2024

CITY OF VICTORIA | Climate Action

Building All-Electric in Victoria

Climate Friendly Homes Case Studies

Zero Carbon Step Code

CREATED IN PARTNERSHIP WITH

Contents

To see the full report, visit:
b2electrification.org/building-all-electric-victoria

Introduction

The City of Victoria is committed to becoming a low carbon city, adopting innovative approaches to reduce community greenhouse gas emissions. In 2023, Victoria became one of the first municipalities to implement B.C.'s Zero Carbon Step Code, requiring new homes to minimize carbon emissions. This report highlights three recent home builds in Victoria that comply with the Zero Carbon Step Code by using electric heating systems for space and water. Overall, these case studies highlight the following:

1. **A climate-friendly home is all-electric.**

   Burning natural gas currently makes up 42 per cent of carbon emissions in Victoria. Under the Zero Carbon Step Code, new homes must use all-electric air and water heating systems, powered by B.C.'s low carbon electricity. On average, all-electric homes have 12 times fewer carbon emissions than homes with all-gas heating.

2. **Building all-electric is increasingly common.**

   Twenty-nine per cent of new homes built in 2020 were all-electric, and by 2023, that number grew to 53 per cent. Whether for the cool air from heat pumps in the summer or to reduce their carbon footprint, many people have been opting for all-electric homes even before the Zero Carbon Step Code came into effect.

3. **All-electric homes have similar utility costs to gas homes.**

   Most new all-electric homes in Victoria use a heat pump and an electric hot water tank, which have similar utility costs to gas-heated homes due to the efficiency of heat pumps and avoiding monthly gas connection fees. The cost can be reduced further with the use of solar panels.

4. **Design choices can reduce the impact of building the home.**

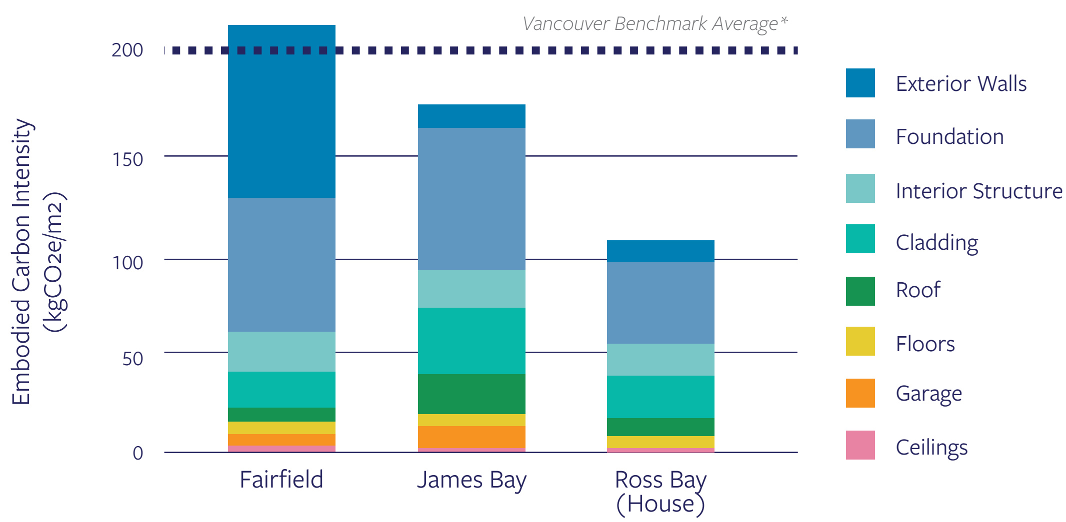
   Making design choices, such as the use of simple architecture, reducing concrete, insulation and glass, using wood-frame construction and salvaging materials from the prior home, can lead to significant reductions in the emissions involved with building the home.

Heating Energy Use	Average GHG intensity (kg CO_2/m^2/year)	Average total GHG emissions per home (kg CO_2/year)
All-electric	1.4	124
Some gas	3.9	594
All gas	8.5	1,223

Here are some key choices to reduce climate impact of building a new home (i.e., embodied carbon):

1. Using slab-on-grade or crawl space construction helps reduce the amount of concrete and insulation needed.
2. Installing windows that are reasonably sized means using less glass.
3. Keeping garages small or not including a garage at all.
4. Choosing wood-frame construction.
5. Keeping the design simple to use fewer materials.
6. Salvaging, reusing, and recycling as much as possible from any demolished buildings on the property.

Embodied Carbon Breakdown



*The benchmark of 200 kgCO2e/m2 is an average value for newly built homes in the Vancouver area, provided here for comparision.

The intent of these case studies is to inspire and support future home builders in creating low carbon homes to reduce our community's impact on climate change.

Case Studies Summary

	Fairfield	James Bay	Ross Bay	
			Home	**Garden Suite**
Heated floor area square feet	4,031	2,433	2,560	600
Annual Energy Use GJ	58.5	45	45.4	40.8
Greenhouse Gas Emissions $kgCO_2e/yr$	179	138	139	125
Greenhouse Gas Emissions Intensity $kgCO_2e/m^2/yr$	0.48	0.6	0.6	2.2
Airtightness (ACH)	1.85	0.98	1.25	1.51
Embodied Carbon $kgCO_2e$	76,900	39,100	25,200	9,900
Embodied Carbon Intensity $kgCO_2e/m^2$	205	171	106	178
Foundation Type	Basement and crawl space	Slab on grade	Unheated crawl space	Slab on grade
Foundation Insulation	R21 ICF	R12 under slab	R12 spray foam	R12 under slab
Exterior Walls	R24 ICF	2x6@16″o/c; R20 batt; 1″ exterior insulation	2x6@16″o/c; R22 batt	R22 Pacific SmartWall
Windows	Double glazed, vinyl, argon gas fill			
Air Barrier	Interior polyethylene			
Exposed Floor	2 x 11 7/8″ TJI @ 16″ o/c, R-31 batt		Not applicable	
Roof	Attic R-40		Attic R-40	
Heating & Cooling	2x heat pump to central ducted air handlers	Air-to-water heat pump for in-floor radiant heating and hot water	Central Split ASHP	Mini Split Ductless ASHP
Heat Pump Model	Daikin RXL24UMVJU	Sanden G53-45HPC	American Standard Quest 4TXD2060	
Hot Water Heating	Electric resistance water tank	Sanden electric storage tank SAN-83SSAQA	Electric resistance water tank	
Ventilation	2x Daikin air handlers, Venmar HRV	Zehnder ComfoAir Q 450 HRV	Central recirculating ventilation	
Supplementary heating	Electric baseboards, electric fireplace	Electric baseboards, wood stove in main house	Electric resistance backup	
Electric panel size	200 amp			

ZERO CARBON STEP CODE

Case Study #1

Fairfield

Setting the New Industry Standard

- **Year Built:** 2023
- **Heated Floor Area:** 4,031 square feet
- **Foundation:** Basement and unheated crawl space
- **Space Heating:** Central air source heat pump
- **Hot Water Heating:** Electric resistance tank heater
- **Energy Step Code:** Step 4

Timeline

2021	May	Early Design
	Oct	Permits
2022	Jan	Demolition
	Feb	Foundation Framing
	Mar	Slab Pour Windows & Doors
	May	Insulation
	June	Drywall
	Oct	Mechanical & Electrical Complete
2023	Jan	Final Inspection & Occupancy

Project Summary

Justin Reynolds, owner of Collaboration Homes, wanted his home to showcase sustainable construction to his clients. He was also motivated by safety, remembering a past gas leak explosion at a relative's house. Though surprised at the higher cost of an electric hot water tank compared to a gas heater, Justin still saw the benefits of an all-electric system as worth it.

Energy, Operational Emissions and Utility Costs

Assuming the home lasts 80 years, it will emit around 14 tonnes of carbon dioxide equivalent. This is a 90 per cent reduction compared to a similar home with natural gas heating and hot water, which would emit over 200 tonnes of carbon dioxide equivalent. The new rooftop solar panels will further reduce these emissions.

Justin's house uses 26 per cent less energy overall compared to the average home in B.C., with 77 per cent less for space heating and 24 per cent less for water heating. The drop in space heating is mainly due to the home's efficient heat pump, which transfers heat instead of generating it, to achieve over 300 per cent efficiency.

The home's estimated costs for heating, cooling and hot water are about seven per cent higher than they would be for an equivalent, gas-powered home.

Embodied Carbon

This house has an estimated embodied carbon intensity of 205 kg CO_2e/m^2, which is slightly above the City of Vancouver's benchmark of 200 kg CO_2e/m^2. This is higher than the home's lifetime operational emissions and equal to the emissions of a gas-powered home over 30 years. The main contributors to the home's embodied emissions are the external wall systems and foundation walls, mostly due to the use of insulated concrete forms (ICF) for the wall structure. ICF construction uses more concrete than traditional wood-frame construction and these projects should consider lower carbon concrete mixes to reduce the impact of using more concrete. The design choices that reduced overall embodied emissions include reasonably sized windows, which used less glass, a smaller than average garage and a basement with an unheated crawl space to reduce the amount of concrete and insulation needed.

Annual Energy Consumption (GJ)	59
GHG Emissions ($kgCO_2e$/year)	179
GHGi ($kgCO_2e/m^2$/year)	0.5
Embodied Carbon ($kgCO_2e$)	76,900
Embodied Carbon Intensity ($kgCO_2e/m^2$)	205
Airtightness (ACH)	1.9

Key Takeaways

1. **A high-performance envelope lessens concerns about electrical capacity.**

   Due to the high-performance envelope of this home, its 200 amp electrical capacity is more than enough to meet its power needs even with an electric vehicle charger. The home's low heating demand requires less electricity from the heat pump, resulting in a monthly energy surplus.

2. **Distributed heating and cooling saves space while improving efficiency and comfort.**

   To optimize heating and cooling in the home, one fan coil was placed in the basement and a second on the upper floor. This setup keeps the ceilings high and open, reduces the distance air needs to travel and ensures better temperature control. It also allows each area to be controlled separately, making the house more comfortable and energy efficient. Justin found his heating system warms up quickly but suggests planning the ductwork ahead of time to avoid installation issues.

3. **All-electric homes are more straightforward to build.**

   Not using a gas system made this project easier. Without the need for natural gas lines and venting for gas-powered water heaters, plumbers could easily install the electrical tank.

4. **Use a Heat Recovery Ventilator damper or filter for smoke events.**

   Installing a Heat Recovery Ventilator (HRV) is important for good air circulation, fresh air, proper humidity, and reducing indoor pollutants. Justin suggests adding a shut-off damper or carbon filter to the HRV to block unwanted smells, like smoke from forest fires.

5. **Solar panels drop summer electricity bills significantly.**

   Justin's 29 solar panels are expected to produce 12,200 kilowatt hours each year. This summer, his electricity bills were very low despite using his electric car and running his heat pump for cooling every day.

ZERO CARBON STEP CODE

Case Study #2

James Bay

David's Low Carbon Dream Home

- **Year Built:** 2022
- **Heated Floor Area:** 2,433 square feet
- **Foundation:** Slab on grade
- **Space & Hot Water Heating:** Central air-source heat pump and single air-to-water heat pump for both in-floor radiant heating
- **Energy Step Code:** Step 4

Timeline

2021	Feb	Early Design
	May	Permits
	June	Demolition
	July	Grading & Foundation
	Oct	Framing
	Aug	Slab Pour
2022	Jan	Windows & Doors
	Mar	Insulation
	Apr	Drywall
	Jun	Mechanical & Electrical Complete
	July	Final Inspection & Occupancy

Project Summary

This high-performance, low-emission home is a testament to homeowner and builder David's commitment to sustainability. He managed the entire project, learning key methods in airtightness and heating, ventilation and air conditioning design along the way. David completed most of the work himself, including exterior insulation, heat recovery ventilator installation and all kitchen, bathroom and interior finishes. The home uses a single heat pump for both underfloor radiant heating and hot water, meeting the highest level of the Zero Carbon Step Code. David also installed solar panels, which cover the home's electricity needs and significantly reduce utility bills.

Energy, Operational Emissions and Utility Costs

Over its 80-year lifespan, this all-electric home will emit just nine tonnes of CO_2, which is 93 per cent less than the same home with natural gas heating and hot water. By choosing the all-electric option, David is preventing 125 tonnes of CO_2 from being released, which is like not driving a gas car for 500,000 km!

Compared to the average home in B.C., David's house uses about 55 per cent less energy overall, around 80 per cent less for space heating and 80 per cent less for water heating.

The homes' estimated heating and hot water expenses are 30 per cent less than those for a similar natural gas-powered home. David's home is especially cost-effective because his heat pump is used for both space heating and hot water, making both systems very efficient. These saving would increase when considering the savings from solar panels.

Embodied Carbon

David's design choices led to an embodied carbon intensity of 171 $kgCO_2e/m^2$, lower than Vancouver's average of 200 $kgCO_2e/m^2$ for new homes. The main reason for this better performance was choosing a slab-on-grade foundation instead of a basement, which saved around 10 tonnes of carbon by reducing the use of concrete. Additionally, the old house was deconstructed and salvaged as much as possible, with old windows and doors sold locally, hardwood floors reclaimed and the new kitchen island made from reclaimed siding, further reducing embodied emissions.

This home's embodied carbon emissions are much higher than its lifetime operational emissions and equal to 23 years of emissions from a similar gas-powered home.

Annual Energy Consumption (GJ)	37
GHG Emissions ($kgCO_2e$/year)	113
GHGi ($kgCO_2e/m^2$/year)	0.5
Embodied Carbon ($kgCO_2e$)	39,100
Embodied Carbon Intensity ($kgCO_2e/m^2$)	171
Airtightness (ACH)	0.98
Annual Energy Consumption (GJ)	37
GHG Emissions ($kgCO_2e$/year)	113

Key Takeaways

1. **Consider issues with natural gas.**

   Originally, the home was going to have a gas fireplace, stove and barbecue. However, as David learned about the inefficiencies and air quality issues with natural gas, he chose an induction stove instead. The home's heating needs are so low that a gas fireplace would have overheated it, so he decided it wasn't needed. In the end, David didn't connect the house to the gas line at all.

2. **Determine an airtightness strategy from the beginning.**

   To improve his home's airtightness, David used Aerobarrier, an aerosol sealant that fills any gaps up to ½ inch wide when sprayed into a pressurized house. This product improved the airtightness from 2.41 air changes per hour (ACH) to an impressive 0.98 ACH. The home's simple design, use of interior wall cavities to reduce exterior wall holes and lack of a basement also helped optimize energy performance. David acted as the "air boss" during the project, ensuring all workers followed his airtightness plan.

3. **Consider future cooling when selecting a heat pump.**

   This project uses a CO_2-based air-to-water heat pump for both in-floor radiant heating and hot water. These systems are easy to install, only requiring a plumber to connect the water lines. David sourced the equipment from Small Planet Supply, who provided a lot of support for the installation. The system has been easy to maintain and doesn't take up much space, as the water tank and distribution equipment fit under the stairs. Though this heating doesn't provide cooling in the summer, David says this hasn't been a problem due to the home's passive cooling design. If needed, there's space to install an air-to-air heat pump for cooling in the future.

ZERO CARBON STEP CODE

Case Study #3

Ross Bay

A High-Performance Homes and Garden Suite

	Main House	Garden Suite
Year Built	2022	2023
Floor Area	2,560 square feet	600 square feet
Foundation Type	Unheated crawl space	Slab on grade
Space Heating	Single air-to-water heat pump for both in-floor radiant heating and hot water tank	Minisplit Air-source Heat Pump
Hot Water Heating	Electric resistance tank heater	Electric resistance tank heater
Energy Step Code	Step 4	Step 5

Timeline

2022	May – June	Architecture/Engineering Design
	June – Aug	Permits
	Oct – Dec	Demolition/Excavation/ Foundation
2023	Jan – Feb	Framing/Roofing/Lockup
	Mar	Surface Rough-ins
	April	Siding/Insulation/Drywall
	May – June	Interior Finishes/Decking

Project Summary

Jeff's 2,560 square foot home in Ross Bay also has a 600 square foot garden suite at the back. Meeting the highest levels of the Energy Step Code and Zero Carbon Performance didn't require anything unusual. The home has a simple, efficient design, and good insulation and airtightness. Choosing electric heating and hot water systems instead of natural gas was key to reducing carbon emissions. Drew Mackie, the site supervisor from Villamar, has been learning about the latest building science advancements, aiming to be an industry leader in sustainability.

Energy, Operational Emissions and Utility Costs

This home achieved Energy Step Code Step 4 for the main house and Step 5 for the garden suite. Using no fossil fuels, both meet the strictest Zero Carbon Step Code emissions standards. Over 80 years, the home and suite will emit just 21 tonnes of carbon dioxide equivalent, which is 89 per cent less than a natural gas home. By building all-electric, Jeff is preventing 195 tonnes of carbon dioxide equivalent from entering the atmosphere, equal to driving a gas car for 800,000 kilometres.

Jeff's house uses about 85 per cent less energy for space heating and 40 per cent less for water heating. Interestingly, the garden suite uses a similar amount of hot water and electricity for appliances, electronics and lighting as the main house due to the home's highly efficient heating, ventilation and air conditioning systems, reducing heating energy needs to below what's needed for lighting and appliances.

The energy model shows that utility costs are nearly the same, with the all-electric home and garden suite costing about $1,100 per year compared to $1,070 for a comparable natural gas home.

Embodied Carbon

The embodied carbon intensity was calculated as 106 $kgCO_2e/m^2$ for the main house and 178 $kgCO_2e/m^2$ for the garden suite, both better than the 200 $kgCO_2e/m^2$ average for new homes in Vancouver. The main sources of embodied emissions are the footing and slab, foundation walls, cladding and windows, making up two-thirds of the overall emissions.

The low embodied carbon is due to several design choices, including wood-frame construction, choosing a crawl space instead of a full basement to reduce concrete use, foregoing a garage and using simple design that required less insulation. The owner also reused materials from the old family home, building a fireplace from reclaimed fir and using cedar boards as decorative features. These efforts, while not included in the calculations, further reduced the carbon impact.

	House	Garden Suite
Annual Energy Consumption (GJ)	45	41
GHG Emissions ($kgCO_2e$/year)	139	125
GHGi ($kgCO_2e/m^2$/year)	0.6	2.2
Embodied Carbon ($kgCO_2e$)	25,200	9,900
Embodied Carbon Intensity ($kgCO_2e/m^2$)	106	178
Airtightness (ACH)	1.3	1.5

Key Takeaways

1. **Simple design helps hit performance targets.**

   The simple but charming architecture of the home improved energy performance and reduced the need for under-slab insulation to meet the Step Code target. The air handler was centrally located to optimize air distribution and the choice of durable, energy efficient materials, like mineral wool insulation instead of fiberglass batt, further enhanced the home's performance. Drew and his crew used a pre-planned air barrier strategy, including rubber gaskets for exterior wall penetrations, to ensure airtightness in the construction process.

2. **Team coordination is essential.**

   Drew noted that a well-coordinated team of subtrades, where everyone understands their roles, responsibilities and timelines, results in a smoother construction process with fewer reworks and costly errors. The homeowner also had a high degree of input, staying involved through daily or weekly discussions with the project team.

3. **Pre-designing mechanical systems makes things easier.**

   Planning and designing the all-electric systems ahead of time helped reduce the number of holes needed in the building. This made the ducting more efficient and reduced air leaks and heat loss.

4. **Building all-electric is straight-forward.**

   "It's just picking different appliances, different heating systems and, if anything, it's less effort because you don't need to worry about running gas," said Drew. To meet the energy and emissions goals, there was no need to hire additional trades or specialists beyond what's needed for any other home.

Methodology

The data for these case studies was collected and analyzed from Energy Step Code compliance forms submitted to the City of Victoria between February and November 2023.

Homeowners and builders were interviewed to learn about their experiences with building and living in the homes.

A computer program called Hot2000 was used to calculate the homes' operational emissions. Homes with electric heating were compared to similar homes heated by natural gas.

The carbon emissions created during the manufacturing of building materials was measured using a program called MCE2. Data from the building plans helped with this calculation.

The cost to run these homes was estimated using current utility rates from BC Hydro and FortisBC. Similar energy uses between homes with different heating systems were compared. Costs related to lighting and appliances were removed to make a fair comparison.

Glossary

BC Energy Step Code: Provincial policy to improve the energy efficiency of new buildings, accomplished through means, such as improving building design, insulation and airtightness.

Zero Carbon Step Code: Provincial policy to reduce carbon emissions from new buildings, which can be accomplished by using all electric systems, such as heat pumps or electric resistance.

Greenhouse Gas Emissions Intensity (GHGi): The amount of greenhouse gases emitted, divided by the floor area.

Kilograms of CO_2 equivalent ($kgCO_2e$): Unit of measurement to quantify the impact of various greenhouse gas emissions (e.g. CO_2, methane and nitrous oxide) by converting them into an equivalent amount of carbon dioxide (CO_2).

Embodied Carbon: The amount of greenhouse gas emissions associated with early and end-of-life stages of a product or whole building, from raw material extraction, manufacturing, transport and construction, as well as demolition, disposal, reuse or recycling.

Domestic Hot Water (DHW): Potable hot water system for showers, sinks, etc.

Energy Recovery Ventilator (ERV): A ventilation device that continuously replaces stale indoor air with fresh outdoor air while exchanging both heat and moisture between fresh and exhaust air.

Air Source Heat Pump (ASHP): A heat pump that draws (i.e., sources) heat from the outside air during the heating season and rejects heat outside during the summer cooling season.

Heating, Ventilation and Air Conditioning (HVAC): Common abbreviation to describe equipment and services related to heating, ventilation and air conditioning.

Emissions Limit: A distinct, measurable step of carbon performance, as defined in the Zero Carbon Step Code. Ranging from EL-1 to EL-4, where higher levels are stricter, permitting fewer carbon emissions. The City of Victoria will implement the highest level, EL-4.

The City thanks BC Hydro for their support on this project.