

Consumption-Based Climate Action Plan Modeling Technical Memo

Prepared for the
District of Saanich
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Background

This report includes modeling of consumption-based greenhouse gas (GHG) reduction scenarios for the District of Saanich through to 2030 and 2050.

Territorial versus Consumption-based Greenhouse Gas Emissions

In contrast to typical community inventories which use a territorial approach, which reflect the emissions that occur within its borders (as well as those associated with electricity and waste disposal), the consumption-based approach considers the lifecycle GHG emissions of all goods and services consumed by members of the community, regardless of where emissions were produced globally. For more information, please see the report “[Saanich 2021 Consumption-Based Ecological and Carbon Footprint Assessment](#)”.

Territorial GHG Inventory & Consumption-based GHG Inventory Modeling

As part of the District of Saanich’s 2026 update to the Climate Action Plan, GHG modeling has been conducted to develop potential reduction scenarios for 2030 and 2050.

This work included two stages:

1. The 2022 Community GHG Inventory using the GPC Basic+ methodology was used as a baseline to model territorial GHG reduction scenarios. This modeling was completed by Licker Geospatial Consulting Ltd. (LGeo) with results, assumptions and included policy impacts presented in their “Climate Action Plan Modeling Report”.
2. The results of the above community inventory modeling were then used as a starting point to model GHG reduction scenarios for consumption-based emissions (CBE). The results of this analysis are presented in this report.
 - CBE modeling uses the same policy and assumptions as the community territorial inventory modeling for the Business-as-Usual (BAU) and Pathway 1 scenarios while also incorporating additional policies and assumptions pertaining to the broader scope of emissions. This approach ensures alignment and comparability of the modelling results.
 - CBE operating emissions come from two sources: 1) directly from the LGeo modeling, and 2) from the [Saanich 2021 Consumption-Based Ecological and Carbon Footprint Assessment](#). The 2021 CBE source covers a broader scope of operating emissions. For example, for aviation the community inventory includes emissions for take-off and landing, whereas the CBE inventory includes emissions for total trip length.
 - The CBE also includes embodied GHG emissions of materials and fuels – the supply chain emissions of all products used by community members, like clothing, vehicles, buildings, etc., and the energy used for extraction, processing and distribution of natural gas, etc.

- An additional third scenario was completed for the CBE modeling, Pathway 2, which includes additional reductions above those included in Pathway 1.

Unless stated otherwise, details on assumptions, sources and policy in the following sections focus on those relevant to modeling the embodied GHG emission portion of the CBE.

Results – BAU and Pathway 1 Scenarios

The modeled CBE for the BAU and Pathway 1 scenarios are shown in Figure 1. The remaining emissions by 2050 are 894 ktCO₂e and 559 ktCO₂e respectively.

This compares to 416 ktCO₂e and 203 ktCO₂e, respectively, in remaining emissions by 2050 for the modeled community territorial inventory emissions (territorial emissions) completed by LGeo.

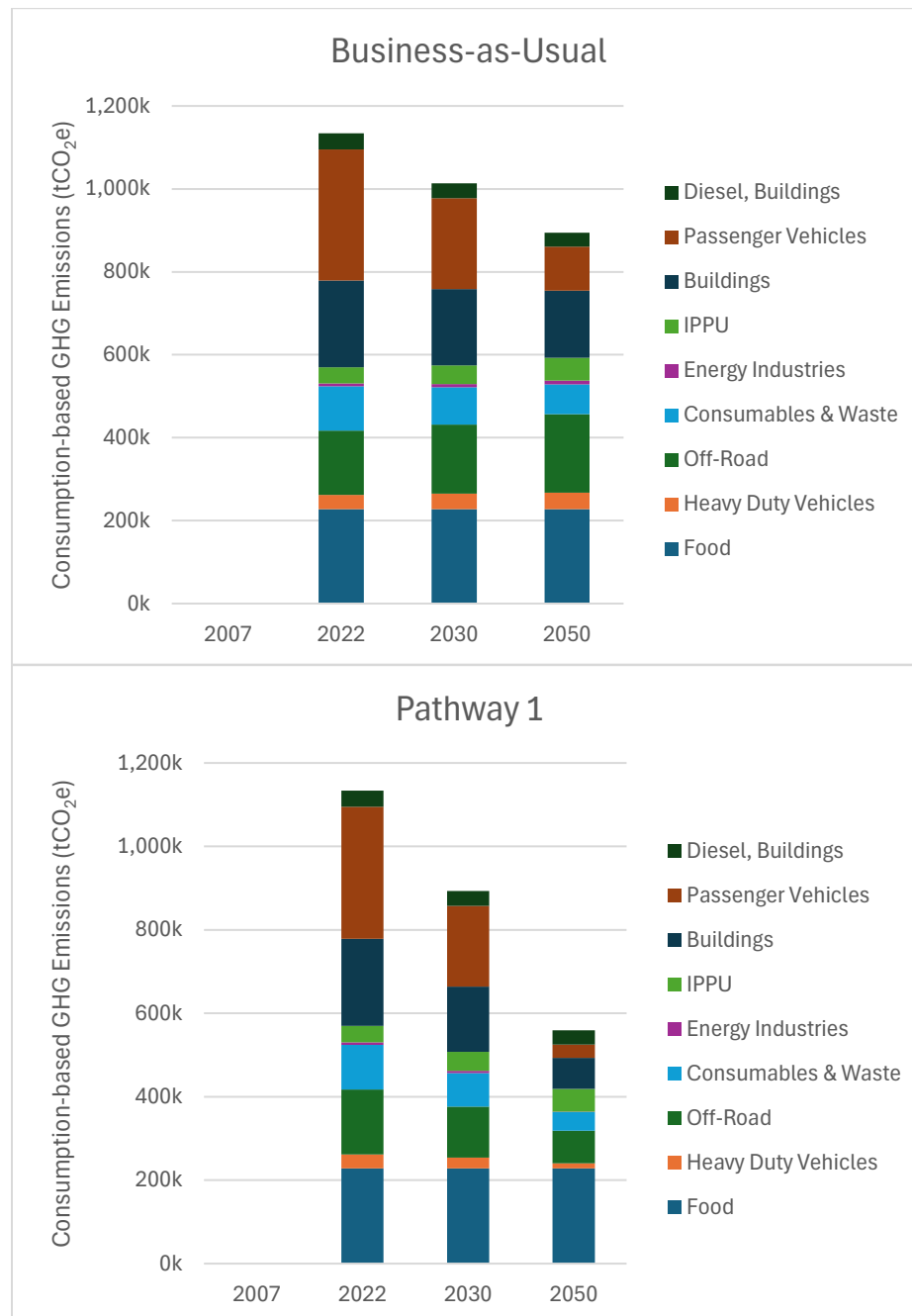


Figure 1: Consumption-based Emissions Summaries for BAU and Pathway 1 Scenarios

Comparing the CBE modeling to results of the community territorial inventory modeling, there are some differences in what is captured within the categories. For example, the CBE includes estimates for all lifecycle emissions for Food, whereas the community inventory only includes local agricultural emissions, included in “Other Stationary Energy”.

Also, the modeled CBE does not include an estimate for 2007 because the earliest CBEI was completed for 2015.

Consumption-based Emissions - Business-as-Usual

	2022	2030	2050
Food	227,963	227,963	227,963
Heavy Duty Vehicles	34,073	37,044	39,379
Off-Road	155,064	166,226	189,178
Consumables & Waste	106,944	90,704	72,093
Energy Industries	6,497	7,429	9,059
IPPU	39,504	45,171	55,079
Buildings	208,772	183,918	161,741
Passenger Vehicles	316,502	218,912	106,031
Diesel, Buildings	38,569	36,237	33,906
	1,133,888	1,013,604	894,428

Consumption-based Emissions - Pathway 1

	2022	2030	2050
Food	227,963	227,963	227,963
Heavy Duty Vehicles	34,073	26,465	12,673
Off-Road	155,064	121,790	77,784
Consumables & Waste	106,944	80,277	44,657
Energy Industries	6,497	5,647	731
IPPU	39,504	45,171	55,079
Buildings	208,772	156,900	73,989
Passenger Vehicles	316,502	192,950	32,489
Diesel, Buildings	38,569	36,237	33,906
	1,133,888	893,400	559,271

Food

The modeled CBE includes estimates for all food consumed by the population of the District of Saanich and associated supply chain waste. In both scenarios (BAU and Pathway 1), emissions from food remain constant at 228 ktCO₂e.

The CBE of food is predicted to decrease at a rate that offsets impacts from population growth. In other words, absolute emissions stay flat while the GHG intensity of food goes down. LGeo used the same assumption with local agricultural GHG emissions.

The predicted GHG intensity reductions are mainly from improvements in soil, fertilizer, manure, and livestock methane management. These assumptions are supported by various sources such as modeling in Canada's 2030 Emissions Reduction Plan and commitments by Agriculture and Agri-Food Canada, the Canadian Alliance for Net Zero Agri food, etc.

Assumptions and Sources:

As part of the CBE modelling, LGeo's assumption was verified to help identify policies that could be implemented to further reduce these emissions.

Assumption: For BAU and Pathway 1, CBE of food are constant out to 2050.

Rationale:

- Absolute emissions from agricultural are projected to remain flat to 2030.
- Implied emissions in the 2030 Emissions Reduction Plan (ERP) modeling include enteric fermentation, nitrogen fertilizers, manure management, and on-farm fuel use.

Source: [2030 Emissions Reduction Plan](#)

- Target to reduce fertilizer emissions by 30% by 2030.

Source: [Canada's fertilizer emissions reduction target](#)

- Canada's methane reduction targets and actions include agriculture. For example, Agriculture and Agri-Food Canada's [Agricultural Methane Reduction Challenge](#).
- Agriculture and Agri-Food Canada's ACS Living Labs and On-Farm Climate Action Fund both target beneficial management practices (BMPs) such as cover cropping, rotational grazing, etc.

Sources: [On-Farm Climate Action Fund](#), [Agricultural Climate Solutions](#)

- Extrapolated reductions from 2030 ERP continues to offset population growth to 2050.
- [Growing a Net Zero Food System](#) report by Deloitte supports potential to extrapolate ERP reductions out to 2050.
- Canadian Alliance for Net Zero Agri food (CANZA) reduction targets are more aggressive than ERP extrapolation – targets are reducing absolute emissions from baseline.

Source: [Leading the Charge Toward a Sustainable Future for Canada's Food Sector](#)

These sources support the assumption of flat absolute emissions to 2050 and that the more aggressive CANZA targets would require additional policy. They also do not mention any substantial policy targeting food waste or diet shift to reduce agricultural emissions.

Heavy Duty Vehicles

By 2050, the CBE for heavy duty vehicles is estimated to increase to 39.4 ktCO₂e for BAU and decrease to 12.7 ktCO₂e for Pathway 1.

Modeled operating GHG emissions (e.g. combustion emissions from diesel) and relevant policies are taken directly from LGeo's assessment. Please see their "Climate Action Plan Modeling Report" for more information.

The modeled CBE includes embodied emissions of vehicle materials and fuels as well as predicted impacts of relevant policy on embodied emissions.

Heavy duty vehicle counts were not included in LGeo's assessment, therefore they were scaled from the 2022 CBE using LGeo's assumed BAU emissions increase. The factors for embodied emissions of vehicle materials are assumed to decrease by 60% by 2050 due largely to decarbonisation of heavy industry such as steel production. The net result is a decrease in the contribution from embodied emissions of materials by 2050. In other words, the GHG intensity of the vehicle materials is estimated to decrease faster than the increase in vehicle numbers.

For the BAU scenario, the embodied emissions factors of diesel (emissions from extraction, processing and transport) are estimated to decrease 20% by 2030 and 40% by 2050. The net result is a decrease in the contribution from embodied emissions of fuels by 2050 despite a significant increase in fuel use.

For the Pathway 1 scenario, LGeo's assumption of renewable diesel use is applied. This results in additional reductions in embodied emissions of fuels compared to conventional diesel in the BAU scenario.

Assumptions and Sources:

Assumption: The embodied emissions of vehicle materials factors are assumed to decrease by 60% by 2050, due largely to decarbonisation of heavy industry such as steel production.

Rationale:

- Vehicle LCA are dominated by steel and aluminum. Heavy industry emissions, including steel, are projected to decrease by about 30% by 2030 in Canada's ERP modeling. Industry has committed to net zero emissions by 2050 but multiple sources show Canada is not on track and lacks a clear trajectory to meet its targets. The CBE modeling assumes about half of the committed reductions are achieved between 2030 to 2050 through incremental improvements, partial deployment of low emission technologies, and limited CCUS (carbon capture utilization and storage) to achieve 60% reductions by 2050.

Sources: [2030 Emissions Reduction Plan](#) ; [Decarbonizing Industry in Canada and the G7](#) ; [Hydrogen and the Decarbonization of Steel Production in Canada](#)

Assumption: For the BAU scenario, the embodied emissions of diesel factors (emissions from extraction, processing and transport) are estimated to decrease about 20% by 2030 and 40% by 2050.

Rationale:

- The Clean Fuel Regulation impacts fossil fuel lifecycle carbon intensity (CBE modeling assumes reductions apply equally across the supply chain), and assumes 12-14% reduction of embodied emissions of liquid fuels by 2030, with minor improvements to 2050, through more recycled biofuel feedstock, etc.

Source: [Canadian clean fuel regulations are now in force.](#)

- Roughly 10-30% of embodied emissions of liquid fuels are due to methane and assume about half of that is allocated to transportation fuels. Regulations call for 75% reduction in methane emissions by 2035. Assume a reduction of 2-4% by 2030 and 5-7% by 2050 for diesel.

Sources: [Methane Emissions Management from the Upstream Oil and Gas Sector in Alberta](#) ; [Canada unveils new rules to lower oil and gas methane emissions](#)

- Emerging technology have potential to reduce emissions. Assume up to 10% by 2050.

Source: [Life Cycle Analysis \(LCA\) of GHG Emissions of Oil Sands Reference Facilities and Emerging Technologies](#)

- Refining has potential to reduce emissions through electrification, efficiency, carbon capture (CCUS), heat recovery, etc. The contribution to reductions is highly variable depending on assumptions – there is not enough clarity or regulations yet to assume aggressive adoption. Assume up to 10% reductions by 2050 – this assumes incremental electrification and efficiency gains with equipment turnover and low CCUS adoption.

Sources: [Carbon Capture, Utilization, and Storage \(CCUS\)](#) ; [CCUS Technology Innovation to Accelerate Broad Deployment in Alberta](#)

Assumption: For the Pathway 1 scenario embodied emissions of renewable fuels is needed to accompany LGeo's assumption of aggressive conversion by 2050. Assume a reduction of 85% by 2030 and 95% by 2050 for renewable diesel compared to the embodied emissions factors of conversional fuels.

Rationale:

- Biofuel feedstocks have limited capacity to scale. Assume the majority of renewable fuels are synthetic and derived from renewables powering direct air capture (DAC)

and refining. These systems can have roughly 80% lower embodied emissions than conventional fuels if fully electrified with renewables like wind. Assume incremental efficiency gains achieve 85% reduction by 2030 and 95% by 2050. (This is far better than most biofuel feedstocks.)

Sources: [Life-Cycle Assessment of Power-to-Liquid Kerosene Produced from Renewable Electricity and CO2 from Direct Air Capture in Germany](#) ; [Saanich 2021 Consumption-Based Ecological and Carbon Footprint Assessment](#) ; [Greenhouse gas reporting: conversion factors 2025](#)

Off-Road Vehicles

By 2050, the CBE for off-road vehicles is estimated to increase to 189 ktCO₂e for BAU and decrease to 77.8 ktCO₂e for Pathway 1.

The off-road category includes CBE from aviation, ferries, personal watercraft, etc. All emissions, including operating emissions, are modeled from Saanich's 2021 CBEI. Modeled operating emissions from LGeo's assessment are not used because they do not incorporate total trip length, which is required for the CBE. Modeled CBE operating emissions apply the same underlying assumptions used by LGeo.

The modeled CBE also includes embodied emissions of vehicle materials and fuels as well as predicted impacts of relevant policy on embodied emissions.

The average lifespan of commercial aircraft, ferries, etc. is relatively long (e.g. 50+ years for a commercial ferry). Because of this long lifespan and their consumption of considerable amounts of fossil fuels in operation, embodied emissions of materials contribute relatively little to total CBE for aircraft, ferries, etc. Therefore, embodied emissions of materials are assumed to increase with population (the same as operating emissions). In other words, the relatively long lifespan commercial aircraft, ferries, etc. means that the average embodied emissions of the fleets will lag far behind reductions in GHG intensity of production.

For the BAU scenario, the embodied emissions factors of diesel and jet fuel (emissions from extraction, processing and transport) are estimated to decrease 20% by 2030 and 40% by 2050 because of reduced supply chain emissions (efficiency improvements, reduced methane leaks, electrification, new technologies, etc.) and increased use of renewable fuels. The net result is a decrease in the contribution from embodied emissions of fuels by 2050 despite a significant increase in fuel use from population growth.

For the Pathway 1 scenario, LGeo's assumptions for renewable fuel use is applied. This results in additional reductions in embodied emissions of fuels compared to conventional diesel and jet fuel in the BAU scenario.

Assumptions and Sources:

For the BAU scenario, the embodied emissions of diesel and jet fuel factors (emissions from extraction, processing and transport) are estimated to decrease about 20% by 2030 and 40% by 2050.

For the Pathway 1 scenario embodied emissions of renewable fuels is needed to accompany LGeo's assumption of aggressive conversion by 2050. Assume a reduction of 85% by 2030 and 95% by 2050 compared to the embodied emissions factors of conventional fuels.

See Heavy Duty Vehicles for more details on assumptions and sources.

Consumables and Waste

By 2050, the CBE for consumables and waste is estimated to decrease to 72.1 ktCO₂e for BAU and to 44.7 ktCO₂e for Pathway 1.

Modeled direct GHG emissions (e.g. landfill and wastewater methane emissions) and relevant policies are taken directly from LGeo's assessment.

The modeled CBE also includes embodied emissions of materials (e.g. the supply chain emissions of the materials that end up in landfill, recycling, and EPR recovery) as well as predicted impacts of relevant policy on embodied emissions.

For the BAU scenario, the embodied emissions of materials are assumed to increase with population growth and decrease as a result of a 60% reduction in the GHG intensity of supply chains by 2050, driven largely by the decarbonization of electricity grids and industry. Overall, this results in a decline in embodied emissions by 2050, despite a significant increase in waste tonnage.

For the Pathway 1 scenario, waste diversion rates from the Saanich Zero Waste Strategy (2026) are used to estimate reduced tonnage, resulting in additional reductions in embodied emissions of materials.

Assumptions and Sources:

Assumption: For the BAU scenario, the embodied emissions of materials factors decrease 30% by 2030 and 60% by 2050.

Rationale:

- Canada's ERP predicts heavy industry emissions will decrease roughly 30% by 2030 (see Heavy Duty Vehicles for details on 60% reduction by 2050). Some materials are predicted to lead the decline, such as paper, and some will lag behind, such as textiles, and some are still not being tracked well enough to even tell, such as

plastics. Canada's ERP predictions for textiles are combined into heavy industry but much of Canada's textiles come from Asia anyway. China's industrial emissions are higher than Canada's now but based on commitments and trends they could catch up on reductions by 2050. Plastics will benefit from methane reduction regulations and other improvements in oil and gas processing (see Heavy Duty Vehicles) but increasing the use of recycled resin could also contribute much of the needed reductions. Assume the average embodied emissions of materials factors for paper, plastics, textiles, etc. decrease at the rate assumed for heavy industry.

Sources: [2030 Emissions Reduction Plan](#) ; [Measuring the Carbon Footprint of Plastics](#) ; [China's textile industry progresses in sustainable development to achieve dual carbon goals](#) ; [Analysis: China's CO2 emissions have now been 'flat or falling' for 21 months](#)

Energy Industries

Modeled GHG emissions and relevant policies associated with energy industries are taken directly from LGeo's assessment. This category is mainly emissions from waste biogas flaring and there are no additional embodied emissions included.

IPPU

Modeled GHG emissions and relevant policies associated with Industrial Processes and Product Use (IPPU) are taken directly from LGeo's assessment for BAU and Pathway 1. This category is mainly emissions from heavy industry (e.g. cement, chemicals, metals) and hydrofluorocarbons (HFC) emissions, mostly from commercial refrigeration (e.g. grocery stores, ice rinks, etc.), and there are no additional embodied emissions included.

Buildings

By 2050, the CBE for buildings is estimated to decrease to 162 ktCO₂e for BAU and to 74 ktCO₂e for Pathway 1.

Modeled operating GHG emissions (e.g. combustion emissions from a gas furnace) and relevant policies are taken directly from LGeo's assessment.

The modeled CBE also includes embodied emissions of building materials and fuels (e.g. the extraction, processing and transport emissions of fuels used for heating) as well as predicted impacts of relevant policy on embodied emissions.

Embodied emissions from building materials are projected to increase due to expected new construction, as reflected in LGeo data. At the same time, decreases in embodied carbon intensity are expected due to shifts in building practices and building types. Based on relevant case studies, embodied emissions factors are assumed to decline by 22% for multifamily buildings and 34% for single-family homes. Overall, the net result is an increase in the contribution from embodied emissions of building materials by 2050.

For the BAU scenario, the embodied emissions factors of fuels decrease significantly, particularly for natural gas which is estimated to decrease 72% by 2030 and 75% by 2050 through limiting methane leaks and flaring.

For the Pathway 1 scenario, the modeled GHG reductions used by LGeo are applied, along with additional associated reduced embodied emissions for fuels.

Assumptions and Sources:

Assumption: Embodied emissions of building materials factors decrease by 22% for multifamily and 34% for single family homes.

Rationale:

- Industry reports show average embodied emissions of building materials of about 180 kg CO₂/m² for single family homes and 450 kg CO₂/m² for multi family homes. Unpublished case studies and industry projections indicate that with anticipated turnover and buildout, new lower carbon construction could lower the average embodied emission factors by 22% for multifamily and 34% for single family homes. This assumes a redevelop strategy consistent with plans for multifamily conversion to create village centres and higher density corridors.

Sources: [Regulating Embodied Emissions of Buildings](#) ; [Emissions of Materials Benchmark Assessment](#) ; [Centre, Corridor and Village Plans](#)

Assumption: For the BAU scenario, the embodied emissions of fuels decrease significantly. The embodied emission factors of heating oil (emissions from extraction, processing and transport) are estimated to decrease 20% by 2030 and 40% by 2050 (see Heavy Duty Vehicles for assumptions and sources). For natural gas, embodied emission factors are estimated to decrease 72% by 2030 and 75% by 2050.

Rationale:

- Regulations call for 75% reduction in methane emissions by 2035. Reductions are through reduced methane venting, flaring, and leaks throughout the extraction, processing and transport of natural gas and other fossil fuels. BC reported reductions of 48% in their 2024 Climate Change Accountability Report which exceeded the 2025 target. Industry is expected to meet the 75% reductions by 2035 and could potentially exceed these by 2050. However, reductions are assumed to be 75% by 2050 for the BAU scenario since there are no further reduction requirements in place. Historically industry has not reduced methane emissions without regulation requiring it.

Sources: [Canada unveils new rules to lower oil and gas methane emissions](#) ; [Climate Change Accountability Report](#)

Passenger Vehicles

By 2050, the CBE for passenger vehicles is estimated to decrease to 106 ktCO₂e for BAU and to 32.5 ktCO₂e for Pathway 1.

Modeled operating GHG emissions (e.g. combustion emissions from gasoline and diesel use) and relevant policies are taken directly from LGeo's assessment.

The modeled CBE also includes embodied emissions of vehicle materials, road materials and fuels as well as predicted impacts of relevant policy on embodied emissions.

Modeled passenger vehicle counts are taken directly from LGeo's assessment. The embodied emissions of vehicle materials factors are assumed to decrease by 60% by 2050 due largely to decarbonisation of heavy industry such as steel production. The net result is a decrease in the contribution from embodied emissions of materials by 2050. In other words, the GHG intensity of the vehicle materials is estimated to decrease faster than the increase in vehicle numbers.

For the BAU scenario, the embodied emissions factors of fuels (emissions from extraction, processing and transport of gasoline and diesel) are estimated to drop 20% by 2030 and 40% by 2050. The net result is a decrease in the contribution from embodied emissions of fuels by 2050 combined with a decrease in fuel use.

For the Pathway 1 scenario, the modeled GHG reductions used by LGeo are applied along with additional associated reduced embodied emissions for fuels.

Assumptions and Sources:

See Heavy Duty Vehicles for assumptions and sources for reductions in embodied emission factors for vehicle materials and transportation fuels.

Note that there is no reduction in embodied emissions of materials factors assumed for 2030 for on-road vehicles due to vehicle lifespan causing a lag in average overall fleet LCA as well as increased EV uptake tending to offset ICE LCA reductions in the near term.

Assumption: EV and battery embodied GHG emissions will reduce faster than ICE embodied emissions and are likely to be similar to heavy industry reductions.

Rationale:

- Battery LCA is highly dependant on grid GHG intensity which is leading in decarbonization efforts. This and other supply chain improvements lead to predictions of EV LCA falling much faster than ICE LCA narrowing the gap between them. The assumptions made for reductions for heavy industry by 2050 are appropriate for EVs and battery LCA as well, even though we are using 2022 ICE vehicles as the baseline.

Sources: [An Industrial Blueprint for Batteries in Europe](#) ; [Future greenhouse gas emissions of automotive lithium-ion battery cell production](#)

Diesel, Buildings

By 2050, the CBE for “Diesel Buildings” is estimated to decrease to 33.9 ktCO₂e for both BAU and Pathway 1. This category is mainly emissions from yard equipment and construction equipment (excavators, etc.).

Modeled operating GHG emissions (e.g. combustion emissions from gasoline and diesel use) and relevant policies are taken directly from LGeo’s assessment.

The modeled CBE also include embodied emissions of fuels, as well as predicted impacts of relevant policy on embodied emissions. The embodied emissions of equipment materials have not been included due to a lack of data.

For both the BAU and Pathway 1 scenarios, the embodied emissions factors of fuels (emissions from extraction, processing and transport of gasoline and diesel) are estimated to decrease 20% by 2030 and 40% by 2050. LGeo’s assessment assumes fuel use remains constant and therefore all CBE reductions are due to reductions in the embodied emissions of fuels.

Assumptions and Sources:

“Diesel, Buildings” emissions are from yard equipment and construction equipment (excavators, etc.).

Assumption: For both the BAU and Pathway 1 scenarios, the embodied emissions factors of fuels (emissions from extraction, processing and transport of gasoline and diesel) are estimated to decrease 20% by 2030 and 40% by 2050. See Heavy Duty Vehicles for assumptions and sources.

Modeled CBE Reductions by Policy – Pathway 1 vs BAU

Figures 2–6 below illustrate the policy impacts across different categories under the Pathway 1 and BAU approaches.

Included policies and assumptions are taken directly from LGeo’s assessment. Please see their “Climate Action Plan Modeling Report” for more information. The charts below follow the layout and groupings in LGeo’s assessment to better enable comparison.

The additional CBE assumptions and impacts are discussed by category in the previous sections above.

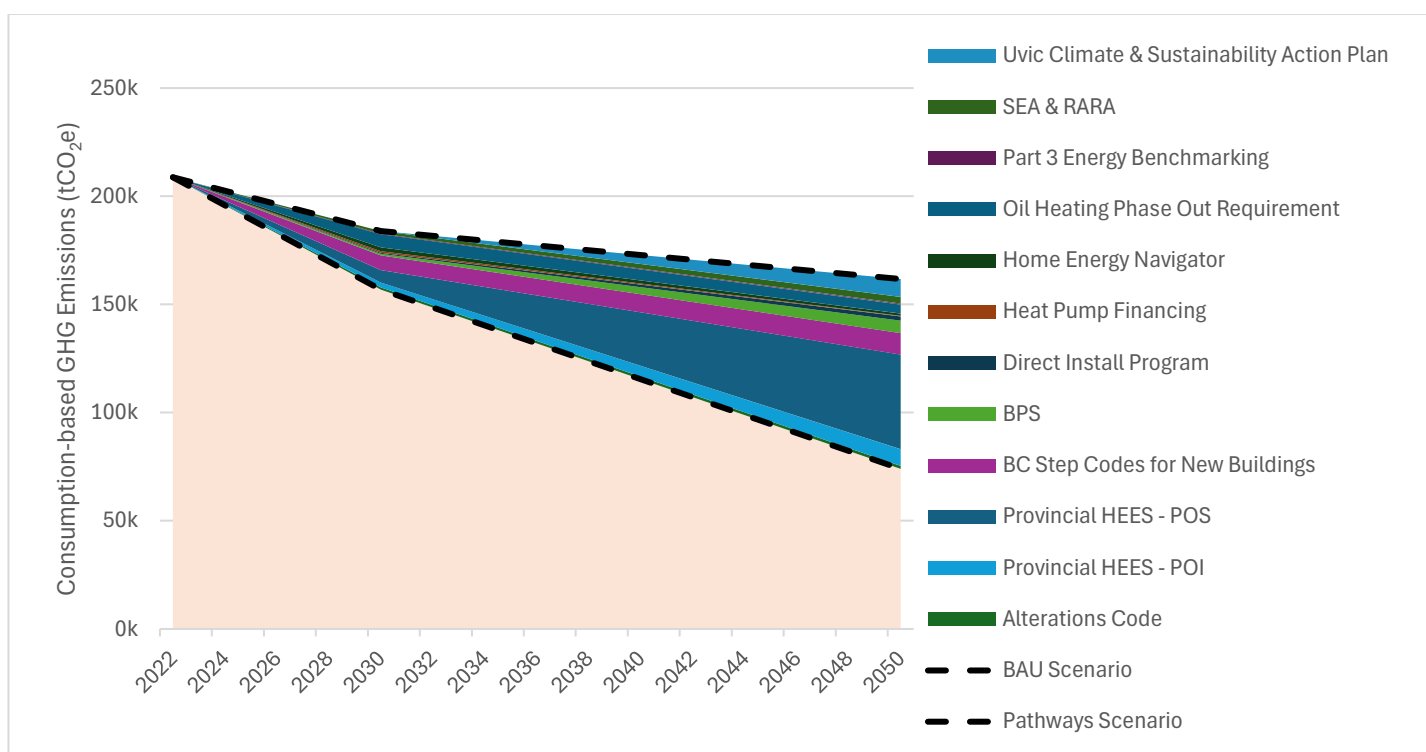


Figure 2: Building CBE Policy Impacts: Pathway 1 vs. BAU

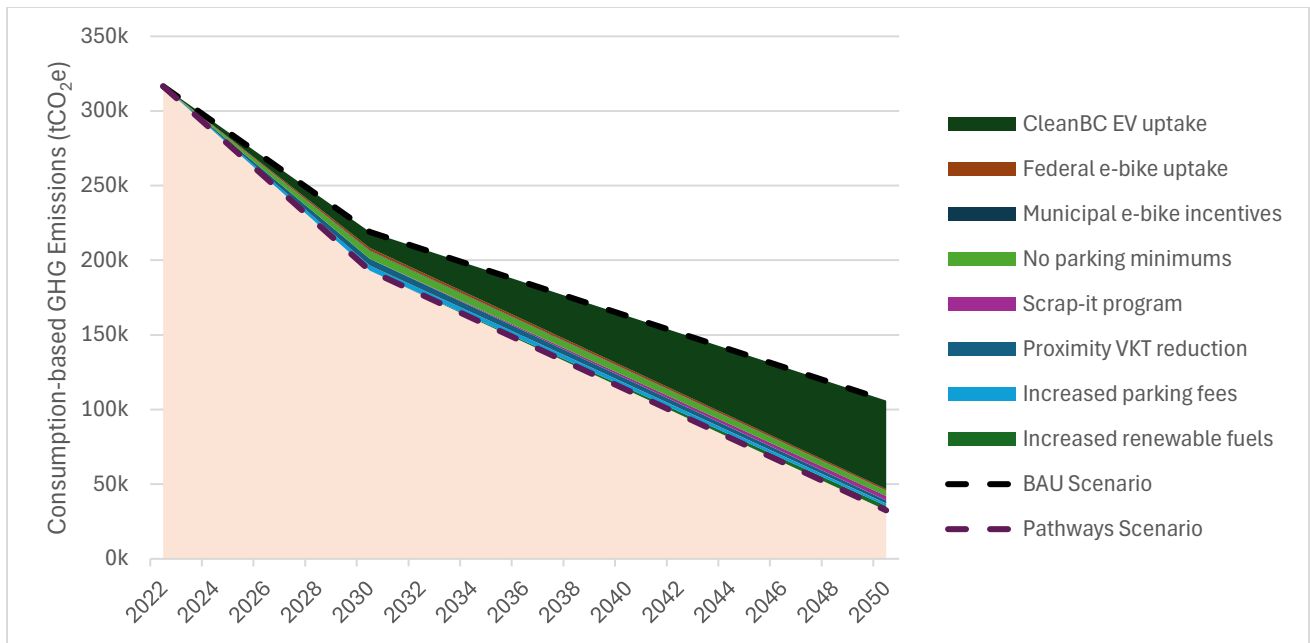


Figure 3: Passenger Vehicle CBE Policy Impacts: Pathway 1 vs. BAU, With ZEV Act

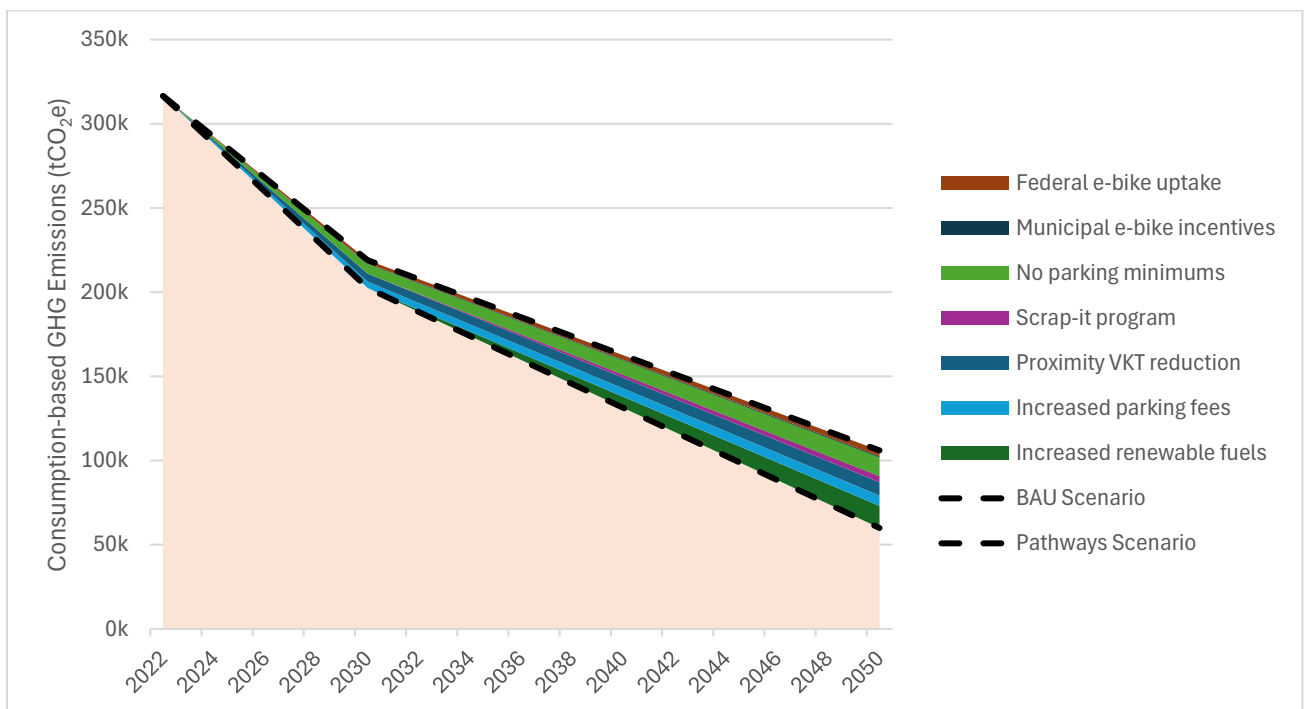


Figure 4: Passenger Vehicle CBE Policy Impacts: Pathway 1 vs. BAU, No ZEV Act

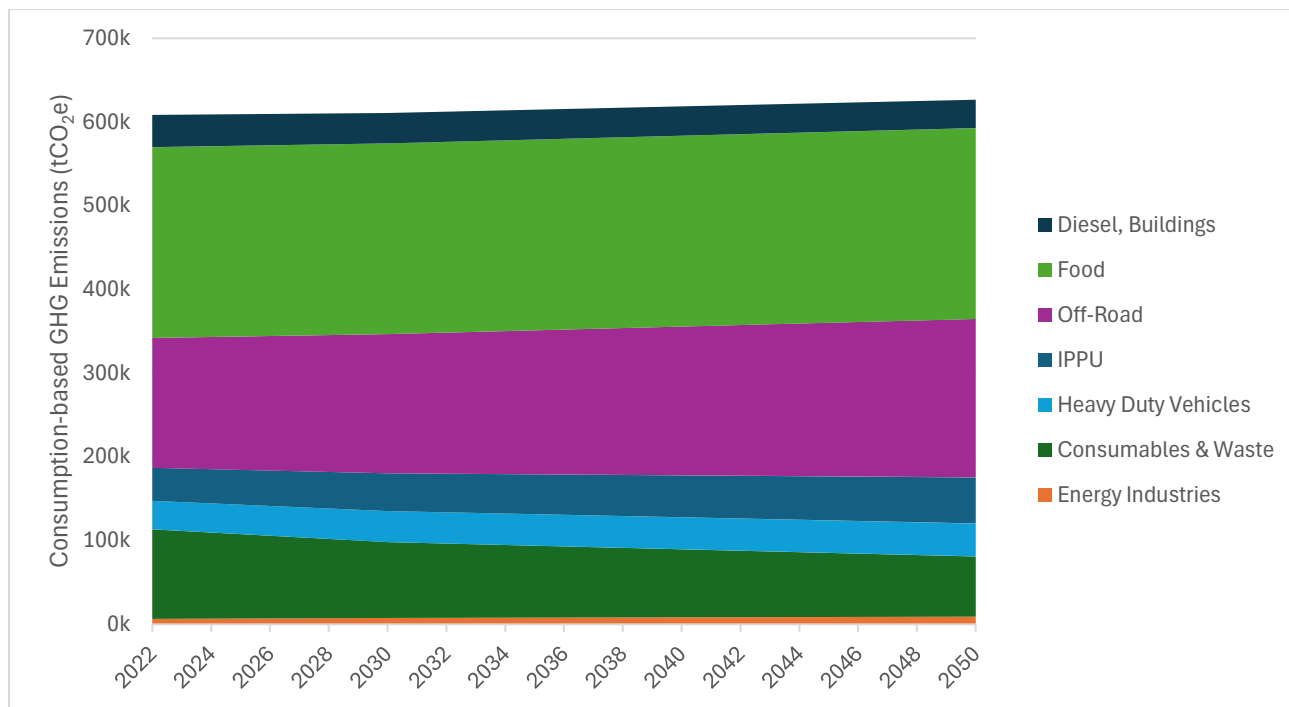


Figure 5: Other Consumption-based Emissions: BAU

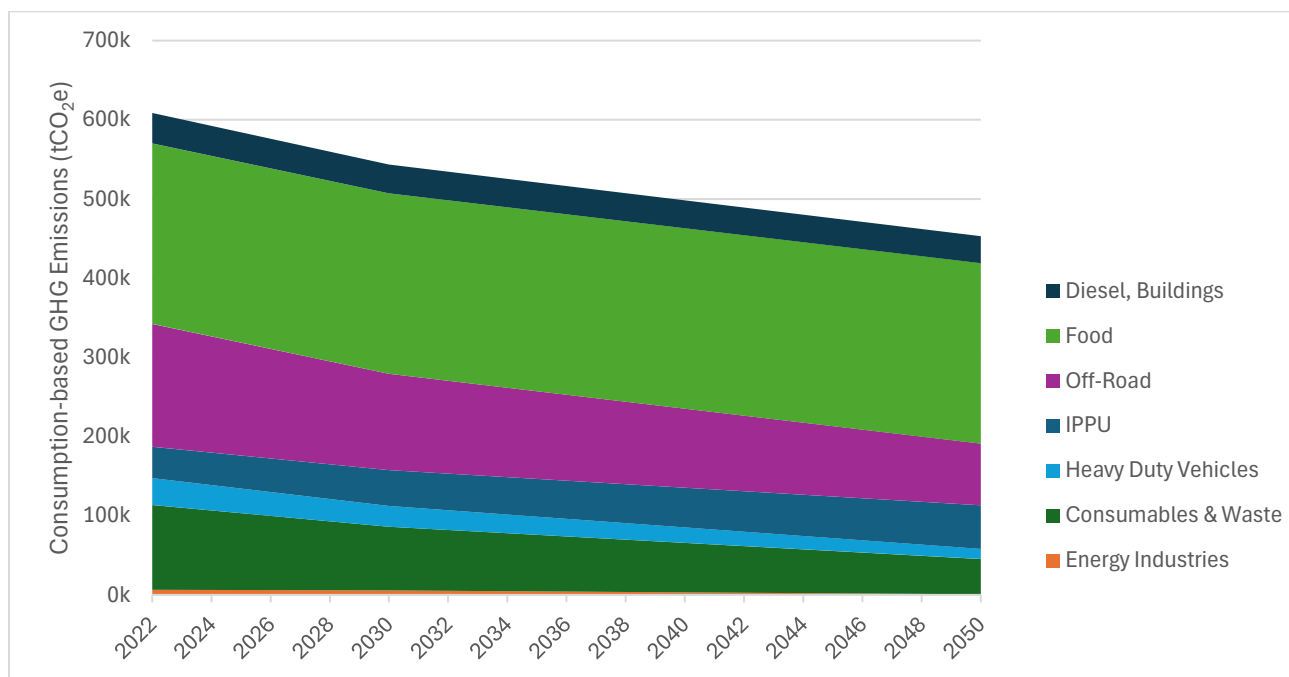


Figure 6: Other Consumption-based Emissions: Pathway 1

Results – Pathway 2 Scenario

The modeled CBE for the Pathway 2 scenario is shown in Figure 7. Remaining emissions by 2050 are estimated at 439 ktCO₂e, compared to 559 ktCO₂e under Pathway 1, representing a 21% reduction in remaining emissions.

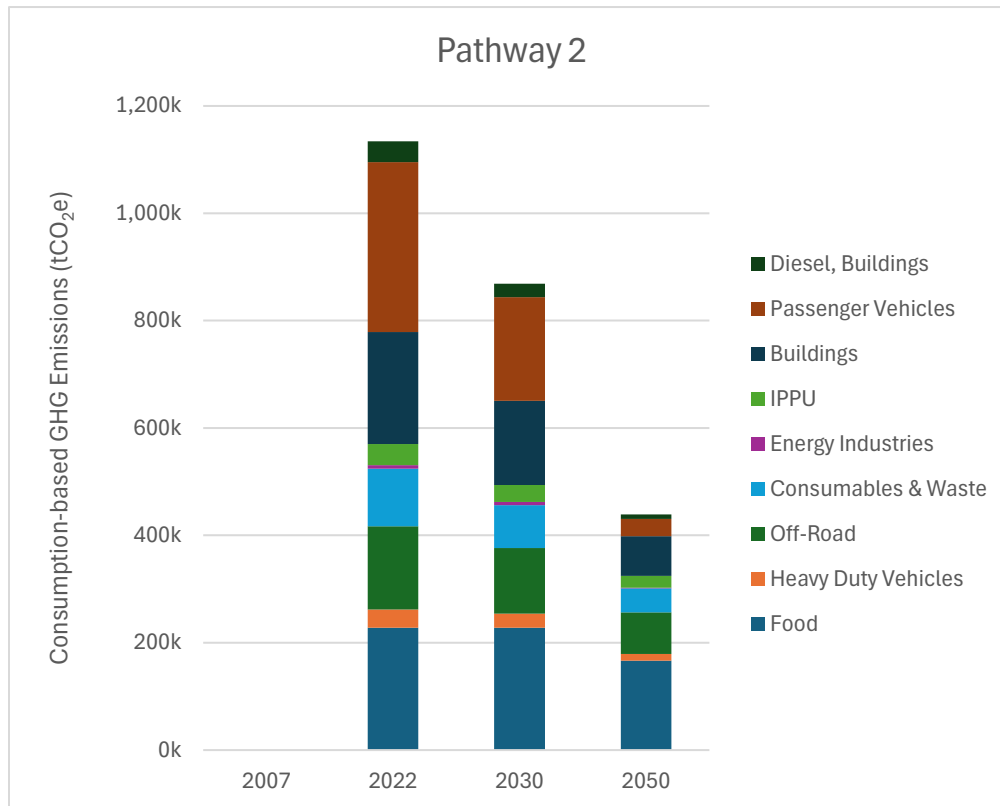


Figure 7: Consumption-based Emissions Summary for Pathway 2 Scenario

In addition to the measures included in Pathway 1, the Pathway 2 scenario incorporates further reductions in three categories: Food, IPPU, and “Diesel, Buildings.” These categories were selected based on their potential for emissions reductions through existing and complementary policies.

Consumption-based Emissions - Pathway 2

	2022	2030	2050
Food	227,963	227,963	166,413
Heavy Duty Vehicles	34,073	26,465	12,673
Off-Road	155,064	121,790	77,784
Consumables & Waste	106,944	80,277	44,657
Energy Industries	6,497	5,647	731
IPPU	39,504	31,619	22,032
Buildings	208,772	156,900	73,989

Passenger Vehicles	316,502	192,950	32,489
Diesel, Buildings	38,569	25,366	8,476
	1,133,888	868,978	439,245

Food

By 2050, the CBE for food is estimated to decrease to 166 ktCO₂e under Pathway 2, compared to 228 ktCO₂e under Pathway 1, representing a 27% reduction.

Food is by far the largest contributor to the predicted remaining emission in 2050, at 41% of the total of Pathway 1. Policy and predicted reductions in Pathway 1 are focussed on production emissions (e.g., management of soil, fertilizer, manure, etc.). Measures relating to food waste or high impact foods are not included.

Eliminating local avoidable food waste (retail, commercial, household) - currently estimated at 50% - through recovery and/or avoided purchasing would reduce food consumption by about 7%. High impact foods like beef and lamb also have a huge impact on total emissions. For example, reducing the average servings per person by 1 serving per week can reduce overall emissions by as much as 20%.

Based on these findings, an overall 27% further reduction in CBE of food by 2050 is assumed for Pathway 2, based on implementing policies that:

- Reduce local food waste (retail, commercial, household). Target 50% reduction in avoidable local food waste, which translates to a 7% reduction in total food CBE. This could be promoted through affordability/zero waste initiatives.
- Promote diet shift (e.g. 1 less serving of red meat per week). Target 20% reduction in food CBE. This could be promoted through 'healthy, affordable' meal initiatives.
- Promote low carbon regenerative local farming. For example, support Regional Food and Agriculture Strategies including the Bear Hill pilot. (Not quantified in modeling but supports meeting this target.)

Assumptions and Sources:

Additional Pathway 2 GHG reductions targeting food waste and diet shift through local policy are derived from [Second Harvest](#) and the [Saanich 2021 Consumption-Based Ecological and Carbon Footprint Assessment](#).

IPPU

By 2050, the CBE for IPPU is estimated to decrease to 22.0 ktCO₂e under Pathway 2, compared to 55.1 ktCO₂e under Pathway 1, representing a 60% reduction.

IPPU emissions are from heavy industry (e.g. cement, chemicals, metals) and HFC emissions, mainly from commercial refrigeration – e.g. grocery stores, ice rinks, etc.

Heavy industry emissions are predicted to decrease 30% by 2030 and 60% by 2050. HFCs, which make up about 38% of the IPPU emissions, are predicted to decrease 85% by 2036, based on commitments in supporting policy.

Overall, Pathway 2 CBE reductions for IPPU are assumed to be 30% by 2030 and 60% by 2050, with HFCs leading the reductions.

Assumptions and Sources:

IPPU emissions are from heavy industry (e.g. cement, chemicals, metals) and HFC emissions, mainly from commercial refrigeration – e.g. grocery stores, ice rinks, etc.

Assumption: For Pathway 2, emission factors are predicted to decrease 30% by 2030 & 60% by 2050.

Rationale:

- See Heavy Duty Vehicles for details on heavy industry assumptions and sources
- The BC GHG inventory shows HFC's make up about 38% of the IPPU emissions. HFC's have strong policy supporting reductions - the main driver is the Kigali Amendment to Montreal Protocol. It is in place with supporting policy – committing to 85% reductions by 2036. Therefore, reductions from refrigerants will likely lead the reductions in IPPU. However, the assumption is that overall IPPU emission factors still decrease at the same rate as heavy industry, 30% by 2030 & 60% by 2050. A 60% decrease in heavy industry is already potentially optimistic and speculative. The higher HFC reductions may just help decrease the average IPPU emissions by 60% by 2050 rather than raise the average.

Sources: [Provincial Inventory of greenhouse gas emissions](#) ; [Hydrofluorocarbon \(HFC\) Phase-down](#) ; [Federal offset protocol: Reducing greenhouse gas emissions from refrigeration systems](#)

Diesel, Buildings

By 2050, the CBE for “Diesel, Buildings” is estimated to decrease to 8.5 ktCO₂e for Pathway 2, compared to 33.9 ktCO₂e for Pathway 1, representing a 75% decrease.

“Diesel, Buildings” emissions are from yard equipment and construction equipment (excavators, etc.).

Yard equipment is well underway to transitioning to electric but commercial uptake is lagging. Studies show that supporting policy, such as phasing-out gas powered yard equipment, improve uptake significantly.

Construction equipment has not yet undergone a substantial transition to electric in BC. While there has been limited uptake of electric generators, pilot projects, and other early

initiatives, much of the needed electric construction equipment is commercially available. For example, in Oslo, 77% of machinery used on municipal construction sites was zero-emission by 2023, and the city is on track to reach 100% by 2030.

Based on these findings an overall reduction in CBE for “Diesel, Buildings” is assumed to be 30% by 2030 and 75% by 2050 for Pathway 2 through implementing local policy:

- A local phase-out / ban on gas powered yard equipment
- Signing on to a Clean Construction Declaration and implementing policy supporting use of electric construction equipment

Assumptions and Sources:

Assumption: For Pathway 2 a local phase-out ban on gas powered yard equipment and policy supporting the use of electric construction equipment are assumed reduce emissions 30% by 2030 and 75% by 2050 from Pathway 1.

Rationale:

- “Diesel, Buildings” emissions in BC are roughly split about 1/3 residential and 2/3 commercial, with the commercial portion split about 20% yard equipment and 80% construction equipment.
- Market share of electric yard equipment is about 45% globally. Uptake is dependent on policy support and commercial uptake is lagging residential.
- Market share of electric construction equipment is low in BC. Electric generators have some uptake and smaller equipment is becoming more available.
- Oslo, Norway is on target to fully electric construction sites by 2030. This shows the equipment is available but as with early EV adoption, availability and sales are prioritized to jurisdictions that are supporting/requiring rollout.

Sources: [Provincial Inventory of greenhouse gas emissions](#) ; [Estimating Emissions from Non-Road Engines for Metro Vancouver](#) ; [2026 Electric Construction Report](#) ; [Outdoor Power Equipment Market](#)

Appendix A – Embodied Emission Factors of Energy Sources

	2022	2030	2050
Electricity*	NA	NA	NA
Natural Gas (tCO ₂ e/GJ)	0.01545	0.004326	0.003863
Heating Oil (tCO ₂ e/GJ)	0.03049	0.024394	0.018295
Gasoline (tCO ₂ e/L)	0.001181	0.0009448	0.0007086
Diesel (tCO ₂ e/L)	0.001128	0.0009023	0.0006767
Renewable Diesel – DAC synthetic (tCO ₂ e/L)	0.0002256	0.0001692	0.00005639

* Embodied emissions of electricity generation in BC are from sources such as infrastructure and decomposing submerged vegetation from fluctuating water levels. The long lifespan of infrastructure results in a very low annual contribution to emissions. There is insufficient data to estimate emissions from decomposing submerged vegetation in BC, however it is assumed to be quite low. In warmer climates the contribution of methane released from decomposition can be high and can result in hydro power having a significant contribution to regional emissions.

Appendix B – Breakdown of Modeled Consumption-based Emissions

Consumption-based Emissions - Business-as-Usual

	2022	2030	2050
Food	227,963	227,963	227,963
Buildings Operating	132,267	126,555	109,242
Buildings Embodied-Materials	38,390	43,869	44,956
Buildings Embodied-Fuels	38,115	13,494	7,543
Waste Direct	14,881	17,016	20,748
Waste Embodied	92,063	73,689	51,344
Energy Industries	6,497	7,429	9,059
Passenger Vehicles Operating	182,057	122,726	64,637
Passenger Vehicles Embodied - Materials	42,235	46,458	21,751
Passenger Vehicles Embodied - Fuels	92,211	49,728	19,643
Heavy Duty Vehicles Operating	21,764	24,886	30,345
Heavy Duty Vehicles Embodied - Materials	3,928	4,492	2,023
Heavy Duty Vehicles Embodied - Fuels	8,380	7,666	7,011
Off-Road Operating	105,868	121,054	147,608
Off-Road Embodied - Materials	743	850	1,036
Off-Road Embodied - Fuels	48,453	44,322	40,534
Diesel, Buildings Operating	26,912	26,912	26,912
Diesel, Buildings Embodied - Fuels	11,657	9,325	6,994
IPPU	39,504	45,171	55,079
	1,133,888	1,013,604	894,428

Consumption-based Emissions – Pathway 1

	2022	2030	2050
Food	227,963	227,963	227,963
Buildings Operating	132,267	102,966	28,280
Buildings Embodied-Materials	38,390	43,869	44,956
Buildings Embodied-Fuels	38,115	10,066	753
Waste Direct	14,881	14,467	8,894
Waste Embodied	92,063	65,810	35,763
Energy Industries	6,497	5,647	731
Passenger Vehicles Operating	182,057	104,182	8,067
Passenger Vehicles Embodied - Materials	42,235	46,458	21,751
Passenger Vehicles Embodied - Fuels	92,211	42,310	2,672
Heavy Duty Vehicles Operating	21,764	16,650	8,873
Heavy Duty Vehicles Embodied - Materials	3,928	4,492	2,023
Heavy Duty Vehicles Embodied - Fuels	8,380	5,324	1,777
Off-Road Operating	105,868	86,457	58,045
Off-Road Embodied - Materials	743	850	1,036
Off-Road Embodied - Fuels	48,453	34,484	18,703
Diesel, Buildings Operating	26,912	26,912	26,912

Diesel, Buildings Embodied - Fuels	11,657	9,325	6,994
IPPU	39,504	45,171	55,079
	1,133,888	893,400	559,271

Consumption-based Emissions – Pathway 2

	2022	2030	2050
Food	227,963	227,963	166,413
Buildings Operating	132,267	102,966	28,280
Buildings Embodied-Materials	38,390	43,869	44,956
Buildings Embodied-Fuels	38,115	10,066	753
Waste Direct	14,881	14,467	8,894
Waste Embodied	92,063	65,810	35,763
Energy Industries	6,497	5,647	731
Passenger Vehicles Operating	182,057	104,182	8,067
Passenger Vehicles Embodied - Materials	42,235	46,458	21,751
Passenger Vehicles Embodied - Fuels	92,211	42,310	2,672
Heavy Duty Vehicles Operating	21,764	16,650	8,873
Heavy Duty Vehicles Embodied - Materials	3,928	4,492	2,023
Heavy Duty Vehicles Embodied - Fuels	8,380	5,324	1,777
Off-Road Operating	105,868	86,457	58,045
Off-Road Embodied - Materials	743	850	1,036
Off-Road Embodied - Fuels	48,453	34,484	18,703
Diesel, Buildings Operating	26,912	18,838	6,728
Diesel, Buildings Embodied - Fuels	11,657	6,528	1,748
IPPU	39,504	31,619	22,032
	1,133,888	868,978	439,245