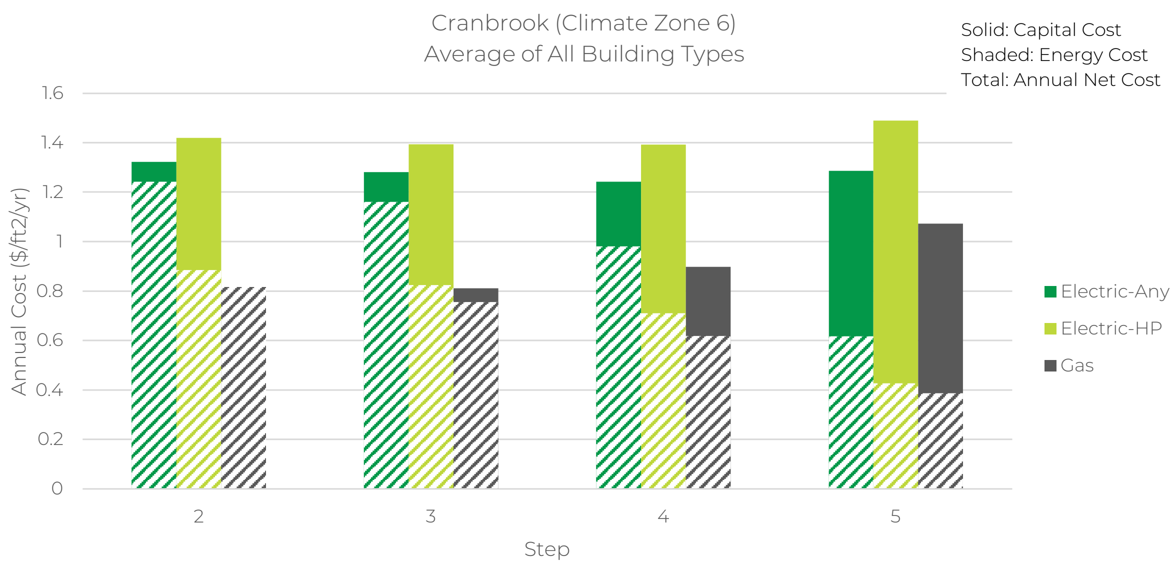

Summerland (Climate Zone 5)
Small SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
Step
Electric-Any
Electric-HP
Gas

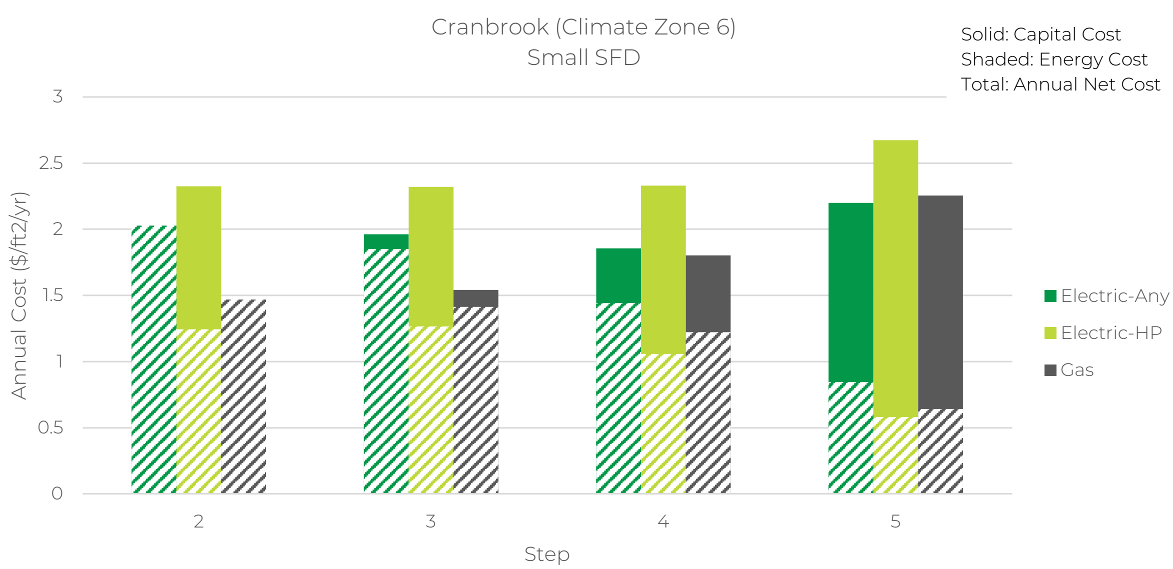

Summerland (Climate Zone 5)
Medium SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
Step
Electric-Any
Electric-HP
Gas

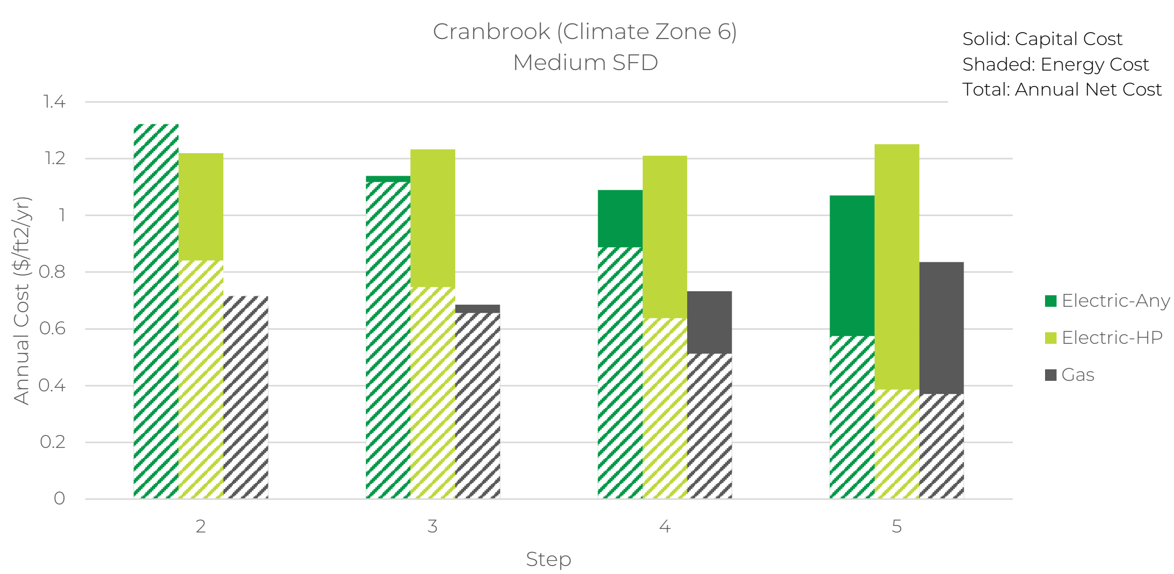

Summerland (Climate Zone 5)
Large SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

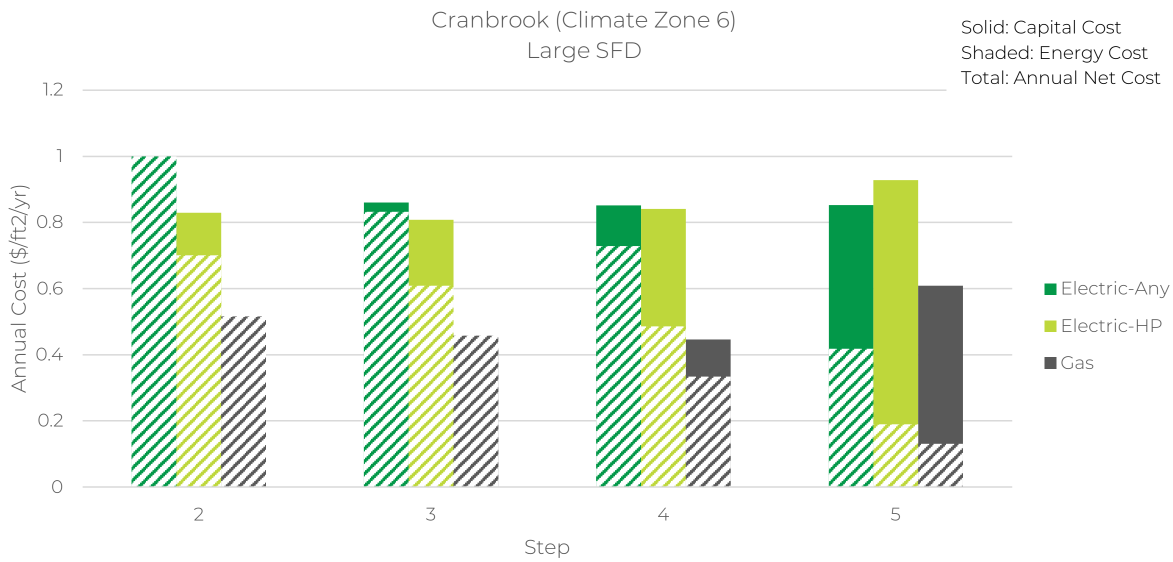

Summerland (Climate Zone 5)
MURB
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

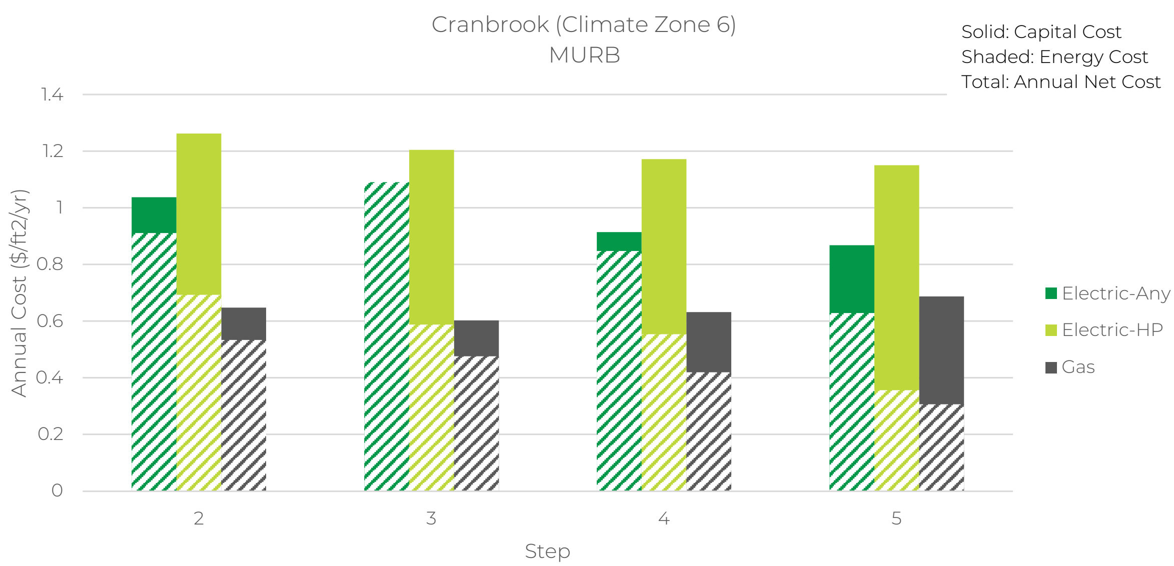

Summerland (Climate Zone 5)
Rowhouse
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

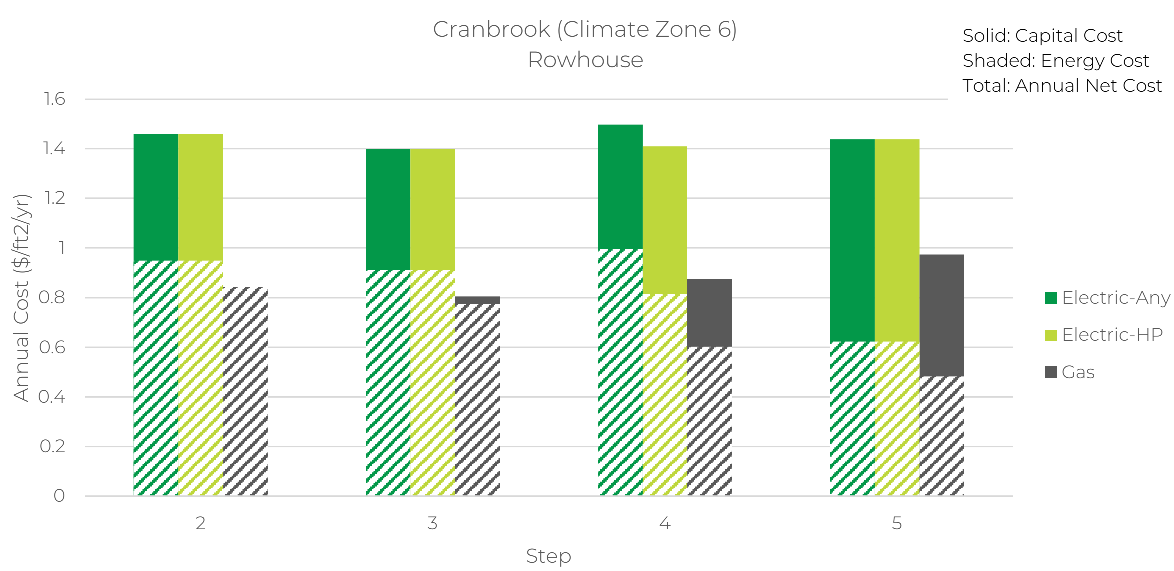

Cranbrook (Climate Zone 6)
Average of All Building Types
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

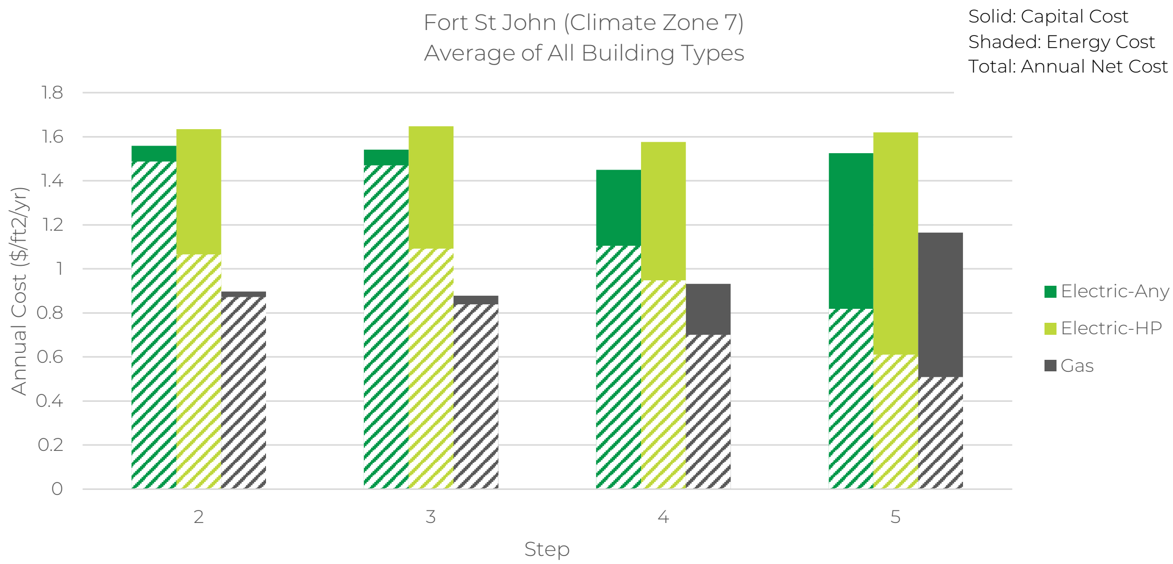

Cranbrook (Climate Zone 6)
Small SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
3
2.5
2
1.5
1
0.5
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

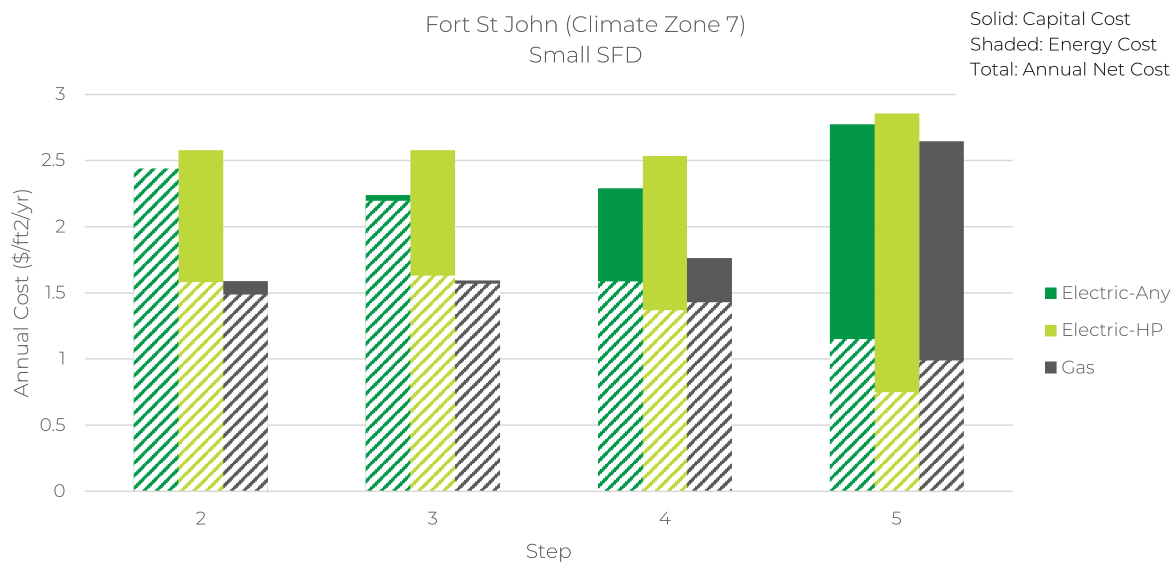

Cranbrook (Climate Zone 6)
Medium SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

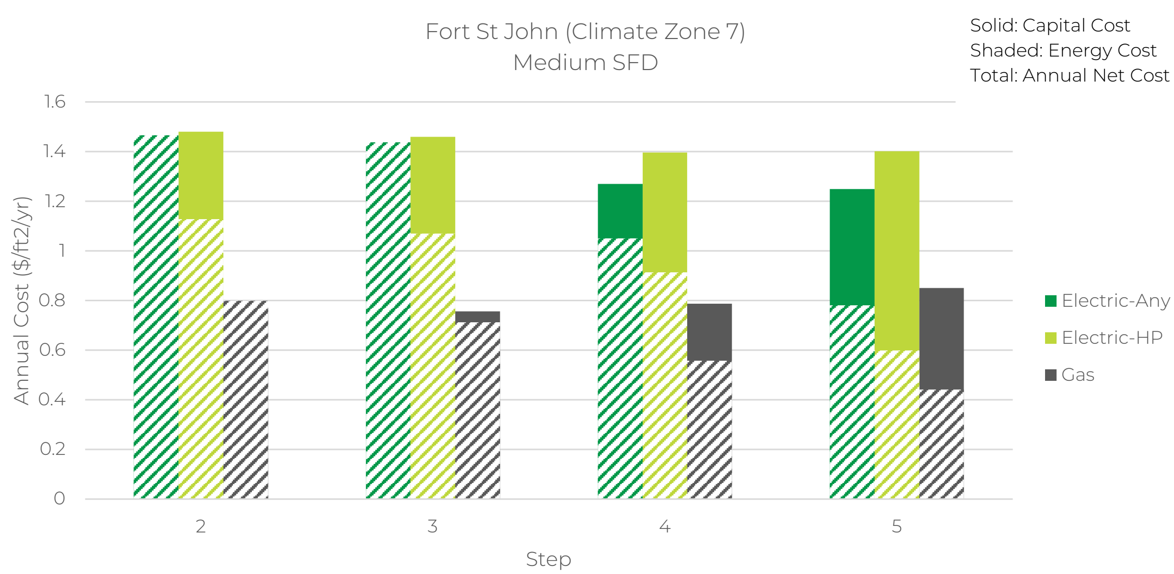

Cranbrook (Climate Zone 6)
Large SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
0
0.2
0.4
0.6
0.8
1
1.2
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

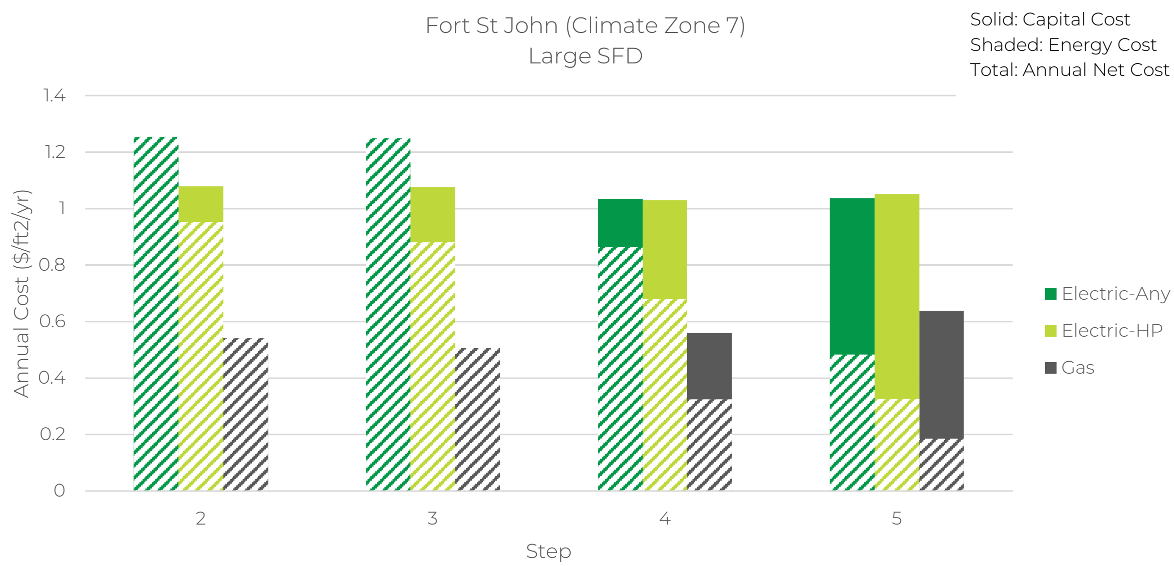

Cranbrook (Climate Zone 6)
MURB
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

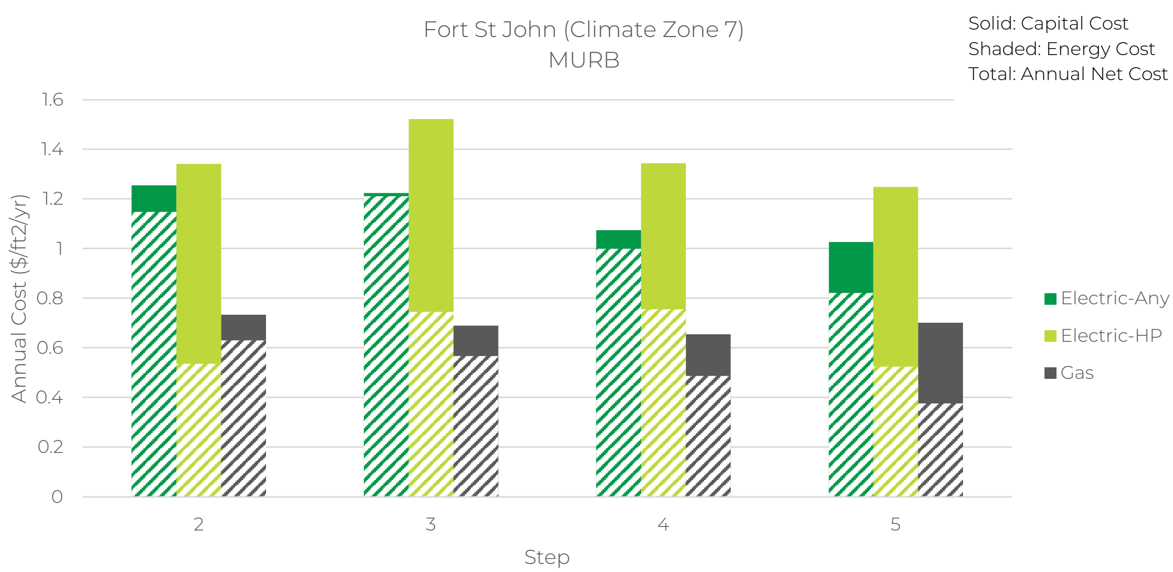

Cranbrook (Climate Zone 6)
Rowhouse
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

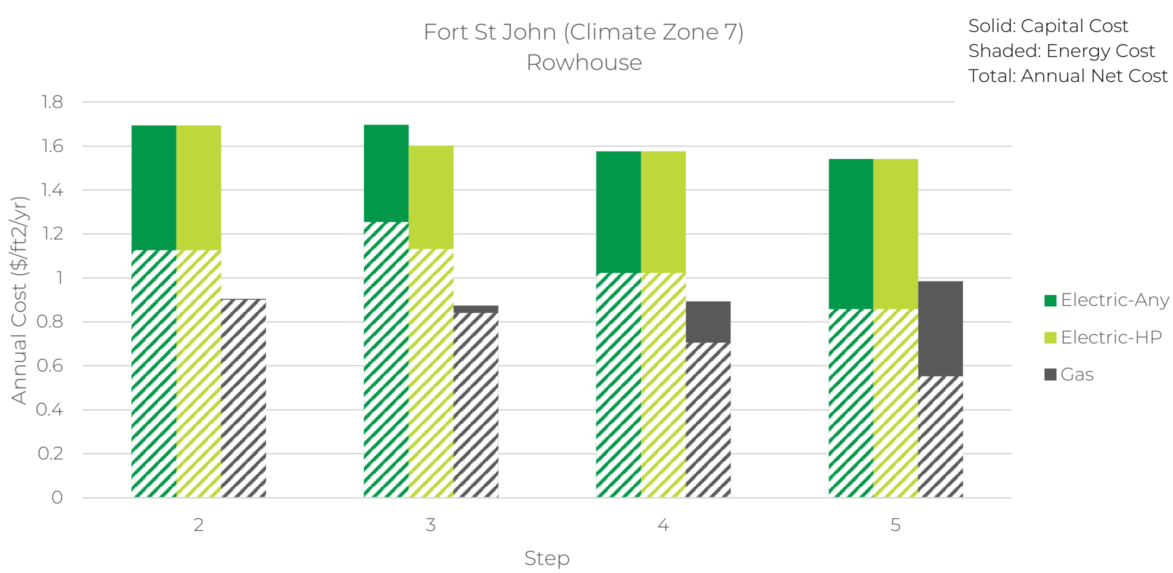

Fort St John (Climate Zone 7)
Average of All Building Types
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

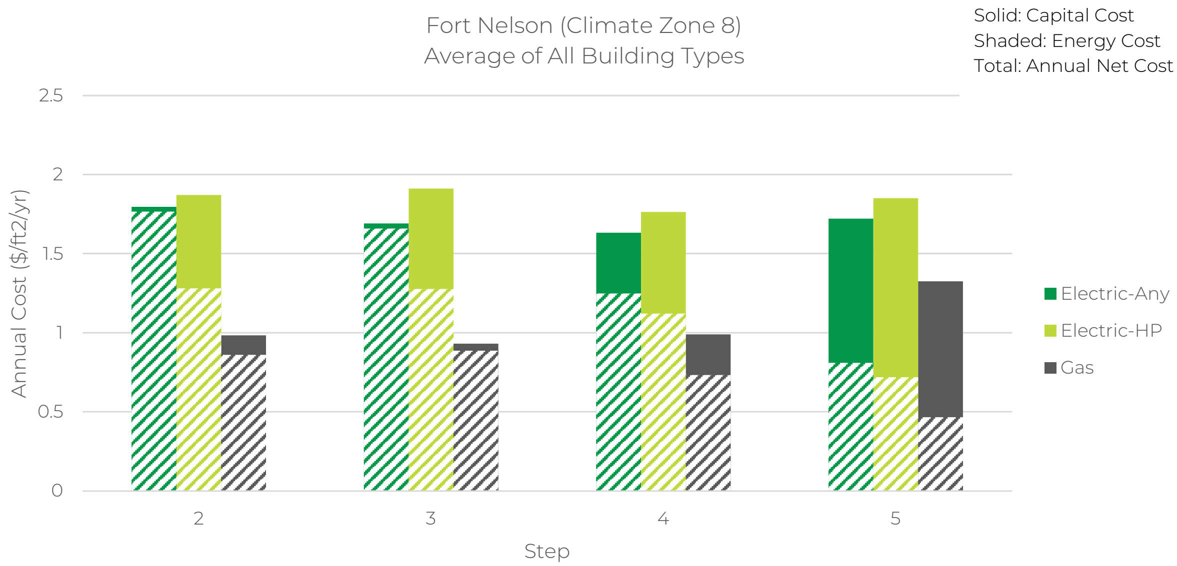

Fort St John (Climate Zone 7)
Small SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
3
2.5
2
1.5
1
0.5
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

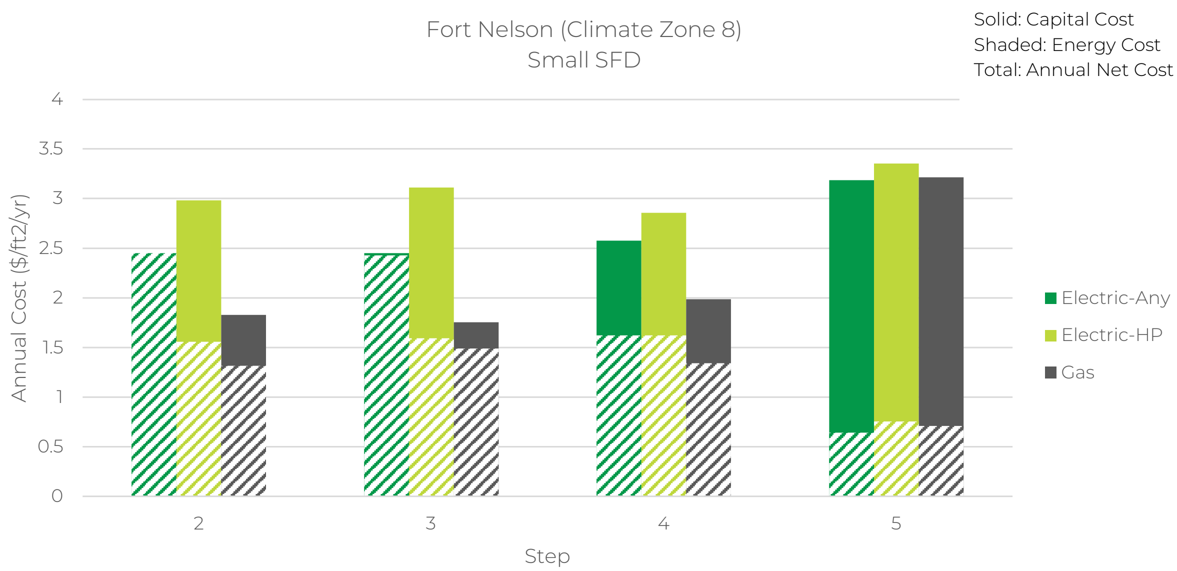

Fort St John (Climate Zone 7)
Medium SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

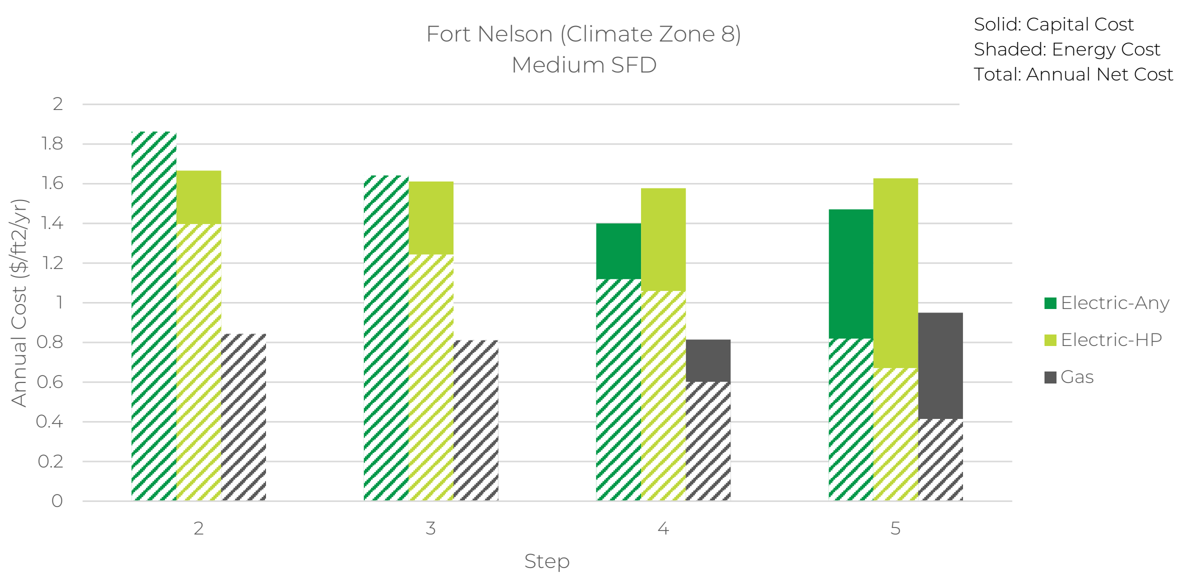

Fort St John (Climate Zone 7)
Large SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

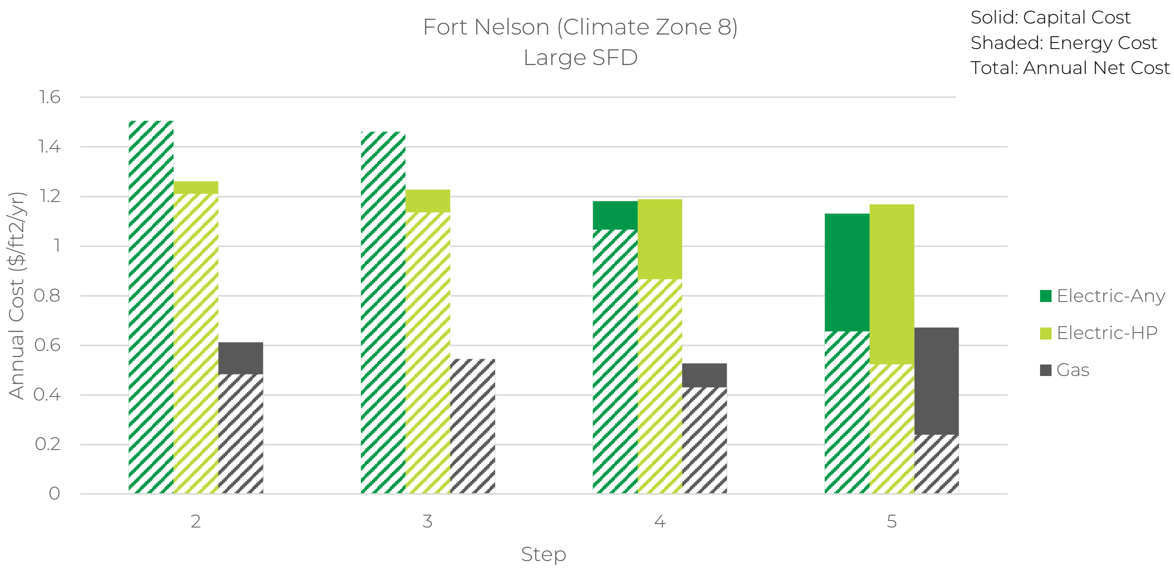

Fort St John (Climate Zone 7)
MURB
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

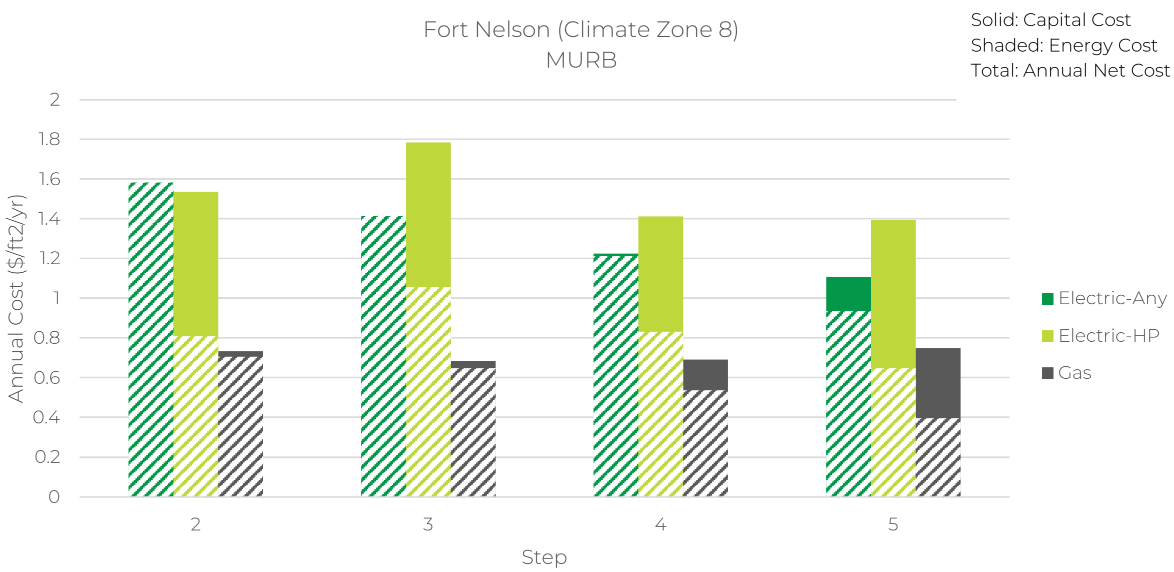

Fort St John (Climate Zone 7)
Rowhouse
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

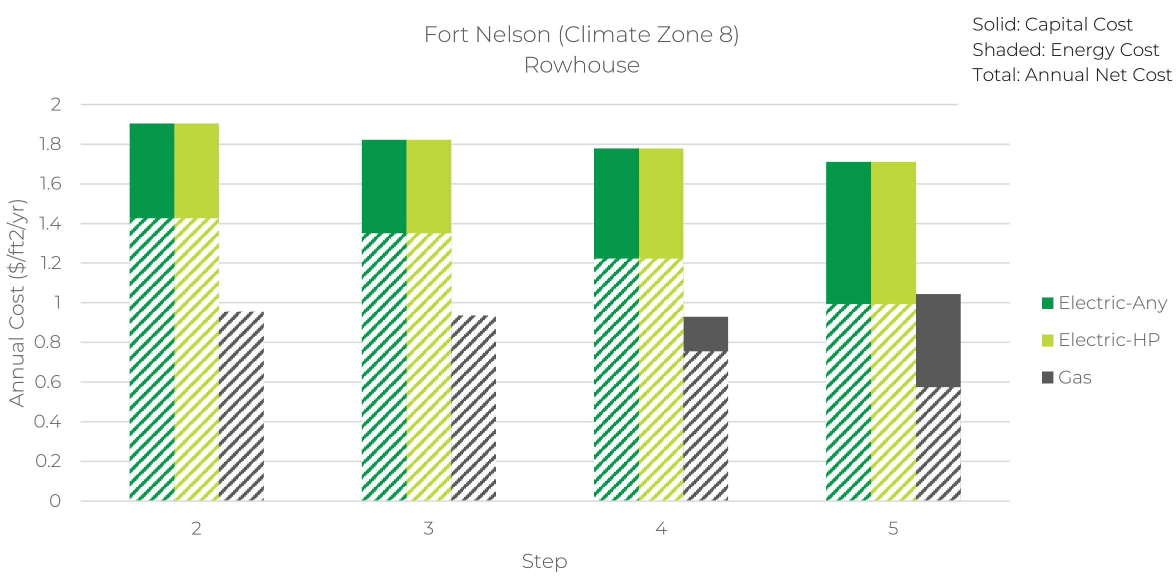

Fort Nelson (Climate Zone 8)
Average of All Building Types
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
2.5
2
1.5
1
0.5
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas


Fort Nelson (Climate Zone 8)
Small SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
4
3.5
3
2.5
2
1.5
1
0.5
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas


Fort Nelson (Climate Zone 8)
Medium SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas


Fort Nelson (Climate Zone 8)
Large SFD
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas


Fort Nelson (Climate Zone 8)
MURB
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas


Fort Nelson (Climate Zone 8)
Rowhouse
Solid: Capital Cost
Shaded: Energy Cost
Total: Annual Net Cost
Annual Cost ($/ft2/yr)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2
3
4
5
Step
Electric-Any
Electric-HP
Gas

Appendix C – GHG Intensity of Electricity in BC

To compare the greenhouse gas intensity (GHGI) of electric heating systems (electric resistance heating and heat pumps) with natural gas heating systems, emission factors of electricity from the grid must be quantified. The Rocky Mountain Institute estimates the following emissions factors for electricity below which electric space heating and DHW systems are less GHG intensive than gas systems [61]:

- 750 tCO_2e/GWh for electric heat pumps in mild climates (Oakland CA)
- 475 tCO_2e/GWh for electric heat pumps in cold climates (Boston MA)
- 180-205 tCO_2e/GWh for electric resistance systems

BC has over 90% hydroelectric generation. Consequently, BC's electricity emissions factor is quite low at 9.3 tCO2e/GWh, as reported in the *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada* from Environment and Climate Change Canada [62]. When also taking into account imports and exports, this increases to 25.3 tCO2e/GWh and 572 tCO2e/GWh for the Integrated grid (southern and western B.C.) and the Fort Nelson grid (northeastern B.C.) respectively [63].

Because space heating systems and DHW demand varies throughout the day, week, and year, it is also important to consider how the GHGI of BC's electricity grid varies over time, which depends largely on the quantity and GHGI of imported power. This appendix explores the time-varying nature of GHGI of BC's electricity grid.

Analysis and Results

Electricity consumed in BC is supplied by electricity generated in BC, as well imports from the United States (US) and Alberta (AB). The generation, as well as import, exports, and load are plotted in *Figure 2* for 2015 to 2019.

BC Hydro's total generation capacity (nameplate capacity) is 12,049 MW [64]. The grid intertie to the US is composed of two 500 kV lines and two 230 kV line, which have carried a maximum of 2807 MW over the past 5 years [65] [66]. Hourly generation data by fuel type from the Northwestern (NW) region of the Western Electricity Coordinating Council (WECC) in the US, along with reported values of GHGI of different generation sources in the NW (coal, natural gas, and oil), were used to calculate hourly GHGI of electricity imports from the US [67] [68].[10,11,12]

The grid intertie to Alberta is composed of two 138 kV lines and one 500 kV line, which have carried a maximum of 976 MW over the past 5 years [65] [66]. Hourly generation by fuel type is not freely

---

[10] This analysis does not consider other imports and exports from the Northwestern region of the US. This assumption may lead to the work presented here over-estimating GHGIs of the BC electricity grid, since California is also connected to the western interconnection (and therefore to BC) and has a lower average GHGI (226 tCO2e/GWh in California compared to 292 tCO2e/GWh of Northwest region [72]).

[11] The values calculated here based on hourly generation data and GHGI of generation sources in the Northwestern region of the US have a higher mean value than the GHGI reported for that region. The mean calculated here is 389.46 tCO2e/GWh, while the reported value for 2018 was 292 tCO2e/GWh [72]. The source of this discrepancy in unclear..

[12] Solar, wind, hydro, nuclear, and "other" generation are assigned a GHGI of 0 tCO2e/GWh in this analysis.

available for Alberta, therefore this analysis uses the average annual GHGI of generation in Alberta of 750 tCO2e/GWh to calculate GHGI of electricity imported from that province [62].

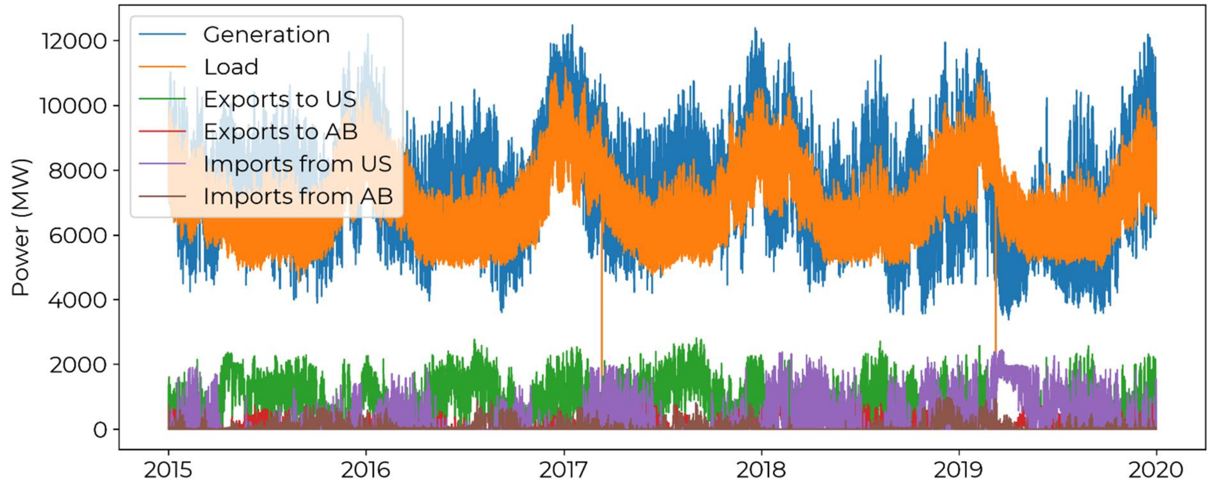


Figure 2: Generation, imports, exports, and load of BC electricity grid. [66] [69]

The GHGI of the electricity grid in BC is estimated based on the GHGI of each region (BC, AB, US) discussed above, using total import/export and load data provided to the public by BC Hydro. From this data, we estimate total generation within BC. The total GHGI of the BC electricity grid is then calculated assuming GHGI of BC generation (excluding exports), imports from the US, and imports from AB. The results from July 2018 through 2019 are plotted in *Figure 3*.

Figure 3 also shows the GHGI of the electricity grid at which electric resistance heating and heat pumps produce less GHG emissions than gas heating in a cold climate, 181 tCO2e/GWh and 476 tCO2e/GWh respectively [61]. Based on generation and import/export patterns from July 2018 through 2019, electric resistance heating is generally less GHG intensive than natural gas heating, and will realize significant annual emissions savings. However, there are times during the winter and spring that electric resistance heating may be more GHG intensive. Electric heat pumps are a much less GHG intensive method of space heating in BC buildings than gas heating at any time of year[13] [61].

The average GHGI of BC's grid is plotted for each hour of each month in *Figure 4*. This highlights that a greater amount of high GHGI power is imported during the night in the winter and summer months, with maximum average GHGI of the BC grid of approximately 160 tCO2e/GWh.

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[13] This analysis does not account for the GHG emissions intensity of heat pump refrigerant leaks. These emissions can be meaningful, though will typically still result in building mechanical systems with much lower life cycle GHG emissions compared to natural gas appliances [77]. The GHG intensity of refrigerants is expected to decrease over time, with the implementation of the "Kigali Agreement" amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer and other policy drivers.

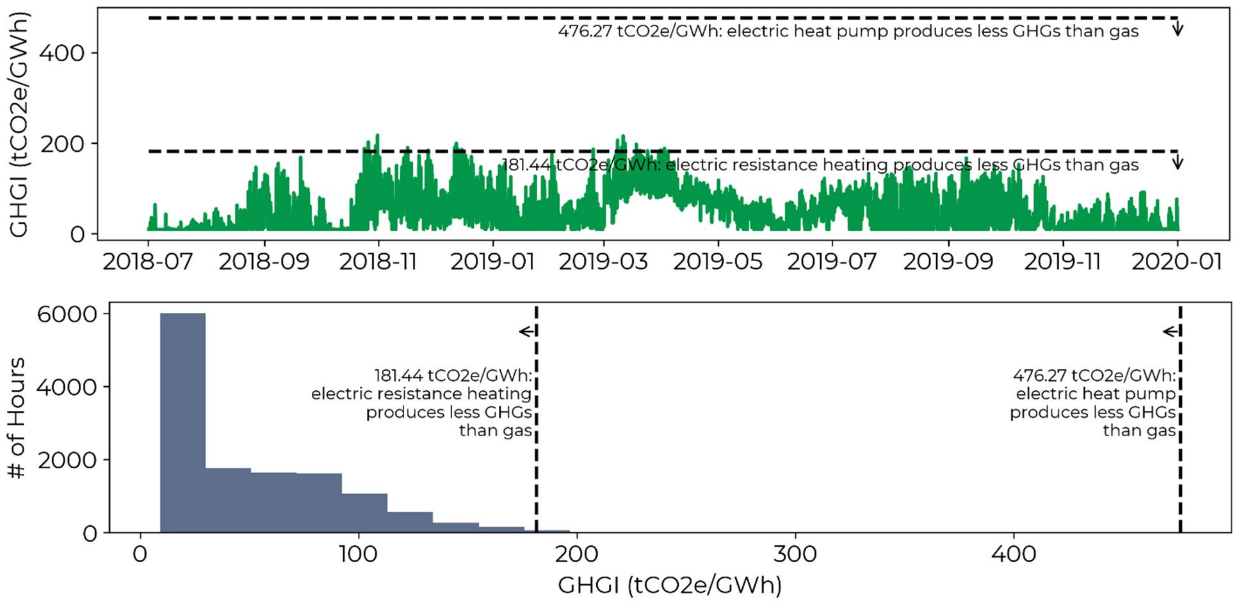

Figure 3. Timeseries (top) and histogram (bottom) of GHGI of BC electricity grid from July 2018 through 2019.

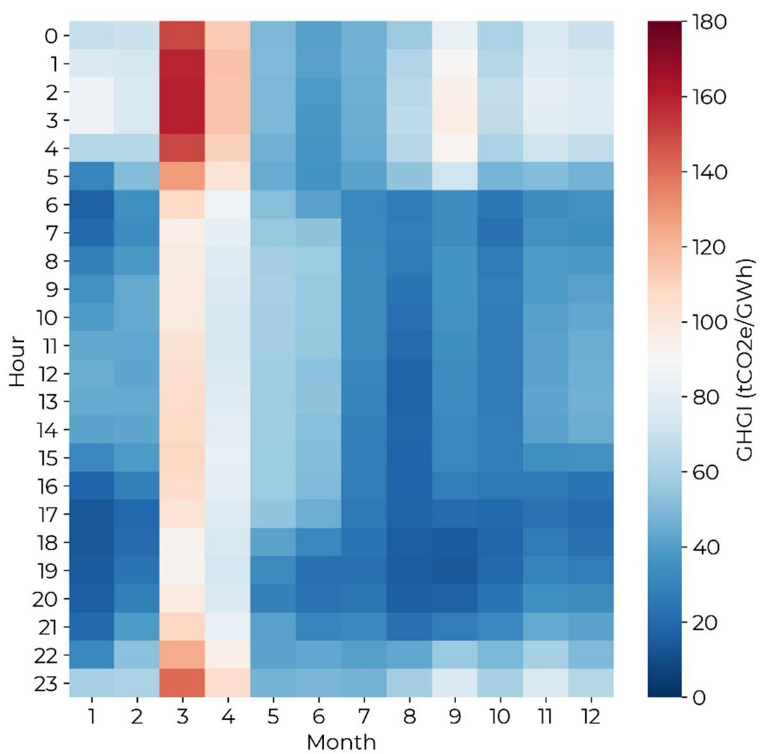

Figure 4: Average GHGI of BC electricity grid for each hour of each month, based on data from July 2018 through 2019.

Discussion

This analysis suggests that we can have confidence that the large majority of the time electric space heating and DHW equipment will achieve low GHG emissions, and there are few hours of the year when the GHG intensity of electric resistance space heat and DHW are likely to result in greater GHG emissions than gas combustion. It is worth noting that greater trade between regions in the future could impact the relative GHG intensity of electricity in BC, particularly for heating loads concentrated in the winter at nighttime when more power tends to imported in BC.

This analysis did not attempt to calculate an annual average GHG intensity of electric equipment, nor the impact of interties within the US (notably between the Northwest and California). This work could also be further informed by recent studies on the hourly GHG intensity of electricity in different US jurisdictions on an hourly basis [70]. Further analysis could be explored for BC to determine the actual historical GHG emissions associated with power imports, and associated emissions implications for electrification.

Appendix D: Model LCES Option Language for Inclusion in Energy Step Code Requirements

The following language is provided for local government consideration as they integrate carbon performance into their Energy Step Code requirements. The language is intended to inform local governments structuring their Energy Step Code requirements to include an LCES Option. Two options are included for the definition of a LCES:

1. An all-electric building.
2. A building with a GHGI of 3kg $CO_2e/m^2/yr$ or less.

Alternate language would be used if the Province establishes an "opt-in" LCES building requirement that local governments can reference directly in building bylaws. As the structure of such an opt-in requirement has not been established yet, the author did not attempt to develop model bylaw language for this scenario.

This model language does not constitute legal advice and is intended for illustrative purposes only, without any express or implied warranty of any kind, including warranties of accuracy, completeness, or fitness for any particular purpose. Use of this model language is without any recourse whatsoever to Brendan McEwen (DBA McEwen Climate and Energy), AES Engineering, BC Hydro, or any other parties. Local governments should seek the advice of their legal counsel to develop their own bylaw amendments.

Model LCES Option Language – All-Electric Building

Definitions

"Low carbon energy system" means a building energy system that uses electricity [*OPTIONAL ADDITIONAL TEXT:* "and/or district energy systems" {to be defined elsewhere by the local government in the bylaw}] as the source of energy for all of its space heating, water heating, cooking and clothes drying appliances and has no gas plumbing in the building for these end uses [*OPTIONAL ADDITIONAL TEXT:* "with the exception that the building may be plumbed for the use of natural gas or propane as fuel for cooking appliances in a commercial kitchen, or water heating exclusively for swimming pools {or other applicable use to be defined by the local government}]. The building may include solar thermal collectors.[14]

"Occupancy" means the occupancy classification referenced in the BC Building Code.

Energy Step Code Requirements

Buildings must be designed and constructed in compliance with the applicable step of the Energy Step Code, as set out in the table below.

Building Types	Requirements		
			Buildings with a Low GHG Energy system
Buildings subject to Part 9 of the building code			
All Part 9 Buildings	Step 5	OR	Step 3
Buildings subject to Part 3 of the building code			
Group C Residential occupancies (except Hotels and Motels) greater than 6 stories	Step 4	OR	Step 2
Group C Residential occupancies (except Hotels and Motels) 6 stories or less	Step 4	OR	Step 3
Group C Residential occupancies – Hotels and Motels	Step 4	OR	Step 2
Group D Business and personal services occupancies or Group E mercantile occupancies	Step 3	OR	Step 2

[OPTIONAL ADDITIONAL TEXT:

Exceptions[15]

Where there is evidence substantiating that constructing the building using a low carbon energy system will alter the local utility infrastructure design requirements on the utility side of the meter so as to

[14] This definition is largely derived from the definition of an "all-electric building" in the *New Construction Model Reach Code: Electric-Preferred Version - Version 2.5* prepared by the California Reach Codes subprogram of the California Statewide Codes & Standards Program. This program is funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric Company (SDG&E®), Southern California Gas Company, and Southern California Edison Company under the auspices of the California Public Utilities Commission and in support of the California Energy Commission [35]. This definition has been altered to include an option to allow connection to district energy, and contemplates allowing gas use for various applications.

[15] This Exceptions clause is provided for illustrative purposes. It is recommended elsewhere in this report that the Energy Step Code Council, electrical distribution utilities and other stakeholders deliberate to develop a model exceptions clause for local governments' consideration.

increase the utility side cost to the homeowner or the developer by {*choose appropriate threshold; alternately, could specify "so as to be technically infeasible in the determination of the Chief Building Official"*} compared to the same building constructed without a low carbon energy system, then the building may be constructed to the lower Step of the Energy Step Code without implementing a low carbon energy system.][16]

[16] This exception clause is partly derived from a similar clause in section 4.106.4.1.1.2 of the 2019 *San Francisco Green Building Code* that provides exemptions for EV Ready new construction. It is pertinent to note that the City and County of San Francisco recently amended their Building Code to require all electric construction (with exemptions for restaurants). These requirements allow for exceptions when an all-electric building is deemed technically infeasible: "The Building Official may issue a permit for construction of a new Mixed-Fuel Building… Upon the Building Official's finding that constructing an All-Electric Building or Project is physically or technically infeasible… *Financial considerations shall not be a sufficient basis to determine physical or technical infeasibility*. [emphasis in the original]" [36]. It is noteworthy that this threshold for technical infeasibility is higher than financial thresholds proposed in the model bylaw language for a low carbon energy system above.

Model LCES Option Language – GHGI

Definitions

“Low carbon energy system” means a building energy system with a greenhouse gas intensity (GHGI) of no more than 3 $kgCO_2e/m^2/yr$.

“Greenhouse Gas Intensity (GHGI)” means a measure of a building’s greenhouse gas (GHG) performance using the definition, calculation, and fuel type emissions factors established in the City of Vancouver’s Energy Modeling Guidelines that are referenced by the BC Energy Step Code, and that is a calculated value determined through energy modeling and reported in kilograms carbon dioxide equivalent per square metre per year ($kgCO_2e/m^2/yr$).[17]

“Occupancy” means the occupancy classification referenced in the BC Building Code.

Energy Step Code Requirements

Buildings must be designed and constructed in compliance with the applicable step of the Energy Step Code, as set out in the table below.

Building Types	Requirements		
			Buildings with a Low GHG Energy system
Buildings subject to Part 9 of the building code			
All Part 9 Buildings	Step 5	OR	Step 3
Buildings subject to Part 3 of the building code			
Group C Residential occupancies (except Hotels and Motels) greater than 6 stories	Step 4	OR	Step 2
Group C Residential occupancies (except Hotels and Motels) 6 stories or less	Step 4	OR	Step 3
Group C Residential occupancies – Hotels and Motels	Step 4	OR	Step 2
Group D Business and personal services occupancies or Group E mercantile occupancies	Step 3	OR	Step 2

[OPTIONAL ADDITIONAL TEXT:

Exceptions[18]

Where there is evidence substantiating that constructing the building using a low carbon energy system will alter the local utility infrastructure design requirements on the utility side of the meter so as to increase the utility side cost to the homeowner or the developer by {*choose appropriate threshold; alternately, could specify “so as to be technically infeasible in the determination of the Chief Building Official”*} compared to the same building constructed without a low carbon energy system, then the

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[17] This definition is largely derived from the definition used in the City of Surrey’s Surrey Building Bylaw, 2012, No. 17850 [30].

[18] This Exceptions clause is provided for illustrative purposes. It is recommended elsewhere in this report that the Energy Step Code Council, electrical distribution utilities and other stakeholders deliberate to develop a model exceptions clause for local governments’ consideration.

building may be constructed to the lower Step of the Energy Step Code without implementing a low carbon energy system.][19]

[19] This exception clause is partly derived from a similar clause in section 4.106.4.1.1.2 of the 2019 *San Francisco Green Building Code* that provides exemptions for EV Ready new construction. It is pertinent to note that the City and County of San Francisco recently amended their Building Code to require all electric construction (with exemptions for restaurants). These requirements allow for exceptions when an all-electric building is deemed technically infeasible: "The Building Official may issue a permit for construction of a new Mixed-Fuel Building… Upon the Building Official's finding that constructing an All-Electric Building or Project is physically or technically infeasible… *Financial considerations shall not be a sufficient basis to determine physical or technical infeasibility*. [emphasis in the original]" [36]. It is noteworthy that this threshold for technical infeasibility is higher than financial thresholds proposed in the model bylaw language for a low carbon energy system above.

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AES Engineering

Calgary
1920 - 639 5th Ave SW
Calgary, AB T2P 0M9
tel: 403.910.4660
fax: 403.910.4662
Calgary@AESengr.com

Vancouver
505 Burrard Street, Suite 950 - Box 91
Vancouver, BC V7X 1M4
tel: 604.569.6500
fax: 604.569.6501
Vancouver@AESengr.com

Victoria
500 - 3795 Carey Road
Victoria, BC V8Z 6T8
tel: 250.381.6121
fax: 250.590.9980
Victoria@AESengr.com

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