ZERO CARBON BUILDING

PERFORMANCE STANDARD VERSION 2

Canada Green Building Council®

June 2022

Zero Carbon Building – Performance Standard Version 2

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DEVELOPMENT PROCESS AND ACKNOWLEDGEMENTS

The Zero Carbon Building – Performance Standard Version 2 (ZCB-Performance v2) was produced through extensive consultation with experts and stakeholders across the country over a two-year period.

Updates to the 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 the Zero Carbon Pilot Program, an initiative designed to facilitate peer learning and capacity building amongst a group of 16 project teams that committed to the two-year immersion program prior to the launch of registration for the Zero Carbon Building standards. The pilot program recognized excellence and leadership in the field, and served to inform the development of tools, policies and pathways to accelerate market transformation. The lessons learned from the pilot program assisted Canada Green Building Council (CAGBC) in identifying opportunities to refine the Zero Carbon Building standards.

In 2019, a series of zero carbon roundtables were held across the country to collect feedback on the Zero Carbon Building standards and discuss the challenges and opportunities in different regions of the country. Three working groups were also formed, bringing significant subject matter expertise to the development process. These groups – focused on energy metrics, carbon accounting, and embodied carbon – reviewed the feedback received through the pilot projects and roundtables and made recommendations to the Zero Carbon Steering Committee. The Steering Committee worked with CAGBC staff to develop a list of final recommendations.

CAGBC extends its deepest gratitude to all our committee and working group members; the pilot project teams; participants in the zero carbon roundtables, and the members of CAGBC's Energy and Engineering Technical Advisory Group. We also wish to acknowledge the support of Steve Kemp, RDH Building Science Inc., and Chris Magwood, Endeavor Center.

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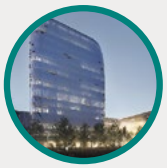
ZERO CARBON PILOT PROJECTS

Mohawk College – Joyce Centre for Partnership & Innovation
Hamilton, ON

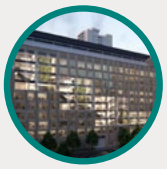
NiMA Trails Residential/ Commercial Building
Guelph, ON

Curé-Paquin Elementary School
Saint-Eustache, QC

Wilkinson Avenue Warehouses
Dartmouth, NS



University of Calgary – MacKimmie Complex
Calgary, AB



Arthur Meighen Building
Toronto, ON

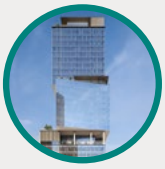
City of Vancouver Fire Hall
Vancouver, BC

Okanagan College – Health Sciences Centre
Kelowna, BC

EcoLock
Kelowna, BC

evolv1
Waterloo, ON

Walkerton Clean Water Centre
Walkerton, ON



The Stack
Vancouver, BC

The HUB
Toronto, ON

TRCA New Headquarters
Toronto, ON

West 8th and Pine
Vancouver, BC

Confidential Project
Winnipeg, MB

Figure 1 – Zero Carbon Building Pilot Projects in Canada

INTRODUCTION

The building industry is one of constant change – from new technologies, techniques, and materials to new design inspirations and directions. Now, that change is being driven by a specific purpose: to lower the industry's carbon emissions and mitigate the worst impacts of climate change.

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 over time - at 420 gigatonnes (Gt) of CO_2e. It's a target designed to keep global warming to 1.5 oC. However, at the world's current rate of 40 Gt of carbon emissions per year, that budget will last a little more than 10 years before we risk a 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.

The building industry is mobilizing to help support Canada's efforts to reduce carbon emissions. Existing buildings are responsible for 17 percent of Canada's carbon emissions,[1] providing an opportunity to make significant carbon reductions as the industry moves toward the elimination of emissions by 2050. This required transition is generating new and innovative pathways to zero carbon, expanding opportunities for industry growth and job creation.

A transition of this magnitude requires a sustained effort. Long-term building asset planning must incorporate important retrofits at key intervention points, such as when different building systems reach the end of their life. Underpinning the industry's transition will be energy and carbon reporting and benchmarking, re-enforced by verification and disclosure of performance to increase accountability and drive deeper reductions. Through these measures, building owners will be empowered to establish climate leadership objectives, find energy cost savings, and increase the value of their assets.

The ZCB-Performance Standard will be a critical part of this transition, as it establishes the framework for how buildings will be assessed against their zero carbon operational goals. The Standard will guide the development of metrics, plans and objectives for building owners and operators alike. Critically, certification to this standard will provide the true measure of the building industry's success in achieving zero carbon while recognizing the leaders who, year over year, demonstrate that their buildings do not contribute to climate change.

[1] 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* (Gatineau, Quebec: Environment and Climate Change Canada, 2016.).
https://www.canada.ca/en/services/environment/weather/climatechange/pancanadian-framework/climate-change-plan.html

ZERO CARBON BUILDING – PERFORMANCE STANDARD V2

The Zero Carbon Building – Performance (ZCB-Performance) Standard is a made-in-Canada framework for verifying zero carbon operations of existing buildings. Zero carbon buildings represent the industry's best opportunity for cost-effective emissions reductions that spur innovation in design, building materials and technology, creating jobs and business opportunities.

The second iteration of the standard introduces greater rigour while increasing flexibility to support the goal of transforming all buildings to be zero carbon. The updates to the ZCB-Performance Standard are designed to facilitate this change by incorporating the findings from ZCB-certified projects and by responding to evolving knowledge that is shaping operational solutions. Special consideration was given to the following four topic areas.

EMBODIED CARBON IN CONSTRUCTION MATERIALS

While the energy efficiency of buildings has improved and reduced the emissions associated with building operations, the relative embodied carbon associated with building materials has increased.[2] Emphasis now needs to be directed at reducing the carbon associated with the life cycle embodied carbon of materials. Of particular importance are the emissions from the production of construction materials, which the industry calls upfront carbon. These emissions become a factor even before a building begins operation.

ENERGY GRIDS AND BUILDINGS

Building operations must now consider the interplay of drawing power from the grid and sending power back, to ensure the exchanges provide measurable carbon reductions. For example, building operations should aim to reduce and shift peak electricity demand to minimize consumption at times when fossil fuels are being used to meet grid power generation needs.

ONSITE RENEWABLES

Onsite renewables offer a cost-effective path to reduce carbon emissions from buildings located in areas with high-carbon electricity grids. They can also be effective in low-carbon grids provided they displace fossil fuel fired power generation typically used to meet peak demand.

NEAR-TERM CLIMATE FORCERS

Refrigerants and methane are near-term climate forcers – GHGs that last a short time in the atmosphere but trap a large amount of heat. As a result, these near-term climate forcers accelerate the impact of climate change. Increasingly, refrigerants are used in heat pumps to enhance efficiency and drive down carbon emissions. This necessitates a better understanding of refrigerant options and best-management practices to minimize potential refrigerant leaks. In addition, the impact of unintended methane releases resulting from extraction, processing and distribution is significant and is now recognized in the IPCC *Guidelines for National Greenhouse Gas Inventories*.[3]

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[2] Röck, M., Saade, M., Balouktsi, M., Rasmussen, F., Birgisdottir, H., Frischknecht, R., Habert, G., Lützkendorf, T., and Passer, A., *Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation* (Amsterdamn: Elsevier, 2019), 3.

[3] Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S., 2019 *Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Volume 2 – Energy* (Switzerland: IPCC, 2019), 4.34.

ENHANCEMENTS TO THE ZCB-PERFORMANCE STANDARD

Building standards must evolve with the market and take advantage of new ideas, new technologies and new processes. With the ZCB-Performance Standard, focus was placed on improving the quality of both the emissions inventory and the emissions reduction opportunities. To further support the effectiveness and market uptake of ZCB-Performance the following key enhancements were made:

1. Requirements for inventorying, monitoring, and offsetting fugitive refrigerant emissions were developed.
2. Emissions reductions opportunities were expanded to include high quality carbon offsets, and additional emphasis was placed on additionality (ensuring emissions reductions would not have otherwise occurred).
3. Embodied carbon requirements were refined to focus on new materials only, excluding pre-existing structures.

These enhancements provide building owners and operators with a more complete picture of their carbon emissions and give them more options to reduce those emissions in ways that align with their organization's priorities and values.

With ZCB-Performance v2, achieving a zero carbon building means taking responsibility for all the carbon emissions associated with operating a building. It is an ambitious but nonetheless critical objective, because within the context of a global carbon budget every bit of carbon counts.

THE FUNDAMENTALS OF GOOD PERFORMANCE REMAIN UNCHANGED

1. Central to the success of any ZCB-Performance project is the application of ongoing operational excellence, including monitoring and pro-active maintenance. Long-term asset management plans are critical to anticipate and leverage natural intervention points (such as the expected end of life of mechanical equipment) to reduce energy costs and transition away from fossil fuels where needed.
2. When evaluating retrofit opportunities, emphasis should remain first 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 are not fossil fuel based and help reduce peak demand on the electricity grid.
3. Meeting a building's energy needs efficiently is a critical next step that helps reduce energy use and saves 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. Consideration should next be given to how a building might generate onsite renewable energy, taking into account 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 that helps minimize grid impacts while reducing or eliminating the need for fossil fuels to meet peak heating demand.
5. Not all buildings are able to reach zero emission operations by relying solely on onsite measures, and any embodied carbon from construction materials can only be offset with measures beyond the building property. Therefore, buildings should consider the potential for offsite renewable energy and carbon offsets as a final measure towards attaining zero carbon.

OVERVIEW

The Zero Carbon Building – Performance (ZCB-Performance) Standard is an annual verification of the performance of zero carbon buildings. Certification is awarded based on 12 months of operations, and projects achieving certification may use the ZCB-Performance certification mark.

Projects that have achieved ZCB-Design are eligible to submit after 12 months of operations. The first ZCB-Performance certification for such projects includes verification of airtightness. The **embodied carbon**[4] of the structural and envelope materials must also be offset, either in the first ZCB-Performance certification or in equal amounts annually over as many as five years.

Projects that have not achieved ZCB-Design must be operational for at least three years to be eligible for ZCB-Performance certification.

Applicants are awarded certification once all requisite documentation is received, and a review by CAGBC confirms the requirements of the ZCB-Performance Standard have been met. There should be no gaps in the performance data from one certification period to the next. Projects must submit within six months of their performance year ending; for example, for a **performance year** that covers April 1 to March 31, all documentation must be provided to CAGBC by October 1.

ZCB-Performance may not be used to make a carbon neutral claim about a product or service originating from a ZCB-Performance certified building, however it may form part of a strategy to achieve this.

		ZCB-Design v2 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	Report embodied carbon	Offset embodied carbon
	Refrigerants	Report total quantity	Offset any leaks
	RECs and carbon offsets	Provide quote	Provide proof of purchase
	Onsite combustion	Provide transition plan	Update 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 certified
Impact and Innovation		Apply two strategies	No requirement

Figure 2 – Summary of Key Zero Carbon Building Requirements

[4] Terms in **bold** appear in the Glossary.

ELIGIBILITY

The ZCB-Performance Standard applies to all 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.

ZCB-Performance may be used to evaluate the efficiency and low-carbon design of entire buildings, as well as newly constructed additions and attached buildings. Additions and attached buildings will be subject to additional criteria. ZCB-Performance project boundaries for attached buildings may be aligned with the project under LEED v4 Operations and Maintenance (O+M) (or later versions).

ATTACHED BUILDINGS

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

- Attached buildings which are physically connected 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 general public. Applicants must seek clarification with CAGBC by emailing zerocarbon@cagbc.org when it is not clear.
- Buildings that have no physical connection, or are connected by corridors, parking, underground, or mechanical/storage rooms are considered separate buildings.
- Attached buildings generally share a common site and will need to consider appropriate separation of that site to determine emission sources to include in the project.
- Attached buildings must have separate ventilation systems and energy meters capable of measuring all energy use. This is necessary to demonstrate compliance with the energy and carbon requirements of the Standard.

ADDITIONS

Additions may pursue ZCB-Performance certification provided they previously certified under ZCB-Design, have remained sufficiently physically distinct to pursue certification, and continue to meet the following rules:

- Additions must be physically distinct, representing a unique area of a building. The distinct space must also be reflected in the project name when registering.
- Additions must have separate ventilation systems and energy meters capable of measuring all energy use. This is necessary to demonstrate compliance with the energy and carbon requirements of the standard.

SCOPE

The ZCB-Performance 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 (5.4 tons) or greater
- Indirect (Scope 2) emissions from purchased electricity, heating, or cooling
- **Embodied carbon** (Scope 3) emissions that are associated with new structural and envelope building materials

REQUIRED DOCUMENTATION

Applicants must complete the *ZCB-Performance v2 Workbook*[5] to demonstrate compliance with the ZCB-Performance requirements.[6] The *ZCB-Performance v2 Workbook* contains a list of required supporting documentation. Applicants should use the most recent version of the *ZCB-Performance v2 Workbook*; however, they may opt to use the version available at the start of the **performance year** being evaluated provided that the emission factors from the most recent version are applied. CAGBC may, at their discretion, request additional submittals or confirmation from the applicant to ensure that the emissions values reported by the applicant are complete and accurate.

[5] Available at https://portal.cagbc.org/cagbcdocs/zerocarbon/v2/ZCB-Performance_v2_Workbook.xlsx

[6] Available at: cagbc.org/zerocarbon.

CARBON REQUIREMENTS

Zero Carbon Building – Performance Standard v2 provides an annual verification of the achievement of zero carbon operations, recognizing that the holistic assessment of carbon emissions is the best measure of progress towards minimizing climate change impacts from buildings.

A **carbon balance** of zero or better must be achieved for ZCB-Performance certification. The **carbon balance** is the net emissions that result from sources and sinks of carbon emissions, calculated as follows:

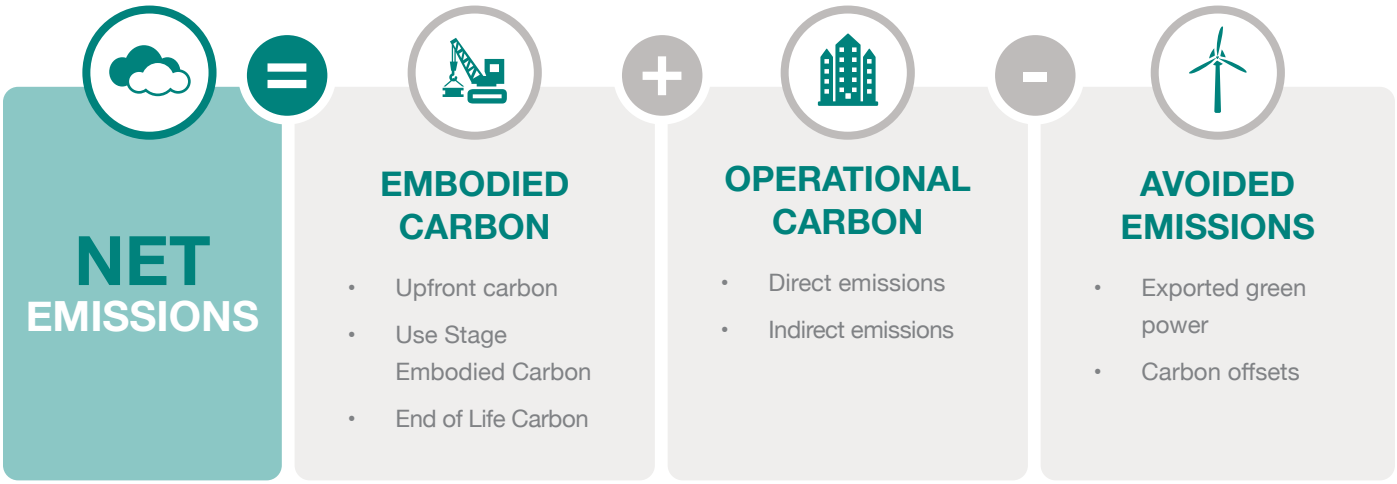

Figure 3 – Calculating a Zero Carbon Balance

The ZCB Workbook simplifies the calculation of the **carbon balance**, and applicants must use this tool for their carbon calculations.

Consistent with the approach taken by Canada's *National Inventory Report*, emissions in the ZCB-Performance Standard are presented in carbon dioxide equivalents (CO_2e), or the volume of CO_2 emissions that would have an equivalent **global warming potential (GWP)** over 100-years. Projects are urged to also consider the 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, methane only survives in the atmosphere for 12.4 years. As a result, measured over the next 20 years, methane has 72 times the heat-trapping potential of CO_2; conversely, over 100 years, it only traps 25 times the heat of CO_2.[7] Using 100-year GWP values misrepresents the large heat-trapping impact of these emissions over the next few decades – the time we have for meaningful action on climate change.[8]

[7] Contribution of Working Group I to the *Fourth Assessment Report of the IPCC, Climate Change 2007 - The Physical Science Basis* (New York: Cambridge University Press, 2012), 33.

[8] Chartered Professional Accountants Canada, *The Time Value of Carbon – Smart Strategies to Accelerate Emissions Reductions* (Toronto: CPA Canada, 2016), 11.

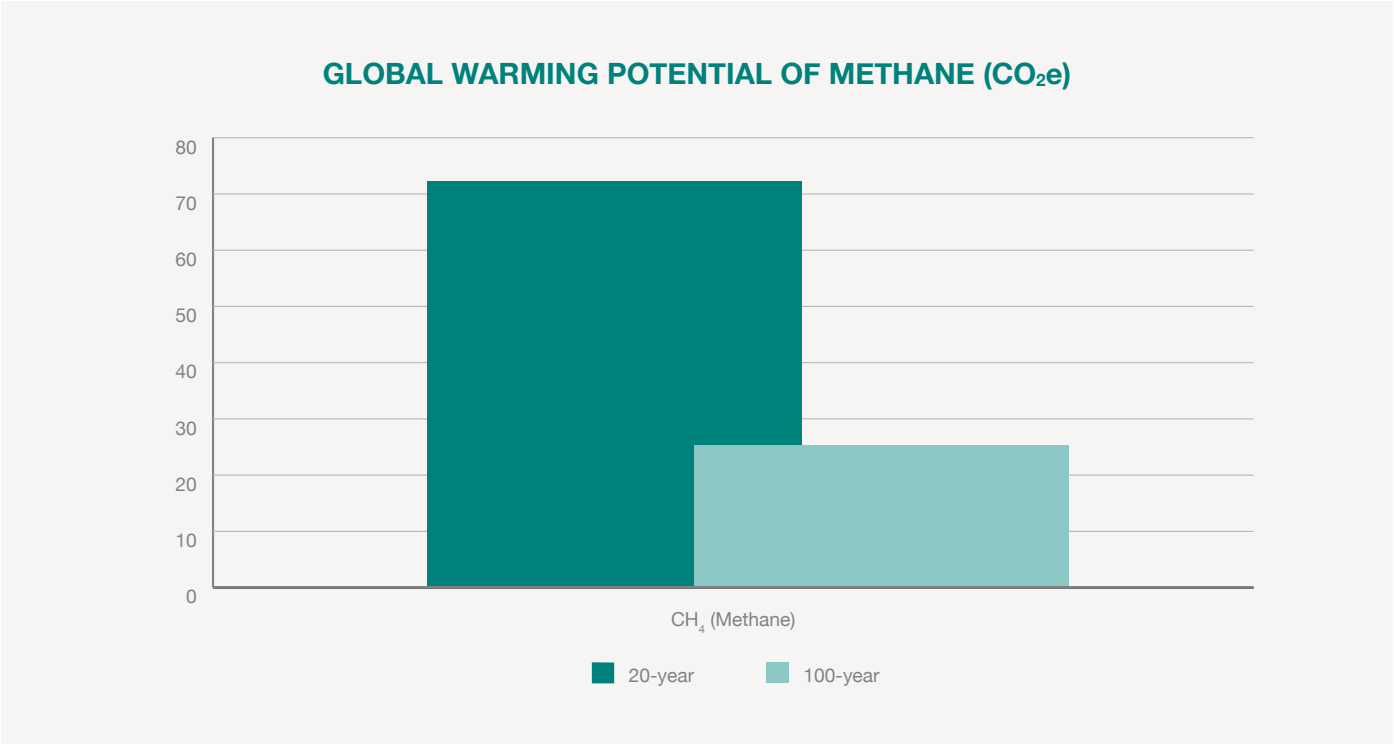

Figure 4 – 20- and 100-year global warming potential (GWP) of methane (source: IPCC 4th assessment report)

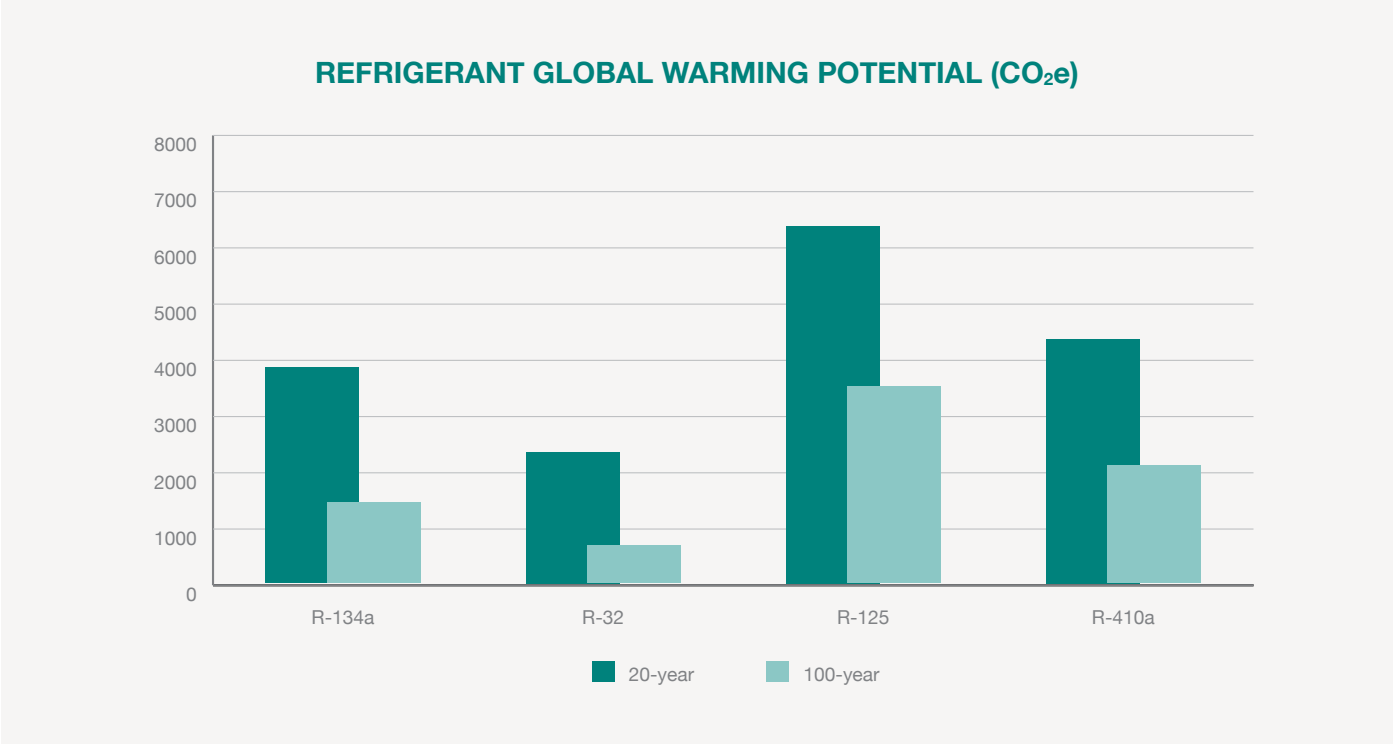

Figure 5 – Global warming potential (GWP) values of common refrigerants (source: IPCC 4th assessment report)

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. ZCB-Performance applicants who use any onsite combustion for space heating or hot water, regardless of whether **zero emissions biofuels** are used, must prepare a *Zero Carbon Transition Plan* for the initial certification and every five years thereafter. The transition plan must describe how heating loads could be reduced over time using passive design strategies (e.g., building envelope improvements). The plan must also describe the current mechanical HVAC strategy and how it could be adapted to accommodate non-combustion-based technologies. Natural intervention points (such as the anticipated end of life of mechanical equipment) should be identified and leveraged in the plan.

Finally, the transition plan must include a financial comparison of the current building operations and a non-combustion-based alternative, including 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*[9] should be used.

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

OPERATIONAL CARBON EMISSIONS

Operational carbon emissions are associated with energy use and releases of refrigerants during regular building operations. The Zero Carbon Building – Performance 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.

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.

ZCB-Performance projects must report the total quantity, type, and the Global Warming Potential (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. Refrigerants which do not have a **GWP** do not need to be reported.

Projects must report any corrective actions taken to address refrigerant leaks and the volume of refrigerants used to recharge systems in the year being evaluated for the ZCB-Performance certification. The recharged refrigerant volume must be included in the carbon balance and offset. **Emission factors** for refrigerants are sourced from the most recent release of Canada's *National Inventory Report* and may be updated from time to time.

COMBUSTION

The *ZCB-Performance v2 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 from time to time. Projects must use the **emissions factors** in the most recent *ZCB-Performance v2 Workbook* available at the time of submission for certification. Fuel used in emergency back-up generators must be included in the zero-carbon balance for ZCB-Performance certification.

BIOGAS

The ZCB-Performance 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-Performance 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 submit 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**[10] include:

a. Solid biomass removed from fields and forests that are managed by following sound environmental management practices.[11] 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.

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 percent 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**.

[9] '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.

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

INDIRECT EMISSIONS

Indirect emissions refer to those 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-Performance certification include only the emissions associated with purchased energy, such as electricity or thermal energy. Projects may include other **indirect emissions** at their own discretion.

DISTRICT HEATING AND COOLING

The *ZCB-Performance v2 Workbook* is preloaded with default e**missions 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-Performance 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.[12] 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.

GRID OR DISTRICT ELECTRICITY

Provincial **location-based electricity grid emissions factors** are used to represent the average emissions of all grid-connected electricity generation in a province. Provincial **location-based electricity grid emissions factors** are included in the *ZCB-Performance v2 Workbook*, which is periodically updated to reflect the latest emission factors from Environment and Climate Change Canada's *National Inventory Report*.[13] 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-Performance v2 Workbook* as well as provide the source of the **residual mix emissions factor**.

The ZCB-Performance 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-Performance v2 Workbook*.

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[12] Scope 2 Guidance | Greenhouse Gas Protocol (ghgprotocol.org) Table 7.1 page 60 https://ghgprotocol.org/scope_2_guidance

[13] Latest version of the report is: Environment and Climate Change Canada, *National Inventory Report 1990-2017: Greenhouse Gas Sources and Sinks in Canada* (Gatineau: Her Majesty the Queen in Right of Canada, 2019), A13.

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). Recognizing that some ZCB-Performance projects may not have access to hourly data, longer timesteps (e.g., daily or monthly) are allowed.

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-Performance program must report their total generated **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.

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 **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 on 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** offsets an equivalent amount of grid electricity. Procured **green power products** cannot be used to reduce other sources of emissions.

To qualify under the ZCB-Performance Standard **green power products** can be generated anywhere in Canada, although 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 provided they meet the program 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-Performance 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 have otherwise been installed. The following hierarchy has been established to ensure 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 at least 15 years. **PPAs** are among the highest-quality forms of **green power product procurement**. They are more common at the corporate level and are not suitable for use by a single building. **PPAs** are also not available in all areas of Canada. All **PPAs** must be certified by either ECOLOGO or Green-e® Energy, or meet the requirements located in Appendix I - 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 located in Appendix I - 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 in Canada.

OTHER INDIRECT EMISSIONS

Recognizing that projects may be quantifying and tracking additional emissions values, project teams may at their discretion include and/or offset additional emissions values. Additional sources of **indirect emissions** include:

- Water use,
- Waste, and
- Transportation emissions from commuting

The accuracy of any additional emissions reported will not be reviewed in detail as methodologies for the quantification of these types of emissions are not standardized within ZCB-Performance.

TIME OF DAY EMISSIONS FOR ONTARIO PROJECTS

Ontario's electricity generation mix is one of the most diverse, and there are significant differences in the carbon intensity of electricity over the course of the day. Fortunately, hourly grid mix data is available. This makes it possible to evaluate building emissions on a more granular level and use strategies such as load shifting to reduce overall emissions.

All-electric buildings located in Ontario may elect to quantify their **indirect emissions** using an alternative approach that recognizes the variation in carbon impacts of electricity generation throughout the day. Applicants pursuing this approach use hourly data to evaluate emissions from electricity, using the marginal **emissions factors** found in the Toronto Atmospheric Fund's report *A Clearer View on Ontario's Emissions*.[14]

The following criteria must be met for projects to be eligible:

- Must be located in Ontario and connected to the provincial grid;
- Must be 100% electric (emergency backup generators excluded);
- Must have smart meters capable of logging energy use at least hourly installed on the building level; and,
- Must have **onsite renewable energy** equipped with a smart meter capable of logging energy generation at least hourly.

The time-of-day pathway is considered a pilot, and projects interested in pursuing this must contact CAGBC in advance at zerocarbon@cagbc.org.

[14] Available at: https://taf.ca/wp-content/uploads/2019/06/A-Clearer-View-on-Ontarios-Emissions-June-2019.pdf.

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 companies and other organizations preparing a corporate-level greenhouse gas (GHG) emissions inventory and forms the basis for the GHG quantification methodology used in the ZCB-Performance Standard.

The GHG Protocol – Scope 2 Guidance

https://ghgprotocol.org/scope_2_guidance

The Scope 2 Guidance standardizes how corporations measure emissions from purchased or acquired electricity, steam, heat and cooling (called **indirect emissions** in the ZCB-Performance 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 - Integral Group

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

The best practice guide 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.

CASE STUDY

CIMA+ Sherbrooke

Certification: ZCB-Performance (June 2019)
Location: Sherbrooke, Quebec
Project Owner: CIMA+
Sustainability Consultant: CIMA+
Mechanical Engineer: CIMA+

CIMA+ Sherbrook is a 10,900m^2 (117,326 ft^2) three-storey office building with an additional two floors of underground parking. The building was originally designed by the CIMA+ engineering team in 2008, with high energy efficiency standards. For the purpose of the ZCB-Performance certification, no changes were required to the building as it had already demonstrated superior energy performance. The building envelope consists of a high-quality curtain wall envelope system with double glazed windows filled with argon. The building also features efficient lighting systems and controls, and the heating system operates exclusively on electricity.

Heating and cooling are provided by a geo-exchange system consisting of 12 wells. The building also recovers thermal energy from the server room to heat parking spaces. Radiant heating for the parking garage is provided by a glycol water loop coupled to the geo-exchange system. Finally, thermal energy is recovered from the exhaust air of the ventilation system through a rooftop heat wheel.

The carbon footprint of the building was calculated to be 1.8 tonnes of CO_2e due to the low-carbon electricity supplied by Quebec's hydroelectrical generation. CIMA+ procured ECOLOGO **renewable energy certificates** to eliminate the remaining carbon emissions associated with the operations. The team is now working at integrating solar energy to bring the emissions down from 1.8 to 0 tonnes of CO_2e in the next few years.

CIMA+'s corporate vision was the main driver for the certification. The knowledge gained from this project also enables the team to better respond to their clients' expectations as they increasingly ask for solutions to reduce their own carbon emissions.

EMBODIED CARBON

ZCB-Performance projects that have structural or building enclosure work performed during the performance year must include the **embodied carbon** in their Zero Carbon Balance. **Embodied carbon** is the emissions from the manufacturing, transport, installation, use, and end-of-life of building materials. **Embodied carbon** emissions from buildings represent approximately 11 percent of all energy-related carbon emissions globally.[15] 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 or the retrofit is complete. Given the timeframe for meaningful climate action is shrinking, there is a growing awareness of the critical importance of addressing **embodied carbon**.

Storing (or 'sequestering') 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; in other words, **upfront carbon** emissions can be a negative value. Projects that wish to account for carbon storage in the building materials may do so using ISO 21930.

Figure 6 – Impact of Upfront and Operational Carbon Emissions

The applicable requirements for offsetting **embodied carbon** are specified in Figure 7. **Embodied carbon** must be offset using a single purchase of carbon offsets or by making equal purchases annually over a period of up to 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.

[15] Global Alliance for Buildings and Construction, *2019 Global Status Report for Buildings and Construction* (Nairobi: UN Environment, 2019), 12.

All projects	Projects previously certified ZCB-Design v2 or v3
Must offset any embodied carbon of new structural and envelope materials used in a retrofit completed in the year being evaluated for the ZCB-Performance certification. Embodied carbon must be determined by conducting a life cycle assessment following the requirements below.	Must offset the embodied carbon from the initial construction or retrofit, as reported in the embodied carbon report that was submitted for ZCB-Design v2.

Figure 7 – Embodied Carbon Offsetting Requirements

REQUIREMENTS FOR CONDUCTING A LIFE CYCLE ASSESSMENT OF A RETROFIT

Applicants must provide an **embodied carbon** report demonstrating that the requirements outlined below have been met. The *ZCB v2 Embodied Carbon Reporting Template* may be used for this purpose.[16]

Applicants must conduct a **life cycle assessment** (**LCA**) 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)

If the **LCA** software used by the project team produces a value for **beyond the life cycle carbon** (life cycle stage D), projects must report that as supplementary information.

The **LCA** must include all retrofit envelope and structural elements, including footings and foundations, and 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 included; however, excavation and other site development, partitions, building services (electrical, mechanical, fire detection, alarm systems, elevators, etc.), and surface parking lots are excluded.

To encourage building material reuse, the **LCA** should include new materials only. Reused materials do not create additional emissions and should be 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 a separate line item. For example, the fit-up of tenant spaces or the renovation of common areas may provide opportunities for **embodied carbon** reductions.

[16] The *ZCB v2 Embodied Carbon Reporting Template* is available at cagbc.org/zerocarbon.

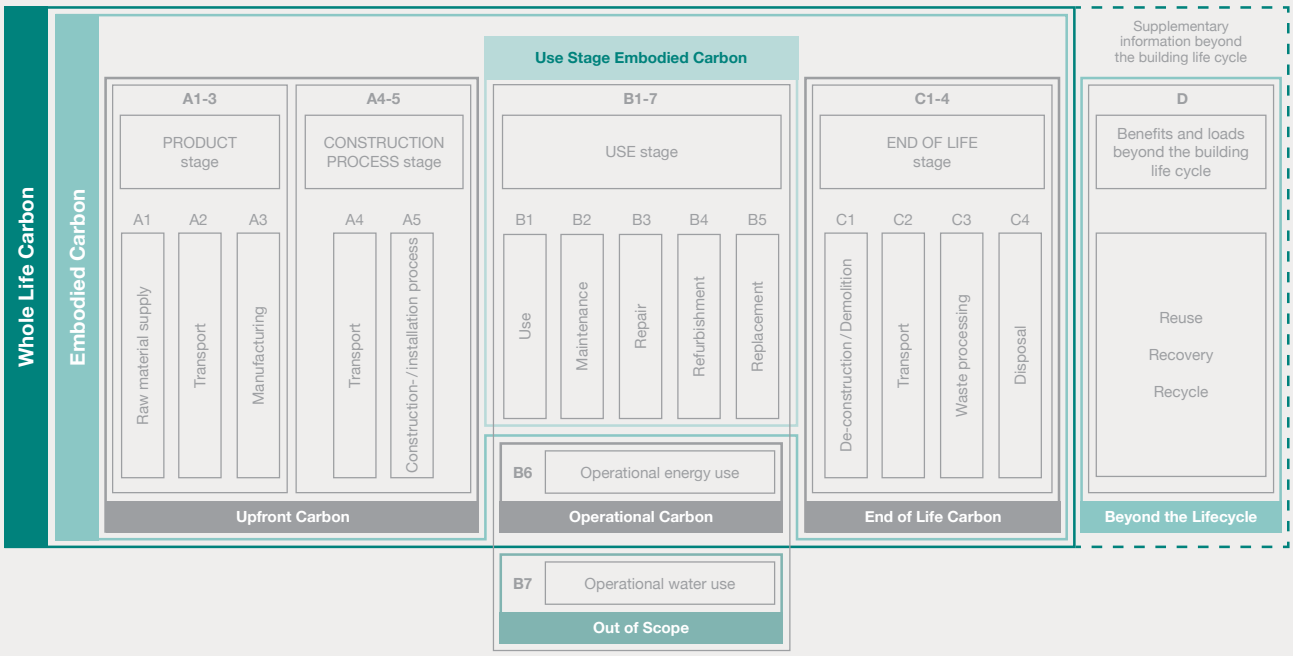


Figure 8 – Embodied Carbon Life cycle Stages[17]

To provide an opportunity to influence design, project teams are encouraged to set a reduction goal early in the retrofit project.

The **embodied carbon** report they submit must include a list of considered and/or implemented recommendations to reduce the **embodied carbon** of the retrofit project. The report submitted must be based on the final design.

The **LCA** must assume a retrofit service life of 60 years. This service life ensures standardized reporting throughout the program and may not reflect the retrofit's designed service life. If the service life of a product used in the retrofit is greater 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 CO_2e) as a total value, as well as broken down in two different ways:

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

The **LCA** is easiest to accomplish using one of the software tools specifically intended for building design teams, with the necessary materials data and **LCA** methods already integrated within the tool.

[17] Figure 8 originally appeared in the World Green Building Council report *Bringing Embodied Carbon Upfront*, 5.

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 through Life Cycle Assessment initiative this primer introduces the concept of embodied carbon of concrete, presents current industry best practices to reduce CO_2 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.

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.

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 lifecycle 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

http://carbonleadershipforum.org/2016/12/30/embodied-carbon-benchmarks/

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.

CASE STUDY
The Phenix

Certification: ZCB-Performance (February 2020)
Location: Montreal, Quebec
Project Owner: Lemay
LCA Consultant: Groupe Agéco
Structural Engineer: Elema
Architect: Lemay

The Phenix is a three-storey, 8,826 m^2 (95,000 ft^2) former industrial building, originally built in 1950. The building underwent a deep retrofit and achieved ZCB-Performance certification for its new use as an office. The project architect, Lemay, implemented an integrated design process to ensure all stakeholders were actively involved early in decision making, enabling the team to meet the high energy performance requirements (including eliminating fossil fuel use) within the approved budget.

The project retained the exposed structure, avoiding the need for new materials and preserving the essence of the building. By keeping the existing structure rather than demolishing it, the project saved over 2,100 tons of **embodied carbon**, equivalent to taking 450 cars off the road for one year. This savings represents a 78 percent reduction in what the **embodied carbon** could have been if the building was built new.

The building envelope was upgraded by focusing on improving the windows and the roof insulation. The roof was a critical area of heat transfer through the envelope. The blown cellulose insulation used in the renovation of the roof amounted to less than 10 percent of the **embodied carbon** of the retrofit (558 tons).

Materials selection was based on preliminary **LCA** analysis. For example, the analysis found that extruded aluminum used for the curtain walls can contribute significantly to **embodied carbon**. The team was able to reduce this by incorporating recycled content and sourcing the aluminum from a region with low-carbon electricity. As the concrete and steel rebar constitute a significant part of the **embodied carbon** of the original structure, the project team minimized the need for new concrete and rebar and specified concrete mixes with recycled content where necessary.

The calculation of the **embodied carbon** included all the required life-cycle stages prescribed in the ZCB-Performance Standard and in accordance with ISO 14040-14044 standards. The **LCA** was performed using both SimaPro 8.5 and the Athena Impact Estimator software. The analysis highlighted the significant opportunity that exists to reduce the upfront **embodied carbon** emissions associated with building construction by renovating existing buildings rather than replacing them.

AVOIDED EMISSIONS

Avoided emissions are emissions reductions that occur outside of the value chain or life cycle of a building. The Zero Carbon Building – Performance Standard recognizes avoided emissions from investing in carbon offset projects as well as avoided emissions based on the grid level impacts provided by exported **green power**.

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.

The 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 and, therefore, better capture the grid-level emissions reductions achieved (baseload electricity generation being unaffected by additions of intermittent **renewable energy**). The GHG Protocol's *Guidelines for Quantifying GHG Reductions from Grid-Connected Electricity Projects* 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*. This working paper advocates for avoided emissions to consider the system-level impacts when bringing products (such as buildings) to market.

Projects 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.

AVOIDED EMISSIONS FROM CARBON OFFSETS

'Avoided Emissions from Carbon Offsets' refers to the emissions that are avoided as a result of 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 reductions will not be canceled over time.
- Leakage: The risk that emissions reductions will result in increased emissions elsewhere.

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

- Certified by Green-e® Climate or equivalent; 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. Projects 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-Performance Standard.

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 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 greenhouse gas 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).

ENERGY REQUIREMENTS

Energy efficiency is critical to ensuring the financial viability of zero carbon buildings. It also promotes resiliency, frees clean energy for use in other economic sectors and geographical regions, and reduces environmental impacts from 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.

ENERGY USE INTENSITY

Energy use intensity (EUI) refers to the sum of all site (not source) energy consumed onsite (e.g., electricity, natural gas, district heat), including all process energy, divided by the building **gross floor area**. Applicants must report the total site EUI of the building in kWh/m^2/year. Reporting **EUI** enables building operators to gauge the effectiveness of energy conservation measures and demonstrate progress over time. It also enables industry to learn from each zero-carbon building.

EUI targets have not been set for operational performance to recognize the range in performance of existing buildings and to encourage the highest number of buildings to achieve zero carbon. Projects undergoing major retrofits to improve energy performance should consider ZCB-Design certification, which features energy performance targets.

RESOURCES

Recommissioning Guide for Building Owners and Managers

https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/pdf/fichier.php/codectec/En/2008-167/NRCan_RCx_Guide.pdf

The *Recommissioning Guide for Building Owners and Managers* provides guidance on how to use recommissioning as a cost-effective way to improve the performance of existing buildings. This guide is an adaptation of the US-EPA guide and development has been managed by Natural Resources Canada's CanmetENERGY in collaboration with the Office of Energy Efficiency.

Advanced Energy Design Guides: Achieving Zero Energy

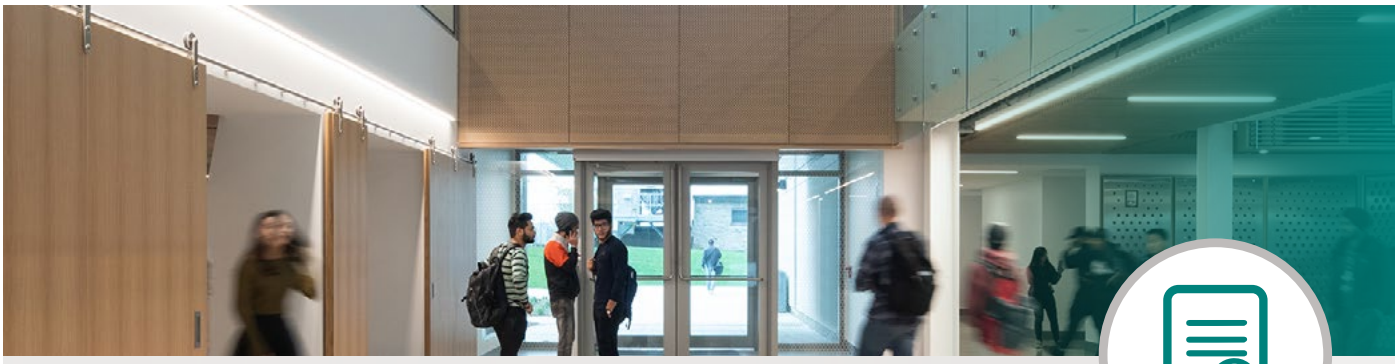
https://www.ashrae.org/technical-resources/aedgs/zero-energy-aedg-free-download

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).

Climate Data for a Resilient Canada

https://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

The Joyce Centre for Partnership & Innovation

Certification: ZCB-Design (May 2018), ZCB-Performance (November 2019)
Location: Hamilton, Ontario
Project Owner: Mohawk College
Architect: B+H / mcCallumSather
Energy Modeller: RDH Building Science Inc.
Commissioning Agent: C3PX Engineering Limited

The Joyce Centre for Partnership & Innovation at Mohawk College is a five-storey building comprised of 8,981 m^2 (96,670 ft^2) of innovative labs, workshops, lecture theatres, industry training centres and showcases. The centre is the first building to achieve both ZCB-Design and ZCB-Performance certification, having demonstrated zero carbon building operations in the first year of operations.

A detailed design process followed by proactive commissioning proved critical to successfully achieving zero carbon in operations. The architectural team hired and retained the commissioning agent in the early stages of the project. The commissioning team ensured compliance with the design specifications and applied enhanced measurement and verification standards for the envelope and mechanical systems. This provided the opportunity to identify and address issues within the building systems. For example, lighting issues were identified and addressed, and crossed piping in the mechanical room was traced as the source of issues with the domestic hot water system.

The quality of construction and installation was closely monitored. The airtightness of the envelope was verified by performing an air leakage test, which was optional at the time but is now a mandatory requirement for projects seeking dual certification under ZCB-Design and ZCB-Performance v2.

A key challenge faced by the project team was the skill level of the technicians and sub-trades related to specific technologies such as heat pumps, geothermal wells, and water temperature amplifiers. These technologies are not used in conventional buildings and there was limited experience among the trades in the local market.

The achievement of both ZCB-Design and ZCB-Performance certification required a commitment from the owner, as well as increased guidance and training of the staff to ensure all elements were designed, constructed and operated as specified.

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.

It is also important to consider seasonal differences in peak electricity demand as minimizing the differences allows the value of existing electricity generation and distribution infrastructure to be maximized, which reduces overall costs. That is, it is more cost-effective to operate infrastructure year-round than to have some of it sit idle for parts of the year.

To address these seasonal differences, applicants for certification under the ZCB-Performance Standard are required to report their 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).

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 domestic hot water needs
- Demand-response capabilities

RESOURCES

Recommissioning Guide for Building Owners and Managers

https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/pdf/fichier.php/codectec/En/2008-167/NRCan_RCx_Guide.pdf

The *Recommissioning Guide for Building Owners and Managers* provides guidance on how to use recommissioning as a cost-effective way to improve the performance of existing buildings. This guide is an adaptation of the US-EPA guide and development has been managed by Natural Resources Canada's CanmetENERGY in collaboration with the Office of Energy Efficiency.

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

AIRTIGHTNESS

Airtightness requirements only apply to ZCB-Design v2 or v3 certified projects that are pursuing their first ZCB-Performance certification.

Airtightness is a critical factor for energy consumption in high-performance buildings. ZCB-Design encourages project teams to target low air leakage rates and allows them to use these lower rates in their energy models. To ensure that air leakage rates meet design expectations and to encourage industry learning, ZCB-Design projects must verify the performance of the building by conducting air leakage testing and submitting the results as part of their first ZCB-Performance certification. Projects that do not achieve the air leakage rate used in the ZCB-Design energy model[18] must describe any corrective action taken and any lessons learned that can be applied to future projects.

Projects previously certified ZCB-Design v2	Other projects
Must conduct air leakage testing and submit results.	No airtightness requirements.

Figure 9 – Airtightness Requirements

Testing should be conducted following *ASTM E3158-18 – Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building*. Applicants are encouraged to average the results from pressurization and de-pressurization testing, unless conducting both tests is unreasonably challenging (e.g., due to high number of intentional mechanical openings to the exterior for which gravity dampers are relied on as a part of the tested air barrier, such as in a multi-unit residential building).

RESOURCES

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.

[18] Refer to the *ZCB-Design v2 Energy Modelling Guidelines* for guidance on how to convert modelled and tested results.

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** however, is not included in the definition of **embodied carbon**.

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 GHG 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**, longevity, 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 the deconstruction/demolition, 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 onsite (e.g., electricity, natural gas, district heat), including all process loads, divided by the building **gross floor area**. EUI must be reported in kWh/m^2/year.

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.

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 (GFA): Consistent with ASHRAE and 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.

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.

Performance year: The year of operations that is used to demonstrate compliance with the ZCB-Performance requirements.

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 15 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 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 one 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 begins to be used.

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

CO_2e: Carbon dioxide equivalents

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

ZCB: Zero carbon building

APPENDIX I

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

- All bundled electricity is generated within Canada;
- 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 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 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 (e.g., proof that **RECs** have been registered with a third-party tracking system).

APPENDIX II

Summary of Addenda Changes

Important changes in July 2021 addenda:

- Pg 11, Additions and attached buildings: The standard was expanded to allow newly constructed additions and attached buildings provided they meet certain criteria.
- Pg 16, Refrigerants: Clarity was provided that refrigerants without global warming impacts do not need to be reported.
- Pg 19, Onsite Renewable Energy: A correction was made to a sentence that stated that onsite renewable energy reduced building energy use intensity (EUI), since that is not how the EUI calculation works in ZCB-Design.
- Pg 22, Resources: A newly published and more comprehensive resource on refrigerant best practices was added to replace an older resource.
- Pg 15, Transition Plan: A clear definition of a transition plan was added to the beginning of the section.

Important changes in June 2022 addenda:

- Pg 18, Green heat: The Standard was updated to allow direct procurement of green heat from district energy providers.
- Pg. 37, Gross floor area: Definition of gross floor area was updated to align with LEED and ASHRAE.

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