Assessment of an “Insulation First” Decarbonization Strategy

Prepared for: NAIMA Canada

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EXECUTIVE SUMMARY

NAIMA Canada, representing mineral fibre insulation manufacturers, commissioned the work detailed in this report. This report presents the findings of a preliminary assessment of an “insulation first” decarbonization strategy for Part 9 residential buildings in Canada. The operational and embodied carbon impacts associated with increasing insulation and airtightness levels in new residential construction were assessed.

Five residential archetypes were examined across two Canadian climate zones: climate zone 6 (Ottawa) and climate zone 7a (Edmonton). This assessment compared NBC 2020 Performance Tier 1 homes with upgraded scenarios that incorporated Tier 5 insulation and airtightness levels while maintaining the Tier 1 mechanical systems and overall design approach.

Energy performance and operation carbon emissions were modelled using HOT2000 within the Volta SNAP platform, and embodied carbon emissions were evaluated using Natural Resources Canada’s Material Carbon Emissions Estimator (MCE^2). The embodied carbon assessment focused on cradle-to-gate emissions (A1 to A3 lifecycle stages) associated with building materials, and select mechanical equipment was also considered.

The results demonstrate that increasing insulation and airtightness levels significantly reduced annual operational carbon emissions across all archetypes and climate zones. The reductions in operational carbon emissions ranged from 0.57 to 2.02 tonnes of carbon dioxide equivalents (CO_2e) per year, while the increase in embodied carbon emissions associated with the additional insulation materials ranged from 2.11 to 6.17 tonnes of CO_2e.

The study also evaluated the “carbon payback period,” defined as the time required for operational carbon savings to offset the additional embodied carbon emissions associated with the upgraded insulation strategy. Across all archetypes, the “carbon payback period” ranged from approximately 3.1 to 5.1 years.

These findings suggest that an “insulation first” approach can provide meaningful long-term carbon reductions while avoiding the need for costly and disruptive envelope retrofits later in a building’s life. Since insulation and airtightness measures are typically implemented once and remain in place for the life of the building, prioritizing these upgrades during initial construction may represent an effective strategy for supporting Canada’s transition toward net zero emissions by 2050.

A WORD FROM NAIMA CANADA

The Canadian Board for Harmonized Construction Codes (CBHCC) published a Climate Change Policy Position on Embodied Greenhouse Gas (GHG) Emissions for inclusion in the 2030 Model National Building Code. The Policy Position was published in July 2025. The CBHCC approach is modeled after the Tiered approach used for Operational Carbon Emissions which was introduced in the 2025 Model National Building Code.

NAIMA Canada believes that the entire life cycle of a building should be considered to provide an accurate assessment of the benefit insulation has on the carbon consumption of the building. NAIMA Canada strongly suggests that further research should be completed to inform the 2030 Model National Building Code. NAIMA Canada's interests in the gaps in embodied carbon assessments were explored in Appendix B.

CONTENTS

BACKGROUND

Insulation is one of the most common and effective energy conservation measures used in residential construction. Increased insulation levels are often required to comply with higher tiers of Canada's National Building Code, as well as voluntary home labelling programs such as ENERGY STAR for New Homes and the Canadian Home Builders' Association's Net Zero Home program.

Insulation retrofits in existing homes can be costly, highly disruptive, and technically challenging to implement. To reduce the need for complex retrofits in the future, NAIMA Canada is proposing an "insulation first" decarbonization strategy, which prioritizes achieving Tier 5 levels of insulation and air tightness in new residential construction. This strategy recognizes that upgrades to windows and heating, ventilation and air conditioning (HVAC) systems are generally less intrusive and can be more easily completed over time, whereas insulation and airtightness improvements are significantly more difficult to implement after construction is complete.

This assessment evaluated the impacts of NAIMA Canada's "insulation first" decarbonization strategy on operational and embodied carbon emissions for five residential archetypes across two Canadian climate zones. The findings of this assessment are intended to support the decarbonization of the Canadian building industry and contribute to Canada's commitment to achieving net zero greenhouse gas emissions by 2050.

SCOPE

Archetypes

Five different archetypes were included in this study:

Archetype	Conditioned Floor Area
Single Detached	2,461 ft^2
Mid Unit Townhome	2,467 ft^2
End Unit Townhome	2,817 ft^2
Mid Unit Stacked Townhome*	2,237 ft^2
End Unit Stacked Townhome*	2,255 ft^2

*The upper and lower units were both considered for the stacked townhome archetypes to account for the foundation and slab, and the roof.

Climate Zones

The archetypes were modelled in climate zone 6 (Ottawa) and climate zone 7a (Edmonton).

Modelling Tools

The energy modelling was completed using version 11.13 of HOT2000 in the Volta SNAP tool. The modelling was done in EnerGuide Rating System 2020 NBC mode. The embodied carbon modelling was completed in Natural Resources Canada's Material Carbon Emissions Estimator (MCE^2) tool. This tool models the cradle-to-gate emissions (life cycle stages A1 to A3) for residential building materials.

Performance Levels

The following specification packages were modelled to establish the base case and develop the upgrade scenarios:

- **Base Case:** NBC 2020 Performance Tier 1
- **Reference Case:** NBC 2020 Performance Tier 5 (used to determine the insulation and airtightness levels required for the upgrade scenario)
- **Upgrade Scenario:** NBC 2020 Performance Tier 1, with all insulation and air tightness values upgraded to match those in the NBC 2020 Performance Tier 5 models

Insulation Materials Modelled

All the insulation products included in this assessment are manufactured by NAIMA Canada members. The products were modelled in MCE^2 using environmental product declaration (EPD) data. The insulation products used for each building component are listed below:

- **Attic:** CertainTeed InsulSafe XC (Edmonton), CertainTeed Northern White (Ottawa)
- **Wall (Cavity):** Owens Corning Pink Next Gen Fiberglas Insulation

- **Wall (Continuous):** Owens Corning Foamular NGX
- **Exposed Floor:** Owens Corning Ultra Pure Closed Cell Spray Foam
- **Sub Slab:** Owens Corning Foamular NGX
- **Basement:** Owens Corning Pink Next Gen Fiberglas Insulation

It should be noted that the results of this assessment apply only to the specific products modelled. The use of alternative insulation products, manufacturers, or material types could significantly affect the embodied carbon results.

METHODOLOGY

Operational Carbon

The archetypes were modelled in Volta SNAP for each climate zone, and it was confirmed that the packages modelled for NBC Performance Tier 1 and NBC Performance Tier 5 achieved compliance. The specifications are tabulated in Appendix A. Then, the Tier 1 packages were modelled with the insulation and airtightness levels from the Tier 5 package to create the upgrade scenarios.

The energy consumption, fuel consumption and operational carbon emission results were extracted from Volta SNAP and tabulated. The annual operational carbon emission results from Volta SNAP use greenhouse gas emissions factors from the *National Inventory Report 1990 –2023: Greenhouse Gas Sources and Sinks in Canada*[1].

Embodied Carbon

The archetypes were modelled in MCE[2] to assess the cradle-to-gate (A1 to A3) emissions of the Tier 1 packages and the Tier 1 with Tier 5 insulation and airtightness packages. EPD data for the insulation products was input into MCE[2] for this assessment.

NAIMA Canada also requested the inclusion of embodied carbon emissions associated with space conditioning, domestic hot water, and ventilation equipment. Embodied carbon data for this equipment was sourced from the RESNET 1150-2025 Standard [2]. The following equipment types were considered in one or more packages:

- Furnace,
- Heat pump,
- Central AC,
- Electric auxiliary heater
- Balanced ventilation with HRV

This was a **high-level** assessment and did not account for HVAC sizing differences between the archetypes for space heating and cooling equipment. The embodied carbon emissions of the equipment were added to the A1 to A3 embodied carbon emissions calculated through the MCE[2] modelling.

RESULTS

The operational and embodied carbon modelling results are tabulated in Appendix A. The following table summarizes the impact of adding Tier 5 insulation and airtightness to the Tier 1 packages.

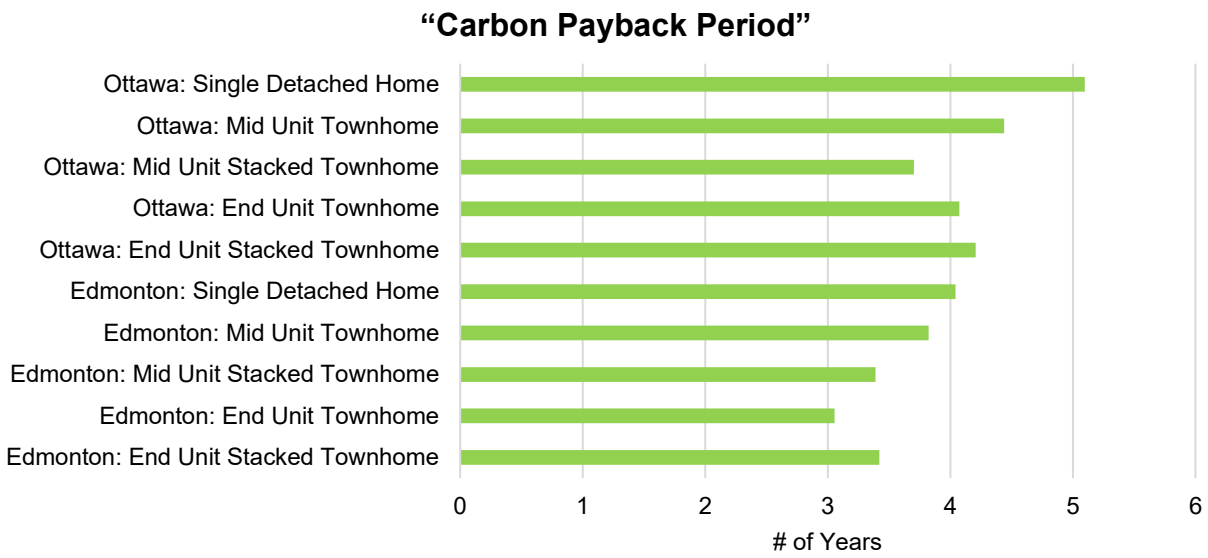
Impact of Adding Tier 5 Insulation and Airtightness to Tier 1 Packages

Archetype	Reduction in Annual Operational Carbon Emissions (tonnes/yr)	Increase in Embodied Carbon Emissions (tonnes)
Edmonton: End Unit Stacked Townhome	1.00	3.42
Edmonton: End Unit Townhome	2.02	6.17
Edmonton: Mid Unit Stacked Townhome	0.72	2.44
Edmonton: Mid Unit Townhome	1.01	3.86
Edmonton: Single Detached Home	1.42	5.74
Ottawa: End Unit Stacked Townhome	0.77	3.24
Ottawa: End Unit Townhome	1.35	5.50
Ottawa: Mid Unit Stacked Townhome	0.57	2.11
Ottawa: Mid Unit Townhome	0.73	3.24
Ottawa: Single Detached Home	1.02	5.20

Next, the “carbon payback period” (the number of years required for the reduction in operational carbon emissions to offset the increase in embodied carbon emissions) associated with the higher insulation levels in the upgrade scenario was calculated. The results are summarized in the table and the graph below.

“Carbon Payback Period”

Archetype	# of Years
Edmonton: End Unit Stacked Townhome	3.4
Edmonton: End Unit Townhome	3.1
Edmonton: Mid Unit Stacked Townhome	3.4
Edmonton: Mid Unit Townhome	3.8
Edmonton: Single Detached Home	4.0
Ottawa: End Unit Stacked Townhome	4.2
Ottawa: End Unit Townhome	4.1
Ottawa: Mid Unit Stacked Townhome	3.7
Ottawa: Mid Unit Townhome	4.4
Ottawa: Single Detached Home	5.1



It would take approximately 3.1 to 5.1 years, depending on the archetype, for the reduction in operational carbon emissions to offset the increase in embodied carbon emissions due to the higher insulation levels.

ADDITIONAL CONSIDERATIONS

This assessment followed the embodied carbon modelling approach commonly used for Part 9 residential buildings and used the MCE^2 tool developed by Natural Resources Canada for the residential construction industry.

NAIMA Canada identified that focusing on lifecycle stages A1 to A3 excludes other significant sources of embodied carbon emissions. These include emissions from temporary propane heaters used during construction (A5 lifecycle phase) and the replacement of building materials at the end of their useful service life (B4 lifecycle phase). A whole-building lifecycle analysis would account for these emission sources.

Additionally, a whole-building life cycle analysis would also highlight that insulation is installed during the construction phase, and in most cases, it remains in place for the life of the building.

Appendix B explores NAIMA Canada's additional considerations under a separate cover.

CONCLUSION

As building codes continue to advance, higher insulation levels will be required in new residential homes. NAIMA Canada recommends an “insulation first” decarbonization strategy for builders constructing homes above minimum building code requirements, as this approach can help avoid intrusive and costly retrofits in the future.

The results of this assessment indicate that the embodied carbon emissions associated with Tier 5 levels of insulation can be offset within five years or less through reductions in operational carbon emissions. As a result, this strategy could contribute to Canada’s 2050 net zero greenhouse gas emissions target.

Further analysis could be undertaken to evaluate how the “carbon payback period” may change when a whole-building life cycle assessment is performed.

REFERENCES

[1] Environment and Climate Change Canada. “*National Inventory Report 1990–2023: Greenhouse Gas Sources and Sinks in Canada*” 2025. Available online at: canada.ca/ghg-inventory

[2] Residential Energy Services Network. "*RESNET 1550-2025 Standard for Quantifying, Verifying and Reporting the Embodied Carbon of Buildings with Dwelling and Sleeping Units*," Residential Energy Services Network, Moorpark, 2026.

APPENDIX A

Specifications

Ottawa Tier 1 Specifications

	End Stacked TH	Mid Stacked TH	End TH	Mid TH	Single Detached
Attic Insulation	R51	R51	R51	R51	R51
Above Grade Wall Insulation	R20	R20	R20	R20	R20
Exposed Floor Insulation	R31	R31	R31	R31	R31
Below Grade Wall Insulation	R20	R20	R20	R20	R20
Sub Slab Insulation	0	0	0	0	0
Windows	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC
Airtightness (ACH @ 50 Pa)	3	3	3	3	2.5
Heat Recovery Ventilator	65% SRE	65% SRE	65% SRE	n/a	n/a
Space Heating	95% AFUE	95% AFUE	95% AFUE	95% AFUE	95% AFUE
Space Cooling	14.5 SEER	14.5 SEER	14.5 SEER	14.5 SEER	14.5 SEER
Domestic Hot Water	0.67 EF	0.67 EF	0.67 EF	0.67 EF	0.67 EF
Drain Water Heat Recovery	-	-	-	-	-

Edmonton Tier 1 Specifications

	End Stacked TH	Mid Stacked TH	End TH	Mid TH	Single Detached
Attic Insulation	R51	R51	R51	R51	R51
Above Grade Wall Insulation	R20	R22	R20	R20	R20
Exposed Floor Insulation	R31	R31	R31	R31	R31
Below Grade Wall Insulation	R20	R20	R20	R20	R20
Sub Slab Insulation	0	0	0	0	0
Windows	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC	1.6 UV 0.26 SHGC
Airtightness (ACH @ 50 Pa)	3	3	3	3	2.5
Heat Recovery Ventilator	65% SRE	65% SRE	65% SRE	n/a	n/a
Space Heating	95% AFUE	95% AFUE	95% AFUE	95% AFUE	95% AFUE
Space Cooling	14.5 SEER	14.5 SEER	14.5 SEER	14.5 SEER	14.5 SEER
Domestic Hot Water	0.67 EF	0.67 EF	0.67 EF	0.67 EF	0.67 EF
Drain Water Heat Recovery	-	-	-	-	-

Ottawa Tier 5 Specifications

	End Stacked TH	Mid Stacked TH	End TH	Mid TH	Single Detached
Attic Insulation	R80	R80	R80	R80	R80
Above Grade Wall Insulation	R22 + R10	R22 + R10	R22 + R10	R22 + R10	R22 + R10
Exposed Floor Insulation	R31	R31	R31 + R10	R31	R31
Below Grade Wall Insulation	R22 + R10	R22 + R10	R24 + R10	R22 + R10	R22 + R10
Sub Slab Insulation	R15	R15	R15	R15	R15
Windows	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC
Airtightness (ACH @ 50 Pa)	1.5	1.5	1	1.5	1.5
Heat Recovery Ventilator	81% SRE	81% SRE	81% SRE	81% SRE	81% SRE
Space Heating	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup
Space Cooling	21 SEER	21 SEER	21 SEER	21 SEER	21 SEER
Domestic Hot Water	2.3 EF HPWH	2.3 EF HPWH	2.3 EF HPWH	2.3 EF HPWH	2.3 EF HPWH
Drain Water Heat Recovery	54.2%	54.2%	54.2%	54.2%	54.2%

Edmonton Tier 5 Specifications

	End Stacked TH	Mid Stacked TH	End TH	Mid TH	Single Detached
Attic Insulation	R80	R80	R80	R80	R80
Above Grade Wall Insulation	R22 + R10	R22 + R10	R22 + R10	R22 + R10	R22 + R10
Exposed Floor Insulation	R31	R31	R31 + R10	R31	R31
Below Grade Wall Insulation	R22 + R10	R22 + R10	R22 + R15	R22 + R10	R22 + R10
Sub Slab Insulation	R15	R15	R15	R15	R15
Windows	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC	0.9 UV 0.26 SHGC
Airtightness (ACH @ 50 Pa)	1.5	1.5	1	1.5	1.5
Heat Recovery Ventilator	81% SRE	81% SRE	81% SRE	81% SRE	81% SRE
Space Heating	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup	11.2 HSPF ASHP 100% Electric Backup
Space Cooling	21 SEER	21 SEER	21 SEER	21 SEER	21 SEER
Domestic Hot Water	2.3 EF HPWH	2.3 EF HPWH	2.9 EF HPWH	2.3 EF HPWH	2.3 EF HPWH
Drain Water Heat Recovery	54.2%	54.2%	54.2%	54.2%	54.2%

The Tier 5 packages were modelled to confirm performance path compliance in Volta SNAP. Then, the insulation and airtightness specifications from these packages were applied to the Tier 1 packages, resulting in the Tier 1 with Tier 5 insulation and airtightness packages.

Data Tables

Edmonton: End Unit Stacked Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	108.81	89.20
Natural Gas (m^3)	1983.21	1442.93
Electricity (kWh)	9710.17	9850.95
OC (t/y)	**8.14**	**7.14**
A1-A3 EC (t)	24.58	28.00
A1-A3 + Mechanicals EC (t)	**25.63**	**29.05**

Edmonton: End Unit Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	174.49	136.18
Natural Gas (m^3)	3823.79	2796.66
Electricity (kWh)	8915.94	8897.00
OC (t/y)	**11.40**	**9.38**
A1-A3 EC (t)	28.68	34.85
A1-A3 + Mechanicals EC (t)	**29.73**	**35.90**

Edmonton: Mid Unit Stacked Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	92.35	78.15
Natural Gas (m^3)	1548.73	1154.23
Electricity (kWh)	9631.73	9769.31
OC (t/y)	**7.26**	**6.54**
A1-A3 EC (t)	20.98	23.42
A1-A3 + Mechanicals EC (t)	**22.03**	**24.47**

Edmonton: Mid Unit Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	93.23	73.80
Natural Gas (m^3)	1737.15	1211.14
Electricity (kWh)	7928.11	7972.54
OC (t/y)	**6.88**	**5.87**
A1-A3 EC (t)	23.31	27.17
A1-A3 + Mechanicals EC (t)	**24.36**	**28.22**

Edmonton: Single Detached Home

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	114.43	87.09
Natural Gas (m^3)	2299.29	1560.22
Electricity (kWh)	8001.64	8053.44
OC (t/y)	**8.01**	**6.59**
A1-A3 EC (t)	26.75	32.49
A1-A3 + Mechanicals EC (t)	**27.80**	**33.54**

Ottawa: End Unit Stacked Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	94.29	79.75
Natural Gas (m^3)	1545.24	1142.74
Electricity (kWh)	10207.62	10332.12
OC (t/y)	**3.57**	**2.80**
A1-A3 EC (t)	24.33	27.57
A1-A3 + Mechanicals EC (t)	**25.38**	**28.62**

Ottawa: End Unit Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	140.38	114.32
Natural Gas (m^3)	2867.58	2165.28
Electricity (kWh)	9331.47	9358.05
OC (t/y)	**6.06**	**4.71**
A1-A3 EC (t)	28.21	33.71
A1-A3 + Mechanicals EC (t)	**29.26**	**34.76**

Ottawa: Mid Unit Stacked Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	82.02	71.28
Natural Gas (m^3)	1226.57	927.15
Electricity (kWh)	10093.93	10208.15
OC (t/y)	**2.95**	**2.38**
A1-A3 EC (t)	20.69	22.80
A1-A3 + Mechanicals EC (t)	**21.74**	**23.85**

Ottawa: Mid Unit Townhome

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	79.98	65.94
Natural Gas (m^3)	1351.80	969.54
Electricity (kWh)	8233.59	8286.63
OC (t/y)	**3.08**	**2.35**
A1-A3 EC (t)	22.90	26.14
A1-A3 + Mechanicals EC (t)	**23.95**	**27.19**

Ottawa: Single Detached Home

Results	Tier 1	Tier 1 with Tier 5 Insulation + AT
Energy Consumption (GJ)	96.60	76.93
Natural Gas (m^3)	1784.36	1249.81
Electricity (kWh)	8374.04	8440.29
OC (t/y)	**3.92**	**2.90**
A1-A3 EC (t)	26.36	31.56
A1-A3 + Mechanicals EC (t)	**27.41**	**32.61**

ABOUT

BUILDING KNOWLEDGE CANADA INC.

Building Knowledge Canada (BKC) originally began in 1986 as a division of Air Solutions, then incorporated interdependently in 2009. BKC is the largest residential energy evaluation/home performance company in Canada with over 43,000+ high performance home evaluations/ratings completed across Canada since it's creation.

The firm specializes in practical building sciences for residential buildings/homes including energy modeling, enclosure and HVAC design and forensics, indoor air quality & thermal comfort design, air tightness testing & air barrier design and forensics, HVAC residential commissioning, enclosure water management detailing & forensics; All with the clear goal of achieving energy efficiency, envelope durability and occupant health and comfort.

Building Knowledge Canada is a leader in building performance strategies and an expert on the industry's cutting edge initiatives. BKC's credentials include qualifications in the following areas:

- Recognized Building Science Trainers: Natural Resources Canada
- High Performance Building Science Training For Builders, Trade Contractors, Architects, Sales/Marketing Teams, Real Estate Industry, Building Officials
- Building Science/Building Envelope Diagnostics & Testing
- Energy Software Modeling and Design Analysis Including Hot 2000 Remrate, and Retscreen
- Building Code Compliance – Mbc and Obc Energy Compliance: Performance/Prescriptive/Comparative
- Air Barrier/Tightness Detailing, Diagnostics and Evaluations
- CMHC Trained Indoor Air Quality Investigators: Training and Audits
- HVAC Design Review, System Diagnostics (HRAI Accredited Staff)
- NET ZERO Home Design Analysis, Modeling and Testing
- LEED
- ENERGY STAR®

BKC contributes its expertise in Building Science Training and Building Code Analysis for several industry partners including both Federal & Provincial public institutions and private manufacturers of construction material and HVAC equipment. Currently BKC is providing Building Science/Energy Efficiency Training and Consultation for the following clients:

- CMHC Canadian Mortgage & Housing Corp
- CHBA Canadian Home Builders Assoc
- Natural Resources Canada
- NRCan LEEP Division
- ENBRIDGE
- EnerQuality Corporation
- Dupont / Dow
- Owens Corning
- Venmar VanEE
- Jeld-Wen
- EEBA Energy & Env Building Alliance
- New Brunswick Power
- BC British Columbia Housing
- OBOA Ontario Building Officials Association
- OHBA Ontario Homebuilders Association

BKC team members have been instrumental in the development of numerous industry standards (NRC, CSA, etc.) and participate on various building code and advanced housing program committees:

- CHBA Net Zero Home Council and Program Management Committee
- National Building Code -Standing Comm Energy and Buildings
- ASHRAE 90.2 Residential low rise Energy Efficiency Standing committee
- ENERGY STAR® for New Homes Advisory Committee and TAC Committee Chair
- CSA F280 -2012 Development and Committee Chair
- CSA TC 424: Energy Systems in buildings and homes
- Ontario Building Code Part 9 2012 Advisory Committee, Part 7, 3 and 12 Review committees
- LEED for Homes Canadian Technical Review Committee

BUILDING KNOWLEDGE CANADA INC.

THE HOME THAT SCIENCE BUILT

Appendix B

NOTE: The content of this appendix extends beyond current industry practices and was requested by NAIMA Canada. Some assumptions were made because reliable and robust data is not consistently available for all Life Cycle Analysis Stages. The reader/user should be aware of this limitation as it may be an important consideration depending on how the data is being used.

PERFORMANCE LEVELS REQUESTED FOR ANALYSIS BY NAIMA CANADA

NAIMA Canada requested energy modelling and embodied carbon modelling of the following specification packages representing various insulation scenarios:

- NBC Performance Tier 1
- NBC Performance Tier 1, with all insulation removed
- NBC Performance Tier 5
- NBC Performance Tier 1, with all insulation upgraded to the levels in the NBC Performance Tier 5 models
- NBC Performance Tier 1, with all insulation and air tightness values upgraded to the levels in the NBC Performance Tier 5 models

ADDITIONAL LIFE CYCLE STAGES

NAIMA Canada also requested a **high-level** that included life cycle stages A4 and A5. The embodied carbon modelling tools in the residential construction industry do not account for stages A4 and A5, therefore external factors were applied. The following high-level assumptions were applied [1]:

- A1 to A3: 75% of the total embodied carbon emissions
- A4 to A5: 8% of the total embodied carbon emissions

This approach falls outside current industry. The residential construction industry primarily focuses on A1 to A3 emissions because these stages account for most of the embodied carbon emissions of the building and are supported by the most reliable and robust data from material manufacturers. While estimates were used when needed, more work is required to develop reliable and robust data for all life cycle stages.

MATERIAL REPLACEMENT

NAIMA Canada recommends that the industry considers the embodied carbon impacts of material and equipment replacement over the lifecycle of a building. They suggested a 20-year replacement periods space heating equipment and shingles, and a 25-year replacement period for windows. Material replacement is difficult to assess due to the uncertainty and variability surrounding when components will be replaced and what replacement products will be selected. More work is required to develop an industry standard approach for products which require replacement during the life of the building.

DATA TABLES

It should be noted that the data under **Tier 1 no insulation does not represent a business-as-usual baseline, because it represents performance below the National Building Code minimum requirements. This deviates from currently established embodied carbon accounting practices. NAIMA Canada requested the inclusion of this package because they are determining a linear scale metric for future research on operational material carbon analysis.*

Edmonton: End Unit Stacked Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	108.81	54.43	205.46	89.20	99.77
Natural Gas (m^3)	1983.21	0.00	4587.97	1442.93	1733.82
Electricity (kWh)	9710.17	15118.75	9612.69	9850.95	9779.67
OC (t/y)	**8.14**	**6.62**	**13.21**	**7.14**	**7.68**
A1-A3 EC (t)	24.58	28.38	23.55	28.00	28.00
A1-A3 + Mechanicals EC (t)	25.63	32.29	24.60	29.05	29.05
A1-A5 + Mechanicals EC (t)	**28.36**	**35.74**	**27.23**	**32.14**	**32.14**

Edmonton: End Unit Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	174.49	80.29	487.35	136.18	148.11
Natural Gas (m^3)	3823.79	0.00	12087.04	2796.66	3116.70
Electricity (kWh)	8915.94	22301.89	10342.55	8897.00	8899.93
OC (t/y)	**11.40**	**9.77**	**28.23**	**9.38**	**10.01**
A1-A3 EC (t)	28.68	35.35	26.84	34.85	34.85
A1-A3 + Mechanicals EC (t)	29.73	39.26	27.89	35.90	35.90
A1-A5 + Mechanicals EC (t)	**32.90**	**43.45**	**30.86**	**39.72**	**39.72**

Edmonton: Mid Unit Stacked Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	92.35	49.16	154.06	78.15	88.32
Natural Gas (m^3)	1548.73	0.00	3219.69	1154.23	1436.16
Electricity (kWh)	9631.73	13655.34	9489.47	9769.31	9676.26
OC (t/y)	**7.26**	**5.98**	**10.47**	**6.54**	**7.05**
A1-A3 EC (t)	20.98	23.70	19.96	23.42	23.42
A1-A3 + Mechanicals EC (t)	22.03	27.61	21.01	24.47	24.47
A1-A5 + Mechanicals EC (t)	**24.38**	**30.56**	**23.25**	**27.08**	**27.08**

Edmonton: Mid Unit Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	93.23	44.84	231.69	73.80	84.13
Natural Gas (m^3)	1737.15	0.00	5450.41	1211.14	1490.38
Electricity (kWh)	7928.11	12454.66	7978.30	7972.54	7952.52
OC (t/y)	**6.88**	**5.46**	**14.18**	**5.87**	**6.41**
A1-A3 EC (t)	23.31	27.41	21.69	27.17	27.17
A1-A3 + Mechanicals EC (t)	24.36	31.32	22.74	28.22	28.22
A1-A5 + Mechanicals EC (t)	**26.96**	**34.66**	**25.17**	**31.22**	**31.22**

Edmonton: Single Detached Home

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	114.43	48.86	313.81	87.09	95.85
Natural Gas (m^3)	2299.29	0.00	7635.68	1560.22	1797.61
Electricity (kWh)	8001.64	13571.98	8181.78	8053.44	8030.89
OC (t/y)	**8.01**	**5.94**	**18.56**	**6.59**	**7.04**
A1-A3 EC (t)	26.75	32.87	25.14	32.49	32.49
A1-A3 + Mechanicals EC (t)	27.80	36.78	26.19	33.54	33.54
A1-A5 + Mechanicals EC (t)	**30.76**	**40.71**	**28.98**	**37.11**	**37.11**

Ottawa: End Unit Stacked Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	94.29	49.75	168.27	79.75	87.67
Natural Gas (m^3)	1545.24	0.00	3541.93	1142.74	1360.27
Electricity (kWh)	10207.62	13819.68	10103.89	10332.12	10280.45
OC (t/y)	**3.57**	**0.82**	**7.40**	**2.80**	**3.22**
A1-A3 EC (t)	24.33	27.96	23.55	27.57	27.57
A1-A3 + Mechanicals EC (t)	25.38	31.87	24.60	28.62	28.62
A1-A5 + Mechanicals EC (t)	**28.09**	**35.27**	**27.23**	**31.67**	**31.67**

Ottawa: End Unit Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	140.38	66.72	381.88	114.32	123.01
Natural Gas (m^3)	2867.58	0.00	9242.79	2165.28	2397.96
Electricity (kWh)	9331.47	18533.84	10466.75	9358.05	9365.02
OC (t/y)	**6.06**	**1.09**	**18.36**	**4.71**	**5.16**
A1-A3 EC (t)	28.21	34.22	26.84	33.71	33.71
A1-A3 + Mechanicals EC (t)	29.26	38.13	27.89	34.76	34.76
A1-A5 + Mechanicals EC (t)	**32.38**	**42.20**	**30.86**	**38.47**	**38.47**

Ottawa: Mid Unit Stacked Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	82.02	46.28	128.98	71.28	78.64
Natural Gas (m^3)	1226.57	0.00	2501.58	927.15	1131.50
Electricity (kWh)	10093.93	12856.26	9950.76	10208.15	10139.93
OC (t/y)	**2.95**	**0.76**	**5.39**	**2.38**	**2.77**
A1-A3 EC (t)	20.69	23.08	19.96	22.80	22.80
A1-A3 + Mechanicals EC (t)	21.74	26.99	21.01	23.85	23.85
A1-A5 + Mechanicals EC (t)	**24.06**	**29.87**	**23.25**	**26.39**	**26.39**

Ottawa: Mid Unit Townhome

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	79.98	41.18	187.06	65.94	73.50
Natural Gas (m^3)	1351.80	0.00	4216.11	969.54	1174.51
Electricity (kWh)	8233.59	11438.75	8348.84	8286.63	8265.63
OC (t/y)	**3.08**	**0.67**	**8.59**	**2.35**	**2.74**
A1-A3 EC (t)	22.90	26.39	21.69	26.14	26.14
A1-A3 + Mechanicals EC (t)	23.95	30.30	22.74	27.19	27.19
A1-A5 + Mechanicals EC (t)	**26.51**	**33.53**	**25.17**	**30.09**	**30.09**

Ottawa: Single Detached Home

	Tier 1	Tier 5	Tier 1 No Insulation*	Tier 1 with Tier 5 Insulation + AT	Tier 1 with Tier 5 Insulation
Energy Consumption (GJ)	96.60	44.00	249.93	76.93	83.36
Natural Gas (m^3)	1784.36	0.00	5877.60	1249.81	1425.18
Electricity (kWh)	8374.04	12221.23	8624.00	8440.29	8411.60
OC (t/y)	**3.92**	**0.72**	**11.79**	**2.90**	**3.23**
A1-A3 EC (t)	26.36	31.95	25.14	31.56	31.56
A1-A3 + Mechanicals EC (t)	27.41	35.86	26.19	32.61	32.61
A1-A5 + Mechanicals EC (t)	**30.33**	**39.69**	**28.98**	**36.09**	**36.09**