GARDEN SUITES

Step to a Greener Future

June 2021

Sustainable Policy Recommendations
for Toronto's Garden Suites

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Architecture for a healthy planet.

THE ARCHITECT BUILDERS COLLABORATIVE Inc.
fighting climate change
with affordable green design

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EXECUTIVE SUMMARY

1. INTRODUCTION

The City of Toronto City Planning Division is currently undertaking a Garden Suites review aiming for as-of-right zoning bylaw and standards by summer 2021. As part of the Expanding Housing Options in Neighbourhoods (EHON) program, the Garden Suites Review mentions consideration for reducing the carbon (upfront, embodied, and operational) footprint or greenhouse gas (GHG) emissions. Strategies to mitigate include requirements for solar energy, green roofs, and Net-Zero Ready and Passive House standards from the upper tiers of the Toronto Green Standard. Garden Suites, with the potential for over 100,000 new houses, offer a rare opportunity to make a rapid and impactful change to the City's carbon footprint (Laneway Housing Advisors, 2020) and help meet the climate goals of TransformTO.

PURPOSE OF REPORT

The report is primarily envisioned as a supplementary document for the City Planning Garden Suites review. It examines the benefits and costs—both financial and carbon—of requiring a minimum level of sustainability in the Garden Suites by-law. Additionally, we envision the report's findings influencing building practices for low-rise residential typologies beyond backyard houses.

RECOMMENDED MINIMUM LEVEL OF GARDEN SUITE SUSTAINABILITY

Based on the findings detailed in this report, we recommend the City take all possible measures to encourage our Energy Step 3 as a minimum level of sustainability for new Garden Suites, to align with EHON and the City's environmental goals and TransformTO, in particular.

Meeting the City's climate goals means moving beyond the current minimum legal requirement for energy efficiency provided in the Ontario Building Code (OBC) SB-12 Supplementary Standard (our Energy Step 1) and beyond the LRR TGS v3 mandatory Tier 1. Tier 1 references Energy Star for New Homes (ESNH) Standard Version 17 (our Energy Step 2). Neither Tier is sufficient to reduce operational carbon to meet TransformTO targets by 2050 or sooner. Our Energy Step 3, based on the current Low Rise Residential Toronto Green Standard Version 3 (LRR TGS v3) Tier 3 voluntary requirement, references the Canadian Home Builders Association (CHBA) Net Zero Ready (NZr) standard.

Graphical representation of four increasingly efficient Energy Steps. Image by TABC.

Energy Step 3 Net Zero Ready offers the City the chance to reach its climate goals. Step 3 reduces GHG emissions by 85% compared to the Step 1 baseline. Despite the increase in average total cost for Step 3 over Step 1 of approximately $38,400 or 13%, by 2041, Step 3 saves an estimated $12,500 in operational cost over Step 1. Given the capital cost increase of roughly $38,000, we estimate capital payback in about 60 years.

Step 3 is 6% less impactful than Step 4 with 91% greenhouse gas (GHG) emissions reductions. However, we recommend Step 3 over Step 4, despite the additional GHG emissions reduction. We calculated the value proposition between Step 3 and Step 4:

- Step 3's cost premium of $38,400 divided by its GHG emissions reduction of 85% equals $442 per each 1% of carbon reduction.
- Step 4's cost premium of $56,900 divided by its GHG emissions reduction of 91% equals $669 per each 1% of carbon reduction.

Put another way, the Step 3 cost premium of $38,400 for the first 85% compared to an additional $18,500 for Step 4's increase of 6% works out to $3,083 per each 1% of GHG emissions reduction above Step 3's 85%. The above calculation demonstrates the additional 6% GHG emissions between Step 3 and Step 4 is very expensive.

Step 3 is our recommendation as a mandatory baseline for new builds. To expedite the process, we developed a Prescriptive Chart (refer to the summary chart below; refer to Appendix F for detailed chart) of thermal values and mechanical efficiencies

intended to streamline reaching higher carbon reductions for new small buildings. However, due to provincial-level control over areas such as the OBC, incentives are recommended to encourage forward momentum.

Thermal Performance Values for Energy Steps				
	Step 1 OBC Minimum	**Step 2** Energy Star TGS Tier 1	**Step 3** CHBA NZr TGS Tier 3	**Step 4** Passive House TGS Tier 4
Roof	R-31	R-44	R-65	R-85
Walls	R-22	R-22 plus R-8 continuous	R-22 plus R-25 continuous	R-22 plus R-36 continuous
Basement Walls	R-20	R-28	R-47	R-58
Slab	R-10	R-15	R-30	R-30
Windows*	U-0.28	U-0.21	U-0.14	U-0.14
Doors	U-0.28	U-0.21	U-0.14	U-0.14
HRV efficiency	75%	75%	89%	93%
DHW min. efficiency	Gas 0.8	Gas 0.80 Electric 0.93	Electric 0.93	COP 2.5
Airtightness**	3.0	2.5	1.0	0.6

*Imperial U-value $Btu/(h \cdot ft^2 \cdot F)$
**Air Changes per Hour @ 50P

2. POLICY LANDSCAPE: SUSTAINABILITY

Various existing frameworks, policies, and regulations were reviewed and provide the framework for no/low carbon Garden Suites. Currently, many of the policies do not apply to small low-rise residential typologies but are easily adaptable or already applicable:

- The OBC provides minimum standards for energy efficiency requirements for newly built houses in Supplementary Standard SB-12.

- Sustainability is a cornerstone of Toronto's Official Plan.
- TransformTO aims for near-zero GHG emissions in new buildings by 2030. All existing buildings retrofitted to achieve net zero emissions by 2050.
- The Zero Emissions Building Framework provides the pathway required for reduced emissions and climate change resilience in the built environment.
- The Toronto Green Standard is a four-tier minimum performance standard for new developments and a stepped performance pathway to achieving zero emissions city-wide.

3. + 4. METHODOLOGY + RESULTS

One of the main barriers to green design is the upfront cost. A better understanding of any added capital costs to go green; the operational savings that result; any cost benefits that exist; and the potential reduction in GHG emissions inform the main research questions for this project.

This research project tests two hypotheses:

- Garden Suite policies provide a unique opportunity for the City to **reduce its carbon emissions** in line with commitments under Transform TO.
- **A better-than-code** (i.e. better than OBC SB-12 minimum requirement for energy efficiency) **Garden Suite can be cost-effective**, particularly over time.

The investigation of the hypotheses required developing a methodology for comparison and cost-benefit analysis rooted in existing and easy to access policy, industry standards, and City of Toronto programs. A key criterion was developing recommendations easily implementable by the Planning and Building Departments by leveraging existing low-rise residential building standards.

A 'STEPPED' APPROACH TO LOW CARBON GARDEN SUITES

A 'stepped' approach similar to the Toronto Green Standard and British Columbia's Energy Step Code was chosen both for ease of alignment with existing City policies and to allow for a gradual adoption by regulators and the market. The design of a prototypical 600-square-foot house was altered to meet the performance targets of each Energy Step, energy-modelled, and priced by a team of experienced builders. The research design consists of an energy efficiency continuum consisting of four Energy Steps:

Step 1: OBC Minimum Baseline Reference Case

- Step 1 OBC Minimum provides the baseline energy model for comparison to the higher steps, based on the OBC Supplementary Standard SB-12.
- Step 1 is the legal, minimum performance standard allowable for housing construction in Ontario, assumed to be the least expensive, least efficient, and most harmful to the environment.

Step 2: Energy Star for New Homes Standard v.17 (TGS Tier 1)

- Step 2 Energy Star is based on the current mandatory Tier 1 of the LRR TGS v3: Energy Star for New Homes Standard (ESNH), Version 17.0.
- Energy Star homes are expected to perform approximately 20% more energy efficiently than the Step 1 OBC baseline reference case.

Step 3: CHBA Net Zero Ready (TGS Tier 3)

- Step 3 Net Zero Ready (NZr) is based on the voluntary Tier 3 of the LRR TGS v3: CHBA Net Zero Labelling Program.
- NZr homes are approximately 50-80% more energy efficient than the Step 1 OBC baseline reference case.
- A full Net Zero Energy (NZe) building produces and consumes roughly the same amount of energy per year. In Toronto, usually with the installation of a solar PV array.
- NZr is similar in design and construction to NZE, but a renewable energy source is not yet installed/connected.

Step 4: Passive House Standard (TGS Tier 4)

- Step 4 Passive House Standard is based on the voluntary Tier 4 of the LRR TGS v3: Canadian Passive House Standard.
- A Passive House Standard home is approximately 80% or better than the Step 1 OBC baseline reference case.
- Strict limits on annual energy consumption for heating, cooling, and domestic hot water.
- Thicker, well-insulated walls are challenging for smaller buildings.

BUILT FORM + SITE CONSIDERATIONS

Due to the preliminary status of the Garden Suites review, several assumptions concerning site selection and built form were necessary to achieve the project goals. The 1-storey, flat roof design designed for this report is based on:

- Zoning by-law 569-2013 Chapter 10.5.60 Ancillary Buildings or Structures.
- Zoning by-law 569-2013 Chapter 150 Specific Use Regulations Laneway Suites.
- Previous detached accessory dwelling unit research, particularly *Backyard Way Forward* (Carriere, 2017).
- A jurisdictional scan of existing by-laws, both intra- and interprovincially for Accessory Dwelling Units (refer to Appendix A).
- OBC minimum distances and spatial separations.
- Consultations with City Planning staff.

ENERGY MODELLING

Methodology

Each Energy Step was energy modelled to predict the annual energy consumption and the resulting carbon emissions for heating, cooling, and domestic hot water consumption. The thermal performance values and equipment efficiencies were determined in consultation with a group of experts in the field and inform a set of prescriptive values for walls, roofs, windows, etc., compiled similarly to the charts found in OBC SB-12. Wall, roof, and floor assemblies for each Energy Step were developed using the values from the prescriptive chart (refer to the summary chart above; refer to Appendix F for detailed chart).

Three energy modelling teams from Ryerson University Graduate Program in Building Science, RDH Building Science, and Green Tectonics, used three separate modelling software (all recognized in the OBC) to produce energy models for the Garden Suite Steps. The annual energy use, operational cost, and GHG emissions were estimated using the energy modelling results. Additionally, Ryerson University Graduate Program in Building Science and RDH Building Science provided generalized and site-specific solar energy potential for the garden suite design.

Results

The Energy Steps aimed to meet performance targets over the Step 1 Baseline Reference: 20% (Step 2), 50-80% (Step 3) and +80% (Step 4). The targets reference the performance standards for each Step. Additionally, the results were compared using the Toronto Green Standard (TGS) target metrics: Total Energy Use Intensity (TEUI), Total Energy Demand Intensity (TEDI), and Greenhouse Gas Intensity (GHGI). The TEUI and TEDI for each Energy Step either nearly met or surpassed the TGS targets. The GHGI across all Energy Steps exceeded the TGS targets reductions at 64% for Step 2, 85% for Step 3 and 91% for Step 4.

OPERATING COSTS

Methodology

From the energy modelling, we predicted annual energy use for each Energy Step. Projecting future changes in the wholesale cost of natural gas and electricity is beyond even the capability of the National Energy Board; thus, for this comparison, we assumed no changes in wholesale supply costs. However, we factored in the federal carbon charge since the legislation already passed in Parliament. The carbon charge is anticipated to rise in $15 per tonne increments, from its current rate of $40 per tonne, to at least $170 per tonne by 2030. We included the increase in operational cost calculations for each Energy Step.

Results

The data indicates Step 2 has the highest operational cost per year at approximately $1,644. The price increase is attributed to the hybrid mechanical system using less of the presently cheaper natural gas and a less energy-efficient building envelope resulting in higher, more expensive electricity costs. Step 4 is the least costly per year at $886, a $758 savings from Step 2, despite using only electricity. When combined with a higher-performing envelope, both Steps 3 and 4 use less energy and thus cost less to operate over time. The operational cost also increased over time when factoring in carbon tax. In the future, if there is a substantial price on carbon, natural gas as a fuel source will be more costly financially, in addition to its environmental cost today and in the future.

CONSTRUCTION COSTS

Methodology

To provide comparable cost estimates for each Energy Step, the authors drew on their extensive network of experienced builders in the Greater Toronto Area. Each builder contributed Class ‘C’ level estimates of the construction costs for each of the four Energy Steps. One Scope of Work (refer to Appendix H) for use during estimation was co-produced and verified by three builders: Hummingbird Hill Homes, Evolve Builders Group, and Vanderwal Builds. The builder cost estimates were averaged and provide the approximate total cost to build each Energy Step.

Results

The cost premium for Step 4 over Step 1 is approximately $56,900 or 20%, with a 91% reduction in GHG emissions. The cost premium for Step 3 is approximately $38,400 or 13% more than Step 1, with an 85% reduction in GHG emissions. The cost premium for Step 2 over Step 1 is approximately $16,400 or 6%, with a 64% reduction in GHG emissions.

TOTAL COMBINED COST TO BUILD + OPERATE

The results indicate the total cost to build Step 4 carries a cost premium of roughly $56,900 over Step 1. However, Step 4's operational costs over time are projected at half that of Step 1. Similarly, Step 3 carries a cost premium of roughly $38,400, with a similar decrease in operational costs over time. Our findings suggest the 'payback' period of the increased capital cost to build Steps 3 and 4 through lowered operation costs is approximately 60 years.

We recommend Step 3 over Step 4, despite the additional GHG reduction. Step 3's cost premium of $38,400 for the first 85% compared to an additional $18,500 for Step 4's increase of 6% works out to $3,083 per each 1% of GHG emissions reduction above Step 3's 85%. The calculations demonstrate the additional 6% of GHG emissions between Step 3 and Step 4 is expensive for an incremental increase in GHG emissions. Thus, we recommend Step 3 and prioritize incentives to build Step in this report.

5. RECOMMENDATIONS

- Energy Step 3 as the minimum standard
- Step 3 incentives:
    - Provide a green subsidy
    - Replicate Durham Region's Green Standard Program
    - Create a 'Near-Zero' research project
    - Provide 'thick wall' bonuses and allowances
    - Provide a development charge refund where applicable
    - Waive permit fees
- Offer Pre-Approved Designs
- Implement a Garden Suites Prescriptive Chart
- Consider the height of specific structures on Garden Suite roofs
- Say 'no' to fossil fuels as an energy source
- Requirement for blower door tests
- Address upfront embodied carbon and aim for a true net zero
- Implement a 'small' Low-Rise Residential Toronto Green Standard

6. CONCLUSION

GARDEN SUITES + THE CLIMATE CRISIS

Energy-efficient Garden Suites have a significant role in reducing a building's carbon output and in pointing the way forward for residential dwellings. However, energy efficiency does not consider upfront embodied carbon. If carbon reduction is the goal, the City must mandate energy efficiency alongside upfront carbon efficiency. Choosing better and less carbon-heavy materials reduces and even sequesters embodied carbon.

GARDEN SUITES + COST

Our cost estimate results suggest there is a cost premium to build no/low carbon Garden Suites. For instance, Energy Step 4's Passive House Standard carries an average cost premium of approximately $56,900, or 20%. Our projected operational cost calculations indicate it takes about 60 years to pay back the upfront increase in capital costs for Steps 3 and 4. If policy, regulation, and bylaw standards cannot be applied at the municipal level, targeted and meaningful incentive programs are required to encourage and promote building better across the city. However, capital cost premiums are predicted to decrease as designers and contractors become more familiar with sustainable building technologies and more products become available on the market.

POLICIES + INCENTIVES

The most effective recommendations from this report are the Garden Suites Prescriptive Chart and a smaller low-rise green standard. However, both require provincial-level changes (i.e.., the Ontario Building Code and Supplementary Standard SB-12 are provincial legislation). Consequently, 'green' Garden Suites are not easily implemented at the municipal level, beyond the planning tools at its disposal for thick wall bonuses and maximum height exceptions..

FOLLOW UP RESEARCH

- Report back on incentives
- Adapt applicable sustainable policy to all low-rise housing typologies
- Develop embodied carbon data for the Garden Suites
- Take a deeper dive into energy sources and consumer costing
- Review rental income and the reduction in payback time
- Explore the possibility of a sunken 2-storey build
- Explore Garden Suite affordability

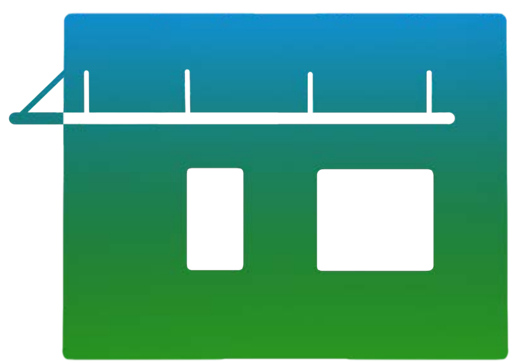
- Consider blue, green and blue-green roof systems
- Develop a 'Green Kit' for homeowners

FINAL COMMENTS

Presently, there are barriers and challenges to regulating no/low carbon Garden Suites. The Toronto Green Standard is implemented through City Planning's site plan control process and is thus not applicable to smaller low-rise buildings. Instead, the mechanisms for enforcement of a low-rise green standard (e.g., the building permit process) are legislated by the province through the OBC.

Without the province granting powers to the City of Toronto allowing an exemption to the OBC, a provincial change to the OBC, or other creative legal solutions, there is no clear path to implementing a better-than-code standard for low-rise residential construction. Under this framework, keeping pace with municipal climate targets, or the climate crisis generally, is a challenge. An additional hurdle is the recent provincial changes to development charges, impeding the city's ability to incentivize going green.

With this in mind, meaningful incentives are a suggested pathway to creating no/low carbon Garden Suites across the city.



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1. INTRODUCTION

1.1. GARDEN + SUITES = GREEN FUTURE

Two years after passing the Laneway Suite bylaw into effect, the City of Toronto is once again looking to the city's backyard spaces to provide housing options. Garden Suites are the latest entry in the plan to expand housing choices within Toronto's extensive low-rise Neighbourhoods, joining the already permitted Laneway Suites and Secondary Suites. Garden Suites are similar to Laneway Suites: a living accommodation contained within a smaller detached accessory building typically located in the rear yard, providing a separate and self-contained unit exclusively for the occupant—but with Garden Suites, no laneway required!

City Planning is currently running a Garden Suites review, part of its Expanding Housing Options in Neighbourhoods (EHON) program, broadening the Laneway Suites study findings and bylaw standards to permit as-of-right zoning for Garden Suites throughout Toronto. By summer 2021, backyards that satisfy the City's Garden Suite zoning policies should have the option to build a tiny home - a crucial next step to unlocking Missing Middle housing options across the city's 'Yellowbelt' of low-rise residential Neighbourhoods (Fig 1).

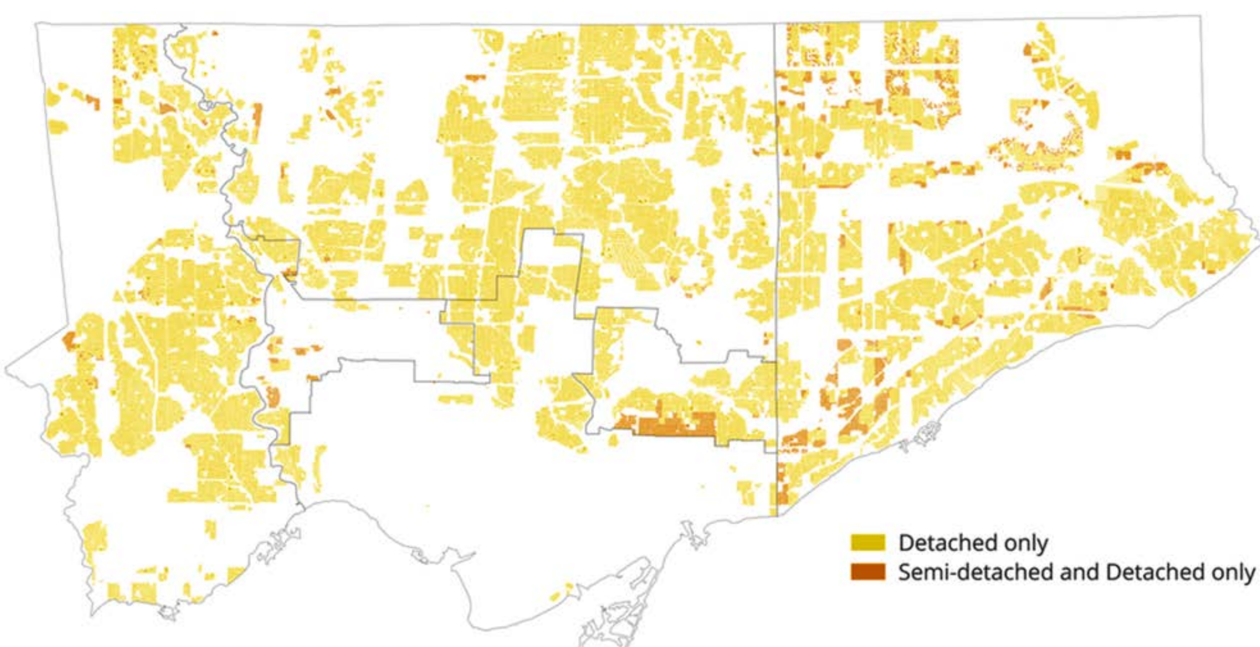


Figure 1. Map depicting the extent of detached and semi-detached properties in the 'Yellowbelt' in Toronto (MapTO, 2017).

In addition to evaluating Garden Suite precedents from other cities, such as Ottawa, Kitchener, Windsor, and Peterborough here in Ontario, the city's review will investigate several key issues and questions for the Toronto context: location, built form, green space, accessibility, neighbourhood character considerations, and affordability. Sustainable policies and by-law standards, a fundamental concern for this report, are also key questions the review aims to address.

The Garden Suites review staff report mentions incorporating green technologies and building approaches into the policies. Ideas include exploring requirements for solar energy, green roofs, and Net-Zero Ready and Passive House standards from the upper tiers of the Toronto Green Standard. The report investigates the city's key sustainability questions and seeks to demonstrate no/low carbon Garden Suites are achievable.

Figure 2. 'Missing Middle' housing typologies: Laneway Suite (left) and a Garden Suite (right). Images by TABC.

1.2 PURPOSE OF THIS REPORT

Primarily, this report aims to provide ideas for sustainability supported by energy modelling and construction estimates and provide feedback early in the review process: to demonstrate no/low Garden Suites are affordable to construct.

The report is envisioned as a supplementary document for the city's reference, with recommendations examining the benefits and the costs—both financially and in carbon (i.e., the currency of fighting climate change)—of requiring a minimum level of sustainability in the Garden Suites by-law standards and regulations.

The report has a secondary purpose of aligning sustainable policies for Garden Suites with the City's larger goals of enhancing sustainability across the city. The research findings, results, and recommendations are hoped to influence building practices for low-rise residential typologies beyond backyard homes.

2. POLICY LANDSCAPE: SUSTAINABILITY

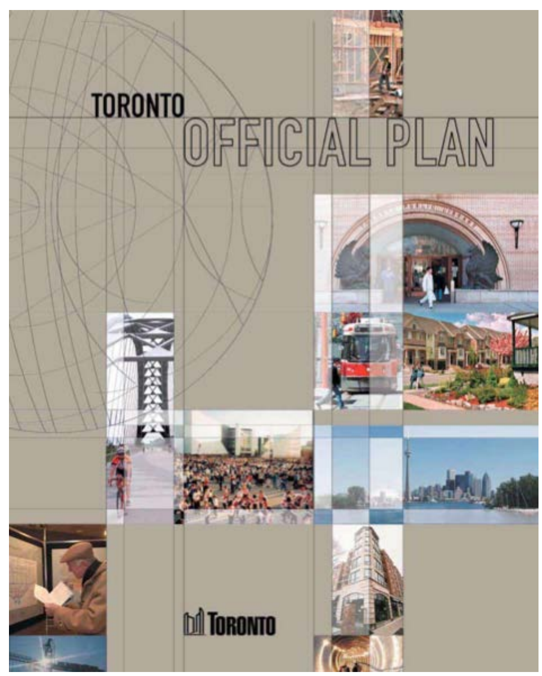
The following sections provide the context for Garden Suites in Toronto as a policy landscape supporting and promoting sustainability, adaptability, and resiliency in the built environment. The various frameworks, policies, and regulations, many implemented over the past decade, provide the framework for understanding sustainable design and construction principles in the city, and the current regulations for ancillary buildings and laneways suites. Currently, many of the policies do not apply to low-rise residential typologies similar to Garden Suites, but are easily adaptable or already applicable.

2.1. ONTARIO BUILDING CODE SUPPLEMENTARY STANDARD SB-12

The Ontario Building Code is a regulation which provides minimum standards for building construction, which includes “environmental integrity” (Toronto, 2021a). The energy efficiency Supplementary Standard SB-12, which came into effect July 7, 2016, provides information to meet the code’s current energy efficiency requirements for houses, and provides the baseline minimum reference case for this report.

2.2. TORONTO OFFICIAL PLAN POLICIES

Sustainability is a cornerstone of Toronto’s Official Plan (OP). The OP recognizes future urban success requires making holistic, intersectional, and sustainable choices. The OP identifies the city's growth as intertwined with environmental, social, and economic perspectives and questions and states: “We have to meet the needs of today without compromising the ability of future generations to meet their needs” (2019, p. 1-1).



Relevant to this report, the OP contains several sections and policies directly addressing the need to create sustainable Neighbourhoods and a vibrant Natural Environment by reducing waste, better managing stormwater runoff, greening our communities, reducing energy consumption and greenhouse gas emissions, and reliance on carbon-based fuels for energy (2019, p. 2-27, 2-29, 3-33, 3-34).

2.3. TRANSFORM TO

"On October 2, 2019 Council voted unanimously to declare a climate emergency and accelerate efforts to mitigate and adapt to climate change" (Toronto, 2021b).

TransformTO is the strategy to meet the climate challenge and sets out the long-term plan for reducing carbon emissions city-wide for health, economic and social benefit. The city's reduction targets for greenhouse gas (GHG) emissions, based on 1990 levels, are as follows (refer to Fig. 3.):

- 30% by 2020
- 65% by 2030
- Net zero by 2050, or sooner

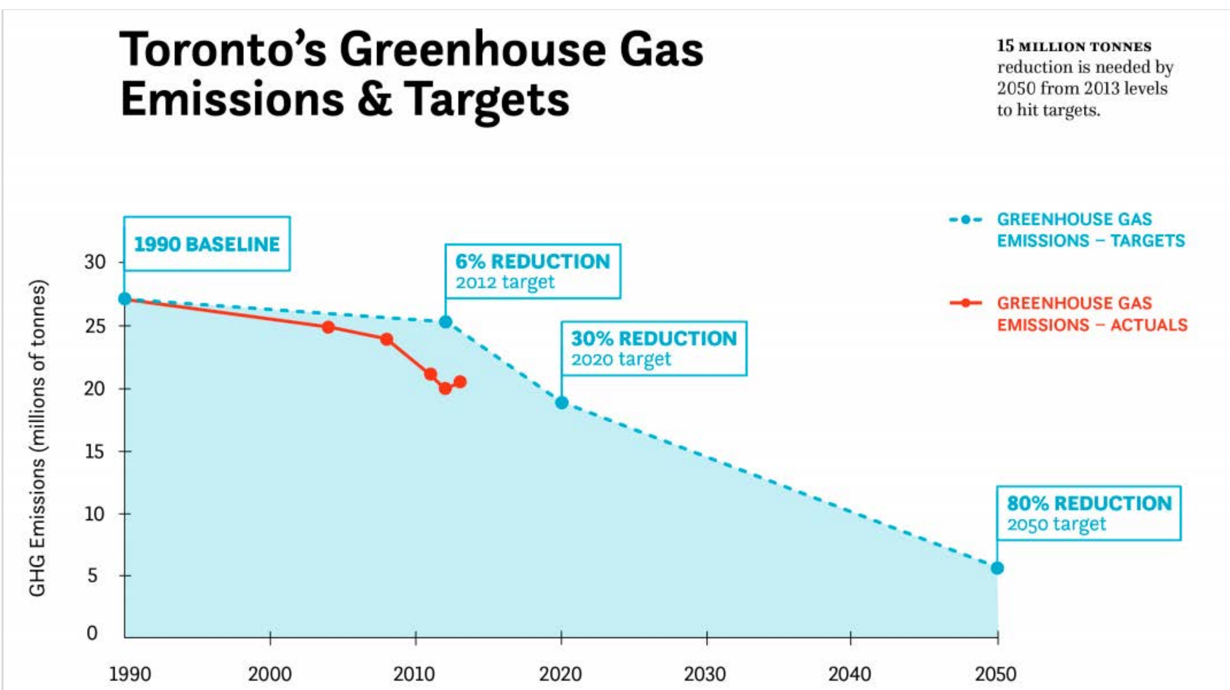


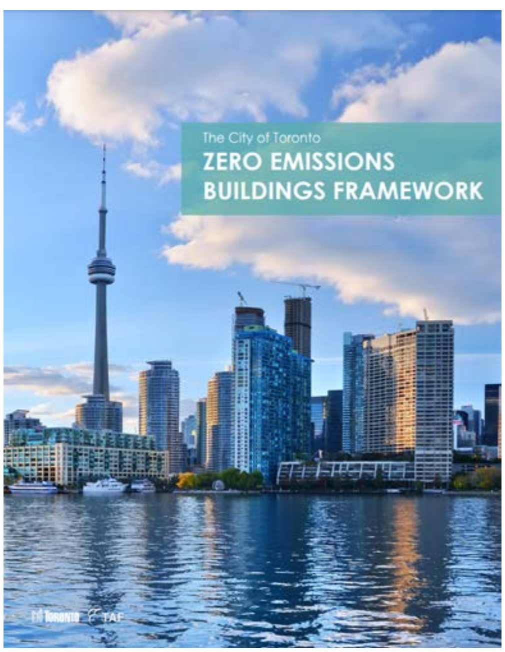
Figure 3. Toronto's GHG emission targets (blue line) versus it's actual emissions (red line) circa 2014 (City of Toronto, 2020b).

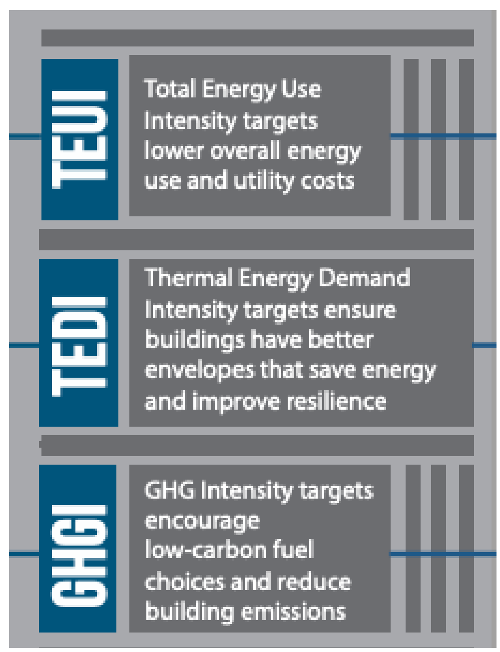
.An estimated 55% of Toronto's GHG emissions are generated from homes and buildings, primarily through heating indoor spaces and water. New buildings - to meet the ambitious goals of TransformTO - require transformational changes in how we design, build and construct. The strategy states that "by 2030, all new buildings will be built to produce near-zero greenhouse gas (GHG) emissions" (City of Toronto, 2021b). Transformational change begins with small steps, but steps that "raise the bar" for new developments - an action identified in TransformTO's strategies to

increase the pace of emissions reductions. Garden Suites are one small step toward larger-scale change. The tiny structures offer the city a chance to raise the bar on energy-efficient standards to mitigate increased emissions from the outset, reduce energy performance retrofits in the future, and create a precedent for low emissions building standards across the city.

2.4. TORONTO ZERO EMISSIONS BUILDING FRAMEWORK (ZEBF)

The ZEBF guides Toronto toward zero-emissions buildings following the policies of the OP and aligned with TransformTO's goals. The ZEBF recognizes the need for new developments to house the growing population and the challenges of addressing growing carbon emissions and provides the pathway required for reduced emissions and climate change resilience in the built environment. The ZEBF provides performance targets specific to Toronto, verified by third-party experts, across several building types, including low-rise multi-unit residential buildings, but not the low-rise residential housing found across Toronto’s stable Neighbourhoods. The performance targets, organized into four tiers and the highest of which are no/low emissions, are guided by three absolute performance target metrics: Total Energy Use Intensity (TEUI), Thermal Energy Demand Intensity (TEDI), and Greenhouse Gas Intensity (GHGI), a set of prescriptive requirements, and energy modelling guidelines. (City of Toronto + TAF, 2017).





2.5. TORONTO GREEN STANDARD LOW-RISE RESIDENTIAL VERSION 3

The ZEBF provides the foundation for the most recent Toronto Green Standard (TGS) Version 3. TGS Version 2.0, first introduced in 2006, was updated on recommendations from the ZEBF to reflect a four-tier minimum performance standard for new developments. The four tiers increase in performance and are a “pathway to zero:” a phasing-out program where the lower tier becomes obsolete, typically in four-year cycles. TGS is a stepped performance pathway to achieving zero emissions city-wide, where the stepped approach incrementally increases the lower tier standards over time.

A checklist for meeting the established guidelines is provided for each Tier, including site and building considerations. Tier 1 TGS is currently required for any planning approval application, with Tiers 2 to 4 voluntary; however, a financial incentive tied to development charges is available when the higher tiers are satisfied. The TGS includes a set of absolute performance targets aligned with the ZEBF’s TEDI, TEUI, and GHGI values. Meeting the standard requires energy modelling and following the guidelines of the program, *Energy Efficiency Report Submission & Modelling Guidelines*.

In its current iteration, in force since May 1, 2018, the Low-Rise Residential (LRR) TGS is limited to residential projects “less than four storeys with a minimum of five dwelling units” (Toronto, 2021c) - which excludes many new residential dwellings from the standard. The Garden Suites Review staff report mentions TGS Tiers 3 and 4 as a key question surrounding sustainability regulation or by-law standards for the incoming policies and by-law standards and regulations.

The City’s interest in the TGS provides the foundation of our research design. The performance standards of the upper tiers use readily transferable programs for low-rise construction, such as Passive House and Net Zero Ready. Using the LRR TGS as the basis for developing four energy modelling scenarios, the hope is to demonstrate the feasibility of applying the LRR TGS to new low-rise residential construction and the potential for reduced carbon emissions across the city.

2.6. CITY OF TORONTO ZONING BY-LAW 569-2013 CHAPTER 10 RESIDENTIAL

Chapter 10 Residential contains regulations and permissions applying to the residential zone category. Section 10.5.60 Ancillary Buildings and Structures lists the standards applicable to buildings or structures accessory to the primary dwelling unit or residential building on the lot. While the current zoning prohibits living accommodation in ancillary buildings, the standards here could influence the size, setbacks, and built form of Garden Suites as a similar building/structure already permissible in the zoning and found across the city's backyards.

2.7. TORONTO ZONING BY-LAW AMENDMENT TO CHAPTER 150.8

The existing chapter 150.8 - Specific requirements for Laneway Suites, in force since Summer 2018, permits as-of-right accessory dwelling units in rear yards adjacent to laneways. The by-law allows gentle intensification of existing stable Neighbourhoods across the city's 'Yellowbelt' of stable low-rise residential neighbourhoods. The impetus for passing the by-law hinges around the lack of Missing Middle housing or housing defined by the city as less than four storeys in height. Additional rental units of varying typologies and tenures under four-storeys are urgently needed in a city faced with a housing crisis and a shortage of mid-range and affordable rental units. Similar sizes, setbacks, and built form considerations could apply to the Garden Suites, either standing alone or incorporating pieces of the Ancillary Buildings and Structure by-law standards.

2.8. GARDEN SUITES + THE CLIMATE EMERGENCY

The City of Toronto faces a housing crisis but also a climate crisis. It is imperative to build new housing, yet sustainability is not addressed nor implemented for 'low' low-rise residential. Noticeably absent from many of the policies above are sustainability standards for housing forms such as Laneway Suites, townhomes, semi-detached, and single detached homes. Consequently, the policies exclude new buildings from a minimum mandatory level for energy efficiency or life cycle carbon costs beyond the Ontario Building Code (OBC). When referenced against the ZEBF, TGS, and the TransformTO mandate, many new low-rise buildings are built to energy performance obsolescence and fail to consider carbon emissions beyond the minimum requirements of the OBC. Garden Suites presents the City of Toronto with an opportunity to move past built environment obsolescence for new housing through no/low carbon minimum standards.

3. METHODOLOGY + RESEARCH DESIGN

One of the major barriers to implementing no/low carbon design is the perceived cost. A better understanding of any added costs to go green and what cost benefits exist, particularly in operational savings over time, is the main research question for this project.

3.1. WORKING HYPOTHESES

This research project is guided by two primary hypotheses:

- Garden Suite policies provide a unique opportunity for the City to **reduce its carbon emissions** in line with commitments under Transform TO.
- **A better-than-code** (i.e. better than OBC SB-12 minimum requirement for energy efficiency) **Garden Suite can be cost-effective**, particularly over time.

3.2. DEVELOPING AN ENERGY EFFICIENT LOW CARBON CONTINUUM

Investigation of the hypotheses required developing a methodology for comparison and cost-benefit analysis, rooted in existing and easy to access policy, industry standards, and city programs.

The final research design consists of an energy efficiency continuum consisting of four 'Energy Steps.' The steps on this continuum are situated within the existing policy and regulatory landscape and conform to the standards of the Ontario Building Code Supplementary Standard SB-12 and the Low-Rise Residential Toronto Green Standard (LRR TGS).

3.3. ENERGY STEPS

The following Energy Steps are based on design and construction practices readily available in the industry, accepted by the Toronto Building Department, with the added benefit of being situated within the existing climate change policy. The four steps also facilitate the comparison of any additional design and construction cost following the continuum's gradient of increasing energy efficiency and carbon savings or the cost delta attributed to reaching a higher measure of sustainability.

3.3.1. STEP 1: OBC SB-12 MINIMUM BASELINE REFERENCE CASE

Step 1 is designed to meet the Ontario Building Code (OBC) Supplementary Standard SB-12. SB-12 provides the minimum legal requirements for energy efficiency design standards. Many programs, such as Energy Star, already cite the use of an OBC baseline reference to set the floor to which higher energy efficiency targets are compared and contrasted. Similarly, for this report, Step 1 provides the baseline energy model for comparison to the higher steps. OBC SB-12 compliance requires submitting a form when applying for a building permit.

3.3.2. STEP 2: ENERGY STAR FOR NEW HOMES STANDARD V. 17 (TGS TIER 1)

LRR TGS Tier 1 is a mandatory requirement and offers the choice between meeting at least Energy Star for New Homes (ESNH) Version 17 (NRCan, 2017) (approximately around 20% more efficient than an OBC minimum reference house) or R-2000 (NRCan, 2018) (around 50% more efficient than a house built to OBC minimum). We chose model Energy Star for this report based on several factors: the similarity in efficiency between R-2000 and our proposed Tier 3 scenario, the visibility of Energy Star in the residential design and construction sector (e.g., labelling of appliances), and the perceived ease of meeting the Energy Star technical requirements by the residential design and construction industry.

The required Energy Star for New Homes Standard (ESNH), Version 17.0 (NRCan, 2017) states: “an Energy Star qualified home is approximately 20% more efficient than a reference house” (p. i). Energy Star provides a ‘happy medium’ between a higher level of energy efficiency above the OBC minimum requirements and the additional costs. The Energy Star standard includes minimum requirements for insulation, building envelope performance, and electrical savings.

Compliance with the Standard requires the submission of the Energy Efficiency Design Summary for Part 9 residential housing, a copy of the Builder Option Package form, and meeting the minimum requirements outlined in ESNH manual.

3.3.3. STEP 3: CHBA NET ZERO READY (TGS TIER 3)

LRR TGS Tier 3 offers a high-performance, low-carbon pathway for design and construction using the Canadian Home Builders Association (CHBA) Net Zero Labelling Program. The definition of NZr recognizes buildings that perform 50-80% more energy efficiently than the OBC baseline reference case and focus on meeting the higher end of this range (GBC; CHBA, 2017).

A Net Zero (NZ) building produces and consumes roughly the same amount of energy per year. Net energy use results from the overproduction of energy in summer (to the grid) and the overconsumption of energy in the winter (from the grid). NZ focuses on primary and integrated components: building envelope, mechanical (HVAC) systems, and connection to a renewable energy system.

Net Zero Ready (NZr) is similar in design and construction to NZ, but renewable energy (solar, wind, water) is not yet installed or connected to the grid. Hypothetically, once the renewable energy source is installed and connected, NZr is transformed to NZ. While NZr consumes less energy than the OBC baseline reference and Tier 1 (50%-80% more efficient (CHBA, 2017)), NZr, NZ, and Passive House Standard are understood to perform better due to stringent requirements for performance.

3.3.4. STEP 4: PASSIVE HOUSE STANDARD (TGS TIER 4)

Tier 4 of the LRR TGS offers another choice of standard, between Net Zero and Passive House. The choice of Passive House over NZ relates directly to the potential inability to install and connect to renewables (e.g., inadequate access for solar capture, size and shading of a solar array, access to other renewables) and the carbon emissions depending on the energy source (e.g., natural gas). Additionally, NZ does not always translate to energy efficiency – because a building produces as much energy as it uses does not guarantee a reduction in energy use.

Passive House reduces energy use on-site, by up to 80%, compared to conventional buildings (Toronto, 2021c). Passive House offers a low energy consumption and energy emissions option. With Passive House, Garden Suites can disconnect completely from the grid, offering the maximum potential for reduced energy use and carbon emissions over time – easy on the environment and the wallet.

Achieving Passive House certification poses its own set of challenges, given the external surface area to internal volume ratio, along with the stringent requirements summarized by Passive House Canada in five points:

1. Super-insulation
2. Highly insulated window systems
3. Drastically reduced thermal bridging
4. Airtight (or as close as possible) building envelope
5. Extremely efficient mechanical system

Due to the potential size limitations on Garden Suites in Toronto (i.e., small footprint and gross floor area available on a typical Toronto lot), moving from Step 3 to 4, while not impossible, presents challenges. One obvious example is the increased wall and roof thickness to meet the required superinsulation where lot setbacks constrain the living space of already small houses or exceed maximum height requirements.

Recognizing the challenges, the report aims to demonstrate meeting Passive House Standards might not be achievable, but reaching *toward* Passive House provides a higher degree of energy performance. Claims to meeting the Passive House Standard will not be made without rigorous substantiation.

Figure 4. Graphical representation of the energy efficiency continuum conceptualized as four increasingly efficient Energy Steps. Image by TABC.

3.4. PHASING OUT LOWER ENERGY STEPS

The Garden Suite Energy Steps are based on the ZEBF and TGS and inspired by British Columbia's Energy Step Code. Described as a "high-performance staircase," the BC Energy Step Code provides a prescriptive and performance pathway to compliance, where lower steps are easier to achieve, and higher steps are "more ambitious" (Government of British Columbia, 2018).

BC's energy steps also include compliance to well-known green-building certification programs, such as Energy Star, Net-Zero Ready, and Passive House. The Step Code permits local governments to require and incentivize specified Steps as an alternative to the building code's prescriptive requirements.

Most importantly, the Step Code follows a planned phase-out of the lowest steps over time. The expectation is, by 2032, the BC Building Code will move in the direction of the higher steps as “a minimum requirement” aligned with the direction of the National Building Code. Such moves help expedite the process of meeting carbon and climate targets. The creation of the Energy Steps can help Toronto move in a similar direction.

3.5. MEETING THE TGS v.3 TARGETS

Meeting the Energy Efficiency, GHG & Resilience performance measures provided by the latest version of the TGS might prove challenging given the differences in building typology. Currently, the performance requirements from the ZEBF are for low-rise Multi-Unit Residential Buildings less than or equal to six-storeys, built using wood frame construction. The performance standards listed in the TGS LRR do not reference the values provided for the three main metrics, TEDI, TEUI, and GHGI of the ZEBF and the Mid to High-Rise Residential TGS standards. Currently, to satisfy the requirements of the TGS v3, building design must meet or exceed the following requirements (refer to Fig. 5). Other TGS targets, such as Air Quality, Water, Ecology, and Solid Waste require further consideration beyond the scope of this report.

Table 1: Building Energy Performance Requirements Tier 1 & 2

Building Type	Total Energy Use Intensity* ($eKWh/m^2$)		Thermal Energy Demand Intensity* ($eKWh/m^2$)		Greenhouse Gas Intensity* ($kgCO2e/m^2$)	
	Tier 1	Tier 2	Tier 1	Tier 2	Tier 1	Tier 2
Multi-unit Residential Buildings (>6 Storeys)	170	135	70	50	20	15

Table 2: High Performance, Near Zero Emissions Requirements Tier 3 & 4

Building Type	Total Energy Use Intensity* (eKWh/m2)		Thermal Energy Demand Intensity* (eKWh/m2)		Greenhouse Gas Intensity* (kgCO2e/m2)	
	Tier 3	Tier 4	Tier 3	Tier 4	Tier 3	Tier 4
Multi-unit Residential Buildings (>6 Storeys)	100	75	30	15	10	5

Figure 5. TEUI, TEDI, and GHGI values for meeting the requirements for each tier of the Toronto Green Standard v3, Checklist for Mid to High-Rise Residential buildings over 6-storeys.

3.6. DESIGNING A GARDEN SUITE

To investigate the hypotheses, we needed to design a model Garden Suite, to provide to the energy modellers to determine energy use per year and for costing drawings to determine the increased capital costs to build green. The following sections

outline our approach to our final design: a 1-storey, 20’x30’, 600 square foot Garden Suite.

3.6.1. SITE SELECTION + BUILT FORM CONSIDERATIONS

Due to the preliminary status of the Garden Suites review and understanding the potential for inconsistencies between this report and the final report to Council, several assumptions concerning site selection and built form were necessary to achieve the project goals, choices detailed in the following sections.

3.6.2. ZONING BY-LAW ANCILLARY BUILDINGS OR STRUCTURES

The city-wide zoning by-law permits ancillary buildings or structures as-of-right in a Residential Zone category. Pertinent to this research are the following limitations: a maximum height of 4.0m, limited to a 1-storey built form (*10.5.60.40 (2)(B)(3)*. Additionally, rear yard and side yard setbacks are provided, with several conditions depending on the lot frontage, distance to existing residential building, adjacency considerations, location of the ancillary building or structure, and lot configuration within the block (e.g., corner lots, through lots)*(10.5.60.20)*.

3.6.3. ZONING BY-LAW LANEWAY SUITES

Chapter 150.8 of the City of Toronto Zoning Bylaw amends the regulations for Ancillary Buildings or Structures in R Zones to allow laneway suites located 7.5m or more from the residential building on a lot to a maximum height of 6m. Laneway Suites located a minimum of 5.0 to 7.5m from the residential building are limited to a maximum height of 4.0m, per the existing Ancillary Building regulations. Laneway Suites 6.0m in height are permitted to include a second storey.

Influencing Garden Suite site selection and built form considerations, Laneway Suite rear yard setbacks are typically 1.5m. Side yard setbacks vary: if the side lot line does not abut a street or lane and there are no openings, 0.0m is allowable. If the side lot line abuts a street or lane, the setback is that of the existing residential building. In all other cases, 1.5m is the requirement.

3.6.4. SITE SELECTION + SETBACKS

Site selection and setback assumptions are based on:

- Previous research, particularly ‘Backyard Way Forward’ (Carriere, 2017).
- A jurisdictional scan of existing by-laws, both intra- and interprovincially for Accessory Dwelling Units (refer to Appendix A for site details).

- Existing by-law standards for Ancillary Structures in Toronto (listed above).
- Minimum distances found in the OBC required for glazing on the sides and rear of the Garden Suite.

In Backyard Way Forward (Carriere, 2017), the author provides an assessment of potential lots and conditions for detached secondary suites in Toronto. The report found a typical downtown lot is 30’ x 120’ (9.14m x 36.58m)(p. 31). One of the study areas chosen by the author, Ward 9 Davenport is assumed here, given Councilor Ana Bailoa’s involvement with decision-making and advocacy for affordable housing (p.17). Additionally, the author points out 43% of properties in the Ward 9 study area “could accommodate a garden suite” given a 1.2m access walkway (p. 19). Considering the 0.9m x 2.1m width and height path of travel for Fire Department Access for the Laneway Suites, this percentage is likely much higher.

3.6.5. BUILT FORM

We started the project envisioning a 2-storey, 2-bedroom, flat roof Garden Suite, similar in built form to Laneway Suites, with deeper setbacks. The decision was primarily based on the desperate need for adding gentle density to stable Neighbourhoods city-wide, particularly in areas becoming unaffordable while experiencing decreases in population (Lorinc, 2021) while addressing the desperate need for family-friendly, shared, and single rental accommodations.

Based on the allowance in the Laneway Suite by-law for a 6.0m height at a minimum distance from the residential building on the lot, coupled with 1.2m setbacks from the side and rear lot lines, a two-storey Garden Suite is not inconceivable per the Laneway Suite regulations and conforms to the Ontario Building Code. Other jurisdictions allow a second storey with conditions, notably Guelph and Ottawa in Ontario, Edmonton and Saskatoon in Alberta (refer to Appendix A).

Later in the process, *The Globe & Mail* published an article about incoming Garden Suite policies, noting Garden Suites are expected to be “significantly smaller” than Laneway Suites for privacy issues, namely the potential for overlook on three sides (Lorinc, 2021). However, the Laneway Suites zoning bylaw already allows for a potentially challenging scenario similar to the privacy and overlook issues mentioned in the article. As noted above, if the side lot line does not abut a street or lane and there are no openings, 0.0m is allowable. If the side lot line abuts a street or lane, the setback is that of the existing residential building. In all other cases (i.e., interior lots), 1.5m is required. The case for a “significantly smaller” Garden Suite is, arguably, complicated by the existing Laneway Suite permissions (Lorinc, 2021).

Considering the opinions of the planners and architects interviewed in *The Globe and Mail* article, preliminary feedback from City Planning, and the jurisdictional scan, we modelled a 1-storey flat roof based on the existing Ancillary Buildings & Structures by-law (refer to drawings below).

While the 1-storey does not conform to the maximum area and lot coverage requirements of the Ancillary Buildings & Structures (discussed in detail in the following section), the design offers a starting point for conversations about Garden Suite size and design. At 600 square feet, the floor plan provides a comfortable layout, including a bedroom, a kitchen, a three-piece bathroom, and a cozy space for living and dining (refer to Appendix B for Garden Suite drawings and renderings and Appendix L for lighting design).

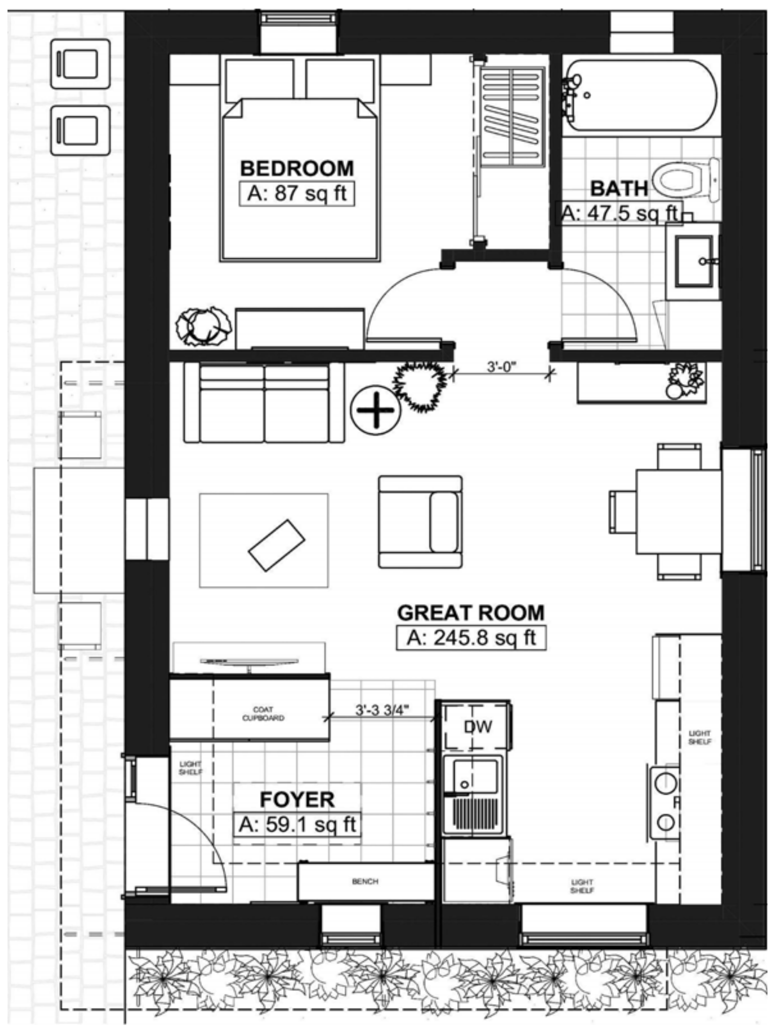


Figure 6. 1-storey Garden Suite floor plan by TABC.

3.6.6. RENDERINGS

Figure 7. 1-storey Garden Suite rendered by TABC.

Figure 8. 1-storey garden suite Interior rendering' by Richa Narvekar.

3.6.7. SIDE YARD SETBACKS

The choice of 1.2 metre (m) minimum side yard setback on one side coincides with the choices made in other jurisdictions permitting windows on all four facades of the Garden Suite, without the need for non-combustible construction and cladding.

Providing 1.2m is viewed as a tradeoff between the minimum distance allowable for openings and the 0.0m allowed on laneway suites on interior lots. Lots with access to a laneway - already a privilege - further privileges the owners with the zoning permission to build to the property line, and potentially, larger accessory dwellings. Allowing 1.2m setbacks on one side for Garden Suites provides buffer space in the side yard while providing floor area.

However, considering the lack of a laneway buffer, the 1.2m setback is allowable for one side yard only. The other side yard setback should be at least 1.6m, providing added landscaped area for the entire lot and dedicated outdoor amenity space for the Garden Suite occupants. The deeper setback on at least one side also facilitates a buffer between other yards and potential or existing accessory buildings (refer to Appendix C for lot set back drawing).

3.6.8. REAR YARD SETBACK + SEPARATION FROM EXISTING DWELLING

Rear yard setbacks may vary for Garden Suites depending on the lot depth and the minimum separation distance from the existing residential building required (based on a minimum of 5 or 7.5m from the Laneway Suite bylaw). On longer lots, rear yard setbacks can provide amenity space for the Garden Suites. At a minimum, a 1.5m minimum setback following the Laneway Suite requirement provides a buffer space, allows for rear windows, and creates additional space between adjacent lots with either existing or planned Ancillary Buildings or Structures.

3.6.9. LOT COVERAGE, MAXIMUM AREA + SOFT LANDSCAPE REQUIREMENTS

As mentioned, the lot coverage, maximum area, and soft landscape requirement from the Ancillary Buildings & Structures by-law were applied to our sample lot size for comparison (refer to Appendix D for lot drawing). The 600 square foot design exceeds the current maximum area and lot coverage from the by-law. However, the soft landscaping requirement - assumed here as all the rear yard excluding the building footprint - is satisfied. Based on the site analysis, we recommend the city include the side and rear yard setbacks in the allowable soft landscape requirement, given the amount of space provided by the proposed setback dimension.

3.6.10. ADDITIONAL LOT CONSIDERATIONS

Using the footprint of the 1- and 2-storey Garden Suite, and the sample lot sizes provided by the City, we analyzed our Garden Suite on different sized lots across Toronto (refer to Appendix E for full range of example lot sizes).

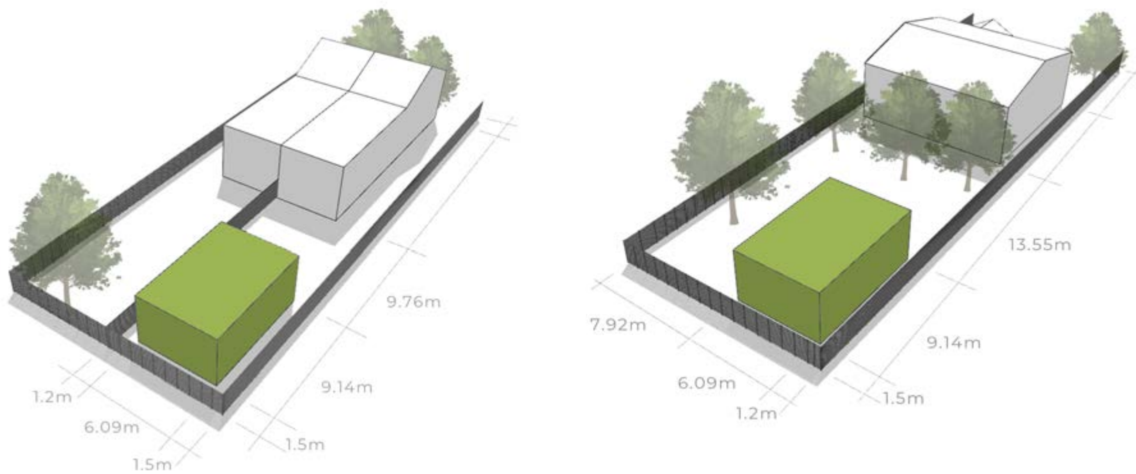


Figure 9. 1-storey garden suite modelling on example lot sizes by TABC.

3.7. ENERGY MODELLING

To investigate the hypotheses, we required energy modelling to understand the amount of energy from what fuel source the Garden Suite consumed per year.

3.7.1. THERMAL VALUES + PRESCRIPTIVE CHART

To provide a level of research vigour, reliability, and validity, a table of thermal values and mechanical assumptions was co-produced and verified by a larger group of experts in the field (refer to summary chart below; refer to Appendix F for detailed chart). Due to time constraints, energy modelling was analyzed for the 1-storey Garden Suite, based on chart and the following set of assumptions:

- Thermal values and energy consumption criteria for Energy Steps 1 and 2 criteria correspond to information readily available in the Ontario Building Code and the Energy Star for New Homes Version 17 Standard.
- Thermal values and energy consumption criteria for Energy Steps 3 and 4 co-produced by RDH Building Science and the Building Science Department at Ryerson University.

- All other values are based on existing literature, research, or relevant program guides, or expert suggestions, as noted.
- When energy modelling commenced, the mechanical system designs listed below were not available. Mechanical efficiency values in the prescriptive chart are based on existing industry standards and OBC requirements.
- Fuel sources differ along the Energy Steps:
  - Step 1 uses conventional gas-fired heating and cooling.
  - Step 2 is hybrid gas and electricity, allowing for future fuel switching.
  - Steps 3 and 4 uses electricity only provided the high performance building envelopes and airtightness.

Thermal Performance Values for Energy Steps				
	Step 1 OBC Minimum	**Step 2** Energy Star TGS Tier 1	**Step 3** CHBA NZr TGS Tier 3	**Step 4** Passive House TGS Tier 4
Roof	R-31	R-44	R-65	R-85
Walls	R-22	R-22 plus R-8 continuous	R-22 plus R-25 continuous	R-22 plus R-36 continuous
Basement Walls	R-20	R-28	R-47	R-58
Slab	R-10	R-15	R-30	R-30
Windows*	U-0.28	U-0.21	U-0.14	U-0.14
Doors	U-0.28	U-0.21	U-0.14	U-0.14
HRV efficiency	75%	75%	89%	93%
DHW min. efficiency	Gas 0.8	Gas 0.80 Electric 0.93	Electric 0.93	COP 2.5
Airtightness**	3.0	2.5	1.0	0.6

*Imperial U-value Btu/(h·ft^2·F)

**Air Changes per Hour @ 50P

3.7.2. WALL + ROOF + FLOOR ASSEMBLIES

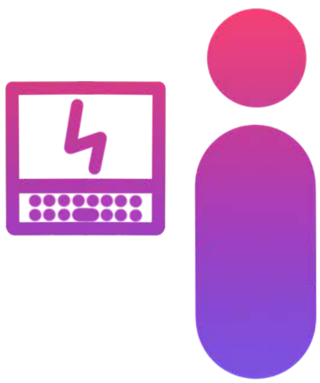
The model suite was designed for the worst-case scenario assembly wall thickness for Energy Step 4's Passive House Standard requirement. From here, the assemblies are interchangeable; building performance improves but the design remains unchanged, creating an 'apples to apples' comparison.

Energy Step 1

- The assemblies are based on TACBOC details, which provide a reference for meeting the minimum requirements of the OBC for typical residential construction in Toronto.
- Materials used in the wall assembly include petrol-based products and do not consider carbon impact.

Energy Step 2

- Wall, roof, and floor assemblies for Energy Step 2 reflect the prescriptive chart requirements for energy efficiency and supplemental information provided in the Energy Star for New Homes (ESNH) Version 17 manual.
- Materials used in the wall assembly include petrol-based products and do not consider carbon impact beyond the ESNH v17 standard.



Energy Steps 3 & 4

- Wall, roof, and floor assemblies for Energy Step 3 and 4 were prepared by Tristan Rouse, a Masters of Building Science student at Ryerson University under the supervision of Paul Dowsett, an architect specializing in no/low carbon design.
- Materials used in the assemblies avoid using petrol-based and are no/low carbon emitters wherever possible.

3.7.3. ENERGY MODELLING TEAMS

Using the above information, three separate teams created the final energy models (refer to Appendix G for detailed information), based on the same set of architectural drawings prepared by The Architect Builders Collaborative:

Ryerson University Graduate Program in Building Science

- Energy models generated by two students from the Graduate Program in Building Science at Ryerson University: Laura Goetz and Maya Shikatani.
- Energy models created using EnergyPlus.
- EnergyPlus is an open-source modelling software funded by the United States Department of Energy Building Technology Office which estimates energy consumption using whole building simulation to provide values for heating, cooling, ventilation, and lighting. More information: https://energyplus.net/
- Supervised by Dr. Russell Richman, Associate Professor, Associate Chair, Graduate Studies, Building Science Department, Ryerson University.

RDH Building Science Inc.

- Energy models generated by two members of the RDH Building Science team: Kristen Yee Loong, P.Eng, Associate, Energy and Sustainability Specialist and Kathleen Narbonne, M.Sc., CPHD, Energy and Sustainability Analyst.
- Energy models created using eQUEST.
- eQuest is an open-source easy-to-use building energy simulation tool initially funded by California utility customers and administered by Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison, with the support of the California Public Utilities Commission https://www.doe2.com/equest/
- Supervised by Alex Lukachko, M. Arch, Principal, Senior Building Science Specialist.

Green Tectonics

- Energy models generated by German Vaisman, B.Arch, MBSc., CPHD of Green Tectonics.
- Energy models were created using Passive House Canada's Passive House Planning Package (PHPP).
- PHPP analyzes a building's adherence to the rigorous Passive House Standard, and is an energy modelling software currently accepted by the Ontario Building Code and the Toronto Green Standard.

3.7.4. SOLAR STUDY

To estimate the amount of energy generated on-site, Jeremy Lytle (Ryerson University) provided the following assumptions:

- A typical Toronto mid-block lot at an east-west orientation
- A 20’ x 30’ Garden Suite estimated to fit an 8 kW solar array
- Panels installed on a 5-degree tilt angle and a flush-mount racking system

3.8. GAS + ELECTRICITY COST CALCULATION ASSUMPTIONS

The annual energy use for each Step can be predicted from the energy models. Putting a price on this energy use is less scientific. As projecting future changes in the wholesale cost of natural gas and electricity is beyond even the capability of the National Energy Board. For the purpose of this comparison, no change in the wholesale supply cost for either gas or electricity is assumed. All calculations use 2021 dollars.

Impact Of the Carbon Charge

The Federal government’s carbon charge program was recently upheld by the Supreme Court of Canada. The most recent federal budget included provisions for the carbon charge to rise in $10 and $15 annual steps from the current rate of $40 / tonne of CO_2 to at least $170 / tonne by 2030. We have taken into account the impact of this carbon charge on the cost of natural gas.

Electricity

The average cost of electricity was calculated from data published by Toronto Hydro in their annual reports. In 2020, Toronto Hydro delivered 5,526,525,856 kWh to all residential customers. This produced gross revenues of $1,120,677,308 across all ‘Time of Use’ rates for an average cost per kWh of $0.2028. This is the rate used to estimate the annual cost of electricity for each Step.

Gas

The actual cost of natural gas per m3 (the measure of sale in Toronto) was calculated from a typical Enbridge gas residential bill from April 2021. As Enbridge breaks out the various costs associated with the consumption of natural gas, including the carbon charge, it is quite easy to calculate the cost of the gas itself, and the cost of the carbon charge which was escalated annually in accordance with the federal legislation. For Steps 3 & 4, where there is no natural gas service, additional savings accrue.

3.9. BUILDER COST ESTIMATES + SCOPE OF WORK

To investigate the hypotheses, we needed comparable cost estimates. One Scope of Work (refer to Appendix I) for use during estimation was co-produced and verified by builders currently working in Toronto and its surrounding area:

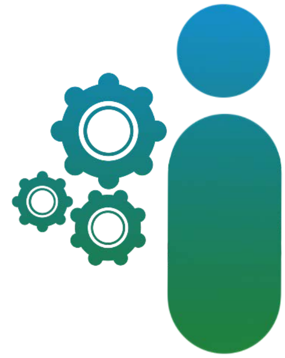
- HummingbirdHills Homes + Construction
- Evolve Builders Group Inc.
- Vanderwal Builds

In addition to the Scope of Work, several other key assumptions were decided upon by the group:

- Site servicing costs are the same for each Builder.
- Line items are provided per the Master Format.
- Differentiations between each Energy Step are clearly noted.
- Upgraded material packages are not included in the base cost comparison, beyond the basic specifications for each step provided in the Scope of Work and are at the discretion of the contractor.
- At the time of costing, the mechanical system designs listed below were not available. Estimations based on previous experience with installation and purchase of similar equipment and systems.
- Builders do not assume commitment to cost estimates for this research project for actual Garden Suites construction, the estimates are purely hypothetical.
- Each builder was provided the same set of costing plans prepared by the Architect Builders Collaborative Inc.
- Overall costs trend higher than usual due to the inflated costs of lumber during the COVID-19 pandemic.

Despite best attempts at harmonizing the estimation processes across builders, we assume potential variability in costing due to differences in business models and approaches of each builder. Additionally, key to decreasing the cost to go greener is making these types of design and construction more mainstream. In the early phases of learning new technologies most teams aren't familiar with how to save costs or innovate, but research indicates most arrive there over time (Bernhardt, 2021).

3.10. MECHANICAL SYSTEM DESIGN



Mechanical system design for ideas beyond the typical gas fired furnace generously provided by representatives at three companies who specialize in lowered carbon emission systems and understand the challenges for heating and cooling small and well-insulated spaces:

- iFlow HVAC Inc.
- Mitsubishi Electric Inc.
- Dettson Canada

Each system was designed using the same heat loss calculations (refer to Appendix I). Heat loss calculations were by:

- HVAC Designs Inc.

4. RESULTS

The following sections outline the results from the energy models, cost estimates, and mechanical designs.

4.1. TORONTO GREEN STANDARD PERFORMANCE METRICS

To recap, the Toronto Green Standard for mid- to high-rise and city-owned properties uses three main metrics for its performance standards:

- **Total Energy Use Intensity** (TEUI) represents the total annual energy use for all uses, both electricity and gas, made comparable by measuring against the area of a building
- **Thermal Energy Demand Intensity** (TEDI) is a subset of TEUI, the total annual energy used specifically for heating of both electricity and gas, made comparable by measuring against the area of a building
- **GreenHouse Gas Intensity** (GHGI) is the total greenhouse gas emissions for the TEUI, both electricity and gas, made comparable by converting all greenhouse gases to their carbon equivalents and measuring against the area of a building

These metrics do not apply to the Low-Rise Residential Toronto Green Standard (LRR TGS) Version 3. The LRR TGS requires each tier to satisfy a program or standard, such as Energy Star, Net-Zero Ready, or Passive house. However, the metrics are helpful to compare how the required standards perform using absolute targets representing how much energy is used, what the energy demand is, and the carbon footprint.

4.2. ENERGY PERFORMANCE COMPARISONS

The following sections depict the combined average totals from the energy modellers (refer to Appendix G for individual modelling team results).

4.2.1. TEUI - TOTAL ENERGY USE INTENSITY

The graph below (Fig. 10) represents the average TEUI for each Energy Steps. The energy use per year decreases with the more efficient steps. Step 4 does not quite hit the projected 80% reduction target, but comes close. Additionally, the TEUI values meet the TGS checklist values (refer to p. 24 and p.27-28).

Figure 10. Average Total Energy Use Intensity (TEUI) across all four Energy Steps with targets.

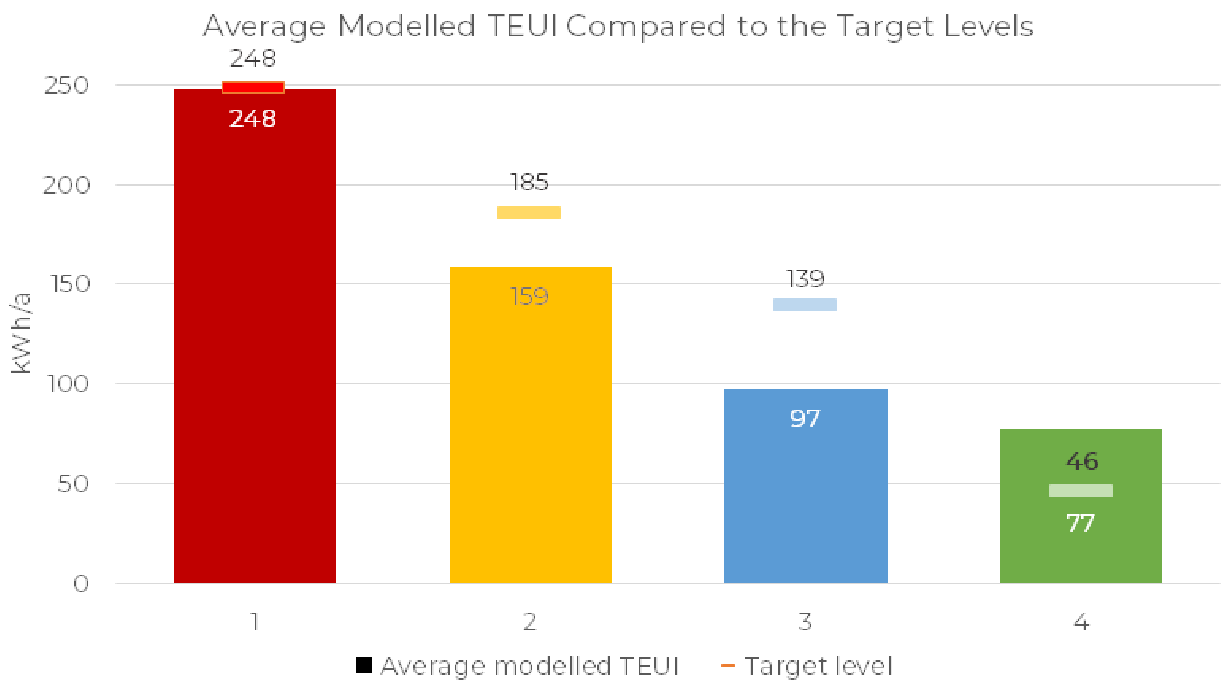
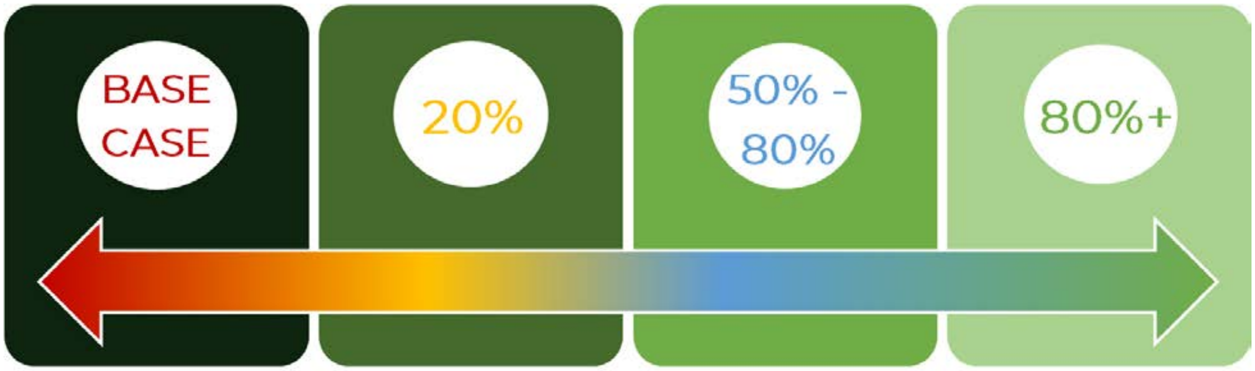


Figure 11. Refresher for the reduction target levels over base case for each Energy Step.



4.2.2. TEDI - TOTAL ENERGY DEMAND INTENSITY

The graph below (Fig. 12) represents the average TEDI for each Energy Steps. As expected, the results indicate a better performing building lowers the energy demand. Similar to the TEUI, Step 4 does not quite meet the target, but comes very close. Additionally, the TEUI values meet the TGS checklist values (refer to p. 24 and p.27-28).

Figure 12. Average Total Energy Demand Intensity (TEDI) across all four Energy Steps with targets.

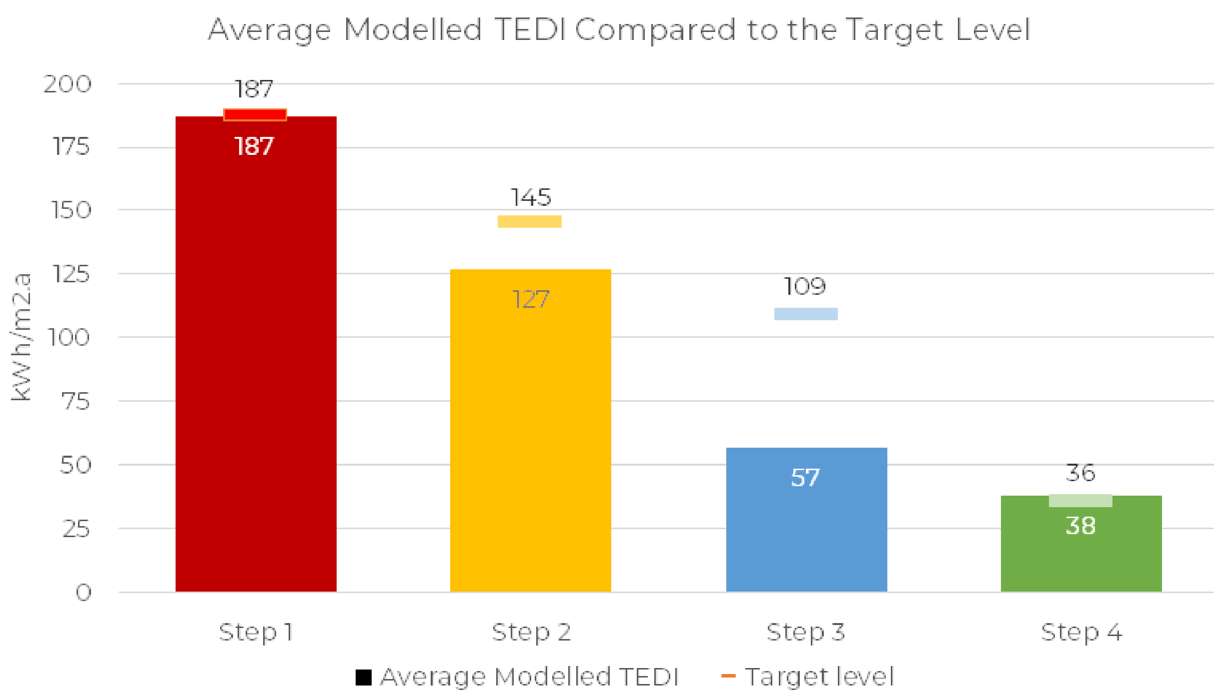


Figure 11. Refresher for the reduction target levels over base case for each Energy Step.

4.2.3. GHGI - GREENHOUSE GAS INTENSITY

The graph below (Fig. 13) represents the average GHGI for each Energy Step and continues the same downward trend across the steps, similar to TEDI and TEUI depicted above, and meets the projected targets. The values on the graph indicate a 91% reduction in carbon emissions over the "business as usual" Step 1 base case. Additionally, the TEUI values meet the TGS checklist values (refer to p. 24 and p.27-28).

Figure 13. Average Greenhouse Gas Intensity (GHGI) across all four Energy Steps with targets.

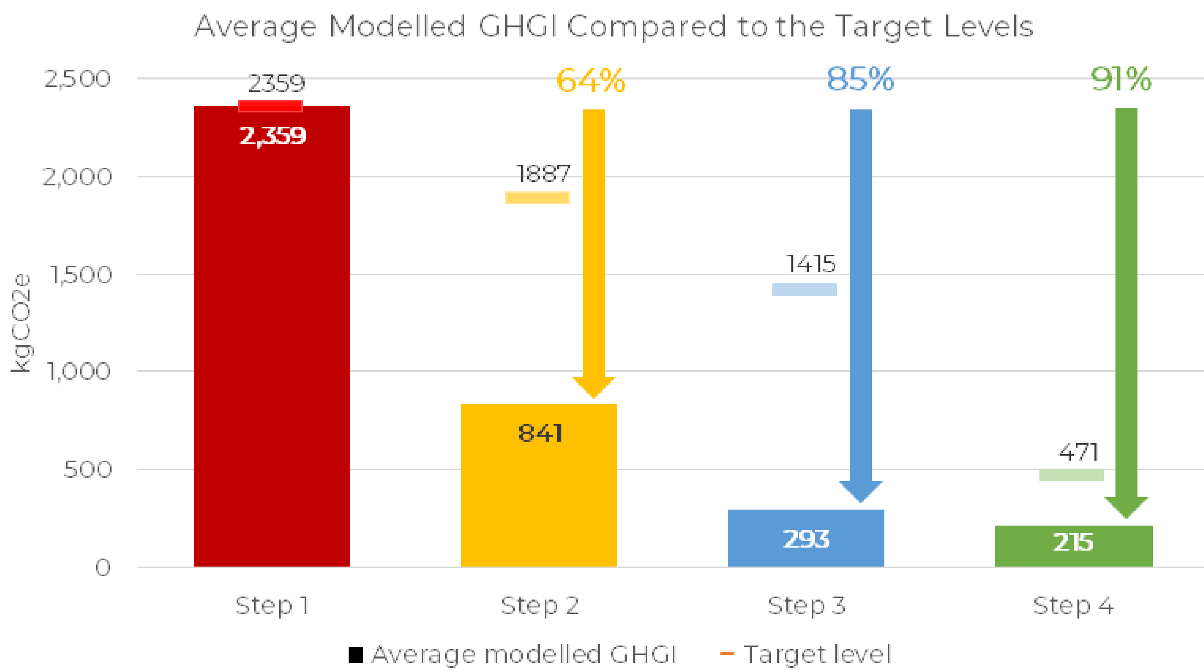


Figure 11. Refresher for the reduction target levels over base case for each Energy Step.

4.3. OPERATIONAL COST COMPARISONS

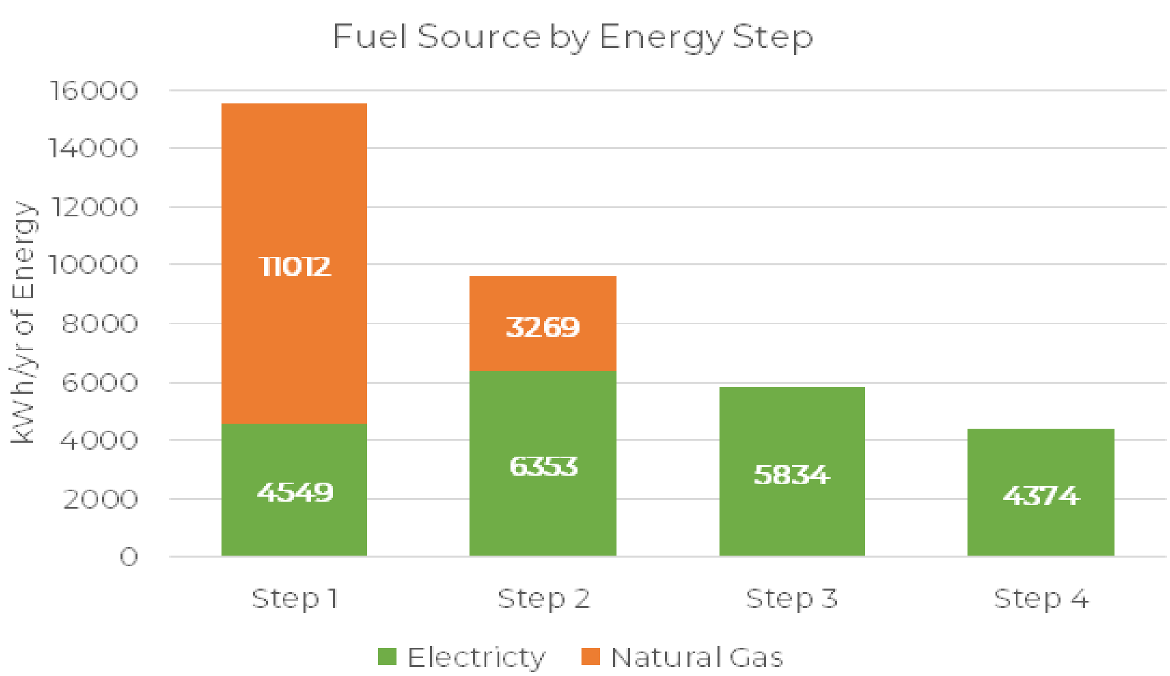
4.3.1. FUEL SOURCES

Step 1, being the baseline lowest cost version, is assumed to use a standard ducted high-efficiency natural gas furnace and stand-alone hot water heater. Step 2 is proposed as an in-between point, with a hybrid gas and electric system, and a step on the way to a zero-carbon system. Steps 3 & 4 do away with fossil fuel fuel sources and their associated carbon emissions altogether thanks to the higher insulation and low heating loads.

The graph below (Fig. 14) displays the fuel sources for each step and the amount of fuel used per year. As mentioned, Steps 1 and 2 use Natural Gas, Step 2 uses a combination of gas and electricity, and Steps 3 and 4 use electricity.

As indicated on the graph, and as expected, Step 1 is the most energy-intensive with a combined total use of 15,561 kilowatt-hours per year (kWh/yr). Step 4 is the least energy-intensive, cutting energy use by a third, using 4374 kWh/yr of electric energy for the entire building.

Figure 14. Fuel source for each Energy Step.



4.3.2. AVERAGE OPERATIONAL COST COMPARISONS: 1 YEAR

The graph below (Fig. 15) depicts the average operational cost for one year (assumed 2021) using the electricity, gas, and fuel source data detailed in the above sections. The data indicates Step 2 is the most expensive to operate per year at approximately $1,644.86. The price increase is attributed to the hybrid mechanical system using less of the cheaper natural gas, a less energy-efficient building envelope, resulting in higher electricity costs due to more energy used for heating and cooling.

Step 4 is the least expensive to operate per year at $886.70, a $758.16 savings from Step 2, despite using only electricity - a fuel source currently more expensive than gas. Step 4 has the highest performing envelope and therefore requires the least amount of energy use, as also evidenced by the comparative TEUI and TEDI values. Step 3 also is less expensive to operate per year than Step 1 and 2.

Figure 15. Average operational cost for each Energy Step for one year.

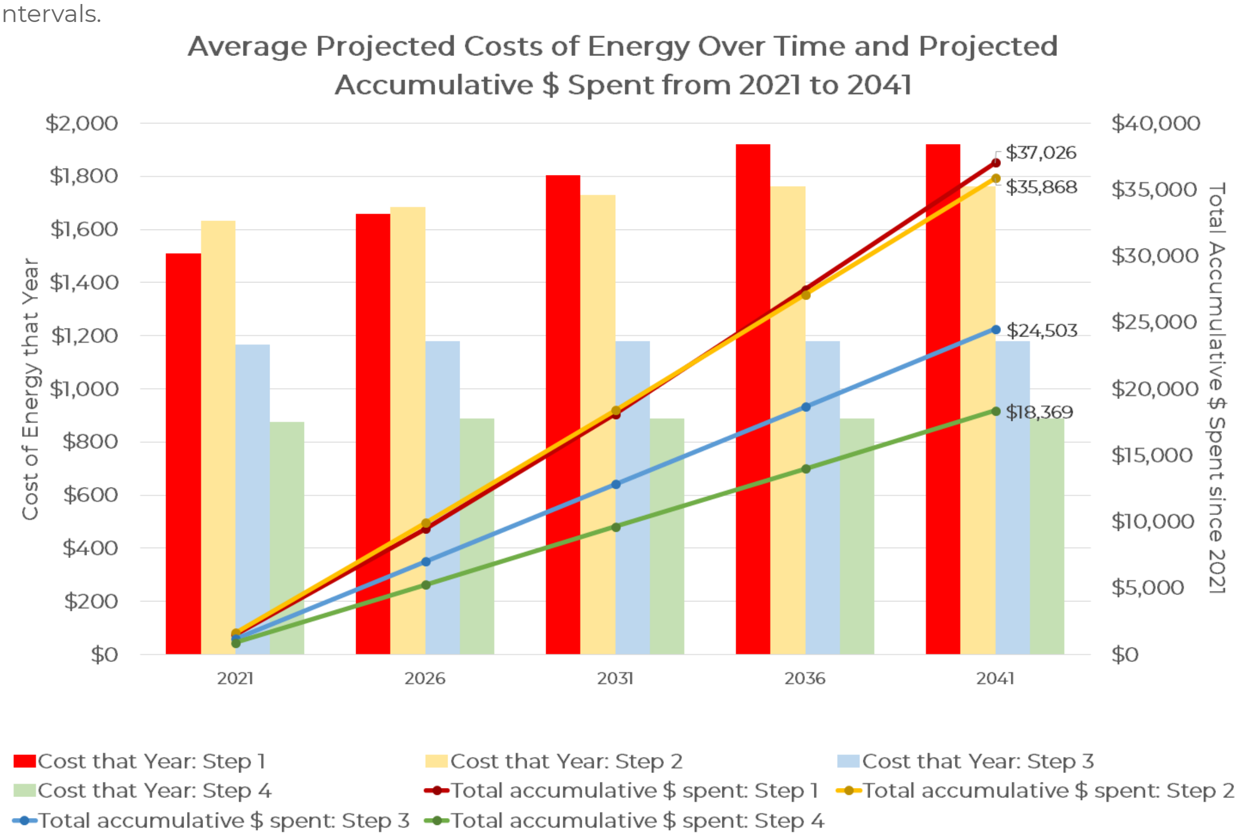
4.3.3. AVERAGE OPERATIONAL COST COMPARISONS: OVER TIME

The bars on the graph below (Fig. 16) represent the operational cost per year for each step over time. The lines on the graph represent the total accumulated money spent on operational costs over time. In both scenarios, time is measured in five year intervals, similar to mortgage terms.

Step 2 starts as the most expensive, but is later eclipsed by Step 1 after 10 years and beyond. The rise in cost for Step 1 is attributed to a less high-performing envelope and the incremental increase of gas when the projected carbon tax is factored into the cost calculations. As stated, Steps 3 & 4 use electricity, currently more expensive than gas. However, when combined with a higher performing envelope, Steps 3 and 4 use less energy and thus cost less to operate over time.

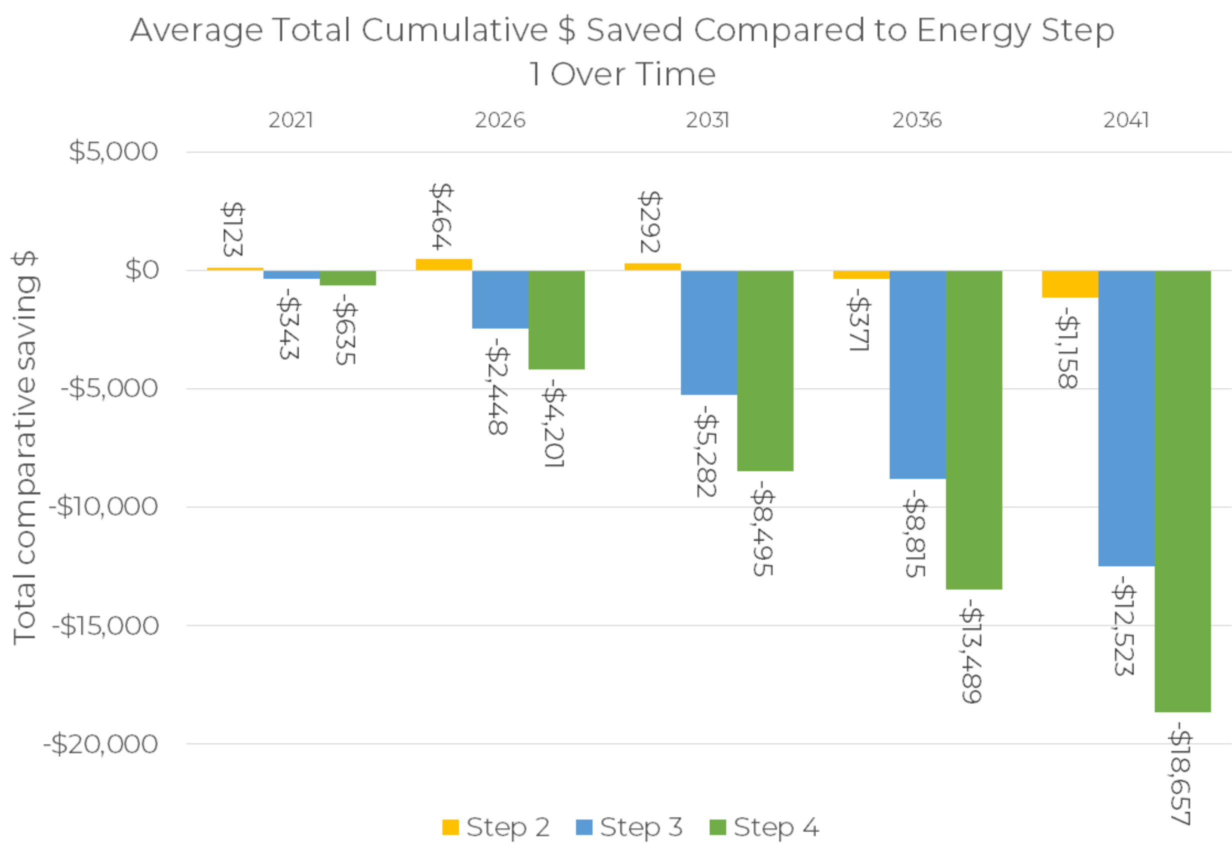
Based on current pricing, the operational costs for a gas-fired heating system will be at least half to a quarter of the cost of an all-electric dwelling. However, if and when gas becomes more costly due to taxes levied on its environmental impact, the operational costs will change.

Figure 16. Average projected operational costs over time for each Energy Step over five-year time intervals.



Using Step 1 as a baseline reference, the predicted average operational savings over time between the Energy Steps are compared on the graph below (Fig. 17). Step 1 primarily uses gas for heating and cooling, which starts off costing less, but becomes more expensive over time when adding the carbon tax. The graph below indicates the differences in building envelope efficiency add up over time. For example, Step 4 offers projected savings of $18,657 after 20 years compared to the baseline Step 1. Step 3 also offers significant savings over the baseline Step 1, with a 20 year projected savings of approximately $8000.

Figure 17. Average projected **operational cost savings** over time for each Energy Step using Step 1 as the baseline reference case.



4.4. SOLAR STUDY RESULTS

Model A (refer to Fig. 18) the site specifications of the assumed site and the two green dots on the lot are existing trees. Model A generates about 6500 kilowatt hours per year. Model B (refer to Fig. 19) represents a best-case scenario for maximum solar potential by removing the large trees. Model B generates close to 1200 hours of full sun a year; this equates to approximately about 9200 kWh generated on site. In both cases, the site presumably generates enough on site solar energy to meet the energy demand of step 3 and 4.

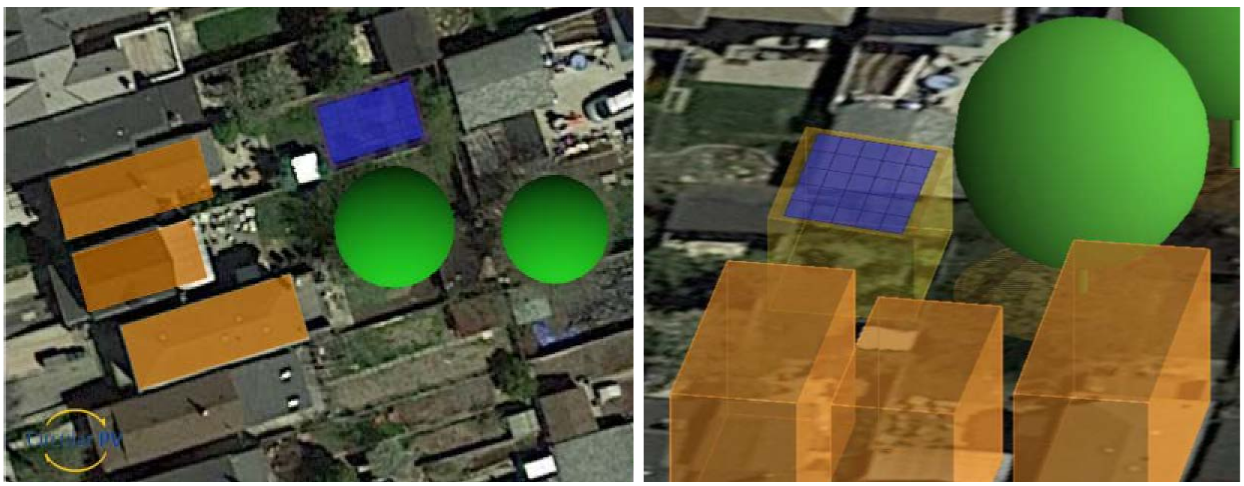


Figure 18. Model A solar study assuming existing trees. Image by Jeremy Lytle, Ryerson University.

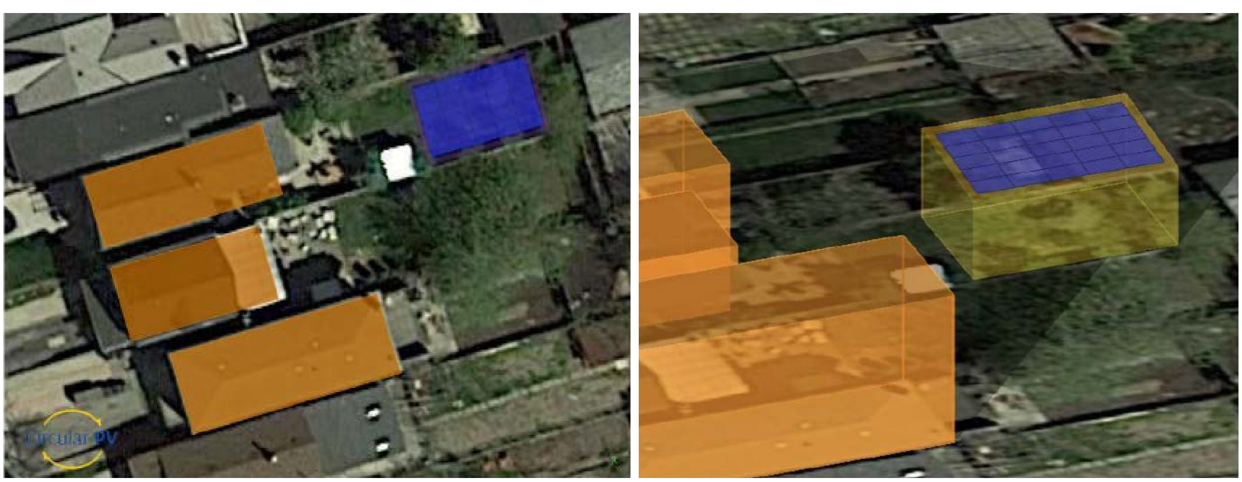


Figure 19. Model B generalized solar study assuming no trees. Image by Jeremy Lytle, Ryerson University.

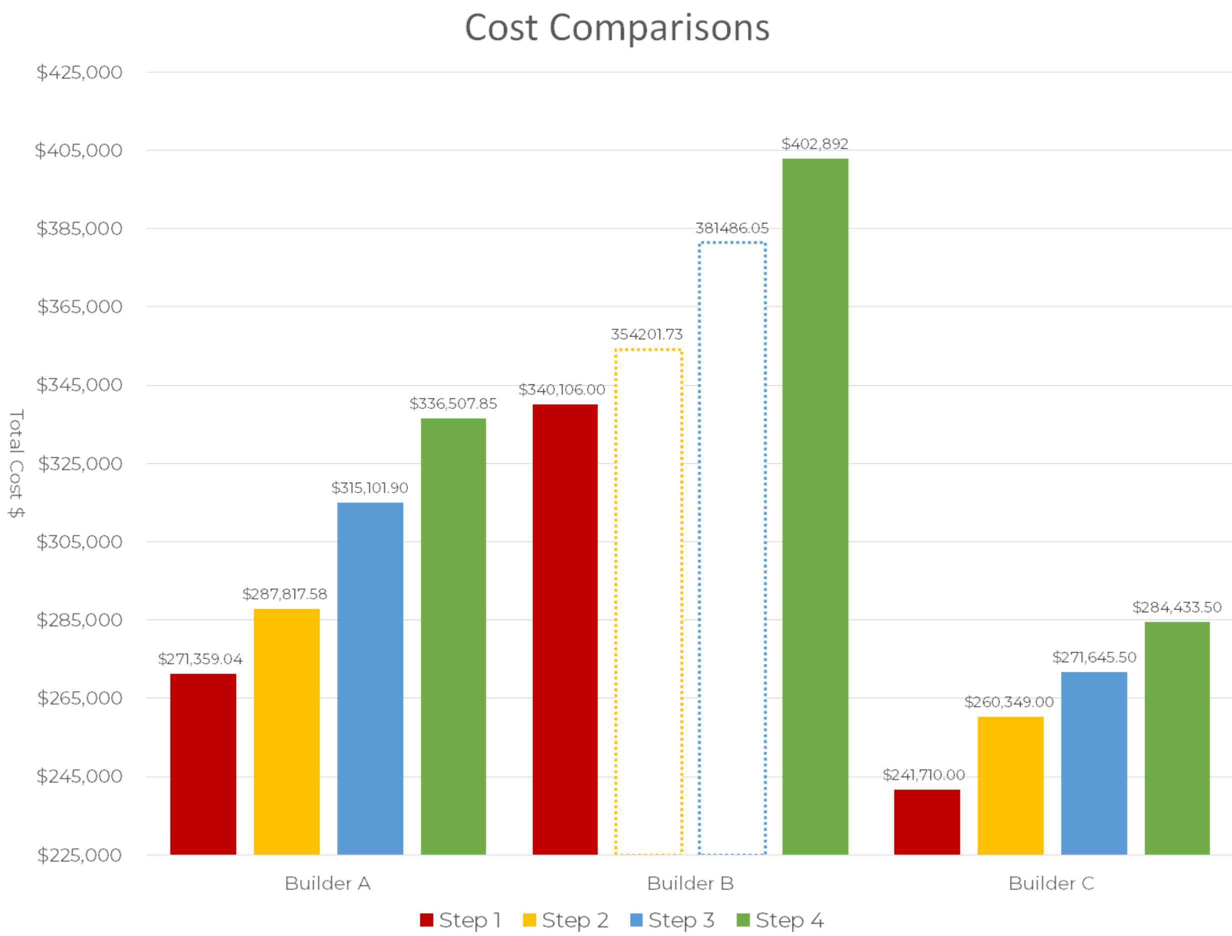
4.5. COST ESTIMATES

Cost estimates for all builders are based on the construction drawings provided and the Scope of Work. However, due to differences in estimation methodology and quality of work, some discrepancies are expected. The price is the full cost to build a 1-storey Garden Suite for each Energy Step (less HST and sitework costs)and not just the cost of the increased efficiency. Refer to Appendix J for individual charts.

4.5.1. COMPARISON OF BUILDERS: A + B + C

The graph below (Fig. 20) displays all three builders numbers together. Steps 2 & 3 for builder B have been assumed for display purposes only, interpolated using the difference in price between the cost estimates for Steps 1 & 4 provided by Builder B, and the data from the other builders' estimates.

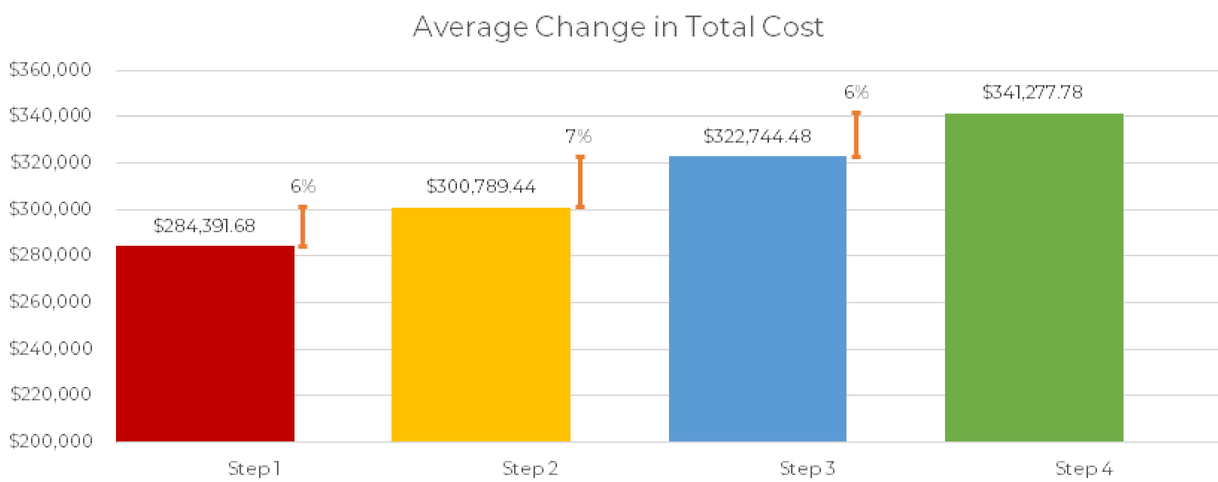
Figure 20. Cost comparison for each Energy Step provided by all three builders.



4.5.2. AVERAGE TOTAL COST + COST PREMIUMS

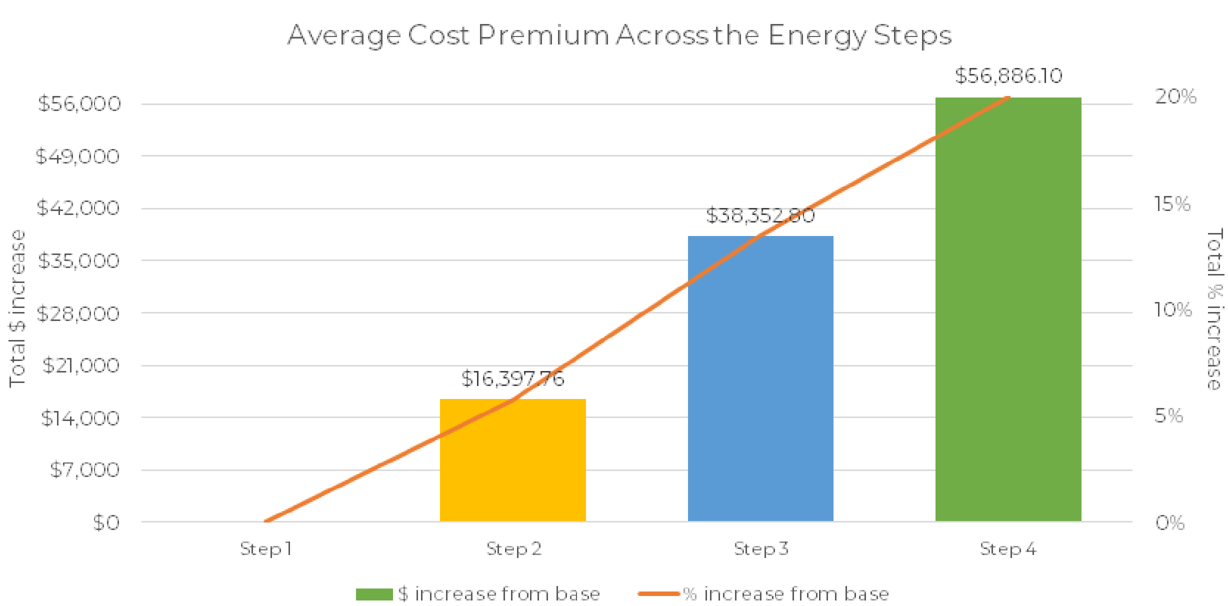
The graph below (Fig. 21) represents the average total cost from each builder estimate. The percent change in cost between each step is approximately 6.5.

Figure 21. Cost comparison for each Energy Step provided by all three builders.



The bars on the graph below (Fig. 22) represent the average increased capital cost per Energy Step, using Step 1 as the baseline. The orange line indicates the percent increase, using each subsequent step as the baseline. As indicated, the cost premium for Step 4 over Step 1 is approximately $56,886, or 20% more. The cost for Step 3 is approximately $38,352 or 13% more than Step 1.

Figure 22. Average cost premium for each Energy Step using Step 1 as the baseline reference.

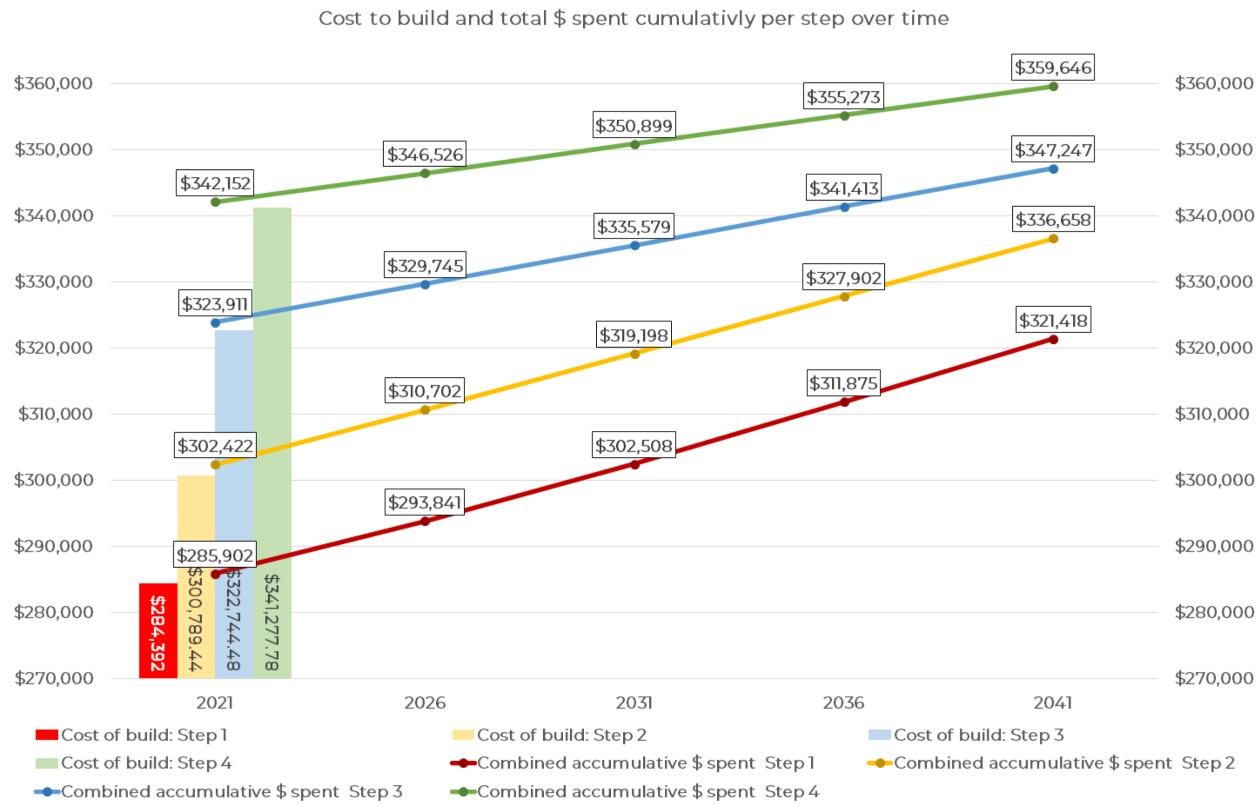


4.6. TOTAL COMBINED COST TO BUILD + OPERATE A GARDEN SUITE

The following section calculates the culminated costs over time based on the total average cost to build each Energy Step and the total operational costs over time, to help highlight combined operational and capital costs and what financial incentives may be most useful to apply.

Figure 23 shows the cumulative cost of building and operating each Energy Step over the next 20 years using five year time intervals. The lines depict the total average capital cost for each Energy Step plus the average cumulative cost of the annual operational costs over time. The bars on the graph represent the total average capital cost to build.

Figire.23. Graph showing both the total cost to build per step plus the cumulative cost over time of the combined capital cost and operational costs from 2021 to 2041.



Although Step 1 is the least expensive to construct, the money spent on energy increases more rapidly over time by almost $35,500 in 20 years compared to Step 4, which has a smaller increase of almost $17,500 in 20 years (refer to average operational cost: over time page 49 - 50).

Figure 24 below again depicts the cumulative total average cost to build each Energy Step plus the average operating costs for each Energy Step over the next 20 years. Here, the bars indicate the cost increase from Step 1 to the higher Energy Steps (3 & 4). Figure 25 below displays how much each Energy Step increases in dollars spent between 2021 and 2041.

Figure 24. Graph showing the cumulative cost over time of the combined capital cost and operational costs from 2021 to 2041 and the difference in cost between Step 1 and the higher Steps over time.

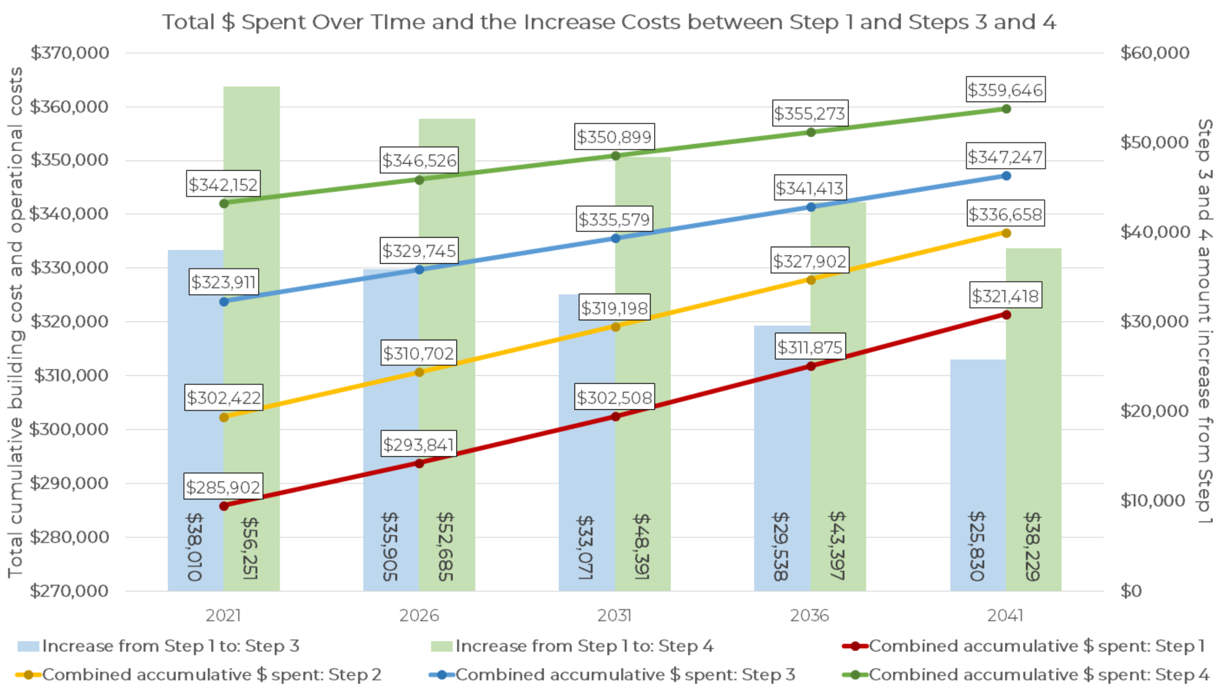
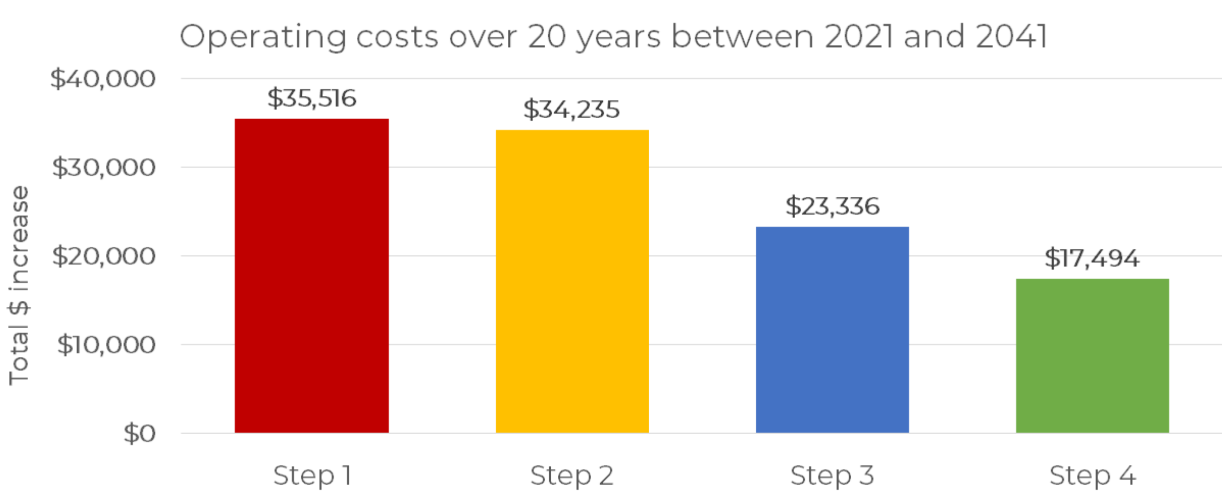


Figure 25. Graph demonstrating money spent per Energy Step over 20 years.



Using the predicted values from the charts above, and assuming operational cost over time maintains a similar trajectory, it is possible to project the time required for the higher Energy Steps 3 and 4 to converge with the Step 1 baseline reference case (refer to Fig. 26 below).

Figure 26. Graph depicting when Steps 2, 3 + 4 converge with Step 1 base case.

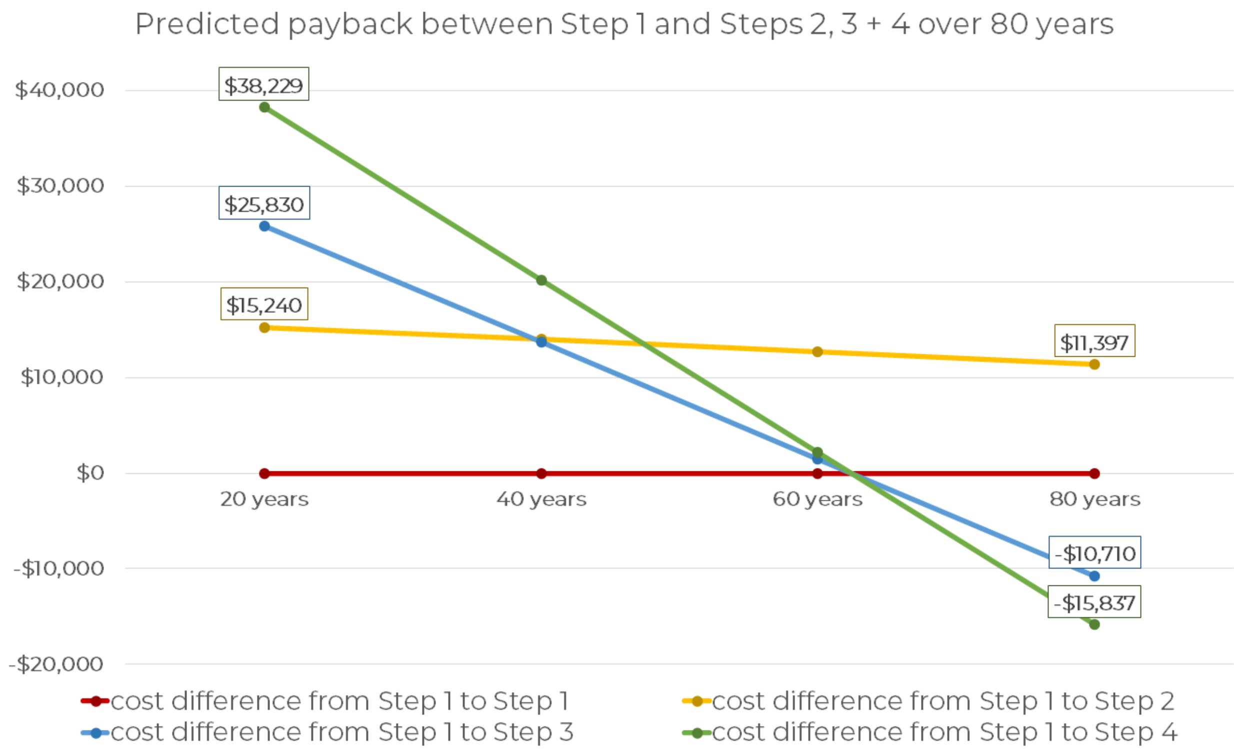


Figure 26 above also indicates it will take approximately 60 years to “earn” back the increased capital cost to build Steps 3 and 4. Therefore, to encourage homeowners to build the higher Steps, incentives should be directed towards the upfront cost of building a no/low carbon Garden Suite, and where incentives will have the greatest impact.

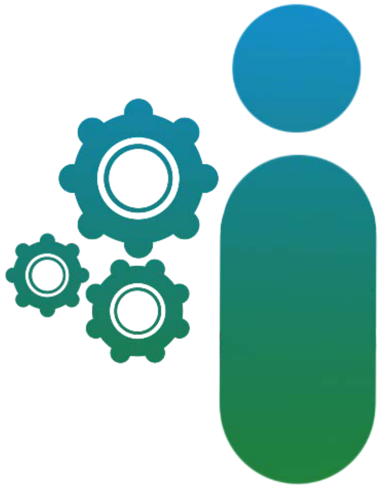
4.7. MECHANICAL SYSTEM DESIGN OPTIONS

Three companies provided mechanical design for the 1-storey Garden Suite. The choices differ and present a range of all-electric opportunities currently available in the market, comparable to the typical gas-fired furnaces found in most homes.

Mitsubishi Canada

Concealed Duct Mini-Split Single Zone Air Source Heat Pump (ASHP) (refer to Appendix K for more information):

- Cold Climate option provides cooling and heating down to -25 degrees Celsius; would not require electric resistance back up.
- Standard units require supplemental heating to adequately heat during the winter.
- Slim ducted systems work well in smaller spaces where standard sized ASHP are not as suitable.
- Outdoor air handler and indoor ceiling concealed unit required.
- Energy Star rating available.



iFlow HVAC Inc.

Combination tank-type electric water heaters and iFlow air handlers are another mechanical systems option. Due to the small heating and cooling loads of the 1-storey Garden Suite, the heat provided by an electric water heater is sufficient for the space, using an air handler and ducts to move the heat around. There are several suggested configurations to choose from:

- iFlow air handler combined with either:
    - an electric tank-type water heater to provide domestic hot water combined and an air conditioning unit for summer cooling
    - an electric tank-type water heater to provide domestic hot water and back-up space heating and a heat pump for summer cooling and heating during the shoulder season (i.e., spring and fall)
    - A heat pump water heater vented to outside to provide domestic hot water and back-up space heating and a heat pump for summer cooling and heating during the shoulder season (i.e., spring and fall)

- Manufacturer's note:
    - No CSA or ASHRAE standard exists with which to assess the combined efficiency of these products

Dettson Canada

Combination Dettson air handler and heat pump:

- Supreme Modulating Series electric furnace provides the right size system, avoiding over-sized equipment typical to small space mechanical design

5. RECOMMENDATIONS

Based on our findings, we recommend City Planning consider the following in its draft Garden Suites regulations in its upcoming Proposals Report to City Council.

5.1. ENERGY STEP 3 AS THE INCENTIVISED MINIMUM

Based on the updates planned for the building codes and the shift toward low carbon construction, continuing to build to the OBC minimum building creates new buildings requiring retrofit from the outset. OBC minimum buildings are insufficient to meet the city's climate goals for the following reasons:

- Offer a minimum level of energy efficiency.
- Natural gas is often the primary fuel source.
- Petroleum-based products are the primary building materials.

Our results indicate meeting the City's climate goals means moving beyond the current minimum requirement of the Low-Rise Residential Toronto Green Standard Version 3 (LRR TGS v3) Tier 1 Energy Star for New Homes (ESNH) Standard Version 17. Energy Step 2 is not as energy efficient as the higher Energy Steps, has less to offer in GHG emissions reductions, with higher operating costs over time.

Step 3 offers the City the chance to reach its climate goals. Step 3 represents an 85% reduction in GHG emissions compared to Step 1's baseline. Despite the increase in average total cost for Step 3 over Step 1 - approximately $38,400 or 13% - by 2041, Step 3 saves an estimated $12,500 in operational cost over Step 1. Given the capital cost increase of roughly $38,000, we estimate capital payback in about 60 years.

Step 3 is 6% less impactful than Step 4's 91% GHG emissions reductions. Nevertheless, we recommend Step 3 over Step 4, despite the additional GHG emissions reduction. To explain, we roughly calculated the value proposition between Step 3 and Step 4:

- Step 3's cost premium of $38,400 divided by its GHG emissions reduction of 85% equals $442 per each 1% of carbon reduction.
- Step 4's cost premium of $56,900 divided by its GHG emissions reduction of 91% equals $669 per each 1% of carbon reduction.

Put another way, Step 3's cost premium of $38,400 for the first 85% compared to an additional $18,500 for Step 4's increase of 6% works out to $3,083 per each 1% of GHG

emissions reduction above Step 3's 85%. The above calculation demonstrates the additional 6% GHG emissions between Step 3 and Step 4 is very expensive.

Step 3 is the mandatory baseline for new builds; however, due to provincial control over areas such as the OBC, incentives are recommended to encourage forward momentum.

5.2. INCENTIVISING ENERGY STEP 3

In order to encourage the uptake of Energy Step 3, meaningful incentives will need to be considered. Below are our suggestions:

5.2.1. OFFER A GREEN SUBSIDY

Based on our findings, we predict operational cost savings over 25 years of roughly $13,000. Given the cost premium of approximately $38,400, a $25,000 subsidy will help homeowners cover the capital costs to go green.

5.2.2. CREATE A SIMILAR PROGRAM TO DURHAM REGION'S GREEN STANDARD

Durham Region's Clean Energy Economy Plan (2018) recognizes "increasing the energy performance of new buildings is much more cost-effective than trying to retrofit them after they have been constructed" (p. 83). Providing incentives to help homeowners reach higher levels of energy efficiency in the construction process helps save money down the road and helps offset the upfront costs. A Durham Region Green Standard, similar to TGS, is proposed in the Draft Community Energy Plan. The plan offers an additional pathway for incentivizing by offsetting upfront capital costs for higher-performance buildings above the mandatory requirement.

The incentive works in conjunction with the local utility provider and Local Improvement Charge (LIC) financing. The LIC program provides the upfront capital to help cover the cost of the upgrades in either a 10- or 20-year payback period. The rate of payback by the homeowner aligns with the avoided energy costs (Durham, 2018).

5.2.3. CREATE A 'NEAR-ZERO' RESEARCH PROJECT

The City of Vancouver and CleanBC are currently sponsoring a program to create more high-performance homes while collecting data (NearZero, 2021). The program offers up to $22,500 for using a heat pump in high-performance buildings, similar to Energy Steps 3 and 4. Applicants are required to meet and report on project milestones and submit questionnaires. The City of Toronto might consider a similar program to incentivize heat pumps in Garden Suites.

5.2.4. ‘THICK WALL + ROOF’ BONUS

The City of Vancouver has implemented by-laws offering the opportunity to increase the density of green buildings. Vancouver’s ‘thick wall’ bonus allows for an adjustment in calculations to the floor space ratio (FSR), meaning the habitable interior space is not penalized as a result of having thicker wall insulation ((10.11-10:16) City of Vancouver, 2021; BC Step Code, 2017). We recommend the following exclusions for exterior wall thickness, directly quoted from the City of Vancouver Bylaw No. 12015:

- Computation of floor area shall exclude 2% of the total area in buildings of three storeys or less if the majority of the exterior wall space contains at least 175 mm of thermal insulation in total thickness.
- In cases where no exclusion from floor area computation is granted, City Planning may choose to exclude an area equal to the area occupied by the insulation thickness that exceeds the applicable thermal performance value for exterior walls in the Ontario Building Code, as verified by a Building Envelope Professional, to a maximum exclusion of 330 mm of thickness for buildings of six storeys or less.

We recommend adding to the following to accommodate the additional ceiling insulation for Passive House and Net Zero construction:

- A maximum exclusion on height of 600 mm of thickness, to accommodate the increased roof insulation thickness that exceeds the applicable thermal performance value for ceilings in the Ontario Building Code, as verified by a Building Envelope Professional.

A key point to consider: the Vancouver density bonuses were created for single family dwellings over 1500ft^2, to offset the additional capital costs of Passive House construction via a projected increase in property values. For Garden Suites, which are accessory to the main dwelling unit, the bonus could apply to the entire lot.

5.2.5. PROVIDE A DEVELOPMENT CHARGE REFUND WHERE APPLICABLE

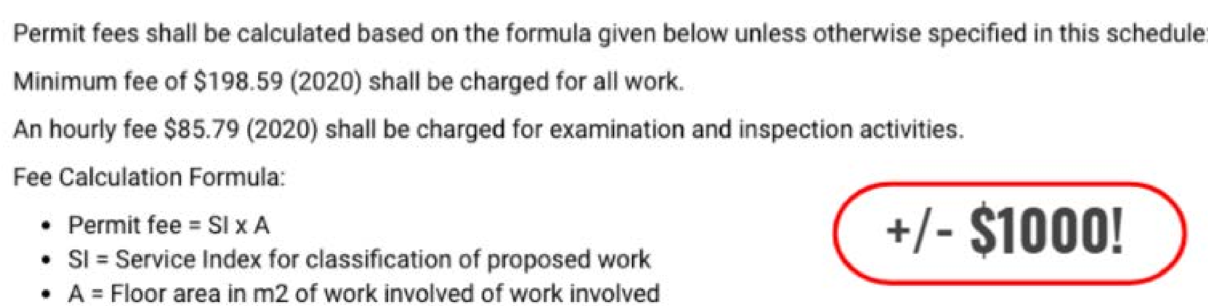
Based on the current TGS Development Charge (DC) Refund program, a similar program could help offset the cost of reaching the higher end of the Energy Step continuum. A partial development charge refund could be made available to Garden Suites demonstrating “higher levels of sustainable design…or near-zero emissions levels of environmental performance” aligned with the current rebate rates (City of Toronto, n.d.b.). Additionally, there is currently a DC deferral program offered for Laneway Suites. Homeowners enter into a DC deferral agreement with the city, with a condition: severing the lot within 20 years of receiving the building permit triggers a payment of the deferred DCs - at the cost for a single detached dwelling.

Given the recent changes in Bill 108, namely the DC charge exemption for adding a second dwelling unit in ancillary structures, DC charges for no/low carbon Garden Suites appear less of an option. The DC exemption for additional unit regulation amends the Planning Act to allow:

- The creation of an additional unit within ancillary structures to existing dwellings
- The creation of one additional unit in an ancillary structure in a new low-rise residential development

5.2.6. WAIVE PERMIT FEES FOR STEP 3 + ABOVE

Waiving permit fees for meeting the higher tiers is another way to incentivize no/low carbon Garden Suites. To jumpstart the creation of new backyard suites, Calgary is partially waiving permit fees until December 31, 2021 (City of Calgary, n.d.). The City of Richmond is considering lowering permit fees for constructing new passive homes (Rantanen, 2021). Similarly, the City of Toronto could consider waiving permit fees for those building Garden Suites to Step 3 and above. Using the formula provided by the City of Toronto Building Department, we calculate savings of approximately $1000 for our 600 square foot, 1-storey Garden Suite.


Permit fees shall be calculated based on the formula given below unless otherwise specified in this schedule:

Minimum fee of $198.59 (2020) shall be charged for all work.

An hourly fee $85.79 (2020) shall be charged for examination and inspection activities.

Fee Calculation Formula:

- Permit fee = SI x A
- SI = Service Index for classification of proposed work
- A = Floor area in m2 of work involved of work involved

Figure 27. Permit calculations for the City of Toronto (City of Toronto, n.d.a.).

5.3. PRE-APPROVED DESIGNS

Reaching for higher levels of energy efficiency is a daunting challenge for homeowners, contractors, and designers. We suggest eliminating this barrier by creating a set of pre-approved designs, similar to Seattle (Fig. 28) and requiring submitted designs to meet the energy efficiency criteria of the higher Energy Steps. Another requirement should be to submit designs that consider the Upfront Embodied Carbon of the building (refer to section 5.8 below).

Figure 28. Example of Seattle's pre-approved Garden Suite website (City of Seattle, 2021).

5.4. IMPLEMENTING A GARDEN SUITE PRESCRIPTIVE CHART

An alternate route to consider after the pre-approved designs is a prescriptive chart. The Garden Suites Prescriptive Chart (refer to Appendix F) can help make going 'green' easier. Providing this information upfront to those who want to create lower carbon Garden Suites, but do not know where to start, may help the city bring more buildings on track with its climate goals.

The main barrier to implementing the prescriptive chart is the permitting system for low-rise residential. Implementation of a prescriptive chart outside the OBC SB-12 requirement requires review and approval at the provincial level. However, if approved by the province, the prescriptive chart could be uploaded with the permit application documents similar to the current EEDS form. Additionally, meeting the requirements of the prescriptive chart might replace energy modelling, often an expensive addition to construction and a barrier to Passive House and Net Zero ready uptake.

5.5. HEIGHT OF SPECIFIC STRUCTURES ON A GARDEN SUITE

City of Toronto Zoning By-law Chapter 150.8 lists several permitted structures, when located on the roof of the ancillary building containing an accessory dwelling unit, may exceed the maximum height for that building by 1.0 metres. Based on lessons learned from the Laneway Suites, mechanical equipment is a recommended addition to the list. An increase in the allowable height of the structures from 1.0 metres to 1.8 metres would accommodate rack-mounted mechanical equipment mounted to support working conditions during a Canadian winter.

5.6. SAY 'NO' TO FOSSIL FUEL AS AN ENERGY SOURCE

Saying no to fossil fuel heating sources for garden suites is a regulatory approach to achieving no/low carbon garden suites. Unfortunately, regulation is emerging as the only way to achieve lowered emissions, particularly without sufficient incentivization. Waiting for people to 'do the right thing' without money to offer only kicks the carbon 'can' further down the road. Not permitting new natural gas lines to backyards, while seemingly punitive, is not a new measure. Notably, Californian cities are already switching to electricity-only in new building construction (Gough, 2021).

5.7. MANDATORY BLOWER DOOR TESTS

Blower door tests pre-drywall installation help improve the building envelope's airtightness and overall energy efficiency. For example, a recent construction project built better-than-code improved airtightness by 30% during a blower door test. The blower door test provided the opportunity to fix any hidden leaks. Requiring a mandatory blower door test before the inspection pre-drywall installation will help improve building envelope airtightness for all Garden Suites.

NRCan is currently offering Canada Greener Homes Grants, including EnerGuide energy audit evaluations covered up to $600 (NRCan, 2021).

5.8. UPFRONT EMBODIED CARBON + AIM FOR TRUE NET ZERO

A recent study found "material selection is the most impactful intervention at the individual building level" with upfront emissions reductions of up to 150% in addition to carbon capture (Builders for Climate Action, 2019). While the focus of our research project is reducing the operational emissions of Garden Suites, in reality, Upfront Embodied Carbon (UEC) emissions coupled with operational emissions provide a building's actual Carbon Use Intensity (Builders for Climate Action, 2019). Thus, consideration for up-front embodied carbon emissions and the potential for carbon storage of building materials is vitally important to lowering carbon emissions in the built environment.

The graph below (Fig. 29), adapted from the paper published by Builder's for Climate Action (2019), provides an overview of how impactful materials are to carbon emissions. The red bars indicate a slight difference in UEC between a code-compliant (our Step 1) and Net Zero Ready (our Step 3) home when carbon-heavy materials are used in construction. Despite savings in operational emissions between the two, the upfront embodied carbon emissions are practically the same. At the very least, asking for Best Conventional Materials helps dramatically reduce the carbon footprint.

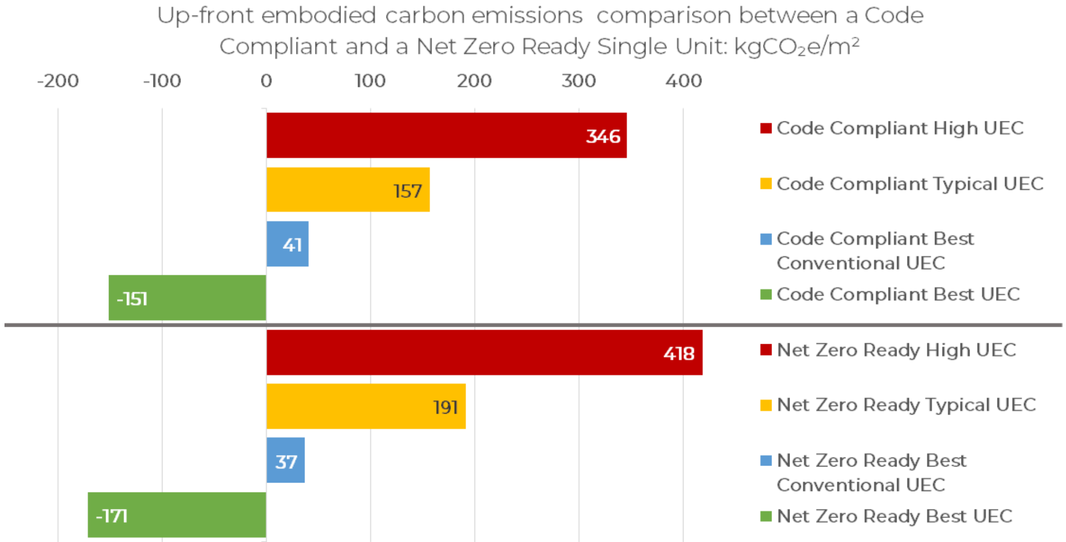


Figure 29. Graph adapted from a recent report exploring the impact of Upfront Embodied Carbon and its relation to energy efficiency (Builders for Climate Action, 2019).

Our recommendation is to specify materials to achieve actual net-zero carbon. Builders and designers invited to submit pre-approved designs should be encouraged to choose materials with Best Conventional or Best Upfront Embodied Carbon from the list below:

High UEC

- High carbon Concrete
- XPS + closed cell spray foam
- Brick Cladding
- Steel interior framing
- Vinyl windows & flooring
- Asphalt shingle roof

Best Conventional UEC

- High SCM concrete
- Cellulose + wood fiberboard insulation
- Wood cladding & framing
- Aluminum clad wood windows
- Engineered wood + FSC hardwood flooring
- Steel roof

Typical UEC

- Average carbon concrete
- Mineral wool insulation
- Fiber cement cladding
- Wood +TJI Interior framing
- Vinyl windows & flooring
- Asphalt shingle roof

Best UEC

- Iso-Span ICF with high SCM concrete
- Expanded glass subgrade insulation
- Straw + wood fiberboard insulation
- Wood cladding & framing
- Compressed straw panel interior walls
- Wood windows
- Linoleum + FSC softwood flooring
- Cedar shake roofing

Figure 30. List adapted from a recent report exploring the impact of Upfront Embodied Carbon of building materials (Builders for Climate Action, 2019).

5.9. IMPLEMENT A SMALLER BUILDING LOW-RISE RESIDENTIAL TORONTO GREEN STANDARD

Understanding the legislative barriers above for implementing the prescriptive chart, we expect the same challenge for implementing a green building standard covering smaller low-rise residential: Garden Suites, Laneway Suites, townhomes, semi-detached, and detached houses - essentially all housing forms less than four storeys with a minimum of five dwelling units. However, we recommend looking for a way to include buildings smaller and with fewer dwelling units than currently covered by the Low-Rise Residential Toronto Green Standard. Our results indicate new houses built to the OBC minimum requirements are not enough to address the climate emergency.

The Garden Suites provide the impetus for incorporating more housing forms into the green standard. While new 'small' low-rise residential development is understood to be less frequent compared to other building typologies, the additional buildings provided by Toronto's backyards are a consideration for their impact on carbon emissions. A recent article points out 30000 lots can potentially host Laneway Suites. Comparatively, there are over 1 million detached or semi-detached housing lots (Laneway Housing Advisors, 2020). Not all backyards will satisfy the zoning requirements. However, considering the energy modelling scenarios presented in this report and multiplying the results across the city, mandating no/low carbon, high performing 'small' low-rise residential is an impactful carbon reduction strategy. The longer we wait to implement a standard, the more 'small' low-rise typologies contribute to higher carbon emissions city-wide. We need to build better now.

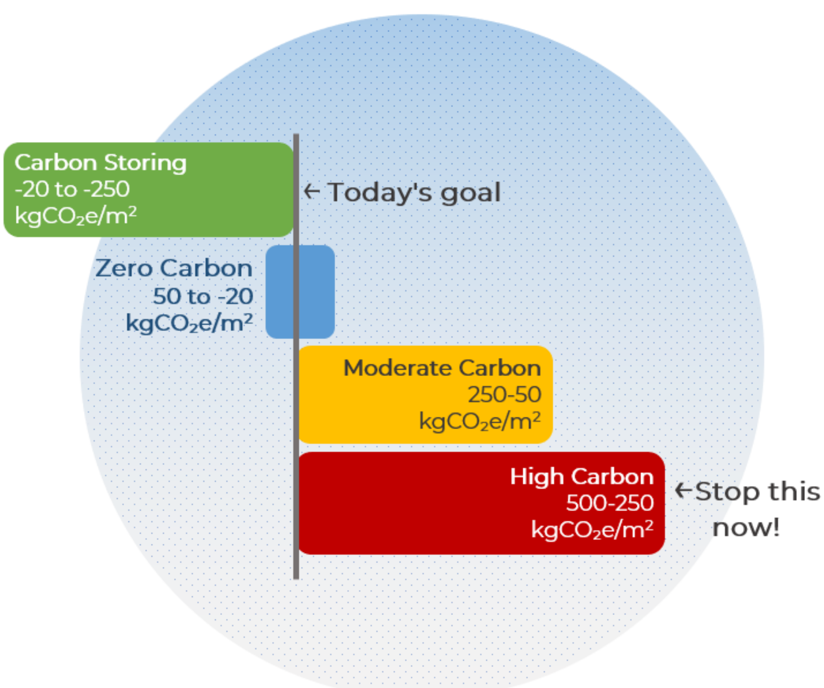


Figure 31. Adapted from a recent report exploring the impact of Upfront Embodied Carbon and its relation to energy efficiency (Builders for Climate Action, 2019).

6. CONCLUSION

Garden Suites are hoped to help ease Toronto's housing crisis by adding gentle density across the city's stable and amenity-rich Neighbourhoods. Garden Suites allow seniors to age in place with familial support nearby, provide young families with more affordable housing options, and provide more rental options in a city with historically low vacancy rates. Garden Suites are also implicated in the climate crisis. Carbon emissions from the built environment - particularly fuel sources - represent 55% of total emissions, half emanating from residential housing. When expanding housing options in Neighbourhoods, we have to consider the cost of expansion without sustainable measures for design and construction beyond what the Ontario Building Code SB-12 currently requires.

6.1. GARDEN SUITES + THE CLIMATE CRISIS

Our research findings suggest Garden Suites offer the opportunity to enact the meaningful change required to address Toronto's climate crisis - but only with coordinated action to implement the report's recommendations.

As indicated in the energy modelling results (page 43-46), energy-efficient Garden Suites play a significant role in either increasing or reducing carbon emissions city-wide. Between Step 1 OBC minimum base case and Step 4 Passive House Standard, there is a potential 91% reduction in Greenhouse Gas Intensity (GHGI). When applied to every future Garden Suite across Toronto, such a reduction is significant progress toward reducing carbon emissions. Step 3 Net Zero Ready has the potential for an 85% reduction from the base case with a lower capital cost increase. The GHGI decrease across the Energy Steps underscores the need for better building standards and the need to revise the current minimum standards if municipalities want to address the climate crisis.

Upfront embodied carbon (UEC) and the choice and sourcing of building materials are equally important to reduce carbon intensity. Choosing better and less carbon-heavy materials reduces and even sequesters the embodied carbon. If carbon reduction is the goal, Toronto must consider mandating energy and upfront carbon-efficient Garden Suites city-wide.

6.2. GARDEN SUITES + COST

Our cost estimate results suggest there is a cost premium to build no/low carbon Garden Suites. For instance, Energy Step 4's Passive House Standard carries an average cost premium of approximately $56,900, or 20%. Our projected operational cost calculations indicate it takes about 60 years to pay back the upfront increase in capital costs for Steps 3 and 4. If policy, regulation, and bylaw standards cannot be applied at the municipal level, targeted and meaningful incentive programs are required to encourage and promote building better across the city.

6.3. POLICIES + INCENTIVES

Presently, there is a policy, regulation, and incentive gap for buildings under four-storeys and less than five dwelling units at both the municipal and provincial government levels.

The most effective recommendations from this report are the Garden Suites Prescriptive Chart (refer to Appendix F) and a smaller low-rise green standard. However, both recommendations require provincial-level changes (i.e.., the Ontario Building Code and Supplementary Standard SB-12 are provincial legislation). Consequently, 'green' Garden Suites are not easily implemented at the municipal level, beyond the planning tools at its disposal for thick wall bonuses and maximum height exceptions.

Additionally, a potential incentive tied to provincial intervention is no longer available. Bill 108 and the development charge exemption for additional units further impede the ability to incentivize going green. Development charge deferral for sustainability is currently not an option. However, there are other incentivization pathways to consider, many already adopted by other Canadian cities. For example, Calgary's waived permit fees helps to offset the costs of no/low carbon design and construction. Vancouver's 'thick wall' density bonuses are also potential incentives for Toronto, with the added benefit of not having to trade off interior space for green design.

6.4. FOLLOW-UP RESEARCH

We identified a number of follow-up items for Garden Suites research. Items include (but are not limited to):

- Report back on incentives:
    - After the first 200 permits are issued, report back to Council on the success of any implemented incentive programs and address them.
- Adapt the sustainable policy landscape to lower-rise housing typologies:
    - Strategies to enact local change under higher forms of government
    - Strategies to provide federal and provincial government with the knowledge and tools required to help municipalities address sustainability
- Develop embodied carbon data for the Garden Suites:
    - Identify Upfront Embodied Carbon for each of the Energy Steps
- Take a deeper dive into energy sources and consumer costing:
    - Provide cost breakdowns and identify hidden costs
    - Look for suggestions to make green energy more accessible
- Rental income and the reduction in payback time:
    - Research into whether and how rental income would bring down the payback costs of building green
- Explore the possibility of a sunken 2-storey build:
    - Conforms to the 4m maximum height
    - Includes a livable basement
    - Explore the impact of the change on the energy modelling results
- Explore Garden Suite affordability:
    - Do two units help address affordability?
    - Analysis of the current Affordable Laneway Suites Program, any applicability to sustainability, and increasing the potential for uptake
    - Are two units possible?
- Blue, green and blue-green roof systems:
    - Cost to install and operate on a Garden Suite

    - Performance for small buildings

- Development of a ‘Green Kit’ for homeowners:
    - Offer homeowners upfront education and options for no/low carbon design and construction
    - Assess if the kit affects uptake of green design using an exit survey

- Explore incentive ideas:
    - Will insurance companies see any value in a more resilient home?
    - Push for a ‘green’ MLS (Multiple Listing Service) to be written into the by-law to increase the visibility and value of a green home

6.5. FINAL COMMENTS

We hope the findings from this report make a compelling case for no/low carbon Garden Suites and all low-rise residential typologies across the city, specifically all new housing under four-storeys and less than five dwelling units. Currently, there is a disconnect between green standards for medium- and high-rise buildings and low-rise buildings, such as Garden Suites.

At the crux of the issue are differences in planning and permitting processes. The Toronto Green Standard is implemented through City Planning’s site plan control process and does not apply to smaller residential buildings. The province administers the identified mechanisms for enforcement of a small building residential green standard (e.g., the permitting process and the Ontario Building Code) with little authority at the local level to change regulations.

Without the province granting powers to the City of Toronto allowing an exemption to the OBC, a provincial change to the OBC, or other creative legal solutions, there is no clear path to implementing a better-than-code standard for low-rise residential construction. Under this framework, keeping pace with municipal climate targets, or the climate crisis generally, is a challenge. An additional hurdle is the recent provincial changes to development charges, impeding the city’s ability to incentivize going green.

Despite these hurdles, it is paramount that we find a way to move forward with going green for the sake of the city’s future. The knowledge and technology are here; all that is left to do is change.

E N D

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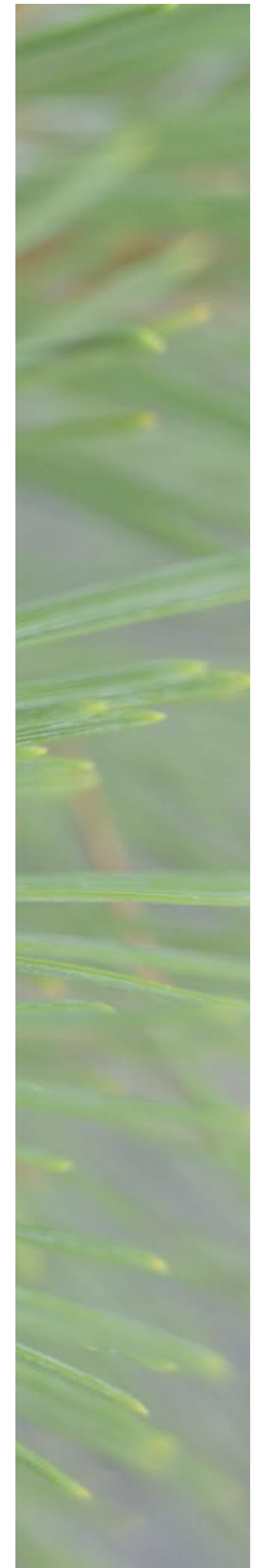


8. APPENDICES

APPENDIX A:

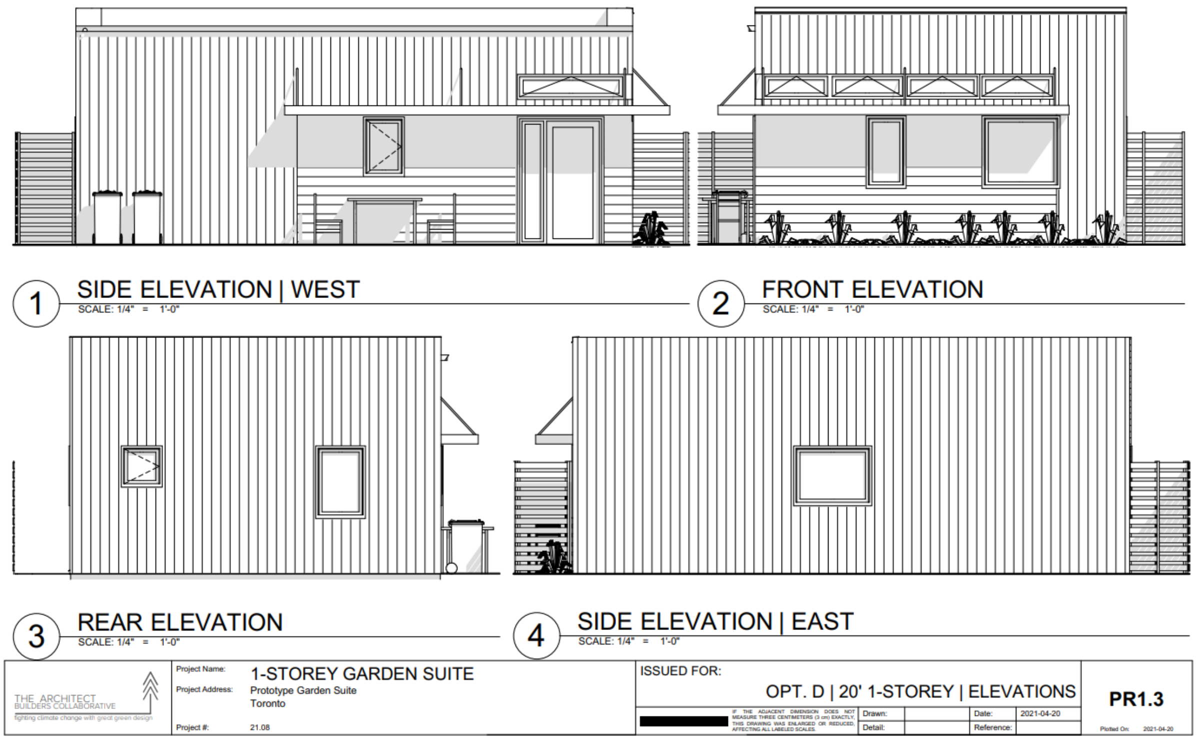
Jurisdictional zoning scan. p.8; p.32

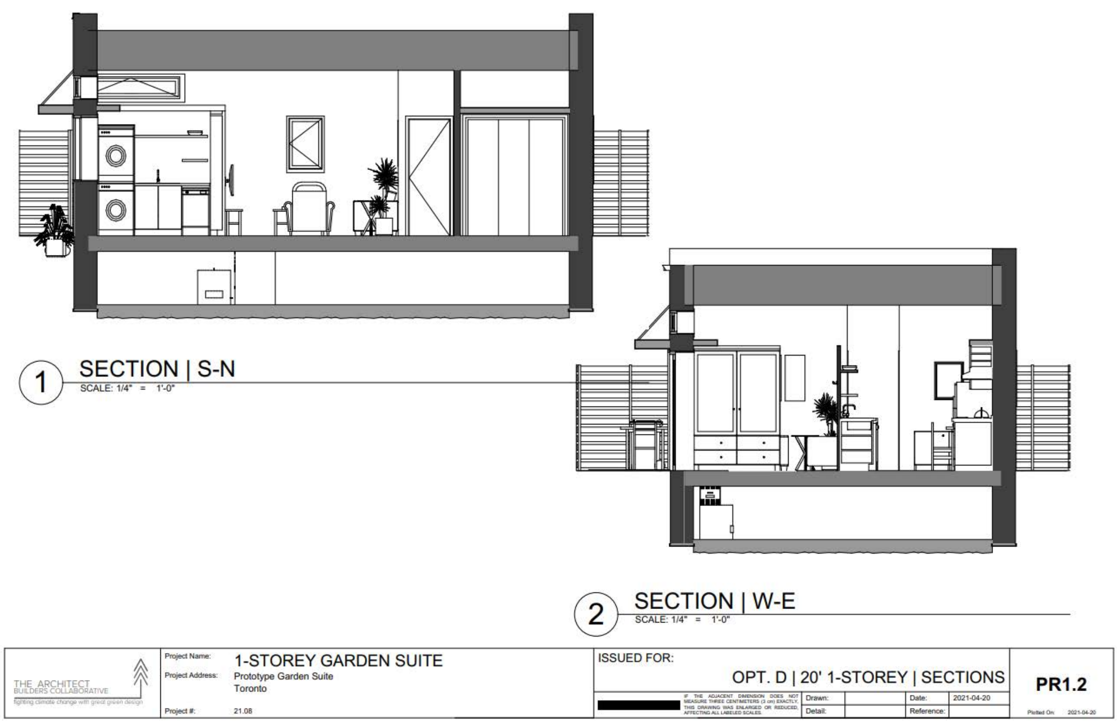
JURISDICTIONAL SCAN - GARDEN SUITE ZONING	SIDE	REAR	(m2)	MAX 2ND FLOOR AREA	LOT COVERAGE	MAX. HEIGHT	SECOND FLOOR ALLOWED	ADDITIONAL NOTES
VICTORIA	0.6M	0.6M	37m2		30-40% MAX, DEPENDING ON EXISTING ZONE REQUIREMENT	3.5M	UNSURE	
EDMONTON	REQ'D. SETBACK FOR ZONE	0.6M	130m2	50-60m2 DEPENDING ON ZONE	18% FOR GARDEN SUITE & OTHER ACCESSORY BUILDINGS, TOTAL SITE COVERAGE INCLUDING ACCESSORY AND PRINCIPAL DWELLING SHOULD NOT EXCEED THE TOTAL MAX. COVERAGE BY MORE THAN 2% OF SITE AREA	1. 6.5M WHERE ROOF SLOPE IS 4/12 OR GREATER 2. 6 .2M LESS THAN 4/12 SLOPE 3. NO LANE 4.3M MAX. RULES FOR PARAPETS	Y BUT W/CONDITIONS	
SASKATOON	0.75 BUT MIN 1.0M ON ONE SIDE	2M	CANNOT EXCEED 77m2 OR THE AREA OF THE PRINCIPAL DWELLING, WHATEVER IS LESS	GFA OF SECOND FLOOR SHALL NOT EXCEED 80% OF THE GFA OF THE FIRST STOREY	REAR YARD COVERAGE 50% MAX	5.8M INCREASED TO 6.2M TO MEAN HT BETWEEN EAVES AND RIDGE ON BUILDINGS WITH GABLE, HIP, GAMBREL ROOF	Y BUT W/CONDITIONS	
OTTAWA	REAR & INTERIOR SIDE LOT LINE: URBAN AREA: 1M MAXIMUM **OR** URBAN & RURAL AREA: 4M MINIMUM	REAR & INTERIOR SIDE LOT LINE: URBAN AREA: 1M MAXIMUM **OR** URBAN & RURAL AREA: 4M MINIMUM			**URBAN AREA:** 1. CANNOT EXCEED 80M2 FOOTPRINT IN THE URBAN AREA 2. NOT BE GREATER IN SIZE THAN 40% OF THE FOOTPRINT OF THE PRINCIPAL DWELLING UNIT 3. EXCEED A LOT COVERAGE OF 40% OF THE YARD IT IS LOCATED	**URBAN AREA:** 1.MAX. HT. NOT TO EXCEED BLDG HT. OF EXIST. PRIMARY DWELLING 3.6M, MAX. HT. BUT FLAT ROOF NOT TO EXCEED 3.2M 3. NOT PERMITTED TO HAVE SHED STYLE ROOF IN THE URBAN AREA	**Urban 2-Storey Coach Houses OP Policy 3.1:** An application to allow the height of up to a two storey coach house in the urban area through a minor variance may be considered where the conditions for minor variances have been considered and the coach house is proposed to contain a garage on the main level.	**NOTE:** Where windows are desired, the Zoning By-law performance standard requires a coach house to be 4 metres from a rear and interior side lot line.
GUELPH	CONTACT FOR MORE INFO/SITE SPECIFIC	CONTACT FOR MORE INFO/SITE SPECIFIC	80m2 OR 45% OF GFA OF MAIN BUILDING		30% INCLUDING ADDITIONAL ACCESSORY BUILDINGS ON LOT	5M, 6.1M WITH GARAGE BELOW, CANNOT EXCEED OVERALL HEIGHT OF MAIN DWELLING	UNSURE	**NOTE:** Not allowed in houses with more than 2 units (triplex, four-plex etc.). Additional min. 1 parking required per dwelling unit; 1 off street min 3m X 6m; exterior min 2.5m X 5.5m. Not allowed in R.3A zones (Cluster townhouses).
TORONTO LANEWAY SUITE	1. 0.0M IF SIDE LOT LINE DOES NOT ABUT A STREET OR LANE & NO OPENINGS (DOORS, WINDOWS) 2. REQ'D MIN. SIDE YARD SETBACK FOR RESIDENTIAL DWELLING IF ABUTTING STREET 3. IN ALL OTHER CASES, 1.5M	0.0M IF REAR LOT LINE DOES NOT ABUT STREET OR LANE AND THERE ARE NO OPENINGS (DOORS, WINDOWS) IN ALL OTHER CASES 1.5M	MUST BE LESS THAN THE GFA OF THE RESIDENTIAL BUILDING ON THE LOT		MAY NOT EXCEED 30% OF THE LOT AREA	4M OR 6M DEPENDING ON DISTANCE FROM RESIDENTIAL BUILDING	Y	

APPENDIX B:

1-storey garden suite drawings + renderings p.33

Elevations + sections by TABC



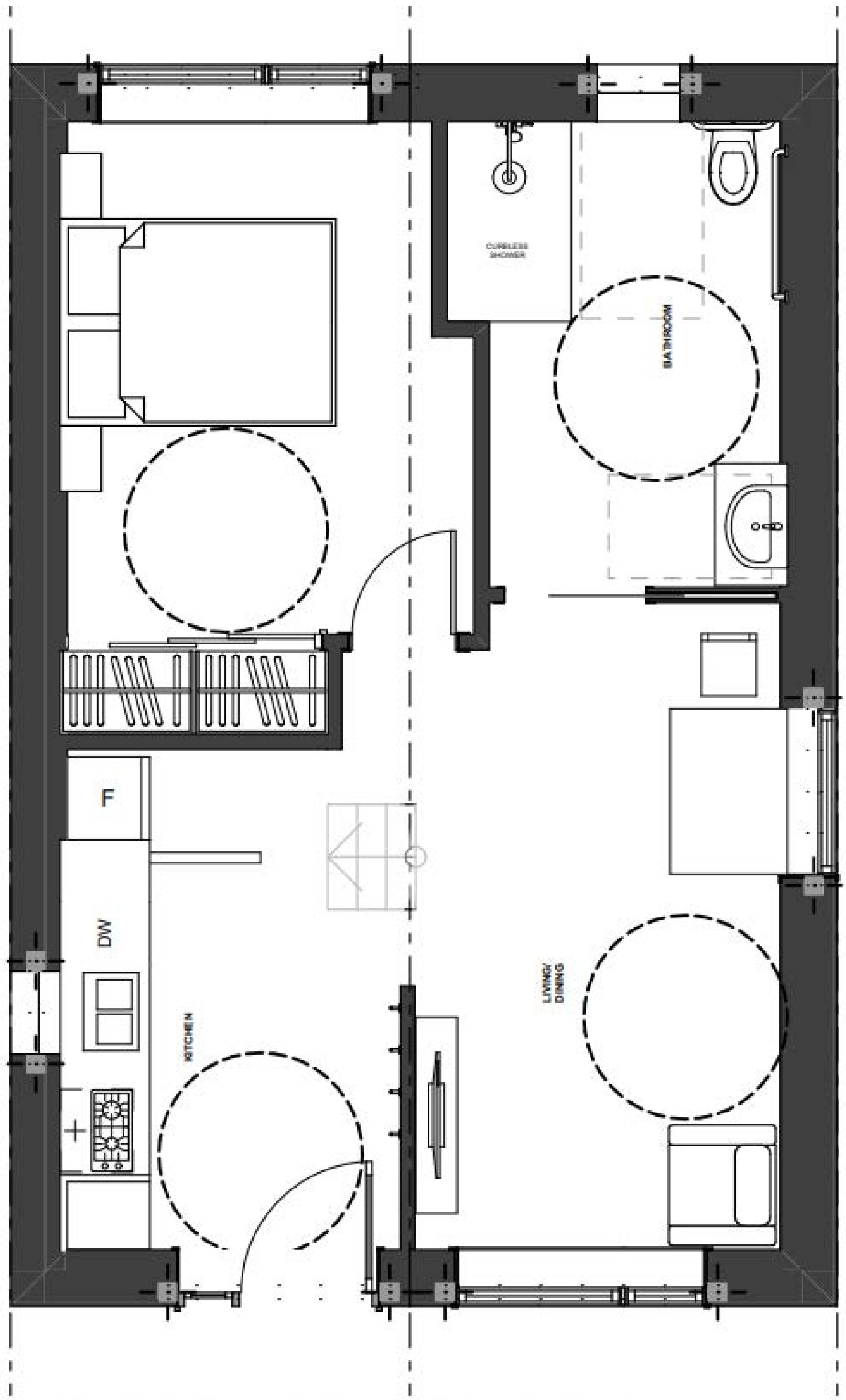


Concepts by TABC

Rendering by Richa Narvekar, B. Arch, M. Arch

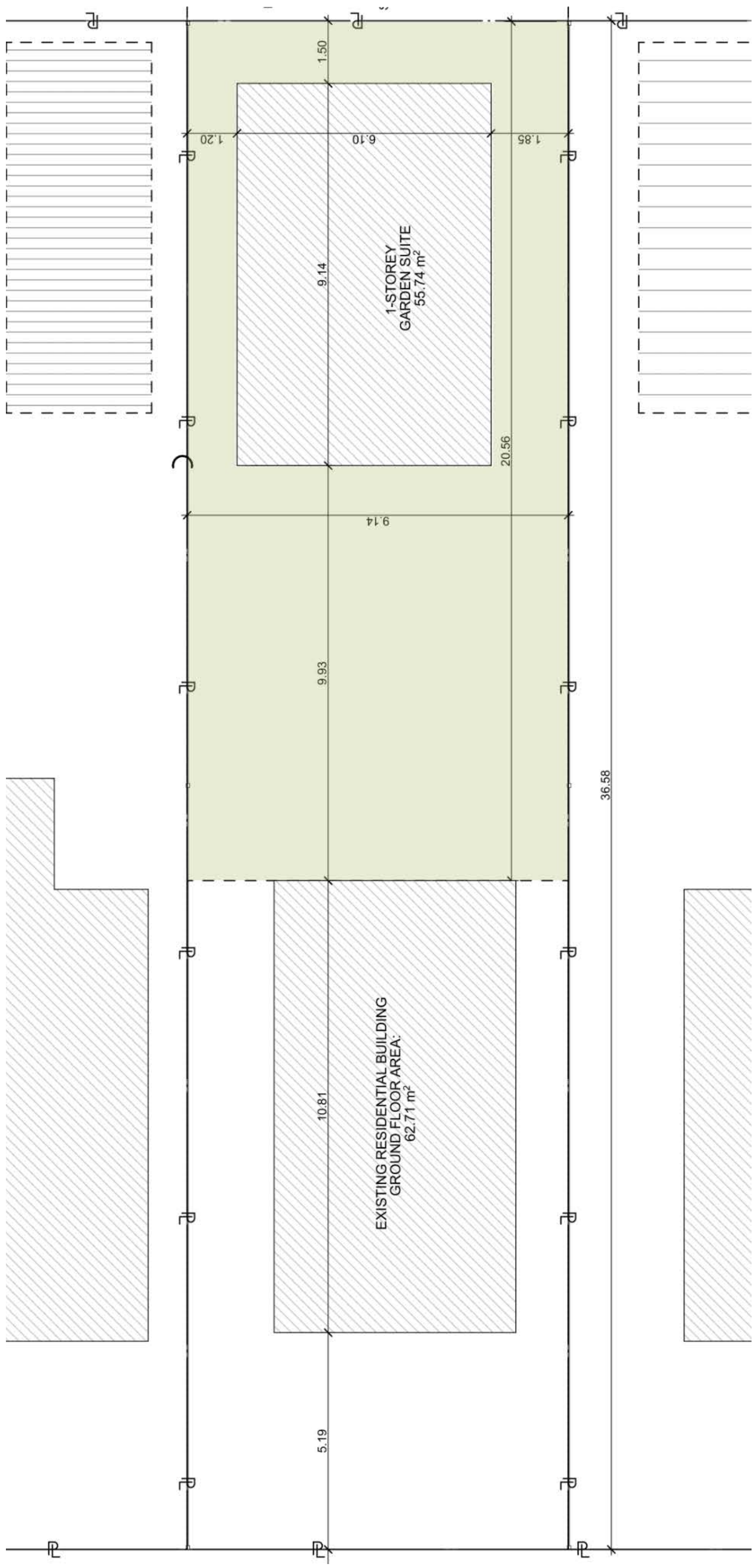
Renderings by TABC

Accessible plan option by TABC



1 ACCESSIBILITY | PLAN
SCALE: 1/4" = 1'-0"

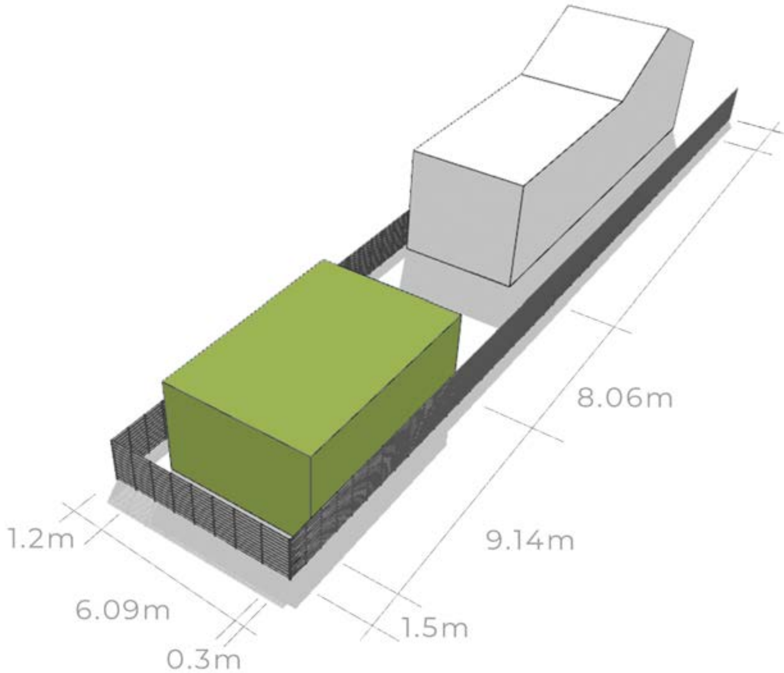
<u>APPENDIX C:</u> Setbacks p.35

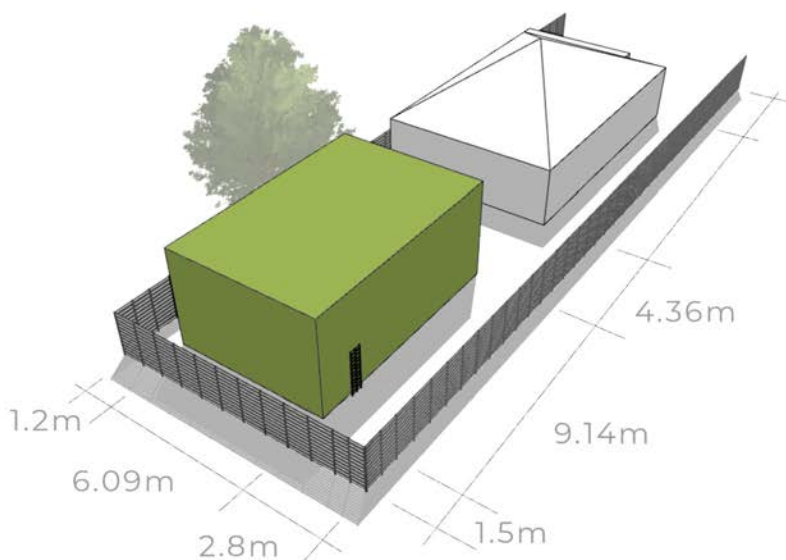


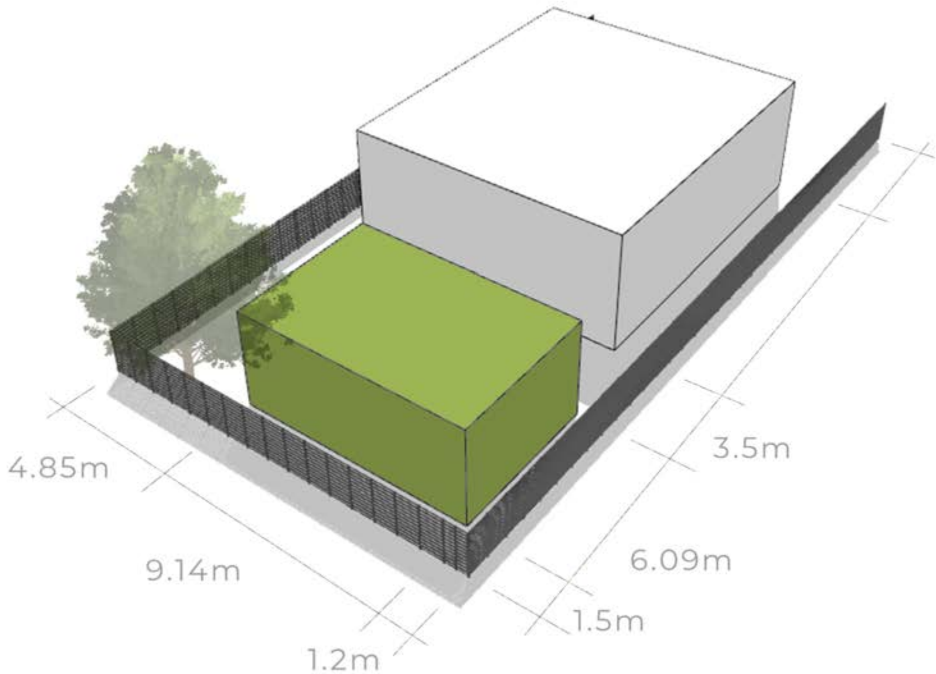
<u>APPENDIX D:</u> Lot coverage, maximum area + soft landscaping chart p.35

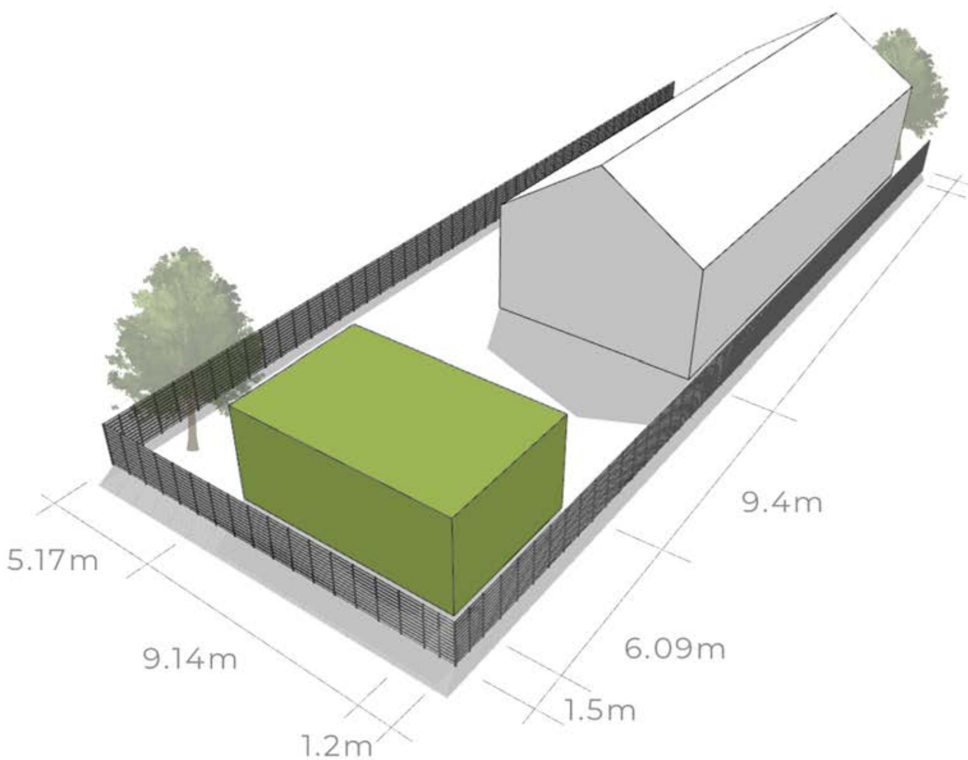
	Existing	Bylaw	Proposed	Notes
PROJECT DETAILS				
Project Address:	Bristol Ave., Toronto			
Legal Description:				
Ward:	Ward 9 Davenport			
Applicable Law:	City of Toronto Zoning By-law 569-2013			
Zoning:	R (d0.6) (x739)			
PROJECT DESCRIPTION				
Existing:	2 Storey Detached Dwelling			Permitted building type
Proposed:	Build new Garden Suite in rear yard			
LOT DETAILS	**Existing**	**Bylaw**	**Proposed**	**Notes**
Use:	Residential		Residential	
Area [m2]:	335.02		335.02	UNCHANGED
Lot Width [m]:	9.14		9.14	UNCHANGED
Frontage [m]:	9.14		9.14	UNCHANGED
Lot Depth [m]	36.58		36.58	UNCHANGED
Parking spaces:	1			
MAIN BUILDING	**Existing**	**Bylaw**	**Proposed**	
GROSS FLOOR AREAS [m²]				**Notes** **See calculations for GFA & exclusions**
Third Floor:				
Second Floor:	62.71			
Ground Floor:	62.71			
Crawlspace	62.71			
Total:	**125.42**		**0.00**	
FSI	**0.37**	**0.00**	**0.00**	
DIMENSIONS				
Building Depth:	10.81	17.00	UNCHANGED	
Building Height:		12.00	UNCHANGED	
SETBACKS				
Front Yard	5.19	Min 6.00	UNCHANGED	
Rear Yard	20.56	Min 7.50	UNCHANGED	
Side Yard [S]	1.30	0.90	UNCHANGED	
Side Yard [N]	2.10	0.90	UNCHANGED	
Rear Yard Area	**188.13**			
GARDEN SUITE				
DIMENSIONS	Existing	Bylaw	Proposed	Notes
Length:			9.14	
Width:			6.10	
Height:		4.0m max.	4.00	10.5.60.40 (2) assumed zoning
Storeys:			1	
SETBACKS & SEPARATION DISTANCE	**Existing**	**Bylaw**	**Proposed**	**Notes**
Rear Yard:		0.30	1.5	10.5.60.20 (2)(C) assumed by-law
Side Yard North:		0.30	1.2	10.5.60.20 (3)(C) assumed by-law
Side Yard South:		0.30	1.9	10.5.60.20 (3)(C) assumed by-law
Separation from House:		Min 7.50	10.2	assumed from laneway by-law
COVERAGES				
Building Footprint [m²]:			55.7	
Lot Coverage (%):		10% max	17%	7% over per 10.5.60.70 (1)(B) assumed by-law
Rear Yard Coverage (%):			30%	
SOFT LANDSCAPING				
Rear Yard Soft Landscaping [m2]:	**188.13**		**132.39**	10.5.50.10 (3) residential buildings other than an apartment building
Rear Yard Soft Landscaping (%):		50% required	**70%**	min. 50% rear yard soft landscaping required for lot frontages > 6.0m
MAXIMUM FLOOR AREAS [m²]		Max 40m2	55.74	15 m2 over per 10.5.60.50 (2)(B) assumed by-law

<u>APPENDIX E:</u> Example lot sizes with the Garden Suite p.36






4.85m
9.14m
1.2m
1.5m
6.09m
3.5m

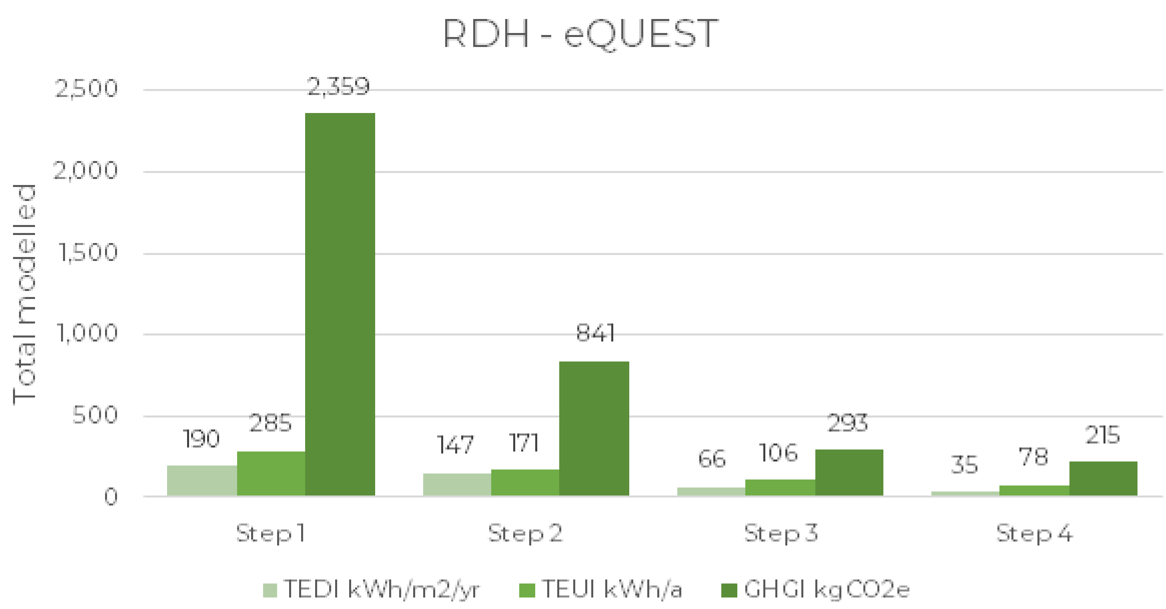

5.17m
9.14m
1.2m
1.5m
6.09m
9.4m

APPENDIX F: Final prescriptive chart with nominal and effective thermal values p.36; p.63

Garden Suite Energy Step Scenarios (based on OBC SB-12)					**But not TEDI (SHD) require
		STEP 1	STEP 2	STEP 3	STEP 4
Component	Thermal Values	OBC Min. (base case, Zone 1, 3.1.1.2.A)	TGS Tier 1 (Energy Star, 20% above code)	TGS Tier 3 (CBHA NZr, up to 80% above code)	TGS Tier 4, (Passive House Standard) from Russell
Ceiling w/out Attic Space	Min. Nominal R	31	44	65	85
	Clearfield	**26.35**	**37.4**	**55.25**	**72.25**
Walls above grade	Min. Nominal R	22	30	47	58
	Clearfield	**18.7**	**25.5**	**39.95**	**49.3**
Basement Walls	Min. Nominal R	20	28	47	58
	Clearfield	**17**	**23.8**	**39.95**	**49.3**
Below grade slab (>600 mm below grade)	Min. Nominal R	—	15	30	30
	Clearfield	-	12.75	25.5	25.5
Heated slab or slab (≤600 mm below grade)	Min. Nominal R	10	15	30	30
Edge of below grade slab (≤600 mm below grade)	Min. Nominal R	10	15	35	30
Windows - Fixed	Max. U	0.28 Btu/(h•ft²•F)	0.21 Btu/(h•ft²•F)	0.12 Btu/(h•ft²•F)	0.12 Btu/(h•ft²•F)
Windows - Operable		0.28 Btu/(h•ft²•F)	0.21 Btu/(h•ft²•F)	0.14 Btu/(h•ft²•F)	0.14 Btu/(h•ft²•F)
SHGC		0.35	0.35	0.35	0.4
Doors		0.28 Btu/(h•ft²•F)	0.21 Btu/(h•ft²•F)	0.14 Btu/(h•ft²•F)	0.14 Btu/(h•ft²•F)
Space Heating Equipment	Min. AFUE	96% gas furnace	Hybrid system: 96% AFUE ENERGY STAR gas furnace, w/ ASHP (HPSF 8.2) Operation: Furnace <-5C ASHP >-5C	Mini-split ASHP, 7.1 HPSF, SEER 14	Mini-split ASHP, 7.1 HPSF, SEER 14
Heating Airflow	cfm	550.00	400.00	included in COPs	
Fan Power	W/cfm	0.30	0.30	included in COPs	
Space Cooling Equipment		EER 11 Window Shaker	SEER 14? 2 stage compressor (not AS crappy)	Mini-split ASHP, 7.1 HPSF, SEER 14	Mini-split ASHP, 7.1 HPSF, SEER 14
HRV Efficiency	Min. SRE	75%	75%***	89%*	93%
HRV Outdoor Air	cfm	low speed = 50 High speed = 100	low speed = 50 High speed = 100	low speed = 50 High speed = 100	low speed = 50 High speed = 100
HRV fan power	W/cfm	1.10	1.10	0.60	0.60
Domestic Water Heater (min. efficiency)	Min. EF	Gas: 0.8	Gas: 0.80 Electric: 0.93	Electric 0.93	Residential DHW-HP COP 2.5
Window to Wall Ratio		17%	20% max	20% max	25% max
Air Tightness	ACH @ 50Pa	3.0 ACH @50pa*	2.5 ACH @50pa;	1.0 ACH @50pa*	0.6 ACH @50pa
Solar Capacity****		x	x	Y	Y
Lighting (% LED vs CFL)**		50	75	100	100
Lighting power density	w/ft2	suite = .46 crawlspace= 0.14	suite = .38 crawlspace= 0.12	suite = .28 crawlspace= 0.1	suite = .28 crawlspace= 0.1
Operating Timeframe	Years	20	20	20	20

APPENDIX G: Individual Energy Modelling results p.38; p.39; p.43

RDH



			2021	2022	2023	2024	2025	2026	2031	2036	2041		
RDH electricity			1 year					5 years	10 years	15 years	20 years		
	step1: x12 of below		$760.80	$760.80	$760.80	$760.80	$760.80	$760.80	$760.80	$760.80	$760.80		
	proj. month	$63.40	$63.40	$63.40	$63.40	$63.40	$63.40	$63.40	$63.40	$63.40	$63.40		
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20		
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20		
	step2 x12 of below		$1,327.56	$1,327.56	$1,327.56	$1,327.56	$1,327.56	$1,327.56	$1,327.56	$1,327.56	$1,327.56		
	Proj. month	$110.63	$110.63	$110.63	$110.63	$110.63	$110.63	$110.63	$110.63	$110.63	$110.63		
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20		
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20		
Elec cost kWh/yr divided by 12 months as per **RDH** numbers to predict projected monthly cost as with Toronto Hydro numbers above	**step3** x12 of below		$1.173.60	$1.173.60	$1.173.60	$1.173.60	$1.173.60	$1.173.60	$1.173.60	$1.173.60	$1.173.60	Predictions in 5-year chuncks	
	proj month	$97.80	$97.80	$97.80	$97.80	$97.80	$97.80	$97.80	$97.80	$97.80	$97.80	proj. month	$0.00
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	proj cost cumul	$429.48
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20	total plus increment	$1.00
	step4: x12 of below		$861.00	$861.00	$861.00	$861.00	$861.00	$861.00	$861.00	$861.00	$861.00		
	proj. month	$71.75	$71.75	$71.75	$71.75	$71.75	$71.75	$71.75	$71.75	$71.75	$71.75		
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20		
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20		
	Average projected monthly of all 4	$85.90	$85.90	$85.90	$85.90	$85.90	$85.90	$85.90	$85.90	$85.90	$85.90		
	Average projected cumulative of all 4	$85.90	$171.79	$257.69	$343.58	$429.48	$515.37	$601.27	$1,030.74	$1,460.22	$1,889.69		

RDH - Predicted electricity cost 1 year and over time

	Electricity (kWh/Year)	2021 Cost kWh/Year	2026 - 5 years	2031 - 10 years	2036 - 15 years	2041 - 20 years
Step 1	3804	$760.80	$760.80	$760.80	$760.80	$760.80
Step 2	6638	$1,327.56	$1,327.56	$1,327.56	$1,327.56	$1,327.56
Step 3	5868	$1,173.60	$1,173.60	$1,173.60	$1,173.60	$1,173.60
Step 4	4305	$861.00	$861.00	$861.00	$861.00	$861.00

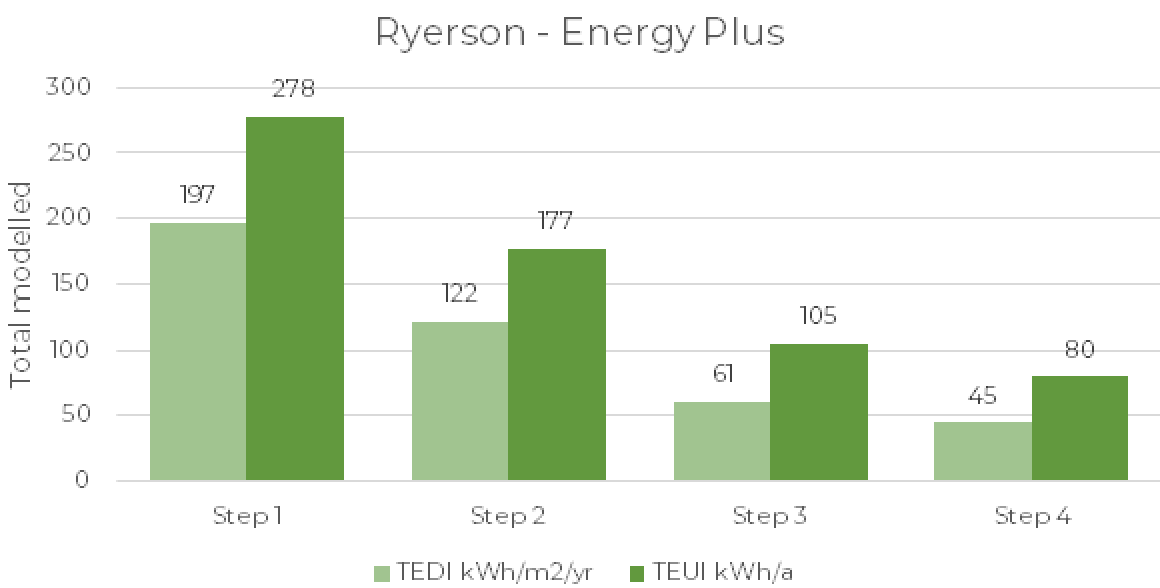
RDH - Predicted gas cost 1 year and over time

	Natural Gas kWh/ Year	Natural Gas m3/ year	Cost m3/ year just Gas	2021	2026	2031	2036	2041
Step 1	11954	1150	$367.22	$629.17	$776.87	$935.11	$1,061.70	$1,061.70
Step2	2813	266.466	$85.09	$348.37	$383.13	$420.36	$450.15	$450.15

RDH - Predicted total gas + electric cost over time.

	2021	2026	2031	2036	2041
Step 1	$1,389.97	$1,537.67	$1,695.91	$1,822.50	$1,822.50
Step 2	$1,675.93	$1,710.69	$1,747.92	$1,777.71	$1,777.71
Step 3	$1,173.60	$1,173.60	$1,173.60	$1,173.60	$1,173.60
Step 4	$861.00	$861.00	$861.00	$861.00	$861.00

Ryerson University



			2021	2022	2023	2024	2025	2026	2031	2036	2041
Ryerson electricity			1 year					5 years	10 years	15 years	20 years
	step1: x12 of below		$1,058.80	$1,058.80	$1,058.80	$1,058.80	$1,058.80	$1,058.80	$1,058.80	$1,058.80	$1,058.80
	proj. month		$88.23	$88.23	$88.23	$88.23	$88.23	$88.23	$88.23	$88.23	$88.23
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20
	step2: x12 of below		$1,213.40	$1,213.40	$1,213.40	$1,213.40	$1,213.40	$1,213.40	$1,213.40	$1,213.40	$1,213.40
	Proj. month		$101.12	$101.12	$101.12	$101.12	$101.12	$101.12	$101.12	$101.12	$101.12
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20
Elec cost kWh/yr divided by 12 months as per **Ryerson** numbers to predict projected monthly cost as with Toronto Hydro numbers above	**step3 x12 of below**		$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00
	proj month		$96.67	$96.67	$96.67	$96.67	$96.67	$96.67	$96.67	$96.67	$96.67
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20
	step4: x12 of below		$888.40	$888.40	$888.40	$888.40	$888.40	$888.40	$888.40	$888.40	$888.40
	proj. month		$74.03	$74.03	$74.03	$74.03	$74.03	$74.03	$74.03	$74.03	$74.03
	proj. cost kWh	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20	$0.20
	total plus increment:		$0.20	$0.40	$0.60	$0.80	$1.00	$1.20	$2.20	$3.20	$4.20
	Average projected monthly 1 2 3 4		$90.01	$90.01	$90.01	$90.01	$90.01	$90.01	$90.01	$90.01	$90.01
	Average projected cumulat 1 2 3 4		$90.01	$180.03	$270.04	$360.05	$450.06	$540.08	$904.79	$994.80	$1,084.81

Ryerson - Predicted electricity cost 1 year and over time

	Electricity (kWh/ Year)	2021 Cost kWh/ Year	2026 - 5 years	2031 10 years	2036 15 years	2041 20 years
Step 1	5294	$1,058.80	$1,058.80	$1,058.80	$1,058.80	$1,058.80
Step 2	6067	$1,213.40	$1,213.40	$1,213.40	$1,213.40	$1,213.40
Step 3	5800	$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00
Step 4	4442	$888.40	$888.40	$888.40	$888.40	$888.40

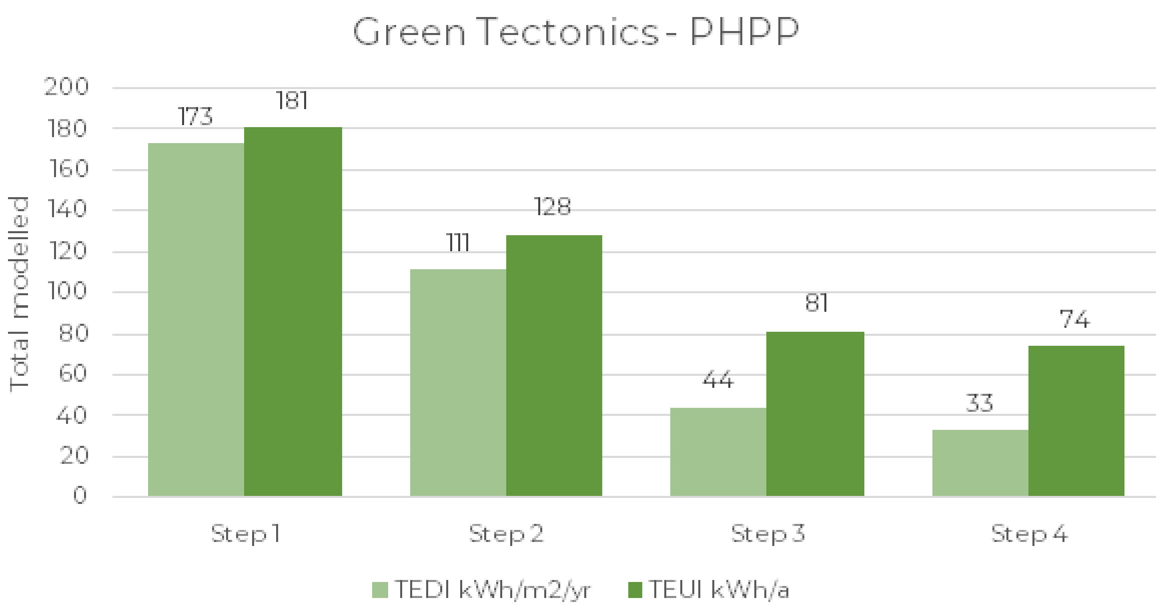
Ryerson - Predicted gas cost 1 year and over time

	Natural Gas kWh/ Year	Natural Gas m3/ year	Cost m3/ year just Gas	2021	2026	2031	2036	2041
Step 1	10069	954.41	$304.76	$571.27	$695.67	$828.96	$935.59	$935.59
Step 2	3725	353.08	$112.75	$376.39	$422.41	$471.72	$511.17	$511.17

Ryerson - Predicted total gas + electric cost over time

	2021	2026	2031	2036	2041
Step 1	$1,630.07	$1,754.47	$1,887.76	$1,994.39	$1,994.39
Step 2	$1,589.79	$1,635.81	$1,685.12	$1,724.57	$1,724.57
Step 3	$1,160.00	$1,160.00	$1,160.00	$1,160.00	$1,160.00
Step 4	$888.40	$888.40	$888.40	$888.40	$888.40

Green Tectonics



<u>APPENDIX H:</u> Scope of Work for costing p.10; p.41

MF DIVISIO	ITEM NAME/DESCRIPTION	STEP 1	STEP 2	STEP 3	STEP 4
2	**Existing Conditions**				
	Site fencing & hoarding	x	x	x	x
	Tree protection	x	x	x	x
	Excavation & trenching	x	x	x	x
3	**Concrete**				
	20" x 8" strip footings	x	x		
	8" poured foundation walls	x	x		
	3" crawlspace slab	x	x	x	x
4	**Masonry**				
	N/A				
5	**Metals**				
	N/A?				
6	**Wood and Plastics**				
	WOOD				
	*FSC certified wood products			x	x
	*Formaldehyde free			x	x
	*Locally sourced if possible			x	x
	FRAMING: (refer to drawings)	x	x	x	x
	Beams (built-up, LVL typ.)	x	x	x	x
	Floor joists (nominal lumber, TJI typ.)	x	x	x	x
	Exterior walls	x	x	x	x
	Interior walls	x	x	x	x
	OSB & plywood	x	x	x	x
	Finished flooring	x	x	x	x
	Preserved wood (foundation)			x	x
	MILLWORK				
	Cabinets	x	x	x	x
	Countertops	x	x	x	x
	Interior casework	x	x	x	x
	BASEBOARDS, CASINGS, TRIMS				
	Solid paint grade wood	x	x	x	x
	PLASTICS				
	*No vinyl, PVC anywhere, as practical			x	x
	*Low VOC			x	x
	*Formaldehyde free			x	x
7	**Thermal & Moisture Protection**				
	EXTERIOR CLADDING				
	Vinyl siding & trim				
	Cement board panels (e.g., Hardie)	x			
	Wood siding (e.g., Accoya)		x	x	x
	EPDM roofing		x	x	x
		x			
	REFER TO DRAWINGS FOR ASSEMBLY DETAILS				
	AIR/ VAPOUR BARRIER				
	Tyvek (or similar)	x			
	Polyetheleme vapour barrier	x	x		
	Smart vapour barrier (e.g., Certainteed)		x	x	x
	Smart air vapour barrier			x	x
	INSULATION				
	Batt, fibreglass	x			
	Mineral wool, blown		x	x	x
	Stone wool, batt		x	x	x
	Stone wool, rigid (Stone Board in drawings)		x	x	x
	Stone wool, semi-rigid		x	x	x
	XPS, rigid	x			
	Spray foam, closed cell	x			

8	**Doors & Windows**				
	DOORS - Exterior				
	Fibreglass	x	x	x	x
	Insulated		x	x	x
	DOORS - Interior				
	High density fibreboard	x			
	Wood		x	x	x
	Hollow core	x			
	Solid core		x	x	x
	WINDOWS				
	Double glazed	x	x		
	Triple glazed			x	x
	EnergyStar certification		x		
	Warm-edge spacers req'd		x	x	x
9	**Finishes**				
	FLOORING				
	Tile, porcelain	x	x	x	x
	Wood	x	x	x	x
	Wood, engineered	x	x	x	x
	Laminate	x			
	WALLS				
	Tile, porcelain @ shower walls, bathroom half-walls, kitchen backsplash	x	x	x	x
	Drywall, painted	x	x	x	x
	CEILINGS				
	Drywall, painted	x	x	x	x
11	**Equipment & Appliances**				
	24" stacking washer & dryer	x	x	x	x
	30" induction range	x	x	x	x
	36" fridge	x	x	x	x
	24" dishwasher	x	x	x	x
22	**Plumbing & Drains**				
	Supply line from main house	x	x	x	x
	New drains as required	x	x	x	x
	Sump pump & perimeter foundation drainage	x	x	x	x
23	**HVAC**	x	x		
	gas furnace	x	x		
	air conditioner	x	x	x	x
	HRV/ERV		x	x	x
	Air Source Heat Pump				
26	**Electrical**				
	new 200A service from new meter	x	x	x	x
	Load panel	x	x	x	x
	Lighting (LED) throughout	x	x	x	x
	Liteline	x	x	x	x
	Exterior security lighting	x	x	x	x
	Occupancy sensors	x	x	x	x
28	**Security & Life Safety**				
	Interconnected smoke detectors	x	x	x	x
32	**Landscape & Exterior Works**				
	Soft and hard landscape in rear yard	x	x	x	x
33	**Utilities**				
	Existing services entry points to remain on main house	x	x	x	x
	All utilities connected to services in basement of main house	x	x	x	x
	Cash Allowances				
CA-1	Plumbing fixtures & Washroom Accessories				
CA-2	Lighting Fixtures				
CA-3	Kitchen Cabinets & Counters				

<u>APPENDIX I:</u> Heat loss calculations p.42

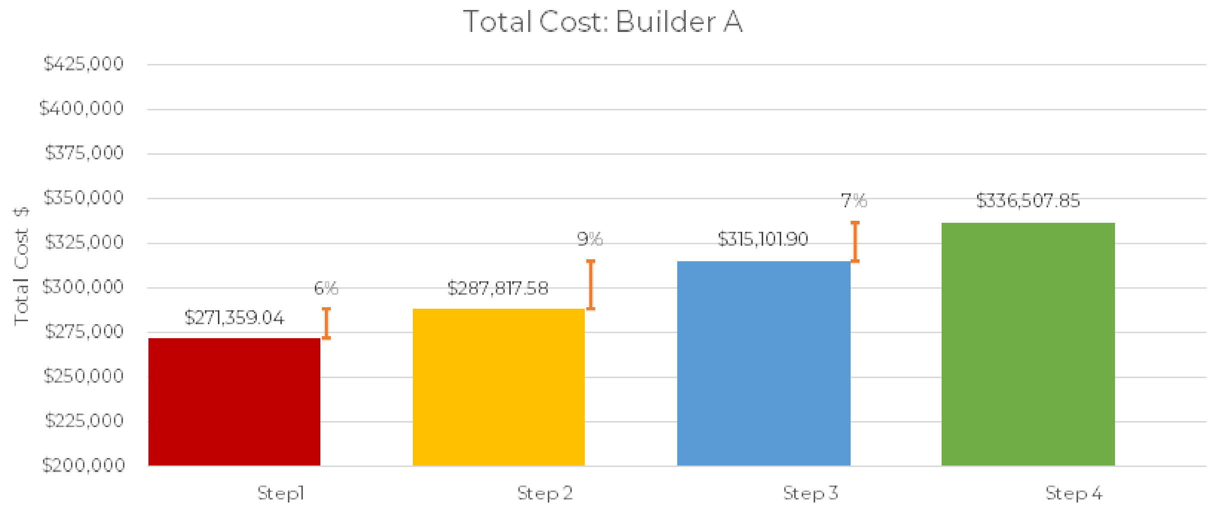
Model Name	Extra Info	ft^2	Heat Loss (Btu/hr)	Cooling Tons
1-STOREY GARDEN	STEP 1	602	12967	0.80
1-STOREY GARDEN	STEP 2	602	9950	0.76
1-STOREY GARDEN	STEP 3	602	6201	0.66
1-STOREY GARDEN	STEP 4	602	5210	0.67
2-STOREY GARDEN	STEP 1	1204	21097	1.18
2-STOREY GARDEN	STEP 2	1204	15776	1.10
2-STOREY GARDEN	STEP 3	1204	9649	1.00
2-STOREY GARDEN	STEP 4	1204	8018	0.98

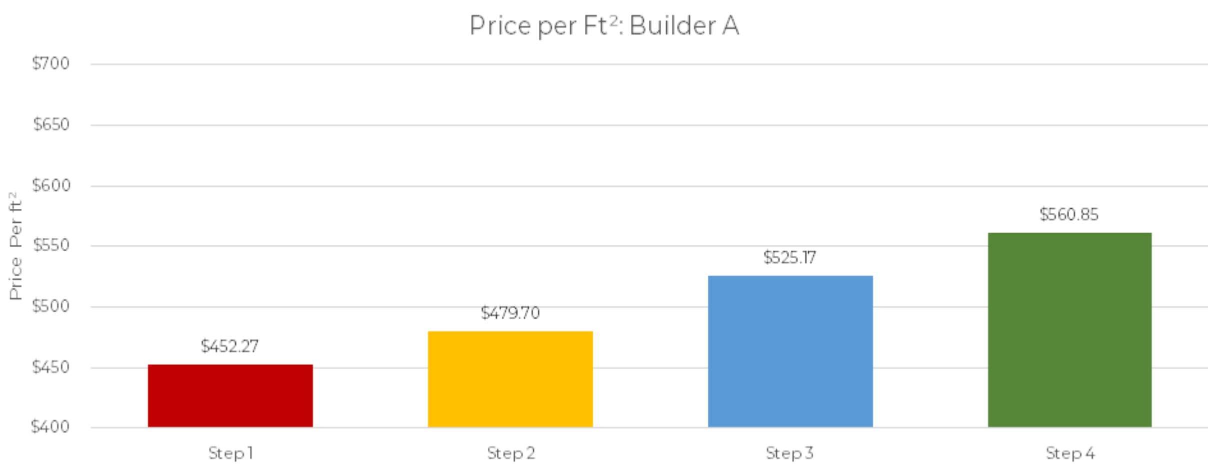
Heat loss calculations provided by HVAC Designs Inc.

APPENDIX J: **Individual builder costing p.52**

Builder A

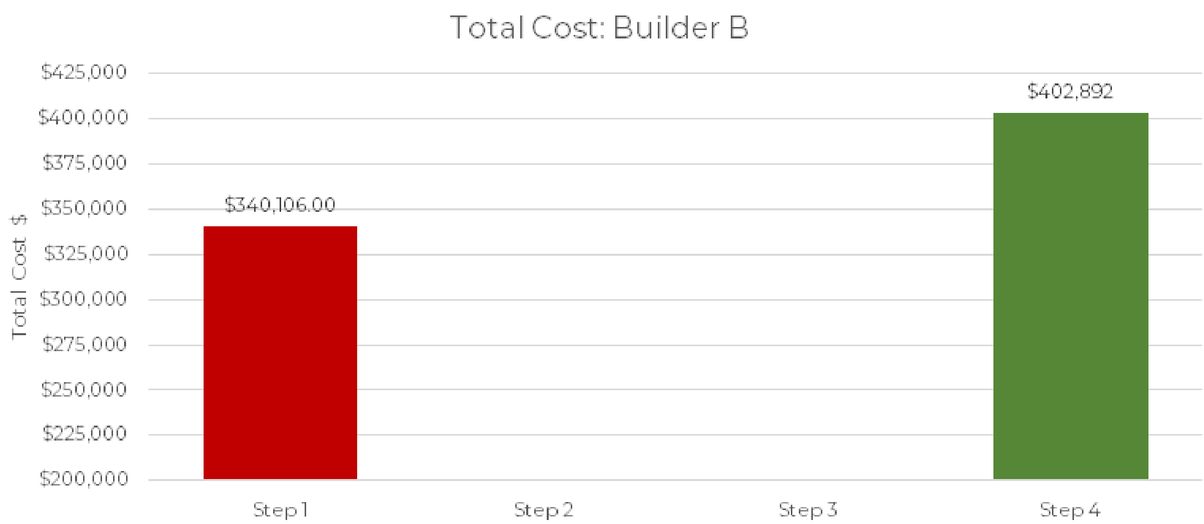
Builder A provided the cost for each Energy Step. From the estimates, we can see the incremental increase in cost from Step to Step in total cost and the total price per square foot for a more efficient building. On average, the total cost increase per step is around 7%.





BUILDER B

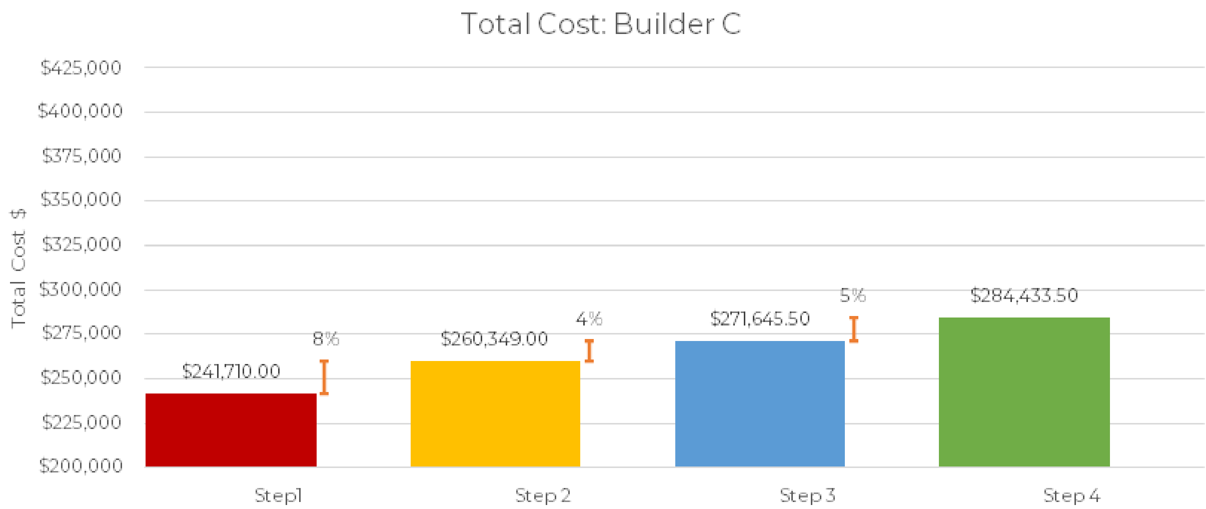
Builder B only provided the cost for Energy Steps 1 and 4. Builder B's estimated costs are the highest of all three builders, represented by the total cost and price per square ft.

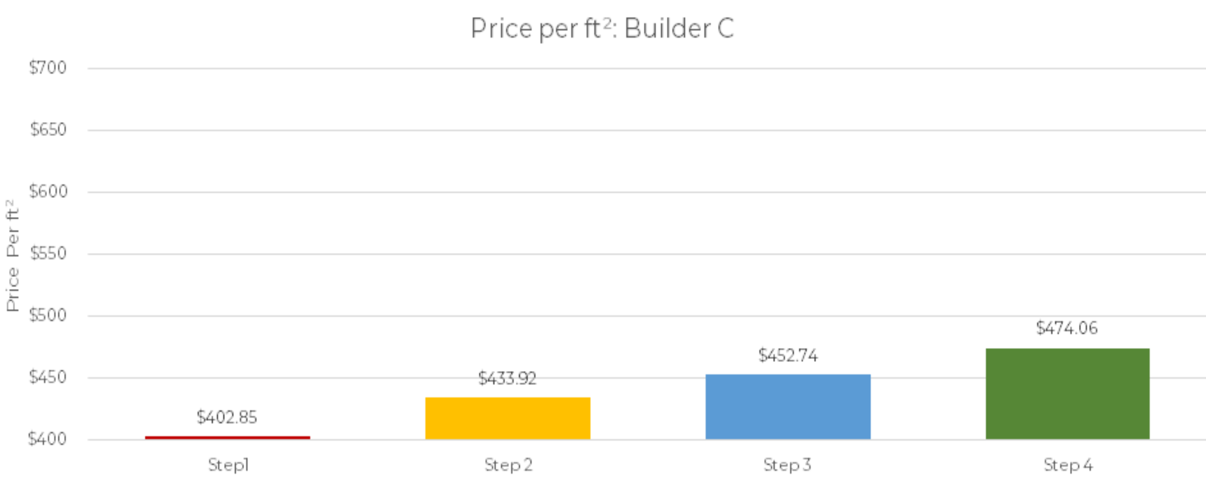


Note: Builder Class C Estimate of Energy Step 1 might be overestimated due to grade and quality of work. The estimate substituted the assemblies only, and assumed ordinary expectations of grade and quality of work

BUILDER C

Builder C provided the cost per each Energy Step. Again, there is an incremental change in cost from Step 1 to 4, of about 6% per step. Overall, the costs are much lower compared to that of builders' A and B.





APPENDIX K: Mitsubishi Canada ASHP p.57

Garden Suite Mitsubishi System selections

Standard systems provide cooling and heating down to -15C. They require suplimentary heat to satisfy winter design temp

Cold Climate systems will provide cooling and heating down to -25C and therefore would not require electric resistance back up.

Bdg Type	Bdg std	Area	H/L	H/G		Standard	Budget	Required Elec heater	Budget		Cold Climate	Budget
		Sqft	BTU/hr	BTU/hr								
1- Storey Garden	STEP 1	602	12,967	10,374		SEZ/SUZ-KA18NAH2	$3,300	5kW	$550		SEZ/SUZ-KA18NAHZ	$3,700
1- Storey Garden	STEP 2	602	9,950	7,562		SEZ/SUZ-KA18NAH2	$3,300	3kW	$450		SEZ/SUZ-KA18NAHZ	$3,700
1- Storey Garden	STEP 3	602	6,201	4,093		SEZ/SUZ-KA12NAH2	$2,500	2kW	$350		SEZ/SUZ-KA15NAHZ	$3,200
1- Storey Garden	STEP 4	602	5,210	3,491		SEZ/SUZ-KA09NAH2	$2,200	2kW	$350		SEZ/SUZ-KA12NAHZ	$3,000
2- Storey Garden	STEP 1	1204	21,097	24,894		SVZ/SUZ-KA24NAH2	$4,000	8kW	$750		SVZ/SUZ-KA30NAHZ	$7,100
2- Storey Garden	STEP 2	1204	15,776	17,354		SVZ/SUZ-KA18NAH2	$3,600	5kW	$550		SVZ/SUZ-KA24NAHZ	$6,600
2- Storey Garden	STEP 3	1204	9,649	9,649		SVZ/SUZ-KA18NAH2	$3,600	3kW	$450		SVZ/SUZ-KA18NAHZ	$4,000
2- Storey Garden	STEP 4	1204	8,018	7,858		SVZ/SUZ-KA18NAH2	$3,600	3kW	$450		PEAD/SUZ-KA15NAHZ	$3,900

Indoor unit
SVZ-KP

- 10 inch height reduction from MVZ
- 12k and 18k btu/h sizes available
- Up to 17.6 SEER
- Up flow capability
- Vertical and horizontal installation ready
- Easy to install
- Ducted heating and cooling
- Energy Star Certified
- Condensation overflow switch connection
- Humidifier interface connections

Indoor unit

CEILING-CONCEALED

- Variable Compressor Speed Inverter Technology
- Ozone-Friendly R-410A Refrigerant
- Adjustable Static Pressure between 0.14 to 0.6 in WG
- Easy Maintenance with Self-Diagnostic Feature
- 3 Fan Speed Settings to Deliver Precise Comfort
- Lead-Lag and Backup Function Support *†
- External Heater Interlock Function
- Auto-Restart after Power Failure
- Built-in High-Performance Drain Pump
- Pipe Length - up to 165 ft.
- Auto Change Over between Cooling & Heating
- Refrigerant Pre-Charged
- Ultra-Slim Body - less than 10" High
- 10-Year Parts and Compressor Warranty*

*Selections are listed with the indoor units listed with just their first 3 digits / the full model number of the outdoor unit.
**Values presented are rough budget numbers for equipment without installation.

APPENDIX L: Lighting design by Deborah Gottesman

gottesmanassociates
ALL FACETS OF LIGHT

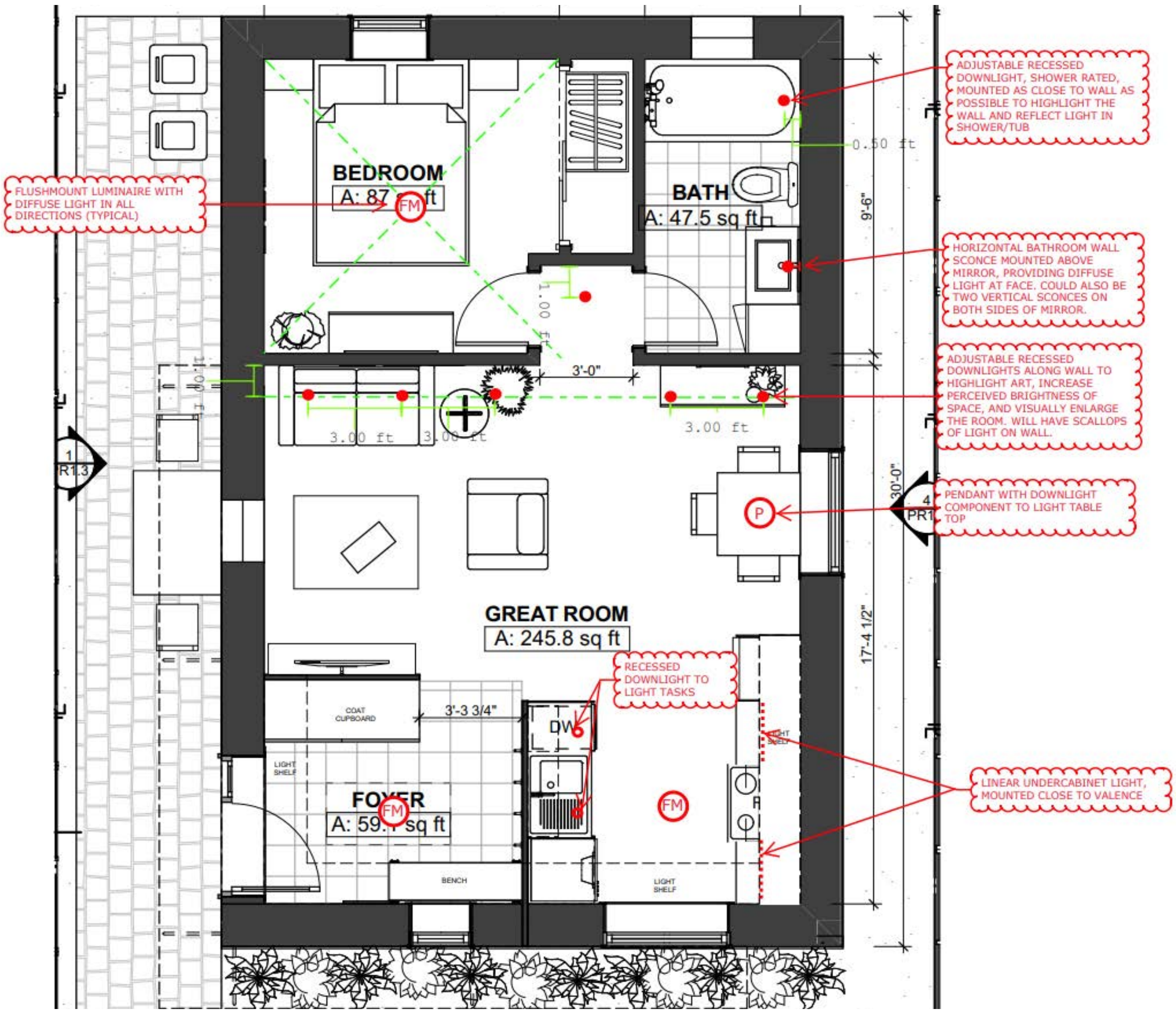
GARDEN SUITES
April 20, 2021

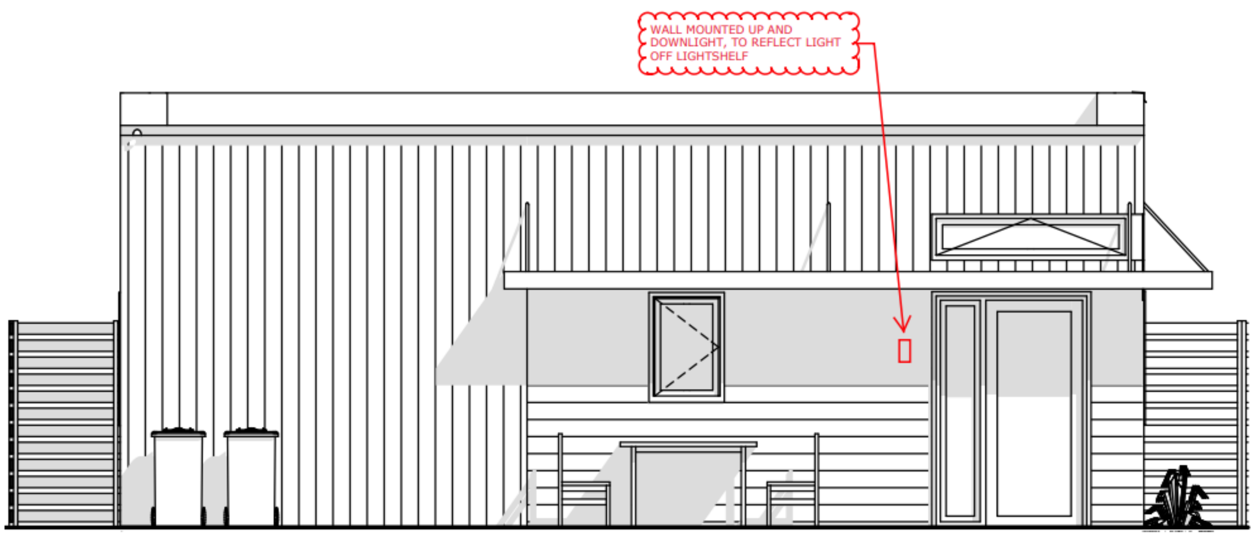
OPTION 1-BASIC LIGHTING LAYOUT						
TYPE	**QTY**	**EST. WATTS EACH**	**TOTAL WATTS**	**EST PRICE EA**	**SUBTOTAL PRICE**	
Downlight	2	12	24	100	$ 200	
Adjustable	7	12	84	100	$ 700	
Pendant	1	25	25	300	$ 300	
Undercabinet Linear	2	15	30	100	$ 200	
Bath Wall Sconce	1	40	40	500	$ 500	
Flush Mount	3	25	75	300	$ 900	
Exterior Light	1	10	10	200	$ 200	
TOTAL			**288**		**$ 3,000**	
PER SF			**0.48**	**W/sf**	**$ 5.00**	**/sf**

OPTION 2-UPGRADED LIGHTING LAYOUT						
TYPE	**QTY**	**EST. WATTS EACH**	**TOTAL WATTS**	**EST PRICE EA**	**SUBTOTAL PRICE**	
RGBW Tape Light in Channel*	32	5	160	$ 100	$ 3,200	
Downlight	2	12	24	100	$ 200	
Wall Washer	6	12	72	150	$ 900	
Adjustable	1	12	12	100	$ 100	
Pendant	1	25	25	300	$ 300	
Undercabinet Linear	2	15	30	100	$ 200	
Bath Wall Sconce	1	40	40	500	$ 500	
Flush Mount	1	25	25	300	$ 300	
Exterior Light	1	10	10	200	$ 200	
TOTAL			**398**		**$ 5,900**	
PER SF			**0.66**	**W/sf**	**$ 9.83**	**/sf**

* White tape Light may be 2W/sf, changes connected load to .5W/sf, and cost to ~$8.23/sf.

Option 1 - Basic Lighting Layout





Option 2 - Upgraded lighting layout