CONSTRUCTION COST ANALYSIS OF HIGH-PERFORMANCE MULTI-UNIT RESIDENTIAL BUILDINGS IN BRITISH COLUMBIA

JUNE 2021

zebx

INTRODUCTION

In April 2017, the Province of British Columbia adopted the BC Energy Step Code as regulation. For large buildings governed by Part 3 of the BC Building Code, the Step Code provides four levels, or steps, of energy efficiency. Currently, British Columbian municipalities can choose to adopt the Step Code and require that new developments meet a minimum step. In 2018, the Province released its CleanBC plan – a plan that laid down a road map to net-zero energy-ready design of new buildings by 2032. The plan established two steps on the way to the 2032 target. Beginning in 2022, all Part 3 buildings constructed in areas governed by the BC Building Code must be designed to achieve Step 2 of the Step Code. By 2027, all Part 3 buildings must achieve Step 3. An alternative compliance path to the highest step of the Step Code (Step 4) is designing a building to meet the more stringent Passive House standard.

When the Step Code was introduced, some concerns were raised regarding the expected additional cost to build more energy-efficient buildings. At the time, some studies were undertaken to estimate the additional cost. As opposed to estimating what a high-efficiency building is likely to cost, this cost analysis is a retrospective analysis that compares net-zero energy-ready (NZER), mid-rise, multi-unit residential buildings (MURB) recently constructed or under construction to similar code-minimum buildings that were constructed or are under construction. For this study, we define NZER as the highest level of the Step Code for large buildings (Step 4) or the Passive House standard.

Forestry Innovation Investment

bty

Our focus on mid-rise MURBs stems from a foundational aspect of the Pattern Language from Passive House course that ZEBx offered in 2020 and early 2021. This course focused on how to design and build NZER wood-framed, mid-rise MURBs as cost-effectively as possible. This particular building type has the potential to address both climate-related issues as well as urbanization issues facing large urban centres in a more balanced way than some other building archetypes. In addition, there was a greater selection of NZER MURBs to study than there was of NZER commercial and office buildings.

The past construction costs presented in this report are no longer applicable to new construction projects. The objective of this study was not to provide a basis for determining the cost of new high-performance buildings, but rather to assess how the costs differ from the code-minimum baseline buildings that began construction at approximately the same time. Although the construction costs are no longer applicable, we believe that the variation in the relative differences is still generally applicable today.

Data collection was a challenge, with only a small pool of NZER MURB builders and developers willing to share construction costs. We are grateful to those that did. We hope that this study provides some insight into the range or cost possibilities and factors which affect cost, as well as some inspiration that NZER MURBs have the potential to be constructed economically relative to current code-minimum MURBs.

Photo credit : Marcon Developments

METHODOLOGY

A comparative analysis requires a baseline against which to compare. To ensure a consistent baseline, BTY Group, a cost consultancy with offices in Vancouver and many other cities around the world, was engaged to generate a baseline for the seven buildings in this study. Because the buildings are located in four different geographical areas (Metro Vancouver, Capital Regional District, Kelowna and the Pemberton Valley), four baselines were created for the study. BTY was provided with an assortment of information about the buildings including:

- location
- gross floor area
- number of suites and levels below and above-grade
- the month and year the construction contract was tendered
- number of elevators

With this information in hand, BTY reviewed its inventory of past projects to find buildings that closely matched the above-noted information for the building(s) in each area. The baseline for each area consists of between two and four similar buildings that were designed to meet the minimum requirements of the BC Building Code or Vancouver Building By-law in effect. The construction costs of the group of buildings in each area were averaged to create a baseline. To better align the baselines with the buildings in the study, some adjustments were made to the baseline costs.

For example, if the baseline buildings did not include cooling (air conditioning), the additional cost for cooling was added and the building baseline adjusted accordingly. Cooling was added to the baseline because not only do six out of the seven NZER buildings have cooling, but a growing number of code-minimum buildings are being constructed with cooling. Cooling systems are not a differentiating factor between code-minimum and NZER buildings. If the baseline buildings had a different number of elevators than the NZER buildings, an adjustment was made to ensure the two sets of buildings for each area had the same number of elevators. Fortunately, the four groups of NZER buildings each had the same number of elevators. Another example of an adjustment relates to the structure. If the NZER buildings in the area had only one level constructed of concrete and the baseline buildings had more than one level constructed of concrete, the baseline building cost was adjusted to reflect one level of concrete and the remainder out of wood. For all adjustments, the calculations were based on historical costs from past projects in BTY's database.

The construction costs include only the building itself and not the exterior grounds, the excavation work or site services leading to the building. This decision was made because these costs varied considerably from one project to the next and depended on a variety of factors that had little or nothing to do with NZER building construction. We included general conditions in the construction costs because typically, the vast majority of general conditions relate to the construction of the building itself. Nonetheless, it is important to note that the general conditions vary significantly across the seven buildings and this may be due to the fact that the overall size of the projects varied. Although the exterior grounds, excavation and site services are excluded, their impact on the general conditions could not be isolated. If the exterior grounds, excavation and site services were extensive, it may have resulted in a slightly higher general conditions cost relative to the baseline.

Photo credit : Strand Development

COST BREAKDOWN

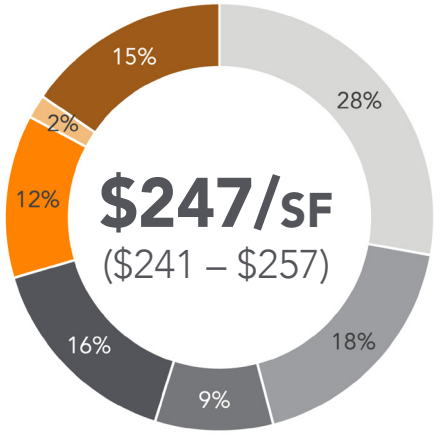
GENERAL CONDITIONS AND REQUIREMENTS	Management (project managers/coordinators, superintendents, etc.), field office (trailers, furniture, office supplies, services, equipment, etc.), field operations support (labor, storage, equipment, tools, fencing, clean-up, etc.), job-site requirements (security, roads, toilets, signage, etc.), project safety requirements (audits, safety equipment, safety supplies, fire protection, etc.), waste management, temporary power, water, heating, etc., scaffolding, hoisting, etc. and excludes insurance and bonding, surveying, warranty, training, legal
ELEVATORS	Elevator cabs, hoistway equipment, machines, drives, controllers
BUILDING ENCLOSURE	Siding and/or cladding, fenestration, shading devices, exterior doors, roofing and roof deck waterproofing, roofing and roof deck assemblies (including insulation), balcony waterproofing, balcony and roof deck guardrails, damp-proofing and waterproofing on concrete walls, exterior canopies
MECHANICAL SYSTEMS	Heating, ventilation and air conditioning (HVAC) system, plumbing system, building automation system, fire protection system
ELECTRICAL SYSTEMS	Electrical distribution system, lighting, fire alarm system
INTERIOR	Steel studs for interior walls, acoustic insulation (if any), gypsum wallboard (GWB), flooring and paint, mill work (kitchen cabinetry, bathroom vanities, entrance lobby fixtures, etc.), finish carpentry (window sills and casing, baseboards, etc.), washroom accessories, interior doors
WOOD FRAMING AND CONCRETE	Concrete footings, walls, suspended slabs and slab-on-grade, elevator shafts, concrete block walls, structural steel and miscellaneous metals, mass timber components, rough carpentry (including wood stud walls), roof trusses

BASELINE BUILDINGS

CITY OF VANCOUVER:

Number of buildings included in baseline	3
Date of construction tender	Jan 2019 – Nov 2020
Gross floor area	64,500 – 86,000 ft² (6,000 – 8,200 m²)
Number of units	52 – 120 residential, 3 – 5 commercial
Number of levels	6 – 7 above grade, 2 underground (parkade)
Number of elevators	1 – 2

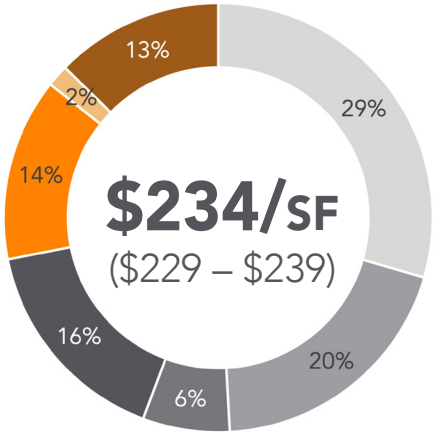
To better align with the two high-performance buildings in City Of Vancouver, where required, the costs for the baseline buildings were individually adjusted to include five above-grade levels and two elevators.



CAPITAL REGIONAL DISTRICT:

Number of buildings included in baseline	2
Date of construction tender	Feb 2019 – Nov 2019
Gross floor area	80,000 – 86,000 ft² (7,450 – 8,450 m²)
Number of units	80 – 85 residential
Number of levels	5 above grade, 1 underground (parkade)
Number of elevators	2

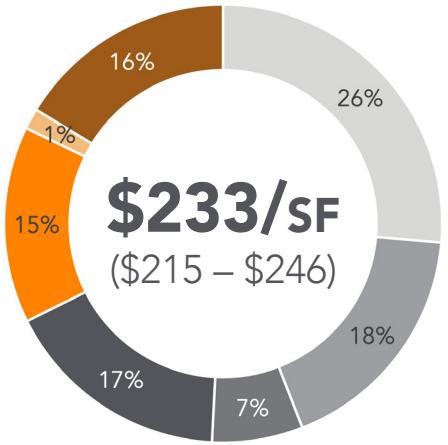
To better align with the two high-performance buildings in the Capital Regional District (CRD), where required, the costs for the baseline buildings were individually adjusted to include two parkade levels, a 2018 construction bid and cooling.



KELOWNA:

Number of buildings included in baseline	3
Date of construction tender	Jun 2018 – Feb 2019
Gross floor area	53,500 – 100,000 ft² (5,000 – 9,300 m²)
Number of units	60 – 103 residential
Number of levels	4 – 6 above grade, 1 underground (parkade)
Number of elevators	1 – 2

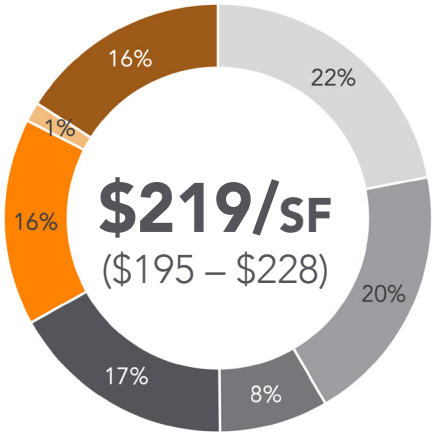
To better align with the two high-performance buildings in Kelowna, where required, the costs for the baseline buildings were individually adjusted to include only one elevator, a 2019 construction bid and cooling.



PEMBERTON:

Number of buildings included in baseline	4
Date of construction tender	Jun 2018 – Apr 2019
Gross floor area	56,000 – 110,000 ft² (5,200 – 10,200 m²)
Number of units	66 – 110 residential, 3 – 12 commercial
Number of levels	5 – 6 above grade, 1 – 2 underground (parkade)
Number of elevators	1 – 2

As there were no projects for comparison in this location, the baseline comprises four similar wood-framed, multi-unit residential buildings constructed or under construction in Squamish. An escalation of approximately 5% is added to account for the difference between the cost of construction in Squamish and Pemberton. To better align with the high-performance building in Pemberton, where required, the costs for the baseline buildings were individually adjusted to include only one elevator, one parkade level, a wood structure above the parkade level and cooling.



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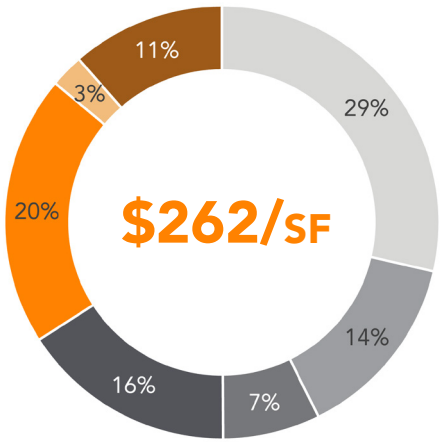
HIGH-PERFORMANCE PROJECT DETAILS

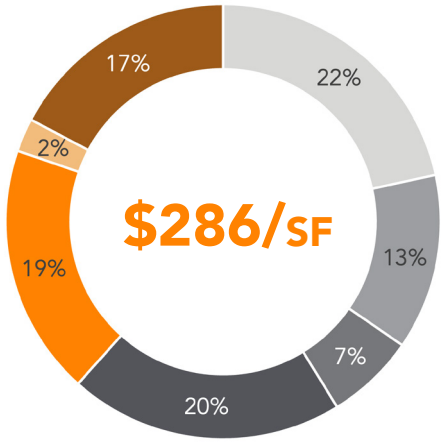
A

Performance Target	Passive House
Date of construction tender	Nov 2019
Gross floor area	53,981 ft² (5,015 m²)
CCDC Contract[1]	5A (Construction Management Contract - for Services)
Number of units	52 residential
Number of levels	6 above grade,1 underground (parkade)
Number of elevators	2
All-electric building	Yes



B

Performance Target	Step 4
Date of construction tender	Apr 2020
Gross floor area	51,051 ft² (4,742 m²)
CCDC Contract[1]	14 (Design-Build Stipulated Price Contract)
Number of units	58 residential
Number of levels	7 above grade
Number of elevators	2
All-electric building	No



GC
ELEV
BE
MECH
ELEC
INT
WFC

1 *CCDC - Canadian Construction Documents Committee*

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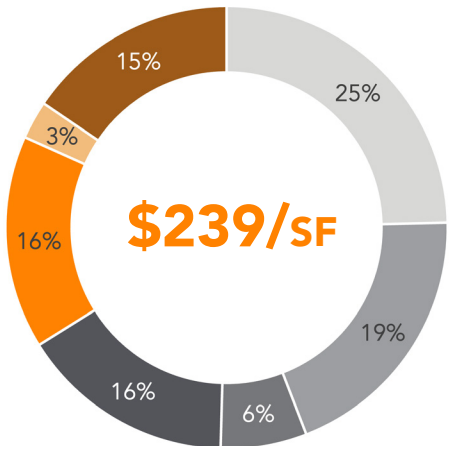
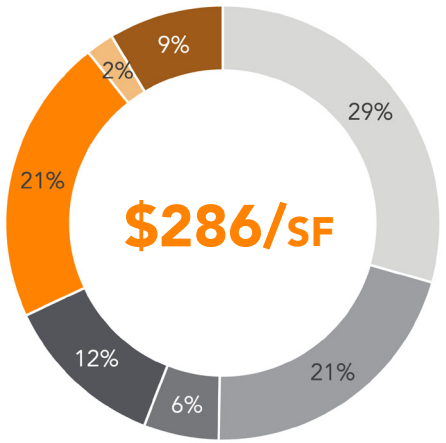
C

Performance Target	Step 4
Date of construction tender	July 2018
Gross floor area	60,644 ft² (5,634 m²)
CCDC Contract[1]	14 (Design-Build Stipulated Price Contract)
Number of units	72 residential
Number of levels	6 above grade, 2 underground (parkade)
Number of elevators	2
All-electric building	No



D

Performance Target	Step 4
Date of construction tender	August 2018
Gross floor area	63,292 ft² (5,880 m²)
CCDC Contract[1]	5B (Construction Management Contract - for Services and Construction)
Number of units	102 residential
Number of levels	6 above grade, 2 underground (parkade)
Number of elevators	2
All-electric building	No



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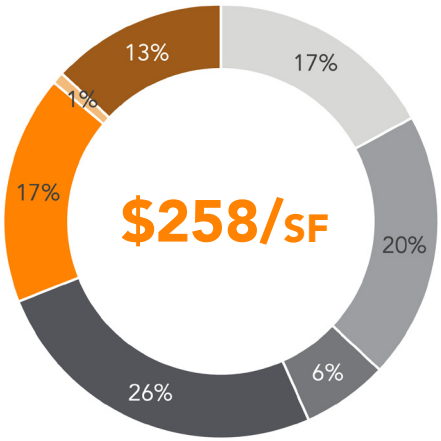
E

Performance Target	Passive House
Date of construction tender	July 2018
Gross floor area	72,548 ft² (6,740 m²)
CCDC Contract[1]	5B (Construction Management Contract - for Services and Construction)
Number of units	220 residential
Number of levels	6 above grade
Number of elevators	1
All-electric building	Yes



F

Performance Target	Step 4
Date of construction tender	August 2018
Gross floor area	66,263 ft² (6,156 m²)
CCDC Contract[1]	N/A (developer/builder)
Number of units	64 residential
Number of levels	4 above grade, 1 underground (parkade)
Number of elevators	1
All-electric building	Yes

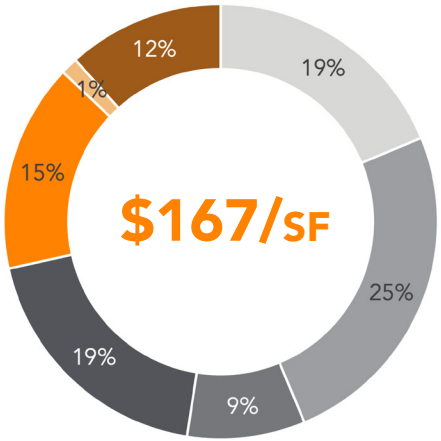
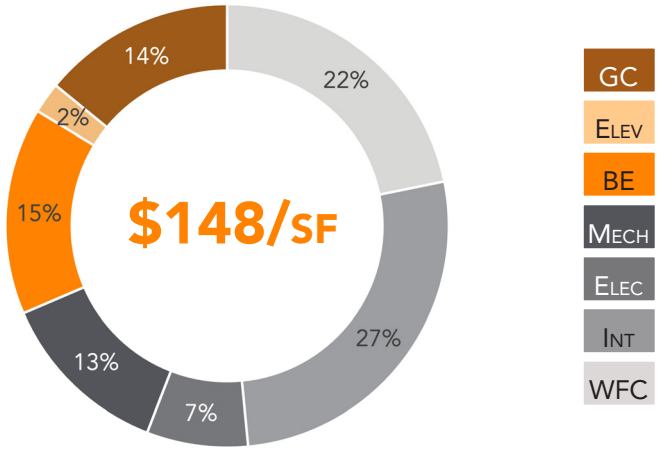


Photo credit : Vidorra Developments

G

Performance Target	Step 4
Date of construction tender	May 2018
Gross floor area	51,957 ft² (4,827 m²)
CCDC Contract[1]	N/A (developer/builder)
Number of units	45 residential
Number of levels	3 above grade,1 underground (parkade)
Number of elevators	1
All-electric building	Yes



OVERALL COST COMPARISON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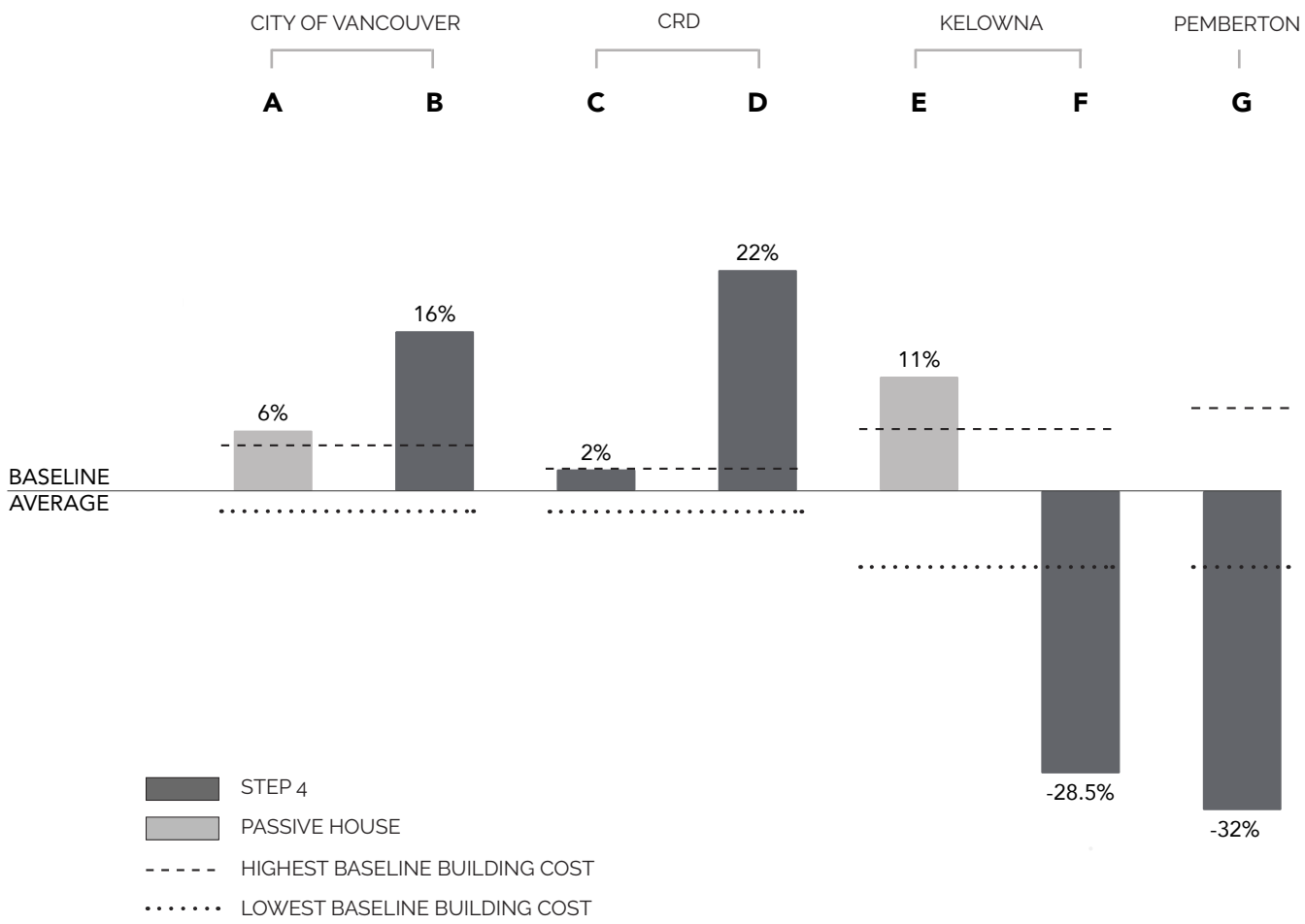
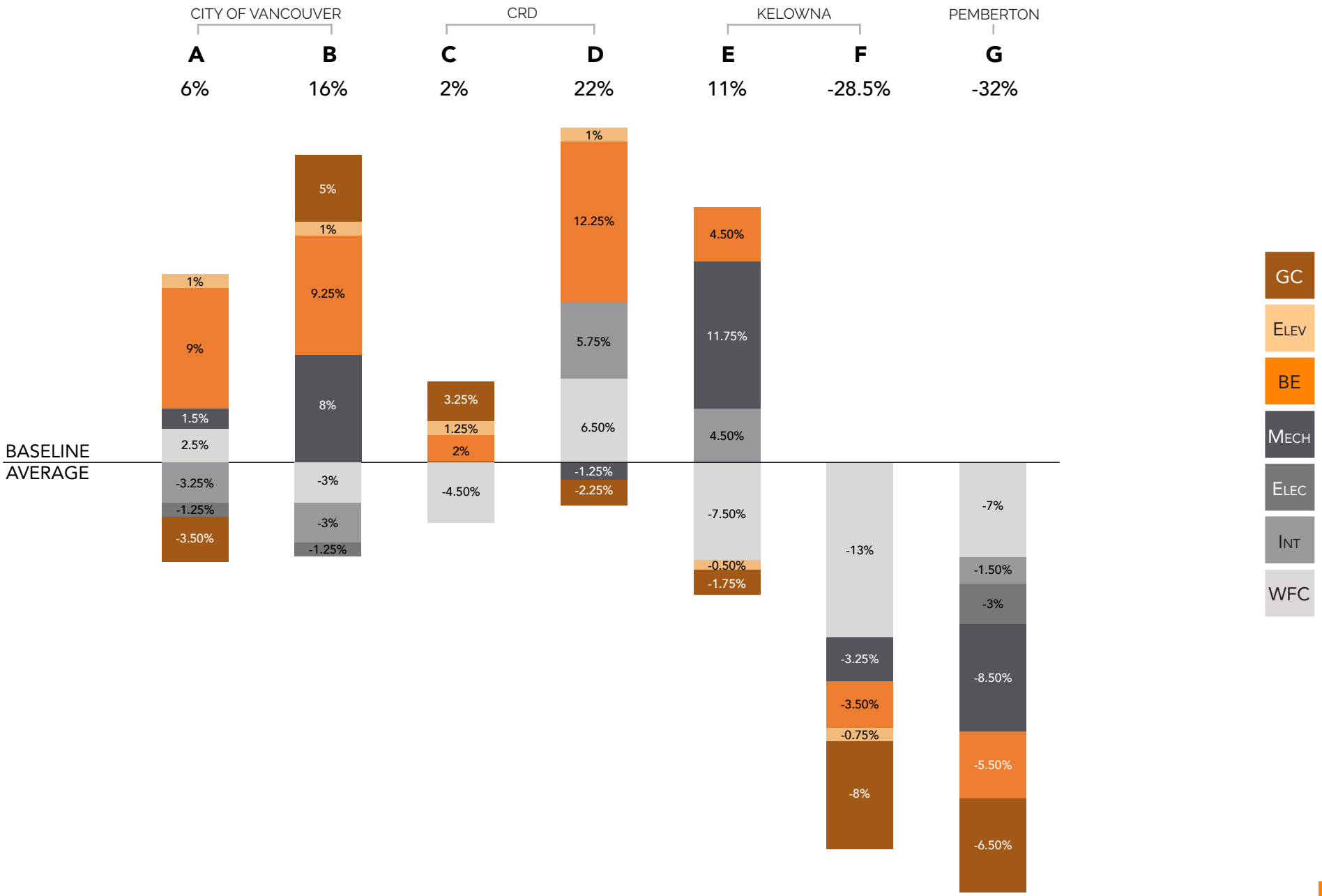


OVERALL COST COMPARISON BY SYSTEM



BUILDING SYSTEM COST COMPARISON

This section provides a cost comparison for each building system relative to the baseline. The difference between the actual construction costs and the baseline costs was affected not only by the performance target, but also by a variety of other factors. Each graph is accompanied by a short list of factors (beyond those associated with high-performance buildings) that the builders believe had an impact on the difference between their construction costs and the baseline costs.

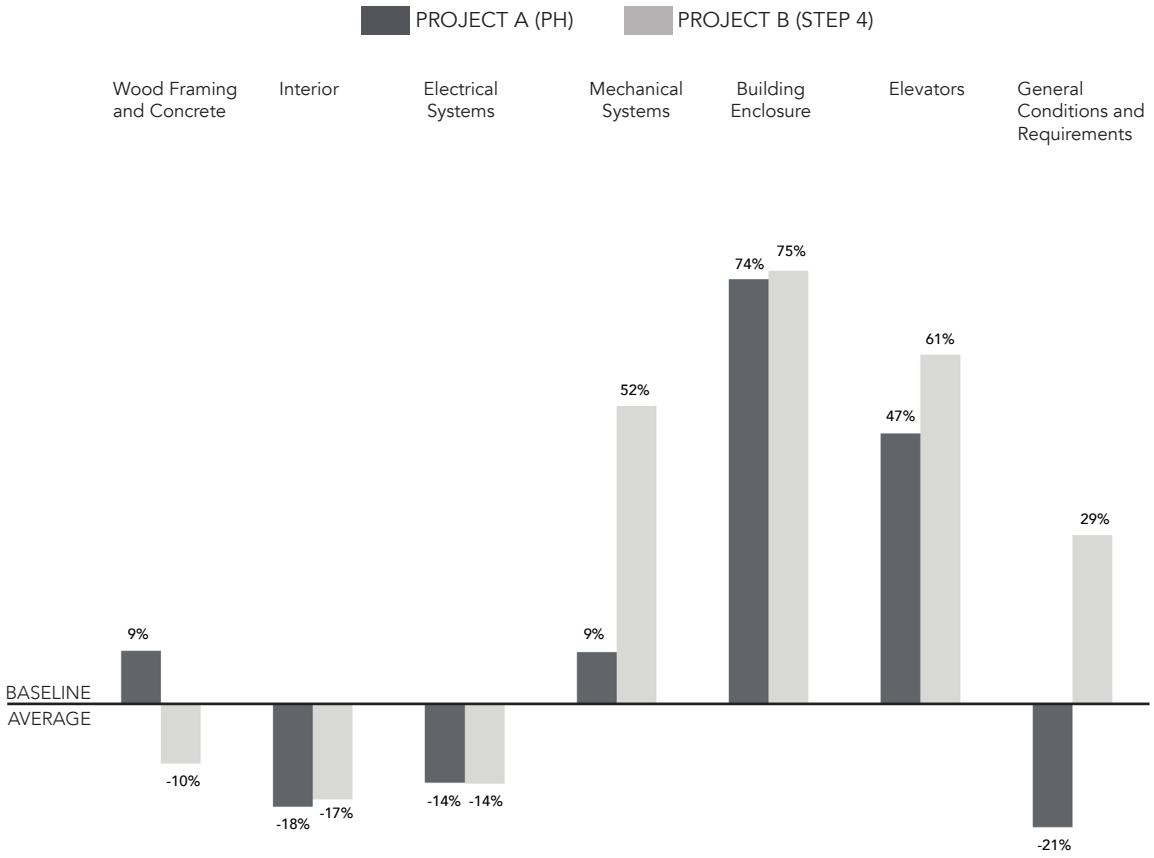
CITY OF VANCOUVER

PROJECT A (Passive House)

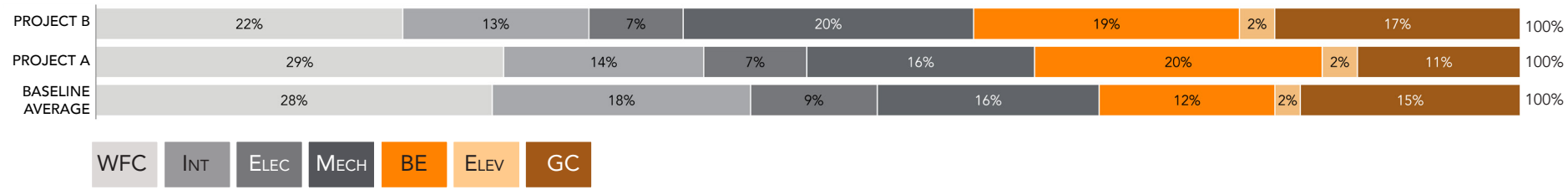
- Above-average volume of concrete for the single-level underground parkade
- Highly complex ground level structure with a transfer slab for the second above-grade level
- Brick veneer on ground-floor exterior walls
- Five heat pumps required for ground-floor units
- Semi-centralized ventilation system with energy recovery ventilators
- Centralized domestic hot water plant using heat pumps

PROJECT B (Step 4)

- High lumber costs
- The ground floor consists of one commercial unit with a full mechanical system installed for heating and cooling (variable refrigerant flow system)
- No cooling for the residential suites (baseline includes cooling)



COST DISTRIBUTION



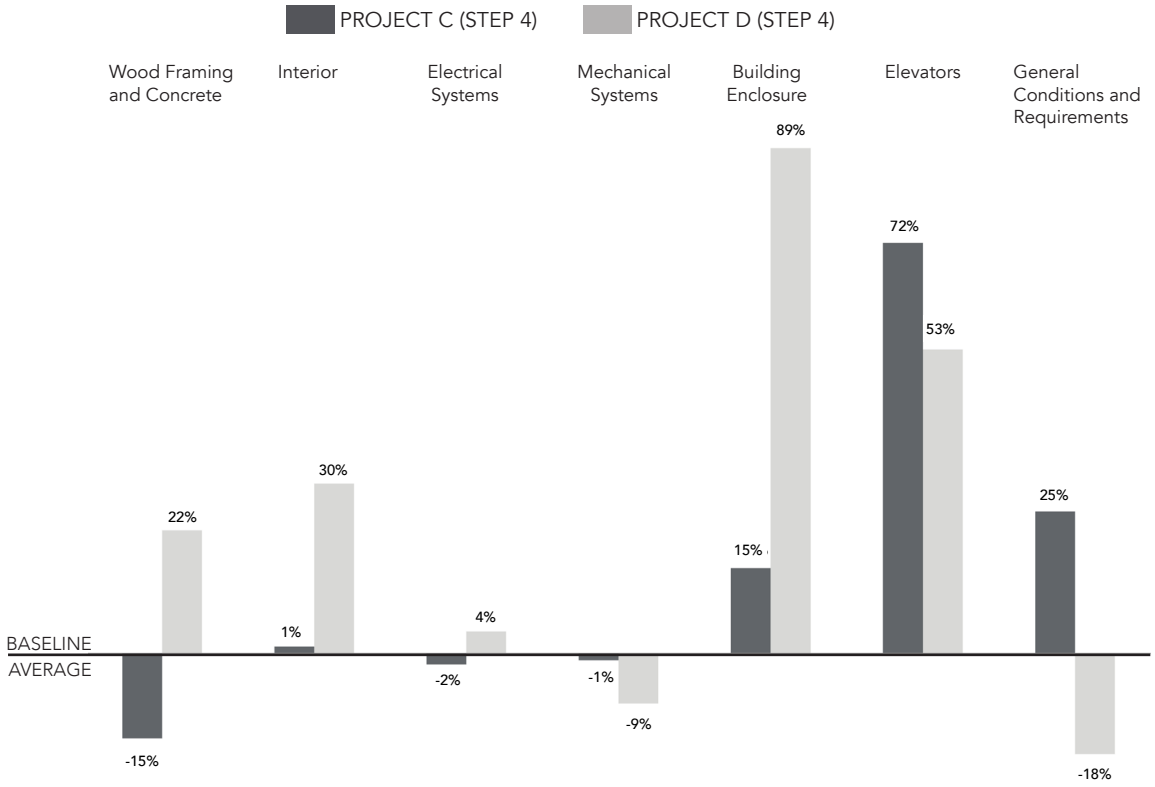
CAPITAL REGIONAL DISTRICT

PROJECT C (Step 4)

- Cross-laminated timber panels used for the above-grade floors and roof
- Very simple building form
- Suites have individual heat pumps for heating and cooling and individual energy recovery ventilators (fully decentralized)
- Centralized domestic hot water generation (gas-fired boilers)
- All hot and cold water piping to each suite is metered

PROJECT D (Step 4)

- Not a simple building form
- Thick concrete shear walls and hold down anchors
- Two underground parking levels
- Prefabricated off-site exterior wall framing
- Building enclosure components with a custom finish (colour)
- Custom aluminum sunshades on three elevations (including at building corners)
- Cooling for common areas by heat pumps
- No cooling for suites (baseline includes cooling)
- Electric baseboard heaters in suites for heating



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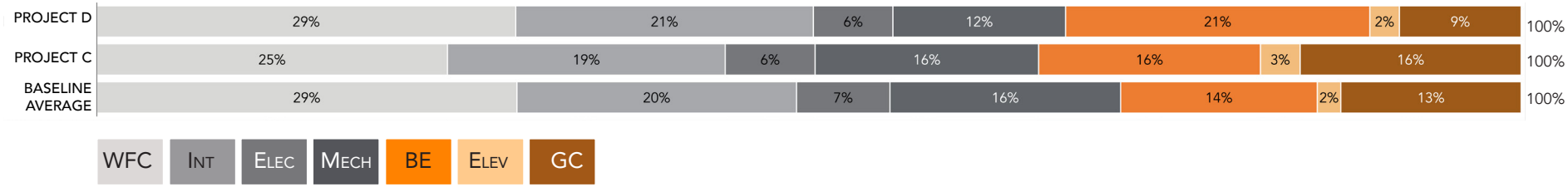


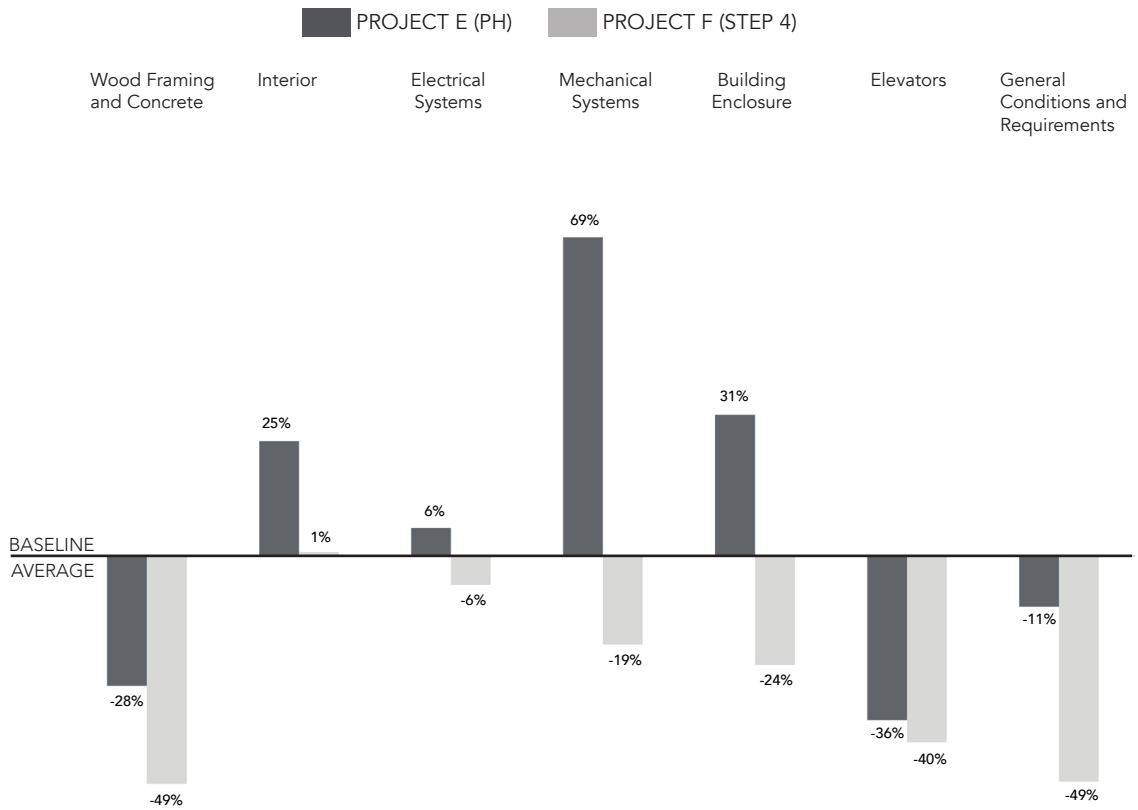
KELOWNA

PROJECT E (Passive House)

- Competitive concrete form work and supply bid/price
- Competitive rough carpentry bid
- Lumber prices were locked in low
- Very simple building form
- Above-average density of suites and washrooms
- Heat pumps used for centralized heating and cooling
- Heat pumps used for centralized domestic hot water generation
- Numerous thermally broken cladding attachment clips
- Exterior siding and PH-certified windows imported from Europe

PROJECT F (Step 4)

- Very simple building form
- No scaffolding or crane used
- Structural insulated panels for exterior walls
- Suites have individual heat pumps for heating and cooling and individual energy recovery ventilators (fully decentralized)
- Domestic hot water is generated with individual water heaters with integral heat pumps



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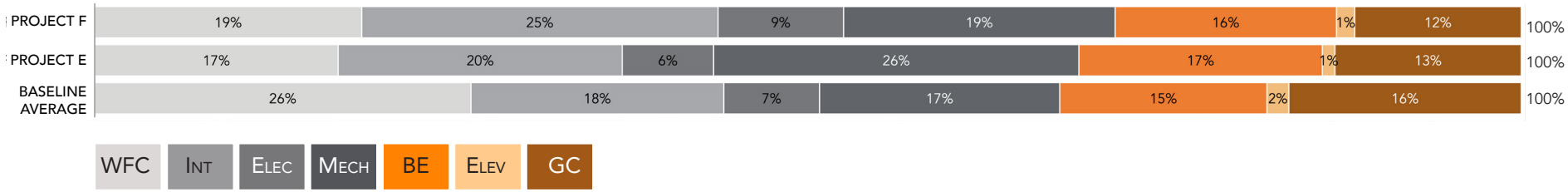
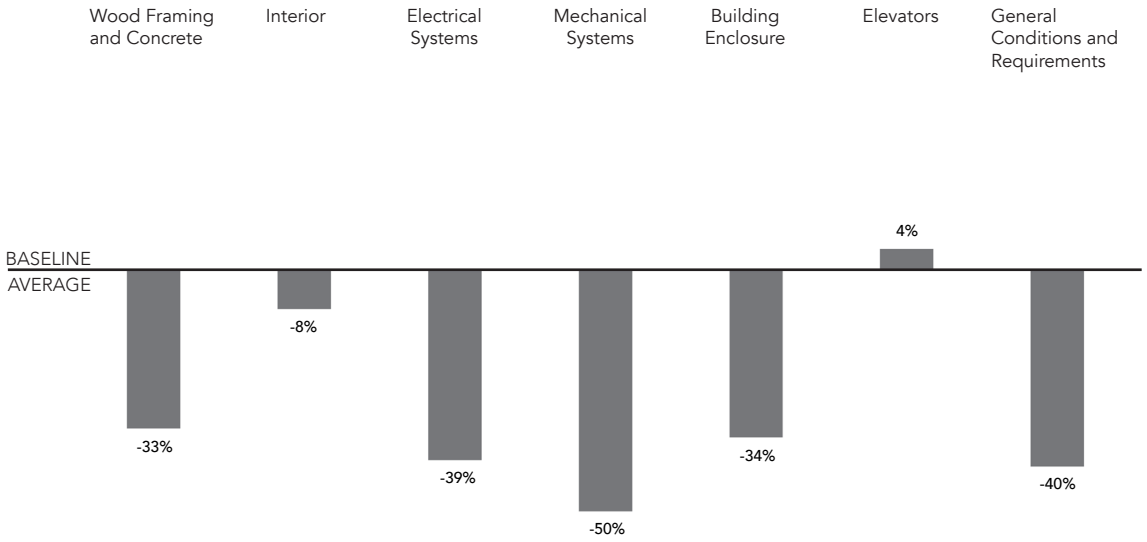


PEMBERTON

PROJECT G (Step 4)

- Very little concrete used
- Insulated concrete forms used for concrete walls
- Own labour forces used for a significant portion of the construction
- Wood studs in exterior walls aligned with spacing of wood joists
- One energy recovery ventilator inter-connected with two heat pumps to temper ventilation air
- Passive House-certified windows imported from Europe
- Previous experience in high-performance buildings



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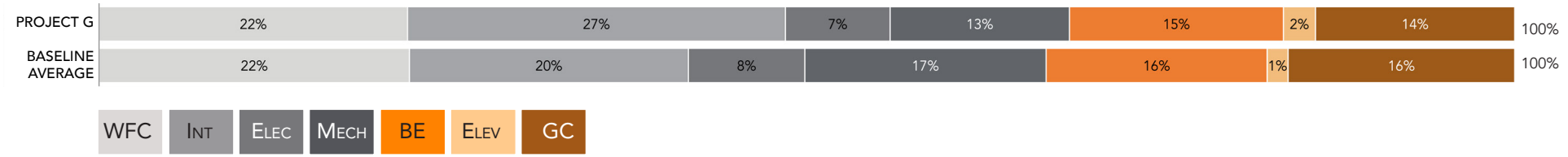

CLOSING COMMENTS

Because of the small number of buildings involved in this study, and the notable variability in construction costs, drawing definitive conclusions on average past construction costs for high-performance, wood-framed, mid-rise multi-unit residential buildings is not possible. Nonetheless, some observations are worth noting.

- Although significant effort was made to try and ensure the values in this report accurately represent actual construction costs, there exists a **small margin of error**. In addition to rounding-related errors, some approximations made during this study contribute to this margin of error. For example, some builders subcontracted the installation of the insulation in both the cavity of the exterior walls and interior demising walls to one trade. In order to determine the insulation cost for the building enclosure, the trades were asked to separate the two costs. Not all did. In cases where they did, an approximate percentage was provided (e.g. 70% for interior walls). In cases where they did not, the percentage was based on the other projects where the percentage was known. Another contributor to the margin of error relates to the baseline adjustments. For example, if a baseline building had no cooling, the additional cost for cooling was applied to the construction cost. The additional cost was based on the average historical cost for cooling, not the building-specific cost for cooling.

- Based on the fact that two **all-electric buildings** were constructed for considerably less than the baseline buildings, we can conclude that high-performance (Step 4), all-electric buildings can be constructed for less than the average cost of similar code-minimum buildings.

- The two projects with the lowest construction costs relative to the baselines were constructed by **developer/builders**. No CCDC construction contracts were issued. For other projects where construction contracts were issued to builders, the CCDC contracts were not the common CCDC 2 (Stipulated Price) contracts. Instead, they were contracts which allowed the builders to have varying degrees of input in the design before construction began. We believe that involving the builder in the design phase may have reduced the construction costs or kept them from escalating through construction. It is important to note that the three projects with the best results relative to the baseline were ones where the builders had the most involvement in the design stage.

- The fact that these buildings are some of the first Part 3 NZER buildings in BC has an impact on construction costs. A **lack of availability** of components, materials and other construction products used for NZER buildings resulted in increased supply costs for some of the projects. We expect that availability will become less of an issue as these NZER buildings become more common and this should result in lower construction costs.

- A recurring theme among builders was the **lack of familiarity** with NZER designs. Some of the project teams were unfamiliar with the most cost-effective design strategies for NZER buildings. We expect that with more experience, both designers and builders will become more familiar with cost-effective construction of NZER buildings. As more pioneering developers adopt NZER building standards for their projects, the number of builders and designers capable of building and designing NZER buildings cost-effectively will grow.

- The overall cost of constructing high-performance buildings is affected by many **project-specific or industry-wide factors**. Some are related to the high-performance aspects of the building while others are not. Typically, the most notable design differences between a code-minimum building and a high-performance building relate to the building enclosure and mechanical systems, but this study indicates that this does not always correlate with an increase in cost for those building elements. In cases where it does, the data suggests that there are ways to reduce other construction costs to compensate for it.

- In 2022, the Province will raise the minimum energy-efficiency requirements for most Part 3 buildings to **Step 2 of the Step Code** (as outlined in the Province's CleanBC Plan). This will raise the baseline for all buildings in BC (except for those in the City of Vancouver) and reduce the difference between the future code-minimum buildings and buildings designed to meet Step 4. The minimum energy efficiency requirements for most Part 3 multi-unit residential buildings in the City of Vancouver are already roughly equivalent to Step 3 of the BCBC. This minimum requirement for the City of Vancouver will be raised in 2025 for most Part 3 buildings.

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Back cover photo credit: Vidorra Developments