

ZERO CARBON BUILDING

DESIGN STANDARD
VERSION 3

Canada Green Building Council®

June 2022



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Zero Carbon Building – Design Standard Version 3

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Evolv1

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Mohawk College's Joyce Center for Partnership & Innovation

355 Wilkinson Avenue Warehouse

Curé Paquin Elementary School



DEVELOPMENT PROCESS AND ACKNOWLEDGEMENTS

The Zero Carbon Building – Design Standard Version 3 (ZCB-Design v3) represents a response to the changes in the Canadian design and construction market since the previous version was launched in 2020.

Updates to the ZCB-Design Standard were developed using the following guiding principles, established by the Zero Carbon Steering Committee:

- Prioritize carbon emissions reductions
- Ensure energy efficient design
- Encourage good grid citizenship
- Incentivize reductions in embodied carbon
- Keep it simple and accessible

Revisions to the Standard were informed by two years of market feedback, as well as changing market expectations related to operational and embodied carbon emissions. The Zero Carbon Steering Committee oversaw the changes to the ZCB-Design Standard, with the support of an Embodied Carbon Working Group and the CAGBC's Energy & Engineering Technical Advisory Group.

CAGBC extends its deepest gratitude to all our committee and working group members. We also wish to acknowledge the support of Chris Magwood, Endeavor Center.



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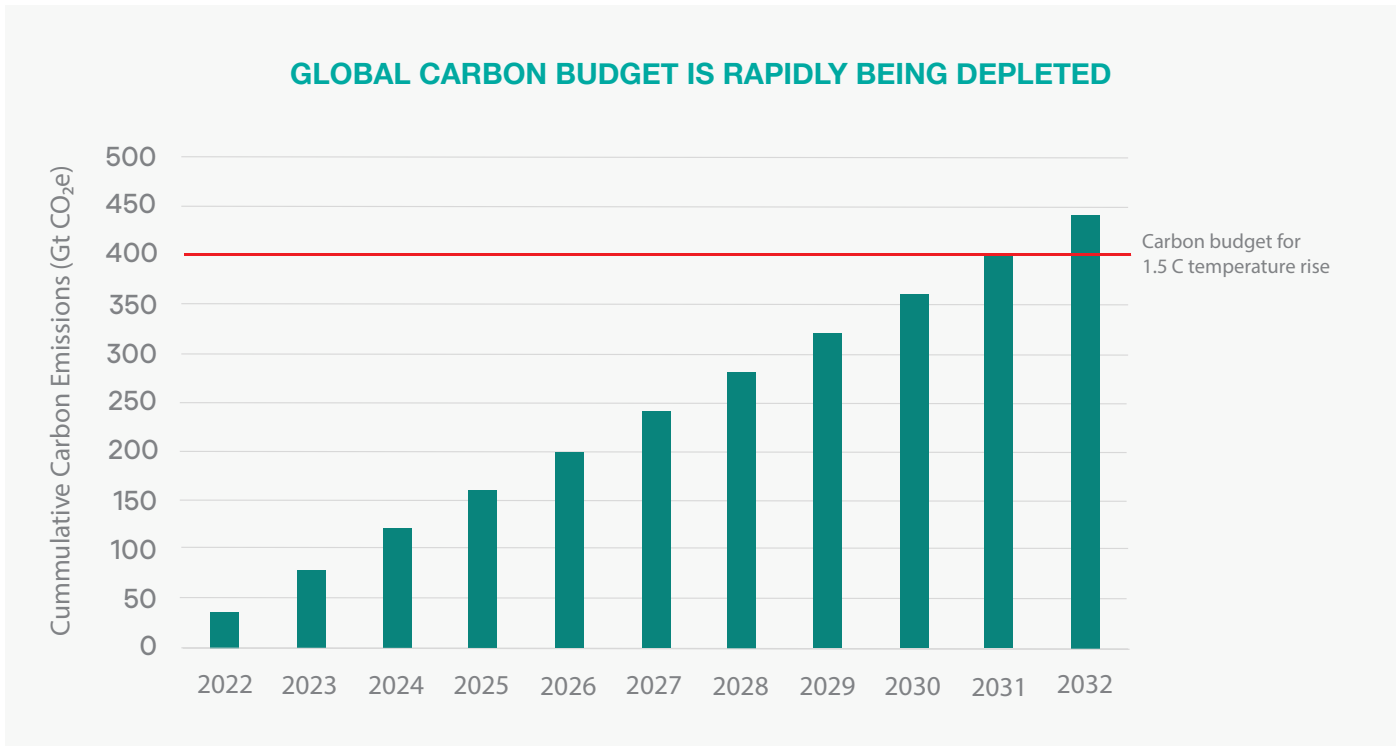


INTRODUCTION

To avoid the worst impacts of climate change, all nations must focus their efforts on carbon reduction. In Canada, building construction and operations must effectively eliminate greenhouse gas (GHGs) emissions to meet the national target of carbon neutrality by 2050. To achieve this goal, each new building design must target zero carbon emissions to avoid retrofits down the line. There is no time to wait.

The Intergovernmental Panel on Climate Change (IPCC) has fixed the world’s available carbon budget – the maximum amount of GHGs that can be released into the atmosphere – at 400 gigatonnes (Gt) of carbon dioxide equivalent (CO₂e)¹. This target has been set to keep global warming to 1.5 C. However, at the world’s current rate of 40 Gt of carbon emissions per year, our remaining budget will last less than 10 years before we risk a global temperature increase that will significantly alter our climate.

A Zero Carbon Building is a highly energy efficient building that produces onsite, or procures, carbon-free renewable energy or high-quality carbon offsets in an amount sufficient to offset the annual carbon emissions associated with building materials and operations.



¹ IPCC, Sixth Assessment Report (UN Environment, 2021).



To stay within this carbon budget and to mitigate the effects of climate change requires action from across the building sector. Every year that passes without significantly reducing GHG emissions contributes to the erosion of the world's carbon budget, shortening what little time we have left to reach zero carbon.

Fortunately, the building sector is mobilizing to help support Canada's efforts to reduce carbon emissions. Building operations are responsible for 17 percent of Canada's carbon emissions,² with construction and materials representing a further 10 percent.³ The transition to zero carbon buildings will generate new and innovative design strategies, expanding opportunities for industry growth and job creation.

The Canada Green Building Council (CAGBC) launched the Zero Carbon Building standards (ZCB standards) in 2017 to assist the industry's transition to zero carbon. Every day, ZCB projects are pushing the boundaries of what is possible and demonstrating that there is a zero-carbon future for all buildings.

Published in 2019, the CAGBC's *Making the Case for Building to Zero Carbon* report confirmed that zero carbon buildings are both technically feasible and financially viable.⁴ On average, zero carbon buildings can provide a positive financial return over a 25-year life cycle when considering national carbon pollution pricing, and require only a modest capital cost premium. Zero carbon buildings' financial returns will only grow as the cost of carbon rises, while also helping to mitigate future costs for utilities and retrofits.

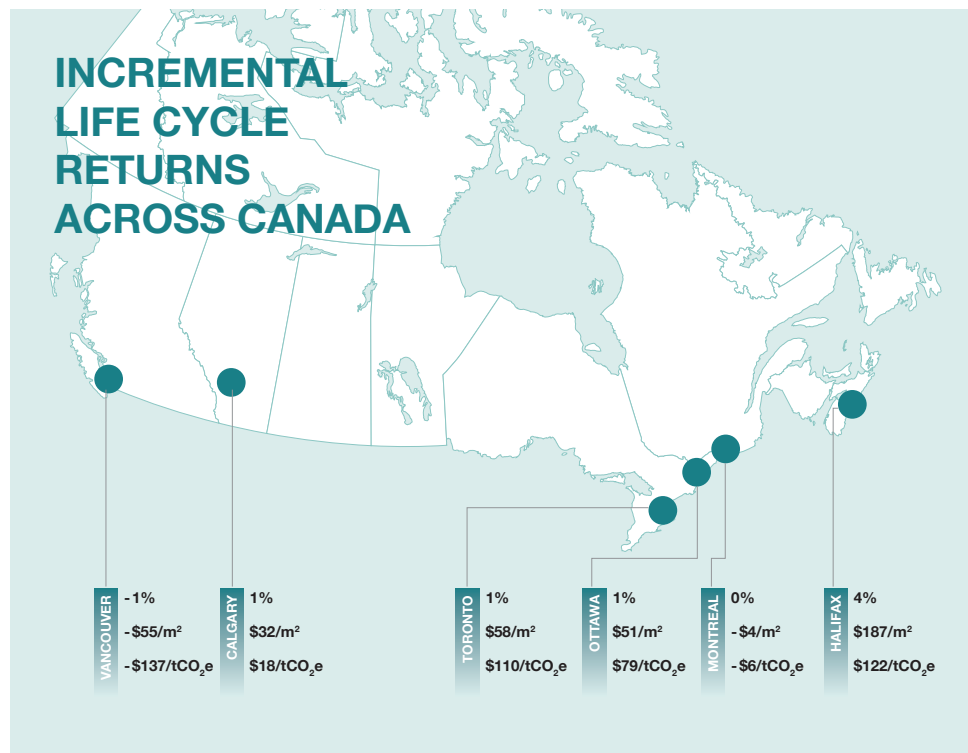


Figure 1 – Incremental life cycle returns across Canada (source: CAGBC's *Making the Case for Building to Zero Carbon* report)

² Environment and Climate Change Canada. Pan-Canadian Framework on Clean Growth and Climate Change. Canada's Plan to Address Climate Change and Grow the Economy, <https://www.canada.ca/en/services/environment/weather/climatechange/pan-canadian-framework/climate-change-plan.html>.

³ Global Alliance for Buildings and Construction, 2021 *Global Status Report for Buildings and Construction*.

⁴ Canada Green Building Council. *Making the Case for Building to Zero Carbon* (2019), www.cagbc.org/MakingTheCase.



In 2021, CAGBC released the *Decarbonizing Canada's Large Buildings* report⁵, which studied the costs of deep carbon retrofits for 1970s and 1990s vintage buildings and identified key market barriers and solutions. The archetypes within the study were able to reduce fossil fuel consumption by at least 93 percent, while slashing energy by more than 70 percent. Many of the archetypes also yielded a positive financial return on a deep carbon retrofit using a 40-year life cycle, with the remainder becoming cost viable as carbon and energy prices increase.

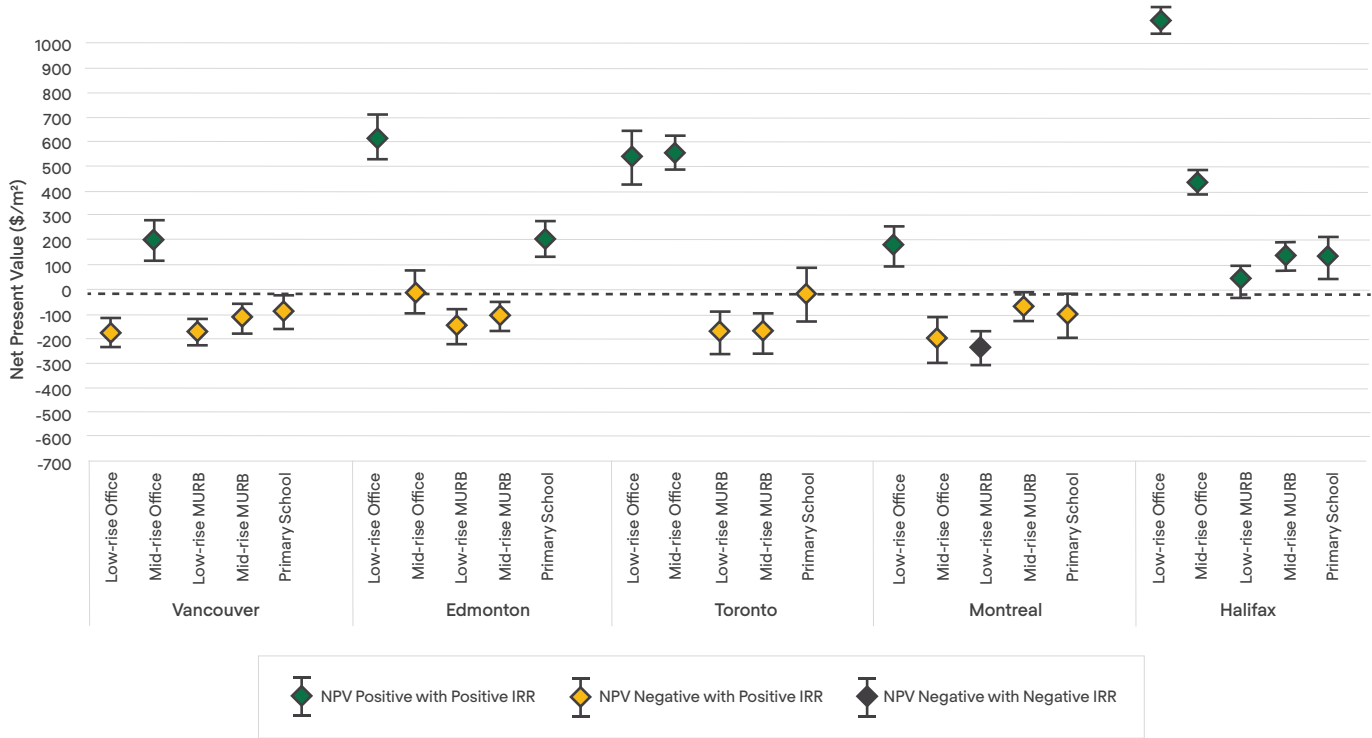


Figure 2 – Net present value of deep carbon retrofits for 1970s vintage buildings (source: CAGBC’s *Decarbonizing Canada’s Large Buildings* report)

⁵ Canada Green Building Council. *Decarbonizing Canada’s Large Buildings* (2021), www.cagbc.org/decarbonize.



ZERO CARBON BUILDING – DESIGN STANDARD V3

The [Zero Carbon Building – Design \(ZCB-Design\) Standard](#) is a made-in-Canada framework for designing and retrofitting buildings to achieve zero carbon. Zero carbon buildings represent the industry’s best opportunity for cost-effective emissions reductions that can also spur innovation in design, building materials and technology, and create jobs and business opportunities.

ENHANCEMENTS TO THE ZCB-DESIGN V3 STANDARD

Building standards must evolve with the market and take advantage of new ideas, new technologies and new processes. The third iteration of the ZCB-Design Standard continues the trend of introducing greater rigour while increasing flexibility to support the goal of achieving zero carbon across all buildings. To further the effectiveness and market uptake of ZCB-Design, the following key enhancements were made:

1. **Embodied carbon**⁶: As market knowledge of low-**embodied carbon** design continues to improve and the availability of low-carbon materials expands, the emphasis needs to shift from reporting and offsetting **embodied carbon** to ensuring a minimum level of achievement. That is why the ZCB-Design v3 Standard introduces a maximum **embodied carbon** threshold, as well as two Impact and Innovation thresholds for higher levels of performance for greater innovation. Targets can be met using an improvement against a baseline or an absolute threshold.
2. Onsite combustion: New building construction and deep carbon retrofits pursuing ZCB-Design make great candidates for electrification due to their passive design approach to energy efficiency. The latest version imposes a limit on onsite combustion for space heating to ensure fossil fuels are used as a last resort only. One Impact and Innovation strategy recognizes projects that provide 100 percent of space heating without onsite combustion, while another recognizes multi-unit residential buildings that provide 100 percent of service hot water without onsite combustion. Combustion is also no longer permitted for fireplaces or residential stoves or ranges.
3. Energy performance: ZCB-Design v3 provides more flexibility to better recognize smart design choices in the achievement of **energy use intensity** (EUI) and **thermal energy demand intensity** (TEDI) targets. Most notably, teams can leverage absolute EUI targets for some building types rather than demonstrate an improvement against a modelled National Energy Code for Buildings baseline. This can make achievement fairer for some projects, while saving time and money spent on energy modelling.
4. District energy and **green heat**: District energy systems will play a significant role in building decarbonization, and their customers can help support this transition. By facilitating the sale of green heat to customers, ZCB-Design v3 helps district energy providers recoup their initial investments and reinvest in further decarbonization over time. ZCB-Design v3 also provides projects new options for demonstrating a future path to operations that do not rely on fossil fuel combustion.

These enhancements reflect changing market expectations and project feedback collected since the publication of ZCB-Design v2 in 2020. These updates provide project teams with additional flexibility to help lower costs to owners and operators.

With the ZCB-Design Standard, achieving a zero carbon building means taking responsibility for all carbon emissions over a building’s life cycle. It’s an ambitious but nonetheless critical objective, because within the context of a global carbon budget – every bit of carbon counts.

⁶ To assist readers, key terms are **bolded** and defined in the [Glossary](#).



THE FUNDAMENTALS OF GOOD DESIGN REMAIN UNCHANGED

1. The application of an integrated design approach is central to the success of any design project targeting zero carbon. Design teams should work together throughout the course of a new building project to find the best, lowest-cost approach to zero carbon.
2. Emphasis should remain on the dual goals of minimizing embodied carbon and reducing energy demand. Improvements to the building's envelope and ventilation strategies not only reduce energy demand, but also enable heating solutions that avoid fossil fuels, while minimizing or even reducing peak demand on the electricity grid.
3. Meeting a building's energy needs efficiently is a critical next step to reduce energy use and help save on energy costs. From heating and cooling to hot water and lighting, efficiency focuses on meeting energy needs with the least energy and carbon emissions.
4. Next, consideration should be given to how a building might generate onsite renewable energy, accounting for grid interactions to ensure real carbon reductions. Energy storage, whether in the form of electrical or thermal storage, is becoming recognized as a valuable strategy to help minimize grid impacts while reducing or eliminating the need for fossil fuels to meet peak heating demand and increasing building resilience.
5. Not all buildings can reach zero emission operations by solely relying on onsite measures, and the embodied carbon of construction materials can only be offset with measures beyond the building property. Therefore, building projects should consider the potential for offsite renewable energy and carbon offsets as a final measure towards attaining zero carbon.



OVERVIEW

The [Zero Carbon Building – Design \(ZCB-Design\) Standard](#) is a framework that guides the design of low-carbon, highly-efficient buildings, and sets a strong foundation for achieving zero carbon once the building is in operation. The Standard recognizes that there are many strategies for reducing carbon emissions at the design and operating stages and provides flexibility for buildings across Canada – of all sizes and uses – seeking to achieve certification.

The ZCB-Design Standard evaluates carbon emissions across the building life cycle, including both construction and operation. Certification is awarded based on the project’s final design, and teams are eligible to submit for certification once construction documents are ready. Projects are awarded certification once all requisite documentation is received and a review by CAGBC confirms the requirements of the ZCB-Design Standard have been met.

ZCB-Design certification may not be used to make a carbon-neutral claim about a product or service originating from a ZCB-Design certified building; however, it may form part of a strategy to achieve a carbon neutral claim. Even the best building design cannot ensure zero carbon operations. Consequently, ZCB-Design certified projects are not permitted to display a certification mark (logo) on the building or make a claim of zero carbon operations. Owner or project communications about the achievement of ZCB-Design certification should instead reflect the expectation that operations will be verified through [ZCB-Performance](#) certification following building occupancy. More information on how to market ZCB-Design certified projects can be found on cagbc.org.

ZCB-Performance certification demonstrates that a building has not impacted the climate over the course of one year of operation, as verified annually using operating data. Projects that achieve ZCB-Design v2 or v3 certification must verify airtightness and offset the embodied carbon of the structural and envelope materials to earn ZCB-Performance. Requirements for certification are established in the ZCB-Performance Standard.

ZCB-Performance certification demonstrates that a building has not impacted the climate over the course of one year of operation.

		ZCB-Design v3 One-time certification for new buildings and major renovations	ZCB-Performance v2 Annual certification for existing buildings
Carbon	Zero carbon balance	Model zero carbon balance	Achieve zero carbon balance
	Embodied carbon	Minimum level of performance required	Offset embodied carbon
	Refrigerants	Report total quantity	Offset any leaks
	RECs and carbon offsets	No purchase required	Provide proof of purchase
	Onsite combustion	For space heating, only below -10 C; transition plan may apply	Update transition plan every 5 years
Energy	Energy efficiency	Meet one of three approaches	Report EUI
	Peak demand	Report seasonal peaks	Report seasonal peaks
	Airtightness	Report and justify modelled value	Conduct testing if ZCB-Design v2 or v3 certified
Impact and Innovation		Apply two strategies	No requirement

Figure 3 – ZCB-Design facilitates operation as a zero-carbon building



ELIGIBILITY

The ZCB-Design Standard applies to all new buildings except single and multi-family residential buildings that fall under Part 9 of the National Building Code. Major renovations to existing buildings may pursue ZCB-Design certification provided they include HVAC, envelope, and/or interior renovations that require a new certificate of occupancy and/or prevent normal building operations from occurring while they are in process. Proposed changes of use to the building are also considered major renovations.

ZCB-Design v3 project boundaries may be aligned with LEED BD+C boundaries; however, LEED ID+C boundaries may not be used.

ZCB-Design may be used to evaluate entire buildings, as well as additions and attached buildings. Additions and attached buildings are subject to additional criteria, as outlined below.

ATTACHED BUILDINGS

Attached buildings may pursue ZCB-Design certification provided they are physically distinct and have a distinct identity. The following rules shall apply:

- Buildings that have no physical connection, or are connected by corridors, parking, or mechanical/storage rooms, are considered separate buildings.
- Attached buildings must be physically distinct to be considered separate for certification.
- Attached buildings must have distinct identity. This ensures that the certification is communicated appropriately to the building users and the public. Applicants must seek clarification with CAGBC by emailing zerocarbon@cagbc.org when compliance is uncertain.
- Attached buildings generally share a common site and will need to consider appropriate separation of that site to determine the emission sources to include in the project.
- Attached buildings must have separate ventilation systems as well as energy meters capable of measuring energy use for electricity, heating, and cooling. This is necessary to demonstrate compliance with the energy and carbon requirements of the Standard.

ADDITIONS

New constructed additions to buildings may pursue ZCB-Design certification provided they are sufficiently physically distinct to pursue certification. The following rules shall apply:

- Additions must be physically distinct, representing a newly constructed, unique area of a building. The distinct space must also be reflected in the project name when registering.
- Additions must have separate ventilation systems as well as energy meters capable of measuring energy use for electricity, heating, and cooling. This is necessary to demonstrate compliance with the energy and carbon requirements of the Standard.



SCOPE

The ZCB-Design Standard applies to the entirety of the building site and includes all emissions outlined below:

- Direct (Scope 1) emissions from the combustion of fossil fuels
- Direct (Scope 1) **fugitive emissions** from the leakage of refrigerants from base building HVAC systems with a capacity of 19 kW or greater
- Indirect (Scope 2) emissions from purchased electricity, heating, or cooling
- **Embodied carbon** (Scope 3) emissions that are associated with new structural and building envelope materials

REQUIREMENTS AT A GLANCE

While a high-level summary of requirements is provided for convenience here, applicants are advised to read the entire Standard for full details on requirements.

- Projects must report **operational carbon**, embodied carbon, and avoided emissions values, and model a zero-carbon balance (note: offsets are allowed as part of the balance).
- Projects must demonstrate that their **embodied carbon** intensity is at or below an established target, or that it meets a percentage reduction target when compared to a baseline building.
- Projects must be capable of providing all space heating with installed non-combustion-based technologies at an outdoor air temperature of -10 C or the design temperature, whichever is higher, and eliminate combustion from fireplaces and residential stoves and ranges.
- Projects that use any combustion for space heating or service hot water must prepare a zero-carbon transition plan.
- Projects must report modelled energy performance using TEDI, EUI, and seasonal peak demand.
- Projects must meet the energy performance requirements of the selected approach to energy efficiency.
- Projects must demonstrate the inclusion of two Impact and Innovation strategies. At least one of these strategies must come from a pre-approved list.

The following additional requirements will apply to ZCB-Design v2 and v3 certified projects when they pursue ZCB-Performance; compliance will be reviewed during the first annual ZCB-Performance review:

- Embodied carbon must be offset.
- Airtightness testing must be performed after construction is complete.



REQUIRED DOCUMENTATION

Applicants must complete the [ZCB-Design v3 Workbook](#)⁷ to demonstrate compliance with the ZCB-Design requirements. The [ZCB-Design v3 Workbook](#) contains a full list of required supporting documentation. Applicants should use the most recent version of the [ZCB-Design v3 Workbook](#); however, they may opt to use the version available at the time of project registration, provided that the emission factors from the most recent version are applied.

The [ZCB-Design v3 Energy Modelling Guidelines](#)⁸ are also an important resource that must be followed. These guidelines contain requirements specific to the development of the energy model required for ZCB-Design certification.

⁷ Available at cagbc.org/wp-content/uploads/2022/06/ZCB-Design_v3_Workbook.xlsx.

⁸ Available at cagbc.org/wp-content/uploads/2022/06/ZCB-Design_v3_energy_modelling_guidelines.pdf



CARBON

The ZCB-Design Standard recognizes that the holistic assessment of carbon emissions is the best measure of progress towards minimizing climate change impacts from buildings. The ZCB-Design Standard provides a framework for superior carbon and energy performance. The intent is that all buildings that achieve ZCB-Design certification will be equipped to achieve zero carbon when operational. Applicants for ZCB-Design certification must quantify, reduce, and optimize emissions across the building’s full life cycle, recognizing the impact of construction materials and building operations. A carbon balance of zero or better must be demonstrated for ZCB-Design certification. The carbon balance is the net emissions that result from sources and sinks of carbon emissions, calculated as follows:

Requirements at a Glance

Projects must report operational carbon, embodied carbon, and avoided emissions values, and model a zero-carbon balance (offsets are allowed).

Projects must achieve a minimum level of performance for embodied carbon.

Projects must be capable of providing all space heating with installed non-combustion-based technologies at an outdoor air temperature of -10 C or the design temperature, whichever is higher, and eliminate combustion from fireplaces and residential stoves and ranges.

Projects that use any combustion for space heating or service hot water must prepare a zero-carbon transition plan.

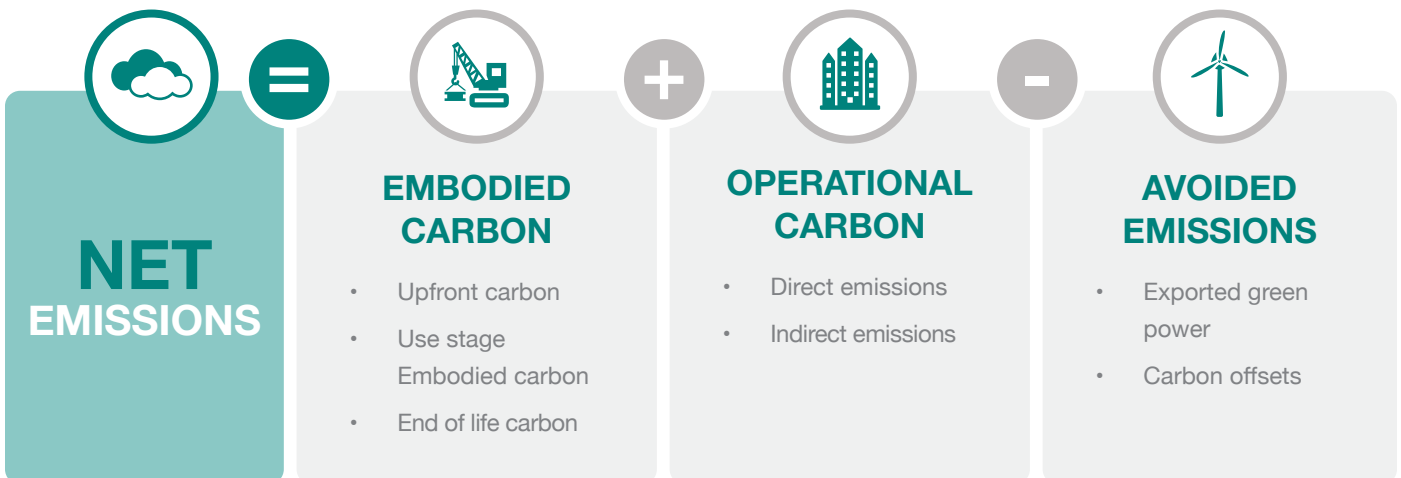


Figure 4 – Calculating a zero-carbon balance



Embodied carbon, operational carbon, and avoided carbon emissions are separately addressed in the next three sections. Together, **embodied carbon** and **operational carbon** over the life of the building are known as **whole life carbon**.

The [ZCB-Design v3 Workbook](#) has been designed to simplify the calculation of the carbon balance, and applicants must use this tool for their calculation of the carbon balance.

Consistent with the approach taken by Canada's *National Inventory Report*, emissions in the ZCB-Design Standard are presented in carbon dioxide equivalents (CO₂e), or the volume of CO₂ emissions that would have an equivalent **global warming potential (GWP)** over 100 years.

However, projects are urged to also consider emissions using 20-year GWP values. Methane and some types of refrigerants act as near-term climate forcers, which means they have a short life but a high heat-trapping potential. For example, as methane only survives in the atmosphere for 12.4 years, it has 72 times the heat-trapping potential of CO₂ when measured over 20 years, but only 25 times the heat-trapping potential of CO₂ over 100 years.⁹ Using 100-year GWP values misrepresents the large heat-trapping impact of these emissions over the next few decades – the period of time that we have left to take meaningful action on climate change.¹⁰

⁹ Contribution of Working Group I to the Fourth Assessment Report of the IPCC, Climate Change 2007 - The Physical Science Basis, p. 33.

¹⁰ Chartered Professional Accountants Canada, The Time Value of Carbon – Smart Strategies to Accelerate Emissions Reductions, p.11.

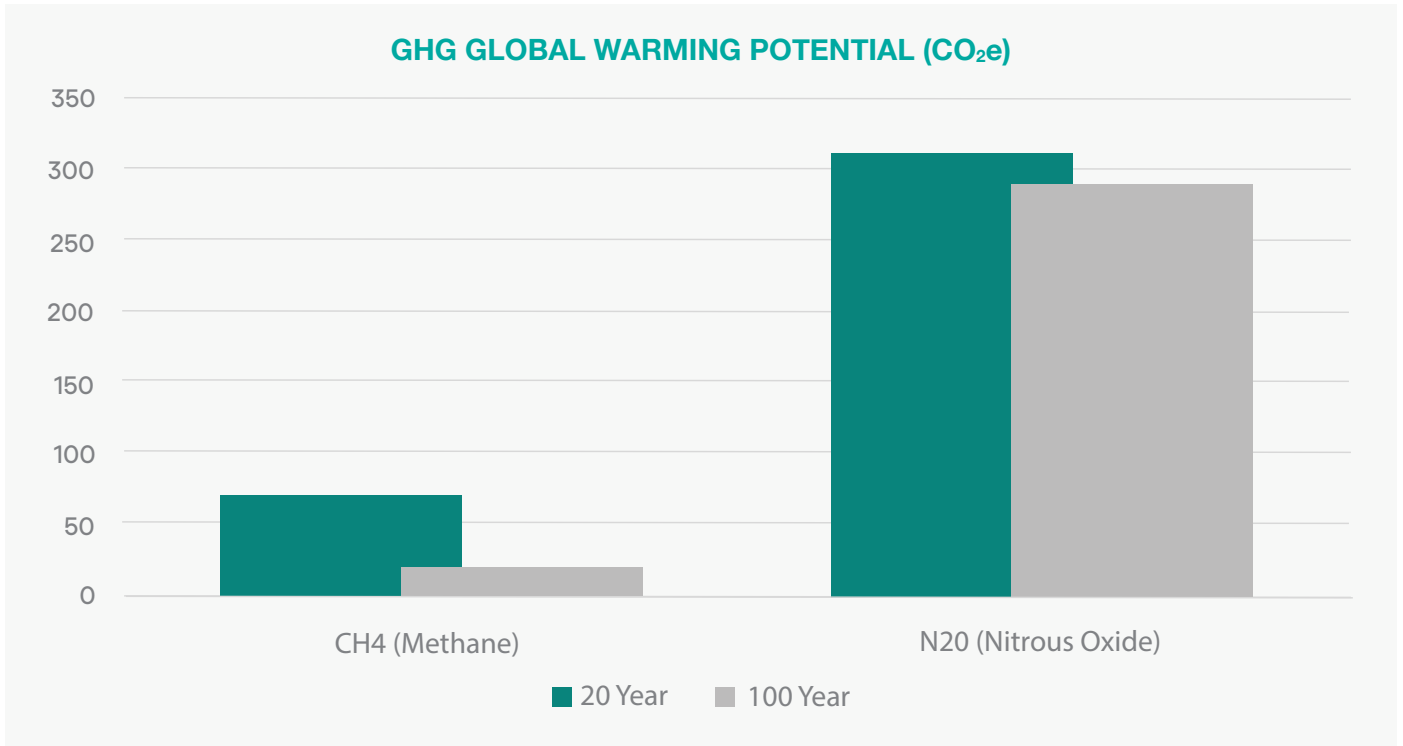


Figure 5 – 20- and 100-year **global warming potential (GWP)** of methane (source: IPCC 4th assessment report)

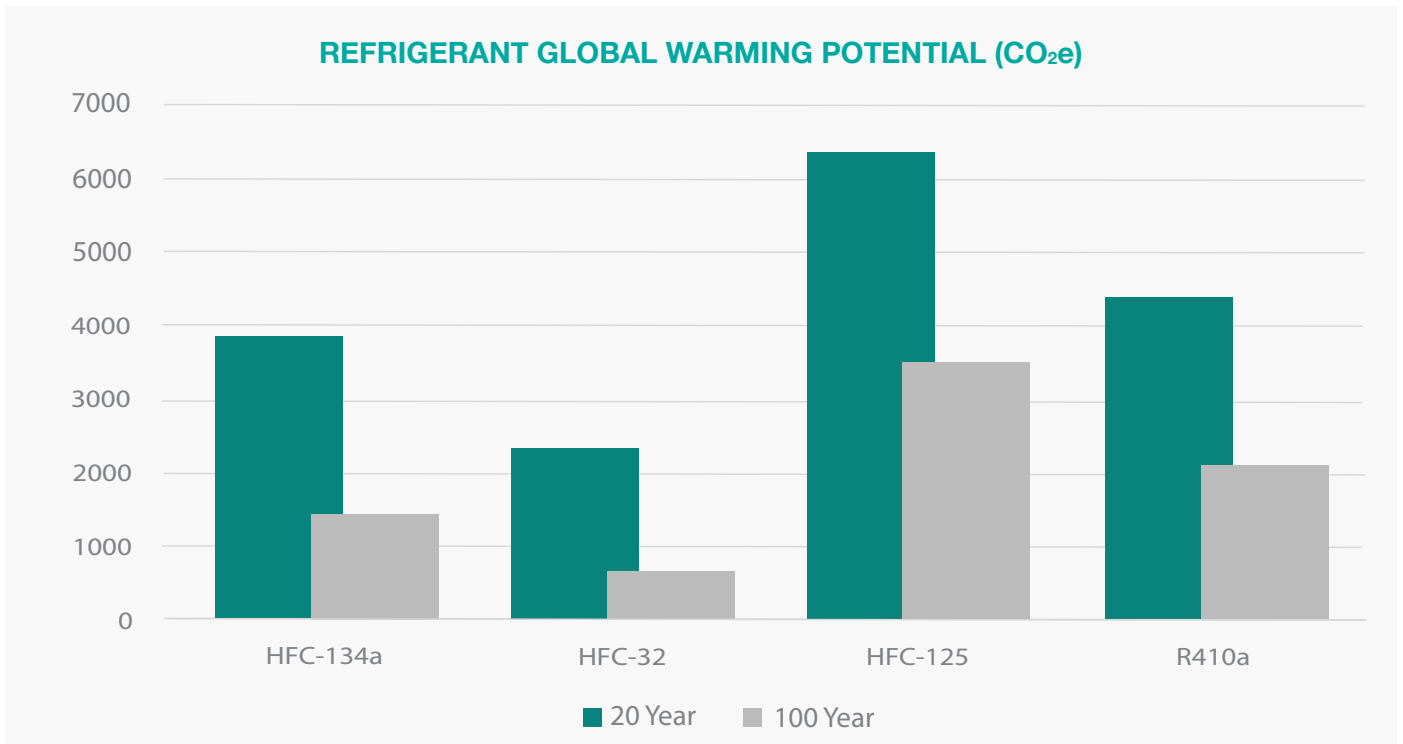


Figure 6 – **Global warming potential (GWP)** values of common refrigerants (source: IPCC 4th assessment report)



EMBODIED CARBON

Embodied carbon emissions are derived from the manufacturing, transport, installation, use, and end-of-life of building materials. The *ZCB-Design Standard* focuses on carbon emissions across the entire life cycle of the building and as such, reductions in **embodied carbon** should be pursued as part of an approach that includes consideration of carbon from building operations (**operational carbon**).

Embodied carbon emissions represent approximately 10 percent of all energy-related carbon emissions globally.¹¹ Furthermore, emissions that occur during the production and construction phases, referred to as upfront carbon, are already released into the atmosphere before the building is operational. Given that the timeframe for meaningful climate action is shrinking, there is a growing awareness of the critical importance of addressing **embodied carbon**.



Figure 7 – Impact of Upfront and Operational Carbon Emissions

METRICS

Embodied carbon includes metrics for the following life cycle stages, illustrated in Figure 8:

- **Upfront carbon** (life cycle stages A1-5)
- **Use stage embodied carbon** (life cycle stages B1-5)
- **End of life carbon** (life cycle stages C1-4)

The total embodied carbon can also be expressed as an intensity value by dividing it by the **gross floor area**.

¹¹ Global Alliance for Buildings and Construction, 2021 Global Status Report for Buildings and Construction, p. 12.

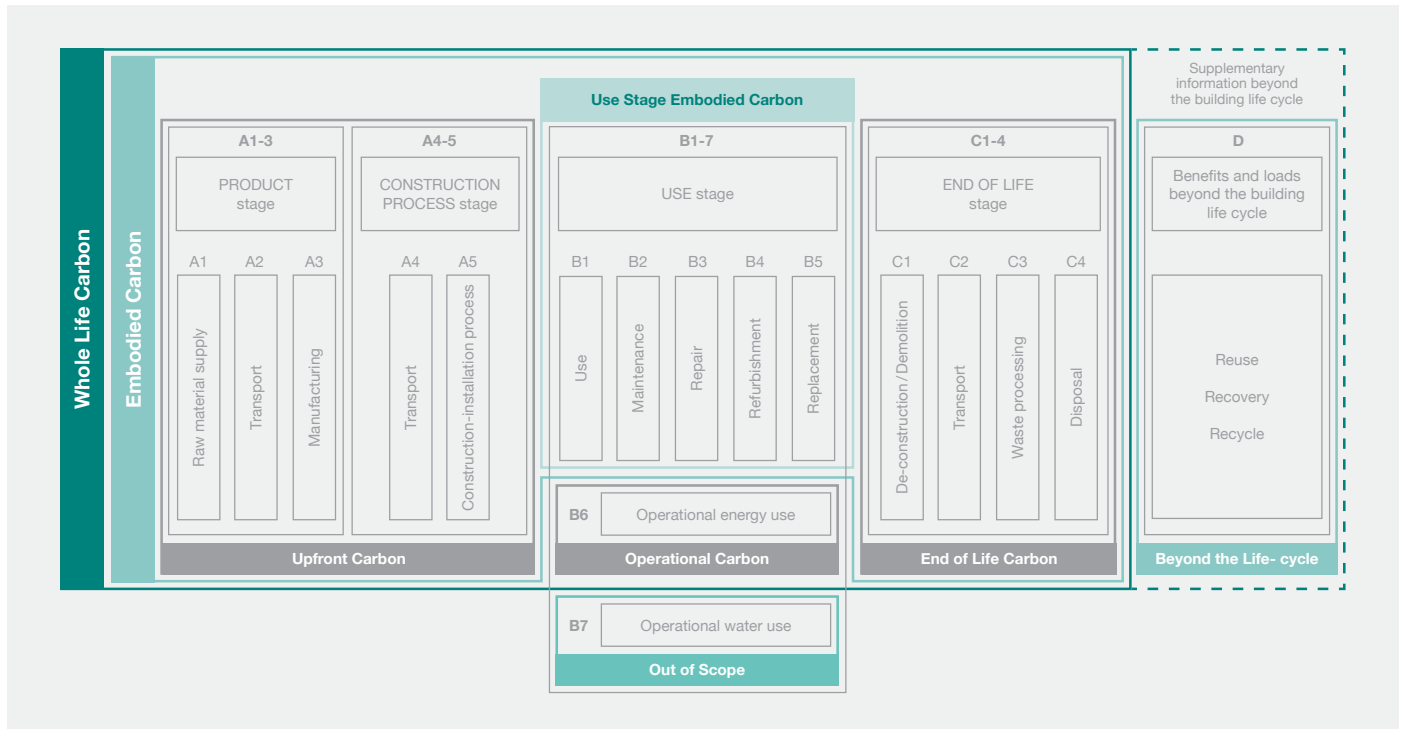


Figure 8 – Embodied carbon life cycle stages

REQUIREMENTS

REPORTING

Applicants must provide an embodied carbon report demonstrating that the requirements outlined below have been met. The [ZCB v3 Embodied Carbon Reporting Template](#)¹² may be used for this purpose.

Projects must conduct a life cycle assessment of the building materials that includes the following life cycle stages, illustrated in Figure 8:

- **Upfront carbon** (life cycle stages A1-5)
- **Use stage embodied carbon** (life cycle stages B1-5)
- **End of life carbon** (life cycle stages C1-4)

Projects must also report their embodied carbon intensity, which is the total embodied carbon divided by the **gross floor area**.

If the **LCA** software used by the project team does not provide a value for any of the life cycle phases above, the project team must provide a narrative explaining what is absent and why. Additionally, if the **LCA** software produces a value for **beyond the life cycle carbon** (life cycle stage D), projects must report that as supplementary information. If stage D is reported, projects must report D1-D3 only. D4 Exported Energy relates to operational carbon and must not be included. Project teams interested in

¹² Available at https://www.cagbc.org/wp-content/uploads/2022/06/ZCB_v3_Embodied_Carbon_Reporting_Template.docx.



maximizing the opportunity for material circularity, recognized in stage D of the life cycle assessment, should consider designing for disassembly.¹³

Biogenic carbon is the carbon temporarily sequestered in materials that are manufactured from renewable resources such as trees and other living organisms, also known as biomaterials. Sequestering (storing) **biogenic carbon** in building materials is one way to reduce **upfront carbon**. Materials can lock carbon away over many decades and, in some instances, in perpetuity. It is sometimes even possible to store more carbon than results from the manufacturing and other upfront life cycle stages of materials. As such, **upfront carbon** emissions can be a negative value.

Biogenic carbon should not be included in the embodied carbon values reported, but projects are encouraged to report it separately. If the **LCA** software produces a value for biogenic carbon, that value may be used; otherwise, the project may choose to quantify **biogenic carbon** using an alternative documented methodology (such as GWPbio¹⁴).

To encourage building material reuse, the **LCA** should include new materials only. The **LCA** must include all permanently installed envelope and structural elements, including footings and foundations, complete structural wall assemblies (from cladding to interior finishes, including basement), structural floors and ceilings (not including finishes), roof assemblies, and stairs. Parking structures are to be included; however, excavation and other site development, partitions, temporary works, building services (electrical, mechanical, fire detection, alarm systems, elevators, etc.), and surface parking lots are excluded.

Projects that wish to evaluate their **embodied carbon** more fully may elect to include materials beyond the structure and envelope at their discretion provided they are reported as separate line items. For example, the fit-up of interior spaces may provide opportunities for **embodied carbon** reductions.

The **LCA** must assume a building service life of 60 years. This service life ensures standardized reporting throughout the program and may not reflect the service life the project is designed for. If the service life of a product used in initial construction is longer than the building's assumed service life, the impacts associated with the product may not be discounted to reflect its remaining service life.

Embodied carbon must be reported in kilograms of carbon dioxide equivalent (kg CO₂e) as a total value, and broken down in two different ways:

1. A life cycle stage analysis including totals for stages A, B, C, and D (if available); and,
2. A contribution analysis broken out by either material type or by building assembly.

The *National Guidelines for Whole Building Life Cycle Assessment*, prepared by the National Research Council under the Low-Carbon Assets through Life Cycle Assessment initiative, provide additional detail on how to perform a whole building LCA. LCA practitioners should rely on this guidance to provide direction when needed (see the Resources section below).

¹³ See ISO 20887:2020 Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance, available at <https://www.iso.org/standard/69370.html>.

¹⁴ See <https://www.worldwildlife.org/projects/biogenic-carbon-footprint-calculator-for-harvested-wood-products>.



MINIMUM PERFORMANCE

ZCB-Design projects must meet a minimum achievement threshold for embodied carbon. Project teams must demonstrate that their embodied carbon intensity is at or below an established target, or that it meets a percentage reduction target when compared to a baseline building, whichever is preferred. Refer to Appendix I for more information on how to establish a baseline building.

Compliance options	
Percent improvement over a baseline	Absolute embodied carbon intensity
≥10%	≤500 kg CO ₂ e/m ²

The minimum performance thresholds were set to be achievable by all building types in all regions of Canada using the best data available. Note that the percent reduction and absolute target alternatives are not necessarily meant to be equivalent. Projects that have unique structural/envelope characteristics or location challenges that make these targets unrealistic are encouraged to contact CAGBC at zerocarbon@cagbc.org to discuss options as soon as possible.

To provide an opportunity to influence design, it is recommended that embodied carbon discussions begin during pre-design, and that analysis begin no later than schematic design.

Absolute embodied carbon values are assessed at or near final design. Projects that further refine their LCA to match the final bill of materials may find that the embodied carbon increases; however, the refined values are not required for certification and will not impact compliance with the minimum performance threshold.

As noted in the Reporting section, **biogenic carbon** is not included in the embodied carbon values reported (although it may be reported separately), and therefore does not contribute to meeting the minimum performance threshold.

Further incentive is provided for projects that exceed the minimum level of performance. See the Impact and Innovation section for additional information.

OFFSETTING

After minimizing **embodied carbon** emissions during design and construction, projects that have achieved ZCB-Design v2 or v3 will be required to offset their **embodied carbon** to achieve ZCB-Performance certification.

Projects that intend to seek ZCB-Performance certification may wish to offset their embodied carbon using the capital budget for design and construction. While this approach is encouraged, ZCB-Performance provides the flexibility to mitigate **embodied carbon** by offsetting equal amounts annually over as many as five years. **Beyond the life cycle carbon** (life cycle stage D) is not included in **embodied carbon** and does not need to be offset when seeking ZCB-Performance certification.



RESOURCES



National Research Council – National Guidelines for Whole Building Life Cycle Assessment

<https://nrc-publications.canada.ca/eng/view/object/?id=f7bd265d-cc3d-4848-a666-8eeb1fbde910>

This document provides comprehensive instruction for the practice of life cycle assessment applied to buildings, based on relevant standards and keyed to various intentions. The goal is to harmonize the practice of whole-building life cycle assessment (wbLCA) across different studies and assist in interpretation of and compliance with relevant standards.

Strategies for Low Carbon Concrete: Primer for Federal Government Procurement

<https://nrc-publications.canada.ca/eng/view/object/?id=d15ccce0-277b-4eed-80ac-d0462b17de57>

Produced by the National Research Council through the Low-Carbon Assets initiative² this primer introduces the concept of embodied carbon of concrete, presents current industry best practices to reduce CO₂ emissions associated with concrete production, identifies approaches in mix design and specification, and provides a high-level overview of the federal procurement process with potential insertion points where new low-carbon concrete policies and procedures could be introduced into the federal procurement process.

ISO 20887:2020 Sustainability in Buildings and Civil Engineering Works – Design for Disassembly and Adaptability – Principles, Requirements and Guidance

<https://www.iso.org/standard/69370.html>

ISO 20887 provides an overview of design for disassembly and adaptability (DfD/A) principles and potential strategies for integrating them into the design process. The document provides information for owners, architects, engineers, and product designers and manufacturers to assist in their understanding of potential DfD/A options and considerations, and for other parties who are responsible for financing, regulating, constructing, transforming, deconstructing, or demolishing construction works.

The Carbon Smart Materials Palette

<https://materialspalette.org/>

The Carbon Smart Materials Palette, produced by Architecture 2030, provides attribute-based design and material specification guidance for immediately impactful, globally applicable and scalable **embodied carbon** reductions in the built environment.



RESOURCES

Bringing Embodied Carbon Upfront

<https://www.worldgbc.org/news-media/bringing-embodied-carbon-upfront>

Bringing Embodied Carbon Upfront is a 'call to action' report focusing on **embodied carbon** emissions, as part of a whole life cycle approach, and the systemic changes needed to achieve full decarbonisation across the global buildings sector.

It was produced by the World Green Building Council.

Embodied Carbon Benchmarking Study

<https://carbonleadershipforum.org/lca-benchmark-database/>

The Carbon Leadership Forums' *Embodied Carbon Benchmarking Study* establishes consensus on the order of magnitude of typical building **embodied carbon**, identifies sources of uncertainty, and outlines strategies to overcome this uncertainty.



OPERATIONAL CARBON

Operational carbon emissions are associated with energy use and the release of refrigerants during regular building operations. The ZCB-Design Standard leverages the methodology of the GHG Protocol's *Corporate Accounting and Reporting Standard* for the quantification of emissions from the operation of the building.

METRICS

Direct Emissions: emissions that occur directly at the project site, including:

- **Fugitive emissions** from refrigerants
- Emissions from the combustion of fossil fuels
- Emissions from the combustion of biogenic materials (biogas & biomass)

Indirect Emissions: emissions that do not occur directly at the project site, including:

- Emissions from district heating & cooling, and any reductions associated with the procurement of **green heat**.
- Emissions from grid purchased electricity, and any reductions associated with **renewable energy** or **green power products**

REQUIREMENTS

Operational carbon must be assessed and reported in the [ZCB-Design v3 Workbook](#), following the details below. Operational carbon represents the largest source of carbon over a building's life cycle when fossil fuels are used for space heating and service hot water, as is currently standard practice across most of Canada. It is therefore critical to achieving the zero-carbon balance requirement of the ZCB-Design Standard. Operational carbon must also be reported annually and compensated for with avoided emissions (carbon offsets and exported green power) to demonstrate that a building has had no climatic impact over a year of operation per the requirements of the [ZCB-Performance Standard](#).

DIRECT EMISSIONS

Direct emissions refer to emissions that occur at the project site as a result of the combustion of fossil fuels or the release of refrigerants.

FUGITIVE EMISSIONS FROM REFRIGERANTS

Low-carbon designs often take advantage of the efficiency provided by heat pump technology, such as variable refrigerant flow (VRF) systems. Refrigerants used in heat pump equipment can contribute to climate change when they leak into the atmosphere or are improperly disposed of at their end of life. Project teams should consider the **global warming potential (GWP)** of different refrigerant options when making design decisions, as the heat-trapping potential of some options can be hundreds or even thousands of times greater than other choices.



ZCB-Design certification requires projects to report the total quantity, type, and **GWP** of each refrigerant contained in all base building HVAC systems with a capacity of 19 kW (5.4 tons) or greater. This is consistent with the *Federal Halocarbon Regulations* (2003) that regulate all federal government buildings in Canada. Reporting the **GWP** will enable project teams to understand the implications of an accidental refrigerant leak. Refrigerants which do not have a **GWP** do not need to be reported.

COMBUSTION

The *ZCB-Design v3 Workbook* applies **emissions factors** to calculate annual building emissions associated with onsite combustion. Provincial GHG factors are used for natural gas, while national factors are used for other fossil fuels (e.g. propane, fuel oil, and diesel). Emission factors are sourced from the most recent release of Canada's *National Inventory Report* and may be updated periodically. Projects must use the **emissions factors** in the most recent *ZCB-Design v3 Workbook* available at the time of submission for certification. Fuel used in emergency back-up generators does not need to be estimated for ZCB-Design certification however, it must be included in the zero-carbon balance for ZCB-Performance certification.

BIOGAS

The ZCB-Design Standard recognizes the benefits of certain forms of renewable natural gas (biogas). Eligible biogas resources (i.e. those that are considered **zero emissions biofuels**) that can be used onsite include gaseous products produced by the anaerobic decomposition of organic wastes from one of the following sources:

- a. Sewage treatment plants;
- b. Manure and other farm and food/feed-based anaerobic digestion processing facilities; and
- c. Landfill gas.

Applicants must either produce their own biogas onsite, or purchase biogas from their natural gas provider for it to be eligible. Eligible biogas emissions are assigned an **emissions factor** of zero and do not contribute to **direct emissions**.

BIOMASS

The ZCB-Design Standard does not treat all biomass as carbon neutral but does recognize the benefits of certain forms of renewable biomass. As such, applicants who use an onsite form of biomass may propose more specific **emissions factors** where they can be verified by a registered professional.

Biomass resources used onsite that are eligible to be treated as **zero emissions biofuels**¹⁵ include:

- a. Solid biomass removed from fields and forests that are managed by following sound environmental management practices.¹⁶ Solid biomass can either be whole plants, parts of plants, or harvesting and industrial by-product residues arising from the harvesting and processing of agricultural crops or forestry products that would otherwise be land filled or incinerated;
- b. Dedicated energy crops with a rotation of less than 10 years; and
- c. Liquid fuels derived from biomass as defined in items (a) and (b) above, including, among other things, ethanol, biodiesel, and methanol.

¹⁵ 'Zero emissions' is meant to characterize certain biofuels from a net-carbon emissions perspective; it is understood that other combustion products are released during combustion.

¹⁶ Refer to *UL 2854 Standard for Sustainability for Renewable Low-Impact Electricity Products* for a definition of 'sound environmental management practices'.



Biomass resources that are ineligible to be treated as **zero emissions biofuels** include:

- a. Municipal solid waste; and
- b. To prevent toxic emissions, those manufacturing process by-products that have been treated in the manners listed below:
 - i. Wood coated with paint, plastics or formica;
 - ii. Wood treated with preservatives containing halogens, chlorine or halide compounds like chromated copper arsenate or arsenic;
 - iii. Wood that has been treated with adhesives; and
 - iv. Railroad ties.

If the treated biomass types (per (b) above) comprise one per cent or less by weight of the total biomass used, and the remainder is from eligible sources of biomass, all biomass may be considered eligible to be treated as a **zero emissions biofuel**.

Eligible **zero emissions biofuels** are quantified with an **emissions factor** of zero and do not contribute to **direct emissions**.

INDIRECT EMISSIONS

Indirect emissions refer to emissions that do not occur directly within the project site, such as emissions associated with purchased energy, water use, waste, and transportation from commuting. As detailed below, **indirect emissions** within the scope of ZCB-Design certification include only the emissions associated with purchased energy, such as electricity or thermal energy.

DISTRICT HEATING AND COOLING

The [ZCB-Design v3 Workbook](#) is preloaded with default **emissions factors** for district steam, district hot water, and three types of district chilled water systems. Applicants are required to identify and enter the fuel being used and, if using district chilled water, the type of chilled water system.

The ZCB-Design Standard recognizes that the default **emissions factors** may not accurately reflect those of the district heating or cooling source for a given building. The **emission factors** for these specific sources may be used where they are available and can be verified by a registered professional.

GREEN HEAT

Green heat is district heating that is generated using clean energy technologies or **zero emissions biofuels**. When the associated **environmental attributes** are bundled in the purchase of **green heat**, each unit of procured **green heat energy** can replace an equivalent amount of district heating in the calculation of the zero-carbon balance. Procured **green heat** cannot be used to reduce other sources of emissions.

The accounting for the district energy provider's **green heat** program must meet the quality criteria established by the GHG Protocol Scope 2 Guidance.¹⁷ The district energy provider must obtain an annual third-party audit of the generation and sale of **green heat** as well as compliance with the quality criteria.

¹⁷ [Scope 2 Guidance | Greenhouse Gas Protocol \(ghgprotocol.org\)](#) Table 7.1 page 60.



ELECTRICITY

Provincial **location-based electricity grid emissions factors** are used to represent the average emissions of all grid-connected electricity generation in a given province. Provincial **location-based electricity grid emissions factors** are included in the [ZCB-Design v3 Workbook](#), which is periodically updated to reflect the latest emission factors from Environment and Climate Change Canada's *National Inventory Report*.¹⁸ Projects may substitute a market-based **residual mix emissions factor** if their local utility has published one. **Residual mix emissions factors** are an emerging way to account for the retirement of **green power products** within a specific geographic boundary; however, they are not widely available in North America. Projects wishing to use this option may enter a custom **emissions factor** in the [ZCB-Design v3 Workbook](#) and provide the source of the **residual mix emissions factor**.

The ZCB-Design Standard recognizes that in some instances electricity may be sourced from a district energy system or an **islanded grid** (a small grid not connected to the provincial grid). The **emission factors** for these specific sources may be used where they are available and can be verified by a registered professional. Projects wishing to use this option may enter a custom **emissions factor** in the [ZCB-Design v3 Workbook](#).

Electricity used by electric vehicle charging stations that service vehicles used outside the project site should be separately metered and excluded from the calculation of **indirect emissions** from grid electricity.

OWNED RENEWABLE ENERGY SYSTEMS

Owned **renewable energy** systems, whether onsite or offsite, reduce the need for electricity grid power, fuel, heating and/or cooling, and thereby reduce the emissions associated with these energy sources. **Renewable energy systems** typically take the form of solar or wind power generation and solar thermal heating.

If **green power** is generated in excess of energy use as evaluated on an hourly basis, it contributes to the avoided emissions from exported **green power** (see Avoided Emissions from Exported **Green Power** section).

All **environmental attributes** (in the form of **renewable energy certificates**) associated with the onsite or offsite generation and/or export of **green power** must be retained by the applicant and cannot be sold to count toward the achievement of the zero-carbon balance. Exceptions may be made in some cases where retaining **environmental attributes** is outside the control of the project team. Examples include where a non-negotiable **net-metering** contract or local energy legislation requires that the attributes be surrendered to the local utility or government.

ONSITE

Onsite renewable energy helps to improve building resilience in the face of power outages, reduces the total energy use and overall demand from the electrical grid, minimizes environmental impacts from power **generation facilities**, and helps build the knowledge and marketplace for a distributed energy future.

Applicants to the ZCB-Design program must report their total modelled **onsite renewable energy**. Note that the usable energy produced by the renewable energy system is the output energy from the system less any transmission and conversion losses, such as standby heat loss or losses when converting electricity from DC to AC.

¹⁸ Latest version of the report is: Environment and Climate Change Canada, *National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada*, A13.



Onsite power generation systems may or may not be net metered. **Net-metering** allows a project to connect renewable power generation equipment to the local grid and receive a credit on their bill for any electricity that is exported to the grid.

OFFSITE

Offsite **renewable energy** systems must be new and **virtually net-metered** to the building seeking certification. **Virtual net-metering** is an arrangement with the utility whereby **green power** generation equipment is installed in another location and net-metered against (deducted from) the building's electricity bill. Alternatively, offsite systems may take the form of **green power** systems installed on adjacent buildings within a campus.

GREEN POWER PRODUCTS

Green power products involve the purchase of **bundled green power** or **green power environmental attributes**. Each kilowatt-hour of procured **green power products** can replace an equivalent amount of grid electricity in the calculation of the zero-carbon balance. Procured **green power products** cannot be used to reduce other sources of emissions.

To qualify under the ZCB-Design Standard **green power products** can be generated anywhere in Canada, however project teams are encouraged to consider local options first. **Green power products** must be generated from:

- Solar energy;
- Wind;
- Water (including low-impact hydro, wave, tidal, and in-stream sources);
- Qualifying biogas (see Combustion section);
- Qualifying biomass (see Combustion section); or,
- Geothermal energy.

Green power products purchased to meet regulatory programs may also contribute to the balance provided they meet the ZCB-Design program's requirements. For example, where a building is in a municipality or province that requires buildings to offset their operational energy consumption with the purchase of **green power**, these purchases can also be used to meet the requirements of the ZCB-Design Standard.

Not all forms of **green power products** provide the same level of **additionality**. **Additionality** refers to the likelihood that the procurement of **green power products** will result in new renewable electricity generation equipment that would not otherwise have been installed. The following hierarchy has been established to ensure that project teams are aware of the different options available and can explore the highest quality options first.

1. Power Purchase Agreements (PPAs): A **power purchase agreement** is a contract for **green power** and the associated **environmental attributes** that typically includes the purchase of a significant volume of electricity under a contract that lasts for at least fifteen years. **PPAs** are among the highest-quality forms of **green power product** procurement. They are most used at the company-wide scale and are not suitable for use by a single building. **PPAs** are also not available in all regions of Canada. All **PPAs** must be certified by either ECOLOGO or Green-e® Energy, or meet the requirements outlined in Appendix II - Requirements for Bundled Green Power Products that are not ECOLOGO or Green-e® Energy Certified. All power must be from **green power** facilities in Canada.
2. Utility Green Power: **Utility green power** is a product offered by some utilities in Canada where the electricity and the associated **environmental attributes** (in the form of **renewable energy certificates**) are sold together. Unlike a **PPA**, **utility green power** purchases often do not require a volume purchase or fixed term. All **utility green power** must be certified by



either ECOLOGO or Green-e® Energy, or meet the requirements outlined in Appendix II - Requirements for Bundled Green Power Products that are not ECOLOGO or Green-e® Energy Certified. All power must be from **green power** facilities in Canada.

3. Renewable Energy Certificates (RECs): **Renewable energy certificates** are market instruments that represent the environmental benefits associated with one megawatt hour of electricity generated from renewable resources such as solar and wind. They can be purchased from a third party. All **RECs** must be certified by ECOLOGO or Green-e® Energy and generated from **green power** facilities located in Canada.

ZCB-Design certification requires at least one price quote for the annual volume of **green power products** anticipated to be required. **Green power product** purchases are verified for ZCB-Performance certification.



RESOURCES



The GHG Protocol – A Corporate Accounting and Reporting Standard

<https://ghgprotocol.org/corporate-standard>

The GHG Protocol Corporate Accounting and Reporting Standard provides requirements and guidance for organizations preparing a corporate-level greenhouse gas (GHG) emissions inventory and forms the basis for the GHG quantification methodology used in the ZCB-Design Standard.

The GHG Protocol – Scope 2 Guidance

https://ghgprotocol.org/scope_2_guidance

The GHG Protocol Scope 2 Guidance standardizes how corporations measure emissions from purchased or acquired electricity, steam, heat and cooling (called **indirect emissions** in the ZCB-Design Standard).

National Inventory Report: GHG Sources and Sinks in Canada

<https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html>

Each year, Canada submits a national GHG inventory to the United National Framework Convention on Climate Change (UNFCCC). The report from Environment and Climate Change Canada covers human caused emissions and removals. Also published in the report are the current **emissions factors** for fuels and electricity in Canada.

The Time Value of Carbon: Smart Strategies to Accelerate Emission Reductions

<https://www.cpacanada.ca/en/business-and-accounting-resources/financial-and-non-financial-reporting/sustainability-environmental-and-social-reporting/publications/time-value-of-carbon-smart-strategies>

Produced by CPA Canada, *The Time Value of Carbon* examines how to accelerate GHG reductions by addressing **near-term climate forcers (NTCFs)**, the short-lived GHGs that significantly contribute to global warming.

Refrigerants & Environmental Impacts: A Best Practice Guide

<https://www.integralgroup.com/news/refrigerants-environmental-impacts/>

This best practice guide by Integral Group is intended to help those responsible for the design, installation, commissioning, operation, and maintenance of building services to make well-informed decisions in the design of refrigerant-based systems. This guide is particularly useful during initial design stages, whenever these systems are being considered.



AVOIDED EMISSIONS

Avoided emissions are emissions reductions that occur outside of the value chain or life cycle of a building. The ZCB-Design Standard recognizes avoided emissions from investments in **carbon offset** projects, as well as avoided emissions based on the grid-level impacts provided by exporting **green power**.

METRICS

The following metrics are used for assessing avoided emissions:

- Avoided Emissions from Exported Green Power: The amount of **renewable energy** that is generated in excess of energy used (as evaluated on an hourly basis) and then exported to the electricity grid.
- Avoided Emissions from **Carbon Offsets**: The amount of **carbon offsets** purchased for the project.

REQUIREMENTS

Avoided emissions must be assessed and reported in the [ZCB-Design v3 Workbook](#), following the direction provided below. Avoided emissions are critical to achieving a zero-carbon balance and are used to offset **operational carbon** and **embodied carbon** when demonstrating that a building has had no impact on the climate over a year of operation, per the requirements of the [ZCB-Performance Standard](#).

AVOIDED EMISSIONS FROM EXPORTED GREEN POWER

If **renewable energy** is generated in excess of energy used (as evaluated on an hourly basis) and then exported to the electricity grid, it is recognized as contributing to avoided emissions, provided that the associated **renewable energy certificates** are retained. Avoided emissions from exported **green power** can only be used to reduce **indirect emissions** from electricity.

A project's avoided emissions are calculated using **marginal electricity grid emissions** factors for each province. These factors are based on the emissions intensity of the non-baseload electricity generation, which better captures the grid-level emissions reductions that are achieved (given that baseload electricity generation is unaffected by additions of intermittent **renewable energy**). The GHG Protocol's *Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects*¹⁹ champions a marginal approach to quantify emissions reductions based on the grid-level carbon impacts. This approach is further supported by a recent working paper from the GHG Protocol titled *Estimating and Reporting the Comparative Emissions Impacts of Products*.²⁰ This working paper advocates for avoided emissions to consider the system-level impacts when bringing products (such as buildings) to market.

Project teams that would rather use provincial **location-based electricity grid emissions factors** to measure avoided emissions may opt to do so at their own discretion. These factors are based on the average emissions intensity of all types of electricity generation within a province. In high-carbon grids where the average emissions intensity is higher than the marginal emissions intensity (for example, where baseload is substantially met with coal-fired electricity generation and marginal electricity is provided from other sources), using the average emissions intensity allows for more appropriate sizing of **renewable energy** systems and recognizes that efforts are underway to decarbonize Canada's electricity grids.

¹⁹ Available at <https://www.wri.org/research/guidelines-quantifying-ghg-reductions-grid-connected-electricity-projects>.

²⁰ Available at <https://www.wri.org/research/estimating-and-reporting-comparative-emissions-impacts-products>.



AVOIDED EMISSIONS FROM CARBON OFFSETS

‘Avoided Emissions from **Carbon Offsets**’ refers to the emissions that are avoided by purchasing high-quality **carbon offsets**, which can be used to offset **direct** or **indirect emissions** on a per tonne basis. High-quality **carbon offsets** ensure that offset projects include safeguards related to:

- **Additionality:** The likelihood that the emissions reductions would not have happened anyway.
- **Permanence:** The likelihood that the emissions removed will not be returned to the atmosphere at a later date (for example, a commitment to maintain a forest could be repealed).
- **Leakage:** The risk that emissions reductions will result in increased emissions elsewhere (for example designating a forest as protected without precautions to prevent increased deforestation in unprotected areas).

To qualify under the ZCB-Design Standard, **carbon offsets** must meet one of the following criteria:

- Certified by Green-e® Climate or equivalent; and/or
- Derived from **carbon offset** projects certified under one of the following high-quality international programs:
 - Gold Standard
 - Verified Carbon Standard (VCS)
 - The Climate Action Reserve
 - American Carbon Registry

While Green-e® Climate certified carbon offsets provide the highest level of consumer confidence, additional programs are listed to ensure a diverse selection of offset project types and geographical locations are available.

Offsets may come from anywhere in the world and any project type that meets the requirements of the programs listed above. Project teams may choose to apply their own criteria when deciding on the selection of **carbon offsets**.

Carbon offsets purchased to meet regulatory programs may also contribute provided they meet the program requirements. For example, where a building is in a municipality or province that requires buildings to offset their carbon emissions with the purchase of **carbon offsets**, these purchases can also be used to meet the requirements of the ZCB-Design Standard.

ZCB-Design certification requires at least one price quote for the annual volume of **carbon offsets** anticipated to be required. **Carbon offset** purchases are verified for ZCB-Performance certification.



RESOURCES

Carbon Offset Guide

<http://www.offsetguide.org/>

The *Carbon Offset Guide* is an initiative of the GHG Management Institute and the Stockholm Environmental Institute designed to help companies and organizations seeking to understand **carbon offsets** and how to use them in voluntary GHG reduction strategies. It may also be useful for individuals interested in using **carbon offsets** to compensate for their personal emissions.

Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects

<https://www.wri.org/publication/guidelines-quantifying-ghg-reductions-grid-connected-electricity-projects>

This report explains how to quantify reductions in GHG emissions resulting from projects that either generate or reduce the consumption of electricity transmitted over power grids. It is a supplement to the *Greenhouse Gas Protocol for Project Accounting* and was produced by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD).



ONSITE COMBUSTION

ZCB-Design projects should aim to eliminate onsite combustion, regardless of whether zero emissions biofuels are used. Such biofuels should be reserved for industries where eliminating combustion is impractical. Eliminating combustion for service hot water can be a challenge, and strategies can vary as a function of service hot water demand; guidance can be found in the CAGBC's [Decarbonizing Canada's Large Buildings](#) report.²¹

REQUIREMENTS

ONSITE COMBUSTION LIMIT FOR SPACE HEATING

Space heating systems should be designed to operate without onsite combustion whenever possible. However, to provide greater design flexibility and recognize current technological and financial barriers, some onsite combustion for space heating is permitted.

Projects must be capable of supplying all space heating with installed non-combustion-based technologies at an outdoor air temperature of -10 C or the design temperature, whichever is higher. Space heating technologies whose performance is not directly affected by outdoor air temperature (e.g., ground source heat pumps, electric resistance) must be demonstrated to be able to meet the same fraction of the annual heating demand as an air source heat pump system supported by onsite combustion. at outdoor air temperatures below -10 C.

CAGBC will consider requests for exemptions to the onsite combustion limit for space heating for projects located in remote regions of Canada on **islanded grids**, or locations with electricity supply issues.

SERVICE HOT WATER

Service hot water systems should be designed to operate without combustion wherever possible. However, there is no limit on combustion for service hot water.

OTHER SOURCES OF COMBUSTION

The following appliances may not be used in buildings seeking ZCB-Design certification:

- Gas stoves and ranges in residential suites. Commercial kitchens are excluded from this requirement.
- Fireplaces, including decorative fireplaces and those used for heating.

ZERO CARBON TRANSITION PLAN

ZCB-Design projects that use any onsite combustion for space heating or service hot water, regardless of whether zero emissions biofuels are used, must prepare a Zero Carbon Transition Plan. A Zero Carbon Transition Plan is a costed plan that outlines how a building will adapt over time to remove combustion from building operations. A well-crafted plan will leverage the natural intervention points in a building's capital plan, when retrofits would normally be required. ZCB-Design requires that the transition plan address space heating and service hot water.

²¹ See Section 3.1.3 of the report, available at, www.cagbc.org/decarbonize.



The Transition Plan must:

- Describe the reasons for onsite combustion and how heating loads have been reduced;
- Describe the mechanical HVAC strategy and how components of the system may be adapted to accommodate non-combustion-based technologies;
- Include measures to facilitate the conversion to non-combustion-based technologies, such as designing the HVAC system to use low-temperature distribution or allocating space for renewable or electrical-sourced heating technologies (e.g., heat pumps);
- Identify and leverage natural intervention points, such as the anticipated end of life of mechanical equipment
- Include a financial comparison of the designed or current systems and an alternative set of non-combustion-based systems;
- Explain the differences between the designed or current systems and the non-combustion-based alternatives in detail, and why the non-combustion-based systems weren't chosen; and,
- Include a 20-year net present value calculation that includes current and projected fuel cost escalation and a three percent discount rate. The [Zero Carbon Building v2 Life Cycle Cost Calculator](#) should be used.²²

DISTRICT ENERGY

ZCB-Design projects that are connected to district energy systems that use combustion to generate heating or cooling must provide one of the following:

1. A Transition Plan for the district energy system that shows how the system will adapt over time to remove combustion from its operations.
2. A Transition Plan for the building that shows how the building can disconnect from the district energy system and provide onsite heating, cooling, and service hot water without the use of combustion.
3. A signed commitment letter from the building owner to procure **green heat** for the project, along with confirmation from the district energy provider that sufficient **green heat** from non-combustion-based sources is available. The **green heat** must be generated from sources on the district energy system to which the building is connected.

²² Available at https://portal.cagbc.org/cagbcdocs/zerocarbon/v2/ZCB_v2_Life-Cycle_Cost_Calculator.xlsx.



RESOURCES



New Buildings Institute – Building Electrification Technology Roadmap

<https://newbuildings.org/resource/building-electrification-technology-roadmap/>

The *Building Electrification Technology Roadmap* is a guide for utilities and other organizations developing, implementing, and supporting electrification projects to advance high efficiency technologies, reduce GHG emissions, and improve public health.

Green Building Council Australia – A Practical Guide to Electrification

<https://new.gbca.org.au/news/gbca-media-releases/electrifying-future/>

A *Practical Guide to Electrification* outlines the steps involved in delivering an all-electric new building and the types of technologies that can be used today to replace natural gas systems with electric solutions. The guide was written for building owners, developers, facility managers, consultants, and building professionals.



ENERGY

Projects pursuing ZCB-Design certification must demonstrate superior energy efficiency. Energy efficiency is critical to ensuring the financial viability of zero-carbon designs while promoting resiliency freeing up clean energy for use in other economic sectors and geographical regions and reducing the environmental impacts of energy production. Efficiency also supports grid harmonization and minimizes negative impacts on electricity grids, such as the need to meet high **peak demands** or absorb large amounts of **renewable energy** generated onsite.

Requirements at a Glance

Projects must report modelled energy performance using TEDI, EUI, and seasonal peak demand.

Projects must meet the energy performance requirements of the selected approach to energy efficiency.

METRICS

Three metrics underpin the ZCB-Design energy requirements:

- **Thermal energy demand intensity (TEDI);**
- **Energy use intensity (EUI); and**
- **Peak demand.**

THERMAL ENERGY DEMAND INTENSITY

Thermal energy demand intensity, or **TEDI**, refers to the annual heat loss from a building's envelope and ventilation, after accounting for all passive heat gains and losses. When measured with modelling software, this is the amount of heating energy delivered to the project from all types of space-heating equipment, per unit of **modelled floor area**.

The inclusion of a **TEDI** metric helps contribute to greater occupant comfort and ensures that building designers focus on minimizing a building's demand for energy prior to producing or procuring **renewable energy**. The metric also helps to ensure long-term energy performance, as building envelopes have long life spans and yield very reliable efficiency gains. Furthermore, building envelopes are typically challenging to retrofit. Finally, improved thermal performance is correlated with improved resilience in the face of power outages, as buildings are better able to maintain comfortable interior temperatures when the power supply is disrupted.

Ventilation strategies such as heat recovery and dedicated outdoor air systems can have significant impacts on **TEDI**. Strategies to improve building envelopes, such as increasing the levels of thermal insulation, can also be effective in reducing **TEDI**. These strategies may increase the amount of **embodied carbon**, however, and project teams are encouraged to weigh the embodied carbon and operational carbon implications of their choice of building envelope strategies. Teams may also wish to consider the grid-level impacts, such as when the grid peaks and what the marginal power generation source is at that time, ensuring that the building's life cycle carbon is minimized.

The TEDI of a given archetype increases as the climate gets colder. For this reason, climate zones are used to determine the TEDI targets for achieving ZCB-Design (see Figure 9).

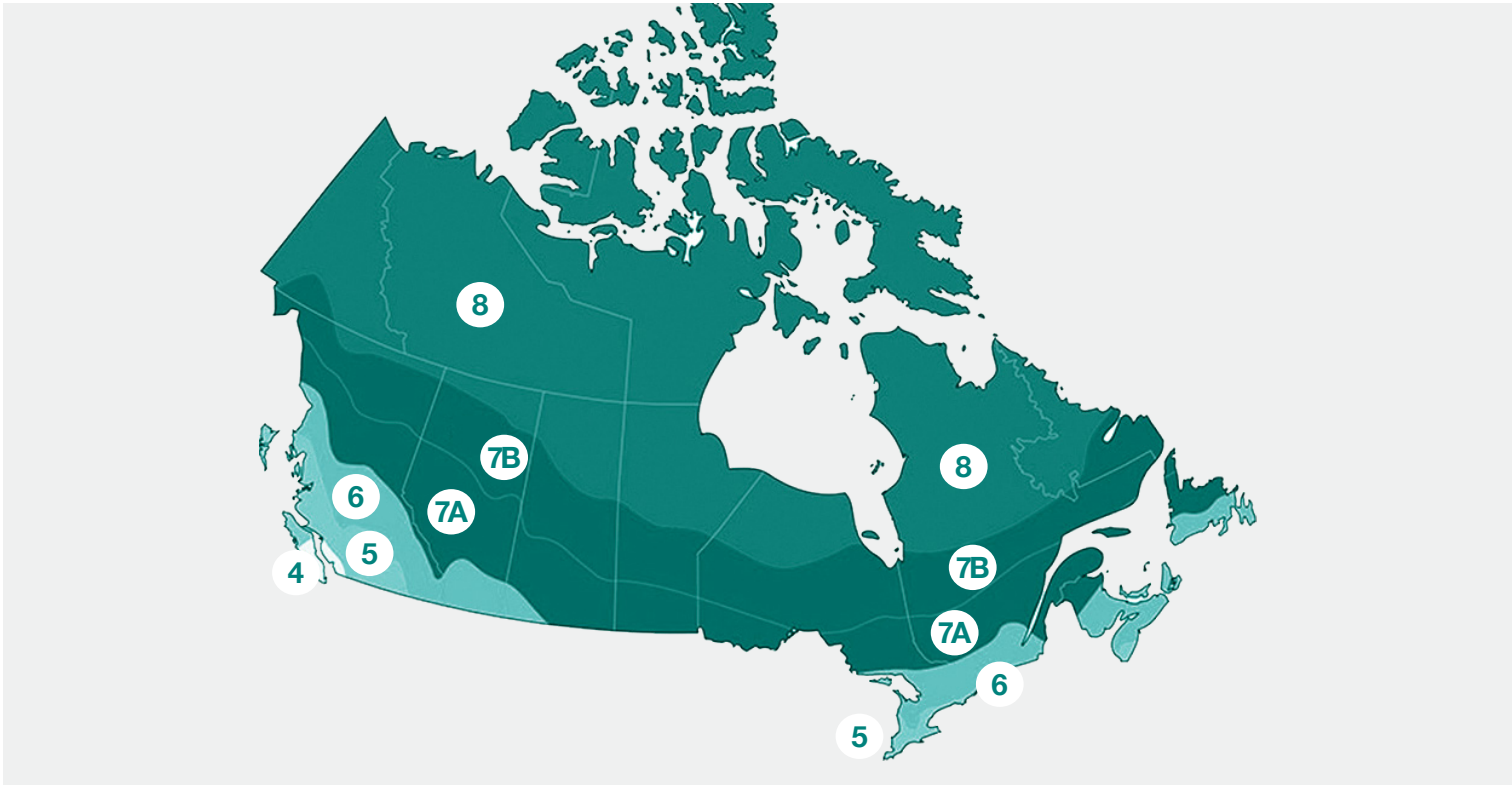


Figure 9 – Climate zones used to determine TEDI targets

ENERGY USE INTENSITY

Energy use intensity (EUI) refers to the sum of all site (not source) energy consumed on the project site (e.g., electricity, natural gas, district heat), including all process energy, divided by the building modelled floor area. EUI is not reduced by the addition of **onsite renewable energy**.

Evaluating **EUI** ensures that the energy efficiency of all building systems is considered holistically. All energy efficiency strategies, both passive and active, contribute to reducing **EUI**. **EUI** is also important as it relates both to design and operations, enabling project teams to verify performance and evaluate design and construction practices.

PEAK DEMAND

Several Canadian electrical grids are experiencing significant stresses as populations grow and extreme weather events challenge the reliability of utility service delivery. Reducing a building's peak electrical demand can help electrical grids cope with population growth and extreme weather, diminishing the need for additional generation and distribution capacity. Managing **peak demand** can also reduce the carbon intensity of electricity in lower-carbon grids, as peak power generation often relies on energy sources that are more carbon-intensive than the baseload energy sources, such as natural gas. CAGBC research has found that peak electrical demand of zero carbon buildings is often lower than for conventional buildings.²³

²³ Canada Green Building Council. *Making the Case for Building to Zero Carbon* (2019). www.cagbc.org/MakingTheCase.



As space heating is electrified, winter peak demand can grow. To understand the impacts of designs on the electrical grids, both summer and winter seasonal peak demand need to be considered.

Project teams should consider measures to reduce **peak demand** such as:

- **Onsite renewable energy**, such as solar and wind power
- Electrical or thermal energy storage
- Heat pump technology for heating, cooling and service hot water needs
- Demand-response capabilities

“Energy efficiency is critical to ensuring the financial viability of zero carbon designs, promotes resiliency, frees clean energy for use in other economic sectors and geographical regions, and reduces environmental impacts of energy production.”

REQUIREMENTS

To allow project teams the flexibility to choose the pathway to zero emissions most suited to their project, three different approaches are available to demonstrate energy efficiency. Energy models created for demonstrating compliance with the energy requirements must be prepared in accordance with the [ZCB-Design v3 Energy Modelling Guidelines](#).

<h3>OPTION 1</h3> <h4>Flexible Approach</h4> <ul style="list-style-type: none"> • Thermal energy demand intensity (TEDI) target • Energy use intensity (EUI) target 	<h3>OPTION 2</h3> <h4>Passive Design Approach</h4> <ul style="list-style-type: none"> • Aggressive thermal energy demand intensity (TEDI) target 	<h3>OPTION 3</h3> <h4>Renewable Energy Approach</h4> <ul style="list-style-type: none"> • Thermal energy demand intensity (TEDI) target • Zero carbon balance for operational carbon achieved without green power products or carbon offsets
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The first approach provides the greatest flexibility for most projects, with both thermal and total energy requirements that provide a path for all projects (see flexible approach below for full details).

The second approach recognizes projects that pursue more aggressive thermal energy demand reductions, putting additional emphasis on the building envelope and ventilation strategies.

The third approach provides a path for projects that wish to achieve zero carbon in their annual operations without relying on purchased measures like **carbon offsets** or **green power products** (e.g., **RECs**). Such projects will generally be smaller, achieving success by focusing on energy-use reductions and **renewable energy** from owned assets.



OPTION 1: FLEXIBLE APPROACH

Energy Efficiency Option 1: Flexible Approach provides a customizable path to satisfying the energy efficiency requirements of ZCB-Design. Projects are required to satisfy both TEDI and EUI requirements but may choose the best available pathway.

TEDI REQUIREMENTS

Projects pursuing Energy Efficiency Option 1: Flexible Approach can choose from four paths to meet TEDI requirements. These options provide flexibility to select the best pathway based on criteria such as whether onsite combustion is used, the project's location, and if the project has unique heating or ventilation loads. Projects that are unsure if their heating or ventilation loads are unique should contact the CAGBC for guidance at zerocarbon@cagbc.org.

Path	Eligibility
No Onsite Combustion	All projects
ZCB-Design TEDI Target	All projects
Adjusted TEDI Target	Projects with unique heating and ventilation requirements (such as laboratories, kitchens and pools) or that are located in climate zones 7 or 8
Detailed TEDI Analysis	Projects with unique heating and ventilation requirements or that are located in climate zones 7 or 8

NO ONSITE COMBUSTION

Projects that use non-combustion-based technologies for all space heating, using equipment with a seasonal coefficient of performance (COP) of at least two, are not required to meet a TEDI target. TEDI must still be reported.

ZCB-DESIGN TEDI TARGET

Projects pursuing this pathway must meet the TEDI targets outlined below, as a function of the project's climate zone.

Climate Zone	TEDI target (kWh/m ² /yr)
4	30
5	32
6	34
7	36
8	40



ADJUSTED TEDI TARGET

Projects with unique heating and ventilation requirements, or that are in climate zones 7 or 8, can use an adjusted TEDI target. Projects pursuing this pathway must use the NECB 2017 prescriptive requirements (i.e., NECB 2017 reference building) to determine the target for the portions of the building that have unique heating/ventilation loads, and the ZCB-Design TEDI Targets (see table above) to determine the target for the remaining space. An adjusted TEDI target for the building is calculated by weighting the two targets based on floor area.

Projects must meet the following requirements:

- The building as a whole must meet the adjusted TEDI target;
- The portions of the building that do not have unique heating/ventilation loads must meet the ZCB-Design TEDI Target (see table above); and
- The entire building shall not exceed the maximum overall thermal transmittance values (U-values) of the NECB 2017 (using either the prescriptive or trade-off methodology).

DETAILED TEDI ANALYSIS

Projects with unique heating and ventilation requirements, or that are located in climate zones 7 or 8, are offered the option of completing a detailed TEDI analysis to demonstrate the main elements contributing to TEDI and the aggressive strategies used to minimize TEDI. Building assemblies shall not exceed the overall thermal transmittance values (U-values) of the NECB 2017 (using either the prescriptive or trade-off methodology). The project must also conduct modelling analysis and prepare a report that includes:

- A thermal breakdown showing TEDI values for each source of heating demand (ventilation, infiltration, envelope, reheat etc.);
- A summary of the actions taken to improve the TEDI for each source of heating demand;
- A rationale for why further action could not be taken for each source of heating demand (such as a financial comparison of different options, or an explanation of technological or programmatic limitations); and,
- A summary of heat gains, including their impact on TEDI.

EUI REQUIREMENTS

Projects pursuing Energy Efficiency Option 1: Flexible Approach are required to demonstrate a minimum level of energy use intensity (EUI) performance. This may be demonstrated using a minimum improvement compared to an NECB 2017 reference building, or by achieving a minimum level of absolute performance, as per the eligibility requirements below.

Path	Eligibility
Reference building performance improvement	All projects
Absolute energy use intensity (EUI) target	Office, multi-unit residential, hotel/motel, retail



RELATIVE PERFORMANCE IMPROVEMENT

Site energy use intensity must be at least 25 percent better than the National Energy Code for Buildings (NECB) 2017, without accounting for renewable energy.

ABSOLUTE ENERGY USE INTENSITY

Projects must meet the EUI targets below, as measured in kWh/m²/yr, without accounting for renewable energy. Targets for climate zones 7 and 8 have been determined using a formula that accounts for the heating degree days used in the energy model weather file.

Climate Zone	Office	Retail	Multi-unit Residential	Hotel / Motel
4	100	90	100	120
5	100	90	110	130
6	100	95	110	130
7 and 8	$0.0078 \times \text{HDD}18 + 78$	$0.0068 \times \text{HDD}18 + 67$	$0.0116 \times \text{HDD}18 + 66$	$0.0091 \times \text{HDD}18 + 92$

ADDITIONAL REPORTING REQUIREMENTS

Energy Efficiency Option 1: Flexible Approach also requires project teams to report the following energy metrics:

- The anticipated **EUI** of the building in kWh/m²/year. EUI does not take **onsite renewable energy** into account.
- The anticipated summer and winter seasonal **peak demand** (or ‘peak power’). Peak demand must represent the highest winter and summer electrical load requirements on the grid, reflecting any peak-shaving impacts from demand management strategies, including onsite power generation or energy storage. **Peak demand** must be reported in kilowatts (kW).



OPTION 2: PASSIVE DESIGN APPROACH

Energy Efficiency Option 2: Passive Design Approach recognizes those projects that pursue more aggressive thermal energy demand reductions by putting additional emphasis on the building envelope and ventilation strategies.

TEDI REQUIREMENTS

Projects must meet a more aggressive set of TEDI targets, determined as a function of the project's climate zone (see below).

Climate Zone	TEDI target (kWh/m ² /yr)
4	20
5	22
6	24
7	26
8	30

ADDITIONAL REPORTING REQUIREMENTS

Energy Efficiency Option 2: Passive Design Approach also requires project teams to report the following energy metrics:

- The anticipated EUI of the building in kWh/m²/year. EUI does not take onsite renewable energy into account.
- The anticipated summer and winter seasonal peak demand (or 'peak power'). Peak demand must represent the highest winter and summer electrical load requirements on the grid, reflecting any peak-shaving impacts from demand management strategies, including onsite power generation or energy storage. Peak demand must be reported in kilowatts (kW).

OPTION 3: RENEWABLE ENERGY APPROACH

Energy Efficiency Option 3: Renewable Energy Approach provides a path for projects that wish to achieve zero carbon in their annual operations without relying on purchased measures such as **carbon offsets** or **green power products** (e.g., **RECs**). Such projects are generally smaller and achieve success by focusing on energy use reductions and **renewable energy** from owned assets.



TEDI REQUIREMENTS

Projects must meet the TEDI targets outlined below, as a function of the project's climate zone.

Climate Zone	TEDI target (kWh/m ² /yr)
4	30
5	32
6	34
7	36
8	40

CARBON REQUIREMENTS

Projects must achieve a zero-carbon balance for **operational carbon** without **green power products** or **carbon offsets**. Refer to the section on **Operational Carbon** requirements for more information on carbon accounting.

ADDITIONAL REPORTING REQUIREMENTS

Energy Efficiency Option 3: Renewable Energy Approach also requires project teams to report the following energy metrics:

- The anticipated **EUI** of the building in kWh/m²/year. EUI does not take **onsite renewable energy** into account.
- The anticipated summer and winter seasonal **peak demand** (or 'peak power'). **Peak demand** must represent the highest winter and summer electrical load requirements on the grid, reflecting any peak-shaving impacts from demand management strategies, including onsite power generation or energy storage. **Peak demand** must be reported in kilowatts (kW).

MODELLING AND DESIGN CONSIDERATIONS

AIRTIGHTNESS

Airtightness is a critical factor for energy consumption in high-performance buildings. Careful attention to detailing at the design phase, and diligent implementation and inspection at construction, are both required.

ZCB-Design does not require projects to perform airtightness testing for certification. As airtightness testing must be conducted prior to ZCB-Performance certification, energy models for projects pursuing ZCB-Design certification can assume an air leakage rate that is lower than the default value prescribed in the [ZCB-Design v3 Energy Modelling Guidelines](#). If project teams wish to use a lower air leakage value, they must explain what strategies are being taken to ensure the lower value is met as well as provide a sensitivity analysis as described in the [ZCB-Design v3 Energy Modelling Guidelines](#).



FUTURE WEATHER

As average global temperatures increase, heating and cooling demands will change. Extreme weather events such as extreme heat and cold, high winds, and flooding are also expected to pose increased risks to buildings and the infrastructure on which they rely, such as electricity grids. Project teams must understand that the weather of today may not be an accurate way to model a building's performance in the future.

Project teams with access to future-weather files are encouraged to perform a sensitivity analysis to evaluate the building's ability to maintain comfort and zero carbon operations. A 2050 or 2080 timeframe may be reasonable, corresponding roughly to building mid-life and end-of-life. Project teams that evaluate the implications of future weather are encouraged to provide their findings in their submission for ZCB-Design certification.



RESOURCES



Low Thermal Energy Demand for Large Buildings

<https://www.bchousing.org/research-centre/library/residential-design-construction/guide-low-energy-demand-large-buildings>

Developed by BC Housing, this guide aims to broaden the common understanding of how large buildings can meet higher levels of performance as required by the ZCB-Design Standard, and has a focus on current Canadian code requirements, construction practice, and tested systems.

Building Envelope Thermal Bridging Guide

<https://www.bchousing.org/research-centre/library/residential-design-construction/building-envelope-thermal-bridging-guide>

Developed by BC Housing, this guide aims to help the construction sector realize more energy-efficient buildings by looking at current obstacles and showing opportunities to improve building envelope thermal performance.

Advanced Energy Design Guide – Achieving Zero Energy

<https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download>

The Advanced Energy Design Guide – Achieving Zero Energy series provides a cost-effective approach to achieve advanced levels of energy savings. Guides offer contractors and designers the tools needed for achieving a zero-energy building including recommendations for practical products and off-the-shelf technology. These Guides have been developed through the collaboration of ASHRAE, the American Institute of Architects (AIA), the Illuminating Engineering Society (IES), and the U.S. Green Building Council (USGBC), with support from the U.S. Department of Energy (DOE).

The National Energy Code for Buildings

<https://nrc.canada.ca/en/certifications-evaluations-standards/codes-canada/codes-canada-publications/national-energy-code-canada-buildings-2017>

Published by NRC and developed by the Canadian Commission on Building and Fire Codes in collaboration with Natural Resources Canada (NRCan), the National Energy Code of Canada for Buildings 2017 (NECB) sets out technical requirements for the energy efficient design and construction of new buildings. The 2017 edition is an important step toward Canada's goal of achieving 'Net Zero Energy Ready (NZER)' buildings by 2030, as presented in the [Pan-Canadian Framework](#).

Illustrated Guide: Achieving Airtight Buildings

<https://www.bchousing.org/research-centre/library/residential-design-construction/achieving-airtight-buildings>

This guide from BC Housing is an industry resource to design, build, and test airtight buildings. It also consolidates information on achieving airtightness in buildings, with a focus on larger or more complex building types, while ensuring building enclosure performance, including moisture management, thermal performance, and durability.



RESOURCES

Climate Data for a Resilient Canada

climatedata.ca

ClimateData.ca is a climate data portal produced collaboratively by the country's leading climate organizations and supported, in part, by the Government of Canada. The goal of this portal is to support decision makers across a broad spectrum of sectors and locations by providing the most up to date climate data in easy-to-use formats and visualizations.



CASE STUDY

evol1

Certification: ZCB-Design (April 2018)

Location: Waterloo, Ontario

Project Owner: The Cora Group

Mechanical Engineer: Stantec

Energy Modeller: Stantec

Architect: Stantec Architecture

evol1 is a three-storey, 10,219m² (110,000 sq.ft) commercial multi-tenant office building, designed to be a hub for next-generation innovation and the millennial workforce. It was the first project to achieve CAGBC's ZCB-Design certification. Achieving a low **TEDI** was of paramount importance to the evol1 design team and, as such, was verified at every iteration of the design energy model and was incorporated into the early parametric modelling.

The design incorporates both active and passive systems to optimize value against construction cost. The evol1 building has a 36.6 per cent window-to-wall ratio and includes a variety of envelope constructions, each including measures to reduce thermal bridging. The north- and south-facing facades use thermally broken clips to attach polyisocyanurate insulation to the building, with fiberglass or aluminum panels attached to the exterior. The south-facing façade also includes a transpired metal solar collector mounted on a structure backed with an insulated metal panel system. This wall is used to pre-heat ventilation air that is then distributed by the central dedicated outdoor air system (DOAS) to the entire building. The second and third floors use a curtain wall system with a continuous ribbon of vision glazing between insulated spandrel panels. All windows in the building are triple pane and are protected from the incident solar radiation with horizontal overhangs on the south elevation and external vertical shades on the east and west side.

The ventilation system incorporates heat recovery: an enthalpy wheel with an efficiency of 81 per cent recovers sensible and latent heat from the building exhaust year-round. An ultra-efficient open-loop **geo-exchange** system combined with a variable refrigerant flow (VRF) distributed heat-pump system deliver heating (and cooling) efficiently to occupied spaces.

evol1 was designed to achieve a **TEDI** of 23.8 kWh/m², surpassing the ZCB-Design target of 34 kWh/m² for climate zone 6.



CASE STUDY

Humber College's Building Nx

Certification: ZCB-Design (May 2019)

Architect: B+H

Location: Toronto, Ontario

Envelope, HVAC & Sustainability Consultant: Morrison Hershfield

Project Owner: Humber College

Humber College Institute of Technology & Advanced Learning's Building Nx is the first retrofit project to achieve ZCB-Design certification.

Originally built in 1989, the five-storey 4,487m² (48,300 ft²) campus office building underwent a deep retrofit and achieved a 70 per cent energy reduction. The decision to refurbish and not demolish the existing structure also saved a significant amount of **embodied carbon** emissions and enabled the building to be occupied throughout the renovation process.

The building envelope underwent a complete transformation. The total window to wall ratio was decreased to 14 per cent, compared to the original 44 per cent. The new windows are triple-pane with low-e coating, in thermally broken frames. The old aluminium curtain walls and spandrel panels were replaced with a combination of aluminum composite panels and pre-finished corrugated steel with an effective insulation value between R-38 and R-42. Other interventions included the internalization of the glass vestibule located at the north entrance, the removal of the chamfers at the northern side, and the removal and infill of a skylight. The new and improved building features a highly insulated and airtight envelope that results in a **TEDI** of 12.5 kWh/m²/year.

An entirely new air-source variable refrigerant flow (VRF) heat recovery system was installed that recovers and transfers heat between zones.

A roof-mounted 25kW solar photovoltaic (PV) system covers approximately 11 per cent of the building's total energy consumption, generating approximately 31,500kWh per year.

The project team used the advantage of working on an existing building to monitor occupancy data along with the internal loads (plug loads) to provide good estimates of the building's energy use before modelling it. This allowed them to set design directions early in the process.



Credit: Ema Peters

CASE STUDY

The Joyce Centre for Partnership & Innovation

Certification: ZCB-Design (May 2018), ZCB-Performance (November 2019)

Location: Hamilton, Ontario

Architect: B+H / mcCallumSather

Project Owner: Mohawk College

Energy Modeller: RDH Building Science Inc.

The Joyce Centre for Partnership & Innovation at Mohawk College is a five-storey building designed for a tight in-fill site, comprised of 8,981 m² (96,670 ft²) of innovative labs, workshops, lecture theatres, industry training centres and showcases. The Joyce Centre for Partnership & Innovation is the first building to achieve both ZCB-Design and Performance certifications.

In order to manage the onerous energy demands of this building type, an energy budget was established early in project design as a strict guideline to prioritize the energy demands. The team set an **energy use intensity (EUI)** target of 75 kWh/m²/year, placing the building among the lowest energy consuming buildings in Canada. This energy budget was the maximum energy limit that the project was to consume.

To achieve the energy budget, an overall heat loss performance target was chosen for the envelope enclosure. The walls and windows were addressed as a system, with the aim to reach an average effective insulation value of R-10. The envelope assembly sections included consideration for expediting construction timelines in balance with high performance and aesthetics. With this, the curtainwall assemblies include extensive thermal break details as well as interior insulated spandrel cavities, integrated with the opaque wall assemblies comprised of a sandwich insulated precast panel system. Windows were triple-glazed aluminum curtain wall sections with U-value of 1.0 W/m²/C. The HVAC system is based on a dedicated outdoor air system (DOAS) with local heating and cooling, supported with a variable refrigerant flow (VRF) **geo-exchange** heat pump.

A high-level energy model was created for the design team to investigate where energy would be used, based on occupancy and demand responsive systems. This model exercise demonstrated that building process and receptacle loads were the single largest energy end-use in the building. Space heating and lighting was the second energy end-use, followed by pumps, fans, space cooling and domestic hot water. A sensitivity analysis was used to study changes in receptacle loads as well as air infiltration.

The Joyce Centre for Partnership & Innovation is operating as expected. Weekly meetings and excellent team communication enabled collaboration throughout design, which ensured the team was able to achieve their energy target.



CASE STUDY

Curé Paquin Elementary School

Certification: ZCB-Design (February 2019) **Sustainability consultant:** GBi
Location: Saint-Eustache, Québec **Architect:** Leclerc Associés Architectes Inc
Project Owner: Commission scolaire de la Seigneurie-des-Mille-Îles

École Curé-Paquin is a 4,368 m² (47,016 ft²) elementary school and the first school in Canada to receive ZCB-Design certification. The school board sees this project as a flagship initiative that will inform students about GHG emissions, climate change, and strategies to reduce their carbon footprint.

Due to Quebec's clean electricity grid, the decision was made to pursue an electrically heated building with careful attention to electricity demand. The design team started with an enhanced building envelope with reduced thermal bridging and triple-pane windows. This approach reduced the **thermal energy demand intensity (TEDI)** of the building and therefore allowed for more options for the heating and cooling system.

A **geo-exchange** system was designed to cover the entire heating and cooling needs of the building. The heat pump system has a nominal capacity of 95 tons and consisted of 36 wells, each 300 feet deep. During the study and testing of the ground, the presence of an important water source was identified below 300 feet, so the designer decided to reduce the initial depth of wells (from 500 feet to 300 feet) to avoid the underground river.

The **geo-exchange** system is coupled to a partial hydronic radiant floor system. An electrical thermal storage unit with a capacity of 240 kWh (46.5 kW) is also used to help store heat for use during Québec's winter peak-electrical-demand periods, which occur in the early morning due to the demand for heating at that time. The ventilation system is equipped with heat recovery that uses energy from the exhaust air to preheat the fresh air and operates at an efficiency between 85 and 95 per cent. Finally, 11.8 per cent of the total energy consumption of the building is provided through onsite solar photovoltaic panels (PV) with a capacity of 27.3 kW, mounted on the gym roof.

The project team followed an Integrated Project Planning and Design Process and ensured that learnings from previous school developments were applied in this new project. The energy model's hourly demand analysis was used as a key tool for the design and sizing of the equipment, as well as for choosing the best combination of building components and systems.



IMPACT & INNOVATION REQUIREMENTS

Design strategies for achieving zero carbon buildings are constantly evolving and improving. New technologies are continually introduced to the marketplace, and ongoing scientific research in this space influences building design strategies.

The intent of Impact and Innovation requirements are to ensure that ZCB-Design project teams use the opportunity that new construction and major retrofits provide to incorporate impactful and innovative technologies and design approaches.

Incorporating such strategies not only improves the carbon and energy performance of projects, but also helps build skills and develop markets across Canada for low-carbon products and services.

Requirements at a Glance

Projects must demonstrate the inclusion of two Impact and Innovation strategies. At least one of these strategies must come from a pre-approved list.

REQUIREMENTS

ZCB-Design certification requires projects to demonstrate the inclusion of at least two Impact and Innovation strategies into design. At least one of these strategies must come from the list of pre-approved strategies below:

- **Onsite renewable energy** systems capable of generating 5% of total energy needs onsite, or solar photovoltaic systems covering 75% of the available roof area after accounting for vents and mechanical equipment. Refer to the Owned Renewable Energy Systems section for details of requirements for **onsite renewable energy** systems.
- Any size installation of **building integrated photovoltaics (BIPV)**. Systems must be seamlessly integrated into building components such as the windows, roofs, or building façades to be eligible. Applicants must provide a narrative explaining any regulatory, market, and design challenges associated with implementing **BIPV**, as well as any notable successes.
- Space heating systems designed to operate without combustion. Projects must be capable of supplying 100% of space heating using non-combustion-based technologies.
- Service hot water systems designed to operate without combustion in multi-unit residential projects. Other building types with significant service hot water needs will be considered on a case-by-case basis.
- **Upfront carbon** emissions (life cycle phase A) equal to or less than zero after accounting for **biogenic carbon** sequestration.
- An improvement beyond the minimum level of performance required for **embodied carbon**. Impact and Innovation may be demonstrated using either a percent improvement over a baseline or an absolute embodied carbon intensity target, per the table below. Refer to Appendix I for more information on how to establish a baseline building.

	Compliance Options	
	Percent improvement over a baseline	Absolute embodied carbon intensity
Embodied carbon strategy 1	≥20%	≤350 CO ₂ e/m ²
Embodied carbon strategy 2	≥40%	≤240 CO ₂ e/m ²



Additional Impact and Innovation strategies may be proposed to CAGBC for approval. Project teams must be prepared to demonstrate the environmental benefits associated with their strategy using the carbon and energy metrics of the ZCB-Design Standard and provide information to support why the strategy is appropriate for the project. Only one of the two required innovation strategies may be an alternative strategy.

Examples of strategies that may be accepted depend on the scale of the project and their associated benefits, but could include:

- Electric or thermal energy storage;
- Advanced strategies for heat recovery from building systems, processes, or wastewater; or
- Heat pump refrigerants with a low **global warming potential (GWP)**.

Projects are encouraged to contact CAGBC at zerocarbon@cagbc.org early in design to review potential alternate innovation strategies.



RESOURCES



Building-Integrated Photovoltaics

https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/pdf/solar-photovoltaic/NRCan_BIPV_Factsheet_EN.pdf

This factsheet by Natural Resources Canada provides details on BIPV in Canada including definitions, examples, and research activities.

Advanced Energy Design Guide – Achieving Zero Energy

<https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download>

The *Advanced Energy Design Guide – Achieving Zero Energy* series provides a cost-effective approach to achieve advanced levels of energy savings. The guides contain information on how to use solar photovoltaics at the project site to reduce carbon emissions and energy use.

Research & Development Roadmap: Next-Generation Low Global Warming Potential Refrigerants

<https://www.energy.gov/eere/buildings/downloads/research-development-roadmap-next-generation-low-global-warming-potential>

This research and development (R&D) roadmap for next-generation low-GWP refrigerants was prepared by the U.S. Department of Energy and provides recommendations that will help accelerate the transition to low-GWP refrigerants across the entire HVAC&R industry.



CASE STUDY

355 Wilkinson Avenue Warehouse

Certification: ZCB-Design (September 2019)
ZCB-Performance (August 2020)

Prime Consultant Engineer: Ruitenberg Inc

Location: Dartmouth, Nova Scotia

Solar Energy Modelling: East Port Properties

Project Owner: East Port Properties

Solar System Design: Supernova Energy Solutions & Cutting Edge Applied Technology

The Wilkinson project is a multi-tenant warehouse development of five buildings totalling approximately 27,870 m² (300,000 ft²), designed with the vision of creating the next generation of zero carbon warehouses. The first phase of the project was the 355 Wilkinson Avenue Warehouse, a 6,038 m² (65,000 ft²) building.

The project team set a goal of providing tenants with a \$0 heating bill. Early engagement with an experienced team of consultants, builders, and operators with the freedom to propose new ideas was critical to the success of the project. They actively tried to avoid an “it’s always been done this way” mode of thinking. In-house energy design aimed to get realistic expectations of performance by using empirical data from previous industrial buildings owned and managed by East Port Properties. It was determined that the objective could be met by installing a robust building envelope, a more efficient electric heat pump heating system with integrated controls, and a solar array sized to meet the heating needs of the building.

An insulated tilt-up sandwich panel system was chosen for the walls, which provides a continuous insulation value and helps minimize opportunities for air infiltration. Bay doors were equipped with vertical storing dock levelers to reduce thermal bridging compared to exposed dock levelers. Heating is provided by a central air to water heat pump system with in-floor radiant heat distribution, along with a back-up condensing boiler for the coldest days of the year.

An advantage of constructing warehouses is the ample roof space available to integrate onsite photovoltaics (PV), which makes them ideal for the deployment of **onsite renewable energy**. The 83.8kW DC PV system consists of 330-watt panels that are roof mounted and facing south at 35° tilt. They are connected to three-phase microinverters and custom export limiting controls.

The objective of a high-performance building with a zero-cost heating target had to be continuously brought to focus with all parties to avoid decisions being made in silos. Meetings with consultants, trades and operators were held throughout construction to ensure operation will match design.



GLOSSARY

Additionality: The likelihood that an investment in **carbon offsets** or **green power products** will result in additional carbon reductions or **renewable energy** development that would not have happened anyway.

Beyond the life cycle carbon: Emissions or emissions savings from the reuse or recycling of building materials at the end of life, or emissions avoided through energy capture by using end of life materials as fuel (life cycle stage D). **Beyond the life cycle carbon** is part of **life cycle assessment** but is not included in the definition of **embodied carbon**.

Biogenic carbon: The carbon temporarily sequestered in materials that are manufactured from renewable resources such as trees and other living organisms, also known as biomaterials.

Building integrated photovoltaic (BIPV): Solar power generating building products or systems that are seamlessly integrated into the building envelope, replacing conventional building material.

Bundled green power product: A product that includes both **green power** and the associated **environmental attributes (RECs)**, such as **power purchase agreements (PPAs)** or **utility green power**.

Carbon offset: A credit for reductions in greenhouse gas emissions that occur somewhere else and that can be purchased to compensate for the emissions of a company or project. High quality **carbon offsets** include third party verification of emissions reductions as well as **additionality**, permanence, and leakage criteria.

Direct emissions: Emissions from the fuel that is burned at the building site, for example, natural gas that may be combusted to heat the building.

Embodied carbon: Carbon emissions associated with materials and construction processes throughout the whole life cycle of a building.

Emissions factor: A conversion factor that is used to estimate the emissions associated with a measurable activity, such as energy use for heating or cooling a building.

End of life carbon: The **embodied carbon** emissions associated with deconstruction or demolition of a building, including transport from site, waste processing, and disposal stages (stages C1-4) of a building's life cycle.

Energy use intensity (EUI): The sum of all **site energy** (not **source energy**) consumed on site (e.g., electricity, natural gas, district heat), including all process loads, divided by the building **modelled floor area**.

Environmental attributes: The representation of the environmental costs and benefits associated with a fixed amount of energy generation.

Fugitive emissions: Emissions that occur accidentally as a result of leaking gas. Natural gas and refrigerants are common sources of **fugitive emissions**.

Generation facility: A power station designed and built to generate electricity.

Geo-exchange: A system that exchanges heat with the earth or a body of water, usually with the goal of providing efficient heating and cooling using heat pumps.

Global warming potential (GWP): A measure of how much heat is trapped by a greenhouse gas over a specified timeframe, relative to carbon dioxide.



Green heat: District heating that is generated using clean energy technologies or **zero emissions biofuels**. **Green heat** may not be generated from the direct combustion of fossil fuels. Examples of **green heat** include thermal energy generated from heat pump technology, qualifying biomass, or qualifying biogas (renewable natural gas).

Green power: Electricity generated from renewable resources, such as solar, wind, geothermal, low-impact biomass, and low-impact hydro resources. **Green power** is a subset of **renewable energy** that does not include **renewable energy systems** that do not produce electricity, such as solar thermal systems.

Green power product: A contractual purchase of offsite **green power**. **Green power** may be in the form of **bundled green power products** or **renewable energy certificates (RECs)**.

Gross floor area: Consistent with ASHRAE & LEED, the **gross floor area** is the sum of the floor areas of all enclosed spaces inside the building. Measurements must include walls and therefore must be taken from the exterior faces of exterior walls. Enclosed parking and access roads are excluded, as are air shafts, pipe trenches, chimneys, and penthouse spaces with headroom height of less than 2.2 meters (7.5 feet).

Indirect emissions: Emissions that do not occur directly within the project site, such as emissions associated with purchased energy, water use, waste, and transportation from commuting.

Islanded grid: A small electricity grid that is not connected to the provincial grid.

Life cycle assessment (LCA): As defined by ISO 14040, **LCA** is a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a building, infrastructure, product, or material throughout its life cycle.

Location-based electricity grid emissions factor: An **emissions factor** for an electricity grid that is based on the average emissions intensity of all types of generation within a defined locational boundary.

Marginal electricity grid emissions factor: An **emissions factor** for an electricity grid that is based on the emissions intensity of the peaking (non-baseload) generation within a defined locational boundary.

Modelled floor area (MFA): The total enclosed floor area of the building, as reported by the energy simulation software, excluding exterior areas and indoor (including underground) parking areas. All other spaces, including partially conditioned and unconditioned spaces, are included in the MFA.

Near-term climate forcer: A greenhouse gas that has a short atmospheric life and a high **global warming potential**, which results in a near-term warming effect.

Net-metering: An arrangement with the electric utility that allows the export of excess **green power** to the local grid in exchange for a credit on the building's electricity bill.

Onsite renewable energy: **Renewable energy** that is generated onsite. Where a site is not connected to the electricity grid, only the energy that can be consumed (or stored and then consumed) onsite is considered **onsite renewable energy**.

Operational carbon: The emissions associated with the energy used to operate the building.

Peak demand: The building's highest electrical load requirement on the grid, measured and reported in kW, reflecting any peak shaving impacts from demand management strategies including **onsite renewable energy** and energy storage.



Power purchase agreement (PPA): A **power purchase agreement** is a contract for **green power** and the associated **environmental attributes** that typically includes the purchase of a significant volume of electricity under a contract that lasts for at least fifteen years.

Renewable energy: A source of energy that is replenished through natural process or using sustainable management policies such that it is not depleted at current levels of consumption. Examples include solar and wind energy used for power generation and solar energy used for heating. Air-source and ground-source (**geo-exchange**) heat pump systems do not constitute **renewable energy** systems.

Renewable energy certificate (REC): An authorized electronic or paper representation of the **environmental attributes** associated with the generation of 1 MWh of **renewable energy**.

Residual mix emissions factor: An **emissions factor** that has been adjusted to account for the retiring of contractual arrangements (such as **RECs**) within a defined geographic boundary.

Site energy: The amount of energy used on the building site.

Source energy: The amount of raw fuel that is required to operate the building, incorporating all transmission, delivery, and production losses (such as in the generation and transmission of electricity).

Thermal energy demand intensity (TEDI): The annual heat loss from a building's envelope and ventilation after accounting for all passive heat gains and losses, per unit of **modelled floor area**.

Upfront carbon: The **embodied carbon** emissions caused in the materials production and construction stages (stages A1-5) of the life cycle before the building is operational.

Use stage embodied carbon: The **embodied carbon** emissions associated with materials and processes needed to maintain the building during use such as for refurbishments (stages B1-5). These are additional to **operational carbon emissions**.

Utility green power: **Utility green power** is a product offered by some utilities in Canada where the electricity and the associated **environmental attributes** (in the form of **RECs**) are sold together.

Virtual net-metering: An arrangement with the electric utility whereby **green power** generation equipment is installed offsite and the electricity produced is credited (deducted from) the building's electricity bill.

Whole life carbon: Emissions from all life cycle stages, encompassing both **embodied carbon** and **operational carbon** together (stages A1 to C4).

Zero carbon building (ZCB): A highly energy-efficient building that produces onsite, or procures, carbon-free **renewable energy** or high-quality **carbon offsets** in an amount sufficient to offset the annual carbon emissions associated with building materials and operations.

Zero emissions biofuel: Biogas or biomass fuels considered to be carbon neutral as the amount of carbon released by combustion approximately equates to the carbon that would have been released by natural decomposition processes.



ACRONYMS

BIPV: Building integrated photovoltaic

CO₂e: Carbon dioxide equivalents

COP: Coefficient of performance

EUI: Energy use intensity

GWP: Global warming potential

HVAC: Heating, ventilation, and air conditioning

KWh: Kilowatt hour

LCA: Life cycle assessment

NECB: *National Energy Code for Buildings*

PPA: Power purchase agreement

REC: Renewable energy certificate

TEDI: Thermal energy demand intensity

VRF: Variable refrigerant flow

ZCB: Zero carbon building



APPENDIX I

Embodied Carbon Requirements for Baseline Buildings

The following criteria must be met for baseline buildings used to demonstrate a reduction in **embodied carbon**.

Service life: Consistent with the requirements for the **LCA** of the proposed building, the baseline building must also use a service life of 60 years.

Scope: The **LCA** must demonstrate an **embodied carbon** reduction using the life cycle stages A, B, & C. The analysis must include structural and envelope materials as detailed in the Embodied Carbon section. Projects that wish to expand the scope of the analysis to look for reductions elsewhere may do so provided both the baseline and the proposed building use the same scope.

Building equivalence: The baseline building must be equivalent to the proposed building. The following must be constant in both the baseline and proposed building:

- Operational energy use
- **Gross floor area**
- Functional use of space
- Building shape and orientation

Baseline buildings must be modelled; they cannot be based on benchmarking. If the baseline building is too difficult to model, the absolute embodied carbon intensity target may be more appropriate.



APPENDIX II

Requirements for Bundled Green Power Products that are not ECOLOGO or Green-e® Certified

Bundled green power products that are not ECOLOGO or Green-e® Energy certified may be used if the applicant can demonstrate that the **green power** facility meets the following criteria:

- Electricity is generated within the calendar year in which the product is sold, the first three months of the following calendar year, or the last six months of the prior calendar year.
- Electricity generating equipment was placed in operation no more than 15 years ago; or repowered no more than 15 years ago such that 80% of the fair market value of the project derives from new generation equipment installed as part of the repowering.
- Local land use polices and building codes are conformed to. The **green power** project must achieve planning permission and all applicable local permits as defined by the Authority Having Jurisdiction;
- The requirements of the acceptable sources of offsite **green power** are met (see **Green Power Products** section);
- For combustion-based systems, the requirements for biogas and biomass are met (see Combustion section);
- For combustion-based systems, all local and regional air quality by-laws and requirements are met, and all necessary air quality permits are received from the Authority Having Jurisdiction;
- For all water-powered systems, the facility's installation and operations must achieve all regulatory licenses, requirements, and all other authorizations pertaining to fisheries, without regard to waivers or variances authorized. These include authorizations issued by the relevant provincial authorities, and under Section 35(2) of the *Fisheries Act*, by the Minister of Fisheries and Oceans or regulations made by the Governor in Council under the *Fisheries Act*;
- For all water-powered systems, the facility's installation and operations may not achieve authorization with terms that allow for the harmful operation and or disruption or destruction of fish habitat, as verified by a registered professional biologist; and,
- For wind-powered systems, the facility must not be in known migratory routes for avian or bat species, and the impacts on avian and bat species must be minimized as verified by a registered professional biologist.



In addition, applicants must provide the following documentation:

- A report from the **generation facility** that notes the methodology and calculations that were used to ensure that the design and operation of the facility will be sufficient to meet the contractual commitment made to the applicant. It will also note and detail the resources used to generate the energy and outline any limiting factors that may impact the ability of the facility to deliver energy. In such cases where resources are prone to fluctuations, a range will be provided to represent the best and worst-case scenarios, noting the methodology used to develop these scenarios (e.g. if the wind blows as anticipated; if the wind blows at the lowest annual recorded levels, etc.).
- Proof of the **generation facility's** commitment to retire the **environmental attributes** (i.e., **RECs**) that have been procured by the applicant. For example, the project team could provide proof that RECs have been registered within a third-party tracking system that will ensure the RECs are retired (not made available to others).

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