Little Mountain Co-Housing, courtesy of Cornerstone Architecture

Identifying Intersections of High-Performance Building Design and Municipal Form & Character Guidelines

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Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organisations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Township of Langley staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the Township of Langley or the University of British Columbia.

Township of Langley
Est. 1873

UBC sustainability

Carrington View, courtesy of Skyline Living

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I would like to thank my project mentors Kevin Ramlu, Green Buildings Manager, and Ajeen Surendran, Building Energy Specialist, at the Township of Langley for their continuous support and guidance throughout this project.

Furthermore, I would like to thank Karen Taylor and the Sustainability Scholars Program for their support and work to provide opportunities for students to contribute to real-life sustainability initiatives. Finally, I gratefully acknowledge the financial support of BC Hydro for this project.

I wish to respectfully acknowledge my position as an uninvited guest living on the ancestral and unceded territories of the xwməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish) and səlílwətaʔɬ (Tsleil-Waututh) Nations.

The following work was conducted for the place now called the Township of Langley, or the ancestral and unceded territories of the q̓ʷa:n̓ƛ̓ʼən̓ (Kwantlen), Màthxwi (Matsqui), q̓ic̓əy̓ (Katzie) and Semiahmoo First Nations. I recognize and respect them as the traditional custodians of the land on which this work was conducted.

There are many cultures, values, and people that are not currently represented within the built environment. It is important to acknowledge that this research only targets a small part what it means to build sustainably.

Executive Summary

The operational energy use of buildings is the second largest source of carbon emissions in the Township of Langley. Addressing these emissions will play a major role in achieving the Township's 2050 target of reducing carbon emissions by 100%. This project was conducted to support that goal by cataloging and describing common design strategies used in very high performing residential buildings and identifying where they intersect with the Township's Form and Character Guidelines to better understand, and support, potentially changing trends in building design and aesthetics.

A database of 40 high-performance residential buildings, meeting standards such as BC Energy Step Code, Passive House, and Net Zero Energy Ready was compiled including, images and a table of their key exterior design characteristics. This database was used to identify common trends and design features of high-performance buildings, meeting standards close to or exceeding Township and the Provincial targets. A review of the Township Community and Neighbourhood Plans was conducted to identify guidelines for building form and character in the Township. Additionally, and interview with a Township planner was conducted to identify guiding philosophies for executing form and character guidelines in the Township of Langley.

Four major design trends emerged among buildings examined in the database.

1. **Orientation to maximize southern exposure**.
   Though often dictated by property lines and existing street grids, orientation can have a significant impact on a building's potential to for passive heating and daylighting, and thus energy use.
2. **Simple overall form**
   Buildings in the database most often had a simple overall form, and used alternative design strategies to create visual interest, such as material variety, and appended elements like overhangs and porches.
3. **Low window to wall ratio & thoughtful window placement**
   Windows were most often placed thoughtfully to maximize potential for daylighting, while balancing heating and overheating potential. Most buildings had an overall low window to wall ratio, but thoughtful window placement allowed for bright and pleasant building interiors none the less.
4. **Exterior Shading**
   This was a very common design feature among database buildings, ranging from roof overhangs, horizontal sun shading devices, exterior roller blinds, and others.

This report additionally highlighted where these design strategies intersect with the Township of Langley's Form and Character Guidelines. Both alignments and conflicts with the Form and Character Guidelines were identified, particularly with encouragement of design outcomes for creating visual interest in the public realm, alignment with the Township's vernacular architecture, and providing outdoor spaces for residents of multistorey MURBs.

Ultimately, it should be recognized that achieving ambitious energy targets will require flexibility to design buildings differently. The buildings compiled in the database demonstrate that creativity and thoughtfulness in design can result in a built environment that is both successful in reducing green house gas emissions and grossly improving energy performance, and in providing an enriching, safe, and beautiful public realm, where Township residents can live, work, and play.

Alberta Street House, courtesy of Lanefab Design/Build

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01. Introduction

Context · Objectives · Background · Approach · Scope & Limitations

Khotso House, courtesy of ONE SEED Architecture + Interiors

1.1. Context

The exterior character of a building is of great importance to its energy performance. Fundamental design decisions made early in the design process including overall form, window size and placement, and exterior shading can reduce the energy consumption of a building by up to 80 percent.[1] The figure below shows some of the design strategies that are typical for achieving energy efficient design, and their proportional potential impact on building energy use.

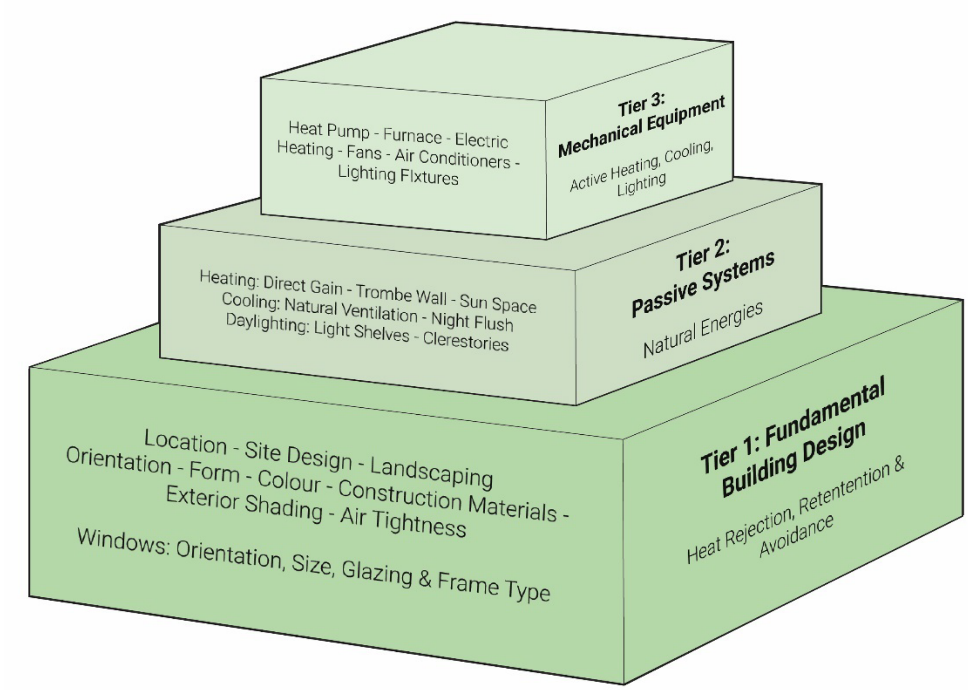

Figure 1: Adapted from 'Heating Cooling and Lighting: Sustainable Design Methods for Architects'

Thoughtful design of a building's 'Tier 1' fundamental elements, and intentional employment of 'Tier 2' passive systems, can significantly reduce a building's reliance on energy intensive mechanical systems because they are designed to make use of free, ambient energy sources such as the sun and wind to provide heating, cooling, ventilation and lighting.

Prior to the invention of mechanical, or 'active' systems for heating and cooling, these 'passive' design strategies were used to keep building occupants comfortable throughout the seasons. A response to climate is one of the main reasons for regional differences in architectural styles. In British Columbia's mild and wet Lower Mainland, for example, pitched roofs with large overhangs are common as they direct water away from the building. In North Carolina's hot and humid climate, wrap around patios are common because they create cool outdoor spaces, and shade windows to help keep heat out of the building's interior. These design strategies are just as effective now as they were in the past, and can be applied to contemporary buildings in order to decrease their operational energy use.

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[1] Norbert Lechner, "Chapter 1: Heating, Cooling, and Lighting as Form-Givers in Architecture," *in Heating, Lighting, Cooling: Sustainable Design Methods for Architects* (Somerset: John Wiley & Sons, 2014), 9, ProQuest Ebook Central.

Alignment with Township Goals

In 2021, Mayor and Council of the Township of Langley unanimously approved the Township's Climate Action Strategy, which adopted a target of reducing Township carbon emissions by 100% by the year 2050. One of the priorities of this strategy is to advance high-performance building design. In the Township of Langley, operational emissions from buildings, being those that are generated by activities related to the use of the building such as heating, cooling, and lighting, account for 30% of the Township's total carbon emissions.

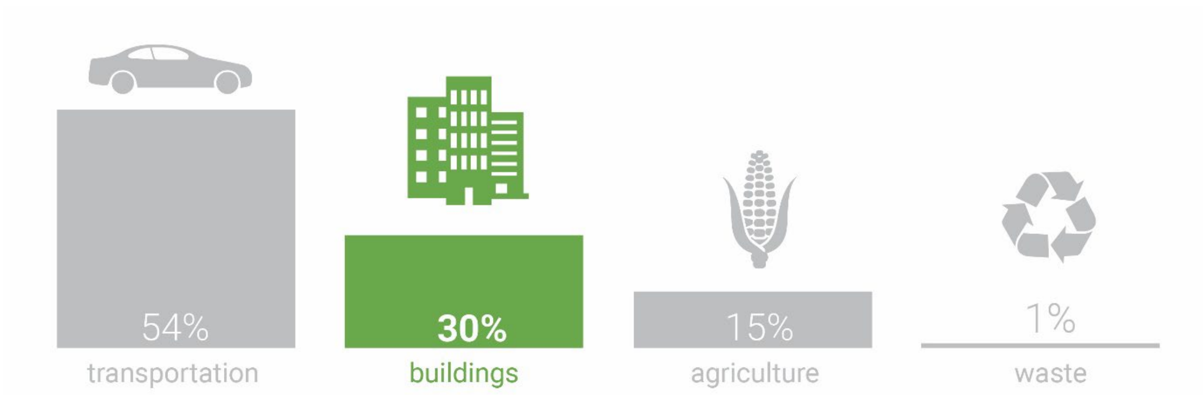


Figure 2: Percent of carbon emissions from each sector in the Township of Langley. (Adapted from the Township of Langley website)

While the Township adopted the BC Energy Step Code in 2019 and has since emphasized high-performance building as a priority in the Climate Action Strategy, it is important to acknowledge other Township priorities, such as Form and Character Guidelines, and understand where they may intersect with building design strategies for increased building energy performance.

Many municipalities across B.C., including the Township of Langley, have detailed Form and Character Development Permit Guidelines developed by Staff and endorsed by Council. These guidelines are firmly preserved as they provide the framework to designers and developers on how buildings in the Township should reflect: history, visual competency, and other priorities. At the highest levels of building performance, however, it must be acknowledged that the general shape and exterior features of a home or building may be different than what a municipality may be used to. These differences in aesthetics must be examined, understood, and supported in the pursuit of enabling cost effective, high-performance building design.

1.2. Objectives

This project aims to provide a tool to Staff, Council, and the public on what to expect in terms of form features of high-performance buildings, and provide a review of how these characteristics intersect with the Township's expectations for Form and Character. These findings may inform Staff of what design strategies may be more common as we work towards reaching the highest energy standards.

This project's key objective is to identify common trends and exterior design characteristics of high-performance buildings. The project's secondary objective is to identify and describe intersections, or lack thereof, of these trends and design characteristics with the Township's Form and Character Guidelines.

This project focuses on residential building typologies only, including Part 9 and Part 3 residential buildings like detached single family homes, townhomes, multiunit residential (MURBs) and mixed use buildings. The exterior characteristics of residential buildings is of particular importance to a municipality like the Township of Langley because residential buildings are fabric buildings, meaning together they form the larger part of the urban fabric and character of the Township's neighbourhoods and communities. It might be suggested that there is a higher tolerance for difference in design among institutional and commercial buildings, because they are less tied to a regional traditional vernacular style – though alignment with Township form and character guidelines for compatibility with local vernacular, community scale, and creating hospitable public realm, among other expectations, is still required.

1.3. Background

Development Permit Form and Character Guidelines

The Township of Langley's Development Permit Form and Character Guidelines are intended to translate community values and goals, defined in the Official Community Plan, into design outcomes. Form and character guidelines are captured in the Township's Community and Neighbourhood Plans, where for each area and neighbourhood in the Township, design outcomes are outlined generally, and building typology specific design expectations are defined.

These guidelines are drawn from what is already present in the Township, long term priorities and goals and the desired future state of each neighbourhood. The Township's Form and character guidelines are focused on the interactions of buildings and the public realm to create vibrant, social, sustainable, and livable communities. A key area of focus is the exterior appearance of buildings where they meet the street, encouraging design and scale for human comfort to create welcoming, visually interesting, and safe public spaces.

High-Performance Building Standards

Many building standards for sustainability can be traced back to the global energy crisis of 1973, when groups of architects and engineers in Canada and the United States began experimenting with more energy efficient home designs. Their experiments focused on building envelope and enclosure assemblies, and were first nicknamed "superinsulation", and later passive house. German architects and engineers picked up on passive house concepts and developed the now well known and internationally recognized Passive House (Passivhaus) certification program. Since then, many standards have emerged globally, developed by private industry, governmental organizations, professional associations and non-profits.

These standards are broad in their range of approaches to setting sustainability targets. Some, like Passive House and the British Columbia Energy Step Code, are performance based standards that set building energy use targets. LEED certification on the other hand, uses a points based system based on levels of sustainable strategies used, including materials and water efficiency, sustainability awareness and education, and many others. WELL certification uses a points system also, and is particularly focused on occupant health, comfort, and knowledge.

This report focuses on design characteristics used by buildings which meet energy based performance standards. Energy targets or performance based standards are an effective method to reduce both energy demand and operative emissions in buildings, while allowing flexibility in building design and function. However, it must be acknowledged that the concept of building sustainably reaches far beyond energy use and carbon emissions only. While these standards are good measures of building performance, they are not all encompassing and are missing features around embodied carbon, social and cultural considerations, and more. There is a great deal of room for future research on intersections of Form and Character Guidelines and sustainable building strategies for performance beyond energy efficiency.

The following section summarize common energy based high performance building standards that are typically met and recognized in British Columbia.

British Columbia Energy Step Code

The BC Energy Step Code is an optional compliance path in the BC Building Code (BCBC) that offers a performance approach to meet levels of energy efficiency which go above and beyond the requirements of the BCBC. BC Energy Step Code operates as a "high performance staircase", grouping performance targets into steps 1, up to, 5 that apply to different building types and regions of the province. The lower steps are straightforward to meet, while the upper steps are more ambitious and require novel approaches to design and construction. The idea of the steps is to create a pathway towards reaching net zero energy ready new construction as a requirement by 2032 (figure 3 & 4). This standard was delineated into steps incrementally increasing in stringency and anticipated to be adopted in temporal phases to provide a pathway for industry to grow with the standard throughout the province. At the time of writing this report, the Township of Langley requires Step 3 for all residential, Type C, occupancies and is anticipates adopting Step Code requirements for other building types in the near future.

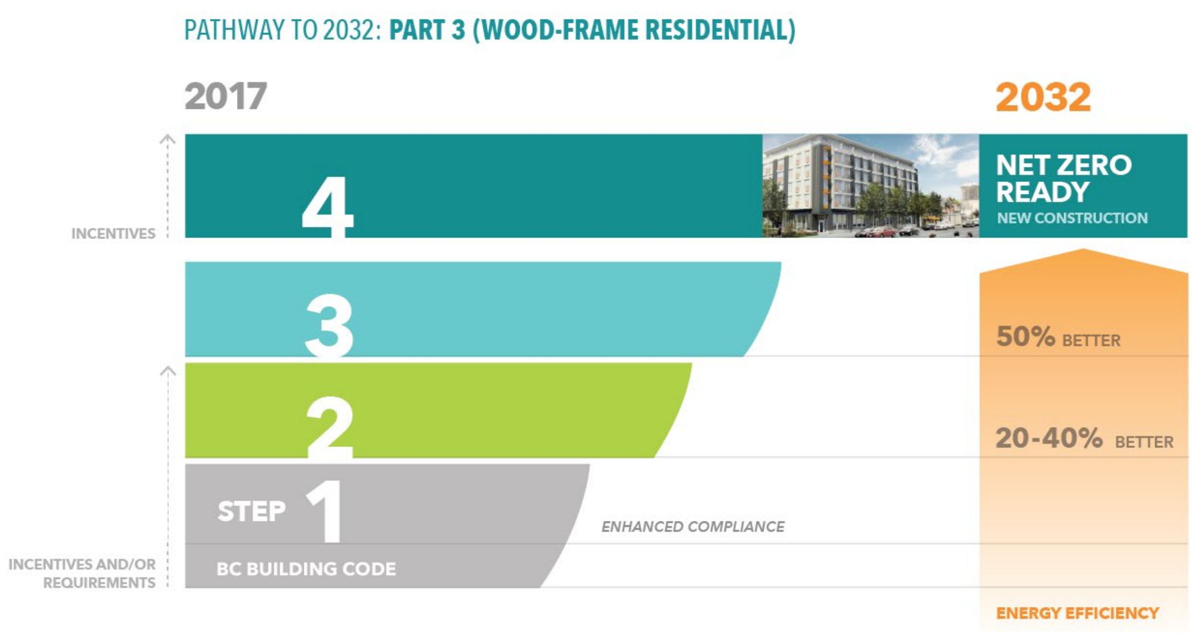


Figure 3: BC Energy Step Codes Steps for Part 3 Wood Frame Residential Buildings. (From Government of BC Building Safety Standards Branch)

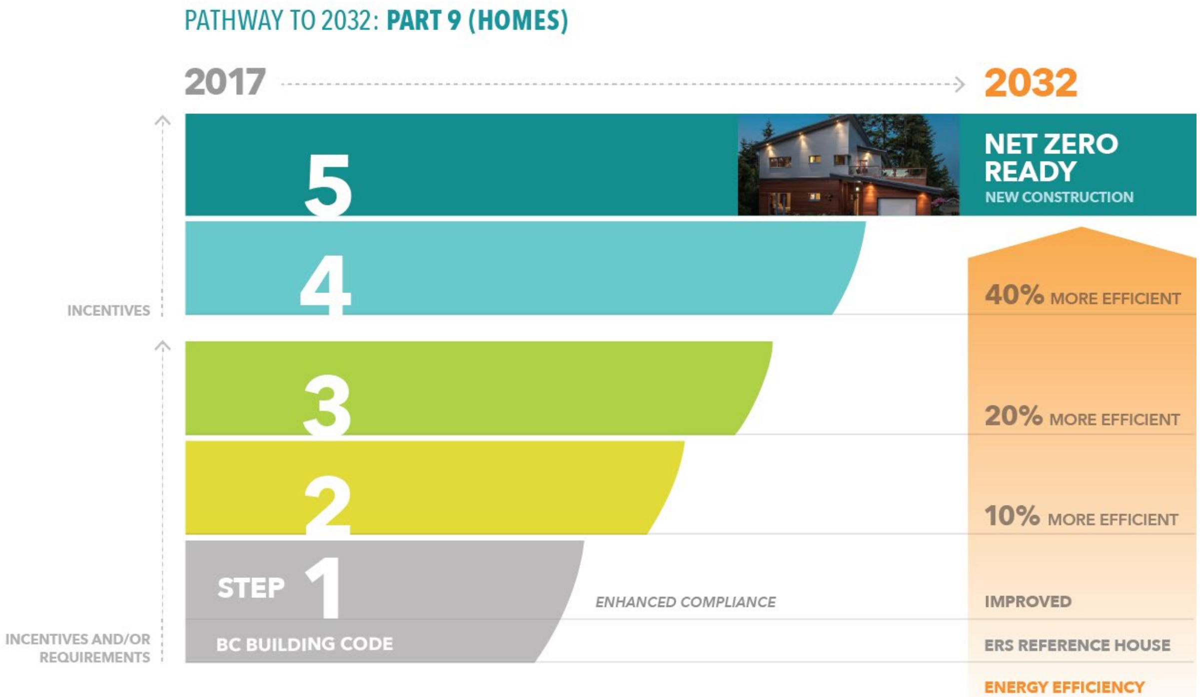


Figure 4: BC Energy Step Codes Steps for Part 9 Homes (From Government of BC Building Safety Standards Branch)

The current BCBC (2018) base requirements allow for two pathways, a prescriptive or performance approach. The prescriptive pathway focuses on the individual elements of a building by defining specific requirements for insulation, windows, furnaces and other equipment and systems. The performance-based pathway requires a performance improvement that can be anything above 0% improvement. The BC Energy Step Code offers an alternative performance based approach which defines the desired outcomes and leaves it up to designers and builders to decide how to achieve it. A combination of energy software modelling and on-site testing is required to prove both the design and constructed building meets the energy targets required by the standard. The targets set by the Step Code include maximum Total Energy Use Intensity (TEUI), Thermal Energy Demand Intensity (TEDI), Mechanical Energy Use Intensity (MEUI), and Air Changes per Hour (ACH) for different building typologies and climate zones.

An additional, in-progress, Provincial standard, called the Carbon Pollution Standard, is undergoing public consultation at the time of this report and anticipates being adopted for application in the 2022 BCBC. This standard, like Step Code, is a multi-level target-based emissions standard where buildings are required to meet specific emissions targets. The code offers both prescriptive and performance-based approaches for compliance, however for municipalities that adopted Step Code, it would be simpler and easier to use the performance-based compliance pathway.

<u>Passive House</u>

Passive House is an internationally recognized, energy based high performance standard, which can be closely compared to the final Step of the Step Code. According to Passive House Canada, Passive House buildings consume up to 90 percent less heating and cooling energy compared to conventional new buildings. Like the BC Energy Step Code, Passive House is a performance-based standard which sets maximums for space heating/cooling energy demand maximum or heating/cooling load maximum, total primary energy demand maximum, and an air tightness requirement. The certification process involves multiple checks with an external reviewer during the planning and design phase, and a proof of execution once construction is completed.

Net Zero & Net Zero Energy Ready

The Canadian Home Builders' Association Net Zero home labelling program has been running since its pilot in 2015. This program provides a two-tiered requirement for certification as either a Net Zero (NZ), or Net Zero Energy Ready (NZER) label for single family homes, townhomes, and MURBs. A Net Zero Energy building can produce as much energy as it consumes and can be designed to be up to 80 percent more energy efficient than a typical new building, according to Natural Resources Canada. To offset the remaining energy they need, they use on site renewable energy systems, such as solar panels. A Net Zero Energy Ready building on the other hand is one that has been designed and built to a level of performance that it could, with the addition of on-site renewable energy technologies, achieve net zero energy performance.

Net Zero or Net Zero Energy Ready certification is determined by an energy performance rating using Natural Resources Canada's EnerGuide Rating System (ERS). This ERS includes an on-site evaluation of the completed construction to collect data including the building's airtightness insulation levels, number of windows, envelope details such as form and articulations, and other information relevant to the building's energy performance. This data is entered into an energy simulator which calculates the building's total energy use per year. This metric provides the EnerGuide Rating, in gigajoules (GJ), where 0 GJ/year would be a Net Zero Home, and 109 GJ/year would be a conventional single-family home. The EnerGuide label also breaks down the proportion of energy consumed by heating, cooling, ventilation, etc., as well as energy consumed by source, such as electricity, natural oil, solar water heating, etc.

The term Net Zero however extends beyond the CHBA certification program as an unofficial building performance standard that is recognized globally, since it a performance target that is relatively simple to understand and quantify– a building which produces as much energy as it consumes. There are a number of buildings in the database compiled for this project which are located in the United States, and so are not certified through the CHBA, but which would be meeting this Net Zero performance target. The Federal Government's 2032 target for building design and construction anticipates having a minimum performance standard baseline aligned with the Net Zero Energy Ready methodology.

1.4. Approach

A mix of online case study scans, literature reviews, and semi-structured interview helped inform the findings of this report.

A database of 40 high performance buildings meeting standards such as BC Energy Step Code, Passive House, or Net Zero Energy Ready was compiled including images and a table of their key exterior design characteristics. This database was used to identify common trends and design features of high-performance buildings.

A review of the Township Community and Neighbourhood Plans was conducted to identify guidelines for building form and character in the Township. Additionally, an interview with a Township planner was conducted to identify guiding philosophies for executing form and character guidelines in the Township of Langley.

Common exterior design characteristics of high-performance building are compiled in the database, and Township form and character expectations were then compared for intersections, which are presented in the findings section of this report.

Scope and Limitations

The scope of this project is defined as the following:

A. In scope:
- Identify common forms and exterior design characteristics of high-performance buildings by compiling a dataset of images and exterior design strategies of 40 high-performance buildings
- Conduct interview with Township staff to identify design requirements and expectations regarding building form and character
- Identify design strategies that are aligned with success meeting high-performance standards, and strategies that are either required by the Township or are typical practice locally that intersect with high-performance design strategies.

B. Out of scope
- High-performance buildings which only meet standards other than BC Step Code Step 4 or 5, Passive House, Net Zero Energy Ready/NetZero, or equivalent energy-based performance standard
- Institutional, commercial, and industrial types of buildings are excluded
- Consideration of design strategies which do not impact the exterior form and character of a building (for example, design of interior spaces, wall assemblies, etc.)
- Consideration of design strategies used by high-performance buildings in climates other than those similar to the Township of Langley's current or projected climate zone.
- Consideration of municipal planning guidelines other than Form and Character

02. Results

Database · Interviews · Discussion

Kiln Apartments, Photo by Eckert And Eckert Photography, Courtesy of GBD Architects

2.1. Database

A database of 40 buildings was compiled to identify trends among the exterior design characteristics of high performance buildings. Buildings included in the database were chosen based on the following criteria.

- The building should meet one or more of the following energy-based high-performance standards commonly used in British Columbia, or equivalent: BC Energy Step Code Steps 4 and 5, Passive House, Net Zero/Net Zero Energy Ready.
- The building should be a residential, or residential mixed use building.
- Exceptions were made for projects with some other important relevance to the project – such as if they were meeting a high-performance standard with remarkable affordability.
- The buildings should have budgets and construction timelines that would be typically found in the Township
- The building should have adequate information accessible publicly online, including photos of all sides of all facades of the building, or location information to view it on Google Maps satellite and street view.
- The building should be located in a climate zone similar to that of the Township of Langley.

To classify the climate zones of each building, The NECB 2017 climate zones were used to classify Canadian buildings, while the ASHRAE 90.1-2010 climate zones were used for American buildings. The two climate classifications systems are similar in that they both use Heating Degree Days (HDD) for classification, but the ASHRAE system also utilizes Cooling Degree Days. A degree day compares the mean outdoor temperatures recorded for a location to a standard temperature, usually the temperature considered to be comfortable before heating or cooling. For annual values, the difference of the daily mean temperature to this standard value are added for every day of the year. ASHARE identifies HDD 5000 to 7000 as zone 7, while NECB further classifies them into zones &A (HDD 5000 to 6000), and 7B (HDD 6000 to 7000). Each of the climate classifications are illustrated in the figures below.

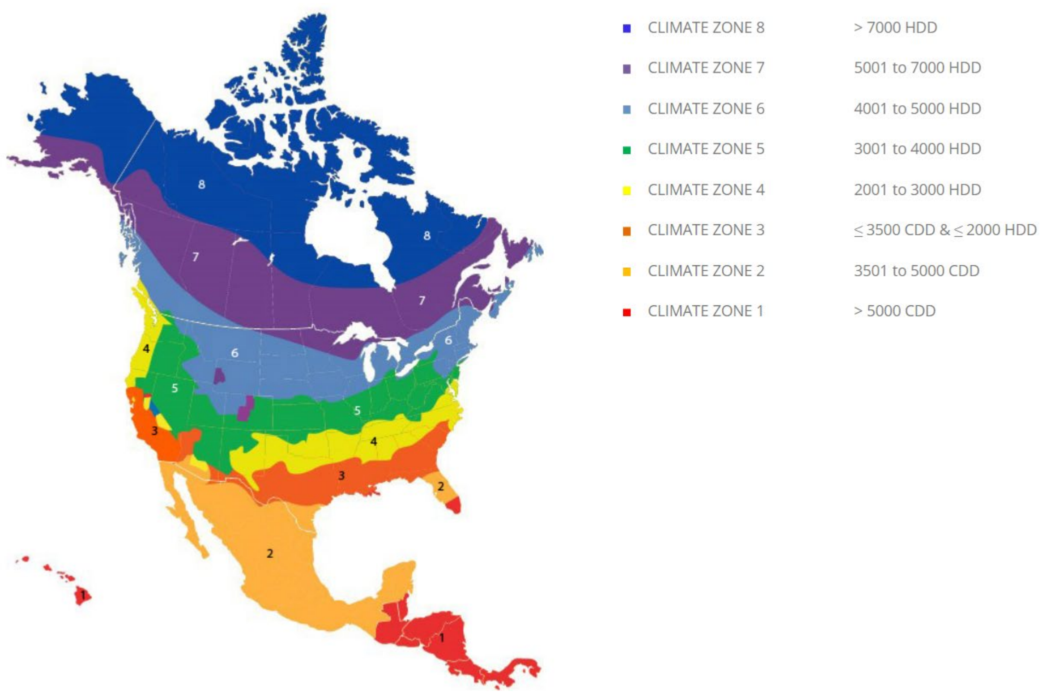


Figure 5: ASHRAE Climate Zones (Courtesy of Akira Living), used to classify American database buildings

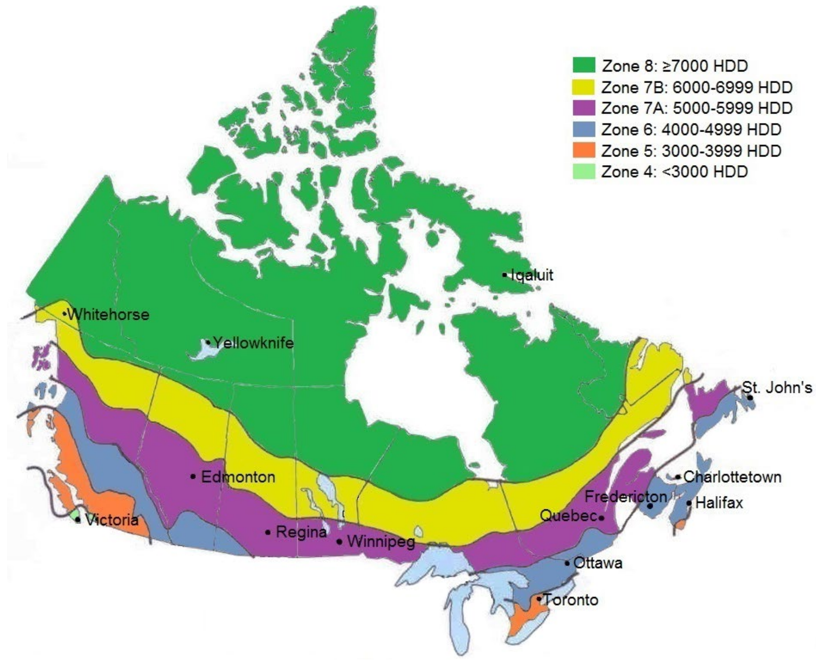


Figure 6: NECB Climate Zones (Courtesy of Naima Canada), used to classify Canadian database buildings

Generally, the ASHRAE and NECB classification align, with the notable exception of Vancouver being classified as zone 5 by ASHRAE, an exception among BC's lower mainland, while it is classified by NECB as zone 4.

The datapoints presented in the following sections were gathered by observation of building photos and images, as well as Google Maps satellite and street view imagery when location data was available.

General Building Information

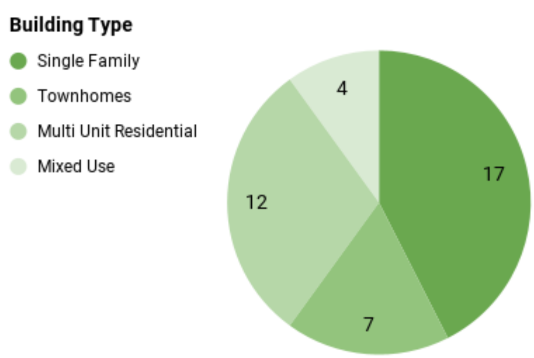


Figure 7: Chart of building types included in the database

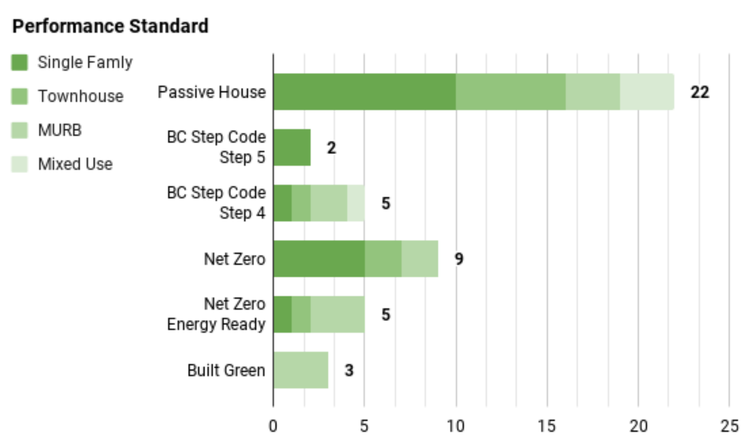


Figure 8: Graph of performance standards met by database buildings

Of the 40 buildings compiled in the database;

- 17 were single family homes,
- 12 were townhouses ranging from duplexes to six-plexes,

- 12 were multi unit residential buildings,
- 4 were mixed use buildings, ranging from 2 storeys to 6 storeys.

Passive House was the most common performance standard met of the buildings in the database, with 22 of the 40 buildings being Passive House certified. Net Zero and Net Zero Energy ready were the second and third most common standards, followed by BC Step Code Step 4 & 5, and the Built Green Standard. Built Green is the green home certification program of the Master Builders Association of King and Snohomish Counties, in Washington, USA.

It should be noted that Passive House projects make up a larger part of the database compared to the other performance standards. It is the most well-established performance standard included in this database – Passive House has been around since the early 1990's and is internationally recognized. BC Energy Step Code, on the other hand, has only been available for adoption since 2019, and its final steps were not anticipated to be required by municipalities immediately after becoming available. Information about Passive House projects is also easily accessible online. Passive House Canada hosts a project map with photos and project specifications of all certified Passive House projects in Canada, while projects from other standards were sought out from the websites of individual builders and designers, and other organizations. It is anticipated, over time, that the number of buildings meeting the Upper Steps of the BC Energy Step Code will increase significantly.

The Township of Langley's climate classification is climate zone 4 (as per BC Building Code 2018, Appendix C), which has less than 3000 Heating Degree Days. In this climate zone, concerns for heating in the winter need to be balanced with overheating/cooling in the summer. Most of the buildings in the database, 31 of 40, are in climate zone 4. The remaining 9 are in climate zone 5, which has more Heating Degree Days, but similar concerns about balancing different thermal needs throughout the seasons.

Figure 9: Table of Database Building Locations

Climate Zone	*City/Region*	*Province/State*	*Count*
4 <3000 HDD (NECB) <2001 to 3000 HDD (ASHRAE)	Vancouver	British Columbia	10
	Victoria	British Columbia	6
	North Vancouver	British Columbia	3
	Seattle	Washington	3
	Township of Langley	British Columbia	2
	New Westminster	British Columbia	1
	Burnaby	British Columbia	1
	Langford	British Columbia	1
	Ruby Creek	British Columbia	1
	Issaquah	Washington	1
	Portland	Oregon	1
	Hillsboro	Oregon	1
5	Arvada	Colorado	3

3000-3999 HDD (NECB) 3001 to 4000 HDD (ASHRAE)	Comox Valley	British Columbia	2
	Nanaimo	British Columbia	1
	Parksville	British Columbia	1
	West Kelowna	British Columbia	1
	Pemberton	British Columbia	1
		Total	40

Orientation

15 of the 40 database buildings are oriented with their longest side running from East to West, while another 13 were oriented Southwest-Northeast, making up a total of 28 of 40 buildings significant south facing façade area. Five buildings are oriented North South, and two North West-Southeast. One L-shaped building has portions oriented both North South and East West, and one other building is oriented North-South and East-West.

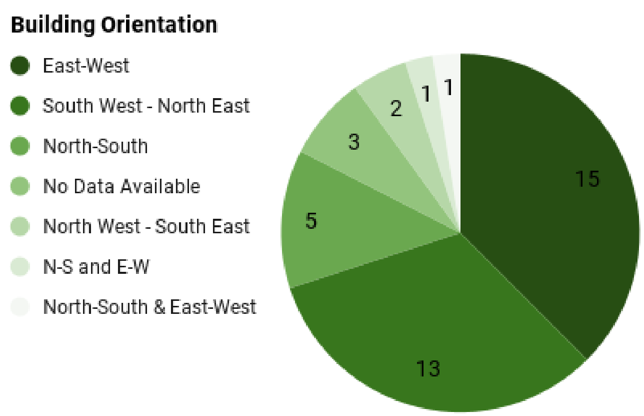


Figure 10: Graph of Database Building Orientations

It should be noted that for a large number of these buildings, their orientation is dictated by the orientation of the parcel of land on which it was built, because of their urban location. It should be acknowledged however that the proportion of buildings in the database with large surface area oriented to the south, being 28 of 40, is large, and so East-West orientation should be noted as a trend of the buildings compiled in this database.

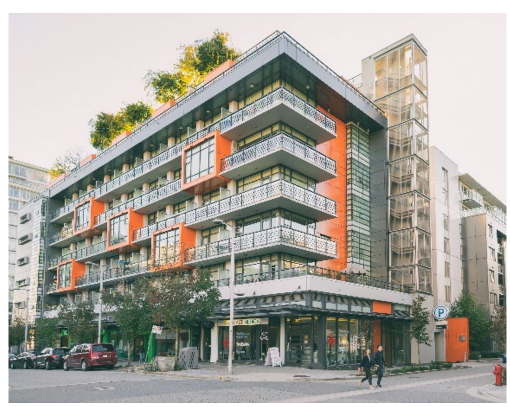
Geometric Articulation

Using observation of imagery and an approximate count of surface area and roof faces, each database building was classified as having either a ‘low’, ‘moderate’, or ‘high’ number of geometric articulations. An observational measure was used because ‘surface area to volume ratio’, the common metric for measuring a building’s degree of geometric articulation, was not available for most of the buildings in the database, so establishing an observational measure was the next best way to compare the buildings. The number and application of articulations can have a meaningful impact on overall energy performance.

Geometric articulation, for the purposes of this report, is defined as changes in plane or massing in a building, such as stepping of the façade, recession of the building entrance, changes in roof plane at ridges, etc. An articulation was only counted if it was part of the thermal envelope – meaning it was articulating a space that is either heated or cooled by the building’s mechanical system. An emergency staircase, for example, that is enclosed, but outside of the building’s insulated walls, would not be counted as part of the building’s articulations.

Classification of either 'low', 'medium', or 'high' degree of geometric articulation was determined by the following ranges:

Figure 11: Table of Geometric Articulation Classifications

	Single Family, Duplexes - Fourplexes	*Fiveplexes - MURBs/Mixed Use*
Low	6-15  *Photo courtesy of Interactive Construction*	6-30  *Photo courtesy of Cascade Built*
Moderate	16-24  *Photo courtesy of b Squared Architecture*	31-50  *Photo courtesy of Corner Stone Architecture*
High	25+  *Photo courtesy of pwnra (Flickr)*	51+  *Photo courtesy of IQRemix (Flickr)*

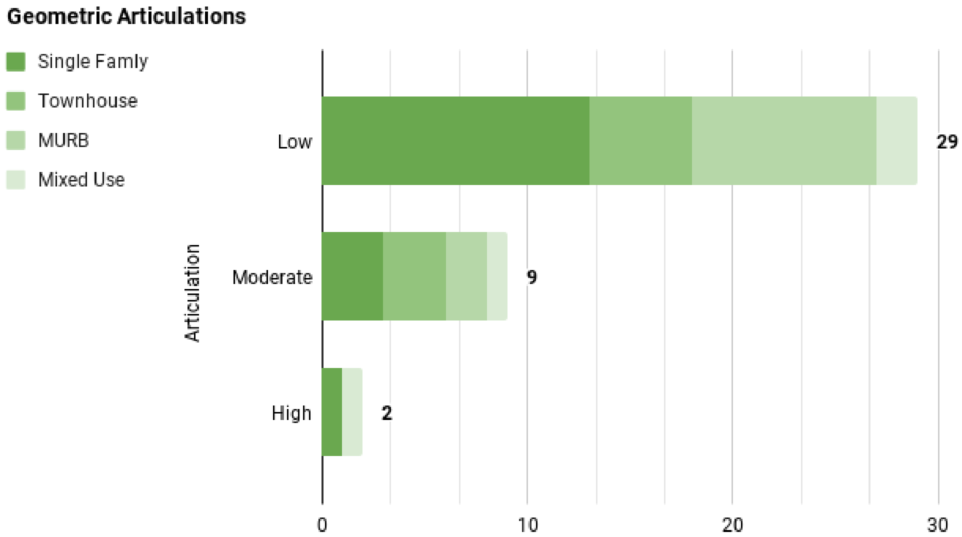


Figure 12: Graph of levels of geometric articulation of database buildings

29 of 40 of the database buildings have a low degree of geometric articulation, while only 11 have a moderate or high degree of geometric rotation. The spread of building type among each category is relatively even.

Roof Type

The figure below provides a simplified illustration of the general roof types identified in the database buildings.

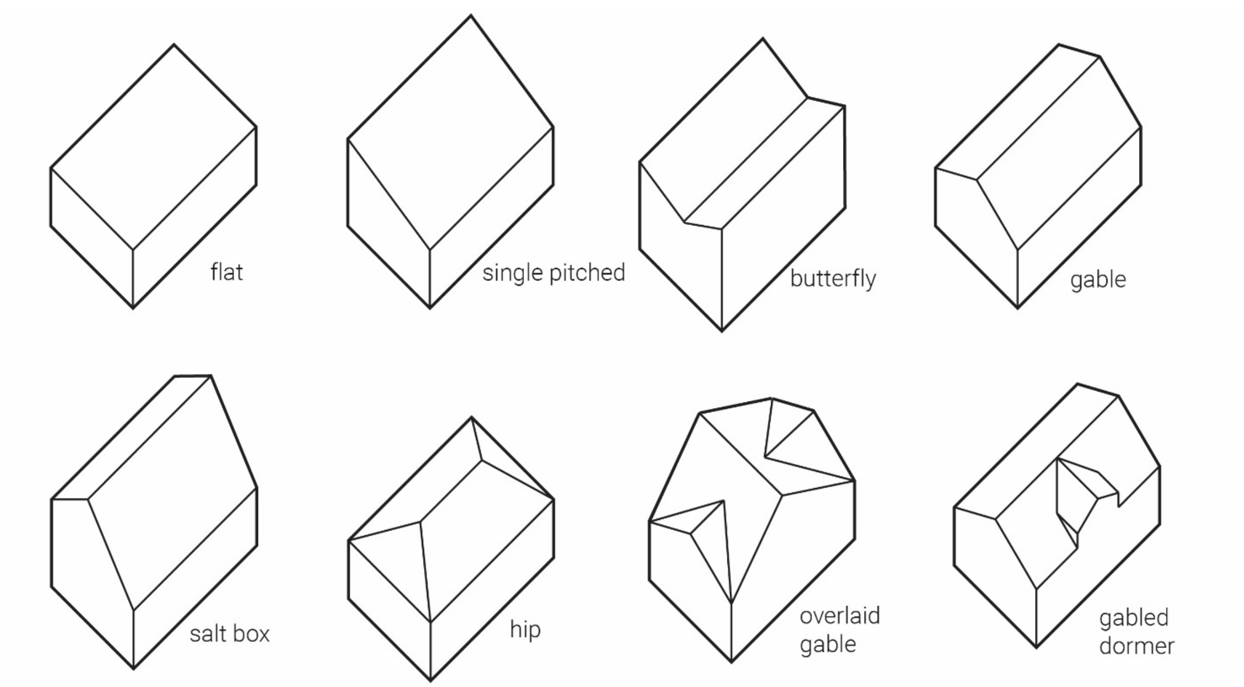


Figure 13: Illustration of Roof Types

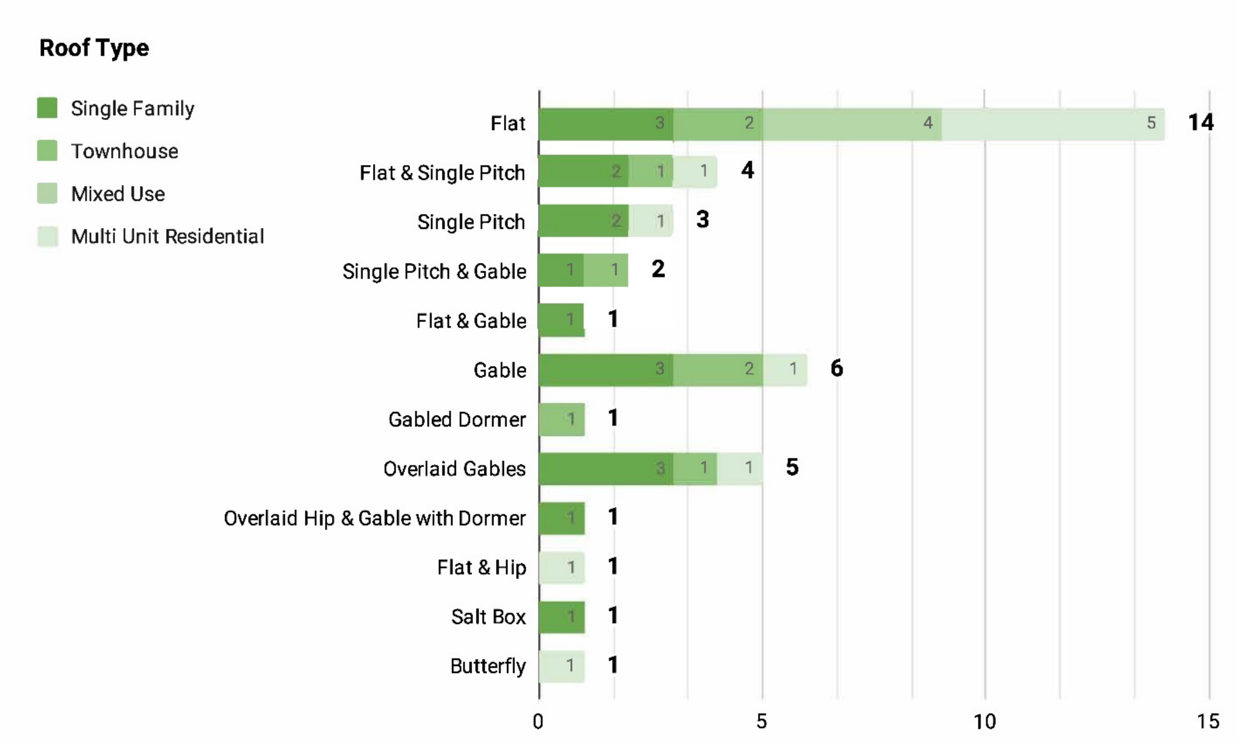


Figure 14: Graph of Roof Types

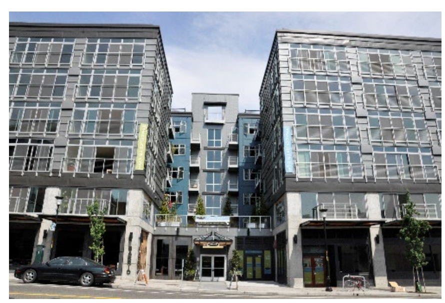
The most common roof type among database buildings overall is flat, including variations and combinations of flat roofs with other types such as single pitch and gable roofs. 14 of the database buildings have a flat roof, and another 6 have a flat-combination roof.

Among MURBs and Mixed-Use buildings, flat roofs were the most common roof type – 9 of the 16 MURBs and Mixed-Use buildings had a flat roof, and two more had a flat-combination roof. Among townhouses and single-family database buildings, there was a relatively even spread across all roof types.

Window to Wall Ratio

Like the geometric articulations data collection, window to wall ratio was approximated and classified into ‘low’, ‘moderate’, and ‘high’ ranges based on observation of building imagery. The following table displays approximate window to wall ratios for each category, and an example image.

Figure 15: Table Classifying Window to Wall Ratios

	Low	*Moderate*	*High*
Single Family	<20%  *Photo courtesy of Uegama Architecture*	21%-50%	>50%  *Photo courtesy of pwrna (Flickr)*
Townhome	<20%  *Courtesy of the Township of Langley*	21%-50%	>50%  *Photo courtesy of Staying LEVEL (Flickr)*
MURB / Mixed Use	<30%  *Courtesy of William Wilson Architects*	31%-60%	>60%  *Photo courtesy of cleverdame107 (Flickr)*

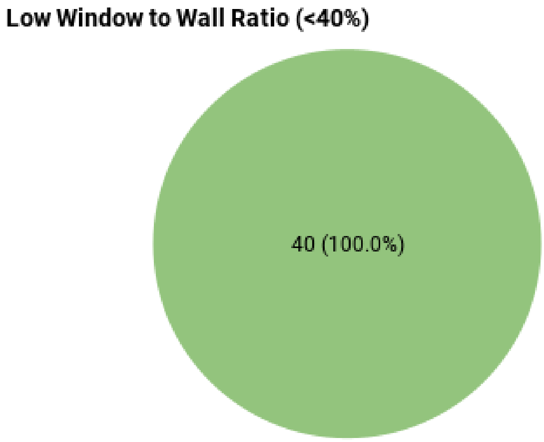


Figure 16: Chart showing number of database buildings with low window to wall ratio

All database buildings have a low window to wall ratio.

Exterior Shading

Fixed exterior shading strategies including roof overhangs, appended sun shading devices, screens, balcony overhangs, etc., is common among the database buildings, a design strategy used on 37 of the 40 buildings. Fixed exterior shading is common among all residential building typologies in the database. Operable exterior shading, including roller blinds and screens was less common, used only on three buildings. Of all database buildings, only 3 did not make use of any exterior shading strategies.

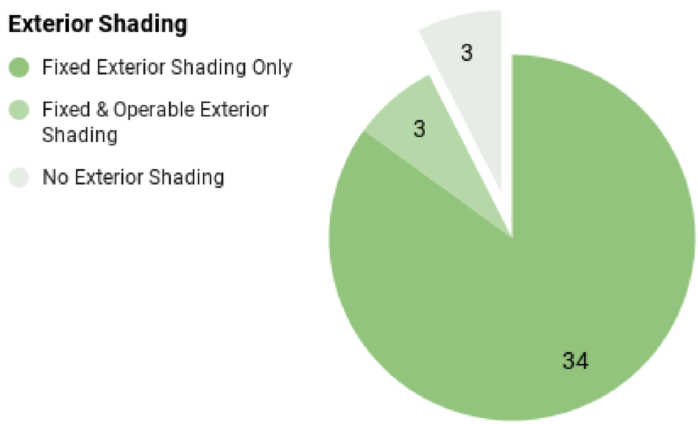


Figure 17: Graph of database buildings using operable, fixed, or no exterior shading strategies exterior shading strategies

The following table illustrates examples of fixed exterior shading strategies used by buildings in the database.

Figure 18: Table with image examples of fixed exterior shading strategies

Roof Overhang

Photo courtesy of Nick Bray Architecture

Horizontal Sun Shading Devices

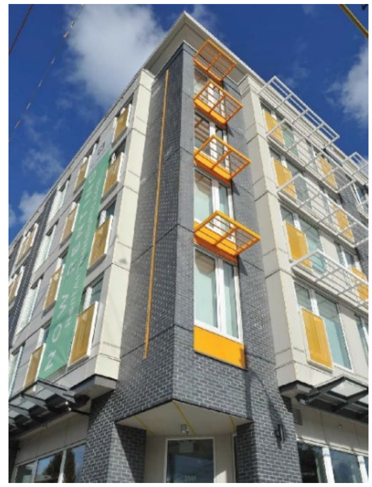


Photo courtesy of Cornerstone Architecture

Balcony Overhangs

Photo courtesy of Design Build Services

Vertical Wall Extensions

Photo by Dasha Armstrong Photography, courtesy of Waymark Architecture

Screens

Photo courtesy of Cascade Built

Recessed Windows

Photo courtesy of Econ Group

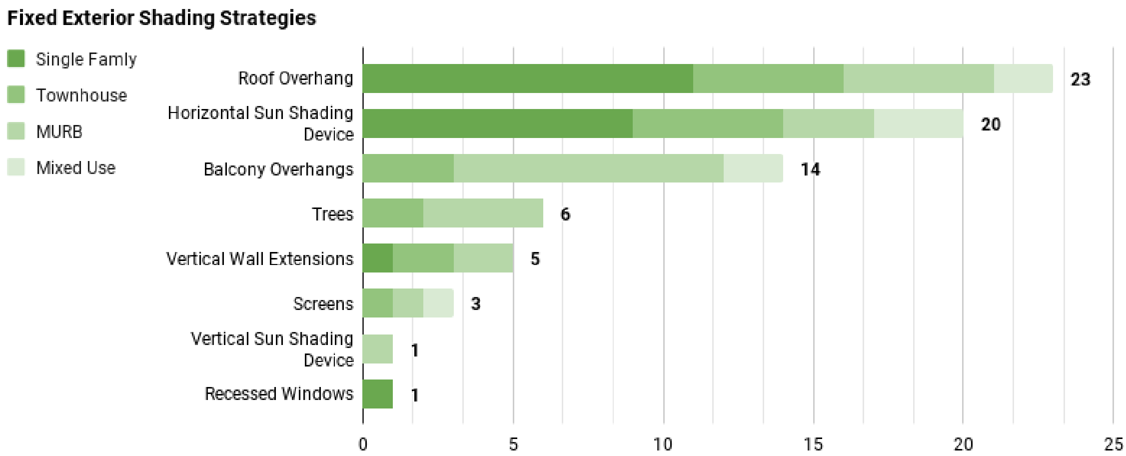


Figure 19: Graph of Fixed Exterior Shading Strategies used by Database Buildings

Of the fixed exterior shading strategies used by buildings in the database, roof overhang was the most common overall, used by 23 buildings, followed by horizontal sun shading devices, used by 20 buildings. Among single family and townhomes, roof overhangs and horizontal sun shading devices were the most common, used by 16 and 14 of the 25 single family/townhomes, respectively. Among MURBs and Mixed-Use buildings, balcony overhangs were the most common, used by 11 of the 16 MURB/Mixed-Use buildings.

Outdoor Amenity Spaces (MURBs & Mixed Use Only)

Design strategies to provide outdoor spaces for occupants of MURBs and mixed-use buildings were observed. Of the 16 MURB/mixed use buildings in the database, one used Juliet Balconies, 6 had a common courtyard or terrace, and 5 used externally supported balconies, and 9 had cantilevered balconies.

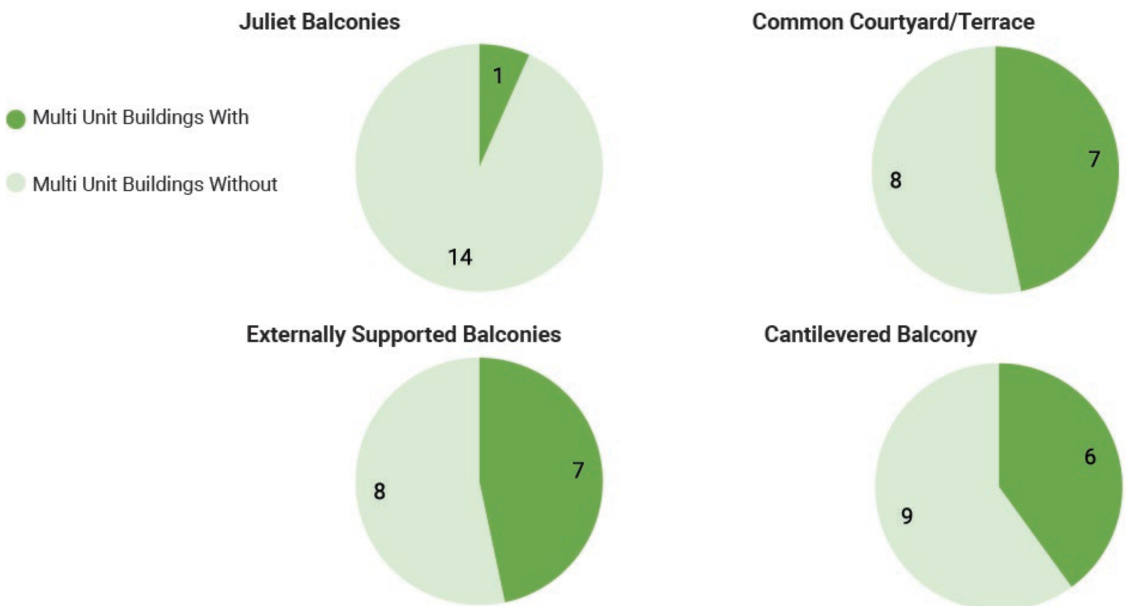


Figure 20: Charts showing number of MURBs and mixed use buildings which have Juliet balconies, a common terrace/courtyard, externally supported balconies, and cantilever balconies

2.2. Interview

An interview with a senior Township planner was conducted to identify guiding philosophies for executing form and character guidelines in the Township of Langley. The interview was semi-structured in nature, a list of questions was presented but the interviewee was encouraged to give any kind of answer they wanted. The goal of the interview was to have a general discussion about expectations for residential buildings in the Township of Langley, and not to draw out prescriptive interpretations of the Community and Neighbourhood plans. Questions ranged from general expectations for the exterior design and appearance of buildings, to discussion about more specific design elements.

During the interview, four design priorities emerged as critical considerations related to the exterior appearance of residential buildings in the Township which could potentially intersect with the common design strategies identified among the high-performance buildings.

Visual Interest in the Public Realm

Many of the Community and Neighbourhood Plans encourage the use of geometric articulation to create visual interest in the public realm, however other strategies used to create visual interest and break up the visual mass of buildings, such as variety in material, colours and textures, appended and decorative elements, and many more, were discussed. It was highlighted that creative thinking will be required to balance visual interest and performance, and that alternative strategies to create visual interest and to break up the visual massing of large buildings, besides geometric articulation, are welcomed when thoughtfully designed.

The overall importance of quality and thoughtfulness in design of a building was additionally emphasized – though buildings may vary in their design approach and style, visual balance and composition of form and geometry, fenestration, and other elements are important for creating and maintaining aesthetically pleasing neighbourhoods.

Alignment with Township Vernacular

Alignment with the existing context and vernacular architecture in the Township was also highlighted as being a design outcome of significant importance. Discussion revealed that this is both important from an aesthetic perspective, to create visually cohesive neighbourhoods and communities, as well as a performance perspective. Vernacular building styles are responsive to the climate of an area, as previously discussed, and so they good references for create comfortable, safe, and pleasant homes to live in. Contemporary interpretations of coastal vernacular styles are for this reason, encouraged over importing architectural styles from places with very different climates.

For example, pitched roofs are often encouraged in Township Community and Neighbourhood plans because they are good at shedding water to prevent it from penetrating the building envelope. Additionally, thoughtful window placement and design is important to create bright living spaces in the overcast lower mainland climate. Dormers were highlighted as a design feature which is effective at bringing light into a building and creating visual interest. It was also mentioned that though exterior shading is not often mentioned in Community and Neighbourhood plans, some strategies, such as a heavy timber sill and lintels, could complement regional vernacular well while providing this additional performance benefit.

Sense of Community

The role of a building's exterior design in creating a sense of community in the Township was also discussed. Elements such as front or wrap around porches, visual definition of a main level by generous fenestration, and street facing balconies create a sense of community and safety in neighbourhoods by animating the pedestrian level of neighbourhoods and creating a sense of 'eyes on the street'.

Access to Outdoor Space for Residents of MURBs and Mixed-Use Buildings

Discussion around design outcomes for MURBs and mixed-use buildings underlined the importance of access to outdoor spaces for residents, especially for those who do not have direct access to the ground from their unit. It was explained that the inclusion of a common outdoor space, such as a rooftop terrace or other extended outdoor amenity space, is a desirable design outcome though it would need to consider resident privacy and safety thoughtfully in its design.

Design strategies for private outdoor space such as Juliet balconies and externally supported balconies were also discussed. It was emphasized that all balcony designs need to be thoughtfully designed to be well integrated into the building's architecture, and not appear as a secondary consideration.

These priorities and desired design outcomes, and their intersections with design strategies for high performance, will be further discussed in the following section.

2.3. Discussion

Orientation

28 of the 40 database buildings were oriented to have significant façade area facing south. This trend of significant southern exposure is likely because it facilitates increased thermal gain for passive heating, and daylighting. As noted previously, orientation is often dictated by the orientation of the parcel of land on which the building is constructed, however the proportion of buildings in the database with large surface area oriented to the south, being 28 of 40, is large, and so East-West orientation should be noted as a trend of the buildings compiled in this database.

The orientation of a building effects the amount of sun it receives throughout the year. When a building has a greater amount of area facing south, its solar gains are maximized, meaning its potential for passive heating increases. Ideally, a building should be oriented within 30 degrees of East-West.[2] When a building is being passively heated by the sun, the need for mechanical heating decreases, and thus its energy consumption also decreases. Considerations need to be made to avoid overheating, while balancing passive heating, as both are useful to reduce mechanical heating and cooling loads depending on seasonal needs.

Orientation decisions should also consider potential for daylighting. Like orientation for thermal gain, south facing façade orientation is useful for its exposure to more direct sunlight hours. With a larger

[2] Integral Group, *Designing Energy Efficient Buildings: A Reference for Planners and Designers* (Surrey: City of Surrey, 2016), 18, https://www.surrey.ca/sites/default/files/media/documents/DesigningEnergyEfficientBuildings.pdf.

surface area facing south, glazing can be used for natural daylighting to reduce electric lighting loads. East and West exposure can also be useful for morning and afternoon daylighting, respectively.

Additionally, thoughtful orientation, in addition to roof design relative to orientation, can have significant impacts on the feasibility of on-site solar energy generation. Good southern exposure is important to maximize the solar gain of a PV array, and so thoughtful orientation of a building, and its roof design, are important considerations in order to design a truly “Net Zero Energy Ready” building.

Intersection with Township Form & Character Guidelines

1. Guidelines for Orientation Relative to the Public Realm

The Township of Langley’s Form and Character Guidelines typically encourage that buildings be oriented to streets, greenways, or other public spaces they might face. This is emphasized in neighbourhood and community plans as being important to provide overview for public safety and encourage resident involvement with activities of the neighbourhood.[3] Orientation to the street in this case does not necessarily mean that building needs to be oriented with its long axis parallel to the street, but rather that the façade which indicates the building’s ‘front’ should face public spaces. Ways that a building might indicate its front include large glazing and an entrance on that façade, among others. Tall buildings are required in some neighbourhood and community plans to be aligned parallel to the street in a North-South direction.

Though the orientation of most buildings is dictated by their lot shape and orientation, it should be acknowledged that optimizing a building’s orientation for balancing thermal gains in the winter and minimizing them in the summer has the potential to significantly impact its performance. . The apparent orientation of a building’s ‘front’ to the street, is discussed further in the sections below.

Articulations

Among buildings of all types in the database, a simple overall form – with 29 of the 40 database buildings being classified as having a low degree of geometric articulation, and 9 as moderate – emerged as a common trend.

Among the 15 MURBs and mixed-use buildings in the database, flat and flat-combination roof types were the most common – 11 of these buildings had a flat or flat-combination roof, and another 1 had a single pitch roof. Among single family homes and townhouses, roof types varied more, but most had simple roof types such as single pitch, flat or gable, or some combination. Only 2 had dormers, and only 5 of 25 had overlaid or intersecting roof types, a more articulated roof form than the others recorded in the database. This indicates a trend of simple roof types among MURB and mixed-use high-performance buildings. Single family homes and townhomes had slightly more articulated roof forms than the larger building types, but overall also had simple roof lines and shapes.

A building with a simpler form lowers the potential for thermal bridging to occur through complex junctions in the building envelope. Fewer complex joints and surfaces can also reduce opportunities for air leakage and moisture infiltration. Additionally, a compact mass can reduce building envelope heat

[3] Township of Langley, Willoughby Community Plan ByLaw (No. 3800), 4.1.2.3 Multiple Unit Development: Site Design.

loss by reducing the building's surface area exposed to the outside. This reduction of heat loss, and air leakage, reduces the energy required to keep a building's interior thermally comfortable. Less moisture infiltration can also reduce mold and mildew growth, contributing to better indoor air quality.

It should be noted that geometric articulation of the roof form however would not impact heat loss if the conditioned space in the building is insulated by an attic or mechanical penthouse floor. In this case, since the roof form is above an insulated floor, the 'seams' and edges of the roof would not create additional heat loss because it is not part of the thermal envelope of the building. Dormers for example, would lead to heat loss through its geometric articulation and glazing, because it would be part of the thermal envelope of a building because the roof would typically need to be part of the thermal envelope for light from the dormer window to penetrate the living space.

<u>Intersections with Township Form & Character Guidelines</u>

1. Geometric Articulation

The Township's Form and Character Guidelines often encourages the use of geometric articulation, such upper storey setbacks and façade modulation, to break up the visual mass of large buildings.[4] Stepping the façade of townhouses is also encouraged to create variation and visual intervals between each dwelling unit.[5] Geometric articulation such as façade projections and recesses, are also encouraged to create 'architectural interest', to create visual interest on street and public facing building facades.[6]

2. *Roof Types*

Varying roof planes through design strategies such as alternating dormers, stepped roofs and gables is encouraged in the Township's Community and Neighbourhood plans to create visual interest. In the Walnut Grove-Redwoods Neighbourhood Plan for example, articulated roof forms are encouraged to help define building massing and add character to the area. In other community plans, such as the Willoughby Community Plan, pitched roofs are required in multiunit residential buildings, unless a green roof or amenity space incorporating landscaping is provided.[7]

Interviews with township staff indicated that pitched roofs are often a desired outcome because of their alignment with the typical vernacular of homes in the township. This design outcome is both related to aligning the character of new buildings to the existing Township context, as well as from a performance perspective for the function of shedding water.

It should be acknowledged that geometric articulation of both a building's façade and roof can have a significant impact of its heat loss. In the interview with a Township planner, it was highlighted that creative thinking will be required to balance visual interest and performance, and that alternative strategies to create visual interest and to break up the visual massing of large buildings, besides geometric articulation, are welcomed when thoughtfully designed.

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[4] Township of Langley, Aldergrove Community Plan Bylaw (No. 1802), Part VI Aldergrove Core Area Plan: 3.6 Scale and Massing.

[5] Township of Langley, Brookswood-Fernridge Community Plan Bylaw (No. 5300), 10.1.3.17, Guidelines, Building Form.

[6] Township of Langley, Brookswood-Fernridge Community Plan Bylaw (No. 5300), 10.1.3.5, Guidelines, Key Guidelines.

[7] Township of Langley, Willoughby Community Plan By-law (No. 3800), 4.1.2.3 Multiple Unit Development: Building Form.

Glazing

All database buildings were categorized as having a low overall window to wall ratio. This indicates a significance in the role of thoughtful window design for achieving high performance energy standards.

Windows and doors can account for more heat gain or loss than any other element in an insulated building envelope.[8] Because of this, their size and placement on a building's façade must be carefully considered to balance needs for daylighting and solar gain in the winter, with minimizing passive thermal gains in the summer and losses in the winter. Thoughtful design of a building's windows can improve internal daylight levels, reduce glare, and help maintain a thermally comfortable building interior, while reducing the need for mechanical heating, cooling, and lighting.

Typically, window to wall ratio can be greater on south and east facing facades to increase daylighting and lower lighting loads. Shading is often recommended for south and west facing glazing as greater sun exposure on these faces can lead to unwanted solar heat gains in the summer and contribute to overheating. On the north façade, a lower window to wall ratio is often best to reduce heat loss in the winter, since north facing windows have less potential for daylighting.

Heat is gained and lost both through the window's frame and glass panels, so it is important to considered both elements in window design. Typically, a single window of the same area as multiple small windows leads to less heat loss because it has a shorter perimeter length through which heat is lost through the frame.

Intersections with Township Form & Character Guidelines

1. *Glazing for Increased Sense of Transparency & Visual Interest*

Township Form and Character Guidelines often encourage of the use of windows at the eye level to create inviting and social neighbourhood, as well as providing natural surveillance.[9] Particular window patterns and sizing can also contribute to the sense that a building is oriented with its front facing the street, which aligns with the orientation expectations discussed in the section above. In the Aldergrove Community Plan, it is noted that shop fronts in mixed use buildings should incorporate a high percentage of glazing, while the Gordon Estate Neighbourhood Plan encourages ample large windows for single family homes to increase a sense of transparency and openness in the neighbourhood.

The use of windows is also encouraged in Township Form and Character Guidelines from the perspective of increasing visual interest of buildings and breaking up a large building's massing. Repeating window patterns and projecting bay windows are encouraged to create architectural interest.

It should be acknowledged that large glazing areas, both as it related to overall window to wall ratio, and the orientation of a building's windows, have a significant impact on a building's passive heat loss and gain and thus its heating and cooling energy loads. A balance needs to be achieved between creating a sense of openness and visual interest in a neighbourhood, while also considering the orientation, placement, and sizing of windows from a performance perspective.

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[8] BRANZ Ltd., "Glazing and Glazing Units," *Level*, https://www.level.org.nz/passive-design/glazing-and-glazing-units/.

[9] Township of Langley, Aldergrove Community Plan Bylaw (No. 1802), Part VI Aldergrove Core Area Plan: 3.1 Intent and Objectives, Great Streets.

2. Alignment with Vernacular

Township Form and Character Guidelines often encourage an alignment between the character of new builds, and those which already exist in the neighbourhood. Additionally, some community and neighbourhood plans specify that window design should be vertically proportioned and approximately the same size as traditional windows.[10] The sizing of windows in traditional home types in the area, such as the vernacular farmhouse style, would most often be considered as aligning with a lower window to wall ratio. The photo to the right, shows the Lattimer Residence, a registered Historic Place located in the community of Milner in the Township of Langley, which exemplifies the vernacular farmhouse style, with its characteristic symmetrical and modestly sized windows. The guidance that windows be used meaningfully to match community vernacular indicates that wise use and design of fenestration has more aesthetic and social engagement value than the sheer number of windows.

Figure 21: Vernacular Farmhouse, Registered Historic Place, Lattimer House, 1910

Exterior Shading

Exterior shading was a very common feature among the database buildings – 37 of the 40 buildings employed exterior shading design strategies. Exterior shading, such as window overhangs, is an effective design strategy to reduce overheating potential, it reduces solar gain to its interior in the summer months, while allowing some sun to penetrate through its windows for daylighting. Exterior shading is particularly effective in comparison to interior blinds or screen because it prevents heat from entering the building's interior, not just light.

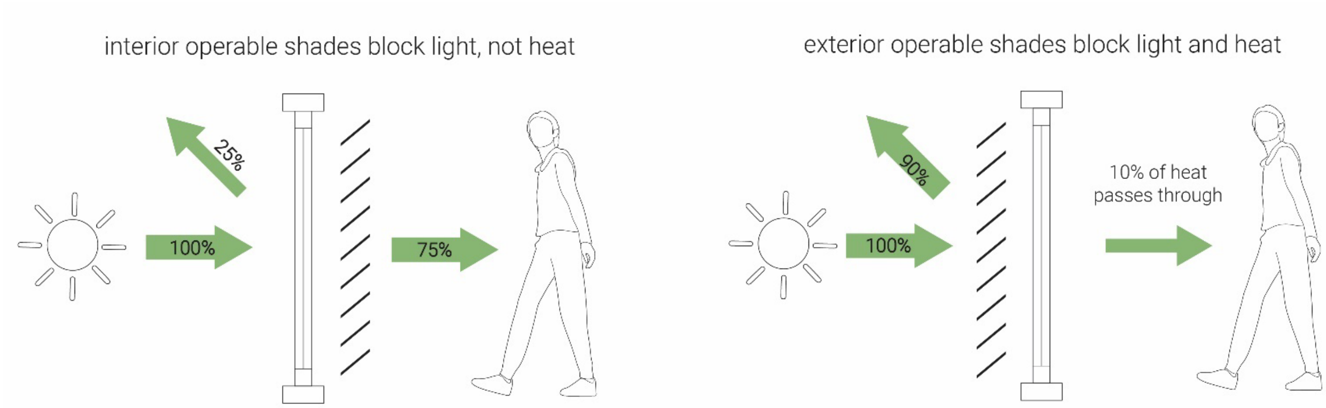

Figure 22: Diagram showing differences between interior and exterior operable shading

[10] Township of Langley, Aldergrove Community Plan Bylaw (No. 1802), Part VI Aldergrove Core Area Plan: 3.9 Architectural Concept: Achieving a Human Scale, Guideline G.

Different shading strategies are useful for different building facades depending on their orientation because of the sun's changing position throughout the day and changing path throughout the year. The following table summarizes these shading strategies for orientation.

Orientation	*Sun Angle*	*Time of Day*	*Most effective type of shading*
South	High angle	Middle of day	Fixed or adjustable above window
East / West	Low angle	Morning/Evening	Operable screens/shutters
SE / SW	Low angle	Morning/evening (winter)	Operable shading

Operable exterior shading is especially useful at reducing unwanted solar gain in the summer months because it can be adjusted depending on the sun's angle throughout the day, unlike fixed shading devices. Operable exterior shading however was much less common among the database buildings, used only on two of 40 buildings, despite its proven effectiveness at reducing unwanted solar gain. This could be because of the North American supply chain for these products is still in development, [11] and they are currently significantly less popular in North America as than in Europe.

Intersections with Township Form and Character Guidelines

1. Porches

The Township of Langley's Form and Character Guidelines encourage the use of wrap around front and side porches for both single family and townhomes. This is encouraged explicitly in plans such as the Gordon Estate Neighbourhood Plan, and implicitly in other plans such as the Brookswood-Fernridge plan, where "small town" and "rural character" elements are encouraged – which the interview with a Township planner indicated front porches supported. Porches are additionally desirable design strategies from a performance perspective, acting as fixed exterior shading to help reduce a building's overheating potential or/and cooling loads.

2. *Alignment with Vernacular*

As discussed previously, Township Form and Character Guidelines often encourage an alignment between the character of new builds, and those which already exist in the neighbourhood. Porches and roof overhangs are characteristic of the Township's existing building stock, and so their employment as strategies for exterior shading would align with this design outcome. The photo to the right shows the Matheson Residence, an example of vernacular residential form in the Township of Langley. The front façade of the building faces south – the roof overhang over the front porch shades its windows and door.

Figure 23: Vernacular Residential Form, Registered Historic Place, Matheson Residence, 1898

[11] Monte Paulsen, "A Pattern Language from Passive House", Lecture, Township of Langley, BC, September 2021.

3. Creating Visual Interest

The Township's Form and Character Guidelines also encourage the use of overhang at the first storey of a MURB/Mixed Use building in order to break up the visual mass of a building to create a human scale pedestrian environment. Like porches, appended overhangs over the first storey of a building too can act as fixed exterior shading devices.

The Township's Form and Character Guidelines also often encourage the use of building design and decorative elements to contribute to the visual interest and character of a neighbourhood. Suggested elements include cornices, dormers, and decorative motifs. Exterior shading devices could be considered to positively impact the visual interest of a building and so may be considered to align with this desired design outcome.

Balconies and outdoor spaces

Among the multiunit and mixed-use buildings in the database, there were three notable design strategies used for outdoor amenity spaces which offered alternatives to the common cantilevered balcony: externally supported balconies, a common courtyard or terrace, and Juliet balconies. These alternative strategies to the cantilevered balcony are notable because they avoid the issue of thermal bridging.

Thermal bridging occurs when a conductive building element creates a pathway from the interior of a building to the exterior environment for heat to travel. Structurally cantilevered balconies can act as major thermal bridging elements when they are not intentionally detailed to prevent to heat loss. When the structural elements of the balcony outside of the building envelope cool down in cold weather, an energy exchange occurs, and heat travels from the interior of the building through the thermal bridge and is lost to the exterior environment. This leads to reduced occupant comfort because of 'cold spots' on the floor created by these thermal bridges, as well as increased heating loads and thus carbon emissions. Additionally, at the meeting point of hot and cold along the thermal bridge, condensation can occur inside the building envelope, which can lead to major damage over time.

Cantilevered balconies can be detailed to avoid thermal bridging using materials such as stainless steel, or with rubber gasket systems that minimize opportunities for heat loss. This however can add additional cost to building design.[12]

An alternative design strategy which still provides a private outdoor space for residents is externally supported balconies. These balconies are designed to separate the balcony from the rest of the building by relying on structural elements outside of the thermal envelope of the building like columns or tension cables, or they can rest on the podium of a building. Juliet balconies also avoid thermal bridging and provide an effective way to naturally ventilate a dwelling unit, however they do not provide a private outdoor space. A common roof terrace or courtyard could also be used as an alternative design strategy to cantilevered balconies.

Among the database buildings, cantilevered balconies, externally supported balconies, and common terrace/courtyard were equally as common, with seven buildings using the first two strategies, and 6 buildings employing the third. Juliet balconies were not common among the database buildings, used

[12] Low Carbon Building Energy Toolkit

only by one. Since no alternative design strategies emerged as a more common design feature than the others, nor were they used more commonly than the typical cantilever balcony style, it can be concluded that cantilever balconies can be included in the design of high performance buildings, albeit they need careful detailing to avoid thermal bridging, however other design strategies exist which can be considered as additional strategies to consider for providing occupants of MURB and mixed use buildings access to outdoor space.

<u>Intersections with Township Form and Character Guidelines</u>

1. Balconies as Integral Design Elements of a Building

Township Form and Character Guidelines often encourage the use of balconies on MURB and mixed-use buildings to provide a private outdoor space to occupants which may not have direct access to the ground from their unit, as well as to break up the visual mass of a building, among other reasons.

It should be acknowledged that balconies need to be carefully designed to avoid heat loss through thermal bridging, and the encouragement the use of balconies, for visual interest reasons, is a design outcome which intersects with this performance concern. The appearance of balconies was emphasized in interview with a Township planner, where it was noted that balconies should be thoughtfully integrated into the architecture of the building and not appear as a secondary consideration. The use of externally supported balconies could align with this design outcome if well executed from an aesthetic perspective. Juliet balconies are less desirable since they do not provide this important private outdoor space for units in large buildings that don't have direct access to the ground.

2. Common Outdoor Spaces

Common outdoors spaces such as common terraces and courtyards are not often explicitly encouraged in the Township's Form and Character Guidelines, except for in the case of flat roofs where a green roof or resident amenity are sometimes required, such as in the Willoughby Community Plan. The interview with a Township planner indicated that balconies provide important private outdoor space for building residents, but the addition of outdoor common space would be viewed as a positive design feature. It was noted that an extended outdoor common amenity space in lieu of balconies could be acceptable if it were well executed with thoughtful design for privacy and quality.

525 Federal, Courtesy of Vandervort Architects

03. Case Studies

Casa Luca · Burnaby NZER · Geos Reihenhaus · Spire Landing

3.1 Casa Luca

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Gross Floor Area	1500 sqft
Number of Floors/Suites	3 storeys
Architect	DLP Architecture
Year Completed	2015

Figure 24: Front elevation of Casa Luca, glazing on the north façade is limited to prioritize solar gains on the south. (Photo courtesy of DLP Architecture)

Built in 2015, this single-family home was designed for clients that need a bigger, more functional space for their growing family. Located in Vancouver's Hastings-Sunrise neighbourhood, Casa Luca achieved Passive House Performance using common construction methods, materials, and Passive House components with only a small cost premium over standard construction techniques. The home took about 1 year to build and had a total hard construction cost of $425,000.

Overall, Casa Luca has a simple form of three adjoining rectangular volumes with shed roofs sloping to the back of the lot towards the south. The simple shape of the building reduces opportunities for heat loss by minimizing the number of complex joints in the building envelope. Material variation and appended overhangs such as horizontal sun shading over the front and back doors add visual interest to the home. In addition to adding visual interest, exterior shading devices such as these horizontal sun shading devices can provide up to 100% blockage of unwanted solar gain to prevent overheating.

Casa Luca is oriented north-south on an east-west street with mountain views to the north. Glazing on the north façade is limited to allow for more generous glazing on the south façade to optimize solar gains for passive heating and daylighting. The thermal envelope on the north façade was likely also bolstered to additionally compensation for the heat loss through the larger glazing on the south façade. A roof top deck was included in the home's design to provide added access to mountain views, and an additional private outdoor space.

Windows on the south façade of the home balance gains in the winter with concerns for overheating in the summer by including operable exterior roller blinds, and horizontal sun shading devices over the south facing doors. This allows the homeowners to have better control over the home's solar gain.

On the south sloping roof is an array of 12 solar PV panels, which supplies about half of the home's total annual energy consumption. The PV array was easily installed on the home's standing seam roof, but a south sloping roof conflicted with Vancouver RS-1 zoning requirements, in which the angle of daylight setback generally supports gables that slope east west, parallel to the street. In order to have a south sloping roof for optimization of the array's solar exposure, a relaxation was needed from the City of Vancouver.

Figure 15: South Elevation of Casa Luca, more generous glazing on the facade allows for solar gains and daylighting, while exterior shading prevents overheating (Photo courtesy of DLP Architecture)

3.2 Burnaby NZER

Figure 26: South East Facade of the Burnaby NZER Home, displaying is traditional style (Photo courtesy of Kemp Construction)

Building Type	Detached Single Family
High Performance Standard	BC Energy Step Code Step 5
Climate Zone	4
Location	Burnaby, BC
Gross Floor Area	6200 sqft
Number of Floors/Suites	2 storeys with secondary suite
Builder	Kemp Construction
Designer	Sarah Gallop Design Inc.
Year Completed	2020

The first Step Code Step 5 House in Burnaby was built for clients whose dream home included high standards of energy efficiency. This home echoes the traditional vernacular of the area, with open gable roofs, lap cladding, decorative corbels and shutters, while achieving Net Zero Energy Ready performance. The total cost of this home is in the 2-3 million-dollar range, and construction was completed in 1 year. This home has high end finishes and features and is large in scale including 7 bathrooms and a home theatre. It should be noted that a large part of its budget likely went towards these features, not energy efficiency measures.

After initial consultation with the builder, an interior designer worked with the clients through the initial design phase. Once approved, the plans were handed back to the builder who consulted with an energy advisor to dial in the home's energy efficiency through the selection of building components and systems. It is worth highlighting that no elements of the initial home design had to be compromised - the builder worked with the designer's plans, and through an iterative process to determine the correct combination of building elements, including window types and insulation thicknesses, they were able to achieve the Step Code Step 5 energy targets.

This home uses a unique building system to reduce on site construction time and major errors which could compromise the home's air tightness, which is critical for achieving ambitious energy targets. It was built using a prefabricated wall system, which is constructed indoors before being transported to site to be raised. Building the panels indoors is the key to the efficiency of this system, as it allows the identification of errors before a home's framing is erected, which can be costly for a project's budget. The manufacturing of the wall frames took 1-2 weeks, and the installation on site was completed in about a week.

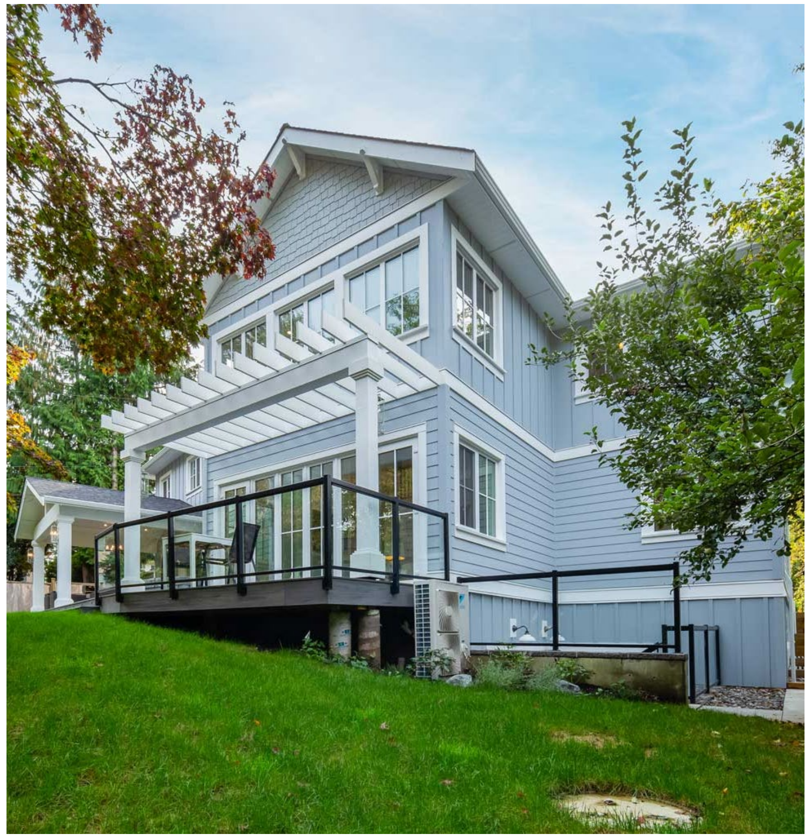

Figure 27: North-east façade of Burnaby NZER, exterior of the double height living room (Photo courtesy of Kemp Construction)

The home has modestly sized windows in general, allowing for more generous windows in the double height living room space on the north-west façade.

The home is designed to allow for the installation of solar panels when the client is ready to make the investment. It is prewired, and the roof trusses are PV rated. Additionally, roof area is left open for maximum panel coverage.

Geos Reihenhaus

Figure 28: North elevation of the Geos Reihenhaus (Photo courtesy of SUN Studio)

Building Type	Townhouses
High Performance Standard	Net Zero
Climate Zone	5
Location	Arvada, CO
Gross Floor Area	1650 sqft per unit
Number of Floors/Suites	4 units with 2-3 storeys
Architect	SUN Studio
Year Completed	2018

Figure 29: South-west view of the townhomes looking into their backyards (Photo courtesy of SUN Studio)

These townhomes are located northwest of Denver, Colorado, in the city of Arvada. They are part of a larger net zero neighbourhood development called Geos., in which condos were sold starting at 225,000 USD, and single-family homes starting at 575,000 USD, which aligned with regional average home sale prices.

The Geos Reihenhaus has an overall simple form, with a low degree of geometric articulation. Simple shifts in the townhomes massing, variation in the cladding material, and the addition of front steps for each unit define the intervals of the building and add to its visual interest. Simple gable roofs sloping north-south allow advantageous positioning of solar panels. As these homes are Net Zero, the PV array on the roof of each townhome creates enough power to offset all operational energy requirements for the house. Furthermore, there is enough surplus power generation to charge an EV for regular use.

The townhomes east-west orientation also allows for advantageous southern exposure on the near façade of the building, which maximizes potential for passive heating and daylighting. Lower window to wall ratio on the townhomes north façade allows for more generous glazing on the south façade. The windows are shaded with roof overhangs to avoid overheating in summer months, which is especially important in Arvada, CO, where there are typically 300 days of sun a year.

3.4 Spire Landing

Figure 30: West facade of Spire Landing, stepped along the slopped site (Photo courtesy of Cornerstone Architecture)

Building Type	Multi unit residential
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Gross Floor Area *Treated Floor Area*	75000 sqft 57300 sqft
Number of Floors/Suites	6 storeys, 95 units
Architect	Cornerstone Architecture
Year Completed	2018

Figure 31: Sun shading devices of the south façade (Photo courtesy of Cornerstone Architecture)

Located in Vancouver's Sunset neighbourhood, Spire Landing is a Passive House certified, purpose built rental building. This building has 74 one bedroom and 21 two bedrooms units.

The design approach for this building takes advantage of the slopping site to reduce the visual mass of the building. The building mass steps along the length of the site, so the 6-storey building presents a predominantly four-storey scale from the pedestrian level. Overall, the building has a low to moderate degree of geometric articulation, with some projecting elements along each façade. These simple shifts in the building's mass, in combination with material variety and landscaping elements, create visual interest and an animated pedestrian edge without the use of a highly expressive façade. Shifts in the building's massing would contribute to heat loss through complex joints in the building envelope, so by using fewer shifts, heat loss in minimized.

Spire Landing features three different design strategies to provide outdoor amenity spaces to occupants. Two types of externally supported balconies are present, several units on the east façade have balconies supported by external structural elements, and some units on the west façade have private roof terraces. Many of the units in the building have Juliet balconies, which provide access to fresh air and increase potential for natural ventilation in the unit, but no private outdoor space. This is supplemented by an ample landscaped common rooftop terrace. This common terrace has seating spaces, a dining area, a children's play area, and a garden work room.

Overall, Spire Landing has a relatively low window to wall ratio, at approximately 30%. On the south façade of the building, horizontal sun shading devices and roof overhang shades windows to avoid overheating. Some glazing on the west façade is shaded by balcony overhangs.

04. Conclusion

Tiny Lot Passive House, courtesy of Interactive Construction

Conclusion

The operational energy use of buildings is the second largest source of carbon emissions in the Township of Langley. Addressing these emissions will play a major role in achieving the Township's 2050 target of reducing carbon emissions by 100%. This analysis was conducted to support that goal by cataloging and describing common design strategies used by high-performance residential buildings and identifying where they intersect with the Township's Form and Character Guidelines. Fundamental design decisions made early in the process of designing a building, such as the placement of windows and orientation on a site, can have significant impact on a building's energy use, so the exterior design characteristics of a building play an important role in designing for high performance.

High-performance buildings can range in appearance from traditional vernacular styles to more contemporary and modern styles and range from small detached single-family homes to very large multi unit residential and mixed-use buildings. In this report, four major design trends emerged among buildings examined in the database. The first was orientation to maximize southern exposure. Though often dictated by property lines and existing street grids, orientation can have a significant impact on a building's potential to use passive heating and daylighting, and thus energy use. Next, fewer geometric articulations emerged as a trend. Buildings in the database most often had simple massing and overall form, and used alternative design strategies to create visual interest, such as material variety, and appended elements like overhangs and porches. Low window to wall ratio was also common among database buildings, windows were placed thoughtfully to maximize potential for daylighting, while balancing heating and overheating potential. Lastly, exterior shading was a very common design feature among database buildings, ranging from roof overhangs, horizontal sun shading devices, exterior roller blinds, and others.

This report additionally highlighted where these design strategies intersect with the Township pf Langley's Form and Character Guidelines. Both alignments and conflicts with the Form and Character Guidelines were identified, particularly with encouragement of design outcomes for creating visual interest in the public realm, alignment with the Township's vernacular architecture, and providing outdoor spaces for residents of multistorey MURBs.

Ultimately, it should be recognized that achieving ambitious energy targets will require flexibility to design buildings differently. With this in mind, it has already been demonstrated that creativity and thoughtfulness in design can result in a built environment that is both successful in reducing GHG emissions and improving energy performance, and in providing an enriching, safe, and beautiful public realm, where Township residents can live work and play.

North Shore Passive House, courtesy of Econ Group

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06. Appendix

Orion, courtesy of Vidorra Developments

Appendix

The following pages display images of each building in the database complied as part of this research report. Their use of key design strategies for high-performance, including orientation, low window to wall ratio, exterior shading, and simple overall form are highlighted.

The buildings in the database range in appearance from traditional vernacular styles to more contemporary and modern styles and range from small detached single-family homes to very large multiunit residential and mixed-use buildings. This report found that some intersections exist between the common design strategies among them, and Township Form and Character Guidelines.

Ultimately, the database demonstrates that creativity and thoughtfulness in building design can result in a built environment that is both successful in reducing green house gas emissions and improving energy performance, and in providing an enriching, safe, and beautiful public realm.

3612 Point Grey

Photo credits: Uegama Architecture

Building Type	Detached Single Family
High Performance Standard	BC Energy Step Code Step 5
Climate Zone	4
Location	Vancouver, BC
Year Completed	2021

Special Notes:
Alignment with regional vernacular

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓		✓

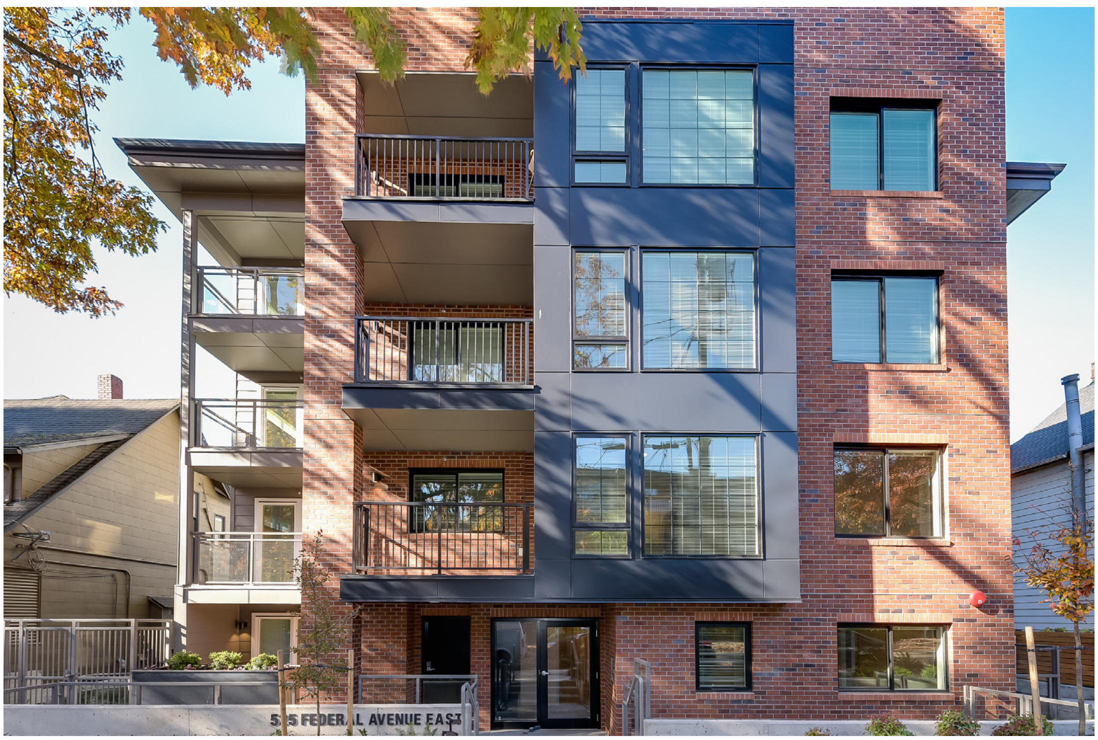
525 Federal

Photo credits: Vandervort Architects

Building Type	Multiunit Residential
High Performance Standard	Built Green 4 Star
Climate Zone	4
Location	Seattle, WA
Year Completed	2020

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓



Absolute Zero

Photo credits: J.ZSIROS Contracting

Building Type	Detached Single Family
High Performance Standard	Net Zero, BC Energy Step Code Step 5
Climate Zone	5
Location	Comox Valley, BC
Year Completed	2019

Special Notes:

Ground located solar panels

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

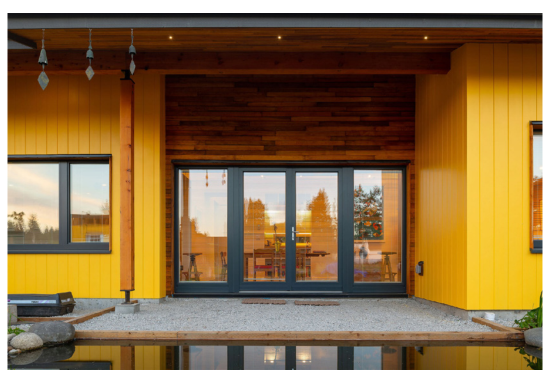
Alberta Street House

Photo credits: Lanefab Design/Build

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	New Westminster, BC
Year Completed	2017

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓



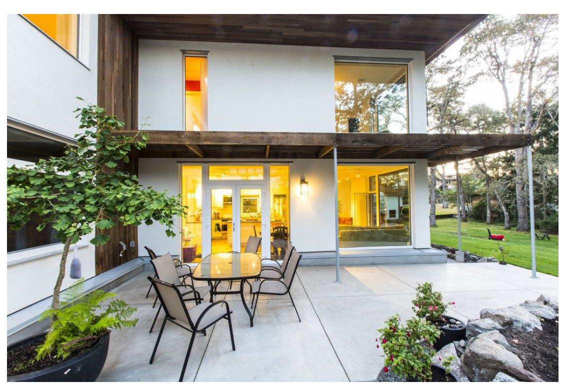
Bernhardt Passive House

Photo credits: Bernhardt Contracting

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Victoria, BC
Year Completed	2013

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓



Black and White House

Photo credits: J.ZSIROS Contracting

Building Type	Detached Single Family
High Performance Standard	Net Zero
Climate Zone	5
Location	Comox Valley, BC
Year Completed	Date Not Available

Special Notes:

Ground located solar panels

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

Burnaby NZER

Photo credits: Kemp Construction

Building Type	Detached Single Family
High Performance Standard	BC Energy Step Code Step 5
Climate Zone	4
Location	Burnaby, BC
Year Completed	2020

Special Notes:
Pre-fabricated wall system
Wired for future solar panel installation
Alignment with local vernacular

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓		

Carrington View

Photo credits: Skyline Living

Building Type	Multiunit Residential
High Performance Standard	BC Energy Code Step 4
Climate Zone	5
Location	West Kelowna, BC
Year Completed	2020

Special Notes:

Rooftop solar panels

Externally supported balconies

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Casa Luca

Photo credits: dlp Architecture

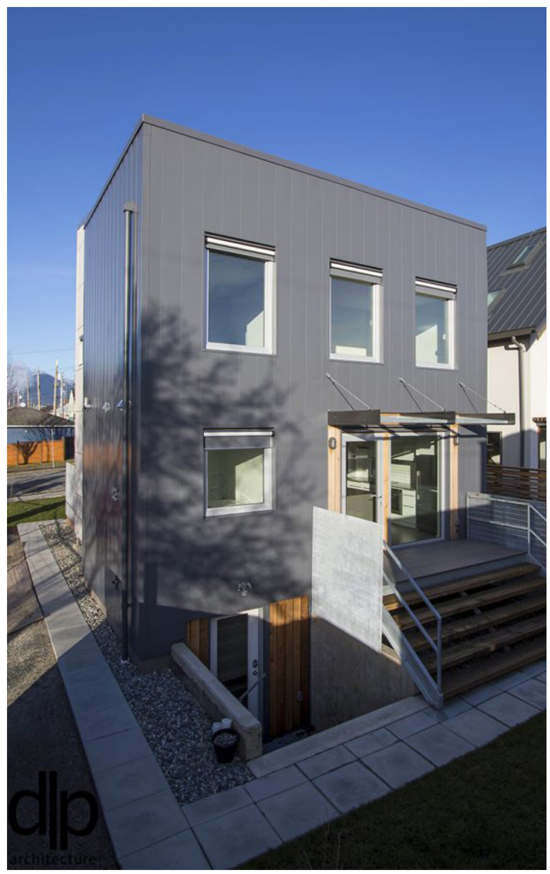
Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2015

Special Notes:

Operable exterior roller blinds

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓



Cascadia Townhomes

Photo credits: StreetSide Developments

Building Type	Townhouses
High Performance Standard	Net Zero Energy Ready
Climate Zone	4
Location	Township of Langley, BC
Year Completed	Unbuilt

Special Notes:

Ground located solar panels

Alignment with local vernacular

Externally supported balconies

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	

Dunbar Passive House

Photo credits: dlp Architecture

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2019

Special Notes:

Operable exterior roller blinds

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Fifth Street Passive House

Photo credits: Interactive Construction Inc.

Building Type	Townhouses
High Performance Standard	Passive House
Climate Zone	4
Location	Victoria, BC
Year Completed	2017

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Fung Roberts Passive House

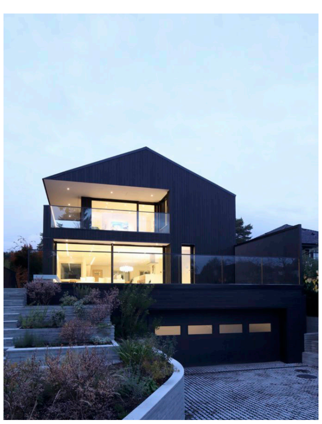
Photo credits: Michael Green Architecture

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	North Vancouver, BC
Year Completed	2016

Special Notes:
Combines existing heritage facade with an addition

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	



Futrhaus

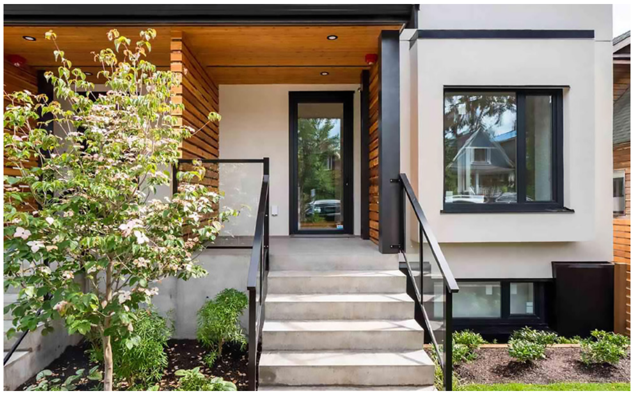
Photo credits: b Squared Architecture

Building Type	Townhouses
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2019

Special Notes:
Passive heating from south facing windows provides more than a third of winter heating needs

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
no data	✓	✓	



Geos Alley House

Photo credits: SUN Studio

Building Type	Detached Single Family
High Performance Standard	Net Zero
Climate Zone	5
Location	Arvada, CO
Year Completed	2018

Special Notes:

Rooftop solar panels

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Geos Reihenhaus

Photo credits: SUN Studio

Building Type	Townhouses
High Performance Standard	Net Zero
Climate Zone	5
Location	Arvada, CO
Year Completed	2018

Special Notes:

Rooftop solar panels

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	

Geos Solar Cottage

Photo credits: SUN Studio

Building Type	Detached Single Family
High Performance Standard	Net Zero
Climate Zone	5
Location	Arvada, CO
Year Completed	2018

Special Notes:

Rooftop solar panels

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Khotso Passive House

Photo credits: ONE SEED Architecture + Interiors

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2016

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	

Kiln Apartments

Photo credits: GBD Architects, photography by Eckert and Eckert Photography

Building Type	Mixed Use
High Performance Standard	Passive House
Climate Zone	4
Location	Portland, OR
Year Completed	2014

Special Notes:

Rooftop solar panels

Common roof terrace amenity space

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Little Mountain Co-Housing

Photo credits: Cornerstone Architecture

Building Type	Multiunit Residential
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2017

Special Notes:
Common ground level outdoor amenity space

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Mary Street Duplex

Photo credits: Bernhardt Contracting

Building Type	Townhouses
High Performance Standard	Passive House
Climate Zone	4
Location	Victoria, BC
Year Completed	2016

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

Mosaic

Photo credits: High Street Ventures

Building Type	Multiunit Residential
High Performance Standard	BC Energy Step Code Step 4
Climate Zone	5
Location	Parksville, BC
Year Completed	Unbuilt

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	

North Park Passive House

Photo credits: Bernhardt Contracting

Building Type	Multiunit Residential
High Performance Standard	Passive House
Climate Zone	4
Location	Victoria, BC
Year Completed	2015

Special Notes:
Externally supported balconies

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

North Shore Passive House

Photo credits: Econ Group

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	North Vancouver, BC
Year Completed	2015

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

Nuutsumuut Lelum

Photo credits: dys Architecture, photography by Lance Sullivan

Building Type	Multiunit Residential
High Performance Standard	Passive House
Climate Zone	5
Location	Nanaimo, BC
Year Completed	2017

Special Notes:
Common interior courtyard
Architecture alludes to traditional long houses

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

One Raven Net Zero

Photo credits: Naikoon Contracting

Building Type	Townhouses
High Performance Standard	Passive House
Climate Zone	BC Energy Step Code Step 5
Location	North Vancouver, BC
Year Completed	2019

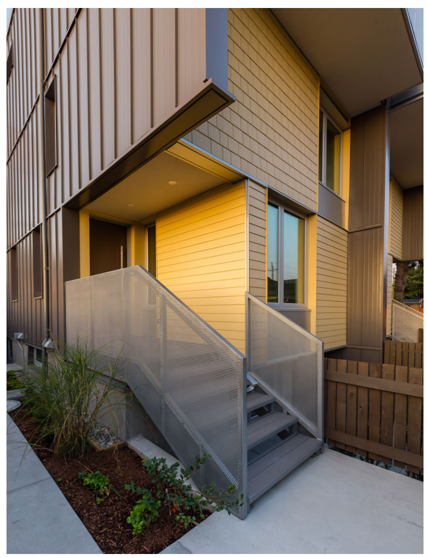
Special Notes:

Laneway infill building

Rooftop solar panels

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	



Orchards at Orenco 1

Photo credits: William Wilson Architects

Building Type	Multiunit Residential
High Performance Standard	Passive House
Climate Zone	4
Location	Hillsboro, OR
Year Completed	2018

Special Notes:

Externally supported balconies

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	

Orion

Photo credits: Vidorra Developments

Building Type	Multiunit Residential
High Performance Standard	BC Energy Step Code Step 4
Climate Zone	5
Location	Pemberton, BC
Year Completed	2020

Special Notes:
12-34% lower project cost than a similar residential built to BC Energy Step Code Step 1

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
no data	✓	✓	✓

Parkview Passive House

Photo credits: Waymark Architecture, photography by Dasha Armstrong Photography

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Victoria, BC
Year Completed	2019

Special Notes:
Cost comparable to average construction costs of typical building

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

Pax Futura

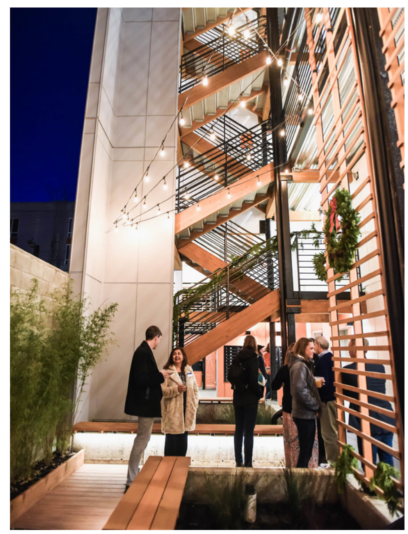
Photo credits: Cascade Built

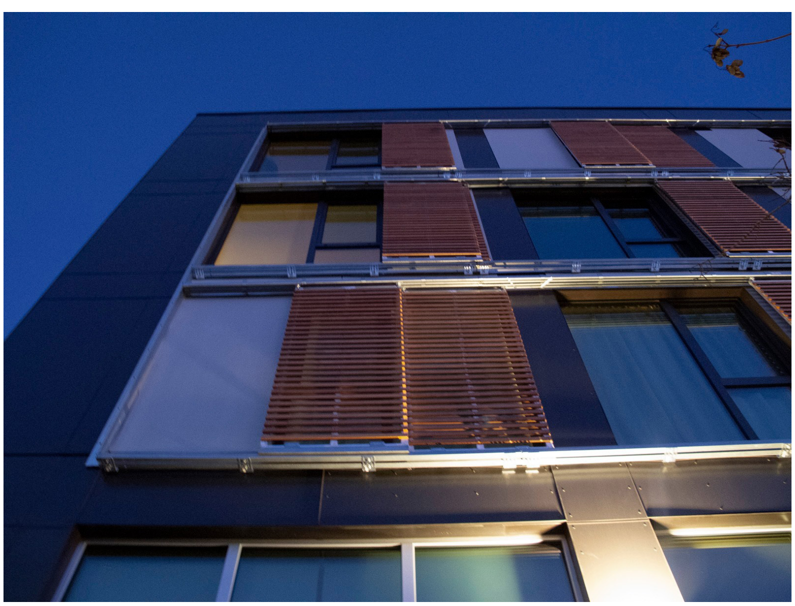
Building Type	Mixed Use
High Performance Standard	Passive House
Climate Zone	4
Location	Seattle, WA
Year Completed	2019

Special Notes:
Rooftop solar panels
Exterior operable shading screens
Common courtyard amenity space

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓





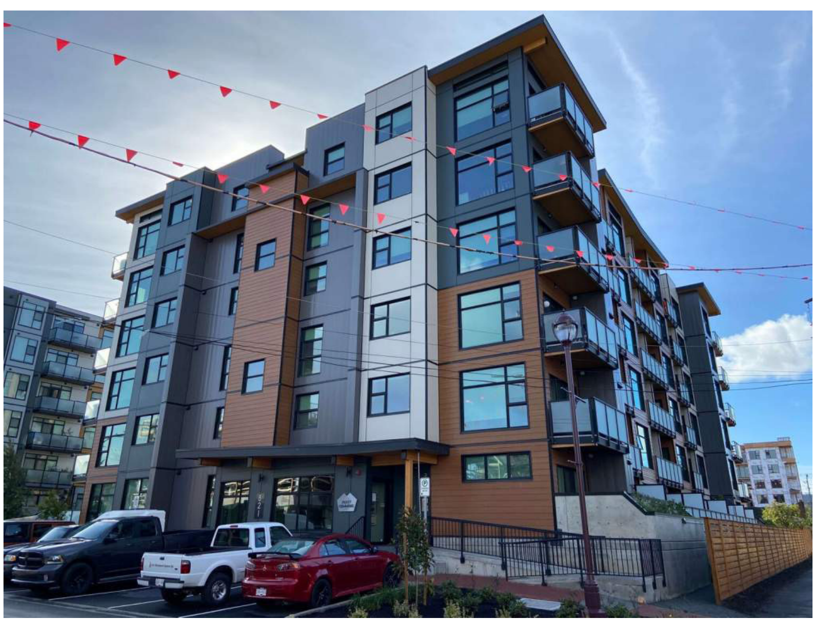
Peatt Commons West

Photo credits: Design Build Services, Jack James Architect

Building Type	Mixed Use
High Performance Standard	BC Energy Step Code Step 4
Climate Zone	4
Location	Langford, BC
Year Completed	2020

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	



Qualico Net Zero

Photo credits: Qualico

Building Type	Detached Single Family
High Performance Standard	Net Zero
Climate Zone	4
Location	Township of Langley, BC
Year Completed	Unbuilt

Special Notes:
Rooftop solar panels
Alignment with regional vernacular

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	

Sienna Apartments

Photo credits: Cascade Built

Building Type	Multiunit Residential
High Performance Standard	Built Green 4 Star
Climate Zone	4
Location	Seattle, WA
Year Completed	2020

Special Notes:
Common ground level outdoor amenity space

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

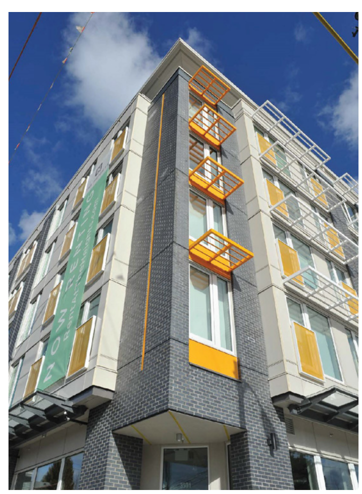
The Heights

Photo credits: Cornerstone Architecture

Building Type	Mixed Use
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2018

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓



The Passive Narrow

Photo credits: Nick Bray Architecture

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Vancouver, BC
Year Completed	2020

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
	✓	✓	✓

Tiny Lot Passive House

Photo credits: Interactive Construction Inc

Building Type	Detached Single Family
High Performance Standard	Passive House
Climate Zone	4
Location	Victoria, BC
Year Completed	2018

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓		✓

Vancouver Passive Duplex

Photo credits: Marken Design + Consulting

Building Type	Townhouses
High Performance Standard	Passive House, Net Zero Energy Ready
Climate Zone	4
Location	Vancouver, BC
Year Completed	2014

Special Notes:
Same construction costs as standard custom home

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
no data	✓	✓	✓

Vanness

Photo credits: ZGF Architects Inc., Community Land Trust and New Commons Development

Building Type	Multiunit Residential
High Performance Standard	Net Zero Energy Ready
Climate Zone	4
Location	Vancouver, BC
Year Completed	unbuilt

Special Notes:
Common rooftop amenity space

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

Yale Nation Passive House

Photo credits: Yale First Nation

Building Type	Townhouses
High Performance Standard	Passive House
Climate Zone	4
Location	Ruby Creek, BC
Year Completed	2017

Special Notes:
Modular prefabricated building

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓

zHomes

Photo credits: Ichijo Technological Homes

Building Type	Townhomes
High Performance Standard	Net Zero, Built Green Emerald Star
Climate Zone	4
Location	Issaquah, WA
Year Completed	2011

Key Design Features:

Orientation	*Low Window to Wall Ratio*	*Exterior Shading*	*Low Geometric Articulation*
✓	✓	✓	✓