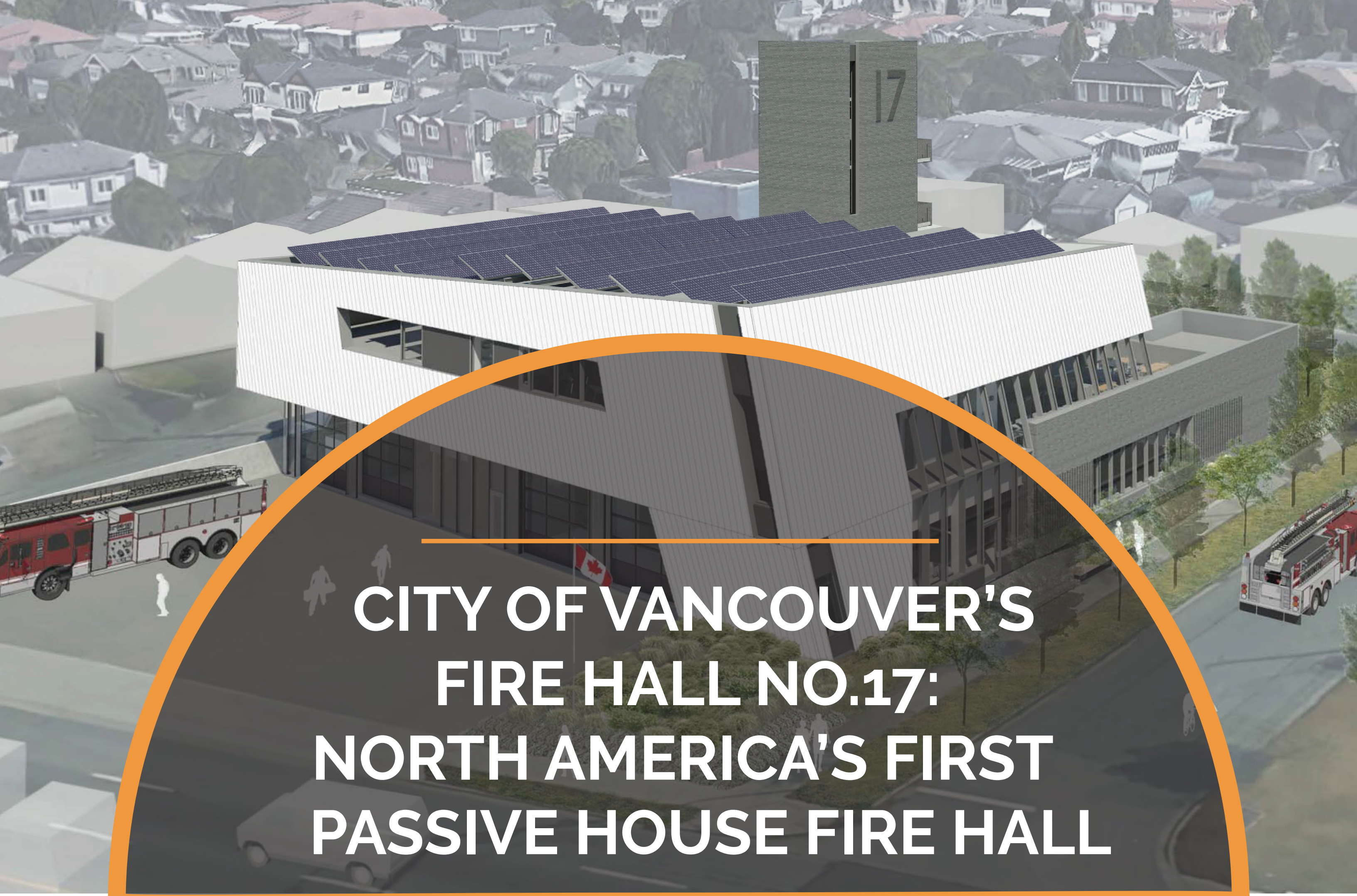


CITY OF VANCOUVER'S FIRE HALL NO.17: NORTH AMERICA'S FIRST PASSIVE HOUSE FIRE HALL

CASE STUDY

In 2018, the City of Vancouver began the design to replace Fire Hall No.17. with a new building. The new facility is the first fire hall in North America to pursue Passive House certification. The project is also pursuing LEED v4 Gold and Zero Carbon Building Standard certifications. Fire Hall No.17 is designed to reduce greenhouse gas emissions by 97% compared to the existing facility with a high-performance envelope, efficient mechanical systems such as geo-exchange heat pumps, and an on-site solar PV array.

September, 2020

PREPARED BY

zebx | The University of British Columbia | City of Vancouver | HCMA Architecture + Design | Integral Group | Morrison Hershfield

QUICK SUMMARY

PASSIVE HOUSE STANDARD

requirements were followed to guide the project design and construction. Fire Hall No.17 is first fire hall in North America to pursue Passive House certification - **page 05**

REDUCED ENERGY USE

by about 96% when the total energy use of the new Fire Hall No.17 is compared to the old fire hall - **page 05**

EMBODIED CARBON ASSESSMENT

estimated the total embodied GHG emissions of the structure and envelope to be 424 $kgCO_2eq./m^2$ over a 60-year building life. This makes up 97% of the building's total life cycle GHG emissions and about 90% of it is released in product and construction phases - **page 06**

INCREASED INSULATION

Separate, high-performance envelopes were designed to differentiate the thermal performance needs of the living spaces from the apparatus bay area - **page 07**

THERMAL BRIDGING

is minimized through the use of Passive House certified windows, slab thermal-breaks, and limited penetrations through the envelope - **page 07**

HEAT PUMP DOMESTIC HOT WATER

using air source heat pumps that are coupled with electric resistance heaters for back-up - **page 09**

HEAT RECOVERY VENTILATORS

are used to recover heat from the exhaust air and heat the fresh incoming air. Six separate efficient HRVs with varied set temperatures serve independent zones based on their need - **page 09**

NET ZERO ENERGY OPERATIONS

is achieved using a rooftop 80kW photovoltaic solar panel array that produces 85,000kWh electrical energy per year - **page 09**

MINIMAL HEATING & COOLING

is required and provided by energy-efficient ground-source heat pumps connected to a closed-loop geo-exchange system - **page 09**

Credit: HCMA

PROJECT CONTEXT

The new Fire Hall No.17 project replaces the existing facility with a high-performance and fully electric building that will also act as a city-wide and post-disaster emergency hub. The new fire hall is the first in North America to pursue Passive House certification.

Project Overview

Building Type	Institutional – Public Safety
Climate Zone	4: Cool-Temperate
Location	Sunset Neighborhood, Vancouver, B.C.
Zoning	Single-family Residential (RS-1)
Gross Floor Area **Treated Floor Area**	1,832 m^2 / 19,719 ft^2 1,767 m^2 / 19,120 ft^2
Building Height	Main Building: 12.61 m Hose Tower: 28.87 m
Number of Floors	Main Building: 3 stories Hose Tower: 6 Stories
Construction Period	November 2018
Projected Move-in Date	February 2021

Project Team

Owner	City of Vancouver
Architect	HCMA
Structural Engineer	Read Jones Christoffersen Ltd (RJC)
Construction Manager	DGS Construction
Mechanical & Electrical Engineer	Integral Group
Sustainability Consultant & PH Consultant	HCMA
PH Certifier	Passive House Institute
Energy Modelling	Morrison Hershfield
Code Consultant	Jensen Hughes

Project Context

The City of Vancouver developed the Zero Emissions Building Plan (ZEBP) to address global climate change concerns by developing a roadmap for all new buildings to achieve zero operational GHG emissions by 2030. In 2017, the Province of British Columbia enacted the B.C. Energy Step Code to incrementally move toward net-zero energy ready buildings by 2032.

The ZEBP accelerates projects' adoption of future energy and emissions targets by encouraging the pursuit of high-performance certifications. For instance, following Passive House certification allows some zoning relaxations such as additional height, depth, site coverage, and wall thickness to accommodate thicker insulated assemblies. Vancouver also demonstrates the feasibility of these targets by implementing zero-emissions building approaches in City-owned and managed building projects.

The old Fire Hall No.17, located at Knight Street in the Sunset neighborhood, was built in 1954 and did not meet current seismic standards. It was energy inefficient and had insufficient space to meet operational needs. The new fire hall doubles the size of the aged facility, becoming Vancouver's second-largest city-wide training facility and post-disaster emergency hub. The new building is designed to be fully electric and achieve multiple high-performance standards: Passive House, Leadership in Energy and Environmental Design (LEED) v4 Gold, CaGBC's Zero Carbon Building Standard, and Net Zero Energy as per the Federation of Canadian Municipalities (FCM).

Fire Hall No.17 is one of the first City-owned buildings developed under the Zero Emissions Building Plan. The project is serving as a model for other communities looking to increase the energy efficiency of their service buildings. This case study aims to provide an overview of the design and early construction processes and share transferrable learnings. The information on this case study is based on the project design phase modeling and not the actual performance.


New Fire Hall No. 17 rendering (credit: HCMA)


Demolition of the old Fire Hall No. 17 (credit: City of Vancouver)

PROCESS HIGHLIGHTS

Fire Hall No.17 is designed to facilitate a quick turnout time for the crew, which led to a complex building layout with more functional zones. The project team focused on using a high-performance envelope, energy-efficient and low-carbon mechanical systems, and an on-site solar PV array.

Design Highlights

The new Fire Hall No.17 is comprised of three main components: 1) apparatus bay with 4 drive-through bays, 2) dual-purpose full-height hose drying and training tower, and 3) administration and accommodation spaces, including offices, a training room, a kitchen, a fitness room, and dormitories. Additionally, the building is equipped with communication and support infrastructure to coordinate all the fire halls in the City of Vancouver in the event of a post-disaster emergency.

The building project team sought to balance the efficiency of the layout design for fire turnout time (the necessary time for crew members to leave the fire hall when signaled) with optimized energy performance. The turnout time requirement and varying building functions resulted in an irregular building shape, which made the design of a high-performance envelope and achievement of the energy-efficiency targets significantly more challenging.

The building's envelope is designed according to the Passive House standard to reduce the overall thermal energy load of the building. To achieve the requirements of the Zero Carbon Building Standard, the building was designed to eliminate the use of fossil fuels and associated GHG emissions.

Fire Hall No.17 is also pursuing LEED v4 Gold and is therefore designed to reduce the environmental impacts beyond energy and emissions. For example, the project is targeting a 40% reduction in water consumption, by incorporating low-flow fixtures and fittings into the building and designing a landscape with local drought-resistant plants that require minimal irrigation. Additionally, the old fire hall was fully demolished before construction and 91% of the demolition waste was diverted from landfills.

Costs Overview

The project is estimated to have higher first costs than a typical fire hall in Vancouver. This is because of multiple factors such as including special programs for emergency management and a data centre that are not common in typical fire halls, including demolition costs of the old fire hall, and incorporating novel design features and strategies to pursue ambitious reductions in energy consumption and GHG emissions.

The Fire Hall No.17 cost premiums are partially offset by a Green Municipal Fund for projects that aim for net-zero energy performance and a loan, both provided by the Federation of Canadian Municipalities (FCM). It is also expected that reduced operating costs resulting from lower energy use of the facility will contribute to offsetting the first costs.

Fire Hall No. 17 construction site (Credit: HCMA)

Slab on grade insulation installation (Credit: HCMA)

ENERGY AND CARBON PERFORMANCE

Fire Hall No.17 demonstrates the feasibility of ambitious reductions in energy use and GHG emissions through the integration of city policies and multiple green building standards. The project is anticipated to offset its operational energy use and associated GHG emissions through on-site renewable energy production.

OPERATIONAL ENERGY

The City of Vancouver sets higher energy targets for City-owned buildings to show leadership. At the time the new Fire Hall No.17 was being designed, the City required all new municipal facilities to demonstrate compliance to LEED Gold with a 30% operation energy cost reduction. Following the adoption of the Zero Emissions Building Plan, the City committed to designing all the new City-owned buildings to the Passive House standard requirements or an alternative zero-emissions standard and using no fossil fuels.

Pursuing Passive House requirements led to a design that exceeds the LEED's energy performance requirements with an estimated energy costs reduction of 80% compared to the ASHRAE 90.1 2010 baseline building. Compared to the previous building, the new facility is anticipated to have a 96% reduction in the total Energy Use Intensity (EUI). Additionally, Fire Hall No.17 is designed to meet the FCM's Site Net-Zero Energy Fund requirements, which dictated the renewable energy to be generated on the project site.

OPERATIONAL CARBON

Passive House focuses on reducing operational energy use, which contributes to reducing carbon emissions. However, it does not offer a target or metric for reducing carbon emissions. Therefore, Fire Hall No.17 also participated in a CaGBC Zero Carbon pilot program, which informed the development of the Zero Carbon Building Standard. The Standard offers stringent targets to reduce operational carbon emissions substantially and offset the remainder with low-carbon renewable energy.

To meet the pilot program's requirements, the project was designed to be fully electric to take advantage of British Columbia's grid that is mostly generated from hydroelectric dams. The facility is also designed to use an on-site geo-exchange system for heating and cooling. Lastly, the solar photo voltaic (PV) panels used in the facility are estimated to generate sufficient on-site renewable energy to offset 100% of the operational energy needs for heating and cooling and the associated GHG emissions.

Estimated building energy use and GHG emissions of Fire Hall No.17 compared with the old Fire Hall No. 17, CaGBC Zero Carbon Building Standard, Passive House, and FCM Site Net-Zero Energy Fund requirements
(Source: Based on the preliminary energy modeling results presented by the project design team at the CaGBC Conference, 2018)

Energy Use & Carbon Emission Indicators	Thermal Energy Demand Intensity (TEDI)	Total Energy Use Intensity (EUI)	On-site Renewable Energy Generation	GHG Intensity [Operational] (GHGI)	Zero Carbon Balance [Operational]	GHG Emissions [Embodied]*
Unit	**kWh/m²yr**	**kWh/m²yr**	**% of total energy use**	**$kgCO_2eq./m^2yr$**	**$kgCO_2eq.$**	**$kgCO_2eq./m^2$**
New Fire Hall No. 17	21	79	- Excl. process load**: 97% - Incl. process load: 61%	0.2	-13,359	424
Old Fire Hall No. 17	-	384	0	60	Not available	Not available
CaGBC Zero Carbon Building Standard Requirements	30	- No limit - Mandartory reporting	≥ 5% EUI	No requirement	≤0	- No limit - Mandartory reporting
Passive House Requirements	15 *(Space Heating Demand)****	120 (PE) OR 60 (PER)	No requirement	No requirement	No requirement	No requirement
FCM Site Net-Zero Energy Requirements	No requirement	No requirement	≥ 100% EUI *(excluding process load)***	No requirement	No requirement	No requirement

* *Structure and enclosure materials over 60 years of the building lifetime*
** *Process load is the energy consumed in support of manufacturing, industrial or commercial processes not related to the comfort and amenities of the building's occupants. The process load for the Fire Hall No.17 is estimated to be 51,000 kWh/yr.*
*** *Space heating demand is a Passive House metric similar to TEDI but more stringent because it uses the treated floor area rather than the gross floor area for calculating annual thermal energy use per square meter.*

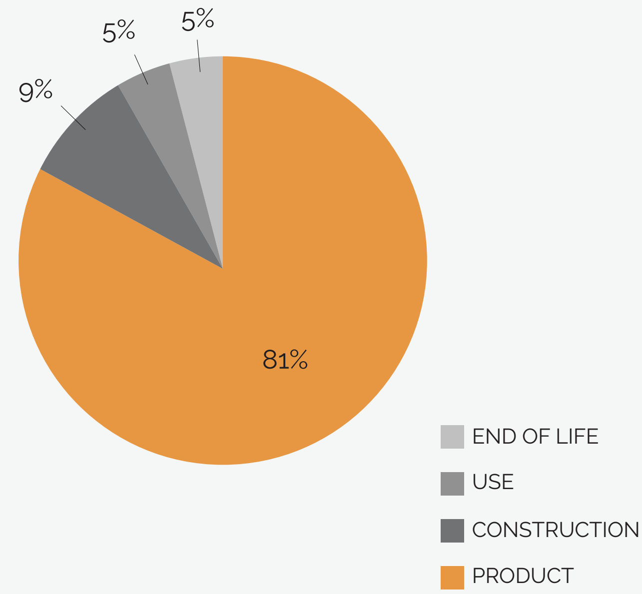
EMBODIED CARBON EMISSIONS

The estimated embodied GHG emissions are 424 kgCO_2eq./m² for the structure and envelope, assuming a 60-year building life. With nearly zero emissions from building operations, the embodied emissions come into greater focus; about 90% of these emissions are emitted before the building starts operating.

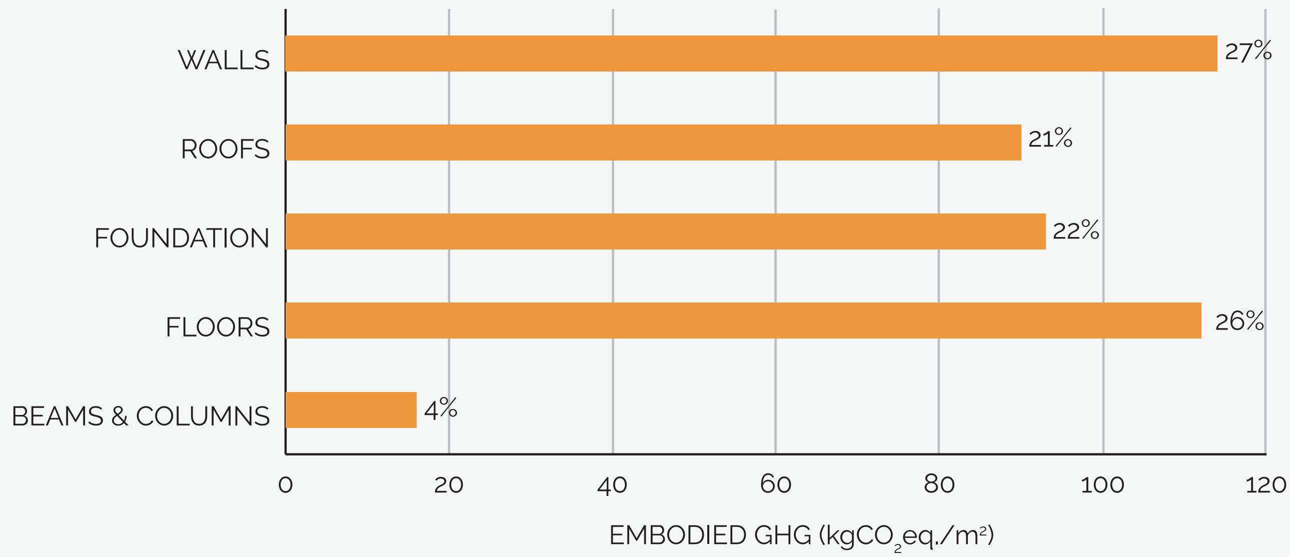
To meet the requirements of the Zero Carbon Building Standard, the project team conducted a Life Cycle Assessment (LCA) of Fire Hall No.17 to quantify the GHG emissions of the building materials, also referred to as embodied carbon emissions. The LCA was conducted using the Athena Impact Estimator for Buildings tool (v5.3.0111) and is based on a bill of materials generated from the project drawings. The study quantified the building structure and envelope, which encompass the majority of the building materials. The scope of the study was cradle-to-grave, which included the production, construction, use (e.g. maintenance and replacement) and end of life (e.g. deconstruction, waste processing, and disposal) stages.

Assuming the service life of the building will be 60 years, the LCA estimated the total embodied carbon emissions of the structure and envelope to be about 778,000 kgCO_2 eq. or 424 kgCO_2eq./m² for the total gross area of 1,832 m². Because the building design has significantly reduced the operational carbon emissions, this amount of embodied carbon is even more significant. This makes up 97% of the building's total life cycle GHG emissions. Additionally, more than 90% of the embodied carbon is released before the building starts its operation. Therefore, future zero-carbon buildings must explore ways to minimize not only their operational but also their embodied carbon emissions.

FIRE HALL NO. 17 POTENTIAL EMBODIED CARBON EMISSIONS BY LIFE CYCLE PHASE



FIRE HALL NO. 17 POTENTIAL EMBODIED CARBON EMISSIONS BY ASSEMBLY GROUP



(Source: LCA report by HCMA for the Zero Carbon Building pilot program, 2019)

HIGH THERMAL PERFORMANCE ENVELOPE

Fire Hall No. 17 is divided into two distinct thermal envelope zones with specific indoor temperature requirements. The envelope assemblies are designed to respond to the specific thermal performance needs of each zone. Details are carefully designed to minimize thermal bridging.

The project team applied an envelope-first design approach to reduce the building's energy loads, before considering improvements to the efficiency of the mechanical systems. The building is split into two envelope zones:
1) the apparatus bays and hose drying/training tower, and
2) the administration and accommodation spaces.
These zones are independently heated and conditioned to meet different indoor environmental needs and comfort levels.

Thermal performance of exterior components of Fire Hall No. 17 (Data source: HCMA)

Envelope Component	Component Description	Average Assembly U-value (W/m²K)
Exterior Wall - Administration and Accommodations Zone	Double Wood Cavity wall with XPS and mineral fibre insulation boards	0.17 (Effective R-33)*
Exterior Wall - Hose Tower	Perforated brick veneer with semi-rigid mineral fibre insulation boards	0.27 (R-21)
Exterior Wall - Apparatus Bay	Reinforced masonry wall with semi-rigid mineral fibre insulation boards	0.195 (R-29)
Roof - Administration and Accommodations Zone	Steel deck with Polyisocyanurate and XPS insulation	0.053 (R-107)
Roof - Hose Tower	Reinforced concrete slab with XPS insulation	0.155 (R 36)
Roof - Apparatus Bay	Reinforced concrete slab with Polyisocyanurate and XPS insulation	0.123 (R-46)
Floor - Administration and Accommodations Zone	Wood stud flooring with Rigid XPS insulation	0.14 (R-40)
Floor - Apparatus Bay	Reinforced concrete slab with Rigid XPS insulation	0.49 (R 11.5)
Exterior Windows	Passive House certified windows, triple glazed Low-e coated	Effective U-value: 0.74 (R-7.6)
Exterior Doors	Passive House certified doors	Effective U-value: 0.81 (R-7)

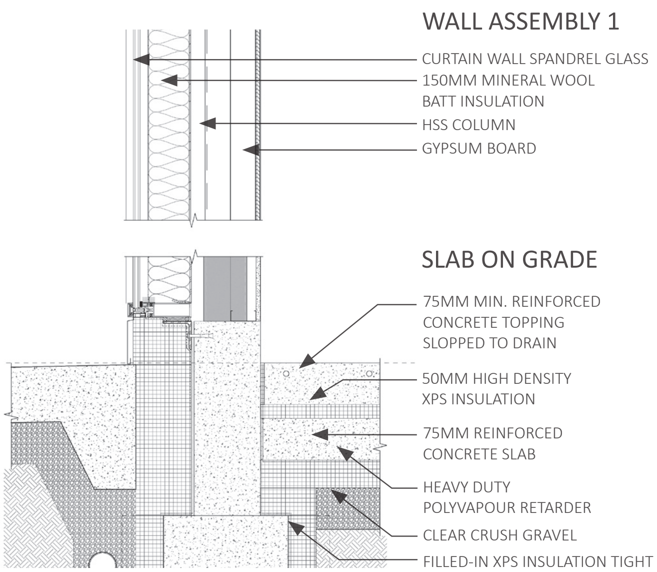
** U-value of the administration and accommodations zone only (excluding apparatus bay and tower)*

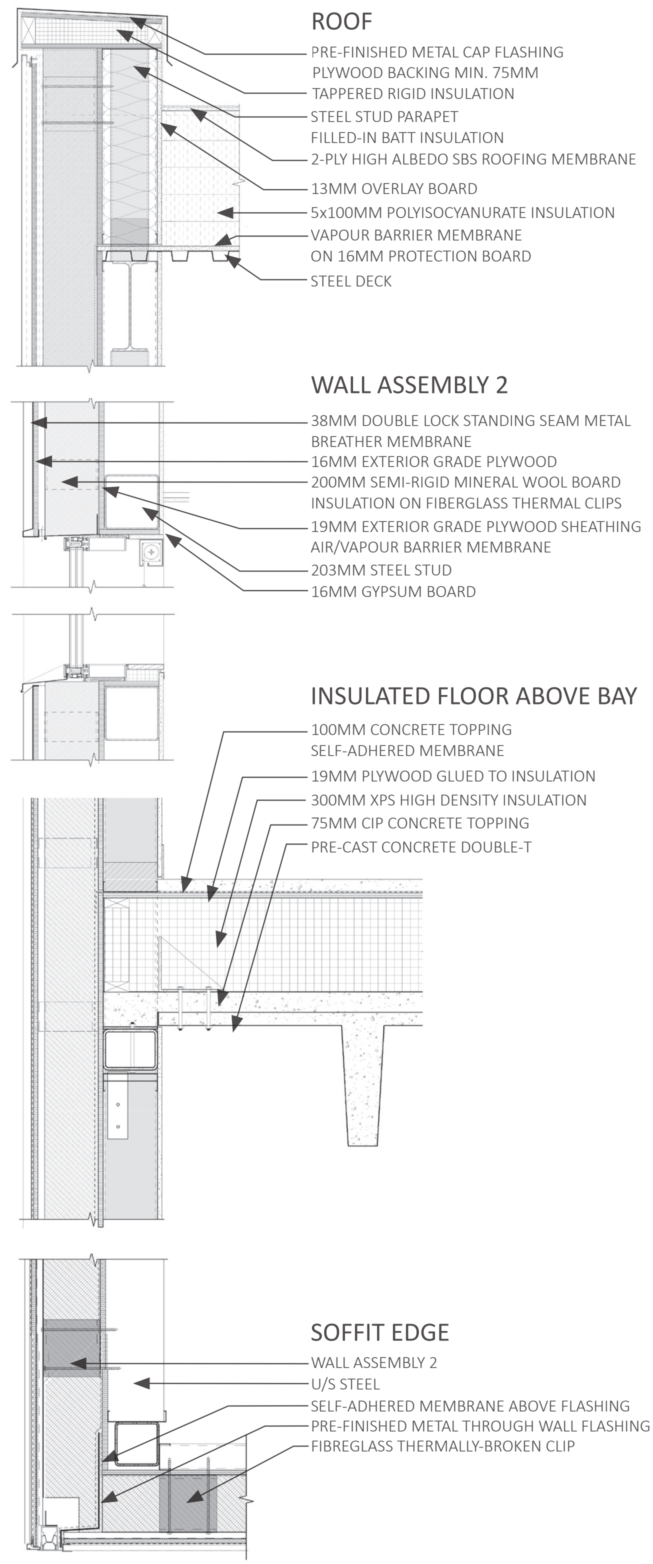
Each zone is enclosed with a different envelope, designed with levels of insulation based on their interior temperature needs. Both envelope designs are highly-insulated and use Passive House certified windows. Thermal bridges are minimized through the use of thermal breaks and the elimination of mechanical system penetrations. Designing the envelopes according to the Passive House standard is anticipated to reduce the building's heat loss by 70% compared to a conventional envelope and to reduce the overall thermal energy load of the building.

Different thermal breaks used in the Fire Hall No.17 envelope construction (Credit: HCMA)

AIRTIGHT ENVELOPE

It was a challenge to meet the Passive House airtightness requirement because of the large overhead doors of the apparatus bay area. Given the lack of Passive House certified overhead doors in the Canadian market, the project received a relaxation to increase the air leakage for the apparatus bay area.





Wall sections of the two different highly insulated envelope designs
Left: The assembly for the wall primarily used in the apparatus bay
Right: The assembly for the wall primarily used in administration and the living areas (Source: Architectural drawings by HCMA)

To prove compliance with the Passive House standard airtightness requirements, a blower door test is conducted to verify an air leakage of 0.6 Air Changes per Hour (ACH) at 50 Pa pressure. The administration and accommodations zone is anticipated to meet the airtightness requirements. Meeting the airtightness requirement for the whole building is challenging, however, due to eight large overhead doors located in the apparatus bays. Few industrial buildings have earned Passive House certification to date and Passive House certified overhead doors are currently not available in the Canadian market. Other industrial projects in the region have faced similar challenges.

The Passive House standard was originally developed based on data from residential buildings. Therefore, it is harder for projects like Firehall No. 17, which have more complex functional requirements such as multiple overhead doors, to meet the Passive House requirements. Recognizing these complexities, the Passive House Institute allowed the project team to conduct a separate airtightness test for the apparatus bay area with a less stringent airtightness requirement. The rest of the building is required to meet the established Passive House airtightness requirement of 0.6 ACH @ 50 Pa. The Institute uses projects like Firehall No.17 as precedents to establish more appropriate targets for specific building typologies.

ENERGY EFFICIENCY STRATEGIES

Electric ground source heat pumps provide hydronic heating and cooling to the building. Efficient heat recovery ventilators are utilized for each independent zone to recover the heat from the exhaust air and pre-heat the incoming air. Domestic hot water is produced by an air source heat pump.

Heating and Cooling

In addition to using highly insulated and airtight envelopes, various strategies are used in Fire Hall No.17 to minimize heating and cooling demands by optimizing solar heat gains and transmission energy losses. These strategies include optimizing building form and orientation, placing 42% glazing on the south and only 18% on the north façade, and using electrochromic glass for windows. Electrochromic glass is electronically tintable and is integrated into the building automation system. It allows flexibility in shading and reduces glare as it can be controlled by building occupants.

The heating, ventilation, air conditioning, and domestic hot water systems are fully electric. The building uses a hydronic heating and cooling system with three high-performance ground source heat pumps (6-ton WaterFurnace Envision units), connected to a closed-loop geo-exchange field, which is placed outside the building site to allow digging for maintenance. Space heating in the apparatus bays is supplied by radiant heating in the concrete floor slabs. The administrative and accommodation areas are heated with hydronic fan coil units utilizing Electrically Commutated Motors (ECM) that control air-flow based on demand. The distribution coils have a changeover mechanism that allows switching between heating and cooling functions as needed.

Most of the domestic hot water (DHW) is provided by Rheem HPLD80 (300 L) DHW tanks with integrated air-source heat pumps. In integrated DHW systems, the heat pump unit is mounted on top of the tanks. In Fire Hall No.17, the heat pumps absorb heat from the mechanical room and the cold air is used to cool the adjacent IT communications room. A supplementary PVI Durawatt (470 L) DHW tank with an 18kW electric coil provides additional hot water during peak demand. A hot water recirculation pump within the DHW system prevents stagnation and ensures unused hot water is recovered and returned to the tanks. DHW piping is minimized throughout the building to reduce heat loss in the pipes.

Ventilation

Five Swegon Gold RX07 Passive House certified heat recovery ventilators (HRVs) and one high-efficiency Zehnder HRV unit are utilized to recover the heat from the exhaust air and heat the incoming air. Using separate HRVs for different zones helps prevent mixing air with different temperatures and reduce the need for reheating air for warmer zones. It also provides better demand control ventilation in the absence of the low-pressure variable air volume (VAV) terminal units, which were not commercially available at the time of design. A Nederman vehicle exhaust extraction system equipped with a silencer is utilized in the apparatus bay to exhaust the harmful pollutants from the fire trucks and other vehicles. The exhaust fan activates when a truck is turned on inside the building and automatically switches off 5 minutes after the departure of the vehicle. A noxious gas monitoring system can override and turn on the vehicle exhaust extraction system when contaminants exceed a set point.

Renewable Energy

Onsite renewable energy is generated by an 80kW rooftop PV solar panel array which provides about 85,500 kWh of electricity per year. According to the hourly energy modeling of the facility, it is anticipated that about 54,800 kWh of this energy will be consumed on-site and the rest will be exported to the municipal electrical grid.

Additionally, by using the rooftop PV panel array, the operational carbon balance of the facility is estimated to be -13,539 kg CO_2 eq., which means the Fire Hall No. 17 exceeds the zero-carbon balance required by the Zero Carbon Building Standard.

Ground source heat pump system installation (Credit: HCMA)

GLOSSARY

Key terms, definitions, and abbreviations used in this case study arranged alphabetically

Air Changes per Hour (ACH)
ACH is the metric for the airtightness of space and measures the air volume removed from the space divided by the volume of the space. Passive House requires an air change of 0.6 times or less per hour at the pressure dif-ferential of 50 Pascals between the indoor and outdoor space.

Air Source Heat Pump
A mechanical system that transfers thermal energy in the opposite natural direction of heat transfer from a colder air source to a warmer indoor space. Heat pumps are a more energy-efficient alternative for space heating, cooling, and domestic hot water.

Airtightness
The resistance to inward or outward air leakage through unintentional leakage points or areas in the building envelope. Airtightness is represented in units of ACH and is commonly tested using a blower door test.

ASHRAE 90.1
it is an American National Standard that provides minimum requirements for energy-efficient designs for buildings except for low-rise residential buildings (i.e single-family, duplexes, townhomes, small apartment buildings, etc.)

B.C. Energy Step Code
A voluntary provincial standard in British Columbia that provides an incremental and consistent approach to achieving more energy-efficient buildings that go beyond the basic requirements of the B.C. Building Code.

Canada Green Building Council's Zero Carbon Building Standard
A green building standard to design new and existing buildings to be zero carbon emissions. ZCB standards focus on the carbon balance across a building's lifecycle, including materials, construction, and operation).

Embodied Carbon Emissions
GHG emissions, measured in equivalent CO_2, associated with building materials during the life cycle of a building, that includes production, construction, use, and end of life (demolition and disposal).

Electrically Commutated Motors (ECM)
are also referred to as a variable-speed motors. ECMs are used in heating, cooling, and air conditioning systems to maintain the designed airflow by using electronic controls to vary the speed.

Electrochromic Glass
An electronically tintable glass that can be controlled by building occupants to improve occupant comfort, maximize access to daylight and outdoor views, reduce solar heat gains.

Extruded polystyrene insulation (XPS)
Rigid, closed-cell foam insulation with low thermal conductivity, high resistance to water penetration, and high compressive strength.

Federation of Canadian Municipalities (FCM)
FCM is a national network of municipal governments, representing 90% of local communities across Canada. FCM funds municipal capital projects that target net-zero energy performance, to incentivize communities to transition to low energy buildings and reduce GHG emissions.

Ground Source Heat Pumps
These heat pumps extract heat from the ground and transfer it to air or water to provide heating and/or domestic hot water for the interior spaces. These heat pumps generally maintain higher efficiency in cold regions compared to air source heat pumps because of the stable ground temperatures.

Heat Pump
A mechanical system that transfers thermal energy in the opposite of the natural direction to transfer heat from a colder space to a warmer space. Heat pumps are an energy-efficient system for space heating, cooling, and domestic hot water.

GLOSSARY

Key terms, definitions, and abbreviations used in this case study arranged alphabetically

Heat Recovery Ventilator (HRV)
A mechanical energy recovery system that recovers heat from the exhaust air to pre-heat the filtered incoming fresh air stream. This reduces the energy required to bring outside air up to ambient room temperature.

Leadership in Energy and Environmental Design (LEED)
An internationally recognized green building rating system, that verifies a building or community was designed and built using strategies aimed at improving performance across energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. Buildings are awarded points based on the extent to which the strategies are achieved, and can qualify for four levels of certification starting from Certified, Silver, Gold, to Platinum certification for the highest number of points.

Life Cycle Assessment (LCA)
A scientific approach and framework to quantify potential environmental impacts from cradle-to-grave (e.g. extraction, production, installation, use, and end of life), and used to inform design and procurement decision-making.

Passive House
An internationally recognized certification program, developed by an independent research institute based in Germany. The program is intended to result in buildings with extremely low space heating and cooling needs and consequently lower environmental impacts, as well as comfortable indoor temperature and air quality.

Polyisocyanurate Insulation
High-density foam insulation that is most widely used on commercial low slope roofing assemblies. It has a high R-value per inch (R6-6.5) compared to other insulation products used in commercial construction.

R-value
The capacity of an insulating material to resist heat flow. The higher the R-value, the greater the insulating power.

Thermal Bridge
An area or a building component which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer. Thermal bridges in a building envelope result in significant heat loss and energy efficiency reduction.

Thermal Energy Demand Intensity (TEDI)
A metric of a building's modeled heating needs used in the B.C. Energy Step Code that is primarily influenced by the building enclosure insulation, airtightness, and ventilation system. A highly insulated, airtight enclosure, with heat recovery ventilation will achieve a lower TEDI value.

Total Energy Usage Intensity (TEUI)
A metric of a building's modeled energy needs used in the B.C. Energy Step Code that in addition to TEDI, includes plug loads, lighting, and other auxiliary systems like elevators and miscellaneous equipment.

U-value
A measure of thermal performance or heat transfer through a surface due to conduction and radiation. Lower U-Value rates indicate more energy-efficient surfaces. U-value is the inverse of the R-value.

Variable Air Volume (VAV) Terminal Unit
A VAV terminal unit or VAV box is a calibrated air damper with an automatic actuator, used in the heating, cooling, and air conditioning systems, that allows providing varying airflow to different splaces in a building.

Zero Emissions Building Plan
A phased approach by the City of Vancouver to reduce carbon emissions in buildings by establishing specific targets and actions to achieve zero-emissions carbon in all new buildings by 2030.

CITY OF VANCOUVER'S FIREHALL NO. 17:
NORTH AMERICA'S FIRST PASSIVE HOUSE FIRE HALL

Learn more at

https://zebx.org/resources/#case-studies

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