BC Energy Step Code and Zero Carbon Step Code

Handbook for Building Officials

Part 9 Residential Buildings

Version 2.0 - March 2025

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Acknowledgments

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Introductory Letters

The construction industry in British Columbia has come a long way since the BC Energy Step Code was first introduced in 2017. During that time, people on both sides of the permit desk familiarized themselves with energy modelling, airtightness testing, and measuring emissions. These practices are commonplace now and represent the new minimum requirement for most new buildings in B.C.

This transformation would not have been possible without building officials, who provide critical information and education for the construction industry. That's why the work on this updated handbook was led by the Building Officials' Association of British Columbia and written in close consultation with leading building officials and homebuilders in B.C. They have first-hand experience and valuable insights into how the Energy and Zero Carbon Step Codes can be applied in a practical, consistent, and cost-effective way.

Although there is much to be proud of, the transition towards net-zero energy ready buildings by 2032 and zero carbon new construction by 2030 is only halfway completed. To meet these goals gradually, minimum requirements are expected to rise again. As always, building officials will continue to be an essential part in helping the construction sector make the transition to high performance, energy efficient and low carbon buildings while increasing the housing supply.

This updated handbook would not be possible without the efforts and support of BC Hydro and leadership of the Building Officials' Association of British Columbia.

Zachary D. May, MBA
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Introductory Letters

The 2018 CleanBC Roadmap outlined measures the province would take to support the building sector's transition to zero-carbon new construction by 2030. Two key measures identified in the roadmap were enhancing the energy efficiency regulations in the BC Building Code for new buildings and regulating carbon with a performance-based standard. The result of this initiative was an updated BC Energy Step Code in 2023 and a new Zero Carbon Step Code in 2024.

Together, these building code changes represent a fundamental policy change for BC. They provide performance-based pathways to achieve the roadmap's province-wide targets for both building energy efficiency improvements and greenhouse gas emission reductions. To address this substantial shift in the regulatory environment, the BOABC assembled a task force to update our 2019 handbook for Building Officials. Now aptly renamed the BC Energy Step Code and Zero Carbon Step Code Handbook for Building Officials, the updated handbook reflects the new code amendments and provides more guidance for Building Officials on following the BC Energy Step Code in their respective jurisdictions.

The BOABC task force benefited from insights shared by Building Officials – and others who interact with them – who had used the original Step Code for several years. The insights gained through their application of the Step Code in practice provided well-rounded feedback that informed the update to this handbook. Although the handbook speaks to Building Officials, it has been informed by expertise from people across the regulatory system. This updated version of the handbook also provides practical guidance and examples to make the information relevant to Building Officials so they can see the regulations in practice. The handbook promotes consistency across jurisdictions and highlights our success stories by sharing the good practices and work that has already been done throughout BC.

This updated handbook was made possible by the generosity of our funding partners, BC Hydro and the Ministry of Housing and Municipal Affairs.

Tyler Wightman
Executive Director & Registrar
Building Officials' Association of BC (BOABC)

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About This Handbook

This handbook focuses on the application of the ***BC Energy Step Code*** (ESC) and the ***BC Zero Carbon Step Code*** (ZCSC) to new Part 9 residential buildings where the Building Code of British Columbia (BCBC) 2024 applies. It is written for Building Officials who oversee their jurisdiction's compliance process, complete plan checks and ***site inspections***, and accept as compliant buildings regulated under the ESC and ZCSC. Other building practitioners may find this handbook to be a useful reference.

Step Code Timelines as of Version 2.0 of This Handbook

- As of May 1, 2023, Part 9 residential buildings must comply with Step 3 or above of the ESC.
- As of March 10, 2025, Part 9 residential buildings must comply with Emission Level 1 (EL-1) or above of the ZCSC.
- Local governments can require or incentivize compliance with higher Steps or Emission Levels.

Provincial minimum requirements will continue to progress through BCBC revisions and updates. The goal is to reach net-zero energy ready targets with the implementation of Step 5 of the ESC by 2032 and EL-4 of the ZCSC by 2030.

Goals of the Energy Step Code

The implementation of the ESC is intended to improve building design and construction in BC regarding operational energy efficiency. The goals of the ESC include:

- Make energy performance requirements consistent for buildings across the province while providing flexibility for local governments to implement them as "unrestricted matters" according to the Building Act.
- Require new buildings to be designed and constructed to modern energy performance-based standards that consider overall annual building energy usage.
- Enable flexibility and innovation in building design.
- Promote a building process that encompasses all parts of the building, especially airtightness, and encourage more collaboration between the design and construction teams.
- Align the BCBC with the energy improvement targets for buildings set out in the CleanBC provincial program, which aims to achieve net-zero energy ready design as a code minimum by 2032.

Goals of the Zero Carbon Step Code

The ZCSC is designed to help local governments and the provincial government achieve their climate change and greenhouse gas (GHG) reduction goals. The goals of the ZCSC include:

- Encourage the adoption of low-carbon technologies and practices in the building sector.
- Align with CleanBC commitments, including the provincial goal of zero-carbon new construction by 2030 and net-zero energy ready buildings by 2032.
- Provide flexibility and choice by offering local governments a tiered approach, allowing them to select and apply specific Emission Level based on their circumstances.
- Promote simplicity and ease of implementation by utilizing both proven technologies and building approaches that may take time to adopt.

How to Use This Handbook

The compliance process requires communication among three key parties. For simplicity, this handbook refers to each party using the following terms:

1. You, the authority having jurisdiction and intended audience for this handbook, are referred to as the ***Building Official***.
2. The permit applicant responsible for code compliance, directly or through contract, is called the ***Builder***.
3. The building ***energy modeller***, typically working as an ***Energy Advisor***, is called the ***Modeller***. The Modeller is also responsible for completing the ***Compliance Checklist***.

Section 1 | Overview of the Step Codes outlines the code requirements for energy efficiency and GHG emissions. It is helpful to review this section to understand the basic metrics and terms, key considerations for how a building meets code requirements, and important exclusions and allowances that can make things tricky.

Section 2 | Step Code Compliance Process and Roles presents the best practices for the compliance process and identifies roles and responsibilities for each of the three key stakeholders in this process.

Section 3 | High-Performance Step Code-Compliant Buildings is less about code compliance and focuses on the design approaches, construction practices, and technology that can make a building energy efficient, low emissions, comfortable, durable, and buildable. Knowing about these factors is helpful for understanding how a ***high-performance building*** is designed and built.

Does This Handbook Apply to Existing Buildings?

The ESC and ZCSC are intended for new construction, but the authority having jurisdiction (AHJ) uses their discretion in applying current code requirements to building alterations and renovations. Current energy and emissions performance requirements would typically apply to large additions and major reconstruction. Small renovations or remodels likely do not require ESC or ZCSC compliance. The following resources provide information on energy efficiency and code requirements for alterations to existing buildings:

› Building and Safety Standards Branch Information Bulletin No. B23-01

› Article 1.1.1.2. and A-1.1.1.2.(1) in Division A of the BCBC

› Vancouver Building Bylaw Part 11 Existing Buildings (for reference)

In Short

Subsection 9.36.6., *Energy Step Code*, of the BC Building Code (BCBC) provides a pathway of energy reduction for new buildings with each Step. Likewise, Section 9.37., *Greenhouse Gas Emissions*, is referred to as the "Zero Carbon Step Code" and it provides a similar pathway for greenhouse gas emission reductions for new buildings.

1 | Overview of the Step Codes

Section Includes:

- The BC Energy Step Code and Zero Carbon Step Code 1
- Overview of the Design and Construction Process. 6
- Energy Modelling 8
- Airtightness Testing 9
- Energy Step Code Metrics 9
- Zero Carbon Step Code Metrics 17

The BC Energy Step Code and Zero Carbon Step Code

The Energy Step Code (ESC) is codified as Subsection 9.36.6. of the BC Building Code (BCBC). In the ESC, energy efficiency requirements are set out through a series of increasingly stringent requirements called "Steps." The Steps correspond to mechanical energy use, thermal energy demand, and whole-building ***airtightness*** of new Part 9 residential buildings (see **Figure 1.1**). The energy performance requirements were created after a consensus-building process with different key stakeholders from across the province and supported by ***energy modelling*** and analysis. Work began in 2015, with technical changes in 2020 and 2023 after feedback from ***Building Officials***, the construction industry, and others.

The Zero Carbon Step Code (ZCSC) is the colloquial name for Section 9.37. of the BCBC. Like the ESC, the ZCSC sets out a series of increasingly stringent requirements, called "***Emission Levels***" (ELs), for reducing the ***greenhouse gas (GHG) emissions*** of new Part 9 residential buildings (see **Figure 1.2**).

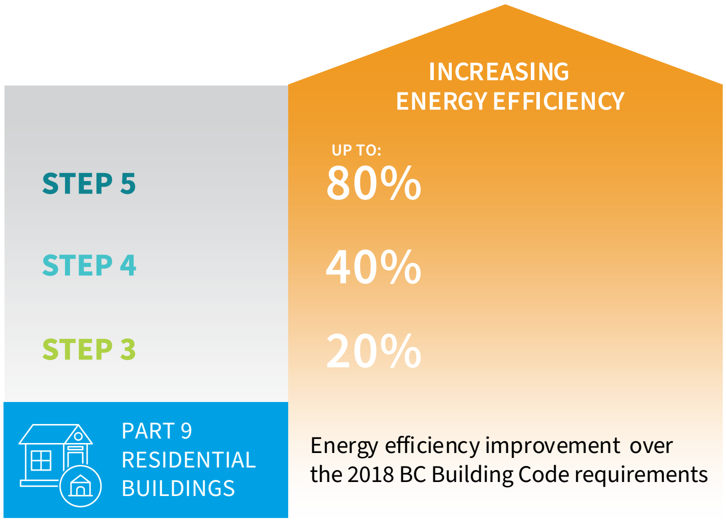


Figure 1.1 As of May 2023, Step 3 of the ESC is the minimum requirement across BC. Steps 1 and 2 (not shown) no longer apply.

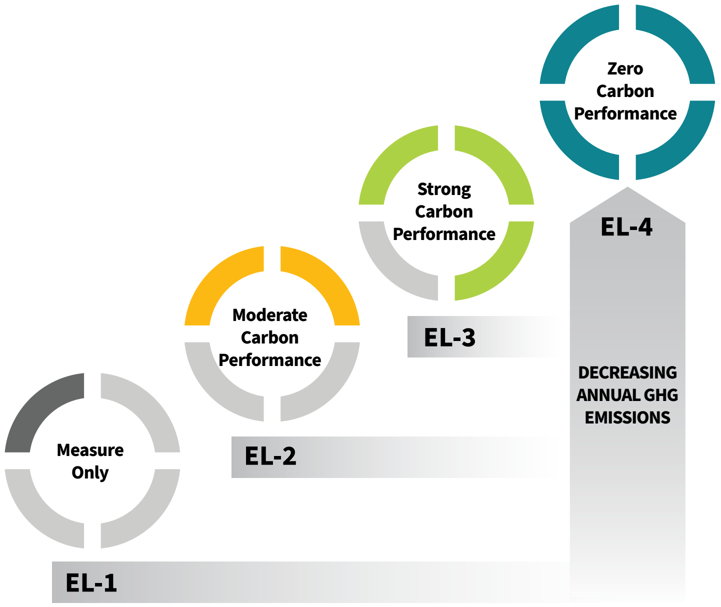


Figure 1.2 As of March 2025, Emission Level 1 (EL-1) of the ZCSC is the minimum requirement across BC.

The Step Codes Work Together

While the ESC and ZCSC address different issues, they complement each other to reduce energy use and GHG emissions in a cost-effective, holistic way.

The Energy Step Code and Zero Carbon Step Code Apply Across the Province

One of the central purposes of the ESC is to provide province-wide consistency in technical building requirements, including requirements for energy efficiency and emissions reductions. The ESC is the mandatory performance-based energy compliance pathway for new Part 9 residential construction where the BCBC applies.* The ESC for Part 9 residential buildings consists of progressive Steps of building energy efficiency requirements. The ESC includes different performance requirements for each climate zone in BC. Here are three key provisions to know about the ESC:

1. The ESC requires a reduction in the annual building energy use based on whole-building energy modelling.
2. The ESC is concerned with reducing the amount of energy used, regardless of the energy source.
3. The ESC considers only the operational energy use in buildings, not the on-site energy production capability.

***Prescriptive ESC Backstop**

The BCBC still contains a prescriptive energy compliance pathway (Subsections 9.36.2. to 9.36.4.), but it must be specifically adopted with a bylaw by the local AHJ. For more information, refer to Information Bulletin B23-01 published by the Building and Safety Standards Branch.

The ZCSC is a framework for limiting GHG emissions. It is the operational emissions compliance pathway for new Part 9 residential construction where the BCBC applies. Here are three key provisions to know about the ZCSC:

1. The ZCSC is distinct from the ESC, but it has a ***performance pathway*** that uses results from the ESC energy modelling. The ZCSC also has a ***prescriptive pathway*** that doesn't use energy modelling results.
2. The ZCSC is concerned with reducing emissions based on the amount of energy and type of energy source (e.g., electricity or combustion fuel) used by the building systems.
3. The ZCSC considers only operational emissions from energy-using equipment, not the embodied emissions associated with building materials or construction.

Local Government Implementation

Meeting the current provincially mandated Steps of the ESC and ELs of the ZCSC is the minimum requirement in all jurisdictions where the BCBC applies. However, the authority having jurisdiction (AHJ) can choose to adopt by bylaw a higher Step and/or EL. They can also mandate more than one option for compliance to offer Builders a choice between different combinations. For more resources and information on code implementation and the opt-in process for higher Steps or ELs, refer to the Resources for Local Governments page on the BC Energy Step Code website, and in particular the *Local Government Best Practices Guide*.

Note that any Step of the ESC or EL of the ZCSC above the currently adopted minimum is available as an optional compliance pathway for any Part 9 residential building where the ESC and ZCSC apply. For this reason, it is beneficial for local jurisdictions, and for you as the Building Official, to be familiar with the requirements of all Steps of the ESC and ELs of the ZCSC.

The ESC and ZCSC do not apply in the City of Vancouver or to federal lands within the province.

Achieving the Steps of the BC Energy Step Code

The ESC provides a clear path to achieving more energy-efficient buildings compared to the previous code requirements (see **Figure 1.1** and **Figure 1.2**). The key compliance item for the ESC is the results of energy modelling and ***airtightness testing***; these results are used to assess whether the building as designed and constructed meets annual energy performance requirements and metrics outlined in the BCBC.

There are many ways to achieve a high-performance building, as set out in **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47 of this handbook. However, achieving the requirements for each Step typically requires the same considerations:

- An enclosure-first approach to help reduce energy demand and enable the use of lower-capacity mechanical equipment.
- Reduced enclosure air leakage, verified by on-site whole-building airtightness testing to confirm the use of a continuous air barrier system.
- More energy-efficient mechanical systems to further reduce the annual energy consumption required to operate the building.
- Detailed energy modelling by a qualified Modeller, typically an Energy Advisor, to provide design recommendations, model annual energy consumption, and demonstrate compliance with ***Energy Step Code*** metrics.

Since the implementation of the ESC in 2017, designers and Builders in BC have been learning how to construct energy-efficient buildings through practice and feedback from energy modelling and airtightness testing. Modellers are involved throughout the major phases of design and construction, so the capacity for airtightness testing and energy modelling will further increase, alongside the general knowledge and skills to execute high-performance buildings. Likewise, Building Officials have implemented the procedures required to track and verify compliance.

Achieving the Emission Levels of the Zero Carbon Step Code

The requirements of the ZCSC focus on the building systems and type of energy source they use to operate. The increasingly stringent ELs in the ZCSC (EL-1 through EL-4) complement the progression of the Steps in the ESC, as illustrated in Figure 1.3. However, achieving a higher Step does not automatically mean compliance with the ZCSC (and vice versa). Achieving the requirements for each EL typically includes using an energy source with a lower GHG emissions factor (i.e., electricity) for space heating equipment and appliances. The performance pathway of the ZCSC also requires reducing annual energy consumption. See **Zero Carbon Step Code Metrics** on page 17 for more detail.

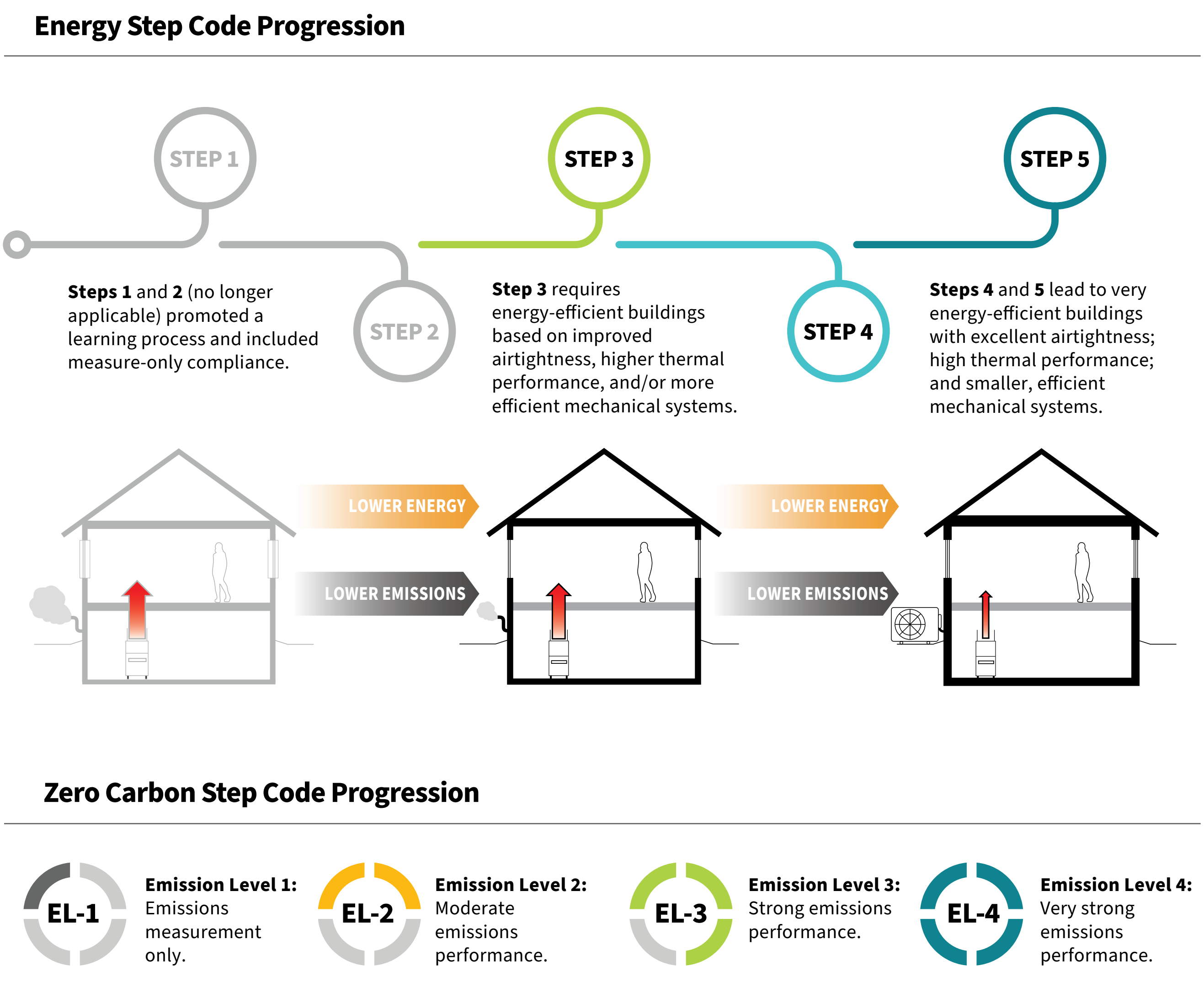


Figure 1.3 Example progression of homes reaching the requirements of the ESC and ZCSC.

Types of Buildings Covered by the Step Codes

The ESC and ZCSC applies to new Part 9 residential buildings. These buildings include single-family homes, homes with a secondary suite, townhouses, and small apartment buildings with no more than 20% of the building's ***floor area*** serving as common space. Log homes are also included but they can also comply under other energy pathways. Non-residential and mixed-use buildings and seasonal homes are not required to comply with the ESC or ZCSC.

Multi-Unit Residential Buildings (MURBs) and Houses with a Secondary Suite

The energy and emissions requirements of the ESC and ZCSC apply to the building as a whole. Energy modelling approaches vary depending on the compliance pathway (see **Energy Modelling Pathways and Energy Modellers** on page 8), but the energy use of all dwelling units in the building must be accounted for in some way. Dwelling units that share a roof are typically modelled as part of the MURB. For example, a house that contains a secondary suite is a MURB with two dwelling units.

Overview of the Design and Construction Process

Under Steps 3 through 5 of the ESC, applicable Part 9 residential buildings must follow the performance-based requirements defined by Subsection 9.36.6. Performance-based compliance uses energy modelling and airtightness testing as part of the design, compliance, and construction process (see Figure 1.4) to demonstrate compliance with the BCBC. As the Building Official, you must be able to verify compliance is met through the collection and review of the required documentation. This includes verifying that the materials, equipment, and systems and their controls installed during construction match the documented energy model inputs.

With Step 4 and Step 5, the combination of lower energy use allowances and more stringent airtightness requirements means all aspects of the building design must be considered at once. This is especially relevant for the related Emission Levels of the ZCSC. Furthermore, achieving good airtightness can be a challenge for Builders who haven't yet built to Step 4 and Step 5 or haven't used better-than-code airtightness as an energy efficiency measure in Step 3 and below.

The performance pathway for the ZCSC includes additional items for consideration and review for the ***building team*** (i.e., the Builder, Modeller, designers, and ***Owner***) and the Building Official. Most importantly, the energy modelling results that are used to show ESC compliance are also used to show ZCSC performance-based compliance. Alternatively, the prescriptive pathway for ZCSC compliance requires verifying the energy sources of various building systems.

Refer to **Section 2 | Step Code Compliance Process and Roles** on page 25 for specific details on the compliance process and the role of the Building Official under the ESC and ZCSC.

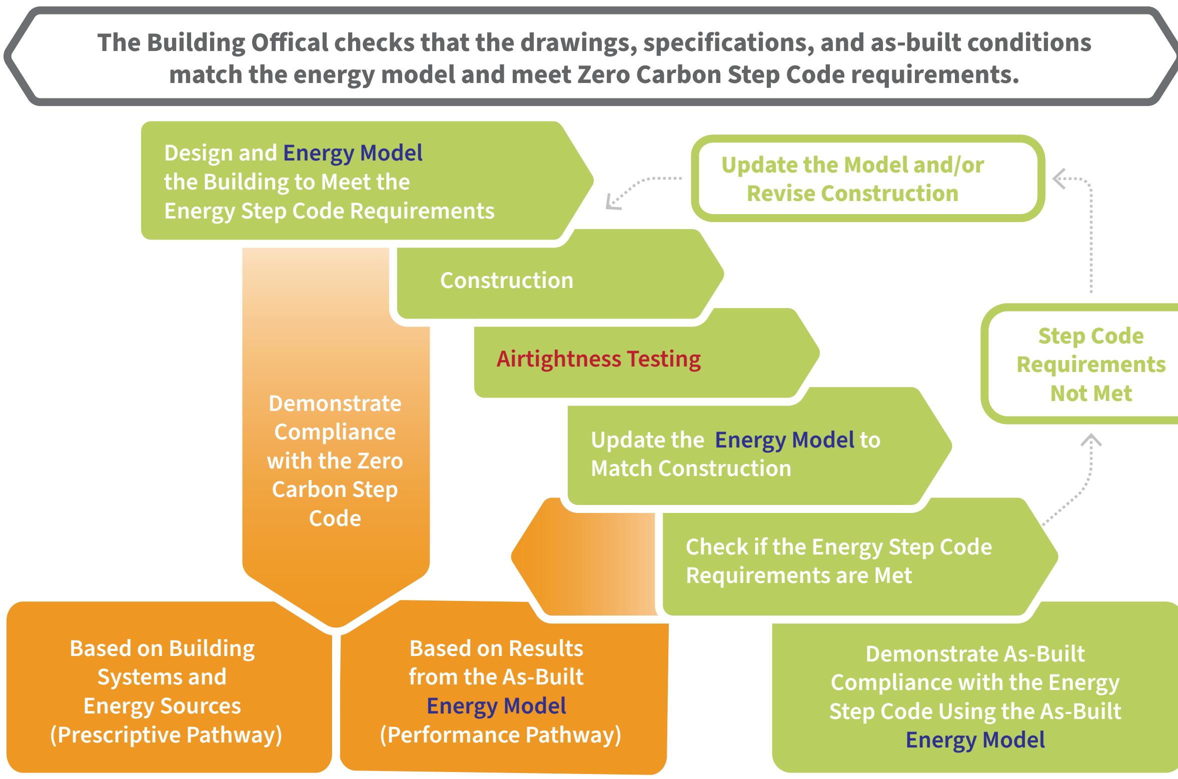


Figure 1.4 Typical Part 9 residential design and construction process for Steps 3 to 5 (green) and EL-2 to EL-4 (orange): the building is to be designed, modelled, and constructed to comply with the airtightness, energy use, and thermal energy requirements of the ESC as well as the annual GHG emissions or energy source requirements of the ZCSC.

Energy Modelling

The ESC mandates energy modelling at all Steps. Energy modelling is integral to confirming that the design meets the requirements of the ESC and the performance path of the ZCSC (see Figure 1.5). The results of code compliance energy modelling for a particular building are based on standardized building operation parameters and occupancy levels. With this approach, the building's modelled energy usage can be used to measure building performance regardless of its actual occupancy or usage pattern. Compliance under the ESC and ZCSC does not guarantee the energy performance or emissions of the actual building.

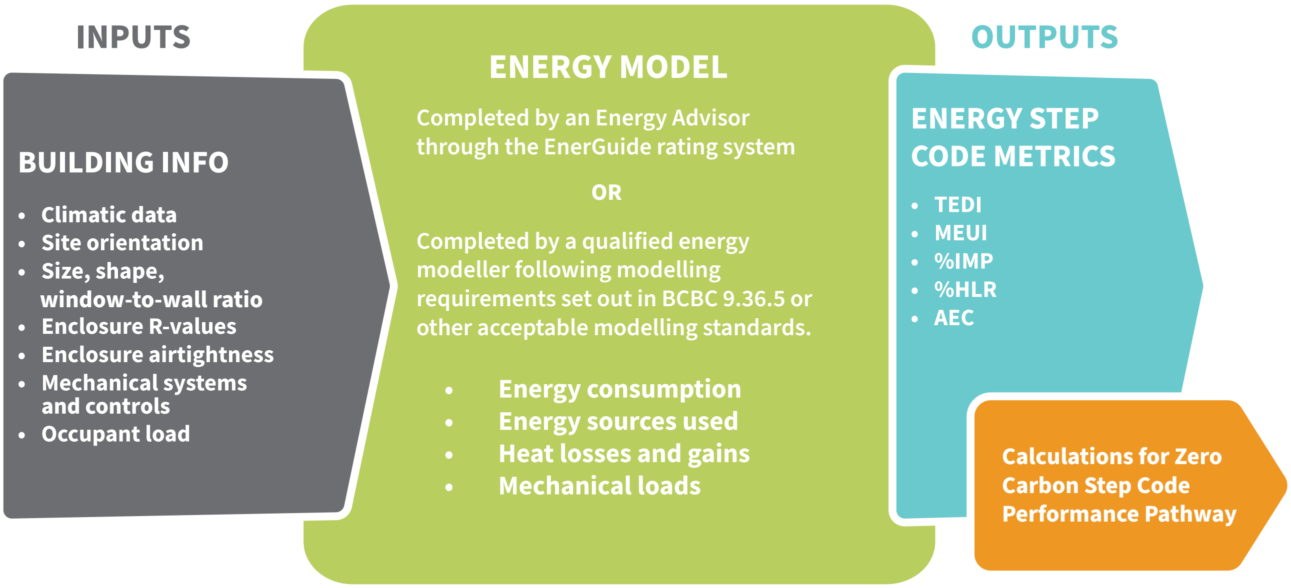


Figure 1.5 Basic energy modelling inputs and outputs required for showing compliance with the ESC and the performance pathway of the ZCSC. The energy step code metrics are described in the section **Energy Step Code Metrics** on page 9.

Energy Modelling Pathways and Energy Modellers

The ESC design and compliance process includes significant participation from a qualified energy modeller (see **Glossary of Terms** on page 70). This Modeller can be either an Energy Advisor providing services through the EnerGuide Rating System (ERS) or an otherwise qualified energy modeller following other available compliance pathways. The other modelling approaches that can be used to show ESC compliance (see BCBC Sentence 9.36.6.3.(3) and Article 9.36.6.4.) are as follows:

› BCBC Subsection 9.36.5.

› NECB Part 8 and the City of Vancouver Energy Modelling Guidelines

› The Passive House Planning Package (for Step 5)

For more information on Energy Advisors, see the Energy Advisors page on the BC Energy Step Code website and the section **Roles and Responsibilities of the Modeller** on page 40. The term ***Modeller*** is used throughout this handbook to represent both Energy Advisors and qualified energy modellers.

Airtightness Testing

Whole-building airtightness testing is required in all Steps of the ESC. This work requires coordination across all members of the building team. Whole-building airtightness testing is completed using calibrated blower door fans. The measured results of testing, including fan airflow and pressure difference across the enclosure, show how airtight or air leaky the building is. Building airtightness is an input in the energy model, both at the design stage (i.e., Pre-Construction) and after completion of the building (i.e., As-Built). Airtightness testing is generally conducted by a qualified service provider, typically the Modeller, because it involves a good understanding of testing and airflow measurement, specialized equipment, and specific reporting capabilities.

Best Practice for Airtightness Testing

Though not a minimum requirement of the ESC, whole-building airtightness testing may also be performed mid-construction to get a preliminary measurement of the building airtightness. Mid-construction airtightness testing can show if repairs are needed while the air barrier components are still easily accessible. For more information on whole-building airtightness testing, see the note on page 25 in **Section 2 | Step Code Compliance Process and Roles**, **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47, and the Illustrated Guide - Achieving Airtight Buildings and BC Energy Step Code Builder Guide published by BC Housing.

Energy Step Code Metrics

The key performance metrics (see **Glossary of Terms** on page 70) of the ESC fall under these three code-defined categories that must all be met as demonstrated through energy modelling:

- Airtightness Level
- Equipment and Systems
- Building Envelope (also referred to as the building enclosure in this handbook)

These categories are summarized in **Figure 1.6**, including the related “Energy Performance” metric category. This section provides more detail on the key performance metrics as well as the area of ***conditioned space*** measurement, which is used to calculate most of the metrics. The ESC performance metrics are reported in Part F of the ESC ***Compliance Checklist*** (see **The Compliance Review Process** on page 25 and **Appendix A** on page 74).

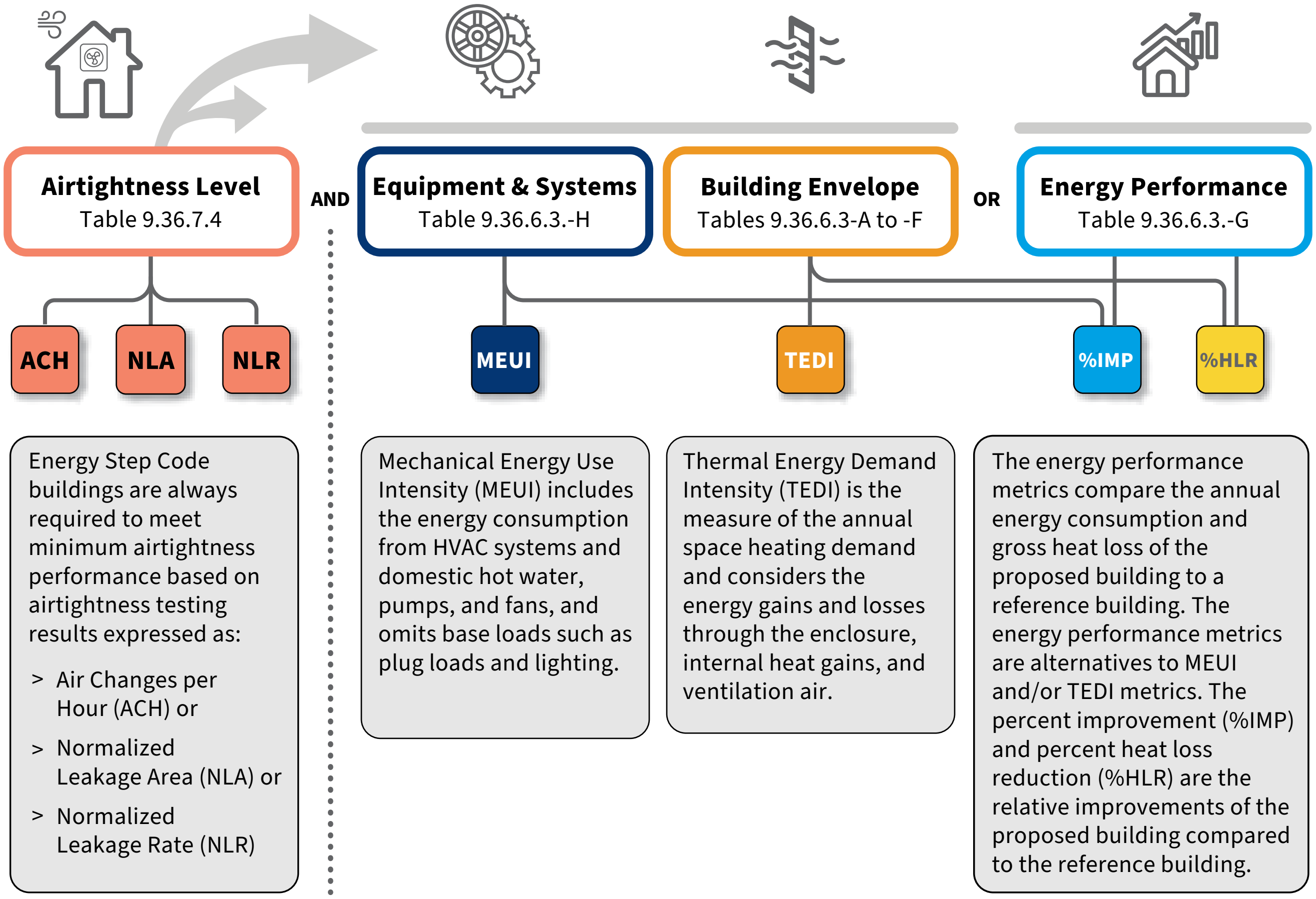
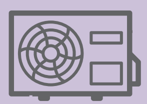


Figure 1.6 Summary of compliance pathways and key performance metrics of the ESC.

On-Site Energy Production is not Included in Energy Step Code Compliance

Results from energy modelling to determine ESC compliance do not include energy offsets from on-site power generation like solar panels.

Energy Step Code Compliance and the BCBC 9.33.3.1. Cooling Requirements



The BCBC 2024 includes requirements for the indoor temperature to be no more than 26°C in at least one living space in each dwelling unit during hot summer periods. In most cases, that means adding mechanical cooling. This requirement is not directly related to the ESC requirements, but adding mechanical cooling will increase the annual energy consumption of the HVAC equipment. There are MEUI relaxations for buildings with cooling in greater than 50% of the conditioned space. Energy model calculations for buildings without mechanical cooling, or with mechanical cooling in only part of the building, must comply with the more stringent requirements.

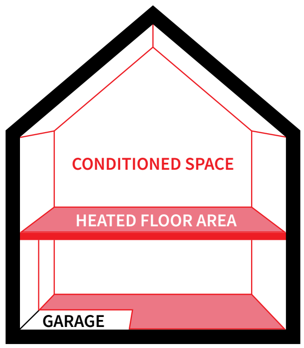


Figure 1.7 The heated floor area is the area of the conditioned space and includes all floor areas within the thermal building enclosure. It excludes unheated areas like the garage.

Heated Floor Area

The ESC uses metrics that normalize the building's annual energy use or demand over the floor area of the conditioned space (i.e., ***heated floor area***; see **Glossary of Terms** on page 70). The energy metrics are divided by the floor area of spaces that use heating and/or cooling equipment. The heated floor area is measured from the interior surface of exterior walls and includes the area of interior walls and stairwells. It is expressed in square metres (m^2). Outdoor areas and unheated crawl spaces, unheated vestibules, and unheated garages are not counted as heated floor area (see Figure 1.7).

The ZCSC metrics also uses the same heated floor area measurement. Note that other building size information including the volume, enclosure surface area, and fenestration area ratio are also based on this definition of conditioned space.

Different Calculations for Floor Area

The heated floor area used for ESC and ZCSC compliance is different from the building floor area (see **Glossary of Terms** on page 70) used for other compliance items like site coverage and floor space ratio. This calculation is different because the heated floor area uses the dimensions taken from the interior surface of exterior walls. The heated floor area does not include the floor area of heated crawl spaces (typically considered as any space less than 1.8 metres tall) unless modelling is performed under the Energuide Rating System, which excludes spaces less than or equal to 1.2 metres tall. However, heated crawl spaces are still included in building volume and mechanical sizing calculations.

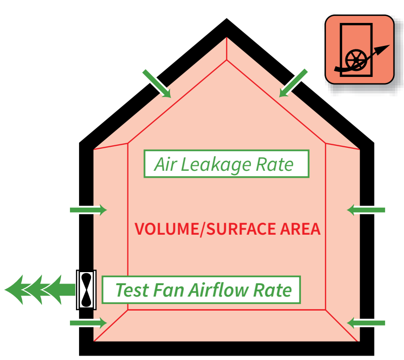


Figure 1.8 The air leakage rate is calculated by measuring the airflow rate through the test fan at a given pressure and multiplying or dividing it by the applicable building size metric.

Airtightness Level (AL)

Airtightness is used to measure how much air leaks in or out of the thermal building enclosure, commonly referred to as the "air leakage rate" (see Figure 1.8).

The ESC sets out the minimum required Airtightness Level (AL-1, AL-3, and AL-4) corresponding to each Step. Airtightness can be measured with three different metrics options. The building team can choose which metric is most appropriate for the given building. These three different metrics enable different building typologies to be measured according to their geometry; this means smaller homes can pass their AL requirement with one metric, where larger homes may use another metric.

The whole-building enclosure airtightness performance is assumed during design and then tested after construction to confirm it has been achieved. All airtightness testing is to be completed in accordance with the acceptable standards listed in BCBC Article 9.36.7.3.

Component vs. Whole-Building Airtightness

The ESC requirement for whole-building airtightness testing does not supersede the required air barrier system properties in BCBC Article Subsection 9.25.3. nor the applicable window, door, and skylight test standards in BCBC Article 9.7.4.2. Note that BCBC Subsection 9.36.2. also outlines air barrier system requirements, but these only apply as part of the prescriptive pathway, not to the ESC. They may still be a good reference for typical air barrier material properties and detailing approaches. For more information about whole-building airtightness, see **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47.

Air Changes per Hour

ACH

Air Changes per Hour at 50 Pascals (ACH_{50}):

$$\textit{Air Changes per Hour}_{\textit{at 50 Pa}} = \frac{\textit{Hourly Airflow}_{\textit{at 50 Pascals}}\ (m^3/hr)}{\textit{Building Volume}\ (m^3)} = \mathbf{ACH}_{50}$$

The air changes per hour (ACH_{50}) metric is calculated from the hourly airflow volume of the test fan divided by the building volume (in equivalent volume units) at a pressure of 50 pascals.

Smaller single-family homes may have a harder time achieving the required AL using ACH_{50} since the building volume is relatively low compared to the enclosure area.

Normalized Leakage Rate

NLR

Normalized Leakage Rate at 50 Pascals (NLR_{50}):

$$NLR_{50} = \frac{\textit{Airflow}_{\textit{at 50 Pascals}}\ (L/s)}{\textit{Building Enclosure Surface Area}\ (m^2)} = \mathbf{L/s \times m^2}$$

The normalized leakage rate (NLR) metric is calculated from the airflow of the test fan in litres per second divided by the total building surface area in square metres. Normalizing by enclosure area is typically less impacted by building size; therefore, the NLR metric may be easier to achieve for small buildings than the ACH_{50} metric.

Normalized Leakage Area

NLA

Normalized Leakage Area at 50 Pascals (NLA_{10}):

$$NLA_{10} = \frac{\textit{Equivalent Leakage Area (ELA)}_{\textit{at 10 Pascals}}}{\textit{Building Enclosure Surface Area}\ (m^2)} = \mathbf{cm^2 / m^2}$$

The normalized leakage area (NLA) metric is based on the calculated total equivalent leakage area in square centimetres (based on the fan airflow) divided by the total building surface area in square metres. NLA_{10} quantifies the theoretical total size of openings in a building's air barrier system, normalized across the building's surface area.

Like NLR, normalizing by enclosure area is typically less impacted by building size, so this metric may be easier to achieve for small buildings. Aside from compliance requirements, NLA also helps illustrate how much air leakage is occurring through the building enclosure.

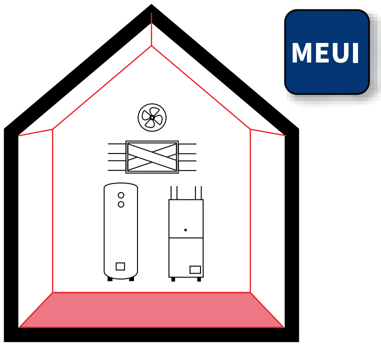


Figure 1.9 MEUI accounts for total energy usage of equipment and systems but excludes base loads such as miscellaneous plug and lighting loads.

Equipment and Systems

Mechanical Energy Use Intensity (MEUI)

The equipment and systems metric addresses the annual energy usage by the building in kilowatt-hours per year, normalized by the conditioned floor area in square metres. It includes the energy consumption from space heating and cooling equipment, fans, water heating equipment, pumps, and auxiliary heating, ventilation, and air conditioning (HVAC) equipment, measured in kWh/m²·year (see Figure 1.9). MEUI excludes base loads such as plug loads and lighting as well as backup heating systems.

Mechanical Energy Use Itensity:

$$MEUI = \frac{\textit{Total Yearly Mech. Energy Useage (kWh/year)}}{\textit{Area of Conditioned Space } (m^2)} = \mathbf{kWh/(m^2 \times year)}$$

The MEUI metric includes relaxation calculations for buildings with smaller floor areas per BCBC Table 9.36.6.3.-H. Smaller buildings may have difficulty meeting the same requirements as larger buildings because they still must use the same type of equipment and systems but have less floor area by which to normalize. Further relaxations are provided for buildings with mechanical cooling in at least 50% of their floor area. The Compliance Checklist has these relaxation calculations built in (see **Appendix A** on page 74). Percent improvement of annual energy consumption (%IMP) can be used for equipment and systems compliance instead of MEUI (see page 15).

Coordinated Mechanical Heating and Cooling Design

Energy modelling to determine the MEUI must include the intended mechanical heating and cooling system equipment, including their capacity and efficiency. The energy modeller must coordinate with the mechanical designer/trade to confirm the assumed mechanical system is correct. All mechanical sizing must follow the CSA standard F280-12 “Determining the required capacity of residential space heating and cooling appliances” per BCBC Article 9.33.5.1. and Sentence 9.36.5.15.(5).

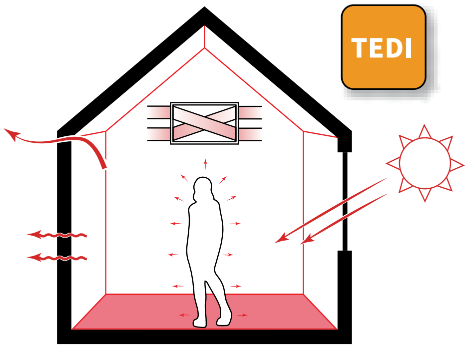


Figure 1.10 TEDI measures energy gains and losses through the building enclosure and ventilation.

Building Envelope

Thermal Energy Demand Intensity (TEDI)

This metric accounts for energy gains and losses through the building enclosure and from ventilation airflow (see Figure 1.10). TEDI is a measure of the annual thermal energy demand in kilowatt-hours per year by the building for space conditioning and for conditioning of ventilation air. This metric is normalized per square metre of area of conditioned space and expressed in kWh/(m^2·year). TEDI considers the thermal insulation of the building enclosure (including opaque assemblies and glazing), solar heat gains, air leakage through the air barrier system, internal heat gains from occupants and equipment, and heat recovery from exhaust air.

Thermal Energy Demand Intensity:

$$TEDI = \frac{\textit{Net Yearly Thermal Energy Demand (kWh/year)}}{\textit{Area of Conditioned Space } (m^2)} = \textbf{kWh}/(\textbf{m}^2 \times \textbf{year})$$

The TEDI metric also includes adjustment factors for the climate of the specific building location. This adjustment factor accounts for the range of heating degree-days below 18°C (HDD) that occur within each climate zone and calculates a TEDI metric based on the HDD of the specific building location. The Compliance Checklist has this adjustment calculation built in (see **Appendix A** on page 74). Percent heat loss reduction (%HLR) can be used for building envelope compliance instead of TEDI (see page 15).

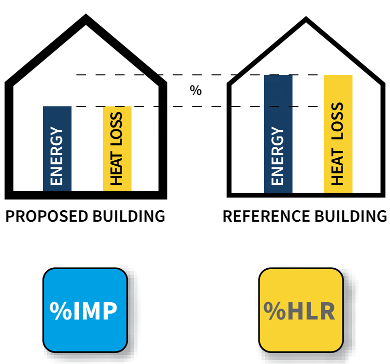


Figure 1.11 Energy performance improvement metrics are calculated from the difference between the modelled house energy usage and/or heat loss and the reference house energy usage and/or heat loss.

Energy Performance

These metrics use a comparison of energy performance between the proposed building and a “code minimum” reference building (see Figure 1.11). The ESC sets out the minimum improvement that the proposed building must be over the reference building.

The percent improvement (%IMP) metric compares the annual energy consumption of the proposed and reference building. It can be used instead of MEUI.

The percent heat loss reduction (%HLR) metric compares the gross space heat loss of the proposed and reference building and can be used instead of TEDI.

The term “proposed house” and “reference house” used throughout the BCBC apply to any Part 9 residential building following the ESC, whether modelled through ERS or other pathways. The energy use of the proposed building and the reference building are determined by energy modelling, with adjustments made to the reference house to represent the typical equivalent building without any energy improvements (i.e., following prescriptive-minimum requirements).

Percent Improvement of Annual Energy Consumption (%IMP)

The percent improvement of annual energy consumption (AEC) is calculated by subtracting the annual energy consumption of the proposed house from the house energy target of the reference house, and dividing the result by the house energy target of the reference house.

"Annual Energy Consumption" in the BCBC vs. EnerGuide Rating System

Note that the AEC value as defined in the BCBC always excludes the base loads, just like MEUI and the ZCSC performance pathway metrics (see **ZCSC Performance Pathway** on page 21). This is different from the "rated annual energy consumption" (sometimes referred to as "total annual energy consumption") as defined in the ERS, which includes base loads and therefore must be adjusted accordingly.

%IMP

Percent Improvement of Annual Energy Consumption (AEC) over Reference House (%IMP)

$$\textit{Percent Improvement} = \frac{\textit{AEC of Reference Building - AEC of Proposed Building (KWh/year)}}{\textit{AEC of Reference Building (kWh/year)}} = \textbf{\%IMP}$$

Percent Heat Loss Reduction (%HLR)

Heat loss reduction is calculated by subtracting the annual gross space heat loss of the proposed house from the annual gross space heat loss of the reference house and dividing the result by the annual gross space heat loss of the reference house.

%HLR

Percent Heat Loss Reduction over Reference House (%HLR)

$$\textit{Percent Heat Loss Reduction} = \frac{\textit{Gross Space Heat Loss of Ref. Building - Gross Space Heat Loss of Prop. Building (GJ)}}{\textit{Gross Space Heat Loss of Reference Building (GJ)}} \times 100 = \textbf{\%HLR}$$

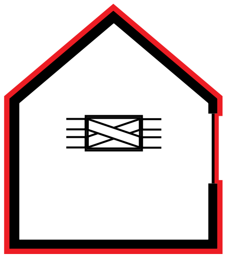
Relationship Between Energy Step Code Metrics and Performance

All ESC metrics relate to one another in terms of overall building energy efficiency. For example, an airtight enclosure with low ACH reduces heat loss and heat gain and therefore also lowers the TEDI. Additionally, an airtight enclosure enables smaller mechanical equipment because less heating/cooling energy is needed to heat and cool the house. Lesser heating/cooling energy results in a lower MEUI. Likewise, a home with a high R-value enclosure and smaller window area reduces heat transfer and therefore requires less energy to heat or cool the home, also resulting in a lower TEDI and MEUI.

When a building design is not optimized in each ESC category, there are several ways to adjust the design and mechanical systems to offset shortcomings. The building scenario examples presented in Table 1.1 describe how the metrics are related and how adjustments to aspects of one metric influence the others. These scenarios are not intended to represent actual buildings or necessarily demonstrate high-performance design. See also **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47 for more information.

Table 1.1 Example ESC compliance scenarios.

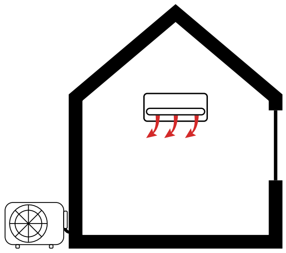
Example 1: Using airtightness and ventilation efficiency to meet TEDI requirements



The project pre-construction report for a Step 3 home shows the building is targeting an air leakage rate of AL-4 (1.0 ACH_{50}), which is two levels better than the required minimum. It also shows a heat recovery ventilator (HRV) with 88% efficiency, which is higher than conventional systems.

The building also has a simple form and a low window-to-wall ratio, so these improvements combined with slightly more insulation in the attic allowed the building to meet the Step 3 TEDI requirement without any other changes.

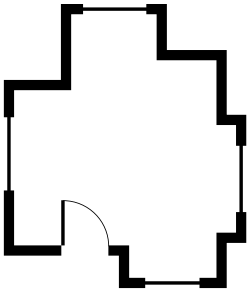
Example 2: Using heat pump energy efficiency to meet MEUI requirements



The plans for a house show an air source heat pump with a coefficient of performance (COP) of 3.0 (i.e., 300% efficient) and an operating temperature down to -22°C. The house also uses an electric resistance hot water heater.

The high-efficiency mechanical equipment provides most of the building's heating and cooling with less energy input. The building also has R-24 walls, low U-value windows, a highly insulated roof, and R-15 below-grade slab insulation. Therefore, the house has a low TEDI and is able to reach Step 5. It also complies with EL-4 of the ZCSC.

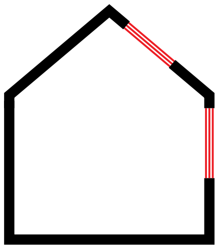
Example 3: Using percent heat loss reduction instead of TEDI to meet building envelope requirements



The house plans show a relatively complex building form, with multiple jogs and corners, and tall ceilings. The walls have 2" of outboard insulation (additional R-10) and high-performance triple-glazed windows. However, the building does not meet the Step 4 TEDI requirements because of the large enclosure area relative to the heated floor area.

Instead, the proposed building complies with the %HLR metric by showing significant improvements to the annual gross space heat loss compared to a reference building with the same building form.

Example 4: Building form and orientation used to meet TEDI requirement



A project is narrowly meeting the TEDI requirement with high R-value walls, but the building site's setback requirements do not allow enough room for the extra insulation without changing the entire footprint. Instead of changing the footprint, the designer specifies higher performance triple-glazed windows and skylights. The updated energy model shows that the building achieves the TEDI with less insulation in the exterior walls.

The window U-value is a key factor in thermal performance of the whole building. Even moderate improvements here can offset the need for more insulation elsewhere.

Zero Carbon Step Code Metrics

The key performance metrics of the ZCSC are the Emission Levels (ELs), the emissions factors, and the annual GHG emissions. Four increasingly stringent Emission Levels are used to set limits on the annual building operational GHG emissions based on the emissions factor of the energy sources used by the building energy systems. The following sections provide more detail on the ZCSC metrics as well as information on what systems are included and excluded. Zero Carbon Step Code performance metrics are reported in Part G of the ESC Compliance Checklist (see **Appendix A** on page 74).

The metrics and compliance pathways are summarized in Figure 1.12.

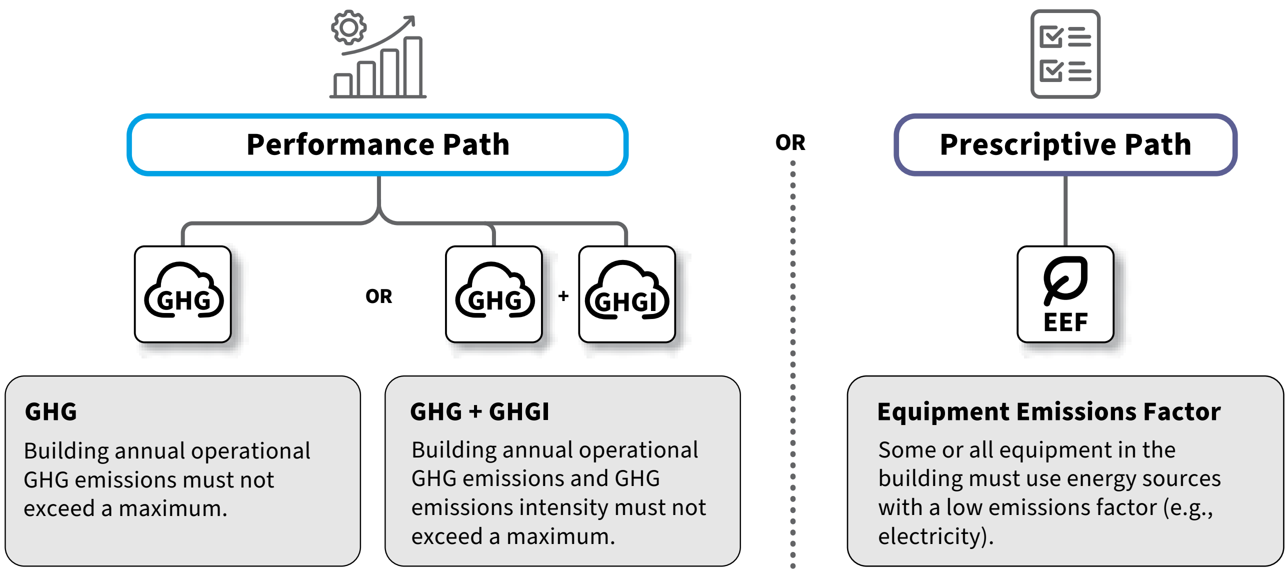


Figure 1.12 Summary of compliance pathways and metrics of the ZCSC (adapted from BCBC Table 9.37.1.3.).

Emission Levels

The ZCSC identifies four Emission Levels (EL-1 through EL-4) related to the annual operational GHG emissions, measured in kilograms of carbon dioxide equivalent ($kgCO_2e$), or the equipment energy source emissions factor requirements. Each Emission Level indicates increasing "carbon performance," meaning the total annual operational GHG emissions of the building is lower with each level, as shown in Figure 1.13. These commonly used carbon performance descriptions for each Emission Level are not actually listed in BCBC Section 9.37. (Table 9.37.1.3.), but they help describe the intent behind each one.

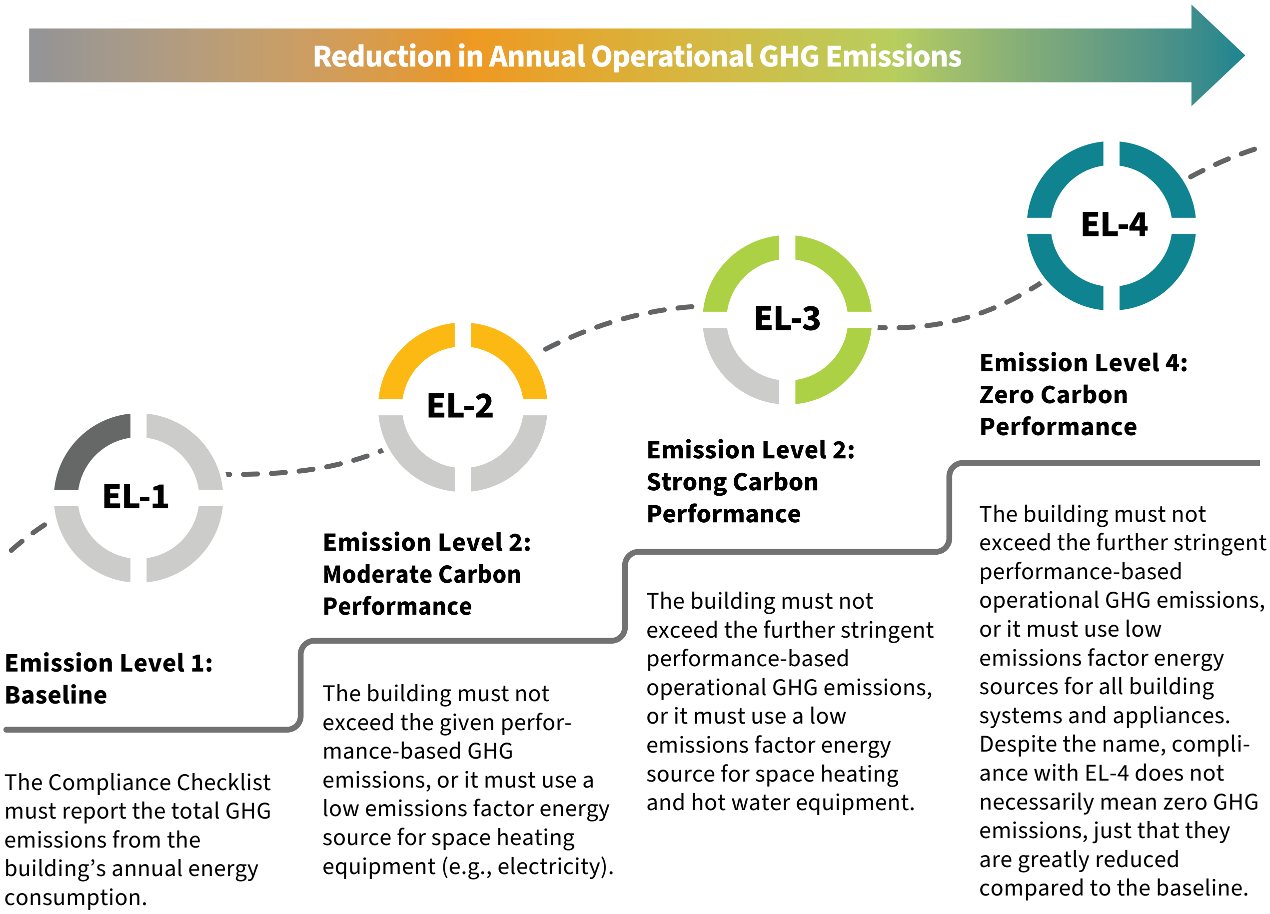


Figure 1.13 Summary of the four Emission Levels that form the basis for the ZCSC.

Emissions Factor

The ZCSC compliance pathways are based on the energy source GHG emissions factor as set out in BCBC Table 9.37.1.3., measured as kilograms of carbon dioxide-equivalent gases emitted ($kgCO_2e$) per kilowatt-hour (kWh) of energy (see Figure 1.14). Electricity has the lowest emissions factor by far, based on BC's power grid, compared to combustion fuels.

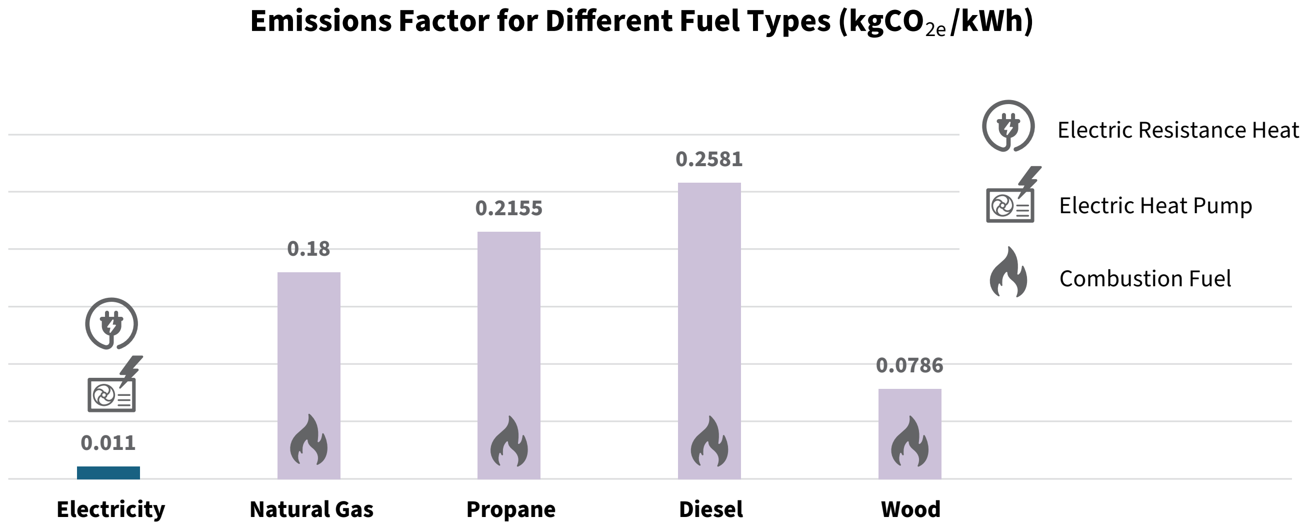


Figure 1.14 The emissions factor for building systems based on common fuel types.

Renewable Natural Gas and the Zero Carbon Step Code

While renewable natural gas (RNG) is typically recognized as a low emissions factor fuel source, the BCBC currently does not consider it as a building system fuel option under the ZCSC.

What is Included and Excluded from the Zero Carbon Step Code?

Under the ZCSC ***performance path***, operational GHG emission calculations include energy used by space heating equipment (including supplemental heat), space-cooling equipment, fans, water heating equipment, pumps, and auxiliary HVAC equipment, regardless of Emission Level. ***Backup heating systems*** as well as building base loads like lighting, plug loads, and laundry and cooking equipment are not included in GHG emission calculations. The calculation methodology is based on the same systems included in the MEUI metric.

Under the ZCSC ***prescriptive path***, each ascending Emission Level includes more building systems that must use low emissions factor energy sources, as outlined in **Figure 1.13**. Most importantly, EL-4 requires that all appliances including laundry and cooking must use low emissions factor energy sources. Like the performance pathway, backup heating systems are not included in any Emission Level, but supplemental heating systems are always included.

Backup Heating Systems Versus Supplemental Heating Systems

Energy use and emissions from any mechanical heating systems intended to operate only during primary system failures, such as wood or natural gas fireplaces or wood stoves, are not required to be counted under the ZCSC. These systems are considered backup heating systems as defined in Building and Safety Standards Branch (BSSB) Information Bulletin B23-03; they are not used to meet the space conditioning load of the home under normal operating conditions.

In contrast, heating systems that provide additional heating energy to supplement or make up for heating equipment that cannot efficiently meet the heating demand under certain normal operating conditions are considered ***supplemental heating systems***, as defined in BSSB Bulletin B23-03. The emissions from these systems must be counted under the ZCSC. For example, the most common form of supplemental heat is from a natural gas or direct electric heater that automatically turns on when the heat pump heating system can't meet the heating demand, such as during very cold weather. In this case, the building mechanical design includes supplemental heating as part of normal operating conditions. Thus, when natural gas is used for supplemental heat, its emissions are counted as part of the GHG calculation under the performance pathway, and the building would not comply under the prescriptive pathway above EL-1.

Decorative and Backup Fireplaces are Excluded from the ZCSC

Indoor fireplaces are excluded from both the performance and prescriptive pathways of ZCSC because, assuming there is a separate primary heating system in the home, they are considered backup heating systems. High-efficiency wood-burning appliances like pellet stoves are not excluded when they are used as the primary heating system.

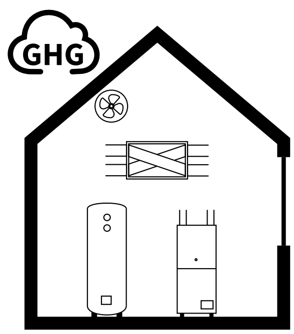
Outdoor Appliances are Not Included in the ZCSC

Amenity appliances outside the building, like patio heaters, fire pits, grilles, driveway heaters, and even pools, are not included in ZCSC pathways since they are not considered building systems and are outside the scope of the BCBC.

ZCSC Performance Pathway

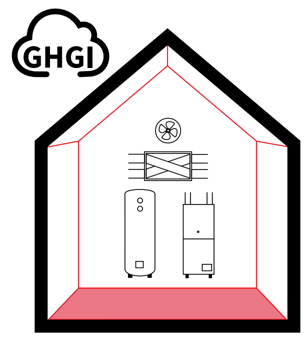
The performance pathway sets overall maximum annual operating GHG emissions for each Emission Level instead of prescribing what equipment must use low-carbon energy (e.g., electricity). This approach allows flexibility in equipment choices but requires an accurate calculation of GHG emissions based on the results of the energy model. The performance pathway uses the two metrics shown in Figure 1.15.

Total Quantity of GHG Emissions Per Year



This metric measures the annual GHG emissions from the home's mechanical equipment (GHG, kg CO_2e/year).

Total Quantity of GHG Emissions Per Square Metre



This metric is the GHG emissions divided by heated floor area, referred to as the greenhouse gas intensity (GHGI, kg CO_2e/m^2/year).

Figure 1.15 Summary of the two metrics used for the ZCSC performance pathway.

The performance pathway offers these two options:

Performance Pathway Option 1 – Compliance is based on not exceeding the total GHG as listed in the left-hand column of Table 9.37.1.3. of the BCBC. If this metric cannot be met, performance-based compliance is based on the next column to the right in Table 9.37.1.3.

Performance Pathway Option 2 – Compliance is based on both not exceeding the total GHG emissions (with higher limits than Option 1) and not exceeding the GHGI as listed in the centre column of Table 9.37.1.3. of the BCBC.

These options allow flexibility to accommodate both small and large homes; small homes typically use Option 1 because their total GHG emissions are lower, while larger homes have more total GHG emissions but can also have lower GHGI.

Annual GHG emissions and GHGI are calculated from the annual consumption for each fuel type using the formula shown in Figure 1.16. The Compliance Checklist has these GHG and GHGI calculations built in (see **Appendix A** on page 74). Backup heating systems and baseloads are excluded from the AEC.

On-Site Energy Production is Not Included in Zero Carbon Step Code Compliance

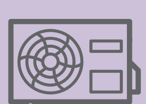
Just like the ESC compliance metrics, results from energy modelling to determine the GHG emissions do not include energy or carbon offsets from on-site power generation like solar panels.

Annual GHG ($kg\ CO_2e$/year)	=	Annual electricity energy consumption (GJ)	x	kWh conversion (277.78 kWh per GJ)	x	Emissions factor (0.011 kg CO_2e/kWh)
			+			
		Annual natural gas energy consumption (GJ)	x	kWh conversion (277.78 kWh per GJ)	x	Emissions factor (0.180 kg CO_2e/kWh)
			+			
		Annual energy consumption from other energy sources (GJ)	x	kWh conversion (277.78 kWh per GJ)	x	Corresponding emissions factor(s) (CO_2e/kWh)
Annual GHGI ($kg\ CO_2e/year/m^2$)	=	Annual GHG (kg CO_2e/year)	÷	Total area of Conditioned Space (m^2)		

Figure 1.16 Formula to calculate the annual GHG emissions and GHGI from the estimated annual fuel consumption for each fuel type.

Performance-based compliance with the ZCSC does not mean all equipment must use low emissions factor energy sources (e.g., only electricity). Homes can still meet the ZCSC requirements under the performance pathway while still using high emissions factor energy sources like natural gas for equipment and appliances. However, their annual energy source consumption must be low enough to offset the higher emissions factors.

Heat Pump Switchover Temperature Best Practices



As outlined in **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47, the heat pump switchover temperature that determines when supplemental heating turns on is a key factor in modelling and calculating the annual energy consumption and related GHG emissions. Emissions calculations can be significantly impacted when the supplemental heating system uses natural gas. Requiring the heat pump switchover temperature be reported with the space heating and cooling information and in any mechanical commissioning documentation can help verify that the energy model and as-built mechanical system use the same operating conditions. It is also an effective way to verify the correct controls are being used to prevent supplementary heater operation when the heating load can be met by the heat pump alone, as required by BCBC 9.36.3.6.(6).

ZCSC Step Code Prescriptive Pathway

The ***prescriptive path*** dictates what equipment and appliances must use low emissions factor energy sources (e.g., electricity instead of combustion fuel). The compliance requirements under the prescriptive pathway are summarized in Table 1.2, which is adapted from Table 9.37.1.3. of the BCBC. Backup heating systems and amenity appliances (see page 20) are excluded from the prescriptive pathway.

Table 1.2 Summary of compliance requirements under the ZCSC prescriptive pathway (adapted from BCBC Table 9.37.1.3. right-most column).

Prescriptive GHG Emission Compliance Option	
Emission Level	**Lower Emissions Factor Equipment Required** (i.e., energy source with an emissions factor ≤ 0.011 $kgCO_{2e}$ /kWh)
EL-2	› Space heating system (including supplemental heating systems)
EL-3	› Space heating system (including supplemental heating systems) › Water heating system
EL-4	› Space heating system (including supplemental heating systems) › Water heating system › Appliances (cooking, laundry)

Zero Carbon Step Code Compliance and the BCBC 9.33.3.1. Cooling Requirements

Heat pump electric heating systems also work as the air conditioner cooling system in the summer. This makes it easier to meet the overheating protection requirements of the BCBC.

Relationship Between Zero Carbon Step Code Metrics and Energy Performance

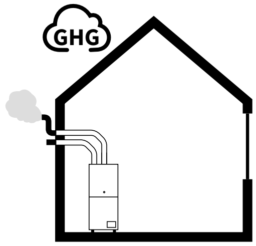
Mechanical equipment that uses electricity to provide heating and/or cooling can help buildings meet the Emission Level requirements of the ZCSC. This equipment includes electric heat pumps and dual-fuel (electric and natural gas) heating systems.

The building scenario examples in Table 1.3 describe how the ZCSC metrics are related to building design and how adjustments influence compliance. None of these scenarios are intended to represent an actual building case study for a given house design or climate zone, or to necessarily demonstrate high-performance design. See also **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47 for more information.

Note that regardless of the building design, GHG performance can also be impacted by the capacity of the heating and cooling equipment chosen in the energy model. Proper sizing of heating and cooling equipment using CSA F280 is required by Article 9.33.5.1. and Sentence 9.36.5.15.(5) of the BCBC. As outlined in **Section 2 | Step Code Compliance Process and Roles** on page 25, all energy modelling submissions to show code compliance must be accompanied by a CSA F280 mechanical sizing report.

Table 1.3 Example ZCSC compliance scenarios.

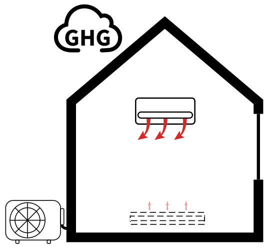
Example 1: Compliance with higher levels of the ZCSC performance pathway likely requires electric heating



A Step 5 home with a natural gas furnace as the primary heat source can only reach EL-2 based on the GHG emissions calculated from the energy model. This is still higher than would be achieved under the ZCSC prescriptive pathway, but the higher emissions factor of natural gas means EL-3 or EL-4 can't be reached without electric heating instead.

Emissions performance is typically driven by the heating system energy source, even with an energy efficient enclosure and Step 5 ESC compliance.

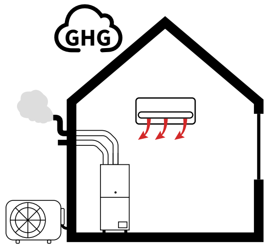
Example 2: Using heat pump energy efficiency to meet GHG requirements



A Step 3 home is targeting EL-4 using the ZCSC performance pathway. The current design uses electric baseboards for heating and an electric hot water tank heater. The building reaches EL-3 under the ZCSC prescriptive pathway, but if the electric baseboards are swapped with an electric heat pump, EL-4 under the performance pathway is achieved.

High-efficiency heating systems reduce the building's energy consumption and associated GHG emissions.

Example 3: Supplemental natural gas heating is a key factor in ZCSC compliance



The Pre-Construction Compliance Checklist for a Step 3 home shows the heating system uses an electric heat pump with a supplemental natural gas furnace. However, on-site you observe the heat pump capacity is smaller than the rating stated in the report.

When the energy model is updated with the heat pump size used on site, it shows that the building no longer achieves the EL-3 GHGI requirement because the natural gas furnace will operate more often than originally modelled. Equipment sizing is important to achieving the ZCSC performance pathway.

2 | Step Code Compliance Process and Roles

In Short

This section presents the best practices for the compliance process. It also identifies the roles and responsibilities that each of these three key stakeholders have in this process:

› ***Building Official*** (you)

› ***Builder*** (responsible for code compliance)

› ***Modeller*** (responsible for energy modelling)

Section Includes:

- The Compliance Review Process 25
- Roles and Responsibilities of the Building Official (You) 30
- Roles and Responsibilities of the Builder 37
- Roles and Responsibilities of the Modeller 40
- Other Compliance Options 43
- Non-Compliance 44
- Step Code Compliance "Do's and Don'ts" 45

The Compliance Review Process

The requirements of the Energy Step Code (ESC) set out the overall building energy performance rather than specific R-value, U-value, or mechanical efficiency requirements. While the documentation and ***energy modelling*** must follow the code requirements, the approach to meeting the energy performance requirements will vary across buildings. The compliance process requires regular communication between you (the ***Building Official***) and the building team responsible for code compliance (i.e., the ***Builder***). The building ***energy modeller***, (i.e., the ***Modeller***) plays a key role on the building team and is fundamental to the design, construction, and compliance process. This section outlines the recommended code compliance process and key considerations for Part 9 residential projects under the ESC and the Zero Carbon Step Code (ZCSC). It includes details on the roles and responsibilities of each relevant party.

Division C Subsection 2.2.8. of the BCBC outlines the minimum compliance submission requirements for the ESC. However, as with all code compliance processes, exactly how code compliance is demonstrated to the authority having jurisdiction (AHJ) through submissions, reviews, inspections, and approvals is established by each jurisdiction. The guidance provided in the highlighted text boxes throughout this section outlines the best-practice compliance process steps. These items may be considered for implementation by the local authority through policies and bylaws.

The Step Code Compliance Checklist

All buildings must have a Step Code compliance report that includes the information listed in the BCBC under Division C Article 2.2.8.3. House Performance Compliance Calculation Report. The commonly used BC Step Code ***Compliance Checklist*** (i.e., the Compliance Checklist) is a standardized version of this report. The Compliance Checklist is a summary of the building energy and emissions metrics. It gives information on the building enclosure, the mechanical systems, the assumed airtightness, annual emissions, and building size. The Compliance Checklist presents the information required to demonstrate BCBC energy and emissions compliance before the building permit is issued, tracks any changes that may have occurred during construction, and confirms the as-built building matches the design and complies with the BCBC. See **Appendix A** on page 74 on for more information on the Compliance Checklist contents.

The energystepcode.ca website is a resource for all parties in the compliance process. Most importantly, it provides standardized up-to-date compliance forms and checklists that you and the building team can use to show and track code compliance. The documents and Compliance Checklist spreadsheet are not strictly required by the BCBC, but they are considered the industry standard for efficiently and accurately showing ESC and ZCSC compliance for Part 9 residential buildings. The compliance guidance in this section refers to the documents contained on this website.

The three types of Compliance Checklists used throughout the design and construction process are described below.

1. **Pre-Construction Compliance Checklist:** The ***Modeller*** completes this report during the design phase prior to construction of the building. This report represents the proposed building and is submitted with the building permit application. It is crucial that the specifications of building components in the Pre-Construction Compliance Checklist are consistent with the specifications shown on the building plans.

2. **Mid-Construction Compliance Checklist:** This optional report records how changes during construction are accounted for in the energy model. It is useful when tracking significant items that impact energy performance, and for updating the energy model to reflect mid-construction ***airtightness testing*** results.

3. **As-Built Compliance Checklist:** This report provides the same information as the pre-construction report except with updated inputs based on the actual constructed building parameters, including airtightness testing results, and the related energy modelling. It is used as part of final submissions for the occupancy permit.

The Compliance Checklist for each phase is generated from the Compliance Checklist spreadsheet. The spreadsheet includes all the input information for all the required compliance items. It also gives supplementary information that can be used as part of your jurisdiction's specific compliance process. When completely and correctly filled out, the checklists provide a consistent and convenient method for gathering the information needed to check for compliance. Most importantly, the spreadsheet also contains all the code references, metric calculations, and adjustment factors to produce results based on the raw energy model results and inputs from the Modeller. Thus, the key compliance information in the Compliance Checklist is the result of automatically populating locked spreadsheet cells. Figure 2.1 shows an annotated screenshot of the relevant Compliance Checklist spreadsheet tabs. **Appendix A** on page 74 on shows examples of the Compliance Checklists.

While technically only a compliance report (i.e., printed or PDF document) that follows BCBC Division C Article 2.2.8.3. is required to show ESC and ZCSC compliance, the standard Compliance Checklist digital spreadsheet file provides a consistent way to present the information for plan checking exercises. The Compliance Checklist spreadsheet also includes detailed explanations and reference information for how the energy model results are used to populate the checklists (see Figure 2.1). The most recent version of this file is available from energystepcode.ca.

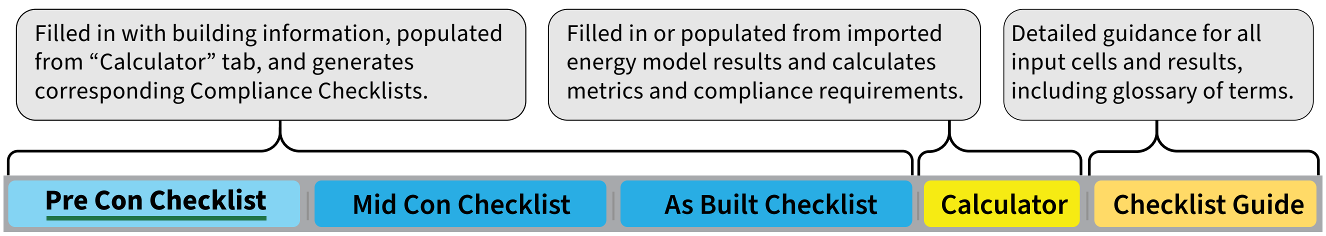


Figure 2.1 Screenshot of the Compliance Checklist spreadsheet tabs relevant to compliance review (Version – February 2025).

Pre-Construction Compliance Flowchart

The flowchart in Figure 2.2 (see also the following pages) outlines a recommended pre-construction compliance/permitting process for a Part 9 residential ESC and ZCSC project. Each role is separated by column, with compliance steps and various responsibilities listed for each. The activities would occur simultaneously as needed to support project progression. Refer to the following corresponding sections for each role category for further discussion of the steps and how they relate to each other.

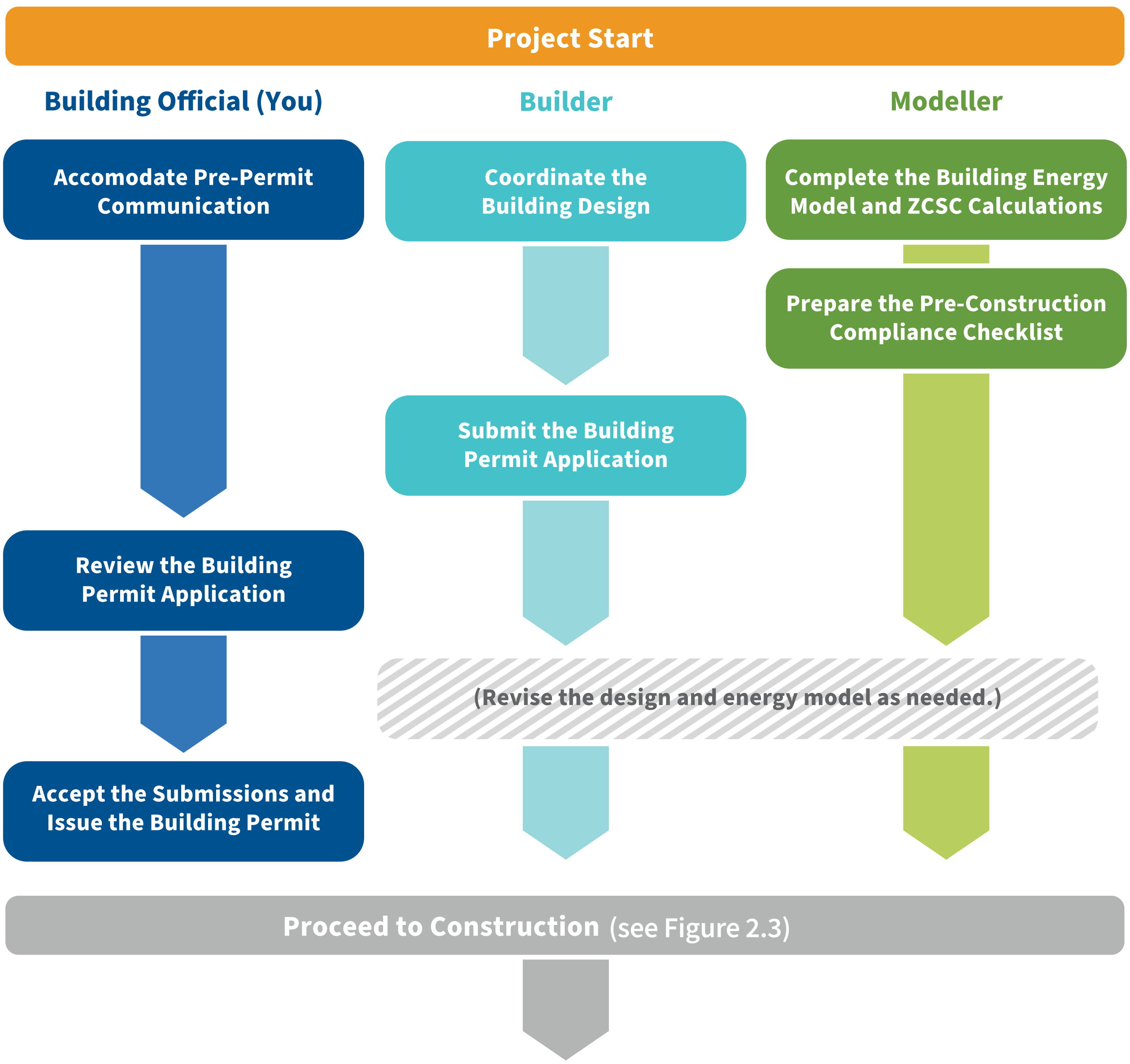


Figure 2.2 Pre-construction compliance flowchart.

Construction Compliance Flowchart

As with all code items, it is the responsibility of the ***Owner*** (and usually through contract, the designer and/or Builder) to ensure that the building complies with the BCBC. This includes ensuring that the building is fully consistent with the specifications modelled in the Pre-Construction Compliance Checklist, or adjusting the construction or model as needed. The flowchart in Figure 2.3 outlines a recommended construction-stage compliance process for a Part 9 residential ESC and ZCSC project.

The Modeller is not responsible for ensuring ESC and ZCSC compliance or coordinating design, construction, or model updates to rectify non-compliance. Those tasks are the Builder's responsibility. However, while the Modeller is not necessarily a ***Registered Professional***, they are still responsible for producing detailed accurate reports that are to be relied upon by the local AHJ.

It is your responsibility as the Building Official to oversee and apply your jurisdiction's code compliance process, indicate acceptance of demonstrated code compliance, and serve in an auditing role to ensure accuracy of the modelled building.

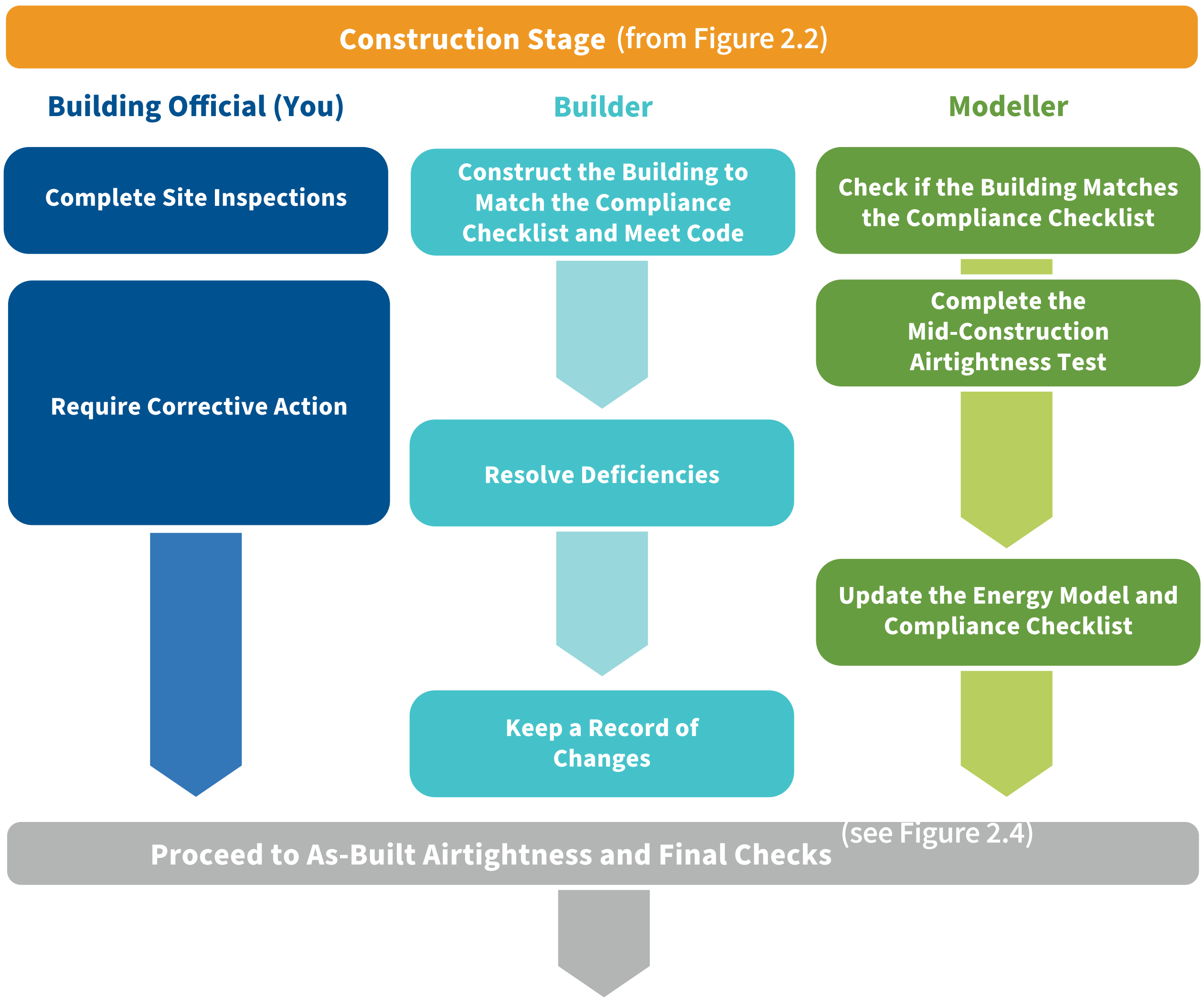


Figure 2.3 Construction compliance flowchart.

As-Built Airtightness and Final Checks Compliance Flowchart

If ***site inspections*** and testing show that improvements are required to reach compliance, the building team can collaborate to determine what approaches can be used. The Modeller will re-run the energy model to confirm the improvements will work. These improvements could mean removing and reinstalling building components, adding insulation, upgrading mechanical equipment, or improving the air barrier. Air barrier improvements would also require additional airtightness testing. The flowchart in Figure 2.4 outlines a recommended compliance process for the final compliance stages of a Part 9 residential ESC and ZCSC project.

When a project is non-compliant, you as the Building Official and local AHJ have many enforcement options and ways to prompt the Builder to improve the building and reach compliance. Refer to **Non-Compliance** on page 44 for more information on ways to prompt compliance and ensure safeguards regarding your liability.

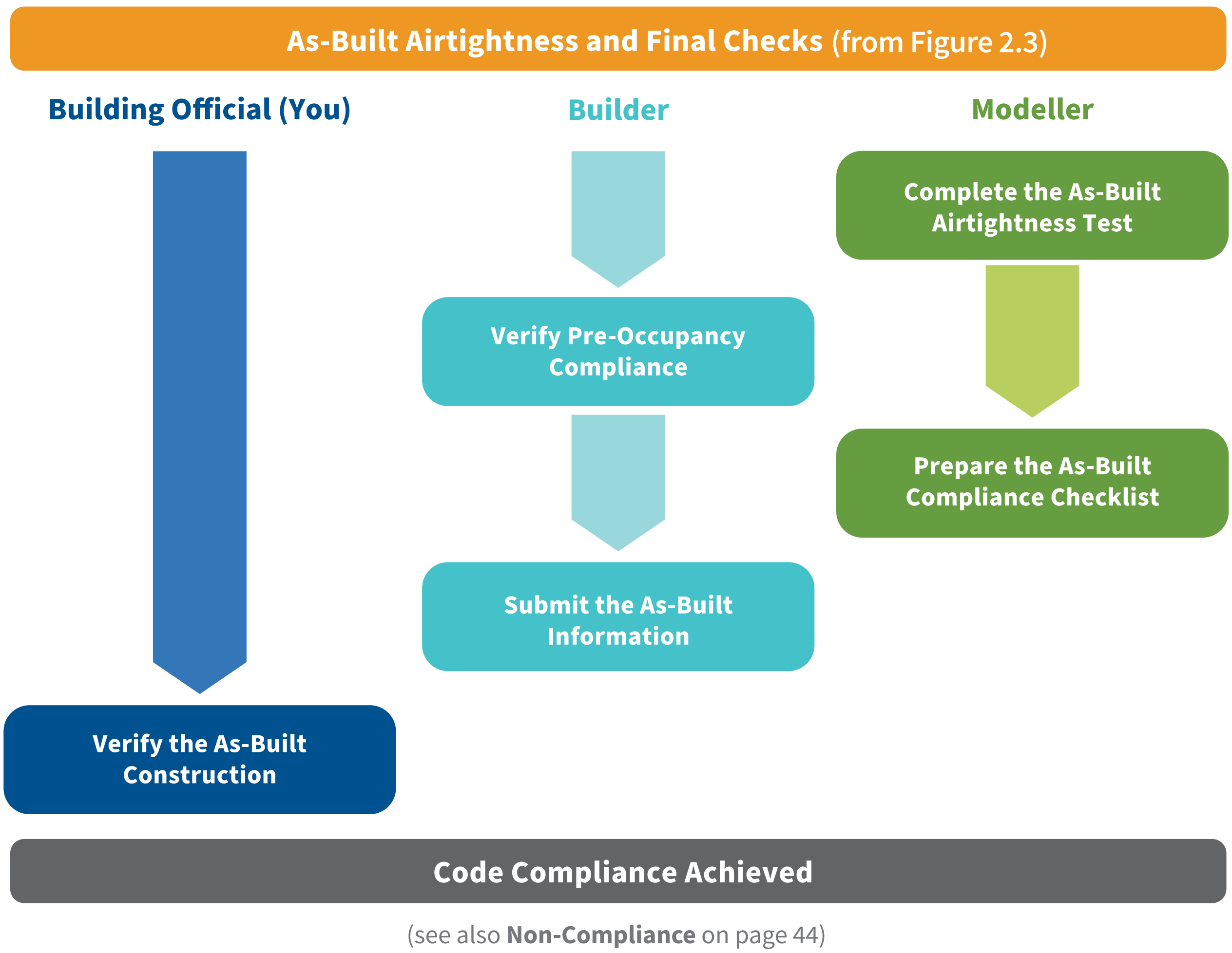


Figure 2.4 As-built airtightness and final checks compliance flowchart.

Roles and Responsibilities of the Building Official (You)

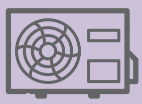
Accommodate Pre-Permit Communication

Most compliance concerns can be addressed with a thorough design approach that includes feedback and input from all parties. While there is not a specific requirement for Building Official involvement at the pre-permit stage, your assistance in clarifying code compliance process items can reduce the risk of compliance issues arising during the construction phase. Even a simple bulletin or checklist regarding your jurisdiction's ESC and ZCSC compliance process can help the building team get started on the right footing.

You may wish to participate in pre-permit meetings to discuss the code compliance process with the Builder and Modeller. Pre-permit meetings give an opportunity to discuss the application and approval process, compliance concerns, and documentation expectations. This can save review time and reduce the likelihood of document resubmission. Pre-permit meetings are particularly beneficial for buildings with complex or unique characteristics.

As the Building Official, you cannot be directly involved in any design decisions except as related to code compliance. Therefore, additional pre-permit compliance tools, such as requirements for third-party review by a Registered Professional, can be implemented for certain circumstances through your local bylaws. The goal of these tools would be to help make building permit submissions and reports more reliable for accurately demonstrating code compliance.

Local governments are authorized to, by bylaw and in select circumstances, require Registered Professionals (i.e., professional architects and/or engineers) to certify that submissions comply with building regulations, including the ESC and ZCSC. The authorization is found in Section 55 of the Community Charter and might be useful for projects with unusual site conditions, size, or complexity. As with all code compliance processes, incentive programs, and bylaws, it is important to consult with your legal counsel before implementing regulations specific to your jurisdiction.



BCBC 9.33.3.1. Cooling Requirements

One common example where requiring a Registered Professional may be prudent is in any building design that is intended to use non-mechanical (i.e., "passive") means to prevent building overheating. This is not strictly ESC or ZCSC compliance related, but if the building complies with energy and emissions requirements without a mechanical cooling system included, it can lead to challenges if the building ends up needing this system later because the intended "passive" approach is not viable. See **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47 for more information on mechanical cooling considerations.

Review the Building Permit Application

Building permit package review for ESC and ZCSC compliance involves reviewing the submitted drawings and the ***Pre-Construction Compliance Checklist***. The report outlines the inputs and calculations based on the building's energy model and forms the basis for code compliance review and tracking. The Compliance Checklist is populated by the Modeller and coordinated by the Builder.

It is important that you review all the documents together to assess if the information submitted in the Compliance Checklist matches the information in the drawings. For example, if the report states the typical above-grade wall assembly is a 2x8 with an average effective R-value of R-30 (Part D ESC Compliance Checklist; see **Appendix A** on page 74) but the drawings show a typical 2x6 wall assembly with just batt insulation, it is obvious the drawings and energy model have not been coordinated and cannot be accepted as sufficiently detailed or accurate. The building permit drawings must clearly show the same key energy and emissions-related components as reported in the Compliance Checklist. It is the Modeller's responsibility to accurately model what is shown in the drawings, but it is the Builder's responsibility to keep the drawings and Compliance Checklist updated to match each other.

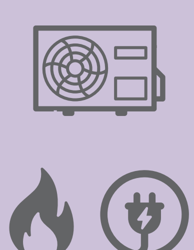
It is prudent for you to request detailed air barrier drawings, especially if the building is aiming to reach a high airtightness level above AL-1. These drawings indicate the intended continuity of the air barrier system and provide some assurance of reaching the building airtightness level. These are typically known as 'Red-line' drawings showing a red line representing the continuous air barrier. See **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47 for more information on building airtightness.

Apart from showing the same basic Compliance Checklist information of the energy and emissions metrics, each building permit submission will be unique. However, it is recommended that you follow a set of standard procedures to maintain consistency between reviews and to ensure nothing is missed.

It is your role to confirm that the building's design meets the metrics of the ESC and the ZCSC. The information in the drawings must match the information in the Compliance Checklist, and the energy model inputs and outputs listed in the Compliance Checklist must meet code requirements. You will need a moderate understanding of each of the items required in the Compliance Checklist and good knowledge of the basics of energy-efficient design and construction principles (refer to **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47).

Note, however, that it is not your responsibility to ensure the building design is the most cost-effective or energy-saving solution for meeting the ESC or ZCSC, or that the building will operate as modelled or as a ***high-performance building*** (see **Energy Modelling** on page 8).

Heat Pump Switchover Temperature for GHG Emissions Compliance



As discussed in **Section 1 | Overview of the Step Codes** on page 1 and **Section 3 | High-Performance Step Code-Compliant Buildings** on page 47 the annual energy consumption and corresponding GHG emissions calculations are based on assumed mechanical heating and cooling operating conditions in the energy model. This includes the assumed heat pump switchover temperature when the supplemental heating kicks in. Emissions calculations can be significantly impacted when the supplemental heating system uses natural gas. Requiring the heat pump switchover temperature be reported with the space heating cooling information and in any mechanical design documentation can help verify that the ZCSC ***performance pathway*** GHG emissions are accurate.

Check these key items on the ESC and ZCSC Compliance Checklist (see also Appendix A on page 74):

- ☐ **Part A: PROJECT INFORMATION**
  - ☐ Confirm that the building location information matches the permit application and shows the correct number of dwelling units. This information is what determines how the building is modelled.
- ☐ **Part B: CODE COMPLIANCE SUMMARY**
  - ☐ Check the compliance path. ESC compliance for Part 9 residential buildings is either through the EnerGuide Rating System (ERS), which requires a certified Energy Advisor, or following other applicable modelling requirements and completed by a qualified energy modeller.
  - ☐ Check that the required Step and Emission Level match the provincial code minimum or your local jurisdiction's bylaw, and the proposed building achieves (or exceeds) both.
  - ☐ Cross-check that the referenced building drawing version matches the permit drawing version.
- ☐ **Part C: "COMPLETED BY" INFORMATION**
  - ☐ For ESC compliance following ERS, cross-check that the Energy Advisor who completed the model and checklist is active and certified, based on their Service Organization. There should also be an energy model "P-file" number (see also **Roles and Responsibilities of the Modeller** on page 40).
  - ☐ For other ESC compliance paths, confirm that the energy modeller has appropriate qualifications, including, if applicable, assurance from a Registered Professional.
- ☐ **Part D: BUILDING CHARACTERISTICS**
  - ☐ Cross-check that the building information matches drawings and uses realistic and attainable thermal performance values and accurate air barrier descriptions. Assessing this section requires good knowledge of enclosure technology.
  - ☐ Check that the proposed assemblies do not ignore performance and durability requirements as set out in other parts of the BCBC, including Section 9.25.
  - ☐ If there are unique high R-value assemblies, a high Airtightness Level indicated, or a complex mechanical system, it is prudent to require further documentation like product data sheets, detailed assembly R-value calculations, and/or an air barrier QA/QC plan.
  - ☐ Always require a CSA F280 mechanical sizing report at the permit application stage. The sizing output is the minimum capacity for the proposed mechanical system listed in the Compliance Checklist. Require that the mechanical equipment specification clearly indicates at least the applicable energy efficiency rating (e.g., COP, SEER, AFUE, etc.) and ideally also notes the switchover temperature where applicable.
  - ☐ Check that the correct "Fossil Fuels" choice has been selected based on building characteristics.
- ☐ **Part E: BCBC SUBSECTION 9.36.5. ENERGY PERFORMANCE COMPLIANCE**
  - ☐ This section may be filled out if the energy modelling was completed following BCBC Subsection 9.36.5. energy modelling requirements, but it is not an indicator of ESC (BCBC 9.36.6.) compliance. That is shown in Part F.
- ☐ **Part F: ENERGY STEP CODE COMPLIANCE**
  - ☐ Check that all proposed ESC metrics are met or exceeded as appropriate, with at least one metric highlighted in green and "Pass" indicated for each category.
  - ☐ Cross-check that the energy modelling software/version is current, and that building geometry, local Heating Degree Days Below 18°C, and indication of mechanical cooling match the drawings. Note the heated floor area will be different from other non-ESC/ZCSC floor area measurements.
- ☐ **Part G: ZERO CARBON STEP CODE**
  - ☐ Check that all proposed ZCSC metrics are met or exceeded as appropriate and indicate "Pass" in each category as required by the local code minimum.
  - ☐ Cross-check that any indications of "Zero Carb" for mechanical equipment match the drawings.

Accept the Submissions and Issue the Building Permit

Once you have reviewed the document package and deemed the design and Compliance Checklist to be acceptable per the ESC and ZCSC requirements, you may issue the building permit.

As with all code compliance items, it is possible that multiple rounds of review, revisions, updated energy model runs, and re-submissions may be necessary prior to issuing a building permit if the design does not show acceptable compliance with the ESC and/or ZCSC, or more commonly, if there are discrepancies between the Pre-Construction Compliance Checklist and the building drawings submitted.

Section 743 of the Local Government Act provides statutory immunity for local governments that accept submissions from professional architects or engineers (Registered Professionals). However, no immunity is provided for reliance on non-professional confirmations of compliance. The degree to which you (and by extension the local government) will rely on non-professional confirmations should be set out in bylaw, Council, and/or Board policy, in consultation with your insurer and legal counsel.

Complete Site Inspections

You can use regular pre-planned ***site inspections*** to verify that what is being constructed matches the design information in the Pre-Construction Compliance Checklist. Part D of the Compliance Checklist becomes the reference for all energy and emissions code compliance items. Any deviations from what is reported here will trigger the need for follow-up and potentially corrective action, including re-modelling and resubmission.

Site inspections for energy and emissions compliance can typically be aligned with the typical standard building inspection sequence (e.g., below-grade, pre-insulation, pre-drywall, etc.), but additional inspections may be warranted, especially with increasingly high-performance buildings. Check or modify your bylaws to account for this. These inspections may include:

- Airtightness test inspection to verify the procedure follows test requirements.
- Mechanical rough-in and equipment inspection of system arrangement and component verification.
- Pre-cladding inspection of air barrier and exterior insulation (where applicable).
- Pre-occupancy inspection to verify the As-Built Compliance Checklist accuracy.

There are many ways that a building may not comply during construction. One of the most common oversights during site inspections is assuming the Builder or Modeller is accurately tracking that the construction matches the Compliance Checklist. Unless formal progress reporting or site visits are part of the compliance process, it is best to assume you are providing some kind of “backstop” with your site inspections and related follow-up.

Conditions/deviations from the Pre-Construction Compliance Checklist that would prompt follow-up (see also **Step Code Compliance “Do’s and Don’ts”** on page 45) include the following:

- ☐ **Insulation**
  - ☐ Insulation is not installed at all below-grade locations listed in the Compliance Checklist, including if the excavation is not deep enough to accommodate the under-slab insulation.
  - ☐ Insulation materials installed on-site have a lower R-value from those listed in the Compliance Checklist.
  - ☐ Insulation materials, coverage, continuity, attachment, and/or thermal calculations do not meet the applicable Article in BCBC Subsection 9.25.2. Thermal Insulation. This includes having appropriate testing and certification. Both the whole-building energy performance and building products must meet their respective code requirements.

- ☐ **Air Barrier**
  - ☐ Primary materials comprising the air barrier system (e.g., sheathing membrane, vapour barrier) are present but are not continuous or sealed with accessories (e.g., tape, sealant).
  - ☐ Air barrier materials are not installed according to the manufacturer's instructions (e.g., membrane wrinkles and creases, use of primer, incompatible materials), or do not meet the applicable Article in BCBC Subsection 9.25.3. Air Barrier Systems, including managing below-grade soil gas ingress.
- ☐ **Fenestration U-value**
  - ☐ Documentation of fenestration energy performance (e.g., window label or engineered shop drawings) shows a U-value greater than noted in the Compliance Checklist.
  - ☐ The energy and window performance ratings labels are inconsistent or missing, or all show the same values even for different window sizes. Windows must meet code requirements for energy performance, air-water-structural performance testing, and product certification.
  - ☐ Window size is larger than shown in the building permit drawings, or new fenestrations are present that are not shown in the building permit application. Checking window sizes may seem cumbersome, but it is a common discrepancy. You can also request the window shop drawings be submitted for further verification.
- ☐ **Mechanical Heating/Cooling**
  - ☐ Products/documentation of mechanical equipment type, capacity, energy efficiency, and intended operation do not match the building drawings or the Compliance Checklist (see also **CSA F280 Mechanical Heating and Cooling Sizing** on page 58).
- ☐ **Domestic Hot Water**
  - ☐ Product/documentation of the domestic hot water (DHW) equipment type, capacity, and energy efficiency does not match the building drawings or the Compliance Checklist.
  - ☐ If applicable, drain water heat recovery is missing or does not match the stated efficiency.
- ☐ **Ventilation**
  - ☐ Product/documentation of the ventilation equipment type, capacity, and operation does not match the building drawings or the Compliance Checklist.

Final (As-Built) whole-building airtightness performance cannot be confirmed until after the building is complete, but the air barrier can still be carefully reviewed and tested during construction. It is recommended that you require a mid-construction airtightness test and corresponding Mid-Construction Compliance Checklist to indicate if the proposed building airtightness is likely to be met. Mid-construction verification before the air barrier is covered (i.e., post air barrier, pre-finishes) can help avoid compliance issues at the end of a project. Always consult with your insurer and legal counsel before implementing bylaws and compliance processes unique to your jurisdiction.

A good rule of thumb for mid-construction airtightness testing is to achieve no more than 20% worse than the final Airtightness Level requirement.

Percent Worse Airtightness at Mid-Construction than Required Airtightness Level (ACH, NLR, NLA, (%))

$$\textit{Percent Worse than Required} = \frac{\textit{Measured Mid-Construction Airtightness} - \textit{Required Airtightness Level}}{\textit{Required Airtightness Level}} \times 100 = \%\ \text{(no more than 20\%)}$$

If quantitative measurements are not possible, theatrical fog and/or thermography scanning can be used to verify the airtightness of critical details and interfaces.

Require Corrective Action

If the constructed building does not match the accepted construction documents and corresponding Compliance Checklist, you may require the Builder to correct the issue before accepting an application or passing an inspection. Correction may involve modifying the construction and/or updating the energy model. Clear policies and bylaws allow for strong enforcement. Your local government, in consultation with your insurer and legal counsel, will be responsible for establishing the bylaws that give direction on when and how corrective action is required. As an example, wording such as "every reasonable effort" regarding building repairs/improvements can allow discretion but still promote strict compliance.

Failing an energy- or emissions-related site inspection is just like any other inspection process: It requires formal oversight and clear direction by you as the Building Official as well as well-documented corrective action by the Builder.

Recordkeeping in accordance with the local policies is also a key component of code compliance. You are responsible for identifying deficiencies relating to code compliance and recording them on inspection reports. The Builder is responsible for tracking and rectifying them before proceeding to re-inspection or follow-up verification.

Key Corrective Action Considerations for ESC and ZCSC Compliance

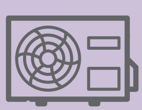
- ☐ **Energy and emissions compliance is just like any other code compliance item.**
- ☐ **Use clear policies and bylaws to inform to what extent corrective action must be taken.**
- ☐ **Use formal recordkeeping tools, including your inspection reports and version-tracked Compliance Checklists from the Builder.**
- ☐ **Complete follow-up site inspections to verify that repairs are correctly implemented.**

Verify the As-Built Construction

Once construction is complete, the ***As-Built Compliance Checklist*** is used to confirm that the actual building and energy model results use the same airtightness, equipment and systems, and building enclosure characteristics. This Compliance Checklist is like earlier reports generated by the Modeller in collaboration with the Builder, but it must now also include the results of the final whole-building airtightness testing. If there are no deviations from the Pre-Construction or Mid-Construction Compliance Checklists, the as-built report can be automatically populated with the same inputs from the previous reports. Note that this is not common.

An As-Built Compliance Checklist completed by the ***Energy Advisor*** under ERS will also list the “N-file” number in Part C rather than the “P-file” number, since the energy model now reflects the results of the final airtightness test (see the section **Roles and Responsibilities of the Modeller** on page 40).

A complete and accurate As-Built Compliance Checklist is always required to show that the building complies with the ESC and the ZCSC. If not, repairs and/or modifications must be completed to reach compliance. Several rounds of issuing corrective direction and inspecting repairs or reviewing energy modelling results may be required if there are significant compliance issues.



Mechanical Commissioning Report

Design and verification of the mechanical distribution and control system is not part of the code-minimum CSA F280 sizing process. As such, you may wish to recommend a mechanical system commissioning report to show the system can operate as intended. This also relates to the operating conditions of dual-fuel heat pump heating systems and the resulting annual GHG emissions calculations. Reporting the heat pump switchover temperature in the mechanical commissioning report can help verify that the energy model and as-built mechanical system use the same number. Refer to the FortisBC New Home Program commissioning sheet for an example of mechanical system commissioning documentation.

On the rare occasion where it is not possible to reach compliance under the ESC and/or ZCSC, refer to **Other Compliance Options** on page 43 and **Non-Compliance** on page 44.

Roles and Responsibilities of the Builder

For simplicity, this handbook refers to the permit applicant and party responsible for code compliance as the Builder. Coordination with the other members of the building team is always the responsibility of the Builder.

Coordinate the Building Design

The Builder must work with the Modeller to develop the building design. Each Builder and their building team will have unique preferences for how the building is to be constructed to meet the ESC and the ZCSC. However, they should allow flexibility and be able to adapt their approach based on energy modelling results and eventual compliance review feedback.

The Builder is responsible for completing the building permit application and ensuring that the building drawings match the information in the Pre-Construction Compliance Checklist. If the project has a dedicated designer or architect, they may also help complete this task.

The Integrated Design Process (IDP) is a collaborative approach that brings together key stakeholders on the building team—including the Licensed Builder, designer, engineers, and subcontractors—early in the design phase. By fostering open communication and shared decision-making, IDP aims to optimize the building's performance, cost-effectiveness, occupant comfort, resilience, and compliance pathway. Builders can use it to foster a collaborative environment and avoid major design conflicts and compliance delays.

Submit the Building Permit Application

Once the building's design documents are complete, the Builder will submit the drawings and the completed Pre-Construction Compliance Checklist as part of the building permit application.

It is recommended that you (the AHJ) require the Builder to have their Modeller retain at least the building energy model file and the Compliance Checklist spreadsheet. These items will provide a back-up document that can be referenced if there are questions or discrepancies related to the Compliance Checklists.

Construct the Building to Match the Compliance Checklist and Meet Code

The Builder is responsible for notifying the Modeller and Building Official of changes to any enclosure or mechanical components during construction that differ from those used in the energy model or reported on the Compliance Checklist. The Builder is also responsible for making construction modifications to match the energy model if there is a discrepancy. This may include changes to insulation placement or thickness, mechanical systems, building enclosure areas, and window or door components used.

A mid-construction airtightness test may identify improvements needed to the overall building airtightness before completion. The Builder will need to prepare the building for testing, which may require temporarily sealing unfinished openings in the enclosure to simulate the finished conditions. Ideally, mid-construction testing is performed after the air barrier materials are in place, windows and doors are installed, and most penetrations have been detailed, but before finishes are covering the air barrier.

Resolve Deficiencies

The Builder, generally through contract with the Owner, is ultimately responsible for ensuring compliance with the ESC and the ZCSC. They must complete the changes and repairs needed to align with the energy model inputs. On the other hand, the Builder must coordinate with the Modeller if the energy model must be re-run with updated inputs to match what is built.

If the building does not meet the minimum required energy and emissions performance requirements near the end of construction, additional energy improvement measures may be warranted before the building is completed. The building team can work together to develop solutions. The most common non-compliance issue is a lower-than-intended building Airtightness Level.

Keep a Record of Changes

The Builder must keep a record of all variances between the accepted permit documents and the constructed building whether through the Building Official's inspections or as part of their own quality management process. This can include changes in the physical construction and changes in the energy model and subsequent Compliance Checklists.

Verify Pre-Occupancy Compliance

The pre-occupancy stage occurs between when construction is completed and an occupancy permit is granted by the AHJ. Construction is considered complete once all components of the building are installed and deficiencies are corrected.

Key pre-occupancy compliance items include:

- ☐ **Final whole-building airtightness testing and air sealing repairs if necessary.**
- ☐ **Mechanical system verification, including recommended commissioning and confirmation of switchover temperature where applicable.**
- ☐ **Verification of fenestration U-value and solar heat gain coefficient (SHGC).**
- ☐ **Energy model updates where applicable.**

Submit the As-Built Information

The Builder may apply for an occupancy permit once final airtightness testing is complete and there are no remaining construction deficiencies. Documentation required for the occupancy permit includes the as-built record drawings and the As-Built Compliance Checklist. Authorities having jurisdiction may also require submission of the energy model and Compliance Checklist spreadsheet file.

Skills, Knowledge, and Abilities of Successful Builders (and their Building Team)

- ☐ **Air Sealing Techniques: Proficiency in techniques to minimize air leakage.**
- ☐ **Insulation Installation: Knowledge of proper installation techniques for various insulation materials.**
- ☐ **High-Performance Building Enclosure Construction: Understanding of building science principles to design and construct an energy-efficient building enclosure.**
- ☐ **Mechanical System Installation: Knowledge of high-efficiency heating, cooling, and ventilation systems, including installation and commissioning.**
- ☐ **Airtightness Testing: Ability to perform, with support from the Modeller, blower door tests to measure building airtightness, and use them to identify air leakage sources.**
- ☐ **Energy Modelling: Familiarity with energy modelling to indicate building energy performance and identify opportunities for improvement.**
- ☐ **Energy Step Code and Zero Carbon Step Code: Understanding of the code requirements, including metrics, energy performance targets, compliance pathways, and documentation procedures.**
- ☐ **High-Performance Building Materials: Familiarity with high-performance building materials and their appropriate applications.**
- ☐ **Problem-Solving: Ability to identify and resolve construction challenges that may impact energy performance and to adapt to evolving building technologies and energy efficiency standards.**
- ☐ **Communication and Collaboration: Ability to communicate effectively with the Building Official and the building team, including the Modeller, subtrades, and other professionals, to ensure compliance with the ESC and the ZCSC.**
- ☐ **Attention to Detail: Ability to use meticulous attention to detail to ensure proper installation and adherence to the Compliance Checklist.**

Roles and Responsibilities of the Modeller

Energy modelling is required for all Steps of the ESC (Article 9.36.6.4. of the BCBC) and all Emission Levels of the ZCSC performance pathway. The building energy modelling is carried out by the Modeller, who is either an Energy Advisor under the ERS or an energy modeller working outside the ERS framework. Under the Passive House Performance Package (PHPP) ESC pathway for Step 5, the Modeller must be a Certified Passive House Designer/Consultant certified through the Passive House Institute. The ESC and ZCSC compliance process focuses on document submissions and compliance forms, not on the specific certifications of the party performing the energy modelling. Therefore, Compliance Checklist submissions from both Energy Advisors and energy modellers are acceptable forms of documentation for their given compliance path.

This handbook refers to the energy modeller and party responsible for completing the Compliance Checklist as the Modeller.

Complete the Building Energy Model and Zero Caron Step Code Calculations

The purpose of the energy model is to confirm that the design meets the required energy and emissions performance levels. The Modeller will create a pre-construction design energy model of the proposed building. As required by Article 2.2.8.2. in Division C of the BCBC, the inputs of this energy model along with the modelling results/calculations will form the basis of the building permit submission for energy compliance. The Modeller will also use the modelling results to calculate the annual GHG emissions for the ZCSC performance pathway.

Differences Between an Energy Advisor and Energy Modeller

Both Energy Advisors and energy modellers can provide code-compliant energy modelling services. An energy modeller can be a useful option for achieving compliance when an Energy Advisor is not available. An Energy Advisor can work as an energy modeller outside of the ERS (see below), but an energy modeller is not qualified to serve as an Energy Advisor.

Energy Advisor (ERS)

The Energy Advisor is registered with a Service Organization and completes the building energy model following the ERS modelling parameters. An Energy Advisor will follow specific requirements set by the ERS, including home labelling and third-party review. The Energy Advisor creates the proposed building energy model in software called HOT2000. This energy model file (i.e., the “P-file”) is assigned an identification number and submitted to Natural Resources Canada (NRCan) for review. The accepted model is then used to populate the Pre-Construction Compliance Checklist. Likewise, an N-file is completed and reviewed after final airtightness testing.

Energy Modeller

An energy modeller will create an energy model following:

› BCBC Subsection 9.36.5., or
› NECB Part 8 and the City of Vancouver Energy Modelling Guidelines, or
› Passive House Planning Package (for Step 5).

No official third-party oversight exists for energy modellers except where the PHPP is used. Energy modellers do not submit a P-file or N-file to NRCan. It is the responsibility of the AHJ to set the requirements for qualifications of an energy modeller, which may include mandatory oversight from a Registered Professional.

If there is no P-file (and later N-file) number reported in Part C of the Compliance Checklist, the energy modelling is not being reviewed under the ERS program.

Prepare the Pre-Construction Compliance Checklist

It is the responsibility of the Modeller to model the building based on the applicable building drawings provided by the Builder, and to work with the Builder to make changes as needed based on the results of the pre-construction compliance review. The Modeller should be included in all correspondence during the building permit application process and confirm changes are made as needed.

The energy model results and emission calculations for the building design are provided by the Modeller using the ***Pre-Construction Compliance Checklist***, which is submitted as part of the building permit application. The ***As-Built Compliance Checklist*** is included in the closeout/occupancy submission.

Check if the Building Matches the Compliance Checklist

While it is ultimately the Builder's responsibility to ensure that the submitted documents match what is built, the Modeller is typically the most qualified party to confirm that the construction is consistent with inputs of the Pre-Construction Compliance Checklist. The Modeller can also be well-suited for identifying any discrepancies and confirming how they would be rectified. However, it is not their responsibility to track and fix discrepancies throughout construction. The Builder is always the one responsible for this.

Complete the Mid-Construction Airtightness Test

While not strictly required, it is prudent for the Modeller to complete site reviews as part of the scope of their work, including completing or at least directly witnessing the mid-construction airtightness testing, if required. The mid-construction airtightness testing will usually require temporarily sealing parts of the incomplete air barrier components.

Final whole-building airtightness performance cannot be confirmed until after the building is complete, but the air barrier can still be reviewed carefully and tested during construction. A mid-construction airtightness test can help indicate if the intended building airtightness is likely to be met. Mid-construction verification before the air barrier is covered can help avoid compliance issues at the end of a project. If quantitative measurements are not possible, theatrical fog and/or thermography scanning can be used to verify the airtightness of critical details and interfaces. A mid-construction airtightness test target that is no more than 20% worse than the required final Airtightness Level is a good rule of thumb. The results of this test should be reported and submitted in the Mid-Construction Compliance Checklist.

Update the Energy Model and Compliance Checklist

As required by the AHJ, the Modeller will update the energy model and Compliance Checklist to reflect any changes made during construction, including the results of the mid-construction airtightness test. The Modeller will work with the Builder to resolve discrepancies between the building and the energy model, and address issues that may be causing the building to not meet the energy and emissions requirements.

Complete the As-Built Airtightness Test

Whole-building airtightness testing must be completed for Part 9 residential buildings under the ESC (BCBC Article 9.36.6.5.). An airtightness test is one of the most important measures of building energy performance. Both the proposed design and as-built building must meet the minimum building Airtightness Levels set out in Tables 9.36.6.3.-A to 9.36.6.3.-F of the BCBC.

At minimum, airtightness testing must be completed in the pre-occupancy state. The airtightness testing must be done in accordance with one of the test standards listed in BCBC Sentence 9.36.5.6.(1).

The assumed building airtightness influences most other aspects of the building energy efficiency. While this assumption should be made by an experienced Modeller in collaboration with the Builder, there may be times when the target is not met (see **Non-Compliance** on page 44).

Differences Between an Energy Advisor and Energy Modeller: Airtightness Testing

Energy Advisor (ERS)

The Energy Advisor is required to complete final post-construction airtightness testing under the ERS, following the specific test standard set by the system (modified CGSB 149.10). The Energy Advisor then completes the updated energy model and submits the N-file for review.

Energy Modeller

The energy modeller is not required to be the one to complete the testing, though it is recommended. Airtightness testing that is not completed by a qualified airtightness testing service provider can be prone to errors and may not comply with the required airtightness test standards listed in the code.

All final airtightness testing should include a detailed test report following the reporting requirements of the given test standard used.

Prepare the As-Built Compliance Checklist

The Modeller will check with the Builder to confirm that the completed construction is consistent with the energy model inputs, and make changes as needed. The Modeller will then fill out the As-Built Compliance Checklist for the Builder to submit. Authorities having jurisdiction may also require submission of supporting documents for record-keeping or auditing, like the full Compliance Checklist spreadsheet.

Other Compliance Options

1. Compliance by Meeting the Provincial Code Minimum

If your jurisdiction has enacted Step and/or Emission Level requirements that are higher than the current provincial code minimum, then a building that doesn't meet these requirements may need to at least comply with the current provincial code minimum. However, consult with your insurer and legal counsel before accepting submissions/applications following this option.

In this case, the Modeller will need to update and review the inputs and outputs of the Compliance Checklist. You will need to be familiar with any compliance requirements that have changed, and you will need to review the updated drawings, updated Compliance Checklist, and constructed building to confirm that they are in alignment and meet the adjusted requirements.

Airtightness Levels Always Apply

The minimum required Airtightness Levels set out in Tables 9.36.6.3.-A to 9.36.6.3.-F of the BCBC cannot be reduced for a given Step, even if the energy model shows that the energy or emissions performance requirements can still technically be met. Improved airtightness is a key goal of the ESC, and if it can't be achieved, then other compliance options must be used.

2. Compliance by Prescriptive Backstop

A building can achieve energy compliance through prescriptive evaluation following the minimum requirements in Subsections 9.36.2. to 9.36.4. of the BCBC. However, local governments must adopt specific bylaws to permit prescriptive-based energy compliance as an equivalent to Step 3. There is currently no prescriptive equivalent to Step 4 or Step 5. For more information, refer to Information Bulletin B23-01 published by the Building and Safety Standards Branch. Emissions compliance under the ZCSC must still be met.

Non-Compliance

Unlike life-safety code issues such as structural or fire safety, the impacts of deficiencies relating to energy performance, emissions, and airtightness are less obvious. Where possible, specific bylaws should be used to provide tools to enforce compliance during a project's design and construction.

In some cases, it may not be possible to achieve compliance through repairs, modifications to the energy model, nor alternative compliance methods. In these situations, it is important that you ensure compliance has been enforced to the extent of the standard of care. Details of non-compliance items should be well documented and saved for the record. Non-compliance items should also be recorded outside of project documentation in some way, either through labelling or on the building title.

Authorities having jurisdiction can choose to enact penalty-based non-compliance policies that further encourage Builders to ensure that their buildings meet the ESC and the ZCSC compliance requirements. Some examples of penalty-based enforcement include:

- Placing a notice of code/bylaw non-compliance on the land title (i.e., Section 57 of the Community Charter in British Columbia)
- Withholding bonds
- Issuing fines
- Withholding the occupancy permit

Withholding the occupancy permit is typically the strongest enforcement tool. It is recommended that your jurisdiction consult with your insurer (for example, Municipality Insurance Association of BC (MIABC)) and legal counsel for specific clarification on how best to implement code non-compliance or permit-related penalties.

Step Code Compliance "Do's and Don'ts"

The following section provides some possible scenarios of design and as-built compliance challenges along with possible action items for dealing with them while managing risks and following compliance best practices.

New Step Code Requirements: Your jurisdiction intends to adopt a higher Step and Emission Level than the provincial minimum.

Do:	Don't:
› Develop and make easily available information about how your compliance process works. › Include information about complying without modelling under the ERS. › Familiarize yourself with the metrics and terms used in the ESC and ZCSC.	› Assume applicants will be able to navigate the process without assistance. › Accept applications submitted without some kind of oversight by a service or professional organization. › Adopt new requirements without training and a formalized compliance process.

New Builder: The Compliance Checklist shows a large custom home aiming for Step 5 and EL-4 modelled through BCBC Subsection 9.36.5. instead of ERS or Passive House Planning Package (PHPP).

Do (as your bylaws permit):	Don't:
› Confirm if compliance must be shown by a Registered Professional. › Consider requiring supplemental design information like an air barrier detail set. › Require submission of a mid-construction airtightness test and corresponding Compliance Checklist.	› Restrict the application based only on lack of experience. › Accept submissions without oversight from some kind of assurance that the Modeller is qualified. › Wait until the pre-occupancy stage to test airtightness or check the building Step Code compliance.

Inaccurate Compliance Checklist: The Pre-Construction Compliance Checklist does not fully match the building permit drawings or mechanical specifications.

Do:	Don't:
› Require revision and resubmission.	› Accept Compliance Checklists that do not fully match the drawings/specifications.

Less Insulation Than Prescriptive Minimums: There is an area of a wall with 50% of the previous prescriptive-minimum R-value, and the Modeller confirms that this was accounted for in the energy model.

Do:	Don't:
› Confirm that the proposed assemblies do not ignore the other insulation requirements set out in BCBC Subsection 9.25.2., such as prevention of condensation. › Confirm if compliance must be shown by a Registered Professional.	› Accept enclosure R-values that are significantly less than typical prescriptive minimums without follow-up. › Base insulation compliance on BCBC Subsection 9.36.6. alone without also checking BCBC Subsection 9.25.2.

No Window Energy Levels: The window products on-site do not have any energy labels to show the U-value or SHGC.	
Do: › Require the window energy performance be confirmed from shop drawings with information per the BC Energy Efficiency Standards regulations. › Where manufacturer information isn't available, require assessment and assurance from a Registered Professional.	**Don't:** › Rely only on energy information from the Builder or Modeller. › Accept products lower than required by the BC Energy Efficiency Standards regulations.

Mechanical System Changes During Construction: A different heat pump system than was originally modelled is being used. It also has the addition of a small natural gas furnace for supplemental heat.	
Do: › Require a new Compliance Checklist based on updated energy modelling before any components are accepted. › Notify the building team that if the project is following the ZCSC prescriptive pathway, the furnace may prompt other design changes to accommodate the performance pathway instead.	**Don't:** › Accept items that aren't modelled and listed in the Compliance Checklist. › Wait until the pre-occupancy stage to check if the major changes to the building affect Step Code compliance.

Can't Achieve Airtightness: The Builder can't achieve the required Airtightness Level even after significant effort. The energy model shows the building can still meet the energy and emissions requirements.	
Do (as your bylaws permit): › Consider if another repair technology like aerosolized sealant can be used. › Consider other compliance options like lower Steps or prescriptive minimums. › If needed, record all aspects of non-compliance on the title.	**Don't:** › Wait until the pre-occupancy stage to confirm the airtightness compliance pathway. › Accept as Step Code compliant a building that does not meet the specific requirements for the required Step in your jurisdiction.

Modelling Results Appear Manipulated: You suspect the energy modelling may be incorrect based on the insulation amounts, window U-values, and a large complex footprint.	
Do: › Require Compliance Checklists be submitted directly by the Modeller. › Confirm the Modeller's certifications claimed are in good standing. › Seek internal or third-party review, including, if possible, review of the raw energy model file.	**Don't:** › Accept Step Code compliance submissions only from the Builder. › Act on suspicion of inaccuracies only. › Accept assurance from the applicant despite your reservations, unless they are a Registered Professional.

In Short

This section is less about code compliance and focuses more on what design approaches, construction practices, and technology can make a building energy efficient, low-emissions, comfortable, durable, and buildable. Knowing about these factors is helpful for understanding how a ***high-performance building*** is designed and built.

3 | High-Performance Step Code-Compliant Buildings

Section Includes:

- Building as a System 47
- Air Barrier System Requirements 51
- Mechanical Equipment and Systems 57

Building as a System

The term "building as a system" can be used to describe the relationships of many parts of a building. For energy efficiency and emissions reduction, the three main considerations that allow a building as a system to operate properly, efficiently, and following code requirements are:

1. The Building Enclosure
2. Mechanical Space Heating and Cooling
3. Ventilation

High-performance code-compliant buildings use an enclosure with good thermal control and ***airtightness***, properly sized heating and cooling components, and an efficient ventilation system. The enclosure-first approach uses a well-insulated and airtight building enclosure with solar control, ideally on a building that is appropriately oriented and shaped, as the basis for building energy efficiency. This strategy reduces heat loss during the heating season and heat gain in the cooling season. A heat recovery ventilator (HRV) is typically incorporated to reduce heat loss or gain from fresh ventilation air. The mechanical system can then be sized to match the reduced thermal demand of the building. As shown in Figure 3.1, this approach uses all three "gears" of the building-as-a-system concept for energy efficiency.

High-Performance Buildings Have:

- Higher R-values
- Low air leakage
- Heat gain control
- Low energy use
- Reduced GHG emissions

The various components of the building enclosure serve as critical barriers, functioning to control the elements and separate the interior from the exterior environment.

The mechanical system is properly sized, installed, and commissioned, and may or may not use combustion fuel as the primary energy source.

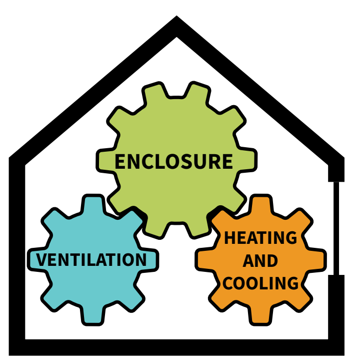


Figure 3.1 The three gears of the building-as-a-system concept.

The building enclosure is itself a system of materials, components, and assemblies that together physically separate the interior environment of a building from the exterior. Good thermal performance, airtightness, and solar heat gain control are used to effectively manage heat flow through the building enclosure. The code-compliant and durable enclosure must also control liquid water, water vapour, sound, fire, and smoke.

Building enclosure assemblies (roofs, walls, and floors) use a series of layers, each serving as one or more of the control layers. The insulation and air barrier materials provide the most direct control of energy flow.

Thermal Performance and Mechanical Systems

The building enclosure resists heat flow using materials with a low thermal conductivity (i.e., high thermal resistance). The measure of the resistance to heat flow in opaque assemblies is generally expressed in the metric units of ***RSI*** (m^2·K/W) and the imperial measurement of ***R-value*** (ft^2·°F·hr/Btu). The measure of heat loss through enclosure components like windows and doors is expressed as ***USI-value*** (W/ m^2·K) or ***U-value*** (Btu/ft^2·°F·hr). The more insulation in the assembly, the higher the assembly R-value and the greater its resistance to heat flow. Conversely, the lower the U-value, the lower the heat loss through the component.

The mechanical system includes space heating, ventilation, and air conditioning (HVAC) as well as DHW heating. These components are particularly important in the context of energy efficiency. While the enclosure-first approach reduces energy loss through the enclosure and thus reduces space heating (and cooling) compared to conventional building approaches, the mechanical equipment itself can also reduce the amount of energy used for heating and cooling.

Figure 3.2 depicts the progression from a conventional building that may not have energy performance as a key design consideration toward a high-performance energy-efficient building that works as a system. The potential characteristics of each building are also listed. Note that this progression doesn't necessarily directly correspond with the ***BC Energy Step Code*** (ESC) Steps or ***Zero Carbon Step Code*** (ZCSC) Emission Levels, but it is similar.

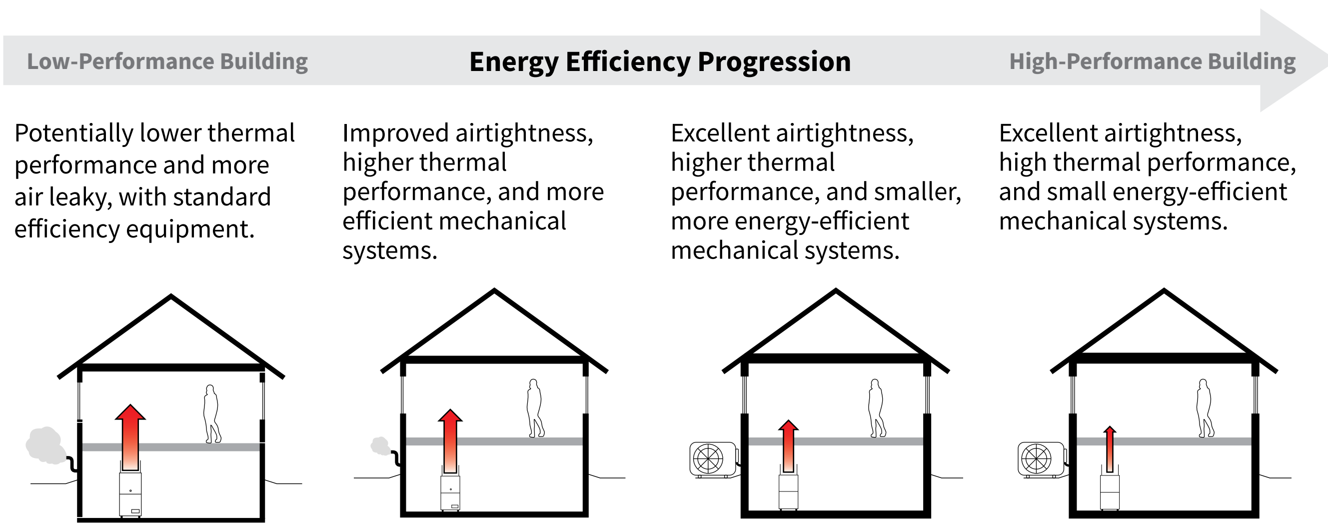


Figure 3.2 Progression from a low-performance building to a high-performance building involves overall improvements to the building enclosure and mechanical system.

Achieving a High Step or Emission Level Does Not Mean Achieving a High-Performance Building

The ESC and ZCSC promote better building practices, and their metrics align well with the enclosure-first approach.

However, basing a building's performance solely off the code energy or emissions metrics, even the highest levels, is not a guarantee the resulting building will be "high-performance."

On the other hand, a high-performance building is one that is designed and built to work as an energy-efficient system, regardless of the specific Step or Emission Level it reaches.

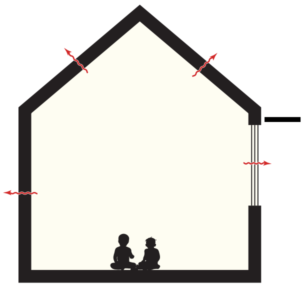


Figure 3.3 The enclosure-first approach prioritizes an airtight and thermally efficient building enclosure that allows thermal comfort in all seasons. It involves overall improvements to the building enclosure and mechanical system.

Enclosure-First Approach

The enclosure-first approach reduces energy consumption and provides a comfortable indoor environment for the occupants (see Figure 3.3). A key strategy in achieving high-performance buildings is the use of well-insulated assemblies. These assemblies use insulation with minimal thermal bridging to resist heat loss or gain and can lower the overall mechanical heating or cooling load. The windows and doors are also thermally efficient to minimize heat loss or, if needed, heat gain.

The restriction of air movement by the air barrier system is one of the most important functions of the building enclosure. Air is a transport mechanism for water, vapour, heat energy, airborne contaminants, and even noise. Uncontrolled air leakage results in excessive heat loss that leads to discomfort and energy waste as well as moisture issues within the building enclosure.

Besides improving the energy efficiency of the building, an enclosure-first approach can also contribute to better occupant comfort, since the building will allow less uncontrolled airflow, warmer interior surfaces, and a more uniform temperature.

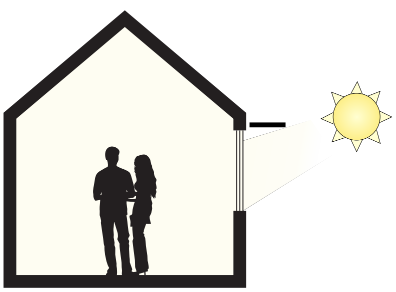


Figure 3.4 Horizontal shades allow winter passive solar heating.

Windows and Shading

Passive solar heating from solar radiation can be beneficial in the heating season if the building is oriented optimally. However, overheating can be a challenge if no measures are taken to limit solar heat gains during the non-heating season, especially late summer.

The solar angle (or elevation) varies seasonally and is lower in the winter when passive solar heat gains are beneficial. The sun is higher in the sky in the summer when heat gains are detrimental. Building components like shading devices, overhangs, and vegetation can be used to allow solar radiation in the winter and limit solar radiation from the summer sun (see Figure 3.4 and Figure 3.5).

If no shading devices are used, glass with a low solar heat gain coefficient (SHGC) can serve to limit solar radiation.

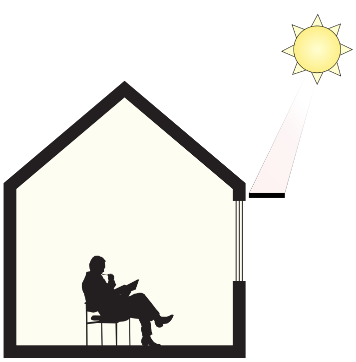


Figure 3.5 Horizontal shades can reduce summer solar radiation.

SHGC and BCBC Article 9.33.3.1. Overheating Requirements

The SHGC is the proportion of solar radiation transferred through the glass and framing of a product. The SHGC is a decimal fraction between 0.0 (totally opaque) and 1.0 (a hole in the wall). Using a higher SHGC (above 0.3) may help reduce energy use through passive solar heat gains to offset heating energy demand, but it can also lead to higher solar heat gain in the summer and the risk of overheating. This is especially important given the overheating protection requirements per BCBC Article 9.33.3.1., which restricts interior temperature to no more than 26°C during hot summer weather, and for high-performance homes where the heat could be slower to dissipate. Where exterior shading cannot be effectively used, a lower SHGC (below 0.3) is typically a more reliable design strategy.

Building Form Factor

Form factor refers to a building's overall shape, form, and size. A building's massing is central to the achievement of TEDI targets. The more complex a building shape, the more enclosure surface area and greater the number of opportunities for heat loss through the enclosure (see **Figure 3.6**). A building with complex junctions and corners will lose far more heat through the enclosure than a building that has been designed as a simple, solid form.

Form factor can also be assessed in terms of a building's vertical surface area to floor area ratio (VFAR). A lower VFAR indicates a lower overall potential for heat loss through the enclosure. Higher VFAR values are often a function of the building's floor plate size as well as the level of articulation.

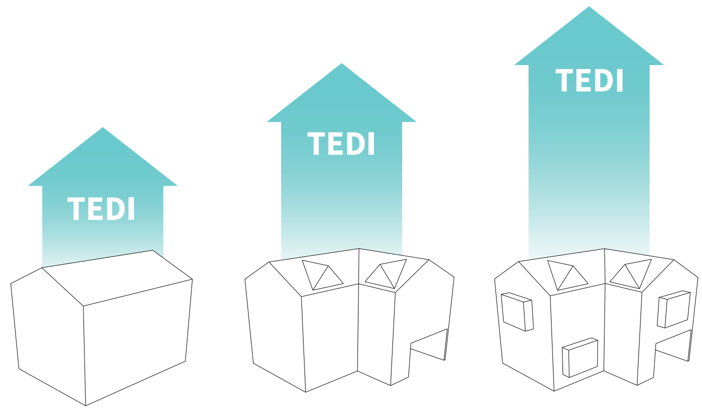


Figure 3.6 Potential impact of building form factor on TEDI for the same enclosure assemblies.

Continuity of the Air Barrier and Insulation

A continuous, durable, air-impermeable, structurally supported, and sufficiently strong air barrier is the result of careful consideration and attention to detail. As discussed in the next section, the air barrier system applies across the entire building enclosure and is the key factor in successfully reaching the required Airtightness Level and producing a high-performance building (see **Figure 3.7**).

The continuity of thermal insulation is also a key factor in achieving good energy efficiency. Conductive materials that penetrate the thermal insulation will lead to heat loss because of thermal bridging. Not all thermal bridging is directly accounted for in typical R-value calculations and ***energy modelling*** software, so detailing for thermal continuity can vary widely across buildings that may have the same modelled energy and emissions performance. For example, structural penetrations and window perimeter details are common thermal bridges that are not included in effective R-value calculations. A high-performance building has thermal continuity across interface details and transitions using insulation overlaps and exterior insulation, and it is designed to avoid large unnecessary thermal bridges.

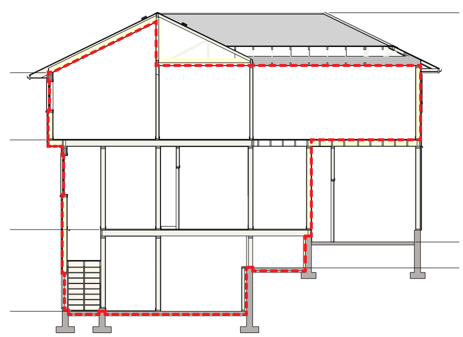


Figure 3.7 The air barrier line of continuity ("redline") is a way to indicate on drawings how the air barrier is achieved across the entire building enclosure.

Durability Risks from Air Leakage and Thermal Bridges

Uncontrolled airflow through the enclosure can lead to moisture damage risks. Interior moisture flowing as vapour through air leakage paths can condensate into liquid on cold surfaces, like the back side of cold exterior sheathing and framing components. This is especially true for buildings with moderate to excellent airtightness, where there may be concentrated airflow at a few discontinuities. Thermal bridging from structural penetrations, especially metal, can also result in cold surfaces that lead to condensation. Air barrier and insulation continuity is a key characteristic of high-performance buildings, regardless of the specific energy of emissions performance requirements met.

Air Barrier System Requirements

The design of an effective air barrier system requires materials, components, and accessories that can be combined to control air leakage. The air barrier system may be relatively straightforward to achieve in the field of an assembly, but ensuring continuity across all interfaces and around penetrations of the building enclosure is more challenging.

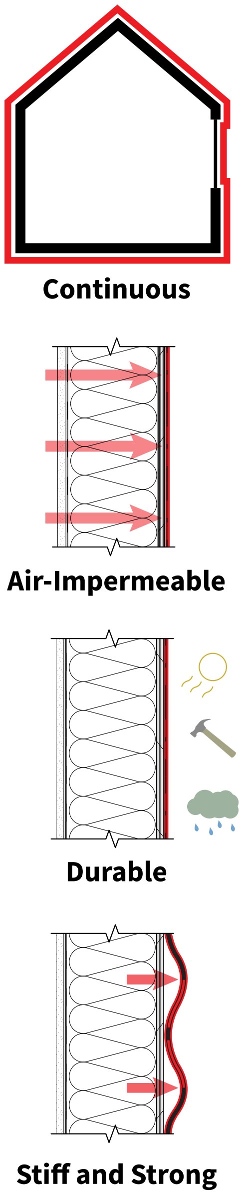


Figure 3.8 Air barrier characteristics.

An effective, code-compliant air barrier system (see Figure 3.8) has the following characteristics:

Continuous: Continuity is the single most important criterion for an effective air barrier system, but it is also one of the most challenging. The system must completely enclose the ***conditioned space***.

Air-Impermeable: All materials, components, and accessories making up the air barrier system must be impermeable to airflow.

Durable: The air barrier system must be designed to last for the entire service life of the building or at least as long as the materials that cover it.

Stiff and Strong: From construction to occupancy, the air barrier system must resist the air forces acting on it, including wind and mechanical pressures. A combination of solid, continuous substrates, fasteners, tapes, sealants, strapping, and sometimes exterior insulation is needed to achieve this.

Air Barrier Strategies

Air barrier systems are usually two conventional types: exterior air barrier systems, with the primary airtight elements placed at the exterior side of the enclosure; and interior air barrier systems, with the primary airtight elements installed at the interior side of the enclosure. Within these systems, various approaches and components can be used to achieve the air barrier.

In general, the exterior approach is simpler because it does not interface with numerous interior elements like framing or service penetrations for electrical and plumbing. The components of the exterior air barrier are also often used as the water-resistive barrier (for example, air-impermeable synthetic sheathing membrane on walls). The effort and care required to achieve a continuous layer to resist moisture intrusion also contributes to the overall continuity of the air barrier.

For more information on air barrier strategies, refer to the BC Energy Step Code Builder Guide **and the** Illustrated Guide - Achieving Airtight Buildings **developed by BC Housing.**

Interior vs. Exterior Air Barrier Performance

Interior penetrations for electrical and plumbing services and disruptions at floors, stairs, and interior walls can make it difficult to achieve a high Airtightness Level. Whole-building air leakage tests have shown that exterior air barrier approaches consistently perform better than interior air barrier approaches (see the next section and **Additional Resources** on page 73).

Above-Grade Wall Exterior Air Barrier Systems

Exterior air barrier approaches use an airtight layer, usually a dedicated membrane, installed over the exterior face of the building structure. It is made continuous with tapes, membranes, and sealants over joints, transitions, and penetrations.

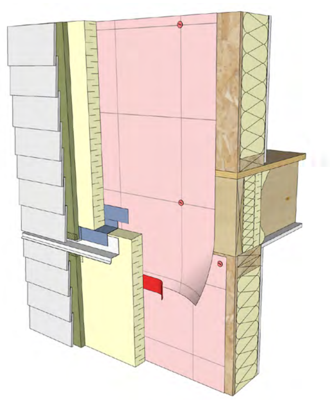


Figure 3.9 Sealed sheathing membrane (taped mechanically fastened synthetic membrane).

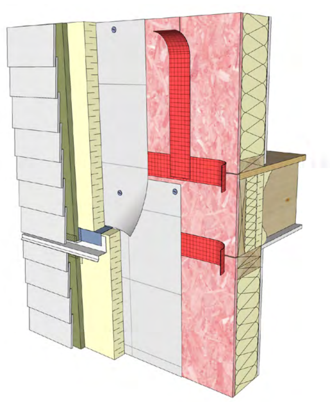


Figure 3.10 Sealed exterior sheathing (sheathing joints taped with high-performance tape).

Air Barrier Materials

The red and pink materials shown in Figure 3.9 to Figure 3.12 highlight the components of the air barrier system and are not intended to represent any specific brands or products.

Sealed Sheathing Membrane

Mechanically fastened systems use an airtight sheathing membrane, also referred to as house wrap, attached to the exterior sheathing with fasteners and washers (see Figure 3.9). Joints, penetrations, and laps are made airtight using sealant, tape, and self-adhered sheathing membrane strips. The sheathing membrane is attached to the building with staples or washer fasteners during construction and then supported by strapping or cladding to avoid damage.

Self-adhered sheathing membranes rely on the adhesion to the substrate and adhesive bonding at membrane laps. The membrane is fully adhered to the continuous substrate upon initial installation, often with chemical primer and/or rollers to ensure a strong bond.

The sealed exterior sheathing membrane approach using conventional air barrier materials and accessories is the most common exterior approach and typically does not require specialty knowledge, skills, or code compliance procedures.

Sealed Exterior Sheathing

The exterior sheathing can also act as the primary air barrier element when joints and interfaces are sealed. This approach uses the exterior wood sheathing together with either sealant, liquid-applied sheathing membrane, strips of membrane, or high-performance sheathing tape to create a continuous air barrier at all the sheathing joints (see Figure 3.10). A sheathing membrane is often required with this approach to provide the water-resistive barrier unless a proprietary sealed sheathing system is used.

Exterior liquid-applied membranes can be useful for complex detailing, but they are sensitive to having a solid continuous substrate and may require reinforcing at joints.

Sealed Exterior Insulation

Taped exterior foam sheathing can be used as an effective air barrier and is often supplied as a proprietary system of materials and components. The airtight foam is used as the primary air barrier element; tape, gaskets, and sealant are used to transition between insulation boards and across other enclosure elements. The permeability and thickness of the foam insulation is of particular importance with respect to the drying capacity of the wall assembly. An assembly with exterior foam insulation and an interior vapour control layer may benefit from using a relatively more permeable interior vapour retarder, such as a smart vapour retarder.

The sealed exterior sheathing and insulation approaches may require specialty knowledge, skills, and code compliance procedures, which can include professional sign-off.

Above-Grade Wall Interior Air Barrier Systems

The interior approaches use an airtight layer applied from the interior of the enclosure interfacing with the various interior elements, transitions, and penetrations.

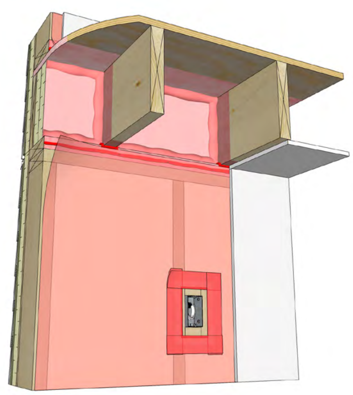


Figure 3.11 Sealed polyethylene.

Sealed Polyethylene

In this system, polyethylene sheets are sealed to the interior framing to form the air barrier (see Figure 3.11). Joints in the polyethylene are sealed and clamped between the framing and the interior finish (or service cavity framing if used; see below). Locations where interior finishes are not normally provided require specific measures to ensure the polyethylene is supported. Penetrations are detailed with pre-formed polyethylene pans and sealant, and infill material like spray foam is used where polyethylene can't be easily installed. Other sheet materials like synthetic woven vapour barrier membrane (i.e., "smart" vapour barriers) can also be used in place of polyethylene as long as they are compatible with the accessories and sealing techniques used.

The sealed polyethylene approach is the most common interior air barrier approach and typically does not require specialty knowledge, skills, or code compliance procedures. However, as noted previously, it is also potentially harder to make airtight enough to reach high Airtightness Levels.

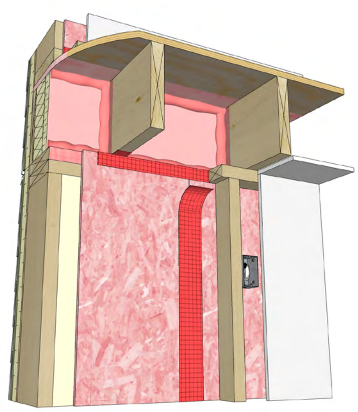


Figure 3.12 Sealed interior sheathing with service cavity.

Sealed Interior Sheathing with Service Cavity

This approach uses an interior layer of sheathing as the primary air barrier element (see Figure 3.12). The sheathing joints are sealed with tape or membrane strips, and the perimeter is set onto gaskets or sealant on the wall framing.

The interior service cavity is typically made from conventional dimension lumber framing after the wall air barrier is complete. It provides a space for services to be run without having to penetrate the interior air barrier and is used when very high-performance interior airtightness is required.

Other Interior Air Barriers

Interior gypsum board and framing members can also be used to provide the air barrier, typically using sealants or gaskets. Special attention is required to seal penetrations in the gypsum board at electrical fixtures and other services as well as at the intersection of partition walls with exterior walls and the ceiling.

Closed-cell polyurethane spray foam is also used around framing and service components to improve air barrier continuity, and it can be used as the primary air barrier material. The airtightness of this approach relies on continuous and uniform spray foam insulation and sealing of framing members.

Spray Foam and Aerosolized Sealant Instead of Air Barrier Planning and Detailing

Achieving the required Airtightness Level, especially for upper Steps, requires an intentional design and construction process to make the building airtight. Even large-scale repairs or specialty sealing products like aerosolized sealant, while helpful in some cases, will have limited effectiveness if airtightness is ignored until the end of the project.

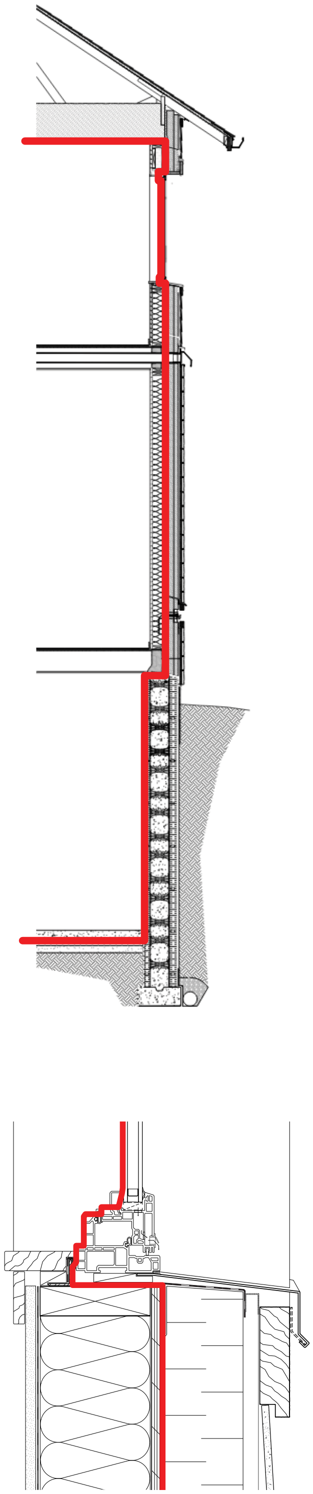


Figure 3.13 Examples of air barrier redlines of continuity across the building section and a window sill detail.

Air Barrier System Detailing

The most critical aspect of an airtight enclosure is the detailing of the interfaces and penetrations because these locations are where discontinuities are most likely to occur. While the individual air barrier materials and components provide control of air movement for each individual assembly, the basis for good continuity is how and where each assembly intersects. This includes the base of wall, windows, service penetrations, roof-to-wall interface, or countless other detail locations. Detail drawings are how the air barrier is planned and implemented.

Air barrier continuity is a key characteristic of a high-performance building that can reach a high Airtightness Level. A good practice for determining and reviewing continuity of the air barrier is to draw a continuous line on drawings all the way around the enclosed space. This can help identify the air barrier location on building plans and sections. A redline drawing is commonly used (see Figure 3.13). The same concept applies to individual detail drawings as well. Adequate drawings provide details for all air barrier interface locations, clearly indicating how continuity is maintained.

Good air barrier details are:

- ☐ **Clear**
- ☐ **Complete**
- ☐ **Annotated with all components labelled**
- ☐ **Cross-referenced in plans and sections**
- ☐ **Highlighted with a redline**
- ☐ **Coordinated to avoid contradictions and misalignment**
- ☐ **Updated to reflect design changes**
- ☐ **Continually refined to improve buildability**
- ☐ **Code-compliant**
- ☐ **Based on collaboration by the *building team***
- ☐ **Not simply focused on two-dimensional interfaces**
- ☐ **Easily reusable across projects**
- ☐ **Not reliant on spray foam or large amounts of sealant**

The following two sections will cover some typical air barrier details for interior and exterior air barrier systems. Satisfactory drawings generally provide at least one detail for each interface with different assembly combinations or penetrating components.

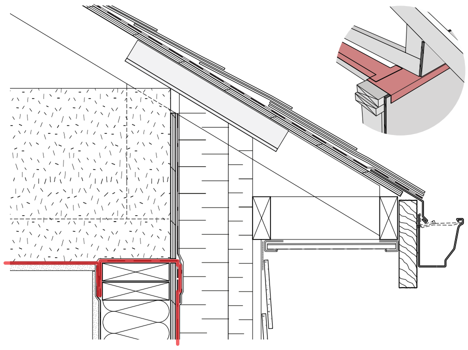


Figure 3.14 Roof-to-wall exterior air barrier redline detail (annotations not shown).

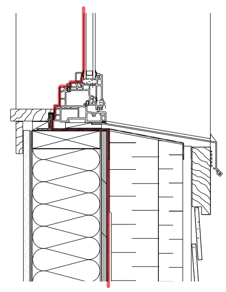


Figure 3.15 Window air barrier redline detail (annotations not shown).

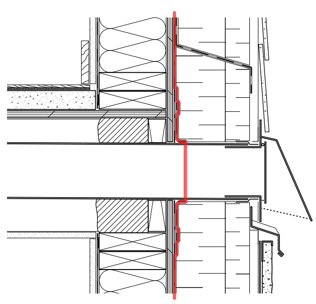


Figure 3.16 Wall penetration exterior air barrier redline detail (annotations not shown).

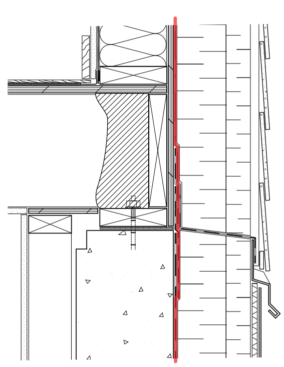


Figure 3.17 Above-grade to below-grade exterior air barrier red line detail (annotations not shown).

Example Exterior Air Barrier Details

Roof-to-Wall Detail

This transition must include components that continue the line of airtightness from the above-grade wall assembly up to the roof assembly (see Figure 3.14). In details with a typical attic roof assembly, this is typically accomplished with a continuous strip of membrane or tape over all top plates and the top edge of the exterior sheathing. Then the ceiling polyethylene sheet is set into sealant at the top plate, and the exterior sheathing membrane is taped or sealed to the top plate membrane. This approach is superior to conventional pre-stripping methods between the top plates because the air barrier is more accessible for sealing.

Window Perimeter Detail

The baseline approach for sealing between the window frame and the rough opening at the sill is either a metal angle wrapped with the sill membrane so the window frame can be set into a sealant bead (see Figure 3.15) or interior backer rod and sealant. The sill angle provides increased moisture penetration resistance. Backer rod and a sealant bead are used at the jamb and head. For any window detailing approach, the air and water seals transfer to the window at the interior plane of the window frame.

Wall Penetration Detail

Complete air barrier drawings will provide individual details for different types and sizes of penetrations (see the wall penetration in Figure 3.16). The air barrier detail for a hose bib is not the same as an exhaust duct. The exterior air barrier at these details must ultimately be sealed in some way to the penetrating component itself, which becomes part of the air barrier. This termination is typically accomplished with a self-adhered membrane, high-performance tape, sealant, compression gasket membrane such as EPDM, and/or liquid-applied detailing membrane. Some systems also use proprietary detailing accessories such as pre-formed gaskets.

Above-Grade to Below-Grade Detail

The line of airtightness must transition across the structural connection between the above-grade wall down to the below-grade assembly (see Figure 3.17). When both assemblies have exterior air barriers, the transition is relatively simple and can be accomplished with a strip of self-adhered transition membrane at the base of the above-grade wall. This transition strip is shingle-lapped under the wall sheathing membrane and taped or sealed to it.

Example Interior Air Barrier Details

Roof-to-Wall Detail

This transition is typically accomplished by lapping and sealing both the ceiling polyethylene and the wall air barrier membrane to the wall top plates (see Figure 3.18). The transition across top plates can also use pre-stripped polyethylene, but membrane or tape over the top plates can be more reliable, durable and easier to detail. Interior demising walls at exterior walls also uses pre-stripping.

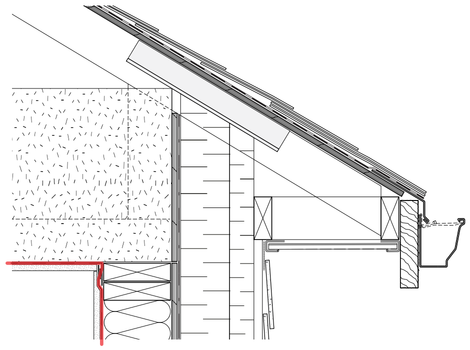


Figure 3.18 Roof-to-wall interior air barrier redline detail (annotations not shown).

Wall Penetration Detail

The interior air barrier at penetrations must ultimately be sealed to the penetrating component with acoustic sealant, mouldable putty, tape, spray foam and/or gaskets (see Figure 3.19). This detail is also often accomplished with pre-formed polyethylene pans or service housings with foam gaskets (often termed “airtight”), though detailing is still required at the wire or pipe holes.

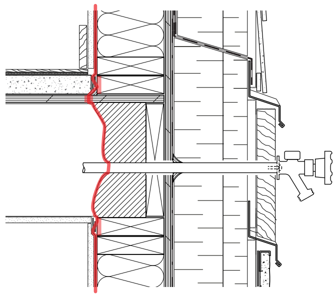


Figure 3.19 Wall penetration interior air barrier redline detail (annotations not shown).

Floor Rim Joist Detail

Interior air barrier transitions across the floor framing detail can be accomplished by sealing the wall interior air barrier membrane to the top and bottom plates and sealing the bottom plate to the floor sheathing (see Figure 3.20). The air barrier is then transitioned with spray foam in each joist cavity at the rim board. This is a common approach in conventional buildings, but it can be difficult to achieve reliable air barrier continuity because of all the interruptions at the floor framing and services run in the joist space.

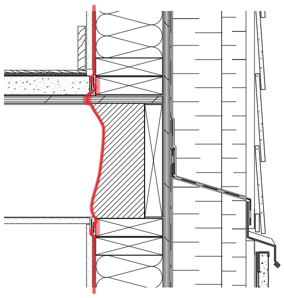


Figure 3.20 Floor rim joist interior air barrier redline detail (annotations not shown).

Above-Grade to Below-Grade Wall Detail

This transition is typically accomplished in a similar way to the floor rim joist detail, with spray foam in the joist cavity (see Figure 3.21). In both cases, the spray foam must be carefully applied to ensure adhesion around all the framing and service components, and connection to the below-grade concrete or a designated air barrier material. Interior spray foam transitions are not well-suited to high-performance buildings aiming to reach a high Airtightness Level.

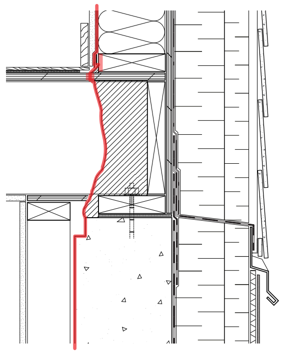


Figure 3.21 Above-grade to below-grade interior air barrier redline detail (annotations not shown).

Mechanical Equipment and Systems

This section discusses key considerations for designing and selecting mechanical equipment and systems that may be used in high-performance buildings to reach various Steps of the ESC and Emission Levels of the ZCSC. This section is not intended to limit the use of any mechanical system or specific product. Part 9 residential buildings can use a wide variety of options as long as the systems are modelled for compliance with the ESC and ZCSC metrics.

Recall: Building as a System

The enclosure-first approach prioritizes the thermal performance and airtightness of a building to reduce thermal losses and gains, and thus reduces the required capacity of heating and cooling equipment. Designing a home with a mechanical-first approach can lead to the need for larger equipment with a high efficiency rating and a non-optimal building enclosure. See **Building as a System** on page 47 for more information. Figure 3.22 shows an example of the house-as-a-system approach.

Another benefit of the enclosure-first approach is the improvement to occupant comfort and mechanical system operation and control. This is also a characteristic of a high-performance building but can be difficult to quantify and is not usually considered a matter of code compliance. Some examples of the enclosure working to improve occupant comfort and mechanical system operation include:

- [ ] **Fewer drafts and heat loss or gain from air leakage.**
- [ ] **More stable interior temperatures and the ability to reach and maintain the desired set point.**
- [ ] **A lower risk of mechanical short-cycling and the ability to use smaller equipment, including air source heat pumps.**
- [ ] **Fresh, filtered ventilation air instead of uncontrolled airflow from air leakage.**
- [ ] **Lower risk of thermal discomfort at exterior spaces in the home and less need for supplemental heat, including local baseboards.**

Prioritizing an energy-efficient and airtight enclosure does not eliminate the need for the mechanical system to be sized according to the minimum code requirements and industry best practices. The following section outlines how CSA F280 plays a role in producing high-performance ESC and ZCSC compliant buildings.

Equipment Operating Efficiencies

Equipment operating efficiency, typically expressed as a percentage or coefficient of performance (COP), measures the efficiency at which input energy is used for useful output heating and cooling energy. It also indicates potential energy savings from not needing as much input energy.

Electric resistance heating equipment is typically considered 100% efficient.

Combustion fuel heating equipment is typically less than 100% efficient.

Electric heat pump heating and cooling equipment is typically 200% to 300% efficient (2.0 to 3.0 COP).

Using high-efficiency equipment is a common energy savings approach for high-performance buildings, and it helps reduce the building's MEUI. However, high-efficiency equipment alone does not result in a high-performance building and does not make up for poor TEDI performance.

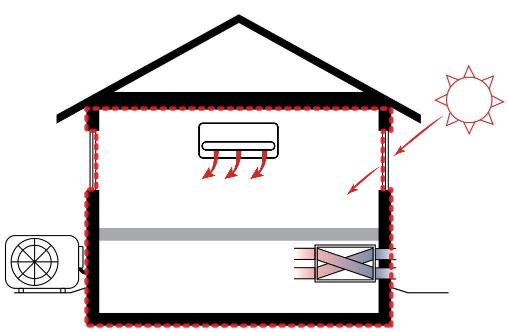


Figure 3.22 Example house-as-a-system approach, with an airtight and thermally efficient enclosure, solar shading to optimize heat gain, ventilation with heat recovery, and a correctly sized air source heat pump.

CSA F280 Mechanical Heating and Cooling Sizing

Article 9.33.5.1. of the BCBC requires that the capacity of residential heating and cooling equipment be determined according to CSA F280 *"Determining the required capacity of residential space heating and cooling appliances."* The CSA F280 standard from the Canadian Standards Association (CSA) defines the calculation methods for mechanical space heating and cooling equipment sizing. The standard applies to all types of heating and cooling equipment.

CSA F280 Sizing Does Not Include Distribution Design, Installation Methods, or Commissioning

The result of a CSA F280 load calculation is simply the required minimum capacity of the mechanical heating and cooling equipment used. However, it does not dictate how the equipment is installed, the distribution approach, or commissioning and controls. BCBC 9.33.4.1. outlines other applicable industry standards that would apply, and CSA SPE-17:23 *HVAC Guide for Part 9 Homes* is also a useful reference. Refer also to the FortisBC online resources for more information on mechanical system design and installation best practices and compliance verification.

CSA F280 defines a calculation method based on the specific building elements that impact heat loss and gain. This may differ from other equipment sizing methods, especially "rules of thumb" sizing used in the past that utilize general building attributes like ***floor area*** or number of rooms. The CSA F280 calculation method can be used to calculate heat gain and loss either as whole-building "block loads" or room-by-room loads. Either method is acceptable and code-compliant. One benefit of calculating room-by-room loads is that these calculations can be used to determine the size of duct runs and terminal equipment such as baseboards and indoor heat pump heads (as a separate task apart from CSA F280 calculations). The CSA F280 methodology is used to size mechanical cooling in the same manner.

Calculations for the CSA standard can be performed using a spreadsheet file provided alongside the standard or verified third-party software programs. A list of verified software programs is provided by the HVAC Designers of Canada, available at hvacdc.ca. Energy modelling tools such as HOT2000 software or the Passive House Planning Package (PHPP) are not approved to conduct CSA F280 calculations and do not meet the requirements of BCBC Article 9.33.5.1. However, inputs used for CSA F280 calculations must match the inputs used for the building energy model as summarized in the ***Compliance Checklist***, the information included on the drawings, and what is built on-site. Technically, any practitioner can complete sizing following CSA F280 as long as they are using verified software, but this work is typically done by an experienced ***Energy Advisor***, a mechanical service provider, or a Registered Professional.

The CSA F280 heat loss and heat gain calculations account for heat transfer into the building caused by:

- Conduction through the building enclosure,
- Radiation through windows and glazed doors,
- Convection due to air leakage, and
- Heat gains inside the space from occupants, lights, and appliances.

The calculated heat loss and heat gain (typically provided as BTUH or kW) must correspond to the heating and cooling capacity of the mechanical equipment used in the building.

Case Study: Accurate F280 Calculation Avoids Oversized Equipment

A new 2000 sq. ft. single-family residence was designed to meet Step 3 of the ESC and EL-2 of the ZCSC in Cariboo Regional District (Climate Zone 6). The ***Builder*** worked with the ***Modeller*** to determine the required R-values and Airtightness Level for the building enclosure to achieve the required metrics. They initially used a "rule of thumb" of 3000 BTUH per 100 square feet to estimate a heating load of 60,000 BTUH. However, the code-required CSA F280 calculation ended up showing that only 45,000 BTUH was needed. Had they proceeded with the original rule-of-thumb sizing, the equipment would have been much larger than needed, resulting in increased construction costs and potential short-cycling, a lower quality of heating, and a shorter equipment life cycle.

CSA F280 Calculation Reports

A high-performance code-complaint building has a mechanical system sized based on a CSA F280 calculation. The AHJ determines when the load calculation report is due. It is recommended that CSA F280 reports are required as part of the building permit submission to allow early verification that the calculation inputs match the information in the Compliance Checklist. The report should be produced and included for code compliance no later than the framing inspection to ensure the as-built conditions will accommodate the mechanical system.

CSA F280 specifies the minimum required information that must be included in calculation reports. Many CSA F280 verified software programs automatically generate reports that include this information. The required information includes, but is not limited to:

- Project name and details
- Building location
- Heating design conditions (i.e., indoor and outdoor design temperatures, per BCBC Subsection 9.33.3.)
- Cooling design conditions (i.e., indoor and outdoor design temperatures, per BCBC Subsection 9.33.3.)
- Building enclosure information (opaque assembly R-values, fenestration U-values, and SHGCs)
- Name and contact information of the designer
- Summary of the calculation results

Appendix B on page 79 includes a mocked-up example of a compliant CSA F280 report and includes annotations and commentary around code compliance and design best practice. Some key code compliance considerations include the following:

- Building enclosure and mechanical system characteristics must match what is shown in the Compliance Checklist and building permit drawings.
- Submittals and/or specifications must show that the equipment has sufficient capacity to meet the loads shown in the CSA F280 report.
- The standard requires that heating and cooling equipment capacities must meet or exceed the calculated heat loss and heat gain, respectively.
- The cooling capacity must not exceed 125% of the nominal system capacity.

Mechanical Cooling to Prevent Overheating

Sentence 9.33.3.1.(2) of the BCBC requires that each dwelling unit have at least one living space capable of maintaining a maximum temperature of 26°C during the summer. A high-performance building designed with an enclosure-first approach, including effective solar heat gain control, can make achieving this easier. However, some form of mechanical cooling is considered to be the most reliable compliance method. Where a Builder wishes to demonstrate compliance using passive overheating protection instead of mechanical cooling, the AHJ will need to clarify the exact compliance requirements. Passive overheating protection typically requires oversight from a Registered Professional. More information about this code requirement is provided in Information Bulletin B24-08 by the Building and Safety Standards Branch.

CSA F280 Sizing for the Refuge Room

A mechanical cooling system sized for the whole building using CSA F280 will typically meet the requirements set out in Sentence 9.33.3.1.(2) of the BCBC. However, if only one living space is cooled using a permanently installed air conditioner, the space is commonly referred to as a "refuge room." In this case, a separate CSA F280 calculation would be needed to account for the unique conditions and concentrated internal heat gains from occupants in the room. These conditions are not reflected in conventional CSA F280 calculations. For more information on mechanical cooling sizing to meet the overheating prevention requirements of the BCBC, see the BSSB Information Bulletin B24-08.

Heat Pump Switchover Temperature

An air source heat pump (ASHP) heating system may require supplemental heating equipment to achieve the required heating system capacity determined using CSA F280. This is because the heating capacity of ASHPs decreases with colder temperatures, and heat pumps have minimum outdoor temperatures below which they cannot operate efficiently (i.e., capture and transfer heat from outdoor air). A heat pump such as a cold-climate air source heat pump (CCASHP) can be sized and selected so that its minimum operating temperature is below the design temperature for many parts of the province. High-performance buildings are well-suited to using CCASHPs as the primary and sole heating source.

Alternatively, supplemental heating equipment, typically using direct electric or combustion fuel-based heat, may be installed and configured to turn on at a given outdoor temperature when the heat pump can no longer meet the heating load. This is known as the switchover temperature, cutoff point, or balance point for ***supplemental heat***. More information about heat pump sizing can be found in the *Air-Source Heat Pump Sizing and Selection Guide* by NRCan.

Zero Carbon Step Code Considerations

Calculations of GHG emissions can be significantly impacted when the supplemental heating system uses natural gas. Energy modelling using the correctly sized equipment and intended switchover temperature is key to verifying that the energy model and as-built mechanical system use the same operating conditions.

Sentence 9.36.3.6.(6) of the BCBC also requires that the heating system must incorporate controls to prevent a supplemental heater from operating when the heating load can be met by the heat pump alone. These controls will impact the energy and emissions performance. The heat pump controls must match the control system from the energy model. A summary sheet or otherwise coordinated submission from both the Modeller and the mechanical designer/supplier can be used to verify this code requirement is met.

Auxiliary Equipment

The Mechanical Energy Use Intensity (MEUI) for Part 9 residential buildings requires that the auxiliary HVAC equipment be accounted for in the overall energy use. This includes fans, humidifiers, and other devices that are not directly accounted for in the heating, cooling, ventilation, and DHW energy use. Refer to **Section 1 | Overview of the Step Codes** on page 1 for more information on how ESC and ZCSC metrics and energy modelling account for this equipment.

Mechanical Equipment Examples

This section provides basic information on common mechanical equipment used in Part 9 residential buildings designed to meet the various Steps of the ESC and Emissions Levels of the ZCSC (see Figure 3.23).

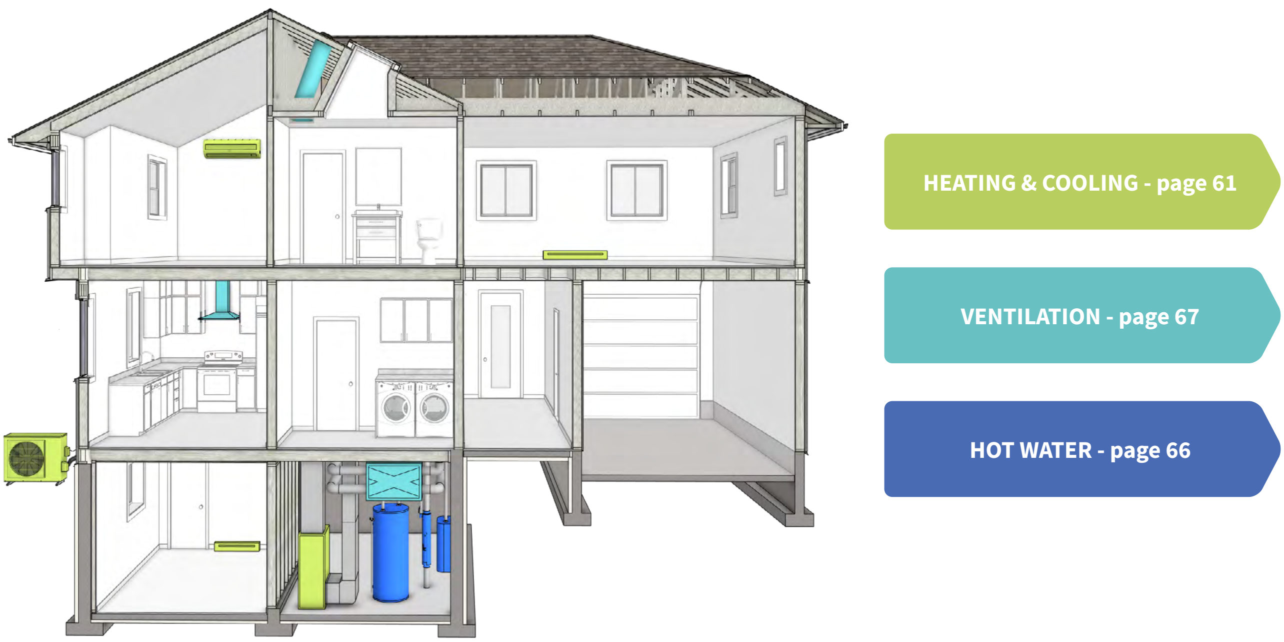


Figure 3.23 Mechanical systems wayfinder (systems shown for reference; not all items would be used at once in a house).

For further information on various common mechanical equipment likely to be used in Part 9 residential buildings, see also the BC Energy Step Code Builder Guide published by BC Housing.

Heating and Cooling Equipment

There are many combinations of energy source, energy transfer, and energy delivery approaches for Part 9 residential buildings, so not all types can be covered in this handbook. It may be more useful to understand how energy is used and delivered for space heating and cooling in a general sense and apply this understanding to any given combination of energy source, equipment, and systems. The tables on page 62 show the different typical heating and cooling ***energy sources*** (Table 3.1), the ***energy transfer*** methods for space heating and cooling equipment (Table 3.2), and the ***heating/cooling delivery*** categories (Table 3.3). The same concepts for energy sources and energy transfer also apply to hot water heating (see **Hot Water** on page 66).

Table 3.1 Energy source categories for mechanical equipment.

Heating and Cooling Energy Sources	
Electricity (lowest emissions factor)	**Combustion Fuel** (higher emissions factor)
Electric Resistance heating uses electrical resistance through coils/ elements and is typically 100% efficient.	**Combustion** fuel heat typically comes from condensing natural gas burners and is typically less than 100% efficient.
Electric Heat Pump systems use refrigerant to transfer heat and are typically 200% to 300% efficient.	

Table 3.2 Energy transfer categories and corresponding energy sources (see Table 3.1) for typical space heating and cooling equipment.

Heating and Cooling Transer Methods (more than one can be used)			
Electric Resistance	**Refrigerant (Heat Pump)**	**Direct Combustion**	**Indirect/Water (Hydronic)**
Air or surfaces are heated by electric resistance heated elements.	Air or surfaces are heated or cooled by heat pump refrigerant, including via water transfer (see right).	Air is heated by combustion-heated elements.	Air or surfaces are heated by water transfer from electric resistance, heat pump, or combustion equipment.

Table 3.3 Energy delivery categories and corresponding energy transfer (see Table 3.2) and sources (see Table 3.1) for space heating and cooling equipment.

Heating and Cooling Delivery Categories (more than one can be used)		
Central Forced Air	**Distributed Force Air (Heat Pump)**	**Radiant**
Air is centrally heating or cooled and delivered via ducts.	Air is heated or cooled at interior heat pump head unit(s) or hydronic fan coils.	Surfaces throughout the building are heated with electric grilles or hydronic loops.

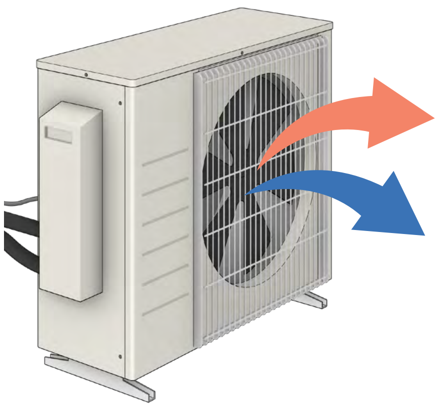


Figure 3.24 Air source heat pump outdoor unit.

Heat Pump Overview

A heat pump is a device that circulates refrigerant that absorbs and releases heat through evaporation and condensing of the refrigerant as it travels between the indoors and outdoors (i.e., indirect energy transfer). Heat is extracted from the outdoor environment in heating seasons and from the indoor environment in cooling seasons. It is used for both heating and cooling, and sometimes just for cooling (i.e., as an air conditioner). Heat pumps can be air source, ground-source, and even water-source. Air source heat pumps are the most common type (see Figure 3.24).

Heat pumps can operate at much higher efficiencies than other typical residential heating options, typically between 200% and 300% efficiency (COP 2.0 to 3.0). Cold-climate air source heat pumps are designed to be able to efficiently extract heat energy from outdoor air down to very cold temperatures (-25°C and lower). These pumps can be a good option for buildings in cold climate zones and where there is no supplemental heating.

Heat Pumps for Low MEUI, Low GHG Emissions, and Overheating Prevention

Heat pumps are typical in high performance buildings because they provide efficient space heating and cooling with electricity. This means lower MEUI and GHG emissions which makes meeting code requirements easier.

Heat Pump with Interior Head(s)

Heat pump units with local forced-air interior heads are typically referred to as “ductless” or “mini-split” systems (see Figure 3.25). They can be sized with just a single interior head, or multiple heads throughout the building. Air is pulled through the interior head by the built-in fan, heated or cooled from the built-in coil, and blown back into the space.

Ductless heat pump systems with a single head can be well-suited to smaller buildings and especially high-performance buildings with reduced heat loss through the enclosure. They can also be used just for cooling the refuge room.

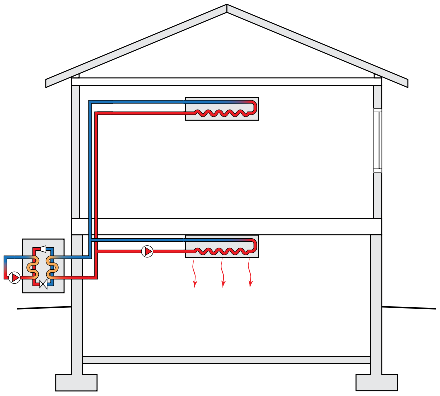


Figure 3.25 Schematic heat pump system with interior heads.

Heat Pump with Central Forced Air

The interior heating/cooling coil from the heat pump can also be paired with a central air handler (see Figure 3.26). The heated or cooled air is delivered through concealed ducts in the building. This approach most closely matches the traditional central forced-air natural gas furnace (see page 65) and can be paired with a supplemental heat source using the same air handler. Like all ducted heating and cooling systems, central forced-air systems are sensitive to correct duct sizing to optimize energy transfer and delivery and to ensure each space is receiving the correct amount of heating or cooling as determined by the required CSA F280 calculations.

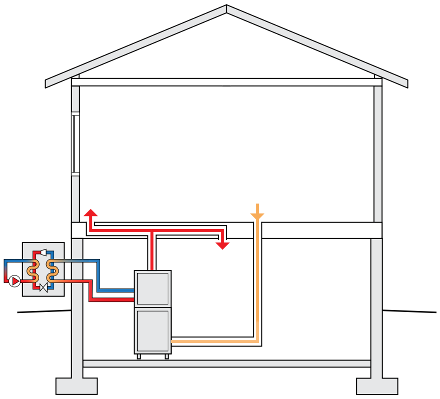


Figure 3.26 Schematic heat pump system with central forced air handler.

Heat Pump with Radiant Floors

This approach uses a combination of the indirect heat transfer through heat pump refrigerant and the radiant hydronic energy delivery (see Figure 3.27). It is also well-suited to high-performance buildings where milder heating temperatures can be used in the floors. However, it can also be sensitive to poor design and installation if the controls do not account for the lower thermal energy demand and heat loss of the building. Chilled water can also be used in heat pump radiant systems for some cooling effect, but radiant cooling alone is not a typical approach for high-performance buildings. Note that hydronic cooling using fan coils is more common and effective (i.e., hydronic distributed forced air, see Table 3.3 on page 62).

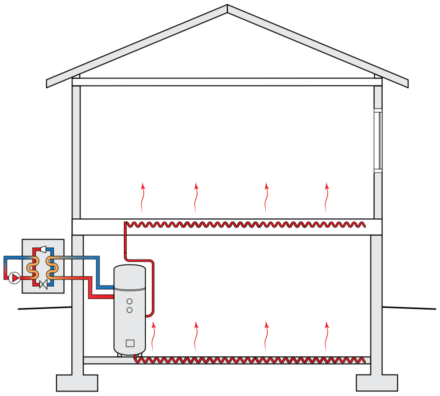


Figure 3.27 Schematic heat pump system with radiant floors.

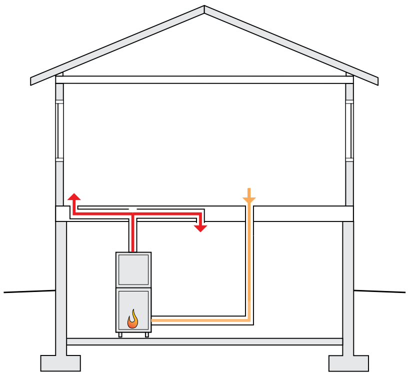


Figure 3.28 Schematic natural gas central forced air furnace system.

Condensing Natural Gas Forced-Air Furnace

High-efficiency condensing furnaces use two heat exchangers to transfer heat energy from burning fuel (combustion heat) directly into the airstream that is circulated throughout the building through ducts.

Condensing natural gas furnaces typically have efficiencies above 95% (see Figure 3.28). The energy demand of these systems is based on the amount of air that must be heated to condition the home, and the temperature difference between the incoming air and the desired temperature. Therefore, the efficiency can be optimized by increasing the temperature of the (cold) ventilation air entering the system using heat recovery, or by using a dedicated separate ventilation system that uses heat recovery (see page 67).

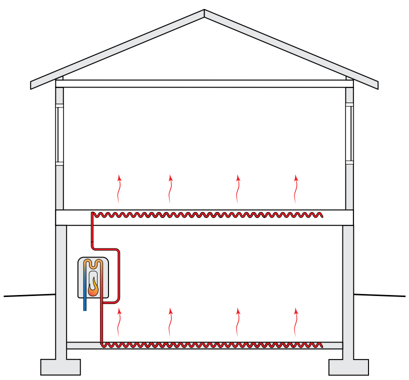


Figure 3.29 Schematic natural gas boiler and radiant hydronic floor system.

Condensing Natural Gas Boiler

Like a furnace, heat exchangers in the boiler transfer combustion heat into a water radiator system, which is circulated throughout the building through concealed pipes (i.e., hydronic loops) set within the building finishes (see Figure 3.29). This indirect transfer approach using radiant heat delivery is often considered the most comfortable form of space heating. However, this system can be at risk of overheating the space in high-performance buildings, because the heating mechanism and thermal mass may be slow to respond to temperature changes and/or low thermal heat loss. A boiler uses the same technology as a tankless/on-demand water heater and is sometimes used to provide both space heating and DHW (see page 66). A boiler can also be used with a forced-air system.

Condensing Natural Gas Boiler as an Efficient Supplemental Heating Source

A high-performance building can still use combustion fuel as supplemental heat. For example, a central forced air heat pump system can use a natural gas boiler (or the tankless hot water heater, see page 66) and hydronic heat exchanger to provide efficient modulating supplemental heat. This may be more efficient than using a natural gas forced air furnace and it can be a good space-saving measure for providing supplemental heat and hot water.

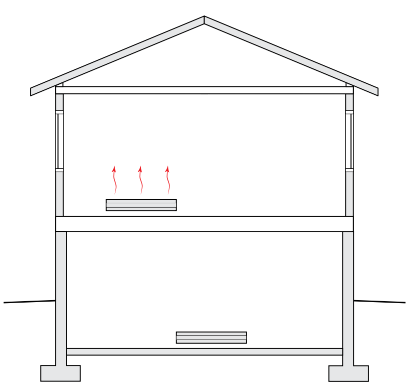


Figure 3.30 Schematic electric baseboard system.

Electric Resistance Heating

Electric heating can be used with all types of heating delivery. It is typically used as baseboard heaters or under-floor electric radiator mats. It can also be used with hot water radiant or forced-air systems, though the concentrated energy draw required for direct electric heating of the whole building may be higher than some buildings can manage. Baseboard heaters are the most common type of electric heat delivery (see Figure 3.30).

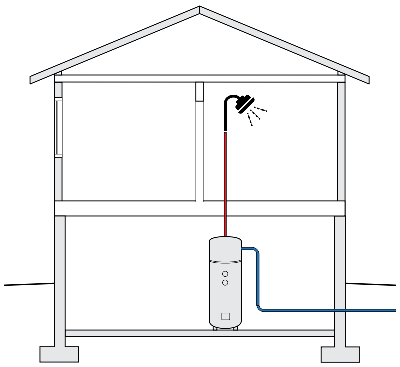


Figure 3.31 Schematic layout of a tank-top electric heat pump hot water tank system.

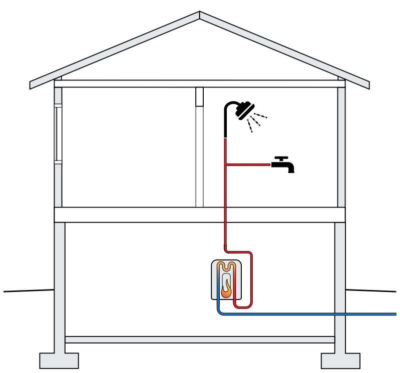


Figure 3.32 Schematic layout of a natural gas tankless hot water system.

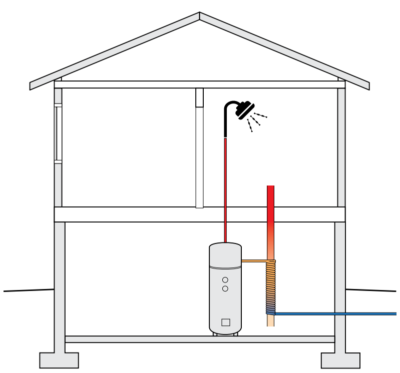


Figure 3.33 Schematic layout of an electric heat pump hot water tank system with drain water heat recovery.

Hot Water

The heating of DHW can account for 15–35% of a building's energy use. Domestic hot water energy use is modelled based on occupant load, so it can only be reduced by using an energy-efficient system and/or drain water heat recovery. Incorporating low-flow fixtures (shower heads and faucets) is a good way to reduce hot water usage, but it is not accounted for in typical energy modelling.

Hot water heating energy comes from the same three energy sources as discussed in the previous section (see **Table 3.1** on page 62).

Heat Pump Water Heater Tank

Conventional systems come as an integrated unit, with the heat pump components mounted directly on top of an insulated tank (see **Figure 3.31**). The tank is sized for the demand of the building it serves, and the water in the tank is kept hot so it is ready to use at any time. This way, less concentrated energy demand is required but the system must operate continuously.

Heat is either extracted from outdoor air through a duct or louvre, or from the surrounding indoor air. The system must be designed to accommodate the air source heat extraction, especially for smaller, confined mechanical rooms that can become cold from the heat extraction. Ducted tank-top heat pump water heaters typically perform better as part of a high-performance building.

Water heating can also be achieved with a conventional outdoor heat pump unit, typically the same unit used for space heating and cooling.

Electric Water Heater

Electric hot water heaters use an electric resistance heated coil to heat water. Tank-type systems are more commonly used to avoid a concentrated electrical energy demand that is needed for tankless electric water heater systems.

Natural Gas DHW Heater

Like the space heating equipment, combustion heat energy is transferred to the water either in a conventional tank-type system or through a tankless water heater (see **Figure 3.32**). High-performance homes typically use condensing natural gas heaters. Tankless water heaters require a large amount of concentrated energy. However, they heat the water as it is being used, and therefore use less energy compared to tank-type natural gas systems.

Drain Water Heat Recovery

Another way to reduce DHW energy use is by recovering some of the heat from wastewater through a drain water heat recovery system (DWHR). The DWHR system is typically a tightly wound copper pipe heat exchanger module installed in a segment of the building's main drainpipe. The heat exchanger is connected in line with the water supply of the building's water heater. Heat is transferred from the drain water in the drainpipe into the water supply and raises its temperature. A DWHR is an effective heat recovery strategy in residential buildings due to high shower usage. However, it is sensitive to the building's plumbing layout. The DWHR performs best when it is directly adjacent to the heater (see **Figure 3.33**).

Ventilation

High-performance airtight buildings need sufficient mechanical ventilation to ensure a healthy indoor environment for building occupants. A well-designed and properly installed system will meet code requirements, provide the right amount of ventilation, and can be used to save energy.

Various ventilation systems can be used, but all types must provide direct ventilation to each bedroom and living space during the heating season, per BCBC Section 9.32. Natural non-mechanical ventilation is only permitted during the non-heating season.

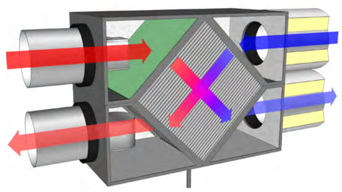


Figure 3.34 Cross-section illustration of heat recovery ventilator operation.

Ventilation with Heat Recovery

A heat recovery ventilator (HRV) or an energy recovery ventilator (ERV) can be used to recover energy from exhaust air and provide comfortable year-round ventilation to homes. HRVs and ERVs are primarily used to recover heat from the exhaust air to temper the supply air, but they can also work in reverse in the cooling season.

These devices use a specialty heat exchanger to passively transfer heat from outgoing exhaust air into the incoming supply air stream without cross-contamination (see Figure 3.34). Air filters within the units filter out pollutants and pollen. ERVs transfer both heat and moisture (i.e., humidity/latent heat) between the supply and exhaust air streams through a specialized heat exchanger. The moisture transfer is intended to help maintain comfortable relative humidity levels, which reduces the need for humidifiers in very cold dry climates. ERVs can also reduce the need for air conditioning in the cooling season. The heat transfer effectiveness of HRVs and ERVs typically ranges from 60% up to above 90% for high-performance systems.

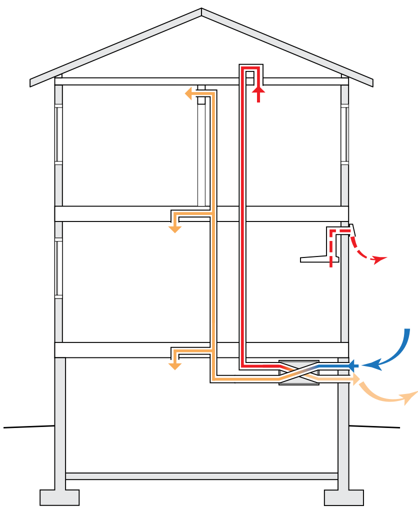


Figure 3.35 Schematic layout of a standalone HRV/ERV system.

The two common HRV/ERV arrangements in Part 9 residential buildings are:

1. **Standalone**. The HRV/ERV uses dedicated ductwork for ventilation air through supply outlets and exhaust inlets for each living space. It is entirely separate from the heating and cooling equipment. The standalone arrangement is common in high-performance buildings because it can be sized and controlled based on ventilation air needs, regardless of heating or cooling demand (see Figure 3.35).
2. **Integrated**. The HRV/ERV connects with the central heating/cooling system and uses its ductwork to deliver fresh air and extract exhaust air. In this arrangement, the HRV/ERV may be sensitive to the effects of inconsistent or varying airflow induced by the central air handler.

Direct Ventilation and Exhaust Fan System

A dedicated fresh air inlet in the central forced-air heating system and an exhaust fan can also serve as an effective basic and code-compliant ventilation strategy (see Figure 3.36). This strategy uses the ducts and circulation fan in the air handler/furnace to supply fresh filtered air, even if the heating system is not running. At the same time, a continuously running exhaust fan, such as a top floor bathroom fan, extracts exhaust air. The ventilation air does not benefit from any heat recovery; therefore, this approach is less energy efficient compared to an HRV/ERV system.

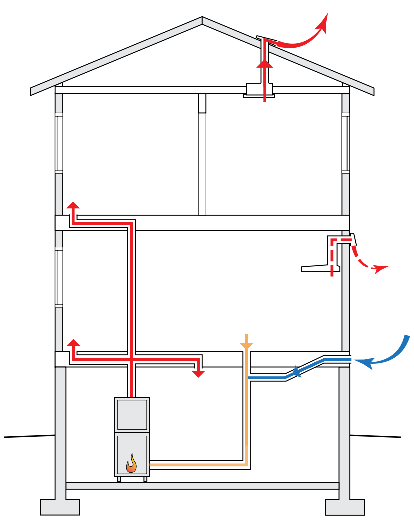


Figure 3.36 Schematic layout of a direct ventilation arrangement with a central furnace, with fresh air and various dedicated exhaust fans.

9.37 GHG Emissions Compliance Examples

The examples in Table 3.4 and Table 3.5 show how a building could be designed to produce fewer GHG emissions to reach the various ZCSC Emission Levels. The examples include relative indicators of how natural gas and electric building systems combinations would meet or have difficulty meeting each Emission Level. The indicators are based on typical building performance for each Step of the ESC and the corresponding annual GHG emissions as well as the ZCSC ***prescriptive pathway*** compliance.

Table 3.4 Examples of ZCSC compliance using gas and electric resistance space heating, and heat pump, gas, and electric appliances.

	Energy Source				Zero Carbon Step Code Emission Level					
	Building System				Performance Pathway			Prescriptive Pathway		
Example	Heating*	Hot Water	Appli-ances	Energy Step Code	EL-2	EL-3	EL-4	EL-2	EL-3	EL-4
A	Combustion Fuel	Combustion Fuel	Combustion Fuel	STEP 3	Likely does not comply	Likely does not comply	Likely does not comply	Not compliant	Not compliant	Not compliant
				STEP 4	May not comply	Likely does not comply	Likely does not comply			
				STEP 5	Likely complies	May not comply	Likely does not comply			
B	Combustion Fuel	Electric Heat Pump OR Electric Resistance	Electric Resistance	STEP 3	May not comply	Likely does not comply	Likely does not comply	Not compliant	Not compliant	Not compliant
				STEP 4	Likely complies	May not comply	Likely does not comply			
				STEP 5	Likely complies	May not comply	May not comply			
C	Electric Resistance	Combustion Fuel	Combustion Fuel	STEP 3	Defer to Pre-scriptive Pathway	May not comply	Likely does not comply	Complies	Not compliant	Not compliant
				STEP 4		May not comply	May not comply			
				STEP 5		May not comply	May not comply			
D	Electric Resistance	Electric Heat Pump OR Electric Resistance	Combustion Fuel	STEP 3	Defer to Prescriptive Pathway		May not comply	Complies	Complies	Not compliant
				STEP 4			Likely complies			
				STEP 5			Likely complies			

*includes supplemental heating

Legend:

Energy Source Types		
Combustion Fuel	Electric Resistance	Electric Heat Pump

Zero Cabon Step Code Compliance				
Complies	Likely complies	May not comply	Likely does not comply	Not compliant

Table 3.5 Examples of ZCSC compliance using heat pump space heating and heat pump, gas, and electric appliances.

Example	Energy Source: Building System			Energy Step Code	Zero Carbon Step Code Emission Level: Performance Pathway			Prescriptive Pathway		
	Heating*	Hot Water	Appli-ances		EL-2	EL-3	EL-4	EL-2	EL-3	EL-4
E	Electric Heat Pump; Combustion Fuel SUPPLEMENTAL	Combustion Fuel	Combustion Fuel	STEP 3	Likely complies	May not comply	May not comply	Not compliant	Not compliant	Not compliant
				STEP 4	Complies	May not comply	May not comply			
				STEP 5	Complies	May not comply	May not comply			
F	Electric Heat Pump	Combustion Fuel	Combustion Fuel	STEP 3	Defer to Pre-scriptive Pathway	May not comply	May not comply	Complies	Not compliant	Not compliant
				STEP 4		May not comply	May not comply			
				STEP 5		May not comply	May not comply			
G	Electric Heat Pump	Electric Heat Pump OR Electric Resistance	Combustion Fuel	STEP 3	Defer to Prescriptive Pathway		Likely complies	Complies	Complies	Not compliant
				STEP 4			Complies			
				STEP 5			Complies			
H	Electric Heat Pump	Electric Heat Pump OR Electric Resistance	Electric Resistance	STEP 3	Defer to Prescriptive Pathway			Complies	Complies	Complies
				STEP 4						
				STEP 5						

Legend:

Energy Source Types		
Combustion Fuel	Electric Resistance	Electric Heat Pump

Zero Cabon Step Code Compliance				
Complies	Likely complies	May not comply	Likely does not comply	Not compliant

Glossary of Terms

Airtightness	A measure of how much a building's enclosure restricts the movement of air between the interior and exterior. The airtightness of a building is also referred to as the "air leakage rate." The assembly of materials that control the airtightness of a building are collectively referred to as the building's air barrier system.
Airtightness Testing	A test using blower door fans to pressurize and/or depressurize the building, with the goal of measuring the building enclosure air leakage rate. Better airtightness testing results indicate a more continuous air barrier system. Airtightness testing is a requirement for all Steps of the BC Energy Step Code.
Builder	The permit applicant responsible for code compliance, directly or through contract.
Building Official	The authority having jurisdiction or governmental body responsible for the enforcement of any part of the BC Building Code or the official or agency designated by that body to exercise such a function.
Building Team	The group of practitioners directly involved in designing, modelling, documenting, and building the home(s). It includes the designer, the energy modeller, the Builder, the Owner, and any additional consultants or subcontractors. For the purposes of this handbook, the building team does not include the Building Official. See also Builder, Modeller, Owner.
BC Energy Step Code	Subsection 9.36.6. of the BCBC, which regulates elements of construction relating to energy efficiency in newly constructed buildings. Requirements for Part 9 residential buildings are listed in Sections 9.36.5. and 9.36.6. of the BCBC. The BC Energy Step Code (ESC) has different levels of performance-based requirements. Improvements in building efficiency are incrementally required over time. The ESC does not specify materials or construction methods. The ESC also does not consider occupant loads or embodied emissions associated with building materials or construction in its energy calculations.
Compliance Checklist	Standardized tool used by Energy Advisors and energy modellers that takes building-specific inputs and produces Compliance Reports. There are different BC Compliance Checklists for each of the major stages of building development in the typical BC Energy Step Code compliance process (i.e., Pre-Construction, Mid-Construction, and As-Built). Compliance Checklists and their Compliance Report outputs are used by the building team to demonstrate to the Building Official that a building meets the applicable BC Energy Step Code and BC Zero Carbon Step Code requirements.
Conditioned space	Per Division A, Article 1.4.1.2. of the BCBC: "any space within a building, the temperature of which is controlled to limit variation in response to the exterior ambient temperature by the provision, either directly or indirectly, of heating or cooling over substantial portions of the year." Conditioned space is the general term in the BCBC to define the area and volume used to normalize energy and emissions metrics. See also Floor Area and Heated Floor Area.
Emission Levels	The requirements for reducing greenhouse gas (GHG) emissions of new buildings as laid out in the BC Zero Carbon Step Code (ZCSC). The ZCSC identifies four Emission Levels (EL-1 through EL-4) for annual GHG emissions, measured in kilograms of carbon dioxide equivalent (kgCO2e). Each Emission Level indicates increasing "carbon performance," which means the total annual GHG emissions of the building do not exceed given performance-based limits.

Energy Advisor	A third-party consultant who has been registered by a Service Organization licensed by Natural Resources Canada (NRCan) to deliver NRCan's EnerGuide Rating System (ERS), ENERGY STAR® for New Homes, and R-2000 programs. An NRCan-Registered Energy Advisor can provide both energy modelling and airtightness testing – the two compliance services needed to demonstrate compliance under the BC Energy Step Code for Part 9 residential buildings.
Energy Modeller	Similar to an Energy Advisor, but may not be affiliated with a Service Organization and the EnerGuide Rating System. Per the BC Energy Step Code, energy modellers do not need to meet specific education or certification requirements, and therefore minimum qualifications may vary by jurisdiction. Energy modellers may use other energy simulation software that meets the BC Energy Step Code's requirements. (All Energy Advisors are energy modellers, but not all energy modellers are Energy Advisors). See also Modeller.
Energy Modelling	A computer-based mathematical replication of aspects of a building, including its overall shape and size, enclosure thermal performance and airtightness, and mechanical systems usage and efficiencies. Whole-building energy modelling is used to quantify the energy use of a building using standardized operation parameters and climate conditions. Energy modelling is also part of the building design process, where theoretical modifications can be tested for their impact on overall energy usage, and for showing code compliance.
Energy Step Code Metrics	The energy performance measurements for thermal energy demand, mechanical energy use, and airtightness, usually normalized (i.e., divided) over the size of the building to allow for comparison between buildings and reference to code requirements.
Floor Area	The space on any storey of a building between exterior walls and required firewalls, including the space occupied by interior walls and partitions, but not including exits, vertical service spaces, and their enclosing assemblies.
Greenhouse Gas Emissions	Emissions that are generated from typical building usage, including heating and cooling. For the purposes of the BC Zero Carbon Step Code, greenhouse gas (GHG) emissions do not include emissions from occupant loads (e.g., lighting, plug loads, and cooking appliances). GHGs that are emitted from buildings include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and others.
Heated Floor Area	The floor area of conditioned space, typically given as square metres (m^2) and measured from the interior surfaces of the building's exterior walls. It is used to normalize the energy and emissions metrics of the BC Energy Step Code and the BC Zero Carbon Step Code. Note that the term is explicitly defined this way according to NRCan's EnerGuide Rating System (ERS). See also Conditioned Space and Floor Area.
High-Performance Building	In the context of code compliance, a building built to high energy efficiency standards with reduced energy needs compared to current standards.
Modeller	Person responsible for Building Energy Modelling and analysis, who through education, training and experience, is competent in simulation, science and systems that pertain to building energy performance. Typically working as an Energy Advisor.

Owner	Any person, firm or corporation controlling the property under consideration during that period of application, as applied to the Building Code.
Performance Pathway	Designing a building to comply with the parameters defined in the BCBC Subsections 9.36.5. and 9.36.6., which requires energy modelling to be carried out and uses energy usage requirements based on overall thermal energy demand and Mechanical Energy Use Intensity. This is the standard compliance pathway for the BC Energy Step Code.
Prescriptive Pathway	Designing a building to comply with the prescriptive requirements defined in the BCBC Subsections 9.36.2. to 9.36.4., which uses requirements based on specific R-values, U-values, and mechanical system efficiencies, and does not require airtightness testing. The compliance path can only be used where an authority having jurisdiction (AHJ) writes into bylaw that where a Part 9 residential building is required to meet Step 3 of the BC Energy Step Code, it may choose the performance or prescriptive pathway. This option is not available if an AHJ requires Step 4 or higher or has not written the prescriptive allowance into bylaw.
Registered Professional	A person who is registered as an Architect with the Architectural Institute of British Columbia under the Professional Governance Act, or a person who is registered as a professional engineer or professional licensee engineering with the Association of Professional Engineers and Geoscientists of the Province of British Columbia under the Professional Governance Act.
Site Inspections	Used to verify that what is being constructed matches the design information in the compliance reports.
Zero Carbon Step Code	A part of the BC Building Code (BCBC) that regulates greenhouse gas emissions in new Part 9 residential buildings. The BC Zero Carbon Step Code (ZCSC) is defined in the BCBC Section 9.37. and only considers operational emissions. The ZCSC does not account for embodied emissions of building materials.

Additional Resources

BC Energy Step Code website - https://www.energystepcode.ca/

BC Energy Step Code Resources for Local Governments - https://energystepcode.ca/for-local-governments/

Builder's Guide to Cold Climates published by Building Science Corporation - https://buildingscience.com/bookstore/books/builders-guide-cold-climates

Building and Safety Standards Branch Information Bulletins - https://www2.gov.bc.ca/gov/content/industry/construction-industry/building-codes-standards/bc-codes/technical-bulletins

Building Enclosure Design Guide published by BC Housing - https://research-library.bchousing.org/Home/ResearchItemDetails/2001

Canadian Home Builders' Association Builders' Manual published by the Canadian Home Builders' Association - https://www.chba.ca/chba-builders-manual/

Compliance Tools for Part 9 Buildings (compliance & verification reports) - https://energystepcode.ca/compliance-tools-part9/

Energy Modelling Guidelines published by the City of Vancouver - http://vancouver.ca

Guide for Designing Energy-Efficient Building Enclosures for Wood-Frame Multi-Unit Residential Buildings published by FPInnovations, BC Housing, and the Canadian Wood Council - https://library.fpinnovations.ca/link/fpipub5771

Illustrated Guide - Achieving Airtight Buildings published by BC Housing - https://research-library.bchousing.org/Home/ResearchItemDetails/1765

Illustrated Guide - Energy Efficiency Requirements for Houses in BC - https://research-library.bchousing.org/

Illustrated Guide - R22+ Effective Walls in Residential Construction in BC (Second Edition) - https://research-library.bchousing.org/Home/ResearchItemDetails/1950

Illustrated Guide - R30+ Effective Vaulted & Flat Roofs in Residential Construction in BC Residential Construction Performance Guide - https://www.bchousing.org/sites/default/files/rcg-documents/2022-04/Illustrated-Guide-R30-Effective-Vaulted-and-Flat-Roofs.pdf

Information Bulletin B23-01 20%-Better Energy Efficiency & Zero Carbon Step Code - https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/20_better_ee__zcsc.pdf

Information Bulletin B23-02 9.36.1.3. Compliance Pathway British Columbia Building Code 2017 Revision 5 - https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/b23-02_93613_compliance_paths.pdf

Information Bulletin B23-03 Zero Carbon Step Code - https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/b23-03_zero_carbon_step_code.pdf

Information Bulletin B24-08 Protection from Overheating in Dwelling Units - https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/construction-industry/building-codes-and-standards/bulletins/2024-code/b24-08_overheating.pdf

Information on the EnerGuide Rating System from Natural Resources Canada - https://natural-resources.canada.ca/energy-efficiency/product-energy-ratings/energuide

Pathways to High-Performance Housing in British Columbia published by FPInnovations - https://library.fpinnovations.ca/link/fpipub6023

Appendix A | Energy Step Code Compliance Checklists

Example Energy Step Code Compliance Checklist – Quality Example

(page 1/3)

Checklist Last Updated: 3/31/2025

BC STEP CODE COMPLIANCE CHECKLIST - PERFORMANCE PATHS FOR PART 9 BUILDINGS

A: PROJECT INFORMATION

Building Permit #:	BP283002 - 2025
Builder:	Compliance Developments Inc.
Project Address:	345 Step Code Street
Municipality / District:	Victoria
Postal Code:	A1B 2C3
PID or Legal Description:	Lot #1, Section 2, Plan 1234 (Victoria)

Pre Construction

Building Type
Single Detached w/Secondary Suite

# of Dwelling Units: 2

B: CODE COMPLIANCE SUMMARY

BC Building Code Performance Compliance Path:
9.36.6. BC Energy Step Code ERS

Energy Step Code	Zero Carbon Step Code
Step Required	**Level Required**
3	EL 2 - Moderate
Proposed Step Achieved	**Proposed Level Achieved**
3	**EL 2 - Moderate**

Achieved ↓
3 | 4 | 5
↑ Required

Achieved ↓
EL 1 | EL2 | EL 3 | EL 4
↑ Required

Based on info provided by the builder & the following drawings:

Plan Author	ABC Designer Inc.
Plan Version	Issued for Building Permit
Plan Date	5-Mar-25

C: COMPLETED BY

Full Name (Print):	Rowan Smith	Date (YYYY-MM-DD):	3/31/2025
Company Name:	DEF Energy Modellers	Service Organisation:	CEA Group Can
Phone:	123-456-7891	Energy Advisor ID #:	6789
Address:	123 Emissions Road Unit #345, Victoria, BC	CODECO placed in Field 8 of H2K	x
Email:	email@email.com		

P File # 4567P00099

Page 1 Pre Construction Checklist Version - Jan 2025

Confirm information corresponds with drawing and submission version/ date.

Information is for the proposed building before any construction has occurred. For any submission during construction this form will read "Mid-Construction."

Entered from the drop-down list in spreadsheet. Many MURB and non-MURB descriptions available.

Includes all dwelling units in the building/ buildings.

Entered from the drop-down list in spreadsheet. Only modelling done under ERS by an Energy Advisor can use this option. Other Step Code options are "NECB" or "PHPP."

Required and achieved step/level to match provincial and local code minimum.

Drawing set and dates matching building permit (BP) submission documents.

Detailed Energy Advisor information must include service organization and ID# which can be verified. Non-ERS Energy Modeller information does not require this, but other qualifications should be reviewed.

File number for the HOT2000 Energy Model sent for ERS review. Review (N-FILE # for as-built).

Check most recent applicable version from energystepcode.ca.

Example Energy Step Code Compliance Checklist – Quality Example

(page 2/3)

Checklist Last Updated: 3/31/2025

D: BUILDING CHARACTERISTICS SUMMARY

	Details (Assembly / System Type / Fuel Type / Etc.)	Average Effective RSI	
Roof / Ceilings	Sloped: attic trusses @ 16" OC w/ R-40 batts	6.34	
	Roof Decks: 2x10 @ 16" OC w/ R-24 rigid	4.65	
	Bay Windows: 12" TJIs @ 16" OC w/ R-24 spray foam	3.70	
Above Grade Walls	2x6 @ 16" OC with R19 batt, rainscreen	2.96	
Rim Joists / Floor Headers and Lintels	R19 batt, rainscreen	3.51	
Floors Over Unheated Space	12" TJIs @ 16" OC with R-40 batt	6.50	
Walls Below Grade	ICF wall (2-5/8" EPS, 8" concrete, 2-5/8" EPS)	3.80	
Slabs	4" concrete with R-10 rigid continuous under slab	1.76	
		Performance Values	
		USI	SHGC
Windows and glazed doors	Double glaze, vinyl picture	1.48	0.32
	Double glaze, vinyl casement	1.59	0.24
	Double glaze, vinyl sliding glass door	1.60	0.28
Doors	Fibreglass with foam core	USI	0.29
Air Barrier System & Location	Walls and floor: interior poly & caulk	ACH	2.50
	Cathedral-style ceilings: interior poly & caulk	NLA	1.62
	Flat roof: SBS base sheet with caulk transition to weather barrier on	NLR	0.81
Space Heating/ Cooling	Principal — ASHP		
	Air-source heat pump with central air handler/ducts	COP	2.50
	Supplementary		
	Elec. baseboard heaters, central thermistat	AFUE	100.00
Domestic Hot Water	Conventional electric DHW tank	EF	0.82
Ventilation		% EFF	L/s
	1x ERV per unit	66.00	196.00
Other			
Fossil Fuels	The building including all units is designed with NO fossil fuel use or infrastructure		

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Manually entered enclosure and mechanical information must match most recent BP drawings set, including R-values, U-values, airtightness, and equipment and efficiencies.

Descriptions match drawings and R-value calculations. Note prescriptive R-values as listed in BCBC Subsections 9.36.2. to 9.36.4. are not applicable. However, assemblies with R-values less than 50% of the prescriptive minimums should be carefully reviewed for compliance with 9.25.2.

High SHGC above 0.45 likely indicates higher assumed/modelled solar thermal heat gain. Requires careful design for cooling.

Descriptions match drawings and window specs. Note prescriptive U-values as listed in BCBC Subsections 9.36.2. to 9.36.4. are not applicable. However, the Province's Energy Efficiency Standards Regulation sets window maximum U-values for Part 9 residential buildings, which still apply.

One proposed airtightness value must meet minimum requirement, assumed until tested.

Equipment to match drawings and CSA F-280 report.

To match drawings, sufficent airflow to meet BCBC Section 9.32. requirements.

Drop-down list entry for reporting information on fossil fuel use but is not a code compliance item.

Example Energy Step Code Compliance Checklist – Quality Example

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Checklist Last Updated: 3/31/2025

E: 9.36.5. ENERGY PERFORMANCE COMPLIANCE

Complete this section if using the Energy Performance Compliance Path in Subsection 9.36.5.

Proposed House Energy Consumption (GJ/year)	
HVAC	
DHW Heating	
SUM	**0**

Reference House Rated Energy Target (GJ/year)	
HVAC	
DHW Heating	
SUM	**0**

The airtightness value used in the energy model calculations for the Proposed house is:
Or Testing Target:

The above calculation was performed in compliance with Subsection 9.36.5. of Division B:

F: 9.36.6. ENERGY STEP CODE COMPLIANCE

Proposed House Rated Energy Consumption (GJ/year): 40 **Reference House Rated Energy Target (GJ/year):** 67

Proposed House Metrics	Unit	Proposed Step Requirement		Proposed Calculations: Proposed House Result	Proposed Calculations: Proposed House Pass or Fail
Step Code Level	Step 3, 4 or 5	3			
Mechanical Energy Use Intensity (MEUI)	kWh/(m²·year)	55	(max)	47	Pass
% Improvement	%	20	(min)	40	
Thermal Energy Demand (TEDI)	kWh/(m²·year)	35	(max)	36	Pass
% Heat Loss Reduction	%	10	(min)	14	
Airtightness in Air Changes per Hour at 50 Pa differential	ACH @ 50 Pa	2.5	(max)	2.50	Pass
Normalized Leakage Area (NLA_{10})	10 Pa (cm²/m²)	1.2	(max)	1.62	
Normalized Leakage Rate (NLR_{50})	L/s/m²	0.89	(max)	0.81	
		Step Code Requirements Met:			**Yes**

Software Used:	Hot 2000	Version:	11.11b35
Heated Floor Area (m²)	234.00	Climate Data (Location):	VICTORIA GONZALES
Building Volume (m³)	700.00	Degree Days Below 18°C (HDD):	2763
Building Surface Area (m²)	600.00		
FWDR:	24.4%	% Of Space Cooled	More than 50%

G: ZERO CARBON STEP CODE

Proposed House Metrics		Unit	Proposed Level Requirement		Proposed Calculations: Proposed House Result	Proposed Calculations: Proposed House Pass or Fail
Zero Carbon Step Code Level		EL-1 - EL-4	EL 2 - Moderate			
Total GHG		kg CO_{2e}/ year	1050	(max)	1403	Fail
CO_{2e} per floor area with max	Per Floor area	kg CO_{2e}/m²/year	6.0	(max)	6.0	Pass
	Max	kg CO_{2e}/ year	2400	(max)	1403	
Prescriptive		Heating	Zero Carb		Zero Carb	Pass
		Hot Water	NA		Zero Carb	
		All building systems, equipment and appliances	NA		Zero Carb	
					Target Reached:	**Yes**

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Filled out to confirm modelling was completed following BCBC Subsection 9.36.5. energy modelling requirements, but it is not an indicator of ESC (BCBC 9.36.6.) compliance.

All results in “Part F” are automatically populated from spreadsheet calculations in “Calculator” tab.

Building-specific MEUI and TEDI code requirements calculated based on floor area and specific HDD.

Mechanical: MEUI or %IAEC

Building Envelope: TEDI or HLR%

Airtightness: ACH or NLR or NLA

Most recent software version

Matches local HDD per AHJ

All results in “Part G” are automatically populated from the spreadsheet calculations in “Calculator” tab.

GHG emissions performance GHG or GHG + GHGI or Prescriptive.

Based on calculator input.

Building-specific ZCSC code requirements calculated based on calculator input. EL-2 requires only heating be “Zero Carb”, EL-3 requires both Heating and Hot Water be “Zero Carb”, and EL-4 requires all three be “Zero Carb”.

Example Energy Step Code Compliance Checklist – Poor Quality Example

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Checklist Last Updated: 3/31/2025

ENERGY STEPCODE BUILDING BEYOND THE STANDARD

BC STEP CODE COMPLIANCE CHECKLIST - PERFORMANCE PATHS FOR PART 9 BUILDINGS

ZERO CARBON STEPCODE

Possible input errors require follow up and may result in rejection/ revisions.

A: PROJECT INFORMATION

Building Permit #:	BP283002 - 2025
Builder:	Compliance Developments Inc.
Project Address:	345 Step Code Street
Municipality / District:	Victoria
Postal Code:	A1B 2C3
PID or Legal Description:	Lot #1, Section 2, Plan 1234 (Victoria)

Pre Construction

Building Type

Single Detached w/Secondary Suite

# of Dwelling Units: 1

Must match building description – 2 dwelling units in homes with secondary suite.

B: CODE COMPLIANCE SUMMARY

BC Building Code Performance Compliance Path:

9.36.6. BC Energy Step Code ERS

Notes ERS but, per Part C below, does not include energy model P-file #, advisor service organization, or ID#, and therefore is not ERS-compliant.

Energy Step Code	Zero Carbon Step Code
Step Required	**Level Required**
3	EL 2 - Moderate
Proposed Step Achieved	**Proposed Level Achieved**
3	**EL 2 - Moderate**

Achieved ↓ 3 4 5 ↑ Required

Achieved ↓ EL 1 EL2 EL 3 EL 4 ↑ Required

Drawing set used for energy modelling must be at least building permit set.

Based on info provided by the builder & the following drawings:

Plan Author	ABC Designer Inc.
Plan Version	Issued for Review
Plan Date	10-Nov-24

C: COMPLETED BY

Full Name (Print):	Rowan Smith	Date (YYYY-MM-DD):	3/31/2025
Company Name:	DEF Energy Modellers	Service Organisation:	
Phone:	123-456-7891	Energy Advisor ID #:	
Address:	123 Emissions Road Unit #345, Victoria, BC	CODECO placed in Field 8 of H2K	
Email:	email@email.com		

No service organization, Energy Advisor ID #, or P-file #. Therefore submission under the ERS cannot be verified.

P File #

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Example Energy Step Code Compliance Checklist – Poor Quality Example

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Checklist Last Updated: 3/31/2025

D: BUILDING CHARACTERISTICS SUMMARY

	Details (Assembly / System Type / Fuel Type / Etc.)	Average Effective RSI	
Roof / Ceilings	Sloped: attic with R-40 batts Roof Decks: 2x10 with R-12 rigid	7.04 2.64	
Above Grade Walls	2x6 with R19 batt, rainscreen	3.35	
Rim Joists / Floor Headers and Lintels	Headers: R12 spray foam, rainscreen Rim joist: R24 spray foam, rainscreen	2.11 4.23	
Floors Over Unheated Space	2x8 with R-12 spray foam	3.17	
Walls Below Grade	R-10 XPS board	1.76	
Slabs	R-10 XPS board continuous under slab	1.76	
		Performance Values	
		USI	**SHGC**
Windows and glazed doors	Double glaze, vinyl picture Double glaze, vinyl casement Double glaze, vinyl sliding glass door	1.48 1.59 1.70	0.32 0.24 0.28
Doors	Steel with fibreglass core	**USI**	0.29
Air Barrier System & Location	Walls and floor: poly Cathedral-style ceilings: poly Flat roof: poly	**ACH** **NLA** **NLR**	0.60
Space Heating/ Cooling	Principal Air-source heat pump with central air handler/ducts Supplementary	-	
Domestic Hot Water	condensing natural gas tankless	**%Eff**	97.00
Ventilation	1x ERV per unit	**% EFF** 95.00	**L/s** 50.00
Other			
Fossil Fuels	The building including all units is designed with NO fossil fuel use or infrastructure		

Incomplete descriptions, missing framing spacing, and some R-values well below typical prescriptive minimums, which may warrant follow up review and reference to Section 9.25.

All RSI-values are nominal instead of effective.

Incomplete air barrier description but a very airtight building is intended.

No equipment specs/ sizes or efficiency of supplemental heat listed.

High efficiency but low CFM, not enough for BCBC Section 9.32. minimum flow requirements.

Incorrect – must account for any natural gas equipment used (see hot water).

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Page 3 of Compliance Report not include in BAD EXAMPLE

Appendix B | Example CSA F280 Report

Example CSA F280 Report

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HEATANDCOOL Software (v2.2)
CSA F280 Verified Software

RESULTS

Check that a validated software was used for the calculations.

Project Information

CALCULATIONS PERFORMED FOR:		**CALCULATIONS PERFORMED BY:**	
ABC Builder			
Project #:	9876.004	Company:	
Project Address:	1234 Sample Street	Project Address:	
Municipality / District:	City of Sample	City / Province:	
Post Code:	A1C 2B3	Post Code:	

BUILDING TYPE: Detached
Number of Below-grade floors: 0
Number of Above-grade floors: 2

Location Details

WEATHER DATA: Vancouver (city hall)
Latitude: 49.25
Summer Mean Daily Temperature Range: 7 °C
Soil Temperature: 11° C

Longitude: -123.12
Window Shading: No
Front of House Facing Direction: SW

Air Tightness / Infiltration (ACH_{50}): 1.5
Assumption or Tested Value: Tested Value

Indoor Design Temperatures:
Heating: 22 °C, 71.6 °F
Cooling: 24 °C, 75.2 °F

Outdoor Design Temperatures:
Heating: -7 °C, 19.4 °F
Cooling: 28 °C, 82.4 °F

Test Details:
# of Bedrooms: 2
# of People: 3

Building Characteristics Summary

	Details (Assembly / System / Fuel Type / Etc.)	Effective RSI-Value / Efficiency
Exterior Walls & Floor Headers	2x6, 16 OC, R20 batts, 12mm gypsum board, 12.7mm plywood sheathing, hardy plank	2.78
Roof / Ceilings	2x4 truss, 24 OC, R40 batts, 12mm gypsum board	6.91
Foundation Walls, Headers, & Slabs	2.5" XPS below slab — **Slab is:** ☐ Below **OR** ☑ Above Frost Line; ☐ Heated **OR** ☑ Unheated	2.2
Floors over Unheated Spaces	n/a	n/a
Windows	ABC Windows	U-0.64 SHGC 0.30
Doors	Insulated wood	U-0.16
Skylights	ZZZ Skylight	U-0.64 SHGC 0.30
Ventilation	ABC HRV, 100 cfm	65/60% @ 0/-25 deg C
Space Conditioning (Heating & Cooling)	Duel fuel, forced-air	

Check that the project coordinates are correct. Longitude impacts solar heat gain through windows.

Check that the building orientation is correct.

Check that the airtightness matches the Compliance Checklist.

Check that outdoor design temperatures match those for the project location in Table C-2.

Check that indoor setpoint temperatures meet the requirements of BCBC Article 9.33.3.1.

Check that the building R-values, U-values, SHGC, and heat recovery efficiency match the Compliance Checklist.

Heating/cooling efficiency not required to be reported, but may be beneficial to confirm coordination between mechanical designer/ supplier and energy modeller/designer.

Example CSA F280 Report

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RESULTS

HEATANDCOOL Software (v2.2)
CSA F280 Verified Software

HEAT LOSS COMPONENT BREAKDOWN, (BTUH)

ROOM NAME	WALL WAL.	CEILING CEI.	FLOOR FLR.	WINDOW & SKYLIGHT WIN.	DOOR & HATCH DR.	FOUNDATION FND.	LEAKAGE LEAK.	VENTILATION VENT.	DISTRIBUTION DIST.	ADDITIONAL ADD.	TOTAL
(#1)Bath #1	28					287	48				**363**
(#2)Bed #1	127		5	897		300	204	403			**1935**
(#3)Entrance - Basement	62				289	406	116				**873**
(#4)Kitchen & Living	1015			1726	289		221	403			**3655**
(#5)Bath #2	207	39					12				**258**
(#6)Hall & Laundry	291	92		269			32				**684**
(#7)Bed #2	438	194		1457			103	403			**2596**
	WAL.	**CEI.**	**FLR.**	**WIN.**	**DR.**	**FND.**	**LEAK.**	**VENT.**	**DIST.**	**ADD.**	**TOTAL**
TOTAL BUILDING	**2167**	**325**	**5**	**4350**	**579**	**993**	**736**	**1210**			**10365**

HEAT GAIN COMPONENT BREAKDOWN, (BTUH)

ROOM NAME	WALL WAL.	CEILING CEI.	FLOOR FLR.	WINDOW & SKYLIGHT WIN.	DOOR & HATCH DR.	LEAKAGE LEAK.	VENTILATION VENT.	DISTRIBUTION & ADDITIONAL DIST.	INTERNAL INT.	TOTAL SENSIBLE SENS.	TOTAL SENSIBLE + LATENT TOTAL
(#1)Bath #1	4					0				4	**5**
(#2)Bed #1	19		1	1857		6	464			2346	**3050**
(#3)Entrance - Basement	8				410	1				420	**546**
(#4)Kitchen & Living	138			3529	255	13	155		3088	7178	**9332**
(#5)Bath #2	27	25				0				53	**69**
(#6)Hall & Laundry	34	61		399		2				495	**644**
(#7)Bed #2	63	127		2879		10	155		358	3592	**4669**
	WAL.	**CEI.**	**FLR.**	**WIN.**	**DR.**	**LEAK.**	**VENT.**	**DIST.**	**INT.**	**SENS.**	**TOTAL**
TOTAL BUILDING	**293**	**213**	**1**	**8664**	**665**	**33**	**773**		**3446**	**14087**	**18314**
										MINIMUM INSTALLED OUTPUT CAPACITY:	**14651**

HEAT LOSS & HEAT GAIN SUMMARY, (BTUH) imperial

ROOM NAME	FLOOR LEVEL	FL AREA (ft^2)	**HEAT LOSS** TOTAL	**HEAT GAIN** SENS.	**TOTAL (sensible + latent)**
(#1)Bath #1	1	84	363	4	5
(#2)Bed #1	1	180	1935	2346	3050
(#3)Entrance - Basement	1	80	873	420	546
(#4)Kitchen & Living	2	344	3655	7178	9332
(#5)Bath #2	3	40	258	53	69
(#6)Hall & Laundry	3	89	684	495	644
(#7)Bed #2	3	215	2596	3592	4669
		AREA	HEAT LOSS	GAIN (sens.)	GAIN (total)
OVERALL BUILDING		1032	10365	14087	**18314**

Installed capacity of installed heating equipment must meet or exceed the total building heat loss.

If the calculation report shows a room-by-room breakdown, check that each room with windows and/or skylights includes heat loss/gain from these components. Windows and skylights are often the largest source of heat loss/gain and omitting them can lead to improperly sized equipment.

Check that heat gain calculation includes internal gains.

Installed capacity of cooling equipment must meet or exceed 80% of the total building heat gain or, if sized for overheating protection, at least 100% of the total building heat gain.

If the building is cooled with a system other than a ground- or water-source heat pump, the installed system capacity must not exceed 125% of the nominal system capacity.

Check that the building area matches architectural drawings and Compliance Checklist.

Notes

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