

Low Carbon Living:
An Alternative (Sub)urban Housing Framework for a Rapidly Growing City

by

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Abstract

Keywords: climate change, low carbon architecture, low carbon lifestyle, urban densification, housing

Post-war immigration, along with the Baby Boom dramatically increased metropolitan populations generating a demand for new housing where suburbanization was the solution. It is in part responsible for the contemporary cities that we live in today, and that are now at the root of the climate crisis. Suburban developments imposed challenges of disconnections between neighbourhoods, services, and amenities within cities that were solved with the implementation of vehicles. This thesis project explores new housing strategies that emphasize how low carbon architecture and lifestyles can be implemented into growing cities to minimize the impacts on climate change and avoid the rampant disconnections of the urban fabric. A sustainable urban development framework has been developed to create a denser and more liveable neighbourhood in the context of Barrie, Ontario, a rapidly growing bedroom community outside of Toronto.

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Preface

For as long as I can remember, climate change has always been something that I have been cognizant of and throughout my life I have made a personal effort to adjust my lifestyle to be environmentally conscious. Through attending the McEwen School of Architecture, I have found my place within the climate change movement in exploring ways that architecture can create positive impacts on the built environment.

It only feels right to investigate these ideas in my hometown of Barrie, which holds a special place in my heart. Barrie provides a unique condition, where the life of the city revolves around the lakefront and its surrounding landscape. Being a bedroom community, Barrie has developed in a manner that places precedent on sprawling neighbourhoods and car-centric design that does not encourage a climate

positive future. Through the means of my education and this thesis, I have had the opportunity to explore the ways in which architecture can make positive and impactful change in reducing carbon emissions in growing cities, such as Barrie.

1.0 Introduction



It is a critical moment in the profession of architecture, where architects are faced with a growing demand for housing and a climate crisis brought on by decades of fracturing relationships with nature. Alternative solutions must be explored to generate a discourse for more sustainable developing methods for the immediate and future generations. This thesis explores how new architectural strategies might inform a sustainable approach for the continuous and intensifying growth of a city, to avoid rampant disconnection of the urban fabric.

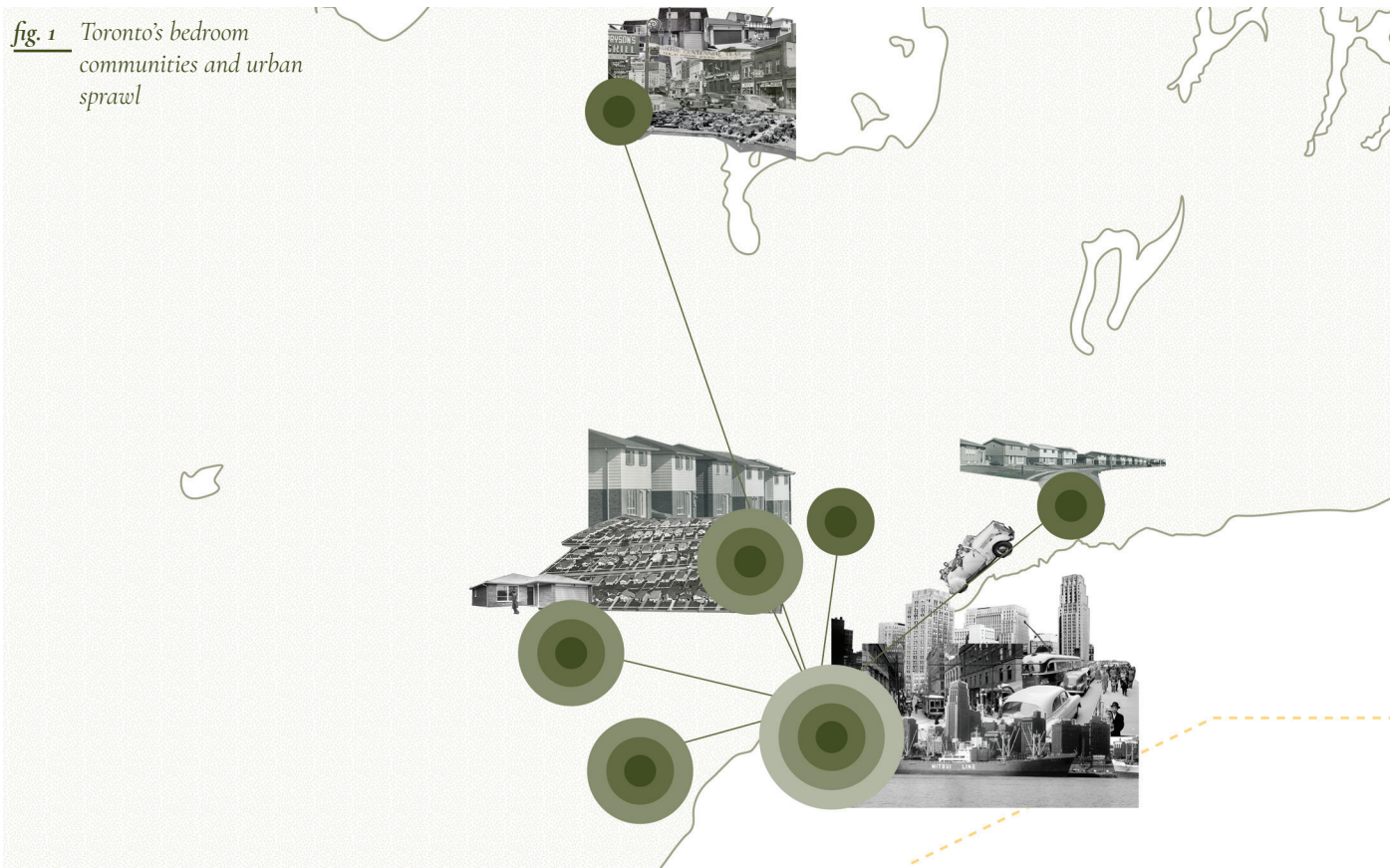
Post-war immigration along with the Baby Boom dramatically increased metropolitan populations generating a demand for new housing through the 1950s. Federal legislation in Canada made it more economically viable for developers to build new homes on a much more expansive scale, creating

entire subdivisions rather than just a few homes resale.¹ Along with the new scale of housing came the dependency on the automobile for everyday travel. The increased use of the automobile further justified the construction of new housing developments to be built further and further away from metropolitan areas, generating conditions such as the bedroom communities.² A bedroom community can be defined as a residential suburb inhabited largely by people

1 J.M. Bumsted, Excerpts from “The Peoples of Canada: Post Confederation History,” *Canada History*, Oxford University Press: 1992, Posted March 20, 2019, <http://www.canadashistory.ca/explore/arts-culture-society/home-sweet-suburb>.

2 “Your Home Our City: Suburban Growth,” *City of Toronto Archives*, accessed October 17, 2021, <https://www.toronto.ca/explore-enjoy/history-art-culture/online-exhibits/web-exhibits/web-exhibits-community-neighbourhoods/your-home-our-city/your-home-our-city-suburban-growth/>.

fig. 1 Toronto's bedroom communities and urban sprawl



that commute to a nearby city for work.³ [fig. 1] The migration out of the city and the dependency on vehicular travel has continued to propagate a further disconnect between suburban neighbourhoods, services, amenities, and access to daily needs. Suburbanization as the post-war housing solution is in part responsible for the contemporary cities that we live in today, and that are now at the root of the climate crisis.

Architects, as residents of our cities and the designers of them, are at the centre of the Climate Crisis, where the *Intergovernmental Panel on Climate Change (IPCC)* has voiced that the human population is responsible for approximately 1.1°C of global

warming above the pre-industrial temperatures.⁴ If there are not rapid and immediate actions in reducing carbon emissions then global warming is expected to exceed 1.5°C of warming in the next 20 years.⁵ The architecture and construction industry is one of the leading industries for global emissions, accounting for 40% of carbon emissions generated annually.⁶ This calls for immediate action within the building sector to encourage a new dialogue of design that focuses on low-carbon approaches

³ Merriam-Webster.com Dictionary, s.v. “bedroom community,” accessed October 29, 2021, <https://www.merriam-webster.com/dictionary/bedroom%20community>.

⁴ Intergovernmental Panel on Climate Change, “IPCC Press Release: Climate change widespread, rapid, and intensifying - IPCC,” (Geneva, Switzerland: August 9, 2021.) https://www.ipcc.ch/site/assets/uploads/2021/08/IPCC_WGI-AR6-Press-Release_en.pdf, 1.

⁵ “IPCC Press Release: Climate change widespread, rapid, and intensifying - IPCC,” 1.

⁶ “Why the Building Sector?” *Architecture 2030*, accessed September 29, 2021, <https://architecture2030.org/why-the-building-sector/>.

especially for developing a new strategy for housing. Through architecture interventions, the current linear flow of carbon consumption can be shifted to a cyclical system by⁷; applying passive and active strategies to minimize operational emissions, utilizing carbon sequestering materials to lower the embodied energy, and exercising urban strategies that encourage low carbon lifestyles, to avoid exhausting the finite resources we have available. As architects, there is a great opportunity to develop an architectural typology that supports a low-carbon lifestyle through architectural interventions that react to a site's climatic and social conditions.

The current practices of architecture in North American society cannot be sustained in the future of the climate crisis as it encourages overconsumption, mass production, and an overall consumerist lifestyle. A holistic and intimate approach to building community is imperative to avoid the mistakes of the post-war housing shortage. Consequently, in the current context of the climate crisis & housing shortage, there is a distinct need for better residential development strategies. **By understanding the current and future effects of climate change, how can residential architecture adapt to encourage low carbon lifestyles through alternative design strategies?** The thesis project proposes a sustainable urban housing strategy in a (sub)urban context of Barrie Ontario to implement denser and more liveable neighbourhoods. (Sub)urban refers to the middle areas between urban and suburban fabrics that are typically utilized by cars to travel from one area to the other. They are not quite urban, and they

⁷ "Home," Decarbonized Design, accessed November 25, 2021, <https://www.decarbonizeddesign.com/>.

are not quite suburban, therefore these areas can benefit from better integration into the context to promote density and walkability creating more inclusive neighborhoods. This presents a unique opportunity to explore new housing strategies that can emphasize sustainability, density, user well-being, and diversity to better integrate the growing population of Barrie and has the potential to be used as a tool in the adaptation to other growing cities.

The City of Barrie is located on the western shore of Lake Simcoe's Kempenfelt Bay which was established as a strategic war route and transportation hub during the *War of 1812*.⁸ The leading economies at the time were initially in the agriculture and lumber industries, whereas today they are established in services and diversified manufacturing.⁹ Due to the proximity to the City of Toronto, the affordability of suburban housing, and ongoing development of Highway 400, Barrie has evolved over time, through accelerated growth, to create contradicting conditions of independent communities around a thriving city core. The City of Barrie is now preparing for rapid growth as the population is projected to double in size over the next 30 years. The future developments of Barrie are at a critical juncture where the strategies that are implemented need to adapt to the present and future climatic changes, ultimately adjusting inhabitant's lifestyles. The Master Plan proposal for the future growth of the city allocates 50% of the growth to developing

⁸ A Brief Summary of Barrie's Long History, *Downtown Barrie*, accessed October 12, 2021, <https://downtownbarrie.ca/a-brief-summary-blog/>.

⁹ Britannica, T. Editors of Encyclopaedia, "Barrie," *Encyclopedia Britannica*, February 12, 2019, <https://www.britannica.com/place/Barrie>.

density in the urban downtown area and 50% to new suburban developments towards the South on greenfield sites.¹⁰ This strategy for new development is a point of contention at this current moment, where new development has an important environmental impact on the future. Therefore, there is an emphasis on the need to densify the more urban areas of Barrie before succumbing to the eventual suburban sprawl on the outer edge of the city. This will encourage the creation of more complete neighbourhoods to decrease vehicular dependency and to implement a more climate positive lifestyle.

The thesis sites itself in the new *Urban Growth Center* of downtown Barrie, situated in a disconnected (sub)urban zone at the intersection of two neighbourhoods. The site is on a main arterial connection to the downtown core from the south and west, which has generated an area that is underutilized by the residents of the city, as well as unenjoyable and unwalkable. There is opportunity in its proximities to surrounding context to reconnect this area to the recreational activities around the lake, the commercial zone of downtown, to the *GO Train* to the south for commuters, and other residential neighbourhoods, to accommodate multiple user groups all within a 15-minute walking radius. A comprehensive program has been designed based on a holistic analysis of the site, its proximities, and the demographics. There are three main programmatic types included in the project; housing, public commercial programming, and public and private urban design elements. The program aims to bring all aspects of the research together to permeate into

the surrounding neighbourhoods to reinforce what already exists and establish notions of walkability, sustainable lifestyles, user well-being, and the ability to adapt to new growth. The location and proximity to local amenities and services allows for diverse user groups and multi-generational living conditions, which is primarily geared towards young professionals, young families, and those who are retired and are seeking to downsize. Therefore, the thesis aims to integrate an inclusive and accessible mix-used residential typology to densify, support, and enrich the existing urban fabric.

Climate change is a present issue that is not going away, and current North American lifestyles and methods of developing suburbs do not produce a sustainable path forward for the future of the environment and people's well-being. There needs to be a stronger discourse on new methods of developing growing cities that does not promote sprawling suburban neighbourhoods on greenfield sites. These types of developments are disconnected and inaccessible by any other means of transportation than a vehicle. The context of Barrie provides a unique opportunity to explore how new growth can be accommodated within existing neighbourhoods to densify and strengthen what is existing through urban and architectural interventions.

¹⁰ City of Barrie Planning Services. "Barrie Official Plan 2051," *City of Barrie*, January 31, 2021, 26.

**2.0 Suburbs + Their Effects on
Climate Change**

2.1 the historical development of suburbs

2.2 the issues generated by suburbs

The suburban neighbourhood is a family typology of architecture and can be found in proximity to most cities across North America. They were designed as an opportunity for people to obtain their dream life following World War II (WWII) and escaping the city to reconnect with nature, one another, as well as starting families in safer conditions. [fig. 2] The impacts that suburbs have on climate change can be understood by analyzing their history and how they have impacted society changes. By understanding the history of suburbs and their issues, new typologies can be designed to promote sustainability and well-being within cities.



fig. 2 Low density sprawl: McClure
Crescent, Toronto

2.1 The Historical Development of Suburbs

The familiar and modern version of suburbia that is recognizable today, began in the United States of America following WWII. The typology was heavily influenced by English cottage style suburbs of 19th century London and spread across colonized countries around the world.¹¹ Following WWII there was a housing shortage in Canada due to few residential developments being constructed since the 1920s. To accommodate the surge in demand for housing, the *Canada Mortgage and Housing Corporation (CMHC)*, as well as the government quickly began to subsidize and promote suburban developments by offering cheap mortgages to potential buyers. Government subsidization of housing made it more

¹¹ Doug Kelbaugh, "Reconfronting Sprawl: Still Paved with Good Intentions and Asphalt," *Public Square: A CNU Journal*, October 30, 2018, <https://www.cnu.org/publicsquare/2018/10/30/reconfronting-sprawl-still-paved-goo-intentions-and-asphalt>.

affordable for developers to build on the outskirts of cities, drawing residents away from urban centers creating a dependence on vehicles for travel.¹² [fig. 3] When people started to move away from more dense cities, the majority would remain at their job in the city creating what is known today as bedroom communities or commuter towns. Suburbanization encouraged city dwellers to escape the city for a new life in the suburbs where there was a better opportunity to start a family and connect with nature.¹³ [fig. 4] This mode of providing housing has expanded and become the predominant form that people know and seek to obtain to start raising their own families today. As cities continue to develop and invest in housing, the more they continue to

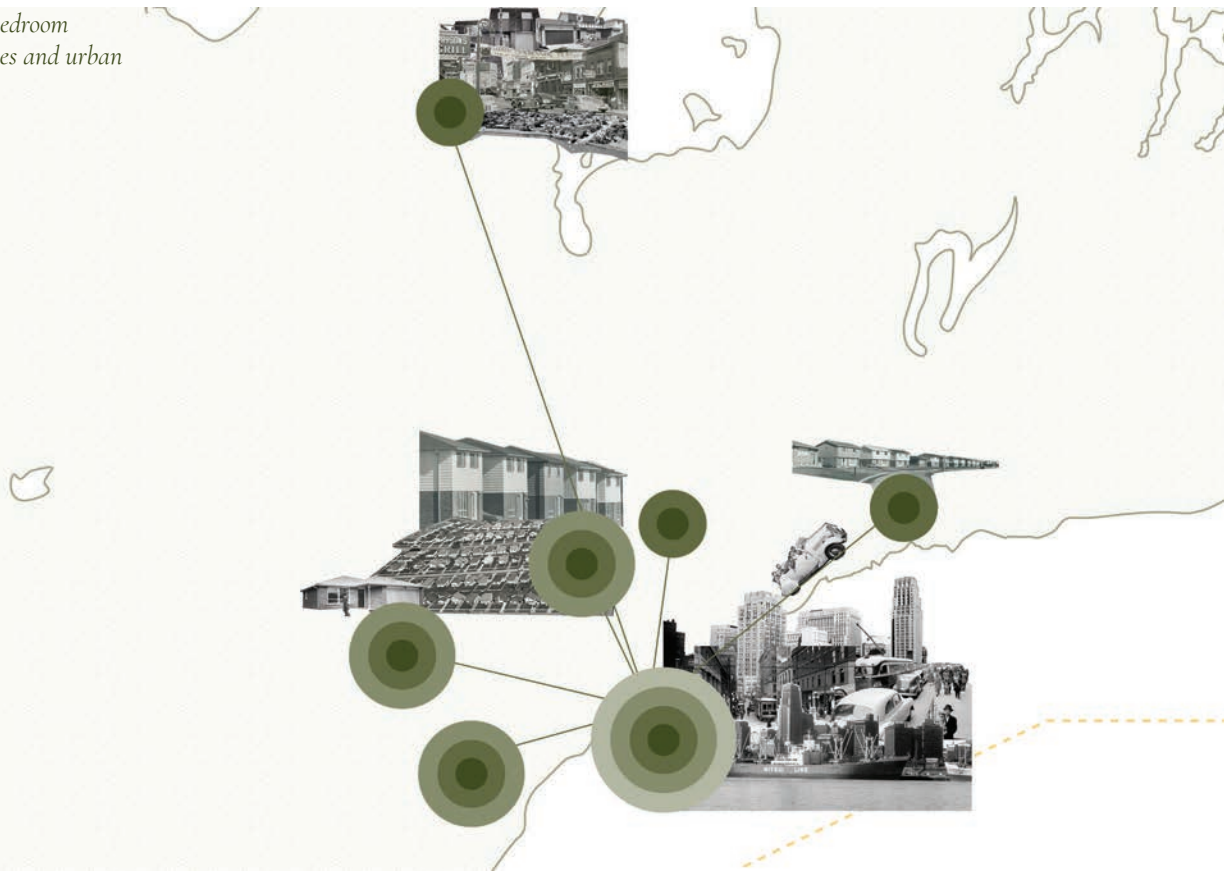
¹² Doug Kelbaugh.

¹³ John Archer, *Architecture and Suburbia*, (Minneapolis MN.: University of Minnesota Press, 2005) 251.



fig. 3 Cars parked in Toronto suburb

fig. 4 Toronto's bedroom communities and urban sprawl



grow and expand outwards, becoming disconnected.

Life in the suburbs was designed around the nuclear family where it "... depended on a clear understanding of family roles. Husbands were the breadwinners, often working far away from the home, while their wives were actually responsible for its daily functioning."¹⁴ Children were central to the design of suburbia, and this is often visible in the design of the house and subdivision. "The suburban focus on children may well be a highly individualist pursuit that raising children may be a dimension of individuation and self-realization that suburbia facilitates best."¹⁵ Houses were articulated in a

¹⁴ J.M. Bumsted, Excerpts from "The Peoples of Canada: Post Confederation History," *Canada History*, Oxford University Press: 1992. Posted March 20, 2019, <http://www.canadashistory.ca/explore/arts-culture-society/home-sweet-suburb>.

¹⁵ John Archer, 256.

manner that ensured children's safety by designing strategic sight lines throughout the home. Kitchens were designed as the hub of the home, where meals were prepared and where the women typically worked. As history developed, the kitchen became more open to other rooms within the house to allowed for mothers to monitor their children's play and activity while they completed their tasks. Where the suburbs were not designed for children, they were designed for the car as a form of escape from city life. The sequence of entry into neighbourhoods and into the home revolve around the car rather people, placing precedents on driveways and garages. Driveways act as a mediating and most public space in suburbs where neighbours can interact with and display a façade for one another. The driveway also acts as a dedicated space for cars to sit while they are not in use, creating an unusable space. Garages act

as an extension of the driveway and, in some cases, they act as the front door after parking the car inside of them. Again, this has become a space within a suburban neighbourhood that allocates an immense amount of space for the car and storage, rather than family and living.

This has been implemented into the strategies that are used to market and sell suburban homes to target families that are looking to escape dense city living. Homes were marketed towards young families with two children by naming developments with fantastical names, concentrating on the price and down payment requirements to attract more buyers. To provide an ease and savings for developers, suburban houses were constructed from a select few of floor plans with an identical floor area, number of bedrooms, and varying layouts to maximize the mortgage values.¹⁶ Therefore solidifying that suburban neighbourhoods were ultimately designed and constructed for the benefit of developers rather than those that live there.

¹⁶ J.M. Bumsted, Excerpts from “The Peoples of Canada: Post Confederation History.”

2.2 The Issues Generated by Suburbs

Suburban developments are problematic in many ways, but the most concerning at this specific point in time, is their effects on climate change and how the environment is often ignored when these types of developments are designed. As they were established to benefit developers, suburbs neglected the well-being of the users and the environment. Some of the issues with suburbs that have contributed to climate change include; low density development and suburban sprawls, car-centric design and dependency, energy demanding homes, the creation of monocultures through the destruction of land, and the reduction of urban life and activity. These issues will be further discussed in the following subsections.

1. low density + sprawl

Following World War II, it became more economically viable for developers to build in larger scales, designing whole neighbourhoods rather than a few homes due to a housing shortage and the Baby Boom.¹⁷ This adjustment in development strategies decreased the density of living conditions from dense urban areas and shifted to sprawling neighbourhoods outside of cities. “The suburbs were built quickly by companies that had gained expertise during the war, and were often developed around a school. The municipalities then had to link these new communities to each other, and to the city, through roads and infrastructures.”¹⁸ Due to the disregard of implementing important infrastructure

¹⁷ J.M. Bumsted, Excerpts from “The Peoples of Canada: Post Confederation History.”

¹⁸ J.M. Bumsted, Excerpts from “The Peoples of Canada: Post Confederation History.”

into new developments, many neighbourhoods became disconnected and unwalkable because of sprawl, beginning the dependency on vehicles for essential travel for services.¹⁹ The neighbourhoods that were constructed outside of cities, favouring developing on greenfield sites, which disrespect the landscape, and requires cities to implement new infrastructure in the area. Each of these factors makes it more and more difficult for residents of suburban neighbourhoods to decrease their carbon consumption purely based on developers' motives and suburban sprawl.

¹⁹ J.M. Bumsted, Excerpts from "The Peoples of Canada: Post Confederation History."

2. car-centric living

Due to suburbs being constructed independently of city infrastructure and services, there was and still is an increased dependency on vehicles to travel from one place to another. Early residents of suburban neighbourhoods were those who were looking to escape urban city life and reconnect with nature and have the "ideal" condition to start a family and many, specifically the husbands, continued to work in cities. This ultimately led them to become dependent on the vehicles to commute to and from work and the construction of more roadways and infrastructure away from cities like Toronto.²⁰ Therefore, it can be understood that "cars are the biggest culprit in the dispersion and fragmentation of our cities."²¹

²⁰ J.M. Bumsted, Excerpts from "The Peoples of Canada: Post Confederation History."

²¹ Doug Kelbaugh.

Further adding to the contributions that vehicles make to carbon emissions, as suburbs are the “ideal” condition for nuclear families and were historically used to support the husband/father’s career while the wife/mother opposed employment to care for the children. Car companies like *Ford* saw this as an opportunity to profit off women’s boredom at home to market the investment for a second family car.²² This allowed them to travel during the day to run errands, see friends, and pick up the children. With dispersion and fragmentation, comes the over consumption and dependence of cars for essential travel leading to more carbon emissions entering the atmosphere.

²² John Archer, 259.

3. *energy demanding homes*

As cities began to expand outwards and people began to relocate to the suburbs, the houses began to expand as well as there is more space to do so. The early reasoning and push to move to the suburbs was for more space for families to grow and it being a safer place for children to play and grow up. As families and houses take up more space, they proportionally use more energy. Jonathan Rose points out in *The Well-Tempered City*: “From 1970 to 2015 the size of the average home in the US doubled, as did the number of cars, and its number of televisions has tripled, all this while the number of occupants per home halved!”²³ Due to the fact that cities keep expanding outwards, it is estimated that a typical house in an American suburb, over a 45-year life cycle, will use 15,455 gigajoules of energy. This amount of energy

²³ Doug Kelbaugh.

It is neither love for nature nor respect for nature that leads us to this ... attitude. Instead, it is a sentimental desire to toy, rather patronizingly, with some insipid, standardized, suburbanized shadow of nature. ... And so, each day, several thousand more acres of our countryside are eaten by the bulldozers, covered by pavement, dotted with suburbanites who killed the thing they thought they came to find.

Jane Jacobs

is enough to travel across the United States and back more than 1000 times.²⁴ Increase of land use has become increasingly more demanding on the environment overtime as larger houses and the low-density sprawl has increased the amount of energy used in comparison to more dense living conditions in city where people are surrounded with amenities in closer proximity.

4. monoculture landscapes

When developers approach a site for a suburban neighbourhood, it was discovered that it is more economically friendly for developers to remove all the trees as it is too expensive to leave them. This leaves planting new trees and vegetation up to the homeowner, which is not only problematic from an environmental standpoint but reduces the

²⁴ Doug Kelbaugh.

access residents have to nature, which contradicts a primary motivation for migrating to a suburb. In Doug Kelbaugh's article on *Reconfronting Sprawl*, he leans on Jane Jacobs when discussing suburbia's impact on nature:

*'It is neither love for nature nor respect for nature that leads us to this ... attitude. Instead, it is a sentimental desire to toy, rather patronizingly, with some insipid, standardized, suburbanized shadow of nature. ... And so, each day, several thousand more acres of our countryside are eaten by the bulldozers, covered by pavement, dotted with suburbanites who killed the thing they thought they came to find.'*²⁵

As suburbs are designed as commodifications for developers, the environment and nature are neglected. Lawns replaced diverse ecosystems,

²⁵ Doug Kelbaugh.



fig. 5 Live in the suburbs advertisement

which have become a pride and burden of suburban neighbourhoods as they are time consuming and a hassle to maintain.²⁶ [fig. 5] The creation of these landscapes is not only damaging to the land that they inhabit, but the land that they surround, as homeowners will do anything to maintain their lawns, particularly producing immense amounts of runoff and utilizing energy to do so.

5. reduction of urban life + activity

When the move to suburban communities began in the 1950s, urban life in cities began to dissipate. Rising land prices in cities made it uneconomic for land to be used for residential purposes, except for high-rise apartment blocks and even these were not as profitable as office blocks. This resulted in large business districts in the heart of cities, with

²⁶ Doug Kelbaugh.

high rise residential along the fringes, and finally out even further were suburban neighbourhoods.²⁷ By minimizing or removing living conditions from urban centers people on the street after work hours began to decrease as well as the life and activity that happens when people live in the city.²⁸ Not only did city centers become less active but suburban blocks were inherently more private due to the lack of commercial and public activity that a ground floor needs to bring life to the street. Due to the lack activity happening on the street and its association with vehicles, outdoor activities and children’s play has moved to backyards for their safety.

²⁷ J.M. Bumsted, Excerpts from “The Peoples of Canada: Post Confederation History.”

²⁸ Jane Jacobs, *The Death and Life of Great American Cities*, (New York, NY: Random House, 1961).

By analyzing suburban developments, their history and issues, resolutions and interventions can begin to be formed to develop a new approach to urban housing. To decrease the dependency on cars, cities should focus on density within built-up areas before resulting to new developments on greenfield sites. What is developed in urban areas should focus on generating a greater sense of community with design that encourages sustainable lifestyles, user well-being, and respects the environment and fabric within its context. The ways in which people live and inhabit the earth should be out of respect and in harmony with nature, not what is more convenient.

3.0 Living with Carbon

**3.1 sustainable urban
development**

**3.2 low carbon architecture
strategies**

3.3 low carbon lifestyle strategies

3.1 Sustainable Urban Development

To begin to live with climate change, a broader discourse on sustainable housing options must develop as current methods of developing, such as suburban neighbourhoods and lifestyles, are detrimental to the environment. Within the residential sector, housing and private transportation are two of the highest components of carbon emission in Canada, accounting for 3.1 tCO₂e/capita/year and 3.54 tCO₂e/capita/year respectively.²⁹ [fig. 6] Suburbs generate more CO₂ than dense cities due to the issues of how they were established and built around independence and reliance on the vehicle. “Building within our existing cities will save us all money, while also revitalizing the local economy and community

²⁹ Lewis Akenji, Magnus Bengtsson, Viivi Toivio, Michael Lettenmeier, Tina Fawcett, Yael Parag, Yamina Saheb, Anna Coote, Joachim H. Spangenberg, Stuart Capstick, Tim Gore, Luca Coscieme, Mathis Wackernagel, Dario Kenner, *1.5-Degree Lifestyles: Towards a Fair Consumption Space for All*, (Berlin, Germany: Hot or Cool Institute, October 2021), 15-17.

design.”³⁰ To make residential neighbourhoods more sustainable, architects and designers need to look for innovative solutions to lower the carbon emissions of residential households while reducing the reliance on vehicles to create better connections within the community. This means working within existing cities where there is already established infrastructure and access to schools, services, and frequent transportation.³¹ Sustainable urban development allows for diverse neighbourhoods to be developed that prioritize bringing people together, user well-being, active modes of transportation, and connecting to the surround community through

³⁰ David Crombie, “We Cannot Sprawl our way to Housing Affordability,” *Toronto Star*, January 18, 2022, <https://www.thestar.com/opinion/contributors/2022/01/18/we-cannot-sprawl-our-way-to-housing-affordability.html>.

³¹ David Crombie, “We Cannot Sprawl our way to Housing Affordability.”

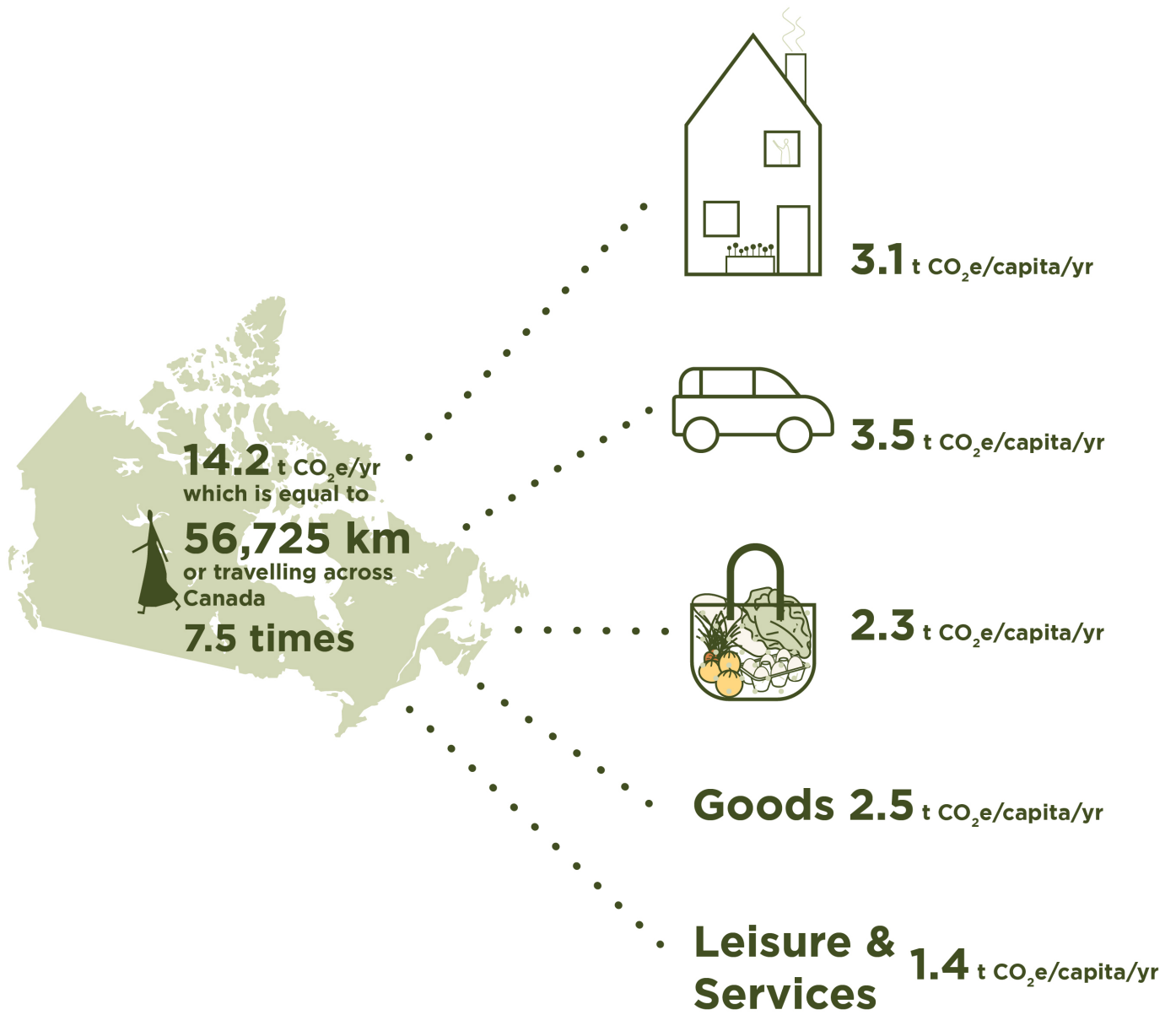


fig. 6 The average Canadian's carbon footprint that can be broken down into multiple contributors including housing, transportation and food consumptions

sustainable architectural methods.

To provide adequate housing, cities must pursue sustainable housing options that are equitable and holistic in how they integrate into the surrounding urban fabric. Sustainable urban development is more than providing access to public transportation, “it means inclusive access for all to local and citywide opportunities and resources by the most efficient and healthful combination of mobility modes, at the lowest financial and environmental cost, and with the highest resilience to disruptive events.”³² Sustainable urban development provides access for people to find opportunities, culture, services, and communities for all that live in the city. It is about providing good land use, infrastructure, and amenities to all communities and designing urban places that bring people, activities, buildings, and public space together.³³ To create connections between neighbourhoods, active modes of transportation are emphasized through walking and cycling paths, as well as public transportation. “Inclusive development is an essential foundation for long-term sustainability, equity, shared prosperity, and civil society in cities.”³⁴ The current lifestyles and developments in North America are detrimental to the environment and adjustments will have to be made to ensure long-term solutions to the climate crisis.

To explore how sustainable urban development can be implemented in a Canadian context, strategies are developed from a theoretical framework that emphasizes low carbon architecture, low carbon lifestyle, and sustainable urban development. A quantitative analysis of site and structure generates architectural resolutions with respect to low carbon design strategies, whereas a qualitative approach derived from a theoretical framework on sustainable urban development begins to inform how architecture can influence meaningful and positive change in communities through low carbon lifestyles. Authors such as Bruce King, David Sim, Jan Gehl, and Jane Jacobs were integral in forming the theory on developing neighbourhoods that are sustainable from a social and user well-being perspective as well as the architectural perspective.

³² “Sustainable Urban Development: This is what urban equity looks like,” *Institute for Transportation and Development Policy*, Accessed March 3, 2022, <https://www.itdp.org/our-work/sustainable-urban-development/>.

³³ Sustainable Urban Development: This is what urban equity looks like.”

³⁴ Sustainable Urban Development: This is what urban equity looks like.”

3.2 Low Carbon Architecture Strategies

As architects we have agency to design better and more sustainable buildings, and by understanding where carbon emissions are coming from within the process, designs can begin to mitigate the effects of climate change. The architecture and construction industry are one of the leading industries for global emissions, accounting for 40% of carbon emissions generated annually.³⁵ As the world's population continues to grow, there will be more demand for raw materials to be extracted and utilized and "... the building sector's demand for raw material and energy for new construction will further tax critical, finite resources and - if our current approach remains unchecked - will continue to layer a geological

³⁵ "Why the Building Sector?" *Architecture 2030*, accessed September 29, 2021, <https://architecture2030.org/why-the-building-sector/>.

stratum's worth of waste across the planet."³⁶ Analyzing the construction process, methods and materials, the embodied carbon of building can be determined. Embodied carbon emissions are all the sources of energy consumption other than the energy used to operate a building.³⁷ These emissions are growing throughout the building sector and can be reduced by optimizing the building process and materials of a project. Whereas carbon that is generated during the life of the building is referred to as operational carbon, this can be mitigated through architectural strategies that make the building more

³⁶ Matti Kuittinen and Alan Organschi, "Decarbonizing Design," Aalto University and Yale University, 2019, Accessed November 25, 2021, <https://www.decarbonizedesign.com/1-our-carbon-problem>.

³⁷ Matti Kuittinen and Alan Organschi, "Decarbonizing Design."

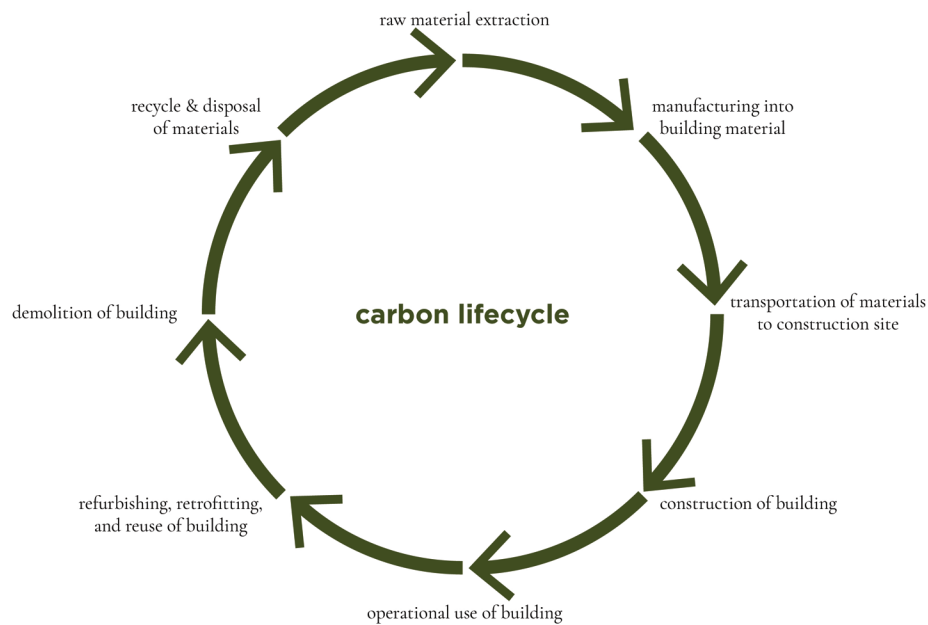


fig. 7 Carbon lifecycle of buildings

efficient.³⁸ [fig. 7] By analyzing these facets of a building, designers can widen the scope to include material and construction efficiency and design low carbon solutions for the construction process, the operating life, and the adaptability or end of life.

1. designing for embodied carbon

Embodied carbon accounts for the carbon generated throughout the materials life, construction process, and the end of the building's life. [fig. 8] It can be mostly found in the materials, accounting for 60-80% of a building's embodied carbon with the remaining being generated by site work, construction equipment, and transportation of materials and

workers, all at 5-15% respectively.³⁹ The building materials that particularly generate the most carbon emissions are concrete, steel, and aluminum, which are responsible for 23% of total global emissions accounting for most of the built environment.⁴⁰ If wood is utilized as a the main construction material, it has an embodied carbon coefficient of 34 kgCO₂e/m², whereas concrete is equal to 147 kgCO₂e/m², and steel 135 kgCO₂e/m².⁴¹ It is important to note that "... the values for embodied carbon of the different materials depend on the region in which the material is produced and the distance to the construction

³⁸ Matti Kuittinen and Alan Organschi, "Decarbonizing Design."

³⁹ Bruce King, *New Carbon Architecture: Building to Cool the Climate*, (Gabriola Island, B.C.: New Society Publishers, 2017), 35.

⁴⁰ "Embodied Carbon Actions, *Architecture 2030*, accessed September 29, 2021, <https://architecture2030.org/embodied-carbon-actions/>.

⁴¹ Bruce King, 23.

site.⁴² Therefore, it is fundamental that materials like concrete and steel begin to be as minimized as possible from the building process and rely on wood as a structural material that has the ability to sequester carbon. Not only is the material selection important to reduce the embodied carbon, but the transportation to the site increases the footprint of a material.

2. *designing for operational carbon*

Operational carbon accounts for the majority of carbon emissions generated by a building throughout its life. By tackling the operational carbon of a building, the overall carbon footprint of the building can be offset. [fig. 9] Addressing the envelope, systems and equipment that are implemented, as well as maximizing passive architectural strategies, the operational carbon of the building can be reduced.⁴³ Buildings have the opportunity to react and take advantage of the environmental conditions of a site to minimize the impact on heating and cooling loads that contribute to its carbon footprint. Implementing passive strategies such as natural cross ventilation, solar shading, and daylighting allows for the building to better react to its environment and not be dependent on mechanical systems. Utilizing on site methods of harnessing renewable energy sources such as solar photovoltaics, will help to mitigate energy related emissions that are generated by the building.⁴⁴ Improving the envelope through increasing insulations, high performing windows, and airtight assemblies are not only beneficial for reducing operational carbon but have a larger impact

42 Bruce King, 22.

43 Bruce King, 36.

44 Matti Kuittinen and Alan Organschi, “Decarbonizing Design.”

in residential projects.⁴⁵ Overall, it is important to address the site and what it has to offer a design project, to begin to develop and utilize natural strategies to reduce emissions over the buildings lifetime.

3. *designing end of life and adaptability*

The last process or phase of a building that should be considered when designing with respect to low carbon architecture is determining how the building can be adapted in the future and its end of life. Buildings should be designed to maximize the quality and functionality of space to be adaptable for future needs and uses. Bruce King discusses how buildings can be adapted for future uses as,

‘we can design new buildings and renovations knowing they will be renovated in the future, using building components that are removeable, cleanable, and able to be refurbished. If people are able to change their buildings more easily, they may not be as likely to replace them.’⁴⁶

By designing buildings to be adaptable and change for future needs, waste can be eliminated by having materials be recycled or reused or returned to the earth for biological reabsorption.⁴⁷ Buildings will continue to hold their economic value and functionality over time therefore designing to these principles of adaptability and end of life will ensure carbon is absorbed throughout the cycles of the building.

45 Bruce King, 37.

46 Bruce King, 36.

47 Matti Kuittinen and Alan Organschi, “Decarbonizing Design.”

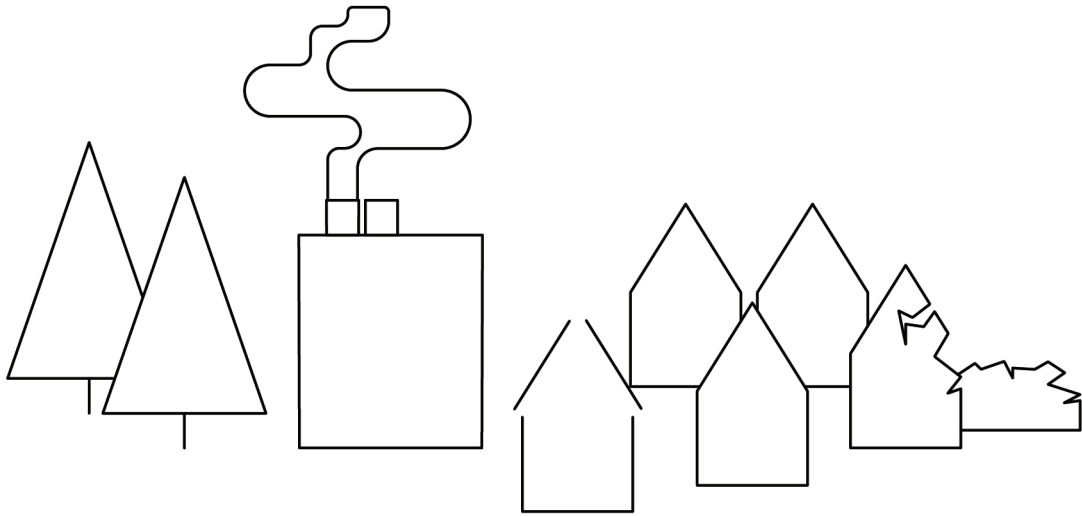


fig. 8 Embodied carbon, emissions generated throughout a buildings lifecycle, excuding the operation

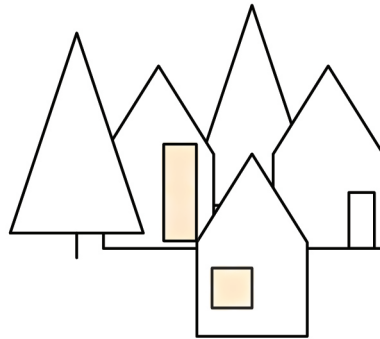


fig. 9 Operational carbon, emissions generated during the life of a building

3.3 Low Carbon Lifestyle Strategies

The qualitative analysis of a site is important to understand what activities and life exist in its proximity. This allows the project to permeate into its context and support what is already existing and in reverse, where the context can support what is being implemented onto the site. **[fig. 10]** Understanding the urban context from a walkable perspective creates a focus on how people move throughout the city without cars and creating activity and space for people to interact. Architecture can influence people's lifestyles to live more sustainably by providing ways for people to live more locally in their community (decreasing the dependency on the vehicle), and for the human scale (creating architecture that can offer more comfort).

1. designing for walkability + proximity

As previously mentioned, understanding the site's context is not only beneficial from a carbon reduction standpoint but to understand how people move and inhabit cities. Designing for proximity analyzes what is existing to determine what can exist on the site to allow programming to permeate into the neighbourhood. It encourages coexisting activities such as dwelling, working, shopping, recreation, etc., and the urban form needs to accommodate different forms and volumes of buildings but fit together as a whole. Utilizing smaller plots and subdivisions of land allow for different typologies and scales of buildings.⁴⁸ Encouraging proximity makes neighbourhoods more accessible for walking, making liveable communities easier to attain. Walkability should be designed at

⁴⁸ David Sim, *Soft City: Building Density for Everyday Life*, (Washington, D.C.: Island Press, 2019), 214.

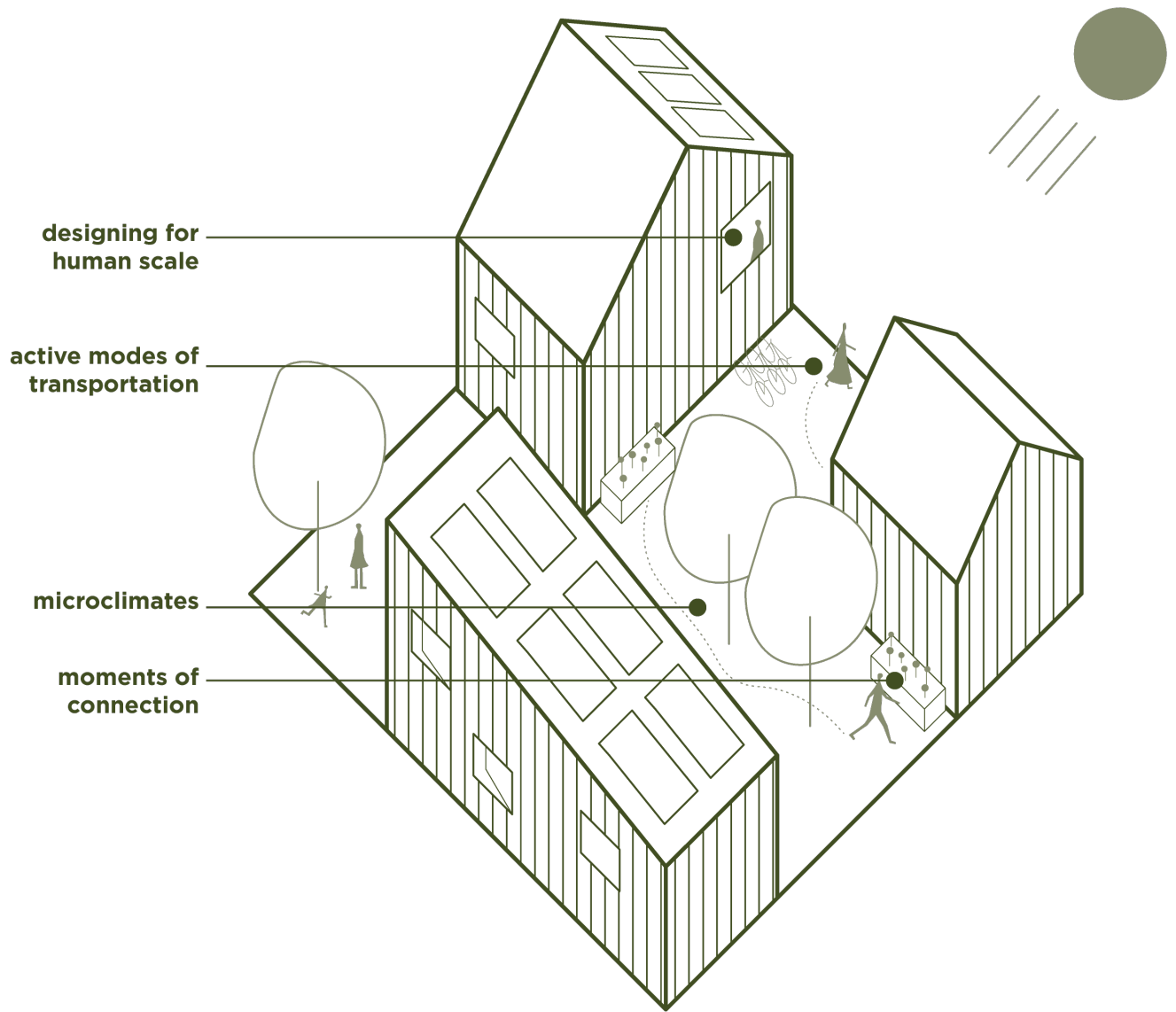


fig. 10 Diagram of sustainable urban development that employs low carbon lifestyle strategies to lower individual carbon footprints

the scale of a neighbourhood, walking in, through and up buildings, increasing visual connections to useful outdoor space.⁴⁹ Activating the ground floor with shops, workplaces institutions and homes creates useful inside and outside movement. Promoting walkability and proximity in a design creates connections between people, life outside, and to nature, ultimately encouraging a more sustainable and local lifestyle.

2. *designing for the human scale*

Designing for the human scale requires an understanding of how people use cities in proximity to the site and the relationships that develop in the city, to create enjoyable opportunities and interactions for people to inhabit at an urban scale. “The success of urban form must be measured in its delivery of a higher quality of life for the people who live with it and its resilience and adaptability to constant changes in society, environment, and economy.”⁵⁰ Cities are constantly changing and evolving and to deliver density at a human scale, details must be developed that can offer people living in and around the buildings comfort and well-being. To create high-quality life to bring people closer, buildings have to be designed at smaller scales that create connection to the ground floor. Jan Gehl emphasizes this connection to the ground floor,

Meaningful contact with ground level events is possible only from the first few floors in a multistory building. Between the third and fourth floors a marked decrease in the ability to have contact with the ground level can be observed. Another threshold exists between the fifth and sixth floors. Anything and anyone above the fifth

*floor is definitely out of touch with the ground level events.*⁵¹

Therefore, building density in cities should be approached from the perspective of low-rise and high-density development as it is more comfortable and digestible for people that inhabit the building and around the building. Using techniques like commercial ground floor with public parks or plazas and walk-up height buildings generates activity on the ground floor but as people move up the building, there is still a connection with that activity.

3. *designing for moments of connection*

Moments of connection are created when designing for the human scale and understanding the movement through the city. The movement of people in a city should be focused on walking and slow modes of transportation as this allows for closer moments of connection in contrast to fast moving vehicles. The design of buildings should maximize these moments connection both vertically and horizontally on the ground floor utilizing both interior and exterior spaces that vary in how public or private they are. Designing visual connections not only promotes social activities but it ensures safety, as Jane Jacobs points out,

*‘... there must be eyes upon the street, eyes belong to those we might call natural proprietors of the street. The buildings on a street equipped to handle strangers and to insure the safety of both residents and strangers, must be oriented to the street. They cannot turn their backs or blank sides on it and leave it blind.’*⁵²

⁴⁹ David Sim, 222.

⁵⁰ David Sim, 212.

⁵¹ Jan Gehl, *Life Between Buildings: Using Public Space*, (Washington, D.C.: Island Press, 2011), 98.

⁵² Jane Jacobs, *The Death and Life of Great American Cities*, (New York, NY: Random House, 1961) 32.

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Jan Gehl

Designing hybrid spaces between interior and exterior such as balconies, terraces, porches, and roof gardens aids in generating these connections. To help aid people in spending time outdoors, creating micro-climate conditions with protected or enclosed outdoor spaces will provide protection from strong winds, especially during winter.⁵³ These interconnected spaces between public micro-climates and private balconies allow for more activity to happen within a project.

⁵³ David Sim, 226.

4.0 Alternatives to Suburbs: Case Study Research





fig. 11 Koota Housing Block interior courtyard surrounded by housing blocks

The precedents that have been investigated for this thesis support the architectural integration of low carbon architecture and sustainable urban developments. The projects that were explored utilize design concepts and strategies for mixed use development, densifying urban areas, designing for user well-being, and developing architecture that utilizes low carbon design strategies and adapting to low carbon lifestyles. Most of the projects explored are located in Europe as there are little urban examples of low carbon and sustainable urban development within North America. The projects explored include; Oopeaa's Koota Housing block, Effekts Urban Village, Grand Huit's Railway Farm and C.F. Møller's Snickarglädjen project.

The Koota Housing Block by Oopeaa is designed around the concept of creating an urban village that focuses on social, ecological, and economical sustainability.⁵⁴ The built form is utilized to designate the more public street front, away from the more private courtyards for residents by following the perimeter of the street and situating private dwelling

⁵⁴ "Koota." OPEEA, accessed September 24, 2021, <https://oopeaa.com/portfolio/koota-2/>.

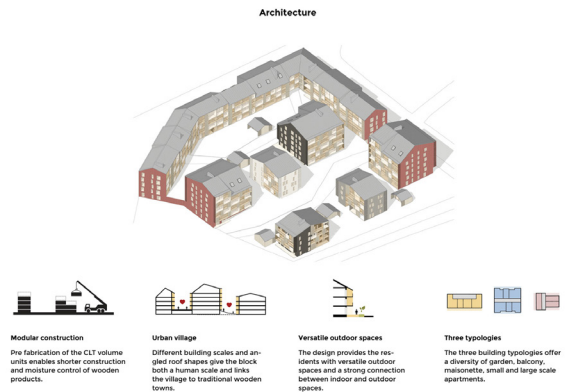


fig. 12 Koota Housing Block architectural site approach

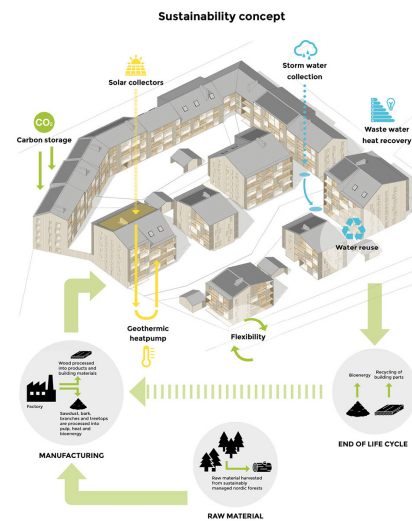


fig. 13 Koota Housing Block sustainability concept

buildings to create private courtyards. [fig. 11 + 12] The project offers a variety of housing typologies for different user groups from single dwellers to families. Contemporary architectural strategies are utilized to minimize carbon emissions in embodied carbon by means of a prefabricated wood structure to minimize waste and sequester carbon.⁵⁵ [fig. 13]

⁵⁵ "Koota."

Effekt's Urban Village is a conceptual approach to building density and community by adapting and growing the to the needs of a changing city. This is employed through the use of contemporary modular wood construction system to provide a mixed use and diverse housing complex.⁵⁶ [fig. 14] The project is designed to reduce carbon from both an operation and embodied perspective by optimizing the construction and designing for disassembly and adaptability while utilizing active design strategies to collect on-site energy. The design focuses on developing an inclusive and diverse urban community with programming and housing that can be catered to the surrounding context and reducing the environmental footprint of the buildings through

⁵⁶ "A Vision for Liveable, Sustainable, and Affordable Homes," *The Urban Village Project*, Accessed November 25, 2021, https://www.urbanvillageproject.com/?utm_medium=website&utm_source=archdaily.com.



fig. 14 Urban Village entry with commercial ground floor and residential above

a kit of parts construction process. The project establishes a housing model that is subscription based to increase the affordability and establishes a base for residents and investors that are interested in sustainable living. Renters can work to ownership by buying shares in the property eliminating down payments and interest rates for first time buyers.⁵⁷ [fig. 15 + 16] The project provides a multi-faceted approached with a variety of living options from a single person, group of roommates, to families or multi-generational families.⁵⁸

⁵⁷ "A Vision for Liveable, Sustainable, and Affordable Homes."

⁵⁸ Megan Schires, "IKEA Explores Future Urban Living for the Many," *Archdaily*, June 4, 2019, <https://www.archdaily.com/918417/ikea-explores-future-urban-living-for-the-many>.

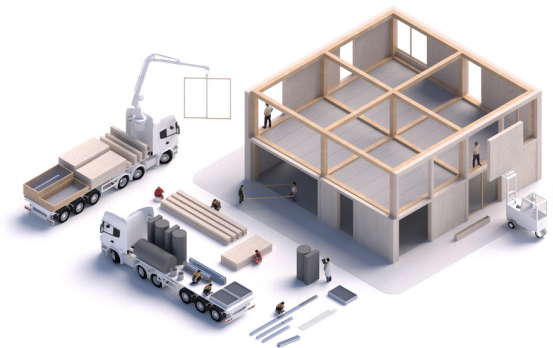


fig. 15 Urban Village kit of parts construction method

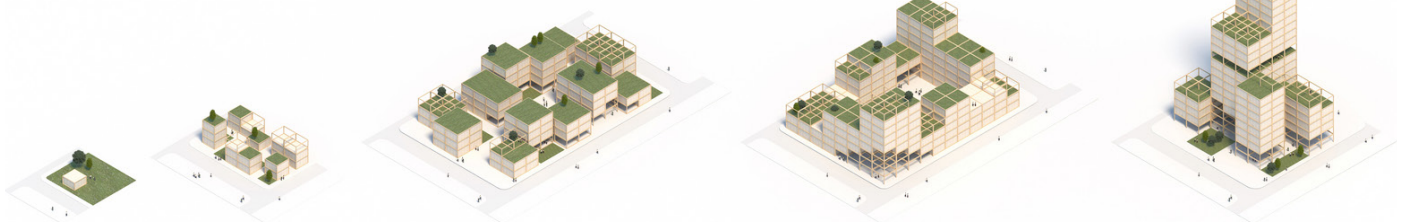


fig. 16 Urban Village adaptable site approach

The Railway Farm Project designed by Grand Huit is a neighbourhood that is designed around urban agriculture, recovering local organic waste and organic waste that is produced during the food production process. [fig. 17] The project utilizes a circular economy of shared food and resources that brings together a community of low-income individuals and horticultural students.⁵⁹ There is an emphasis on all of the programs within the building working together to create a circular economy that not only supports those that inhabit the project but penetrates into the greater community. Urban agriculture is integrated into every level of the architecture, spanning from the ground floor greenhouses to in unit and on the roof. [fig. 18] The intention is to minimize the need for energy, food, and economic resources by implementing programming that includes a restaurant and grocery store that sell food produced on site and welcomes partnering farmers.⁶⁰ With the use of mass wood construction, an innovative envelope system is designed to control carbon emission through bioclimatic treatments for both summer and winter conditions.⁶¹



fig. 17 The Railway Farm greenhouse



fig. 18 The Railway Farm courtyard with gardens

⁵⁹ Carlos González, “Much More than a Farm, The Railway Farm by Grand Huit, Melanie Drevet,” *Metalocus*, February 9, 2022, <https://www.metalocus.es/en/news/much-more-a-farm-railway-farm-grand-huit-melanie-drevet>.

⁶⁰ “Rail Farm,” *Grand Huit*, Accessed February 10, 2022, <https://grandhuit.eu/projet/ferme-du-rail/>.

⁶¹ “The Rail Farm,” *Ferme du Rail: Paris Ourcq*, Accessed February 10, 2022, <https://www.fermedurail.org>.



fig. 19 Snickarglädjen perimeter buildings framing an interior courtyard



fig. 20 Snickarglädjen passive and active design strategies

Finally, Snickarglädjen by C.F. Møller Architects is a timber residential block housing 120 apartments built on the principles of the *Garden City* concept.⁶² To distinguish between public and private, landscaping and framed courtyards are utilized to provide outdoor environments focused on recreation, health, and community. [fig. 19] The design is ambitious in encouraging a sustainable lifestyle with diverse housing typologies and community oriented public programming such as food production, outdoor gym, and a playground.⁶³ [fig. 20]

The case studies that were investigated provide insight into holistic approaches to architectural design that reacts to the social and environmental conditions and needs of a site. The projects are useful examples for developing strategies to tackle new housing developments that encourage lifestyle changes through an architectural design that responds to the climatic conditions.

⁶² “Snickarglädjen,” C.F. Møller Architects, Accessed March 21, 2022, <https://www.cfmoller.com/p/Snickargladjen-a-modern-garden-district-13750.html>.

⁶³ “Snickarglädjen.”

5.0 Barrie

- 5.1 history of barrie's development**
- 5.2 barrie's urban identity**
- 5.3 the future growth of barrie**

I acknowledge that the City of Barrie resides on the traditional territory of the Anishinaabeg people, which include the Odawa, Ojibwe, and Pottawatomi Nations collectively known as the Three Fires Confederacy. I also acknowledge the Huron Wendat Nation who occupied these lands prior to the middle of the 17th century

“City of Barrie Land Acknowledgement,” City of Barrie, accessed September 29, 2021, <https://www.barrie.ca/Culture/Heritage/Pages/Land-Acknowledgement.aspx>.

5.1 History of Barrie's Development

The City of Barrie is located on the head of Kempenfelt Bay which is on the western edge of Lake Simcoe. [fig. 21] This area marks the end of an Indigenous portage route known as the Nine Mile Portage, which follows Willow Creek, a tributary of the Nottawasaga River that flows into Georgian Bay. The City of Barrie resides on the traditional territory of the Huron-Wendat, Haudenosaunee, and Anishinaabe peoples and was settled during the War of 1812 as a storehouse at the mouth of the Nine Mile Portage.⁶⁴ The post became an important detour for supplies and troops to bypass the United States forces and this route widened in order to transport

goods.⁶⁵ Following the war, the colonial government opened a portion of land on the northwestern edge of Kempenfelt Bay to be surveyed for settlement and was named Barrie after the naval Commodore Robert Barrie who oversaw the construction.⁶⁶ There are several moments over the course of Barrie's history that have attributed to the city's growth.

⁶⁴ Nick Moreau, "Barrie," *The Canadian Encyclopedia*, Article published October 17, 2012; last edited December 16, 2020, <https://www.thecanadianencyclopedia.ca/en/article/barrie#>.

⁶⁵ "A Brief Summary of Barrie's Long History", *Downtown Barrie*, Accessed October 12, 2021, <https://downtownbarrie.ca/a-brief-summary-blog/>.

⁶⁶ Nick Moreau, "Barrie."



fig. 21 Bird's eye view of Barrie,
Ontario 1958

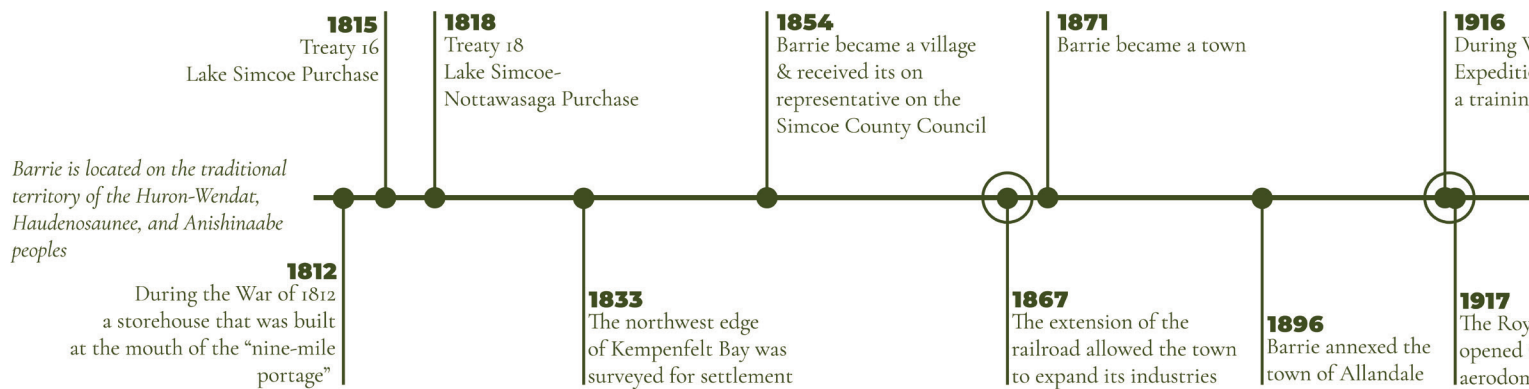


fig. 22 Timeline of historic events and notable moments of growth in Barrie.

In 1867, the area that is now the City of Barrie was divided between two towns on the north and south side of Kempenfelt Bay, Barrie to the north, and Allandale to the south. The Early industry of the area consisted of agriculture and lumber due to the fertile soils and expansive forests.⁶⁷ In 1867, the railway was extended into Barrie, which allowed for the opportunity to expand exports and industry in the area. At this time the industries grew to include transportation as well as expanded its natural resources industry.⁶⁸ Coming to the end of the 19th century, Barrie annexed the town of Allandale as it continued to grow into a larger town.⁶⁹

67 T. Editors of Encyclopaedia Britannica, "Barrie," *Encyclopedia Britannica*, February 12, 2019, <https://www.britannica.com/place/Barrie>.

68 A Brief Summary of Barrie's Long History, *Downtown Barrie*.

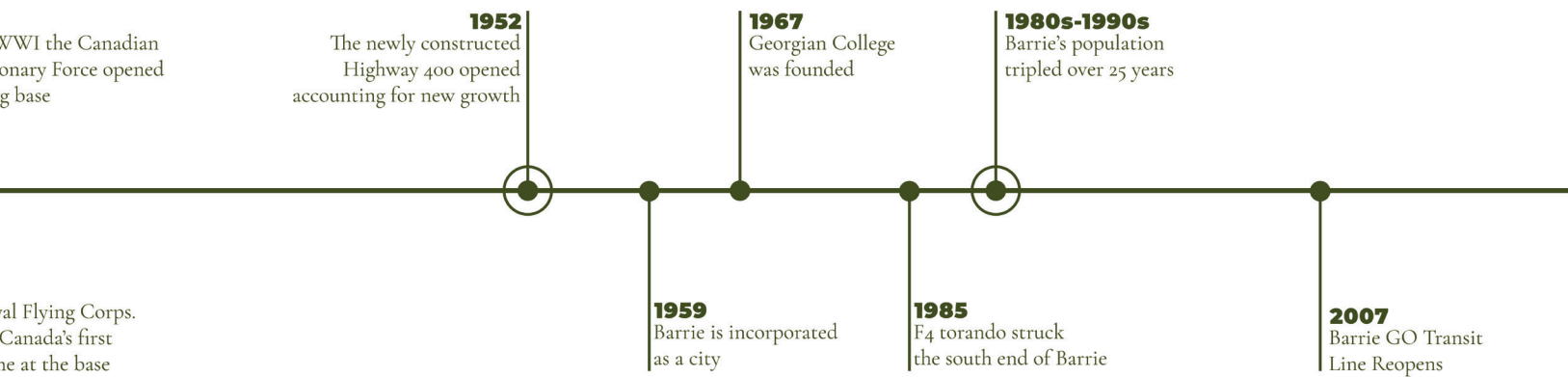
69 Nick Moreau, "Barrie."

During World War I, the *Canadian Expeditionary Forces* and the *Royal Flying Corps*. established a training and aerodrome base southwest of Barrie, Base Borden. This facility is still operational today as Canada's largest training facility and attributes to Barrie's growth and economy as many individuals that work at the base choose to live in Barrie.⁷⁰

Following World War II, when suburbanization was at its peak, Barrie saw an increase in growth due to the construction of Highway 400.⁷¹ This extension of the highway connected Barrie to the City of Toronto, allowing those who wished to escape to suburban living, to easily commute to their jobs in the city. This established Barrie as one of Toronto's furthest bedroom communities due to its prime

70 Nick Moreau, "Barrie."

71 A Brief Summary of Barrie's Long History, *Downtown Barrie*.



location between Toronto and “Cottage Country”. The growth at this time was contained around the western edge of the lake, connecting the Northern Barrie community to the Southern Allandale community and the highway.

around Highway 400 in the South-end of the city. This caused a mass increase in suburban housing, expanding north and south into rural agricultural lands to accommodate for this swift growth over a short period of time. [fig. 21]

While the 1950s established Barrie as a commuter community for those who wished to leave the City of Toronto, there was not much economic activity within Barrie itself until the 1980s and 1990s.⁷² At this point in Barrie’s history, the population tripled over 25 years. This increase in population was driven by new economic opportunities in the city as well as housing being more affordable than in the Greater Toronto Area. The economic opportunities at this time were developed in manufacturing and services that established an industrialized area

⁷² A Brief Summary of Barrie’s Long History, *Downtown Barrie*.

5.2 Barrie's Urban Identity

Coming into the 21st century, the City of Barrie has seen a steady population growth, which can be attributed to its connection to Toronto and vacation areas in the north as well as its economic opportunities. Barrie has a unique opportunity because of its diverse economic, social, and environmental activities and proximities.

Today the City of Barrie has grown to create an identity for itself outside of being a bedroom community for the commuters that travel to Toronto. The current population of the city is approximately 150,000 residents, with an economy that is focused on healthcare, social assistance, manufacturing, retail, and tourism.⁷³ The life of the city is centered around the waterfront where there are public parks, activities, amenities, businesses, and retail for the

residents to enjoy.

Throughout the history of Barrie, it has gone through surges of rapid growth, and as the city has matured, it has developed in horseshoe like rings from the waterfront. [fig. 23] Within the rings there are pockets of service areas for the local neighbourhoods, but the main hub of the city is located at the center and end of the bay. This makes residents highly dependent on vehicular movement to travel, as the infrastructure of the city is designed around the car and not humans. Arterial roads connect the outer neighbourhoods and service pockets to one another and to the downtown, whereas Highway 400 cuts directly through the city, creating a divide for communities in the west from the east. The development of the highway was helpful in growing the city and has become an important aspect of the population of Barrie as many utilize

⁷³ Nick Moreau, "Barrie."



fig. 23 Mapping the City of Barrie's development and sprawl

this route for commuting. As Nick Moreau states:

‘Many residents [of Barrie] commute to Toronto and other cities for work. The 2016 census found that the Barrie Census Metropolitan Area (which includes Innisfil and Springwater) has 95,540 commuters. Nearly one in five of those commuters (18 per cent) have a long commute. A long commute is defined by Statistics Canada as at least an hour spent getting to work. Barrie has the largest proportion of commuters with a long commute of all CMAs in Canada.’⁷⁴

The number of commuters in Barrie is a consequence of suburban development, car-centric living, and the escape of metropolitan areas like Toronto. On average there are approximately 55,000 people who commute using a vehicle in Barrie.⁷⁵ This amounts to 3.26 Megatons of carbon emissions a year per vehicle.⁷⁶ [fig. 24] Due to the issue of Barrie being developed around the car, there is a growing dependency on this infrastructure. Even with the public transit connection to Toronto, via the GO Train, residents still heavily favour driving to get to their destination. In 2019, the daily ridership on the GO Train on average was 742 people and a total of 204,000 people utilized the train in Barrie.⁷⁷ [fig. 25] The ridership on the GO Train has been severely

⁷⁴ Nick Moreau, “Barrie.”

⁷⁵ Government of Canada, “Geography – Find Information by Region,” *Government of Canada, Statistics Canada*, accessed October 17, 2021, <https://www150.statcan.gc.ca/n1/en/geo?MM=1&>

⁷⁶ Government of Canada, “Greenhouse Gases Equivalent Calculator – Calculations and Reference,” *Government of Canada, Natural Resources Canada*, accessed December 7, 2021, <https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/refs.cfm#vehicles>.

⁷⁷ Metrolinx, “Ridership Performance Year to Date,” February 13, 2020, <https://blog.metrolinx.com/2020/02/13/go-transit-ridership-map-updated-find-out-how-your-station-or-lines-are-doing/>.

fig. 24 (top) Commuting by car from Barrie statistics

fig. 25 (bottom) Commuting by rail from Barrie statistics



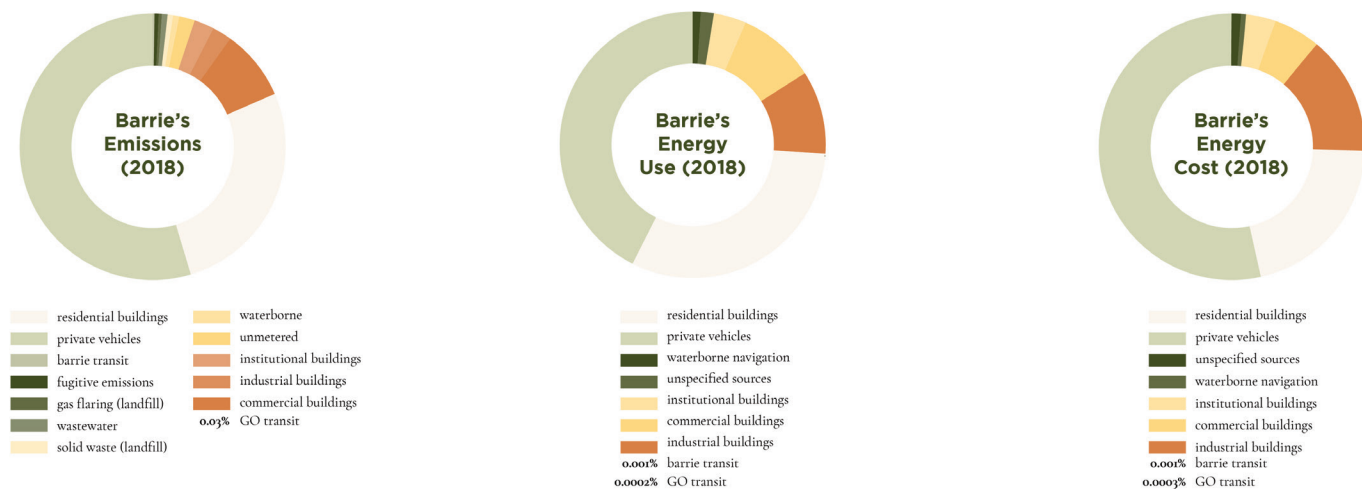


fig. 26 Barrie's emissions, energy use, and energy cost as of 2018

impacted by the pandemic in 2020 where the daily average is less than 100 people utilizing the service from Barrie.⁷⁸ This service is underutilized amongst residents even though it takes the same time to travel to Toronto by train than it does by car.

In 2019 Barrie declared a climate emergency and set out to develop a plan that would reduce greenhouse gas emissions to meet the city's target for net-zero emissions by 2050. As of 2018, the current emissions that are generated in the City of Barrie are approximately 1.06 million tonnes of carbon dioxide. The current amount of energy consumption in Barrie is approximately 20.4 million Gigajoules

of energy, costing approximately \$600 million.⁷⁹ The highest contributors to emissions, energy use, and energy cost in Barrie are residential buildings and private vehicles. If the current trend of energy usage continues without modifications, Barrie will see carbon emissions over 1.4 million tonnes, with the highest contributors being buildings and transportation.⁸⁰ This requires drastic changes to resident's lifestyles to reach the net-zero target by 2050 that the city has set out to attain.

Architectural interventions can aid in reducing carbon emissions at a built scale and influencing

⁷⁸ Metrolinx, "Ridership Performance Year to Date," November 19, 2020, <https://blog.metrolinx.com/2020/11/19/how-covid-has-impacted-transit-metrolinx-releases-ridership-map-covering-all-go-transit-rail-routes/>.

⁷⁹ "Community Energy and Greenhouse Gas Reduction Plan Presentation," *City of Barrie*, April 15, 2021, (video, 12:46) <https://www.youtube.com/watch?v=pU3ypPOWMsY>.

⁸⁰ "Community Energy and Greenhouse Gas Reduction Plan Presentation," *City of Barrie*, April 15, 2021, (video, 12:46) <https://www.youtube.com/watch?v=pU3ypPOWMsY>.

lifestyle modifications at an urban scale. Ways that design can act as an agent for change is by activating the public realm, increasing the density, making spaces more walkable, creating access to amenities that the area is lacking, implementing public space and attractions, and diversifying the housing typology to encourage all demographics to interact with the site. To reduce commuting, architectural programming such as co-working spaces and offices can allow people to work locally, and rather than creating a dependency on the vehicle architecture can create connections to public and active modes of transportation. These strategies will give life to a city by allowing users to live life and interact with one another closer to home.



fig. 27 Barrie's projected greenhouse gas emissions

5.3 The Future Growth of Barrie

Over the next 30 years the City of Barrie is projected to grow into a medium sized city, which ranges in size from 100,000 to 1 million residents.⁸¹ Within this time frame, the city's population is projected to double, and it is an opportunity to plan a more sustainable and resilient city. To plan for this new growth, the city has put together a master planning document for 2051 to have a positive impact on new and existing developments, the economy, social interactions, and the built and natural environment.⁸²

The 2051 *Master Plan* for Barrie has identified strategic areas of growth where new development can occur on a social, residential, sustainable, and economic

⁸¹ "Choose a City," *Government of Canada*, March 31, 2020, <https://www.canada.ca/en/immigration-refugees-citizenship/services/new-immigrants/prepare-life-canada/choose-city.html>.

⁸² City of Barrie, "Barrie Official Plan 2051," 10.

level. Each of the areas identified within the city provide different opportunities for growth. They include; the *Urban Growth Center*, *Strategic Growth Areas*, *Intensification Corridors*, *Major Transit Stations*, and *Employment Areas*. [fig. 28] The *Urban Growth Center* [fig. 29] of the city will develop and extend the downtown area to reinforce it as a hub for business and residential activity, as well as tourism. This area will provide a broad range of uses to the residents of Barrie, including offices, commercial, institutional, cultural, and residential typologies to establish a high-density area within the core of the city. The *Strategic Growth Areas* [fig. 30] are key locations that have been identified throughout the city that promise higher levels of intensification. These areas will be developed as long-term centers for activity with mixed-use design for residential, economic, and social growth. The *Intensification Corridors Areas*



0.5 1 2km

fig. 28 Barrie's 2051 Master Plan
Map

[fig. 31] are arterial streets that connect Barrie’s growth centers to one another, which are planned for higher density, mixed-use development, and support public and active modes of transportation. The *Major Transit Station Areas* [fig. 32] are the areas around and including high transit stops in the urban core of the city. These are the Barrie South GO station and the Allandale Waterfront GO Station, which are significant connection points to Toronto. The areas allocated will be protected for transit use and are within a ten-minute walk to the station. The transit areas will be pedestrian friendly, support active and public transportation, provide a diverse mix of uses, as well as a variety of housing options, including affordable housing. Finally, the *Employment Areas* [fig. 33] are allocated zone of economic opportunity for attracting jobs in the clustered areas of office, business, and manufacturing zones. Within these areas, land will be provided to promote economic activity in Barrie allocated to industrial, manufacturing, warehousing, major offices, and major retail and commercial.⁸³ Each of these areas provide promise for further development and densification within the existing city limits.

The plan for growth allocates 50% of the new developments to the *Urban Growth Center*, *Strategic Growth Areas*, and *Major Transit Stations* and 50% to new developments within the *Greenfield Sites* located on the South-end of the city. The *Greenfield Sites* [fig. 34] are agricultural land that is intended to be used for sprawling suburban neighbourhoods, parks, and schools.⁸⁴ This intended use for the land goes against the city’s objective for generating more

⁸³ City of Barrie, “Barrie Official Plan 2051,” 15-21.

⁸⁴ City of Barrie, “Barrie Official Plan 2051,” 25.



fig. 29 Barrie’s 2051 Master Plan
Map, Urban Growth
Center



fig. 30 Barrie’s 2051 Master Plan
Map, Strategic Growth
Areas



fig. 31 Barrie's 2051 Master Plan
Map, Intensification
Corridors



fig. 32 Barrie's 2051 Master
Plan Map, Major Transit
Station Areas



fig. 33 Barrie's 2051 Master Plan
Map, Employment Areas

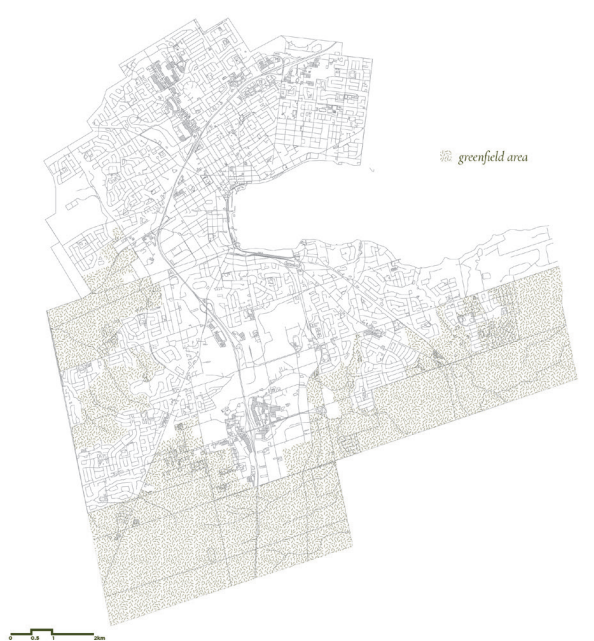


fig. 34 Barrie's 2051 Master Plan
Map, Greenfield Areas

complete neighbourhoods within the core of the city.⁸⁵ By planning for new developments to occur on unoccupied land means that new infrastructure, services, and amenities will need to be provided for the area to create a small community on the perimeter for the city. With respect to the location of these new developments occurring on the outskirts, the residents will still be dependent on vehicles to travel to the inner city for certain services and the amenities and attractions of the core. Therefore, there should be an emphasis on densifying the existing limits of the city, to generate holistic and self-sufficient neighbourhoods. By doing so, the city will become more walkable and pedestrian friendly, which will promote public and active forms of transportation, create smaller interactions between commercial and residential typologies, it will produce density to reconnect the neighbourhoods to one another, and emphasize a connection to the natural environment.

Within the 2051 *Master Planning* document, there are a series of objectives for developers and planners to meet when undertaking projects. The objectives aim to provide guidance and standards to attain a higher level of design excellence for a more livable city. The objectives are planning to generate a(n), *attractive city*, *connective and mobile city*, *waterfront and green city*, *resilient city*, *prosperous city*, and *cultural city*. While these objectives are aimed at an urban city scale, this thesis aims to align with the following strategies at an architectural scale; an *attractive city*, a *connective and mobile city*, and a *resilient city*. The strategies for creating an *attractive city* will aim to increase the standards for design practices and elevate the goals for sustainability and resiliency. This

⁸⁵ See Note 84 above.

entails designing for the human scale, diversity, and equity within the city.⁸⁶ By designing to the context, new built form should transition in accordance with the scale and different types of buildings it surrounds. The thesis will provide a diverse design to accommodate all uses of public and private spaces that are needed for the site. A *connective and mobile city* prioritizes public and active transportation networks with attractive and complete streets.⁸⁷ This means the streets should prioritize walkability and active transportation methods as much as public and vehicular transportation on roads. These spaces should be inclusive and accessible to all members of the community. Designing for a *resilient city* is the most prominent objective of the plan from an architectural perspective within this project. The city aims to reduce energy and carbon emissions to reach its target for net-zero emissions by 2050. To attain this goal, the city plans to adopt a circular economy to reduce waste and regenerate natural systems.⁸⁸ To align with this strategy, architecture can adapt this methodology by assessing the lifecycle of the building and designing to adapt to future needs and end of life. Another aspect of this objective is to protect the natural environment and design for climate resiliency at all scales. New built forms should maximize energy efficiency through the performance of the building, while working with respect to the natural surroundings.

The City of Barrie needs to work on densifying the existing core before opting for new development on the outskirts of the city. Any new projects that are

⁸⁶ City of Barrie, "Barrie Official Plan 2051," 60.

⁸⁷ City of Barrie, "Barrie Official Plan 2051," 82.

⁸⁸ City of Barrie, "Barrie Official Plan 2051," 133.

undertaken within the city need to align with the goals of creating a low carbon living environment. Developing a low carbon lifestyle for users will decrease the dependency on vehicles for travel and generate more dense and liveable neighbourhoods. This is immensely important for a city like Barrie, as the major carbon emissions contributors come from private vehicles and residential buildings. The strategies that were observed play a part in developing a discourse in low carbon design, but developers and planners need to integrate this approach at an urban and architectural level to influence lifestyle changes of the residents in a city.

6.0 A Low Carbon (Sub)urban Housing Framework

6.1 site selection

6.2 site analysis

6.3 program

6.4 framework design strategies

The Low Carbon Housing Framework was developed through the methodology along with the theoretical framework. The methodological approach to the thesis primarily focused on second source readings, historical research, empirical analysis, synthesis of research through diagrams and infographics, and precedent research. Analyzing the history and development patterns of suburban communities and their impacts on city life informed a comprehensive understanding to initiate a sustainable housing approach to densify the city. Through empirical analysis and site visits, it became evident that the approach to the project must be rooted in its context and these findings were synthesized through diagrams, infographics, and cartographic mapping exercises. Investigating precedents informed the Low Carbon Framework by analyzing the design strategies that were employed to generate liveable,

dense, and low carbon housing conditions. With these methods of research, a Low Carbon Housing Framework was developed to depict how a site should be approached through quantitative and qualitative analysis to determine the programming and design strategies that are applicable for carbon reduction from an architectural and lifestyle approach. [fig. 35]

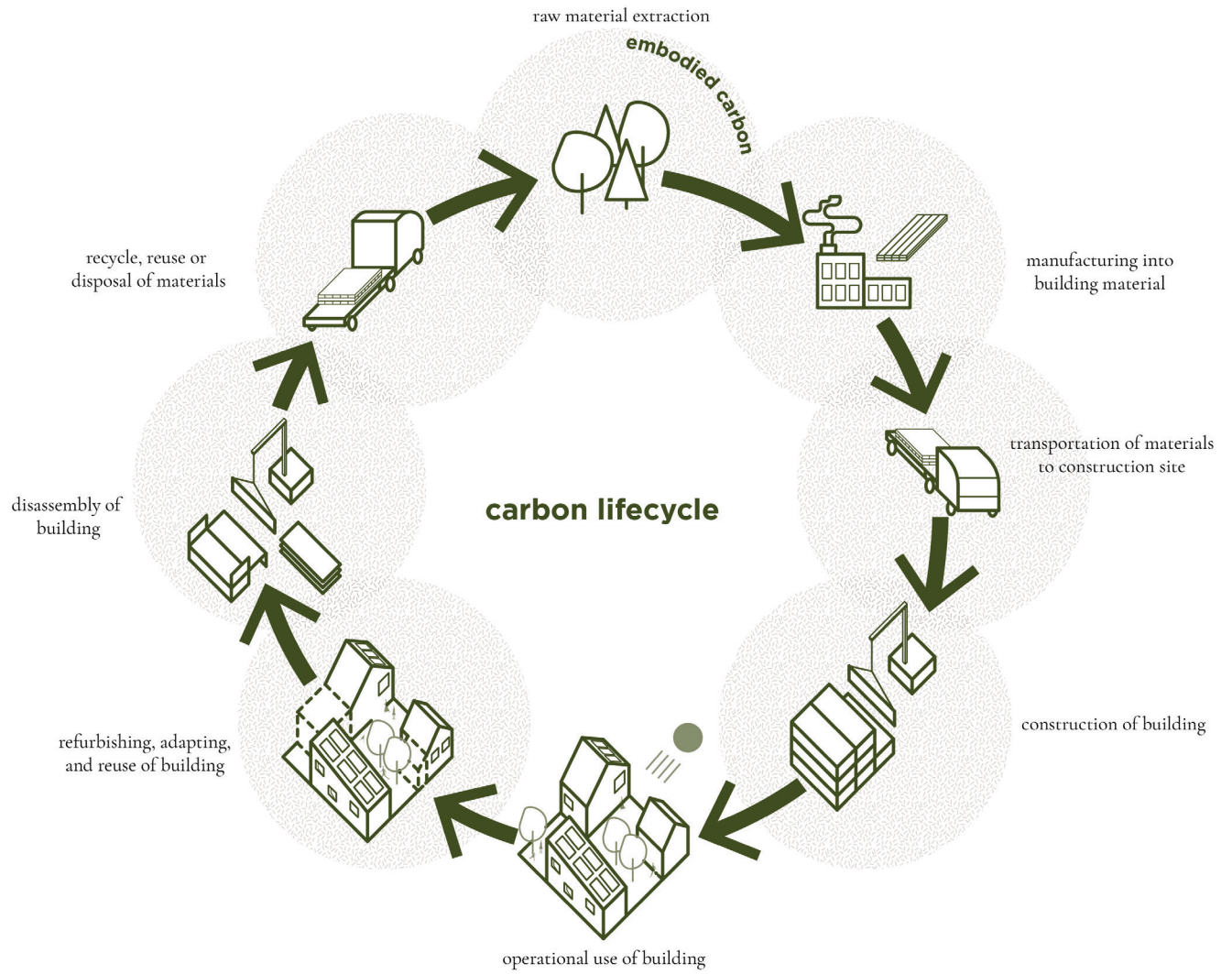


fig. 35 Project's carbon lifecycle

6.1 Site Selection

To design a dense and liveable neighbourhood, new developments must depend on surrounding context to expand and contribute to life in the city. As cities like Barrie look to accommodate new growth, they need to prioritize the densification of the built-up area before resorting to occupying outskirt greenfield sites. There are opportunities to do so in areas between self-reliant neighbourhoods, which can be referred to as (sub)urban. These neighbourhoods exist between neighbourhoods or between suburban and urban conditions, where individuals are heavily relying on vehicles for everyday travel as amenities are not within proximity. To begin to live with the changing climate, cities like Barrie, need to become more interconnected between neighbourhoods to promote more walkable, liveable, and environmentally sustainable conditions.

As the city of Barrie was primarily developed around the vehicle as the primary mode of transportation, the city began to sprawl faster than it could densify. This creates an opportunity to situate the architectural intervention on a site located within the (sub)urban zones between suburban neighbourhoods. [fig. 36] The site for the architectural proposal is located on the edge of the Downtown and the neighbourhood of Allandale, which used to be occupied by a now demolished used-car dealership. The site is located within the urban growth center of the city, to the west sits a commercial strip along an arterial road that travels towards the downtown. To the east of the site is the recreational hub of the city, the lakefront which is home to walking and cycling trails around the bay and cultural attractions. The area that the site is in lacks the density and proximity to amenities and services that both Downtown and Allandale

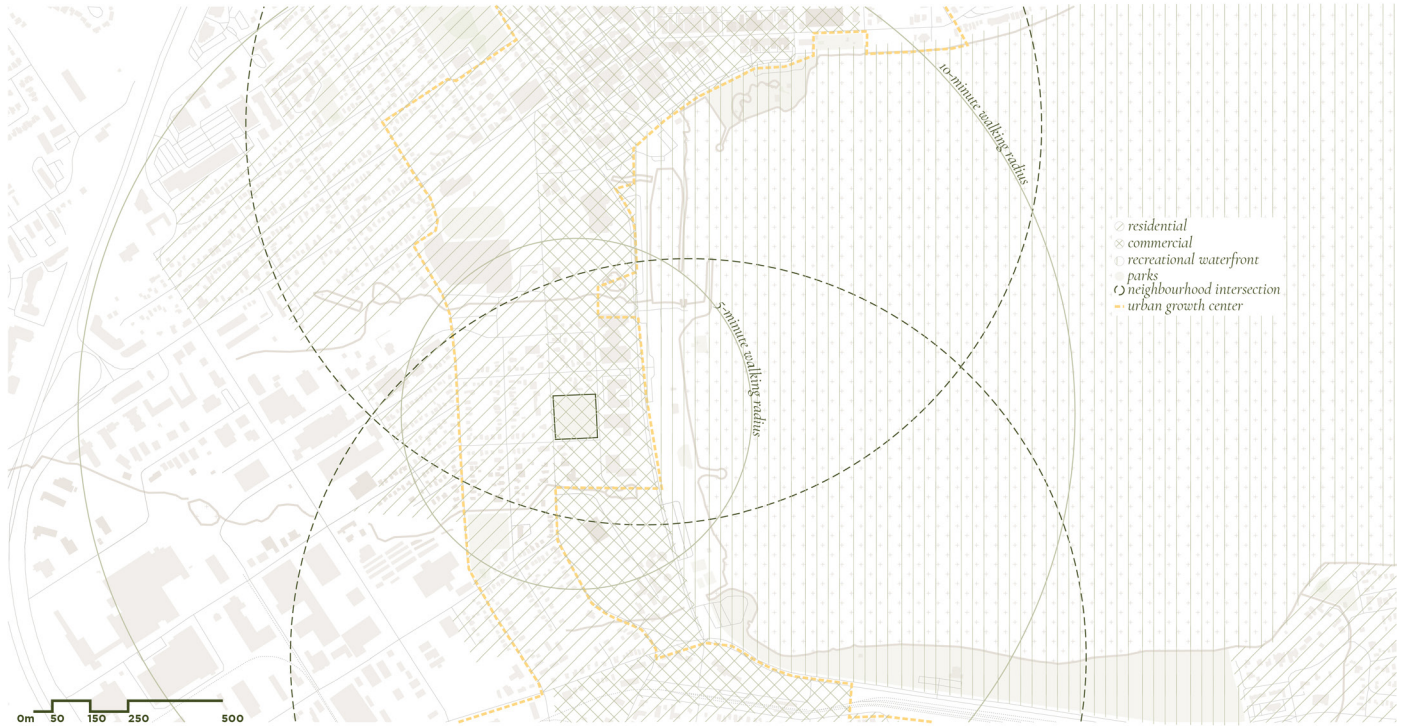


fig. 36 Mapping the forces that act on the project's site

have access to. Therefore, there is an opportunity to extend, and connect downtowns density and walkability around the bay to the surrounding neighbourhoods of the city through the use of low carbon architecture and lifestyle design strategies.

6.2 Site Analysis

Following the site selection, it must be analyzed from a quantitative and qualitative perspective which informs the programmatic and architectural approach to the design. The site analysis informs how the site can be developed and what services and amenities will support the surrounding neighbourhood to develop a community that is rooted in its context.

1. quantitative analysis

A quantitative analysis assesses the climatic impacts on the site in order to optimize passive and active design strategies. Solar radiation, solar shading, wind speed and direction, and dry bulb temperature data were projected onto the site to analyze the optimal opportunities for design interventions. [fig. 37-39] The solar radiation and shading study help to determine the zones on the site that are ideal for

outdoor gathering spaces and building masses that do not shade the exterior spaces. Due to the large condominium buildings along the eastern edge of the site, the northwestern side of the site has the most optimal opportunity for solar access. The wind analysis further depicts areas for exterior gathering spaces along with harnessing natural ventilation during the summer months. From this analysis, it has become evident that the predominant wind direction comes from the north-west in the winter and summer as well as south-east in the summer. Therefore, building to the edge of the site on the north-west will create a microclimate condition for an exterior public space. These buildings should not be too high to ensure that it is not blocking the rest of the building masses to the south from harnessing natural ventilation.

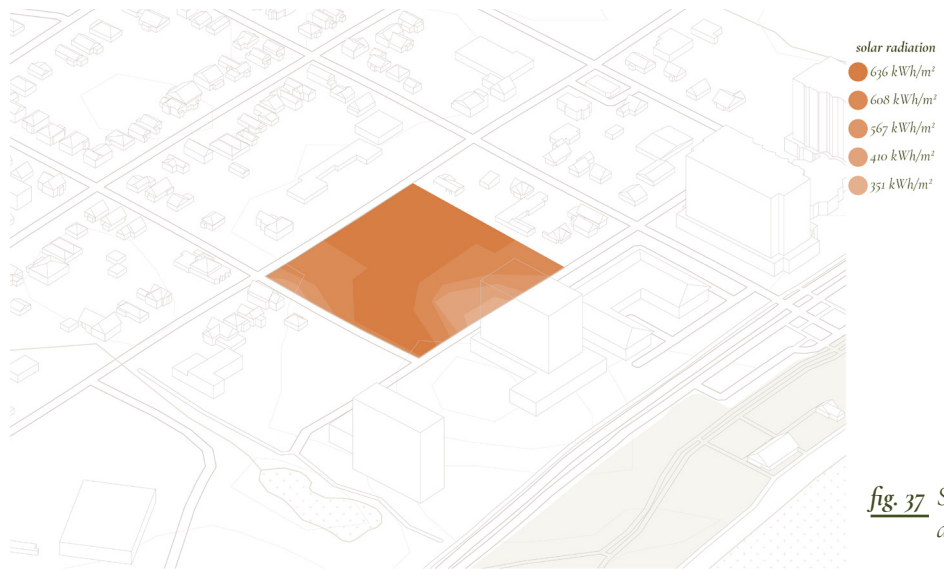


fig. 37 Solar radiation analysis

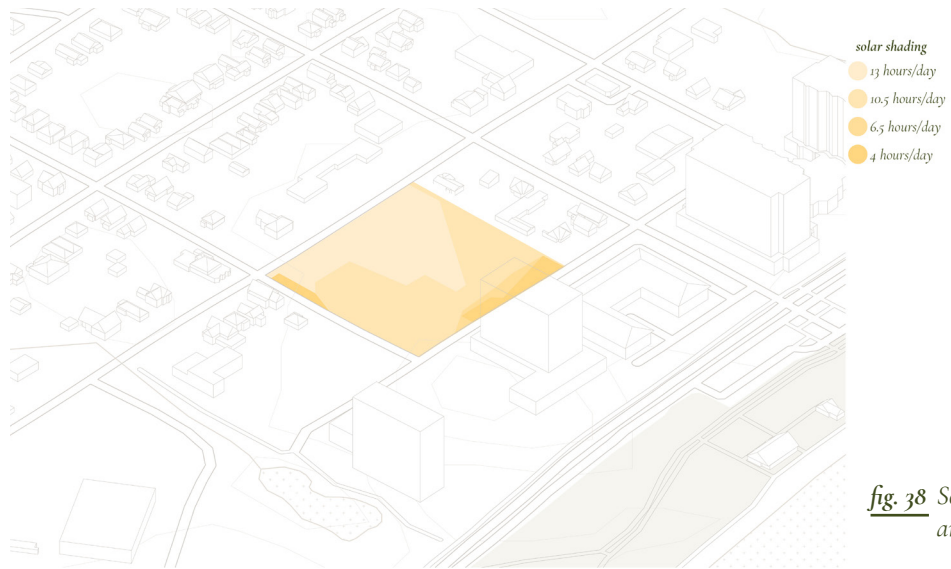


fig. 38 Solar shading analysis

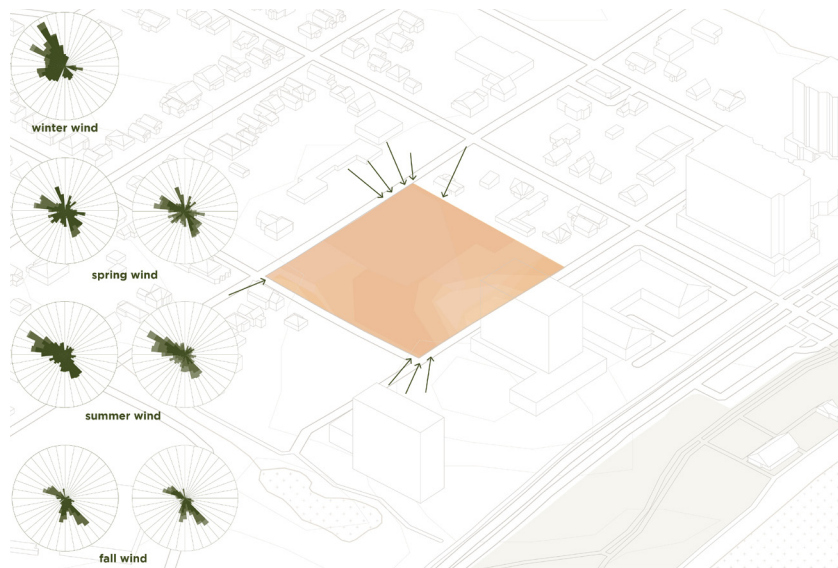


fig. 39 Wind direction and dry bulb temperature analysis

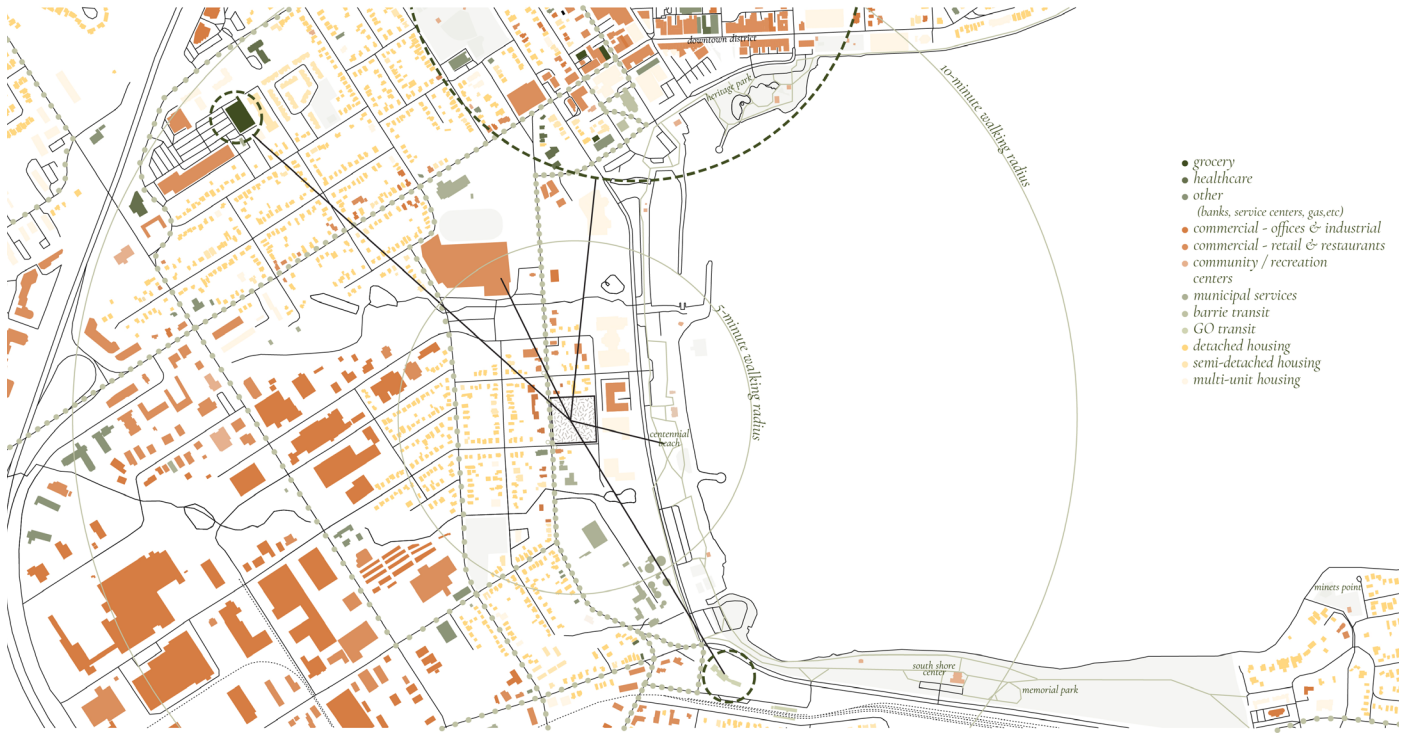


fig. 40 Existing services, businesses and amenities within site context

1. qualitative analysis

To understand how to implement lifestyle strategies onto the site, a qualitative analysis was overlaid onto the quantitative analysis to study how individuals would access the site, traffic flows and transit opportunities, connections to amenities and services within proximity and the potential views and vistas of the lakefront. A major connection that is integral to the design is visually and physically connecting the project to the lakefront. **[fig. 40 + 41]** An axis that cuts across the site connects the site from Bradford Street to the lakefront using a pedestrian street condition activated with a public plaza. Due to the majority of traffic and transportation access coming from Bradford Street onto the site, a generous opening with public programming opens the street front to welcome users onto the site. Due to the north, east, and southern street fronts of the site

being inherently more private and having less traffic, denser proportions of housing units were placed in these areas to frame private outdoor spaces for residents. The commercial and housing typologies have been developed based off this analysis and understanding of the site's context.

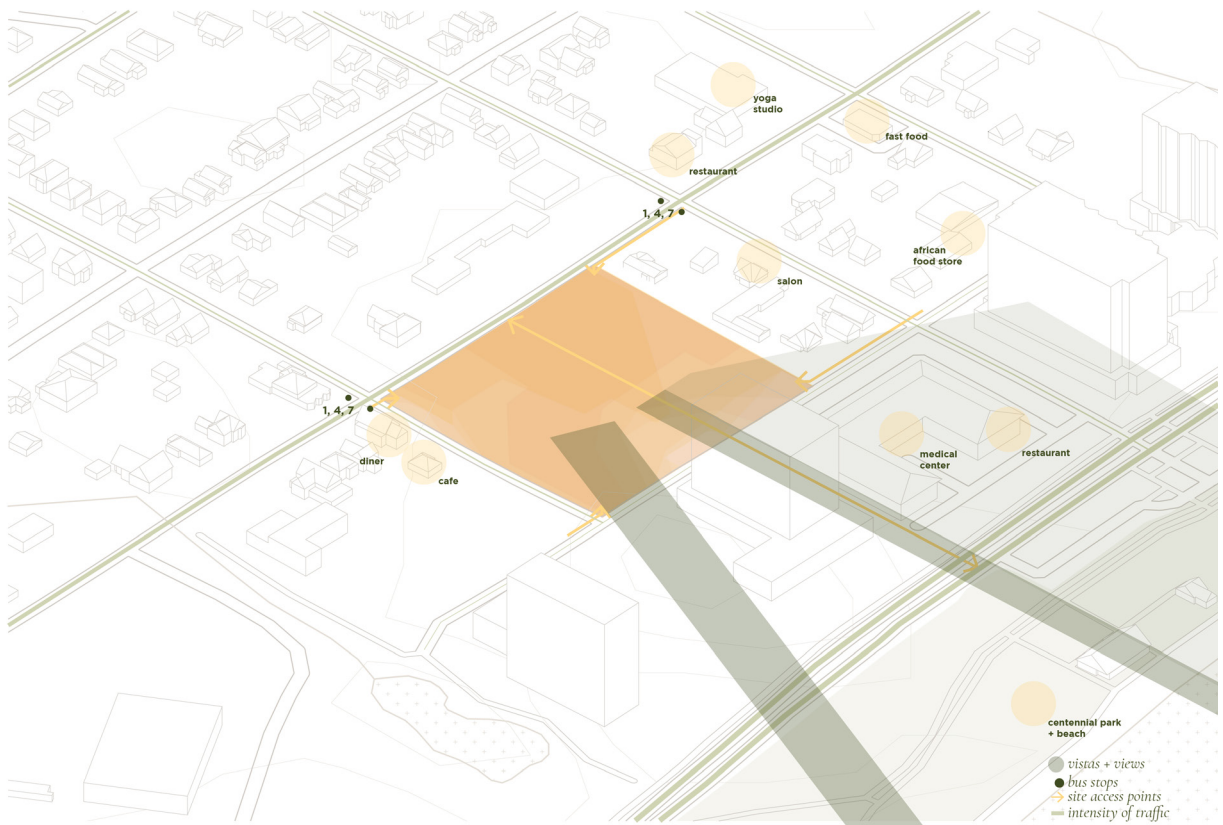


fig. 41 Qualitative site analysis exploring views, vistas, pedestrian access points, businesses and services within proximity, and traffic flow around the site

6.3 Program

The project's program is defined by the quantitative and qualitative analysis as well as by what amenities exist within proximity to the site. A diverse mixed-use approach to the program generates opportunities for a higher quality of life for those that inhabit these spaces as well as connecting people to one another and with the life that surrounds them.⁸⁹ Diversity within cities is generated by developing co-existing activities, such as dwelling, working, and learning, which promote and encourage life within the context of the built form.⁹⁰ Therefore, the programming is dependent on enhancing the existing context and providing services and amenities that are not within a walkable distance.

The site is located on Bradford Street, which has

⁸⁹ David Sim, 3.

⁹⁰ David Sim, 212.

pockets of commercial activity leading towards downtown. [fig. 42] Within a five-minute radius of the site there are locally run businesses and services such as medical clinics, a yoga studio, hair salons, restaurants, a café, and bakery. For recreational activity, the lakefront is located 5 minutes away which has walking and cycling trails, and the downtown district is a 10-minute walk to the north and includes local businesses, retail, and restaurants. To encourage proximity and density within this area, a commercial ground floor program was developed to provide adaptable commercial units for small businesses. This includes a café and restaurant to encourage life on site throughout the day and night, as well as a co-working space to provide a workspace for individuals on site, reducing commutes. A daily market was implemented to provide access to local food for residents and the community as the closest

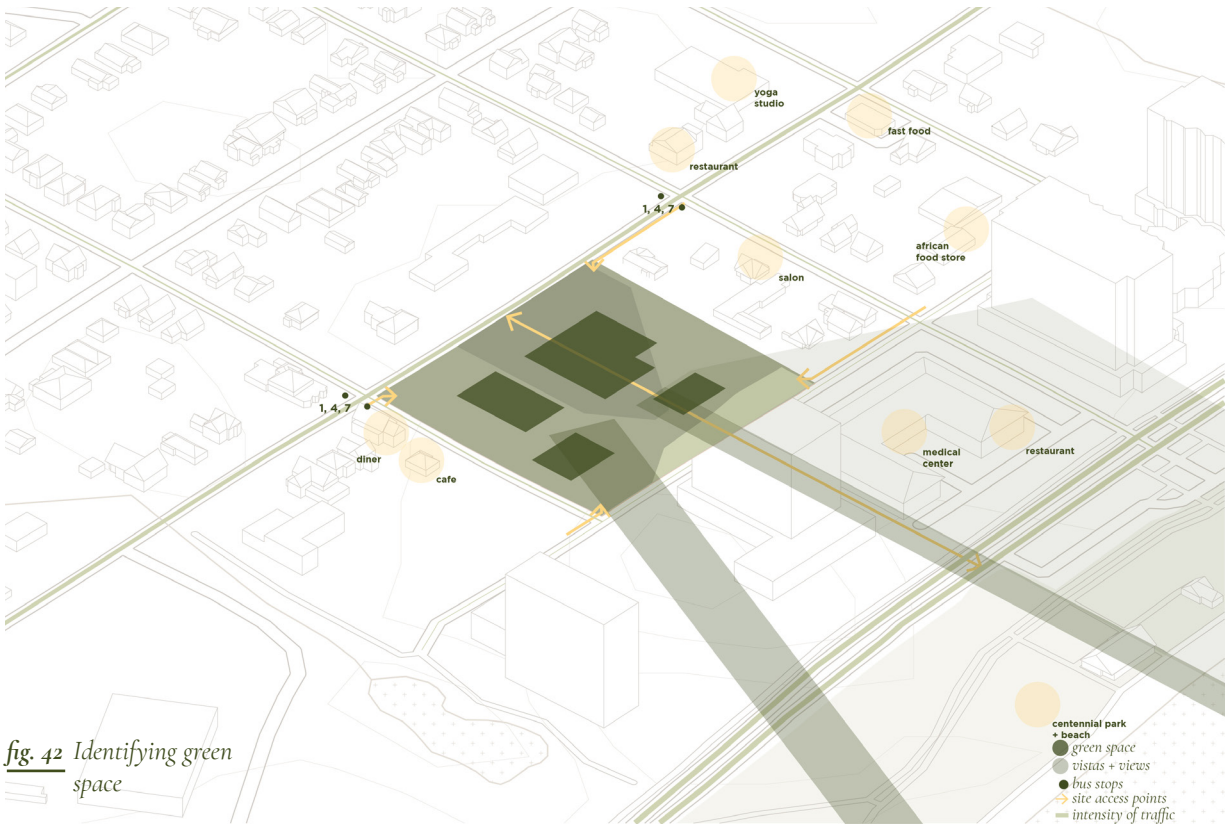


fig. 42 Identifying green space

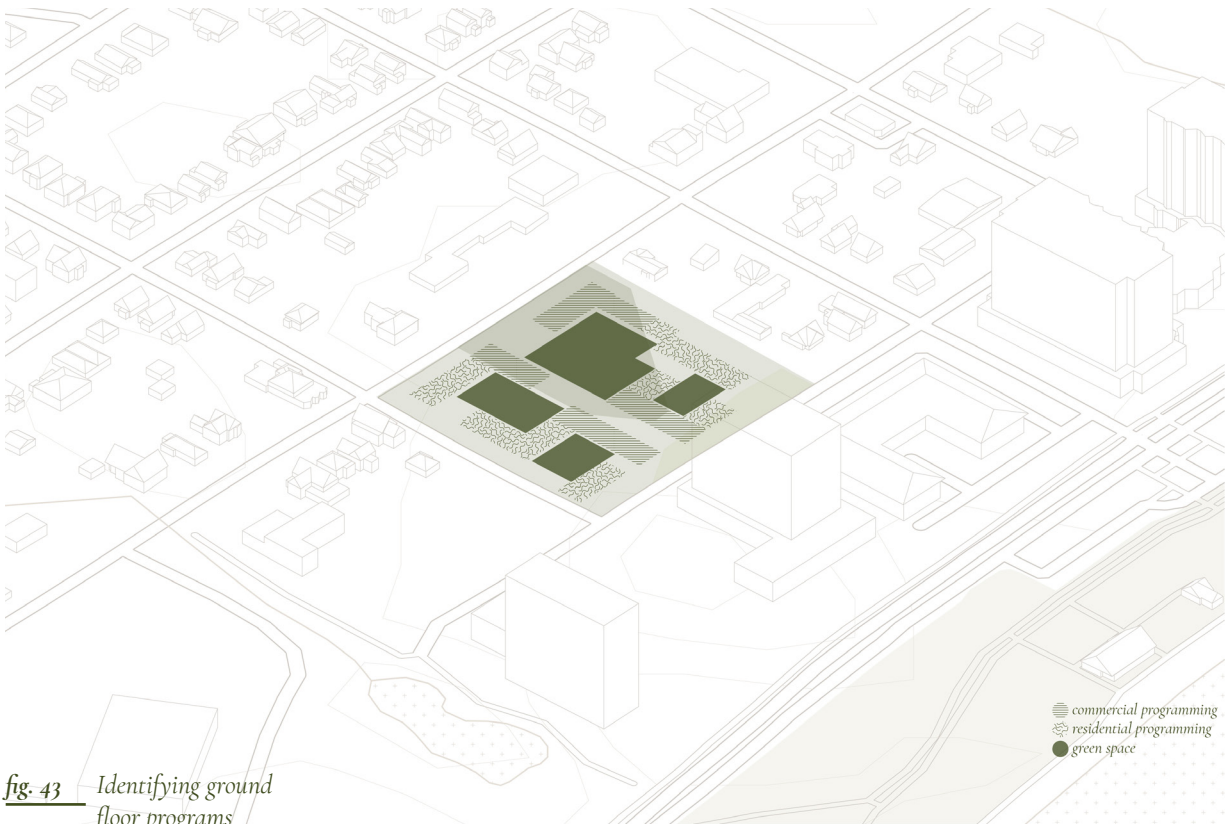


fig. 43 Identifying ground floor programs

grocery store is over 10 minutes away. [fig. 43] The commercial programming activates the ground floor throughout all times of the day and is designed with the intention to be adaptable as the site and city changes.

The housing typologies are generated by the current and future needs within the city of Barrie. 40% of Barrie's population is between 20 and 44, and 11% of the population is 65 plus and is projected to increase to 19%. Therefore, there is a demand for family housing for lower wage paying jobs and senior housing.⁹¹ Barrie Municipal Non-Profit Housing Corporation has indicated that there is also a high demand for 1-bedroom units to house seniors and singles. The city is projected to account for 40% of the future job growth in Simcoe County, therefore, "[t]he availability and affordability of housing is an important factor in attracting a strong and agile labour force to Barrie which in turn assists the city in attracting employers."⁹² The City of Barrie's 2051 *Master Plan* also requires 20% of the housing units developed should be affordable housing, to ensure that there is a variety of housing options.⁹³

Over the next 25 years, the city of Barrie's population is projected to grow at a rate of 2.2%, higher than the provinces average growth rate of 1%.⁹⁴ [fig. 44] Most of the growth that is anticipated will be driven by migration from within the province seeking an area that is within proximity to Toronto and "cottage

country" to the north. It is estimated that the majority of individuals migrating to Barrie will be within the 0-54 age group who are seeking housing for existing and future families, young professionals, and retirees.⁹⁵ Over this time, Barrie's housing mix forecast will begin to transition from low density to medium and high density housing, providing the opportunity to provide more dense living conditions within the city that challenge the lifestyles that are typically generated by low-density conditions. [fig. 45]

To accommodate for the current housing needs and the future growth of the city, two housing models are utilized rental and ownership, with 20% of the rental apartments being allocated to affordable subsidized housing. [fig. 46] There is a diverse mix of housing typologies to adapt and accommodate to the growth of the city with 1-bedroom plus den rental apartments, 1-bedroom plus den loft units, 2-bedroom rental apartments, 2-bedroom plus den rental apartments, and 3-bedroom townhouses on the ground floor. These typologies are influenced by the current and future housing needs in Barrie, where one-bedroom rental units and family housing are what is primarily needed.

⁹¹ City of Barrie Planning Services Department, *Affordable Housing Strategy: A 10-Year Plan*. February 2015, 5.

⁹² City of Barrie Planning Services Department, *Affordable Housing Strategy: A 10-Year Plan*, 5.

⁹³ City of Barrie, "Barrie Official Plan 2051," 133.

⁹⁴ Watson & Associates Economists Ltd, *Long-Term Growth Scenarios Review: City of Barrie*, October 28, 2018, 1-2 – 1-3.

⁹⁵ Watson & Associates Economists Ltd, *Long-Term Growth Scenarios Review: City of Barrie*, October 28, 2018, 3-3 – 3-4.

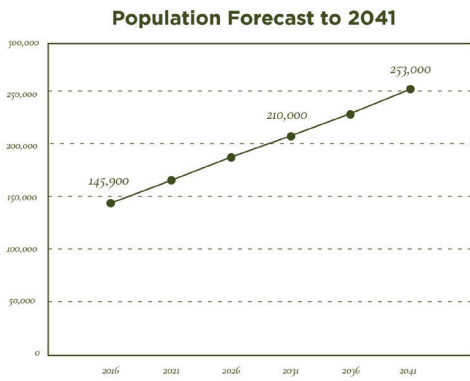


fig. 44 Barrie's population forecast

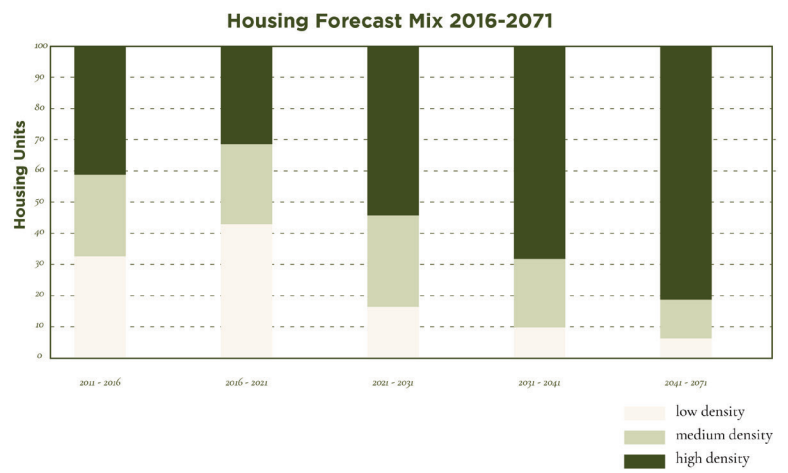


fig. 45 Barrie's housing mix forecast

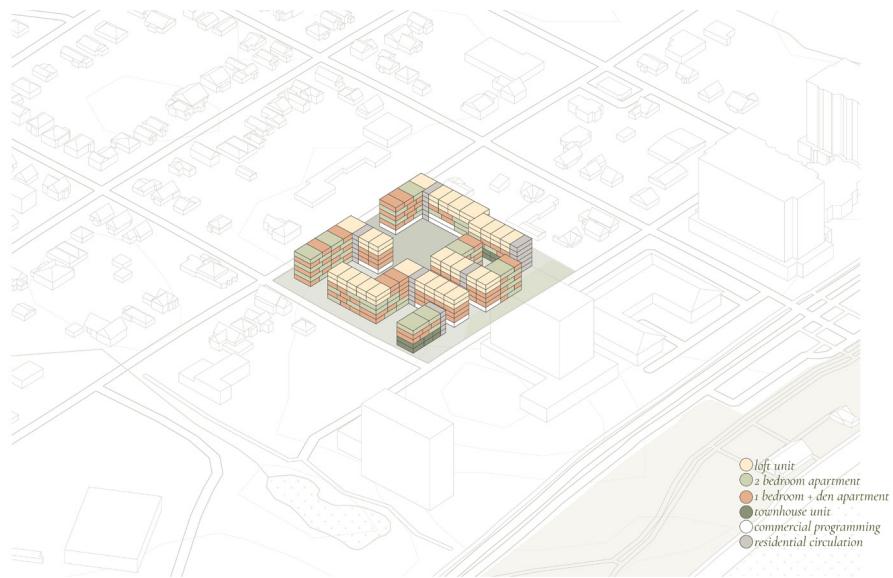


fig. 46 Unit stacking on top of commercial programming

6.4 Framework Design Guidelines

The framework must be able to adapt to the specific conditions of a site to best integrate the architecture into the surrounding context. This begins with site analysis from a quantitative and qualitative perspective to inform how the design begins to take shape on the site. The design strategies that have been developed are rooted in theory on low carbon architecture and sustainable urban development, and low carbon lifestyles. The aim is to address housing from architectural, urban, and low carbon perspectives in order to have positive impacts on both the climate and occupant lifestyles.



identity + inclusivity



community gardens



human scale



local + recycled materials



diversity

1. architectural design strategies

Designing at the architectural scale places an emphasis on designing for the human scale to offer comfort and well-being for those living in and around the buildings. [fig. 47] Strategies that should be implemented into the built form include; identity and inclusivity, diversity, human scaled design, local material and typology precedents, and community gardens or gathering spaces. These strategies provide the opportunity for individuals to identify with the built form and provides spaces to bring people together.

fig. 47 Architectural design strategies implemented into the project's design



proximity



variety of outdoor spaces



microclimate



providing parking alternatives



density

2. urban design strategies

Designing for the urban scale leans on the context of the site to generate new life and activities on the site.

[fig. 48] This utilizes strategies such as designing a variety of outdoor spaces, microclimates, providing parking alternatives, and increasing density. Providing connections to the context enriches a project to provide a high quality of life for residents and community members who use the site.

fig. 48 *Urban Design Strategies implemented into the project's design*

3. low carbon design strategies

Low carbon strategies should be implemented to target both the operational and embodied carbon of the built form. [fig. 49] Utilizing strategies such as passive solar shading in the summer, natural ventilation, passive solar heating in the winter, solar net grid connection, and optimizing the construction of the built form. By utilizing these methods of design, simplifying the construction, and minimizing the operational impact of the building masses, it will aid in promoting positive impacts on lifestyles and behaviours to contribute less to individual carbon footprints.

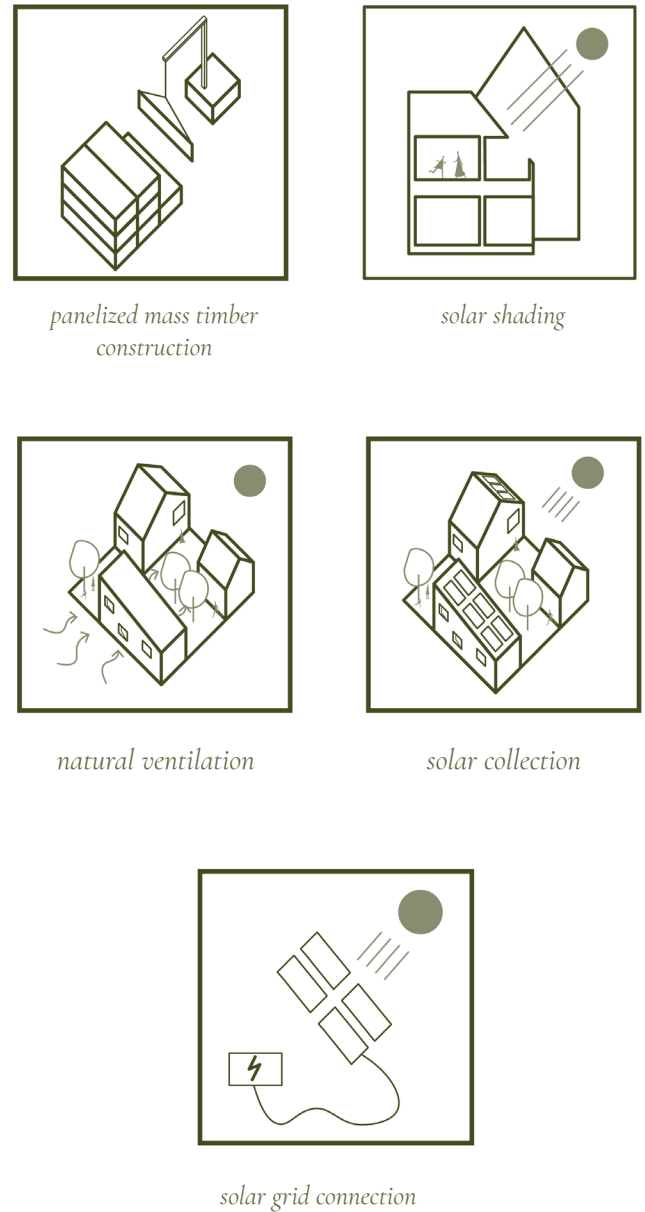


fig. 49 Low carbon design strategies implemented into the project's design

7.0 Thesis Project

7.1 urban design

7.2 low carbon design

7.3 architectural design

7.4 project metrics

The qualitative and quantitative analysis of the site and context inform how the built form will be developed on the site. The design strategies are utilized to carve spaces that respond to the quantitative analysis and bring life onto the site from a lifestyle and qualitative perspective. Throughout the process, optimization of the building forms were run continuously through the climate study software to visualize how the site and structure would react to the environmental conditions and how the masses impact the site. [fig. 50] The buildings impact on the site were studied by observing the shadows that are cast and how they affect the green spaces, as well as the potential solar collection on the roof tops. The building masses are modified by adding and eliminating storeys and integrating roof slopes, to react to the climate data. This ensures that there is ample access to sun within the green spaces by

minimizing the height of the massings located on the pedestrian street, where it is already more shaded by the surround context. [fig. 51 + 52] To address the prevailing winds from the north-west, the building masses toward the south of the site should be higher than the north-west to ensure those units capture natural ventilation.

The thesis project utilizes architectural, urban, and low carbon design strategies to propose an alternative housing development that minimizes carbon emissions from a lifestyle and architectural perspectives. The project addresses key areas of carbon emissions in housing, transportation, and food access, and uses the design strategies to create a liveable environment that is rooted in its context.

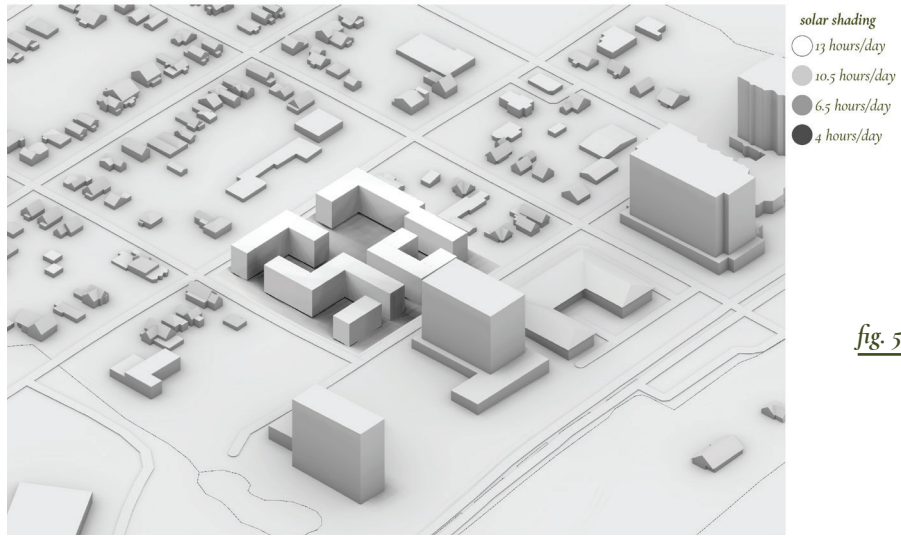


fig. 50 Running the massing through solar shading analysis (summer shown) to understand the implications the massing has on the site



fig. 51 Running the massing through solar radiation analysis (summer shown) to understand the implications the massing has on the site

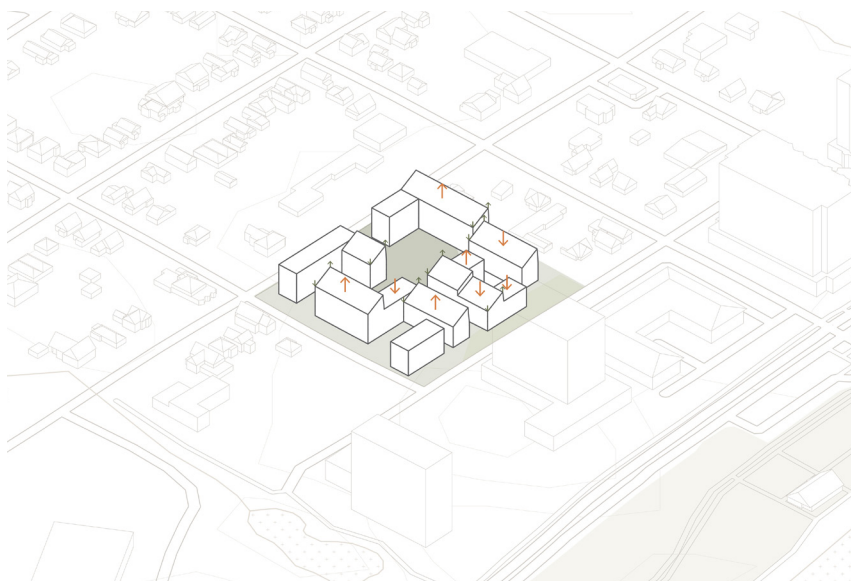


fig. 52 Modifying the massing based off of the solar study of the building forms.

7.1 Urban Design

1. outdoor spaces + microclimates

Through the site analysis, the first locations of the project that were determined were the outdoor spaces. [fig. 53] Due to the western side of the site being inherently more public and having more solar access than the eastern side, an exterior public space was placed here. [fig. 54] To connect the outdoor plaza to the eastern side of the site and to create a connection to the lakefront, a central pedestrian street is implemented with various commercial programming. [fig. 55] The building forms are organized in a manner to frame the exterior spaces and to create more private courtyards for the residential units. The ground floor of the design layers public and private spaces for various moments of connections for both residents and community members. By framing the buildings around these spaces, microclimates are created to protect from

strong winds in the north and provide solar access to the south. The creation of microclimate conditions allows people to spend more time outdoors and being more at one with the climate.

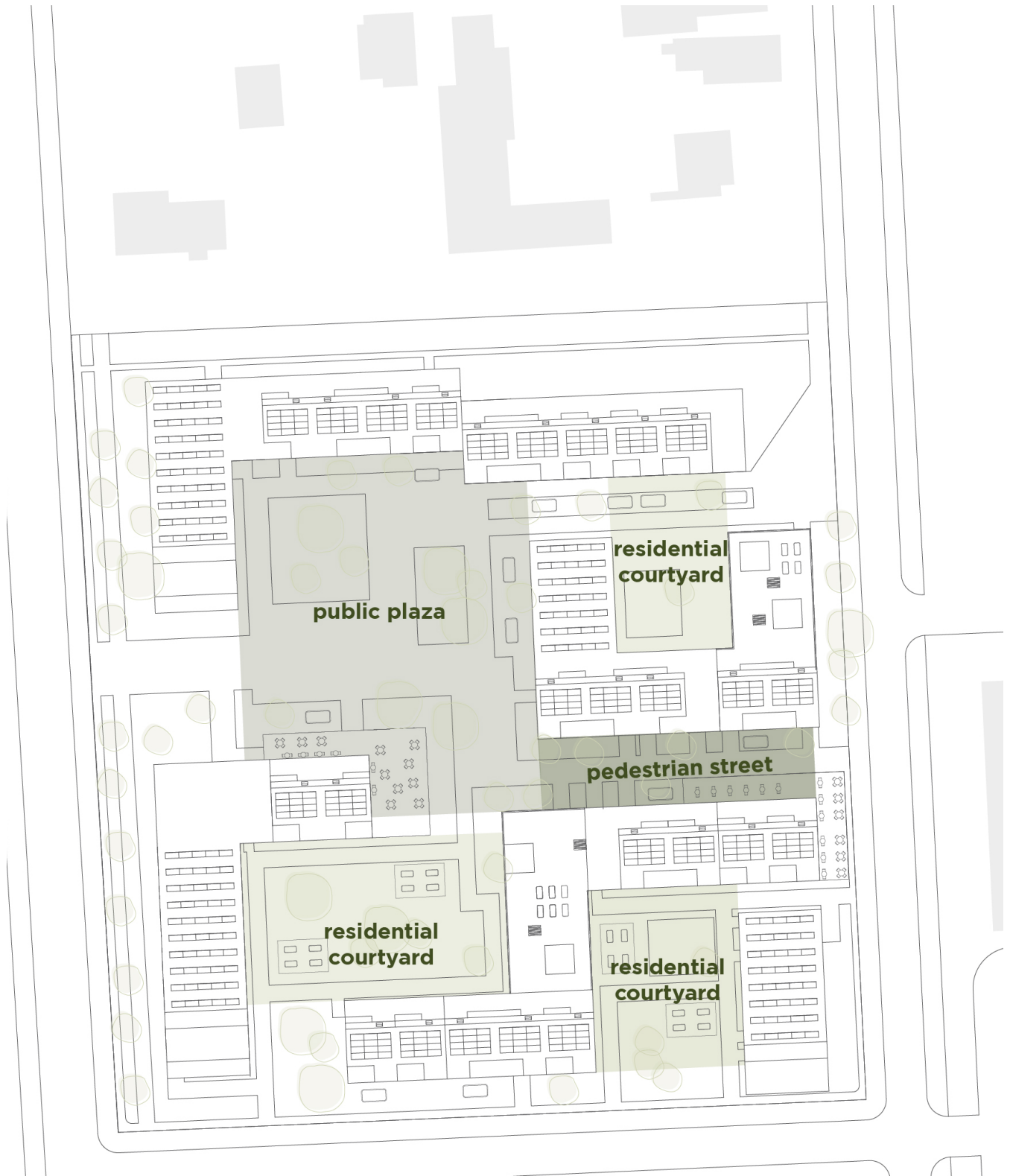


fig. 53 Site plan highlighting exterior spaces



fig. 54 Perspective of public plaza





fig. 55 Perspective of pedestrian street looking towards west in the direction of the public plaza



fig. 56 North-south elevation along Bradford Street

2. *proximity + density*

The project's programming relies on the proximity of services and businesses to develop a diverse mix of commercial and residential programming. A pedestrian street runs through the site from the lakefront and leads to a public plaza on the west side of the site, opening to an entrance on Bradford Street. [fig. 56] The pedestrian street and public plaza are lined with commercial programming that not only supports those living on site but the community as well. Starting on the north-western side of the plaza is a daily market and co-working space, along the pedestrian street working towards the west is a fitness studio, café, daycare, retail spaces, event space, laundromat, and restaurant. [fig. 57]

Density plays an important part in developing the project to meet the needs of a growing city. As the

City of Barrie moves towards higher density of living conditions, the project situates itself as a medium density design with 162 units, meeting the city's requirements for medium density between 125-300 units.⁹⁶ Maintaining a smaller scale to the project offers a sense of comfort at the human scale by humanizing larger environments and ensuring that there is a connection to the ground floor.⁹⁷

⁹⁶ City of Barrie, "Barrie Official Plan 2051," 35.

⁹⁷ David Sim, 226.

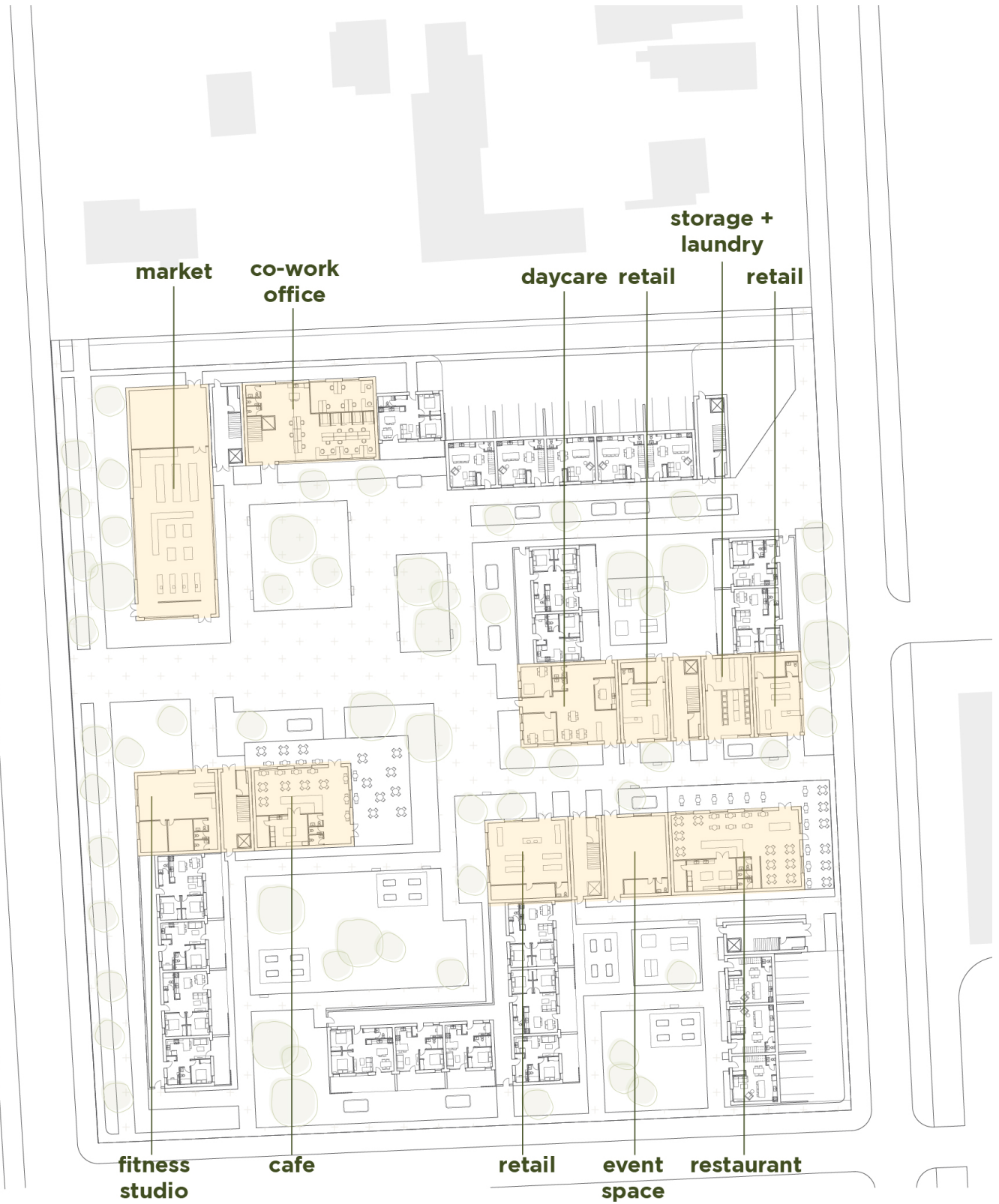


fig. 57 Ground floor plan highlighting commercial programming



fig. 58 Ground floor plan highlighting car share spaces

3. parking alternatives

By siting the project within the urban center of the city, there is an opportunity to encourage alternative modes of transportation by eliminating the car. The site is in proximity to both public and active modes of transportation, with bus routes leading to all areas of the city, including a route to the GO Transit station. To the east of the site, and along the lake shore are a series of walking and cycling trails that connect downtown to the south end of the city. Privately owned vehicles are removed from the site to promote walkability within the city except for electric car share located underneath the townhouse units on the ground floor. [fig. 58] Designing walkable environments allows for easy accessibility and connectedness with the least amount of effort. [fig. 59]



fig. 59 Exterior perspective of public plaza opening up from the pedestrian street

7.2 Low Carbon Design

To maximize the benefits of the climatic conditions on site, active and passive strategies were employed to reduce energy demands and create comfortable living environments.

The active strategies that are integrated into the project are onsite solar connection and prefabricated panel construction that optimizes a mass timber grid. The building running horizontally (east to west) across the site utilize pitched roofs that match the optimal angle for solar collection. [fig. 60] For the buildings running vertically (north to south) on the flat roofs solar panels have also been placed. The buildings are designed based off a mass timber grid of 8 feet by 40 feet to optimize the construction and minimize material waste. A prefabricated method of construction requires fewer resources and produces less waste therefore contributing less carbon

emissions. By implementing these strategies into the design, it can promote behaviours and lifestyles that have smaller carbon impacts.

Natural daylight, summer solar shading and natural ventilation, and winter solar heat gains are the main passive strategies that have been implemented into the project. Utilizing a single loaded corridor for units allows for the opportunity for inhabitants to open their windows to allow for cross ventilation. Priority was given to balconies for southern exposure therefore unit circulation is located toward the north or west. The balconies were designed to be integrated within the building mass. The overhangs of the balconies are designed to act as shading devices allowing the sun to enter interior spaces during the winter and provide shade during the summer. [fig. 61]

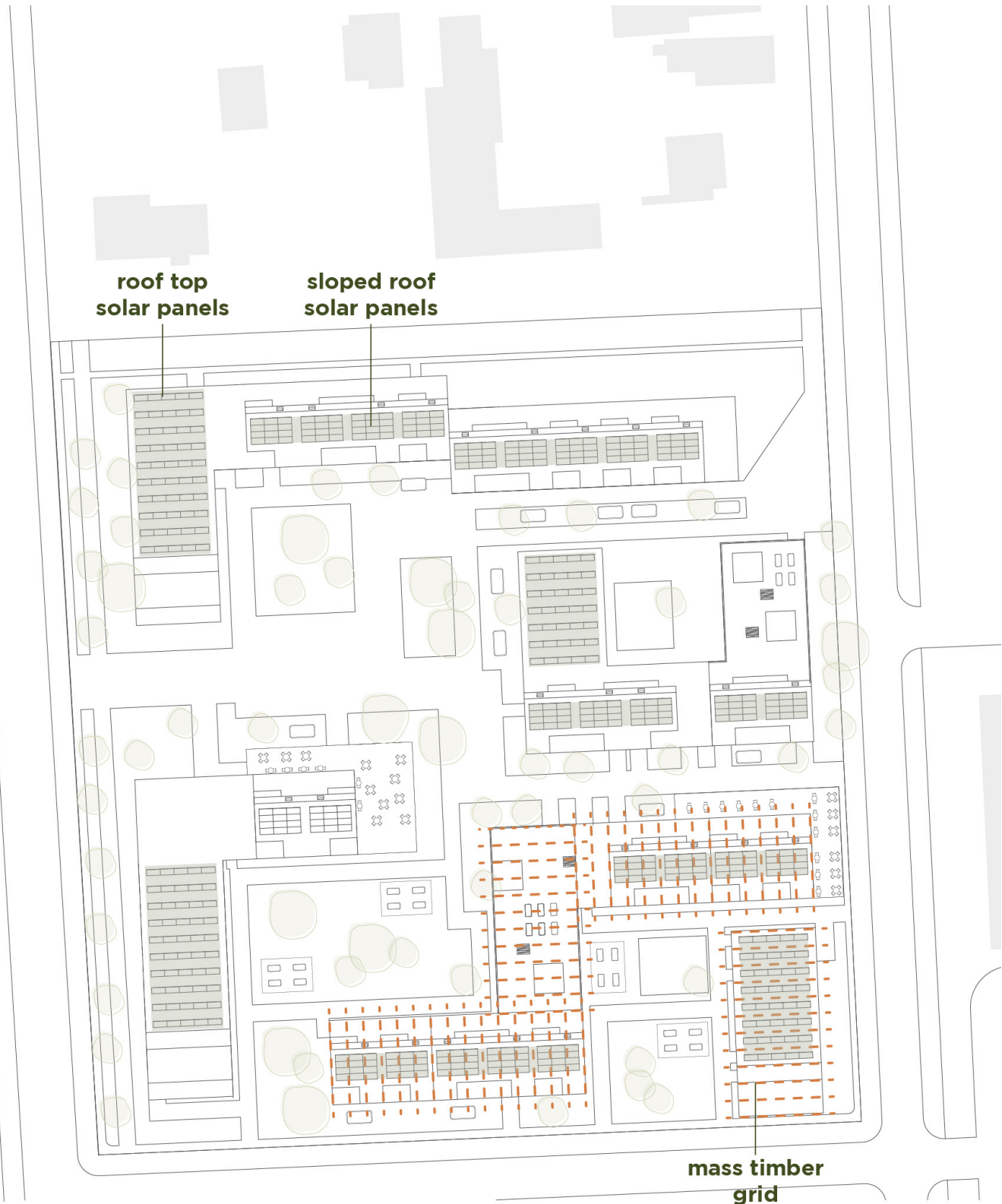


fig. 60 Roof plan highlighting locations of solar panels and mass timber grid



fig. 61 North-south section through residential units and public plaza highlighting the passive strategies implemented



7.3 Architectural Design

The architectural strategies that are implemented into the design of the project aim to promote an inclusive and comfortable living environment. The buildings are designed to a maximum of six-storeys to maintain a human scale and a connection to the ground floor even on the highest floor. [fig. 62]



fig. 62 East-west elevation through pedestrian street



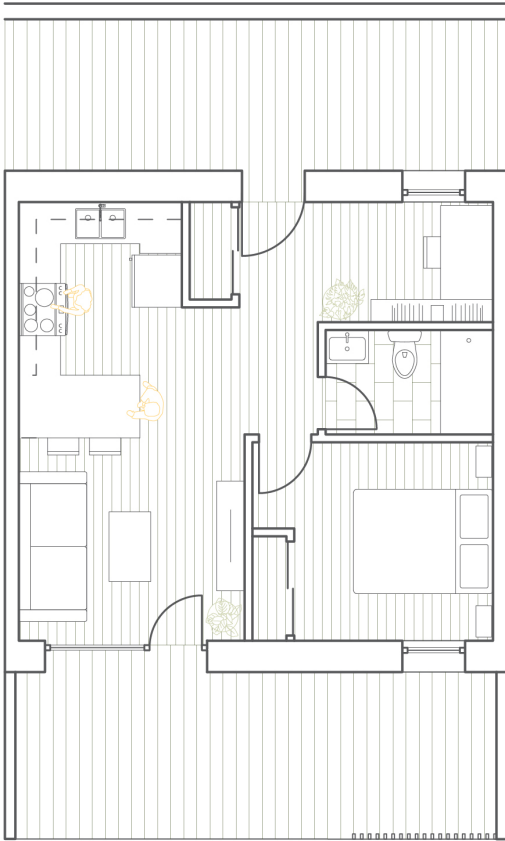


fig. 63 One bedroom plus den unit plan

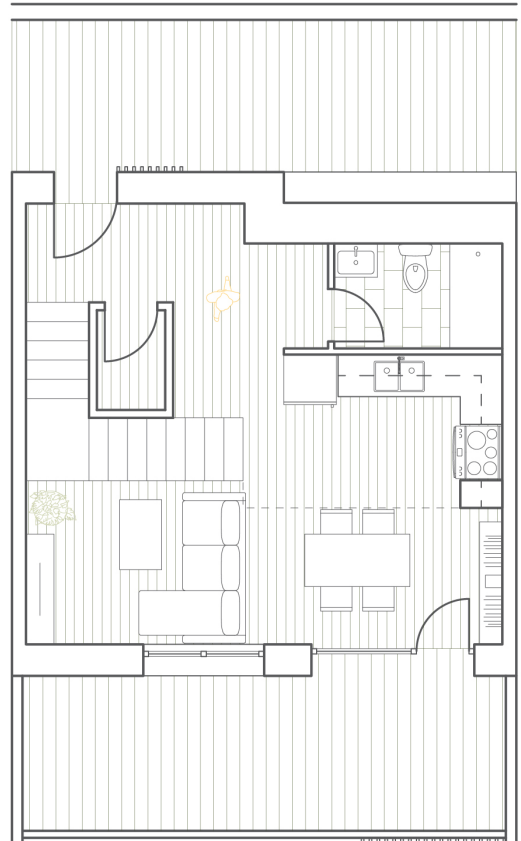


fig. 64 One bedroom loft unit (ground floor plan)

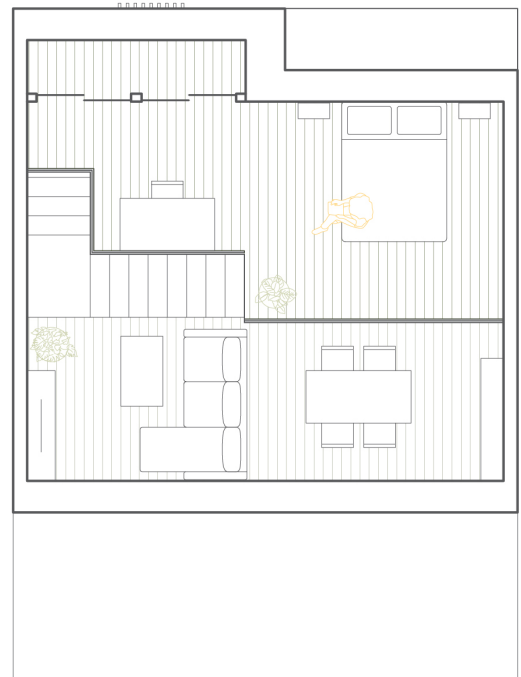


fig. 64 One bedroom loft unit (loft floor plan)

There are four types of units to provide diverse living conditions to accommodate for the new growth in Barrie. The one-bedroom unit and lofts contain a den as a flexible workspace for young professionals. There is a two-bedroom apartment and a two-bedroom apartment with a den for small families, couples, or roommates to provide flexible housing. On the ground floor, in the more private areas of the site, are three-bedroom townhouses that are geared for ownership and families. [fig. 63-69] A typical unit layout can be seen in the third-floor plan which highlights the different types of units. [fig. 70]

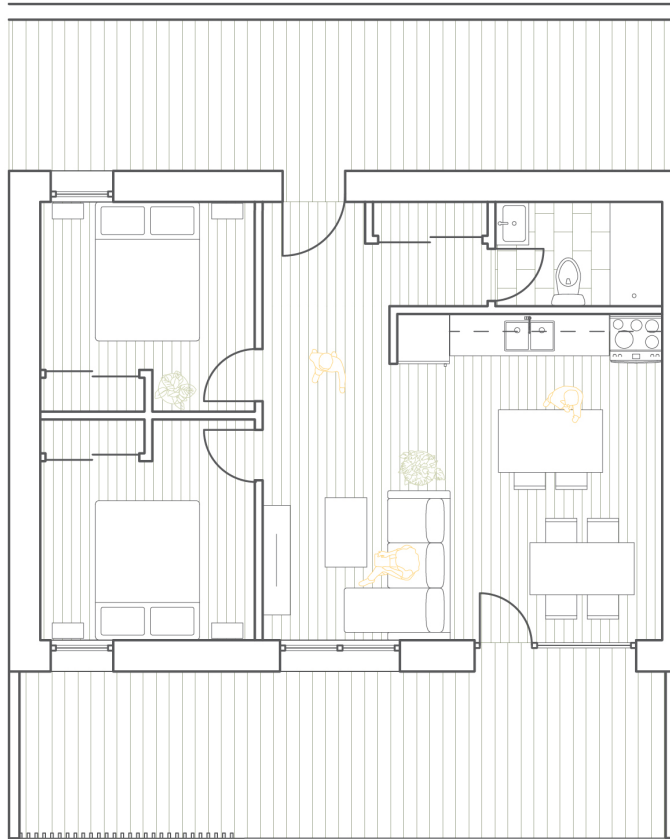
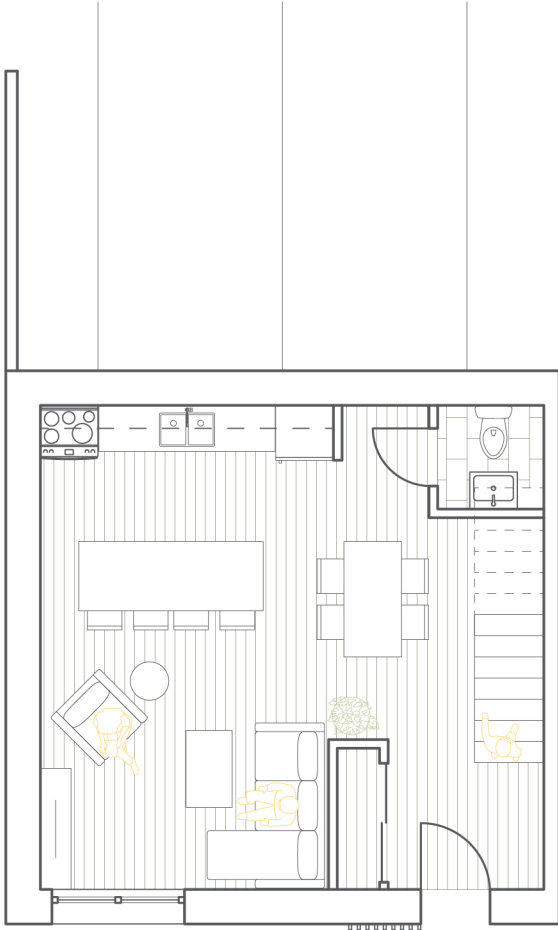


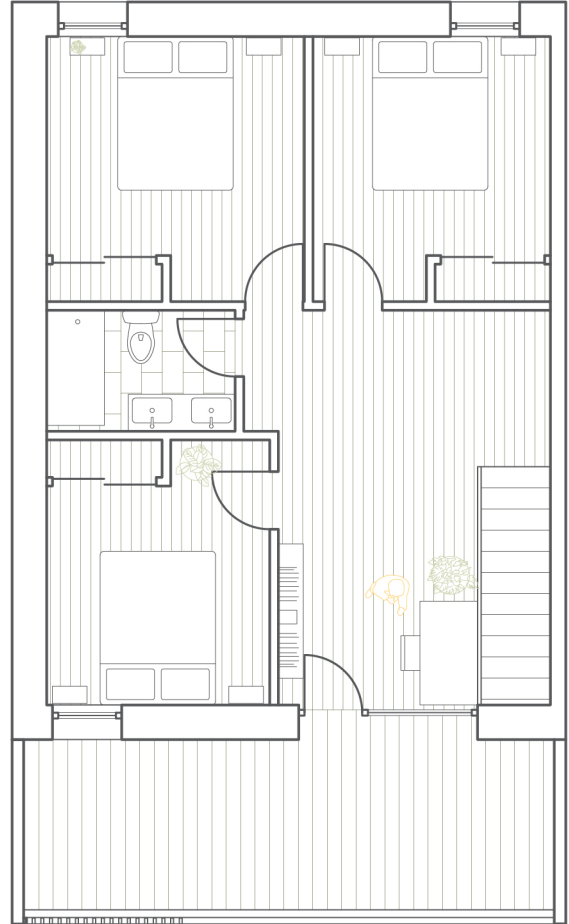
fig. 65 Two Bedroom unit plan



fig. 66 Two Bedroom plus den unit plan



*fig. 67 3 bedroom Townhouse
(ground floor plan)*



*fig. 67 3 bedroom townhouse
(second floor plan)*



fig. 68 Interior perspective of a 2 bedroom apartment



fig. 69 Interior perspective of the loft



fig. 70 Third floor plan illustrating a typical layout for units



The units are designed with generous outdoor spaces and corridors to provide residents with a sense of community and ownership of their homes. [fig. 71-72] These spaces are designed for residents to create their own identity of their units. Working in conjunction with the residential units and the daily market, greenhouses and community gardens are implemented throughout the upper floors of the buildings for the purpose of onsite food production and providing spaces for the residents to gather.

fig. 72 Exterior perspective from a unit balcony looking onto a private residential courtyard

fig. 71 East-west section highlighting the human scale of the project and maintaining a connection to the ground floor





7.4 Project Metrics

To address carbon within the design of the project, the strategies aim to impact positive lifestyle and behavioural change for those who interact with the site. The project aims to target the top three highest areas of carbon footprints of the average Canadian: housing, transportation, and food. The average Canadian has a carbon footprint of 14.2 tonnes of carbon emissions per year, where houses are responsible for 3.1 tonnes of carbon emissions, the car is accountable for 3.5 tonnes of carbon, and food emits 2.3 tonnes of carbon per year.⁹⁸ [fig. 73] The following subsections discuss the ways that the project aims to reduce emissions within these areas:

⁹⁸ Lewis Akenji, Magnus Bengtsson, Viivi Toivio, Michael Lettenmeier, Tina Fawcett, Yael Parag, Yamina Saheb, Anna Coote, Joachim H. Spangenberg, Stuart Capstick, Tim Gore, Luca Coscieme, Mathis Wackernagel, Dario Kenner, 17.

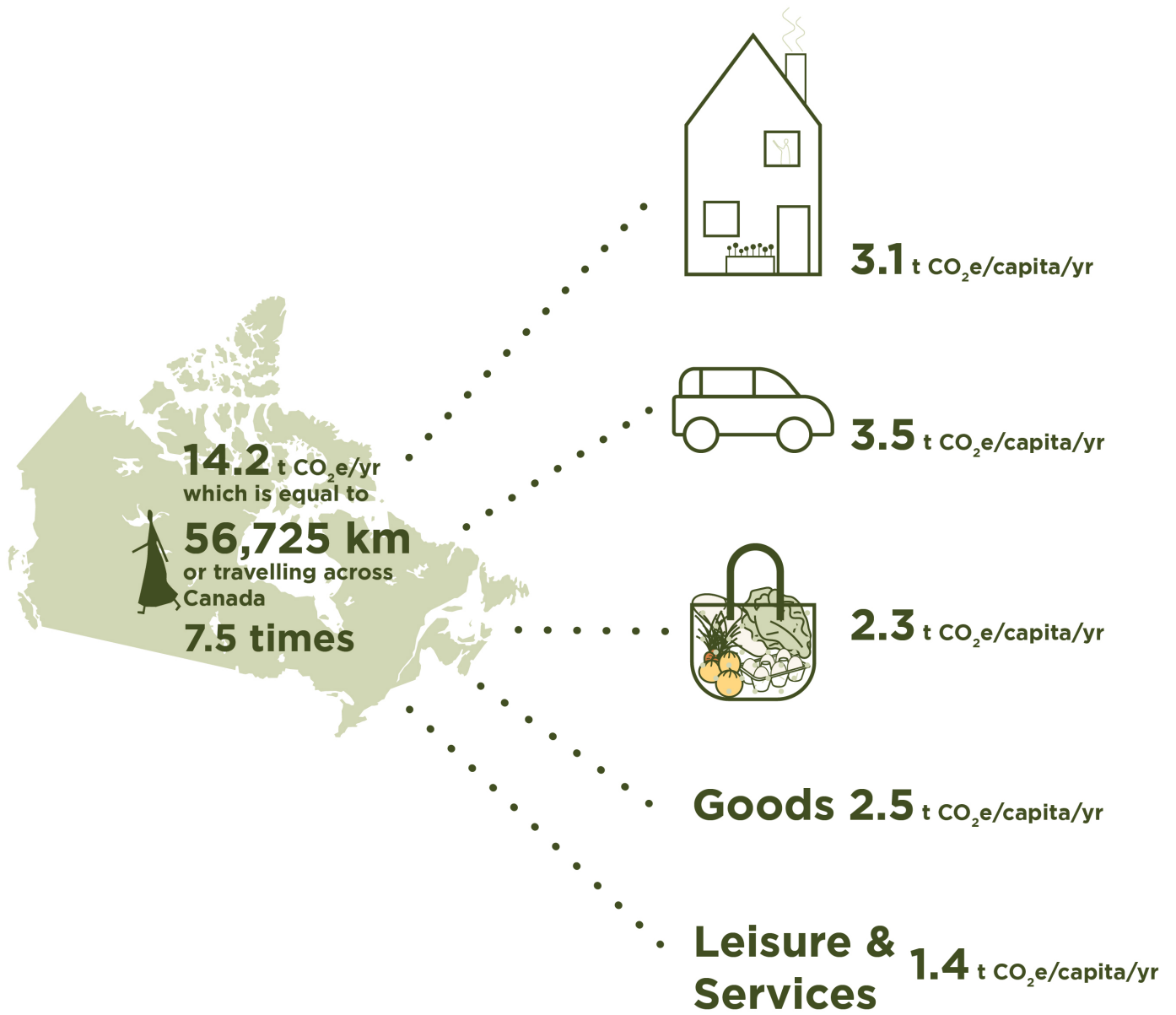


fig. 73 The average Canadian's carbon footprint that can be broken down into multiple contributors including housing, transportation and food consumptions

fig. 74 North-south detailed section illustrating the envelope strategy



1. housing

The architectural approach to the project investigates ways that the design can reduce carbon emissions utilizing a lifecycle approach, targeting both the embodied and operational carbon. To reduce the embodied carbon, the thesis explores a lifecycle approach to design solutions for each phase of the project's life. By utilizing a mass timber grid and reducing the dependency on carbon intensive materials such as concrete and steel, the embodied carbon can be reduced by 10-50% of a typical mid-rise residential building. [fig. 74] This percentage is dependent on multiple factors including the transportation, manufacturing process of the materials, and the construction process.⁹⁹

⁹⁹ "Mass timber solutions for eight story mixed-use buildings: A comparative study of GHG emissions," *Buro Happold*, March 6, 2021, <https://www.burohappold.com/news/mass-timber-solutions-for-eight-story-mixed-use-buildings-a-comparative-study-of-ghg-emissions/#>, 15.

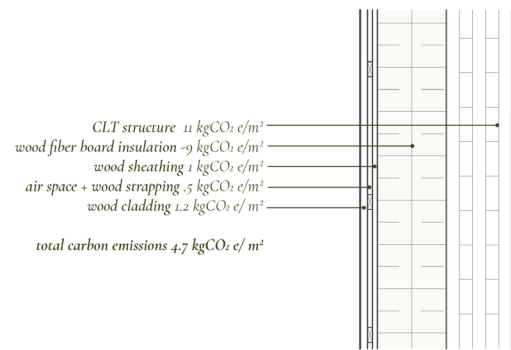


fig. 75 Envelope strategy of the thesis project and the associated material carbon emissions

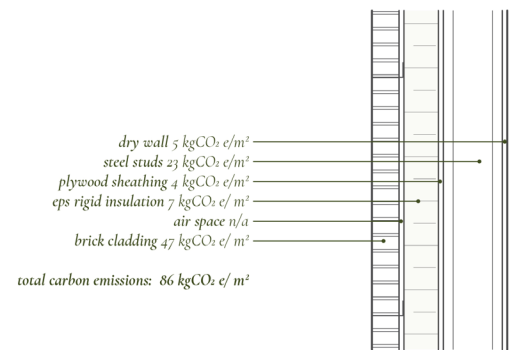


fig. 76 A typical mid-rise residential envelope assembly and the associated material carbon emissions

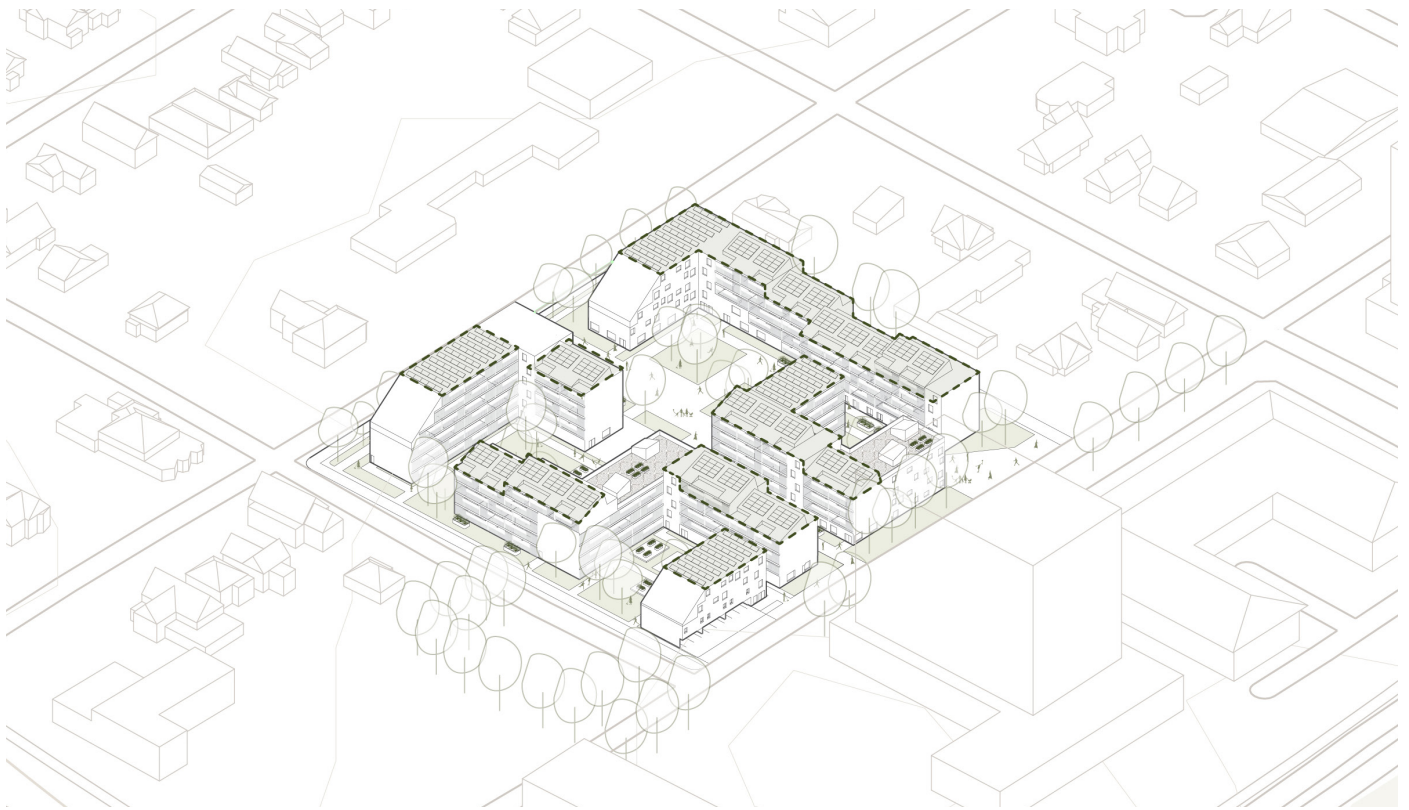


fig. 77 Project isometric highlighting the rooftop solar collection

The wall assembly of the project takes a low carbon approach and has a material carbon impact of 4.7 kg CO₂e/m², [fig. 75] whereas a typical residential structure has a total carbon emissions of 86 kg CO₂e/m² [fig. 76].¹⁰⁰

To reduce the operational carbon of the project, solar collection has been utilized with the use of solar PV panels located on the sloped and unprogrammed roof. [fig. 77] A typical multi-residential unit requires 6,944 kWh/year of energy.¹⁰¹ The solar panels that are located on the roofs of the buildings have the potential to generate up to 11,869 kWh/year. With

the use of passive design strategies and a low carbon envelope, the project has the potential to reduce energy use of a typical residential.

¹⁰⁰ "BEAM Estimator," *Builders for Climate Action*, accessed May 3, 2022, <https://www.buildersforclimateaction.org/beam-estimator.html>.

¹⁰¹ Statistics Canada, Table 25-10-0061-01 Household energy consumption, by type of dwelling, Canada and provinces, accessed February 15, 2022, <https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2510006101>.

2. transportation

Due to the project's urban context and proximity to public and active transportation methods, the car has been eliminated from the site with the exception of electric car share spaces that are located under the townhouse units. [fig. 78] By eliminating the car from the site, 283.5 metric tonnes of carbon emissions can be reduced from a transportation perspective. Not only are carbon emissions reduced from a lifestyle perspective with the elimination of the vehicle, but it can also be reduced from a material standpoint as the structure does not rely on as much concrete because there is no below grade construction. Through eliminating the additional need for concrete, the material carbon footprint would not have to add the additional 93 kg CO₂e/m².¹⁰² The intention of the car share is to provide residents access to a vehicle

¹⁰² BEAM Estimator.

if in need of one and as cars become less depended on in the future, the townhouse units can reclaim this space that is currently being allocated to the car. The implementation of a co-working space allows individuals living on site and within the community to work closer to home. [fig. 79] The space provides 40 workstations and has the potential to reduce carbon emission up to 680 kg CO₂e/year per desk depending on the length and frequency of an individual's commute.¹⁰³

¹⁰³ Lewis Akenji, Magnus Bengtsson, Viivi Toivio, Michael Lettenmeier, Tina Fawcett, Yael Parag, Yamina Saheb, Anna Coote, Joachim H. Spangenberg, Stuart Capstick, Tim Gore, Luca Coscieme, Mathis Wackernagel, Dario Kenner, 62.

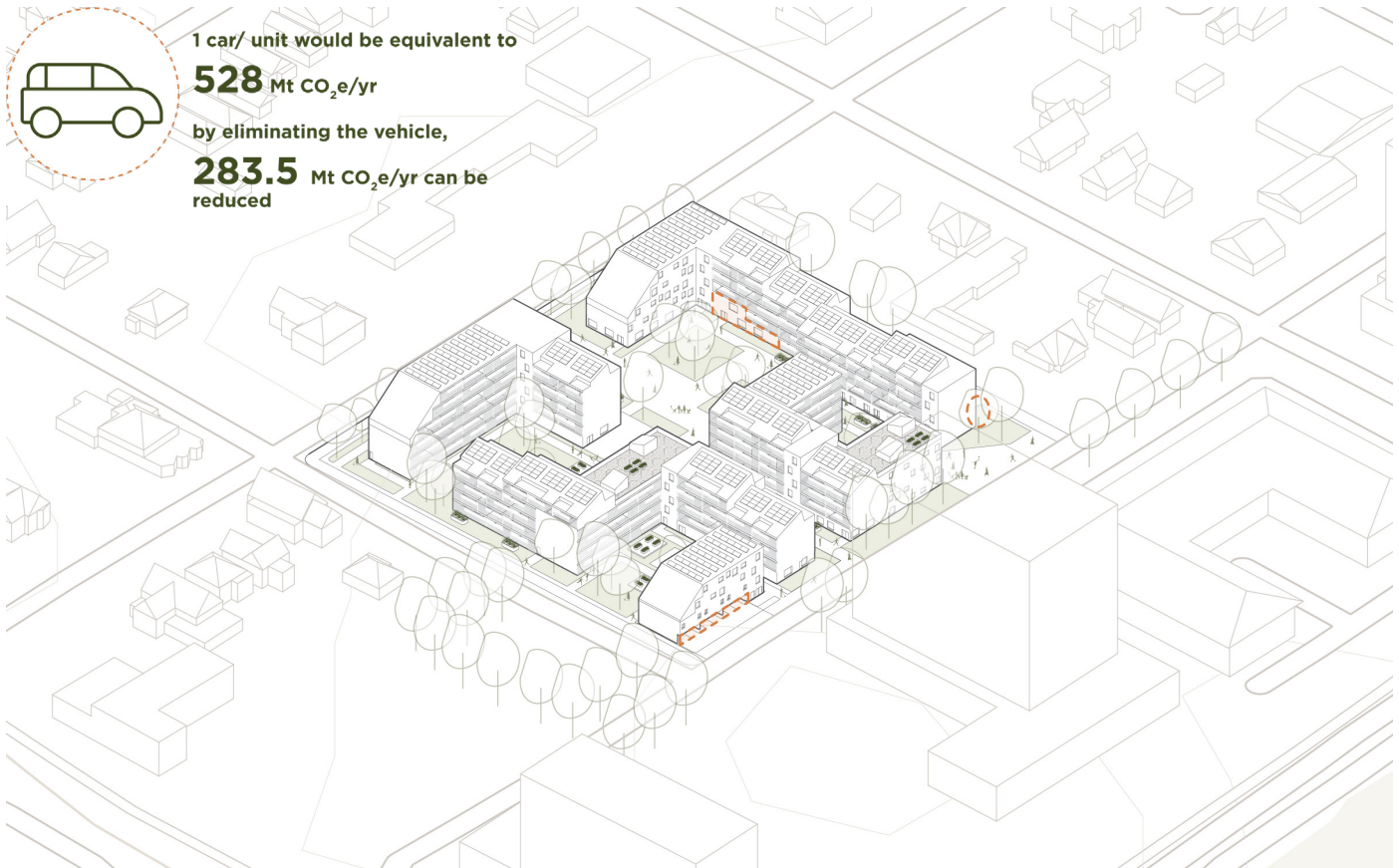


fig. 78 Project isometric highlighting electric car share spaces



fig. 79 Interior perspective of co-working space

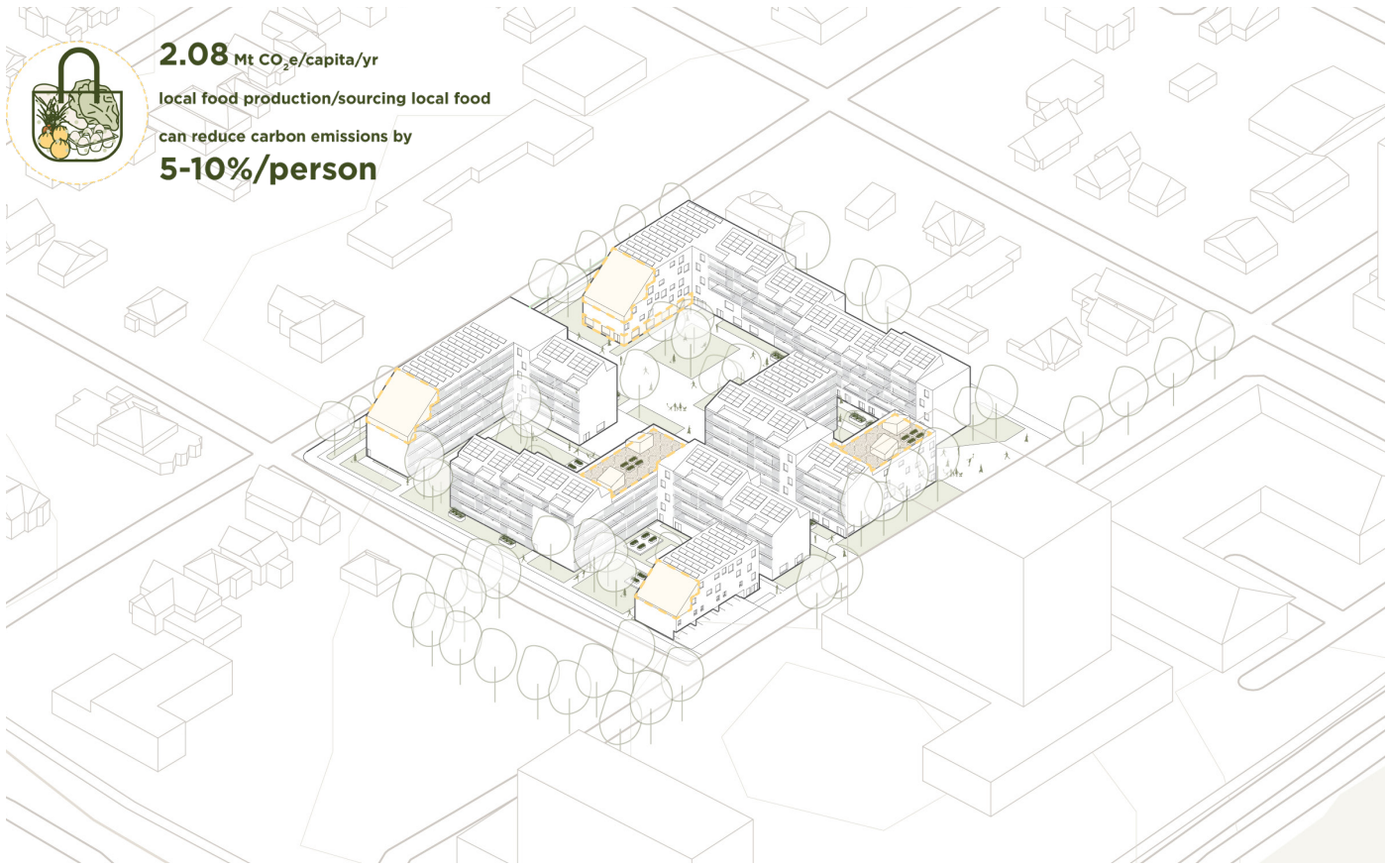


fig. 80 Project isometric highlighting greenhouses and food production areas on site



fig. 81 Rooftop perspective of the community roof gardens and greenhouses

3. *food*

Due to the lack of accessible grocery stores within a ten-minute walking radius, a daily market was implemented into the program to serve the local community. With the integration of this programming came the opportunity to explore how food could work in a cyclical manner on site. Located on the southern exposures of the building forms, as well as the community roof top garden spaces, greenhouses have been designed for on-site food production that works in conjunction with the daily market and supplies residents with fresh produce year-round. [fig. 80-81] This program is design to support the needs of the daily market with the larger greenhouses on the southern facades and the residents have the opportunity to grow and care for the plants grown on the roof top gardens. On average food is accountable for 2.08 Mt CO₂e/person/year,¹⁰⁴ and by utilizing onsite food production, carbon emissions can be reduced by 5-10% per person.¹⁰⁵ Not only is the integration of this program beneficial from a carbon emissions reduction standpoint, but it provides residents a space to cultivate and be more connected with nature as a community.

¹⁰⁴ Lewis Akenji, Magnus Bengtsson, Viivi Toivio, Michael Lettenmeier, Tina Fawcett, Yael Parag, Yamina Saheb, Anna Coote, Joachim H. Spangenberg, Stuart Capstick, Tim Gore, Luca Coscieme, Mathis Wackernagel, Dario Kenner, 17.

¹⁰⁵ Samuel Sigal, "How to reduce your food's carbon footprint, in two charts," VOX, February 20, 2020, <https://www.vox.com/future-perfect/2020/2/20/21144017/local-food-carbon-footprint-climate-environment>.

8.0 Conclusion



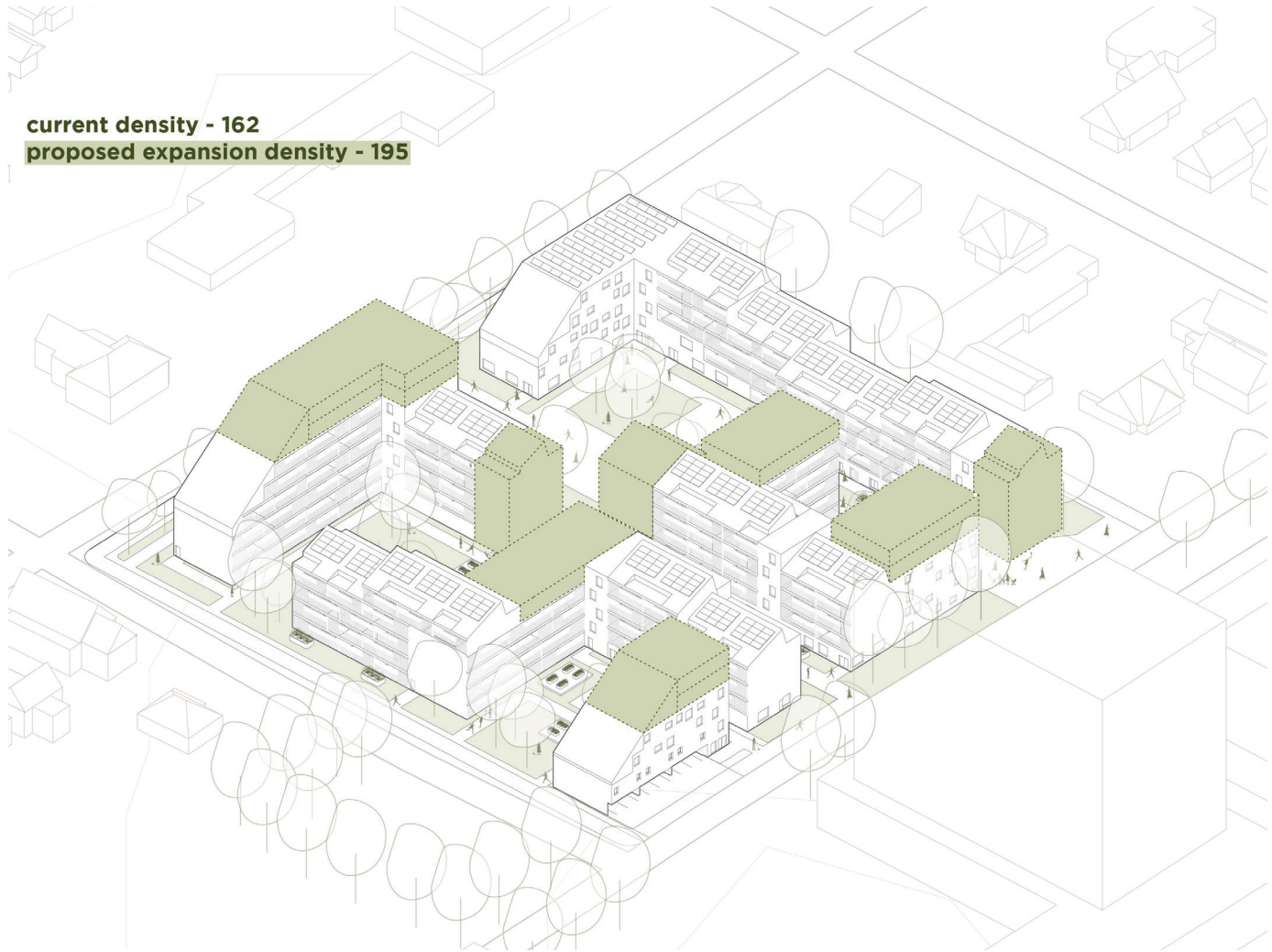


fig. 82 Project isometric illustrating how the building could be adapted for growth in the future

The architecture community is faced with complex issues of a housing crisis as well as a climate crisis. The current emphasis placed on the speed of new housing development and an equally strong movement towards sustainable architecture, neglects the connection between architecture, sustainable lifestyles, and liveable communities. The framework developed throughout this thesis focuses on the integration of social and environmental sustainability in the development of residential architecture. It is important that the issues that are generated by sprawling suburban neighbourhoods, which create disconnections and fractured communities, begin to be acknowledged within the architectural field. The framework was developed as a return to a sensitive architectural approach that tackles both intimate issues within the immediate context as well as the larger crises currently faced to develop a holistic site approach and design.

The intentions of the thesis began by investigating the following question: **By understanding the current and future effects of climate change, how can residential architecture adapt to encourage low carbon lifestyles through alternative design strategies?**

To begin to answer the thesis question, an understanding of the existing issues within residential architecture must be studied. Generating an understanding of where the issues lie within suburban design and the disconnection that they create by the means of monocultural landscapes and car-centric living, theory can be explored to develop solutions. Theory in sustainable urban development and low carbon design were studied throughout this thesis to develop an approach to architecture that reduces carbon from a built perspective as well as encouraging lifestyle improvements. The theory informed a site approach and set of design strategies that can be applied to the project. The design strategies explore architectural, urban, and low carbon methods of design to create a people-oriented design that is rooted in its context while utilizing sustainable building methods.

The design proposal of the thesis project begins to answer the second half of this question by taking what was learned throughout the research and applies the framework to develop a site-specific approach to sustainable urban development. The site for the project was determined based on overlapping forces of having to accommodate for new growth while seeing a need to densify the city of Barrie.

Over the next 30 years, Barrie is projected to see a rapid population, where the current plan emphasizes 50% of new growth being allocated to developing the built-up area of the city, and 50% to new suburban developments on greenfield sites towards the outskirts of the city.¹⁰⁶ By situating the thesis to explore new means of residential development, the project sites itself in the downtown core of Barrie. Through rigorous site analysis, a quantitative and qualitative understanding was developed to begin to design a program that was informed by the context and the future need for the city. The design began to develop from the analysis, reacting to the site conditions with design strategies that address the urban realm, architecture, and low carbon principles. The project is not only able to reduce carbon from an architectural and material standpoint but encourage a low carbon lifestyle for individuals living on site and within the community. There is space for this project to grow and accommodate the future needs of the city as it begins to develop into a denser urban fabric. There is the potential to expand the design by providing additional units vertically on the built forms that run north-south to the south, as well as densifying the ground floor along the pedestrian street, and finally, as vehicles become less depended on, allowing the townhouse units to inhabit the car share spaces on the ground floor. [fig. 82] The current density of the site is 162 units, and with the addition illustrated, there is the potential to increase the density to 195 units. The qualitative principles of the project should still maintain in place to ensure there is a human scale, identity, and providing spaces for moments of connection and to the ground floor.

¹⁰⁶ City of Barrie Planning Services. "Barrie Official Plan 2051," 26.

The Low Carbon Living Framework presents an opportunity to adapt and transfer the process to other sites within growing cities to densify before they result to sprawl. Throughout the city of Barrie, there are multiple opportunities to take what has been learned throughout this process and the framework that was developed, to apply it to other sites to accommodate for the new growth while also densifying. [fig. 83] Not only does it become transferable, but there is the potential to further explore how a low carbon residential typology like this, has the potential to influence municipal policy changes, to advocate for denser walkable neighbourhoods, integrating public and active transportation systems, as well as multi-city connections. This is the ultimate objective of the thesis, to begin a discourse on how to begin to live with climate change and make neighbourhoods and cities more liveable for the future.

"Cities have the potential to be places of beneficial interaction and platforms for connection, consciously juxtaposing the differences as they densify and diversify. We create ever-evolving, gentle urban symbioses, discovering the opportunities for healthier, more sustainable, more enjoyable, and more meaningful relationships, by being neighbours."¹⁰⁷

¹⁰⁷ David Sim, 6.



fig. 83 Mapping potential sites in Barrie for new interventions

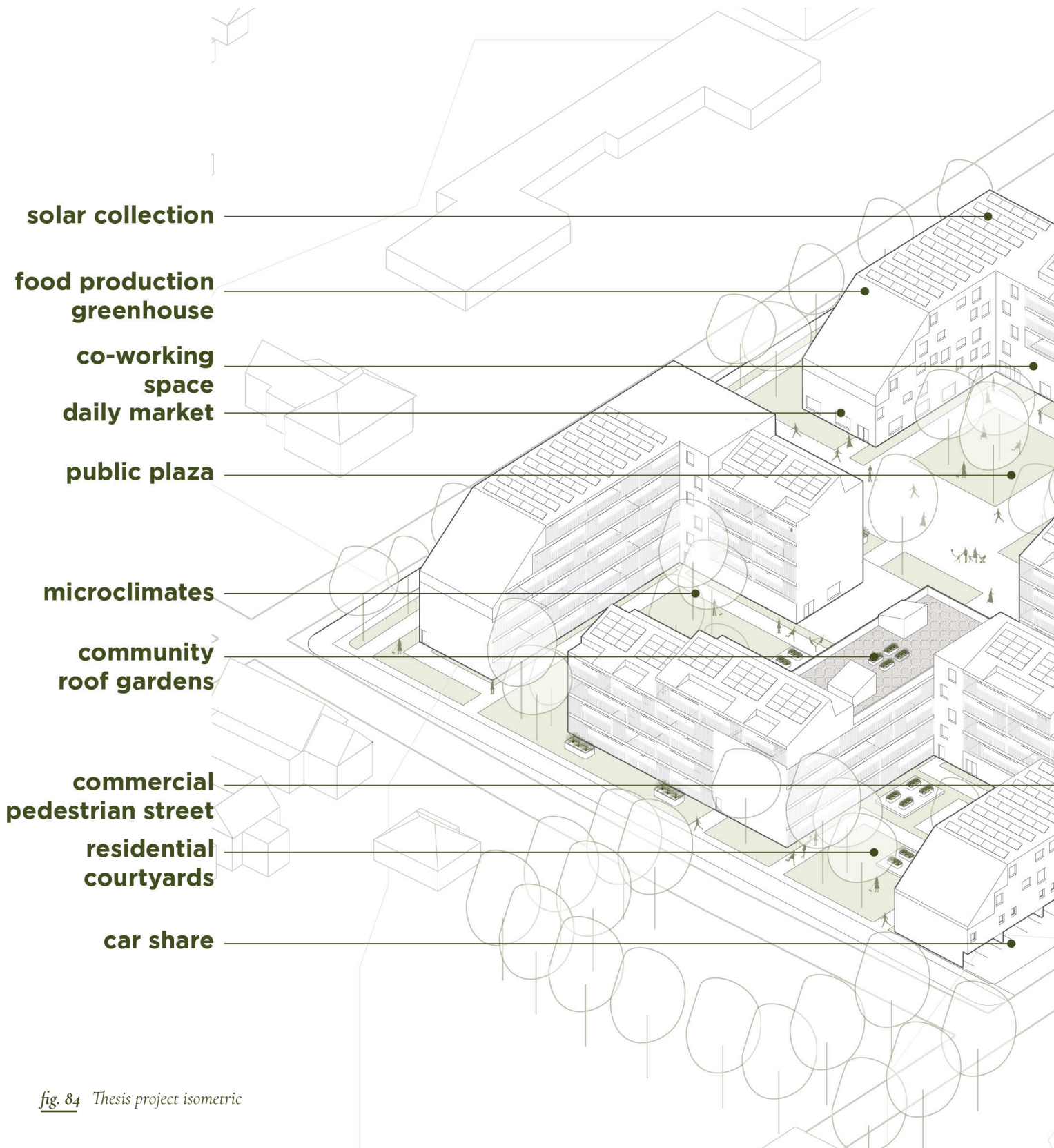
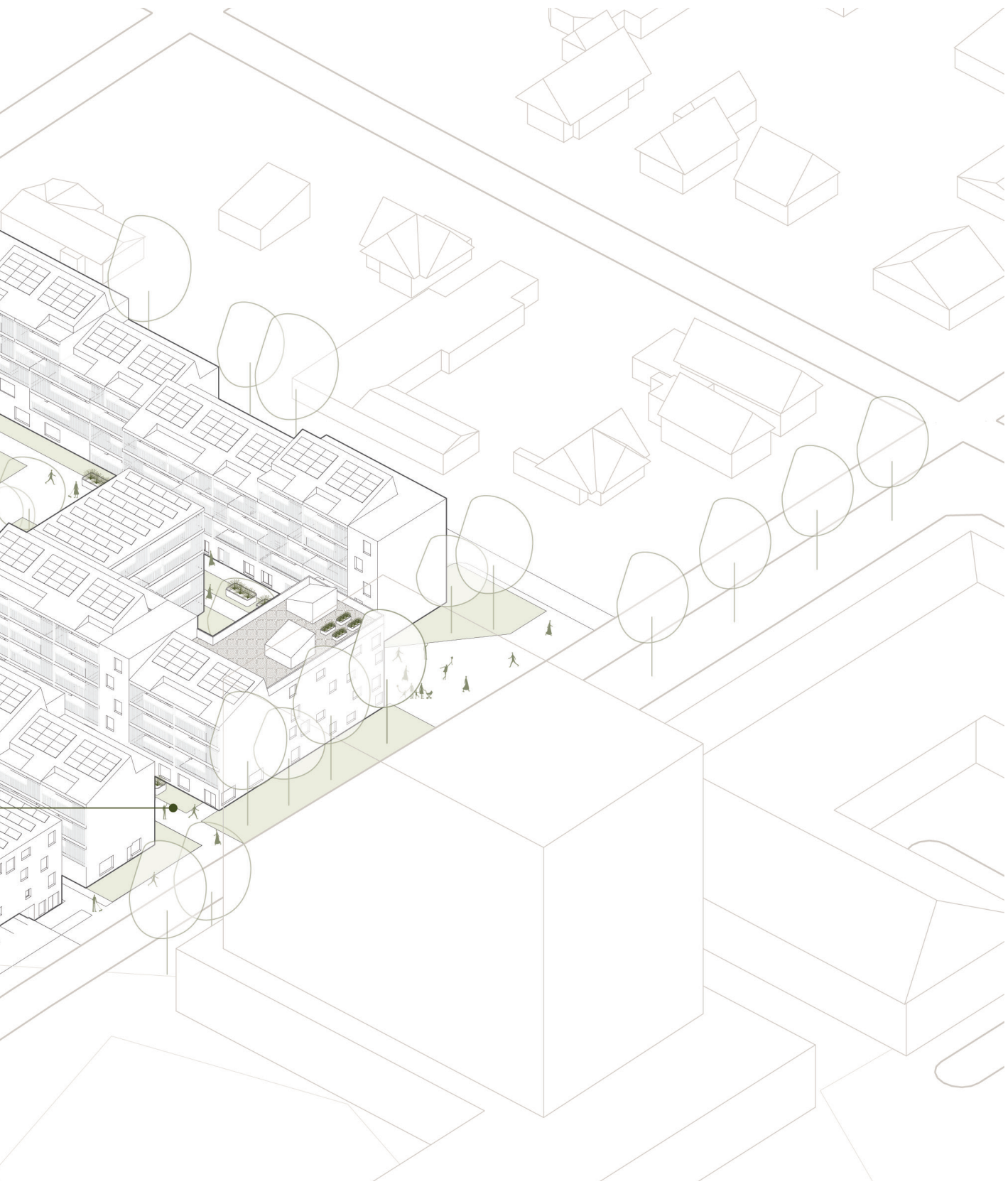


fig. 84 Thesis project isometric



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