HURON PERTH HEALTHCARE ALLIANCE

EMBODIED AND OPERATIONAL CARBON ANALYSIS

HURON PERTH HEALTHCARE ALLIANCE

AVON CREST SITE
46 General Hospital Dr, Stratford, ON

WalterFedy Project No: 2023-0128-01

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1 Introduction

This report focuses exclusively on the embodied and operational carbon impacts of various scenarios for Avon Crest. This report does not provide a recommendation of any of the scenarios. This high level analysis considers calculations of embodied carbon and operational carbon aligning with the industry developments in this area. The definitions of embodied carbon and operational carbon are followed from the Canada Green Building Council: Zero Carbon Building Design Standard (v3). Quantifiable values in this report should be considered for order of magnitude only. Primary assumptions for each of the calculations are listed.

1.1 Embodied carbon

Embodied carbon represents the carbon emissions of the full life cycle of building materials. The life cycle carbon emissions are broken down into stages in the CaGBC ZCB-Design Standard (V3);

- Product (i.e. manufacturing and raw material supply emissions)
- Construction (i.e. on-site installation emissions)
- Use stage (i.e. maintenance, repair, refurbishment, and replacement emissions)
- End of life (i.e. deconstruction, transportation, and waste processing emissions)

Figure 1 displays the embodied carbon stages and components included in each in additional detail.

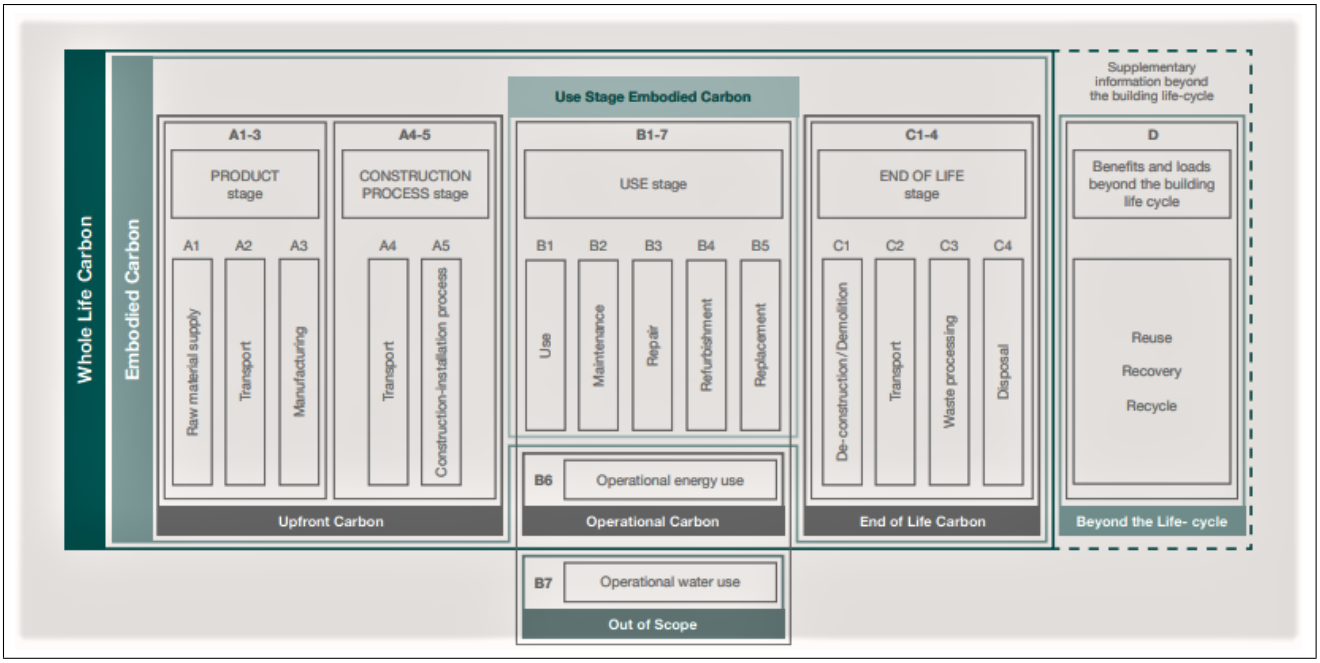

Figure 1: Embodied carbon stages, Reference CaGBC ZCB-design Standard (v3) pg 20

Embodied carbon can be accounted for by using softwares such as OneClick, which provides a detailed breakdown of embodied carbon related to each building element and stages outlined above. This is also commonly referred to as a Life Cycle Assessment or LCA. The LCA must include all envelope and structural elements including;

- Footings
- Foundations
- Complete wall assemblies
- Floors
- Ceilings

- Roof assemblies
- Stairs
- Parking structures.

All other elements are not to be included in a LCA assessment unless otherwise specified.

1.2 Operational carbon

Operational carbon is the carbon emissions associated with energy consumption. The typical energy sources for most buildings in Canada are electricity and natural gas. Electricity carbon emissions are derived from grid emissions from power generation sources (i.e. nuclear plants, fossil fuel plants, and hydroelectric dams). Further details regarding the Ontario and Canadian electricity grid emissions factors can be found via the following sources.

- Independent Electricity System Operator (IESO)
- Government of Canada
- The Atmospheric Fund (TAF)

Natural gas carbon emissions are a result of the combustion of natural gas which releases carbon emissions. Provincially determined emissions factors are used to determine electricity and natural gas carbon emissions.

2 Methodology and Assumptions

The Ontario electricity grid emission factor is expected to change over time. Independent Electricity System Operator (IESO) projections (Annual Planning Outlook IESO, Jan 2020, pg 32) forecast over a doubling of the Ontario electricity grid emission factor. This is largely driven by the increasing electricity demand and retirement of the Pickering nuclear generating station. Given the uncertainty of future Ontario electricity grid emission factors we have assumed the current Ontario grid emission factor as per the 2021 The Atmospheric Fund (TAF) report. Assumptions applied throughout the methodology are summarized as follows.

- GHG emissions factor assumptions are as per Table 1.

Table 1: GHG emission factors

Description	Unit	Value
Electricity GHG Emission Factor	[mtCO2e/kWh]	0.000040
Natural gas GHG Emission Factor	[mtCO2e/m^3]	0.001910

Electricity GHG factors as per TAF (A Clearer View of Ontario's Emissions, 2021 edition)
Natural gas GHG factors as per Ontario Building Code SB-10 (Energy Efficiency Requirements, Article 1.1.2.2.)

2.1 Baseline Assumptions

Stratford General Hospital (SGH) and Avon Crest are jointly metered for electricity and natural gas consumption.

Figure 2 displays hourly electricity consumption for both Avon Crest and SGH in 2019. Each colour represents a different electricity end use at the sites. Above the 0 y-axis represents the consumption of electricity while below the axis represents the generation of electricity. For example, the on-site CHP generates electricity and is displayed below the 0 y-axis.

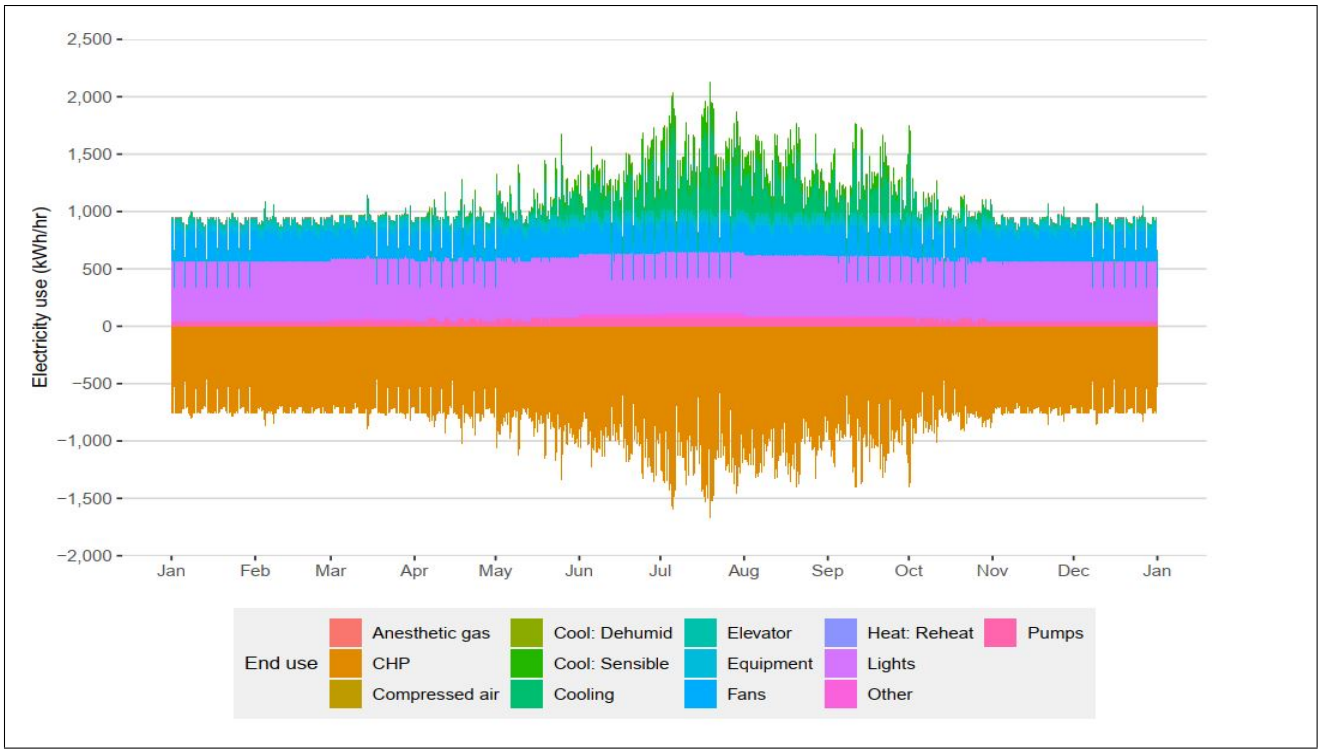

Figure 2: Hourly Electricity Utility Use (2019)

Figure 3 displays hourly natural gas consumption for both Avon Crest and SGH in 2019. Each colour represents a different end use of natural gas consumption at the sites.

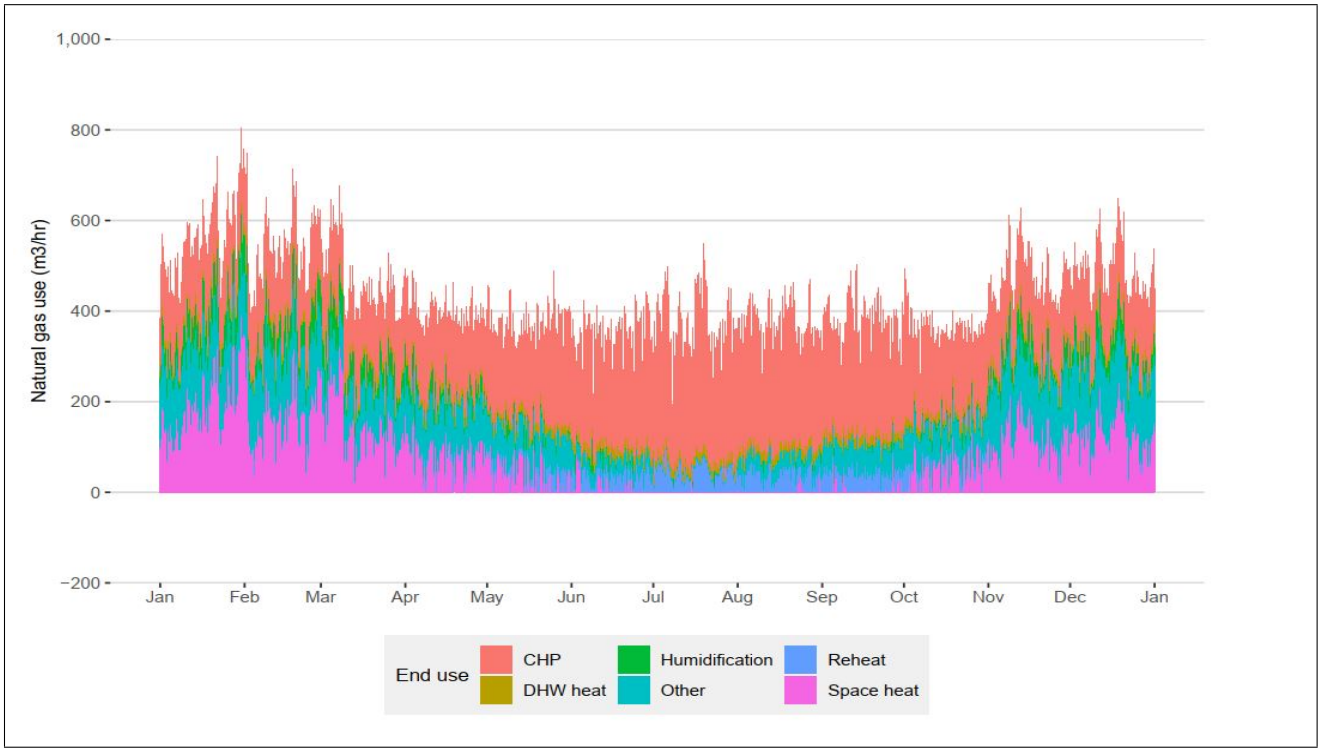

Figure 3: Natural Gas Utility Use (2019)

Baseline annual energy consumption, GHG emissions, and utility costs for the combined facilities is summarized in Figure 4

Category	Utility	Unit	Value
Utility use	Electricity use	[kWh/yr]	1,645,700
	Electricity demand (mth av)	[kWh/hr]	299
	Natural gas use	[m3/yr]	3,381,342
	Water use	[m3/yr]	58,443
GHG emissions	Electricity GHGs	[tCO2e/yr]	66
	Natural gas GHGs	[tCO2e/yr]	6,421
	Total GHGs	[tCO2e/yr]	6,487

Figure 4: Baseline Summary (2019)

- **Avon Crest annual electricity consumption:** The assumptions for estimating the high-level consumption of electricity at Avon Crest are as follows.
  - It is estimated that 4% of the total electricity consumption of SGH and Avon Crest is consumed at Avon Crest as Avon Crest is not individually sub metered. This is estimated at a high-level based on the understood electricity consuming sources at Avon Crest and SGH and the building floor areas of each facility.
  - Natural gas consumption from electricity production from the Combined Heat and Power (CHP) unit is estimated 50% with an estimated 4% of that being consumed at Avon Crest for electricity use. Due to a lack of sub-metering data available, these percentages have been applied as high-level assumptions based on the understanding of electricity consuming sources at Avon Crest and SGH and the building floor areas of each facility.
    - SGH: 52,000 m^2
    - Avon Crest: 5,500 m^2
  - Should a more detailed analysis be completed, sub-metering of natural gas and electricity could be completed for a number of cycles to more accurately understand the usages of Avon Crest.
- **Annual natural gas consumption:** The assumptions for estimating the high-level consumption of natural gas at Avon Crest are as follows.
  - It is estimated that 12% of the total space heating natural gas consumption of SGH and Avon Crest is consumed at Avon Crest as Avon Crest is not individually sub metered. Recently, an ASHRAE Energy Audit was conduct at SGH which outlined estimated energy end uses including natural gas consumed for space heating. This is estimated at a high-level based on the understood space heating requirements at Avon Crest and SGH and the building floor areas of each facility.
  - It is estimated that 50% of the natural gas consumed from the CHP is utilized for space heating with an estimated 12% of that being consumed for space heating at Avon Crest. Due to lack of sub-metering available, these percentages have been applied as high-level assumptions based on the understanding of space heating requirements at Avon Crest and SGH and the building floor areas of each facility.
  - Should a more detailed analysis be completed, sub-metering of natural gas and electricity could be completed for a number of cycles to more accurately understand the usages of Avon Crest.

High-level estimate of the electricity and natural gas use at Avon Crest based on the assumptions above is summarized in Table 2

Table 2: High-level estimate of the electricity and natural gas use for Avon Crest

Description	Unit	Value
Annual Electricity Consumption	[kWh/year]	66,000
Annual Natural gas Consumption	[m^3/year]	190,000
Annual Operational GHG Emissions	[$mtCO_2e$/year]	360

Values should be considered for order of magnitude only

2.2 Scenario Assumptions

Five different scenarios were analyzed for Avon Crest and exclusively focus on the embodied and operational carbon impacts of each scenario.

2.2.1 Scenario 1: Maintain in current state

Scenario 1 reflects an approach where Avon Crest is maintained in its current state with the building requiring a roof replacement and envelope work and would remain with no occupants.

- **Operational carbon assumptions:** Electricity and natural gas use is estimated to remain the same as the current consumption and the GHG emission factors outlined in Table 1 are assumed.
- **Embodied carbon assumptions:** It is assumed that the roof would be replaced and that 50% of the windows and walls would require upgrading. Embodied Carbon is estimated using OneClick's data base of local Environmental Product Declarations (EPDs). Based on local averages, embodied carbon intensities were estimated at 10 mtCO2e/m^2 for roof replacement and 18 mtCO2e/m^2 for windows and walls based on the weighted average of window and wall area at Avon Crest. Embodied Carbon inventory is an emerging inventory and historical data is unavailable in many cases. OneClick software assumes the facility is constructed at present day. The analysis on embodied carbon values provides order of magnitude analysis utilizing the assumptions built within the OneClick software. The CaGBC Net Zero Carbon Design Standard (v3) definitions and bounds for embodied carbon are used.

2.2.2 Scenario 2: Demolition of Avon Crest

Scenario 2 reflects an approach where Avon Crest is demolished (level to the ground).

- **Operational carbon assumptions:** It is assumed that after demolition, the building would cease to consume electricity and natural gas and no longer generate operational carbon emissions.
- **Embodied carbon assumptions:** The embodied carbon as a result of the end of life stage (C1-C-4, in Figure 1) is the carbon associated with de-construction, transportation, waste processing, and disposal of materials. Using OneClick's data base, an average cradle to grave (A1-A4, B4-B5, C1-C4) of 0.45 mtCO2e/m^2 of floor area was assumed. Based on OneClick's data base, typically the end of life stage (C1-C-4, in Figure 1) results on average in 6% of cradle to grave carbon emissions. Embodied Carbon inventory is an emerging inventory and historical data is unavailable in many cases. OneClick software assumes the facility is constructed at present day. The analysis on embodied carbon values provides order of magnitude analysis utilizing the assumptions built within the OneClick software. The CaGBC Net Zero Carbon Design Standard (v3) definitions and bounds for embodied carbon are used. Figure 5 displays a screen capture from OnelClick highlighting the North American embodied carbon benchmark and typical breakdown of embodied carbon by life-cycle stage.

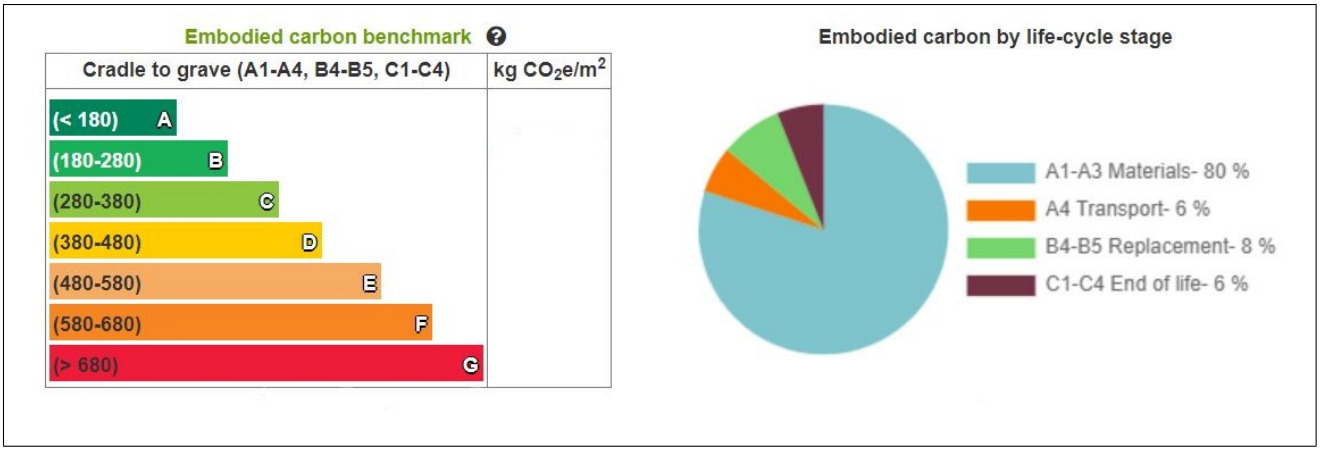

Figure 5: OneClick screen capture highlighting the North American embodied carbon benchmark and typical breakdown of embodied carbon by life-cycle stage.

2.2.3 Scenario 3: Partial refurbishment and partial demolition of Avon Crest

Scenario 3 reflects an approach where the front half (2,880 m^2) of Avon Crest is refurbished and the back half (2,600 m^2) is demolished.

- **Operational carbon assumptions:** Electricity and natural gas use intensity (kWh/m^2 and m^3/m^2) is estimated to double for the refurbishment area as a result of facility having occupants. GHG emission factors outlined in Table 1 are assumed. It is assumed that after demolition, the demolished section would cease to consume electricity and natural gas and would no longer generate operational carbon emissions.
- **Embodied carbon assumptions:** The embodied carbon as a result of the end of life stage (C1-C-4, in Figure 1) is the carbon associated with de-construction, transportation, waste processing, and disposal of materials. Using OneClick's data base, an average cradle to grave (A1-A4, B4-B5, C1-C4) of 0.45 mtCO2e/m^2 of floor area was assumed. Based on OneClick's data base, typically the end of life stage (C1-C-4, in Figure 1) results on average in 6% of cradle to grave carbon emissions. It is assumed that the front refurbished section would required a full envelope upgrade include the roof, walls, and windows. Based on local averages, embodied carbon intensities were estimated at 10 mtCO2e/m^2 for roof replacement and 18 mtCO2e/m^2 for windows and walls based on the weighted average of window and wall area. Embodied Carbon inventory is an emerging inventory and historical data is unavailable in many cases. OneClick software assumes the facility is constructed at present day. The analysis on embodied carbon values provides order of magnitude analysis utilizing the assumptions built within the OneClick software. The CaGBC Net Zero Carbon Design Standard (v3) definitions and bounds for embodied carbon are used.

2.2.4 Scenario 4: New construction 2 story building, 3,250 m^2

Scenario 4 reflects an approach where the existing structure is demolished and a new 3,250 m^2 2 story building is constructed.

- **Operational carbon assumptions:** Electricity and natural gas use intensity (kWh/m^2 and m^3/m^2) is assumed based on average Broader Public Sector (BPS) data for electricity and natural gas consumption for supportive health care facilities. GHG emission factors are outlined in Table 1.
- **Embodied carbon assumptions:** The embodied carbon as a result of the end of life stage (C1-C-4, in Figure 1) is the carbon associated with de-construction, transportation, waste processing, and disposal of materials. Using OneClick's data base, an average cradle to grave (A1-A4, B4-B5, C1-C4) of 0.45 mtCO2e/m^2 of floor area was assumed. Based on OneClick's data base, typically the end of life stage (C1-C-4, in Figure 1) results on average in 6% of cradle to grave carbon emissions. It is assumed that the new construction embodied carbon intensity would be inline with the average identified above. The analysis on embodied carbon values

provides order of magnitude analysis utilizing the assumptions built within the OneClick software. The CaGBC Net Zero Carbon Design Standard (v3) definitions and bounds for embodied carbon are used.

2.2.5 Scenario 5: New construction Net Zero, 2 story building, 3,250 m^2

Scenario 5 reflects an approach where the existing structure is demolished and a new 3,250 m^2, Net Zero, 2 story building is constructed.

- **Operational carbon assumptions:** It is assumed that the new construction would be design to meet CaGBC Net Carbon Design (v3) standard. Therefore, the annual net operational emissions from electricity and natural gas would be 0.
- **Embodied carbon assumptions:** The embodied carbon as a result of the end of life stage (C1-C-4, in Figure 1) is the carbon associated with de-construction, transportation, waste processing, and disposal of materials. Using OneClick's data base, an average cradle to grave (A1-A4, B4-B5, C1-C4) of 0.45 $mtCO2e/m^2$ of floor area was assumed. Based on OneClick's data base, typically the end of life stage (C1-C-4, in Figure 1) results on average in 6% of cradle to grave carbon emissions. It is assumed that the new construction embodied carbon intensity would meet CaGBC Net Zero Carbon Design (v3) standards and would be fully offset resulting in a net zero carbon balance. The analysis on embodied carbon values provides order of magnitude analysis utilizing the assumptions built within the OneClick software. The CaGBC Net Zero Carbon Design Standard (v3) definitions and bounds for embodied carbon are used.

3 Operational and Embodied Carbon Summary

Table 3 summarizes the quantifiable embodied and operational impacts of various scenarios for Avon Crest. These numeric results should be considered for order of magnitude only. Primary assumption for each scenario are outlined in Section 2.2. This report does not provide a recommendation of any of the scenarios. The high level analysis considers calculations of embodied carbon and operational carbon aligning with the industry developments in this area.

Table 3: Operational and Embodied Carbon Analysis Results

Scenario	Operational Carbon [mtCO2e/yr]	Embodied Carbon [mtCO2e]	GHG Emissions (year 1) [mtCO2e]	GHG Emissions (25 years) [mtCO2e]	GHG Emissions (50 Years) [mtCO2e]
Scenario 1 Maintain	360	340	700	9340	NA
Scenario 2 Demolition	0	150	150	150	150
Scenario 3 Partial Refurbishment	380	310	690	9810	19310
Scenario 4 New Construction	200	1100	1300	6100	11100
Scenario 5 New Net Zero Construction	0	730	0	0	0

Glossary of Terms

- **Operational Carbon:** Carbon emissions associated with energy use and the release of refrigerants during regular operations. (CaGBC Net Zero Design Standard v3)
- **Embodied Carbon:** Carbon emissions associated with materials and construction processes throughout the whole life cycle. (CaGBC Net Zero Design Standard v3)
- **Metrics Tons of Carbon Dioxide Equivalent (mtCO2e):** Represents the number of metric tons of CO2 emissions with the same global warming potential as one metric ton of another greenhouse gas. (Environmental Protection Agency, EPA)
- **GHG Emissions (25 years) [mtCO2e]:** Represents the total carbon emissions of a particular scenario over a 25-year period. Operational carbon is the sum of annual GHG emissions over the 25-year period, while embodied carbon is a one-time GHG emission value. This metric is the sum of both operational and embodied carbon over the 25 year period.
- **GHG Emissions (50 years) [mtCO2e]:** Represents the total carbon emissions of a particular scenario over a 50-year period. Operational carbon is the sum of annual GHG emissions over the 50-year period, while embodied carbon is a one-time GHG emission value. This metric is the sum of both operational and embodied carbon over the 50 year period.